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Inventory

Woody vegetation associated with rocky outcrops in Southern Amazonia: a starting point to unveil a unique flora

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Abstract: Vegetation associated with rocky outcrops is responsible for increasing floristic and landscape diversity, since its flora can be different from the adjacent landscape. Our objective was to characterize the woody vegetation associated with the rocky outcrop of the RPPN Mirante da Serra, Cristalino region, Mato Grosso State, Brazil. In a Deciduous Seasonal Forest associated with granite outcrops, we demarcated a plot of 1ha. We performed collections on this plot, installed for conducting monitoring studies, and also random collections on trails near the plot to better represent the outcrop flora. We totaled 126 species, 95 genera and 39 families. Overall, 18 species were increased to the Flora of Cristalino - with seven new records to the flora of Mato Grosso and four new records to the Amazon Domain. We found two threatened and 17 Brazilian endemic species. The rocky outcrop present in the RPPN Mirante da Serra is an important conservation area for a continuous execution of floristic studies in a manner to enable a monitoring program of the area, considering the new occurrence records and also because it contains threatened species.
Keywords: *Conservation; Cristalino; Deciduous Seasonal Forest; Floristics.*

Vegetação lenhosa associada a afloramentos rochosos na Amazônia Meridional: um marco inicial que revela uma flora única

Resumo: A vegetação que se associa a afloramentos rochosos é responsável por incrementar a diversidade florística e de paisagens, uma vez que a flora pode ser distinta da paisagem circundante. Nosso objetivo foi caracterizar a vegetação lenhosa sobre o afloramento rochoso da RPPN Mirante da Serra, região do Cristalino, estado de Mato Grosso, Brasil. Em uma Floresta Estacional Decidual associada a afloramento granítico, demarcamos uma parcela de 1 ha. Realizamos coletas nesse *plot*, instalado para a realização de estudos de monitoramento e, ainda, coletas aleatórias em trilhas próximas da parcela para melhor representar a flora do afloramento. A amostragem resultou em um total de 126 espécies, 95 gêneros e 39 famílias. Ao todo, 18 espécies foram incrementadas à Flora do Cristalino, das quais sete são novos registros à flora do estado de Mato Grosso e quatro ao Domínio da Amazônia. Encontramos duas espécies ameaçadas e 17 endêmicas do Brasil. O afloramento rochoso presente na RPPN Mirante da Serra é uma importante área de conservação para uma contínua realização de estudos florísticos de modo a possibilitar um programa de monitoramento da área, considerando os novos registros de ocorrência e, também, por conter espécies ameaçadas.
Palavras-chave: *Conservação; Cristalino; Floresta Estacional Decidual; Florística.*

Introduction

Rocky environments are characterized by temperature fluctuations, desiccant winds, water scarcity and high evaporation rates (Porembski & Barthlott 2000, Oliveira & Godoy 2007), as they can occur in places exposed to the sun, winds and frosts, as well as in permanently dark and humid places (Fernandes & Baptista 1988, Porembski 2007). These attributes allow environments to condition the spatial distribution of plants, forming suitable microhabitats so that they germinate and settle. It means that species do not occur randomly because rocky microhabitats affect species distribution due to the influence of soil depth, with greater sediment accumulation in flattened areas and shallower or absent soils in more rugged locations (Jumpponem et al. 1999, Conceição & Pirani 2005). In fact, the vegetation of environments like this differs markedly from that of the surroundings (Porembski et al. 1997, Barthlott & Porembski 2000).

The absence of large accumulations of soil and the little storage of rainwater that is lost quickly with runoff is exacerbated, especially in places with a steep slope. Rocky environments often make it possible to observe displacement of individual plants and entire clumps, which are susceptible to detaching from the rocky substrate when saturated with water during heavy rains (Porembski 2007). In contrast, other rocky environments may have sites with higher sediment and nutrient accumulation, which are more conducive to the occurrence and densification of tree-shrub strata, in contrast to the steeper areas with smaller soil layer or larger portion of exposed rock, favoring smaller plant species or promoting most sparse distribution among species (Conceição & Pirani 2005). Rocky outcrops also interfere with water flow, with rapid loss of runoff water on steep slopes and water retention in flat and semi-concave areas (Benites et al. 2003). Other factors such as evolution, potential solar radiation, substrate type, area and age of outcrop, anthropogenic factors and microclimate also influence the distribution of vegetation in rocky outcrops, promoting specialization of organisms occurring in these habitats, contributing to the formation of vegetative mosaics and also protecting species from environmental changes (Wiser 1998, Moura et al. 2011, Silveira et al. 2015), making these environments a priority for conservation.

Thus, studies with vegetation associated with rocky outcrops seek to associate plant species mainly with topography, substrate, water availability and climate severity. These factors provide several possible microhabitats for plant establishment, elucidating the role of environmental filters in the structuring of outcrop communities (Silva 2016). In addition, rocky outcrops can provide possible places of refuge during climate change, thus contributing to maintaining the high species diversity of tropical regions (Colinvaux et al. 2000, Speziale & Ezcurra 2014). In fact, the diversity of occurrence sites and the factors that influence species distribution are the main premises that have aroused a growing interest in the investigation of vegetation on rocky environments in Brazil (Moura et al. 2011). Rocky environments are present in all phytogeographic domains of Brazil, as well as the transition bands between these domains, thereby providing geologic, geomorphologic, climatic and phytophysiognomic diversity (IBGE 2001, Ab'Sáber 2003).

Vegetation-related investigations of Brazilian rocky outcrops have been conducted mainly in Central Brazil, Southeast region and Chapada Diamantina (Bahia), addressing the smaller vegetation of the grassland and savannah formations on granites, quartzites, sandstones and cangas (e.g., Scarano 2002, Caiafa & Silva 2005, Conceição & Pirani 2005, Oliveira & Godoy 2007, Viana & Lombardi 2007, Messias et al. 2012, Viana et al. 2016). However, there is a demand for studies aimed at understanding the Amazon forest formations that occur on these outcrops, such as dry forests or seasonal forests (Scarano 2007, Melo et al. 2014).

In the state of Pará, the so-called Amazon rocky grassland (in portuguese - *pt*, '*campo rupestre da Amazônia*'), a low vegetation with few trees on canga in Serra dos Carajás, was investigated (Silva et al. 1996). The terrain relief associated with the impermeability of the canga retains water in the soil, directly influencing the vegetation physiognomy and its floristic composition (Silva et al. 1996). In eastern Mato Grosso State, the rocky cerrado (in *pt*, '*cerrado rupestre*') with quartzite predominance has high basal area and species diversity and structural stability of the woody community due to the fact that this phytophysiognomy is present in a transition region between Cerrado and Amazon, and because of the good preservation status of the conservation unit in which the area is located (Maracahipes et al. 2011). Also in Mato Grosso state, two savannas on sandstone rocks were compared with low nutrient concentration, showing low floristic similarity. The first savanna was called "Transitional Rocky Cerrado" (in *pt*, '*cerrado rupestre de transição*') because it occurs in a transition area between Cerrado and Amazon, with great influence of the Cerrado flora of Central Brazil, while the second was called "Rocky Savannah Amazon" (in *pt*, '*savana amazônica rochosa*') because its floristic composition is influenced by Amazon vegetation types, which occur surrounding this vegetation type (Pessoa 2014).

In northern Mato Grosso state, previous diagnosis of rocky outcrops in areas of the Cristalino and Xingu State Parks were performed (Sasaki et al. 2010, Zappi et al. 2011, 2016). These studies emphasized the need to intensify the vegetation sampling and the floristic composition determination on the rocky outcrops that occur in Mato Grosso. Such environments occur in small portions in a fragmented way; the preliminary results, in the case of Cristalino region, are surveys performed mainly on trails for ecotourism. In this sense, our objective was to characterize the woody vegetation of a rocky outcrop of the 'RPPN Mirante da Serra', located in the Cristalino region, Southern Amazon, and to verify its conservation relevance. In order to achieve this goal, we elaborated the following questions: 1) What are the floristic characteristics of the rocky outcrop in the RPPN Mirante da Serra? 2) Are there endemic and threatened species in this area?

Material and Methods

1. *Study Area*

We conducted this study in an area of Deciduous Seasonal Forest associated with granitic rocky outcrop in the RPPN Mirante da Serra, Cristalino region (Figure 1), located in the Novo Mundo municipality, near the Alta Floresta border, in the northernmost region of the state of Mato Grosso (09°35'12 "S, 55°54'59" W; elevation ~248-351 m). The Cristalino region is a term locally used to refer to the Mato Grosso part of the Cristalino River Basin, which flows into the Teles Pires River (Zappi et al. 2011). The areas constituting the region are the Cristalino State Park (PEC) and the four Private Natural Heritage Reserves (RPPNs according to the Brazilian Legislation) managed by the Cristalino Ecological Foundation (FEC), called Cristalino, Gavião Real, Castanheira and Mirante da Serra.

In the study region, the climate is warm, seasonally dry (three to five months per year), with annual average temperatures above 26ºC

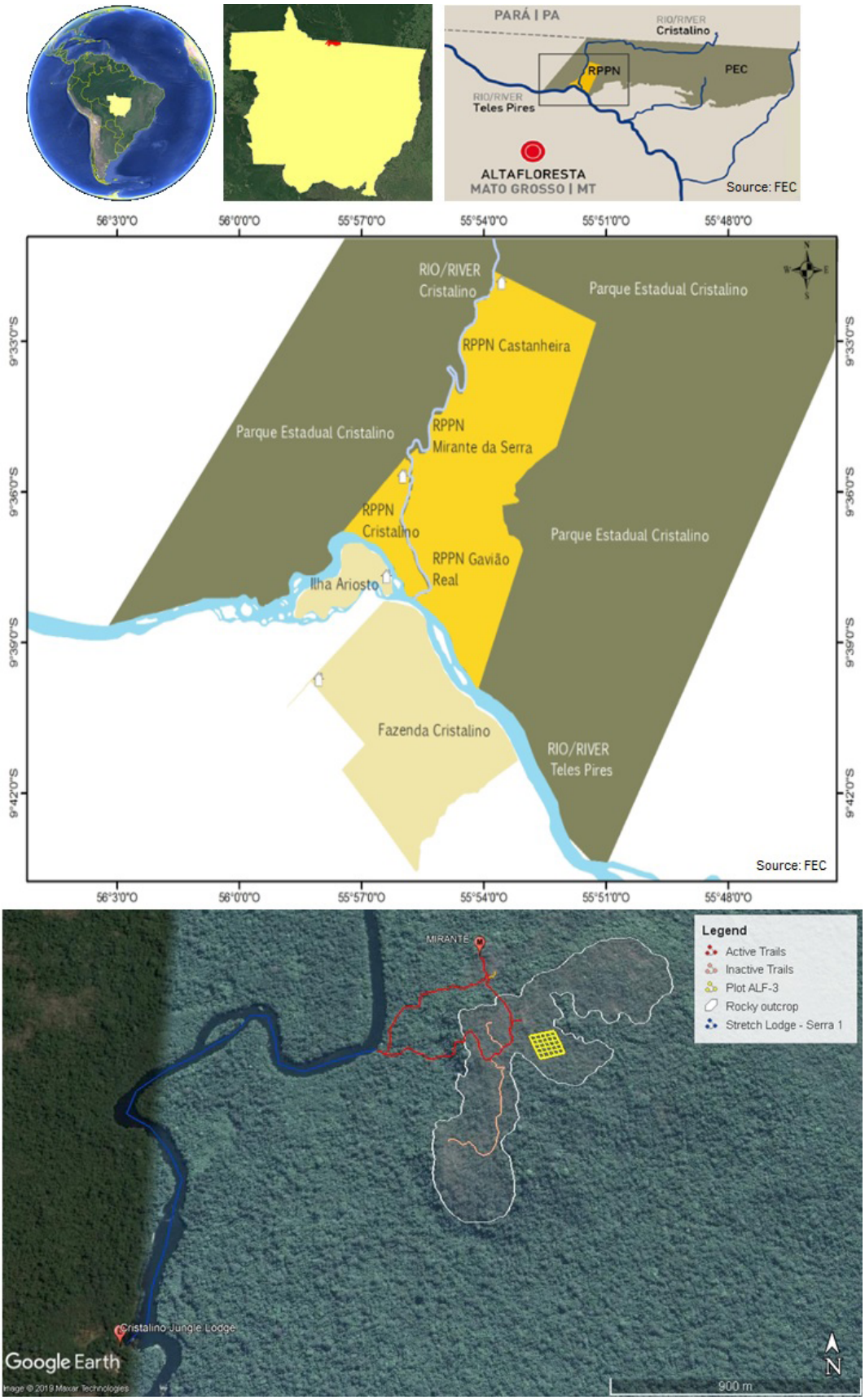

Figure 1. Location of the RPPN Mirante da Serra (study area) in the Cristalino Region, Southern Amazon, Mato Grosso, Brazil.

and mean annual rainfall between 2,400 mm and 2,800 mm (Alvares et al. 2013, Oliveira-Filho 2017). During this study (July 2016 - July 2017), the total annual rainfall was 2,080.27 mm, with the rainy period from September to April and the dry period – months with precipitation <100 mm – from May to August. February was the month with the highest precipitation (350.28 mm), August with the lowest (22.1 mm) and the months of June and July showed no precipitation. The average annual temperature during the study was 26.52 ºC, with the highest temperatures in April (minimum mean = 22.35 ºC) and August (maximum mean = 36.08 ºC). These data were obtained from station A-924, municipality of Alta Floresta-MT, at 61.5 km from the study area, approximately. In the rocky outcrop studied, the temperatures in the drought period can reach 43 ºC (E. Gressler, personal observation).

The relief forms of the region are structurally complex, varying from flat to mountainous, being characterized in four geomorphological units: I. Cachimbo Plateau; II. Northern Depression of Mato Grosso; III. Interplanaltic depression of the Juruena/Teles Pires; and IV. Rivers – Residential Plateaus of the Southern Amazon (IBGE 2006). The sampled area is situated in this last geomorphological unit. Considering the entire Cristalino region, soils are generally acidic, medium to low fertility, sandy and susceptible to erosion; low nutrient and water availability quartzarenic neosols predominate, with dystrophic red-yellow argisols, alic red-yellow argisols, dystrophic lithic neosols and dystrophic dark red oxissols (Mato Grosso 2001). The studied outcrop presents a litholic neossol formed mainly by granite.

The vegetation of the Cristalino region has areas of ecological tension, characterized by contacts between rainforest and seasonal forest; seasonal forest and savanna (Figure 2); and rainforest and savanna. Sasaki et al. (2010) and Zappi et al. (2011) described eight phytophysiognomies for the region. The vegetation associated with the rocky outcrop studied here was described by Sasaki et al. (2010) and Zappi et al. (2011) as a Dry Forest, found on the higher slopes or occasionally on the tops of the mountains, presenting most of the trees fully or almost totally leafless during the dry season. The canopy is relatively open (20 - 25 m high) with emerging trees up to 30 m high and the understory ranging from dense to open.

2. Data collection

Based on the RAINFOR network methodology described by Phillips et al. (2016), we allocated a permanent plot of 1-ha area, installed for conducting monitoring studies. The plot was located at 335 m altitude and marked by iron rebar (5 mm in diameter and 1 m in length) fixed to the ground. During the period from July 2016 to July 2017 we collected the individuals in reproductive stage found in the plot, in the access paths and in the 10 m surrounding the plot. We provided the habits of each species based on basic books of plant morphology (e.g., Gonçalves & Lorenzi 2011); in particular, we considered as trees the freestanding individuals >3m height (Oliveira-Filho 2017). We used IBGE (2012) as the phytogeographic classification system to assign each species to its respective vegetation type, a step in which we were also supported by Sasaki et al. (2010) and Zappi et al. (2011). To compose the botanical collection, we followed the procedures recommended by Fidalgo & Bononi (1989) and IBGE (2012). The collected materials were incorporated into the collection of the Southern Amazon Herbarium - HERBAM, Mato Grosso State University, Alta Floresta - MT.

Species were identified through partnerships with botanists experienced in the regional flora, as well as the use of dichotomous keys in review works (Goldenberg et al. 2012, Oliveira et al. 2012, Zappi et al. 2017), comparison with materials deposited in the HERBAM collection and online herbarium databases that provide expertly reviewed exsiccate images (e.g., Reflora, SpeciesLink, Tropicos, Kew Herbarium Collection, New York Botanical Garden - NYBG Virtual Herbarium, and Field Museum). We also consulted specialists in some more complex groups, such as the Myrtaceae families (Marcos Sobral, Carolyn Proença and Marla Ibrahim), Malvaceae (Sue Frisby), Rubiaceae (Daniella Zappi), Fabaceae (José M. Fernandes) and Melastomataceae (Fernandes Guimarães and Renato Goldenberg). In order to obtain greater confidence and success in identifying infertile individuals that were measured in the plot, we collected an individual sample for comparison with the HERBAM scientific collection, whose collection consists mainly of samples from the regional flora, including those from the Cristalino State Park.

The species list was structured from the compilation of our random collections, the composition of the 1-ha plot, the species occurring within 10 m around the 1-ha area and the materials deposited in HERBAM from previous surveys carried out during the 'Flora Cristalino Program'. We validated the accepted and correct spelling of the scientific names and their authors based on Flora do Brasil 2020 em construção (2019); APG IV (2016) was consulted for the genealogical classification of botanical groups. We also obtained information regarding conservation status and endemism of each species from the Red List of 'Centro Nacional de Conservação da Flora' (CNCFlora; http://www.cncflora.jbrj.gov.br) to provide a quantitative relevance of the Cristalino region for biodiversity conservation.

Results and Discussion

From the compilation of the data in our study and the materials deposited in HERBAM, we listed 126 woody species, 95 genera and 39 families for the vegetation associated with the RPPN Mirante da Serra rocky outcrop. Considering these species, eight were identified to the genera level due to the complexity of the groups and the absence of fertile material (Table 1). The families with the largest number of species were Fabaceae (20), Malvaceae (13), Apocynaceae and Rubiaceae (eight species each), and Bignoniaceae and Myrtaceae (seven each).

The largest representativeness of Fabaceae is expected because it is one of the most diverse families in inventories from Brazil and the Amazon (BFG 2015). Furthermore, in several studies conducted in the Cerrado (e.g., Campos et al. 2006; Walter & Guarino 2006; Ferreira-Júnior et al. 2008) and in the Cerrado-Amazon transition (e.g., Ivanauskas et al. 2004; Haidar et al. 2013), Fabaceae is also highlighted as one of the richest in species, denoting the high establishment capacity of this family in the most varied types of environments. A study evaluating the soils of the area studied here will possibly confirm the idea that nitrogen fixation capacity is a good strategy for legume maintenance in areas whose soil has low fertility conditions, such as slopes and tops of hills. However, not all legume species have this capability. When we consider the classic classification of Fabaceae into three subfamilies, species of the Papilionoideae subfamily have higher nodulation potential, whereas in Mimosoideae species nitrogen fixation is common and Caesalpinioideae is more uncommon (Colleta 2010; Macedo 2010).

Figure 2. Aspects of the Deciduous Seasonal Forest associated with rocky outcrop in the RPPN Mirante da Serra, Cristalino Region, Southern Amazon, Mato Grosso, Brazil. A: Study area in the rainy season. B: Study area in the dry season. C: Saxicolous Tree. D: Rocky outcrop Tree. E: Arboreal individuals in shallow soil.

Among the 20 species of Fabaceae recorded in the investigated area, 10 belong to the Papilionoideae subfamily. Therefore, at least 50% of Fabaceae can be potential nitrogen-fixing potentials whether we consider the classic classification as well as the new classification (LPWG 2017) that divides legumes into six subfamilies. On the other hand, the scarcity of studies conducted on deciduous forests associated with rocky outcrops hampers comparisons with more similar areas. Indeed, there is a poverty of data from rocky outcrops in Brazilian Amazon as a whole (Silva 2016). One of the few studies in this regard, which was not conducted in Amazon or Cerrado-Amazon transition, but in the core area of Cerrado, found the same pattern of high floristic relevance of Fabaceae (Felfili et al. 2007). In other locations in South America (e.g. the inselbergs of the Guyanes and of Venezuela), in a rank of 10 families, respectively, the most representative were Cyperaceae, Poaceae, Bromeliaceae, Rubiaceae, Melastomataceae, Orchidaceae, Fabaceae, Apocynaceae, Euphorbiaceae and Myrtaceae (Barthlott & Porembski 2000). However, this comparison is generalized, because the authors do not define whether such ranking refers to savannas or deciduous forests associated with rocky environments. However, Fabaceae is the seventh family in this rank and the first three families are monocotyledons, represented essentially by herbaceous plants, a group that was not addressed in our study.

The genera with the greatest species richness in the studied area were *Eugenia* L. (Myrtaceae), with five species, and *Aspidosperma*

Table 1: Woody species of Deciduous Seasonal Forest associated with rocky outcrop in the RPPN Mirante da Serra, Cristalino region, Southern Amazon. Threatened categories according to CNC Flora (DD: Deficient Data; LC: Least Concern; NE: Not Evaluated; VU: Vulnerable). *Taxa added to the Cristalino flora as result of our sampling survey.

Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Anacardiaceae														
Astronium lecointei Ducke	NE	not endemic	tree			x	x					x	x	Indivíduo 628
Spondias mombin L.	NE	not endemic	tree				x			x		x	x	*in loco*
Apocynaceae														
Aspidosperma macrocarpon Mart. & Zucc.	LC	not endemic	tree				x	x				x	x	Da Silva, D.R. 128
A. multiflorum A.DC.	NE	endemic	tree				x	x		x		x	x	Sasaki, D. 2248
A. subincanum Mart.	NE	not endemic	tree				x					x		Indivíduo 360
Aspidosperma sp.			tree				x					x		Indivíduo 349
Mandevilla scabra (Hoffmanns. ex Roem. & Schult.) K.Schum.	NE	not endemic	liana				x					x	x	Da Silva, D.R. 146
Marsdenia cf. macrophylla (Humb. & Bonpl.) E.Fourn.	NE	not endemic	shrub, liana				x					x	x	Da Silva, D.R. 118
M. weddellii (Fourn.) Malme	NE	unkown	liana				x					x	x	Da Silva, D.R. 137
Odontadenia sp.			liana				x					x		Morfotipo 71
Arecaceae														
Bactris acanthocarpa Mart.	NE	not endemic	palm	x				x				x	x	Sasaki, D. 1180
Syagrus cocoides Mart.	NE	endemic	palm				x					x	x	Da Silva, D.R. 141
Aristolochiaceae														
Aristolochia sp.			liana				x					x		Morfotipo 28
Bignoniaceae														
Adenocalymma impressum (Rusby) Sandwith	NE	not endemic	liana				x					x		Ribeiro, R.S. 250
Fridericia cinnamomea (DC.) L.G.Lohmann	NE	not endemic	liana				x			x		x		*in loco*

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Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Handroanthus capitatus (Bureau & K.Schum.) Mattos	NE	not endemic	tree				x					x	x	Da Silva, D.R. 119
H. serratifolius (Vahl) S.Grose*	NE	not endemic	tree				x					x		Koch, A.K. 843
Pyrostegia venusta (Ker Gawl.) Miers	NE	not endemic	liana			x	x	x		x		x	x	*in loco*
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	NE	not endemic	tree				x	x				x		Henicka, G.S. 107
Tynanthus polyanthus (Bureau ex Baill.) Sandwith	NE	not endemic	liana			x	x	x				x	x	Sasaki, D. 1625
Bixaceae														
Cochlospermum orinocense (Kunth) Steud.	NE	not endemic	tree				x	x				x	x	Sasaki, D. 1337
C. regium (Mart. ex Schrank) Pilg.	LC	not endemic	shrub				x					x	x	Da Silva, D.R. 95
Calophyllaceae														
Kielmeyera regalis Saddi	NE	endemic	tree, shrub					x	x	x		x	x	Henicka, G.S. 111
Caricaceae														
Jacaratia digitata (Poepp. & Endl.) Solms	NE	not endemic	tree			x		x				x	x	Morfotipo 10
Clusiaceae														
Clusia panapanari (Aubl.) Choisy	NE	not endemic	shrub, hemiepiphyte				x					x	x	Sasaki, D. 1606
C. weddelliana Planch. & Triana	NE	not endemic	tree, hemiepiphyte				x		x	x		x	x	Da Silva, D.R. 186
Combretaceae														
Buchenavia tomentosa Eichler	NE	not endemic	tree				x			x		x	x	Gallo, S.C. 190
Combretum laxum Jacq.	NE	not endemic	liana		x	x	x				x	x	x	Da Silva, D.R. 184

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Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Connaraceae														
Connarus coriaceus G.Schellenb.	NE	not endemic	liana			x	x			x		x		Sasaki, D. 2234a
Cucurbitaceae														
Siolmatra pentaphylla Harms*	NE	not endemic	liana, subwoody vine				x					x		Gallo, S.C. 69
Erythroxylaceae														
Erythroxylum anguifugum Mart.	LC	endemic	tree, shrub				x			x		x	x	Da Silva, D.R. 138
E. leptoneurum O.E.Schulz	NE	not endemic	shrub				x					x		Da Silva, D.R. 125
Euphorbiaceae														
Croton hadrianii Baill.*	NE	endemic	shrub				x					x	x	Da Silva, D.R. 168
Manihot anomala Pohl	NE	not endemic	shrub				x					x		Gallo, S.C. 71
M. tristis Müll.Arg.	NE	endemic	shrub, liana				x			x		x	x	Da Silva, D.R. 145
Maprounea guianensis Aubl.	NE	not endemic	tree					x				x		*in loco*
Fabaceae														
Amburana cf. *acreana* (Ducke) A.C.Sm.	VU	not endemic	tree					x				x		Indivíduo 878
Anadenanthera peregrina (L.) Speg.	NE	not endemic	tree				x		x	x		x	x	Da Silva, D.R. 134
Bauhinia cf. *brevipes* Vogel*	NE	not endemic	tree, shrub				x					x		Da Silva, D.R. 180
B. depauperata Glaz.	unkown	unkown	shrub				x			x		x		Henicka, G.S. 17
Bauhinia cf. *rufa* (Bong.) Steud.*	NE	not endemic	shrub				x					x		Da Silva, D.R. 181
Camptosema ellipticum (Desv.) Burkart	NE	not endemic	liana, subwoody vine				x		x	x		x	x	Gallo, S.C. 123
Chamaecrista cf. *brevicalyx* (Benth.) H.S.Irwin & Barneby*	DD	endemic	shrub				x					x		Da Silva, D.R. 163
Chloroleucon acacioides (Ducke) Barneby & J.M.Grimes	NE	not endemic	tree				x					x	x	Da Silva, D.R. 188

Continue...

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Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Dalbergia gracilis Benth.	NE	not endemic	shrub, liana				x				x	x	x	Sasaki, D. 1618
Enterolobium maximum Ducke	NE	not endemic	tree					x				x		Nascimento, J. 34
Erythrina fusca Lour.	NE	not endemic	tree				x	x				x	x	Gallo, S.C. 190
E. ulei Harms	NE	not endemic	tree				x					x	x	Da Silva, D.R. 93
Galactia striata (Jacq.) Urb.*	LC	not endemic	shrub, subwoody vine				x					x		Da Silva, D.R. 148
Hymenaea courbaril L.	LC	not endemic	tree	x	x		x	x				x	x	PFC. 241
Machaerium acutifolium Vogel	NE	not endemic	tree				x					x	x	Gallo, S.C. 34
M. amplum Benth.	NE	not endemic	tree; shrub; liana				x					x		Gallo, S.C. 193
Periandra coccinea (Schrad.) Benth.	NE	endemic	liana, subwoody vine				x					x		Da Silva, D.R. 175
Platymiscium trinitatis Benth.	NE	not endemic	tree				x					x	x	PFC. 239
Senegalia polyphylla (DC.) Britton & Rose	NE	not endemic	tree			x	x	x			x	x	x	*in loco*
S. tenuifolia (L.) Britton & Rose	NE	not endemic	shrub, liana				x					x		*in loco*
Lamiaceae														
Amasonia lasiocaulos Mart. & Schauer ex Schauer*	NE	not endemic	shrub				x					x		Ribeiro, R.S. 219
Vitex polygama Cham.	NE	endemic	tree				x					x	x	Da Silva, D.R. 132
Loganiaceae														
Strychnos araguaensis Krukoff & Barneby	NE	not endemic	liana				x					x		Nascimento, J. 32
Lythraceae														
Physocalymma scaberrimum Pohl	LC	not endemic	tree				x					x		PFC. 289
Malpighiaceae														
Banisteriopsis megaphylla (A.Juss.) B.Gates	NE	endemic	liana				x					x	x	Da Silva, D.R. 143

Continue...

...Continuation

Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
B. stellaris (Griseb.) B.Gates	NE	endemic	liana				x					x	x	Sasaki 1936
Diplopterys lutea (Griseb.) W.R.Anderson & C.C.Davis	NE	not endemic	liana				x					x		PFC. 466
Janusia janusioides (A.Juss.) W.R.Anderson*	NE	not endemic	liana				x					x		Da Silva, D.R. 193
Malvaceae														
Ceiba samauma (Mart.) K.Schum.	NE	not endemic	tree				x					x	x	Da Silva, D.R. 153
C. speciosa (A.St.-Hil.) Ravenna	NE	not endemic	tree				x					x	x	Henicka, G.S. 32
Eriotheca globosa (Aubl.) A.Robyns	NE	not endemic	tree				x	x				x	x	Sasaki, D. 2465
Helicteres brevispira At.St.-Hil.	NE	not endemic	shrub				x					x	x	Koch, A.K. 849
H. muscosa Mart.	NE	endemic	shrub				x					x	x	Da Silva, D.R. 922
H. pentandra L.	NE	not endemic	shrub				x			x		x	x	Da Silva, D.R. 194
Luehea candicans Mart. & Zucc.	LC	not endemic	tree				x					x	x	Da Silva, D.R. 124
Mollia lepidota Spruce ex Benth.	NE	not endemic	tree				x					x	x	Da Silva, D.R. 139
Pachira paraensis (Ducke) W.S.Alverson	NE	not endemic	tree	x			x			x		x	x	Da Silva, D.R. 190
Peltaea sp.			shrub				x			x		x	x	Da Silva, D.R. 171
Pseudobombax longiflorum (Mart.) A.Robyns	NE	not endemic	tree	x			x			x		x	x	Da Silva, D.R. 189
P. tomentosum (Mart.) A.Robyns*	LC	not endemic	tree				x					x		Da Silva, D.R. 185
Theobroma speciosum Willd. ex Spreng.	NE	not endemic	tree	x				x				x	x	Da Silva, D.R. 98
Marcgraviaceae														
Norantea guianensis Aubl.	NE	not endemic	tree, shrub, liana				x			x		x	x	Da Silva, D.R. 116
Melastomataceae														
Ernestia sp.			shrub				x					x		Da Silva, D.R. 150
Mouriri apiranga Spruce ex Triana	NE	not endemic	tree			x	x		x		x	x	x	Gallo, S.C. 188
Tibouchina barbigera (Naudin) Baill.	NE	not endemic	tree				x			x		x	x	Da Silva, D.R. 162

Continue...

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Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Meliaceae														
Cedrela odorata L.	VU	not endemic	tree	x			x					x	x	Gallo, S.C. 185
Menispermaceae														
Odontocarya cf. *tamoides* (DC.) Miers	NE	not endemic	liana				x					x		Morfotipo 55
Moraceae														
Ficus amazonica (Miq.) Miq.	LC	not endemic	tree				x					x	x	Da Silva, D.R. 94
Ficus obtusifolia Kunth	NE	not endemic	tree, hemiepiphyte				x					x	x	Sasaki, D. 2028
Ficus schumacheri (Liebm.) Griseb.*	DD	not endemic	tree, hemiepiphyte				x					x		Da Silva, D.R. 167
Ficus sp.			tree, hemiepiphyte				x					x		Indivíduo 5
Myristicaceae														
Compsoneura ulei Warb.	NE	not endemic	tree	x	x	x		x				x	x	Sasaki, D. 1225
Iryanthera juruensis Warb.	NE	not endemic	tree	x	x		x					x	x	Nascimento, J. 36
Myrtaceae														
Campomanesia grandiflora (Aubl.) Sagot*	NE	not endemic	tree				x					x		Gallo, S.C. 29
Eugenia aurata O.Berg	LC	endemic	tree				x					x	x	Gallo, S.C. 100
E. dysenterica (Mart.) DC.*	NE	endemic	tree				x					x		Da Silva, D.R. 129
E. flavescens DC.	NE	not endemic	tree; shrub				x					x	x	Da Silva, D.R. 121
E. stictopetala Mart. ex DC.	NE	not endemic	tree				x					x	x	Da Silva, D.R. 131
Eugenia sp.			tree				x					x		Indivíduo 1035
Myrcia rufipes DC.	NE	endemic	tree; shrub				x		x	x		x	x	Da Silva, D.R. 97
Ochnaceae														
Ouratea sp.			tree				x					x		Da Silva, D.R. 100
Opiliaceae														
Agonandra brasiliensis Miers ex Benth. & Hook.f.	NE	not endemic	tree				x					x		Indivíduo 994
Polygalaceae														
Bredemeyera floribunda Willd.	NE	not endemic	liana				x			x		x	x	Da Silva, D.R. 187

Continue...

...Continuation

Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
B. lucida (Benth.) Klotzsch ex Hassk.	NE	endemic	liana				x			x		x	x	Ribeiro, R.S. 135
Securidaca diversifolia (L.) S.F.Blake	NE	not endemic	liana				x		x	x		x	x	Ribeiro, R.S. 134
Rhamnaceae														
Gouania colurnifolia Reissek*	NE	not endemic	liana				x					x		Da Silva, D.R. 177
Rubiaceae														
Bertiera guianensis Aubl.	NE	not endemic	tree, shrub				x		x	x		x	x	Da Silva, D.R. 130
Cordiera sessilis (Vell.) Kuntze	NE	not endemic	tree				x	x		x		x	x	Zappi, D.C. 1445
Coutarea hexandra (Jacq.) K.Schum.	NE	not endemic	tree				x	x	x	x		x	x	Da Silva, D.R. 140
Dialypetalanthus fuscescens Kuhlm.	NE	not endemic	tree				x	x		x		x	x	Da Silva, D.R. 127
Guettarda spruceana Müll.Arg.*	NE	not endemic	tree				x					x	x	Sasaki, D. 1850
Randia armata (Sw.) DC.	NE	not endemic	tree, shrub			x	x	x			x	x	x	Gallo, S.C. 24
Rudgea crassiloba (Benth.) B.L.Rob.	NE	not endemic	tree				x					x		Indivíduo 134
Simira rubescens (Benth.) Bremek. ex Steyerm.	NE	not endemic	tree				x		x	x		x	x	Sasaki, D. 1607
Rutaceae														
Ertela trifolia (L.) Kuntze	NE	not endemic	shrub				x					x	x	Sasaki, D. 1535
Esenbeckia pilocarpoides Kunth	LC	not endemic	tree, shrub				x	x				x	x	Sasaki, D. 1218
Metrodorea flavida K.Krause	NE	not endemic	tree	x		x	x	x				x	x	*in loco*
Zanthoxylum rhoifolium Lam.	NE	not endemic	tree				x	x				x	x	Sasaki, D. 1216
Salicaceae														
Casearia gossypiosperma Briq.	LC	not endemic	tree				x					x	x	PFC. 261
C. pitumba Sleumer	NE	not endemic	tree				x					x		Indivíduo 151
Sapindaceae														
Allophylus racemosus Sw.	NE	not endemic	shrub				x					x	x	Ribeiro, R.S. 223

Continue...

...Continuation

Family *Species*	Threatened category (CNCFlora)	Endemic to Brazil	Habit	Submontane Rainforest ('Floresta Ombrófila Densa Submontana')	Alluvial Rainforest ('Floresta Ombrófila Densa Aluvial')	Submontane Open Rainforest ('Floresta Ombrófila Aberta Submontana')	Deciduous Seasonal Forest ('Floresta Estacional Decidual')	Semideciduous Seasonal Forest ('Floresta Estacional Semidecidual')	'Campinarana Florestada/Gramíneo-lenhosa'	'Campo Rupestre da Amazônia'	Pioneering Formations with River Influence ('Formações Pioneiras com Influência Fluvial')	RPPN 'Mirante da Serra'	Parque Estadual Cristalino	Voucher
Trigoniaceae														
Trigonia laevis Aubl.*	NE	not endemic	liana				x	x			x	x		Da Silva, D.R. 157
T. nivea Cambess.	NE	not endemic	liana			x	x					x	x	Ribeiro, R.S. 136
Urticaceae														
Cecropia sciadophylla Mart.	NE	not endemic	tree	x			x					x	x	*in loco*
Urera baccifera (L.) Gaudich. ex Wedd.	NE	not endemic	shrub					x		x		x	x	*in loco*
Vitaceae														
Cissus duarteana Cambess.	NE	endemic	subwoody vine		x	x	x					x	x	Da Silva, D.R. 147
C. erosa Rich.	NE	not endemic	liana				x		x	x		x	x	Da Silva, D.R. 142
C. tinctoria Mart.*	NE	not endemic	liana				x					x		Da Silva, D.R. 176
Vochysiaceae														
Callisthene fasciculata Mart.	NE	not endemic	tree				x					x	x	Da Silva, D.R. 133
Qualea dinizii Ducke*	NE	unkown	tree					x				x		Da Silva, D.R. 192

Mart. & Zucc. (Apocynaceae) and *Ficus* L. (Moraceae), with four species each. These three genera are among the most important of their respective families, with wide distribution and high diversity in the Neotropical region, being *Ficus* and *Eugenia* pantropical ones (TROPICOS 2017). In Brazil, 387 species of *Eugenia* have been reported, of which 302 are endemic (BFG, 2015). However, as taxonomic treatments are finalized, there is a growing tendency for information to be updated by the Flora do Brasil 2020 project. Currently, 386 species (299 endemic) are reported for *Eugenia*, with the highest concentration found in the Atlantic Forest (257) and the Amazon (92) (Flora do Brasil 2020 em construção, 2019). For *Aspidosperma*, there are 67 species (31 endemic), while 85 (23 endemic) are reported for the *Ficus* genus, both with higher concentrations in the Amazon (37 and 55 species, respectively) (Flora do Brasil 2020 em construção 2019). *Aspidosperma* (Salis et al. 2004) and *Eugenia* (Ivanauskas et al. 1999) are also among the species-richest ones.

From this study we added 18 taxa (1.3%) to Flora do Cristalino, which now totals 1,383 species (Zappi et al. 2011). Our sampling was concentrated in a Deciduous Seasonal Forest, a forest formation that corresponds to less than 5% of the total area of Cristalino. This was one of the least sampled phytophysiognomies (80 species) from the inventories of the Cristalino Flora Program (Sasaki et al. 2010, Zappi et al. 2011). Among the 18 species added to Flora do Cristalino, seven are trees, four are shrubs, five are lianas and two species were recorded with life-form variation, namely, *Bauhinia* cf. *brevipes* registered as tree and shrub, and *Galactia striata*, registered as shrub and subwoody vine. *Croton hadrianii* and *Pseudobombax tomentosum* had their identifications complemented from the collections made during our study. These two species were collected from previous inventories, but were deposited in HERBAM at a generic level. Other species that we highlight in the present survey are *Campomanesia grandiflora* and *Eugenia dysenterica*, both belonging to the family Myrtaceae. The species *C. grandiflora* comprises a new registry for the State of Mato Grosso, whose distribution in Brazil was restricted to the states of the Northern Region, Bahia and Maranhão (Sobral et al. 2015). *Eugenia dysenterica* is a new record for the Amazon, whose distribution is confirmed in the most varied savannah and forest formations in Brazil and Bolivia, but in Brazil its occurrence is only cited for the Cerrado, Caatinga

and Atlantic Forest Domains (Sobral et al. 2015). These plant species found in a specific locality surrounded by various sections of another ecosystem are called "relictual" (Ab'Sáber 2003).

In this study we compiled 65 tree species (including four hemiepiphytes: *Clusia weddelliana* (Clusiaceae), *Ficus obtusifolia*, *Ficus* cf. *schumacheri* and *Ficus* sp. (Moraceae)), 18 shrubs (including the hemiepiphyte *Clusia panapanari*), 29 lianas (including the subwoody vines) and two palm species. In addition, four species were recorded as shrubs and lianas: *Marsdenia* cf. *macrophylla* (Apocynaceae), *Manihot tristis* (Euphorbiaceae), *Dalbergia gracilis* and *Senegalia tenuifolia* (Fabaceae); seven as trees and shrubs: *Kielmeyera regalis* (Calophyllaceae), *Erythroxylum anguifugum* (Erythroxylaceae), *Eugenia flavescens* and *Myrcia rufipes* (Myrtaceae), *Bertiera guianensis* and *Randia armata* (Rubiaceae) and *Esenbeckia pilocarpoides* (Rutaceae). The species *Machaerium amplum* (Fabaceae) and *Norantea guianensis* (Marcgraviaceae) were found as trees, shrubs and lianas. The variability of life forms of these species represents their competitive strategies and high adaptability to the conditions imposed by the environment (Via et al. 1995). Considering these authors, we believe that the isolation, allied to the pedological characteristic and the regional climatic seasonality, are factors that favor the plasticity of the species life form in the studied area.

Among the 126 species compiled in this study, 66 were unique to the Deciduous Seasonal Forest, 50 were shared with neighboring phytophysiognomies and nine species were recorded only in neighboring phytophysiognomies (Table 1). However, we emphasize that there may be an influence of the intensified sampling effort on the area of rocky outcrops studied here. Moreover, during the elaboration of Flora do Cristalino, the collections intensified in the areas of Rainforest, while smaller sampling effort was allocated for the outcrop areas (e.g., Zappi et al. 2011). Nevertheless, the authors showed differences in species diversity between these areas.

Regarding the conservation status and endemism of the species we obtained from the CNCFlora (2019) and Flora do Brasil 2020 databases under construction (2019), respectively, the following information could be assessed: 1 - In the Cristalino region there are two species classified in the 'Vulnerable' threat category and 12 species classified in the category of 'Least Concern', two species as 'Deficient Data' and the others were not evaluated (see Table 1). 2 - In the Cristalino region there are 17 species classified as endemic in Brazil, three species whose endemism is unknown and the others are not endemic. The occurrence of endemic and threatened species confirms the importance of the protected areas (State Park Cristalino and four private reserves) in the Cristalino region, especially taking into account the rapid deforestation rate associated with slow development, and dissemination of studies on biological diversity in the South Amazon region.

Final considerations

The species increment results for Flora do Cristalino, with some being new records for Mato Grosso and others composing new records for the Amazon, as well as the presence of endemic and threatened species, reinforce the need for investigations of these outcrops that occur forming a corridor of rocky outcrop vegetation islands amid the rainforests from the South Amazon border. This corridor of rocky vegetation, covering the northern region of Mato Grosso and the southern portion of Pará, may be determinant for a broader distribution of some species, such as those with anemochoric dispersion.

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Authors' Contributions

Dennis Rodrigues da Silva: Substantial contribution in the concept and design of the study; contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Célia Regina Araújo Soares-Lopes: Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation.

Eliana Gressler: Contribution to data analysis and interpretation; Contribution to critical revision, adding intellectual content.

Pedro V. Eisenlohr: Substantial contribution in the concept and design of the study; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethics

The authors declare that they have complied with the guidelines established by the ethics principles. In this sense, there is no sort of plagiarism, double submissions, already published articles and possible frauds in research.

Data availability

Data obtained in field collections are deposited in 'Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado - SISGEN' from Brazilian Government and are also in process of incorporation into 'speciesLink' database.

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Editorial

Biota Neotropica: twenty years supporting biodiversity science

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Building everyday science comprises a complex and entangled process that relies on multiples processes. It involves training, funding, manage experiments, tests and re-tests, readings, presentations, discussions, incorporate reviews, and finally, submit and publish the results of the research. The latter one is a very sensitive and important phase of the research because it is not always easy to deal with criticism and rejection. It is not an easy procedure at all.

Scientific publication registers the advance achieved and will support new studies in the future. This is why to choose the right journal is a strategic decision not just to be read, but to give visibility to the research carried out and have the opportunity to discuss it with pairs, and to interact with the specialized scientific community. The best reward is to see your results being cited and used by other researchers to advance the state of knowledge in your field of research.

Concerned with the low number of journals focused on Neotropical biodiversity, and that none of them was open access, the BIOTA/FAPESP Program, launched in 2001 the **Biota Neotropica,** an open access peer reviewed electronic journal (Joly et al 2010). The BIOTA/FAPESP Program was created in 1999 with the mission of understanding biodiversity, ranging from characterization to ecosystem functioning and ecosystem services, and to support its conservation and sustainable use. In the early 2000's, a dozen of big thematic projects made herculean efforts on the production of inventories, thematic and taxonomic reviews, as well as identification keys. But, there were no journals prepared to publish "crude" taxonomic information, so essential for biodiversity science.

Therefore, **Biota Neotropica** was built upon publishing the results of original research, not only generated by the projects of the BIOTA/FAPESP Program, but covering the Neotropical region as a whole. Since it was launched the following categories of papers were established: articles, thematic or taxonomic reviews, identification keys, short communications and points of view, a forum for discussion of controversial/polemic questions.

From the beginning, the journal was designed to be online and open source, which means fully available for reading online and to download the full paper without any charge. At the time this was absolutely pioneer in Brazil, and reinforced one of the main objectives of the BIOTA/FAPESP Program, i.e. free access to all biodiversity information generated by the research projects within the Program, including the Environmental Information System/SinBiota with georeferenced information about species occurrence and distribution. This innovative approach made **Biota Neotropica** not just another journal, but a great contribution to biodiversity scientists and for the advance of Biodiversity Science.

Since the start **Biota Neotropica** adopted a strict editorial policy, using the double-blind system, and the experience of the leading researchers of thematic projects being developed under the umbrella of the BIOTA/FAPESP Program. In 2001 only one number was published, but with its increasing recognition the journal started to attract papers from all over the Neotropical Region, and currently it is published quarterly and on average each number has 20 papers.

After twenty volumes, 67 issues, 1,643 papers and around 70,000 citations[1], **Biota Neotropica** has become a reference as a Latin American Journal. In the last five years the Journal Impactor Factor has grown over 94% becoming the highest impact factor among Brazilian journals in the area of biodiversity (https://www.scijournal.org/). Currently it is indexed by ISI/Web of Science, and is part of the SciELO - Biodiversity Heritage Library collection.

Surely the group of 80 research, sitting in the Auditorium of FAPESP on April 8th,1996, to discuss the need for Research Program encompassing the large spectrum covered by the thematic "characterization, conservation and sustainable use of biodiversity" (Joly 2001), could not imagine the success of the BIOTA/FAPESP Program created on the 25th of March 1999. Let alone the importance of journal they decided to launch 2 years later.

Finally, the continuous support of FAPESP was crucial to provide regular publication without any interruption, a fundamental requisite for indexation.

The photo used in the cover of the commemorative edition of **Biota Neotropica**, volume 20 number 1, was selected from the thematic review Small-sized fish: the largest and most threatened portion of the

[1] https://analytics.scielo.org/?journal=1676-0603&collection=scl

megadiverse neotropical freshwater fish fauna Castro, R.M.C. & Polaz, C.N.M. 2020, and it is a tribute to Prof. Ricardo Macedo Corrêa e Castro from the Faculdade de Filosofia Ciências e Letras de Ribeirão Preto/USP, who was engaged in the BIOTA Program since its planning in 1996 and a member of the first Editorial Commission of **Biota Neotropica**.

Author Contributions

All authors contributed equally to manuscript preparation.

Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Article

Type of shelter and first description of the echolocation call of disk-winged bat (*Thyroptera devivoi*)

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Abstract: Thyropteridae is a family of bats endemic to the Neotropical region, and *Thyroptera devivoi* is the only species in the family that occurs exclusively in forest patches within savannas of northern South America and north of the Brazilian Cerrado. Primary data on the species are still scarce. Therefore, in this study our objective was to fill knowledge gaps on geographical distribution, roost-use, and echolocation for the species. We observed a *T. devivoi* colony of 15 individuals living under a dead palm leaf. The bats used the leaf as a roost for at least four days. After capturing one individual, we confirmed the species identification via skull size and the oblong shape of the adhesive disk. The new record reinforces the association of this species with non-forested formations, and its occurrence mainly in savannas. Echolocation calls of *T. devivoi* are consistent with those known for the genus, with multiharmonic, low intensity and high frequency pulses. Despite these new data, more studies are certainly needed to enhance distribution data for the species, as well as to clarify the biological and ecological requirements of the species.
Keywords: *echolocation, Brazil, Cerrado, Chiroptera, roost, Thyropteridae.*

Tipo de abrigo e primeira descrição da chamada de ecolocalização de morcegos com asas de disco (*Thyroptera devivoi*)

Resumo: Thyropteridae é uma família de morcegos endêmica da região Neotropical e *Thyroptera devivoi* é a única espécie da família que ocorre exclusivamente em manchas florestais das savanas do norte de América do Sul e do Cerrado Brasileiro. Dados primários da espécie são ainda escassos e o objetivo deste estudo foi preencher lacunas de conhecimento sobre distribuição geográfica, uso de abrigos e padrões de ecolocalização da espécie. Nós observamos uma colônia de *T. devivoi* com 15 indivíduos vivendo sob uma folha morta de palmeira. Os morcegos usaram a folha como abrigo ao menos por quatro dias. Depois de capturar um indivíduo, nós confirmamos a identificação da espécie por meio da morfologia do crânio e do disco adesivo. O novo registro reforça a associação da espécie com formações não florestais e a ocorrência principalmente em savanas. Os chamados de ecolocalização de *T. devivoi* são consistentes com o conhecido para o gênero, com pulsos multi-harmônicos de baixa intensidade e alta frequência. A despeito destes novos dados, mais estudos são certamente necessários para aprimorar os dados de distribuição assim como os requerimentos biológicos da espécie.
Palavras-chave: *abrigo, Brasil, Cerrado, Chiroptera, ecolocalização, Thyropteridae.*

Introduction

The Neotropical region has a rich and unique bat fauna, with six endemic families (Gardner 2008). Among those families exclusive of the Neotropics, the Thyropteridae, known as Disk-winged bats, are peculiar bats distinguished by the presence of adhesive suction pads near the thumbs and ankles, which allows bats to attach to smooth surfaces of leaves that are used as roosts (Riskin & Fenton 2001, Wilson 2007). These insectivorous leaf-roosting bats may spend at least half of their lives in the roost, but most *Thyroptera* roost data involves the young, still-furled leaves of *Heliconia* species (Findley & Wilson 1974, Riskin & Fenton 2001, Vonhof & Fenton 2004, Montero & Gillian 2015). Such roosts are well described and are the best-known roost type for this group of bats. However, such leaves usually form temporary roosts because developing leaves may remain furled for up to 60 h and occupation lasts for only a day (Vonhof & Fenton, 2004).

The family Thyropteridae has five recognized species, all belonging to the genus *Thyroptera* and occurring throughout the Neotropical region (Wilson 2007, Velazco et al. 2014). The most common and well known are *Thyroptera discifera* (Lichtenstein & Peters 1854) and *T. tricolor* Spix 1823. Both species are distributed from Central America to south-eastern South America (Findley & Wilson 1974, Tschapka et al. 2000, Vonhof & Fenton 2004, Dechmann et al. 2006, Gillam & Chaverri 2012, Buchalski et al. 2014, Montero & Gillam 2015). The other species are *Thyroptera lavali* Pine et al. 1993, an Amazonian species occurring in northern South America (Solari et al. 2004), and the recently described *Thyroptera wynneae* Velazco et al. (2014), known only by four specimens collected in the forests of Peru and southeastern Brazil (Hoppe et al. 2014, Velazco et al. 2014). The fifth species, *Thyroptera devivoi* Gregorin et al. (2006), is the only one known to occur in non-forested habitats, as it lives in savanna ecosystems found in the municipality of Bom Jesus, state of Piauí, (08°52′S, 44°57′W); Jalapão, in the state of Tocantins (10°33′S, 46°45′W); Barreirinhas, in the state of Maranhão (3º0´S, 43º6´W) (Santos et al. 2013); Tamton, Upper Takutu-Upper Essequibo Region, Guyana (2°21′N, 59°42′W) (Gregorin et al. 2006) and in the Department of Casanare, Colombia (06°02′15″N, 070°12′43″ W) (Rodriguez-Posada et al. 2017).

Although widely distributed, species of Thyropteridae are very elusive and not usually captured in mist nets, a fact that means they are generally poorly sampled in inventories, and few studies exist on the biology and ecology of most species (Solari et al. 2004, Velazco et al. 2014) reassuring the importance of any data on these rare animals. With the popularization in the recent years of bat recorders and acoustic study methods, bat vocalizations have begun to be used for sampling and species identification (Rydell et al. 2002, Barataud et al. 2013, Jung et al. 2014, Arias-Aguilar et al. 2018), especially for taxa rarely captured by traditional netting methods (O'Farrell & Gannon 1999).

However, to unequivocally identify vocalizations recorded in nature, especially in places with a large number of species with undescribed calls, it is necessary to have a call database that permits between-species comparisons (Arias-Aguilar et al. 2018). Moreover, some bats emit very low-intensity calls that are difficult to capture with most bat recorders, so that only fragmentary information is available for such Neotropical bat families, as the Thyropteridae, Furipteridae, Phyllostomidae, and Natalidae (Fenton 2013, Falcão et al. 2015). Within the Thyropteridae only two species have echolocation calls described in detail and they are *T. discifera* (Tschapka et al. 2000) and *T. tricolor* (Fenton et al. 1999, Barataud et al. 2013). Both species are characterized by low intensity broadband calls, with multiple harmonics.

Therefore, in this study, we aimed to fill knowledge gaps on the ecology, distribution, and echolocation of *Thyroptera devivoi*, one of the least-known but most ecologically distinct species in the family Thyropteridae. Accordingly, we present new information on roost use and provide the first detailed description of vocalizations for the species.

Materials and Methods

1. *Study Area*

Fieldwork was carried out in Chapada das Mesas National Park (CMNP), a Brazilian federal protected area located in Carolina municipality, Maranhão state (Figure 1). The National System of Nature Conservation Units - SNUC in its Article 8 defines that National Parks are Units of Integral Protection. According to Köppen-Geiger classification, Carolina has a Aw tropical climate (humid tropical savanna)-(Peel et al. 2007), with high temperatures ranging between 26-29°C and low temperatures between 20-23°C, with two well-defined seasons: dry winters (May to September) and rainy summers (October to April). Average annual rainfall is 1614 mm. August is the driest month and March that of greatest precipitation. The region is in a vegetational transition zone, with high biodiversity including species of three important Brazilian morphoclimatic domains: the Amazon, the Caatinga and the Cerrado (Ab'Sáber 2000). CMNP area is largely occupied by Cerrado and has a typical mosaic landscape, with enclaves of forest formations in a matrix predominantly composed by savannas and pastures (Olson et al. 2001, Moraes & Lima 2007). Bat captures of took place in a large forest enclave in the Cerrado located in the north of the park at coordinates 6°56'52.5"S, 47°21'37.7"W.

2. *Bat roost, collection, and identification*

We found a colony of *Thyroptera devivoi* in a roost and filmed it before the sunset on 11/October/2015 (Figure 2). Two days later (13/October/2015) we returned to the roost site to make a visual estimation of the number of individuals present in the colony. Later on that same day, we installed and opened three mist nets forming a triangle around the exit of the roost. On 14/October/2015 we returned to the bat roost to record the bat calls in the colony and to manually capture a specimen for correct species identification. Capture was achieved with the aid of a cloth bag installed at the roost exit. We collected a specimen and took tissue samples from the bat's patagium. The specimen was euthanized via anesthetic inhalation (Isoflurane) and later fixed and deposited in the Chiroptera Collection of the University of Brasília – CCUnB under accession number CCUnB1189.

For species identification, we used identification keys and articles related to the genus *Thyroptera* (Pine 1993; Solari et al. 2004; Gregorin et al. 2006; Velazco et al. 2014; Díaz et al. 2016). We made the following external and cranial measurements based on Velazco et al. (2014): Total Length (TL), Length of Tail (LT), Hind Foot Length (HF), Ear Length (Ear), Free Tail Length (FTL), Forearm Length (FA), Greatest Length of Skull (GLS), Condyloincisive Length (CIL), Braincase Breadth (BB), Rostral Length (ROL), Zygomatic Breadth (ZB), Postorbital Breadth (PB), Maxillary Toothrow Length (MTRL), Width at M3 (M3-M3), Length of Mandible (LMA) and Mandibular Toothrow Length (MANDL).

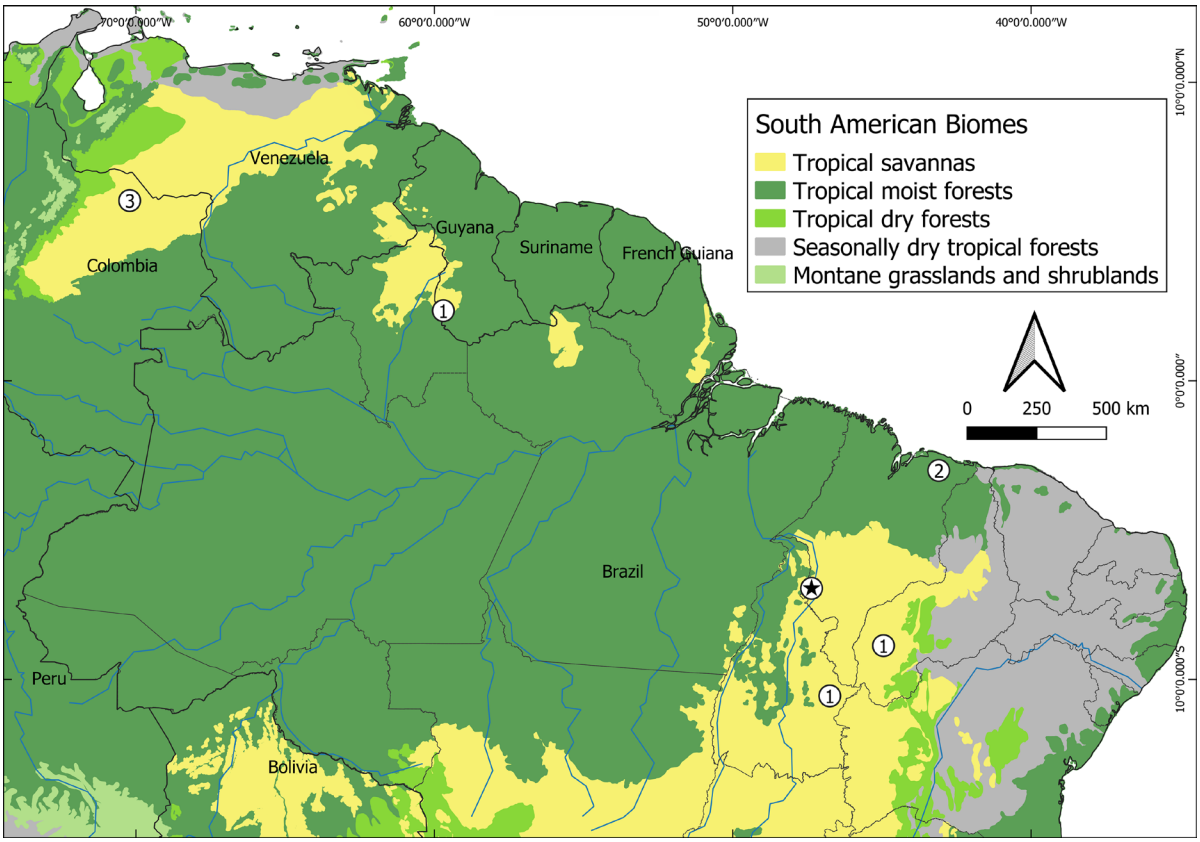

Figure 1. Map of the known localities of *Thyroptera devivoi* records, showing an occurrence restricted to neotropical savannas. Numbers refer to previous records: 1) Gregorin et al. (2006); 2) Santos et al. (2013); 3) Rodriguez-Posada et al. (2017). The limits for the South American biomes were obtained from Olson et al. (2001). Locality 2 is in a transition zone, but the capture of *T. devivoi* in this study occurred in a Cerrado area (see Santos et al. 2013). The star refers to the location of the present study.

Figure 2. The dead palm leaf used as roost by a colony of *Thyroptera devivoi* found in 2015 at Chapada das Mesas, Maranhão state, Brazil.

3. *Sound recordings and analyzed acoustic parameters*

We recorded bat echolocation calls using a Song Meter SM2BAT (Wildlife Acoustics, Maynard, Massachusetts, USA) ultrasonic bat detector in mono, with a single SMX-US (Wildlife Acoustics) omnidirectional microphone and a sampling frequency of 384 kHz. Files were saved as WAV files. To capture the echolocation calls ot the colony's individuals the recorder was placed about 1.5 meters below the entrance to the bat roost. The recorder was programmed to record one file of 30 seconds duration every two minutes during the entire night from 16:50 until 06:00. We selected for analyses those call sequences with at least three pulses and the best aspect-noise-ratio. We measured the following six acoustic parameters of each recorded pulse: pulse duration (ms) - measured from the start to the end of the pulse; pulse interval (ms) - measured from the start of one pulse to the start of the next pulse; maximum frequency (kHz) - measured at the start of the pulse; minimum frequency (kHz) - measured at the end of the pulse; peak frequency, which corresponded to the maximum intensity frequency; and bandwidth, which correspond to the difference between the maximum frequency and the minimum frequency.

We analyzed data using Avisoft-SAS Lab Pro version 5.1.05.30 (Avisoft Bioacoustics, Berlin, Germany), and processed calls with automatic element separation using -20 dB of maximum amplitude, using a 3-threshold algorithm. Pulses were plotted simultaneously on the spectrogram, showing the relationship between frequency, time, and intensity. On the oscillogram, temporal digitization of recordings represented pulse intensity and time. Spectrograms were constructed from 512 fast Fourier transforms using a Hamming window function with 93.75% overlap between consecutive fast Fourier transforms and a frame length of 100%.

The recordings and collections in this work were made as part of the Rede de Pesquisa project Biota do Cerrado under the license number 46596-1 ICMBio/MMA.

Results

No individuals were captured with mist nets. Though, manually we captured one adult male (Figure 3). We visually estimated that the colony consisted of 10 to 15 individuals that were dwelling inside of the sheath of a dead palm leaf that was hanging in the forest canopy (it was the only palm surrounded by neighboring trees) (Figure 2).

Figure 3. Specimen of *Thyroptera devivoi* collected in 2015 at Chapada das Mesas, Maranhão state, Brazil, showing the oval-shaped adhesive suction pads and skull morphology.

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There was an approximate 2.5 m height roost entrance facing downwards (Figure 2). The colony used the same roost for at least four days. The collected *T. devivoi* specimen was easily distinguished from the other species of the genus by the presence of oval-shaped adhesive suction pads, forearm greater than 35 mm, GLS greater than 14 mm and less than 15 mm, bicolored ventral hairs with darker bases and light brown tips, and calcaneus without obvious dermal projections (Pine 1993, Gregorin et al. 2006, Velazco et al. 2014, Díaz et al. 2016) (Table 1, Figure 3).

Analysis showed *Thyroptera devivoi* echolocation pulses are frequency modulated (FM), broadband, with low intensity and high frequency. The calls are multiharmonic, with three harmonics, but we were not always able to capture all of them. Most of the time the second harmonic was the one with most energy. We recorded 305 pulses of 65 calls, during one entire night. The pulses had broad bandwidth, ranging from 50 kHz to more than 150 kHz, with regular intervals of about 0.01ms and a short duration (0.002 ms) (Table 2; Figure 4).

Table 1. Measurements obtained from the male specimen of *Thyroptera devivoi* collected in 2015 at Chapada das Mesas, Maranhão state, Brazil (this study) and those obtained by Velazco et al. (2014) for males of the five species of the genus *Thyroptera*. Measurements from Velazco et al. (2014) are averages, with the intervals observed between parentheses and lastly the sample size.

Measurements (millimeters)	*T. devivoi* ♂ (this study)	Velazco et al. (2014)				
		T. devivoi ♂	*T. lavali* ♂	*T. wynneae* ♂	*T. discifera* ♂	*T. tricolor* ♂
Total Length (TL)	62.5	—	74.0	66.1 (64.4 – 68.0) 3	74.0, 76.0	71.9 (67 - 77) 12
Length of Tail (LT)	24.8	20.4, 21.7	23.0	26.3 (26.0 - 26.7) 3	33.0, 35.0	28.6 (25 - 30) 12
Hind Foot Length (HF)	2.8	—	6.0	4.1 (3.9 - 4.4) 3	5.5, 7.0	5.9 (4 - 7) 10
Ear Length (Ear)	12.6	—	8.0	12.0 (11.0 - 12.7) 3	13.5, 14.0	12.4 (11 - 13) 7
Free Tail Length (FTL)	3.3	4.8 (3.8 - 5.5) 3	—	3.4 (3.1 - 4.0) 3	—	6.0 (4.4 - 7.3) 7
Forearm Length (FA)	36.9	36.5 (35.7 - 37.7) 3	39.0, 39.0	33.7 (33.0 - 34.2) 3	32.8 (32.2 - 33.4) 4	36.7 (33.5 - 40.0) 18
Greatest Length of Skull (GLS)	14.5	14.9 (14.7 - 15.1) 3	15.5, 15.2	13.3 (12.9 - 13.8) 3	14.1 (13.5 - 14.5)	14.3 (13.8 - 15.7) 18
Condyloincisive Length (CIL)	10.8	13.8 (13.7 - 13.9) 3	14.6, 15.0	13.1 (12.5 - 13.6) 3	13.7, 13.7	13.5 (12.9 - 14.4) 18
Braincase Breadth (BB)	7.3	7.0 (6.7 - 7.2) 3	7.3, 7.2	6.7 (6.5 - 6.9) 3	6.9 (6.6 - 7.0) 3	7.3 (6.9 - 7.5) 17
Rostral Length (ROL)	5.5	5.8	—	4.9 (4.9 - 5.0) 3	—	—
Zygomatic Breadth (ZB)	7.8	7.5 (7.4 - 7.7) 3	8.1	7.0 (6.8 - 7.2) 3	7.1 (6.9 - 7.4) 3	7.4 (7.1 - 7.7) 10
Postorbital Breadth (PB)	2.9	2.7 (2.5 - 2.8) 3	2.8, 2.8	2.5 (2.5 - 2.6) 3	2.6 (2.6 - 2.7) 3	2.7 (2.6 - 2.8) 17
Maxillary Toothrow Length (MTRL)	5.6	6.0 (5.7 - 6.1) 3	6.2, 6.3	5.4 (5.3 - 5.6) 3	5.7 (5.5 - 5.8) 4	5.9 (5.6 - 6.3) 18
Width at M3 (M3-M3)	5.8	5.4 (5.3 - 5.5) 3	5.6, 5.5	4.8 (4.8 - 5.0) 3	5.0 (4.8 - 5.1) 3	5.2 (5.0 - 5.5) 18
Length of Mandible (LMA)	11.0	10.9 (10.6 - 11.3) 3	11.3	10.2 (9.9 - 10.6) 3	10.4 (10.0 - 10.6) 3	10.4 (9.6 - 10.7) 15
Mandibular Toothrow Length (MANDL)	6.9	6.1 (5.8 - 6.3) 3	6.3	5.8 (5.5 - 6.2) 3	6.0 (5.9 - 6.1) 3	6.1 (5.8 - 6.3) 15
Weight	—	—	4.0	3.3 (2.6 - 3.8) 3	—	4.4 (3.4 - 5.1) 11

Table 2. Measurements of the echolocation calls of *Thyroptera devivoi* recorded in 2015 at Chapada das Mesas, Maranhão state, Brazil (this study), and measurements obtained from the literature for other species of the genus. Measurements of the fundamental harmonic (HF), first harmonic (H1), and second harmonic (H2).

Measurements	*T. devivoi* (*this study*)			*T. tricolor*[1]		*T. tricolor*[2]	*T. tricolor*[3]	*T. discifera*[3]		*T. discifera*[4]		
Harmonics	HF	H1	H2	HF	H1	H1	H1	HF	H1	HF	H1	H2
Number of pulses analyzed	27	125	150	9	61	—	30	5	10	52	—	—
Duration (ms)	2.1 ± 0.4	2.2 ± 0.3	2.2 ± 0.2	6.0 ± 0.9	8.5 ± 1.5	1.1	3.2 ± 0.4	2.9 ± 0.5	2.5 ± 0.3	0.9 ± 0.2	—	—
Pulse interval (ms)	12.0 ± 2.3	11.7 ± 2.4	11.7 ± 2.4	—	*102.0 ± 4.0	—	—	—	—	10.7 ± 1.7	—	—
Start frequency (kHz)	56.2 ± 3.5	137.6 ± 3.6	162.1 ± 6.1	—	—	123.2	—	—	—	—	—	—
End frequency (kHz)	46.7 ± 1.4	116.3 ± 3.6	136.9 ± 3.8	20.8 ± 0.9	41.6 ± 2.1	92.0	—	—	—	—	—	—
Peak frequency (kHz)	51.2 ± 2.3	127.3 ± 3.0	146.6 ±4.6	—	—	103.1	51.0 ± 2.2	53.0 ± 2.7	112.5 ± 7.3	50.0	100.0	150.0
Bandwidth	9.5 ± 3.9	21.4 ± 4.1	25.2 ± 5.7	22.6 ± 0.9	45.8 ± 0.7	31.31	27.0 ± 5	39.0 ± 8.5	35.5 ± 4.4	—	—	—

* Data here come from only one of the sequences

[1] Fenton et al. 1999, [2] Rivera-Parra & Burneo 2013, [3] Barataud et al. 2013, [4] Tschapka et al. 2000

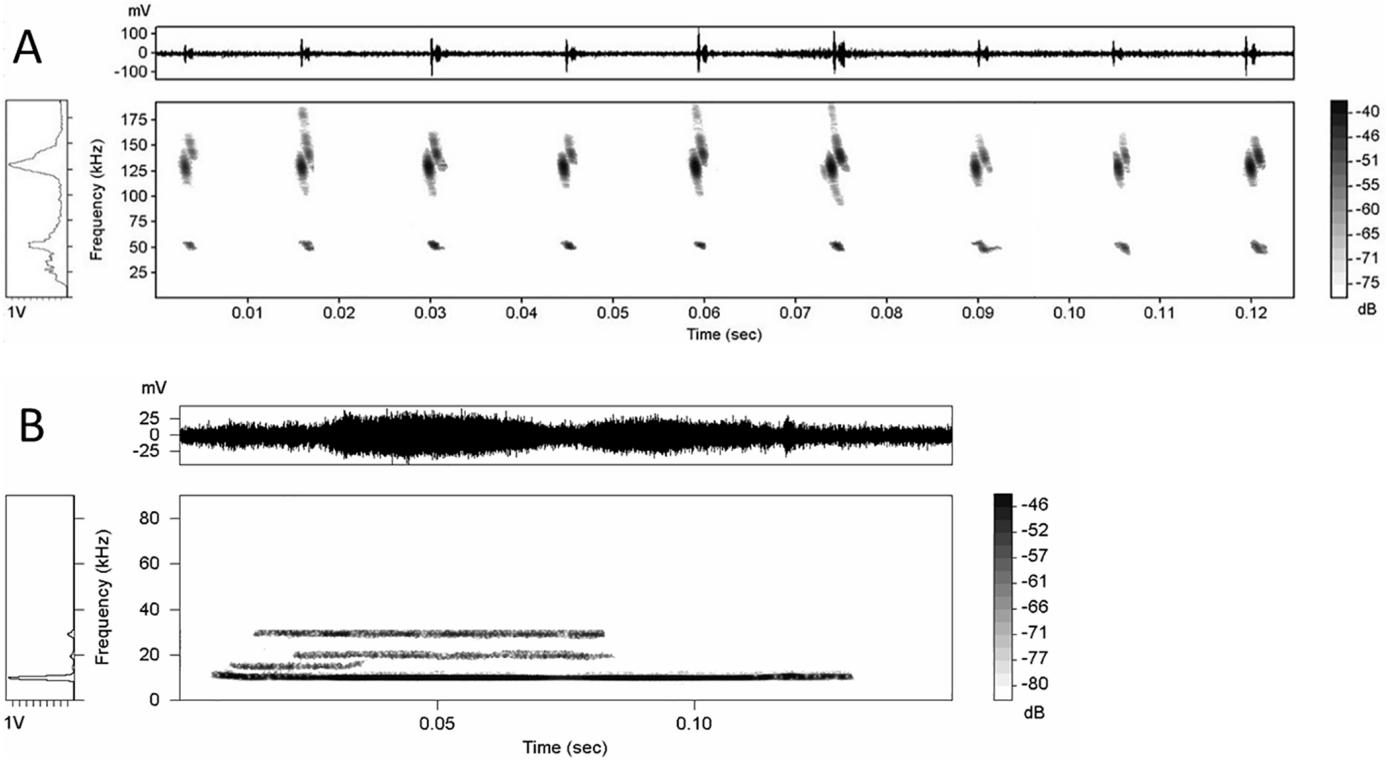

Figure 4. Sequence of search phase echolocation calls (A) and social calls (B) of *Thyroptera devivoi* recorded in 2015 at Chapada das Mesas, Maranhão state, Brazil. Power spectrum (left), oscillogram (top) and spectrogram (center), dB = loudness volume.

One type of social call was also recorded. These were multiharmonic with fundamental frequencies at 10 kHz, 20 kHz and 30 kHz. Calls had long duration and were emitted at extended intervals. Social calls were emitted throughout the night with the first registration at 18:24 and the last at 05.22.

Discussion

Our new geographical record reinforces the presence of *T. devivoi* in the northern portion of the Cerrado, being the sixth known location for this species (Gregorin et al. 2006, Rodriguez-Posada et al. 2017). *Thyroptera devivoi* is one of the lesser known species of this family (Gregorin et al. 2006, Velazco et al. 2014), and has a disjunct distribution, with populations in the northern Brazilian Cerrado and other populations inhabiting the savannas of Colombia and Guiana, in northern South America (Gregorin et al. 2006, Rodriguez-Posada et al. 2017) (Figure 1). In a personal communication to the IUCN, B. Lim (Royal Ontario Museum, Toronto) suggests that populations occurring in the Cerrado can be separated from those occurring in the other savannas of northern South America (Llanos and Rupununi savannas), so that they may be two different species (Solari 2015). As with previous records, the studied *T. devivoi* colony was found in a forest enclave naturally embedded in a savanna matrix, confirming that *T. devivoi* a thyropterid endemic to savanna areas (Gregorin et al. 2006, Santos et al. 2013, Velazco et al. 2014, Rodriguez-Posada et al. 2017), and the only one known with such preferences.

When disturbed, the bats of the colony flew into the woods within a radius of approximately 5-10 meters near the roost, even during the day, which allowed us to estimate the number of individuals using the roost. The studied colony represents a relatively large group when compared to another species of the genus (*T. tricolor*), where groups may contain up to 11, with a mode of 4 to 7, individuals (Findley & Wilson 1974, Vonhof & Fenton 2004). The roost was large (Figure 2) and despite its ephemeral nature (i.e. it would soon transform into a structure not suitable for roosting), it was a multi-day roost, compared to the more commonly used furled *Heliconia* spp. leaf roots that are occupied for only one night (Vonhof & Fenton 2004). The use of a larger roost allows a colony to contain more individuals, and the roost durability allows the colony to stay for several days.

Because they depend on ephemeral and specific roosts (i.e. smooth unfurled leaves, dead leaves), roosts may often be a limiting resource and the local abundance of *Thyroptera* species is associated with the availability of such roosts (Findley & Wilson 1974, Vonhof & Fenton 2004). Current knowledge on thyropterid roost use is largely based on studies of a single species (*T. tricolor*). However, Velazco et al. (2014) suggest that there is a strong selection in *Thyroptera* to diversify the type of roosts used, with species using smoother (e.g., *Heliconia* spp. and *Musa* spp.) or rougher roosts (e.g., dry leaves of *Cecropia* spp. or palm trees). These differences on roost preference may allow the sympatric occurrence of congeneric (2 up to 4) in some localities (Velazco et al. 2014) and could also explain the generalist approach of *T. devivoi* by its capacity to use roosts with more rugged surfaces, like dead dried leaves recorded here and previously (Gregorin et al. 2006, Velazco et al. 2014). Another hypothesis raised by Velazco et al. (2014) is that *Thyroptera* species with a light or whitish venter would roost on leaves that permits light entrance through the leaves, while darker venter species would roost in dead leaves. Though, it is interesting to call the attention that *T. devivoi* from Jalapão was collected in a "vereda" rich in *Heliconia* (Gregorin et al. 2006) while we found the species in dead leaves.

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As with most of the available information about the family, little is known about the acoustic biology of Thyropteridae, and that which exists mainly refers to two species (*T. discifera* and *T. tricolor*), with some studies focused on social calls (Chaverri et al. 2010, 2013, Chaverri & Gillam 2013, 2015, Montero & Gillam 2015), while others concentrated on echolocation calls (Fenton et al. 1999, Tschapka et al. 2000, Barataud et al. 2013, Rivera-Parra and Burneo 2013). Echolocation calls of *T. devivoi* recorded by us are of low intensity, which make them difficult to detect (Fenton et al. 1999, Dechmann et al. 2006). This seems to be a characteristic of the bats of the genus *Thyroptera,* since similar calls were identified by Fenton et al. (1999), Tschapka et al. (2000), Barataud et al. (2013) and Rivera-Parra and Burneo (2013). Echolocation characteristics of *T. devivoi* recorded in this study are more similar to those of *T. discifera* recorded by Tschapka et al. (2000) (Table 2). However, they are different from *T. discifera* calls registered by Fenton et al. (1999), which had low bandwidth and long duration (5 to 8 ms). The results of Dechmann et al. (2006) on *T. discifera* echolocation show strong contrasts to those calls of *T. discifera* recorded by Fenton et al. (1999) and Tschapka et al. (2000). The kind of high-frequency and low-intensity calls recorded dissipate rapidly in space and are used for short-range detection in areas with many obstacles. This allows the bats to obtain high-quality detailed information on their surroundings (Schnitzler and Kalko 2001). We recorded a social call similar to that described by Montero and Gillam (2015) for *T. tricolor*, who qualified it as SQCF (short quasi-constant frequency). We do not know the purpose of this call for *T. devivoi*, but it is present during certain times of the night between periods of echolocation and, therefore, may possibly be emitted in flight.

There are few data on the echolocation of bats of the *Thyroptera* family. Acoustic data are from only three of the five species, being *T. tricolor* (Fenton et al. 1999, Rivera-Parra and Burneo 2013, Barataud et al. 2013), *T. discifera* (Tschapka et al. 2000 and Barataud et al. 2013 e) and *T. devivoi* (this study). Despite the scarcity of data, we believe that echolocation calls of the Thyropteridae bats can be identified by the presence of three FM harmonics, the first about 50 kHz, the other about 100 kHz and the last about 150 kHz, with pulses of short duration, small interval between pulses and large bandwidth. Except for Fenton et al. (1999) that recorded quasi-constant frequency (QCF) calls, long duration, and low bandwidth, all other studies have identified similar multi-harmonic calls (although not all have recorded the three harmonics.), with short duration and interval between the pulses, and large bandwidth (see table 2). The absence of a third harmonic may be due to the difference between the recording equipment as they may restrict the sample rate of the recordings (Biscardi et al. 2004). All acoustic parameters analyzed in this study overlap with literature data, except for the bandwidth that is lower in *T. devivoi* in all harmonics when compared with other species. However, as there are few samples of other species, we suggest caution in the acoustic identification of species of the family *Thyroptera*. The data that exists so far is not robust enough to identify any of the species with certainty.

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Authors Contributions

Renato O. L. Rosa and Ludmilla M. S. Aguiar: Substantial contribution in the concept and design of the study.

Renato O. L. Rosa and Thiago F. Oliveira: Contribution to data collection.

Renato O. L. Rosa, Claysson H. A. Silva, Thiago F. Oliveira, Mauricio Silveira and Ludmilla M. S. Aguiar: Contribution to data analysis and interpretation.

Renato O. L. Rosa, Claysson H. A. Silva, Thiago F. Oliveira, Mauricio Silveira and Ludmilla M. S. Aguiar: Contribution to manuscript preparation.

Mauricio Silveira and Ludmilla M. S. Aguiar: Contribution to critical revision, adding intellectual content.

Conflicts of interest

The authors declare no conflicts of interest. Neither part of this manuscript has financial interest or other matter that could potentially influence the authors.

Ethics

The recordings and collections in this work were made as part of the Rede de Pesquisa project Biota do Cerrado under the license number 46596-1 ICMBio/MMA.

Data availability

All primary data of this manuscript are in the tables and supplementary material.

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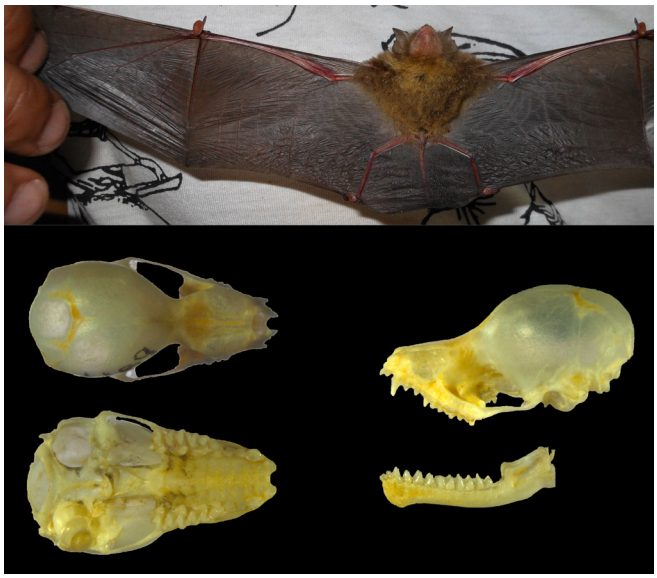
Erratum

Erratum: Type of shelter and first description of the echolocation call of disk-winged bat (*Thyroptera devivoi*)

In the article "Type of shelter and first description of the echolocation call of disk-winged bat (Thyroptera devivoi)", with the DOI code number: http://dx.doi.org/10.1590/1676-0611-BN-2019-0821, published at Biota Neotropica 20(2): e20190821, on page 4:

Where it was written:

Should read:



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Short Communication

Twigs occupied by *Pheidole* Westwood, 1839: Is there a difference between species?

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Abstract: *Pheidole* is a genus with wide geographical distribution and diversity, especially in the leaf litter of neotropical forests, where nests are found at the soil-litter interface, in the soil and vegetation, among leaves, seeds, and twigs. Despite the availability of twigs and *Pheidole* species diversity in the leaf litter, most of this resource is not occupied, which suggests the existence of filters. This study analyzes whether twigs occupied by *Pheidole* species differ for the outer structure and anatomy of the wood. Twigs were collected from preserved Atlantic Forest fragments in southeastern Brazil. Twigs with *Pheidole* colonies were measured and the wood anatomy analyzed. We collected 224 twigs with *Pheidole* colonies, but the analysis was done at 41% due to wood decomposition. Five species were recorded in these twigs, which differ for the outer structure and anatomy of the wood. These results suggest the existence of preference in the occupation of twigs determined by wood structure.
Keywords: *ant; fiber length; dense ombrophilous forest; vessel length; wood.*

Galhos ocupados por *Pheidole* Westwood, 1839: há diferença entre espécies?

Resumo: *Pheidole* é um gênero com ampla distribuição geográfica e diversidade, especialmente na serapilheira das florestas da Região Neotropical, onde os ninhos são encontrados na interface solo-serapilheira, solo, vegetação, entre folhas, sementes e galhos. Apesar da disponibilidade de galhos e diversidade de espécies de *Pheidole* na serapilheira, a maior parte deste recurso não é ocupada, o que sugere a existência de filtros. Neste trabalho analisamos se galhos ocupados por espécies de *Pheidole* diferem em relação à estrutura externa e anatomia da madeira. A coleta de galhos foi realizada em fragmentos conservados de Mata Atlântica na região Sudeste do Brasil. Os galhos com colônias de *Pheidole* foram mensurados e a anatomia da madeira analisada. Foram coletados 224 galhos com colônias de *Pheidole*, mas a análise foi realizada em 41% devido à decomposição da madeira. Nestes galhos foram registradas cinco espécies, que diferem em relação à estrutura externa e anatomia da madeira. Estes resultados sugerem a existência de preferência na ocupação do galho determinada pela estrutura da madeira.
Palavras-chave: *formiga; comprimento de fibra; floresta ombrófila densa; comprimento de vaso; lenho.*

Introduction

Pheidole Westwood, 1839 is considered a hyperdiverse genus, for the 1,095 described species (Bolton 2019), with a set of morphological and behavioral characteristics that confer great adaptive success (Wilson 2003). The species distribution is wide, especially in habitats under warm and humid climate (Economo et al. 2015), as is the case in the Neotropical Region. Nests are built in the soil, leaf litter, and vegetation (Wilson 2003), from degraded areas to primary and continuous vegetation areas such as tropical forests (Delabie et al. 2000). *Pheidole* species are traditionally recognized by their generalist and detritivorous habit (Moreau 2008), consuming various soil invertebrates such as mites (Wilson 2005), but preferring seed consumption (Wilson 2003).

In the leaf litter, *Pheidole* colonies are found in seed remains, between leaves, under stones (Hölldobler & Wilson 1990), in fruits, associated or not with other invertebrates (Castaño-Meneses et al. 2015), and in living wood or wood under different stages of decomposition (Delabie et al. 1997; Carvalho & Vasconcelos 2002), such as in twigs.

Twenty-one species were recorded in twigs (Fernandes et al. 2012; Souza-Campana et al. 2017), but it is a low number compared to the total diversity of *Pheidole* in the leaf litter (Suguituru et al. 2015). Thus, despite this species diversity and availability of twigs in the leaf litter of the rainforests (Sagata et al. 2010), few *Pheidole* species occupy them.

Working in areas of native forest and *Eucalyptus* plantations with a developed understory, Fernandes et al. (2018) showed that *P. sospes* Forel, 1908 occupies twigs with the same diameter, regardless of the diversity of twigs in the native forest. However, the same was not observed for *P. sarcina* Forel, 1912. Given this, we start from the premise of the existence of filters during occupation of twigs by *Pheidole* species. Thus, the present study investigates the structure of twigs occupied by *Pheidole* species in the Atlantic Forest leaf litter. We have hypothesized that twigs occupied by *Pheidole* differ for the external (length, diameter, and number of perforations) and internal structure of the wood (vessel diameter, vessel length, and fiber length), as it avoids competition between species.

Material and Methods

Collections were made in 2015, from 9 am to 1 pm to maintain the standardization used by our group in all collections, on days not preceded by rain to prevent the twigs from being too humid, in preserved Atlantic Forest fragments in southeastern Brazil. In total there were six collection sites – "Cachoeira Pedra Bonita"; "Lago da Mata"; "Pousada Rural Sítio Matsuo"; "Sítio Cantos da Mata"; "Parque das Neblinas - Trilha da Cetesp"; and "Parque das Neblinas" (Figure 1), with altitudes between 600 to 850 m and average annual temperature approximately 20 ºC (Tomasulo & Cordeiro 2000). According to the Köppen classification, the climate of the region is mesothermic with a dry winter (Cwb), with an annual rainfall accumulation of 1,500 mm (Cptec-Inpe 2019).

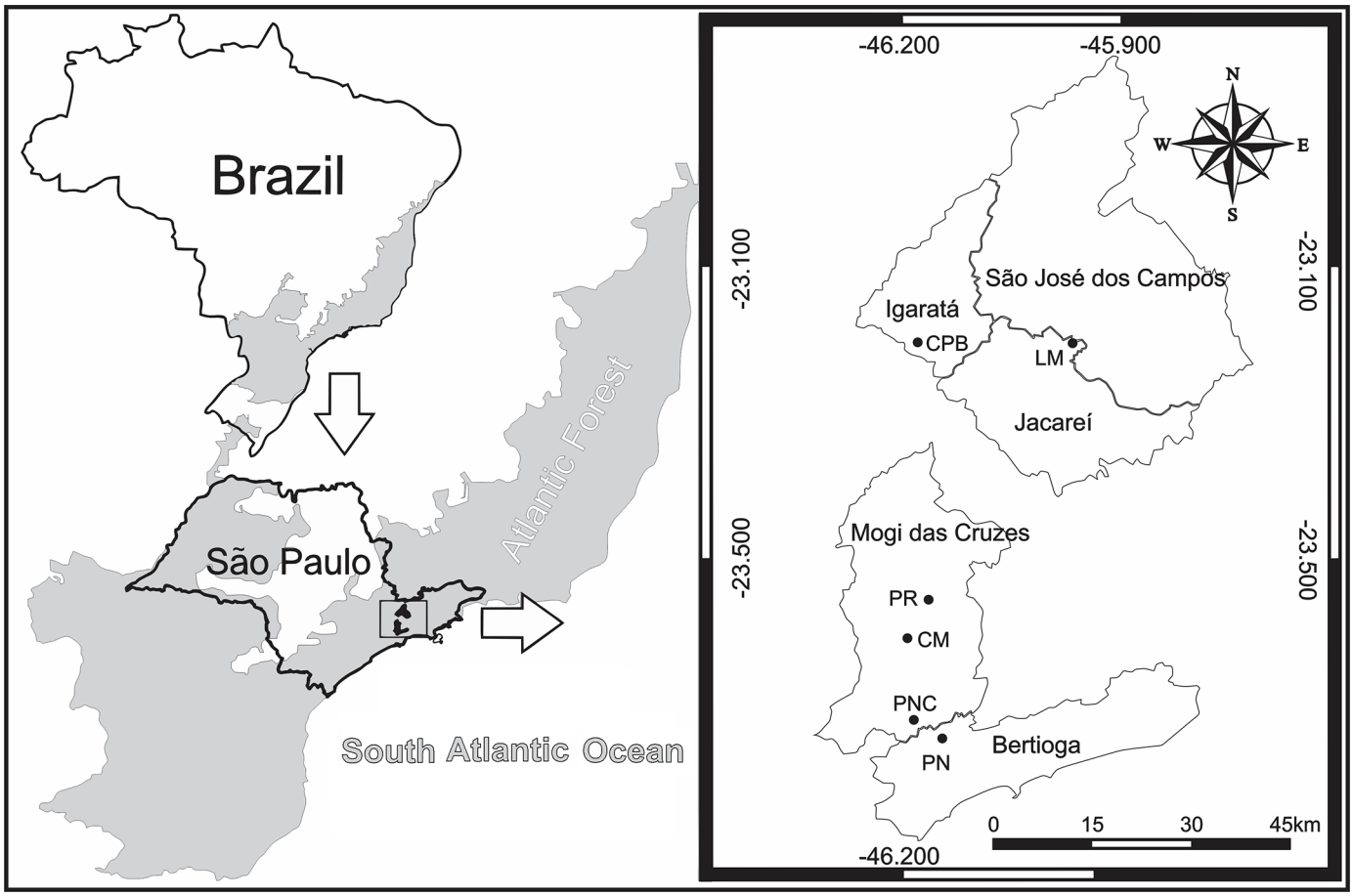

Figure 1. Geographic location of collection areas in the São Paulo State, Brazil. Legend: CPB – "Cachoeira Pedra Bonita" (23°12'28"S; 46°10'39"W); LM – "Lago da Mata" (23°12'33"S; 45°58'02"W); PR – "Pousada Rural Sítio Matsuo" (23°33'31"S; 46°09'45"W); CM – "Sítio Cantos da Mata" (23°36'40"S; 46°11'28"W); PNC – "Parque das Neblinas - Trilha da Cetesp" (23°43'21"S; 46°10'57"W); PN – "Parque das Neblinas" (23°44'51"S; 46°08'39"W).

A linear transect with seven plots distanced 10 m apart was established in each area. Each plot measured 16 m where all twigs (= nests) were collected. The twigs were individually wrapped in plastic bags. In total, 42 plots and 672 m of leaf litter were analyzed. In the laboratory, each twig was checked for ant colonies, but only twigs with *Pheidole* colonies had the outer structure and wood anatomy analyzed.

We classified twigs as occupied if they contained ≥ 10 workers; if fewer than 10 workers were present, twigs were considered occupied if they contained immatures, queens, or males (Fernandes et al. 2012). *Pheidole* species were identified following the key proposed by Wilson (2003). Moreover, an interactive key was used through the Lucid platform elaborated by Dr. John T. Longino (available at https://sites.google.com/site/newworldpheidole/). The vouchers are deposited in the collection of the Alto Tietê Myrmecology Laboratory at the University of Mogi das Cruzes (SP), and in the Padre Jesus Santiago Moure Entomological Collection (DZUP) at the Federal University of Paraná.

We tried to identify wood species based on the literature and on samples from the Forest Institute Xilaryum (SPSFw), but due to wood conditions such as natural degradation, we could not determine the species. To analyze the outer structure of twigs we measured the length using a ruler, and the diameter (three measurements: two at the ends and one at the center) with a digital caliper. The entire surface of the twig was examined under a Motic SMZ-168 stereoscope, and carefully inspected for holes using a rotating support and an entomological pin (Nº 0).

Then the twigs were opened and the number of adults (workers, queens, and males) and immatures were counted. To analyze the internal structure (wood anatomy), we used wood fragments to prepare macerations according to the modified Franklin method (Berlyn & Miksche 1976). The wood fragments were stained with aqueous safranin and mounted in a solution of water and glycerin (1:1). Fiber and vessel measurements (mm) (Figure 2) were performed on an Olympus CX31 microscope equipped with a camera (Olympus Evolt E330) and a computer with image analyzer software (Image-Pro 6.3). Terminology followed the IAWA list (Iawa 1989).

Twig dimensions, number of perforations, and wood anatomical features were assessed by parametric analysis of variance (one-way analysis of variance). When a significant difference was observed, the Tukey test was used to identify pairs of significantly different means.

Results and Discussion

Five hundred and seventy-five twigs with ants were collected and 224 (39%) had *Pheidole* species. Wood anatomy was analyzed on 92 twigs out of a total of 224, since the wood of the other twigs with *Pheidole* colonies was in an advanced stage of decomposition, preventing analysis.

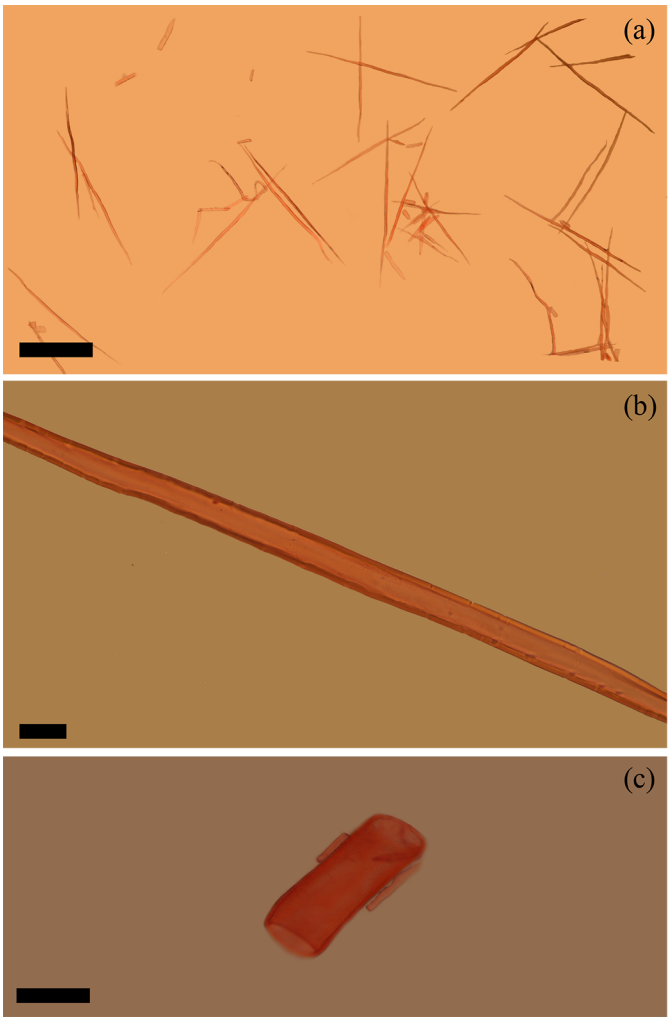

Figure 2. Cell dimensions in wood colonized by *Pheidole* species. A. Vessel element length (scale bar = 250 µm); B. Vessel diameter (scale bar = 10 µm). C. Fiber length (scale bar = 100 µm).

In the twigs with appropriate characteristics for wood anatomy analysis, we identified *P. flavens* Roger, 1863; *P. sarcina*; *P. sigillata* Wilson, 2003; *P. sospes* and *Pheidole* gr. *tristis* sp. (Table 1). All these species are considered common inhabitants of twigs, because they are ant that colonized 10 or more twigs in a given leaf litter area (Fernandes et al. 2018). Our results show also that *P. sarcina* is the species that most uses twigs in the leaf litter as a resource, which corroborates the results of Fernandes et al. (2018).

Pheidole species differ for the outer structure (length, diameter, and number of perforations) of the occupied twig (Table 1). The species

Table 1. Number of occupied twigs, twig dimensions, and number of perforations by *Pheidole* species.

Species	Colonized twigs (%)	Length (cm)	Diameter (cm)	Perforations (Nº)
Pheidole flavens	8	12 -35 (26^{b})	0.7 -1.8 (1.2^{c})	0 -3 (1^{c})
Pheidole sarcina	40	9 -237 (49^{ab})	0.6 - 8.6 (1.7^{b})	0 -10 (2^{bc})
Pheidole sigillata	19	11 -671 (86^{a})	0.4 - 4.9 (1.6^{bc})	0 - 5 (2^{bc})
Pheidole sospes	22	19 -195 (63^{ab})	0.9 -8.5 (1.3^{c})	0 - 8 (3^{b})
Pheidole gr. *tristis* sp.	10	24 -198 (71^{ab})	0.7 - 5.3 (3.1^{a})	1 – 13 (5^{a})

Minimum and maximum (mean) values for twig length, diameter, and number of perforations. Distinct letters in the same row differ statistically ($P < 0.05$) by the Tukey test.

recorded in the present study have different strategies, that is, while *P. flavens* houses their small colonies in smaller diameter twigs, *P.* gr. *tristis* sp. occupies larger diameter twigs and its colonies are comparatively larger (Figure 3).

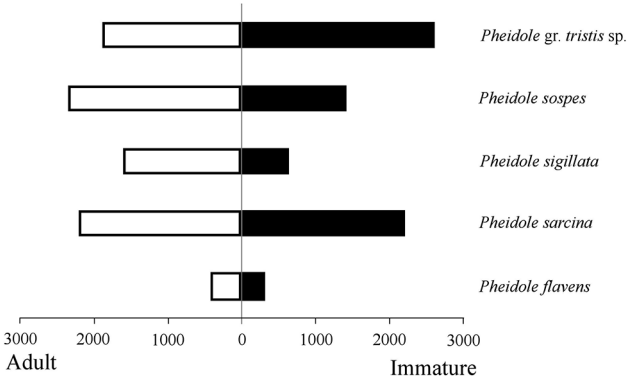

Figure 3. Abundance of adults (workers, winged males, and queens) and immatures in twigs according to *Pheidole* species.

As *Pheidole* is a very diverse group in the leaf litter of tropical forests (Delabie et al. 2000; Silva & Brandão 2010), possibly the different twig occupation strategies are related to the competition for this resource. Our results suggest that ant occupation of the twig may be related to the specific attributes of the wood.

Longer vessels occurred in twigs occupied by *P.* gr. *tristis* sp. when compared to other species. Vessel diameter differed between woods: larger vessels occurred in woods occupied by *P.* gr. *tristis* sp., and narrower vessels in woods occupied by *P. flavens* and *P. sarcina*. Vessel diameter in woods occupied by *P. sigillata* and *P. sospes* did not differ from that of other woods. Longer fibers occurred in woods occupied by *P.* gr. *tristis* sp. and *P. sospes* (Figure 4).

In general, the larger cell sizes found in woods colonized by *P.* gr. *tristis* sp. (in larger twigs) may be related to radial development of anatomical features. During growth in trunk diameter, twigs or roots, there is an increase in vessel and fiber length, and in vessel diameter (Lachenbruch et al. 2011). Hence, because they have a larger diameter (Table 1), we suggest that twigs occupied by *P.* gr. *tristis* are older than other twigs occupied by other ant species.

Apparently there is no relationship between wood species and ant species occupation, as also observed by Armbrecht et al. (2004). Thus, there is an association between twig diameter and ant species, in which *P.* gr. *tristis* sp. seeks to nest on wider twigs compared to the other four ant species studied.

Our results suggest that from five species, only two differ in their twigs: *P. sarcina* occupies smaller and larger diameter twigs, and *Pheidole* gr. *tristis* sp. occupies twigs with the largest diameter, but in less proportion. Possibly *P. sarcina* is the most generalist in the twig occupation, which corroborates the results found by Fernandes et al. (2018). These authors have shown that this species occupies most of the twigs in Atlantic forest areas.

To understand whether there are associations between ant species and wood species, in the next studies we will seek to identify wood from knowledge of tree species that are close to leaf litter collection

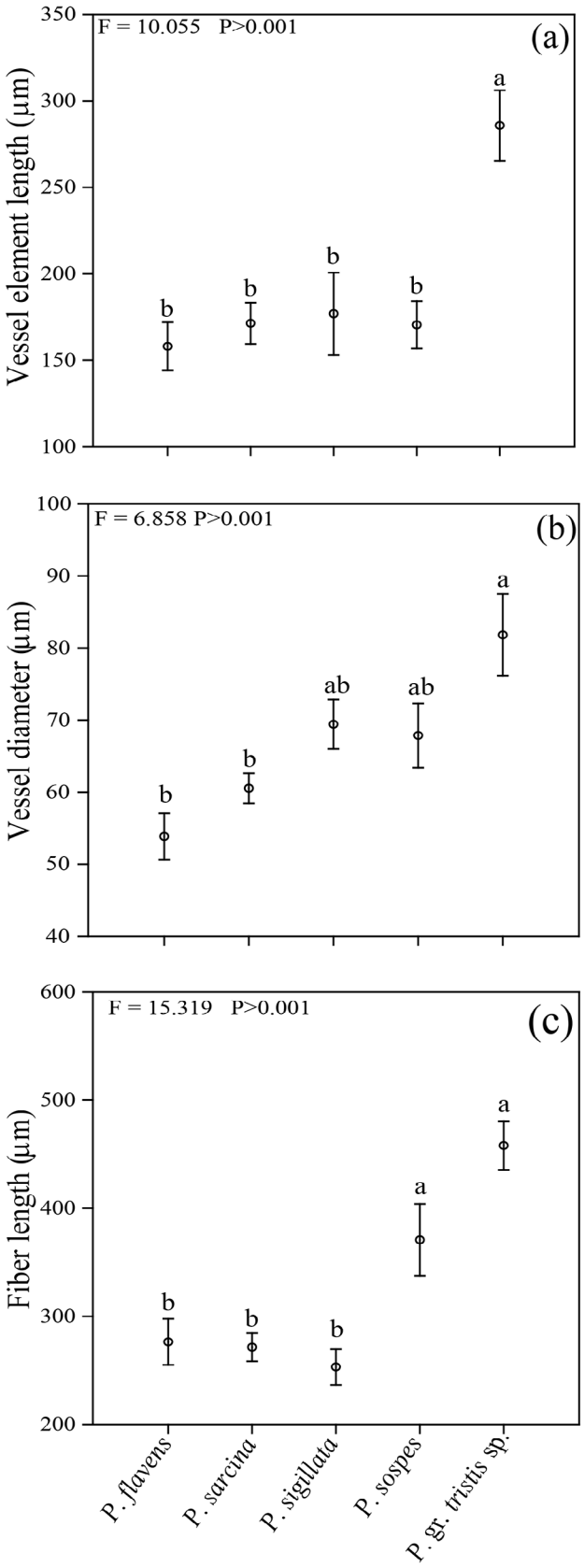

Figure 4. Wood anatomical features occupied by *Pheidole* species. Distinct letters differ statistically ($P < 0.05$) by the Tukey test.

sites. Therefore, we will have some indicative and a known number of species to compare with the literature information and also with the samples from the xilaryum.

We emphasize that there are no other studies relating ant species to wood anatomy comparing and discussing our information. Thus, we understand that our study is pioneering in this regard, so the delineation of how to develop this investigation more appropriately is being developed as difficulties arise. Overall, our results contribute to understanding the natural history of a hyperdiverse genus, mainly involving characteristics related to the choice of the nesting site.

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Author Contributions

Suellen C. Barroso: contribution to data collection; contribution to data analysis and interpretation and manuscript preparation.

Eduardo L. Longui: substantial contribution to manuscript preparation; contribution to data analysis and critical revision, adding intellectual content.

Tae T. Fernandes: substantial contribution in the concept and design of the study; contribution to data collection and manuscript preparation.

Carla M. Oliveira: contribution to data collection and manuscript preparation.

Alexandre C. Ferreira: contribution to species identification.

Rogério R. Silva: substantial contribution to manuscript preparation and contribution to critical revision, adding intellectual content.

Maria Santina C. Morini: substantial contribution in the concept and design of the study; contribution to manuscript preparation and critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Inventory

Non-volant mammalian species richness in the ecotonal Brazilian midnorth: checklist for Maranhão State

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VIEIRA, O.Q., OLIVEIRA, T.G. **Non-volant mammalian species richness in the ecotonal Brazilian midnorth: checklist for Maranhão State**. Biota Neotropica 20(2): e20190912. https://doi.org/10.1590/1676-0611-BN-2019-0912

Abstract: The state of Maranhão, located in the westernmost portion of the Northeast Region of Brazil, is characterized by a dynamic and unstable ecotone among the Amazon, Caatinga and Cerrado biomes that presents a high degree of biodiversity with high vulnerability to anthropogenic activities. Despite the enormous potential for sheltering high levels of species diversity and abundance, little is known about many aspects the state's biodiversity, especially with regard to mammalian fauna. A capture-recapture methodology using live-traps was employed to inventory the non-volant, small mammal community. In addition, we recorded medium and large mammals based on direct and indirect observations, camera-trap surveys, and interviews. An extensive literature search of published research was also performed to maximize the elaboration of a complete mammal species checklist for Maranhão. A total of 89 non-volant mammal species, representing 9 orders and 27 families were recorded in the state of Maranhão. Of these taxa, 25.84% are included in the Brazilian Red List for endangered species, while 20 are considered as being endemic to Brazil. The preservation status of some areas, coupled with the strong presence of agro-pastoral environments, contributed to some unusual species occurrences, while the state's ecotonal nature was noted by the numbers of species associated with the Amazon (N=65) and Cerrado (N=66) biomes.. Given the rapid development and effects of numerous anthropogenic impacts occurring in the state, it is a crucial time to quantify, even at specific scales, the environmental richness of Maranhão. The significant levels of biodiversity, high degree of endemism, and the presence of numerous rare and endangered species characterizes Maranhão as being among the most biologically important parts of Brazil. Nonetheless, many gaps in our basic knowledge regarding the biodiversity of this area remain, such that the execution of additional biological inventories is imperative, as are greater efforts to clarify certain species limits and necessary taxonomic revisions, most notably that for small mammals.

Keywords: *mammals; ecotone; biodiversity; endemism; Maranhão.*

Riqueza de espécies de mamíferos não-voadores no meio norte ecotonal brasileiro: checklist para o Estado do Maranhão

Resumo: A denominação de estado ecótono, por estar localizado na região meio-norte do Brasil, entre a Amazônia a Caatinga e o Cerrado, confere ao Maranhão não só áreas ricas e abundantes de espécies, mas também à necessidade de cuidados especiais na sua conservação, por se tratarem de ambientes de dinâmicos e, portanto, pouco estáveis. Apesar de seu enorme potencial para abrigar altos níveis de riqueza e abundância de espécies da flora e fauna, o Maranhão ainda possui uma riqueza biológica pouco conhecida, notadamente quanto à sua mastofauna. A metodologia empregada para inventariar a comunidade de pequenos mamíferos não-voadores foi a de captura-recaptura, utilizando armadilhas do tipo live-traps. Para os mamíferos de médio e grande porte utilizou-se a visualização direta e indireta através da transecção de trilhas pré-estabelecidas assim como entrevistas e uso de armadilhas fotográficas. Para maximizar a busca das espécies já registradas para o estado foram também realizadas buscas de literatura através de plataformas digitais confiáveis. Foram registradas 89 espécies de mamíferos não-voadores no território maranhense, distribuídos em 9 ordens e 27 famílias. Dos táxons listados 25.84% constam na lista brasileira dos animais ameaçados de extinção, enquanto que 20 são endêmicos do território brasileiro. O estado de conservação de algumas áreas aliado à forte presença de ambientes agro-pastoris contribuíram para ocorrências não usuais, enquanto que a natureza ecotonal foi notada pela proximidade do número de espécies associadas aos biomas Amazônia (N=65) e Cerrado (N=66). Em tempos de desenvolvimento aliada a inúmeros impactos antrópicos sobre o meio ambiente é salutar que se quantifique, mesmo que em escalas específicas, a riqueza ambiental do estado. Diversidade expressiva, endemismo, espécies raras e ameaçadas destacam o Maranhão como um dos principais estados do meio norte do Brasil, entretanto são muitas as lacunas de conhecimento, o que torna imperativo não somente novos trabalhos de inventários mas também maiores esforços na precisão taxonômica das espécies, notadamente na de pequenos mamíferos.

Palavras-chave: *mamíferos, ecótono, biodiversidade, endemismo, Maranhão.*

Introduction

Maranhão is among the least known states of Brazil in terms of its biodiversity, either due to the classic veil line proposed by Preston (1948) or the geographical bias in funding allocated to support biological inventory studies (Magnusson et al., 2016). Nevertheless, its extensive area presents many attributes that allow for high levels of biodiversity, diverse vegetation in particular. Roughly 64.1% of the territory of Maranhão occurs within the Cerrado biome, 34.8% within the Amazon biome and 1.1% is classified as part of the Caatinga biome (Stella 2011).

A total of 138 municipalities in Maranhão occur within the Cerrado biome, 110 within the Amazon biome and 15 within the Caatinga biome. The Amazon represents the largest continuous area of rainforest in the world and is recognized for its extreme ecological importance and essential environmental services (MMA, 2007). Such recognition is supported by the large variety and complexity of ecosystems presented by the biome, which affords progressive increases in species richness (Peres 2005). The Cerrado biome is considered to be the most diverse tropical savanna in the world, also presenting a large variety of habitats and remarkable alternation of species between different phytophysiognomies (Medeiros et al. 2011).

Despite the natural richness of these biomes, Maranhão is currently experiencing a period of increasing agriculture, urban expansion and a growing population density, all of which can have direct impacts on local fauna (Stehmann & Sobral 2017). Although it covers about 64.1% of the state territory and presents one of the highest rates of preservation, with 71.9% of its natural vegetation remaining, the Cerrado biome in Maranhão is also considered highly threatened (Stella 2011, Brazil 2015). For example, the MATOPIBA region (an acronym designated by using the initials for the states of Maranhão, Tocantins, Piauí and Bahia) represents a large portion of the Cerrado biome in which the average devoted to cotton, corn and soybean production has grown by 400% between 1990 and 2010 (Lorensini et al. 2015). Historically covering 34.8% of the state territory, the Amazon biome portion of Maranhão is also highly threatened, having been reduced to remnants representing just 23.82% of its original area due to the drastic transformations of forest and non-forest ecosystems, this is the lowest percentage of remaining vegetation among the nine Brazilian Amazon States (Santos 2007, Stella 2011, IMESC 2019).

Mammals occurring in the state of Maranhão are closely linked to the vegetation of the environment and strongly related to the quality and size of habitat remnants (Chiarello 1999, Peres 2000). Despite the extensive literature regarding mammal species composition of the Amazon and Cerrado biomes in general, there is little knowledge about mammalian distributions in Maranhão (i.e. Wallacean Shortfall). Mammal species can influence the entire dynamic of the ecosystems in which they occur, having important ecological roles in the dispersal of seeds, spores and plant propagules, as well as regulating natural prey populations. A proper biological inventory of mammal species for Maranhão is necessary to achieve a better understanding regarding the conservation status of habitat remnants in the state.

Therefore, given that the biodiversity of Maranhão is so rich and equally threatened by trends in socio-economic development, the state deserves special attention setting priorities for the region that result in positive outcomes for conservation, sustainable use and the benefits derived of this biological diversity for the rest of the country. Part of the conservation concerns for Maranhão are due to a systematic lack of knowledge regarding its fauna, notably that of non-volant terrestrial mammals, including information gaps for many geographic areas and greater degrees of knowledge for certain mammalian orders relative to others.

Currently there is no single checklist for the species of mammals occurring in the state of Maranhão, our comprehensive knowledge is limited to isolated records in a few publications and mostly addressing species composition of the Cerrado and Amazon biomes independently (Ávila-Pires 1989, 1992, Oliveira et al. 2007, 2011). Basic information on the geographic occurrence and abundance of mammal species at various locations, as well as actions seeking to estimate the actual species richness of this region, are needed. Therefore, the main objective of the current study is to present a comprehensive checklist for non-volant mammal species known to occur in the state of Maranhão.

Materials and Methods

1. Study area

The study corresponds to the Brazilian state of Maranhão, with roughly 331,983 km^2. The state has transitional conditions between the super humid climate of the Brazil's northern region and the semi-arid climate of the northeast region of the country, with a predominance of forest vegetation, open fields and Cerrado habitats, and a large variety of ecosystems including mangroves, sand dunes, estuaries, extensive beaches and lake basins (Köppen, 1948, Maranhão 2002). Additionally, the *Mata dos Cocais* area, a *babassu* palm formation that is classified by IBGE (1992) as an Open Ombrophilous Forest, stands out for its uniqueness and is considered a characteristic landscape of Maranhão (Rios 2001). The average annual temperature for the whole area is 26ºC, with a large temperature range between the northern and southern portions of the state, a rainfall regime that is highly correlated with the geographic occurrence of the different biomes, annual precipitation of around 1,100 mm in the southwestern region where the Cerrado biome is dominant and often exceeding 2,000 mm annually in Amazon biome areas (Pinto et al. 2011, Brasil 2013).

2. Data collection

Inventories were realized at 15 study sites throughout the state of Maranhão, selected to include portions of the Amazon and Cerrado regions, as well as transitional areas between the two biomes in the most diverse plant formations (Figure 1). Because the percentage of Caatinga cover in the state is negligible (ca. 1.1%), we decided to only sample sites within the Amazon and Cerrado biomes of the state. Live-traps appropriate for small mammals and camera traps were installed at sampling locations along predetermined transects of varying sizes within each of the study sites. The total sampling effort resulted in 71,082 nights/live-trapping, 1,283 transect km/traveled and 9,639 nights/camera-trapping (Table 1). The data presented here have been collected since 1994, but with greater consistency from 2004-2018. Additional information regarding biological inventories from different parts of Maranhão acquired from the bibliographic survey was also included.

3. *Small mammals*

The current small mammal survey was performed using the standard methodology of installing live-traps in capture lines along the selected sampling locations at each of the study sites. A capture station consisting of Sherman (8 x 8 x 23 cm) and Tomahawk (14 x 14 x 40 cm) live-traps was established every 20 m, the first type being deployed at each capture station and the second type at alternating stations. In closed-canopy habitats, Sherman live-traps were installed at a height of 1.5–2.5 m above ground at alternate stations to Tomahawk live-traps located on the ground. Peanut butter mixed with banana and/or other fruits was used to bait the live-traps, which were actively deployed for seven consecutive nights (Auricchio & Salomão 2002, Lambert et al. 2006, Umetsu & Pardini 2007). The sampling protocol for small mammals is outlined in Table 1. All marsupial and small rodent species identifications were based on published systematic studies, as well as other important compilations regarding the taxonomy and geographic distribution of these groups (Paglia et al. 2012, Brandão et al. 2015, Gardner 2008, Miranda & Da Silva 2015, Patton et al. 2015, Percequillo et al. 2015, Quintela et al. [in press]). Species identifications were later confirmed by specialists. Voucher specimens were also collected for reference, comparison and confirmation of certain species identifications with other scientific materials and under the appropriate federal government collecting permits including: IBAMA 38/2010, IBAMA 45398-3, IBAMA 113/2004, IBAMA 2001.009125/2008-67, IBAMA 08/2010, IBAMA 035/2009/CGFAP, IBAMA 036/2009/CGFAP, IBAMA 037/2009/CGFAP, IBAMA 038/2009/CGFAP, IBAMA 39/2009/CGFAP, SEMA/MA 05/2017). Voucher specimens collected during the current study have been deposited in the vertebrate natural history collections of the *Universidade Estadual do Maranhão* and the *Museu Paraense Emílio Goeldi* (Supplementary material).

4. *Medium and large-sized mammals*

A variety of non-invasive sampling methods were used in the current study to identify medium and large-sized mammal species, including evidence from bones, skin, tracks, carcasses, vocalizations and photographs. To this end, camera-traps were deployed along several walking transects, while additional trails were also surveyed on foot and at different times of the day during the entire data collection period realized at each of the sampling areas, a standard methodology for this type of study (Oliveira et al. 1988, Oliveira & Cassaro 2005, Wilson & Delahay 2001). Whenever necessary, species identifications were supported by consulting several field guide references (Emmons & Feer 1997, Oliveira & Cassaro, 2005, Bonvicino et al. 2008).

The mammal species detected here were also classified by their appropriate threat categories according to criteria of the International Union for Conservation of Nature - IUCN (Version 13 - IUCN, 2017),

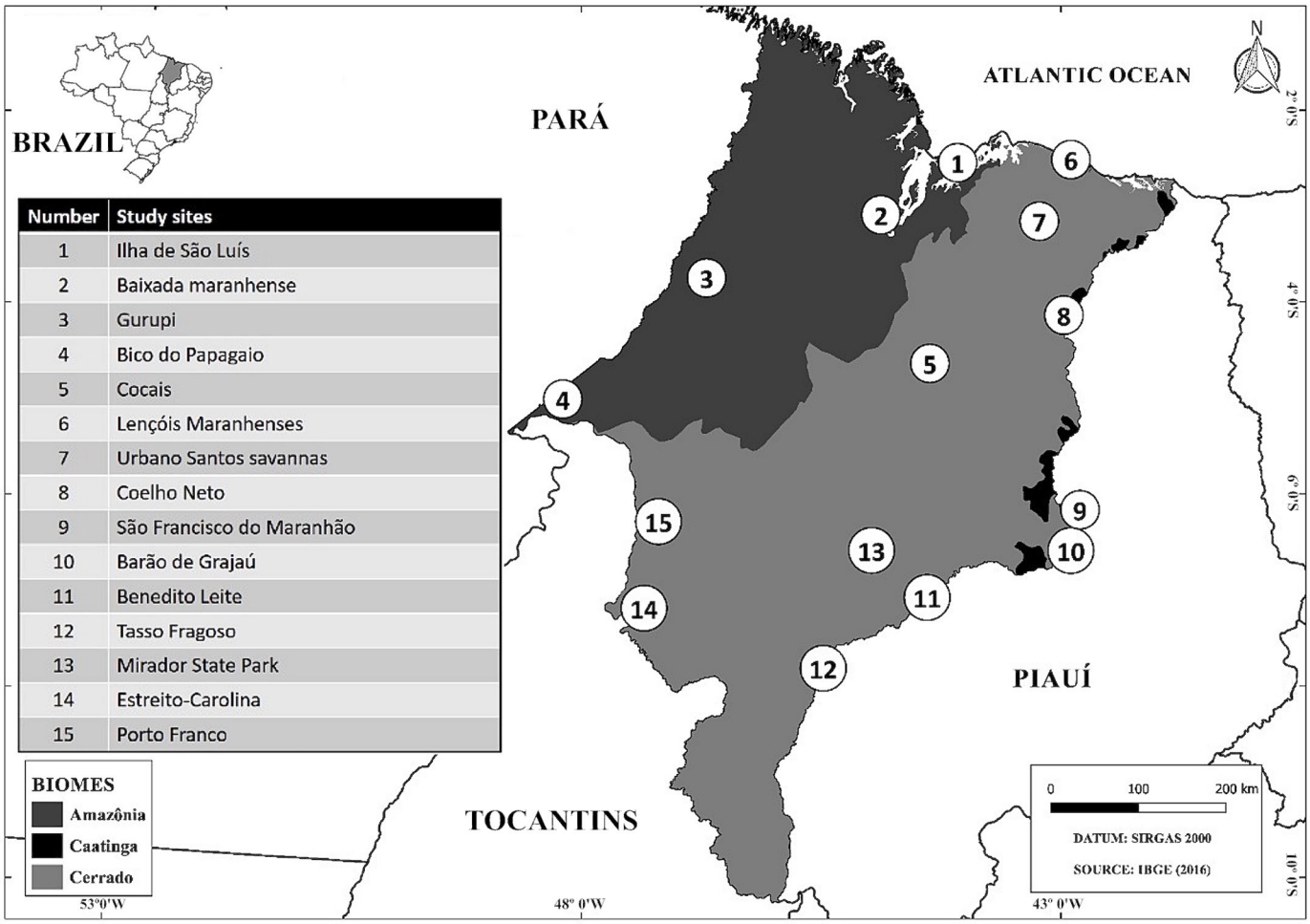

Figure 1. Location of study sites where non-volant mammal species were sampled in the state of Maranhão, Brazil.

Table 1. Geographic locations and sampling efforts for the study sites included in elaborating the current non-volant mammal species checklist for the state of Maranhão, Brazil.

	Sampling locations	Sampling periods	Central geographic coordinates	Sampling effort		
				Live-traps (nights/trapping)	Walking transects (km)	Camera-traps (nights/ trapping)
1	Ilha de São Luís	2010-2015	2°38'43.69" S / 44° 8'55.42" O	21.568	211	5.548
2	Baixada Maranhense	2017-2018	3°11'18.98" S / 44°56'52.29" O	2.520	15	-
3	Região do Gurupi	2003-2014	3°50'50.20" S / 46°45'52.37" O	10.080	98	25
4	Região do Bico do Papagaio e adjacências	1994/2008-2010	5° 6'40.00" S / 48°15'46.26" O	14.173	398	560
5	Região dos Cocais	2012-2013	4°44'19.71"S / 44°26'16.19" O	2.520	17	70
6	Região dos Lençóis Maranhenses	1994	2°36'46.53" S / 42°58'4.05" O	-	30	-
7	Cerrados de Urbano Santos	2005	3°15'21.21" S / 43°17'49.94" O	1.536	15	70
8	Região de Coelho Neto/MA	2008	4°14'5.25" S / 43° 2'27.73" O	2.520	17	70
9	Região de São Francisco do Maranhão	2009	6°15'54.25" S / 42°52'23.11" O	1.688	78	395
10	Região de Barão de Grajaú/MA	2009	6°41'24.58" S / 43° 2'29.19"O	2.110	82	410
11	Região de Benedito Leite/MA	2009	7°10'47.26" S / 44°32'23.00" O	1.960	66	355
12	Região de Tasso Fragoso/MA	2009	7°55'3.55" S / 45°37'18.59" O	1.822	85	420
13	Parque Estadual do Mirador	2013-2018	6°41'17.43" S / 45° 7'5.13" O	3.936	30	1.616
14	Região de Estreito-Carolina/MA	2002	7°17'29.34" S / 47°29'22.82" O	2.651	117	-
15	Região de Porto Franco/MA	2009	6°23'15.13" S / 47°20'17.73" O	1.978	25	100
	Total Effort			71.062	1.283	9.639

these same criteria were also used in the most recent evaluation of the conservation status for threatened fauna in Brazil (ICMBio, 2018).

Results

A total of 89 non-volant, wild mammal species were confirmed as occurring within the state boundaries of Maranhão (Table 2, Figures 2 and 3). Considering mammal species occurrences by biome, a total of 66 species were found to be associated with the Cerrado biome, and 65 species with the Amazon, 5 of which were recorded exclusively in the Amazonian region of the state.

Considering only non-volant mammals that are known to occur in Brazil, species richness in Maranhão represents 12.70% of the total richness proposed by Paglia et al. (2012) and 11.2% of that proposed by Quintela et al. (in press). (Table 3). The mammal species diversity of Maranhão is representative of 27 families and 9 orders. The three most diverse non-volant mammal orders in Brazil are the Rodentia, Primates and Didelphimorphia, although many taxonomic aspects of the first and last of these groupings are still poorly defined. Regarding the mammalian fauna of Maranhão according to the current results, the order Rodentia is the most representative (24 species), followed by Carnivora (20 species) and relegating Didelphimorphia (13 species) to the rank of third most diverse mammal order for the state.

A total of 23 of the 89 species recorded here, or 25.84%, are included in the Brazilian Red List of threatened and endangered animals (ICMBio, 2018). Of these 23 species, the order Carnivora is the most highly represented (10 species), followed by Primates (5 species) and Artiodactyla (3 species). Regarding IUCN threat of extinction categories, mammal species classified as being Vulnerable (VU) were the most highly represented (18 species).

Discussion

Systematic biological inventories are essential for assessing the conservation status of a region's biodiversity and help in providing guidelines to select priority areas for environmental protections (Diniz-Filho et al. 2004, Jenkins et al. 2015). The current study employed different approaches to collecting information regarding mammal species occurrence in Maranhão in order to create the most comprehensive state checklist possible. Nonetheless, and despite all of

Table 2. Checklist of non-volant mammal species registered as occuring in the state of Maranhão, Brazil.

TaxoN	Threat Category	Common Name	Biome	End Br	Type Of Record	Sampling Location
DIDELPHIMORPHIA						
Didelphidae						
Caluromys philander (Linnaeus, 1758)		Mucuri / Bare-tailed Woolly Opossum	Am, MA, Ce, Pt		C, V, Io	L3, L5, L6, 1, 2, 3, 4, 5, 7, 9, 11, 14
Chironectes minimus (Zimmermann, 1780)		Mucura-d'água / Water Opossum	Am, MA, Ce, Pt, Pp		Io, I	L4, L6, 3, 4
Didelphis albiventris Lund, 1840		Mucura / Guaiba Dwarf Mouse Opossum	Ce, Ca, Pt, Pp		C, V, Io	L3, L5, L6, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
Didelphis marsupialis Linnaeus, 1758		Mucura / Common Opossum	Am		C, V, Io	L3, L5, L6, 1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 14, 15
Gracilinanus agilis (Burmeister, 1854)		Mucuri / Agile Gracile Opossum	Ce, Ca, Pt		C	L3, L4, L5, L6, 1, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15
Marmosa murina (Linnaeus, 1758)		Mucuri / Linnaeus's Mouse Opossum	Am, MA, Ce, Pt		C	L3, L5, L6, 1, 3, 4, 5, 7, 8, 9, 10, 12, 13, 14, 15
Marmosops (Sciophanes) cf. *parvidens* (Tate, 1931)		Mucuri / Slender Opossum	Am		C	L6, 3, 4
Metachirus nudicaudatus		Mucura / Guianan Brown Four-eyed Opossum	Am, MA, Ce, Pt		C	L4, L6, 3, 4
Marmosa (Micoureus) demerarae		Mucuri / Woolly Mouse Opossum	Am, MA, Ce, Ca		C	L6, 2, 3, 4, 5, 9, 11, 12, 13
Monodelphis americana (Müller, 1776)		Mucuri / Northern Three-striped Opossum	MA, Ce		C	L6, 3, 4
Monodelphis domestica (Wagner, 1842)		Mucuri / Gray Short-tailed Opossum	MA, Ce, Ca, Pt		C	L3, L6, 1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 14, 15
Philander opossum (Linnaeus, 1758)		Mucura-de-quatro-olhos / Gray Four-Eyed Opossum	Am, Ce, Pt		C	L3, L6, 3, 4, 14
Thylamys karimii (Petter, 1968)		Mucuri / Karimi's Fat-tailed Mouse Opossum	Ce, Ca	x	C	L3, 4, 10, 11, 12, 13, 14, 15
PILOSA						
Bradypodidae						
Bradypus variegatus Schinz, 1825		Preguiça / Brown-throated Sloth	Am, MA		V, Io, I	L2, L3, L5, L6, 1, 3, 4, 5, 6, 7, 9, 13, 14, 15
Cyclopedidae						
Cyclopes didactylus (Linnaeus, 1758)		Tamanduaí / Silky Anteater	Am, MA, Ce		V, I	L2, L5, L6, 1, 3, 4, 6
Megalonychidae						
Choloepus didactylus (Linnaeus, 1758)		Preguiça-real / Linnaeus's Two-toed Sloth	Am		V, I	L5, L6, 3, 4
Myrmecophagidae						
Myrmecophaga tridactyla Linnaeus, 1758	VU	Tamanduá-bandeira / Giant Anteater	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L5, L6, 3, 4, 5, 9, 12, 13, 14, 15
Tamandua tetradactyla (Linnaeus, 1758)		Mambira / Tamandua	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15
CINGULATA						
Dasypodidae						
Cabassous unicinctus (Linnaeus, 1758)		Tatu-rabo-de-couro / Southern Naked-tailed Armadillo	Am, MA, Ce, Ca, Pt		Io, I	L3, L5, L6, 3, 4, 5, 7, 9, 13, 14, 15
Dasypus kappleri[1] Krauss, 1862		Tatu-quinze-quilos / Greater Long-nosed Armadillo	Am		Io, I	L4, L6, 3, 4
Dasypus novemcinctus Linnaeus, 1758		Tatu-comum / Nine-banded Armadillo	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L5, L6, 1, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15
Dasypus septemcinctus Linnaeus, 1758		Tatu-xina / Seven-banded Armadillo	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L5, 4, 5, 7, 12, 13, 14, 15

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Euphractus sexcinctus (Linnaeus, 1758)		Tatu-peba / Six-banded Armadillo	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L5, L6, 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15
Priodontes maximus (Kerr, 1792)	VU	Tatu-canastra / Giant Armadillo	Am, MA, Ce, Pt		Io, I	L3, L5, L6, 3, 4, 11, 12, 13
Tolypeutes tricinctus (Linnaeus, 1758)	EN	Tatu-bola-da-caatinga / Brazilian Three-banded Armadillo	Ce, Ca	x	Io, I	L3, L4, L5, 7, 13
PRIMATES						
Aotidae						
Aotus azarae infulatus (Kuhl, 1820)		Quatro-olhos / Feline Night Monkey	Am	x	V, Io, I	L3, L6, 3, 4, 5, 7, 11, 13, 14, 15
Atelidae						
Alouatta ululata Elliot, 1912	EN	Capelão / Maranhão Red-handed Howler Monkey	Am, Ca	x	V, Io, I	L2, L3, 3
Alouatta belzebul (Linnaeus, 1766)	VU	Capelão / Red-handed Howler Monkey	Am, MA	x	V, Io, I	L3, L6, 3, 4, 5, 6, 12, 13, 14, 15
Alouatta caraya (Humboldt, 1812)		Capelão / Black-and-Gold Howler Monkey	MA, Ce, Ca, Pt, Pp		V, Io, I	L6, 14
Callitrichidae						
Callithrix jacchus (Linnaeus, 1758)		Soim / Common Marmoset	MA	x	V	L2, L3, 5, 6, 7, 8, 9, 10, 11, 12, 13
Saguinus niger (É. Geoffroy, 1803)	VU	Soim / Black-handed Tamarin	Am	x	V	L6, 3, 4, 15
Cebidae						
Cebus kaapori Queiroz, 1992	CR	Cairara / Ka'apor Capuchin	Am	x	V, Io, I	L6, 3
Sapajus apella (Linnaeus, 1758)		Macaco-prego / Guianan Brown Tufted Capuchin	Am		V, Io, I	L2, L3, L6, 1, 3, 4, 6, 7, 8, 14, 15
Sapajus libidinosus (Spix, 1823)		Macaco-prego / Bearded Capuchin	MA, Ce, Ca	x	V, Io, I	5, 12, 13
Saimiri sciureus (Linnaeus, 1758)		Mão-de-ouro / Common Squirrel Monkey	Am		V, Io, I	L3, L6, 1, 3, 4, 14, 15
Pitheciidae						
Chiropotes satanas (Hoffmannsegg, 1807)	CR	Cuxiú-preto / Black Saki	Am	x	V, Io, I	L6, 3, 4
CARNIVORA						
Canidae						
Cerdocyon thous (Linnaeus, 1766)		Raposa / Crab-eating Fox	MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Chrysocyon brachyurus (Illiger, 1815)	VU	Lobo-guará / Maned Wolf	Ce, Pt, Pp		Io, I	L3, 4, 12, 13, 14, 15
Lycalopex vetulus (Lund, 1842)	VU	Raposa / Hoary Fox	Ce, Pt	x	V, Io, I	L3, 5, 7, 9, 10, 11, 12, 13, 14, 15
Speothos venaticus (Lund, 1842)	VU	Cachorro-do-mato / Bush Dog	Am, MA, Ce, Pt		V, I	L3, L6, 3, 4, 7, 12, 13, 14, 15
Procyonidae						
Nasua nasua (Linnaeus, 1766)		Quati / South American Coati	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 2, 3, 4, 5, 6, 7, 8, 12, 13, 14, 15
Potos flavus (Schreber, 1774)		Macaco-da-meia-noite / Kinkajou	Am, MA, Ce		I	L6, 3, 4
Procyon cancrivorus (G. Cuvier, 1798)		Guaxinim / Crab-eating Raccoon	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15
Mustelidae						
Eira barbara (Linnaeus, 1758)		Papa–mel / Tayra	Am, MA, Ce, Ca, Pt		V, I	L3, L6, 3, 4, 5, 7, 12, 13, 14, 15
Galictis cuja (Molina, 1782)		Furão / Lesser Grison	MA, Ce, Ca, Pp		C, V, Io, I	L3, L6, 3, 4, 5, 7, 12, 13, 15

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Galictis vittata (Schreber, 1776)		Furão / Greater Grison	Am, MA, Ce, Ca, Pt		V, Io, I	L6, 3, 14
Lontra longicaudis (Olfers, 1818)		Lontra / Neotropical Otter	Am, Ma, Ce, Pt, Pp		V, I	L2, L3, L6, L7, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15
Pteronura brasiliensis (Gmelin, 1788)	VU	Ariranha / Giant Otter	Am, MA, Ce, Pt		V, Io, I	L6, L9, 3, 4, 7
Mephitidae						
Conepatus semistriatus[2] (Boddaert, 1785)		Gambá / Striped Hog-nosed Skunk	Am, MA, Ce, Ca, Pt		C, V, I	L3, L4, L6, 3, 5, 9, 12, 13, 14
Felidae						
Leopardus pardalis (Linnaeus, 1758)		Maracajá-verdadeiro / Ocelot	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15
Leopardus tigrinus (Schreber, 1775)	EN	Maracajá-í / Northern tiger cat	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 3, 4, 5, 6, 7, 9, 10, 12, 13, 14, 15
Leopardus wiedii (Schinz, 1821)	VU	Maracajá-peludo / Margay	Am, MA, Ce, Ca, Pt, Pp		C, V, Io, I	L3, L6, 3, 4, 5, 7, 10, 13, 14, 15
Leopardus colocola (Molina, 1782)	VU	Gato-palheiro / Pampas cat	Ce, Pt, Pp		V, I	L3, 5, 10, 11, 12, 13, 14, 15
Panthera onca (Linnaeus, 1758)	VU	Onça-pintada/preta / Jaguar	Am, MA, Ce, Ca, Pt, Pp		Io, I	L3, L6, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15
Puma concolor (Linnaeus, 1771)	VU	Onça-vermelha / Cougar	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L6, 3, 4, 5, 7, 12, 13, 14, 15
Herpailurus yagouaroundi (É. Geoffroy, 1803)	VU	Gato-mourisco / Jaguarundi	Am, MA, Ce, Ca, Pt, Pp		V, I	L2, L3, L6, 2, 3, 4, 5, 6, 7, 11, 12, 13, 14, 15
PERISSODACTYLA						
Tapiridae						
Tapirus terrestris (Linnaeus, 1758)	VU	Anta / South American Tapir	Am, MA, Ce, Ca, Pt		V, Io, I	L3, L6, 3, 4, 12, 13, 14, 15
ARTIODACTYLA						
Tayassuidae						
Tayassu pecari (Link, 1795)	VU	Queixada / White-lipped Peccary	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L6, 3, 4, 12, 13, 14, 15
Pecari tajacu (Linnaeus, 1758)		Caititu / Collared Peccary	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 3, 4, 5, 6, 7, 12, 14, 15
Cervidae						
Blastocerus dichotomus (Illiger, 1815)	VU	Suçuapara / Marsh Deer	Ce, Pt		Io, I	L3, 13, 14
Mazama americana (Erxleben, 1777)		Veado-mateiro / South American Red Brocket	Am, MA, Ce, Pt		V, I	L3, L6, 3, 4, 5, 7, 12, 13, 14, 15
Mazama gouazoubira (G. Fischer, 1814)		Veado-catingueiro / South American Brow Brocket	Am, MA, Ce, Ca, Pt, Pp		V, I	L2, L3, L6, 3, 4, 5, 6, 7, 12, 13, 14, 15
Mazama nemorivaga (F. Cuvier, 1817)		Veado-foboca / Amazonian Brown Brocket Deer	Am		V, I	4
Ozotoceros bezoarticus (Linnaeus, 1758)	VU	Veado-galheiro / Pampas Deer	Ce, Pt, Pp		Io, I	L3, 4, 12, 13, 14
RODENTIA						
Sciuridae						
Sciurus aestuans Linnaeus, 1766		Quatipuru / Brazilian Squirrel	Am		C	L3, L6, L8, 3, 4, 5, 7, 14, 15
Cricetidae						
Calomys expulsus[3] (Lund, 1841)		Rato-do-chão / Caatinga Laucha	Ce, Ca	x	C	L3, 4, 7, 9, 10, 11, 12, 13, 14, 15
Cerradomys scotti (Langguth & Bonvicino, 2002)		Rato-do-mato / Lindbergh's Rice Rat	Ce, Pt		C	L3, 5, 9, 10, 11, 13, 14, 15
Hylaeamys megacephalus (G. Fischer, 1814)		Rato-do-mato / Azara's Broad-headed Rice Rat	Am, MA, Ce, Pt		C	L8, 5, 9, 12

Continue...

Continuation...

Holochilus sciureus Wagner, 1842		Rato-d'água / Amazonian Marsh Rat	Am, Ce, Ca		C	L6, 1, 2, 3, 11
Necromys lasiurus (Lund, 1841)		Rato-do-mato / Hairy-tailed Akodont	Am, MA, Ce, Ca, Pt, Pp		C	L3, L6, 1, 3, 4, 7, 8, 11, 12, 13, 14
Nectomys rattus (Pelzeln, 1883)		Rato-d'água / Amazonian Water Rat	Am, Ce, Ca, Pt		C	L3, L6, L8, 3, 4
Oecomys cf. *bicolor* (Tomes, 1860)		Rato-da-árvore / White-bellied Arboreal Rice Rat	Am, Ce, Pt		C	L3, L6, 3, 4, 5, 9, 11, 12, 13
Oligoryzomys cf. *nigripes* (Olfers, 1818)		Rato-do-mato / Black-footed Colilargo	MA, Ce, Ca, Pt, Pp		C	L6, L8, 1, 3, 4, 5, 9, 10, 11, 12, 14
Rhipidomys emiliae (J. A. Allen, 1916)		Rato-da-árvore / Eastern Amazon Climbing Mouse	Am	x	C	L3, L6, L8, 3, 4, 9, 13
Rhipidomys cf. *macrurus* (Gervais, 1855)		Rato-da-árvore / Long-tailed Climbing Mouse	Ce, Ca	x	C	5, 10, 14
Thalpomys cf. *lasiotis* (Thomas, 1916)		Rato-do-chão / Hairy-eared Mouse	Ce	x	C	13
Wiedomys pyrrhorhinos (Wied-Neuwied, 1821)		Rato-de-fava / Red-nosed Mouse	Ca	x	C	9, 10, 11
Caviidae						
Galea spixii (Wagler, 1831)		Preá / Spix's Yellow-toothed Cavy	Am, MA, Ce, Ca, Pt		V, I	L3, L6, 1, 3, 4, 5, 6, 7, 13, 14, 15
Hydrochaeris hydrochaeris (Linnaeus, 1766)		Capivara / Capybara	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L6, L8, 2, 3, 4, 5, 12, 13, 14, 15
Kerodon rupestris (Wied-Neuwied, 1820)	VU	Mocó / Rock Cavy	Ca	x	V, I	L3, L4, 9, 11, 12, 13, 14
Cuniculidae						
Cuniculus paca (Linnaeus, 1766)		Paca / Spotted Paca	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L2, L3, L6, 1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 13, 14, 15
Dasyproctidae						
Dasyprocta prymnolopha Wagler, 1831		Cutia / Black-rumped Agouti	Am, MA, Ce, Ca	x	V, Io, I	L2, L3, L6, L8, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15
Erethizontidae						
Coendou prehensilis (Linnaeus, 1758)		Ouriço, porco-espinho / Brazilian Porcupine	Am, MA, Ce, Ca, Pt		V, Io, I	L4, L6, 3, 4, 5, 7, 9, 10, 11, 12, 13, 14, 15
Echimyidae						
Dactylomys cf. *dactylinus* (Desmarest, 1817)		Toró, rato-do-bambu / Amazon Bamboo Rat	Am		C, V, I	L4, L6, L8, 3, 4, 15
Echimys chrysurus (Zimmermann, 1780)		Rato-da-árvore / White-faced Spiny Tree-rat	Am		C, V	L1, L3, L4, L6, L8, 3, 4, 7
Makalata cf. *didelphoides*		Rato-coró / Red-nosed Armored Tree-rat	Am		C, I	L3, L6, L8, 1, 3, 4, 5, 9, 13, 15
Proechimys roberti Thomas, 1901		Rato-de-espinho / Robert's Spiny-rat	Am, Ce	x	C, I	L3, L6, L8, 1, 2, 3, 4, 5, 7, 9, 12, 13, 14, 15
Thrichomys laurentius (Thomas, 1904)		Punaré, rabudo / São Lourenço's Punaré	MA, Ca	x	C, I	L3, 5, 7, 8, 10, 11, 12, 13, 14
LAGOMORPHA						
Leporidae						
Sylvilagus brasiliensis (Linnaeus, 1758)		Coelho, tapeti / Tapeti	Am, MA, Ce, Ca, Pt, Pp		V, Io, I	L3, L6, 3, 4, 5, 7, 9, 11, 12, 13, 14, 15

Legend: Species under taxonomic revision: [1] = *Dasypus beniensis* **(Feijo & Cordeiro-Estrela 2016);** [2] = *Conepatus amazonicus* **(Feijó & Langguth 2013);** [3] = *Calomys mattevii* **(Gurgel-Filho et al.** 2015); Threat category (ICMBio, 2018): CR = Critically Endangered, EN = Endangered, VU = vulnerable; Biome: Am = Amazon, MA = Mata Atlântica/Atlantic Forest, Ce = Cerrado, Ca = Caatinga, Pt = Pantanal, Pp = Pampas; End BR = Endemic to Brazil; Type of Record: C = capture, V = direct observation/camera-trap, Io = indirect observation/tracks or remains, I = Interview; Sampling locations: L1 = Oliveira & Mesquita (1998), L2 = Oliveira & Bogéa (2004), L3 = Oliveira et al. (2007a), L4 = Oliveira et al. (2007b), L5 = Gardner et al. (2008), L6 = Oliveira et al. (2011), L7 = Mesquita & Meneses (2015), L8 = Patton et al. (2015), L9 = Prist et al. (2017), 1 = Ilha de São Luís, 2 = Baixada Maranhense, 3 = Região do Gurupi, 4 = Região do Bico do Papagaio e adjacências, 5 = Região dos cocais, 6 = Região dos Lençóis Maranhenses, 7 = Cerrados de Urbano Santos/MA, 8 = Região de Coelho Neto/MA, 9 = Região de São Francisco do Maranhão, 10 = Região de Barão de Grajaú/MA, 11 = Região de Benedito Leite/MA, 12 = Região de Tasso Fragoso/MA, 13 = Parque Estadual do Mirador, 14 = Região de Estreito-Carolina/MA, 15 = Região de Porto Franco/MA.

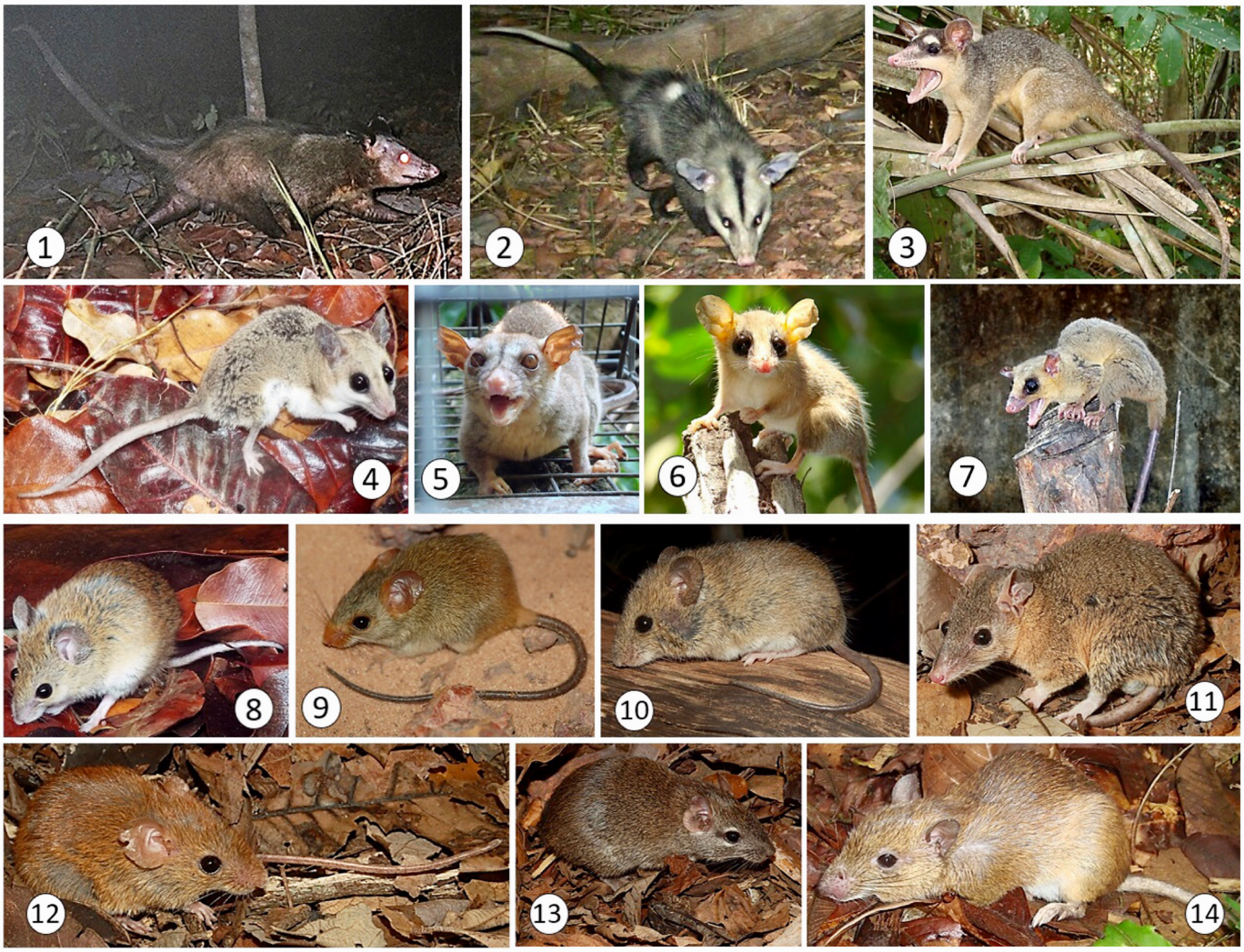

Figure 2. Records of small non-volant mammalian species in Maranhão state, Brazil. 1 = *Didelphis marsupialis*, 2 = *Didelphis albiventris*, 3 = *Phylander opossum*, 4 = *Thylamis karimii*, 5 = *Caluromys philander*, 6 = *Gracilinanus agilis*, 7 = *Marmosa (Micoureus) demerarae*, 8 = *Thalpomys cf. lasiotis*, 9 = *Wiedomys pyrrhorhinos,* 10 = *Calomys expulsus*, 11 = *Monodelphis domestica,* 12 = *Cerradomys scotti,* 13 = *Thrichomys laurentius,* 14 = *Proechimys roberti*

the evidence considered in elaborating the resulting checklist, it is likely that the actual species richness of non-volant mammals for the state of Maranhão is somewhat greater than what is reported here.

Compared to previously published information, the checklist based on the current assessment adds 4 unique records for the state of Maranhão. Oliveira et al. (2007a, 2011) listed 82 species as occurring in Maranhão, while Lima (2009) added one important record of *Tolypeutes tricinctus*, species present in the Nascentes do Rio Parnaíba National Park, the area of which is mostly located within the state boundary of Piauí state and extends into just a small part of Maranhão. Although less representative quantitatively, Oliveira & Mesquita (1998), Oliveira & Bogéa (2004), Oliveira et al. (2007b), Gardner (2008), Mesquita & Meneses (2015), Prist et al. (2017) and Patton et al. (2015) were also consulted, corroborating the occurrence of the species already described for some of the study locations. The last two of these publications represent complete taxonomic revisions and result from international collaborations to most accurately define the identification, distribution and taxonomy of South American mammal species as a whole.

Non-volant mammal species richness in Maranhão in the Amazon (N = 65) and Cerrado (N = 66) regions of Maranhão is similar. This represents 16.3% and 26.3% respectively, of the total species diversity for this group at the national level. Nineteen species were recorded at more than 10 of the study sites, corroborating their characterization as generalists occurring in all of dominant landscapes of Maranhão. Among the 16 that Paglia et al. (2012) listed as being exclusive to the Amazon (Table 2), only *Choloepus didactylus*, *Cebus kaapori*, *Chiropotes satanas*, *Mazama nemorivaga* and *Marmosops* cf. *parvidens* were recorded exclusively in the Amazonian portion of the state. *Didelphis marsupialis*, *Sapajus apella*, *Aotus azarae infulatus*, and *Sciurus aestuans* were recorded outside the Amazon domain, thus confirming their expected presence in forested areas beyond the Amazon-Cerrado ecotone (Feijó & Langguth 2013, Pinto & Roberto, 2016, Lima et al. 2017, Patton et al. 2015). *Rhipidomys emiliae*, *Dactylomys* cf. *dactylinus* and *Makalata* cf. *didelphoides* complete the list of Amazonian species recorded in forested areas within savanna landscapes, thus highlighting the role of these forests as corridors that allow the expansion of small Amazonian mammals into the Cerrado (Redford & Fonseca 1986, Costa 2003, Carmignotto 2005).

Figure 3. Records of medium and large non-volant mammalian species in Maranhão state, Brazil. 1 = *Tamandua tetradactyla,* 2 = *Myrmecophaga tridactyla,* 3 = *Priodontes maximus,* 4 = *Dasypus novemcinctus,* 5 = *Cyclops didactylus,* 6 = *Eira barbara,* 7 = *Lycalopex vetulus,* 8 = *Cerdocyon thous,* 9 = *Speothos venaticus,* 10 = *Nasua nasua,* 11 = *Procyon cancrivorus,* 12 = *Conepatus semistriatus,* 13 = *Galictis cuja,* 14 = *Galictis vitatta,* 15 = *Lontra longicaudis,* 16 = *Leopardus colocola,* 17 = *Herpailurus yagouaroundi,* 18 = *Puma concolor,* 19 = *Leopardus wiedii,* 20 = *Leopardus tigrinus,* 21 = *Leopardus pardalis,* 22 = *Panthera onca,* 23 = *Sapajus apella,* 24 = *Aotus azarae infulatus,* 25 = *Chiropotes satanas,* 26 = *Cebus kaapori,* 27 = *Alouatta caraya,* 28 = *Callithrix jacchus,* 29 = *Saguinus niger,* 30 = *Ozotoceros bezoarticus* , 31 = *Mazama americana,* 32 = *Mazama gouazoubira,* 33 = *Tayassu pecari,* 34 = *Pecari tajacu,* 35 = *Tapirus terrestris,* 36 = *Dasyprocta prymnolopha,* 37 = *Cuniculus paca,* 38 = *Coendou prehensilis,* 39 = *Hydrochaeris hydrochaeris*

Table 3. Comparison of non-volant mammal species richness for recent in Brazil and the states of Maranhão (MA), Mato Grosso do Sul (MS), Mato Grosso (MT), São Paulo (SP), Rio de Janeiro (RJ) and Santa Catarina (SC).

Order	Brazil		State					
	Paglia et al. (2012)	Quintela et al. (in press)	MA	MS	MT	SP	RJ	SC
Didelphimorphia	55	59	13	17	31	24	14	17
Pilosa	8	12	5	2	5	3	4	4
Cingulata	11	12	7	7	9	5	5	5
Primates	118	125	11	6	26	10	9	3
Carnivora	33	35	20	20	21	17	17	26
Perissodactyla	1	2	1	1	1	1	1	1
Artiodactyla	10	10	7	6	7	8	4	7
Rodentia	234	255	24	33	67	58	49	54
Lagomorpha	1	2	1	1	1	1	1	1
Total	471	512	89	93	168	127	104	118

MA = this paper; MS = Tomas et al. (2017); MT = Brandão et al. (2019); SP = Vivo et al. (2011); RJ = Rocha et al. (2004); SC = Cherem et al. (2004);

Echimys chrysurus is the last Amazonian species to reach the forest formations in the Cerrado biome, between the municipalities of Urbano Santos and Vargem Grande, clearly because of the deciduous forests in that region (Oliveira & Mesquita, 1998).

Maranhão state houses 20 species endemic to Brazil (Table 2). It is worth noting the case of Primates, with four out of five species being associated to the Amazonian portion of the state, which currently faces a critical conservation outlook (Oliveira et al 2011). *Cebus kaapori* and *Chiropotes satanas* were recorded in areas of primary and disturbed forests, besides this they are both rare and highly threatened throughout their range (Almeida & Vieira 2010). *Saguinus niger* has a range similar to *C. kaapori* and *C. satanas* within the state, nevertheless the species was recorded more often in disturbed habitats, and this species tends to be common in anthropic environments (Mendes-Oliveira 1996). *Thylamys karimii*, has been reported on the western portion of Maranhão state in the Bico do Papagaio region, yet its single record was in a marginal portion of that region, in open areas of Cerrado savanna as expected (Carmignotto & Monfort 2006, Gardner 2008). *Lycalopex vetulus* and *Thalomys lasiotis* were recorded only in the Cerrado portion of the state; both species are typically associated to the central Cerrado further south, however *L. vetulus* has been expanding its range towards the north and northeast regions of the country, and the same seems likely for *Thalomys lasiotis* (Marinho-Filho et al. 2002, Dalponte 2009, Lemos et al. 2013). Three species were recorded marginally outside their typical biomes, *Wiedomys pyrrhorhinos*, *Kerodon rupestris* and *Callithrix jacchus*, the first two outside the Caatinga (Oliveira et al. 2003, Gonçalves et al. 2005, Oliveira & Bonvicino 2011), while the last one outside the Atlantic Forest. *C. jacchus* is an introduced species (Da Rosa et al. 2017) that has reached the central part of the Maranhão Babaçú Forest ecoregion, this area has witnessed major habitat destruction particularly in the Itapecuru river basin (Silva Jr. 1999).

Certain species that are most often associated with open habitats in the state, such as *Cerdocyon thous* (recorded at all sampling points), *Lycalopex vetulus* and *Galictis cuja*, showed that their actual distributions can extend beyond the proposed limits of savanna or grassland type environments. Nonetheless, these unusual occurrences may be best explained by the effects of expanding agro-pastoral environments on the displacement of both generalists and highly specialized species, which show some tendencies to disperse from disturbed areas through open habitat formations (Michalski & Peres 2005, Umetsu & Pardini 2007, Oliveira 2009).

Among the rare species for Maranhão, *Blastocerus dichotomus* stands out with its distribution reaching the southern limits of the state where there are well-preserved areas of Cerrado near Chapada das Mesas and Nascentes do Parnaíba National Parks. *Tolypeutes tricinctus*, a threatened species that is relatively sensitive to anthropogenic disturbances, was documented by means of personal interviews in the region of Urbano Santos and Mirador State Park, though in the latter, it has apparently not been seen for 20 years. *Alouatta ululata* is usually found in open and transitional babaçu forests (Gregori, 2006), yet we recorded this species in the Amazonian region, far west than its known distribution limit. The occurrence of species outside of their proposed distributions, according to the literature, highlights the ecotone effects of the terrestrial environment in Maranhão, which also contributes to the high levels of biodiversity and shows that this transitional zone among several biomes can appear to be much more species rich than when considering these biomes separately (Marimon et al. 2006, Mews et al. 2012, Marimon et al 2014).

Considering only the list of species, independent of the size of the sampling areas, Oliveira et al. (2010) recorded 57 non-volant mammal species in an inventory of Mato Grosso state, which is also characterized as a transitional area between the Amazon and Cerrado biomes and is located in the middle of a region known as the Amazonian Deforestation Arc for its high deforestation rates. Comparing these biomes separately, an inventory conducted in Amazonia National Park, located in the state of Pará, compiled a list of 86 species in an area 10 times smaller than the territory of Maranhão (Oliveira et al. 2016), while 52 species were registered just in Mirador State Park, which includes only 2% of all Cerrado vegetation occurring in the state of Maranhão (Oliveira et al. 2014).

In spite of the diverse criteria, as well as constant updates to the list, the Amazon and Cerrado biomes support at least 399 and 251 mammal species, respectively (Paglia et al. 2012). However, it is also observed that states closer to major urban centers, and where most researchers are concentrated, register numbers of species close to those observed in the current study. For example, in Mato Grosso do Sul, a very large state territory presenting a diversity of biomes, including Cerrado, Atlantic Forest and Pantanal, Tomas et al. (2017) compiled a list of 93 species. Recently Brandão et al. (2019) listed 168 non-volant mammals for Mato

Grosso, a state straddling the Amazon-Cerrado ecotone. Cherem et al. (2004) elaborated a list of 118 non-volant species occurring in the state of Santa Catarina, while Rocha et al. (2004) documented 104 species for the state of Rio de Janeiro, the latter presenting fewer biomes and fauna typical of Atlantic Forest. In São Paulo, a state with a much greater tradition of executing biological inventories, Vivo et al. (2011) compiled a list of 127 non-volant mammal species, which suggests that the species diversity so far recorded for the state of Maranhão is representative, although with significant gaps in the effort to sample such an enormous habitat diversity as that presented by the two dominant biomes. It should also be mentioned that very few scientific studies of non-volant mammals occurring in the state of Maranhão have been published in the primary literature, with much of the available information on this subject having appeared in unconventional outlets and/or formats, such as technical and research reports, dissertations, theses and congress proceedings with restricted disclosure and dissemination, contributing to our collective lack of comprehensive information about this group of animals.

The interaction between geomorphological and climatic aspects typical of ecotones favors the evolutionary process of genetic and ecological diversification in communities and populations (Brasil, 2007). Thus, the relatively large number of mammal species presented here as occurring in Maranhão is a direct reflection of the state being located in a transitional region between three major biomes, the Amazon, Caatinga and Cerrado. Because of this high-level of species richness and diversity of habitats, Maranhão requires special consideration in conserving the integrity of these dynamic and not very stable environments (Marimon et al. 2014). The presence of such an ecological stress zone would also justify the observation of a non-diminishing west-east trend in species richness, whereby the most diverse mammal communities are located in lowland forests along the Amazon basin to the Andes and less species diversity is characteristic of the drier, more easterly boundaries of the region toward Pará-Maranhão (Eisenberg & Redford, 1999).

Finally, it is noteworthy that Maranhão is currently being subject to intense habitat fragmentation, primarily due to the impacts of expanding commercial farming and livestock activities. The study sites sampled for the current study correspond to habitat remnants that act as vital refuges for non-volant mammals and countless other wildlife species. Considering that landscape integrity is a good indicator of biodiversity, conservation actions in such areas, even fragmented landscapes, are of fundamental importance to the protection of natural resources and the variety of flora and fauna (De Araújo et al. 2016, Brazil 2018). Additional studies of the mammalian fauna of Maranhão, and other parts of the Northeast region of Brazil, are necessary for a better understanding of species diversity, abundance and distribution. The lack of information, both taxonomic and geographical, regarding non-volant mammals of Maranhão also reinforces the need for further work, such as that presented here, which can result in more accessible scientific publications that document the important biodiversity occurring in this rapidly changing landscape.

Supplementary material

The following online material is available for this article:

Table S1 - Specimen identification numbers for individuals that were collected and donated to vertebrate collections at each institution.

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Author Contributions

Odgley Quixaba Vieira: contributed to the conception and design of this study, contribution to data collection data collection, contribution to data analysis and interpretation, contribution to manuscript preparation.

Tadeu Gomes de Oliveira: substantial contribution in the concept and design of the study, contribution to data collection data collection, contribution to data analysis and interpretation, contribution to manuscript preparation, contribution to critical revision, adding intellectual content.

Conflicts of Interest

The authors declares that they have no conflict of interest related to the publication of this manuscript.

Ethics

Data obtained from interviews are in fact reports and accounts from local people without any standardized structure. Some of the data presented were collected starting in 1994 (see Table 1 of paper), which was before the implementation of "Plataforma Brasil" and the Resolution Nº466/12/CNS. The later deals with information obtained, partially or wholly, from humans.

Data availability

This research is part of an ongoing doctoral dissertation with the proposed analyses unfinished as of right now. Therefore data archiving in public repositories is partially unavailable at the moment. Notwithstanding, the development of the databases within this research project is being done jointly with the Ecologic-Economic Zoning of Maranhão State project (ZEE Maranhão) using Geographic Information Systems (GIS). As such, some of the data are available for public use on the official website of ZEE Maranhão.

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First record of the genus *Hyalella* (Amphipoda: Hyalellidae) from Santa Catarina State, Brazil, with description of two new species

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Abstract: The amphipod *Hyalella* Smith, 1874 is exclusive to the Americas, and the South region of Brazil presents the greatest diversity of the genus. This paper presents two species of *Hyalella* from Santa Catarina state, Brazil. A new species from the municipality of Palmeira is characterized by oval eyes, absence of flanges, epimeral plates not accuminated, presence of three lateral pappose setae on article 4 in antenna 2, absence of plumose setae in the maxilliped, presence of comb-scales and absence of serrate setae in the gnathopods, presence of curved seta on the inner ramus of the uropod 1 and absence of lateral setae on the telson. A new species from Rio das Antas municipality main characteristics are absence of flanges, epimeral plates accuminated, absence of plumose setae and distal nail in the maxilliped, presence of comb-scales and absence of serrate setae in gnathopods, presence of curved seta on the inner ramus of the uropod 1 and absence of lateral setae on the telson. Here we expand the distribution and increase the morphological and taxonomic knowledge of the genus.
Keywords: *Crustacea, freshwater, systematic, taxonomy.*

Primeiro registro do gênero *Hyalella* (Amphipoda: Hyalellidae) para o estado de Santa Catarina, Brasil, com descrição de duas novas espécies

Resumo: O gênero de anfípodes *Hyalella* Smith, 1874 é exclusivo das Américas, e a região Sul do Brasil apresenta a maior diversidade do gênero. Este artigo apresenta duas novas espécies de *Hyalella* para o estado de Santa Catarina, Brasil. Uma nova espécie do município de Palmeira é caracterizada por olhos ovais, ausência de flanges, placas epimerais não acuminadas, presença de três setas paposas laterais no artigo 4 na antena 2, ausência de setas plumosas no maxilípodo, presença de comb scales e ausência de setas serradas nos gnatópodos, presença de seta curva no ramo interno do urópodo 1 e ausência de setas laterais no télson. Uma nova espécie do município de Rio das Antas tem como principais características ausência de flanges, placas epimerais acuminadas, ausência de setas plumosas e unha distal no maxilípodo, presença de comb scales e ausência de setas serradas nos gnatópodos, presença de seta curva no ramo interno do urópodo 1 e ausência de setas laterais no télson. Aqui expandimos a distribuição e aumentamos o conhecimento morfológico e taxonômico do gênero.
Palavras-chave: *Crustacea, dulcícola, sistemática, taxonomia.*

Introduction

The genus *Hyalella* Smith, 1874 consists of species restricted to the Nearctic and Neotropical biogeographical regions, and it occurs from Patagonia to the southern region of Canada (Bueno et al. 2014). Populations of the genus are found in a great variety of habitats, such as flooded areas, in association with aquatic vegetation, lakes, ponds and in underground aquatic environments (Grosso & Peralta 1999; Rodrigues et al. 2017).

South America bears almost 80% of the diversity of the genus (Rodrigues et al. 2014; Colla & César 2015; Streck et al. 2017; Bastos-Pereira et al. 2018; Streck-Marx & Castiglioni 2019), yet only less than a third of the ecological studies with the genus deals with its southern species. There are 76 species described (Bueno et al. 2019; Streck-Marx & Castiglioni 2019), 28 of which are from Brazil (Rodrigues et al. 2014; Streck et al. 2017; Bastos-Pereira et al. 2018; Peralta & Isa Miranda 2019; Streck-Marx & Castiglioni 2019). The Southern Brazilian region presents the greatest diversity of the genus *Hyalella*.

There are 12 known species occurring in Rio Grande do Sul (Streck-Marx & Castiglioni 2019): *H. curvispina* Shoemaker, 1942; *H. pampena* Cavalieri, 1968; *H. montenegrinae* Bond-Buckup & Araujo, 1998; *H. pseudoazteca* González & Watling, 2003; *H. castroi* González, Bond-Buckup & Araujo, 2006; *H. pleoacuta* González, Bond-Buckup & Araujo, 2006; *H. bonariensis* Bond-Buckup, Araujo & Santos, 2008; *H. imbya* Rodrigues & Bueno, 2012; *H. kaingang* Araujo & Cardoso, 2013; *H. gauchensis* Streck & Castiglioni, 2017; *H. georginae* Streck & Castiglioni, 2017; and *H. palmeirensis* Streck-Marx & Castiglioni, 2019. For Paraná state, there are only two records for the genus: *H. brasiliensis* Bousfield, 1996; *H. formosa* Cardoso & Araujo, 2014 (Cardoso et al. 2014; Streck et al. 2017). Geographically close, but found in Argentina, there is also *H. misionensis* Colla & Cesar, 2015; this species is included in the taxonomical remarks and discussion sections.

This paper aims to extend the distribution of the genus *Hyalella* in the Southern Brazil, with the description of two new species from the central region of Santa Catarina State.

Material and Methods

The specimens were collected in different localities of Santa Catarina state, both belonging to the Uruguay Basin; one in a flooded area of Ribeirão Antônio (27°35'28.2''S 50°7'54.4''W; ~880m of altitude) in the municipality of Palmeira, central portion of the state; and another in a private lake, on road SC135, municipality of Rio das Antas (26°57'1.9''S 51°6'47.5"W; 772m of altitude), northern in relation to the other (Figure 1).

The material was collected using a hand net and preserved in 70% ethanol. The head length was obtained from the insertion of the antennas until the beginning of the first thoracic segment, the body length was measured from the head to the last segment, except for the telson.

Random animals from both locations were selected to be dissected and mounted on slides. First, they were colored for 24 h using the "red congo" dye to increase color contrast. After that, the dissection was performed under a Carl Zeiss Stemi 508 stereoscope, using glycerin as a dissection medium with the aid of fine needles. The dissected appendages were put on slides containing natural Canada balsam as medium and covered by cover slip. We used varnish to seal the slides. The photos used as base for the illustrations were produced with a Carl Zeiss Primo Star microscope, with an Carl Zeiss AxioCam ERc5s camera coupled. The illustrations were made using the CorelDraw X7 software. The description of cuticular structures followed terminology by Zimmer et al. (2009). The type material was deposited in Museu de Zoologia da Universidade de São Paulo (MZUSP) and in Coleção de Crustáceos da Universidade Federal de Lavras (CCUFLA).

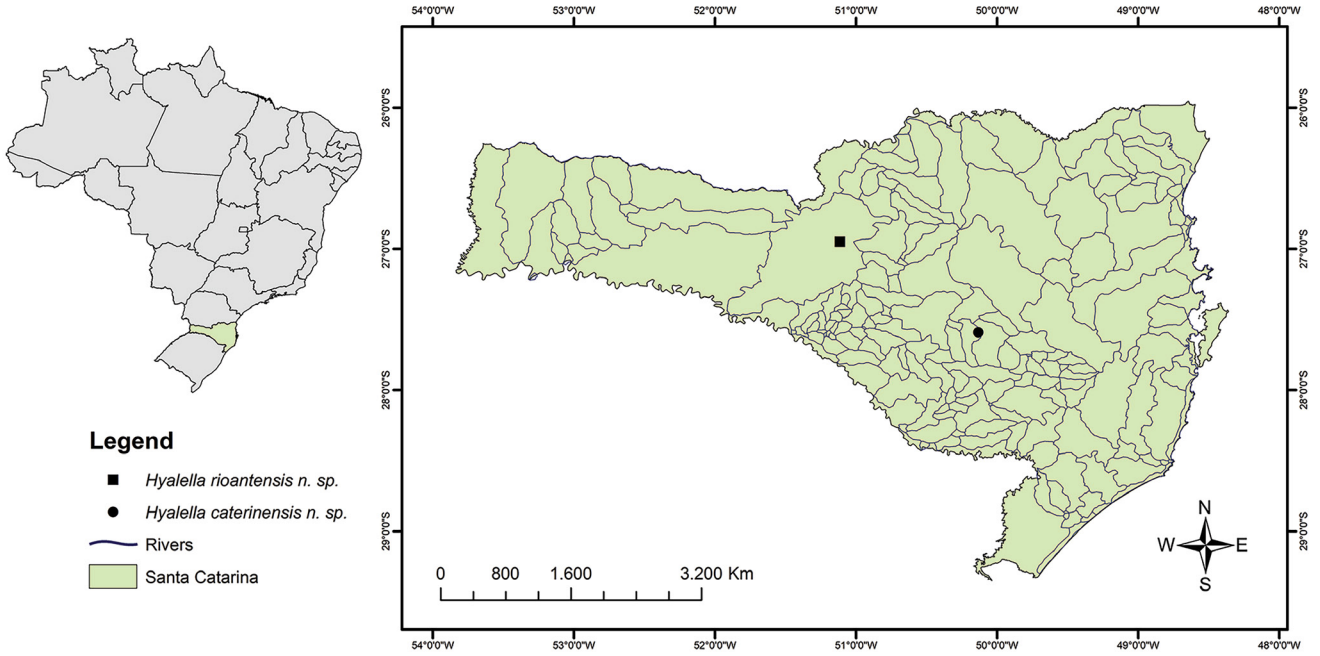

Figure 1. Map showing collection sites in Santa Catarina State.

Results

1.Taxonomy

Order Amphipoda Latreille, 1816
Suborder Senticaudata Lowry & Myers, 2013
Family Hyalellidae Bulycheva, 1957
Genus *Hyalella* S. I. Smith, 1874
***Hyalella catarinensis* n. sp. Reis & Bueno**
(Figures 2-7)

Type material. Holotype male, body length = 7.88 mm, head length = 0.68 mm, Alagado do Ribeirão Antônio, municipality of Palmeira, Santa Catarina state, Brazil, (27°35'28.2''S 50°7'54.4''W) MZUSP 39529, December/2012, G. Bond-Buckup, C. Sokolowicz coll. Paratype female, body length = 6.76 mm, head length = 0.60 mm, MZUSP 39530; twenty whole individuals and two male and one female in slides CCUFLA 405 (same collection data of the holotype).

Diagnosis. (Figures 2-7) Smooth body surface. Epimeral plates not accuminated. Antenna 2 article 4 with three lateral pappose setae. Maxilla 1, Maxilla 2 and Mandibles with presence of papposerrate setae. Maxilliped without comb-scales and plumose setae. Gnathopod 2 with presence of comb-scales, without serrate setae, palm longer than posterior margin of propodus. Inner ramus on uropod 1 of male with two dorsal cuspidate setae, with accessory seta; one curved seta followed by four cuspidate setae apically, only one with accessory seta. Telson 1.7x longer than wide, apically rounded with three apical cuspidate setae, with accessory seta. Coxal gills sac-like present on segments 2 to 6. Sternal gills present on segments 2 to 7.

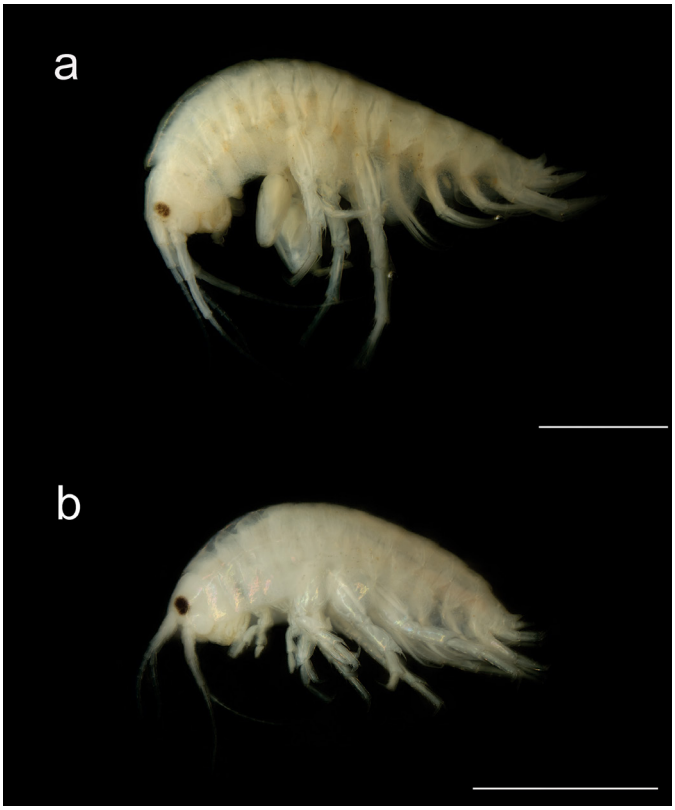

Figure 2. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2'' S 50°7'54.4'' W). Holotype, male, 7.88 mm, MZUSP 39529 (a). Paratype, female, 5.25 mm, MZUSP 39530 (b). Scale bars = 2 mm.

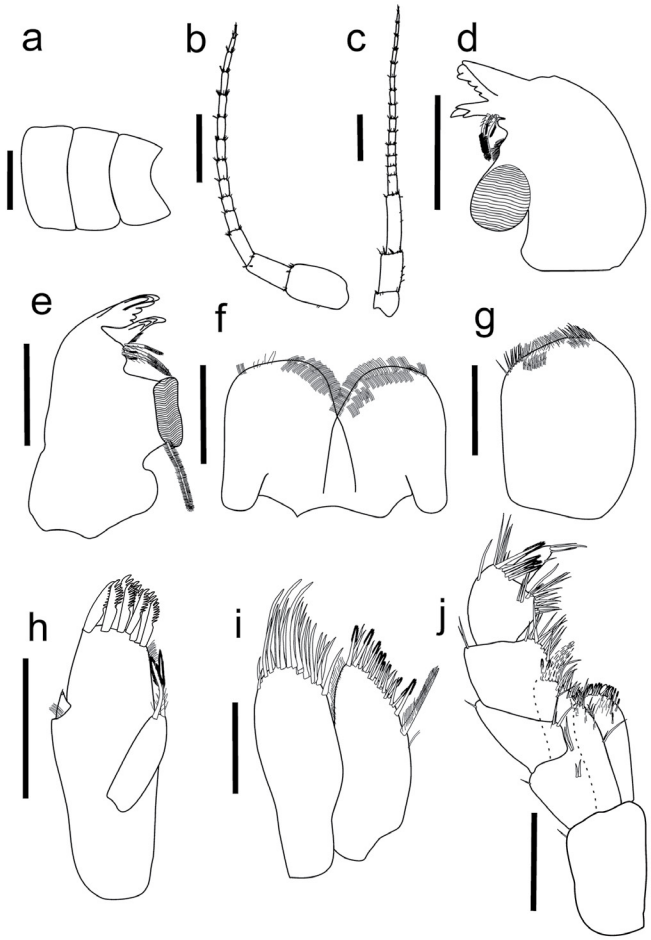

Figure 3. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2'' S 50°7'54.4'' W). Paratype, male, 7.60 mm. Epimeral plates not accuminated (a). Antenna 1 (b). Antenna 2 (c). Right mandible (d). Left mandible (e). Lower lip (f). Upper lip (g). Maxilla 1 (h). Maxilla 2 (i). Maxilliped (j). Scale bars: a = 2mm; b and c = 500 µm; d to j = 200 µm.

Description of male. Mean body length: 5.40 ± 0.72 mm (N = 10), minimum body length = 4.44 mm, maximum body length = 7.88 mm; mean head length: 0.57 mm ± 0.07 mm (N = 10), minimum head length = 0.48 mm, maximum head length = 0.70 mm. Body surface smooth. Epimeral plates not accuminated (Figure 3a). Coxae 1–4 subequal in size and shape, slightly overlapping. Coxa 1 similar to 2 and 3. Coxa 3 wider than 4. Coxa 4 longer than wide, excavated posteriorly. Coxa 5 posterior lobe narrower than anterior lobe. Coxa 6 anterior lobe small. Coxa 7 reduced. Head 1.26x smaller than first two thoracic segments. Eyes oval and pigmented.

Antenna 1 (Figure 3b) 3.2x smaller than body length, 1.3x smaller than antenna 2, 2x longer than peduncle of antenna 2; peduncle 2.6x longer than head; article 1 longer than 2, article 3 shorter than 1 and 2; flagellum with 14 articles, 4.3x longer than peduncle; aesthetascs occurring distally on flagellum from article 7 to 12.

Antenna 2 (Figure 3c) 2.5x smaller than body length, peduncle slender, 3.4x longer than wide, 1.7x longer than head; article 4 shorter

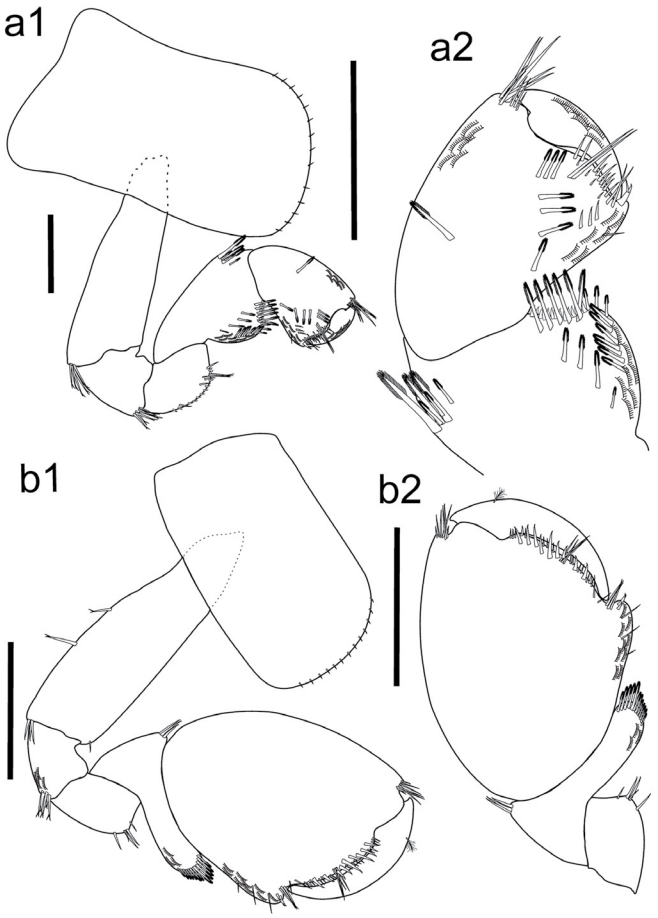

Figure 4. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2" S 50°7'54.4" W). Paratype, male, 7.60 mm. Gnathopod 1 (a1). Detail of the carpus, propodus and dactylus (a2). Gnathopod 2 (b1). Detail of the merus, carpus, propodus and dactylus (b2). Scale bars = 500 µm.

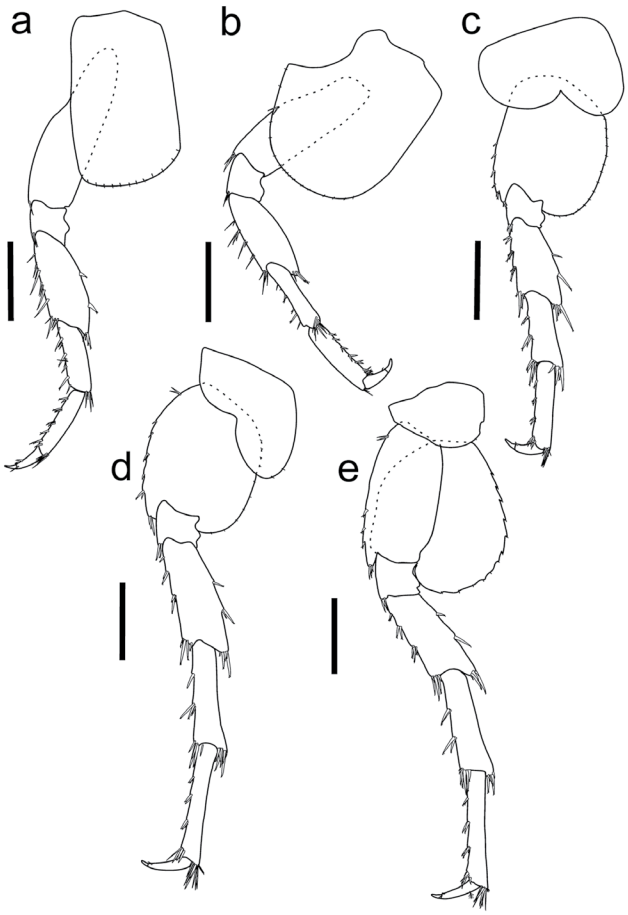

Figure 5. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2" S 50°7'54.4" W). Paratype, male, 7.60 mm. Pereopod 3 (a). Pereopod 4 (b). Pereopod 5 (c). Pereopod 6 (d). Pereopod 7 (e). Scale bars: 500 µm.

than article 5, with three lateral pappose setae; flagellum with 14 articles, 1.5x longer than peduncle;

Mandible without palp; incisor toothed; left (Figure 3e) lacinia mobilis with four teeth and setal row with five papposerrate setae, molar process with accessory seta; right mandible (Figure 3d) with four papposerrate setae; molar process broad and cylindrical.

Upper lip (Figure 3g) margin rounded; distal border covered by setules and simple setae on distal ventral and dorsal faces. Lower lip (Figure 3f) outer lobes rounded with apical setules.

Maxilla 1 (Figure 3h) inner plate slender, 2.7x shorter than outer plate, with two long apical papposerrate setae. Outer plate with seven to nine serrate setae. Palp short, uniarticulate, longer than wide, reaching more than half of the distance between the base of the palp and base of setae on outer plate, with a distal short seta and setules.

Maxilla 2 (Figure 3i) inner plate slightly shorter than outer plate, inner plate with one papposerrate seta, ten pappose setae, several simple setae; outer plate with several simple distal setae; inner and outer plates covered by several setules.

Maxilliped (Figure 3j) inner plate 6.3x longer than wide, with several pappose and three cuspidate apical setae; outer plate 6.3x smaller than inner plate, with three pappose and several simple setae on the margin; palp subequal to inner plate and 6x longer than outer plate, four articles; article 1 1.2x longer than wide, outer margin with a simple setae; article 2 1.1x wider than long, inner margin with several long simple setae; article 3 2.3x longer than wide, inner margin with several long simple setae, outer margin with pappose and long simple setae; dactylus unguiform, 1.7x longer than third article, distal setae simple shorter than nail, distal nail present.

Gnathopod 1 (Figure 4a1, a2) subchelate; coxal plate 1.8x longer than wide, with simple setae on the margin; basis and ischium with simple setae dorsally with accessory setae; merus with simple setae with accessory setae, margin with denticles; carpus 1.6x wider than long, shorter than propodus, with lateral distal lobe produced and forming a scoop-like structure, with several pappose setae and comb-scales; propodus 1.3x longer than wide, hammer-shaped, with several simple long setae on disto-anterior margin, comb-scales present, inner margin with 4 pappose setae, with few simple setae and comb-scales on the disto-posterior margin; palm slope oblique, margin slightly concave, palm with many simple setae, posterior distal corner with one cuspidate setae with an accessory seta; dactylus claw-like, comb-scales present on distal margin.

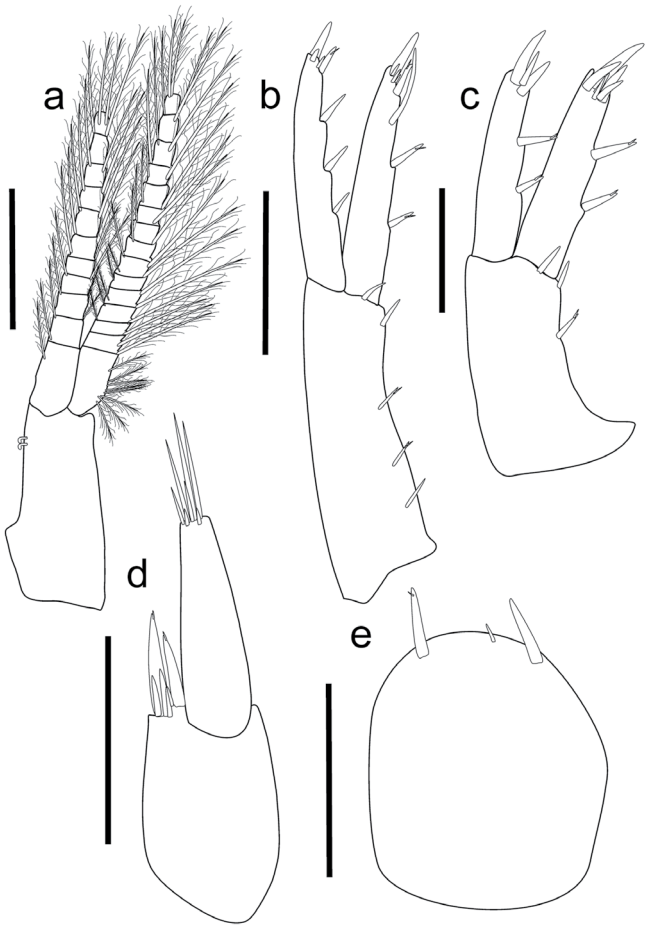

Figure 6. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2" S 50°7'54.4" W). Paratype, male, 7.60 mm. Pleopod (a). Uropod 1 (b). Uropod 2 (c). Uropod 3 (d). Telson (e). Scale bars: a,b,d and e = 500 µm; c = 250 µm.

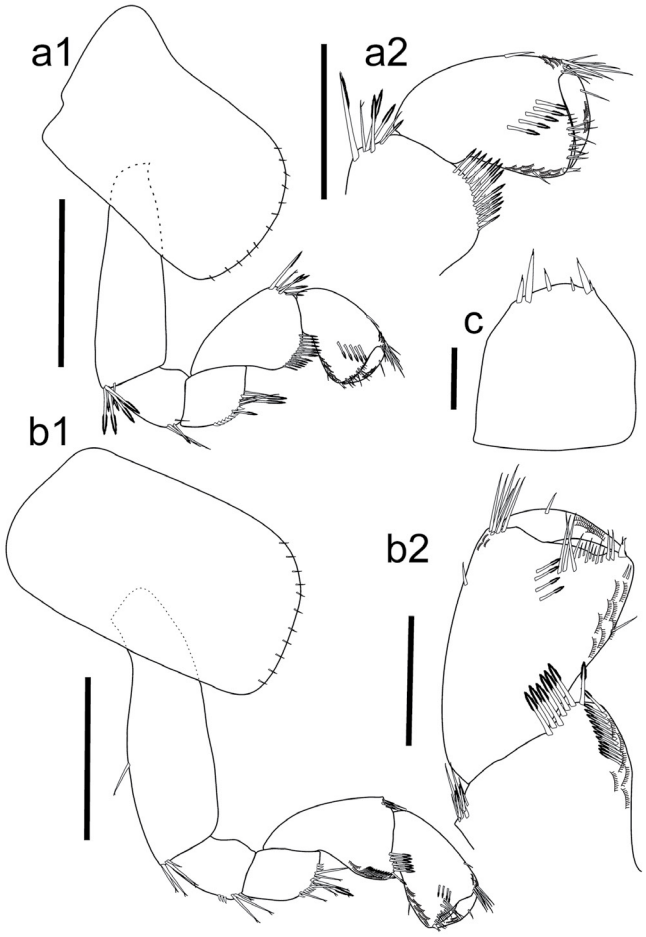

Figure 7. *Hyalella catarinensis* n. sp., municipality of Palmeira, Santa Catarina State, Brazil (27°35'28.2" S 50°7'54.4" W). Paratype, female, 6.76 mm. Gnathopod 1 (a1). Detail of the carpus, propodus and dactylus (a2). Gnathopod 2 (b1). Detail of the carpus, propodus and dactylus (b2). Telson (c). Scale bars: a1 and b1 = 500 µm; a2 and b2 = 250 µm; c = 100 µm.

Gnathopod 2 (Figure 4b1, b2) subchelate; coxal plate 1.8x longer than wide, with simple setae on the margin; basis with several simple setae with accessory seta on posterior margin; merus with simple setae on posterior margin; carpus 1.6x wider than long, posterior lobe narrow produced between merus and propodus, margin with pappose and simple setae, with comb-scales; propodus ovate, 1.3x longer than wide, comb-scales present; palm longer than posterior margin of propodus, convex, with one row of several cuspidate setae and simple setae, posterior distal corner with two long and strong cuspidate setae, only one with accessory seta, and with a cup for dactylus; dactylus claw-like, congruent with palm, plumose seta dorsally, comb-scales absent.

Pereopods 3 to 7 (Figure 5a-e) simple. Pereopods 3 and 4 merus and carpus posterior margin with clusters of simple setae; propodus posterior margin of pereopods 3 and 4 with cuspidate setae with accessory seta; dactylus 1.9x shorter than propodus on Pereopods 3 and 1.9x on Pereopod 4. Pereopods 5 to 7 merus, carpus and propodus posterior margin with three-four marginal clusters of one-eight cuspidate setae with accessory seta, dactylus 2.4x shorter than propodus. Pereopod 3 and pereopod 4 similar sizes; pereopod 5 smaller than others; pereopod 6 larger than pereopod 7, which is similar in size to the pereopod 3.

Pleopods (Figure 6a) peduncle 1.6x shorter than rami, with two coupling spines; both rami with several plumose setae.

Uropod 1 (Figure 6b) 1.2x longer than uropod 2; peduncle 1.6x longer than outer ramus and 1.6x than inner ramus, with five cuspidate setae with accessory seta; rami subequal; inner ramus with two dorsal cuspidate setae with accessory seta on the margin, and curved seta followed by four cuspidate setae apically, only one with accessory seta; outer ramus with three dorsal cuspidate setae on the margin and four cuspidate setae apically, only one with accessory seta.

Uropod 2 (Figure 6c) 1.2x shorter than uropod 1, peduncle 2.7x longer than outer ramus and 2.4x than inner ramus, 2.2x wider than outer ramus and 1.8x than inner ramus, with three cuspidate setae, only one with an accessory seta; inner ramus with two dorsal cuspidate setae with an accessory seta and six cuspidate setae apically; outer ramus with two dorsal cuspidate setae with an accessory seta and three apical cuspidate setae.

Uropod 3 (Figure 6d) 1.8x shorter than peduncle of uropod 1 and 1.4x than peduncle of uropod 2; peduncle 1.7x longer than wide, with six cuspidate setae, only two with accessory seta; inner ramus absent; outer ramus uniarticulate, subequal in length to peduncle; basal width 1.8x more than apex of ramus, with seven simple setae apically.

Telson (Figure 6e) entire, 1.7x longer than wide, apically rounded, with three apical cuspidate setae with accessory seta, without setae laterally.

Coxal gills sac-like, present on pereonites 2 to 6. Sternal gills tubular present on pereonites 2 to 7.

Female (Figure 2b)**.** Mean body length: 4.96 ± 0.61 mm (*N* = 10), minimum body length = 3.72 mm, maximum body length = 6.76 mm; mean head length: 0.52 ± 0.07 mm (*N* = 10), minimum head length = 0.36 mm, maximum head length = 0.67 mm. Gnathopod 1 (Figure 7a1, a2) similar to male gnathopod 1; carpus 1.3x longer than wide, without comb-scales; with posterior lobe produced and forming a scoop-like structure, with pectinate margin, with several pappose setae; propodus 2.4x longer than wide, hammer-shaped, palm 3.6x shorter than posterior margin of propodus, with comb-scales, inner margin with few simple setae with accessory seta, palm slope transverse with comb-scales, dactylus claw-like, with comb-scales. Gnathopod 2 (Figure 7b1, b2) similar in size and shape to gnathopod 1; different in shape to male gnathopod 2 and smaller; propodus 1.6x as long as wide, subchelate, inner margin with few simple setae, palm oblique with several long simple setae, with comb-scales. Uropod 1 similar in size and shape to male uropod 1, except for the absence of curved seta. Telson (Figure 7c) similar in shape to male, with six cuspidate setae with accessory seta.

Taxonomical remarks. Among all species that occur in southern Brazil, *Hyalella catarinensis* n. sp. shares the presence of curved seta in the inner ramus of uropod 1 with *H. bonariensis*, *H. brasiliensis*, *H. castroi*, *H. curvispina, H. gauchensis*, *H. georginae*, *H. kaingang*, *H. misionensis*, *H. montenegrinae*, *H. palmeirensis*, *H. pampeana* and *H. pleoacuta*. In this group, the new species differs from *H. pleoacuta* and *H. kaingang* by the absence of flanges and from *H. pleoacuta*, *H. kaingang* and *H. palmeirensis* by the epimeral plates not accuminate. The absence of plumose setae in maxilla 2 distinguishes the new species from *H. curvispina*, *H. montenegrinae*, *H. pampeana* and *H. brasiliensis*. By the absence of plumose setae in the maxilliped it is possible to differentiate *H. catarinensis* n. sp. from *H. montenegrinae*, *H. castroi* and *H. pleoacuta*. *Hyalella catarinensis* n. sp. does not resemble *H. brasiliensis*, *H. georginae* and *H. palmeirensis* due to the propodus of gnathopod 2 having a palm longer than posterior margin. The characteristic that makes it possible to differentiate the new species from a large group of species including *H. pampeana*, *H. montenegrinae*, *H. bonariensis*, *H. kaingang*, *H. georginae*, *H. gauchensis* and *H. palmeirensis* is the absence of lateral setae in the telson. The presence of three lateral pappose seta in antenna 2 article 4 is a unique feature not found in any of the previously described species. All similarities and differences between *H. catarinensis* n. sp. and others species can be checked on Table 1.

Etymology: The species epithet "*catarinensis*" is in reference to the state of Santa Catarina and a reference of the first record of the genus for the state.

Habitat and Ecological Conservation: Epigean. Place of collection of the specimens without traces of pollution, however, with maize plantations in the surroundings.

***Hyalella rioantensis* n. sp. Penoni & Bueno**

(Figures 8-13)

Type material. Holotype male, body length = 8.03 mm, head length = 1.05 mm, private lake in road SC 135, municipality of Rio das Antas, state of Santa Catarina, Brazil, (26°57'1.9''S 51°6'47.5"W), MZUSP 39531, May/2005, Bond-Buckup coll. Paratypes female, body length = 6.44 mm, head length = 1.12 mm, MZUSP 39532; 110 whole individuals and 17 male and 10 female in slides CCUFLA 88 (same collection data of the holotype).

Diagnosis. (Figures 8-13) Body surface smooth. Epimeral plates accuminated. Eyes round, pigmented. Antenna 1 0.8x shorter than antenna 2. Antenna 2 about half body length. Maxilla 1 palp longer than wide, more than half the distance between base of palp and base of setae on outer plate; inner plate slender, with two papposerrate apical setae. Maxilla 2 inner plate with 23 papposerrate and several simple setae on inner margin. Gnathopod 1 propodus 1.6x longer than wide, hammer-shaped, inner face with two rows of simple seta and cuspidate seta, anterior and posterior margins with comb-scales. Gnathopod 2 ovate, palm equal in size to posterior margin of propodus, slope oblique. Uropod 1 of male with curved seta on inner ramus. Uropod 3 peduncle wider and shorter than ramus, with five distal setae with accessory seta and a dorsal simple seta. Telson slightly longer than wide, apically rounded, with four apical cuspidate setae with accessory seta. Coxal gills sac-like and sternal gills present on segments 2 to 7.

Description of male. Mean body length: 6.24 ± 1.02 mm (*N* = 10), minimum body length = 6.09 mm, maximum body length = 8.03 mm; mean head length: 0.74 mm ± 0.12 mm (*N* = 10), minimum head length = 1.05 mm, maximum head length = 0.84 mm. Body surface smooth. Epimeral plates accuminated (Figure 9a). Coxae 1–4 slightly overlapping. Coxa 1 similar to 2 and 3. Coxa 3 narrower than 4. Coxa 4 deeper than wide, excavated posteriorly. Coxa 5 wider than longer. Coxa 6 longer than wide. Coxa 7 reduced. Head smaller than first two thoracic segments. Eyes round and pigmented.

Antenna 1 (Figure 9b) about 0.83x half body length, 0.8x the total length of antenna 2, 1.8x longer than peduncle of antenna 2; peduncle 1.3x longer than head; article 1 1.4x longer than 2, article 3 0.6x shorter than 1 and 0.8x shorter than article 2; flagellum with 11 to 14 articles, 1.5x longer than peduncle; aesthetascs occurring on flagellum from article 5 distally.

Antenna 2 (Figure 9c) 0.9x the length of half the body; peduncle slender, 1.8x longer than head, article 4 0.8x shorter than article 5, flagellum with 14 to 18 articles, 1.1x longer than peduncle.

Mandible without palp; incisor toothed; left (Figure 9e) lacinia mobilis with four teeth and setal row with five papposerrate setae; right mandible (Figure 9d) with four papposerrate setae; molar process broad and cylindrical with accessory seta.

Upper lip (Figure 9g) margin rounded; distal border covered by setules on ventral and dorsal faces. Lower lip (Figure 9f) outer lobes rounded and distally notched, with setules on dorsal and ventral faces.

Maxilla 1 (Figure 9h) inner plate slender, shorter than outer plate, with two apical papposerrate setae and setules on the margins. Outer plate with nine serrate setae. Palp short, uniarticulate, longer than wide, reaching more than half of the distance between the base of the palp and base of setae on outer plate, with distal setules.

Maxilla 2 (Figure 9i) inner plate subequal to outer plate, inner plate with several papposerrate setae and few simple setae; outer plate with a pappose setae and several simple setae; inner and outer plates covered by setules.

Maxilliped (Figure 9j1, j2) inner plate longer than wide, with three cuspidate distal setae and several apical and medial pappose setae, without comb-scales; outer plate subequal to inner plate, with several

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Table 1. Differences and similarities between the two new species (H. catarinensis n. sp. and H. rioantensis n. sp.) and species recorded for southern Brazil. References: (1) In this paper; (2) Santos et al., 2008; (3) Bousfield, 1996; (4) González et al., 2006; (5) Grosso & Peralta, 1999; (6) Streck et al., 2017; (7) Bueno et al., 2011; (8) Colla & César, 2015; (9) Bond-Buckup & Araujo, 1998; (10) Streck-Marx & Castiglioni, 2019; (11) Cavalieri, 1968; (12) González & Watling, 2003.

Species	Occurance (localities)	Body surface	Epimeral plates	Maxilla 1 Plumose setae in inner ramus	Male gnathopod 2 Propodus ratio	Male gnathopod 2 Comb scales	Male uropod 1 Inner ramus with curved setae	Male uropod 1 Number of apical seta on inner ramus	Male uropod 1 Ratio rami/ peduncle	Uropod 3 Number of setae apically	Uropod 3 Ratio ramus/ peduncle	Male Telson Format	Male Telson Setation
(1) *H. catarinensis sp. nov.*	Palmeira/SC	Smooth	Not accuminated	Absent	1.3x longer than wide	Yes, in carpal posterior lobe and propodus margin	Yes	4 cuspidate setae	Peduncle 1.6x longer than outer ramus and 1.6x than inner	7 simple setae	Ramus 3.3x shorter than peduncle	Round	3 apical cuspidate setae
(1) *H. rioantensis sp. nov.*	Rio das Antas/C	Smooth	Accuminated	Absent	1.3x longer than wide	Yes, in basis, ischium and carpal posterior lobe	Yes	5 cuspidate setae	Peduncle 1.1x longer than outer and subequal than inner	4 cuspidate setae	Ramus 1.3x longer than peduncle	Round	4 apical simple setae
(2) *H. bonariensis*	Salto, Buenos Aires, Argentina	Smooth	Not accuminated	Absent	1.25x longer than wide	Yes, only at the propodus margin	Yes	8 cuspidate setae with acessory seta + 2 cuspidate setae	Peduncle longer than rami	4 long simple setae + 4 shorter setae	No information	Quadrangular	2-3 apical cuspidate setae, sometimes with plumose setae
(3) *H. brasiliensis*	Prudentópolis/ PR	Smooth	Accuminated	No information	No information	No information	Yes	No information	Peduncle longer than rami	Did not specify number of apical setae	Ramus longer than peduncle	Apically rounded	5-6 apical cuspidate setae
(4) *H. castroi*	São José dos Ausentes/RS	Smooth	Accuminated	Absent	No information	Yes, only at the propodus margin	Yes	No information	Peduncle longer than rami	>7	Peduncle wider than ramus	Apically rounded	8 distal simple setae
(5) *H. curvispina*	Tramandaí/RS	Smooth	No information	Present	No information	Yes, only at the propodus margin	Yes	No information	No information	No information	Subequal	Apically rounded	2 stout spines + several alender and shorter spines
(6) *H. gauchensis*	Palmeira das Missões/RS	Smooth	Not accuminated	Absent	1.4x longer than wide	Yes, in basis, isquium, merus, carpal posterior lobe and propodus	Yes	4 cuspidate setae	Peduncle 1.3x longer than rami	8 simple setae	Subequal	Apically rounded	6 apical cuspidate setae + 6 plumose setae apically
(6) *H. georginae*	Palmeira das Missões/RS	Smooth	Not accuminated	Absent	1.5x longer than wide	Yes, in basis, isquium, merus and propodus posterior margin of lobe	Yes	4 cuspidate setae	Peduncle 1.2x longer than rami	8 simple setae + 1 cuspidate seta	Subequal	Apically rounded	7 apical cuspidate setae w/ accessory seta + 4 plumose setae laterally
(7) *H. kaingang*	São Francisco de Paula/RS	With flanges	Accuminated	Absent	1.5x wider than long	No	Yes	2 cuspidate setae	Peduncle longer than rami	9-13 simple setae + 1 cuspidate seta with acessory seta	Ramus 1.1x shorter than peduncle	Round	6-7 distal simple setae + plumose setae laterally
(8) *H. misionensis*	Misiones/ Argentina*	Smooth	Accuminated	Absent	No information	Yes, only at the propodus distoposterior border	No	5 cuspidate	Peduncle longer than rami	4-5 simple slender + one connate	Ramus wider than peduncle	Round	2 long simple setae on distal margin + 3 small setae
(9) *H. montenegrinae*	Aparados da Serra/RS	Smooth	No information	Present	No information	No information	Yes	2 robust 1 simple	No information	8-10 thin and long	Subequal	Apically rounded	7-9 apical 'farpada' setae + 3 plumose setae laterally
(10) *H. palmeirensis*	Palmeira das Missões/RS	Smooth	Accuminated	Absent	Length 1.5 times maximum width	Yes, only at the propodus posterior margin of lobe	Yes	2 cuspidate	Peduncle 1.2x longer than rami	3 cuspidate + 1 simple	Peduncle wider than ramus	Apically rounded	2 apical long simple setae + 6 plumose setae laterally
(11) *H. pampeana*	Arroio Vitel, Buenos Aires, Argentina	No information	No information	2 bipectinadas	Wider than long	No information	Yes	6	Peduncle 1.5x longer than rami	4-8 thin	Ramus longer than peduncle	Apically rounded	2-5 apical simple + 3 bipectinadas laterally
(4) H. pleoacuta	São José dos Ausentes/RS	With flanges	Accuminated	Absent	No information	Yes, in propodus distoposterior border and in palm margin	Yes	1 connate	Peduncle longer than rami	4 simple + 1 connate	Subequal	Round	2 long seta on distal margin + 1-2 shorter setae ocasionally
(12) *H. pseudoazteca*	Reserva Ecológica de Taim/RS	With flanges	Accuminated	Absent	No information	No information	No	5	Peduncle longer than rami	4 simple +1 connate	Ramus as longer as peduncle	Apically pointed	2 apical marginal simple setae

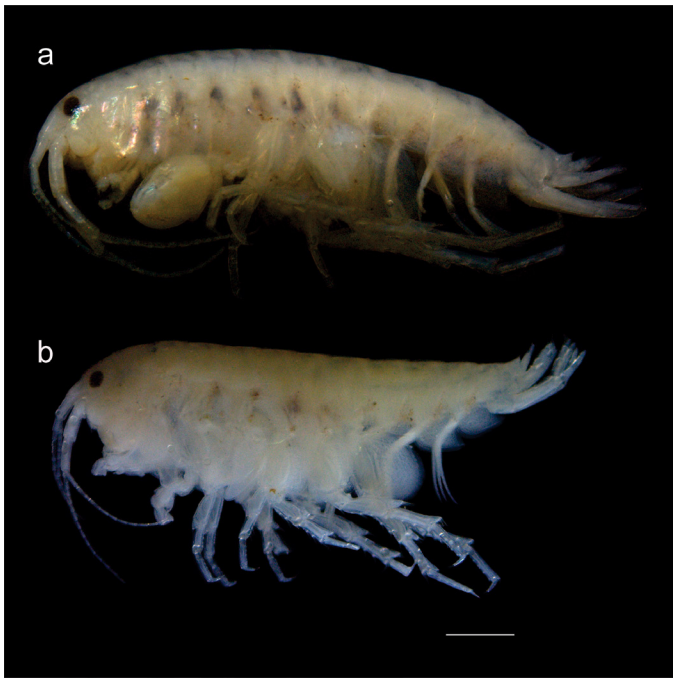

Figure 8. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Holotype male, 8.03 mm, MZUSP 39531 (a); paratype, female, 6.77 mm, MZUSP 39532 (b). Scale bars = 1000 µm.

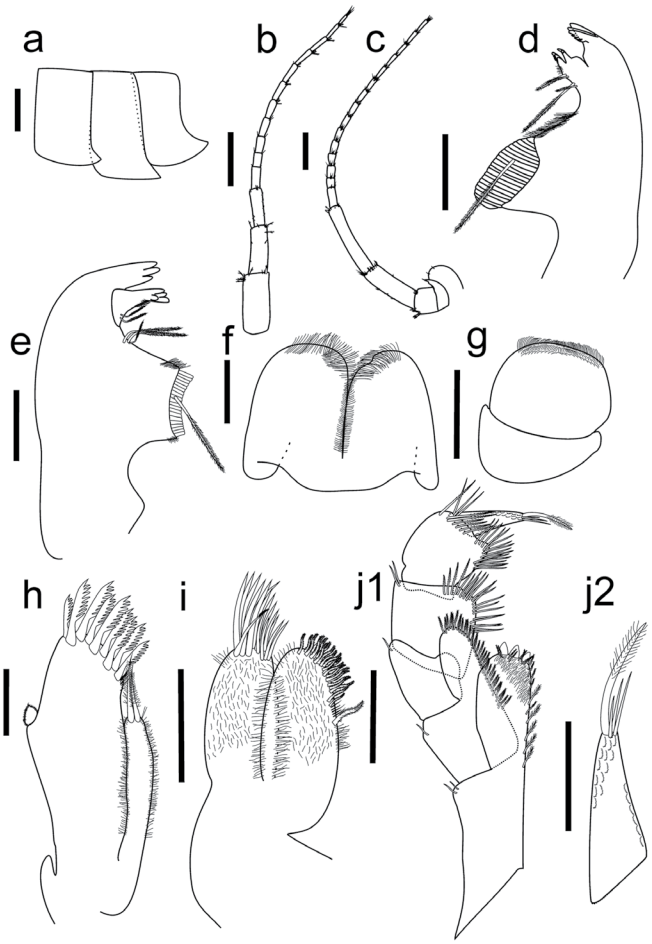

Figure 9. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Paratype, male, 7.96 mm. Epimeral plates accuminated (a). Antenna 1 (b). Antenna 2 (c). Right mandible (d). Left mandible (e). Lower lip (f). Upper lip (g). Maxilla 1 (h). Maxilla 2 (i). Maxilliped (j1). Detail of the maxilliped (j2). Scale bars: a = 1000 µm; b and c = 500 µm; d and e = 100 µm; f, i and h= 125 µm; g = 200 µm; j1 = 250 µm; j2 = 125 µm.

apical and medial pappose setae, without comb-scales; palp longer than inner and outer plate, with four articles; article 1 1.3x longer than wide, outer margin with one simple seta; article 2 1.5x longer than wide, inner margin with four pappose setae and several simple setae; article 3 1.7x longer than wide, outer and inner margins with simple and pappose setae, without comb-scales; article 4 unguiform, 0.8x shorter than third article, 3.4x longer than wide, one distal long pappose setae, with comb-scales, and distal nail absent.

Gnathopod 1 (Figure 10a1, a2) subchelate; coxal plate 1.7x longer than wide, with simple setae on the margin; basis and ischium with dorsal and apical pappose setae and comb-scales; merus with pappose setae on distal margin, with comb-scales; carpus 1.5x longer than wide, 1.2x longer than the propodus, with lateral distal lobe produced, with three simple setae on inner margin, pappose setae and comb-scales on posterior lobe; propodus length 1.6x maximum width (quadrangular), hammer-shaped, with pappose setae on disto-anterior margin, with comb-scales, inner margin with simple setae on the disto-posterior margin, with comb-scales; palm slope transverse, with many simple setae, margin slightly concave, posterior distal corner with one long and strong cuspidate seta with accessory seta; dactylus claw-like, with comb-scale, with one plumose seta dorsally.

Gnathopod 2 (Figure 10b1, b2, b3) subchelate; coxal plate 1.8x longer than wide, with simple setae on the margin; basis and ischium with simple setae, some with accessory seta, and comb-scales on posterior margin; merus with few simple setae on posterior margin, some with accessory seta, without comb-scales; carpus 2x wider than long, posterior lobe produced between merus and propodus, forming a scoop-like structure, margin with pappose setae; propodus ovate, 1.3x longer than wide; palm equal in size to posterior margin of propodus, slope transverse, margin with several simple setae, posterior distal corner with comb-scales and with a deep cup for the dactylus; dactylus claw-like, congruent with palm, plumose seta dorsally, comb-scales absent.

Pereopods 3 to 7 (Figure 11a-e) simple. Pereopods 3 and 4: merus and carpus posterior margin with several pappose and simple setae with accessory seta; propodus posterior margin of pereopod 3 and 4 with pappose setae, simple and cuspidate setae with accessory seta; dactylus 3.3x and 4.4x shorter than propodus, respectively, with a plumose seta dorsally. Pereopods 5 to 7: merus, carpus and propodus posterior margin with several cuspidate setae some of them with accessory seta, dactylus 3.3x, 4.9x and 5.5x shorter than propodus, respectively, with a plumose seta dorsally, except on pereopod 7. Pereopods 4 and 5 similar sizes; pereopod 5 smaller than pereopod 3; pereopod 7 longer than pereopod 6.

Pleopods (Figure 12a) peduncle 2.7x longer than wide, 0.6x the mean size of rami, with two coupling spines; both rami with several plumose setae.

Uropod 1 (Figure 12b) 1.4x longer than uropod 2; peduncle slightly longer than outer ramus and subequal to inner ramus, with four to six cuspidate setae with accessory seta; inner ramus slightly longer than outer ramus, 5.6x longer than wide, with three cuspidate setae on the

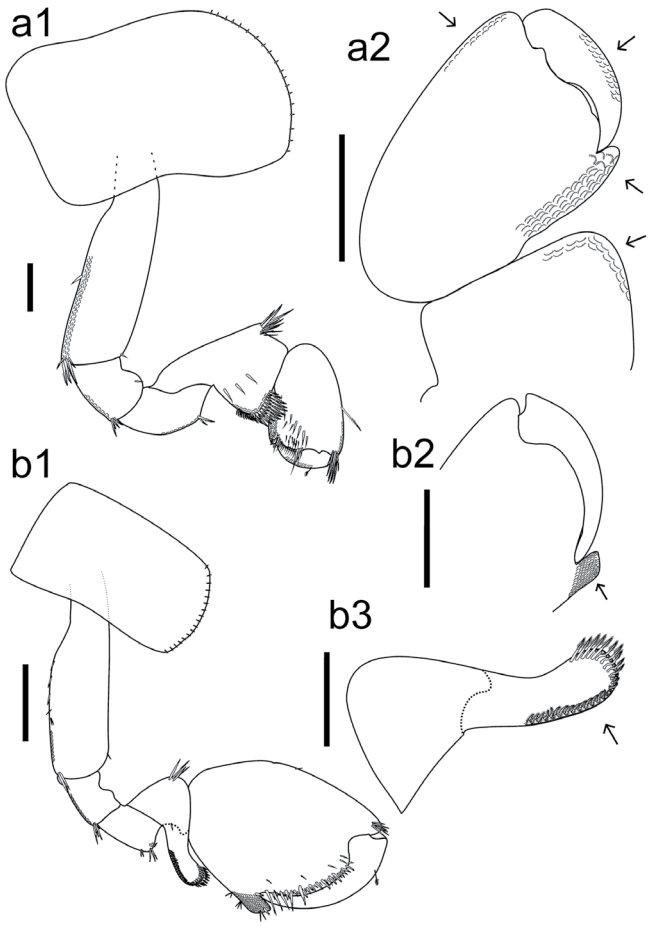

Figure 10. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Paratype, male, 7.96 mm. Gnathopod 1 (a1). Detail of the carpus, propodus and dactylus (a2). Gnathopod 2 (b1). Detail of the propodus and dactylus (b2). Detail of the carpus (b3). Scale bars = 200 µm.

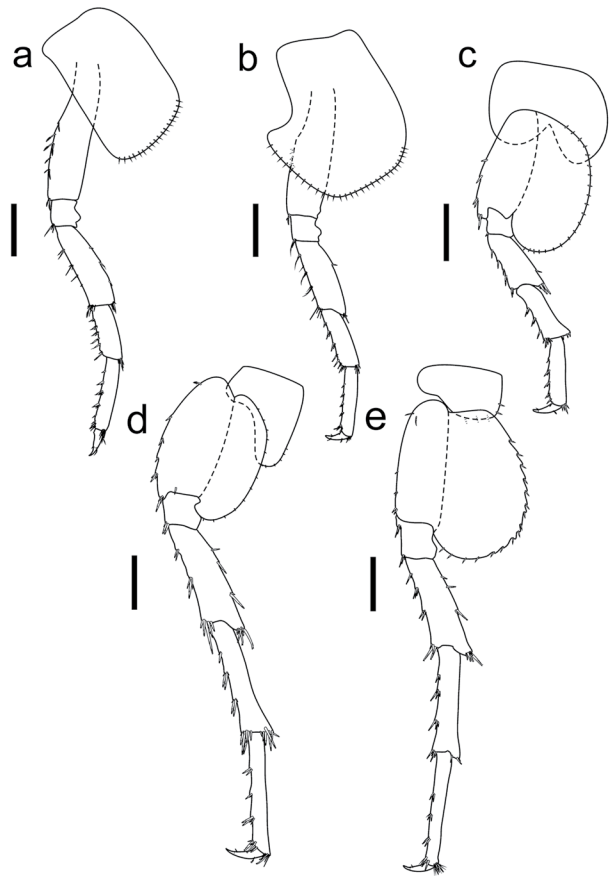

Figure 11. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Paratype, male, 7.96 mm. Pereopod 3 (a). Pereopod 4 (b). Pereopod 5 (c). Pereopod 6 (d). Pereopod 7 (e). Scale bars = 500 µm.

margin and five cuspidate setae apically, male with a curved seta; outer ramus 5.5x longer than wide, with four cuspidate setae on the margin, four cuspidate setae apically.

Uropod 2 (Figure 12c) 1.9x longer than uropod 3, peduncle subequal to rami, with three or four cuspidate setae with accessory seta; inner ramus 1.2x longer than outer ramus, 4.3x longer than wide, outer ramus 4.1x longer than wide, with four cuspidate setae with accessory seta on the margin, four cuspidate setae with accessory seta apically, one of them much smaller than the others.

Uropod 3 (Figure 12d) 0.7x shorter than peduncle of uropod 1 and slightly longer than peduncle of uropod 2; peduncle globose, 1.5x longer than wide, without or with up to three basal simple setae, six distal cuspidate setae with accessory seta; inner ramus absent; outer ramus uniarticulate; ramus 1.3x longer than peduncle, 4.4x longer than wide, with four cuspidate setae.

Telson (Figure 12e) entire, slightly (1.1x) longer than wide, apically rounded, with four apical cuspidate setae with accessory seta, simetrically, without setae laterally. Variations: three to five apical cuspidate setae with accessory seta.

Coxal gills sac-like and tubular sternal gills present on pereonites 2 to 7.

Female (Figure 8b)**.** Mean body length: 6.24 ± 1.12 mm (N = 10), minimum body length = 5.98 mm, maximum body length = 7.86 mm; mean head length: 0.80 ± 0.17 mm (N = 10), minimum head length = 0.74 mm, maximum head length = 0.88 mm. Gnathopod 1 (Figure 13a1, a2) similar to male gnathopod 1; carpus 1.5x longer than wide, with comb-scales; posterior lobe produced and forming a scoop-like structure, with pectinate margin, with several pappose setae; propodus 1.6x longer than wide, hammer-shaped, with comb-scales, palm shorter than posterior margin of propodus, inner margin with few simple setae, palm slope transverse, dactylus claw-like. Gnathopod 2 (Figure 13b1, b2) similar in shape and size to gnathopod 1; propodus 1.9x longer than wide, with comb-scales, inner margin with few simple setae, palm slope transverse with few simple setae. Telson (Figure 13c) 1.2x longer than wide, similar in shape to male, with two to four cuspidate setae with accessory seta.

Taxonomical remarks. Among all species that are described for Brazil, *Hyalella rioantensis* n. sp. differs from *H. pleoacuta*, *H. kaingang* and *H. pseudoazteca* by the absence of flanges. The new species differs from *H. bonariensis*, *H. gauchensis* and *H. georginae* by epimeral plates accuminated. The absence of plumose setae in maxilla 2 distinguishes *H. rioantensis* n. sp. from *H. Catarinensis* n. sp., *H. curvispina*, *H.*

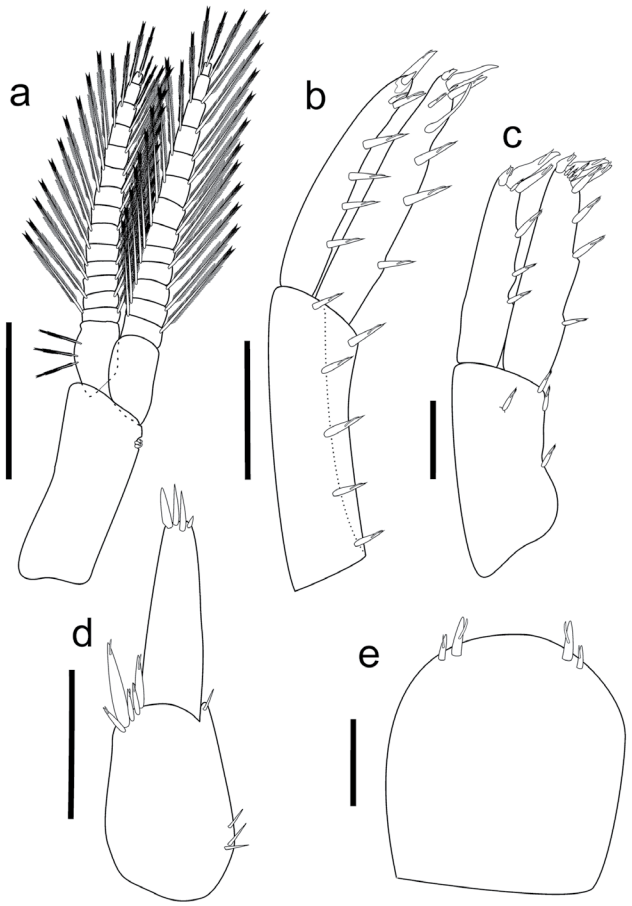

Figure 12. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Paratype, male, 7.96 mm. Pleopod (a). Uropod 1 (b). Uropod 2 (c). Uropod 3 (d). Telson (e). Scale bars: a = 500 µm; b = 400 µm; c and d = 200 µm; e = 125µm.

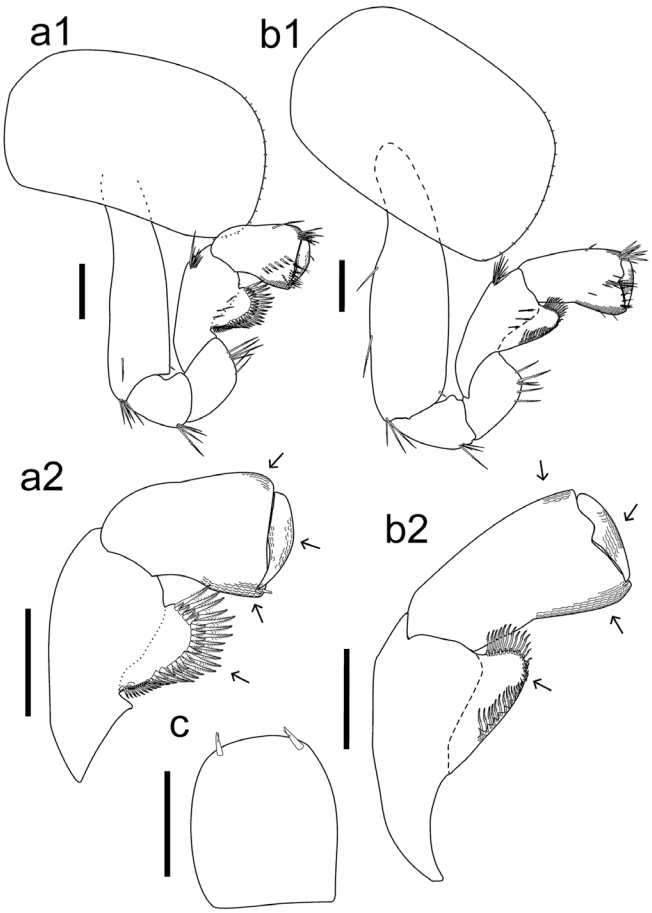

Figure 13. *Hyalella rioantensis* n. sp., municipality of Rio das Antas, Santa Catarina State, Brazil (26°57'1.9" S 51°6'47.5" W). Paratype, female, 6.77 mm. Gnathopod 1 (a1). Detail of the carpus, propodus and dactylus (a2). Gnathopod 2 (b1). Detail of the carpus, propodus and dactylus (b2). Telson (c). Scale bars = 200 µm.

montenegrinae, *H. pampeana* and *H. brasiliensis*. Additionally, *H. rioantensis* n. sp. also differs from *H. montenegrinae*, *H. castroi* and *H. pleoacuta* by the absence of plumose setae in the maxilliped. The two new species presented in this work also differ in the distal nail of the maxilliped, which is absent in *H. rioantensis* n. sp., and it is different from *H. castroi*, *H. curvispina*, *H. kaingang*, *H. misionensis*, *H. pleoacuta*, *H. pseudoazteca* and *H. palmeirensis*'s maxilliped. The palm equal in size to the posterior margin of propodus in gnathopod 2 discerns *H. rioantensis* n. sp. from *H. georginae*, *H. gauchensis*, *H. pleoacuta*. It is possible to differentiate *H. rioantensis* n. sp. from *H. pampeana*, *H. montenegrinae*, *H. bonariensis*, *H. kaingang*, *H. georginae*, *H. gauchensis* and *H. palmeirensis* by the absence of lateral setae on telson. The characteristic that distinguishes *H. rioantensis* n. sp. from *H. pseudoazteca* and *H. misionensis* is the presence of curved setae on inner ramus of male uropod 1. All similarities and differences between *H. rioantensis* n. sp. and others species can be checked on Table 1.

Etymology. The species epithet "*rioantensis*" is in reference to the municipality of Rio das Antas.

Habitat and Ecological Conservation. Epigean. Lake in private property, with preserved native vegetation; without pollution or apparent contamination.

Discussion

The genus *Hyalella* is exclusive to American freshwater systems and has a great geographic distribution within the continent. The greatest diversity of the genus so far can be found in colder waters (Rodrigues et al. 2014), such as the Titicaca lake (González & Watling 2003; Adamowicz et al. 2018), temperate lakes along northern United States (March 1978), and even the South region of Brazil. Moreover, Santa Catarina state comprises 18 main subwatersheds, seven of them belonging to the Parana-Uruguay basin (Santa Catarina 2016), the one that occurs both *H. catarinensis* n. sp. and *H. rioantensis* n. sp. Considering this, we can assume that the lack of species recorded for the state of Santa Catarina is mainly due to insufficient research and / or collection, and not due to the scarce diversity of amphipods for the state.

Among all the characteristics that *Hyalella catarinensis* n. sp.. shares with *Hyalella rioantensis* n. sp. as highlighted are the absence of flanges; coxa 1 similar to 2 and 3; left mandible with lacinia mobilis with four teeth, a row of five papposerrate setae; right mandible with four papposerrate setae; maxilla 1 with inner plate smaller than outer plate, with two papposerrate setae; inner plate of maxilla 2 with

papposerrate setae, outer plate with simple setae, plates covered with setules; maxilliped inner plate longer than wide, without comb scales, outer plate with setae, article 1 of palp longer than wide, outer margin with a one seta, article 3 of palp longer than wide, inner and outer margin with the simple and pappose setae; gnathopod 1 coxal plate wider than long, with simple setae on the margin, carpus longer than wide, palm of the propodus with many simple setae, distal posterior margin with cuspidate and accessory setae, dactylus with comb-scales; coxal plate in gnathopod 2 1.8x longer than wide, with simple setae on margin, merus with simple setae, propodus 1.3x longer than wide, with dorsal plumose seta, without comb-scales; inner ramus of uropod 1 with curved setae; telson with apex rounded and without lateral arrows.

The main characteristics that differentiate *Hyalella catarinensis* n. sp. from *H. rioantensis* n. sp. are eyes oval and lateral pappose setae in article 4 of antenna 2, present only in *H. catarinensis* n. sp.; pappose setae on the inner plate of the maxilla 2, present only in *H. catarinensis* n. sp.; pappose setae on the outer plate of maxilla 2, present only in *H. rioantensis* n. sp.; distal nail absent in *H. rioantensis* n. sp.; absence of comb scales on maxilliped in *H. catarinensis* n. sp.; presence of comb scales on merus and carpus, dactylus with plumose setae on gnathopod 1 in *H. rioantensis* n. sp.; presence of comb scales on carpus of gnathopod 2 in *H. catarinensis* n. sp. and on palm of propodus in *H. rioantensis* n. sp.; both species differ in number of setae and ramus/peduncle ratio in uropod 1 and uropod 2; telson with three apical setae and accessory seta in *H. catarinensis* n. sp., with only three apical without accessory setae in *H. rioantensis* n. sp..

In this manuscript we update the taxonomic knowledge for the genus and expand its known area of occurrence. In this sense, the diversity of *Hyalella* increases to 16 species only in the southern region of Brazil. We expect that this work will contribute to future taxonomic research, besides contributing to the conservation of freshwater habitats, essential for the occurrence of these species and many other species.

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Author's contribuition

Giovanna O Reis: Substantial contribution in the concept and design of the study; contribution to data collection, analysis and interpretation; contribution to manuscript preparation, critical revision and adding intellectual content.

Ludmila R. Penoni: Substantial contribution in the concept and design of the study; contribution to data collection, analysis and interpretation; contribution to manuscript preparation, critical revision and adding intellectual content.

Alessandra A.P. Bueno: Contribution to manuscript preparation, critical revision and adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Point-of-view

After 10 years the myth of *Crotalaria* spp. and dragonflies remains alive

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Brito, J.S. Louback-Franco, N. Mendoza, C.C. Nonato, F.A.S. Juen, L. Michelan, T.S. **After 10 years the myth of *Crotalaria* spp. and dragonflies remains alive**. Biota Neotropica. 20(2): e20190907. https://doi.org/10.1590/1676-0611-BN-2019-0907

Abstract: The struggle to control insect-borne diseases can lead to make rash decisions. For instance, the controversial method of planting of *Crotalaria* spp. to attract predatory dragonflies can be used to control insect vectors of dengue fever and several other medically significant insect-borne diseases. Nevertheless, there is no scientific support for this assumption. Despite the lack of evidence, in Brazil, there remains a multitude of online articles and grey literature sources still promote *Crotalaria* planting as a means to prevent dengue fever. Here we discuss the reasons why Odonata would not be attracted by *Crotalaria* and, therefore, it cannot not be considered as an efficient method for vector control. Finally, the best practice to avoid the spread of insect-borne diseases in the tropics is to avoid the accumulation of standing water in urban areas.
Keywords: *Mosquitoes, tropical diseases, zika, invasive species.*

Após 10 anos, o mito de *Crotalaria* spp. e libélulas permanece vivo

Resumo: A luta contra doenças pode levar as pessoas a tomar decisões precipitadas. Um método controverso que estamos discutindo é o da *Crotalaria* atraindo libélulas, porém nenhuma pesquisa científica apoia essa premissa. As libélulas são predadoras generalistas e, eventualmente, são empregadas de uma maneira incorreta como predadoras de mosquitos vetores. No Brasil, depois de dez anos, ainda encontramos pessoas que estão plantando *Crotalaria* com a tentativa de evitar a propagação da dengue. Discutimos as razões pelas quais os Odonata não seriam atraídos pela *Crotalaria* e, portanto, não poderiam ser utilizados como método eficiente de controle de vetores. Por fim, não deixar a água parada é a maneira mais eficaz de evitar doenças tropicais.
Palavras-chave: *Mosquitos, doenças tropicais, zika, espécies invasoras.*

A background on Odonata

The order Odonata (Insecta) (Figure 1), known as the dragonflies and damselflies, is one of the oldest insect groups on the planet (Mitterboeck & Adamowicz 2013). These insects are very common around the water bodies (e. g. waterfalls, ponds, streams, rivers, and lakes) and play important functional roles in these environments, as both predators of small arthropods, amphibians and fish, and prey items for larger vertebrate predators (Miguel et al. 2017). Dragonflies attract public attention because of their striking range of coloration and body size, and ease in which they are observed in nature, making them a flagship species for aquatic environments (Marco & Viana 2005, Miguel et al. 2017). Additionally, they have importance as bioindicators, due to their environmental sensitivity (Clausnitzer et al. 2009, Oliveira-Junior et al. 2015, Carvalho et al. 2018, Oliveira Júnior & Juen 2019).

Figure 1. Illustration of a damselfly from the genera *Argia* spp. (Zygoptera) and one individual of *Crotalaria* genera (*Crotalaria junceae*) (Image: Ricardo Ribeiro da Silva).

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The life cycle of Odonata comprises two stages, which have different ecophysiological requirements: the larval stage, which is strictly aquatic (mainly dependent on water conditions) and comparatively long in duration; and the adult stage, during which winged adults, that have a short lifetime, keep a close relationship with the vegetation surrounding aquatic environments (Stoks & Córdoba-Aguillar 2011, Mendes et al. 2017). Both life stages are voracious generalist predators, consuming a great variety of prey items, including small organisms such as other arthropods, tadpoles, and fishes (Corbet 1999). Nevertheless, larvae and adults do not occupy the same ecological niche, and thus, they do not use the same resources. Therefore, different strategies exist between life stages of Odonata in the methods deployed to search for and capture prey.

Over evolutionary history, larvae have developed strategies to increase predation success, such as the use of camouflage. Adults, on the other hand, feed on flying insects they can catch during flight but is some situation they can prey other types of organisms (Fincke 1984). Accordingly, vision plays an important role in the predation success of dragonflies. In fact, odonates have one of the most advanced visual systems in the animal kingdom, and it is known that most dragonflies can see ultraviolet light, and because of this they are able to see across four spectral sensitivities (Harris et al. 2011). Moreover, their highly developed visual system plays an important role in other aspects of dragonfly behavior, such as finding mates, oviposition site selection, and the avoidance of predators (Corbet 1999, Harris et al. 2011). Due to their complex vision, they are excellent predators, for example, some species of the genera *Mecistogaster* can remove insects trapped in spider webs (Fincke 1984). Some dragonfly species also appear to use olfactory systems (e.g. *Libellula* species) to detect prey species, but most taxa cannot detect smells or be attracted to aromatic substances (Suhling et al. 2014). There is a great amount of evidence that indicates dragonflies and damselflies could use the olfactory cues to detect preys too (Suhling et al. 2014; Piersanti et al. 2014).

Control of disease vectors

Based on their predatory success, in fields like medicine and agriculture, some insects are used to control other insects populations, which are considered in some situations as pests in some cases (Nam et al. 2000, Yaser et al. 2010), and even to control the spreading of non-native plant species (Room et al. 1981, Sheppard et al. 2003). In medicine, some studies use biological agents to control human diseases (Acquah-Lamptey & Brandl 2018), and in ecology, these agents are often used to control populations of 'problematic' species (e.g. crop pests or invasive species). In fact, dragonfly larvae have shown a great capacity and efficiency as biological control agents of mosquito larvae (Fincke et al. 1997, Andrade 2011, Quiroz- Martínez & Rodríguez-Castro 2007, Roberts 2012, Venkatesh & Tyagi 2015). Among global regions, tropical areas stand out due to the high number of medically significant insect-borne diseases, for example, dengue, malaria, chikungunya and zika virus, which are all transmitted by culicid mosquito. Most government actions include the use of chemical controls (e.g. insecticides) to eliminate vectors; other actions encompass the elimination of breeding habitats (WHO 2019). For both dengue virus and malaria, the adult females of the vector species require clean water to lay their eggs, a necessary condition for larval until they reach the adult stage (WHO 2019).

The *Crotalaria* fallacy

In Brazil, problems with neglected tropical diseases, together with zika virus, are very common and remain key public health concerns among both policymakers and medical authorities (Ministério da Saúde do Brasil 2019). The main challenge for authorities is to make the importance of avoiding the creation of suitable habitats for vectors clear (Ministério da Saúde do Brasil 2019, WHO 2019). One controversial act promoted by some communities and local policymakers are to use the *Crotalaria* spp. (a genus of *Leguminosae* family) (Figure 1) to attract natural predators of the vectors, such as dragonflies (Kuster 2010, Matos & Vaz 2017). The main goal is to reduce vector populations, and thus the number of people infected by insect-borne diseases. According to proponents of this method, the presence of *Crotalaria* spp. attracts adult dragonflies; thereafter the females would lay their eggs in the water, near to these plants; and the larvae predate the mosquito larvae, thus reducing adult emergence of the vector.

However, there is no scientific evidence that *Crotalaria* spp. attracts dragonflies, when the former is present in the environment (Wutke et al. 2015). We found just the article from Murugan et al. (2015) that conducted an experiment using nanoparticles obtained from *Crotalaria verrucosa* L (Linnaeus, 1753). The aim of the study was to evaluate if the presence *Crotalaria*'s compounds could enhance the predation rates of dragonflies on mosquitoes from Culicidae. The results indicated that after nanoparticles compounds were used, predation rates of dragonfly larvae on culicidians increased (Murugan et al. 2015). Although that study was rigorously conducted, following all steps established by the scientific method (different from the movements occurring in Brazil) and the authors highlighted that additional studies are necessary for more conclusions.

Most species of *Crotalaria* spp. are perennial shrubs native to the Neotropical region and are considered exotic in several countries where they have been introduced (Polhill 1982, Vieira and Pessoa 2001). Therefore, the use of these plants to control vector populations, without any solid evidence of their effectiveness as a means to promote vector control, can cause unnecessary ecological damage to the environment, and also for agriculture and livestock (Keane and Crawley 2002, Pyšek & Richardson 2010, Andrade 2011). According to our research, this myth began around 2010 and, unfortunately, has been perpetuated so far. More worrying is that the seeds have been distributed in the state of Pará, in the Amazon, so it is strong evidence that *Crotalaria* spp. it has a high potential risk of invading protected areas in Brazil, such as the Amazon rainforest (Fonseca et al. 2006), as well as dispersing in some areas of the Cerrado biome (Fernandes et al. 2015).

In spite of the reasons presented by government representatives supporting the use of *Crotalaria*, there is no evidence of any strong ecological relationship between dragonflies and *Crotalaria* species. It means that some officials may think they are helping the local population but in fact, they are spending public money on something that will not solve the dengue problem. As previously discussed, dragonflies have highly developed visual systems, and any shiny surface gets their attention, mostly because of their behaviors, including foraging and reproductive ones, occurring on or surroundings of aquatic environments (Corbet 1999, Stevani et al. 2000). These places (e.g. ponds, rivers, streams) have shiny surfaces, which do reflect the sunlight, for this way the dragonflies are attracted by them.

Additionally, the attractiveness of the dragonflies to shiny surfaces is so strong that several studies (Stevani et al. 2000, Wildermuth & Horvéth 2005, Kriska et al. 2006) already found female dragonflies laying their eggs on car bonnets, and the reason being is that the metallic surfaces reflect sunlight in a similar way to aquatic surfaces.

Additionally, there is another way to explain this possible relationship without considering a causal link: the dragonflies are territorial individuals, where the male need physical habitat structures, such as branches and foliage, to defend oviposition resources and to catch prey (Corbet 1999, Remsburg & Turner 2009). If some water body has an individual of *Crotalaria* nearby, a type of biotic component that will provide these kinds of physical structures, then male dragonflies will use it as a perch. In other words, dragonflies may use any suitable plant (*Crotalaria* or other species) close to the water as a perch, hence, there is no reasonable argument to promote this specific plant species.

Concluding remarks

One of the greatest possibilities to explain why some people think that these plants would attract the dragonflies might be an anecdotal experience: Unwittingly, someone might have been seen a dragonfly perching on a *Crotalaria* plant and thought that there was some strong ecological factor underpinning this interaction.

However, no one has subsequently performed a study to test if this fact really happens in nature using the scientific method. Web searches of academic and non-academic databases showed very little published information about this, with much of the material being found in the grey literature, such as government reports, religious folders, videos, conferences, symposium proceedings, opinions in blogs and other nonpeer- reviewed sources (Figure 2) (see also Supplementary Material 1).

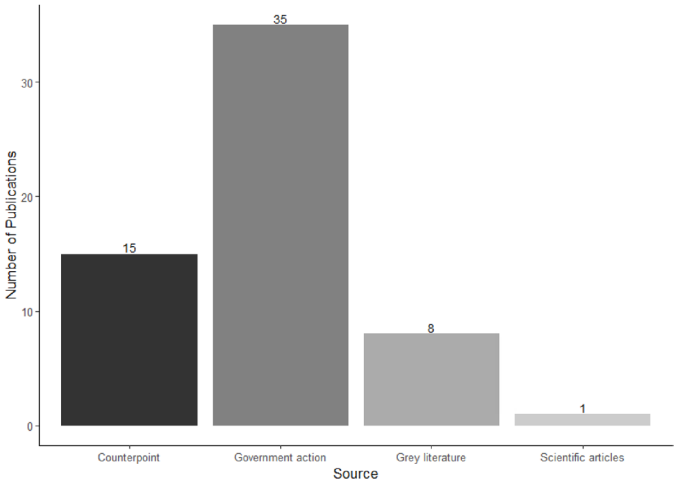

Figure 2. Histogram with the types of material found on the internet about the relationship between *Crotalaria* and dragonflies and damselflies; Counterpoint: considers any information that did not support the *Crotalaria* use, from symposiums or blogs; Government actions: encompass actions taken by local policymakers from their official media; Grey literature: considers material from symposiums, meetings, or information of blogs; Scientific articles: consider studies about dragonflies, *Crotalaria* and insect-borne diseases following the scientific method.

Therefore, there is no clear scientific evidence on the use of *Crotalaria* spp. to control for insect-borne diseases. This is a dangerous way to use a biological control agent because other scientific studies (i.e. surveys that used some organisms to eliminate pests) were carefully performed before introducing an organism, especially an exotic species like *Crotalaria* spp. Additionally, these misuse of biological control in a great number of Brazilian municipalities became widespread, occurring in all regions (Figure 3), indicating at least a non-use of scientific guidelines (Supplementary Material 2). Thus, it should be better let clearer for governments and communitarian leaders that, without the use of validated methods through scientific method, it's dangerous to grow a great number of non-native plant species in the cities.

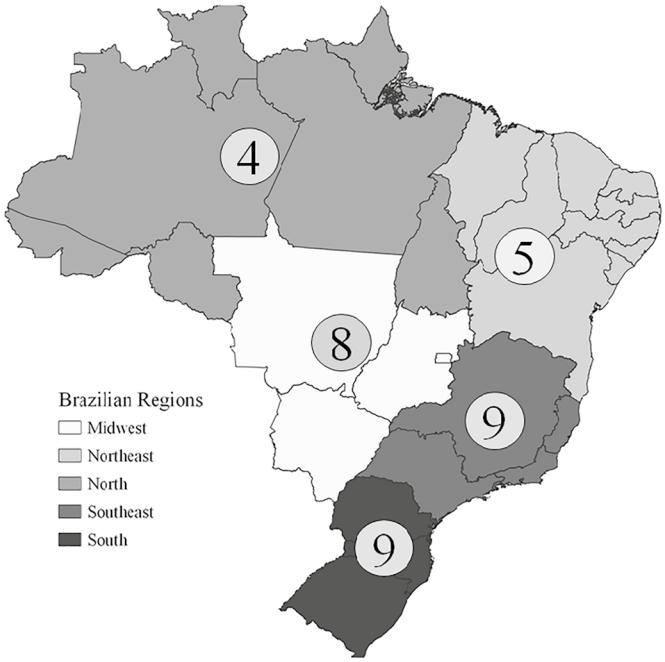

Figure 3. The spread and number of *Crotalaria* used in whole Brazilian regions. The information was taken from official media of local governments, supporting the use of this plant against the insect-borne diseases.

Finally, the main problem is the purposeful spread of *Crotalaria*, with the damage going beyond an ecological disturbance of natural environments or agriculture. The use of *Crotalaria* becomes a profitable market, where people sell the seeds to environmental agencies or even directly to local communities, just to make a quick profit on the lack of scientific clarity on this matter. Thus, as scientists, we need to do more disseminate accurate and reliable information about this subject, in order to convince policymakers, and influential people within society (e.g. religious leaders) to use academic studies such as ours to help solve environmental and public health problems. The best way to eliminate diseases such as dengue, malaria, and zika is to prevent containers with standing water in urban areas, and this information is already freely available in the public domain. With this act, we hope to promote the spread of evidence-based approaches for controlling insect-borne diseases.

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Supplementary material

The following online material is available for this article:
Material 1 - Counterpoint
Material 2 - Electronic Adress Local

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Author contributions

Joás da Silva Brito: Contribution to concept and design of the study, in manuscript preparation; Contribution to critical revision.

Nayara Louback-Franco: Contribution to manuscript preparation; Contribution to critical revision.

Cristian Camilo Mendoza: Contribution to manuscript preparation; Contribution to critical revision.

Flávia Alessandra da Silva Nonato: Contribution to manuscript preparation; Contribution to critical revision.

Leandro Juen: Conceptualization, supervised and designed the study and wrote the manuscript.

Thaísa Sala Michelan: Conceptualization, supervised and designed the study and wrote the manuscript.

All authors edited the manuscript and approved the submitted version.

Conflicts of interest

"The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript".

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Erratum

Erratum: Using distribution models to estimate blooms of phytosanitary cyanobacteria in Brazil

In the article “Using distribution models to estimate blooms of phytosanitary cyanobacteria in Brazil” with the DOI code number https://doi.org/10.1590/1676-0611-bn-2019-0756, published at Biota Neotropica 20(2):e20190756, the "ACKNOWLEDGEMENTS" should be:

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Short Communication

Morphological differences in a population of Rufous-collared Sparrow (*Zonotrichia capensis*, Statius Müller, 1776) (Passerine, Emberizidae) at different elevations in the Tropical Andes

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Abstract: Populations that breed along steep elevation gradients show diverse physiological and morphological changes in response to the different environmental conditions. The latter has been discussed by Bergmann's and Allen's ecogeographic rules about body and appendage sizes and environmental temperature. We compared morphometric measures (mass, bill width, tarsus, wing, and tail length) of a *Zonotrichia capensis* population in two localities at different elevations with similar latitudes and photoperiods on the western slope of the Colombian Central Andes. We compared a Low Elevation locality (LE) at 1800 m a.s.l. and a High Elevation locality (HE) at 3853 m a.s.l. that have approximate wind speeds of 1.3 m/s and 8.4 m/s, respectively. During 12 months of sampling, we captured 46 adults using mist-nets; 26 in the LE and 20 in the HE. Each individual was sexed using molecular techniques at the Laboratory of Genetics of the Department of Biological Sciences of Universidad de Caldas. Individuals (males + females) from the HE had longer wings and tails than those from the LE ($F_{1,44} = 5.93$; $P = 0.019$). Also, wings of males in the HE were longer than those of females in both localities and tails of males in the HE were longer than those of LE males. Our results did not agree with what was expected according to Allen's and Bergmann's ecogeographic rules. Longer wings and tails increase sustainment, maneuverability, and balance in low atmospheric pressures and strong air currents and these conditions are found at high elevation habitats. Most likely, the longer wings found for HE males allow greater movement during territorial behavior. Further, these differences in morphological traits along elevational gradients could result from micro-evolutionary changes between localities or phenotypic plasticity of individuals exposed to different environmental conditions.
Keywords: *wing length, tail length, adaptive traits, paramo, territory, ecogeographic rules*

Diferencias morfologicas en una poblacion de Copetón (*Zonotrichia capensis*, Emberizidae) a diferente altitud en los Andes tropicales.

Resumen: Las poblaciones que se reproducen en gradientes altitudinales, adoptan diversos cambios morfológicos para afrontar las condiciones ambientales. En el presente estudio se compararon las medidas morfológicas (peso corporal, longitud del tarso, ala, cola y culmen) de una población de *Zonotrichia capensis*, a diferente altitud en los Andes colombianos. Las localidades de tierra baja (TB) y alta (TA) se encuentran a 1800 m.s.n.m. y 3853 m.s.n.m., con velocidad aproximada del viento de 1.3 m/s y 8.4 m/s, respectivamente. Durante 12 meses se realizó la captura de 46 individuos (TB n=26, TA n=20) para la medición de los rasgos morfológicos. La longitud del ala de los individuos de TA fue mayor que en TB. Así mismo, en machos de TA la longitud del ala fue mayor que en hembras en general. Es posible que a las más grandes incrementen la eficiencia del vuelo en zonas ventosas y con baja presión atmosférica, como ocurre en TA. Probablemente la diferencia del tamaño del ala entre los machos de TA y las hembras, se deba a un mayor desplazamiento dentro de la conducta territorial. Estas diferencias podrían ser el resultado de cambios microevolutivos entre localidades o la plasticidad fenotípica de individuos expuestos a diferentes condiciones ambientales.
Palabras clave: *Longitud del ala, longitud de cola, rasgos adaptativos, páramo, territorial, reglas ecogeográficas.*

Introduction

Ecogeographic variations in the morphometry of bird populations have been associated with climatic, latitudinal, and elevational factors (Alderich & James 1991, Blackburn & Ruggiero 2001). In particular, two of the most important ecogeographic principles in Bergmann's and Allen's rules relate to thermoregulation (Mayr 1970). Bergmann´s rule suggests that smaller individuals are found in warmer parts of a species' range and larger individuals are located in cooler regions (Bergmann 1847). Further, Allen´s rule suggests that the size of the appendages (e.g., bill, wings, and limbs) are relatively shorter in colder environments (Allen 1877). The usual explanation for these ecogeographic rules concerns the need for organisms to prevent or promote heat dissipation (Blackburn *et al.* 1999). For instance, large animals with smaller extremities expend less energy in thermoregulation because of their smaller surface to volume ratio. This has been a reference framework to explain the morphological differences between bird populations exposed to different environmental conditions (Gutierrez-Pinto *et al.* 2014, Sun *et al.* 2016, Blackburn *et al.* 1999). However, other environmental factors besides temperature have been proposed to contribute to geographic variations in body size, such as humidity, primary productivity, seasonality, and resource availability (Meiri *et al.* 2007, Graves 1991, Guillaumet *et al.* 2008, James 1970). Environmental changes resulting from elevational gradients have been associated with variations in morphological traits between bird populations, as well as between sexes. These such traits include body mass, plumage color, wing length, tail, peak, among others (Landmann & Winding 1995, Bears *et al.* 2008, Blackburn & Ruggiero 2001, Graves 1985, Price 1991). In this regard, morphological differences between sexes have been explained by differences in foraging behavior, territoriality, courtship, and escape (Landmann & Winding 1993, Bears *et al.* 2008, Fisher *et al.* 2004). It is suggested that each sex can respond differently regarding behavior and morphology with altitude (Bears *et al.* 2009, Zammuto & Millar 1985).

Although the greatest bird diversity is concentrated in the Tropics and many of these species have populations distributed along a broad altitudinal range (Rising *et al.* 2010, Ghalambor *et al.* 2014, Tarlow *et al.* 2001), there are few studies in the region that show morphological variations in bird populations in response to elevation (Caro *et al.* 2013, Gutierrez-Pinto *et al.* 2014, Blackburn & Ruggiero 2001, Traylor 1950). This limits the formulation of hypotheses about the contribution of environmental factors in elevational gradients to the evolution of populations at a micro-evolutionary scale. This can be a key approach to understanding the diversification patterns that occurred in the Andes. Especially, in middle elevations where birds are more diverse and it is suggested that speciation rates are higher (Kattan & Franco 2004). Additionally, understanding morphological or phenotypical variation with elevation can provide insight into how animals adapt to their current environment. Finally, studying bird adaptations to elevational gradients may also aid in predicting the outcomes of climate change (Báez et al. 2016).

The Rufous-collared Sparrow (*Zonotrichia capensis* Statius Müller, 1776) (Passerine, Emberizidae) has one of the largest distributions of any Neotropical passerine, from southern Mexico to Cape Horn, Chile. Its extensive distribution spans a multitude of environments and a variety of habitats, such as coastal, paramo, humid forest, and urban areas, from lowlands, at sea level, to highland areas (4600 m a.s.l) (Rising *et al.* 2010, Chapman 1940). This makes the Rufous-collared Sparrow a suitable species to address questions associated with adaptation to contrasting environmental conditions. *Z. capensis* is a socially monogamous species, with a monomorphic plumage and aggressive territorial defense by males during the reproductive season (Rising *et al.* 2010, Miller & Miller 1968, Moore *et al.* 2002). These features, combined with recognized morphologic differences between subspecies and differences in behavior, vocalization, and life-history traits between and within populations throughout the distribution range (Cardona *et al.* 2017, Danner *et al.* 2011, Handford 1985), makes it an ideal study organism. This study identified the morphological changes in a *Z. capensis costaricensis* non-migratory population at different elevations in the Colombian Central Andes. Since morphological traits in birds can vary due to environmental factors related to elevation and considering that *Z. capensis* displays differences in its physiology and life-history traits with elevation, we expected that, according to the ecogeographic rules of Bergman or Allen, individuals that live at higher elevations will have a larger body size and smaller appendages size.

Materials and methods

In the Colombian Central Andes, the Rufous-collared Sparrow is present between 1000 and 3700 m a.s.l. (Hilty *et al.* 2001). The population has three reproductive peaks throughout the year and there is an evident reduction in clutch size with an increase in altitude in the Central Andes (Cardona *et al.* 2017). Pairs stay in the territory year-round and territorial behavior shown by males only during the breeding season, which includes territorial songs, flights towards the intruder, approaching and attacking the intruder, and spending extended periods close to the intruder (Miller & Miller 1968, Moore *et al.* 2002). Additionally, juveniles differ from adults in plumage characteristics (Miller & Miller 1968).

1. Study site

To compare the morphology of *Z. capensis* at different elevations, we selected two localities situated on a continuum without geographical barriers, with similar latitudes and photoperiods on the western slope of the Colombian Central Andes. Both localities are part of the Chinchiná River basin in the department of Caldas. In this study site, it is possible to find individuals of the species throughout the altitudinal gradient between the two localities. The region has a bimodal precipitation pattern, with the greatest amount of rainfall occurring during April-May and October-November, whereas minor rainfall concerning the annual average rainfall takes place in June-September and December-March (Morales *et al.* 2012). The localities differ in elevation by 2000 m and are separated in a straight line by 26 km. The high elevation locality (HE) is located in the *vereda* La Laguna (4°58'49.3"N - 75°20'06.8"W; 3853 m a.s.l.), in the paramo region, with an average annual temperature of 7.1 ºC (min. 4.4 ºC and max. 10.3 ºC), annual rainfall of 1848 mm (Cenicafé & FNC 2016) and average annual wind speed of 4.1 m/s (Cárdenas 2016). The HE locality was covered by a glacier during the Pleistocene approximately 10,000 years ago (Thouret *et al.* 1997). The Low elevation locality (LE) is located in the *vereda* Alto del Naranjo (5°00'29.8"N - 75°33'41.2"W; 1800 m a.s.l.) in the coffee region, with an average annual temperature of 20.7 ºC (min. 16.8 ºC and max. 26.3 ºC), annual rainfall of 2817 mm (Cenicafé & FNC 2016), and approximate average annual wind speed of 1.3m/s (Baldi & Guzm 1998).

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2. *Capture procedures, morphometric measurements, and blood sampling*

For bird capture, we used five mist-nets (12 x 2.5 m x 36 mm) and obtained a total capturing effort of 1120 and 1680 hours net^{-1} for the LE and HE localities, respectively, from December 2015 to December 2016. The captured birds were marked using bands with a unique color combination for later identification and released at the same capturing place. Five morphometric measurements were registered for the adult individuals, including wing chord and tail lengths using an ornithological ruler (± 0.5 mm); bill length from the base, tarsus length using a digital caliper (±0.03 mm), and mass using a scale (±1 g). All measurements were performed by the same investigator. For sex determination of the captured birds, we collected a drop of blood obtained by brachial venipuncture (Quirici *et al*. 2014) and the blood was stored in an FTA classic card (Whatman®).

3. *Molecular sexing*

The sex determination of the individuals was performed by molecular techniques. DNA extraction was performed using the DNeasy Blood and Tissue kit (Qiagen®), following the manufacturer's protocol. Subsequently, we performed PCR amplification of the conserved flanking regions (exons) and non-conserved regions (introns) of the *chd* (chromodomainhelicase-DNA-binding protein) gene, which is present on both sex chromosomes (Z and W) and allows differentiating females (chd-ZW) from males (chd-ZZ). The regions were amplified using primers P2 (5-TCTGCATCGC-TAAATCCTTT-3´) and P8 (5'-CTCCCAAGGATGAGRAAYTG-3') (Griffiths *et al.* 1998). PCR was performed on a Techne TC-PLUS thermocycler, according to the following conditions: initial denaturation at 95°C for 5 min, followed by 5 cycles at 94 °C for 40 s, 55 °C for 40 s, and 72 °C for 55 s; subsequently, 30 cycles at 94°C for 30 s, 48 °C for 30 s, and 72 °C for 45 s, completing the reaction with a final extension cycle at 72 °C for 5 min. The PCR products were visualized on horizontal 3% agarose gels with 1X TBE pH 8.0 running buffer at 70 volts (for 6 hours), stained with SYBR Safe® dye and photo-documented on a GelDoc-It®2 310 Imager (UVP). The birds were identified as females when two bands were present or as males when an exclusive band was observed. The molecular analyses were performed at the Laboratory of Genetics of the Department of Biological Sciences (Faculty of Exact and Natural Sciences) of Universidad de Caldas (Colombia).

The morphometric traits between the localities were compared by two-way analyses of variance (ANOVAs) (Zar 1996), after assessing goodness-of-fit to a normal distribution and homogeneity of variances through Shapiro-Wilk and Levene tests, respectively. The morphometric traits between sexes, as well as between and within localities, were compared using a Tukey *post hoc* test (Zar 1996). Pairwise correlations between the morphometric traits were determined through Pearson's correlation coefficient. These analyses were performed using R version 3.3.1 (R Core Team. 2016).

Results

We captured 46 adults, specifically, 20 and 26 in HE and LE localities, respectively. Molecular sexing showed 14 males for each locality and 6 females (HE) and 12 females (LE). Individuals (males + females) from HE had on average 3.4% longer wings than LE individuals ($F_{1,44} = 5.93$; $P = 0.019$, Figura 1.A). Likewise, tail length was on average 4.3% longer in HE locality than LE locality ($F_{1,41} = 5.79$; $P = 0.02$, Figura 1.B). We found no significant differences between localities for morphometric measures such as bill length ($F_{1,41} = 1.38$; $P = 0.05$), tarsus length ($F_{1,43} = 0.979$; $P = 0.328$), and mass ($F_{1,42} = 1.084$; $P = 0.3$). Similarly, these measures do not show significant differences between sexes ($P > 0.05$). The comparison of the morphometric traits between sexes and between and within localities shows that males from HE had longer wings than females from both localities, on average 6.2% and 7.2% longer compared to HE and LE females, respectively (Tukey HSD, $P = 0.015$; and $P < 0.01$, respectively, Figura 1.C). Likewise, HE males had longer tails than LE males (Tukey HSD, $P = 0.019$, Figura 1.D). Moreover, we did not find a correlation between morphometric traits such as mass and wing length ($r = 0.27$; $P = 0.07$), mass and tail length ($r = 0.30$; $P > 0.05$), or wing and tail length ($r = 0.27$; $P = 0.08$).

Discussion

Our results did not agree with what was expected according to Allen's and Bergmann's ecogeographic rules. Conversely, the length of the appendages, in this case, the wings and tails, was greater in the highland individuals. Differences in flight-related morphologic structures among birds at different elevations have been observed in populations of passerines from temperate regions, including *Junco hyemalis* (Bears *et al.* 2008) and *Passer montanus* (Sun *et al.* 2016). These studies suggest that the longer length in flight structures (wing and tail) at high elevations is associated with low atmospheric pressure and strong wind speed. Longer wings and tails help to increase flight efficiency, maneuverability, as well as balance and lift in conditions of high elevation (Landmann & Winding 1993, Altshuler & Dudley 2006, Maybury & Rayner 2001). Likewise, morphometric differences in wings between males from HE and females from both localities may be due to the territorial behavior of males of *Z. capensis*, similar to other species such as the dark-eyed junco (*J. hyemalis*) in western Canada and the henna-capped foliage-gleaner (*Clibanornis rectirostris*) in southeastern Brazil (Faria *et al.* 2007, Bears *et al.* 2008). Most likely, territorial behavior under windy conditions, such as those found in HE locality, could lead to more efforts in flight displacement to maintain and defend the territory. Thus, longer wings can be beneficial to maneuverability and greater displacement of males under conditions of high elevation (Landmann & Winding 1993, Bears *et al.* 2008, Fisher *et al.* 2004).

Differences in morphological traits between individuals along elevational gradients could reflect the strong selection imposed by local environmental conditions. These morphological differences can result from micro-evolutionary changes during the process of local adaptation of populations or phenotypic plasticity of individuals exposed to different environmental conditions. It is possible that in the Tropical Andes, climatic shifts related to global climate change can alter species local adaptation processes throughout their distribution ranges (Gardner *et al.* 2014, Goodman *et al.* 2012).

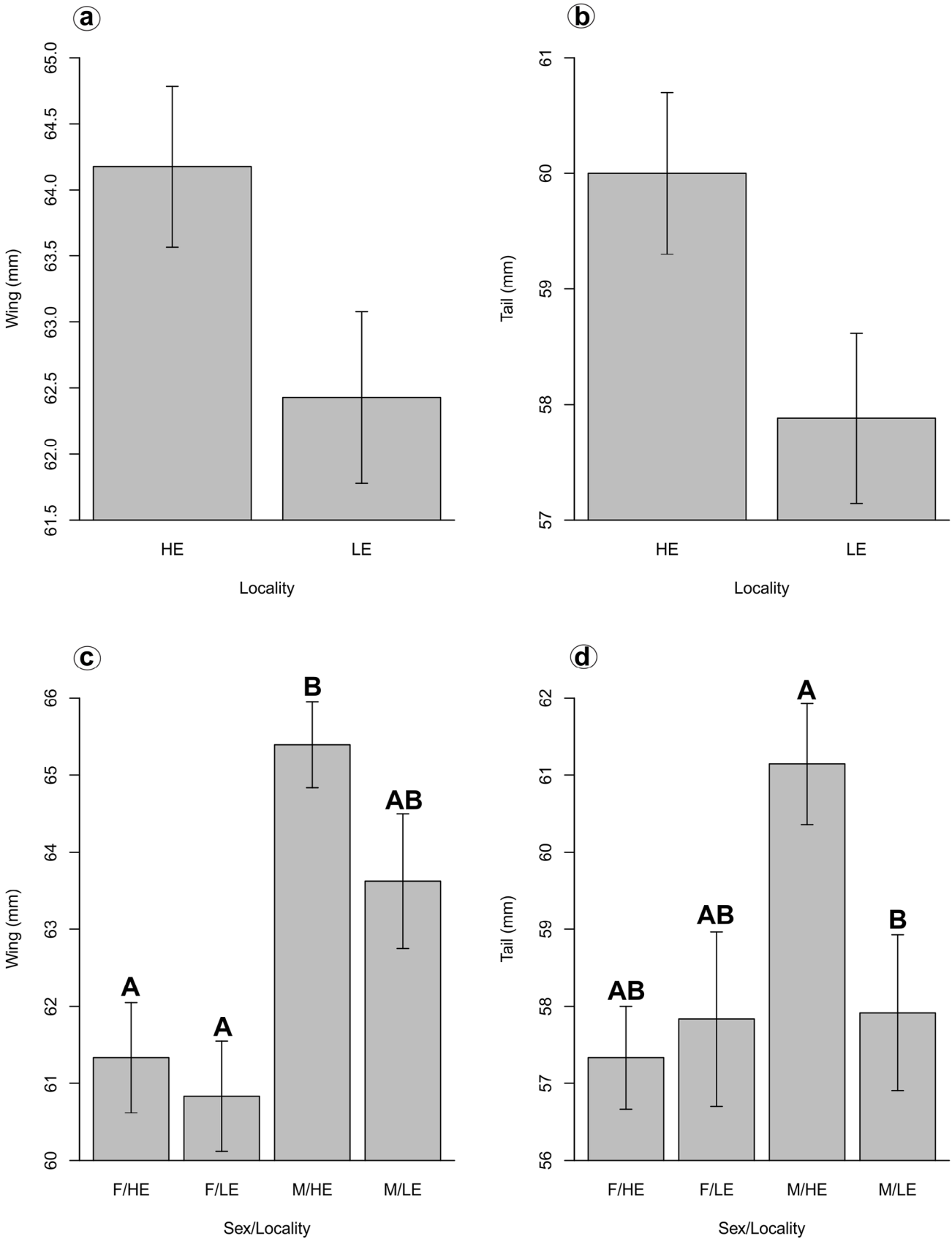

Figure 1. Morphology of *Z. capensis* in the Central Andes, Colombia. Comparison of morphological traits. There were significant differences between localities in **(A)** wing length and **(B)** tail length (male + female). Likewise, there were significant morphological differences between sexes (female: F and, male: M), between and within localities in **(C)** wing length, males from HE had longer wings than females from both localities, and **(D)** in tail length, between HE and LE males. Different letters above the bars indicate significant differences ($P < 0.05$).

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Author contributions

Ana Busi (Corresponding Author) performed a substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation and; contribution to manuscript preparation.

Leydy J. Cardona-Salazar performed a contribution to data collection.

Daniela Gómez Castillo performed a contribution to data collection.

Paula A. Ossa-López performed a contribution to data analysis and interpretation; contribution to manuscript preparation.

Fredy A. Rivera-Páez performed contribution to manuscript preparation; contribution to data analysis and interpretation.

Rodrigo A. Vásquez performed a contribution to critical revision, adding intellectual content.

Gabriel J. Castaño-Villa performed a substantial contribution in the concept and design of the study; contribution to data analysis and interpretation; contribution to manuscript preparation and; contribution to critical revision, adding intellectual content

Conflicts of interest

The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript.

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Article

Protocol for Membracidae inventory (Hemiptera, Auchenorrhyncha, Membracoidea): what are the ideal collection methods for the Atlantic Forest?

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Abstract: Membracidae are phytophagous insects that present different types of behavior, requiring a specific protocol for fast and efficient collection. This article evaluates the best methods for sampling these insects in Atlantic Forest areas. The protocol was applied in four areas of the Atlantic Forest in Paraíba state, Brazil, and involved a team of four people at a cost of US$180 per area. Each area contained 100 sampling units subdivided into 30 yellow sticky cards in the canopy and 30 yellow sticky cards in the lower stratum, 30 active collections and 10 light traps. In total, 2,678 specimens belonging to 91 species were sampled. The highest abundance and richness values were obtained using active collection (N = 1,517; S = 42) and cards in the canopy (N = 345; S = 53). All methods exhibited high complementarity, with more than half of the species (S = 50; 54.35%) recorded exclusively by only one of the methods applied. Similarity analysis revealed that active collection differs significantly from all other methods (R = 0.10, p = 0.0001) and that the sticky cards in the canopy differ from the collection in the lower stratum (p = 0.0001), whereas the other method pairs did not exhibit significant differences. In all areas, the active collection, the sticky cards in the canopy and the lower stratum had the best sample sufficiency, with at least 60% of the estimated values. To inventory Membracidae specimens in areas of the Atlantic Forest, a protocol that combines different collection methods is required, which in principle requires more time and expense. However, it is worth noting that it is possible to adjust this protocol according to the researcher's need. For a faster survey that includes the largest number of species, we suggest a combination of active collection and a light trap.
Keywords: *Biodiversity; Brazil; Estimators; List of species; Sampling standardization; Treehoppers.*

Protocolo para inventário de Membracidae (Hemiptera, Auchenorrhyncha, Membracoidea): quais os métodos de coleta ideais para Floresta Atlântica?

Resumo: Membracídeos são insetos fitófagos que apresentam diferentes tipos de comportamento, o que requer um protocolo específico para uma coleta rápida e eficiente. Este artigo avalia quais os melhores métodos para amostragem desses insetos em áreas de Floresta Atlântica. O protocolo foi aplicado em quatro áreas de Floresta Atlântica na Paraíba e envolveu uma equipe de quatro pessoas, ao custo de U$180 por área. Contém 100 unidades amostrais subdivididas em 30 cartões adesivos amarelos no dossel, e 30 no estrato inferior, 30 coletas ativas e 10 armadilhas luminosas. No total foram amostrados 2.678 espécimes pertencentes a 91 espécies. As maiores abundâncias e valores de riqueza foram obtidos usando a coleta ativa (N = 1.517; S = 42) e os cartões do dossel (N = 345; S = 53). Todos os métodos apresentaram alta complementaridade, com mais da metade das espécies (S = 50; 54,35%) registradas exclusivamente por apenas um dos métodos aplicados. A análise de similaridade mostrou que a coleta ativa difere significativamente de todos os outros métodos (R = 0,10; p = 0,0001), e que os cartões adesivos no dossel diferem da coleta no estrato inferior (p = 0,0001), enquanto os outros pares de métodos não apresentaram diferenças significativas. Em todas as áreas, a coleta ativa, os cartões adesivos no dossel e no estrato inferior, respectivamente, foram os que apresentaram melhor suficiência amostral, com valores de no mínimo 60% do estimado. Foi demonstrado que, para inventariar membracídeos em áreas de Floresta Atlântica, é necessário um protocolo que combine diferentes métodos de coleta, o que à priori, demanda mais tempo e custo. Contudo, vale ressaltar que é possível ajustar este protocolo de acordo com a necessidade do pesquisador. Indicamos que para um levantamento mais rápido e que contemple o maior número de espécies, o ideal é utilizar uma combinação de coleta ativa e armadilha luminosa.
Palavras-chave: *Biodiversidade; Brasil; Estimadores; Lista de espécies; Amostragem padronizada; Soldadinhos.*

Introduction

Extensive quantitative samplings are typically problematic because they require long periods of time, a large number of people and, consequently, significant resources (Cardoso 2009, Magurran 2011). Because increasingly fewer resources have been allocated for these purposes, rapid survey methods or protocols have become more popular (Oliver & Beattie 1996, Duelli 1997, Jones & Eggleton 2000, Muelelwa et al. 2010). In this context, rapid biodiversity assessments (RBA) have been increasingly implemented in inventory and monitoring studies, being used for diverse taxa in different habitats and ecosystems (ants/litter: Alonso & Agosti 2000, Agosti & Alonso 2000; spiders/Mediterranean oak forests: Cardoso et al. 2008; ants: Souza et al. 2012; scarab beetles/Amazon: Braga et al. 2013).

The use of RBA should ensure that the diversity of the taxon sampled reflects its composition in the areas where it is applied (Jones & Eggleton 2000, Gillies et al. 2009). For this purpose, collection protocols are developed or adapted (Borisko et al. 2007, Buss & Borges 2008, Cardoso et al. 2008) using numerous collection methods to sample the largest possible number of representatives of the species that are part of a given assembly.

Well-structured protocols, in addition to facilitating inventory and monitoring studies, ensure the possibility of data sharing in comparative studies based on the use of these protocols (Gotelli & Colwell 2001). In the present study, we present a sampling protocol to inventory Membracidae in the Atlantic Forest. The family currently has about 3,500 described species and 428 genera, classified into nine subfamilies (Deitz & Wallace 2010). In Brazil, there are about 690 described species and 121 genera (Evangelista et al. 2019). Although membracids have a worldwide distribution, eight subfamilies are restricted to the New World.

Membracids exhibit a complex and unique variety of pronotal forms, with projections of various shapes and colors, including mimicry, camouflage, aposematism, and defense against predators (Evangelista et al. 2017). Treehoppers exhibit interaction with more than 100 herbaceous and woody host plant families, and they are considered pests in some due to damage caused by egg insertion into plant tissue (Deitz & Wallace 2010); these insects establish an intricate mutualistic network with ant species, receiving protection from predators and parasitoids while providing honeydew —a sugary product resulting from the metabolism of their carbohydrate-rich diet— to the formicids (Funkhouser 1950, Wood 1993). In many cases, these relationships overlap with a wide spectrum of social regimes, ranging from solitary individuals to gregarious species with offspring defense and maternal care behaviors (Lin et al. 2004, Lin 2006).

In addition, we highlight the fact that membracids were listed as good biological indicators of environmental changes, with broad possibilities of being employed in monitoring studies (Brown 1997). Recently, studies conducted in phytogeographical zones of rainforest (southern Brazil) on ecological networks involving these insects, their attendant ants (mutualistic interactions) and host plants (antagonistic interaction), were developed to better understand the role of these insects in the ecosystems (Gadelha et al. 2016, Gadelha et al. 2017).

The application of this protocol presupposes the following question: what is the best method for collecting Membracidae in the Atlantic Forest? In this context, considering that these insects inhabit different niches, such as the canopy, border and lower stratum of the forest, we aimed to evaluate the efficiency of different collection methods that allow capture of these insects in these locations, and to test the hypothesis that a combination of different methods is necessary to inventory the diversity of Membracidae in areas of the Atlantic Forest.

Material and Methods

1. Study areas

The protocol was applied from May 2015 to April 2016 in four areas of the Atlantic Forest of Paraíba, which are subject to a mean annual temperature of 25°C, 80% relative humidity, approximately 1,700 mm of rainfall and a warm humid tropical climate, type As' in the Köppen classification (Alvares et al. 2013): Area 1 – Refúgio da Vida Silvestre (Wildlife Refuge; RVS) *Mata do Buraquinho* (519.75 ha), located in the urban perimeter of the municipality of João Pessoa (07º08'38"S; 34º51'34"W); Area 2 – Reserva Particular do Patrimônio Natural (Private Natural Heritage Reserve; RPPN) *Engenho Gargaú* (1,058.6 ha), located in the municipality of Santa Rita, (07º01'52"S; 34º57'41"W), approximately 15 km from João Pessoa; Area 3 – Reserva Biológica (Biological Reserve; REBIO) *Guaribas* (SEMA 2 – 3,016.09 ha), located in the municipalities of Mamanguape (06º40'40"S; 41º12'47"W) and Rio Tinto (06º44'59"S; 41º07'11"W), 51 km from João Pessoa; and Area 4 – RPPN *Fazenda Pacatuba* (*Pacatuba* Farm; 266.53 ha) (7º02'33"S; 35º08'14"W), located in the district of Santa Helena, municipality of Sapé, 47 km from João Pessoa.

2. Collection methods

Samples were collected by four people for seven days, the first and last days being used to place and remove sticky cards, respectively. The sampling method was based on sampling units (Magurran 2011, p. 143) because the presence of gregarious species in Membracidae could cause distortions if the sampling was based on the number of individuals.

The samplings used 100 sampling units per area using the following capture methods: 60 double-sided yellow sticky cards (Promip ©) (23 x 11 cm/side), distributed in the canopy (30) and in the lower stratum (30); 10 nocturnal collections, on a white cloth background (2 x 2 m), with mixed mercury light (250W and 220v), fed by a por Table generator, featuring a two-cycle motor with a frequency of 60 Hz and ~ 700W; and 30 active collections (manual process) using capture nets or directly the killing jars.

Each sticky card corresponds to one sampling unit. The sticky cards in the canopy were distributed 50 m from the border, near the trails inside the forest, at least 30 m apart from each other, using a slingshot with metal support, high-speed throwing lines and yellow Durepox© spheres. The sticky cards of the lower stratum were arranged 1.5 m above ground level, beginning 50 m from the border, approximately 20 m apart. The sampling time for these collection methods was five days.

The light trap operated from 6:00 pm to 9:00 pm, with collection points spaced 100 m apart, and each sampling unit corresponded to 90 minutes of collection. In the active collection, each sampling unit corresponded to the inspection of the plants at the border, up to 2 m in height, along 30 m, interspersed by 20 m, for a total transect of 900 m. Once well represented in the active collection (more than 50 specimens), species were no longer captured, and only the abundance was recorded.

3. *Material preparation*

Insects collected with sticky cards were subjected to a glue removal procedure by immersion in Varsol® (24h) and acetone (C_3H_6O) (24h). It is important to note that the collection on sticky cards rarely causes damage that prevents the taxonomic identification or inclusion of specimens in the entomological collections, even because membracids have a hard and well sclerotized cuticle. However, our field experience suggests that as soon as the sticky cards are removed from the plants, specimens should be carefully transferred with forceps to a flask with the glue remover, and the sticky cards with insects still adhered to the glue should never be closed.

After being assembled and dried, the specimens were incorporated into the collection of the Entomological Collection of the Departamento de Sistemática e Ecologia (Department of Systematics and Ecology; DSEC) at the Federal University of Paraíba (UFPB).

4. *Data analysis*

Data on abundance, species richness and composition were analyzed according to area and collection method. Species with at least ten collected individuals were considered restricted to one area or method. The number of species shared and unique to each method was illustrated in a Venn diagram built using the Venny 2.1 program (Oliveros 2015).

The efficiency of each method was measured based on the mean accumulation of species per sampling unit. The relationship between species richness and abundance, per method, was calculated using a simple linear regression. The methods were compared by rarefaction, considering the accumulation of species according to abundance.

To test the similarity between the methods according to species composition, an analysis of similarity (ANOSIM) was carried out using the Bray-Curtis index (9,999 permutations) and Bonferroni sequential correction. The Jaccard similarity index was also calculated to analyze the complementarity between the collection methods used.

Regression, rarefaction, ANOSIM and Jaccard index analyses were performed using the program Past 3.21 (Hammer et al. 2001).

Nonparametric estimators of species richness were applied to each area when the four collection methods were used simultaneously and separately. To verify the sample sufficiency, the observed richness was compared to the mean estimate obtained from the abundance (ACE and Chao1) and species incidence estimators (ICE, Chao2 Jackknife 1 and 2, and Bootstrap). Estimates were obtained using the software EstimateS 9.1.0 (Colwell 2013).

Results

A total of 2,678 specimens belonging to 91 species of 44 genera (Table 1) were collected. The most abundant species was *Bolbonota melaena* (Germar, 1835) (N = 366), which, together with *Harmonides dispar* (Fabricius, 1803) (N = 317), *Enchenopa squamigera* (Linnaeus, 1758) (N = 258) and *Leioscyta spiralis* (Haviland, 1925) (N = 208), corresponded to 42.9% of all specimens collected. Among the four most abundant species, *H. dispar* was the species were collected (N = 26, 8,2%) by active collection, but. It was the most collected species using the light trap method (N = 87; 27.4%), although most of its specimens (64.4%) were recorded in sticky cards in both the canopy (N = 89; 28.1%) and in the lower stratum (N = 115; 36.3%).

The method that collected the greatest abundance was active collection (N = 1,517 or 56.65%), followed by the card in the canopy (N = 542 or 20.24%), light attraction (N = 345 or 12.88%), and card in the lower stratum (N = 274 or 10.23%) methods. The method that recorded the highest number of species was the one that used sticky cards in the canopy (S = 53), followed by the methods of active collection (S = 42), light trap (S = 42) and sticky cards in the lower stratum (S = 22). The accumulation of species revealed that the addition of new species is greater per sampling unit using the light trap (1.05 species added to each sampling unit). The use of sticky cards in the lower stratum was the least productive method and required an average of 5.5 cards for new records of species (0.18 species added per card) (Table 2).

Species richness exhibited a positive and significant relationship with abundance in all methods applied, with greater use of light traps. When comparing the methods by rarefaction (cutoff point of 261 individuals), the most efficient methods were those that used sticky cards in the canopy (S = 42.71 ± 2.31) and collection with light traps (S = 37.14 ± 1.69), with no significant difference between both. Active collection (S = 27.40 ± 2.12) and sticky cards in the lower stratum (S = 21.61 ± 0.60) are the methods with the lowest species richness in rarefaction (Figure 1).

All methods exhibited high complementarity (at least 70%) (Table 3). More than half of the species (S = 50; 54.35%) were recorded exclusively by one of the methods applied (Active – 14 spp.; Canopy – 17 spp.; Lower – 2 spp.; Light – 16 spp.). However, most species were not considered restricted to the method because they had a small number of specimens (eight or fewer individuals). Species that were considered restricted were recorded only in the active collection (S = 9) and with sticky cards in the canopy (S = 2). Of the 91 species recorded, only 20 (21.98%) were shared by at least three of the four collection methods used, and of these, five species had individuals collected in all methods (*Enchenopa gladius* (Fabricius, 1803), *Enchenopa monoceros* (Germar, 1821), *Erechtia* sp. 1, *Harmonides dispar* and *Horiola picta* (Coquebert, 1801)) (Figure 2 and Table 1).

The ANOSIM revealed that there are significant differences in species composition according to the collection method (R = 0.10; p = 0.0001), and active collection differs from all other methods. The collection with sticky cards in the canopy differs from collection in the lower stratum (p = 0.0001) but has a composition similar to that of collection with a light trap (p = 0.98). Additionally, no significant differences in species composition were found between the collection methods with sticky cards in the lower stratum and the use of light traps (p = 0.15).

All areas were sufficiently well sampled when the four methods were used concomitantly (Table 4). By analyzing the methods separately in each area, the active collection and the sticky cards in the canopy and lower stratum were those that exhibited the best sampling sufficiency, with values that were at least 60% of estimated. The light trap, however, exhibited values below 50% of sample sufficiency for most areas (Table 5).

Application of the protocol required the presence of four people/area for seven days, and two days were used to place and remove cards. The 100 sampling units compose the number of samples that optimizes time, sample effort and cost, estimated at US$180 dollars/seven days of collection. This value meets the food requirements, purchase of sticky cards, throwing lines and fuel for the light trap; however, reducing the

Table 1. Membracidae collected in four areas of the Atlantic Forest of Paraíba: EGG, RPPN Engenho Gargaú; FZP, RPPN Fazenda Pacatuba; MTB, RVS Mata do Buraquinho; RBG, Reserva Biológica Guaribas, using the methods of active collection (A), sticky cards in the canopy (B), sticky cards in the lower stratum (C) and a light trap (D). * restricted to active collection; ** restricted to canopy collection.

Species	EGG				FZP				MTB				RBG				Total
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	
Bolbonota melaena (Germar, 1835)	95				153	4			50				58	5	1		366
Harmonides dispar (Fabricius, 1803)		12	13	7	7	27	6	2		17	13	11	19	33	83	67	317
Enchenopa squamigera (Linnaeus, 1758)*	43				7				122				86				258
Leioscyta spiralis (Haviland, 1925)	19		1		14	1			171		2						208
Erechtia gibbosa (De Geer, 1773)	24	4	1		1	5			102	7			4	4			152
Colisicostata scutellaris (Buckton, 1902)					70	18		1	35	26		1					151
Procyrta pectoralis (Fabricius, 1803)		1				6		14		48		3		16	8	53	149
Enchenopa gladius (Fabricius, 1803)		3	24		4		8		1	11	33	10	8		10	34	146
Horiola picta (Coquebert, 1801)		1	1	1		1			4	6	2	1	54	11	16	7	105
Neotynelia martinsi Creão-Duarte & Sakakibara, 2000		7		1				1		4		18		18		18	67
Enchenopa concolor (Fairmaire, 1846)*	3				1				49				4				57
Membracis luizae Evangelista & Sakakibara, 2010*					1				54								55
Cyphonia clavata (Fabricius, 1787)					1				38		1					2	42
Ceresa ustulata Fairmaire, 1846					30												30
Enchenopa gracilis (Germar, 1821)	21				7												28
Pseuderechtia sp.2**														28			28
Erechtia sp.3		18				1	1							5	1		26
Enchenopa monoceros (Germar, 1821)		3		1	1				1					9	8	1	24
Heteronotus mourei Creão-Duarte & Sakakibara, 1992		1			1	1		7	7	7							24
Peltosticta yonkei Sakakibara, 1976**		12								9				3			24
Notocera camelina Sakakibara, 1977			2		5						10		3		3		23
Horiola ferruginea Fairmaire, 1846					21					1							22
Ceresa vitulus (Fabricius, 1775)	2	4			5	1			5	3				1			21
Todea sp.					4	2			1	6				1	5		19
Amastris rotheai Evangelista & Sakakibara, 2007		1						2				1		5		8	17
Tolania furcata-group sp.		3				8		1						4			16
Erechtia sp.1			1		6	4							3			1	15
Cyphonia nordestina Sakakibara, 1968*					14												14
Melusinella nervosa (Fairmaire, 1846)*	13																13
Pseuderechtia sp.1						5	7							1			13
Cymbomorpha olivacea (Fabricius, 1803)					1			2					1			8	12
Notocera cerviceps (Fowler, 1894)		1												9	2		12
Amblyophallus exaltatus (Fabricius, 1803)*	2				9												11
Ceresa atlantica Andrade, 2015*	10				1												11
Havilandia pruinosa (Haviland, 1925)	1	1								6		1	2				11
Stilbophora tripartita (Fairmaire, 1846)					9					1							10
Postanomus cornutulus (Stål, 1862)		1												6		3	10
Amastris elevata (Funkhouser, 1922)	1					4		2								1	8
Talipes appendiculatus (Fonseca, 1936)		7												1			8
Amastris sp.5					5		1	1									7
Darnis olivacea Fabricius, 1803		1								6							7
Enchophyllum ensatum (Coquebert, 1801)									7								7
Germariana terminalis (Walker, 1858)		4				3											7

Continue...

Continuation...

Heteronotus albospinosus Haviland, 1925				1	3		1		1				1			7
Lycoderides capixaba Sakakibara, 2013		3										1	3			7
Enchophyllum nigrocupreum (Walker, 1858)		4				1									1	6
Erechtia sp.2							1				1		2		2	6
Pseuderechtia neivai (Fonseca, 1941)		2	4													6
Tolania peltacauda-group sp.1								2				1			3	6
Anobilia splendida Tode, 1966							1			3		1				5
Enchenopa sp.					2			1		1		1				5
Tropidoscyta torva (Germar, 1835)								1							4	5
Amastris sp.													1		3	4
Euwalkeria sp.															4	4
Sundarion sp.								1					1		2	4
Amastris guttata Fonseca, 1942												1			2	3
Amastris sp.1		1													2	3
Calloconophora sp.	1														2	3
Eumela fornicata (Germar, 1821)								1							2	3
Micrutalis sp.1		2											1			3
Amastris funkhouseri Haviland, 1925	1								1							2
Amastris sp.6													2			2
Amastris sp.7													2			2
Bocydium sp.		2														2
Ceresa sp.				2												2
Cymbomorpha sp.2									2							2
Cymbomorpha vaginata (Germar, 1835)								2								2
Enchenopa auridorsa Sakakibara & Marques, 2007	2															2
Membracis sp.1					2											2
Micrutalis binaria (Fairmaire, 1846)															2	2
Neotynelia pubescens (Fabricius, 1803)				1	1											2
Notogonioides sinopae Sakakibara, 1996								2								2
Potnia diringshofeni Creão-Duarte & Sakakibara, 1997		2														2
Smiliorachis sp.1						2										2
Stictopelta sp.									1	1						2
Tolania peltacauda-group sp.2								2								2
Amastris sp.2								1								1
Amastris sp.4								1								1
Anobilia nigra Tode, 1966													1			1
Cladonota apicalis (Stål, 1869)				1												1
Cymbomorpha sp.1											1					1
Harmonides sp.												1				1
Membracis sp.2								1								1
Membracis tectigera Olivier, 1792					1											1
Micrutalis sp.2															1	1
Micrutalis sp.3					1											1
Micrutalis tripunctata (Fairmaire, 1846)													1			1
Neotynelia nigra (Funkhouser, 1940)		1														1
Neotynelia vertebralis (Fairmaire, 1846)								1								1
Paraceresa brasiliensis Remes Lenicov, 1971				1												1
Smiliorachis sp.2															1	1

Table 2. Sampling efficiency and regression among species abundance and richness of Membracidae for the methods of active collection, sticky cards in the canopy, sticky cards in the lower stratum and a light trap used in four areas of the Atlantic Forest of Paraíba from May 2015 to April 2016. N, sampling units.

Method	Abundance	Richness	N	Efficiency
Active	1517	42	120	0.35±0.38
Canopy	542	53	120	0.44±0.42
Lower	274	22	120	0.18±0.16
Light	345	42	40	1.05±0.66

Table 3. Jaccard similarity index and complementarity (in bold) of four collection methods (active collection, sticky cards in the canopy, sticky cards in the lower stratum, and a light trap) of Membracidae applied in four areas of the Atlantic Forest of Paraíba from May 2015 to April 2016.

	Active	Canopy	Lower	Light
Active		**0.6986**	**0.7451**	**0.7612**
Canopy	0.3014		**0.7500**	**0.7297**
Lower	0.2549	0.2500		**0.8113**
Light	0.2388	0.2703	0.1887	

permanence in the field to five days should not adversely impact the final result of the inventory and will reduce the total cost of the protocol.

Discussion

The combination of the different methods used in the present study for the collection of Membracidae is ideal for the efficient sampling of a given area, which was confirmed by our results and corroborates the proposed hypothesis. However, depending on the goals to be achieved and/or available logistics, some methods may be considered more appropriate and combined in different ways. The active collection, sticky cards in the canopy and light traps are the most indicated methods for collecting a larger number of Membracidae species in the Atlantic Forest. If it is impossible to use a light trap, it is necessary to combine active collection and sticky cards in the canopy and lower stratum, and if it is impossible to combine methods, active collection is the most preferred because of its low cost. However, it should be noted that the efficacy of this method is directly linked to the experience and ability of collectors.

The abundance of specimens collected by the methods used indicates that active collection is the most promising, and this method is very different from the other methods used. Sticky cards and light traps are attractive methods and, as such, have little effect on gregarious species, such as *Bolbonota melaena* and *Enchenopa squamigera*, and subsocial species as *Leioscyta spiralis* and *Erechtia gibbosa* (De Geer, 1773) (for notes on the nomenclature used for behaviors see Lin 2006, tab. 1). Species that exhibit this behavior are reluctant to abandon eggs and nymphs (Tallamy & Wood 1986, Godoy et al. 2006), which greatly facilitates the capture of these insects in active collection. This is the reason why so many individuals from the same species are collected by this method and the reason why these four species contribute to more than one-third of the total abundance.

When the richness is compared according to method used, sticky cards in the canopy is the best method, and this result is also maintained when the collection option is limited to a certain number of individuals per method, as shown by rarefaction. The Membracidae inhabit the parts of plants that are more exposed to light, such as apical branches and inflorescences (Creão-Duarte et al. 2017), and therefore were recognized as sun loving insects (Funkhouser 1950). As the forest canopy is the habitat where this condition is higher, these insects naturally occur in this location in greater diversity, and sticky cards are one of the best methods to access this fauna (Kopp & Yonke 1970, Johnson & Freytag 1997, Wallace & Troyano 2006).

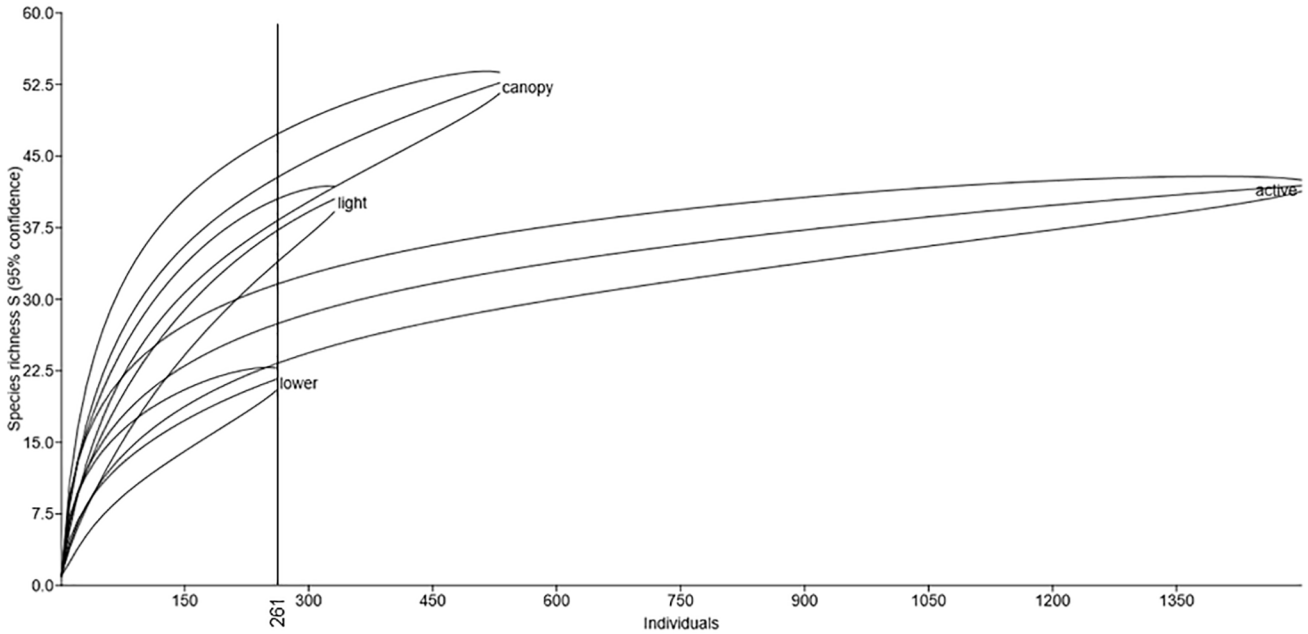

Figure 1. Rarefaction curve (95% confidence interval) among methods of active collection, sticky cards in the canopy, sticky cards in the lower stratum and a light trap for Membracidae in four areas of the Atlantic Forest of Paraíba, collected from May 2015 to April 2016.

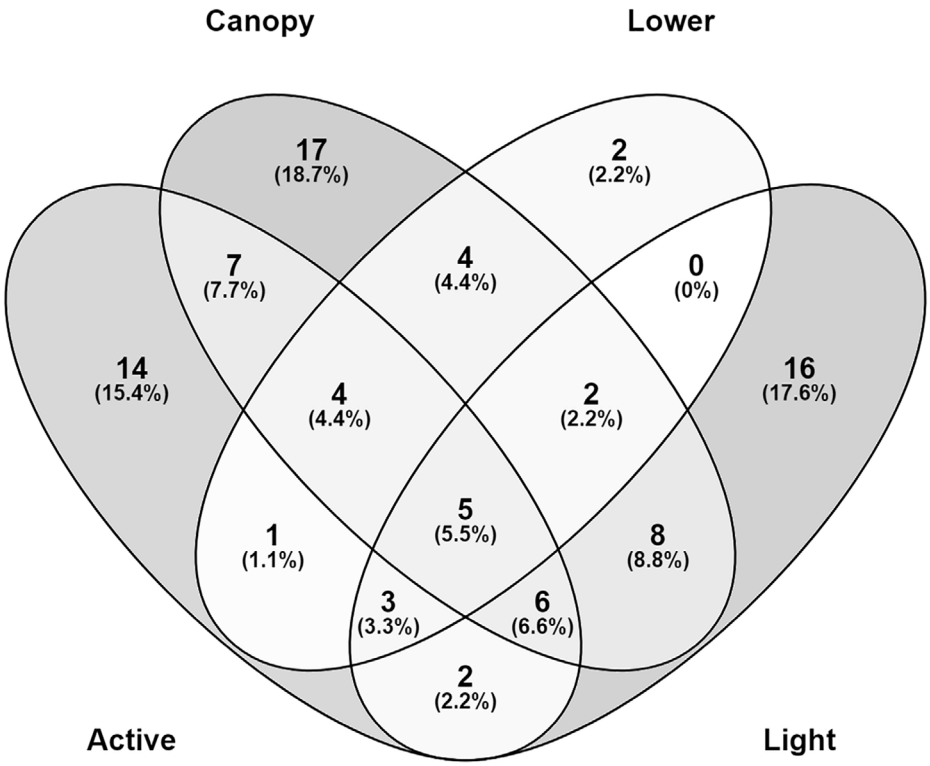

Figure 2. Venn diagram produced from shared and unique species of Membracidae collected in four areas of the Atlantic Forest of Paraíba from May 2015 to April 2016, using methods of active collection, sticky cards in the canopy, sticky cards in the lower stratum and a light trap.

Table 4. Sampling sufficiency of Membracidae collected in four areas of the Atlantic Forest of Paraíba from May 2015 to April 2016, using methods of active collection, sticky cards in the canopy, sticky cards in the lower stratum and a light trap. EGG, RPPN Engenho Gargaú; FZP, RPPN Fazenda Pacatuba; MTB, RVS Mata do Buraquinho; RBG, REBIO Guaribas. N, abundance; S, species richness.

	RBG	MTB	FZP	EGG
N	789	929	563	397
S	48	36	58	41
Singletons	11	11	21	12
Doubletons	9	3	10	7
Uniques	15	13	26	16
Duplicates	11	4	9	10
1. Estimators of abundance				
ACE	56.11	50.36	83.51	53.58
Chao 1	53.49	49.73	77.06	49.23
Mean richness estimate	54.80	50.05	80.29	51.41
Sampling sufficiency (%)	87.59	71.93	72.24	79.76
2. Estimators of incidence				
ICE	62.51	49.95	90.8	61.33
Chao 2	56.66	51.44	90.18	51.8
Jackknife 1	62.85	48.87	83.74	56.84
Jackknife 2	66.88	57.72	100.49	62.82
Bootstrap	55.22	41.29	68.97	48.33
Mean richness estimate	60.82	49.85	86.84	56.22
Sampling sufficiency (%)	78.92	72.22	66.79	72.92

The collection methods exhibited high complementarity, which explains the need for combining different methods. The species recorded in the light trap and sticky cards of the lower stratum exhibited greater complementarity and, consequently, lower fauna similarity. These data suggest the stratification of the treehopper fauna's composition in the studied areas, where species such as *Enchenopa gladius* and *Notocera camelina* Sakakibara, 1977 are most collected on the sticky cards placed in the lower strata, compared to the upper strata (Lourenço 2017). The vertical variation in arthropod fauna from different forest strata of tropical forests (Campos et al. 2006, Grimbacher & Stork 2007) it was also registered for Membracidae by Mason & Loye (1981) and Johnson & Freytag (1997).

Lower complementarity and, consequently, greater fauna similarity occurred among sticky cards placed in the canopy and active collection at the border (Table 3), which are places where habitat conditions (tender parts of plants exposed to the sun) are similar; therefore, a more similar Membracidae fauna is expected (Creão-Duarte et al. 2017). The results of Davis & Sutton (1998), who indicated that invertebrate communities typical of the forest canopy (dorsal border) can move, in whole or in part, from the canopy to areas near the border, contribute to explaining this similarity. Even considering that the border effects resulting from forest fragmentation have marked effects on the floristic and faunal composition of the fragments, especially when the latter are small, some groups of insects may increase at the border (Laurance et al. 2002), including Membracidae, which rely on a large community of attendant ants (Dejean & Giberneau 2000).

As expected, the species composition resulting from active collection differed from that resulting from all other methods due to the very nature of the method, which is subject to the experience and

Table 5. Sampling sufficiency of Membracidae collected in four areas of the Atlantic Forest of Paraíba from May 2015 to April 2016, using methods of active collection, sticky cards in the canopy, sticky cards in the lower stratum and a light trap. Abundance estimators: ACE and Chao 1; Incidence estimators: ICE, Chao 2, Jackknife 1, Jackknife 2 and Bootstrap. EGG, RPPN Engenho Gargaú; FZP, RPPN Fazenda Pacatuba; MTB, RVS Mata do Buraquinho; RBG, REBIO Guaribas. N, abundance; S, species richness.

	N	S	Mean abundance estimate	Sampling sufficiency (abundance)%	Mean incidence estimate	Sampling sufficiency (incidence)%
RBG Active	245	13	13.76	94.48	19.09	68.08
RBG Canopy	173	27	39.93	67.63	39.45	68.45
RBG Lower	137	10	10.88	91.95	12.33	81.10
RBG Light	234	26	29.22	88.98	33.23	78.25
MTB Active	648	16	20.99	76.24	20.84	76.78
MTB Canopy	167	21	26.79	78.40	33.96	61.84
MTB Lower	63	8	21.26	42.34	15.01	59.96
MTB Light	51	13	46.20	25.98	26.78	44.81
FZP Active	386	31	48.42	64.03	46.10	67.25
FZP Canopy	100	22	32.23	68.27	31.34	70.20
FZP Lower	27	8	11.88	67.37	11.99	66.73
FZP Light	50	23	39.42	58.35	48.64	47.29
EGG Active	238	15	19.59	76.57	19.16	78.29
EGG Canopy	102	27	35.86	75.29	42.66	63.30
EGG Lower	47	8	13.32	60.06	12.64	63.29
EGG Light	10	4	9.78	40.90	8.05	49.70

ability of the collectors, whereas the other methods are methods that attract a species. The composition of divergent species such as those inventoried by sticky cards in the canopy and in the lower stratum are due to the differences in fauna that naturally exist in the vertical strata of the rainforest (Charles & Basset 2005, Brehm 2007). Compositions of similar species—such as those inventoried using sticky cards in the canopy and by use of the light trap—result from these methods accessing species that inhabit the same sites, predominantly the canopy.

The lack of a list of species of Membracidae for the areas where the protocol was applied seems to prevent any comparison to estimate the reliability of the diversity sampled. Similar previous situations have determined the need to know stop rules, i.e., indicators that the sampling performed is sufficient (Magurran 2011). The representation of at least two specimens per species collected was the stop rule suggested by Colwell & Coddington (1994); when species accumulation curves reach the asymptote is also recognized as an indication of sample sufficiency, although large-scale collecting efforts do not ensure this (Longino et al. 2002). Coddington et al. (1991) suggest that a sampling intensity of 10:1 (specimens:species) for tropical rainforest conditions would be sufficient for a reliable richness estimate. Sørensen et al. (2002) suggested 30–50:1 for the assemblages of spiders in a montane forest. Cardoso (2009) considers that an inventory can be considered "reasonable" when approximately 50% of the estimated species are sampled, "comprehensive" when 70–80% of the estimated species are sampled and "exhaustive" when it reaches 90% of species.

When we consider our results, by area, regarding these stop rules, we conclude that they are satisfactory and meet the expectations of a protocol. Sampling sufficiency by area may be classified as comprehensive according to Cardoso (2009); we observed that our results exhibit values of specimens/species better than those suggested by Sørensen et al. (2002); and even when we consider the proposal by Coddington et al. (1991), which is more rigorous, we observed that the application of the protocol in two of the four areas are within the rigors of the proposals of these authors.

Considering the sampling sufficiency by method, the lowest values were observed in the light traps in three of the four areas and resulted from a high number of *singletons* and *uniques* in relation to the number of *doubletons* and *duplicates*, which refutes the need for a greater number of samplings using this method; however, expense and logistic difficulties should be weighed against initiatives different from those proposed here.

The combination of collection methods to inventory Membracidae in the Atlantic Forest presented here is the most appropriate. However, for an expeditious survey that includes the largest number of species, ideally, one would use a combination of active collection with a light trap.

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Author contributions

Valberta Alves Cabral: conceptualization and design of the study; field work; material identification and data curation; contribution to manuscript preparation.

Antonio José Creão-Duarte: conceptualization and design of the study; material identification and data curation; original manuscript preparation.

Aline Lourenço: material identification and data curation; field work; contribution to manuscript preparation.

Carolina Nunes Liberal: contribution to manuscript preparation; contribution to critical revision.

Alessandre Pereira-Colavite: field work; contribution to manuscript preparation, review and editing.

Conflicts of interest

The authors declare no conflict of interest.

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Reptiles of the Serra das Torres Natural Monument: using the Rapid Assessment method to fill a knowledge gap in the Atlantic Forest of southeastern Brazil

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Abstract: Data on the composition of local reptile assemblages in several Brazilian ecosystems can still be considered relatively restricted in scope in most cases. In this study, we conducted surveys in the Serra das Torres Natural Monument, located in the municipalities of Atílio Vivacqua, Muqui, and Mimoso do Sul, using the Rapid Assessments method (RAP) during 30 days in the rainy season of 2018. We sampled actively for approximately 1320 hours with a 6–10 person crew, supplemented by 720 hours of passive sampling (30 bucket-days) using pitfall traps with drift fences. We recorded 34 reptile species during our sampling method (2 amphisbaenid, 11 lizards, and 21 snakes) and an occasional encounter, after the end of sampling, that added a chelonian species to the list, *Hydromedusa maximiliani*, totaling 35 reptile species. The Dipsadidae was the family with the greatest snake species richness and, the Gymnophtalmidae had the greatest lizard species richness. The species richness recorded in the Serra das Torres Natural Monument (Ntotal = 35) represents ca. 27% of all reptile species found in the state of Espírito Santo (N = 130). The most abundant lizard species was *Leposoma scincoides* followed by *Ecpleopus gaudichaudii* and, the most abundant snake species was *Bothrops jararaca* being markedly higher than that recorded in similar studies. Twenty-seven percent of the reptile species recorded in our study are endemic to the Atlantic Forest and 30% (N = 10) have been recorded less than five times previously in the Brazilian state of Espírito Santo. Our study reinforces the need for the conservation of the Serra das Torres Natural Monument because of its importance as a reservoir of a considerable portion of the reptile biodiversity of Espírito Santo state, and of the Atlantic Forest biome as a whole.
Keywords: *Amphisbaenia; Brazilian state of Espírito Santo; Community; Herpetofauna; Lizards; Snakes; Squamata.*

Répteis do Monumento Natural Serra das Torres: usando o método de avaliação rápida para preencher uma lacuna de conhecimento na mata atlântica do sudeste do Brasil

Resumo: O conhecimento das assembleias de répteis para muitos ecossistemas no Brasil pode ser considerado ainda relativamente restrito. Neste estudo, nós realizamos amostragens no Monumento Natural Serra das Torres, localizado nos municípios de Atílio Vivacqua, Muqui e Mimoso do Sul, no estado do Espírito Santo, utilizando o método de avaliação rápida (RAP) durante 30 dias na estação chuvosa de 2018. Amostramos cerca de 1320 horas de busca ativa durante os períodos diurno e noturno, com uma equipe de 6 a 10 pessoas, suplementada por 720 horas de amostragem com armadilhas de queda com cercas guia (30 dias-balde). Registramos 34 espécies de répteis squamatas durante as amostragens (2 anfisbenídeo, 11 lagartos e 21 serpentes) e um encontro ocasional posterior que acrescentou uma espécie de quelônio à lista, *Hydromedusa maximiliani*, totalizando 35 espécies de répteis. Dipsadidae foi a família com a maior riqueza de serpentes, e Gymnophtalmidae foi a família com maior riqueza de lagartos.

A riqueza de espécies que registramos no Monumento Natural Serra das Torres (Ntotal = 35) representa ca. 27% de todas as espécies de répteis encontradas no estado do Espírito Santo (N = 130). A espécie de lagarto mais abundante foi *Leposoma scincoides* seguido por *Ecpleopus gaudichaudii*, enquanto a espécie mais abundante de serpente foi a *Bothrops jararaca*, sendo marcadamente maior do aquela registradas em estudos similares. Vinte e sete por cento das espécies de registradas em nosso estudo são endêmicas da Mata Atlântica e trinta por cento das espécies (N = 10) tinham menos de cinco indivíduos registrados anteriormente no estado do Espírito Santo. Nosso estudo reforça a necessidade de conservação do Monumento Natural Serra das Torres devido à sua importância como reservatório de uma considerável parcela da biodiversidade de répteis do estado do Espírito Santo, bem como do bioma Mata Atlântica.

Palavras-chave: *Amphisbaenia; Comunidade; estado do Espírito Santo; Herpetofauna; Lagartos; Serpentes; Squamata.*

Introduction

Data on the composition of local reptile assemblages in Brazilian ecosystems can still be considered relatively restricted in most cases. Although there is a reasonable number of studies on the reptile assemblages of some Brazilian forest remnants, most do not address the community as a whole, but rather, focus on a specific group, such as the snakes (Strüssmann & Sazima, 1993; Argôlo, 2004; Rocha et al. 2008; Pontes & Rocha 2008; Sawaya, 2008; Pontes et al. 2009;), lizards (e.g. Martins, 1991, Oliveira et al. 2019), or provide a compilation of the records available for an area, combining personal data with records obtained in previous studies (e.g. Vitt et al. 2008, Dias & Rocha 2014). However, comprehensive checklists of the reptile assemblage of a given ecosystem, based on a single, consolidated field inventory, are relatively rare, and most have focused on the rainforests of southeastern Brazil (Rocha, 1998; Almeida-Gomes et al., 2008; Vrcibradic et al., 2011; 2014; Rocha et al, 2018), although some important efforts are available for gallery forests in Central Brazil (e.g. Brandão & Araújo, 2001), and for the vast Lençóis Maranhenses region of northeastern Brazil (e.g. Miranda et al. 2012).

Understanding species composition, richness and abundance is a fundamental issue for countless conservation actions (Sutherland et al. 2013) and many ecological and taxonomic questions can be explored from this data set from a given area. Inventories of the reptile assemblages of the ombrophilous forest of Espírito Santo state, in southeastern Brazil, are restricted to a single introductory checklist of the reptiles of the Duas Bocas Biological Reserve (Tonini et al. 2010), in the municipality of Cariacica. Although there is an important set of specimens collected throughout the state, deposited in herpetological collections (e.g. Instituto Nacional da Mata Atlântica) efforts to discover the reptile fauna of the ombrophilous forest in Espírito Santo state remain as occasional collections, without short or long-term studies and either without information about the abundance of species.

The Serra das Torres Natural Monument, situated in southern Espírito Santo state (referred to here as the MONAST: Monumento Natural Serra das Torres) encompasses an array of upland environments characterized by high levels of biodiversity in some groups of fauna and flora (IPEMA 2010), but surprisingly there are no data available on its reptile assemblage. In this study, we inventoried the forests of MONAST through intensive sampling over a three-month period and we present the results here as the first comprehensive reptile checklist for the region of this pristine remnant of forest in the Brazilian state of Espírito Santo.

Material and Methods

1. Study site

The MONAST is located in southern Espírito Santo state, and includes parts of the municipalities of Atílio Vivacqua, Mimoso do Sul, and Muqui, in southeastern Brazil (-21.0209, -41.2378) (Figure 1). The MONAST encompasses the largest complex of forest remnants in southern Espírito Santo, with approximately 10,450 hectares of Atlantic rainforest. This forest remnant includes mountains that reach 1100 m a.s.l. at their highest point (Oliveira et al. 2013) and the vegetation types are composed of semideciduous seasonal forest, submontane dense ombrophilous forest, and dense ombrophilous forest, all at varying levels of conservation (Magnago et al. 2008). The mean annual temperature is approximately 24.5ºC and mean rainfall is around 1290 mm (Oliveira et al. 2013).

2. Surveys of reptiles

We used the Rapid Assessment (RA) method to assess the species richness and abundance of reptiles in the MONAST during January, February, and March 2018. The RA method provides an efficient approach for the collection of reliable and replicable data in a short period of time (Patrick et al. 2014).

The RA method we employed in the present study consisted of intensive sampling over ten consecutive days at each of the three study sites located within the MONAST (a total of 30 field days) with a field team between six and 10 members, at 18 different locations. We conducted time-limited active searches (Crump & Scott Jr. 1994) between 0900 and 1200 hours for the daytime period, and between 1800 and 2200 hours for the crepuscular/nighttime period, with a total of approximately 1320 hours of sampling effort. We conducted the active searches in preserved forest fragments located as far as possible from areas of anthropogenic impact, including areas at altitudes ranging from ca. 600 m to 1100 m a.s.l. To guarantee the best possible estimate of local species richness, we also recorded the reptile species found in the habitats in the vicinity of the MONAST, including human habitations, pasture, and plantations. We did not conduct an active search more than once at the same geographic coordinate.

We also collected reptiles using four systems of pitfall traps with drift fences (Corn 1994) installed in different forest fragments, in particular the best-preserved habitats, and at different altitudes. Each system consisted of 40 buckets (of 20 L), which were arranged in a straight line at each study site.

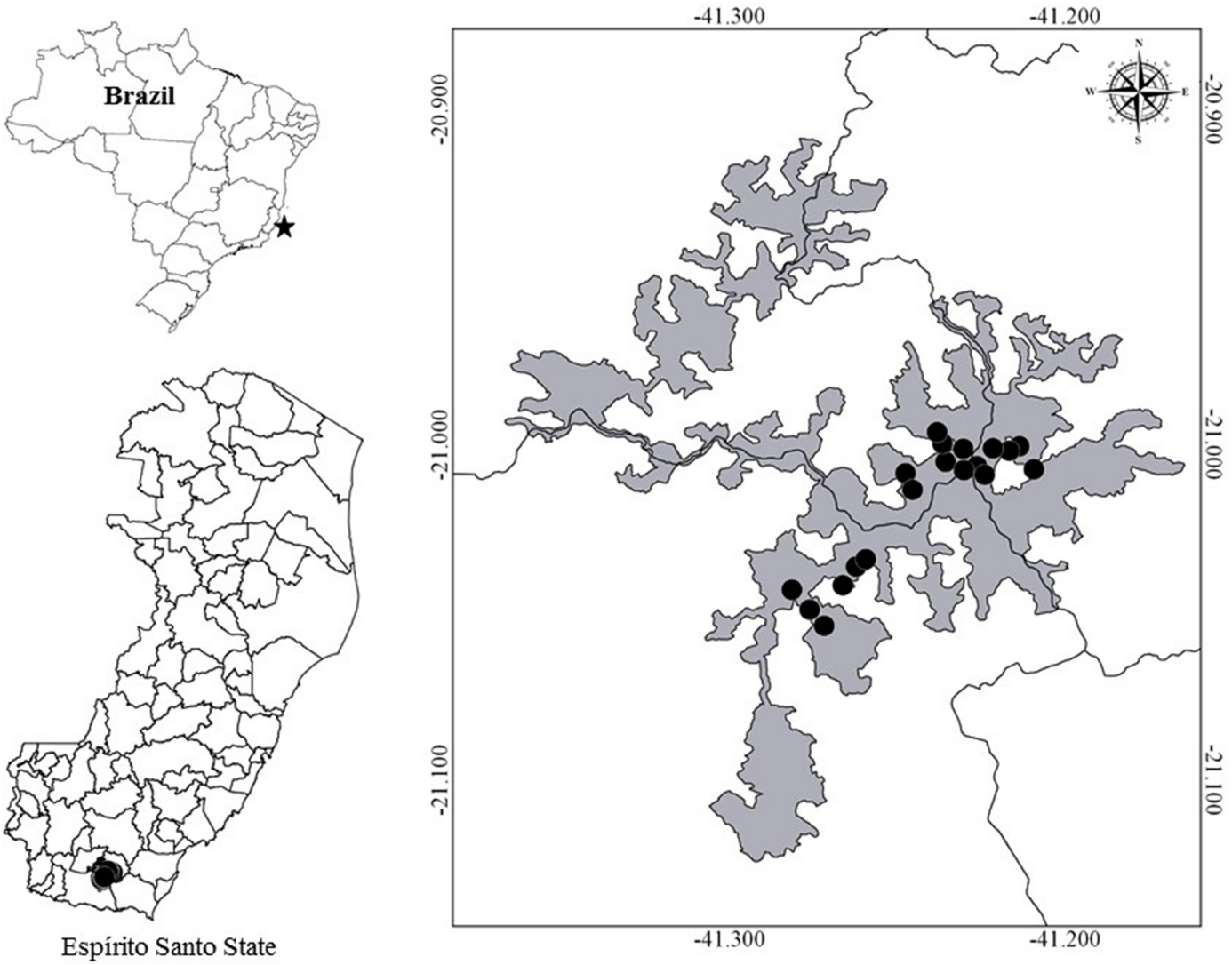

Figure 1. Points sampled in the Serra das Torres Natural Monument in the Brazilian state of Espírito Santo (black dots). The enlarged figure on the right shows the limits of the Natural Monument in relation to the three municipalities (Atílio Vivacqua, Mimoso do Sul, and Muqui) in which it is located.

We installed the traps three days prior to the sampling period at each of the three sites, with all buckets remaining active until the 10th consecutive day of sampling. We removed all the buckets and fences at the end of the sampling period at each site and then moved them to the next sampling area. The overall sampling effort of the pitfall traps was approximately 720 hours. At the end of the survey, we removed all the pitfall systems from the MONAST.

We identified the reptile species using specific references (e.g., Ávila-Pires 1995; Marques et al. 2001; Silva Jr et al. 2016) with confirmation by specialists, whenever necessary. The taxonomic identity of the species known to occur in Espírito Santo was confirmed through consultations at the herpetological collections of the National Atlantic Forest Institute (INMA: Instituto Nacional da Mata Atlântica), in Santa Teresa, Espírito Santo state, and the Museu Nacional (NMRJ) in Rio de Janeiro state, in order to minimize possible errors with regard to species occurrence. We considered these two collections to represent accurately the herpetofauna known to occur in the Brazilian state of Espírito Santo.

We constructed a species accumulation curve based on the cumulative number of species recorded during the RA (S) as a function of sampling effort (n). We estimated species richness by the Bootstrap method, which we considered to be the diversity index best suited to our data (Magurran 2004). We also classified species occurrence as "rare" or "common" based on the number of previous records from Espírito Santo, using the data available in online databases (Species Link 2018). Based on these previous records from Espírito Santo state, we classified species in four classes of occurrence: (i) 1–5 occurrences, (ii) 6–10 occurrences, (iii) 11–20 occurrences, and (iv) more than 20 occurrences. We considered species in the (i) 1-5 occurrences category to be "rare" in the state of Espírito Santo.

The collection of voucher specimens was authorized by Sisbio/RAN Nº 57085-6 and the Espírito Santo for the Environment (IEMA) Nº 033-2017. The vouchers were deposited at the MNRJ, in Rio de Janeiro and INMA, in Espírito Santo state. We did not collect specimens of some easily-recognized species (e.g., *Salvator merianae,* and *Boa constrictor*) due to their large body size, which would require additional resources for specimen collection.

Results

We obtained 257 specimens of 35 reptile species representing 15 families distributed in two orders, Chelonia (N = 1) and Squamata (N = 34) during our inventory of the Serra das Torres Natural Monument (Table 1, Figure 2 and 3). The Squamata species recorded were represented by two amphisbaenids, 11 lizards, and 21 snakes.

Table 1. Reptile species recorded in the Serra das Torres Natural Monument in Espírito Santo, southeastern Brazil, showing the abundance (number of records), sampling method, and endemism in the Brazilian Atlantic Forest. OE: occasional encounter; AS: Active search; PT: pitfall trap; END/AF: Endemic to the Brazilian Atlantic Forest. * = recorded after the end of the sampling method. ** = non-indigenous species.

Species	Abundance	Method	END/AF
TESTUDINES			
Chelidae			
Hydromedusa maximiliani (Mikan, 1820)*	1	OE	x
SQUAMATA: Amphisbaenia			
Amphisbaena alba Linnaeus, 1758	1	OE	—
Leposternon microcephalum Wagler, 1824	1	OE	—
SQUAMATA: Lacertilia			
Diploglossidae			
Ophides fragilis (Spix, 1825)	2	OE/AS	—
Gekkonidae			
Hemidactylus mabouia (Moreau de Jonnès, 1818)**	1	AS	—
Phyllodactylidae			
Gymnodactylus darwinii (Gray, 1845)	16		x
Gymnophthalmidae			
Ecpleopus gaudichaudii Duméril & Bibron, 1839	38	PT	x
Heterodactylus imbricatus Spix, 1825	2	PT	x
Leposoma scincoides Spix, 1825	54	AS/PT	x
Placosoma glabellum (Peters, 1870)	1	PT	x
Leiosauridae			
Enyalius boulengeri Etheridge, 1969	27	AS/PT	—
Mabuyidae			
Brasiliscincus agilis (Raddi, 1823)	11	AS	x
Teiidae			
Salvator merianae Duméril & Bibron, 1839	5	AS	—
Tropiduridae			
Tropidurus torquatus (Wied, 1820)	7	AS	—
SQUAMATAS: Serpentes			
Boidae			
Boa constrictor Linnaeus, 1758	1	AS	—
Colubridae			
Chironius bicarinatus (Wied, 1820)	2	AS	x
Spilotes pullatus pullatus (Linnaeus, 1758)	1	OE	—
Dipsadidae			
Dipsas variegata (Duméril, Bibron & Duméril, 1854)	3	AS	—
Elapomorphus quinquelineatus (Raddi, 1820)	2	AS/PT	—
Erythrolamprus miliaris miliaris (Linnaeus, 1758)	4	OE/AS	—
Erythrolamprus reginae (Wagler in Spix, 1824)	1	PT	—
Imantodes cenchoa (Linnaeus, 1758)	3	AS	—
Leptodeira annulata annulata (Linnaeus, 1758)	3	AS	—
Oxyrhopus clathratus Duméril, Bibron & Duméril, 1854	2	AS	—
Oxyrhopus petolarius digitalis (Reuss, 1834)	2	AS	—
Philodryas patagoniensis (Girard, 1858)	1	OE	—
Dipsas neuwiedi (Ihering, 1911)	2	AS	—
Siphlophis longicaudatus (Andersson, 1901)	1	AS	—
Taeniophallus affinis (Günther, 1858)	5	AS/PT	—
Thamnodynastes nattereri (Mikan, 1828)	2	AS	—
Xenodon neuwiedii Günther, 1863	3	AS	—

Species	Abundance	Method	END/AF
Elapidae			
Micrurus corallinus (Merrem, 1820)	2	AS	x
Micrurus lemniscatus carvalhoi Roze, 1967	1	AS	—
Tropidophiidae			
Tropidophis paucisquamis (Müller in Schenkel, 1901)	2	AS	x
Viperidae			
Bothrops jararaca (Wied, 1824)	47	AS/OE	—

Figure 2. Examples of the reptile species recorded in the Serra das Torres Natural Monument in Espírito Santo state, southeastern Brazil. (A): *Imantodes cenchoa*; (B) *Chironius bicarinatus*; (C) *Oxyrhopus petolarius digitalis*; (D) *Dipsas variegata*; (E) *Tropidophis paucisquamis*; (F) *Taeniophalus affinis*; (G) *Oxyrhopus clathratus*; (H) *Erythrolamprus reginae*.

Figure 3. Examples of the reptile species recorded in the Serra das Torres Natural Monument in Espírito Santo state, southeastern Brazil. (A) *Heterodactylus imbricatus*; (B) *Brasiliscincus agilis*; (C) *Enyalius boulengeri*; (D) *Placosoma glabellum*; (E) *Leposoma scincoides*; (F) *Ecpleopus gaudichaudii*; (G) *Gymnodactylus darwinii*; (H) *Amphisbaena alba*.

The snake family with the largest number of species was the Dipsadidae (N = 13 species), while in the case of the lizards, the most diverse family was the Gymnophtalmidae (N = 4 species). The most abundant lizard species in our inventory were *Leposoma scincoides* (N = 54) and *Ecpleopus gaudichaudii* (N = 38), followed by *Enyalius boulengeri* (N = 27) (Figure 4). The rarest lizard species were *Heterodactylus imbricatus* and *Ophiodes fragilis*, both recorded only twice and *Placosoma glabellum* and the exotic, invasive gekko *Hemidactylus mabouia*, which were both recorded only once (Figure 4). The most abundant snake species was *Bothrops jararaca* (N = 47 specimens), while the other 21 snake species were all recorded less than five times during the study (Figure 5). We recorded two species of Amphisbaenia, *Amphisbaena alba* (N = 1) and one *Leposternon microcephalum*. We also recorded one *Hydromedusa maximiliani* after the end of the RA sampling.

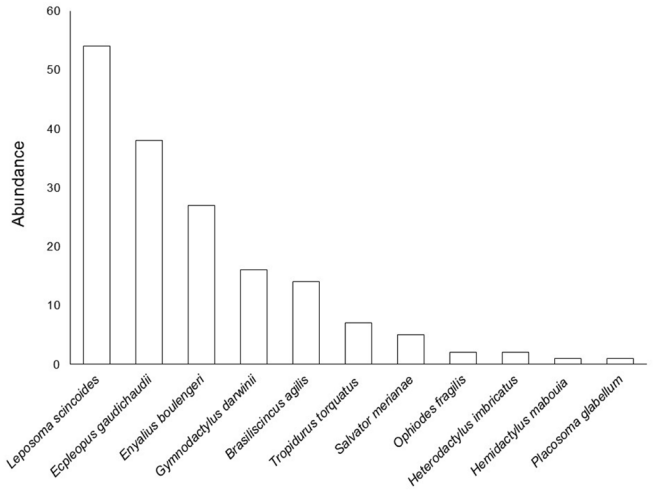

Figure 4. Lizard species richness and abundance recorded in the Serra das Torres Natural Monument in Espírito Santo state, southeastern Brazil.

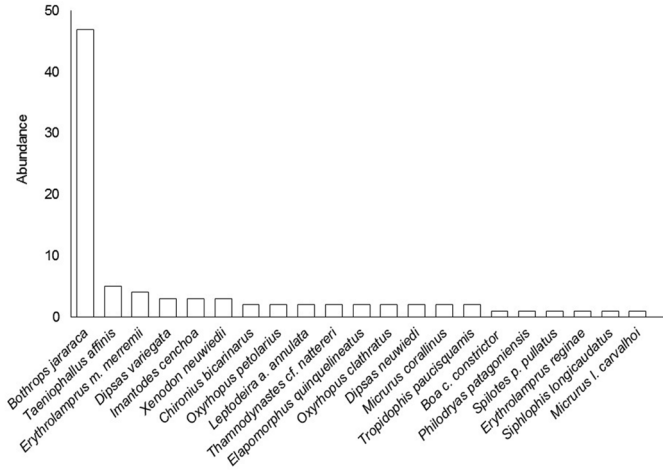

Figure 5. Snake species richness and abundance recorded in the Serra das Torres Natural Monument in Espírito Santo state, southeastern Brazil

This chelonian was included in the MONAST species list and richness but was not included in the analyses. Additionally, we did not collect a voucher specimen of *H. maximiliani* due to the threatened status (vulnerable) of the species in Espírito Santo state (IPEMA 2007; Bérnils et al. *no prelo*).

The species accumulation curve did not reach the asymptote, although the total species richness estimated for the MONAST based on the Bootstrap index was 36, only slightly above the actual species richness recorded in our study (34 species) (Figure 6). The largest number of species was recorded by active searching (N = 24 species), whereas only eight species were collected in the pitfall traps (Table 1). Four species (three lizards and one snake) were recorded exclusively by the pitfall traps.

Eight of the 11 lizard species (72%) recorded in the MONAST are endemic to the Atlantic Forest biome and two of the snakes are also endemic to this biome (Table 1). Ten (30%) of the reptiles recorded in the present study had less than five previous records from the state of Espírito Santo, and were thus classified as "rare", and the same number (10 species, 30%) had been recorded more than 20 times, and were thus classified as "common" (Figure 7).

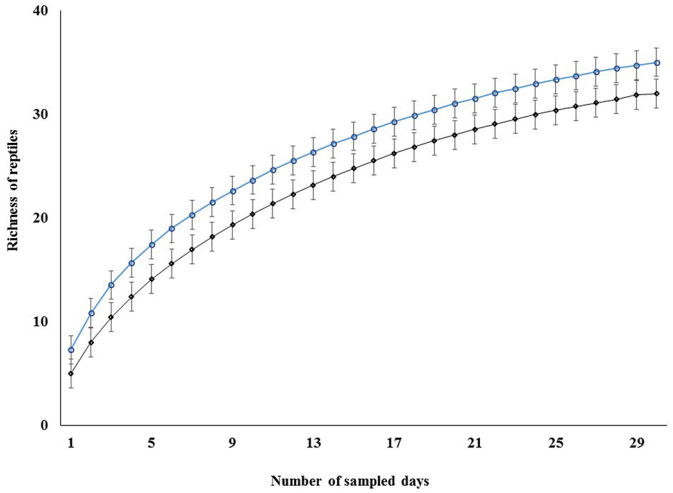

Figure 6. Accumulation (black line) and rarefaction curves (blue line) of the reptile species recorded during the 30 days of the sampling period in the Serra das Torres Natural Monument in Espírito Santo state, southeastern Brazil.

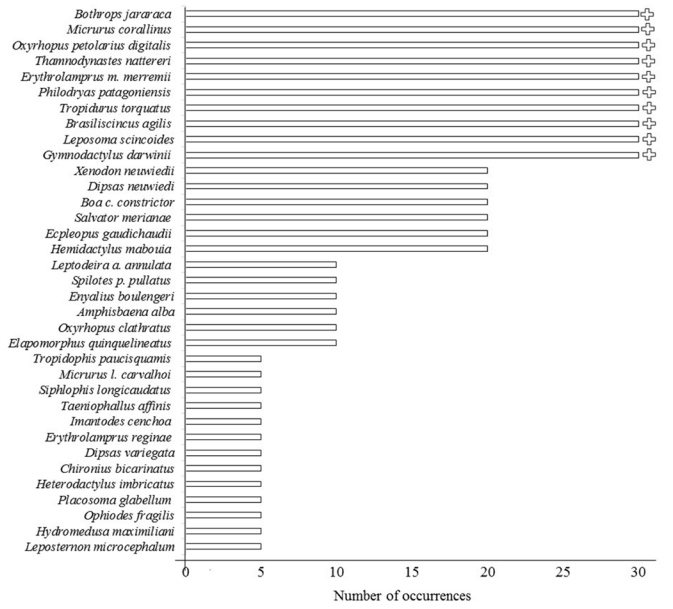

Figure 7. Number of previous records, according to data on herpetological collections in the state of Espírito Santo, of the reptile species occurring in the Serra das Torres Natural Monument.

Discussion

The reptile species richness recorded in the MONAST (N_{total} = 35) represents ca. 30% of all the squamates found in the Brazilian state of Espírito Santo (N = 117, see Costa & Bérnils 2018). This indicates that the MONAST protects a large proportion of the overall reptile biodiversity of Espírito Santo and, in turn, of the Atlantic Forest biome. The species richness of Serra das Torres is also similar to other remnants ombrophilous forest in southeastern Brazil where reptile surveys have been conducted. For example, Moura et al. (2012) recorded 40 reptile species (1 amphisbaenid, 9 lizards, and 29 snakes) in Serra do Brigadeiro, in the Brazilian state of Minas Gerais, while Almeida-Gomes et al. (2014) recorded 37 species

(one chelonian, one crocodilian, 10 lizards, and 24 snakes) in the Guapiaçu Ecological Reserve, in Rio de Janeiro. It is important to note that our inventory recorded 34 species (excluding *H. maximiliani*, found after the end of sampling), while the predicted species richness was only a little higher (36 species), despite the fact that the accumulative species curve did not reach the asymptote. These findings support the reclassification of the MONAST remnants as a more restrictive category of conservation unit, such as a state park, to better guarantee the protection of the reptile diversity of this important Atlantic Forest complex.

Hemidactylus mabouia, a non-indigenous lizard, was recorded in a forest fragment next to a banana plantation at the borders of the MONAST. This gekko is native to Africa, and has invaded a number of different natural environments in Brazil (Rocha et al. 2011, Telles et al. 2015, Oliveira et al. 2016), including many ombrophilous forest remnants (Rocha et al. 2011; Telles et al. 2015). The occurrence of *H. mabouia* in the MONAST is consistent with the dispersal of the species in other regions, where it is associated with open areas impacted by human activities (Rocha et al. 2011; Oliveira et al. 2016). The record of *H. mabouia* collected in the present study suggests that this species may begin to invade MONAST's natural environments.

The dominance of the family Dipsadidae in the present study is consistent with the pattern found in other areas of the Atlantic Forest (e.g. Hartmann et al. 2009, Freitas 2014). The Dipsadidae includes most tropical snakes, with more than 700 species (Vidal et al. 2010, Uetz et al. 2019), and the predominance of dipsadids recorded in the present study indicates a conservative snake community structure in Serra das Torres. Gymnophthalmidae was the most diverse lizard family (N = 4 species) in MONAST. This family as composed of small lizards, typically semi-fossorial, which forage in the leaf-litter (Dixo and Verdade 2006). In our samplings, gymnophthalmids were captured mainly in the pitfall traps, what is in accordance with the habitats of most species.

The most abundant lizards in our study were *Leposoma scincoids* and *Ecpleopus gaudichaudii*, whereas *Heterodactylus imbricatus* and *Placosoma glabellum* were the least abundant in the community. This result is comparable with other studies in Atlantic Forest remnants were the species of the Gymnophthalmidae family are major components of local leaf-litter reptile communities (e.g. Maia et al. 2011, Cruz et al. 2014). For example, *E. gaudichaudii* represented a large proportion of the leaf-litter reptile community in the Morro Grande Forest Reserve, in São Paulo state (54%), whereas *Heterodactylus imbricatus* was the least abundant lizard (3%) (Dixo and Verdade 2006). In the MONAST, 32% of the lizards recorded during the survey were *Leposoma scincoides*, and 23% were *E. gaudichaudii* while *H. imbricatus* represented only 1.2% and *Placosoma glabellum* only 0.6% of the lizard's abundance. These four lizard species are endemic to the Atlantic Forest of southern and southeastern Brazil (Tozetti et al. 2017) and are considered species dependent on forested areas (Dixo and Verdade 2006). Since these species depend on preserved areas, local changes in the environment, even on a small scale, can result in changes in the composition or even the local extinction of these species (Román-Cuesta and Martínez-Vivalta 2006).

The most abundant snake was *Bothrops jararaca*. This pitviper has a wide distribution in the Atlantic Forest, occupying well-preserved, impacted, and anthropogenic areas (Sazima 1988, 1992, Campbell and Lamar 1989). Although *B. jararaca* is a common snake in the communities in which it occurs, its abundance varies considerably among localities. In Serra do Mendanha, in Rio de Janeiro state, for example, *B. jararaca* is relatively rare, with only 10 records being obtained in a 62-month study (Pontes and Rocha 2009), whereas in the Juréia-Itatins Ecological Station, in São Paulo state, the species was relatively abundant, with 60 records being collected during a 15-month study (Marques and Sazima 2004). In the MONAST, *Bothrops jararaca* was more abundant (N = 47 records in 30 days of sampling) than all the other snake species combined (N_{total} = 42). Although it is important to consider the differences in the methods adopted in the different studies, the abundance of *B. jararaca* in Serra das Torres indicates that this forest remnant is a potentially important site for the conservation of this pitviper species.

We also recorded nine reptile species (27% of the total) that are endemic to the Atlantic Forest in our study at MONAST (Table 1). Overall, approximately 100 species are endemic to this biome (Tozetti et al. 2017). The Atlantic Forest is one of the world's most biodiverse biomes, although it is also one of the most threatened, reinforcing its status as a conservation hotspot (Myers et al. 2000, Ribeiro et al. 2009, Colombo and Joly 2010). Additionally, one chelonian (*Hydromedusa maximiliani*) and one snake (*Tropidophis paucisquamis*) are considered as vulnerable (VU) in the red list of threatened species in the state of Espírito Santo (Bérnils et al. *no prelo*). *Hydromedusa maximiliani* is endemic to the Atlantic Forest domain, where it inhabits streams at high altitudes (above 600 m a.s.l.) in the states of Bahia, Espírito Santo, Minas Gerais, São Paulo, and Rio de Janeiro (Argôlo & Freitas 2002). The main threat to the conservation of *H. maximiliani* is the alteration of the vegetation cover, which modifies the species' natural habitat and provokes shifts in the temperature beyond the optimum it requires to survive (Almeida et al. 2007). *Hydromedusa maximiliani* is also listed as Vulnerable in the IUCN Red List (IUCN 2019). *Tropidophis paucisquimis* is endemic to Atlantic Forest, occurring in the states of Espírito Santo, Rio de Janeiro, São Paulo, Paraná and Minas Gerais (Oliveira et al. 2019) and are mainly associated with the Serra do Mar and Serra da Mantiqueira mountain chains at an altitudinal range from 500 to 1261 m. (Curcio et al. 2012). The dwarf boa *T. paucisquamis* is rare in inventory studies and there are only four records of the species in Espírito Santo state (this study) and only 50 specimens from 26 localities are deposited in scientific collections of the entire Brazil (Oliveira et al. 2019). This species has among its antipredator mechanisms the cephalic autohemorrhage which has been described for species of the *Tropidophis* genus as a physiological product of increased blood pressure associated with a behavioral response caused by stress or fright (Smith et al. 1993). However, information about the biology and natural history of *Tropidophis paucisquamis* are poorly known. The presence of a high number of endemic species, habitat-dependent species and endangered species make MONAST an important refuge for the reptile fauna of the Atlantic forest.

In addition, 10 (30%) of the reptiles recorded in our study have less than five previous records in Espírito Santo (Figure 7). The rarity of these species in the state probably reflects in many cases the lack of studies in this region of southeastern Brazil. For example, *Micrurus lemniscatus carvalhoi*, is known to occur in western Argentina and eastern Paraguay, and is widespread in most Brazilian biomes, although only two previous records were available from Espírito Santo (Castro et al. 2017). This is typical of most of the rare species recorded in the present study and, considering the ongoing deforestation in Espírito Santo, we would strongly recommend that further studies of the state's herpetofauna be carried out.

The importance of the MONAST for the protection of the region's herpetofauna only began to be revealed in the past decade (e.g. Oliveira et al. 2009, 2012, 2013), and the new data presented here further reinforce the importance of this Atlantic Forest remnant for the conservation of the Atlantic Forest herpetofauna. The present study is the first inventory for southern Espírito Santo and it has been fundamental to the filling of a large knowledge gap in this portion of Atlantic Forest. Finally, we would recommend that the local environmental authorities focus on the need to maintain the integrity of the habitat structure of the entire remnant that harbors the Monumento Natural Serra das Torres.

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Author contributions

Jane C. F. Oliveira: Substantial contribution to the conception and design of the work; Contribution in the acquisition of the data; Contribution in the analysis and interpretation of the data; Contribution in the writing of the work; Contribution in the critical review appending intellectual content.

Rafael dos Santos: Contribution to data collection.

Mateus Leite Lopes-Silva: Contribution to data collection.

Lorena P. Vasconcelos Barros: Contribution to data collection.

Bárbara Risse-Quaioto: Contribution to data collection.

Cátia Moura Militão: Contribution to data collection; Contribution to critical revision, adding intellectual content.

Pedro Fatorelli: Contribution to data collection; Contribution to critical revision, adding intellectual content.

Flávia A. L. Belmoch: Contribution to data collection.

Thiago Marcial Castro: Contribution to species identification in the herpetological collection.

Carlos Frederico Duarte Rocha: Substantial contribution to the conception and design of the work; contribution in the acquisition of the data; contribution in the analysis and interpretation of the data; contribution in the writing of the work; contribution in the critical review appending intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Inventory

An annotated list of plant viruses and viroids described in Brazil (1926-2018)

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KITAJIMA, E.W. **An annotated list of plant viruses and viroids described in Brazil (1926-2018)**. Biota Neotropica 20(2): e20190932. https://doi.org/10.1590/1676-0611-BN-2019-0932.

Abstract: A list of plant species, in alphabetical order by their scientific name, and the viruses found naturally infecting them in Brazilian territory, with some comments, was prepared . The production of such a list was based on a yearly catalog of publications on plant viruses collected by the author, from 1926 to 2018. Listed species of viruses were those recognized by the International Committee on Taxonomy of Viruses (ICTV), but also those characterized and still waiting official recognition, were included. Several cases of putative viral diseases were listed for historical reasons expecting to raise interest for their clarification. This list includes 345 plants species belonging to 74 families naturally infected by plant viruses in Brazil. Fabaceae and Asteraceae had most virus-infected species, respectively 49 and 36. Until 2018, a total of 213 plant virus and 6 viroid species belonging to 57 genera and 22 families and 6 orders, officially recognized by ICTV, were found naturally infecting these plants. *Begomovirus and Potyvirus* genera have most representatives, with 45 and 42 species, respectively. There are 59 characterized plant viruses, up to species level, described in Brazil waiting for the inclusion in the ICTV Master Species List. One hundred and thirteen viruses were identified up to genus level but still uncharacterized, while four putative isometric viruses and eleven presumptive viral diseases ("unidentified") are included in the list. A reverse catalog, listing viruses and the plant species in which they were found is also included.
Keywords: *ICTV, plant species, virus species.*

Lista comentada de vírus e viróides de planta descritos no Brasil (1926-2018)

Resumo: Esta publicação consiste em uma listagem de espécies de plantas, em ordem alfabética de seus nomes científicos, e dos vírus que foram encontrados naturalmente infetando-as em território brasileiro, com alguns comentários. O preparo de tal lista foi basedo nas publicações sobre vírus de plantas e as doenças que eles causam, colecionadas pelo autor de 1926 a 2018. Os vírus listados incluem aqueles já oficialmente reconhecidos pelo International Committee on Taxonomy of Viruses (ICTV), constantes do "Master Species List 2018". Também estão incluídos vírus já caracterizados, aguardando oficialização pelo ICTV, e outros casos de possíveis viroses, cujo agente causal ainda não se acha adequadamente caracterizado. A listagem inclui 345 espécies de plantas, pertencentes a 74 famílias, que foram encontradas naturalmente infetadas por diferentes vírus. Fabáceas e Asteráceas foram as famílias que tiveram mais espécies infetadas por vírus, respectivamente 49 e 36. Até 2018, 213 espécies de vírus e 6 de viróides, pertencentes a 57 gêneros e 22 famílias e 6 ordens, oficialmente reconhecidas pelo ICTV, acham-se descritas no Brasil. Os gêneros *Begomovirus e Potyvirus* têm mais espécies representadas, com 45 e 42 respectivamente. Além das espécies identificadas e aceitas pelo ICTV, foram incluídas na lista 59 possíveis espécies que ainda aguardam oficialização, 113 vírus identificados a nível de gênero, quatro possíveis vírus isométricos e onze presumíveis viroses, de agentes etiológicos não confirmados. Foi incluída também uma lista reversa, com catalogação dos vírus e viróides descritos no Brasdil e suas respectivas plantas hospedeiras.
Palavras-chave: *ICTV, espécies de plantas, espécies de vírus.*

Introduction

The concept that viruses are part of the bioma is still a controversial subject. Their chemical composition is akin of the cellular organisms. They have DNA or RNA as their genome, proteins (protective, enzymes) and lipid and glycid (in membrane bounded viruses). Being unable to replicate by themselves, viruses rely entirely on a cellular host to do so, as a molecular parasite. As far as we know, most of cellular organisms, from pro- to eucaryotes, have been found infected by one or more viruses, some of them already integrated into their genomes (Shors, 2008; Hull, 2014). Recent works, using next generation sequencing (NGS) or high-throughput sequencing (HTS) technologies (Reuter et al., 2015), discovered a huge number of virus-like sequences in several environments (Walker et al., 2019). Their proposition to incorporate them in the present official taxonomic system seems unreal as discussed by van Regenmortel (2016), who mentions that "the phenotypic and biological properties of members of new species taxa proposed on the basis of metagenomic data must be known before it becomes feasible to try to incorporate such hypothetical species in the current official system of virus classification".

Because the intimate relationship of viruses in the biology and evolution of cellular organisms, common sense and the ever-increasing evidences strongly suggest that viruses must be part of the living world. Theories about the origin of viruses are speculative but we can roughly list three main lines (Forterre, 2006; Garcia-Arenal et al., 2003; Koonin & Dolja, 2006; Lefeuvre et al., 2019; Krupovic et al., 2019; Simmonds, 2009): (1) involution of a parasitic prokaryote, which gradually lost most of their genes, for the redundancy with those of host, keeping only those demanded for its own replication. Poxviruses and Mimiviruses are natural candidates for such possibility; (2) an aggroupment and reorganization of normal cell mRNAs containing information which led to their self-replication. The origin of most of RNA viruses would fit in this scenario; (3) a relic of the precellular, RNA world, when ribozymes permitted the self replication of RNA molecules. The existence of some viroids could be explained by this possibility. On the other hand, viruses, as molecular parasites, have been exerting important role in the evolution of living beings throughout the time. It is a well documented fact that gene swapping between organisms of the same or different species can be mediated by viruses. Recent works have shown a large variety of viruses, whose genome (integer or part) have been found integrated in the genome a large number of organisms of unrelated kingdom. Viral infection may be a key selection factor, eliminating susceptible species. Humanity has managed to tame several viruses for its own sake, to produce vaccines or use them as a genetic engineering tool to deliver specific genes, or to eliminate plagues, using them as insecticides or herbicides, as vector of expression of proteins, and also inducing hypovirulence in fungus (Shors, 2008; Hull, 2014).

Plants, as all the living beings, are susceptible to many viruses. Although there are several cases of viruses being able to infect both plants and arthropod vector, so far no virus is known to infect plants and vertebrates in the nature. Indeed, virology began with studies with a plant virus- *Tobacco mosaic virus* (TMV) at the end of the 19th century when it was discovered that the causal agent of a tobacco disease, referred to as mosaic, was able to keep its infectivity even after being filtered in bacteria-retaining porcelain filters. The term *contagium vivum fluidum* was initially attributed but later replaced by "virus" (which means poison). Soon viruses were found not only in other plants but also in practically all living beings. Also, TMV was the first virus to be purified around 1930 by centrifugation and demonstrated to be made up essentially by protein and a small amount of RNA, and also the first to be visualized by early transmission electron microscope in the late 1930s, revealing to be rodlike (Hull, 2014).

Plant viruses rarely cause dramatic and extensive damages to human activity as the pandemy of some human and animal viruses. On the contrary, their action is more subtle but inexorable and may cause consistent and constant losses in the quality and quantity of most of cultivated plants (vegetables, ornamentals, fruits, grains, industrial crops, forestry, etc.). Thus a good deal of plant pathology research is devoted to the study of plant viral diseases, especially because there are no economically available chemicals for curative treatment, as fungicides, antibiotics, nematicides, etc. efficient to control plant viruses. Usually, after identifying the causal virus, the management of the viral diseases concentrates on the use of genetically bred resistance varieties, cross-protection by mild strains, control of the vector, if any, crop techniques (rotation, time and local for cultivation). Recently, use of genetic engineering by gene transference between different organisms and even use of viral genes, have been tried to improve resistance in some crops, against viral infection. But only few of those transgenic plants are being used commercially, for they still face strong resistance by some sectors of the society (Hull, 2014; Rezende & Kitajima, 2018).

Brazil, being one of the most important world producer of animal and plant-derived commodities, has special interest in understanding plant viral diseases to properly manage them. Presently about 100 researchers and graduate students are involved in investigations of many different plant viruses, to identify, characterize them and develop suitable management programs to reduce the hazards resulting from viral infection. The main problem is the vast extension of the country (8.5 square million kilometers) spanning from the equator to the subtropics, and presenting very diverse weather and soil conditions. The hot to milder climate favor the permanent presence of spontaneous vegetation, several of them potential host for a large number of crop affecting viruses, and worse, the continuous presence of all kind of vectors (arthropods, fungus, nematodes). Also, the lack of a rigorous and efficient quarantine system results in the continuous introduction of living part of plants and together, all sort of pests and pathogens, including viruses.

Historically, plant virology in Brazil began in two distinct centers in the years 1930's. One, at the Instituto Biológico, at São Paulo (SP), with A.A. Bittancourt and K.M. Silberschmidt, the last just arriving from Germany. The second, at the Instituto Agronomico, Campinas-IAC (SP) with A.S. Costa, with training at Princeton, US. Both groups developed important and pioneer researchs on plant viruses, mostly on vegetable crops, tobacco, cotton and citrus. Silberschmidt's group was the first to demonstrate the role of whitefly as the vectors, of what is now known as begomoviruses. Costa demonstrated that a serious tomato and tobacco disease, known as "vira cabeça" was caused by Orthotospovirus. Perhaps one of the best works of Brazilian plant virology was to control the epidemy of citrus tristeza, caused by *Citrus tristeza virus* (CTV). This virus was introduced from Argentina, and resulted in the death of roughly 10 million orange plants in the state of São Paulo in the 1930's. The recovery of citrus industry was based on the finding that mortality was linked to the use of sour orange as rootstock. Its replacement by other CTV tolerant rootstock varieties solved the problem, and additionally the finding that infection of a citrus plant by a mild, protecting strain of CTV (premmunization, cross-protection) resulted in additional protection. Presently, together with other technical advances, these two procedures permitted an impressive growth of the citrus industry, and now more than 200 million orange trees are grown in the state of São Paulo, transforming this region in the largest world producer of industrialize orange juice. Costa's group had a significant growth, so that in the beginning of the year 1970's, twelve researchers were part of it, but economical problems affecting IAC, ended up with the migration of most of

Costa's group members to other institutions as Universidade de São Paulo, Universidade de Campinas and Universidade de Brasília. This in part permitted the dispersion of the plant virology "know-how" to several research centers throughout the country, which also became the focus for the training of new generations of plant virologists. Universidade Federal de Viçosa (MG), Universidade Federal do Ceará, Universidade Federal Rural de Pernambuco, Universidade Federal do Rio Grande do Sul also participated in the nucleation of new centers of virology in Brazil. At the same time, Brazilian plant pathologist organized themselves in associations- Sociedade Brasileira de Fitopatologia (SBF) in 1967 and shortly later, the Grupo Paulista de Fitopatologia, presently Associação Paulista de Fitopatologia (GPF), in 1975, which promoted annual meetings. GPF started to publish the journal Summa Phytopathologica soon after foundation, while SBF produced Fitopatologia Brasileira in 1976, now (since 2014) Tropical Plant Pathology, to divulge results of phytopathological researches. Plant virology is part of actions promoted by the Brazilian Society of Virology. Also, training of many Brazilian plant virologists abroad as graduate students or posdocs was another important factor in the progress of plant virology in Brazil, bringing in new knowledge and research philosophy. Countries as US, Spain, the Netherlands, Japan, France, Italy, Germany among others, deserve to be mentioned in such a collaborative efforts. Some visiting scientists (T.J. Grant, W.C. Bennet, R.J. Best, C. Wetter, M. Nelson, D. Peters, etc.) also contributed to the advancement of the Brazilian plant virology.

Historically Brazil registered some important viral outbreaks in its crops: mosaic in sugar cane caused by Sugar cane mosaic virus (SCMV) in the early XXth century, which forced growers to replace noble cane for virus-resistant, rustic cultivars; Citrus tristeza virus (CTV) in 1940's wiping up to 10 million orange trees; constant threat of "vira-cabeça" disease caused by several species of orthotospoviruses in solanaceous crops being controlled by resistant varieties; a cocktail of viruses affecting strawberry yield until 1970', solved by the production of virus-free stocks; a disaster on bean production in the 1970-1980 caused by the whitefly-transmitted *Bean golden mosaic virus* (BGMV), now under control by tolerant and even genetically modified varieties, which obliged Brazil, the world largest producer, to import bean for a while; mosaic in papaya, caused by Papaya ringspot virus (PRSV), solved by the use of systematic roguing, etc. Details of the history of plant virology in Brazil have been described by Costa (1986) and Kitajima (1995).

To cope with such diseases and also to survey other viruses present mostly in cultivated plants, but also infecting spontaneous vegetation considering their potential as source of viruses for economic crops, Brazilian plant virologists actively investigated them. Continuous efforts have been made to control several of these viruses, which cause yield losses, using field practices, control of vectors (biological, chemical), breeding for resistance, etc. Reports of such works were published in specialized journals and bulletins, as well as presented in scientific meetings. A systematic collection of such publications were made, starting 1926 to 2018. Part of this listing has been published (Kitajima, 1986; 1995). Based on such a list, an annotated list of plant viruses described in Brazil was prepared, providing an alphabetical list of host plants, indicating the viruses found infecting them, with brief comments. As appendix, a reverse list is presented, enrolling the viruses and hosts in which they were found, following the most recent "Master virus list" produced by International Committee on Taxonomy of Viruses (ICTV) (ICTV, 2019)

Material and Methods

There are several lists of viruses described for some group of plants (e.g. ornamentals-Albouy & Devergne, 2000; tropical plants- Brunt et al., 1990; Poaceae- Lapierre & Signoret, 2004; Solanaceae- Marchoux et al., 2008; whitefly-borne viruses- Anderson & Morales, 2005) or a country/region of the world (e.g. Argentina- Fernandez Valiela, 1995; Asia- Murayama et al., 1998). To produce this Brazilian plant virus list, a data base was produced by a continuous compilation of whatever publication (articles, reviews, divulging articles, abstracts, technical bulletin) produced by Brazilian plant virologists. This list is ordered by the year of publication, and then alphabetically by author's name. Whenever possible, printed version of these publications were collected and digitalized. The list starts in 1926 and was yearly updated, and in the present publication, ends in 2018. A first listing was published by the Brazilian Phytopathological Society covering 1926 to 1985, and a second, covering the period 1986 to 1993 (Kitajima, 1986; 1995). Since then, a yearly production list from 1986 to 2018 was prepared by the author. These publications from 1926 to 2018 served as the basis for the present work. The present listing was prepared, going through these publications and picking up those reporting cases of natural infection by viruses in any species of plant, cultivated or not, made in the Brazilian territory.

Until the 1950's plant virus identification was entirely based on symptoms and some biological properties, as stability *in vitro*, mode of transmission (mechanical, by vector, grafting, seed) and host range. Later, serodiagnosis and electron microscopy was introduced, giving a more precise and reliable identification of the causal viral agent. Only after the 1980's, with the use of molecular techniques, a faster and cost-efficient detection and identification procedure for plant viruses became available. Thus, for instance, what was referred to as "viruses of the infectious chlorosis of malvaceae complex" around 1930 to 1960 (Silberschmidt, 1943), is now known to incorporate a long list of begomoviruses. In the present list, early descriptions were respected as it was made originally by author(s) with the resources then available. In some cases, identification could be reassessed and corrected, if this was such a case. Today routinely plant viruses are correctly identified mostly by molecular tools as PCR or RT-PCR and in some instances, by NGS/HTS. However, in many instances the required Koch's postulate have not been completed (Hull, 2014; Rezende & Kitajima, 2018). Also, virus identity followed, whenever possible, the classification as accepted by the International Committee on Taxonomy of Viruses (ICTV), including the periodic updating. Besides virus species officially accepted by ICTV and part of the Master List, we listed several viruses already characterized, but still waiting for official recognition. And finally, for historical reasons, and a stimulus for a reassessment, cases of possible viral diseases, with correct identification still pending, were included.

The list was prepared ordering the plant species, alphabetically by scientific name, and whenever possible, indicating the common name. In each species, viruses naturally infecting them were listed following the order presented in the ICTV list (genus and species), with a small comment on described symptoms, geographical location, economical importance, some additional information and the references. Shortened references are listed after each virus described to facilitate the search for it by the reader. To have the correct scientific names of host plants and describer's authority, information provided by the site "International Plant Name Index" were adopted. A separate list was prepared, on reverse way, by virus name, and the infected host, but without comments. Certainly, this list must have mistakes, and the author requests for the careful reader to feed-back him with the correct information, so that the error can be corrected. To access the list of publications on plant viruses mostly from Brazil, made by Brazilian plant virologists, from 1926 to 2018, please find the site http://www.lfn.esalq.usp.br/NAP.

Results and Discussion

From 1926 to 2018, 345 plants species belonging to 74 families could be listed as naturally infected by plant viruses and viroids in Brazil (see list below). Among these families, Fabaceae and Asteraceae had most virus-infected species, respectively 49 and 36. There are a total of 213 plant virus and 6 viroid species, belonging to 57 genera, 22 families and 6 orders, officially recognized by ICTV and included in the ICTV's Master List of 2018B, found naturally infecting these plants in Brazilian territory. *Begomovirus* (*Geminiviridae*) is the genus with most representatives, with 45 described species, followed by *Potyvirus* (*Potyviridae*), with 42, *Potexvirus* (*Alphaflexiviridae*) and *Carlavirus* (*Betaflexiviridae*), with 13 and 9, respectively. On the other hand, 59 characterized plant virus (unclassified) at species level described in Brazil, are waiting for the inclusion in the Master List. One hundred and thirteen viruses, are reported most of them identified to the genus level, but still uncharacterized at species level (unidentified). Finally four putative isometric viruses, still unidentified and ten presumptive viral diseases ("unidentified") are included in the list. Tomato (*Solanum lycopersicum*- Solanaceae) is the species in which, by and large, more viruses have been described (37 recognized, 9 unclassified, and 4 unidentified), followed by potato (*Solanum tuberosum*-Solanaceae) (17 recognized and 1 unclassified) and common bean (*Phaseolus vulgaris*- Fabaceae) (17 recognized, and 1 unidentified). Such numbers certainly reflects the susceptibility of these cultures to viruses, some of them inducing significative losses, and the attention they received by the virologists. Also, the recent introduction of new assay methods as the next generation sequencing is rapidly increasing the detection of new viruses, although in many cases little work has been done to complete the characterization of the virus, including the fulfillment of the Koch's postulate.

A reverse list, enrolling the plant viruses and their respective host plant species, found naturally infected, is presented at the end of the text (Table 1). *Cucumber mosaic virus* (CMV- *Cucumovirus*) was the virus found infecting the largest number of different plant species (59), followed by *Potato virus Y* (PVY- *Potyvirus*) (31) and *Tomato spotted wilt virus* (TSWV- *Orthotospovirus*) (23). It should be emphasized that despite being largely disseminated, CMV causes usually only diseases of marginal importance in cultivated plants. Considering different Brazilian regions, the number of described cases decreases from Southeast, South, Center-West, Northeast and North reflecting the population of plant virologists in each region and the intensity of agricultura activities.

Because systematics is a dynamic process, it is likely that taxonomic positions of orders, families, genera and species of plant viruses may suffer alterations in the future, as well as due to more critical identification procedures, especially sequencing. We expect to incorporate such changes, besides the inclusion of new viruses to update continuously this list.

List of plant species with viruses and viroids found infecting them, described in Brazil (1926-2018).

A

****Abelmoschus esculentus* Moench (okra) Malvaceae**

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

Bright yellow mosaic symptoms were described in cultivated okra, with low incidence, and identified as being caused by whitefly transmitted virus of the ICMC, in S. Paulo state (1). The cv. 'Chifre de Veado, seleção Sta. Cruz 47' developed in the UFRRJ revealed to be highly resistant against begomovirus (2). Whitefly transmitted begomovirus, possibly related to ICMC was also described infecting okra in Manaus, AM (3).

Ref.: (1) Costa, A.S. Phytopathol.Zeit. 24: 97. 1955; (2) Sudo, S. et al. Fitopatologia 9: 72; 1974; (3) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979

*Before the advent of the molecular tools to identify different begomoviruses, most of whitefly transmitted viruses were referred to as ICMC, which today is known to comprehend a large number of different begomovirus species identified using molecular tools. For historical reasons, these cases will be registered in this annotated list as ICMC.

***Sida micrantha mosaic virus* (SimMV)**

SimMV was detected in the states of GO and DF, infecting okra causing mosaic symptoms (1).

Ref.: (1) Aranha, A.S. et al. Trop.Plant Pathol. 36: 14. 2011.

****Abutilon striatum* Dicks (Chinese lantern) Malvaceae**

Begomovirus

***Abutilon mosaic Brazil virus* (AbMBV)**

First description of an infectious chlorosis in Chinese lantern in Brazil was made by Silberschmit (1). The disease commonly affects this ornamental wherever the plant is cultivated causing bright yellow mosaic. The causal agent is not seed-borne but is transmissible by grafting to *A. striatum* and *Sida* spp. It may be mechanically transmitted with difficulty. This begomovirus was first to be demonstrated to be vectored by the whitefly *Bemisia tabaci* (2,3). AbMBV, initially referred to as Infectious chlorosis virus, was found infecting several species of malvaceae, besides economically important cultures as common bean, soybean and tomato. Its genome was completely sequenced showing to be different from an isolate of West Indies, and formally named as *Abutilon mosaic Brazil virus*- AbMBV (4).

Ref.: (1) Silberschmidt, K. Arq.Inst.Biol. 14: 105. 1943; (2) Orlando, A. & Silberschmidt, K. Arq.Inst.Biol. 16: 1. 1946; (3) Flores, E. & Silberschmidt, K. Phytopath.Z. 60: 181-195.1967; (4) Paprotka, T. et al. Arch.Virol. 155: 813. 2010.

****Acanthospermum hispidum* DC (bristly starbur, goat's headbristly starbur, goat's head) Asteraceae**

Curtovirus unidentified

Brazilian tomato curly top virus (BrCTV)

Bristly starbur's plant exhibiting general chlorosis, vein clearing, witches' broom symptoms were found to be infected by a possible isolate of the *Beet curly top virus* (CTV), being leafhopper transmitted (1,2). These infected bristly starbur's plants may serve as the reservoir for the virus which was found infecting tomato and tobacco in the state of São Paulo. This virus should be molecularly characterized to confirm the suspicion that it represents a Brazilian isolate of *Beet curly top virus* (BCTV).

Ref.: (1) Bennett, C.W. & Costa, A.S. J. Agric. Res. 78: 675. 1949; (2) Costa, A.S. III Sem.Bras.Herbicidas e Ervas Daninhas p. 69. 1960

****Acmella oleracea* (L.) R.K.Jansen (Jambu) Asteraceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

During surveys made on jambú, a native plant of the Amazon basin used as spice in local cuisine, in the state of Pará for possible viral diseases, plants exhibiting mosaic symptoms were found. The causal agent was able to be transmitted mechanically to several test plants, and molecular assays identified it as an isolate of CMV, subgroup IA (1).

isolado do CMV do subgrupo IA (1).

Ref.: (1) Quadros, A.F. et al. Res.431, 40º Cong.Paul.Fitop., 2017.

Table 1. List of plant viruses and viroids described in Brazil, indicating the plant species in which they were found infecting naturally.

Based on the Master Species List 2018 B, of the International Committee on Virus Taxonomy.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
Serpentovirales	*Aspiviridae*	*Ophiovirus*	*Citrus psorosis ophiovirus*
			***Citrus* sp.**
Serpentovirales	*Aspiviridae*	*Ophiovirus*	*Mirafiori lettuce big-vein ophiovirus*
			Lactuca sativa
Mononegavirales	*Rhabdoviridae*	*Cytorhabdovirus*	*Strawberry crinkle cytorhabdovirus*
			Fragaria x ananassa
Mononegavirales	*Rhabdoviridae*	*Cytorhabdovirus unclassif.*	Maize chlorotic vein banding virus
			Zea mays
			Soursop yellow blotch virus
			Anonna muricata
Mononegavirales	*Rhabdoviridae*	*Cytorhabdovirus unclassif.*	*Cytorhabdovirus (unidentified)*
			Arracacia xanthorhiza
			Beta vulgaris* L.var. *cicla
			Callistephus chinensis
			Orchid (*Laelia* sp.)
			Phaseolus vulgaris
			Pisum sativum
			Pogostemum patchouly
			Tapeinochilus ananassae
			Triticum aestivum
Mononegavirales	Rhabdoviridae	*Dichorhavirus*	*Citrus chlorotic spot dichorhavirus*
			***Citrus* sp.**
Mononegavirales	*Rhabdoviridae*	*Dichorhavirus*	*Citrus leprosis N dichorhavirus*
			***Citrus* sp.**
Mononegavirales	*Rhabdoviridae*	*Dichorhavirus*	*Clerodendrum chlorotic spot dichorhavirus*
			Anonna muricata
			Clerodendrum x speciosum
			C. thomsonae, C. splendens
			Hibiscus rosa-sinensis
			Malvaviscus arboreus
			Spathiphyllum wallisii
Mononegavirales	*Rhabdoviridae*	*Dichorhavirus*	*Coffee ringspot dichorhavirus*
			Coffea arabica
			***Coffea* spp.**
			Psilanthus ebracteolatus
			Spathiphyllum wallisii
Mononegavirales	*Rhabdoviridae*	*Dichorhavirus*	*Orchid fleck dichorhavirus*
			Orchids (several genera and species)
Mononegavirales	*Rhabdoviridae*	*Dichorhavirus unclassif.*	*Dichoravirus* unidentified
			Allamanda cathartica
			Bidens pilosa
			Cestrum nocturnum
			Gardenia jasminoides
			Monstera deliciosa

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Mussaenda erythrophylla
			Piper callosum
			Piper nigrum
			Ruellia chartacea
			Solanum violaefolium
Mononegavirales	*Rhabdoviridae*	*Nucleorhabdovirus*	*Eggplant mottled dwarf nucleorhabdovirus*
			Hibiscus rosa-sinensis
Mononegavirales	*Rhabdoviridae*	*Nucleorhabdovirus*	*Sonchus yellow net nucleorhabdovirus*
			Kalanchoe blossfeldiana
Mononegavirales	*Rhabdoviridae*	*Nucleorhabdovirus*	*Sowthistle yellow vein nucleorhabdovirus*
			Bidens pilosa
			Cotyledon orbiculata
Mononegavirales	*Rhabdoviridae*	*Nucleorhabdovirus unclassif.*	*Gomphrena virus*
			Gomphrena globosa
			Joa yellow blotch virus
			Solanum aculeatissimum
Mononegavirales	*Rhabdoviridae*	*Nucleorhabdovirus unclassif.*	*Nucleorhabdovirus (unidentified)*
			Ananas comosus
			Carica papaya
			Chrysanthemum morifolium
			Clerodendrum x speciosum
			Coreopsis lanceolata
			Cosmos sulphureus
			Cucurbita moschata* X *C. maxima
			Lactuca sativa
			Manihot esculenta
			Passiflora edulis
			Pogostemum patchouly
			Porophyllum ruderale
			Raphanus sp.
Mononegavirales	*Rhabdoviridae*	*Varicosavirus*	*Lettuce big-vein associated varicosavirus*
			Lactuca sativa
			Sonchus oleraceus
Bunyavirales	*Fimoviridae*	*Emaravirus*	*Fig mosaic emaravirus*
			Ficus carica
Bunyavirales	*Phenuiviridae*	*Tenuivirus putative*	Wheat white spike virus
			Triticum aestivum
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Bean necrotic mosaic orthotospovirus*
			Phaseolus vulgaris
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Chrysanthemum stem necrosis orthotospovirus*
			***Alstroemeria* sp.**
			***Bouvardia* sp**
			Callistephus chinensis
			Chrysanthemum morifolium
			Eustoma grandiflorum

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Gerbera jamesonii
			Senecio douglasii
			Sinningia speciosa
			Solanum lycopersicum
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Groundnut ringspot tospovirus*
			Arachis hypogaea
			Boerhavia coccinea
			Caesalpinia echinata
			Callistephus chinensis
			Capsicum annuum
			Capsicum baccatum
			Citrullus lanatus
			Coriandrum sativum
			Cucumis sativus
			Eustoma grandiflorum
			Guibourtia hymenifolia
			***Hippeastrum* sp.**
			Lactuca sativa
			Nicotiana tabacum
			Solanum lycopersicum
			Solanum melongena
			Solanum sessiliflorum
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Iris yellow spot tospovirus*
			Allium cepa
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Tomato chlorotic spot tospovirus*
			***Bouvardia* sp**
			Caesalpinia echinata
			Callistephus chinensis
			Capsicum annuum
			Capsicum baccatum
			Cichorium endivia
			Dieffenbachia spp
			Eryngium phoetidum
			Gerbera jamesonii
			Lactuca sativa
			Mirabilis jalapa
			Nicotiana tabacum
			Physalis peruviana
			Solanum aethiopicum
			Solanum lycopersicum
			Solanum sessiliflorum
			Spylanthes oleracea
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Tomato spotted wilt tospovirus*
			***Alstroemeria* sp.**
			Arachis hypogaea
			***Bouvardia* sp**
			Caesalpinia echinata
			Campanula medium

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Capsicum annuum
			Capsicum baccatum
			Capsicum chinense
			Capsicum frutescens
			Cicer arietinum
			Dieffenbachia spp
			Emilia sagittata
			Eucharis grandiflora
			Eustoma grandiflorum
			Lactuca sativa
			Lens culinaria
			Nicotiana tabacum
			Pisum sativum
			Senecio douglasii
			Sinningia speciosa
			Solanum lycopersicum
			Solanum melongena
			Solanum tuberosum
Bunyavirales	*Tospoviridae*	*Orthotospovirus*	*Zucchini lethal chlorosis tospovirus*
			Citrullus lanatus
			Cucumis anguria
			Cucumis melo
			Cucumis sativus
			Cucurbita moschata
			Cucurbita pepo **var.** ***Caserta***
Bunyavirales	*Tospoviridae*	*Orthotospovirus putative*	*Tospovirus (unidentified)*
			Amaranthus **sp.**
			Bidens pilosa
			Capsicum annuum
			Chrysanthemum leucanthemum
			Chrysanthemum morifolium
			Cichorium intybus
			Commelina **spp.,**
			Dahlia variabilis
			Glycine max
			Gnaphalium spicatum
			Orchid (*Oncidium* sp.)
			Petunia x hybrida
			Portulaca oleracea
			Sesamum indicum
			Sida **sp.**
			Solanum mammosum
			Spylanthes oleracea
			Tropaeolum majus
Picornavirales	*Secoviridae*	*Comovirus*	*Andean potato mottle virus*
			Solanum aethiopicum
			Solanum melongena

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Solanum sisymbriifolium
			Solanum tuberosum
Picornavirales	*Secoviridae*	*Comovirus*	*Bean rugose mosaic virus*
			Glycine max
			Phaseolus vulgaris
Picornavirales	*Secoviridae*	*Comovirus*	*Cowpea severe mosaic virus*
			Calopogonium mucunoides
			Canavalia ensiformes
			Centrosema pubescens
			Crotalaria juncea
			Crotalaria paulinea
			Glycine max
			Macroptilium lathyroides
			Phaseolus lunatus
			Phaseolus vulgaris
			Psophocarpus tetragonolobus
			***Pueraria* sp.**
			Vigna luteola
			Vigna mungo
			Vigna radiata
			Vigna unguiculata
			Vigna unguiculata* Subsp. *sesquipedalis
			Vigna vexillata
Picornavirales	*Secoviridae*	*Comovirus*	*Squash mosaic virus*
			Citrullus lanatus
			Cucumis anguria
			Cucumis melo
			Cucumis sativus
			Cucurbita moschata* X *C. maxima
			Cucurbita pepo
			Cucurbita pepo* var. *Caserta
Picornavirales	Secoviridae	*Comovirus unclassif.*	Turnip ringspot virus
			Eruca sativa
Picornavirales	*Secoviridae*	*Nepovirus*	*Grapevine fanleaf virus*
			Vitis vinifera
Picornavirales	*Secoviridae*	*Nepovirus*	*Hibiscus latent ringspot virus*
			Hibiscus rosa-sinensis
Picornavirales	*Secoviridae*	*Nepovirus*	*Tobacco ringspot virus*
			Cucurbita pepo* var. *Caserta
Picornavirales	*Secoviridae*	*Nepovirus*	*Tomato ringspot virus*
			***Rubus* spp.**
			Solanum tuberosum
Picornavirales	*Secoviridae*	*Waikavirus*	*Maize chlorotic dwarf virus*
			***Brachiaria* sp.**
			***Panicum* sp.**
Picornavirales	*Secoviridae*		*Dioscorea mosaic associated virus*
			***Dioscorea* spp.**
Picornavirales	*Secoviridae*		*Strawberry mottle virus*

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Fragaria x ananassa
Picornavirales	*Secoviridae putative*		Lettuce mottle virus
			Lactuca sativa
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic mite-borne filamentous virus*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic virus A*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic virus B*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic virus C*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic virus D*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Allexivirus*	*Garlic virus X*
			Allium sativum
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Alternanthera mosaic virus*
			***Angelonia* sp.**
			***Helichrysum* sp.**
			Portulaca oleracea
			Salvia splendens
			***Scutellaria* sp.**
			***Torenia* sp.**
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Bamboo mosaic virus*
			Bambusa vulgaris
Tymovirales	*Alphaflexiviridae*	Potexvirus	*Cactus virus X*
			Several cactaceae species
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Cassava common mosaic virus*
			Manihot esculenta
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Cymbidium mosaic virus*
			Orchid (several genera)
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Hydrangea ringspot virus*
			Hydrangea macrophylla
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Malva mosaic virus*
			Malva parviflora
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Opuntia virus X*
			Several cactaceae species
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Potato aucuba mosaic virus*
			Solanum tuberosum
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Potato virus X*
			Solanum tuberosum
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Schlumbergera virus X*
			Several cactaceae species
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*White clover mosaic virus*
			***Trifolium* sp.**
Tymovirales	*Alphaflexiviridae*	*Potexvirus*	*Zygocactus virus X*
			Several cactaceae species
Tymovirales	Alphaflexiviridae	*Potexvirus unclassif.*	Caladium virus X
			Caladium bicolor

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
Tymovirales	*Alphaflexiviridae*	*Potexvirus unclassif.*	Patchouli virus X
			Pogostemum patchouly
Tymovirales	*Alphaflexiviridae*	*Potexvirus unclassif.*	Senna virus X
			Senna occidentalis
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Cole latent virus*
			Armoracia rusticana
			***Brassica* spp.**
Tymovirales	Betaflexiviridae	Carlavirus	*Cowpea mild mottle virus*
			Glycine max
			Phaseolus vulgaris
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Garlic common latent virus*
			Allium sativum
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Melon yellowing-associated virus*
			Cucumis melo
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Potato virus M*
			Solanum tuberosum
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Potato virus S*
			Solanum tuberosum
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Shallot latent virus*
			Allium sativum
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Sweet potato C6 virus*
			Ipomea batatas
Tymovirales	*Betaflexiviridae*	*Carlavirus*	*Sweet potato chlorotic fleck virus*
			Ipomea batatas
Tymovirales	*Betaflexiviridae*	*Carlavirus unclassif.*	Cassia mild mosaic virus
			Cassia macranthera
			Cassia sylvestris
Tymovirales	*Betaflexiviridae*	*Carlavirus unclassif.*	*Carlavirus (unidentif.)*
			Allium ascalonicum
			***Alstroemeria* sp.**
			Hevea brasiliensis
Tymovirales	*Betaflexiviridae*	*Foveavirus*	*Apple stem pitting virus*
			Malus sp.
			Pyrus communis
Tymovirales	*Betaflexiviridae*	*Foveavirus*	*Grapevine rupestris stem pitting-associated virus*
			Vitis vinifera
Tymovirales	*Betaflexiviridae*	*Capillovirus*	*Apple stem grooving virus*
			***Citrus* spp.**
			Malus sp.
Tymovirales	*Betaflexiviridae*	*Trichovirus*	*Apple chlorotic leaf spot virus*
			Malus sp.
Tymovirales	*Betaflexiviridae*	*Vitivirus*	*Arracacha virus V*
			Arracacia xanthorhiza
Tymovirales	*Betaflexiviridae*	*Vitivirus*	*Grapevine virus A*
			Passiflora alata
			Vitis vinifera
Tymovirales	*Betaflexiviridae*	*Vitivirus*	*Grapevine virus B*

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Vitis vinifera
Tymovirales	*Tymoviridae*	*Maculavirus*	*Grapevine fleck virus*
			Vitis vinifera
Tymovirales	*Tymoviridae*	*Marafivirus*	*Citrus sudden death-associated virus*
			***Citrus* spp.**
Tymovirales	*Tymoviridae*	*Marafivirus*	*Maize rayado fino virus*
			Zea mays
Tymovirales	*Tymoviridae*	*Marafivirus unclassif.*	Grapevine rupestris vein feathering virus
			Vitis vinifera
Tymovirales	*Tymoviridae*	*Tymovirus*	*Eggplant mosaic virus*
			Peperomia obtusifolia
			Solanum lycopersicum
Tymovirales	*Tymoviridae*	*Tymovirus*	*Passion fruit yellow mosaic virus*
			Passiflora edulis* f. *flavicarpa
Tymovirales	*Tymoviridae*	*Tymovirus*	*Petunia vein banding virus*
			Petunia x hybrida
Tymovirales	*Tymoviridae*	*Tymovirus*	*Tomato blistering mosaic tymovirus*
			Nicotiana tabacum
			Solanum lycopersicum
			Solanum violifolium
Tymovirales	*Tymoviridae*	*Tymovirus unclassif.*	Cassia yellow mosaic associated virus
			Cassia hoffmannseggii
Tymovirales	*Tymoviridae*	*Tymovirus unclassif.*	*Senna virus X*
			Cassia macranthera
Tymovirales	*Tymoviridae*	Tymovirus unclassif.	*Tymovirus (unident.)*
			Lactuca sativa
------	*Amalgaviridae*	*Amalgavirus unclassif.*	*Amalgavirus (unident.)*
			Solanum lycopersicum
------	*Benyviridae*	*Benyvirus*	*Beet necrotic yellow vein virus*
			Beta vulgaris* L., subsp. *vulgaris
-----	*Benyviridae*	*Benyvirus*	*Rice stripe necrosis virus*
			Oryza sativa
-----	*Bromoviridae*	*Alfamovirus*	*Alfalfa mosaic virus*
			Carica papaya
			Glycine max
			Mendicago sativa
			Solanum tuberosum
			Stizolobium aterrimum
			***Trifolium* sp.**
-----	*Bromoviridae*	*Bromovirus*	*Brome mosaic virus*
			Triticum aestivum
-----	*Bromoviridae*	Cucumovirus	*Cucumber mosaic virus*
			Acmella oleracea
			Aeschynanthus pulmer
			Allamanda cathartica
			***Alstroemeria* sp.**

Continuation Table 1.

Realm Riboviria			
Order	*Family*	*Genus*	*Species*
			Andira vermifuga
			***Anthurium* spp.**
			Arachis repens
			Asclepias curassavica
			Brassica napus
			Caesalpinia echinata
			Calopogonium mucunoides
			Capsicum annuum
			Capsicum frutescens
			Catharanthus roseus
			Citrullus lanatus
			Cleome affinis
			***Commelina* spp**
			Cucumis anguria
			Cucumis melo
			Cucumis metuliferus
			Cucumis sativus
			Cucurbita pepo
			Cucurbita pepo* var. *Caserta
			Cyclanthera pedata
			***Desmodium* sp.**
			Eucharis grandiflora
			Eustoma grandiflorum
			Gladiolus x hortulanus
			Gloxinia sylvatica
			***Impatiens* spp.**
			Justicia sp.
			Lactuca sativa
			***Lilium* sp.**
			Momordica charantia
			***Musa* spp.**
			Nasturtium officinale
			***Nematanthus* sp.**
			Nicotiana tabacum
			Ocimum campechianum
			Orchid (*Dendrobium*)
			Passiflora edulis* f. *flavicarpa
			Peperomia caperata
			Phaseolus lunatus
			Phaseolus vulgaris
			Piper nigrum
			Pisum sativum
			Salvia splendens
			Solanum americanum
			Solanum lycopersicum
			Solanum nigrum
			Solalnum paniculatum
			Spinacia oleracea

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Strelitzia reginae
			Tetragonia expansa
			Tradescantia diuretica
			Vanilla planifolia
			Vigna unguiculata
			Zea mays
			Zeyheria tuberculosa
			Zingiber officinale
-----	*Bromoviridae*	*Ilarvirus*	*Apple mosaic virus*
			Prunus persica
			Prunus persica* var. *nucipersica
-----	*Bromoviridae*	*Ilarvirus*	*Prune dwarf virus*
			Prunus persica
			Prunus persica* var. *nucipersica
-----	Bromoviridae	Ilarvirus	*Prunus necrotic ringspot virus*
			Prunus persica
			Prunus salicina
			***Rosa* spp.**
-----	*Bromoviridae*	*Ilarvirus*	*Tobacco streak virus*
			***Alstroemeria* sp.**
			Ambrosia polystachya
			Apium graveolens
			Cynara scolymus
			Dahlia variabilis
			Eustoma grandiflorum
			Fragaria x ananassa
			Glycine max
			Gossypium hirsutum
			Helianthus annuus
			Nicotiana tabacum
			Phaseolus vulgaris
			Solanum lycopersicum
			Solanum tuberosum
			Talinum patense
-----	*Bromoviridae*	*Ilarvirus unclassif.*	*Ilarvirus (unidentif.)*
			Chrysanthemum morifolium
			Euphorbia splendens
-----	*Closteroviridae*	*Ampelovirus*	*Grapevine leafroll-associated virus 1*
			Vitis vinifera
-----	*Closteroviridae*	*Ampelovirus*	*Grapevine leafroll-associated virus 3*
			Vitis vinifera
-----	*Closteroviridae*	*Ampelovirus*	*Grapevine leafroll-associated virus 4*
			Vitis vinifera
-----	*Closteroviridae*	*Ampelovirus*	*Pineapple mealybug wilt-associated virus 1*
			Ananas sativus
-----	*Closteroviridae*	*Ampelovirus*	*Pineapple mealybug wilt-associated virus 2*
			Ananas sativus
-----	Closteroviridae	*Ampelovirus*	*Pineapple mealybug wilt-associated virus 3*

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Ananas sativus
		Ampelovirus unclassif	Grapevine leafroll-associated virus 5
			Vitis vinifera
		Ampelovirus unclassif.	Grapevine leafroll-associated virus 6
			Vitis vinifera
-----	*Closteroviridae*	*Closterovirus*	*Citrus tristeza virus*
			***Citrus* spp.**
-----	*Closteroviridae*	*Closterovirus*	*Grapevine leafroll-associated virus 2*
			Vitis vinifera
		Closterovirus unclassif.	*Closterovirus unident.*
			Arracacia xanthorhiza
-----	*Closteroviridae*	*Crinivirus*	*Sweet potato chlorotic stunt virus*
			Ipomea batatas
-----	*Closteroviridae*	*Crinivirus*	*Tomato chlorosis virus*
			Capsicum annuum
			Eruca sativa
			Physalis angulata
			***Raphanus* sp.**
			Solanum aethiopicum
			Solanum lycopersicum
			Solanum melongena
			Solanum tuberosum
-----	*Endornaviridae*	*Alphaendornavirus*	*Phaseolus vulgaris alphaendornavirus 1*
			Phaseolus vulgaris
-----	*Endornaviridae*	*Alphaendornavirus*	*Phaseolus vulgaris alphaendornavirus 2*
			Phaseolus vulgaris
-----	*Kitaviridae*	*Cilevirus*	*Citrus leprosis virus C*
			***Citrus* spp.**
-----	*Kitaviridae*	*Cilevirus putative*	Ligustrum leprosis virus
			***Ligustrum* spp.**
-----	*Kitaviridae*	*Cilevirus putative*	Passion fruit green spot virus
			Passiflora edulis* f. *flavicarpa
-----	*Kitaviridae*	*Cilevirus putative*	Solanum violifolium ringspot virus
			Solanum violifolium
			Unxia kubitzki
-----	*Kitaviridae*	*Cilevirus putative*	*Cilevirus (unidentified)*
			***Anthurium* spp.**
			Beaumontia grandifolia
			Brunfelsia uniflora
			***Clerodendrum* spp.**
			Cordyline terminalis
			Dracaena marginata
			Eugenia uniflora
			Hedera canariensis
			***Hibiscus* spp.**
			Lysimachia congestiflora
			Orchid (several genera)
			Pelargonium hortorum

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Plumbago auriculata
			Salvia leucantha
			Schefflera actinophylla
			Spathiphyllum wallisii
			Thunbergia erecta
	Luteoviridae	*Enamovirus putative*	Citrus vein enation virus
			***Citrus* spp.**
-----	*Luteoviridae*	*Enamovirus putative*	Grapevine enamolike virus
			Vitis vinifera
-----	*Luteoviridae*	*Luteovirus*	*Barley yellow dwarf virus PAV*
			Avena sativa
			Triticum aestivum
-----	*Luteoviridae*	*Polerovirus*	*Beet western yellows virus*
			Raphanus raphanistrum
-----	*Luteoviridae*	*Polerovirus*	*Carrot red leaf virus*
			Daucus carota
-----	*Luteoviridae*	*Polerovirus*	*Cotton leafroll dwarf virus*
			Gossypium hirsutum
-----	*Luteoviridae*	*Polerovirus*	*Maize yellow mosaic virus*
			Zea mays
	Luteoviridae	*Polerovirus*	*Melon aphid-borne yellows virus*
			Cucumis melo
-----	*Luteoviridae*	*Polerovirus*	*Potato leafroll virus*
			Ambrosia elatior
			Bidens pilosa
			Capsicum annuum
			Conyza canadensis
			Datura stramonium
			Galinsoga parviflora
			Physalis floridana
			Solanum aculeatissimum
			Solanum lycopersicum
			Solanum melongena
			Solanum nigrum
			Solalnum paniculatum
			Solanum tuberosum
			Solanum variabile
			Solanum viarum
			Vernonia polyantes
-----	*Luteoviridae*	*Polerovirus*	*Sugar cane yellow leaf virus*
			Saccharum officinarum
-----	*Luteoviridae*	*Polerovirus putative*	Cotton anthocyanosis virus
			Gossypium hirsutum
			Cotton vein mosaic virus
			Gossypium hirsutum
-----	*Pospiviroidae*	*Apscaviroid*	*Citrus dwarfing viroid*
			***Citrus* spp.**

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
-----	*Pospiviroidae*	*Apscaviroid*	*Grapevine yellow speckle viroid 1*
			Vitis vinifera
-----	*Pospiviroidae*	*Coleviroid*	*Coleus blumei viroid 1*
			Coleus blumei
-----	*Pospiviroidae*	*Hostuviroid*	*Hop stunt viroid*
			Vitis vinifera
-----	*Pospiviroidae*	*Pospiviroid*	*Chrysanthemum stunt viroid*
			***Chrysanthemum* sp.**
			Chrysanthemum morifolium
			***Citrus* spp.**
			Vitis vinifera
-----	Pospiviroidae	*Pospiviroid*	*Citrus exocortis viroid*
			***Citrus* spp.**
			Vitis vinifera
-----	*Potyviridae*	*Brambyvirus putative*	Stylosanthes mosaic associated virus 1
			Stylosanthes guianensis
	Potyviridae	*Brambyvirus putative*	Stylosanthes mosaic associated virus 2
			Stylosanthes guianensis
	Potyviridae	*Brambyvirus putative*	Stylosanthes mosaic associated virus 3
			Stylosanthes guianensis
-	*Potyviridae*	*Bymovirus*	*Wheat spindle streak mosaic virus*
			Triticum aestivum
	Potyviridae	*Ipomovirus*	*Sweet potato mild mottle virus*
			Ipomea batatas
	Potyviridae	*Macluravirus*	*Artichoke latent virus*
			Cynara scolymus
	Potyviridae	*Potyvirus*	*Alstroemeria mosaic virus*
			***Alstroemeria* sp.**
	Potyviridae	*Potyvirus*	*Arracacha mottle virus*
			Arracacia xanthorhiza
	Potyviridae	*Potyvirus*	*Bean common mosaic virus*
			Cyamopsis tetragonolobus
			Lens culinaria
			Phaseolus vulgaris
			Senna occidentalis
			Vigna radiata
	Potyviridae	*Potyvirus*	*Bean yellow mosaic virus*
			Arachis hypogaea
			Gladiolus x hortulanus
			Glycine max
			***Hippeastrum* sp.**
			***Lilium* sp.**
			Lupinus alba
			Phaseolus vulgaris
			Pisum sativum
	Potyviridae	*Potyvirus*	*Bidens mosaic virus*
			Arracacia xanthorhiza
			Bidens pilosa

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Coreopsis lanceolata
			Galinsoga parviflora
			Helianthus annuus
			Lactuca sativa
			Pisum sativum
			Zinnia elegans
	Potyviridae	*Potyvirus*	*Brugmansia suaveolens mottle virus*
			Brugmansia suaveolens
	Potyviridae	*Potyvirus*	*Canna yellow streak virus*
			Canna paniculata
	Potyviridae	*Potyvirus*	*Carrot thin leaf virus*
			Daucus carota
	Potyviridae	*Potyvirus*	*Catharanthus mosaic virus*
			Catharanthus roseus
	Potyviridae	*Potyvirus*	*Celery mosaic virus*
			Apium graveolens
			Petroselinum sativum
	Potyviridae	*Potyvirus*	*Cowpea aphid-borne mosaic virus*
			Arachis hypogaea
			Canavalia ensiformes
			Canavalia rosea
			Cassia hoffmannseggii
			Crotalaria juncea
			***Desmodium* sp.**
			Glycine max
			Passiflora edulis* f. *flavicarpa
			Passiflora coccinea x P. setacea
			Phaseolus lunatus
			Phaseolus vulgaris
			Senna occidentalis
			Sesamum indicum
			Thunbergia alata
			Vigna unguiculata
			Vigna unguiculata* subsp. *sesquipedalis
	Potyviridae	*Potyvirus*	*Dasheen mosaic virus*
			Alocasia macrorhizos
			Amorphophallus konjac
			***Anthurium* spp.**
			Caladium bicolor
			Colocasia esculenta
			Dieffenbachia amoena
			Syngonium wendlandii
			Xanthosoma atrovirens
			Zantedeschia aethiopica
	Potyviridae	*Potyvirus*	*Hippeastrum mosaic virus*
			Eucharis grandiflora
			***Hippeastrum* sp.**
	Potyviridae	*Potyvirus*	*Hyacinth mosaic virus*

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Hyacinthus orientalis
	Potyviridae	*Potyvirus*	*Johnson grass mosaic virus*
			***Brachiaria* sp.**
			Panicum maximum
			Pennisetum purpureum
			Sorghum bicolor
			Zea mays
	Potyviridae	*Potyvirus*	*Konjac mosaic virus*
			Zamioculcas zamiifolia
	Potyviridae	*Potyvirus*	*Leek yellow stripe virus*
			Allium sativum
	Potyviridae	*Potyvirus*	*Lettuce mosaic virus*
			Cichorium endivia
			Erigeron bonariensis
			Galinsoga parviflora
			Lactuca sativa
			Sonchus asper
			Sonchus oleraceus
	Potyviridae	*Potyvirus*	*Maize dwarf mosaic virus*
			Zea mays
	Potyviridae	*Potyvirus*	*Malva vein clearing virus*
			Malva parviflora
	Potyviridae	*Potyvirus*	*Onion yellow dwarf virus*
			Allium cepa
			Allium fistulosum
			Allium sativum
	Potyviridae	*Potyvirus*	*Papaya ringspot virus*
			Carica papaya
			Citrullus lanatus
			Cucumis anguria
			Cucumis melo
			Cucumis metuliferus
			Cucumis sativus
			Cucurbita maxima
			Cucurbita moschata
			Cucurbita pepo* var. *Caserta
			Cyclanthera pedata
			Fevillea trilobata
			Luffa operculata
			Psiguria triphylla
			Zeyheria tuberculosa
	Potyviridae	*Potyvirus*	*Pea seed-borne mosaic virus*
			Pisum sativum
	Potyviridae	*Potyvirus*	*Peanut mottle virus*
			Arachis hypogaea
			Arachis pintoi
	Potyviridae	*Potyvirus*	*Pepper mottle virus*
			Capsicum frutescens

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
	Potyviridae	*Potyvirus*	*Pepper yellow mosaic virus*
			Caesalpinia echinata
			Capsicum annuum
			Capsicum baccatum
			Capsicum chinense
			Solanum lycopersicum
	Potyviridae	*Potyvirus*	*Pfaffia mosaic virus*
			Pfaffia glomerata
	Potyviridae	*Potyvirus*	*Potato virus A*
			Solanum tuberosum
	Potyviridae	*Potyvirus*	*Potato virus Y*
			Amaranthus sp.
			Bidens pilosa
			Caesalpinia echinata
			Capsicum annuum
			Capsicum baccatum
			Capsicum frutescens
			Conyza canadensis
			Emilia sonchifolia
			Galinsoga parviflora
			Gnaphalium spicatum
			Nicandra physaloides
			Nicotiana tabacum
			Physalis angulata
			Physalis peruviana
			Phytolacca decandra
			Solanum aculeatissimum
			Solanum americanum
			Solanum atropurpureum
			Solanum lycocarpum
			Solanum lycopersicum
			Solanum melongena
			Solanum nigrum
			Solanum palinacanthum
			Solalnum paniculatum
			Solanum tuberosum
			Solanum viarum
			Sonchus oleraceus
			Vernonia polyantes
			Viola odorata
			Zanthosylum rhoifolium
			Zeyheria tuberculosa
	Potyviridae	*Potyvirus*	*Soybean mosaic virus*
			Glycine max
			Senna occidentalis
	Potyviridae	*Potyvirus*	*Sugar cane mosaic virus*
			Cymbopogon winterianus
			Saccharum officinarum

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Sorghum bicolor
			Zea mays
	Potyviridae	*Potyvirus*	*Sunflower chlorotic mottle virus*
			Zinnia elegans
	Potyviridae	*Potyvirus*	*Sweet potato feathery mottle virus*
			Ipomea batatas
	Potyviridae	*Potyvirus*	*Sweet potato latent virus*
			Ipomea batatas
	Potyviridae	*Potyvirus*	*Sweet potato mild speckling virus*
			Ipomea batatas
	Potyviridae	*Potyvirus*	*Sweet potato virus G*
			Ipomea batatas
	Potyviridae	*Potyvirus*	*Tobacco etch virus*
			Solanum lycopersicum
	Potyviridae	*Potyvirus*	*Tulip breaking virus*
			***Lilium* sp.**
	Potyviridae	*Potyvirus*	*Turnip mosaic virus*
			Armoracia rusticana
			Brassica carinata
			Brassica oleracea
			B. rapa
			Brassica napus
			Nasturtium officinale
			Raphanus raphanistrum
			Sinapsis alba
			Spinacia oleracea
			Tropaeolum majus
	Potyviridae	*Potyvirus*	*Watermelon mosaic virus*
			Caesalpinia echinata
			Citrullus lanatus
			Cucumis melo
			Cucurbita moschata
			Cucurbita pepo* var. *Caserta
			Cybistax antisyphilitica
	Potyviridae	*Potyvirus*	*Yam mild mosaic virus*
			***Dioscorea* spp.**
	Potyviridae	*Potyvirus*	*Yam mosaic virus*
			***Dioscorea* spp.**
	Potyviridae	*Potyvirus*	*Zucchini yellow mosaic virus*
			Benincasa hispida
			Caesalpinia echinata
			Cayaponia tibiricae
			Citrullus lanatus
			Cucumis anguria
			Cucumis melo
			Cucumis sativus
			Cucurbita pepo* var. *Caserta
			Cybistax antisyphilitica

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Luffa cylindrica
			Sicana odorífera
			Trichosanthes cucumerina
	Potyviridae	*Tritimovirus*	*Wheat streak mosaic virus*
			Triticum aestivum
	Potyviridae putative		Elephant grass mosaic virus
			Pennisetum purpureum
	Potyviridae putative		Cotylendon Y virus
			Cotyledon orbiculata
	Potyviridae putative		Senna virus Y
			Cassia macranthera
			Cassia sylvestris
	Potyviridae putative		*Potyviridae unidentified*
			Allium ascalonicum
			Alternanthera tenella
			Centrosema pubescens
			Chrysanthemum frutescens
			Cichorium intybus
			Clitoria ternatea
			***Commelina* spp**
			***Crinum* sp.**
			Crotalaria juncea
			Cucurbita pepo* var. *Caserta
			Digitaria sanguinalis
			Heliconia stricta
			Hypochaeris brasiliensis
			***Impatiens* spp.**
			Kalanchoë sp.
			Macroptilum atropurpureum
			Paspalum conjugatum
			Phaseolus vulgaris
			Pogostemum patchouly
			Rhoe discolor
			Stylosanthes guianensis
			Stylosanthes scabra
			***Tulipa* sp.**
-----	*Reoviridae*	*Fijivirus*	*Mal de Rio Cuarto virus*
			Zea mays
	Reoviridae	*Fijivirus*	*Pangola stunt virus*
			Digitaria decumbens
	Reoviridae putative		Cassava frogskin disease associated virus
			Manihot esculenta
	Reoviridae putative		Grapevine Cabernet sauvignon virus
			Vitis vinifera
-----	*Solemoviridae*	*Sobemovirus*	*Papaya lethal yellowing virus*
			Carica papaya
	Solemoviridae	*Sobemovirus*	*Southern bean mosaic virus*
			Glycine max

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Phaseolus vulgaris
	Solemoviridae	*Sobemovirus*	*Sowbane mosaic virus*
			Chenopodium murale
-----	*Tombusviridae*	*Alphacarmovirus*	*Carnation mottle virus*
			Dianthus caryophyllus
	Tombusviridae	*Alphanecrovirus*	*Tobacco necrosis virus A*
			Bidens pilosa
			Brassica oleracea* var. *gemmifera
			Carica papaya
			Fragaria x ananassa
			Helianthus annuus
			Manihot esculenta
			Nicotiana tabacum
			Pogostemum patchouly
			Solanum lycopersicum
	Tombusviridae	*Alphanecrovirus putative*	Squash necrosis virus
			Cucurbita pepo
	Tombusviridae	*Betacarmovirus*	*Hibiscus chlorotic ringspot virus*
			Hibiscus rosa sinensis
	Tombusviridae	*Umbravirus putative*	Papaya meleira virus 2
			Carica papaya
-----	*Totiviridae*	*Totivirus putative*	Papaya meleira virus
			Carica papaya
-----	*Virgaviridae*	*Furovirus*	*Soil-borne wheat mosaic virus*
			Triticum aestivum
	Virgaviridae	*Hordeivirus*	*Barley stripe mosaic virus*
			Hordeum vulgare
	Virgaviridae	*Tobamovirus*	*Hibiscus latent Fort Pierce virus*
			Hibiscus rosa-sinensis
	Virgaviridae	*Tobamovirus*	*Odontoglossum ringspot virus*
			Orchid (several genera)
	Virgaviridae	*Tobamovirus*	*Pepper mild mottle virus*
			Caesalpinia echinata
			Capsicum annuum
			Capsicum frutescens
			Couroupita guianensis
			Eriotheca pubescens
			Matayba ealeagnoides
			Psycothria mapourioides
			Sclerolobium melinonii
	Virgaviridae	*Tobamovirus*	*Sunn-hemp mosaic virus*
			Cicer arietinum
			Crotalaria juncea
	Virgaviridae	*Tobamovirus*	*Tobacco mosaic virus*
			Caesalpinia echinata
			Capsicum annuum
			Dieffenbachia amoena

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Impatiens hawkeri
			Nicotiana tabacum
			Petunia x hybrida
			Solanum lycopersicum
			Zinnia elegans
	Virgaviridae	*Tobamovirus*	*Tomato mosaic virus*
			Capsicum annuum
			***Hemerocallis* sp.**
			Solanum lycopersicum
	Virgaviridae	*Tobamovirus*	*Tomato mottle mosaic virus*
			Solanum lycopersicum
	Virgaviridae	*Tobamovirus putative*	*Tobamovirus (unidentif.)*
			***Calibrachoa* sp.**
			Ocimum basilicum
			Physalis angulata
			Rhoe discolor
			***Torenia* sp.**
			***Verbena* sp.**
	Virgaviridae	*Tobravirus*	*Pepper ringspot virus*
			Capsicum annuum
			Cynara scolymus
			Eustoma grandiflorum
			Gerbera jamesonii
			Gloxinia sylvatica
			Pogostemum patchouly
			Solanum lycopersicum
			Solanum tuberosum
			Solanum violifolium
	Virgaviridae	*Tobravirus*	*Tobacco rattle virus*
			Solanum tuberosum
DNA plant viruses			
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Banana streak OL virus*
			***Musa* spp.**
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Bougainvillea chlorotic vein banding virus*
			Bougainvillea glabra
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Dioscorea bacilliform AL virus*
			***Dioscorea* spp.**
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Piper yellow mottle virus*
			Piper nigrum
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Schefflera ringspot virus*
			Schefflera actinophylla
Ortervirales	*Caulimoviridae*	*Badnavirus*	*Sugar cane bacilliform IM virus*
			Saccharum officinarum
Ortervirales	Caulimoviridae	*Badnavirus*	*Sugar cane bacilliform MO virus*
			Saccharum officinarum
	Caulimoviridae	*Badnavirus putative*	Sugar cane bacilliform BB virus
			Saccharum officinarum
	Caulimoviridae	*Badnavirus putative*	Sugar cane bacilliform Kerala

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Saccharum officinarum
	Caulimoviridae	*Badnavirus putative*	*Badnavirus (unident.)*
			Yucca elephantipes
Ortervirales	*Caulimoviridae*	*Caulimovirus*	*Cauliflower mosaic virus*
			Brassica oleracea, B. rapa
			Brassica napus
			Matthiola incana
			Nasturtium officinale
			Sinapsis alba
Ortervirales	*Caulimoviridae*	*Caulimovirus*	*Dahlia mosaic virus*
			Dahlia variabilis
Ortervirales	*Caulimoviridae*	*Caulimovirus*	*Strawberry vein banding virus*
			Fragaria x ananassa
	Caulimoviridae	*Caulimovirus putative*	*Caulimovirus (Unidentif.)*
			Beta vulgaris* L. var. *cicla
			Hibiscus rosa-sinensis
			Psidium guajava
Ortervirales	Caulimoviridae	*Cavemovirus*	*Cassava vein mosaic virus*
			Manihot esculenta
Ortervirales	*Caulimoviridae*	*Cavemovirus*	*Sweet potato collusive virus*
			Ipomea batatas
Ortervirales	*Caulimoviridae*	*Petuvirus*	*Petunia vein clearing virus*
			Petunia x hybrida
-----	*Geminiviridae*	*Begomovirus*	*Abutilon mosaic Brazil virus*
			Abutilon striatum
	Geminiviridae	*Begomovirus*	*Bean golden mosaic virus*
			Galactia striata
			Glycine max
			Macroptilium erythroloma
			Macroptilium lathyroides
			Macroptilium longepedunculatum
			Phaseolus lunatus
			Phaseolus vulgaris
	Geminiviridae	*Begomovirus*	*Blainvillea yellow spot virus*
			Blainvillea rhomboidea
	Geminiviridae	*Begomovirus*	*Centrosema yellow spot virus*
			Centrosema brasilianum
	Geminiviridae	*Begomovirus*	*Chino del tomate Amazonas virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Cleome leaf crumple virus*
			Cleome affinis
	Geminiviridae	*Begomovirus*	*Cnidoscolus mosaic leaf deformation virus*
			Cnidoscolus urens
	Geminiviridae	*Begomovirus*	*Cotton chlorotic spot virus*
			Gossypium hirsutum
	Geminiviridae	*Begomovirus*	*Cowpea golden mosaic virus*
			Vigna unguiculata
	Geminiviridae	*Begomovirus*	*Euphorbia mosaic virus*

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Euphorbia yellow mosaic virus*
			Euphorbia heterophyla
			Glycine max
			Macroptilum atropurpureum
			Phaseolus vulgaris
	Geminiviridae	*Begomovirus*	*Macroptilium yellow spot virus*
			Calopogonium mucunoides
			***Canavalia* sp.**
			Macroptilium lathyroides
			Phaseolus vulgaris
	Geminiviridae	*Begomovirus*	*Melochia mosaic virus*
			***Melochia* sp.**
	Geminiviridae	*Begomovirus*	*Melochia yellow mosaic virus*
			***Melochia* sp.**
	Geminiviridae	*Begomovirus*	*Okra mottle virus*
			Glycine max
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Passionfruit severe leaf distortion virus*
			Passiflora edulis* f. *flavicarpa
	Geminiviridae	*Begomovirus*	*Pavonia mosaic virus*
			***Pavonia* spp.**
	Geminiviridae	*Begomovirus*	*Pavonia yellow mosaic virus*
			***Pavonia* spp.**
	Geminiviridae	*Begomovirus*	*Sida angular mosaic virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida bright yellow mosaic virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida chlorotic mottle virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida chlorotic vein virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida common mosaic virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida golden mosaic Brazil virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida micrantha mosaic virus*
			Abelmoschus esculentus
			Capsicum chinense
			Glycine max
			***Malva* sp.**
			Nicotiana tabacum
			Oxalis latifolia
			Phaseolus vulgaris
			***Sida* spp**
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Sida mosaic Alagoas virus*
			***Sida* spp**

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
	Geminiviridae	*Begomovirus*	*Sida mottle Alagoas virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida mottle virus*
			Glycine max
			***Sida* spp**
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Sida yellow leaf curl virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida yellow mosaic Alagoas virus*
			***Sida* spp**
	Geminiviridae	*Begomovirus*	*Sida yellow net virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Sweet potato leaf curl Sao Paulo virus*
			Ipomea batatas
	Geminiviridae	*Begomovirus*	*Tomato chlorotic mottle virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato golden leaf distortion virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato golden mosaic virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato golden vein virus*
			Capsicum annuum
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato interveinal chlorosis virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato leaf distortion virus*
			Solanum lycopersicum
			Solanum melongena
	Geminiviridae	*Begomovirus*	*Tomato mild mosaic virus*
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato mottle leaf curl virus*
			Solanum lycopersicum
			Solanum melongena
	Geminiviridae	*Begomovirus*	*Tomato rugose mosaic virus*
			Capsicum annuum
			Capsicum baccatum
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato severe rugose virus*
			Campomanesia adamantium
			Canavalia ensiformes
			Capsicum annuum
			Chenopodium album
			Glycine max
			Nicandra physaloides
			Nicotiana tabacum
			Phaseolus vulgaris
			Solanun commersonii
			Solanum lycopersicum

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Solanum tuberosum
	Geminiviridae	*Begomovirus*	*Tomato yellow spot virus*
			Leonurus sibiricus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Tomato yellow vein streak virus*
			Nicandra physaloides
			Solanum lycopersicum
	Geminiviridae	*Begomovirus*	*Triumfetta yellow mosaic virus*
			Triumfetta semitriloba
	Geminiviridae	*Begomovirus unclas.*	"Encarquilhamento"
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Engrujo
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Gaya yellow mosaic virus
			Gaya guerkeana
	Geminiviridae	*Begomovirus unclas.*	Hyptis sp. rugose mosaic virus 1 & 2
			***Hyptis* sp.**
	Geminiviridae	*Begomovirus unclas.*	"Infectious chlorosis of malvaceae complex"
			Abelmoschus esculentus
			Althaea rosea
			Glycine max
			Gossypium hirsutum
			Luehea grandiflora
			Malva parviflora
			Malvastrum coromandelianum
			Oxalis oxyptera
			***Pavonia* spp.**
			Phaseolus vulgaris
			Phenax sonneratii
			***Sida* spp**
			Solanum lycopersicum
			***Triumfetta* sp.**
			Waltheria indica
			***Wissadula* sp.**
	Geminiviridae	*Begomovirus unclas.*	Macroptilium yellow net virus
			Macroptilium lathyroides
	Geminiviridae	*Begomovirus unclas.*	Malvaviscus yellow mosaic virus
			Malvaviscus arboreus
	Geminiviridae	*Begomovirus unclas.*	Okra mosaic Mexico virus
			***Malva* sp.**
	Geminiviridae	*Begomovirus unclas.*	Passion fruit little leaf mosaic virus
			Passiflora edulis f. *flavicarpa*
	Geminiviridae	*Begomovirus unclas.*	Physalis yellow spot virus
			***Physalis* sp.**
	Geminiviridae	*Begomovirus unclas.*	Sida golden yellow mosaic virus
			***Sida* spp**
	Geminiviridae	*Begomovirus unclas.*	Sida yellow spot virus
			***Sida* spp**

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
	Geminiviridae	*Begomovirus unclas.*	Soybean chlorotic spot virus
			Glycine max
	Geminiviridae	*Begomovirus unclas.*	Sweet potato golden vein associated virus
			Ipomea batatas
	Geminiviridae	*Begomovirus unclas.*	Tomato chlorotic vein virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato crinkle virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato crinkle leaf yellows virus
			Macroptilum atropurpureum
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato infectious yellows virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato mild leaf curl virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato mosaic Barbados
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato severe mosaic virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	Tomato yellow mosaic virus
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	"Yellow net"
			Solanum lycopersicum
	Geminiviridae	*Begomovirus unclas.*	*Begomovirus (unident.)*
			Cardiopetalum calophyllum
			Clitoria fairchildiana
			Corchurus hirtus
			Herissantia crispa
			Hibiscus rosa-sinensis
			***Ipomea* sp.**
			Lippia alba
			Macroptilium lathyroides
			Malva parviflora
			Physalis angulata
			Salvia splendens
			***Sida* spp**
			Sidastrum micranthum
			Vigna luteola
	Geminiviridae	*Curtovirus putative*	Brazilian tomato curly top virus
			Acanthospermum hispidum
			Capsicum annuum
			Nicotiana tabacum
			Portulaca oleracea
			Solanum lycopersicum
			Solanum tuberosum
	Genomoviridae	*Gemycircularvirus*	*Odonata associated gemycircularvirus* 1
			Momordica charanthia
	Nanoviridae putative		Temperate fruit decay associated virus

Continuation Table 1.

Realm Riboviria			
Order	***Family***	***Genus***	***Species***
			Malus sp.
			Pyrus communis
			Vitis vinifera
	Putative viral disease -isometric virion		Purple granadilla mosaic virus
			Passiflora edulis
	Putative viral disease -isometric virion		*Mimosa sensitiva* mosaic virus
			Mimosa sensitiva
	Putative viral disease -isometric virion		unidentified
			Beaucarnea recurvata
			Caryocar brasiliense
			***Diascia* sp.**
	Putative viral disease-unknown morphology		Citrus zonate chlorosis
			***Citrus* spp.**
	Putative viral disease-unknown morphology		Citrus cristacortis
			***Citrus* spp.**
	Putative viral disease-unknown morphology		Citrus rumple
			***Citrus* spp.**
	Putative viral disease-unknown morphology		Citrus vein enation
			***Citrus* spp.**
	Putative viral disease-unknown morphology		Citrus leaf curl
			***Citrus* spp.**
	Putative viral disease-unknown morphology		Grapevine LN33 stem grooving
			Vitis vinifera
	Putative viral disease-unknown morphology		Grapevine vein necrosis
			Vitis vinifera
	Putative viral disease-unknown morphology		*Unidentified*
			Cydonia oblonga
			Ruta graveolens
			Senna bicapsularis

****Aeschynanthus pulmer* (Blume) G. Don. (Lipstick plant) Gesneriaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Chlorotic spots on lipstick plant leaves were found to be caused by CMV infection in the state of São Paulo. There is no information regarding losses (1).

Ref.: (1) Alexandre, M.A.V. et al (ed). Plantas Ornamentais: Doenças e Pragas. 319pp. 2008.

****Allamanda cathartica* Schott. (Golden trumpet) Apocynaceae**

Dichorhavirus

***Dichorhavirus* unidentified**

Chlorotic spots were found on leaves of golden trumpet plants in a residential garden in Manaus, AM. Transmission electron microscopy revealed the presence of cytopathic effects characteristics of those caused by nuclear type of *Brevipalpus*-transmitted viruses. This

possible dichorhavirus remains unidentified (1).
Ref.: (1) Rodrigues, J.C.V. et al. Trop. Plant Pathol 33: 12. 2008.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Ringspot symptoms on leaves of golden trumpet plants were observed in SP (1, 2) and DF (3). Flowers tend to drop prematurely in the affected plants. There is no data on losses. The causal agent was identified as CMV, which was transmitted experimentally by mechanical means and by aphids.
Ref.: (1) Silberschmidt, K. & Herbas, R. Zentralbl. Bakt. Parasit. Infektionskrank.Hygiene 123: 330-335. 1969; (2) Alexandre, M.A.V. et al (ed). Plantas Ornamentais: Doenças e Pragas. 319pp. 2008.(3) Rodrigues, M.G.R. et al. Fitopatol.bras. 9: 151-155. 1984.

***Allium ascalonicum* Baker (Green onion) Liliaceae**
Carlavirus and *Potyvirus*
***Carlavirus* and *Potyvirus*, unidentified**
Carlavirus and potyvirus were detected in green onion showing symptoms of chlorotic stripes in São Paulo, SP. These viruses, however, were not identified at species level (1).
Ref.: (1) Colariccio, A. et al. Virus Rev.& Res. (Res. VII ENV p. 281). 1996

***Allium cepa* L. (Onion) Liliaceae**
Orthotospovirus
***Iris yellow spot virus* (IYSV)**
The first report of IYSV infecting onion in Brazil occurred in a sample of onion cv. 'Pêra Baia' from Rio Grande, RS, showing elliptical lesions with chlorotic center and depressed/necrotic margins, referred to as 'sapeca' by growers. Causal agent was identified as a Orthotospovirus (1). Later similar disease was observed in onion fields in Petrolina, PE, also known locally as 'sapeca'. Further works identified the causal Orthotospovirus, distinct from others previously describes in Brazil, as IYSV, originally found infecting *Iris* sp. (2,3). The vector was identified as *Thrips tabaci* (4)
Ref.: (1) de Ávila, A.C. et al. Fitopatol.bras. 6: 535. 1981; (2) Pozzer, L. et al. Fitopatol. Bras. 19: 321, 1994; (3) Plant Dis.83: 345. 1999; (4) Nagata, T. et al. Plant Dis. 83: 399. 1999.
Potyvirus
***Onion yellow dwarf virus* (OYDV)**
The first report of yellow stripe mosaic along the leaf and stunting symptoms in onion was made in Piedade and Santa Cruz do Rio Pardo, SP, and in Belo Horizone, MG. These symptoms were known locally as 'crespeira'. The causal agent was identified as OYDV (1), later confirmed by immunological and molecular techniques (3, 4). There are reports of distinct varietal response in onion infected by OYDV (2)
Ref.: (1) Costa, A.S. et al. Rev.Olericult. 3: 67. 1966; (2) Assis, M.I.T. et al. Fitopatol. Bras. 18: 287. 1993 ;(3) Fitopatol.bras. 20: 469.1995; (4) Muller,N.T.G. & Daniels, J. Fitopatol.bras. 25: 445. 2000.

***Allium fistulosum* L. (Bunching onion) Liliaceae**
Potyvirus
***Onion yellow dwarf virus* (OYDV)**
Stripe mosaic, less severe than that observed in onion, was observed in bunching onion. Plants became chlorotic and less vigorous, and leaves may become curved down. The first report was made in samples from Campinas, SP, and the causal agent, identified as an isolate of OYDV, transmitted by aphids and perpetuated by vegetative reproduction. Infected plants may serve as source of inoculum of OYDV for nearby onion plantations (1).
Ref.: (1) Costa, A.S. et al. O Biológico 37: 158. 1971.

***Allium sativum* L. (Garlic) Liliaceae**
Allexivirus
***Garlic virus A* (GarV-A)**
***Garlic virus B* (GarV-B)**
***Garlic virus C* (GarV-C)**
***Garlic virus D* (GarV-D)**
***Garlic virus X* (GarV-X)**
***Garlic mite-borne filamentous virus* (GarMbFV)**
A complex of these allexviruses was found in garlic samples in several Brazilian states (DF, GO, BA, MG and RS) by molecular detection (1-3).
Ref.: (1) Melo Fo, PA et al. Fitopatol.bras. 26: 535. 2001; (2) Fayad-André, MS. et al. Trop.Plant Pathol. 36: 341. 2011; (3) Oliveira, M.L. et al. Trop.Plant.Pathol. 39: 483. 2014.
Carlavirus
***Garlic common latent virus* (GarCLV)**
Dusi et al. (1) reported the presence of a carlavirus in ca. 60% of the sampled asymptomatic garlic plants, representing several cultivars, in the DF, in a serological survey. The virus was identified molecularly as GarCLV (2), which is part of the viral complex found infecting garlic (3). GarCLV was also found in samples collected at BA and MG (4) and PR and SP (5).
Ref.: (1) (1) Dusi, A.N. et al. Fitopatol.bras. 19: 298. 1994; (2) Fajardo, T.V.M. et al. Virus Rev. & Res. 2: 191. 1997 ; (3) Fitopatol.bras. 26: 619. 2001; (4) Fayad-André, MS. et al. Trop.Plant Pathol. 36: 341. 2011; (5) Mituti, T. Diss.Mestrado, IAC. 2009.
***Shallot latent virus* (SLV)**
First detection of SLV infecting garlic in Brazil was made by RT-PCR assays in samples collected in the states of SP and PR (1).
Ref.: (1) Mituti, T et al. Plant Dis. 95: 227. 2011..
Potyvirus
***Onion yellow dwarf virus* (OYDV)**
***Leek yellow stripe virus* (LYSV)**
Yellow stripe symptoms on garlic leaves were found to be caused by OYDV and/or LYSV infection initially in the state of RS (1). These potyviruses occur usually as a part of a viral complex (poty-, carla- and allexivirus) present in garlic which significantly reduces garlic yield. Attempts to produce virus-free garlic plants resulted in high yields both qualitative- and quantitatively (2). Identification of OYDV and LYSV infecting garlic was made by serological (3, 4) or molecular means (5) in samples from DF. Garlic isolate of OYDV apparently does not infect onion and vice-versa. LYSV has been detected in garlic samples from several parts of Brazil (6). Co-infection of LYSV and OYDV has been found in the states of BA and GO (7), PR, MG and SP (8). Genome of a garlic isolate of LYSV was entirely sequenced (9). Serological assays demonstrated that noble garlics were co-infected by OYDV and allexiviruses, in Itajai, SC (10).
Ref.: (1) Daniels, J. et al. Fitopatol.bras. 2: 82. 1978; (2) Carvalho, M.G. Inf. Agropec. 12: 41. 1986; (3) Assis, M.I.T. et al. Fitopatol. bras. 18: 288. 1993; (4) Dusi, A.N. et al. Fitopatol.bras. 29: 298. 1994; (5) Fajardo, T.V.B. et al. Fitopatol.bras. 26: 619. 2001; (6) Fayad-André,MS et al. Virus Rev. & Res. 14(supl): 60. 2009; (7) Fayad-André, MS. et al. Trop.Plant Pathol. 36: 341. 2011; (8) Mituti, T. Diss. Mestrado, IAC. 2009; (9) Bampi, D. et al. Summa Phytopathol 40 (supl.), CDRom. 2014; (10) Araújo, ER et al. Summa Phytopathol. 44: 195. 2018.

***Alocasia* sp., *Alocasia macrorhizos* (L.) Schott. (Taro) Araceae**
Potyvirus
***Dasheen mosaic virus* (DsMV)**
Surveys made in the Federal District (DF) detected DsMV, by biological assays and electron microscopy, infecting taro (*Alocasia* spp.), exhibiting mosaic symptoms (1).

Ref.: (1) Rodrigues, M.G.R. et al. Fitopatol.bras. 9: 291. 1984.

***Alstroemeria* sp. (Peruvian lily) Alstroemeriaceae**
Orthotospovirus
***Chrysanthemum stem necrosis virus* (CSNV)**
***Tomato spotted wilt virus* (TSWV)**

Peruvian lily plants showing necrotic lines and rings were observed in the city of São Paulo, SP, and found to be infected by CSNV or TSWV (1,2).
Ref.: (1) Duarte, L.M.L. et al. Rev. Bras. Hort. Orn. 5: 24.1999; (2) Duarte, L.M.L. Virus Rev. Res. 6: 50. 2001.
Carlavirus
***Carlavirus* unidentified**

Chlorotic bands on the leaves of Peruvian lily found in São Paulo, SP, was found associated with the presence of an unidentified carlavirus.
Ref.: (1) Seabra , P.V. et al. Arq. Inst. Biol. (supl.) 64: 61. 1997.
Cucumovirus
***Cucumber mosaic virus* (CMV)**

Natural infection of Peruvian lily by CMV was verified in the city of São Paulo, SP, resulting in mosaic, chlorotic spots and bands, as well as thin leaves (1-3).
Ref.: (1) Costa, A.S. Summa Phytopathol. 9: 39. 1983; (2) Duarte, L.M.L. et al. Rev. Bras. Hort. Orn. 5: 24..1999; (3) Tombolato, A.F.C. et al. Cultivo commercial de plantas ornamentais, 22p. 2004.
Ilarvirus
***Tobacco streak virus* (TSV)**

Serological tests found TSV associated to chlorosis, necrotic spots and stripes on the leaves of Peruvian lily in São Paulo, SP (1).
Ref.: (1) Duarte L.M.L. et al. Rev. Bras. Hort. Orn. 5: 24.1999.
Potyvirus
***Alstroemeria mosaic virus* (AlsMV)**

A potyvirus was detected in Peruvian lily with thin leaves, vein banding and color breaking in the flowers in São Paulo, SP (1,2). More recently this virus was identified as AlsMV by RT-PCR (3).
Ref.: **(1)** Alexandre, M.A.V. et al. Res. X Cong. Bras. Floric. Plant. Ornam. 69. 1995; **(2)** Duarte, L.M.L. et al. Rev. Bras. Hort. Orn. 5: 24. 1999; (3) Rivas,E.B. et al. Summa Phytopathol. 39 supl. CDRom. 2013.

***Althaea rosea* Cav. (Common hollyhock) Malvaceae**
Begomovirus
Infectious chlorosis of malvaceae complex (ICMC)

A bright yellow mosaic in common hollyhock was described in São Paulo, SP. The causal agent was transmitted by whitefly and considered as part of ICMC (1,2)
Ref.: (1) Costa, A.S. Phytopathol. Zeit. 24: 97. 1955; (2) Silberschmidt, K. & Tommasi, L.R. Ann. Acad. Bras. Cien. 27: 195. 1955.

***Alternanthera tenella* Colla (Joseph's coat) Amaranthaceae**
Potyvirus
***Potyvirus* unidentified**

Mosaic symptoms in *A. tenella* were noticed in the state of Paraná, associated with an uncharacterized potyvirus, which caused local lesions in *Chenopodium amaranticolor* and *C. quinoa* (1). Serological assays revealed relatioship with PVY but differs in the CP sequence with PVY and other potyviruses (2).
Ref.: (1) Fukushigue, C.Y. et al., Fitopatol.bras. 17: 209. 1992; (2) Fitopatol.bras. 25: 441. 2000.

***Amaranthus sp.* (Amaranth) Amaranthaceae**
Orthotospovirus
***Orthotospovirus* unidentified**

Arching, roughness, vein clearing, chlorotic spots, necrotic rings and curly top symptoms in amaranth were found associated to infection by an unidentified Orthotospovirus in the state of São Paulo (1).
Ref.: (1) Costa, A.S. & Forster, R. Bragantia 2: 83. 1942.
Potyvirus
***Potato virus Y* (PVY)**

Natural infection of amaranth by an isolate of PVY, without mention of symptoms, was reported in the state of Minas Gerais (1).
Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

***Amaranthus spinosus* L. (Spiny amaranth) Amaranhaceae**
Potyvirus
***Zucchini yellow mosaic* (ZYMV)**

During a survey of viruses in cucurbit producing areas in the state of Tocantins, ZYMV was found infecting *A. spinosus*, part of the spontaneous vegetation surrounding cucurbit fields, in the municipality of Lagoa da Confusão (1).
Ref.: (1) Aguiar, R.W.S et al. Planta Daninha 36: :e018171593. 2018.

***Ambrosia elatior* L. (Ragweed) Asteraceae**
Polerovirus
***Potato leafroll virus* (PLRV)**

There is a report of infection of ragweed by PLRV in the state of Minas Gerais, without details of the symptoms (1).
Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996

***Ambrosia polystachya* DC, Asteraceae**
Ilarvirus
***Tobacco streak virus* (TSV)**

A case of natural infection of *A. polystachya* by TSV was reported in the state of São Paulo, resulting in mosaic symptoms. This is the only successful case of TSV transmission by the thrips *Frankliniella* sp., collected in the flowers from TSV-infected *A.polystachya* to tobacco and soybean. (1, 2).
Ref.: (1) Costa, A.S. & Lima No., V.C. Fitopatologia 11: 11. 1976; (2) Lima No., V.C. et al. Rev. Setor Cien.Agr.UFPr 4: 1. 1982.

***Amorphophallus konjac* K. Koch (Konjac) Araceae**
Potyvirus
***Dasheen mosaic virus* (DsMV)**

Yellowing, mosaic and poor root development of cultivated konjac plants was verified in the state of São Paulo. Serological assays and electron microscopy identified DsMV as the causal agent of the disease (1).
Ref.: (1) Chagas, C.M. et al. Fitopatol.bras. 18: 551. 1993.

***Ampelopsis heterophylla* Blume (Porcelain berry) Vitaceae**
Hostuviroid
***Hop stunt viroid* (HSVd)**

Molecular assays detected HSVd infecting porcelain berry during a survey of viroids in grapes (1).
Ref.: (1) Fajardo, T.V.M. et al. Australasian Plt.Dis.Notes 13: 3. 2018.

***Ananas comosus* (L.) Merr. (Giant pineapple) Bromeliaceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**

Chlorotic streaks on the leaves of Giant pineapple were associated with an unidentified nucleorhabdovirus, detected by electron microscopy. This anomaly was found in Tarauacá, AC, without further information about incidence or losses (1).
Ref. (1) Kitajima, E.W. et al. Phytopahtol. Zeit. 82: 83. 1975.

***Ananas sativus* Schult. (Pineapple) Bromeliaceae**
Ampelovirus

***Pineapple mealybug associated wilt virus* (PMWaV 1, 2, 3)**

Infection of pineapple plants by PMWaV 1 e 2 results in symptoms as leaf reddening, leaves with yellow edge, downward curling of leaf edge and drying of the leaf extremity. Plants have reduced roots and are easily pulled out. Wilting of plants occurs and may end with their death. PMWaVs are mealybug –transmitted, but not mechanically or through seeds, being pineapple their sole host plant, and the disease is wide-spread wherever pineapple is cultivated. Control of the mealybug vectors and ants associated to them and production of virus-free plants are the proposed control measures for the disease (1). First identification of these viruses in Brazil was made in the state of Bahia, based on symptomatology and electron microscopy (2). PMWaV-1 e 2 were detected in the state of Espirito Santo (3), Paraiba and Paraná (4) PMWaV-2 and 3 in the state of Rio Grande do Sul (4); PMWaV-1, 2, 3 in the states of Bahia, Minas Gerais, Mato Grosso and Pará (4). These viruses were originally classified as *Closterovirus*, but now are reclassified to the genus *Ampelovirus* (5).

Ref.: (1) Sanches et al. Murcha associada a cochonilha. *In* Reinhard, D.H. et al. (Ed.) Abacaxi produção- aspectos técicos. Embrapa Mandioca e Fruticultura. Comumicação para transferência de tecnologia. p.62. 2000; (2) Nickel, O. et al. Fitopat'ol.Bras. 25: 200. 2000; (3) Peron, FN et al. Trop Plat Pathol 34(supl): S267. 2009; (4) Santos, K.C. Diss.MS Univ.Fed.Rec.Bahiano 60p. 2013; (5) Mayo, M.A. Arch. Virol. 147. 2002.

***Andira vermifuga* Mart. Ex Benth. Fabaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

A serological survey detected CMV in seedlings of *A. vermífuga* in a nursery in Brasília, DF (1).

Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40(supl): res.354.2. 2015.

***Angelonia* sp. (Angelonia) Plantaginaceae**

Potexvirus

***Althernanthera mosaic virus* (AltMV)**

AltMV-infected angelonia plants, exhibiting mosaic symptoms, were found in São José do Rio Preto, SP (1).

Ref.: (1) Alexandre, M.A.V. et al. Trop.Plant Pathol. 33 (supl): S291. 2008.

***Anonna muricata* L. (Soursop) Anonnacea**

Cytorhabdovirus unclassified

Soursop yellow blotch virus (SYBV)

Plants of cultivated soursop, showing yellow blotches on their leaves, were found in Pacajús, CE. A mechanically transmissible cytorhabdovirus was identified as the causal agent of the disease being able to infect soursop and other annonacea plants experimentally (1). The virus was purified and partially characterized molecularly, but it is still unclassified (2). Epidemiological studies suggest a contagious type of disease dispersion (3). Under experimental conditions, SYBV-infected plants had significative reduction on plant size (ca. 60% in height and 40% in trunk diameter) and in fruit yield (ca. 90% in fruit number and weight) (3).

Ref.: (1) Kitajima, E.W. et al. Plant Dis. 72: 276. 1993; (2) Martins, C.R.F. et al. Fitopatol. Bras. 24: 410. 1999; (3) Santos, A.A. et al. Rev.Cien.Agron. 34: 19. 2003; (4) Santos, A.A. et al. Summa Phytopathol.30: 90. 2007.

Dichorhavirus

***Clerodendrum* chlorotic spot virus (ClCSV)**

Soursop plants showing yellow spots on the leaves were found in a backyard orchard in Catanduva, SP, associated with infestation by *Brevipalpus* mites. It resembled the description of similar symptoms made by Bitancourt, in 1955 (1). Ultrastructural analysis of the chlorotic lesions revealed the presence of cytopathic effects similar to that caused by the nuclear type of *Brevipalpus*-transmitted viruses (2). Similar symptoms were reproduced by experimental mite-infection by the ClCSV (3).

Ref.: (1) Bitancourt, A.A. Arq.Inst.Biol. 22: 161. 1955; (2) Kitajima, E.W. et al. Exp.Appl.Acarol. 30: 135. 2003; (3) Kitajima, E.W. et al. Scientia Agricola 63: 36. 2008.

***Anthurium* sp., *A. andreanum* Lind., *A. scherzerianum* Schott. (Anthurium) Araceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV was detected associated to mosaic symptoms on leaves of anthurium in Mogi das Cruzes, SP (1).

Ref: **(1)** Miura, NS. et al. Summa Phytopathol 35:(supl) res. 043 CDRom 2009.

Cilevirus

***Cilevirus* unidentified**

Samples of anthurium plants showing ringspots on their leaves, coming from Cruz das Almas, BA, were examined by electron microscopy. Typical cytopathic effects caused by cilevirus were observed in the tissues of affected leaf parts, suggesting that the causal agent was a cytoplasmic type of *Brevipalpus*-transmitted virus, a possible member of the genus *Cilevirus* (1).

Ref.: **(1)** Ferreira, P.T.O. et al. Virus Rev. Res. 9: 249. 2004.

Potyvirus

***Dasheen mosaic virus* (DsMV)**

DsMV was found in anthurium from several commercial plantations in São Paulo, SP. The virus was detected by ELISA in anthurium plants showing leaf deformation, chlorotic and ringspots and necrotic streaks (1-4).

Ref.: (1) Rivas, E.B. et al. Virus Rev.Res. 2: 192. 1997. (2) Lima et al. Fitopatol.bras. 29: 105. 2004; (3) Tombolato, A.F.C. et al. Boletim Técnico, 194, 47p. 2002.. (4) Tombolato, A.F.C. et al. (Ed.) Cultivo commercial de plantas ornamentais. p61. 2004.

***Apium graveolens* L. (Celery) Apiaceae**

Ilarvirus

***Tobacco streak virus* (TSV)**

Celery plants cv. 'Americano Dourado' were found with general yellowing and/or chlorotic spots on their leaves, in Mogi das Cruzes, SP. General yellowing was considered a varietal characteristic but the yellow spots were attributed to the infection by TSV. Comparative infection assays revealed differences in TSV susceptibility among the several tested cultivars. (1).

Ref.: (1) Costa, A.S. Summa Phytopathol. 14: 57. 1988

Potyvirus

***Celery mosaic virus* (CeMV)**

Bright yellow mosaic and reduction in the plant size were observed in cultivated celery in the state of São Paulo. Electron microscopy indicated the presence of a possible potyvirus, which induced a characteristic large, fibrous nuclear inclusion. It was transmitted mechanically to celery and several assay plants and was named Celery yellow mosaic virus (1). It was also transmitted by aphids and was able to infect some other apiaceae plants (2,3). The virus was also found in the Federal District and states of Rio de Janeiro (4) and Paraná (5). It is serologically related to the *Celery mosaic virus* (CeMV) described in Europe, being possibly an isolate (6). It was also found infecting naturally parsley in Piracicaba, SP (7). A large scale comparison of genomes of other apiaceae potyviruses indicated a close similarity with a virus found in wild *Daucus* from Australia, considered CeMV, also inducing nuclear fibrous inclusion (8).

Ref.: (1) Kitajima, E.W. & Costa, A.S. Bragantia 27: VII; IX. 1968;

(2) Oliveira, M.L. & Kitajima, E.W. Fitopatol. Bras. 6: 35. 1981; (3) Oliveira, M.L. et al. Fitopatol.bras. 6: 57. 1981; (4) 6: 105. 1981; (5) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984; (7) Novaes, Q.S. et al. Summa Phytopathol. 26: 250. 2000; (8) Moran, J. et al. Arch. Virology 147: 1855. 2002.

***Arachis hypogaea* L. (Groundnut, peanut) Fabaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

GRSV was detected by immunoassays in accessions of *Arachis* sp., used as green coverage in the Carpina Experimental Station of the UFRPe (1). A high incidence of groundnut plants with mosaic, ringspots, necrosis and reduction of the leaf size was noticed in a commercial plantation in Itapolis, SP. The causal agent was identified as GRSV based on laboratory assays (electron microscopy, RT-PCR, biological assays) (2).

Ref.: (1) Andrade, G.P. et al. Fitopatol.bras. 28: S246. 2003; (2) Camelo-Garcia, V.M. et al. J.Gen.Plt.Pathol. 80: 282. 2014.

***Tomato spotted wilt virus* (TSWV)**

Symptoms of top necrosis, rosette at the stem's end, reduced size of plants, leaves with mosaic and ringspots were observed in an experimental plot of Instituto Agronomico, in Campinas, SP, and attributed to infection by TSWV (1). A confirmation of the virus identity was achieved later using serology and molecular techniques (2).

Ref.: (1) Costa, A.S. O Biológico 7: 248. 1941; Bragantia 10: 67. 1950: (2) Andrade, G.P. et al. Fitopatol. Bras. 21: 421. 1996

Potyvirus

***Bean yellow mosaic virus* (BYMV)**

A mild mosaic in groundnut caused by an isolate of BYMV, which was severe to bean plants, was identified in the state of S.Paulo (1).

Ref.: Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). p. 305. 1972;

***Cowpea aphid-borne mosaic virus* (CABMV)**

Groundnut plants showing mosaic symptoms were observed in the state of Paraiba, and initially considered cause by *Peanut stripe virus* (isolate of *Bean common mosaic virus*) (1). However, following works identified the virus as CABMV (2).

Ref.: (1) Pio Ribeiro, G.P. et al. Fitopatol.bras. 19: 329. 1994; (2) Andrade, G.P. et al. Fitopatol.bras. 24: 261. 1999.

***Peanut mottle virus* (PeMoV)**

An aphid-borne and mechanically transmissible potyvirus was found associated with symptoms of mosaic or mottling on groundnut leaves in the states of São Paulo (1, 3) and Paraíba (2). The causal virus was identified as PeMoV.

Ref.: (1) Costa, A.S. & Kitajima, E.W. Fitopatologia 9: 48. 1974; (2) Pio Ribeiro, G.P. et al. Fitopatol.bras. 19: 329. 1994; (3) Andrade, G.P. et al. Fitopatol. bras. 21: 421. 1996

***Arachis pintoi* Krapov &Gregory (Pinto peanut) Fabaceae**

Carlavirus

***Cowpea mild mottle virus* (CMMV)**

An isolate of CMMV was found infectig *A.pintoi*, in the state of Paraná (1).

Ref.: (1) Mituti, T. et al. An.Jornada Acad.Embrapa Soja. 2005.

Potyvirus

***Peanut mottle virus (*PeMoV)**

Pinto peanut plants of an experimental plot of Embrapa Cerrados (Planaltina, DF) appeared with chlorotic ringspot on their leaves. Biological and serological assays, complemented by electron microscopy identified the causal agent as PeMoV (1).

Ref.: (1) Anjos, J.R.N. et al. Fitopatol.bras. 23: 71. 1998

***Arachis repens* Handro (Creeping peanut) Fabaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Creeping peanut plants showing mosaic and ringspot on their leaves were found in a garden in Brasília, DF. Causal agent was identified as CMV based on biological, immuno, molecular assays and electron microscopy (1).

Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 29. 2003.

***Armoracia rusticana* G. Gaertn., B. Mey.& Scherb. (Horseradish) Brassicaceae**

Carlavirus

***Cole latent virus* (CoLV)**

Horseradish plants showing mosaic symptoms, found in Divinolândia, SP, was found to be coinfected by *Turnip mosaic virus*- TuMV (potyvirus) and CoLV (1).

Ref.:(1) Eiras,M. et al. Trop.Plant Pahol. 33(supl): S250. 2008.

Potyvirus

***Turnip mosaic virus* (TuMV)**

TuMV was found naturally infecting horseradish, producing mosaic symptoms in Divinolândia, SP (1).

Ref.: (1) Eiras, M. et al. Summa Phytopathol. 33 (supl): S45. 2007.

***Arracacia xanthorhiza* Bancoft ("White carrot") Apiaceae**

Cytorhabdovirus

***Cytorhabdovirus* unidentified**

A still unidentified cytorhabdovirus was found by NSG assay in a sample of *A. xanthorhiza* from the germplasm bank of Embrapa Hortaliças (Brasília, DF). It was phylogenetically close to the *Alfalfa dwarf virus*- ADV (1).

Ref.: (1) Gomes, S.S. et al. Virus Review & Res. 21: 142. 2016.

Vitivirus

***Arracacha virus V* (ArVV)**

A possible new vitivirus was found in *A. xanthorhiza,* from the Germplasm Bank of Embrapa Hortaliça (Brasília, DF) by NGS. It is not associated with external symptoms and no evidence of transmission is available (1). This virus had its entire genome sequenced and revealed to be a new species in the genus vitivirus, and the name Arracacha virus V has been suggested (2).

Ref.: (1) Oliveira, L.M. et al. Virus Review & Res. 21:130. 2016; ; (2) Oliveira, L.M. et al. Arch.Virol. 162: DOI 10.1007/s00705-017-3326-0.2017.

Closterovirus

***Arracacha virus 1* (AV-1)**

NSG of samples of *A. xanthorhiza* from the Germplasm Bank of Embrapa Hortaliças (Brasília, DF) detected a still unidentified closterovirus. It seems closely related to the *Beet yellows virus*- BYV and to the *Grapevine leafroll-associated virus 2*- GLRaV-2) (1,2). Complete sequencing of the genome of this virus revealed that it is distinct from known closteroviruses, hence the name AV-1 is being proposed (3).

Ref.: (1) Costa, G.A. et al. Virus Review & Res. 21: 138. 2016; (2) Oliveira, L.M. et al. Arch.Virol. 162: 2141. 2017; (3) Orílio, A.F. et al. Arch.Virology 163: 2547. 2018.

Potyvirus

***Arracacha mottle virus* (ArMoV)**

A mosaic affecting *A. xanthorhiza* was observed in experimental field of Embrapa Hortaliça (Brasília, DF). Further studies indicated that it was caused by a still undescribed species of potyvirus (1). Its complete genome was sequenced and the virus named ArMoV (2).

Ref. (1) Orílio, A.F. et al. Fitopatol.bras. 32 (supl): S194. 2007. Orílio, A.F. et al. Arch.Virol. 158:291. 2013.

***Bidens mosaic virus* (BiMV)**

BiMV was found naturally infecting *A. xanthorhiza* causing mosaic symptoms in the experimental field of Embrapa Hortaliça (Brasília, DF) (1).
Ref.: (1) Orílio, A.F. et al. Plant.Dis. 101: 262. 2017.

***Asclepias curassavica* L. (Milkweed) Apocynaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Chlorotic spots and bands were observed in leaves of milkweed in a sample collected at Itaquera, SP. Causal agent was identified as CMV (1).
Ref.: (1) Silberschmidt, K. Plant Dis.Reptr. 39: 555. 1955.

***Avena sativa* L. (Oat) Poaceae**
Luteovirus
***Barley yellow dwarf virus PAV* (BYDV-PAV)**
General chlorosis and stunting in oats was identified as being caused by aphid-borne BYDV-PAV. The disease was registered in the states of Rio Grande do Sul (1, 2) and Paraná (3). Yield losses were evaluated in the state of Rio Grande do Sul (4).
Ref.: (1) Deslandes, J. Agros 2 (2): 88. 1949; (2) Caetano, V.R. Rev. Soc.Bras.Fitopatol. 2: 53. 1968; Tese Doutorado, ESALQ/USP, 75p. 1972; (3) Barbosa, C.J. et al. Fitopatol.bras. 18: 292. 1993; (4) Nicolini, F. et al. Fitopatol.bras.27: S210. 2002.

B

***Bambusa vulgaris* Schrad. (Bamboo) Poaceae**
Potexvirus
***Bamboo mosaic virus* (BaMV)**
Chlorotic spots and mosaic symptoms were observed in bamboo plants, without apparent damage, in a botanical collection at the Biological Expt. Sta. of the Universidade de Brasília. Biological assays and electron microscopy detected a potexvirus, name BaMV (1). It was subsequently purified and a specific antiserum was produced (2). The virus was afterwards found in Taiwan where was causing losses in bamboo shoot production (3).
Ref.: (1) Kitajima, E.W. et al. Phytopathol.Zeit. 90: 180. 1977; (2) Lin, M.T. et al. Phytopathology 67: 1439. 1977; (3) Lin, N.S. et al., Plant Dis. 77: 448. 1993.

***Beaucarnea recurvata* Lem. (Ponytail palm) Dracenaceae**
Unidentified isometric virus
Mosaic symptoms in ponytail palm was associated with the presence of unidentified isometric viruslike particles in leaf extracts (1).
Ref.: **(1)** Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95. 2010.

***Beaumontia grandifolia* Wall. (Easter lily vine) Apocynaceae**
Cilevirus
***Cilevirus* unidentified**
Green spots on senescent leaves of *B. grandifolia* were observed in the campus of the Agricultural College (ESALQ) of the Universidade de São Paulo, Piracicaba, SP, associated with the presence of *Brevipalpus* mites. Electron microscopy revealed cytopathic effects caused by the cytoplasmic type of *Brevipalpus*-transmitted virus, suggesting infection by an unidentified cilevirus. (1)
Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 32 (supl): 11. 2006.

***Benincasa hispida* (Thunb.) Cogn. (Wax gourd), Cucurbitaceae**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
Wax gourd plants exhibiting mosaic and crinkle on their leaves were observed in an experimental field of the Universidade Federal de Minas Gerais. The plant was found to be infected by ZYMV after biological and serological assays (1).
Ref.: (1) Rocha, F.D.S. et al. Trop.Plt.Pathol. 38 (supl.): res. 376-1. 2013.

***Beta vulgaris* L. var. *cicla* (Chard) Amaranthaceae**
Cytorhabdovirus
***Cytohabdovirus* unidentified**
Caulimovirus
***Caulimovirus* unidentified**
Stunting, leaves with vein clearing and necrotic spots were observed in a commercial plantation of chard in Piedade, SP. Electron microscopy revealed the presence of a cytorhabdovirus and caulimovirus, based on their morphology. Identity of these presumed viruses was not determined. (1).
Ref. : (1) Chagas, C.M. et al. Fitopatol.bras. 24: 466. 1999.
Potyvirus
***Turnip mosaic virus* (TuMV)**
Natural infection of chard by TuMV was noticed in the state of São Paulo, resulting in mosaic symptoms. Identification was made by biological, serological and molecular assays (1).
Ref.: (1) Ribeiro Jr., M.R. et al. J.Plant Pathol. 100: 189. 2018.

***Beta vulgaris* L., subsp. *vulgaris* (Beet) Amaranthaceae**
Benyvirus
***Beet necrotic yellow vein virus* (BNYVV)**
In november, 2012, during a survey made in the region of São José do Rio Pardo, SP, table beet plants showing severe symptoms of rhizomania (excessive growth of the root system), without obvious symptoms in the aerial parts, were found. RT-PCR assays using specific primers for BNYVV produced nucleotide fragments, with 93-97% identity with BNYYV type A, described in the literature. The virus was able to be transmitted through contaminated soil (1). The soil fungus *Polymyxa betae* was found in the soil where BNYVV-infected plants occurred, and experimentally demonstrated to vector BNYYV (2).
Ref.: (1) Rezende, JAM et al. Plant Dis. 99: 423. 2015; (2) Camelo-Garcia,V. et al. Cong.Paul. Fitopat. res.94, 2017.

***Bidens pilosa* L. (Beggar's ticks) Asteraceae**
Orthotospovirus
***Orthotospovirus* unidentified**
A report was made on the infection of *B. pilosa* by an unidentified Orthotospovirus in the state of São Paulo, without reference to symptomatology (1).
Ref.: (1) Costa, A.S. & Forster, R. Bragantia 2: 83. 1942.
Nucleorhabdovirus
***Sowthistle yellow vein virus* (SYVV)**
A nucleorhabdovirus was recovered from *B. pilosa* with stunting and large foliar blades in Brasília, DF. It was mechanically transmissible to several assay plants, including lettuce. Based on similarity of the host range and immunoassays with specific antiserum the virus was identified as an isolate of SYVV (1, 2).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 16: 141. 1991; (2) Res. 13º Coloq. Soc. Bras. Mic.Elet. p.59. 1991.
Dichorhavirus
***Dichorhavirus* unidentified**
B. pilosa with chlorotic spots on the leaves were found in a residential garden in Manaus, AM, during a survey. Electron microscopy of the lesion tissues revealed cytopathic effects similar to those caused by dichorhaviruses, which was not identified (1).
Ref.: (1) Rodrigues, J.C.V. et al., Trop.Plant Pathol. 33: 12. 2008.
Polerovirus

***Potato leafroll virus*- PLRV**

Natural infection of *B. pilosa* by PLRV was reported in the state of Minas Gerais, without references to the symptoms (1).

Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

Potyvirus

***Bidens mosaic virus* (BiMV)**

B. pilosa plants were found showing mosaic symptoms in the state of São Paulo. Symptoms were result of an infection by a new potyvirus species as indicated by biological and serological assays and electron microscopy, named BiMV (1). It causes similar symptoms of another potyvirus described in Florida, US (*Bidens mottle virus*- BiMoV) but these viruses are considered different species of potyvirus. BiMV may occasionally be found infecting cultivated plants and ornamentals. It is aphid-borne, and mechanically transmissible. It was also detected in Brasília, DF (3). Analysis of the nucleotide sequence of the coat protein gene of a BiMV isolated from pea suggests that BiMV may be an isolate of PVY (4). However, complementary genome analysis demonstrated that BiMV and PVY are distinct viruses (5).

Ref.: (1) Kitajima, E.W. et al. Bragantia 20: 503. 1961; (2) Kuhn, G.B. et al. Fitopatol.bras. 5: 39. 1980; (3) 7: 185. 1982; (4) Dutra, S.L. et al. Virus Rev.& Res. 9: 252. 2004; (5) Sanches, M.M. et al. Arch.Virol. 159: 2181. 2014.

***Potato virus Y* (PVY)**

PVY was found infecting naturally *B. pilosa* in the state of Minas Gerais, without reference to the symptom (1).

Ref.: (1) Oliveira, C.D. et al. Fitipatol.bras. 21: 427. 1996.

Alphanecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from roots of asymptomatic *B. pilosa* growing in greenhouse of Instituto Agronomico, Campinas, SP (1).

Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960.

****Blainvillea rhomboidea* Cass. Asteraceae**

Begomovirus

***Blainvillea yellow spot virus* (BlYSV)**

Golden mosaic and stunting in plants of *B. rhomboidea* were observed in the state of São Paulo, and considered a whitefly transmitted virus (1). It was also observed in the state of Pernambuco (2). A begomovirus, tentatively identified as BlYSV was isolated in Coimbra, MG, possibly distinct from other known begomoviruses, and possibly similar to the causal agent of previous descriptions (3).

Ref.: (1) Costa, A.S. Summa Phytopathol. 4: 13. 1978; (2) Lima, G.S.A. et al. Virus Rev.& Res. 6: 158. 2001 ; (3) Castillo Urquiza, G.P. et al. Arch.Virol. 153: 1985. 2008.

****Boerhavia coccinea* Mill. (Scarlet spiderling) Nyctaginaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

B. coccínea plants growing near groundnut fields in Campina Grande, PB, were found showing vein clearing, mosaic and leaf deformation. Serological assays indicated that these plants were infected by GRSV, and may serve as its reservoir for the groundnut crop (1).

Ref.: (1) Andrade, G.P. et al. Fitopatol.bras. 24: 358. 1999.

****Bougainvillea glabra* Choisy; *B. spectabilis* Willd. (Bouganvillea) Nyctaginaceae**

Badnavirus

***Bougainvillea chlorotic vein banding virus* (BCVBV)**

Badnavirus-like particles were found by electron microscopy in bougainvillea samples from Campinas, SP, showing mottling and chlorotic spots (1). PCR assays performed from total DNA extracts from these samples, amplified a fragment of 465 nt, using specific primers for badnaviruses. Sequence analysis revealed that this badna virus from bougainvillea represented a new species and named BsCVB (2,3). A similar virus was detected in bougainvillea from the campus of ESALQ/USP in Piracicaba, SP (4) which was transmitted by the mealybug *Planococcus citri* (5). Sequence comparison of isolates from the state of São Paulo indicated that they differ from those collected in Andradas and Uberlândia, state of Minas Gerais and Brasília, DF (6). There are reports of the presence of BsCVB in the region of Seropédica, RJ and Ourinhos, SP (7).

Ref.: (1) Chagas, C.M. et al. Virus Rev. Res. 6: 153. 2001; (2) Alexandre, M.A.V. et al. Fitopatol.bras. 29 (supl.): S 150. 2004. ***(3)*** Rivas, E.B. et al. J. Gen.Plant Pathol 71: 438. 2005; (4) Yamashita, S. et al. Summa Phytopathol. 30: 68. 2004; (5) Kuniyuki, H. et al. Summa Phytopathol. 32 (supl.): S20. 2006; (6) Alexandre et al. Summa Phytopathol 38 (supl.) CDRom 2012; (7) Brioso, P.S.T. Virus Rev.&Res. 17 (supl.). 346. 2012.

****Bouvardia* sp. (Bouvardia) Rubiaceae**

Orthotospovirus

***Chrysanthemum stem necrosis virus* (CSNV)**

***Tomato chlorotic spot virus* (TCSV)**

***Tomato spotted wilt virus* (TSWV)**

Chlorotic mosaic symptoms were observed on the leaves of bouvardia in São Paulo, SP. Following studies by biological and serological assays and electron microscopy revealed that these plants were co-infected by the Orthotospoviruses TSWV e CSNV (1). In another sample with mild mosaic, also from São Paulo, infection by TCSV was confirmed (2).

Ref.: (1) Seabra, P.V. et al. Virus Rev. Res. 5: 197. 2000.; **(2)** Rivas, E.B. et al. Virus Rev.& Res. 7: 22. 2002 .

****Brachiaria* sp. (Signalgrass) Poaceae**

Waikavirus

***Maize chlorotic dwarf virus* (MCDV)**

Mosaic symptoms were observed in signalgrass plants in an experimental plot at Embrapa Gado de Corte, Campo Grande, MS. Molecular assays detected MCDV associated with these symptoms (1).

Ref.: (1) Silva, K.N. et al. Virus Rev & Res.20 (supl.): 211.2015.

Potyvirus

***Johnson grass mosaic virus* (JGMV)**

Samples with suspected viral infection, collected during surveys made in the Germplasm Bank of Embrapa Gado de Corte, Campo Grande, MS, submitted to RT-PCR assays, revealed to be infected by JGMV (1).

Ref.: (1) Schuch, H.C. et al. Virus Rev. & Res. 21: 135. 2016.

****Brassica carinata* A.Br. (Abyssinian cabbage) Brassicaceae**

Potyvirus

***Turnip mosaic virus* (TuMV)**

Some Abyssinian cabbage under experiment for its introduction and adaptation in the Universidade Federal de Uberlândia, MG, considering its high content of vitamin A, appeared with mosaic symptoms. Biological assays and electron microscopy indicated that the symptoms were caused by infection with an isolate of TuMV (1).

Ref.: (1) Rodrigues, F.A. et al. Fitopatol. Bras. 20: 338. 1995

****Brassica oleracea* L. var. *botrytis* L. (Cauliflower); var. *italica* Plenck (Broccoli); var. *gemmifera* DC (Cole); var. *pekinensis* (Chinese cabbage); *B. rapa* L. (Turnip)**

Brassicaceae

Carlavirus

***Cole latent virus* (CoLV)**

CoLV causes latent infection in many cultivated brassicas. Its first report was made on infected cole plants in the state of São Paulo, and detection was made by electron microscopy which showed the presence of elongated and flexuous particles 13 nm x 650 nm (1, 2). Afterwards, CoLV has been detected in the states of Minas Gerais (2) and Federal District (3, 4). The inclusion of CoLV in the genus *Carlavirus* was confirmed by genome sequencing (4). Two Brazilian isolates of CoLV had their genome entirely sequenced (5).

Ref.: (1) Kitajima, E.W. et al. Bragantia 29:181. 1970; (2) Costa, A.S. et al. Rev.Oleric. 12: 82.1972; (3) Costa, C.L. et al. Fitopatologia 9: 49. 1974; (4) Mello, S.C.M. et al. Fitopatol.bras. 12: 352. 1987; (4) Belintani, P. et al. J. Phytopathology 150: 330. 2002; (5) Oliveira, AM. et al. Res.29 Cong.Bras.Virol. 2018.

Potyvirus

***Turnip mosaic virus* (TuMV)**

Initial reports of TuMV infecting brassicas in Brazil were made on cabbage sampled in the state of São Paulo and in chinese cabbage, from Viçosa, MG, and afterward, in several brassicas in the states of Paraná and Federal District (1-5). Type I and II of TuMV were identified in the state of São Paulo (6). TuMV-infected chinese cabbage plants were found in Divinolândia and S.José R.Pardo, SP (7).

Ref.: (1) Silberschmidt, K. & Roston, E. Cien.Cult. 5: 211. 1953; (2) Tokeshi, H. et al. Rev.Olericult. 3: 175. 1963; (3) Costa, A.S. et al. Rev.Oleric. 12: 82. 1972; (4) Lima, M.L.R.Z.C. et al. Rev.Setor Cien. Agr.,UFPR 2: 12.1980; (5) de Ávila, A.C. et al. Fitopatol.bras. 5:311. 1980; (6) Colariccio, A. et al. Summa Phytopathol. 25: 35. 1999; (7) Eiras, M. et al. Trop. Plant Pathol. 40 (supl.) CD Rom Res. 445.1. 2015

Alphanecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from asymptomatic cole, kept under greenhouse conditions, in the Instituto Agronomico, Campinas, SP (1).

Ref.: Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960. 2018.

Caulimovirus

***Cauliflower mosaic virus* (CaMV)**

This isometric, aphid-borne DNA virus was first described in Brazil associated with symptoms of vein banding on cole leaves (1). Report of CaMV infecting several cultivated brassicas were made in 1963, but based only on symptoms, without further experimental identification (2). CaMV has been identified infecting several brassicas in the states of Paraná (4), Distrito Federal (5) and Espirito Santo (6). CaMV was also found infecting and causing mosaic in the ornamental *Matthiola incana* (hoary stock) in the state Rio Grande do Sul (3). An isolate of CaMV recovered from cauliflower in Venda Nova, ES, was characterized molecularly (7). Transmission by aphids (*Myzus persicae* and *Brevicoryne brassicae*) has been demonstrated (8). CaMV was found infecting chinese cabbage (*B.* rapa) in Santo Antonio do Pinhal, SP (9).

Ref.: ((1) Kitajima, E.W. et al. Bragantia 24: 219. 1965; 2) Tokeshi, H. et al. Rev.Olericultura 3: 175; 1963; (3) Siqueira, O. & Dionelo, S.B. Fitopatologia (Lima): 8: 19. 1973; (4) Lima, M.L.R.Z.C. et al. Rev.Setor Cien.Agr., UFPR, 2: 12. 1980; (5) Cupertino, F.P. et al. Fitopatol.bras. 11:394. 1986; (6) Costa, H. et al. Fitopatol.bras. 16: XXVIII. 1991; (7) Zerbini, F.M. et al. Fitopatol.bras. 17:326. 1992; (8) Ambrozibivus, L.P. Fitopatol.Bras.22: 330. 199; (9) Oliveira, M.J. et al. Res.20, 40º Cong.Paul.Fitop., 2017.

***Brassica napus* L. (Canola) Brassicaceae**

Cucumovirus

***Cucumber mosaico virus* (CMV)**

Potyvirus

***Turnip mosaic virus* (TuMV)**

Caulimovirus

***Cauliflower mosaic virus* (CaMV)**

These three viruses (CMV, TuMV e CaMV) were found naturally infecting canola plants with mosaic symptoms in the state of Paraná (1).

Ref.: (1) Barbosa, C.J. et al. Fitopatol. Bras. 20: 286. 1995;

***Brugmansia suaveolens* (Willd.) Bercht. & J. Presl. (White angel trumpet) Solanaceae**

Potyvirus

***Brugmansia suaveolens mottle virus* (BsMoV)**

Some white angel trumpet plants from the germplasm collection of the Dept. Medicinal Plants of the Instituto Agronomico, Campinas, SP, were found showing mottling symptoms on their leaves. Further assays demonstrated that these plants were infected by a mechanical and aphid transmissible potyvirus, identified preliminarily as a possible isolate of PVY (1). Its genome was sequenced and revealed to represent a new species of potyvirus, which was named BsMoV (2). An isolate of this virus was found naturally infecting white angel trumpet plants at Parque do Papa, Curitiba, PR, causing mottling (3).

Ref.: (1) Habe, M.H. et al. Fitopatol.bras. 18: 286. 1993; (2) Lucinda, N. et al. Arch.Virol. 153: 1971. 2008; (3) Souza, T.A. et al. Virus Rev. & Res. 20:138-139. 2016.

***Brunfelsia uniflora* D .Don. (Yesterday-Today-Tomorrow) Solanaceae**

Cilevirus

***Cilevirus* unidentified**

Green spots and ringspots were observed on senescent leaves of *B. uniflora* in a residential garden in Águas de S. Pedro, SP, associated with infestion by tenuipalpid mites *Brevipalpus*.. Electron microscopy of the tissues from the lesions revealed cytopathic effects characterist of those caused by *Cilevirus.* The causal virus, however, remains unidentified (1). Transmission of these symptoms by *B. phoenicis s.l.* was confirmed (2).

Ref.: (1) Nogueira, N.L. et al. Summa Phytopathol. 29: 278. 2003; (2) Ferreira, P.T.O. et al. Fitopatol.bras. 28: S250. 2003.

C

***Cactus bahiensis* Rose & Russell*; Cereus triangularis* Haw*; C. hexagonus* (L.) Miller; *C. triangularis* Haw; *Hylocereus undatus* (Haworth) Button & Rose; *Nopalea cochenillifera* (L.) Salm. Dick.*; Mamillaria* sp.*; Opuntia vulgaris* Miller; *O. leucotricha* De Candolle; *O. tuna* Mill.*, Echinocereus* sp.*; Lobivia* sp.*; Pereskia aculeata* (L.) Kaarsten*; P. bleo* (HBK) De Candolle (Cactus) Cactaceae**

Potexvirus

***Cactus virus X* (CVX**

***Opuntia virus X* (OpVX)**

***Schlumbergera* virus X (SchVX)**

***Zygocactus virus X* (ZyVX)**

Asymptomatic infection by CVX was observed in many assayed cactus species from the states of São Paulo and Federal District. Mechanical transmission assays resulted in the infection of test plants as *Gomphrena globosa, Chenopodium amaranticolor* and *C. quinoa*. Serology with specific anti-CVX serum and electron microscopy which detected typical potexvirus-like particles in extracts and in infected cells confirmed the presence of CVX in these plants. A novel protocol for purification managed to get purified CVX and a specific antiserum was produced (1). Several other cactus potexviruses (CVX, OpVX e SchVX) were found in *Hylocereus undatus* showing chlorotic

and necrotic spots and mosaic, collected in São Paulo, SP (2). These viruses were identified by molecular assays (3, 4). Isolates of SchVX, CVX, ZyVX were found infecting *Opuntia cochenillifera* (Cochineal cactus) in the state of Pernambuco (5). Among these viruses, the Brazilian isolate of SchVX had its genome sequenced (6).
Ref.: (1) Aragão, F.J.L. et al. Fitopatol.bras. 18: 112. 1993. (2) Tozetto, A.R.P. et al. Arq.Inst.Biol 72 (supl): 77. 2005; (3) Duarte, L.M.L. et al. Fitopatol.bras. 27(supl.): S203. 2002. (4) Duarte, L.M.L. et al. Journal Plant Pathol. 90: 545. 2008; (5) Lamas, N.S. et al. Virus Rev. &.Res. 19 (supl): 217. 2014; (6) Sanches, M.M. et al. Genome Announcements, v. 3, p. e00133-15, 2015.

***Caesalpinia echinata* Lam. (Brazil wood) Fabaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot iírus* (TCSV)**
***Tomato spotted wilt virus* (TSWV)**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Potyvirus
***Pepper yellow mosaic virus* (PepYMV)**
***Potato virus Y* (PVY)**
***Watermelon mosaic virus* (WMV)**
***Zucchini yellow mosaic vrus* (ZYMV)**
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**
***Tomato mosaic virus* (ToMV)**
During a survey to detect viruses in woody plants made in a nursery of Distrito Federal, the above-listed viruses were detected in Brazil by biological and/or serological assyas. There is no reference about symptoms nor further confirmation of the identity of these viruses by molecular means (1, 2).
Ref.: (1) Batista, J.G. et al. Virus Review & Res. 21: 122. 2016; (2) Santos, M.F.B. et al. Trop.Plant Pathol. 41 (supl.) 2016.

***Caladium bicolor* Vent. (Calladiums) Araceae**
Potexvirus
***Caladium* virus X (CalVX)**
Potyvirus
***Dasheen mosaic virus* (DsMV)**
Co-infection of calladiums by DsMV and a potexvirus resulting in chlorotic necrotic spots on the leaves were observed on plants collected in São Paulo, SP (1). The potexvirus was found to be a new species based on biological, serological and molecular assays. A fragment of 740 nt amplified by RT-PCR had less than 75% identity with those of other potexvirus, indicating a new species, which was named ClVX (2). Ultrastructural observations confirmed the presence of cylindrical inclusions, typical of potyviruses, as well great fibrous masses, characteristic of potexviruses. These inclusions could be noticed also by light microscopy (3).
Ref.: (1) Rivas, E.B. et al. Fitopatol.bras. 29:150-151. 2004 (2) Rivas, E.B. et al. Plant Pathol. 87:109-114. 2005 (3) Rivas, E.B. et al. Arq. Inst. Biol. 7: 457.2004.

***Calibrachoa* sp. (Million bells) Solanacea**e
Tobamovirus
***Tobamovirus* unidentified**
An unidentified tobamovirus was detected in Million Bells in São Paulo, SP. No description of symptoms was made (1).
Ref (1) Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95.2010.

***Callistephus chinensis* L. (Aster) Asterace**ae
Cytorhabdovirus
***Cytorhabdovirus* unidentified**
Aster plants with systemic chlorosis and leaf distortion were observed in an experimental field of the Instituto Agronomico, Campinas, SP. Electron microscopy revealed the presence of cytorhabdovirus in the tissue of these plants, but it could not be identified (1).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Fitopatol.bras. 4: 55. 1979
Orthotospovirus
***Chrysanthemum stem necrosis virus* (CSNV)**
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
Co-infection of aster plants by these three Orthotospoviruses, resulting in symptoms of mosaic, bronzed and deformed leaves and stem necrosis was noticed in a commercial plantation in Holambra, SP (1,2).
Ref.: (1) Alexandre, M.A.V. et al. Summa Phytopathol. 25: 353. 1999; (2) Rivas, E.B. et al. Res. 13º Cong. Bras. Floricultura e Plantas Ornamentais. 138. 2001

***Calopogonium mucunoides De*svaux (Calopo) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**
Calopo plants with mosaic symptoms were found in the Federal District associated with infection by serotype I of CPSMV (1).
Ref.: (1) Lin, M.T. & Anjos, J.R.N. Plant Dis. 66: 67. 1982.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Mosaic symptoms were observed on Calopo plant in the state of Paraná. The causal agent of the disease was identified as an isolate of CMV (1).
Ref.: (1) Almeida, A.M.R. et al. Virus Rev. & Res. 2: 194. 1997.
Begomovirus
***Macroptilium yellow spot virus* (MaYSV)**
Natural infection of calopo by the begomovirus MaYSV was observed in the state of Alagoas (1).
Ref.: (1) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.

***Campanula medium* L. (Bell flower) Campanulaceae**
Orthotospovirus
***Tomato spotted wilt virus* (TSWV)**
Mosaic, necrosis and ringspots on the leaves and flowers of Bell flower were observed in a commercial plantation in Atibaia, SP. Further assays identified the causal agent as an isolate of TSWV (1).
Ref.:(1) Gioria, R. et al. Summa Phytopathol. 36: 176. 2010.

***Campomanesia adamantium* (Cambess) O. Berg. Myrtaceae**
Begomovirus
***Tomato severe rugose virus* (ToSRV)**
C. adamantium plants growing together with jack bean (*Canavalia ensiformis*) in the state of Mato Grosso do Sul were found showing vein clearing, chlorotic spots and leaf deformation. RT-PCR assays indicated that they were infected by ToSRV (1).
Ref.: (1) Stangarlin, O.S. et al. Summa Phytopathol. 40 (supl.) CD Rom. 2014.

***Canavalia ensiformes* D.C. (Jack bean) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**
Jack bean plants exhiting severe mosaic and bubbly leaves were found in the state of Ceará. The causal agent was identified as CPSMV (1).
Ref.: (1) Lima, J.A.A. & Souza, C.A.V. Fitopatol.bras. 5: 417. 1980.
Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

Mosaic symptoms on jack bean leaves were observed in the state of São Paulo. The unidentified viral agent was mechanically transmitted to Jack bean, soybean, pea and sweet pea, but not to cowpea and common bean (1). This condition probably was similar to a later report made in Jack bean samples from the state of Pernambuco tentatively attributed to a potyvirus, as well as to a similar case found in the Federal District, which was aphid-borne (2, 3). Similar case was registered in the state of Rio de Janeiro (2). The virus was purified and a specific antiserum was produced, showing serological relationship with several legume potyviruses as CABMV, BCMV, SMV (3). Although tentatively named *Canavalia* mosaic virus- CanMV (4.5), it is probably an isolate of the CABMV.

Ref.: (1) Silberschmidt, K. & Nobrega, N.R. O Biológico 8: 129. 1943; (2) Costa, C.L. et al. Fitopatol. Bras. 14: 115. 1989; (3) Santos, O.R. et al. Fitopatol.bras. 16: XXVII. 1991; (4) Costa, C.L. et al. Fitopatol. Bras.9: 400. 1984; (5) Santos, O.R. Diss.Mest.,UnB, 78 p. 1991.

Begomovirus

***Tomato severe rugose virus* (ToSRV)**

A case of natural infection of Jack bean by ToSRV was found in the state of Mato Grosso do Sul (1).

Ref.: (1) Stangarlin, O.S. et al. Summa Phytopath. 40 (supl.) CDRom. 2014.

****Canavalia rosea* (Sw.) DC (=*C. maritima* Thouars) (Beach bean) Fabaceae**

Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

Beach bean commonly grows in coastal regions of Brazil. Plants showing mosaic and chlorotic spots on their leaves wee found in several beaches near Caraguatatuba, SP. Subsequent assays revealed that these plants were infected by a potyvirus, with similar characteristics of *Canavalia maritima* mosaic virus (CanMMV) described in Puerto Rico (1). More detailed studies including genome sequencing indicated that this potyvirus infecting beach bean in Brazil is an isolate of the CABMV (2).

Ref.: (1) Kitajima, E.W. et al.Virus Rev&Res9: 252. 2004; (2) Madureira, P.M. et al. Arch. Virol. 153: 743. 2008.

****Canavalia* sp. Fabaceae**

Begomovirus

***Macroptilium yellow spot virus* (MaYSV)**

MaYSV was found infecting an unidentified species of *Canavalia* in the state of Alagos (1).

Ref..: (1) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.

****Canna paniculata* Ruiz & Pav. Cannaceae**

Potyvirus

***Canna yellow streak virus* (CaYSV)**

C. paniculata plants showing yellow streaks on their leaves were found in a public park in Piracicaba, SP. Mechanical transmission assays only manage to infect the same species. CI region amplified by RT-PCR revealed identity with CaYSV, described in the UK (1).

Ref.: (1) Alexandre, M.A.V. et al. Aust.Plant Dis.Notes 12: 38. 2017

****Capsicum annuum* L. (Pepper) Solanaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

***Tomato chlorotic spot virus* (TCSV)**

***Tomato spotted wilt virus* (TSWV)**

***Orthotospovirus* unidentified**

Unidentified Orthotospovirus was found infecting pepper with mosaic and leaf deformation symptoms in Manaus, AM (1) and in the Federal District (2). Diversity of Orthotospoviruses infecting pepper was noticed in the state of São Paulo, as judged by responses of inoculated 'Manteiga' bean, which reacted either with chlorotic or necrotic lesions (3). Natural infection of pepper by TSWV was observed in the Federal District (4), while GRSV was found in pepper in Janaúba, MG (5). In the state of São Paulo, pepper plants were infected by TCSV (6) and GRSV (8). In a survey in pepper fields in the valley of São Francisco, in the state of Pernambuco, a high incidence of GRSV was noticed (7).

Ref.: (1) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979; (2) Cupertino, F.P. et al. Fitopatol. Bras. 5: 395. 1980; (3) Costa, A.S. & Gaspar, J.O. Summa Phytopathol. 7: 5. 1981; (4) Boiteux, L.S. et al. Capsicum and Eggplant Newsletter 12: 75. 1993; (5) Fitopatol. Bras. 19: 285. 1994; (6) Colariccio, A. et al. Fitopatol.bras. 20: 347. 1995; (7) de Avila, A.C. et al. Fitopatol. Bras. 21: 503. 1996; (8) Colariccio, A. et al. Summa Phytopathol. 27: 323. 2001.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV infecting pepper was first registered in samples from Embú, SP, in plants showing mosaic symptoms (1). CMV satellite virus was detected in pepper samples from the state of Minas Gerais (2). Pepper samples from several regions of the state of São Paulo were infected by subgroup I CMV (3).

Ref.: (1) Mallozzi, P. Rev.Soc.Bras.Fitopat. 4: 101. 1971; (2) Boari, A.J. et al. Fitopatol.bras. 25: 143. 2000; (3) Frangioni, D.S.S. et al. Summa Phytopathol. 29: 19. 2003

Crinivirus

***Tomato chlorosis virus* ToCV**

ToCV was detected in pepper plants showing interveinal chlorosis and epinasty sampled in S. Miguel Arcanjo, SP (1).

Ref. (1) Barbosa, J.C. et al. Plant Dis. 94: 374. 2010.

Polerovirus

***Potato leafroll virus* (PLRV)**

An isolate of PLRV was recovered from pepper plants showing generalized chlorosis. It was considered that such plants may serve as the source of PLRV for tomato crops (1).

Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Coopercotia fev.62,p.34.

Potyvirus

***Pepper yellow mosaic virus* (PepYMV)**

Two isolates of potyvirus recovered from pepper showing mosaic symptoms in a commercial pepper plantation in Bragança Paulista, SP and Brasília, DF were identified, based on biological, serological and molecular assays, as a new species and designated PepYMV. This virus was able to infect pepper varieties resistant to PVY (1). Subsequently, the virus was shown to be widespread in Brazil, being registered in the states of AM, PE, BA, MG, ES and SP (2). Its genome has been entirely sequenced (3).

Ref.: (1) Inoue-Nagata, A.K. et al. Arch. Virol. 147: 840. 2002; (2) Virus Rev. & Res. 8: 186. 2003; (3) Lucinda, N et al. Arch.Virol. 157.: 1397.2012.

***Potato virus Y* (PVY)**

Symptoms of significant plant size reduction, vein banding and bubble type of mosaic and curling on leaves and malformed fruits of pepper were reported in the state of São Paulo, and the causal agent was identified as an isolate of PVY (1). Resistant varieties were obtained by a breeding program (2). PVY-caused disease on peppers was also registered in the states of Rio de Janeiro (3, 4), Minas Gerais, Federal District and Espirito Santo (5).

Ref.: (1) Costa, A.S. & Alves, S. Bragantia 10: 95. 1950; (2) Nagai, H. Braglantia 27: 311. 1968; (3) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econo. do Estado, Sec.Agric. Abast., RJ. 84p. 1978; (4) Brioso, P.S.T. et al. Fitopatol. Bras. 18: 274.

1993; (5) Truta, A.A.C. Virus Rev.& Res. 5: 193. 2000.
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**
***Tobacco mosaic virus* (TMV)**
***Tomato mosaic virus* (ToMV)**

These tobamoviruses were detected in pepper samples with mosaic symptoms, from Salto and Bragança Paulista, SP. Identification of these viruses were made by biological assays (1, 2) and by RT-PCR (3).
Ref.: (1) Kobori, R.F. et al. Fitopatol. Bras. 26: 516. 2001; (2) Cezar, M.A. et al. Summa Phytopathol. 29: 359. 2003.(3) Cezar, M.A. et al. Summa Phytopathol. 32 (supl): S37.2006.
Tobravirus
***Pepper ringspot virus* (PepRSV)**

PepRSV was first identified in pepper plants showing chlorotic lines and rings on their leaves in São Carlos, SP. The viral nature of the disease was confirmed by biological assays and electron microscopy and named vein banding (1, 2) or ringspot (3) virus. Further works indicated likeliness with *Tobacco rattle tobravirus*, but considered distinct (6) and officially named PepRSV. A cytopathological peculiarity of PepRSV is that its virions are commonly arranged perpendicularly onto mitochondrial surface (5). PepRSV has a wide experimental host range and is seed-borne (3) possibly associated with infection of polen grains (4). Soil transmission of the virus has been demonstrated in association to nematodes of the genus *Trichodorus and/or Paratrichodorus* (7). The virus found in pepper plants in the state of Paraná (8). Isolates of PepRSv were found infecting tomato in Luziania, GO, and infectious clones were produced (9).
Ref.: (1) Silberschmidt, K. Phytopathol.Zeit. 46: 209. 1962; (2) Silberschmidt, K. Phytopathol.Zeit. 46: 209. 1962; (3) Costa, A.S. & Kitajima, E.W. Rev Soc.Bras. Fitopatol. 2: 25. 1968; (4) Camargo, I.J.B. et al. Phytopathol.Zeit. 64: 282. 1969; (5) Kitajima, E.W. & Costa, A.S. J. Gen.Virol. 4: 177. 1969; (6) Kitajima, E.W. et al. Bragantia 28: 1. 1969; (7) Salomão, T.A. et al. Arq. Inst. Biol.. 42: 133. 1975; (8) Lima, M.L.R.Z.C. et al. Rev.Setor Cien.Agr.UFPR 5:91. 1983; (9) Tavares, M.L. MS Diss., UnB, 2017.
Begomovirus
***Tomato golden vein virus* (ToGVV)**
***Tomato severe rugose virus* (ToSRV)**

Pepper plants showing leaf curl from various regions in the state of São Paulo were found to be infected by ToGVY (1) and ToSRV (1, 2). ToRSV was also found infecting pepper in the state of Minas Gerais (3) and in Campo Grande, MS (4).
Ref: (1) Nozaki, D.N. et al. Fitopatol.Bras.31:321.2006; (2) Paula, D.F. et al. Virus Rev.& Res. 11(supl): 189. 2006. (3) Nozaki, D.N. et al. Virus Rev&Res 15(supl) 114.2010; (4) Stangarlin O.S. et al. Trop. Plant Pathol. 39 (supl.) CDRom 204.
***Tomato rugose mosaic virus* (ToRMV)**

Greenhouse-grown pepper plants were found with leaf curl and stuting symptoms in Marília, SP. ToRMV was found in these plants by molecular technique but there is no biological evidence that this virus is the causal agent of the disease (1).
Ref.: (1) Cotrim, M.A.A. et al. Summa Phytopathol. 30: 100. 2004.
Curtovirus unclassified
Brazilian tomato curly top virus (BrCTV)

Leaf yellowing, short internodes and reduced size, flattened fruits symptoms were observed in the state of São Paulo. The causal agent was identified as the same virus causing curly top in tomato (BrCTV), transmitted by leafhopper. Bristly starbur (*Acanthospermum hispidum)* may serve as virus source (1). Similar condition was found in Manaus, AM (2).
Ref.: (1) Costa, A.S. & Nagai, H. Rev.Oleric. 6: 83. 1966; (2) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979.

***Capsicum baccatum* L (Chili pepper), *C. baccatum* var. *praetermissum* (Pimenteira Cumari) Solanaceae**
Orthotospovirus
***Groundnut ringspot virus*(GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
***Tomato spotted wilt virus* (TSWV)**
Potyvirus
***Pepper yellow mosaic virus* (PepYMV)**
***Potato virus Y* (PVY)**
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**

These viruses were detected during surveys made in the germplasm collection of *C. baccatum* of Embrapa Hortaliças, Brasília, DF (1-5).
Ref.: (1) Boiteux, L.S. et al. Euphytica 67: 89. 1993**;** (2) Nagata, T. et al. Fitopatol.bras. 18: 425. 1993;(3) Lima, M.F. et al. Acta Hort. (ISHS) 917: 285. 2010; (4) Lima, M.F. et al Trop. Plt. Pathol. 35(supl) S175. 2010; (5) Lima, M.F. et. J. Plant Pathol. 92:122. 2010.
Begomovirus
***Tomato rugose mosaic virus* (ToRMV)**

Samples of *C. baccatum* with mosaic and foliar deformation symptoms were collected in Petrolina de Goiás, GO. PCR assays detected ToRMV in these plants but its role as the etiological agent of the disease could not be demonstrated (1), which was later made using biobalistic methods, in which *C. annuum* plants revealed to be also susceptible to ToMRV (2).
Ref.: (1) Ferreira, G.B. et al. Fitopatol.bras. 29: S202. 2004; (2) Bezerra-Agasie, I.C. et al. Plant Dis. 90: 114. 2006.

***Capsicum chinense* Jacq. (Cumari pepper) Solanaceae**
Orthotospovirus
***Tomato spotted wilt virus* (TSWV)**

Leaf local lesions followed by systemic chlorotic ringspots, mosaic and stunting were observed in *C. chinense* cultivated under greenhouse conditions (1, 2) and under field conditions in Brasilia, DF (3). Resistance to TSWV of *C. chinense* was broken by infection with GRSV and TCSV isolates (4).
Ref.: (1)Nagata T. et al. Fitopatol. Bras. 18: 425. 1993. (2) Boiteux, L.S. & Nagata, T. Plant Dis 77: 210. 1993; (3) Boiteux, L.S. et al. Euphytica 67: 89. 1993**.**
Potyvirus
***Pepper yellow mosaic virus* (PepYMV)**

C. chinensis plants exhibiting mosaic and foliar deformation, collected at Parauapebas and Santarém, PA. were found to be infected by PepYMV as demonstrated by serological and molecular assays, complemented by electron microcospy (1).
Ref.:(1) Carvalho, T.P. et al. Trop.Plt.Pathol. 40 (supl): 44.1. 2015.
Begomovirus
***Sida micrantha mosaic virus* (SimMV)**

SmMV was detected infecting *C. chinense in* Campo Florido, MG (1).
Ref.: (1) Teixeira, E.C. et al. Trop.Plt Pathol. 33(supl): S289. 2008.

***Capsicum frutescens* L. (Chili pepper) Solanaceae**
Orthotospovirus

***Tomato spotted wilt virus* (TSWV)**

Chlorotic rings were observed on the leaves of many accessions of *C. frutescens* in the germplasm collection of Embrapa Hortaliças, Brasília, DF. Causal agent was identified as TSWV (1). The same virus was found in samples from different genotypes being assayed under field conditions and showing chlorotic rings and reduction of leaf size as well as stunting (2, 3).

(1) Boiteux, L.S. et al. Euphytica 67: 89. 1993**;** (2) Lima, M.F. et al. Hort.Bras. 28: S1187. 2010; (3) Lima, M.F. et al. Acta Hort. (ISHS) 917: 285. 2010

Cucumovirus

***Cucumber mosaic virus* (CMV)**

C. frutescens plants exhibiting mosaic and leaf deformation were observed in the state of Pará. Presence of isometric particles in leaf extracts and RT-PCR assays using specific primers pointed to CMV as the causal agent of the disease (1).

Ref.: (1) Carvalho, T.P. et al. Trop.Plt.Pathol. 38 (supl.) 286-1.2013.

Potyvirus

***Pepper mottle virus* (PeMV)**

PeMV was detected infecting *C. frutescens,* based upon biological and serological assays (1).

Ref.: (1) Torres Fo..J. et al. Virus Rev.& Res. 5: 197. 2000.

***Potato virus Y* (PVY)**

Biological and immunoassays identified PVY infecting *C. frutescens* in the state of Minas Gerais (1). This virus was also detected by serological means, in several *C. frutescens* genotypes collected in the state of Goiás and Distrito Federal (2, 3).

Ref.: (1) Truta, A.A.C. et al. Virus Rev. & Res. 5: 193. 2000. **(2)** Lima, M.F. et al. Hort. Bras. 28: S1187. 2010; (3) Lima, M.F. et al. Acta Hort. (ISHS) 917: 285. 2010.

Tobamovirus

***Pepper mild mottle virus* (PMMoV)**

PMMoV was detected in *C. frutescens* seeds coming from the state of São Paulo, based on biological, serological and molecular assays and electron microscopy (1). The same virus was found in plants of different genotypes of chili pepper in the states of Goias and Distrito Federal by serology (2-4).

Ref.: (1) Eiras, M. et al. Summa Phytopathol. 29: 60. 2003. **(2)** Lima, M.F. et al. Hort.Bras., 28: S1187-S1194. 2010. (3) Lima, M.F. et al. Acta Hort. (ISHS) 917: 285-290. 2010. (4) Lima, M.F. et al. Acta Hort. (ISHS) 917: 285. 2010.

**** Cardiopetalum calophyllum* Schltdl. Annonaceae**

Begomovirus

***Begomovirus* unidentified**

A systematic survey is being made on plants forming the Cerrado bioma in Central Brazil. During this survey, from several samples collected in the state of Goiás, only *C. calophyllum* revealed to be infected by an unidentified begomovirus, detected by PCR assay (1).

Ref.: (1) Rocha, G.A. & Dianese, E.C. Res.36, 50º Cong.Bras.Fitopat. 2017

****Carica papaya* L. (Papaya) Caricaceae**

Nucleorhabdovirus

***Nuclerhabdovirus* unidentified**

Solo papaya plants from the Humaitá colonization project near Rio Branco, AC were found showing severe mosaic, epinasty, leaf distortion and yellowing. Mechanical transmission of the disease was unsuccesful. Electron microscopy of infected tissues revealed the presence of a possible nucleorhabdovirus, suggesting a relation with the papaya apical necrosis, described in Venezuela, also associated with a rhabdovirus (1, 2).

Ref.: (1) Ritzinger, C.H.S.P. & Kitajima, E.W. Fitopatol.bras. 12: 146. 1987; (2) Kitajima, E.W. et al. Fitopatol.bras. 16: 141. 1991.

Alfamovirus

***Alfalfa mosaic virus* (AMV)**

AMV was found infecting field papaya causing mosaic symptoms, in Piracicaba, SP. Identification was based on mechanical transmission and molecular assays, and electron microscopy (1).

Ref. (1) Moreira, A.G. et al. J. Gen. Plt. Pathol . 76: 172. 2010.

Potyvirus

***Papaya ringspot virus* type P (PRSV-P)**

PRSV-P is by and large, the most important pathogen for papaya plantations in Brazil, being present wherever papaya is cultivated. Bitancourt in 1935 (1) described a mosaic in papaya, but published images suggest that the symptoms probably resulted from mite infestation (2). PRSV-P causes a devastating disease characterized by symptoms of mosaic, leaf blistering and deformation, oily streaks in the stems and petioles and typical ringspots on the fruits. The condition is referred to as "mosaic" in Brazil. First official register of the virus was made in 1969 in Monte Alto, SP (3, 4). The virus is spread by aphids, though they do not form colonies in papaya plants. PRSV-P has been described in most states of Brazil (Northeast- Ceará, Rio Grande do Norte, Pernambuco, Bahia; Southeast- Espirito Santo, Minas Gerais; Center West- Goias, Distrito Federal) (5-9). There is no varietal resistance, and the control measure being used successfully is the systematic elimination ("rouguing") of infected plants. In the state of Espirito Santo the rouguing became compulsory by Law, and later in all papaya producing and exporting states, in 1994 and extended to 2009. Attempts to use mild strains for cross-protection failed, possible because of the irregular distribution of PRSV-P in the infected plant. Transgenic PRSV-P-resistant papaya plants were produced but they are still waiting for official permission to be used in field conditions (10). Coat protein gene of several Brazilian isolates of PRSV-P has been sequenced (11). In the state of Espirito Santo, where PRSV-P was controlled by continuous rouguing program, apparently a selection of a mild strain took place, which did not had a protecting role against severe isolates (12). Except for a single case reported in the state of Amazon (13), PRSV-P has not been observed in the Amazon basin.

Ref.: (1) Bitancourt, A.A. O Biológico 1: 41. 1935; (2) Costa, A.S. O Biologico 7: 248. 1941; (3) Costa, A.S. et al. O Agronomico 21: 38. 1969; (4) Rev.Soc.Bras.Fitopatol. 3: 55. 1969; (5) Lima, J.A.A. et al. Fitossanidade 1: 56. 1975; (6) Almeida, A.M.R. & Carvalho, S.L.C. Fitopatol.bras. 3: 65. 1978; (7) Barbosa, F.R. & Paguio, O.R. Fitopatol.bras. 7: 37. 1982; (8) Kitajima, E.W. et al. Fitopatol. Bras. 9:607. 1984; (9) 12: 106. 1987; (10) Nickel, O. et al. Fitopatol. Bras. 29: 305. 1995; (11) Souza Jr., M.T. & Gonsalves, D. Fitopatol.bras. 24: 362. 1999; (12) Moreira, A.G. et al. Virus Rev.& Res. 11 (supl): 48. 2006; (13) Brioso, P.S.T. et al. Trop.Plt. Pathol. 38: 196. 2013.

Sobemovirus

***Papaya lethal yellowing virus* (PLYV)**

The first report of PLYV was made on papaya samples collected at Vertentes and Pombos, state of Pernambuco, with generalized yellowing on the leaves, which dropped later. Plant tips were chlorotic and deformed, following by wilting and death of the plant; fruits wilted, followed by intense latex exudation. The condition was called lethal yellowing and its viral etiology was confirmed by mechanical transmission assays, and the abundant presence of isometric particles, ca. 30 nm in diameter, in leaf extracts (1). Soon after, the disease was observed in the states of Bahia (2), Rio Grande do Norte (3), Ceará (6) and Paraíba (7). An isolate from the state of R.G. Norte was purified and a specific antiserum was produced (4) and revealed to be identical to the original isolate found in the state of Pernambuco (5). Genome sequence analysis indicated that PLYV would belong to the family *Tombusviridae* (8), possibly to the genus *Sobemovirus* (10-12). There are evidences for the soil transmission of PLYV (9).

Ref.: (1) Loreto, T.J.G. et al. O Biológico 49: 275. 1983; (2) Vega, J. et al. Fitopatol.bras. 13: 147. 1988; (3) Kitajima, E.W. et al. Fitopatol. bras. 17: 282. 1992; (4) Oliveira, C.R.B. et al. Fitopatol.bras. 14: 114.1989; (5) Kitajima, E.W. et al. Fitopatol.bras. 17: 336. 1992; (6) Lima, J.A.A. et al. Fitopatol.bras. 19: 437. 1994; (7) Camarço, R.F.E.A. et al. Fitopatol. Bras. 21: 413. 1996; (8) Silva, A.M.R. et al. Fitopatol.bras. 22: 529. 1997; (9) Camarço, R.F.E.A. et al. Fitopatol. bras. 23: 453. 1998; (10) Silva, A.M.R. et al. Virus Rev.& Res. 5: 196. 2000; (11) Amaral, P.P.R. et al. Virus Rev. & Res. 7: 154. 2002; (12) Pereira,A.J. et al. Virus Rev.& Res. 16 (supl.) CDRom. 2011.

Alphanecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from asymptomatic papaya plants kept under greenhouse conditions at the Instituto Agronomico, Campinas, SP (1).

Ref.: Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960.

Umbravirus

Papaya meleira virus 2 (PMeV2)

Totivirus unidentified

Papaya meleira virus (PMeV)

Spontaneous exudation of latex, of aqueous consistency from fruits, leaves and stems were first observed in commercial papaya plantations in Linhares, ES. Fruits become stained after exuding latex dries and also tasteless, worthless for the market. The condition was coined as "meleira" by the growers and hence the name of the virus Papaya meleira virus (PMeV). Epidemiological studies suggested viral etiology, and the causal agent was demonstrated to be transmissible through injection of latex from affected plants (1). The disease was associated with the presence of isometric particles, ca. 50 nm in diameter in látex extracts and in lacticifer cells and dsRNA, ca. 6 x 10^6 Da (2). The disease was found soon after in the states of Bahia (3), in the submedium São Francisco- state of Pernambuco (4), state of Ceará (6), and Jaíba, state of Minas Gerais (8). There is an unconfirmed case of transmission using whitefly extract (5). The virus was purified and showed to have a dsRNA genome with 12 kpb (7). The use of NSG permitted to obtain the complete genome sequence of PMeV, ca. 9000 nt, similar to members of mycoviruses of the family *Totiviridae* (9, 10). A second ssRNA virus (4500 nt), referred to as PMeV-2, similar to the Papaya virus Q- PVQ, was described in papaya in Ecuador (genus *Umbravirus*), was also found associated to meleira, in Mexico, and also confirmed in Brazil (10).

Ref.: (1) Rodrigues, C.H. et al. Fitopatol. Bras. 14: 118. 1989; (2) Kitajima, E.W. et al. Fitopatol.bras. 18: 118. 1993; (3) Barbosa, C.J. et al. Fitopatol. Bras. 22: 331. 1997; (4) Lima, M.F. et al. Fitopatol.bras. 24; 365.1999; (5) Habibe, T.C. et al. Fitopatol.bras. 26: 526. 2001; (6) Lima, R.C.A. et al. Fitopatol.bras. 26: 522. 2000; (7) Maciel-Zambolin, E. et al. Plant Pathology 52:389. 2003; (8) Boari, A.J. et al. Fitopatol. bras. 29: S73. 2004. (9) Abreu E.F. et al. Arch. Virol. 160: 3143..2015; (10) Antunes, T.F.S. et al. Plos One 11, p. e0155240. 2016.

***Caryocar brasiliense* Camb. (Soari nut, pequi) Caryocaraceae**

Isometric virus unidentified

Plants of *C. bransiliense* with mosaic, chlorotic spots and interveinal chlorosis on their leaves were observed in Brasília, DF. Mechanical inoculation resulted in local lesion in some legume assay plants tested, but pequi could not be infected. Isometric particles were noticed in leaf extracts examined by electron microscopy.

Ref.: (1) Costa, C.L. et al. Fitopatol.bras. 14: 115. 1989.

***Cassia hoffmannseggii* Mart ex Benth Fabaceae**

Tymovirus

Cassia yellow mosaic associated virus (CaYMaV)

A tymovirus, tentatively named CaYMaV, was found causing bright yellow mosaic in *C. hoffmanseggi,* a wild legume common in the Northeastern Brazil, occasionally in co-infection with CABMV, in the state of Pernambuco. From the sequence of the coat protein, the closest tymovirus is *Kennedya yellow mosaic virus*.

Ref.: (1) Nicolini, C. et al. Virus Genes 42: 28. 2012.

Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

Mosaic bearing *C. hoffmanseggi* plants are common in several municipalities of the state of Pernambuco, and was found to be infected by CABMV. This isolate of CABMV causes local lesion in *Chenopodium amaranticolor* and is able to infect sesame when mechanically inoculated (1, 2). It is transmitted by aphids in non-persistent, styletar way (2). Serology indicated that this isolate from *C. hoffmanseggi* is close to the subgroup of BCMV among potyvirus (3).

Ref.: (1) Paguio, O.R. & Kitajima, E.W. Fitopatol.bras. 6: 187. 1981; (2) Souto, E.R. & Kitajima, E.W. Fitopatol.bras. 16: 256. 1991; (3) 17: 292. 1992.

***Cassia macranthera* DC , *Cassia sylvestris* Vell. Fabaceae**

Carlavirus

Cassia mild mosaic virus (CasMMoV)

A mild mosaic on the leaves of *C. sylvestris*, noticed in Brasília, DF, was found to be caused by a carlavirus (1), which was also associated with a dieback of *C. macranthera* (2). Evidences that an aerial vector, probably aphids, is involved in the spread of the virus was obtained in the state of Paraná (3). This carlavirus, named CasMMoV, was also found in the state of São Paulo, causing pod necrosis (4).

Ref.: (1) Lin, M.T. et al. Plant Dis.Reptr. 63: 501. 1979; (2) Lin, M.T. 64: 587. 1980; (3) Lima Nº., V.C. et al. Fitopatol.bras. 16: LII. 1991; (4) Seabra, P.V. et al. Virus Rev. & Res. 3: 143. 1998, 2001.

Tymovirus

***Senna* virus X (SeVX)**

Potyvirus

***Senna* virus Y (SeVY)**

An unidentified elongated virus was found in leaf extracts of *C. macranthera* with chlorotic spots on its leaves in Viçosa, MG. Sequence analysis of nucleic acid present in leaf extracts of symptomatic plants indicated the presence of at least two distinct viruses. A new potyvirus, named Senna virus Y, and another isometric virus, a tymovirus, referred to as *Senna* virus X (1).

Ref.: (1) Beserra Jr., J.E.A. et al. Trop.Plant Pathol. 36: 115. 2011.

***Catharanthus roseus* (L.) G.Don. (Periwinkle) Apocynaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Occurrence of periwinkle plants showing mosaic symptoms on their leaves is quite common in Brazil. The first identification that the condition is caused by CMV was made in the state of São Paulo (1-5). Molecular analysis indicated that CMV isolate infecting periwinkle belongs to the same clade of other Brazilian CMV isolates (6).

Ref.: (1) Costa, A.S. Summa Phytopathol. 9: 39. 1983; (2) Duarte, L.M.L. et al. Fitopatol.bras. 17: 215. 1992; (3) Alexandre, M.A.V. et al. Bol.Tecn. 1: 47. 1995;(4) Espinha, L.M. et al. Fitopatol.bras. 19(supl.): 307. 1994; (5) Duarte et al. Virus Rev.& Res. 6 (supl.): 155. 2001; (6) Duarte, L.M.L. et al. Tropical Plant Pathol. 33(supl.): S290. 2008.

Potyvirus

***Catharanthus mosaic virus* (CatMV)**

A potyvirus was found in a sample of periwinkle withe leaf mosaic and distortion, from Pirassununga, SP, by electron microscopy (1). Subsequent biological and molecular assays identified the causal agent as a new species of potyvirus, referred to as CatMV (2).

Ref. (1). Seabra, P.V. et al. Arq.Inst. Biol. (supl.) 66: 116.1999; (2) Maciel, S.C. et al. Sci.Agric. 68: 687. 2011.

***Cayaponia tibiricae* (Naud.) Cogn., Cucurbitaceae**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
This Brazilian wild cucurbit was found exhibiting mosaic symptoms in Atibaia, SP. Further assays indicated that the causal agent was ZYMV, suggesting that this plant may serve as a natural reservoir for ZYMV (1).
Ref.: (1) Yuki, V.A. et al. Plant Dis. 83: 486. 1999.

***Centrosema brasilianum* L. Fabaceae**
Begomovirus
***Centrosema yellow spot virus* (CeYSV)**
Yellow spots on leaves of *C. brasilianum* in the state of Pernambuco was verified to be caused by CeYSV infection (1).
Ref.: (1) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.

***Centrosema pubescens* Benth. Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**
CPSMV, serotype I, was found infecting *C. pubescens* in Brasília, DF (1).
Ref.: (1) Lin, M.T. & Anjos, J.R.N. Plant Dis. 66: 67. 1982
Potyvirus
***Potyvirus* unidentified**
Unidentified potyvirus was found by electron microscopy, co-infecting phytoplasma in *C. pubescens* in an experimental plot of Embrapa Gado de Corte, Campo Grande, MS (1). This virus was later purified and a specific antiserum, produced. However, further works for its identification were not conducted (2).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 16: XXV.1991; (2) Batista, M.F. et al. Fitopatol. Bras. 20: 339. 1995.

***Cestrum nocturnum* L. (Night jasmine) Solanaceae**
Dichorhavirus unclassified
***Cestrum* ringspot virus (CeRSV)**
Chlorotic and ringspots on green leaves, and green spots on senescent leaves were observed in night jasmine in a residential garden in Atibaia, SP, associated with infestation by *Brevipalpus* mites. Electron microscopy revealed cytopathology typical of dichorhavirus in tissues from the lesions (1). The disease was transmitted by *B. phoenicis s.l.* and *B. obovatus* (2).
Ref.: (1) Freitas-Astua, J. et al. Fitopatol. bras. (supl.) 27: 205. 2002; (2) Summa Phytopathol. 30: 80. 2004

***Chenopodium album* L. (Goosefoot) Amaranthaceae**
Begomovirus
***Tomato severe rugose virus* (ToSRV)**
Natural infection of goosefoot by ToRSV was registered in Sumaré, SP (1).
Ref. (1) Barbosa, J.C. et al. Trop.Plant Pathol. 33(supl): S286. 2008.

***Chenopodium murale* L. (Sowbane) Amaranthaceae**
Sobemovirus
***Sowbane mosaic virus* (SoMV)**
SoMV was first observed in Riverside, CA, USA, causing mottling in sowbane plants. It is an isometric, seed-borne virus, occurring in high concentration in infected tissues. It was transmitted by the hoppers *Circulifer tenellus* (Baker) and *Halticus citri* Ashmead, and by the leaf miner fly *Liriomyza langei* Frick and officially described in 1961 (3). In Brazil, SoMV was found in Campinas,SP, and was the first plant virus to be purified and a specific antiserum to be produced (1, 2).
Ref.: (1) Silva, D.M. et al. Rev.Agricultura, Piracicaba, 32: 189. 1957; (2) Bragantia 17: 167. 1958; (3) Bennett, C.W. & Costa, A.S. Phytopathology 51: 546. 1961.

***Chrysanthemum frutescens* L. (=*Argyranthemum frutescens* (L.) Sch.Bip.) (Paris Daisy) Asteraceae**
Potyvirus
***Potyvirus* unidentified**
A still unidentified potyvirus, though purified and partially characterized, was detected in Paris Daisy in the state of São Paulo (1).
Ref.: (1) Paiva, F.A. & Desjardins, P.R. Fitopatol. Bras. 7: 542, 1982.

***Chrysanthemum leucanthemum* L. (Oxeye daisy) Asteraceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Oxeye daisy plants with necrotic spots on their leaves were found in the garden of Hotel Nacional, Brasília, DF, in high incidence. Unidentified Orthotospovirus was found associated with the disease (1).
Ref.: (1) Oliveira, C.R.B. & Kitajima, E.W. Fitopatol.bras. 14: 89. 1989.

***Chrysanthemum morifolium* Ramat. (Florist's daisy) Asteraceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
An unidentified nucleorhabdovirus was detected by electron microscopy in florist's Daisy with yellow stripes on the leaves, sampled in Capão Bonito, SP (1).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Fitopatol. Bras. 4: 55. 1979
Orthotospovirus
***Chrysanthemum stem necrosis virus* (CSNV)**
An Orthotospovirus, distinct from previously known species, was identified as the causal agent of stem and leaf necrosis in cultivated florist's daisy, collected in Atibaia, SP (1). Later similar isolates were found in Cotia, Ibiuna and Vargem Grande Paulista, state of São Paulo, infecting mainly cv. Polaris (2). This virus was also found infecting tomato plants, causing systemic necrosis in Viçosa, MG (3). Molecular studies confirmed that it is a new Orthotospovirus species and named CSNV (4). CSNV was also found infecting florist's Daisy in the state of Rio de Janeiro (5).
Ref.: (1) Duarte, L.M.L. et al. J. Phytopathol. 143: 569. 1995; (2) Alexandre, M.A.V. et al. Fitopatol. Bras. 21: 80. 1996; (3) Resende, R.O. et al. Fitopatol. Bras. 20: 299. 1995; (4) Bezerra, I.C. et al. Fitopatol. Bras. 21: 430. 1996; (5) Brioso, P.S.T. et al. Fitopatol. Bras. 29: S140. 2004.
Ilarvirus
***Ilarvirus* unidentified**
Unidentified ilarvirus was reported infecting florist's daisy in the state of São Paulo (1).
Ref.: (1) Rivas, E.B. et al. Fitopatol. Bras. 19: 311. 1994
Viroid
Pospiviroid
***Chrysanthemum stunt viroid* (CSVd)**
CSVd was detected by R-PAGE, in the state of São Paulo, infecting florist's daisy (1). It was later characterized by sPAGE, RT-PCR, RT-qPCR and sequencing (2).
Ref.: (1) Dusi et al., Plant Pathology 39: 636. 1993;(2) Gobatto,D. et al. J.Plant Pathol. 96: 111. 2014.

***Chrysanthemum* sp. (=*Dendranthema* sp.) (Chrysanthemum), Asteraceae**
Pospiviroid

***Chrysanthemum stunt viroid* (CSVd)**

CSVd was detected in cultivated Chrysanthemums, by molecular means, in samples collected at Atibaia, Artur Nogueira and Holambra, SP (1).

Ref.: (1) Gobatto, D. et al. Trop.Plant Pathol. 37 (supl.). CDRom. 2012.

****Cicer arietinum* L. (Chickpea) Fabaceae**

Orthtotospovirus

***Tomato spotted wilt virus* (TSWV)**

Chickpea plants showing chlorosis and distortion of apical leaves were observed in Brasília, DF. The causal agent was identified as an isolate of TSWV (1).

Ref.: (1) Boiteux, L.S. et al. Fitopatol.bras. 19: 278. 1994.

Tobamovirus

***Sunn hemp mosaic virus* (SHMV)**

A tobamovirus was isolated from chickpea showing yellowing and premature death in an experimental plot of the Instituto Agronomico, Campinas, SP (1), which was tentatively identified as SHMV, a tobamovirus specialized for legumes (2).

Ref.: (1) Costa, A.S. et al. Summa Phytopathol. 14: 42. 1988; (2) Fitopatol.bras. 13: 115. 1988

****Cichorium endivia* L. (Endive) Asteraceae**

Orthtotospovirus

***Tomato chlorotic spot virus* (TCSV)**

TCSV was identified as the causal agent of a systemic necrosis on the endive's leaves (1, 2).

Ref.: (1) Pedrazzoli, D.S. et al. Summa Phytopathol. 26: 132. 2000; (2) Colariccio, A. et al. Summa Phytopathol. 27: 325. 2001.

Potyvirus

***Lettuce mosaic virus* (LMV)**

During a survey of plant viruses in the state of Rio de Janeiro, a low incidence of mosaic affecting endive was noticed. Causal agent was identified as an isolate of LMV (1).

Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984.

****Cichorium intybus* L. (Chicory) Asteraceae**

Orthotospovirus

***Orthotospovirus* unidentified**

Mosaic and yellow spots on chicory leaves have been observed since 1938 in several regions of the state of São Paulo. The etiological agent was considered an Orthotospovirus (1).

Ref.: (1) Costa, A.S. & Costa, C.L. Rev.Oleric. 11: 33. 1971.

Potyvirus

***Potyvirus* unidentified**

An unidentified potyvirus was found in chicory showing mosaic symptoms in Londrina, PR (1).

Ref.: (1) Mituti, T. et al. Virus Rev.&Res. 11(supl): 187. 2006.

****Citrullus lanatus* (Thumb.) Matsui & Nakai (Watermelon) Cucurbitaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

Mosaic and leaf distortion was observed in 20-40% of watermelon plants in commercial fields in the state of Goias, associated with infestation by the thrips *Frankliniella schultzei.* Molecular assays identified the causal agent as GRSV (1).

Ref.: (1) Lima, M.F. et al. Virus Rev & Res.20 (supl.): 216-217. 2015

***Zucchini lethal chlorosis virus* (ZLCV)**

Plants of watermelon grown in irrigated area of Guadalupe, PI,were found showing mosaic and leaf deformation. Electron microscopy detected Orthotospovirus infection, and the causal agent was tentatively identified as ZLCV, though further assays are required to confirm this identification (1). Epidemy of ZLCV in watermelon was observed in several areas of Central Brasil (2), including Uruana, GO (3).

Ref.: (1) Beserra Jr., J.E.A. et al. Summa Phytopathol. 39 (supl) CDRom. 2013; (2) Lima, M.F. et al. Trop.Plt.Pathol. 39 (supl.) CD Rom. 2014; (3) Marques, M.L.S. et al. Summa Phytopath. 40 (supl) CDRom. 2014.

Comovirus

***Squash mosaic virus* (SqMV)**

SqMV was found co-infecting watermelon with PRSV-W, in the states of Piaui (1), Maranhão (2), Rio de Janeiro (3) and Tocantins (4).

Ref.: (1) Lima, J.A.A. et al. Fitopatol.bras. 5: 417. 1980; (2) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (3) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (4) Alencar, N.E. et al. J. Biotechnol. Biodiv. 3: 32. 2011.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Watermelon cultivated in areas of "submédio São Francisco", state of Pernambuco, was found infected with CMV (1).

Ref.: (1) Lima, M.F. et al. Fitopatol.bras. 22: 337. 1997

Potyvirus

***Papaya ringspot virus W* (PRSV-W)**

PRSV-W is widespread in cucurbits, including watermelon. It was found infecting commercial plantations of watermelon in the states of Distrito Federal (1), Ceará (2), São Paulo (3), Maranhã (4), Pernambuco (5), Rio de Janeiro (6), Minas Gerais (7), Roraima (8), Santa Catarina (9) and Piauí (10).

Ref.: (1) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 51. 1974; (2) Lima, J.A.A. et al. Fitopatol.bras. 5: 414. 1980; (3) Lin, M.T. et al. Res.20º Cong.Bras.Oleric.: 144. 1980: (4) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (5) de Ávila, A.C. et al. Fitopatol.bras. 9: 113. 1984; (6) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (7) Pavan, M.A. et al. Fitopatol.bras. 10: 301. 1985; (8) Ferreira, M.A. et al. Fitopatol.bras. 28: S249. 2003; (9) Colariccio, A. et al. Fitopatol. bras. 32 (supl): S306. 2007; (10) Beserra Jr., J.E.A. et al. Summa Phytopathol. 39 (supl) CDRom. 2013.

***Watermelon mosaic virus* (WMV)**

WMV was detected infecting watermelon in surveys made in the region of "submédio São Francisco", state of Pernambuco (1).

Ref.: (1) Lima, M.F. et al. Fitopatol.bras. 22: 337. 1997.

***Zucchini yellow mosaic virus* (ZYMV)**

ZYMV was first reported in Brazil, in samples of watermelon with mosaic, collected in Votuporanga, SP. Identification was confirmed by biological assays, serology and immuno electron microscopy (1). Later, ZYMV infecting watermelon was also detected in the states of Pará (2), Rondonia (3), Santa Catarina (4), Tocantins (5) and Piauí (6).

Ref.: (1) Vega, J. et al. Fitopatol.bras. 20: 72. 1995; (2) Poltronieri, L.S. et al. Fitopatol. Bras. 25: 669. 2000; (3) Ferreira, M.A. et al. Fitopatol.bras. 28: S249. 2003. (4) Colariccio,A et al. Fitopatol.bras. 32 (supl):S306. 2007; (5) Alencar, N.E .et al. J. Biotechnol. Biodiv. 3: 32. 2011.(6) Beserra Jr., J.E.A. et al. Summa Phytopathol. 39 (supl) CDRom. 2013.

****Citrus* spp. Rutaceae**

Citrus aurantifolia Christm. (Mexican lime), *C. aurantium* L. (sour orange), *C. grandis* (L) Osbeck (pomelo), *C. limon* (L) Burm.f. (lemmon), *Citrus medica* L. (citron), *C. paradisi* Macf. (grapefruit), *C. sinensis* Osbeck (orange), *C. reticulata* Blanco (mandarin)

Ophiovirus

***Citrus psorosis virus* (CPsV)**

Psorosis in citrus is characterized by chlorosis and formation of

"oak leaf" pattern in young leaves, scaly bark in stems and trunk, concave gummosis and blind pockets in plants older than 12 years. In Brazil this condition has been found in several citrus growing regions of the state of São Paulo (1, 2). In the state of Bahia (BA) similar symptoms occur in citrus, except for the absence of symptoms in young leaves (3), thus psorosis in BA (tBA) seems to be different from the conventional one (5). There is report of CPsV infection in *Poncirus trifoliata* (4). Field experiments using protected and non-protected plants suggest winged vector (6).

Ref.: (1) Rossetti, V. & Salibe, A.A. O Biologico 27: 29. 1961; (2) Rossetti, V. & Salibe, A.A. Bragantia 21: 107. 1962; (3) Passos, O.S. et al. Proc.6 th Conf.IOCV p. 135. 1974; (4) Salibe, A.A. Fitopatologia (Lima) 11: 30. 1976; (5) Nickel, O. Fitopatol.bras. 196. 1997; (6) Barbosa, C.J. et al. Res. 14 Conf. IOCV: 143. 1998.

Dichorhavirus

***Citrus leprosis virus N* (CiLV-N)**

Within the citrus leprosis syndrome, which have several causal viruses, CiLV-N, also trasmitted by *Brevipalpus* mite, causes leaf lesions slightly different from those caused by the more aggressive and disseminated CiLV-C (*Cilevirus*). Leaf lesions tend to be smaller, bright chlorotic spot with a dense central spot. CiLV-N occurs in region of lower temperature and higher altitudes, mostly in backyard orange plants. It has been found in the states of São Paulo, Minas Gerais and Rio Grande do Sul and possibly in Panamá (1). Its genome was completely sequenced from samples collected in Monte Alegre do Sul, São Bento do Sapucaí and Ibiuna, SP, and it was concluded to be a distinct member of the genus Dichorhavirus. *B. phoenicis s.s.* was identified as the vector (2). A virus causing similar symptoms, with a broader host range, infecting several citrus types was observed in Mexico, but genome analysis demonstrated thet the causal agent is an isolate of *Orchid fleck virus* (OFV).

Ref.: (1) Rodrigues, J.C.V. et al. Exp.Appl.Acarol. 30: 161. 2003; (2) Ramos-González, P.L. et al. Phytopathology 107: 963. 2017.

***Citrus chlorotic spot virus* (CiCSV)**

During survey of plant viruses in the state of Piauí, some sweet oranges were found showing chlorotic spots and blotches on the leaves and fruits in Teresina, PI. Electron microscopy of the tissues from lesions revealed cytopathic effects characteristic of dichorhaviruses. These plants were infested by *Brevipalpus* mites, identified as *B. yothersi af.*, considered as possible vector. Molecular assays produced the entire genome sequence of the causal virus, confirming that it is a dichorhavirus, distinct from other known members of this genus, being designated CiCSV (1).

Ref.: (1) Chabi-Jesus, C. et al. Plant Dis. 102: 1588. 2018.

Capillovirus

***Apple stem grooving virus* (ASGV)**

Swollen fruits of Cleopatra mandarin were observed in the state of São Paulo. Biological and molecular assays, complemented by electron microscopy indicated the presence of ASGV in these plants, which causes also a condition known as tatter leaf (1).

Ref.: (1) Lovisolo, O. et al. Fitopatol.bras. 28: 54. 2003.

Marafivirus

***Citrus sudden death associated virus* (CSDaV)**

Sudden death of citrus, a highly destructive disease of orange trees, grafted on top of rangpur lime and volkameriana lemmon, characterized by a change in the color of the leaves, which becomes more opaque, followed by a quick decline and death of adult plants in few months. Also a yellowing is apparent in the trunk, at the grafted region. It occurs more fequently in the beginning of the rainy season, when vegetative growth of orange trees is more intense. The disease caught attention in 2001 in the Southern region of the "Triângulo Mineiro", state of Minas Gerais. It quickly spread to commercial grooves and soonafter, to the Northern region of the state of São Paulo (1). Epidemiological studies suggested that the disease agent had a winged vector, possibly aphids (2). Anatomical studies demonstrated a phloem degeneration in the grafted area, this situation being reminescent of damages caused by *Citrus tristeza virus* (CTV) in intolerant rootstock/scion combination (3). An isometric virus, identified as a new species of the genus *Marafivirus* was found associated with the disease, and named CSDaV (4-6). This virus is present in orange trees graft-inoculated with buds from symptomatic trees, which took about two years to express the symptoms. Asymptomatic orange trees grafted on rootstocks as Cleopatra mandarin or sweet orange, growing next to the affected plants in the field were infected by CSDaV. The virus was detected in aphids which fed on diseases trees, and in plants inoculated with these aphids (7).

Ref.: (1) Gimenes-Fernandes, N. et al. Summa Phytopathol. 27: 93. 2001; (2) Bassanezi et al. Phytopathology 93: 502. 2003; (3) Román, M.P. et al. Plant Dis. 88: 453, 2004; (4) Maccheroni, W. et al. J.Virol. 79:3028. 2005; (5) Barros, C.C.P. et al. Fitopatol.bras. 29: S278. 2004: (6) Harakawa, R. Summa Phytopathol. 30: 101. 2004; (7) Yamamoto, P.T. et al. Plant Dis. 95: 104. 2011.

Closterovirus

***Citrus tristeza virus* (CTV)**

By and large, tristeza was the most destructive disease for the citrus industry in Brazil. It destroyed about 10 million orange trees grafted on top of sour orange, mostly in the state of São Paulo in 1940's. and is an example how a quick response based on scientific researches, permitted the recovery of the culture, and transforming the state of São Paulo as the world largest producer and exporter of orange juice, with more than 200 million planted trees. The disease was tamed by the change of the rootstock, followed by a cross protection using mild strains of the causal virus. Tristeza is caused by *Citrus tristeza virus* (CTV), transmitted by aphids. It was introduced in South America from South Africa, and quickly spread. In the state of São Paulo tristeza was initially found in grooves of the Paraíba valley (1-3). During the early stages of the occurrence of tristeza, Webber (4) observed the similar diseases described in Java and South Africa, suggesting viral etiology. The postulated winged vector was confirmed as being the aphid *Toxoptera citricidus* Kirk., originally identified as *Aphis tavaresi* Del Guercio (5). Symptoms of tristeza in susceptible rootstock/scion combination is characterized by a general decline, reduction of the leaf blade, mineral deficiency symptoms, especially of Zn, on the leaves, rotting of root system, followed by death. Anatomical studies indicated marked changes in the phloem at the grafting region. The disease is considered as a result of the phloem collapse at the grafting zone (primary symptoms) with subsequent degradation of the root system, producing leaf symptoms (secondary symptoms), and death of the plant. Some forms of tristeza causes stem pitting as the result of the collapse of the phloem. On the other hand, mild forms of the disease were also noticed (6-8). Concern about the possibility of introduction of CTV in citrus culture in the US resulted in funds for tristeza research in Brazil, supported by visiting specialists as C.W. Bennett and T.J. Grant in the 1950's, and financial support to the cross-protection project (16). Viral etiology for tristeza gained support when elongated, thread-like particles, present in leaf extracts, were consistently associated with the disease in 1964 (9), which were found *in situ* in phloem tissues (11). Further works involving purification confirmed the viral nature of tristeza, as being caused by CTV. Cross protection using mild strains of CTV to control severe forms, as those causing stem pitting, was conceived by Giacommetti & Araújo (10), and executed by Müller & Costa (12, 13, 16), to face a threat represented by a very severe variant of CTV, known as "Capão Bonito". This cross-protection or preimmunization program permitted the revival of some citrus forms almost extinct as 'Pera' sweet Orange and Mexican lime. Being phloem limited virus, CTV

is not mechanically transmissible, but it has been demonstrated that it can be transmitted slashing stems with sharp blades (15). Virus-free clones could be obtained by micrograft (18). The use of monoclonal antibodies and molecular tools demonstrated that a single plant is infected by a complex of several CTV isolates (19). Genome of mild and severe isolates of CTV have been sequenced (20). Infectious clone of CTV is already available, produced by W.O. Dowson's group in Florida (21).

Ref.: (1) Bitancourt, A.A. O Biológico 6: 268. 1940; (2) Moreira, S. O Biológico 8: 269. 1942; (3) Bitancourt, A.A. & Rodrigues Fo., A.J. Arq.Inst.Biol. 18: 313. 1948; (4) Webber, H.J. O Biológico 9: 345. 1943; (5) Meneghini, M. O Biológico 14: 115. 1948; (6) Bennett, C.W. & Costa, A.S. J.Agric.Res. 78: 207. 1949; (7) Moreira, S. et al. Rev. Agricultura (Piracicaba) 24: 335. 1949; (8) Grant, T.J. & Costa, A.S. Phytopathology 41: 114. 1951; (9) Kitajima, E.W. et al. Nature 201: 1011. 1964; (10) Giacometti, D.C. & Araújo, C.M. Proc.3rd Conf. IOCV: 14. 1965; (11) Kitajima, E.W. & Costa, A.S. Proc.4th Conf. IOCV p. 59. 1968; (12) Muller, G.W. et al. Rev Soc.Bras.Fitopatol. 2: 33. 1968; (13) Muller, G.W. & Costa, A. Rev. Soc. Bras. Fitopatol. 5:117. 1972; (14) Muller, G.W. Summa Phytopath. 2: 245. 1976; (15) Garnsey, S.M. & Muller, G.W. Proc.10th Conf. IOCVÇ46.. 1988; (16) Costa, A.S. & Muller, G.W. Plant Dis. 64: 538. 1980; (17) Muller,G.W. & Costa, A.S. Proc.Workshop of Citrus Tristeza and *T. citricidus* in Central America: Development of management strategies and use of biotechnology for control (Maracay): 126-131. 1992; (18) Baptista, C.R. et al. Fitopatol.bras. 20: 288. 1995; (19) Corazza-Nunes, M.J. et al. Res. 14 Conf. IOCV: 133 1998/ (20) Targon, M.L.P.N. et al. Fitopatol.bras. 24: 362. 1999; (21) Satyanarayana, T. et al. Virology 280: 87. 2001.

Cilevirus

***Citrus leprosis virus C* (CiLV-C)**

Citrus leprosis (CL) is considered one of the most destructive diseases in the citrus industry, and is characterized by localized lesions (chlorotic and/or necrotic ringspots) on the leaves, stems and fruits. Intense leaf and fruit drop may occur. If untreated, stem lesions may fuse resulting in an inexorable die-back, leading to the plant death in few years. It is transmitted by the tenuipalpid *Brevipalpus* mites. CL was first reported in Brazil, in the 1930's in the state of São Paulo (SP) (1). Its viral etiology was deduced from the spreading of grafted bark lesion to the recipient bark and presence of virus-like particles in tissues of lesions, and mechanical transmission to some indicator plants besides citrus. The genome of the causal virus was sequenced revealing to be distinct from known plant viruses, and it was officially designated *Citrus leprosis virus C* (CiLV-C) and the genus *Cilevirus* was created to incorporate it. Field control of CL is based on mite survey and spraying with acaricide specific for *Brevipalpus*, a costly process (2, 3). CL is widespread in Brazil (besides SP, in the states of Rio Grande do Sul, Paraná, Rio de Janeiro, Minas Gerais, Goiás, Distrito Federal, Mato Grosso do Sul, Bahia, Sergipe, Pernambuco, Pará, Amazonas, Rondonia, Roraima, Acre) (2) and though restricted to the American continent, it is present from Argentina to Mexico and represents presently a serious threat to the orange industry of USA. Though experimentally able to infect a wide range of plant species- up to 40 species of 18 botanical families (4), CiLV-C was, so far, found naturally infecting only *Commelina benghalensis* L in Brazil (5). Common bean (*Phaseolus vulgaris*) demonstrated to be an excellent indicator plant, since it reacts to mite inoculated CiLV-C in five days, compared to 3-4 weeks, in sweet orange (6). A new isolate of CiLV-C, referred to as São José do Rio Preto (SRP), molecularly distinct from the standard isolate (Cordeirópolis- CRD) has been identified and is being rapidly disseminating in SP (7). After changes in the taxonomy of mites of *B. phoenicis* group (8), *B. yothersi* was identified as CiLV-C vector. Beard et.al. (8) and Sanchez-Velasquez et al. (9) are credited by this identification, though they mention only its presence in leprosis-affected citrus orchards. Experimental transmission of CiLV-C by *B. yothersi* was reported by Ramos-González et al. (7). *B. papayensis* was demonstrated to experimentally transmit CiLV-C (10).

Ref. : (1) Bitancourt, A.A. Arq.Inst.Biol. 22: 161. 1955; (2) Bastianel, M. et al. Plant Dis. 94: 284. 2010; (3) Rodrigues, J.V.R. et al. Exp. Appl.Acarol. 30: 161. 2003; (4) Garita et al. Trop.Plant Pathol. 39: 43. 2014; (5) Nunes et al., Plant Dis.96: 770. 2012; (6) Garita et atl., Plant Dis. 97:1346. (7) Ramos-González, P.L. et al. Viruses 8: 153, 2016; (8) Beard, J. et al. Zootaxa 3944. 2015; (9) Sanchez-Velasquez et al.PLosOne 10:1. 2015; (10) Nunes, M.A. et al. Plant Dis. 102: 1946. 2018

Enamovirus

***Citrus vein enation virus* (CVEV)**

First report of vein enation in citrus was made with lemmon grafted on Volkameriano lemmon in commercial grooves of the state of São Paulo. Woody galls were observed in the scion, suggesting a transmissible agent, possibly similar to vein enation, a disease of possible viral etiology, but with still uncharacterized causal agent. Identification of the condition was made using rough lemmon Florida grafted on rangpur lime (1). There are evidences that the aphid *Toxoptera citricidus* may transmit this disease (2).

Ref.: (1) Jacomino, A.P. & Salibe, A.A. Proc.12 Conf. IOCV :357. 1993; (2) Carvalho, S.A. et al. Fitopatol.bras. 28:95. 2001

Apscaviroid

***Citrus dwarfing viroid* (CDVd)**

This viroid, previously known as citrus viroid III, was detected in the state of São Paulo in 2001, causing size reduction of infected plants (1, 2). A case of co-infection of CDVd and HSVd-Ca (causal agent of xylopsorosis) was reported and characterized in the sweet Orange 'Navelina' (3).

Ref.: (1) Targon, M.L.P.N. et al., Laranja 22: 243. 2001; (2) Eiras, M. et al., Trop. Plant Pathol. 35: 303. 2010.

Hostuviroid

***Hop stunt viroid* (HSVd)**

Cachexia or xyloporosis of citrus is a disease characterized by stem pitting in cambial tissues and projections in the bark. Originally considered of viral etiology, it was found that the disease is of viroidal etiology. It was known in the state of São Paulo for decades, but its molecular detection was only made in 1989 (1). Other isolates of HSVd were characterized in Tahiti lemmon and 'Navelina' sweet orange (2, 3).

Ref.: (1) Fonseca, M.E.N. & Kitajima, E.E. Fitopatol.bras. 14: 164. 1989; (2) Eiras,M. et al. Trop. Plant Pathol. 35: 303. 2010; (3) Trop. Plt.Pathol. 38: 58. 2013..

Pospiviroid

***Citrus exocortis viroid* (CEVd)**

Exocortis was known as false gummosis since 1947, but better characterized in 1954 in the state of São Paulo (SP) (1) and confirmed as being caused by viroid in the 1970's. Infection by CEVd results in the cracking and scaling of the trunk bark. Some isolates cause stunting. Use of nucelar clones eliminate this pathogen in most of citrus cultivated in SP, except in few clones of Tahiti lemmon. CEVd was characterized molecularly in 1988 (2). A bark-cracking phenotype of 'Tahiti' acid lime was found to be associated with CEVd in the state of São Paulo (3). CEVd was also detected in grapevine (4).

Ref.: (1) Moreira, S. O Agronômico 6:10. 1954; (2) Fonseca, M.E.N. et al. Fitopatol.bras. 13: 145. 1988; (3) Eiras, M. et al. Trop.Plant Pathol. 35: 303. 2010; (4) Eiras, M. et al. Summa Phythopathol. 36 (supl.) CDRom. 2010.

Possible viral diseases

Zonate chlorosis

Zonate chlorosis was described in the 1930's in sweet orange, lemmon and grapefruit, in the states of São Paulo and Rio de Janeiro, in the coastal áreas. There were suspected samples from the states of Bahia, Minas Gerais, Paraná and Rio Grande do Sul. Symptoms are represented by chlorotic bands alternating with green areas, producing elliptical rings or irregular symmetrical lines, parallel to the central vein of the leaves. Fruits may exhibit circular or elliptical chlorotic areas in green fruits, and brown archs and rings in mature fruits. Viral etiology was suggested based on certain similarity with leprosis and "concentric ring blotch" (from South Africa) (1, 2), but this hypothesis should be confirmed. It was not graft or mechanically transmitted, but greenhouse assays indicated possible transmission by *B. phoenicis s.l.* mites (3, 4). Similar disease was found in the state of Sergipe (5).

Ref.: (1) Bitancourt, A.A & Grillo, H.V.S. Arch.Inst.Biol. 5: 247. 1934; (2) Bitancourt, A.A. O Biológico 1: 255. 1935; (3) Rossetti, V. et al. Arq.Inst.Biol. 32: 111. 1965; (4) O Biológico 31: 113. 1965; (5) Boari, A.J. et al. Summa Phytopathol. 31: 35. 2005.

Cristacortis

A condition characterized by narrow invagination, forming concavities in the stems and trunk in 1-2 years old plants. When bark is removed, a ridge is noticeable in its inner portion, which gives the name to the disease. The ridge is formed by tissues of the cortex. In Brazil the first report of cristacortis was made in Mogi Guaçú, SP, in a groove of Clementina mandarin, imported from Spain. Symptoms were observed in Hamlin orange, which served as rootstock. Thermotherapy has been used to free the pathogen from infected plant (1). Viral etiology was not demonstrated yet. There is a report of this codition in citron in the Southern Minas Gerais state (2).

Ref.: (1) Rossetti, V. Anais III Cong.Bras.Frutic. vol. 1:117. 1975; (2) Botrel, N. et al. Pesq.Agropec.Bras. 26: 2075. 1991.

"Rumple"

"Rumple" is a disease which affects fruits of some lemmon clones. It is known to occur in Florida (USA), Ethiopia, Cyprus, Lebannon, Italy and Turkey. Viral nature of the etiological agent has not been demonstrated yet. In Brazil, a possible case of rumple was reported in the Citrus Center of the Instituto Agronomico, in Cordeirópolis, SP, in Lisbon lemmon. Symptoms were irregular depressions on the fruit skin, which evolved from yellowish green color to dark brown (1). There is another report of "rumple"-like condition in the state of Rio Grande do Sul (2).

Ref.: (1) Salibe, A.A. Cien.Cult. 23 (supl.): 221. 1971; (2) Rossetti, V. et al. Proc. 9th Conf. IOCV p. 180. 1984.

Citrus leaf curl

A citrus disease characterized by leaf curl and die back. In Brazil is known as "crespeira", being graft transmissible. Viral etiology suspected, but not confirmed yet (1, 2).

Ref.: (1) Salibe, A.A. Plant Dis.Reptr. 43: 1081. 1959; (2) Proc.3rd Conf. IOCV: 175. 1965.

***Cleome affinis* DC. Capparaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

A mosaic in *C. affinis* was reported to be caused by CMV infection in the Zona da Mata, state of Pernambuco (1).

Ref: (1) Nicolini, C. et al. Trop.Plt Pathol. 34(supl): S271. 2009.

Begomovirus

***Cleome leaf crumple virus* (ClLCrV)**

A golden mosaic was observed in *C. affinis* in Campinas, SP, and considered to be caused by a whitefly transmitted virus of the infectious chlorosis of malvacea complex (1). A similar disease was noticed in the state of Pernambuco and partially sequenced (2, 3). Other isolates were described in the states of Alagoas and Pernambuco (4). Several isolates were obtained in the states of Amazonas, Tocantins, Mato Grosso, Goiás, Pernambuco and Bahia. Molecular analysis divided these isolates into three groups, with similarities to some known begomoviruses as SmMV, ToYSV and SiYLCV, but they were considered as being a new begomovirus species, ClLCrV (5). Comparison of several samples collected in the Northeast of Brazil revealed that all of them were essentially identical do ClLCrV from MT (6).

Ref.: (1) Costa, A.S. Summa Phytopathol. 6: 3. 1980; (2) Lima, G.S.A. et al. Virus Rev.& Res. 6: 158. 2001 (3) Listik, A.F. et al. Summa Phytopathol. 32:397. 2006; (4) Assunção, L.P. et al. Planta Daninha 24: 239.2006; (5) Fernandes, N.A.N. Tese Dr. UnB. 2010; (6) Silva , S.J. et al. Arch.Virol. 156: 2205. 2011.

***Clerodendrum x speciosum* Tiejism.& Binn. (Bleeding heart), *C. thomsonae* Balf. (Glory bower)**

***C. splendens* G. Don. (Flaming glory bower). Lamiaceae**

Dichorhavirus

***Clerodendrum chlorotic spot virus* (ClCSV)**

C. x speciosum plants exhibiting chlorotic/necrotic spots on their leaves were found in several residential gardens and public parks in Piracicaba, SP, associated with infestation by the tenuipalpid mite *Brevipalpus phoenicis s.l.* Similar condition was observed in plants of *C. thomsonae* and *C. splendens.* Ultrastructural observation in tissues of the lesions demonstrated cytopathic effects typical for dichorhaviruses (1). Experimental transmission with *Brevipalpus* mites collected from diseased plants to healthy ones was successful, reproducing the symptoms. The virus was named ClCSV. There are evidences of mite transmission of ClCSV to other plant species (2). Vector-virus relationship seems to be of persistent-circulative-replicative type, since there are ultrastructural evidences that ClCSV replicates in the mite vector (3, 7). This virus was purified and there is a specific anti-serum available (4). ClCSV was recorded in the state of Amazonas (5). ClCSV has been partially sequenced and may be detected by RT-PCR, in both infected plants and in mites which fed on symptomatic leaves (6). Complete sequence of ClCSV was obtained, confirming to be a dichorhavirus (7).

Ref.: (1) Kitajima, E.W. et al. Scientia Agricola 63: 36. 2008; (2) Ferreira, P.T.O. et al. Fitopatol. Bras. 29 (supl) 78. 2004; (3) Kitajima, E.W. et al. Virus Rev.&Res. 11 (supl): 188. 2006. (4) Kubo, K.S. et al. Fitopatol. Bras. 31 (supl): S184. 2006; (5) Rodrigues, J.C.V. et al. Trop. Plant Pathol. 33: 12. 2008; (6) Kubo, K.S. et al. Summa Phytopathol. 34(supl.): S97. 2008; (7) Kitajima, E.W & Alberti, G. Zoologica 160: 173. 2014; (7) Ramos-González, P.L. et al. Arch.Virol. 163: 2519. 2018.

Rhabdoviridae

***Rhabdovirus* unidentified**

There is a report of detection of an unidentified rhabdovirus in *C. thomsonae* with vein clearing symptoms. This virus was graft transmitted to tobacco and *Nicotiana glutinosa*, besides glory bower (1).

Ref.: (1) Schutta, L.R. et al. Summa Phytopathol. 23: 54. 1997

Cilevirus

***Cilevirus* unidentified**

Green spots on senescent leaves of *C. thomsonae* associated with infestation by *Brevipalpus phoenicis s.l.* mites, which experimentally transmitted the condition to healthy plants. Electron microscopy revealed cytopathic effects similar to those caused by cileviruses (1). In a few samples, cytopathic effects caused by dichorha- and cilevirus were found in the same cell from the lesion, clearly indicating a double infection, adding another evidence that the two infecting viruses were unrelated (2).

Ref.: (1) Kitajima, E.W. et al. Scientia Agricola 63: 36. 2008; (2) Kitajima, E.W. et al. Exp.Appl.Acarol. 30: 135. 2003.

***Clitoria fairchildiana* R.A. Howard Fabaceae**
Begomovirus
***Begomovirus* unidentified**
Transmission assays and PCR tests detected a begomovirus, yet to be identified, in *C. fairchildiana* in the state of Rio de Janeiro (1).
Ref. (1) Brioso, P.S.T. Virus Res.Rev. 19 (supl.2): 216. 2014.

***Clitoria ternatea* L. (Asian pidgeonwings) Fabaceae**
Potyvirus
***Potyvirus* unidentified**
An unidentified potyvirus, possibly related to BCMV, was found naturally infecting *C. ternatea*, causing mosaic symptoms in the state of Ceará. The virus was purified and a specific antiserum was produced (1-3).
Ref.: (1) Lima, J.A.A. et al. Fitopatol.bras. 6: 523. 1989; (2) Lima, J.A.A. et al. Fitopatol Bras.18: 213. 1993; (3)19: 312. 1994.

***Cnidoscolus urens* (l.) Arthur (Bull nettle) Euphorbiaceae**
Begomovirus
***Cnidoscolus mosaic leaf deformation virus* (CnMLDV)**
A golden mosaic was observed in *C. urens* associated with a begomovirus, in the state of Alagoas (1). Molecular analysis of this virus indicated that it was new species of begomovirus, and was named CnMLDV (2).
Ref. (1) Assunção, L.P. et al. Planta Daninha 24: 239.2006; (2) Melo, A.M. et al. Arch.Virol. 161: 2605. 2016.

***Coffea arabica* L., *Coffea* spp. (Coffee) Rubiaceae**
Dichorhavirus
***Coffee ringspot virus* (CoRSV)**
Ringspots on leaves and berries of coffee plants were first described in Caçapava, SP, viral etiology being suggested (1). Later works confirmed the viral nature of the disease by detection of cytopathic effects typical of dichorhaviruses (2), mechanical and mite (*Brevipalpus phoenicis s.l.*) transmission (3, 4) and the virus referred to as CoRSV. It has been considered of marginal economical importance but in the 1990's cases of high incidence in Southern region and Triângulo Mineiro, the state of Minas Gerais, with losses due to the intense defoliation and reduced yields (6, 7) and also because berries with lesions resulted in beverage of lower quality (10, 13). CoRSV is mechanically transmissible to several assay plants, and in some of them, systemic infection may result if plants are kept in higher temperatures (11). The virus was purified and a specific antiserum obtained (12), and its genome was partially sequenced (14). CoRSV was suspected to be grouped with OFV, though serological relationships were distant (13). CoRSV was also detected in Distrito Federal (5) and in the states of Paraná (8) and Bahia (16), and outside Brazil, there is only a register in Costa Rica (9). Other *Coffea* species and some hybrids of the germplasm bank of Centro do Café, Instituto Agronomico, Campinas, SP, were found naturally infected by CoRSV, as well as one non *Coffea* species (*Psilanthus ebracteolatus*, Rubiaceae) (15). Genome of an isolate of CoRSV from Lavras was sequenced, confirming this virus as a member of the genus *Dichorhavirus* (17). The mite vector of CoRSV was reassessed experimentally as *B. papayensis* (18).
Ref.: (1) Bitancourt, A.A. O Biológico 4: 405. 1938; 5: 33. 1939; (2) Kitajima, E.W.. & Costa, A.S. Ciência e Cultura 24: 542. 1972; (3) Chagas, C.M. O Biológico 39: 229. 1973; (4) Chagas, C.M. et al. Phytopathol.Zeit.102: 100. 1981; (5) Branquinho, W.G. et al. Fitopatol.bras. 12: 140. 1988; (6) Juliatti, F.C. et al. Fitopatol.bras. 20: 337.1995; (7) Figueira, A.R. et al. 20: 299. 1995; (8) Rodrigues, J.C.V. & Nogueira, N.L. Fitopatol.bras. 26: 513. 2001; (9) Rodrigues, J.C.V. et al. Plant Dis. 86: 564. 2002; (10) Boari, A.J. et al. Virus Rev.&Res. 8 supl:192.S246. 2003; (11) S247. 2003; (11) Summa Phytopathol. 30: 453. 2004; (12) Boari, AJ et al. Summa Phytopathol. 32: 192. 2006; (13) Locali, E.C. et al. Fitopatol.bras. CDRom. 2008; (14) Kitajima,EW et al. Sci.Agric. 68: 503. 2012; (15) Almeida, J.E.M. & Figueira, AR Coffee Science 9: 558. 2014.; (16) Ramalho,T.O. et al. Virology 464-465: 385. 2014; ; (17) Nunes, M.A. et al. Plant Dis. 102: 1046. 2018.

***Coleus blumei* Benth. (Coleus) Lamiaceae**
Coleviroid
***Coleus blumei viroid 1* (CbVd 1)**
During a survey to find plants susceptible to the *Citrus exocortis viroid* (CEVd), some *C. blumei* were found naturally infected by an unidentified viroid. This viroid was considered of a new species, and named CbVd1 (1, 2), which was later detected in other countries.
Ref.: (1) Fonseca, M.E.F. et al. Plant Dis. 74: 80. 1990; (2) Fonseca, M.E.N. et al., J Gen.Virol.-75: 1447. 1994.

***Colocasia esculenta* (L) Schott. (Taro) Aracae**
Potyvirus
***Dasheen mosaic virus* (DsMV)**
Taro plants showing mosaic on their leaves were observed in Brasília, DF, and found to be infected by an isolate of DsMV, which was also detected in many other aroids, edible and ornamental (1). The virus was reported infecting taro in the state of Rio de Janeiro (2).
Ref.: (1) Rodrigues, M.G.R. et al. Fitopatol. Bras. 9: 291. 1984; (2) Kitajima, E.W. et al. Fitopatol. Bras. 9: 607. 1984;

***Commelina benghalensis* L., *Commelina* spp., (Wandering jew) Commelinaceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Commelina spp. plants were found to be infected by an unidentified Orthotospovirus in the state of São Paulo, with thin lines, forming symmetrical figures along the veins (1).
Ref.: (1) Pavan, M.A. et al. Fitopatol.bras. 17: 186. 1992.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
First reference of infection of *Commelina* spp. by CMV was made in 1940's by Silberschmidt & Nóbrega, on plants growing close to banana plantation (1). An isolate of CMV recovered from *C. agraria* was used to compare other isolates of CMV (2). *C. benghalensis* and *C. erecta* with mosaic symptoms from three different regions of the state of São Paulo were found infected by CMV, based on biological and serological assays and electron microscopy (3).
Ref.: (1) Silbershcmidt, K. & Nóbrega, N.L. O Biológico 7: 216. 1941; (2) Brioso, P.S.T. Tese Dr., UnB., 1986; (3) Duarte, L.M. et al. Fitopatol. Bras. 19: 248. 1994.
Cilevirus
***Citrus leprosis virus C* (CiLV-C)**
Natural infection of *C. benghalensis* growing among sweet orange trees in an organic orchard by CiLV-C, associated with *Brevipalpus phoenicis s.l.* mite infestation was described in the state of São Paulo (1).
Ref.: (1) Nunes, M.A et al. Plant Dis. 96: 770. 2012.
Potyvirus
***Potyvirus* unidentified**
A still unidentified potyvirus was found associated with mosaic symptoms in *Commelina* sp. In the state of Rio Grande do Norte (1) and São Paulo (2).
Ref.: (1) Pinheiro, C.S.R. et al. Fitopatol. Bras. 18: 319. 1993; (2) Moura, M.F. et al. Trop. Plant Pathol. 40 (supl.) CD Rom Res. 333.1. 2015.

***Conyza canadensis* (L.) Cronquist (Horseweed) Asteraceae**
Polerovirus
***Potato leafroll virus* (PLRV)**
Potyvirus
***Potato virus Y* (PVY)**
Field horseweed plants were found infected by PLRV and PVY in the state of Minas Gerais, without a description of symptoms (1).
Ref.: Oliveira, C.D. et al. Fitopatol. bras. 21: 427. 1996.

***Corchurus hirtus* L. (Orinoco jute) Malvaceae**
Begomovirus
***Corchorus* mottle virus (CoMV)**
Orinoco jute plants were found showing yellow mosaic on their leaves in the state of Paraíba. These plants were found to be infected by a begomovirus, transmissible by biolistic means to some *Sida* species and *Nicotiana benthamiana* and named CoMV(1). It is probably similar to a begomovirus recovered from *C. hirtus* with mottling in the state of Pernambuco, molecularly distinct from other known begomoviruses, being closer to AbMBV (2).
Ref.: (1) Fontenelle, R.S. et al. Virus Rev.&Res. 16 (supl.) CDRom. 2011; (2) Blawid, R. et al. Arch. Virol. 158: 2603. 2013.

***Cordyline terminalis* (L.) Kunth. (Ti plant) Agavaceae**
Cilevirus
***Cilevirus* unidentified**
Ringspots were observed on the leaves of Ti plant in the campus of the Agricultural College (ESALQ), Universidade de São Paulo, campus of Piracicaba, SP, associated with infestation by *Brevipalpus phoenicis s.l.* mites. Electron microscopy revealed cytopathic effects similar to those caused by cileviruses. Causal virus is not identified yet, but it could be related to the Hibiscus green spot viurs (HGSV) which was present nearby (1).
Ref.: (1) Ferreira, P.T.O. et al. Virus Rev. & Res. 9: 249. 2004.

***Coreopsis lanceolata* L. (Lance-leaved coreopsis) Asteraceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
Potyvirus
***Bidens mosaic virus* (BiMV)**
Coreopsis lanceolata plants showing conspicuous mosaic on their leaves were found in a city park of Brasília, DF, and found to be caused by an isolate of BiMV. Electron microscopic observation of infected tissues revealed the presence of an unidentified nucleorhabdovirus in some of these plants (1, 2).
Ref.: (1) Kitajima, E.W. et al. Fitopatol. Bras. 16: 141.1991; (2) Rodrigues, M.G.R. et al. Fitopatol.bras. 10: 306. 1985.

***Coriandrum sativum* L. (Coriander) Apiaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
Coriander is a seasoning vegetable widely cultivated in the Northeast of Brazil. In a commercial plantation in Petrolina, PE, coriander plants with chlorotic rings, malformation of apical leaves and stoppage of growth were noticed. Biological and serological assays demonstrated that the causal agent was GRSV (1).
Ref.: (1) Lima, M.F. et al. Fitopatol.bras. 25: 443. 2000.

***Couroupita guianensis* Hook. Lecythidaceae**
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**
PMMoV was detected by serological means, without mention to symptoms and viral identity confirmation by other procedures (1).
Ref. : (1) Santos, F.M.B. et al. Trop.Plant Pathol. 41 (supl.).CDRom. 2016

***Cosmos sulphureus* CAV. (= *Bidens sulphureus* (CAV.) SCH.BIP. (Yellow cosmos) Asteraceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
Yellow cosmos plants showing mild mottling were observed in a residential garden in Brasília, DF, and possible infection by an unidentified nucleorhabdovirus was found by electron microscopy (1).
Ref.: (1) Sá, P. et al. Fitopatol.bras. 16: 141. 1991.

***Cotyledon orbiculata* L (Pig's ear) Crassulaceae**
Nucleorhabdovirus
***Sonchus yellow net virus* (SYNV)**
Potyvirus
Cotyledon virus Y (CotYV)
A potyvirus and a nucleorhabdovirus were found in leaf tissues of pig's ear collected in São Paulo, SP. These viruses could be separated by mechanical inoculation, respectively in *Datura stramonium* and *Chenopodium amaranticolor.* Serology indicated that the nucleorhabdovirus is related to *Sonchus yellow net virus* while the potyvirus revealed to be of a new species (1,2), confirmed by further sequence analysis (3) and tentatively named CotVY.
Ref.: (1) Duarte, L.M.L. et al. Fitopatol.bras. 29: S150. 2004; (2) Duarte, L.M.L. et al. Summa Phytopathol. 31: 63. 2005; (3) Duarte, L.M.L. et al. J.Plant Pathol. 96: 143. 2014.

***Crinum* sp. (River lily) Amaryllidaceae**
Potyvirus
***Potyvirus* unidentified**
River lily plants from Londrina, PR, showing mosaic symptoms revealed to be infected by a still unidentified potyvirus by electron microscopy and RT-PCR (1)
Ref.: (1) Barboza, A.L. et al. Fitopatol. Bras. 31: 212. 2006.

***Crotalaria juncea* L. Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**
Mosaic and leaf deformation of *Crotalaria juncea*, observed in Brasília, DF, were found to be caused by serotypes I and II of CPSMV (1).
Ref.: (1) Lin, M.T. & Anjos, J.R.N. Plant Dis. 66: 67. 1982.
Potyvirus
***Cowpea aphid-borne mosaic virus* (CABMV)**
Mosaic symptoms were observed in *C. juncea* and *C. spectabilis* growing within an experimental field of passion fruit in Brasília, DF. Biological and serological assays identified the causal agent as an isolated of CABMV (1).
Ref.: (1) Maciel, S.C. et al. Summa Phytopathol. 30: 110. 2004.
***Potyvirus* unidentified**
An unidentified potyvirus was associated to a mosaic in *Crotalaria* sp. in Campinas, SP. This potyvirus was transmitted mechanically and by aphids to several other legume plants (1).
Ref.: (1) Freitas, D.S. et al. Fitopatol.bras. 23: 317. 1998.
Tobamovirus
***Sunn hemp mosaic virus* (SHMV)**
An outbreak of mosaic was observed in an experimental field of *C. juncea* in Instituto Agronomico, Campinas, SP. The disease was attributed to a tobamovirus, probably SHMV, with suggestion of the presence of a vector (1).
Ref.: (1) Costa, A.S. et al. Fitopatol.bras. 13: 115. 1988.

***Crotalaria paulinea* Schrank. Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

C. paulinea plants showing mosaic symptoms were noticed in S.Luis, MA. CPSMV was identified as the etiological agent based on biological and serological assays (1).

Ref.: (1) Nascimento, A.K.Q. et al. Fitopatol.bras. 29: S49. 2004.

***Cucumis anguria* L. (Cackrey) Cucurbitaceae**

Orthotospovirus

***Zucchini lethal chlorosis virus* (ZLCV)**

Three cackrey plants, grown under greenhouse conditions in Brasília, DF, were found showing symptoms of possible viral infection. Further biological, serological and molecular assays identified ZLCV as the causal agent (1). Natural infection of cackrey by ZLCV was observed also in the state of S.Paulo (2).

Ref.: (1) Lima, M.F.et al. Virus Rev & Res.20 (supl.): 217. 2015; (2) Camelo-Garcia, V. et al. Trop.Plt.Pathol. 40: 345. 2015.

Comovirus

***Squash mosaic virus* (SqMV)**

SqMV was detected in *C. anguria* grown nearby Manaus, AM (1,2) e MA (3).

Ref.: (1) Lin, M.T. et al. Fitopatol.bras. 2: 86. 1977; (2) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979 (3) Kitajima, E.W. et al. Fitopatol. bras. 7: 537. 1982.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV was found causing mosaic symptoms in cackrey in the states of São Paulo (1) and Rio de Janeiro (2).

Ref.: (1) Lin, M.T. et al. Res.XX Cong.Bras.Oleric. p.144. 1980; (2) Pozzer, L. & Brioso, P.S.T. Virus Rev.& Res. 4: 149. 1999.

Potyvirus

***Papaya ringspot virus*-W (PRSV-W)**

A high incidence of chlorotic cakerey plants were registered in Brasília, DF and found dto be caused by an isolate of PRSV-W (1). Similar condition was reported in the states of Amazonas (2), Maranhão (3), Rio de Janeiro (4) and Minas Gerais (5).

Ref.: (1) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 50. 1973; (2) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979; (3) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (4) Kitajima, E.W. et al. Fitopatol. bras. 9: 607. 1984 (5) Lima, M.F. et al. Trop.Plt Pathol 35 (supl): S284. 2010.

***Zucchini yellow mosaic virus* (ZYMV)**

ZYMV was found infecting cackrey plants in the state of Minas Gerais, causing yellow mosaic (1).

Ref.: (1) Lima, M.F. et al. Trop.Plt Pathol 35 (supl): S284. 2010.

***Cucumis melo* L. (Melon) Cucurbitaceae**

Orthotospovirus

***Zucchini lethal chlorosis virus* (ZLCV)**

Few melon plants, grown under greenhouse conditions in Brasília, DF, were found infected by ZLYV (1).

Ref.: (1) Lima,M.F.et al. Virus Rev & Res.20 (supl.): 217 .2015

Comovirus

***Squash mosaic virus* (SqMV)**

A serological survey made in melon fields in Mossoró, RN, resulted in the detection of SqMV associated with mosaic symptoms (1). There is also report of SqMV infecting melon in the state of Ceará (2).

Ref.: (1) Rocha, H.G.C. et al. Fitopatol.bras. 22: 341. 1997; (2) Silva, E.R. et al. Trop.Plt.Pathol. 38 (supl): 190. 2013.

Carlavirus

***Melon yellowing-associated virus* (MYaV)**

A serious problem characterized by leaf yellowing and loss of brix in the fruits was observed in commercial fields of Mossoró, RN, the main melon producer area in Brazil, and referred to locally as "amarelão" (yellowing). Its transmission by whiteflies was demonstrated (1). There were suggestions that the disease could be caused by a *Crinivirus* (2), but they were never confirmed. Further works indicated that the syndrome was associated to a whitefly-borne and graft transmissible carlavirus, named MYaV (3, 4). MYaV was also found in the states of Pernambuco and Bahia (4, 5) Molecular analysis, after complete genome sequencing, indicated that MYaV is a carlavirus quite distinct from known members (6).

Ref.: (1) Santos, A.A. et al. Fitopatol.bras. 27: S 211. 2002; (2) Lima, J.A.A. et al. Fitopatol.bras. 27: S 207. 2002; (3) Nagata, T. et al. Plant Pathology 52: 797. 2003; (4) Virus Rev& Res.9: 29. 2004.(5) Lima, MF et al. Trop Plt Pathol 34(supl) S278. 2009; (6) Costa, T.M. et al. Virus Rev. & Res.20: 128. 2016.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV was found infecting melons and causing mosaic symptoms in commercial plantations in Mossoró, RN (1) and in the state of Rondônia (2).

Ref. (1) Rocha, H.G.C. et al. Fitopatol.bras. 22: 341. 1997: (2) Gonçalves, M.F.B. et al. Fitopatol.bras. 29: S91. 2004.

Polerovirus

***Cucurbit aphid-borne yellows virus* (CABYV)**

NGS on samples from melon plants showing severe yellowing allowed the detection of CABYV. Based on the genome sequence it was estimated that the virus has been introduced in Brazil about 68 years ago (1).

Ref.: (1) Costa, T.M. et al. Arch.Virol. 164: 249. 2019.

Potyvirus

***Papaya ringspot virus*-W (PRSV-W)**

First report of infection of melon by PRSV-W was made in the state of Pará (1), describing symptoms of mosaic, leaf deformation, interruption of the plant development, yield losses, and dissemination by aphids. Later, it PRSV-W was detected on melons in the states of CE (2), SP (3), PE (4), RN (6), BA (7). Sources of resistance towards PRSV-W were reported (5).

Ref.: (1) Albuquerque, F.C. et al. Rev Oleric. 12: 94. 1972; (2) Lima, J.A.A. et al. Fitopatol.bras. 5: 414. 1980; (3) Lin, M.T. et al. Res.20º Cong.Bras.Oleric.: 144. 1980; (4) Choudhury, M.M. & Lin, M.T. EMBRAPA/CPTSA Pesq.And. 3p. 1982; (5) Della Vecchia, P. & de Ávila, A.C. Fitopatol.bras 10: 467. 1985; (6) Rocha, H.G.C. et al. Fitopatol.bras. 22: 341. 1997; (7) Cruz, E.S. et al. Summa Phytopathol. 25: 21. 1999

***Watermelon mosaic virus* (WMV)**

Melons infected by WMV were found with mosaic symptoms, in commercial fields in the submédio S. Francisco, states of Pernambuco and Bahia (1).

Ref.: (1) Cruz, E.S. et al. Summa Phytopathol. 25: 21. 1999.

***Zucchini yellow mosaic virus* (ZYMV)**

Melons with mosaic symptoms, infected by ZYMV detected by serological means, were found in the state of Rio Grande do Norte (1).

Ref.: (1) Lima, J.A.A. et al. Fitopatol. Bras. 21: 426. 1996.

Gammacarmovirus

***Melon necrotic spot virus* (MNSV)**

Necrotic streaks at the stem base and decline of melon plants were observed in several commercial fields in the states of Rio Grande do Norte and Ceará. Melon seedlings were planted on soils collected from affected fields. Though asymptomatic, molecular assays manage to detect MNSV in these plants. This Brazilian MNSV isolate had a high identity with isolates described previously in Spain (1).

Ref.: (1) Moura, M.C.F. et al. Plant Dis. 102: 1049. 2018.

***Cucumis metuliferus* E. Mey (Horned melon) Cucurbitaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Potyvirus
***Papaya ringspot virus-W* (PRSV-W)**

During a serological survey of viruses in cucurbits of spontaneous vegetation, in Zona da Mata, state of Pernambuco, plants of horned melon were found infected by CMV and PRSV-W (1).
Ref: (1) Nicolini, C. et al. Trop.Plt Pathol. 34(supl):S271. 2009.

***Cucumis sativus* L. (Cucumber) Cucurbitaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**

Concentric ringspots were observed on leaves of cucumber grown in Vitoriana, SP. GRSV was found to be the causal agent (1).
Ref.: (1) Spadotti, D.M.A. et al. New Dis.Rept. 29: 25. 2014.
***Zucchini lethal chlorosis virus* (ZLCV)**

Infection of cucumber by ZLCV resulted in a yellow mosaic along the veins, followed by severe crinkling and mosaic. Such condition was first described in the state of São Paulo, attributed to a Orthotospovirus (1), which was identified as ZLCV, in a case that occurred in Brasília, DF (2).
Ref.: (1) Costa, A.S. et al. Rev.Oleric. 12: 100. 1972; (2) Nagata, T. et al. Plant Dis. 82: 1403. 1998.
Comovirus
***Squash mosaic virus* (SqMV)**

First report of SqMV infecting cucumber in Brazil was made in a sample collected at Colômbia, SP (1).
Ref.: (1) Chagas, C.M. O Biológico 35: 326. 1970.
Cucumovirus
***Cucumber mosaic virus* (CMV)**

Infection of cucumber by CMV is rare, and was first registered in the state of São Paulo, in samples showing mosaic symptoms (1), and subsequently reported in the states of Paraná (2), Minas Gerais (3) and Sergipe (5). A comparison of the genome sequence of CMV isolated from cucumber grown in different regions, demonstrated a prevalence os those of subgroup IA, one case of IB, and none of subgroup II (4).
Ref.: (1) Costa, A.S. et al. Rev.Oleric. 12: 100. 1972; (2) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984; (3) Carvalho, M.G. et al. Fitopatol.bras. 12: 148. 1987; (4) Eiras, M. et al. Fitopatol. Bras. 29: S42. 2004; (5) Almeida, A.C.O. et al. Fitopatol.bras. 31: S322. 2006.
Potyvirus
***Papaya ringspot virus W* (PRSV-W)**

PRSV-W has been the most common virus found infecting cucumber in Brazil, being first registered in the state of São Paulo (1). It causes severe mosaic and leaf malformation (1). The virus was found infecting cucumber in the states of Rio de Janeiro (3), Maranhão (4), Minas Gerais. Studies with inheritance of cucumber resistance to PRSV-W, indicated that it is of polygenic type (2).
Ref.: (1) Costa, A.S. et al. Rev.Oleric. 12: 100. 1972; (2) Silva, N. & Costa, C.P. Rev. Oleric. 15: 12. 1975; (3) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econo. do Estado, Sec. Agric.Abast., RJ. 84p. 1978: (4) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (5) Pavan, M.A. et al. Fitopatol.bras. 9: 309. 1985.
***Zucchini yellow mosaic virus* (ZYMV)**

Cucumber sample from Indaial, SC, showing severe mosaic and leaf deformation revealed to be infected by ZYMV, based on biological and serological assays (1).
Ref.: (1) Caner, J. et al. Res. VI Enc.Nac.Virol. p.180. 1992.

***Cucurbita maxima* Duch. (Pumpkin) Cucurbitaceae**
Potyvirus
***Papaya ringspot virus* W (PRSV-W)**

PRSV-W is commonly found in pumpkin causing mosaic. A good level of resistance to this virus was observed in "abobora-menina" in the state of São Paulo (1). Genetics for pumpkin resistance to PRSC-W has been made (2).
Ref.: (1) Nagai, H. & Ikuta, H. Res. Cong. An. Soc. Amer. Cien. Hort.-Reg.Tropical 19 (Campinas).p.13. 1981; (2) Maluf, W. & Sousa, E.L.S. Hort.Bras. 2: 22. 1984.

***Cucurbita moschata* L. (Pumpkin, squash) Cucurbitaceae**
Orthotospovirus
***Zucchini lethal chlorosis virus* (ZLCV)**

Infection of *C. moschata* by ZLCV results in severe mosaic, yellow mottling, leaf distortion and smaller size of the plants and may end with the death. These symptoms were known on this cucurbit, but the identification of the causal virus was only made in 1997 in the state of São Paulo (1).
Ref.: (1) Rezende, J.A.M. et al. Fitopatol.bras. 22: 92. 1997.
Potyvirus
***Papaya ringspot virus- W* (PRSV-W)**

Mosaic in *C.moschata* caused by PRSV-W has been reported in the states of CE (1) and R. Janeiro (2).
Ref.: (1) Lima, J.A.A. et al. Fitopatol.bras. 5: 414. 1980; (2) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984.
***Watermelon mosaic virus* (WMV)**

Serodetection indicated the presence of WMV in the state of R.Janeiro, infecting *C. moschata* (1).
Ref.: (1) Brioso, P.S.T. et al. Fitopatol. bras. 2: 190. 1997.

***Cucurbita moschata* Duchesne X *C. maxima* Duchesne (Hybrid pumpkin, Tetsukabuto) Cucurbitaceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**

A sample of this hybrid cucurbit showing mosaic symptoms from Sta.Izabel, state of Pará, revealed to be infected by an unidentified nucleorhabdovirus, by electron microscopy (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 16: 141. 1991.
Comovirus
***Squash mosaic virus* (SqMV)**

Tetsukabuto pumpkin with vein clearing, mosaic and blistering collected in Brasíllia, DF, revealed to be infected by SqMV. Identification by serology and electron microscopy, and beetle (*Diabrotica bivittula*) transmission (1).
Ref.: (1) Batista, M.F. Diss.MS, PG Fitop., UnB, 59p. 1979.

***Cucurbita pepo* L. (Pumpkin) Cucurbitaceae**
Comovirus
***Squash mosaic virus* (SqMV)**

SqMV was found in pumpkin with mosaic symptoms in Brasília, DF (1). A high incidence of SqMV in pumpkin was registered in the state of Rio Grande do Sul (2).
Ref.: (1) Cupertino, F.P. et al. Fitopatologia 9: 51. 1974; (2) Siqueira, O. et al. Fitopatologia (Lima) 9: 72. 1974.
Cucumovirus
***Cucumber mosaic virus* (CMV)**

Pumpkin infected by CMV was found serologically in the state of Rondonia (1).
Ref.: (1) Gonçalves, M.F.B. et al. Fitopatol.bras. 29: S91. 2004.
Alphanecrovirus
Squash necrosis virus (SqNV)

An isometric virus was found co-infecting pumpkin with other viruses, in Brasília, DF. Mechanical transmission assays consistently caused only local lesions in assay plants. This virus occurs in high

concentration in the lesion tissues. It did not reveal relationship with *Tobacco necrosis virus* (TNV), and named SqNV (1), but it was transmitted by the fungus *Olpidium radicale*, which is the vector of other alphanecroviruses *Melon necrotic spot gamacarmovirus* (MNSV) in Japan and *Cucumber necrosis tombusvirus* (CuNV) in Canada, though unrelated serologically to SqNV (2).
Ref.: (1) Lin, M.T. et al. Fitopatol.bras. 8: 622. 1983; (2) Lin, M.T & Palagi, P.M. Fitopatol.bras. 8: 622. 1983.

***Cucurbita pepo* L. var. *Caserta* (Zucchini squash) Cucurbitaceae**
Orthotospovirus
***Zucchini lethal chlorosis virus* (ZLCV)**
Orthotospovirus infecting zucchini squash was reported in the state of São Paulo (1, 2), Distrito Federal and Paraná (4). After the 1990's incidence of Orthotospovirus in zucchini squash increased; it was identified and considered a new species among Orthotospoviruses, by serology and molecular assays and designated ZYLV (4-6). The thrips vector was identified as *Frankliniella zucchini* (7).
Ref.: (1) Costa, A.S. et al. Rev.Oleric. 12: 100. 1972; (2) Kitajima, E.W. & Costa, A.S. Rev Soc.Bras.Fitopatol. 5: 180. 1972; (3) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 51. 1974; (4) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984; (4) Rezende, J.A.M. et al. Fitopatol.bras. 22: 92. 1997; (5) Pozzer, L. et al. Fitopatol. Bras. 21: 432. 1996; (6) Pozzer, L. Tese de Dr., UnB. 104p. 1998 (7) Nakahara S. & Monteiro R.C. Proc. Entom. Soc. Wash. 101: 290. 1999.
Comovirus
***Squash mosaic virus* (SqMV)**
SqMV was identified infecting zucchini squash in the state of Tocantins (1)
Ref: (1) Alencar, N.E. et al. J. Biotechnol. Biodiv. 3: 32. 2011.
Nepovirus
***Tobacco ringspot virus* (TRSV)**
Natural infection of Zucchini squash by TRSV was reported in Campinas, SP (1).
Ref.: (1) Cupertino, F.P. & Costa, A.S. Bragantia 29: IX. 1969.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was registered infecting zucchini squash in the states of Paraná (1) and Minas Gerais (2).
Ref.: (1) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984; (2) Carvalho, M.G. et al. Fitopatol.bras. 12: 148. 1987.
Potyvirus
***Papaya ringspot virus*-W (PRSV-W)**
The first mention of PRSV-W, formerly known as WMV-1, infecting cucurbits was made in the state of São Paulo, during field experiment using reflective surface to reduce aphid incidence (1). Most cucurbits are susceptible to PRSV-W, an aphid-borne virus, and the infection results in mosaic, blistering and thinning of the leaf extremities, reduced growth of the plant, fruits with blistering, smaller size, and overall reduction of the yield. PRSV-W has been registered in zucchini squash in Brasília, DF (2), and in the states of Rio de Janeiro (3), Paraná (4) and Minas Gerais (5). Mild strains has been successfully used for control by cross-protection (6).
Ref.: (1) Costa, C.L. & Costa, A.S. Rev. Oleric. 11: 24. 1971; (2) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 61. 1974; (3) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econo. do Estado, Sec.Agric.Abast., RJ. 84p. 1978; (4) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984; (5) Pavan, M.A. et al. Fitopatol.bras. 10: 309. 1985; (6) Rezende, J.A.M. et al. Fitopatol.bras. 19: 55. 1994.
***Watermelon mosaic virus* (WMV)**
WMV was detected during a screening for virus infection of zucchini squash in Campinas, SP (1), and the identity of the virus was confirmed by further biological and serological assays (2). WMV infecting zucchini squash was observed in sub-médio S. Francisco, state of Pernambuco (3).
Ref.: (1) Crestani, O. et al. Res. Virológica 87 (Maceio, AL). 1987; (2) de Sá, P. & Kitajima, E.W. Fitopatol.bras. 16: 217. 1991; (3) Dusi, A.N. et al. Fitopatol.bras. 15: XXVI. 1999.
***Zucchini yellow mosaic virus* (ZYMV)**
ZYMV infecting zucchini squash was found in the states of São Paulo (1) and Tocantins (2).
Ref.: (1) Vega, J. et al. Fitopatol.bras. 20: 72. 1995; (2) Alencar, N.E. et al. J. Biotechnol. Biodiv. 3: 32. 2011.
***Potyvirus* unidentified**
Zucchini squash was found infected by a potyvirus, unrelated serologically to other known potyvirus which infect cucurbits. It is aphid-borne, and has been purified and a specific antiserum was produced (2). However, the identity of this virus remains obscure.
Ref.: (1) Santos, C.D.G. et al. Summa Phytopathol. 16: XXVIII. 1991; (2) Lima, J.A.A. Fitopatol.bras. 19: 294. 1994.

***Cyamopsis tetragonolobus* (L) Taub (Guar) Fabaceae**
Potyvirus
***Bean common mosaic virus (*BCMV)**
Guar plants from a multiplication field in Cambé, PR, were found with mosaic symptoms. Biological and serological tests and electron microscopy indicated tat the causal agent was BCMV (1).
Ref.: (1) Faria, M.L. et al. Fitopatol.bras. 15: 127. 1990.

***Cybistax antisyphilitica* (Mart.) Mart. (Green ipê) Bignoniaceae**
Potyvirus
***Watermelon mosaic virus* (WMV)**
***Zuchini yellow mosaic virus* (ZYMV)**
A survey made on a nursery of woody plants, in Distrito Federal, these potyviruses were found by biological assays. No mention to the symptoms nor further confirmation of virus identities (1).
Ref.: (1) Batista, J.G. et al. Virus Rev. & Res. 21: 122. 2016

***Cyclanthera pedata* (L.) Schrad. var. *edulis* (Slipper gourd) Cucurbitaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was detected in Slipper gourd plants in the germplasm collection of Embrapa Hortaliça, Brasília, DF (1).
Ref.: (1) Lima, M.F. et al. Trop.Plt.Pathol. 38 (supl.): 208. 2013.
Potyvirus
***Papaya ringspot virus W* (PRSV-W)**
C. pedata plants showing mosaic symptoms were found in Anhembi, SP, and found to be infected by an isolate of PRSV-W (1). Similar finding was made in the Federal District (2).
Ref.: (1) Rezende, J.A.M. Plant Dis. 84: 1155. 2000; (2) Lima, M.F. et al. Trop.Plt.Pathol. 38 supl.) 208. 2013.

***Cydonia oblonga* MILL. (Quince) Rosaceae**
Unidentified virus
Leaf ringspots in quince, observed in the state of São Paulo, was considered of possible viral etiology (1).
Ref.: (1) Issa, E.O Biológico 25: 80. 1959.

***Cymbopogon winterianus* Jowitt (Citronella) Poaceae**
Potyvirus
***Sugar cane mosaic virus* (SCMV)**
Natural infection of SCMV in citronella was observed in a germplasm collection of the Instituto Agronomico, Campinas, SP, resulting in mosaic and stunting. The virus was mechanically transmissible and identified as an isolate of SCMV (1).

Ref. (1) Costa, A.S. et al. Bragantia 10: 301. 1950.

***Cynara scolymus* L. (Artichoke) Asteraceae**
Ilarvirus
***Tobacco streak virus* (TSV)**
Low incidence of witch's broom and leaf malformation symptoms were observed in artichoke samples from Piedade, SP. Biological assays detected an isolate of TSV in these plants (1).
Ref.: (1) Costa, A.S. & Tasaka, H. O Biológico37: 176. 1971.
Macluravirus
***Artichoke latent virus* (ArLV)**
A virus, with similar characteristics with ArLV described in California, USA, was found in artichoke samples, with necrotic symptoms on their leaves, collected in São Roque, SP. Apparently the presence of this virus is unrelated with the observed symptoms (1).
Ref.: (1) Costa, A.S. & Camargo, I.J.B. Rev.Soc.Bras.Fitopat. 3: 53. 1969.
Tobravirus
***Pepper ringspot virus* (PepRSV)**
Yellow bands on artichoke leaves were observed in commercial plantations in Ibiúna e Piedade, SP, with low incidenced. Biological assays and electron microscopy indicated that the tobravirus PepRSV was the causal agent (1,2).
Ref.: (1) Chagas, C.M. et al. O Biológico 35: 13. 1969; 38: 35. 1972; (2) Camargo, I.J.B. et al. Rev.Soc.Bras.Fitopatol. 4: 59. 1971.

D

***Dahlia variabilis* Desf. (Dahlia) Asteraceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Chlorotic spots and rings were observed on the leaves of dahlia in São Paulo, SP, and the causal agent identified as the same causing "vira-cabeça" of tobacco, presently known as one of the several Orthotospovirus species (1). Orthotospovirus was also found in dahlia in the state of Rio de Janeiro (2).
Ref.: (1) Silberschmidt, K. & Loureiro, R. O Biológico 32: 270. 1966; (2) Kitajima, E.W. et al. Fitopatol. Bras.9: 607.1984.
Ilarvirus
***Tobacco streak virus* (TSV)**
TSV was identified infecting dahlia and causing chlorotic rings on the leaves in the state of São Paulo (1, 2).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Phytopathol. Zeit. 42: 113. 1961; (2) Roberti, R. et al. Fitopatol. Bras. 17: 194. 1992.
Caulimovirus
***Dahlia mosaic virus* (DMV)**
Mosaic and vein banding are the symptoms caused by infection of dahlia by DMV, na aphid-borne virus. In Brazil the first report was made in samples collected in the state of Rio de Janeiro, the virus being detected and identified by electron microscopy (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol. Bras. 9: 607. 1984

***Datura stramonium* L. (Jimson weed) Solanaceae**
Orthotospovirus
***Zucchini lethal chlorosis virus* (ZLCV)**
ZLCV was found infecting field Jimson weed plants in the state of S.Paulo. Identification was made by molecular assays (1).
Ref.: (1) Camelo-Garcia, V. et al. Trop.Plt.Pathol. 40: 345. 2015.
Polerovirus
***Potato leafroll virus* (PLRV)**
An isolate of PLRV, causing yellow top on tomato, was recovered from a field jimson weed plant, with chlorosis (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Coopercotia Fev./62,p.34. 1962.

***Daucus carota* L. (Carrot) Apiaceae**
Polerovirus
***Carrot red leaf virus* (CaRLV)**
A reddening or yellowing of leaves may be present occasionally in carrot cultivated in Brazil. The causal agent has been identified as an aphid [*Cavariella aegopodii* (Scop.)]-borne virus, CaRLV. This virus has been detected in the states of São Paulo and Minas Gerais (1).
Ref.: (1) Costa, A.S. et al. Supl.Agric.O Estado de S.Paulo 643: 15. 1967; Costa, A.S. et al. Summa Phytopathol. 1: 5. 1975.
Potyvirus
***Carrot thin leaf virus* (CTLV)**
Symptoms of mild mosaic and thin leaves were observed in a commercial carrot plantation in Piedade, SP. Electron microscopy indicated the association of the condition with a potyvirus, inducing cylindrical inclusion of type II. This virus is mechanically and aphid-transmissible, and was identified as an isolate of CTLV (1-3).
Ref.: (1) Kitajima, E.W. et al. Bragantia 27: XII. 1968; (2) Costa, A.S. et al. Rev. Olericult. 9. 1969; (3) Camargo, I.J.B. et al. Bragantia 30: 31. 1971.

***Desmodium* sp. Fabaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Potyvirus
***Cowpea aphid-borne mosaic virus* (CABMV)**
Desmodium sp. plants were found co-infected by CMV and CABMV in the Zona da Mata, state of Pernambuco (1).
Ref (1) Nicolini, C. et al. Trop.Plt Pathol 34 (supl): S271. 2009.
Begomovirus
***Desmodium* yellow spot virus (DeYSV)**
Golden mosaic symptoms were observed in plants of *Desmodium* sp. in the state of Alagoas and suspected to be caused by a begomovirus (1). In another similar occurrence, the disease was considered as being caused by a new species of begomovirus, named DeYSV (2).
Ref. (1) Assunção, L.P. et al. Planta Daninha 24: 239. 2006 (2) Lima, A.T.M. et al. Trop Plt Pathol 34 (supl): S275. 2009.

***Dianthus caryophyllus* L. (Carnation) Caryophyllaceae**
Alphacarmovirus
***Carnation mottle virus* (CarMV)**
CarMV was detected in several samples of asymptomatic carnation, collected in different parts of the state of São Paulo. Identification of the virus was based on biological and serological assays, complemented by electron microscopy (1). Later, CarMV isolates from the states of São Paulo and Minas Gerais were detected by molecular means (2).
Ref.: (1) Caldari Jr., P. et al. Fitopatol.bras. 22: 451. 1997; (2) Alexandre, M.A.V. et al. Hort.Bras.33: 257. 2015.

***Diascia* sp. (Twinspur) Scrophulariaceae**
Isometric virus, unidentified
Isometric, virus-like particles were found in twinspur plants suspected of viral infection. No further information is available (1).
Ref.: (1) Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95. 2010.

***Dieffenbachia amoena* Hort. ex.Gentil *; D. picta* Schott., *Dieffenbachia* sp. (Dumbcane) Araceae**
Orthotospovirus

***Tomato chlorotic spot virus* (TCSV)**

***Tomato spotted wilt virus* (TSWV)**

TCSV and TSWV have been reported infecting dumbcane plants, without mention to symptoms (1). TCSV, on the other hand, was detected by molecular means in dumbcane plants with chlorotic spots, rings and vein banding on their leaves (2, 3).

Ref.: (1) Galleti, S.R. et al. Virus Rev.& Res. 5: 197. 2000; (2) Rivas, E.R. et al. Fitopatol.bras. 26: 515. 2001. (3) Rivas, E.B. et al. Arq.Inst. Biol. 70: 615. 2003.

Potyvirus

***Dasheen mosaic virus* (DsMV)**

DsMV was serodiagnosed in commercial plants of dumbcane showing mosaic, vein banding and chlorotic spots on their leaves, in the state of São Paulo (1, 2).

Ref.: (1) Rivas, E.B. et al. Summa Phytopathol. 24: 71. 1998, (2) Rivas, E.B. et al. Arq. Inst.Biol. 70: 615. 2003

Tobamovirus

***Tobacco mosaic virus* (TMV)**

Chlorotic spots and rings were observed on leaves of *D. picta* in the state of S.Paulo, and the causal agent identified as an isolate of TMV (1).

Ref.: (1) Rivas, E.B. et al. Plant Dis. 84:707. 2000.

****Digitaria decumbens* Stent (Pangola grass) Poaceae**

Fijivirus

***Pangola stunt virus* (PaSV)**

Pangola plants showing reddening of the leaves and stunting were found in the state of São Paulo. Isometric particles, ca. 70 nm in diameter, were associated with the disease, in phloem tissues. Causal virus was identified as PaSV (1) and demonstrated to be transmitted by a hopper of the genus *Sogata* (2).

Ref.: (1) Kitajima, E.W. & Costa,A.S. Proc.7th Int.Cong.Electron Microscopy (Grenoble, Fr) p.131. 1970; (2) Costa, A.S. & Kitajima, E.W. Fitopatologia (Lima) 9: 48. 1974.

****Digitaria sanguinalis* (L) Scop. (Hairy crabgrass) Poaceae**

Potyvirus

***Potyvirus* unidentified**

Presence of an unidentified *Potyvirus* in hairy crabgrass was reported in the in the state of São Paulo. Some assay plants (*Gomphrena globosa*, *Chenopodium amaranticolor*) could be mechanically infected (1).

Ref.: (1) Vega, J. et al. Summa Phytopathol. 7: 7. 1981.

****Dioscorea* spp. (Yam) Dioscoreaceae**

Secoviridae

***Dioscorea* mosaic associated virus (DMaV)**

A new virus was found in yam plants showing mosaic symptoms. Molecular studies indicated that the sequence of two fragments of ssRNA (5 and 3.8 kb) are similar to members of the genus *Torradovirus* (family Secoviridae) (1). This secovirus had their genome completely sequenced and tentatively named DMaV (2).

Ref.: (1) Hayashi, E.A.I. et al. Archives of Virology 161: 317. 2016; (2) Hayashi, E.A.I. et al. Arch.Virol. 162: 317. 2017.

Potyvirus

***Yam mild mosaic virus* (YMMV)**

YMMV was detected in plants of yam cv. São Tomé (*D. alata*) with mosaic symptoms, in Itapissum, PE (1), and in yam cultivated in the state of Paraíba (2). Molecular studies indicated that these isolates are related to those found in Guadelupe (3) and their genomes have been entirely sequenced (4).

Ref.: (1) Andrade, GP et al. Fitopatol.bras. 31: S344. 2006. (2) Andrade,GP et al. Fitopatol.bras. 32 (supl): 322. 2007; (3) Andrade, GP et al. Trop.Plant Pathol. 36 (supl) CDRom 2011; (4) Rabelo Fo., F.A.C. et al. Arch.Virol. 158: 515. 2013.

***Yam mosaic virus* (YMV)**

A survey in the samples from the germplasm collection of Embrapa Mandioca e Fruticultura, multiplied in Embrapa Horaliças, Brasília, DF, revealed that yam plants of cvs. Yam Giboia and Maresby, showing high incidence of mosaic, were infected by YMV. Electron microscopy confirmed the presence of potyvirus, and the causal virus was transmitted mechanically to healthy yam plants (1). A possible case of infection of yam by YMV was reported in the state of Sergipe (2). YMV has been detected in cultivated yam in the states of Pernambuco and Alagoas (3), Paraíba (4) and Bahia (5).

Ref.: (1) de Ávila, A.C. et al. Fitopatol.bras. 7: 447. 1982; (2) Boari, A.J. et al. Summa Phytopathol. 31: 35. 2005; (3) Pio-Ribeiro, G. et al. Fitopatol.bras. 31 (supl):S309. 2006; (4) Andrade, G.P. et al. Fitopatol.bras. 32 (supl): 322. 2007; (5) Costa, D.P. et al.XVII Enc. Nac.Metodologia e Gestão de Lab. Da Embrapa. 2013.

Badnavirus

***Dioscorea bacilliform virus AL* (DBV)**

DBV was detected by electron microscopy in plants sampled in the state of Sergipe (1). This virus has been also reported in the states of Pernambuco and Paraíba (2), and Alagoas (3), and a possible case in Bahia (4). A study on variability of Brazilian isolates of DBV was made (5).

Ref.: (1) Boari, A.J. et al. Summa Phytopathol. 31: 35. 2005. (2) Paula, D.F. et al. Virus Ver&Res 11(supl): 189. 2006.(3) Lima, J.S. et al. Virus Rev.& Res. 15 (supl): 185.2010; (4) Costa, D.P. et al. XVII Enc.Nac.Metodologia e Gestão de Lab. Da Embrapa. 2013; (5) Lima, J.S. et al. Trop.Plant Pathol. 38: 349. 2013.

****Dracaena marginata* Lam. (Dragon tree) Dracaenaceae**

Cilevirus

***Cilevirus* unidentified**

Senescent leaves with green spots, associated with *Brevipalpus* mite infestation, was observed in dragon tree plants in Piracicaba, SP. Electron microscopy revealed cytopathic effects typical of cilevirus infection (1).

Ref.: (1) Nogueira, N.L. et al. Fitopatol. bras. 29: S234. 2004.

E

****Emilia sagittata* DC (Tasselflower) Asteraceae**

Orthotospovirus

***Tomato spotted wilt virus* (TSWV)**

Biological and serological assays detected a case of natural infection of tasselflower by TSWV in São Paulo, SP (1).

Ref.: (1) Colariccio, A. et al. Fitopatol. bras. 21: 423. 1996.

****Emilia sonchifolia* (L) DC (Lilac tasselflower) Asteraceae**

Potyvirus

***Potato virus Y* (PVY)**

A case of natural infection of lilac tasselflower by PVY was registered in the state of Minas Gerais (1).

Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

****Erigeron bonariensis* L. (Flax-leaf fleabane) Asteraceae**

Potyvirus

***Lettuce mosaic virus* (LMV)**

Natural infection of *E. bonariensis* by LMV was reported in the state of São Paulo as assessed by biological, serological and molecular assays, complemented by electron microscopy (1).

Ref.: (1) Chaves, A.L.R. et al. Fitopatol.bras. 28: 307. 2003.

****Eriotheca pubescens* (Mart. & Zucc.) Schott & Endl. Malvaceae**

Tobamovirus

***Pepper mild mottle virus* (PMMoV)**

PMMoV was detected by serology in seedlings of *E. pubescenes* in Brasília, DF (1).

Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40(supl): 354.2. 2015.

****Eruca sativa* Hill (Rocket) Brassicaceae**

Comovirus

Turnip ringspot virus (TuRSV)

An isolate of TuRSV infecting rocket plants was registered in the state of Paraná (1).

Ref. (1) Picoli, M.H.S. et al. J. Phytopathology 160: 55. 2012.

Crinivirus

***Tomato chlorosis virus* (ToCV)**

Rocket plants showing internerval chlorosis in lower leaves was observed in Mauá, PR. RT-PCR assays revealed that these plants were infected by ToCV (1).

Ref.: (1) Boiteux, L.S. et al. Plant Dis. 100: 1027. 2016.

Potyvirus

***Turnip mosaic virus* (TuMV)**

Mosaic symptoms were observed in a commercial field of rocket in the region of Botucatú, SP. Biological, serological and molecular assays demonstrated that the symptoms were due to infection by an isolate of TuMV, belonging to the group BR (1).

Ref.: (1) Ribeiro Jr., M.R. et al. Trop.Plt.Pathol. 43: 371. 2018.

****Eryngium phoetidum* L. (Long coriander) Apiaceae**

Orthotospovirus

***Tomato chlorotic spot virus* (TCSV)**

Yellowing, epinasty, small size of leaves, bronzing, vein chlorosis and stunting symptoms were observed in long coriander plants cultivated in Sta.Isabel, PA. RT-PCR assays indicated that these plants were infected by TCSV (1).

Ref.: (1) Quadros, A.F.F. et al. Summa Phytopathol. 42 (supl) res.11. 2016.

****Eucharis grandiflora* Planch. & Linden (Amazona lily) Amaryllidaceae**

Orthotospovirus

***Tomato spotted wilt virus* (TSWV)**

Amazon lily plants from a commercial nursery in Atibaia, SP, were found showing chlorotic spots and rings on their leaves. Laboratory tests including biological and RT-PCR assays indicated that these plants were infected by an isolate of TSWV (1).

Ref.: (1) Alexandre, A.M.V. et al. New Dis.Rept. 30: 13. 2014.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV was found infecting Amazon lily with mosaic symptoms, collected in São Paulo, SP, following biological, serological, molecular assays and electron microscopy (1). This isolate of CMV could be grouped in the same clade of other Brazilian isolates (2).

Ref.: (1) Cilli, A. et al. Virus Rev.&Res. 7: 151. 2002; (2) Duarte, L.M.L. et al. Tropical Plant Pathol. 33(supl.): S290. 2008.

Potyvirus

***Hippeastrum mosaic virus* (HiMV)**

Amazon lily plants infected by CMV was also co-infected by a potyvirus which was identified as HiMV based on RT-PCR assays and sequencing of the resulting amplicon (1).

Ref. (1): Alexandre, M.A.V. et al. Trop.Plt. Pathol. 36 (supl.): CDRom. 2011.

****Eugenia uniflora* L. (Pitanga, Suriname cherry) Myrtaceae**

Cilevirus

***Cilevirus* unidentified**

E. uniflora plants showing chlorotic rings on their leaves were found in Águas de S. Pedro, SP, associated with infestation by *Brevipalpus* mites. Electron microscopy revealed cytopathic effects typical of cilevirus in the tissues of the lesion (1).

Ref.: (1) Nogueira, N.L. & Rossi, M.L. Summa Phytopathol. 30: 111. 2004.

****Euphorbia heterophyla* L *(=E. prunifolia* Jacq.), (Wild poinsettia) Euphorbiaceae**

Begomovirus

***Euphorbia yellow mosaic virus* (EuYMV)**

Wild poinsettia showing a bright mosaic on their leaves is quite common in most of the Brazilian territory. Originally this condition was described in the state of São Paulo, and demonstrated to be whitefly-borne, and mechanically transmissible to some assay plant species. Occasionally this virus was found naturally infecting other plant species (1, 2). An isolate obtained in Brasília, DF, was characterized molecularly as a new begomovirus species, but its biological properties are unknown. Sequence analysis revealed 87.3% identity with a Peruvian isolate of EuMV, enough to be considered a distinct species, which was named *Euphorbia* yellow mosaic virus (EuYMV) (3). Some assay plants were infected by EuYMV by biobalistic (4).

Ref.: (1) Costa, A.S. & Bennett, C.W. Phytopathology 40: 266. 1950; (2) Costa, A.S. & Carvalho, A.M.B. Phytopathol. Zeit. 38: 129. 1960; (3) Rocha, W.B. et al. Fitopatol.bras. 29 (supl): S148. 2004; (4) Fernandes, F.R. et al. Arch.Virol. 156: 2063. 2011.

Gemycircularvirus

Pteropus associated gemycircularvirus 5 (PaGmV-5)

Molecular assays resulted in the detection of a gemycircular virus in wild poinsettia plants, with similarities in nucleotide sequence with PaGmV-5 (1).

Ref.: (1) Rezende, R.R. et al. Arch.Virol. 163: 3163. 2018.

****Euphorbia splendens* Bojer ex. Hook (Christ's thorn) Euphorbiaceae**

Ilarvirus

***Ilarvirus* unidentified**

Christ's thorn plants showing chlorotic mosaic and necrotic rings were found in the state of São Paulo. Biological and serological assays, light and electron microscopy indicated that these plants were infected by a still unidentified ilarvirus. (1).

Ref.: (1) Matos, M.F. et al. Fitopatol.bras. 19: 273. 1994.

****Eustoma grandiflorum* (Raf.) Shinners (Lisianthus) Gentianaceae**

Orthotospovirus

***Chrysanthemum stem necrosis virus* (CSNV)**

CSNV was found infecting lisianthus plants in a nursery at Atibaia, SP (1).

Ref. (1) Duarte, L.M.L. et al. Plant Dis. 98: 285. 2014.

***Groundnut ringspot virus* (GRSV)**

Lisianthus plants with chlorotic mosaic, necrotic rings and foliar deformation were sampled in Atibaia, SP. Further experiments indicated that these plants were double-infected by GRSV and CSNV (1).

Ref.: (1) Alexandre, M.A.V. et al. Summa Phytopathol. 25: 353. 1999

***Tomato spotted wilt virus* (TSWV)**

An isolate of TSWV was found infecting lisianthus, resulting in stunted plants, and necrotic spots on their leaves (1).

Ref.: (1) Freitas, J.C. et al. Fitopatol. Bras. 21(supl.): 425. 1996.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Leaf blistering and necrotic streaks, and witches' broom were observed in lisianthus growing in the state of São Paulo. Laboratory assays identified CMV as the causal agent (1, 2).

Ref.: (1) Borsari, P.L. et al. Fitopatol.bras. 22: 332. 1997 (2) Alexandre, M.A.V. & Duarte, L.M.L.(Ed.) Plantas ornamentais: Doenças e Pragas. 319pp. 2008.

Ilarvirus

***Tobacco streak virus* (TSV)**

Lisianthus from commercial plantations in the state of São Paulo were found infected by a possible ilarvirus (1), identified as TSV (2). Symptoms were chlorotic or necrotic spots and rings on their leaves.

Ref.: (1) Rivas, E.B. et al. Fitopatol. Bras. 19:311. 1994; (2) Freitas, J.C. et al. Fitopatol. Bras. 21(supl.): 425. 1996.

Tobravirus

***Pepper ringspot virus* (PepRSV)**

Samples of lisianthus from Jundiaí, SP, exhibiting mosaic, necrotic lines on the leaves and color breaking of flowers. The causal agent was identified by biological and serological tests and electron microscopy as PepRSV (1).

Ref.: (1) Alexandre, M.A.V. et al. Res. VII Enc.Nac.Virol.: 282. 1996.

F

****Fevillea trilobata* L. Cucurbitaceae**

Potyvirus

***Papaya ringspot virus W* (PRSV-W)**

Mechanical transmission assays and RT-PCR detected PRSV-W infecting *F. trilobata* in Brasília, DF (1).

Ref.: (1) Castro, G.M. et al. Plant Dis. 100: 2540. 2016.

***Zucchni yellow mosaic virus* (ZYMV)**

Mosaic symptoms were observed in *F. trilobata* in a germplasm collection of Embrapa Hortaliças, Brasília, DF. Further biological, serological and molecular assays and electron microscopy identified the causal virus as an isolate of ZYMV (1).

Ref.: (1) Boiteux, L.S. et al. Plant Dis. 97: 1261. 2013.

****Ficus carica* L. (Fig) Moraceae**

Emaravirus

***Fig mosaic virus* (FMV)**

Fig plants in the state of São Paulo were found with a mosaic, transmissible by eryophiid mites [*Aceria ficus* (Cotte)] and grafting, and FMV was considered the causal agent (1,2). Virus-infected but asymptomatic plants had no yield losses (3).

Ref.: (1) Zaksveskas, M.L.R. Fitopatologia (Lima) 8: 21a; 21b. 1973; (2) Zaksveskas, M.L.R. & Costa, A.S. Fitopatologia (Lima) 9: 74. 1974; (3) 10: 65. 1975.

****Fragaria x ananassa* Duch. (Strawberry) Rosaceae**

Cytorhabdovirus

***Strawberry crinkle virus* (SCrV)**

The first register of SCrV in Brazil was made in the state of Rio Grande do Sul (RS), in a strawberry collection of IPEAS, in plants showing chlorosis and crinkled leaves (1). The virus was also found in the state of São Paulo (2) and other regions of RS (3).

Ref.: (1) Siqueira, O. Rev.Soc.Bras.Fitopatol. 2: 176. 1968; (2) Betti, J.A. et al. Fitopatologia (Lima) 8: 2. 1973; (3) Nickel, O. et al. Trop. Plt.Pathol. 34 (supl.): S267. 2009.

Secoviridae, undefined genus

***Strawberry mottle virus* (SMoV)**

SMoV-infected cultivated strawberries (interspecific hybrids of *Fragaria*) are asymptomatic. First register was made in the state of São Paulo (1). This virus may be detected through the use of a wild strawberry (*Fragaria vesca*) as indicator plant using the aphid vector *Pentatrichopus fragaefolii* (Ckll). Symptoms in the indicator are represented by pale veins, spots and mosaic, epinasty and roughness on the leaves. Some assays plants as *Chenopodium quinoa, Cassia occidentalis, Leonotis nepaetifolia, L. sibiricus* could be infected by SMoV by the aphid, but retroinoculation to *F. vesca* could not be achieved. It is transmissible mechanically to *C. amaranticolor* and *C. quinoa* (1). Electron microscopy revealed isometric viruslike particles in the phloem vessels (2).VIDE and ICTV list SMoV as belonging to the family *Secoviridae* but in an undefined genus (ICTV, 2011). Recently SMoV had its genome entirely sequenced revealing to be similar to *Satsuma dwarf virus*, a nepovirus.

Ref.: (1) Carvalho, A.M.B. et al. Bragantia 20: 563. 1961; (2) Kitajima, E.W. et al. Ciência e Cultura 23: 649. 1972.

Ilarvirus

***Tobacco streak virus* (TSV)**

Some strawberry varieties, kept in the germplasm collection of the Instituto Agronomico, Campinas, SP, as well as some introductions, developed vein necrosis, sometimes followed by chlorotic lines or ringspots. The condition was graft transmissible and TSV was identified associated to the disease, through immunoelectron microscopy (1).

Ref.: (1) Vega, J. et al. Summa Phytopathol. 16: 20. 1990.

Alphaecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from the root system of asymptomatic strawberry plants kept under greenhouse conditions in Instituto Agronomico, Campinas, SP (1).

Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960.

Caulimovirus

***Strawberry vein banding virus* (SVBV)**

A virus causing vein banding in the indicator *F. vesca* var. *sempeflorens* was recovered from asymptomatic hybrid strawberry cultivars in the state of São Paulo. The aphid *Chaetosiphum thomasi* was able to transmit the virus, which was identified as StVBV (1). Electron microscopy of infected tissues revealed cytopathic effects indicating that StVBV would be a caulimovirus (2), which was later confirmed by biochemical studies made in the USA.

Ref.: (1) Betti, J.A. et al. Fitopatologia (Lima) 8: 73. 1973; (2) Kitajima, E.W. et al. J.gen.Virol. 20: 117. 1973.

G

****Galactia striata* (Jacq.) Urb. (Florida hammock milkpea) Fabaceae**

Begomovirus

***Bean golden mosaic virus* (BGMV)**

A mosaic affecting *G. striata* was observed in several regions of the state of São Paulo, and attributed to an isolate of BGMV, because its transmission to bean by whiteflies, induced golden mosaic (1).

Ref.: (1) Costa, A.S. et al. Summa Phytopathol.l 6: 40. 1980.

****Galinsoga parviflora* Cav. (Gallant soldier) Asteraceae**

Polerovirus

***Potato leafroll virus* (PLRV)**

Natural infection of gallant soldier plants by PLRV was reported in the state of Minas Gerais, without mention to symptoms (1).

Ref.: (1) Oliveira, C.D. et al. Fitopatol. bras. 21: 427. 1996.

Potyvirus

***Bidens mosaic virus* (BiMV)**

***Lettuce mosaic virus* (LMV)**

***Potato virus Y* (PVY)**

LMV (1) and BiMV (2) were found infecting *G. parviflora* in the

state of São Paulo, while in the state of Minas Gerais, this plant was found infected by PVY (3). No mention on possible symptoms was made.
Ref.: (1) Sanches, M.M. et al. Summa Phytopathol 36:346-347, 2010; (2) Sanches, M.M. et al. Summa Phytopathol. 36: 347. 2010; (3) Oliveira, C.D. et al. Fitipatol. bras. 21: 427. 1996.

***Gardenia jasminoides* J. Ellis (Gardenia) Rubiaceae**
Dichorhavirus
***Dichorhavirus* unidentified**
A gardenia plant showing chlorotic spots on leaves were observed in a residential garden in Urucu, AM. Electron microscopy revealed cytopathic effects similar to those caused by dichorhaviruses (1).
Ref: (1) Rodrigues, J.C.V. et al. Trop .Plt. Pathol. 33: 12. 2008.

***Gaya guerkeana* K. Schum. Malvaceae**
Begomovirus
Gaya yellow mosaic virus (GaYMV)
A possible new species of begomovirus was found in this native malvacea in the state of Alagoas, and named GaYMV. No attempt for biological characterization was made (1).
Ref.; (1) Tenoria, A.A.R. et al. Trop.Plt.Pathol. 38 (supl.): 196. 2013.

***Gerbera jamesonii* Bolus ex Hooker f (Transvaal daisy) Asteraceae**
Orthotospovirus
***Chrysanthemum stem necrosis virus* (CSNV)**
***Tomato chlorotic spot virus* (TCSV)**
CSNV and TCSV were found infecting Transvaal Daisy in the state of São Paulo resulting in necrotic spots and vein necrosis on their leaves. Transmission assays, serology and RT-PCR were used to detect these viruses (1).
Ref.: (1) Alexandre, M.A.V.et al. Summa Phytopathol. 29: 69. 2003.
Tobravirus
***Pepper ringspot virus* (PepRSV)**
G. jamesonii plants collected in Cachoeira do Sul, RS, showing chlorotic rings and bands on their leaves, were found to be infected by PepRSV (1).
Ref.: (1) Chagas, C.M. et al. Fitopatol. bras. 12: 346. 1987.

***Gladiolus x hortulanus L.H. Bailey* (Gladiolus) Iridaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Gladiolous plants with mosaic symptoms were found in the state of SãoPaulo. Causal agent was identified as CMV (1).
Ref.: (1) Costa, A.S. Summa Phytopathol. 9: 39. 1983.
Potyvirus
***Bean yellow mosaic virus* (BYMV)**
Gladiolus infection by BYMV results in mosaic symptoms and such plants may serve as source of inoculum for BYMV for bean crops (1). BYMV in gladiolous was reported in Holambra (2) and Capão Bonito, SP (3).
Ref.: (1) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972; (2) Alexandre M.A.V. et al. Virus Rev. & Res. 7: 17. 2002; (3) Alexandre, M.A.V. et al. Rev. Bras. Hort. Orn. 16: 95. 2010.

***Gloxinia sylvatica* (Kunth.) Whieh (Bolivian sunset) Gesneriaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was found infectig *G. sylvatica* plants, showing chlorotic spots on their leaves in the state of São Paulo. Biological and serological assays were used to identify CMV (1).
Ref. : (1) Alexandre, M.A.V. et al. Rev. Brasileira Hort. Orn. 11: 49. 2005.
Tobravirus
***Pepper ringspot virus* (PepRSV)**
Symptoms of vein banding on the leaves were observed in Bolivian sunset plants in Brasília, DF. These symptoms were attribute to PepRSV infection based on biological and serological assays complemented by electron microscopy (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol. bras. 23: 489. 1998.

***Glycine max* (L) Merr. (Soybean) Fabaceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Orthotospovirus infection of soybean seems to be rare in Brazil. First report was made in the state of São Paulo, and some outbreaks may occur depending on the cultivated variety. Symptoms of Orthotospovirus infection are chlorotic spots on lower leaves and systemic chlorotic spots or rings, terminal bud torsion, growth paralysis (1, 2).
Ref.: (1) Costa, A.S. et al. 1º Simp.de Soja (Campinas). 1970; (2) Costa, A.S. et al. Summa Phytopathol. 11: 45. 1985.
Comovirus
***Bean rugose mosaic virus* (BRMV)**
BRMV, a beetle-transmitted virus, was found infecting soybean, cultivated in the Federal District, showing mosaic and blistering (1). It was also detected in the state of Paraná causing a rugose mosaic (2) and spots on seed (3). BRMV was also reported in experimental fields of Embrapa Cerrado, Planaltina, DF (4).
Ref.: (1) Cupertino, F.P. et al. Fitopatol.bras. 16: 246. 1991; (2) Martins, T.R. et al. Fitopatol. Bras. 18: 318. 1993; (3) Silva, M.F. et al. Fitopatol.bras. 26: 511. 2001; 4) Anjos, J.R.N. Fitopatol.bras. 17: 151. 1992; (5) Anjos, J.R.N. et al. Fitopatol.bras. 24: 85. 1999.
***Cowpea severe mosaic virus* (CPSMV)**
CPSMV was detected in soybean causing bud blight, in Central Brazil (1) and also in the state of Paraná (2).
Ref.: (1) Anjos, J.R.N. & Lin, M.T. Plant Dis. 68: 305. 1984; (2) Bertacini, P.V. et al. Fitopatol.bras. 19: 271. 1994.
Carlavirus
***Cowpea mild mottle virus* (CPMMV)**
CPMMV, a whitefly-borne carlavirus, initially reported in Brazil causing angular mosaic in cv.'Jalo' bean, was able to infect soybean causing mild mosaic and bud blight (1). In 2001 there was an outbreak of bud blight and stem necrosis in soybean fields at Barreiras, BA, the causal agent being identified as CPMMV (2). The virus was also found in the states of Goias, Mato Grosso, Maranhão and Paraná (3), São Paulo (4), Minas Gerais (5) and Pará (6).
Ref.: (1) Costa, A.S. et al. An.II Sem.Nac.Pesq.Soja (Brasilia): 247. 1981; (2) Almeida, A.M.R. et al. Circ.Tecn. EMBRAPA/Soja 36. 2002; (3) Almeida, A.M.R. et al. Fitopatol. bras. 28: S287. 2003; (4) Bicalho, A.A.C. et al. Virus Rev. & Res. 16 (supl.) CDRom. 2011; (5) Zanardo, L.G. et al. Trop.Plt.Pathol. 38(supl.): 189. 2013; (6) Zanardo, L.G. et al. Trop.Plt.Pathol. 38 (supl.): 190. 2013.
Alfamovirus
***Alfalfa mosaic virus* (AMV)**
AMV was first reported in soybeans in Brazil, in an experimental field of Embrapa Soja, Londrina, PR. This virus caused bright yellowing (calico mosaic) on leaves and stunting of plants (1). Seed transmission occurred in some AMV-infected soybean, and in some cultivars, the virus-induced bud blight (2).
Ref.: (1) Almeida, A.M.R. et al. Fitopatol.bras. 7: 13. 1982; (2) Costa, A.S. et al. Anais II Semin.Nac.Pesq.Soja (Brasília): 264. 1981.
Ilarvirus
***Tobacco streak virus* (TSV)**

TSV-induced bud blight is commonly seen in more developed soybean plants. Other symptoms include irregular yellow spots on leaves and necrotic streaks along the veins, growth paralysis followed by tip death and bending. Intense axilar budding may occur producing a witches' broom type of appearance to the plant. This condition was first described in the state of São Paulo (1). Seed transmission of TSV may occur (2). Experimental inoculation of soybean by TSV demonstrated that precocious infection may result in almost total yield loss and about 50%, in late infections (3). Incidence of TSV is present in practically all soybean growing regions, but usually in low incidence. In some varieties, TSV may cause witches' broom symptoms, without bud blight (4).

Ref.: (1) Costa, A.S. et al. Bragantia 14: VII. 1955; (2) Costa, A.S. & Kiihl, R.A.S. Rev.Soc. Bras. Fitopatol. 4: 35. 1971; (3) Lima No., V.C. & Costa, A.S. Fitopatologia (Lima) 9: 58. 1974; (4) Scagliusi, S.M.M. & Costa, A.S. Fitopatol.bras 17: 187. 1992.

Potyvirus

***Bean yellow mosaic virus* (BYMV)**

Mosaic and wrinkling of soybean leaves were found in the state Rio Grande do Sul, and attributed to BYMV infection (1).

Ref.: (1) Hagedorn, D.J. et al. Plant Dis.Reptr. 53: 165. 1969; (2) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972.

***Cowpea aphid-borne mosaic virus* (CABMV)**

CABMV was detected by serology, infecting several soybean lines in a field assay in Teresina, PI (1). Probably is the same isolate recovered from soybean cv.'Tropical', in Fortaleza, CE (2).

Ref.: (1) Santos, A.A. Pesq.Agropec.Bras. 21: 899.1986; (2) Sousa, A.E.B.A. et al. Fitopatol. bras. 21: 470. 1996.

***Soybean mosaic virus* (SMV)**

SMV is probably the most common virus present in soybean crops. First report of its presence was made in the state of Rio Grande do Sul, and afterwards in all soybean producing regions [states of Paraná, São Paulo, Minas Gerais, Mato Grosso do Sul, Mato Grosso, Goiás, Distrito Federal] (2, 3, 6, 8, 9). It is naturally disseminated by aphids and infected seeds. Varietal resistance was found. Typical symptoms are mosaic and wrinkling on leaves and spotted seeds, and bud blight in cvs. with resistance of hypersensitivity type (3). *Cassia occidentalis* is susceptible and may serve as source of inoculum, since it grows commonly nearby soybean fields (4). Seed transmission rate may vary according to the soybean genotype (5). Experimental inoculation may result in black and depressed lesions, of irregular shape in pods of some varieties (7). A condition known as 'yellow shoot' was initially considered caused by a potyvirus distinct from SMV (10), but subsequent molecular works indicated that it is an isolate of SMV (11, 12).

Ref.: (1) Vasconcelos, F.A.T. Anais Inst.Sup.Agron. 26: 181. 1963; (2) Issa, E. O Biológico 31: 42. 1965; (3) Costa Lima No., V. Tese Dr. ESALQ/USP. 1974; (4) Costa, A.S. et al. 1º Simp.de Soja (Campinas). 1970; (5) Porto, M.D.M. & Hagedorn, D.J. Phtyopathol. 65: 713. 1975; (6) Almeida, A.M.R. Fitopatol.bras. 5: 125. 1980; (7) Almeida, A.M.R. & Kihil, R.A.S. Fitopatol.bras. 6: 281. 1981: (8) Santos, A.A. Fitopatol.bras. 7: 546. 1982; (9) Figueira, A.R. et al. Fitopatol.bras. 10: 308. 1985; (10) Deslandes, J.A. et al. Summa Phytopathol. 10: 25. 1984: (11) Rezende, J.A.M. & Costa, A.S. Summa Phytopathol. 12: 187.1986; (12) Santos, R.C. et al. Virus Rev. & Res. 8: 200. 2003.

Sobemovirus

***Southern bean mosaic virus* (SBMV)**

Curved spots in soybean seeds, referred to as 'moustache spots', was found to be caused by an isolate of SBMV in the state of São Paulo (1).

Ref.: Costa, A.S & Vega, J. Fitopatol.bras. 12: 145. 1987.

Begomovirus:

***Bean golden mosaic virus* (BGMV)**

BGMV, which is a serious virus for bean crops, was also found infecting soybean, though not causing serious concern, in the state of São Paulo (1).

Ref.: (1) Costa, A.S. et al. An. Io.Sem.Pesq.Soja II: 145. 1979.

***Euphorbia yellow mosaic virus* (EuYMV)**

Natural infection of soybean by EuYMV resulted in stunting of soybean plants. The symptoms were reproduced through whitefly transmission of the causal virus EuYMV, in the state of São Paulo. Such infection is rare and considered of marginal importance (1). In Luziânia, GO, soybean with interveinal chlorosis and leaf roll symptoms was found to be infected by an isolate of EuYMV, as revealed by molecular assays (2).

Ref.: Ref.: (1) Costa, A.S. et al. 1º Simp.de Soja (Campinas). 1970; (2) Tavares, M.L. et al. Virus Rev & Res.20 (supl.): 192.2015.

"Infectious chlorosis of malvaceae complex" (ICMC)

***Okra mottle virus* (OMoV)**

***Sida micrantha mosaic virus* (SimMV)**

***Sida mottle virus* (SiMoV)**

Mosaic symtoms in soybean caused by whitefly (*Bemisia tabaci*)-transmitted begomoviruses, though not rare, seems to be of minor importance. Early report of begomvirus in soybean was attributed to ICMC. Experimental infection caused yield losses up to 59% (1). SiMoV and OMoV were detected in soybean by molecular means in the state of Goiás (2, 3, 5). In Brasília, DF, SmMV was detected in soybean used as vegetable (4) and an infectious clone of this virus was obtained (4). SimMV was also found infecting soybean in Distrito Federal (5).

Ref.: (1) Costa, A.S. Phytopathol.Zeit. 24: 97. 1955 (2) Mello, R.N. et al. Virus Rev.& Res. 7: 157. 2002. (3) Fernandes, F. R. et al. Arch. Virol. 154: 1567. 2009.(4) Fonseca, M.E.N. et al. Tropical Plt. Pathol. 34 (supl): S266. 2009; (6) Freitas, D.M.T.A. et al. Virus Rev.& Res. 19 (supl): 220. 2014.

Soybean chlorotic spot virus (SCSV)

A begomovirus was detected infecting soybean plants, causing chlorotic spots on leaves, in Jaíba, MG. Molecular assays indicate that the causal agent, named SCSV, is distinct from known begomoviruses. It was transmitted by biolistic means, but no attempts of whitefly transmission is reported (1).

Ref.: (1) Coco, D. et al. Arch.Virol. 158: 457. 2013.

***Tomato severe rugose virus* (ToSRV)**

Asymptomatic infection of ToSRV in soybean, planted nearby tomato fields was noticed in samplings made in Central Brazil. Detection was based on PCR assays. Soybean experimentally infected by whiteflies did not show symptoms (1).

Ref.: (1) Macedo, M.A. et al. Plant Dis. 101: 1959. 2017.

****Gnaphalium spicatum* LAM. (=*Gamochaeta spicata* (LAM.) Cabrera) Asteraceae**

Orthotospovirus

***Orthotospovirus* unidentified**

Chlorotic spots and deformation of leaves were observed in *G. spicatum* plants in the state of São Paulo. Causal agent was identified as an Orthotospovirus (1).

Ref.: (1) Pavan, M.A. et al. Fitopatol.bras. 17: 186. 1992.

Potyvirus

***Potato virus Y* (PVY)**

G. spicatum was found naturally infected by PVY in the state of Minas Gerais. No reference to symptoms was made (1).

Ref.: (1) Oliveira, C.D. et al. Fitipatol.bras. 21: 427. 1996.

****Gomphrena globosa* L. (Globe amaranth) Amaranthaceae**

Nucleorhabdovirus

***Gomphrena* Virus (GoV)**

During virus recovery assays from cultivated plants, a *G. globosa* plant inoculated with a lettuce sample, developed local lesions, in which a nucleorhabdovirus was found. This virus was able to infected several assay hosts. It could not be characterized but it may be related to *Sowthistle yellow vein virus* (1).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Virology 29: 523. 1966;

***Gossypium hirsutum* L. (Cotton) Malvaceae**
Ilarvirus
***Tobacco streak virus* (TSV)**
First cases of cotton infection by TSV was reported in the state of São Paulo (1). It was demonstrated that field infection of cotton by TSV requires previous infection, pré-conditioning, by cotton anthocyanosis, an aphid-borne virus, a putative polerovirus (2). Infection alone by TSV is feasible under experimental conditions, but results only in localized infection. Systemic infection by TSV results in stunting, internerval chlorosis, intense axilar budding, and yield losses (1).
Ref.: (1) Costa, A.S. et al. Bragantia 13: I. 1954; Costa, A.S. Phytopath. Zeit. 65: 219. 1969.
Polerovirus
Cotton anthocyanosis virus (CotAV)
An intense reddening of cotton leaves is caused by CotAV, a putative polerovirus, and transmitted by the aphid *Aphis gossipyii* Glov. Reddening of the leaves is preceded by chlorotic spots, and these symptoms may be taken as magnesium deficiency. However, contraty to a true Mg defficiency, application of this element does not revert symptoms (1, 2). Anthocyanosis is common in most cotton crops, but in low incidence. The disease has been reported in the states of São Paulo and Bahia (4). *Sida rhombifolia*, kenaf and okra are natural alternative hosts. CotAV-resistant cotton genotypes, as BJA, 592, NU 16, have been identified (5). Genome sequencing of CotAV indicated that it is very closely related to the Cotton leafroll dwarf virus, also an aphid borne polerovirus (6, 7).
Ref.: (1) Costa, A.S. & Sauer, H.F.G. Bragantia 13: 237. 1954; (2) Costa, A.S. Phytopathol.Zeit. 28: 167. 1956; (3) Costa A.S. Phytopath. Zeit. 65: 219. 1969 (4) Freire, E.C. et al. IPEAL (71/74). 1974; (5) Costa, A.S. et al. Summa Phytopathol. 7: 6. 1981; (6) Andrade, R.R.S. et al. Anais do 9º Cong.Bras.Algodão. 2013; (7) Fausto, A.K.S. et al. Virus Review & Res. 21: 116. 2016.
***Cotton leafroll dwarf virus* (CLRDV)**
Cotton vein mosaic virus (CotVMV)
Vein mosaic of cotton was known since 1930' in the state of São Paulo, a disease characterized by vein mosaic, associated with the down curving of the leaf margins. In some cotton cultivars, leaves may become bluish. It was demonstrated to be aphid-borne and the causal virus known as CotVMV. A severe form of vein mosaic was known as type Ribeirão Preto. Cotton research group from Instituto Agronomico de Campinas developed resistant varieties (1, 2). After 1990's cotton culture advanced to Central Brazil, especially in the state of Mato Grosso, where a high incidence of the so called "mal azul" (blue disease) occurred, mostly in varieties introduced from USA. It was assumed that it was an epidemy of CotVMV because these introduced types were highly susceptible to it (3, 4). Molecular works developed with virus recovered from cotton plants affected by "mal azul", using specific primers for luteoviruses, amplified genome fragments with ca. 90% of similarity with coat protein gene of *Chickpea stunt disease associated enamovirus* (CpSDaV) (5). Sequence analysis suggested that this cotton virus could be a new polerovirus, and the name Cotton leafroll dwarf virus- CLRDV has been suggested (6). This virus was found in cotton plants from several Brazilian states as São Paulo, Paraná, Goiás, Federal District, and these isolates revealed little variability (7). *Capsicum* sp. was infected by this cotton virus when mass aphid inoculated. Two isolates of this virus from Goiás and Mato Grosso were able to break resistance, and had their genomes sequenced (8).
Ref.: (1) Costa, A.S. & Forster, R. Bol.Tecn.IAC 51. 1938; (2) Costa, A.S. & Carvalho, A.M.B. Cultura e Adubação do algodoeiro, Inst.Bras. Potassa p.433.. 1965; (3) Andrade, D.F.P. & Lamas, F.M.. Fitopatol. bras. 25: 446. 2000; (4) Takimoto, J.K. et al.,. Fitopatol. Bras. 28 (supl.) 28: 254. 2003; (5) Corrêa, L.R. et al. Arch.Virol. 150:1357. 2005; (6) Franca, T.S. et al. Virus Rev&Res 11 (supl): 192. 2006. (7) Silva, T.F. et al. Virology Journal 5: 123. 2008; (8) Silva, A.K. et al. Arch. Virology 160: 1371, 2015.
Begomovirus
Infectious chlorosis of malavaceae complex" (ICNC)
In the state of São Paulo, where first cases of cotton infection by begomovirus were registered, the pathogen was identified as ICNC, transmitted by whitefly *Bemisia tabaci.*Though in low incidence, the disease was well disseminated, but without economic importance. Infected plants exhibit yellow mosaic and blistering of leaves, stunting, partial or total sterility, and the condition has been referred to as "pseudo mosaic". Spontaneous vegetation growing nearby cotton cultures, as *Sida* spp. harbor the virus, which is transmitted to cotton by whiteflies, however whiteflies was unable to transmit ICMC from cotton to cotton. This viral disease was first described in the state of São Paulo, but seems to occur wherever cotton is cultivated (1-5).
Ref.: (1) Bitancourt, A.A. Conf. Nac.Algodoeira, SP, p.15. 1935; (2) Costa, A.S. Bol.Tecn. IAC 37. 1937; (3) Costa, A.S. & Forster, R. Rev. Agricultura 12: 453. 1937; (4) Orlando, A. & Silberschmidt, K. Arq. Inst.Biol. 16: 133. 1945; (5) Costa, A.S. Bragantia 13: XXIII. 1954.
***Cotton chlorotic spot virus* (CCSV)**
A begomovirus was identified infecting cotton and causing chlorotic spots, internerval chlorosis and distortion on leaves, in the state of Paraíba. Molecular characterization indicated that the virus seems to be a new species and named CCSV (1).
Ref.: (1) Almeida, M.M.S. et al. Genome Announc. 1(6). e00661-13-e00661-13. 2013.

***Guibourtia hymenifolia* (Moric.) J.Léonard Fabaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
GRSV was detected in *G. hymenifolia* by immunoassay in Brasília, DF (1).
Ref.: (1) Santos, F.M.B. et al. Trop.Plt. Pathol. 41 (supl.): CDRom. 2016.

H

***Hedera canariensis* (Kirchn.) Bean (Ivy) Araliaceae**
Cilevirus
***Cilevirus* unidentified**
Green spots on senescent leaves were observed in ivy growing in the campus of the Universidade de São Paulo (ESALQ), Piracicaba, SP, associated with infestation by the tenuipalpid mite *Brevipalpus phoenicis s.l.,* Electron microscopy of tissues from these green spots demonstrated cytopathic effects characteristic of cileviruses, which is still unidentified (1).
Ref.: (1) Kitajima, E.W. et al. Scientia Agric. 67: 348. 2010

***Helianthus annuus* L. (Sunflower) Asteraceae**
Ilarvirus
***Tobacco streak virus* (TSV)**
Infection of sunflower by TSV results in growth paralysis. Young leaves become chlorotic, bent downwards e malformed; lower leaves may show vein clearing and necrosis; tip blight may occur. Such

disease was reported in the state of São Paulo. Identification of TSV was made by biological assays (1).
Ref.:(1) Costa, A.S. & Costa, C.L. Rev.Soc.Bras.Fitopat. 5: 61. 1972.
Potyvirus
***Bidens mosaic virus* (BiMV)**
Sunflower plants showing systemic necrosis on their leaves were observed in the state of São Paulo, and demonstrated to be caused by BiMV using biological assays and electron microscopy (1).
Ref.: Costa, A.S. & Kitajima, E.W. Supl.Agri.O Est.S.Paulo. nov. 1966.
Alphaecrovirus
***Tobacco necrosis virus* (TNV)**
TNV was recovered from roots of asymptomatic sunflower plants, maintained under greenhouse conditions in the Instituto de Agronômico, Campinas, SP (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960.

***Helichrysum* sp. Mill. (Helychrisum) Asteraceae**
Potexvirus
***Althernanthera* mosaic virus (AltMV)**
Serological assays identified AltMV as the causal agent of mosaic in helychrisum, collected at São José do Rio Preto, SP (1).
Ref.: (1) Alexandre, M.A.V. et al. Trop.Plt Pathol. 33 (supl): S231. 2008.

***Heliconia stricta* Huber. (Heliconia) Heliconiaceae**
Potyvirus
***Potyvirus* unidentified**
Heliconia exhibiting chlorotic spots on their leaves were found in a commercial plantation at Registro, SP. A still unidentified potyvirus was found by RT-PCR associated with the disease (1).
Ref.: (1) Harakava, R. et al. Summa Phytopathol. 39 supl CDRom. 2013.

***Hemerocallis* sp. (Daylily) Hemerocallidaceae**
Tobamovirus
***Tomato mosaic virus* (ToMV)**
A tobamovirus, identified as ToMV by molecular assays, was detected in daylily plants sampled in the state of São Paulo with mosaic symptoms (1, 2).
Ref.: (1) Duarte, L.M.L. et al. Virus Rev.& Res. 11 (supl.): 191. 2006; (2) Duarte, L.M.L. et al. Summa Phytopathol. 33: 409. 2008

***Heliotropium indicum* L. (Indian heliotrope) Boraginaceae**
Orthotospovirus
***Zucchini lethal chlorosis virus* (ZLCV)**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
During a survey on viruses infecting weeds around commercial cucurbit fields in the state of Tocantins, ZLCV and ZYMV were found in *H. indicum* in the municipality of Formoso do Araguaia. CMV was the only virus found in this plant in Figueirópolis (1).
Ref.: (1) Aguiar, R.W.S. et al. Planta Daninha 36: e018171593. 2018.

***Herissantia crispa* (l.) Brizicky (Bladdermallow) Malvaceae**
Begomovirus
***Begomovirus* unidentified**
An unidentified begomovirus was found causing mosaic in bladdermallow in the state of Alagoas (1).
Ref: (1) Assunção, L.P. et al. Planta Daninha 24: 239. 2006.

***Hevea brasiliensis* Mull. Arg. (Rubber tree) Euphorbiaceae**
Carlavirus
***Carlavirus* unidentified**
Mosaic, internerval chlorosis and smaller size of leaf blade were noticed in rubber trees produced at Embrapa Amazonia Ocidental, Manaus, AM, and kept at Embrapa Biotecnologia, Brasília, DF. Carlavirus-like particles were found in leaf extracts and tissue sections of these plants. However, no mechanical transmission was achieved to indicator plants. This unidentified carlavirus has yet to be characterized (1).
Ref.: (1) Gama, M.I.C.S. et al. Fitopatol.bras. 8: 621. 1983.

***Hibiscus rosa-sinensis* L (Hibiscus), *H. schizopetalus* (Mast.) Hook.f. (Japanese lantern), *H. syriacus* L (Rose of Sharon) Malvaceae**
Dichorhavirus
***Clerodendrum chlorotic spot virus* (ClCSV)**
Chlorotic spots, with irregular borders, distinct from those smaller, caused by HCRSV, were noticed on green leaves of hibiscus in Campos de Goytacazes, RJ, Campinas and Piracicaba, SP, associated with *Brevipalpus* mite infestation. Electron microscopic analysis of tissues from these lesions revealed cell alterations typical of those caused by dichorhaviruses. Mite transmission experiments with ClCSV using infected *Clerodendrum x speciosum* plants as source of inoculum, reproduced the same symptoms in uninfected hibiscus (1). In a sample collected from Campos de Goytacazes, RJ, which were double infected by ClCSV and HGSV, some parenchymal cells were observed double infected by these two viruses, a fact considered demonstrative that dichorha- and cileviruses are completely distinct. ClCSV-infected hibiscus plants were found in Manaus, AM (3).
Ref.:(1) Kitajima, E.W. et al. Scientia Agricola 67: 348. 2010; (2) Kitajima, E.W. et al. Summa Phytopathol. 27: 105. 2001 (3) Rodrigues, J.C.V. et al. Trop.Plt. Pathol. 33:12. 2008.
Nucleorhabdovirus
***Eggplant mottled dwarf virus* (EMDV)**
A nucleorhabdovirus was found by electron microscopy, co-infecting with phytoplasma, hibiscus plants with witches' broom symptoms in the state of São Paulo. This nucleorhabdovirus was tentatively identified as EMDV, based on similar case abroad (1).
Ref.: (1) Caner, J. et al. Summa Phytopathol. 3: 155. 1977.
Nepovirus
***Hibiscus latent ringspot virus* (HLRSV)**
During researches undertaken to characterize a Brazilian isolate of HCRSV, several samples were co-infected by HLRSV, as deduced by serological analysis. Further assays demonstrated that both viruses were co-transmitted by chrysomelids, probably due to a transcapsidation of the HLRSV genome by coat protein of HCRSV (1).
Ref.: (1) Araújo, S. et al. Fitopatol.bras. 14: 124. 1989.
Cilevirus
***Hibiscus* green spot virus (HGSV)**
Several *Hibiscus* species as *H. rosa-sinensis, H. syriacus, H. schizopetalus*, have been found with green spots or ringspots, sometimes brown to reddish-brown spots on their leaves, associated with infestation by tenuipalpid mite *Brevipalpus phoenicis s.l.* Electron microscopy of tissues from such lesions revealed the occurrence of cytopathic effects typical of cileviruses (1, 2). The unidentified causal virus was named HGSV and it was shown that it was mite transmissible to plants as kenaf (3). HGSV have been found disseminated in Brazil, being registered in the states of São Paulo, Rio de Janeiro, Minas Gerais, Amazonas and Distrito Federal. It was also observed abroad in Bolivia, Panama and Cuba (4, 5). It probably is

distinct from another green spot causing virus, described in Hawaii which is similar to cileviruses, but has a tripartite genome, being designated HGSV 2, belonging to the genus *Higrevirus* (6).
Ref.: (1) Kitajima, E.W. et al. Abst.Scandem 88: 63. 1999; (2) Kitajima, E.W. et al. Expt.Appl.Acarology 30: 135. 2003; (3) Ferreira, P.T.O. et al. Summa Phytopathol. 30: 68. 2004; (4) Kitajima, E.W. et al. Virus Rev.& Res. 9: 248. 2004.(5) Rodrigues, J.C.V. et al. Trop. Plant Pathol. 33:12. 2008; (6) Melzer, M. J. et al Phytopathology 102:122, 2012.

Betacarmovirus

***Hibiscus chlorotic ringspot virus* (HCRSV)**

First description of the occurrence of HCRSV was made in Brasília, DF, in hibiscus plants showing conspicuous small chlorotic spots on leaves. Identification of the virus was based on biological assays and serology. The virus was purified from mechanically infected kenaf plants and a specific antiserum was produced. Some molecular information about the genome RNA and capsidal protein were obtained. HCRSV was successfully transmitted by the chrysomelid beetle *Diabrotica speciosa* (1). A serological survey indicated that practically all hibiscus samples from several regions of Brazil were infected by HCRSV, sometimes even being asymptomatic. Clonal propagation must be the cause of such geographic dispersion (2).
Ref.: (1) Araújo, S. et al. Fitopatol.bras. 13: 144. 1988; (2) 14: 124. 1989

Tobamovirus

***Hibiscus latent virus Fort Pierce* (HLV-FP)**

Hibiscus plants showing chlorotic spots were found in a commercial nursery in Limeira, SP. Initial suspicion of infection by HCRSV was discarted by serology, and instead tobamovirus-like particles were found in leaf extracts examined by electron microscopy. Further biological, serological and molecular assays indicated that this tobamovirus was an isolate of HLV-FP. The virus was purified and a specific antiserum was produced. Further serological survey indicated that HLV-FP was present in low incidence in hibiscus growing in parks and gardens in the region of Piracicaba and Águas de São Pedro, SP (1). An infectious clone of this HLV-FP was produced after its genome has been completely sequenced (2).
Ref.:(1) Alves, P.M. Summa Phytopathol. 41(supl): res.39. 2015; (2) Gao, R. et al. Virus Genes 51:1. 2016.

Caulimovirus

***Caulimovirus* unidentified**

First observed by electron microscopy, a caulimovirus yet to be characterized was found, co-infecting hibiscus with HGSV (1).
Ref.: (1) Kitajima, E.W. et al. Abst.Scandem 88: 63. 1999.

Begomovirus

***Begomovirus* unidentified**

An unidentified begomovirus was detected by molecular means in hibiscus showing golden mosaic symptoms in the state of Rio de Janeiro (1).
Ref (1) Almeida, M.M.S. et al. Virus Rev.&Res 14(supl) 225. 2009.

Hibiscus golden mosaic virus (HGMV)

A begomovirus, distinct from others known previously based on its bipartite genome sequence, was found infecting hibiscus with mosaic symptoms in Igarapé-Mirim, PA (1).
Ref.: (1) Quadros, A.F.F. et al. Res.29 CBVirol. 2018.

***Hippeastrum* sp. (Amaryllis) Amarilidaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

GRSV has been detected in amaryllis, showing chlorotic spots on leaves, by biological and molecular assays and electron microscopy in the state of São Paulo (1).
Ref.: (1) Duarte, L.M.L. Virus Rev. & Res. 6: 50. 2001

Potyvirus

***Bean yellow mosaic virus* (BYMV)**

Infection of amaryllis by BYMV was reported in the state of São Paulo, without additional details (1).
Ref. (1) Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95.2010.

***Hippeastrum mosaic virus* (HiMV)**

A case of necrotic mosaic in amaryllis caused by HiMV was reported in the state of São Paulo (1, 2).
Ref. (1) Duarte, L.M.L. et al. Trop.Plt Pathol 34(supl): S274. 2009; (2) Alexandre, M.A.V. et al. Journal of Plant Pathology 93: 643. 2011.

***Hordeum vulgare* L. (Barley) Poaceae**

Hordeivirus

***Barley stripe mosaic virus* (BSMV)**

A rodlike virus was found infecting barley cv. 'Puebla' introduced from Mexico, and causing stripe mosaic on leaves in an experimental field of Embrapa Cerrado, Planaltina, DF. Further assays identified the causal virus as BSMV which is seed transmitted. The field was destroyed after the confirmation of the presence of BSMV, a quarantine pathogen (1)
Ref.: (1) Anjos, J.R.N. et al. Fitopatol. bras.12: 278. 1987.

***Hyacinthus orientalis* L. (Hyacinth) Asparagaceae**

Potyvirus

***Hyacinth mosaic virus* (HyaMV)**

Hyacynth plant showing mosaic symptoms were found in a flower market in São Paulo, SP. Suspicion that the mosaic was due to a viral infection was confirmed by ELISA and RT-PCR assays. An amplified fragment of the CP was sequenced revealing a high identity (96%) with that of HyaMV (1).
Ref.: (1) Alexandre, M.A.V. et. Al. Trop.Plt. Pathol. 42: 51. 2017.

***Hydrangea macrophylla* L. (Hydrangea) Hydrangeaceae**

Potexvirus

***Hydrangea ringspot virus* (HRSV)**

HRSV was detected in hydrange plants found in Mogi das Cruzes, SP, showing ringspot symptoms on leaves. Further tests identified the causal agent of the disease as an isolate of HRSV (1).
Ref: (1) Dória, K.M.A.B.V.S. et al. Summa Phytopathol. 37: 125. 2011.

***Hypochaeris brasiliensis* (Less.) Griseb. (Brazilian cat's ear) Asteraceae**

Potyvirus

***Lettuce mosaic virus* (LMV)**

H. brasiliensis is a common weed nearby soybean plantations. A potyvirus was found infecting this plant which was identified as an isolate of LMV (1).
Ref.: (1) Silva, J.A. et al. New Disease Rptr.38: 23. 2018.

***Hyptis* sp. Lamiaceae**

Begomovirus

Hyptis rugose mosaic virus 1 and 2 (HyRMV1, 2)

Two distinct begomoviruses were identified naturally infecting *Hyptis* sp. plants in the state of Alagoas, possibly new species. No further information availabe (1).
Ref.: (1) Nascimento, L.D. et al. Trop.Plt.Pathol. 38(supl.): 195. 2013.

I

***Impatiens balsamina* L., *I. walleriana* Hook f. (=*I. sultani*), *I. hawkeri* W.Bull (Garden balsam, Touch-me-not) Balsaminaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Impatiens balsamina (1) in Lavras, MG and *I. walleriana* em Atibaia, SP (2) were found infected by CMV.

Ref.: (1) Boari, A.J. et al. Fitopatol.bras. 21: 422. 1996; (2) Duarte, L.M.L. Fitopatol.bras. 21: 424. 1996.

Potyvirus

***Potyvirus* unidentified**

Mottling and floral variegation were observed in *I. balsamina* and *I. sultani* plants in a residential garden in Brasília, DF. A mechanically transmissible potyvirus was recovered (1). A similar case was recorded in the state of Paraná (2).

Ref.: (1) Cupertino, F.P. et al. Fitopatol.bras. 15: 127. 1990; (2) Lima, M.L.R.Z.C. et al.Rev.Setor Cien.Agr. 2: 169. 1980.

Tobamovirus

***Tomato mosaic virus* (ToMV)**

A tobamovirus, identified as ToMV was found causing mosaic and blistering on leaves of *Impatiens hawkeri* in São Paulo, SP (1). Identification of this isolate of ToMV was made based on molecular assays (nucleotide sequence of the coat protein) (2,3).

Ref.: (1) Rivas, E.B. . et al. Plant Dis. 84: 707. 2000; (2) Duarte, LML et al. Virus Rev&Res. 11 (aupl): 191. 2006; (3) Duarte, L.M.L. et al. Summa Phytopathol. 33:409. 2008.

***Ipomea batatas* (L.) Lam. (Sweet potato) Convulvulaceae**

Carlavirus

Sweet potato C6 virus (SP6CV)

The carlavirus SP6CV was detected by NMC-ELISA in sweet potato sampled in the state of São Paulo (1).

Ref.: (1) Silva, M.G. et al. Res.420, 50o Cong.Bras.Fitopat., 2017.

Carlavirus

***Sweet potato chlorotic fleck virus* (SPCFV)**

Crinivirus

***Sweet potato chlorotic stunt virus* (SPCSV)**

Potyvirus

***Sweet potato latent virus* (SPLV)**

***Sweet potato mild speckling virus* (SPMSV)**

***Sweet potato virus G* (SPVG)**

An extensive survey made on the sweet potato germplasm collection kept at Embrapa Hortaliças, Brasília, DF, with sampling of more than 100 genotypes, several previously unreported viruses were found by NCM-Elisa besides SPFMV, as listed above. However, no further biological assays were performed.

Ref.: (1) Fernandes, F.R. et al. Trop.Plant Pathol. 37 (supl.) CDRom. 2012.

Ipomovirus

***Sweet potato mild mottle virus* (SPMMV)**

SPMMV has been detected in serological surveys made in samples from the states of Pernamcuco and Paraíba, without further information (1).

Ref.: (1) Souza, C.A. et al. Trop.Plt.Pathol. 38 (supl): 754-2. 2013.

Potyvirus

***Sweet potato feathery mottle virus* (SPFMV)**

This was the first virus registered infecting sweet potato in Brazil, being well disseminated. Infected plants show varied degree of mosaic, depending on cultivars. SPFMV was identified based on its biological and morphological characteristics. Initial reports were made in the states of São Paulo and Rio de Janeiro, and later, Pernambuco, Paraíba, Rio Grande do Sul (1-3, 6, 7, 9). The use of vegetative propagation and aphid dissemination are responsible for the high incidence and rate of spreading, causing a condition known as degenerescence, with significative impact on the yield. Use of virus-free plants obtained by meristem tissue culture is being effective as control measure (4, 5), despite a high rate of re-infection under field conditions (8).

Ref.: (1) Costa, A.S. et al. Fitopatologia (Lima) 8: 7. 1973; (2) Kitajima, E.W. & Costa, A.S. Bragantia 33: XLV. 1974; (3) Kitajima, E.W. et al. Fitopatologia (Lima) 10: 57. 1975; (4) Carvalho, A.C.P.P. et al. Hort.Bras. 6: 49. 1988; (5) Gama, M.I.C.S. Fitopatol.bras.13: 283. 1988; (6) Gueiros Jr., F. et al. Fitopatol. bras. 20: 308.1995; (7) Pozzer, L. et al. Fitopatol.bras. 20: 65. 1995; (8) 464. 1995; (9) Kroth, L.L.. & Daniels, J. Fitopatol.bras. 27: S 206. 2002.

Cavemovirus

***Sweet potato collusive virus* (SPCV)**

An isolate of SPCV was found during a survey made on the germplasm collection of Embrapa Hortaliças, Brasília, DF by NMC-ELISA (1). This virus was also found by NMV-ELISA in sweet potato sampled in the state of São Paulo (2).

Ref.: (1) Fernandes, F.R. et al. Trop.Plant Pathol. 37 (supl.) CDRom. 2012; (2) Silva, M.G. et al. Res.420, 50o Cong.Bras.Fitopat., 2017.

Begomovirus

Sweet potato golden vein associated virus (SPGVaV)

Sweet potato mosaic associated virus (SPMaV)

During a survey in the sweet potato germplasm bank of the Embrapa Hortaliças, in Brasília, DF, two possible new begomovirus was found by RCA/RFLP, respectively SPGVaV and SPMaV (1). SPGVaV was also found in a survey using molecular tools, carried out in the Active Germplasm Bank of sweet potato of the Universidade Federal Rural de Pernambuco, Recife, PE (2).

Ref.: (1) Paprotka, T. et al. Virus Res. 149: 224, 2010; (2) Souza, C.D.A. et al. Trop.Plt.Pathol. 38 (supl.): CDRom res. 604-2. 2013

***Sweet potato leaf curl virus São Paulo virus* (SPLCV-SP)**

Sweet potato showing leaf curl symptoms from several parts of Brazilian North and Northeast regions were analysed using molecular tools at Embrapa Hortaliças, Brasília, DF (1, 4). SPLCV was later detected in the states of São Paulo (2) and Pernambuco (3). A possible isolate of SPLCV was found infecting sweet potato causing vein chlorosis and necrosis in Alvares Machado, SP. Molecular assays revealed that there is a 12,4% difference in nucleotide sequence compared to the standard isolate. It may, thus, represent a new begomovirus species (5). SPLCV was also detected in sweet potato producing fields in Pelotas, RS, by molecular assays (6).

Ref: (1) Albuquerque, L.C. et al. Virus Rev.&Res. 14(supl): 223. 2009; (2) Albuquerque, L.C. et al. Arch.Virol. 156; 1291. 2011; (3) Souza, C.D.A. et al. Trop.Plt.Pathol. 38 supl.604-2. 2013; (4) Souza, C.A. et al. Trop.Plant Pathol. 41 (supl.) 2016; (5) Albuquerque, L.C. et al. Arch.Virol. 156: 1291. 2011; (6) Maich, S.L.S.P. et al. Res. 29 Cong.Bras.Virol. 2018

Mastrevirus

***Sweet potato symptomless virus 1* (SpSV/1)**

A survey made on 100 sweet potato samples, collected in different producing areas in Brazil, by RT-PCR, detected SpSV/1. About half of the positive cases came from Northeast, being also detected in South, Southeast and Center-West regions. One of the isolates presented 99% sequence identity with that described in Taiwan. Transmission was confirmed by grafting (1).

Ref.: (1) Souza, C.A. et al. Plant Dis.102:b2052. 2018.

J

***Justicia sp.* (Shrimp plant, Water-willow) Acanthaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Shrimp plant was found in Horto Municipal, Fortaleza, CE, exhibiting concentric rings and spots on leaves. Biological and serological assays identified CMV as the causal agent of this disease.

Ref.: (1) Araripe, D.F.A. & Lima, J.A.A. Fitopatol.bras 18: 275. 1993.

K

***Kalanchoë blossfeldiana* Poelln. (Flaming katy) Crassulaceae**
Nucleorhabdovirus
***Sonchus yellow net virus* (SYNV)**
A *Nucleorhabdovirus* was found in *K. blossfeldiana* plants introduced from the Netherlands. Infected plants showed chlorotic spots. Detection of this virus associated to the symptoms was made by electron microscopy and serology confirmed its identity as SYNV. No mechanical transmission was achieved. This same virus was detected in another crassulaceae plant, *Cotyledon orbiculata*, and managed to be transmitted to *K. blossfeldiana*, resulting in systemic infection (1).
Ref.: (1) Duarte, L.M.L. et al. Summa Phytopathol. 31: 63. 2005.

***Kalanchoë sp.* (Kalanchoe) Crassulaceae**
Potyvirus
***Potyvirus* unidentified**
Potyvirus-like particles were found in extracts of *Kalanchoë sp.* showing mosaic and blistering, collected at Teresópolis, RJ. The causal agent was mechanically transmitted to the same host species and to *Chenopodium quinoa*, causing local lesions. This virus was purified and a specific antiserum produced. Heterologous reaction was obtained with potyviruses PVY, CABMV e BCMV but this virus remains unidentified (1).
Ref.: (1) Braz, A.S.K. et al. Fitopatol. Bras. 21: 422. 1996.

L

***Lactuca sativa* L. (Lettuce) Asteraceae**
Ophiovirus
***Mirafiori lettuce big-vein virus* (MiLV)**
Varicosavirus
***Lettuce big-vein associated virus* (LBVaV)**
These two viruses are involved in the lettuce big-vein syndrome, characterized by thickening of leaf veins, reducing the commercial value of the product; in some varieties as the American, heads are not formed. It is a typical winter disease, when under milder climate, symptons become evident. Transmission is made by soil chytrid fungus *Olpidium brassicae* (1). It was found in the green belt of São Paulo, SP (1), as well as in Campinas e Baurú, SP (2). Serology, molecular assay and electron microscopy identified these viruses (1). It was also detected in the state of Paraná (2).
Ref.: (1) Lot, H. Phytopathology 92: 288, 2002; (2) Colariccio, A. et al. Fitopatol.bras. 27: S201. 2002; (2) Sanches, M.M et al. Summa Phytopathologica, 33:378. 2007. (3) Lima No., V.C. Summa Phytopathol. 30: 83. 2004.
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
Electron microscopy detected a nucleorhabdovirus yet uncharacterized, in lettuce samples with chlorotic spots and vein clearing, collected in Federal District and Teresópolis, RJ (1, 2).
Ref.: Kitajima, E.W., & Marinho, V.L.A. Fitopatol.bras. 7: 534. 1982; (2) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984.
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
***Tomato spotted wilt virus* (TSWV)**
Leaf deformation, wrinkling, ringspots and systemic necrosis symptoms with varied incidence in commercial lettuce plantations are caused by Orthotospoviruses. Originally such a disease was reported in the state of São Paulo (1, 2), with later reports in the states of Pernambuco (3) and Rio Grande do Sul (5). In the state of São Paulo TCSV (4) and GRSV (8) were identified infecting lettuce. In a survey made in the São Francisco valley, state of Pernambuco, a high incidence of GRSV was observed (6), and also in hydroponic cultures in the state of São Paulo (7). Some resistant genotypes have been found (9, 11). TSWV was detected in lettuce in the state of Alagoas (10). Surveys on lettuce fields in the state of Tocantins found plants infected by GRSV (12), as well as in hydroponic cultures in the state of Pará (13).
Ref.: (1) Costa, A.S. & Forster, R. Bragantia 2: 83. 1942; (2) Chagas, C.M. O Biológico 36: 256. 1970; (3) Moraes, G.J. et al. Hortic.Bras. 6: 24. 1988; (4) Colariccio, A. et al., Fitopatol.bras. 20: 347. 1995; (5) Daniels, J. & Canci, P. Fitopatol. Bras. 20: 301. 1995; (6) de Ávila, A.C. et al. Fitopatol.bras. 21: 503. 1996; (7) Yuki, V.A. et al. Summa Phytopathol. 22: 57. 1996; (8) Chaves, A.C.R. et al. Fitopatol. Bras. 25: 439. 2000; (9) Silva, N. & Pavan, M.A. Fitopatol.bras. 26: 5ll. 2001; (10) Lima, G.S.A. et al. Virus Rev. & Res. 6: 157. 2001; (11) Yamazaki, E. et al., Fitopatol.bras. 26: 527. 2001;(12) Lima No., A.F. et al. Fitopatol.bras. 31(supl):S347. 2006; (13) Hayashi, E.A. et al. Trop.Plt.Pathol. 38 (supl): 455-1. 2013.
Sequivirus
***Lettuce mottle virus* (LeMoV)**
LeMoV was first identified in lettuce plantations in Brasília, DF. Infected plants show symptoms, essentially similar to those caused by LMV, and the causal agent is mechanically transmissible, with practically the same host range. Suspicion of an infection by a virus distinct from LMV was raised when the causal virus was not aphid transmitted. Further assays demonstrated that this virus is isometric, and named LMoV (1, 3). It was partially purified and an antiserum obtained (2). Besides DF, LMoV was also detected in Caxias, RS, Rio Novo, SC and Campinas, SP (1). It is a possible member of the family *Sequiviridae* and genus *Sequivirus*, related to ao *Dandelion yellow mosaic sequivirus* (DaYMV) (4,5). A survey made in the state of São Paulo indicated that LMoV is quite widespread (6). LMoV was found naturally infecting *Galinsoga parviflora* (7). LMoV was also detected in the state of Minas Gerais (8).
Ref.: (1) Marinho,V.L.A. & Kitajima, E.W. Fitopatol.bras. 11: 923. 1986; (2) Marinho, V.L.A. et al. Fitopatol.bras. 11: 937. 1982; (3) Kitajima,E.W. & Pavan, M.A. Lettuce mottle virus. In Davis, R.M. et al. (eds.). Compendium of lettuce diseases. St.Paul, APS Press. pp.44. 1997; (4) Chaves, A.L.R. et al. Fitopatol.bras. 26: 514. 2001; (5) Jadão, A.S. et al., Arch. Virol. 152:999-1007, 2007. (6) De Marchi et al. Summa Phytopathol 38:245-247, 2012. (7) De Marchi, B.R. et al. Summa Phytopathol. 38: 245. 2012; (8) Lucas, M.A. et al. Trop.Plt. Pathol. 38(supl.): 200. 2013.
Tymovirus
***Tymovirus* unidentified**
A yet to the characterized tymovirus was found infecting lettuce in Piedade, SP. This tymovirus isolate may be related to the *Eggplant mosaic tymovirus* (EMV) and *Turnip yellow mosaic tymovirus* (TYMV) (1).
Ref.: (1) Colariccio, A. et al Summa Phytopathol 36 (supl): #205 CDRom. 2010.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Infection of lettuce by CMV was reported in the state of São Paulo, and considered of very rare occurrence (1).
Ref.: (1) Costa, A.S. Summa Phytopathol. 9: 39. 1983.
Potyvirus
***Bidens mosaic virus* (BiMV)**
BiMV was found naturally infecting lettuce and causing mosaic in S.Manoel, SP (1). Cases of BiMV infection of lettuce seem rare, and it was also registered in Campinas and Baurú, SP, in places invasive plants as *Bidens pilosa* and *Galinsoga parviflora*, natural hosts of BiMV, are common (2).

Ref. (1) Suzuki, G.S. et al. Summa Phytopathol. 35:231. 2009; (2) Sanches, M.M. et al. Summa Phytopathol. 36: 347. 2010.

***Lettuce mosaic virus* (LMV)**

LMV is the most common virus in lettuce crops and may cause yield losses in highly susceptible varieties. Infection results in symptoms as mosaic, blistering and malformed heads. This virus is seed-borne and spread in the field by aphids, and mechanically transmissible to a wide host range. First report in Brazil was made in the 1940's in São Paulo, SP (1). It is present everywhere lettuce is grown, but has been formally described in the states of Federal District (3), Rio de Janeiro (4), Paraná (5), Rio Grande do Sul (6), Sergipe (12), Mato Grosso do Sul (13). Resistant varieties have been produced (2). LMV is also present in hydroponic cultures (7). LMV is commonly introduced in commercial field by contaminated seeds and then spread by aphids. There are virus isolates as LMV-Most able to break resistance in lettuce produced by genes *mo1*^{1} e *mo1*^{2} (8). *Sonchus* spp., *Erigeron* spp. and *Galinsoga parviflora* were found naturally infected by LMV and may serve as source of inoculum (9-11).

Ref.: (1) Kramer et al. O Biológico 11: 121. 1945; (2) Nagai, H. & Costa, A.S. Arq.Inst.Biol. 38: 95. 1971; (3) Costa, C.L. et al. Fitopatologia (Lima) 9: 49. 1974; (4) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econ. do Estado, Sec. Agric.Abast., RJ. 84p. 1978; (5) Lima, M.L.R.Z.C. et al. Fitopatol. bras. 9: 403. 1984; (6) Daniels, J. & Canci, P. Fitopatol.bras. 20: 301. 1995; (7) Cossa, A.C. et al. Fitopatol.bras. 27: S202. 2002; (8) Krause-Sakate, R. et al. Phytopathology 92: 563. 2002; (9) Chaves, A.L.R et al., Summa Phytopathol. 29: 61. 2003; (10) Fitopatol.Bras.28: 207. 2003; (11) Sanches, M.M. et al. Summa Phytopathol 36: 346. 2010; (12) Floresta, L.V. et al. Fitopatol.bras. 31 (supl) S322. 2006; (13) Stangarlin, O.S. et al. 50 CBFito. res.406. 2017.

***Turnip mosaic virus* (TuMV)**

TuMV was detected in lettuce plants with mosaic symptoms collected in the state of São Paulo. Identification was based on biological, serological and molecular assays (1).

Ref.: (1) Ribeiro Jr., M.R. et al. J.Plant Pathol.100: 189. 2018.

****Lens culinaria* L. (Lentil) Fabaceae**

Orthotospovirus

***Tomato spotted wilt virus* (TSWV)**

Natural infection of lentil by TSW was reported in Brasília, DF, resulting in pod necrosis (1).

Ref.: (1) Fonseca, M.E.N. et al. Plant Dis. 79: 320. 1995.

Potyvirus

***Bean common mosaic virus* (BCMV)**

Lentil with mosaic symptoms, from the state of Rio Grande do Sul, was found infected by BCMV (1).

Ref.: (1) Costa, C.L. et al. Fitopatologia (Lima) 10: 52. 1975.

****Leonurus sibiricus* L. (Chinese motherwort, Honeyweed) Lamiaceae**

Begomovirus

***Tomato yellow spot virus* (ToYSV)**

Infection by begomovirus, now identified as ToYSV, was described in 1960's in several tomato growing regions of the state of São Paulo. An intense yellow mosaic characterizes the symptom, and the causal virus was transmitted by the whitefly *Bemisia tabaci*. It was mechanically transmitted to honeyweed besides tobacco and *N. glutinosa.* The virus was considered related to, but distinct from Infectious chlorosis of malvaceae complex and EuYMV (1,2). Molecular assays made on tomato plants showing yellow mosaic, similar to previously described, collected in the state of Paraná, identified the causal virus as ToYSV (3)

Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Phytopathol.Zeit. 38: 129. 1960; (2) Flores, E. & Silberschmidt, K. Phytopathol.Zeit. 43: 221. 1962; (3) Boiteux, L.S. et al. Trop Plt Pathol. 34 (supl): S266. 2009.

****Ligustrum lucidum* W.T. Aiton (Glossy privet); *Ligustrum sinense* Lour. (Japanese privet); *Ligustrum japonicum* Thunb. (wax-leaf privet) Oleaceae**

Cilevirus

***Ligustrum* leprosis virus (LigLV)**

Chlorotic and ringspot symptoms on leaves of *L. lucidum* forming a living fence were observed in the campus of the Univ. Federal do Paraná, Curitiba, SP. These symptoms were similar to those described in Bella Vista, Argentina, and referred to as "lepra explosiva". Similar cases were also found in Águas de S.Pedro, Holambra, Monte Alegre do Sul e Piracicaba, SP, and in Brasília, DF, associated with *Brevipalpus* mite infestation. Electron microscopy of the tissues from these lesions revealed cytopathic effects of the type caused by cileviruses (1-6). Transmission from privet to privet by *Brevipalpus phoenicis s.l.* could be demonstrated (2,5), as well as from privet to bean plants (4). Electron microscopy of leaf lesion of *L. sinense* sampled in B.Vista, Argentina, where this condition was first described, resulted in similar results obtained with Brazilian samples (7). The privet virus was tentatively named *Ligustrum* ringspot virus in Brazil, but due to priority reasons, it is being called *Ligustrum* leprosis virus (LigLV) (7).

Ref.: (1) Lima, M.L.R.Z.C. et al. Phytopathology 81: 1216. 1991; (2) Rodrigues, J.C.V. et al. Fitopatol. bras. 20:292. 1995; (3) Nogueira, N.L. et al. Fitopatol.bas. 29: S234. 2004; (4) Kitajima, E.W. et al. Expt.Appl.Acarol. 30: 135.2003; (5) Kitajima, E.W. et al. Summa Phytopathol 38 (supl.) CDRom 2012. (6) Kitajima, E.W. et al. Scientia Agricola 67: 348. 2010; (7) Kitajima, E.W. et al. Virus Rev & Res.20 (supl.): 196. 2015.

****Lilium* sp. (Lily) Liliaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Seedlings of lily, produced commercially by micropropagation, showing chlorotic spots were demonstrated to be infected by CMV serogroup I. Identification was based on serological and molecular techniques (1). The same virus was recovered from cultivated lily plants from Atibaia and Holambra, SP (2).

Ref.: (1) Alexandre, M.A.V. et al. Fitopatol.bras. 26: 513. 2000. (2) Jadão, A.S. et al. Trop.Plt Pathol. 33 (supl): S298. 2008

Potyvirus

***Bean yellow mosaic virus* (BYMV)**

Field lily plants with mosaic symptoms, cultivated in the state of São Paulo were found infected by BYMV (1).

Ref. (1) Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95.2010.

***Tulip breaking virus* (TBV)**

Necrotic spots and mottling were observed on lily leaves, being commercially grown in Brasilia, DF. Biological and serological assays, complemented by electron microscopy confirmed the infection of these lily plants by an isolate of TBV (1).

Ref.: (1) Furlanetto, C. et al. Fitopatol. bras. 21: 431. 1996.

****Lippia alba* Mill.N.E.Br. ex Britt & Wilson Verbenaceae**

Begomovirus

***Begomovirus* unidentified**

Mosaic symptoms in *L. alba* plants sampled in the state of Alagoas was attributed to a begomovirus, yet to be identified, associated with

infestation by whiteflies (1).
Ref.: (1) Assunção, I.P. et al. Fitopatol.bras. 29: S161. 2004.

***Luehea grandiflora* Mart. Malvaceae**
Begomovirus
Infectious chlorosis of malvaceae complex (ICMC)
Posssible infection of *L. grandifolia* plants, showing mosaic symptoms, by a begomovirus considered as ICMC, was registered in the state of São Paulo (1).
Ref.: (1) Silberschmidt,K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

***Luffa aegyptiaca* Mill. (Sponge gourd) Cucurbitaceae**
Orthotospovirus
***Zucchini lethal chlorosis virus* (ZLCV)**
During a survey made in the state of S.Paulo for natural hosts for ZLCV, this virus was detected in field sponge gourd plants (1).
Ref.: (1) Camelo-Garcia, V. et al. Trop.Plt.Pathol. 40: 345. 2015.

***Luffa cylindrica* Roem. (Loopha) Cucurbitaceae**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
Loopha plants exhibiting leaf necrosis, mosaic, ringspots and distortion and drying of fruits, were sampled in a commercial field in Jales, SP. Subsequent analysis indicated that this condition was caused by infection by an isolate of do ZYMV, identified by biological and serological assays and cytopathological analysis (1). ZYMV-infected loopha plants were also found in the state of Pará (2).
Ref.: (1) Colariccio, A. et al. Summa Phytopathol. 23: 58. 1997; (2) Hayashi, E.A. et al. Trop.Plt.Pathol. 38 (supl): .455-2. 2013.

***Luffa operculata* Cogn. Cucurbitaceae**
Potyvirus
***Papaya ringspot virus* (PRSV-W)**
Natural infection of *L. operculata* by PRSV-W was reported in the state of Ceará, identification of the virus being made by biological and serological methods (1).
Ref.: (1) Lima, J.A.A. & Florindo, M.I. Fitopatol.bras. 22: 213. 1997.

***Lupinus alba* L. (White lupine); *L. luteus* L.(Yellow lupine) Fabaceae**
Potyvirus
***Bean yellow mosaic virus* (BYMV)**
White and yellow lupines showing mosaic symptoms were observed in Cascavel, PR, and the causal agent identified as BYMV (1-3).
Ref.: (1) Almeida, A.M.R. Fitopatol.bras. 16: 288. 1991; (2) Ramagem, R.D. et al. Fitopatol. bras. 17: 178. 1992; (3) 179. 1992.

***Lysimachia congestiflora* Hemsl. (Golden globes) Primulaceae**
Cilevirus
***Cilevirus* unidentified**
L. congestiflora exhibiting chlorotic spots on leaves were found in a residential garden in Águas de S.Pedro, SP. Electron microscopy indicated the presence of a cilevirus, according to the observed cytopathic effects (1).
Ref.: (1) Nogueira, N.L. & Rossi, M.L. Fitopatol.bras. 30 (supl.): S189. 2005.

M

***Macroptilum atropurpureum* (DC) Urban (Siratro, Purple bush bean) Fabaceae**
Potyvirus
***Potyvirus* unidentified**
Mosaic symptoms in siratro were found to be caused by a mechanical and aphid transmitted potyvirus, yet to be identified. These plants occurred in the states of Ceará (1) and São Paulo (2).
Ref.: (1) Marques, M.A.I. & Albersio, J.A.A. Res. VI Enc.Nac.Virol. 170. 1992; (2) Regatieri, L.J. et al. Fitopatol.bras. 28: S289. 2003.
Begomovirus
***Euphorbia yellow mosaic virus* (EuYMV)**
EuYMV was found infecting siratro in Caruaru, PE, being identified by molecular assays (1).
Ref.: (1) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.
Tomato crinkle leaf yellows virus (TCrLYV)
Siratro infected by TCrLYV, as determined by molecular assays was found in Maceió, AL and Quipapa, PE (1).
Ref.: (1) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.

***Macroptilium erythroloma* (Benth) Urban Fabaceae**
Begomovirus
***Bean golden mosaic virus* (BGMV)**
Natural infection of *M. erythroloma* by BGMV, resulting in a severe yellow mosaic was found in Nova Odessa, SP (1).
Ref.: (1) Chagas, C.M. et al. Arq.Inst.Biol. 48. 113. 1981.

***Macroptilium lathyroides* (L) Urban (=*Phaseolus lathyroides*) (Phasey bean) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**;
A report was made in the state of Ceará, on the natural infection of phasey bean by CPSMV, resulting in mosaic symptoms (1, 2).
Ref.: (1) Lima, J.A.A. & Chagas, J.M.F. Fitopatologia (Lima) 9: 58. 1974; (2) Lima, J.A.A. & Santos, D.G. Fitopatol.bras. 10: 313. 1985.
Begomovirus
***Bean golden mosaic virus* (BGMV)**
M. lathyroides with mosaic symptoms, found in the state of Ceará, was associated with infection by a begomovirus, considered similar to Cowpea golden mosaic virus (1). In similar cases, noticed in União dos Palmares, AL (2), and in the states of Pernambuco and Sergipe (3) the causal virus was identified as BGMV.
Ref.: (1) Lima, J.A.A. et al. Virus Rev. & Res. 3 (supl.1):143.1998; (2) Nascimento, L.D. et al. Fitopatol. bras. 31 (supl): S204. 2006; (3) Silva, J.C.V. et al. Plant Pathol. 61: 457. 2012.
***Macroptilium* yellow net virus (MaYNV)**
MaYNV was found infecting phasey beans in the Brazilian Northeast (1).
Ref.: (1) Silva, S.J.C.. et al. Plant Pathol. 61: 457. 2012.
***Macroptilium yellow spot virus* (MaYSV)**
Cases of infection of phasey bean by MaYSV were reported in the states of Paraíba and Alagoas (1) as well as in Pernambuco and Sergipe (2). These last two isolates have been characterized by biological methods and molecular tools (3).
Ref.: (1) Silva, S.J.C. et al. Plant Pathol. 61: 457. 2012; (2) Almeida, K.C. et al. Virus Rev.& Res. 17 (supl.): 36. 2012; (3) Almeida, K.C. et al. Abst.7th Intl.Geminivirus Symp. P.60. 2013.
***Begomovirus* unidentified**
A golden mosaic in phasey beans was observed in Juazeiro, BA (1), and in the state of Ceará (2), caused by a still unidentified begomovirus.
Ref: (1) Assunção, L.P. et al. Planta Daninha 24: 239. 2006; (2) Nascimento, A.K.Q. et al. Trop Plt Pathol 33(supl): 299. 2008.

***Macroptilium longepedunculatum* Mart. Et. Benth. (=*Phaseolus longipedunculatus*) Fabaceae**
Begomovirus

***Bean golden mosaic virus* (BGMV)**

Yellow mosaic bearing *M. longepedunculatum* plants were found in the Santos Dumont airpot, downtown of Rio de Janeiro, RJ. The virus was whitefly transmited showing some differences in host range with AbMBV in comparative studies without occurring cross protection (1), and considered as a possible isolate of BGMV (2).

Ref.: (1) Flores, E. & Silberschmidt, K. An.Acad.Bras.Cien. 38: 327. 1966; (2) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972.

***Malus sp.* (Apple) Rosaceae**

Foveavirus

***Apple stem pitting virus* (ASPV)**

Incidence of ASPV among apple culture in Brazil is high. It causes stunting and loss of vigor in the indicator variety (1). ASPV was detected in clones from commercial apple grooves from Angatuba and Paranapanema, SP, by índex grafting (2), as well as in orchards from the states of Santa Catarina (3) and Rio Grande do Sul (4).

Ref.: (1) Betti, J.A. & Ojima, M. Summa Phytopathol. 5: 29. 1979; (2) Betti, J.A. et al. Summa Phytopathol. 21: 49. 1995; (3) Nickel, O. et al. Fitopatol.bras. 23: 321. 1998; (4) Nickel, O. & Fjardo, T.V.M. Trop. Plt.Pathol. 38(supl.): 28. 2013.

Capillovirus

***Apple stem grooving virus* (ASGV)**

First descriptions of occurrence of ASGV in cultivated and asymptomatic apple plants were made in the state of São Paulo, by mechanical inoculation assays on test plants, including peach (1). Identification was confirmed by immuno electron microscopy (2). Minigrafiting and thermotherapy procedures managed to eliminate ASGV and ACLSV from infected plants (3). An internal necrosis in the rootstock Maruba Kaido, in the Experimental Station at Caçador, SC, was associated with infection by ASGV (4). Later ASGV was detected by serology in cvs. Rozala Gala and Fuji grafted on top of Maruba-Kaido in commercial nursery of the state of Rio Grande do Sul (5). This detection was complemented by the analysis of the coat protein gene (6). Two isolates of ASGV had their entire genome sequenced and showed high identity with the standard isolate (7).

Ref.: (1) Betti, J. & Kitajima, E.W. Rev.Soc.Bras.Fitopat. 5: 125. 1971; (2) Gaspar, J.O. & Betti, J.A. Summa Phytopathol. 11: 62. 1985; (3) Betti, J.A. & Gaspar, J.O. Summa Phytopathol. 12: 19. 1986; (4) Betti, J.A. et al. Summa Phytopathol.. 14: 33. 1988; (5) Nickel, O. et al. Fitopatol. bras. 24: 444. 1999; (6) Nickel, O. et al. Fitopatol.bras. 25: 445. 2000.; (7) Souza, E.B. et al. Trop. plant Pathol. 42: 391. 2017. *Trichovirus*

***Apple chlorotic leaf spot virus* (ACLSV)**

Latent infection of apple by ACLSV was first noticed in the state of São Paulo. The virus was detected by mechanical inoculation on assay hosts, including peach (1). Speckled mosaic in the cultivar Anna, grown in Paranapanema, SP, was attributed o ACLSV infection (2), which was confirmed by immuno electro microscopy (3). This virus was also detected in the states of Santa Catarina and Rio Grande do Sul (4).

Ref.: (1) Betti, J. & Kitajima, E.W. Rev.Soc.Bras.Fitopat. 5: 125. 1972; (2) Betti, J.A. et al. Summa Phytopathol. 10: 126. 1984; (3) Gaspar, J.O. & Betti, J.A. Summa Phytopathol. 11: 62. 1985; (4) Castro, L.A.S. et al. Fitopatol.bras. 23: 314. 1998.

Ilarvirus

***Apple mosaic virus* (ApMV)**

Mosaic symptoms were observed in apple plants imported from Argentina in 1959 and considered to be caused by ApMV. Symptoms were either vein banding or vein clearing. Graft transmission experiments reproduced these symptoms in 40% of tested plants (1). ApMV was also found in Pelotas and Vacaria , RS (2).

Ref.: (1) Issa, E. O Biológico 25: 64. 1959; (2) de Castro, L.A.S. & Daniels, J. Fitopatol. bras. 19: 313. 1994.

Unclassified ssDNA virrus

Temperate fruit decay associated virus (TFDaV)

Apple trees with stunting, chlorosis, weak budding and dried branches were observed in Viçosa, MG. Molecular assays indicated the presence of an unclassified ssDNA virus (TFDaV), associated with this condition (1). See details in *Vitis vinífera.*

Ref.: (1) Basso, M.F. et al. Virus Research 210: 27. 2015.

***Malva* sp. Malvaceae**

Begomovirus

Okra mosaic Mexico virus (OkMMV)

***Sida micrantha mosaic virus* (SimMV)**

***Tomato leaf distortion virus* (ToLDV)**

Malva sp. plants collected in different parts Brazil were found to be infected by several distinct begomoviruses. A sample from the Amazon basin had 87% of identity with OkMMV. Samples from the states of Rio de Janeiro and Goiás showed high identity with SmMV, okra isolate. Finally, plants coming from the state of Rio de Janeiro presented 90% of identity with ToLDV (1).

Ref.: (1) Fernandes, N.A.N. et al. Trop.Plt Pathol 34 (supl): S271. 2009.

***Malva parviflora* L. (Malva) Malvaceae**

Potexivrus

***Malva mosaic virus* (MaMV)**

Systemic necrosis of leaves was observed in malva plants in the state of São Paulo. Electron microscopy associated a potexvirus, possibly *Malva mosaic virus* with this condition (1).

Ref.: (1) Costa, A.S. & Kitajima, E.W. Bragantia 29: LI. 1970.

Potyvirus

***Malva vein clearing virus* (MVCV)**

Malva plants showing vein clearing and mottling on leaves were found in the state of São Paulo, associated with a potyvirus, detected by electron microscopy (1). It is assumed that this potyvirus is *Malva vein clearing virus* (MVCV) described in the USA and Europe (2).

Ref.: (1) Kitajima, E.W. et al. Bragantia 21: CIII. 1962; (2) Costa, A.S. & Duffus, J.E. Plant Dis.Reptr. 41: 1006. 1957.

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

Angular spots and golden mosaic symptoms were observed in *Malva* sp. plants in S.Paulo and Mogi das Cruzes, SP and Porto Alegre, RS. The disease was associated with infection by ICMS (1).

Ref.: (1) Silberschmidt,K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955

***Begomovirus* unidentified**

An unidentified begomovirus was detected by molecular means in malva plants with mottling, mosaic, golden mosaic and vein clearing collected in Brasilia, DF, without additional information (1).

Ref.: (1) Fonseca, M.E.N. et al. Fitopatol.bras. 28: S248. 2003.

***Malvastrum coromandelianum* Garcke (False mallow) Malvaceae**

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

A mosaic observed in false mallow plants collected in Brotas, SP, was considered as caused by whitefly transmitted ICMC (1).

Ref.: (1) Silberschmidt, K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

***Malvaviscus arboreus* Cav. (Turk's hat) Malvaceae**

Dichorhabdovirus

***Clerodendrum* chlorotic spot virus (ClCSV)**

A dichorhavirus was first detected in Turk's hat plants forming a living fence in a residential garden in Piracicaba, SP, exhibiting chlorotic ringspots on their leaves. Electron microscopy detected cytopathic effects typical of dichorhavirus, and it was shown to be transmitted by *Brevipalpus* mites. The viral agent was identified as ClCSV (1, 2). It was also found in the state of Rio de Janeiro (2). Its genome was completely sequenced and confirmed to be a member of the genus *Dichorhavirus*, distinct from other known members (3).
Ref.: (1) Kitajima, E.W. et al. Exp.Appl.Acarology 30: 135. 2003; 2) Kitajima, EW et al. Scientia Agricola 67: 348. 2010; (3) Ramos-González, P.L. et al. Arch.Virol. 163: 2519. 2018.

Begomovirus

***Malvaviscus* yellow mosaic virus (MaYMV)**

Yellow mosaic symptoms on *M. arboreus* leaves were known since the 1950's in the Experimental farm of the Instituto Agronômico de Campinas. Molecular analysis indicated that these plants were infected by a begomovirus named MaYMV, phylogenetically related to begomoviruses from North and Central America. A peculiarity of MaYMV is that it harbors a sequence of nonanucleotides, of nanovirus and alphasatelite types (1).
Ref.: (1) Lima, A.T.M. et al. Virus Ver.&Res. 16 (supl.) 217. CDRom. 2011

***Manihot esculenta* Kranz (Cassava) Euphorbiaceae**

Nucleorhabdovirus

***Nucleorhabdovirus* unidentified**

Electron microscopy of an asymptomatic cassava plant, sampled in the state of São Paulo was found to be infected by an unidentified nucleorhabdovirus (1).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Fitopatol.bras. 4: 55. 1979

Potexvirus

***Cassava common mosaic virus*- (CsCMV)**

Presence of CsCMV, infecting field plants of cassava cv. 'Aipim carvão', was first registered in an experimental field of Instituto Agronomico, Campinas, SP. This cassava disease is of rare occurrence and considered of marginal importance. Leaf symptoms are conspicuous mosaic followed by distortion. It is mechanically transmissible and is perpetuated by the use of cuttings from infected plants; it may be transmitted by the use of cutting tools (1). CsCMV was identified as a new species of potexvirus by its morphology and cytopathology (3-6). It was purified and a specific antiserum, obtained (2). This virus was detected in the germplasm bank maintained at the Embrapa/Mandioca e Fruteiras, Cruz das Almas, BA (7). CsCMV was detected in the state of Paraná (8), where it seems to be widespread (9).
Ref.: (1) Costa, A.S. J.Agronomia (Piracicaba) 3: 239. 1940; (2) Silva, D.M. et al. Bragantia 21: XCIX. 1962; (3) Kitajima, E.W. et al. Bragantia 24: 247. 1965; (4) Kitajima & Costa, A.S. Bragantia 25: XXIII. 1966; (5) Costa, A.S. & Kitajima, E.W. CMI/AAB Descr.Plant Viruses 90. 1972; (6) Costa, A.S. Fitopatologia (Lima) 8: 5. 1973; (7) Meissner Fo., P.E. & Santana, E.N. Fitopatol.bras. 22: 342. 1997 (8) Carnelossi, P.R. et al. Virus Rev. & Res 15 (supl): 132. 2010; (9) Silva, J.M. et al. Trop.Plant Pathol. 36: 271. 2011.

Phytoreovirus

Cassava frogskin disease associated virus (CaFDaV)

Frogskin of cassava is a disease characterized by hyperplastic symptoms like verrucosis. Roots become thinner with a thick cortical zone, brittle and wrinkled, with crevices. No obvious foliar symptoms are present. In Brazil, frogskin has been observed in the Amazon basin and it was also found in the germplasm collection of Embrapa Mandioca e Fruteiras, Cruz das Almas, BA. Besides symptoms, diagnosis can be made by the detection of dsRNA made by molecular means (1, 2). CaFDaV was previously described in Colombia (4). A phytoplasma of the group SrIII was detected associated with frogskin syndrome (7) as previously reported in Colombia (5). In the state of Rio de Janeiro frogskin was found only associated with CaFDaV, but not with phytoplasma (6).
Ref.: (1) Fukuda, C. Res.I Cong.Lat.Am.Raizes Trop./IX Cong.Bras. Mandioca res.105. 1992. (2) Poltronieri, L.S. et al. Fitopatol.bras. 23: 322. 1998; (3) Isoton, MF et al. IV Enc.Jovens Talentos Embrapa.p.23. 2009; (4) Calvert, L. et al. J.Phytopathol. 156: 647. 2008; (5) Alvarez, E. et al. Plant Dis. 93: 1139. 2009; (6) Brioso, P.S.T. et al. Summa Phytopathol. 39 (supl) CDRom. 2013; (7) Souza, A.N. et al., Plant Dis.98: 771, 2014.

Alphanecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from asymptomatic cassava plants, kept under greenhouse conditions, in Instituto Agronomico, Campinas, SP (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: CXLVII. 1960.

Cavemovirus

***Cassava vein mosaic virus* (CaVMV)**

Vein mosaic in cassava was first reported in cassava in the cv. 'Vassourinha', grown in an experimental field of Instituto Biológico, SP (1). Similar condition was observed in the cv. 'Brava Preta de Suruhy' in Instituto Agronomico, Campinas, SP (2). Symptoms of the disease are characterized by vein mosaic or banding in adult leaves, and a chlorosis which may spread to whole plant. The causal virus, CaVMV was identified as a possible caulimovirus, but it is now considered the type member of the genus *Cavemovirus* (3). It is not transmissible mechanically, and the vector is unknown. CaVMV was purified and a specific antiserum has been produced (4). The virus was detected serologically infecting cassava in the state of Piauí (5) and Ceará (6). In the state of Bahia, CaVMV infecting cassava was identified based on symptoms (8). No significative yield loss caused by CaVMV in cassava crops was observed, in a field assay carried out in the state of Ceará (7).
Ref.: (1) Silberschmidt, K. O Biológico 4: 177. 1938; (2) Costa, A.S. J.Agronomia (Piracicaba) 3: 239. 1940; (3) Kitajima, E.W. & Costa, A.S. Bragantia 25: 211. 1966; (4) Lin, M.T. & Kitajima, E.W. Fitopatol.bras. 5: 419. 1980; (5) Santos, A.A. & Silva, H.P. Fitopatol. bras. 7: 545. 1982; (6) Santos, A.A. & Kitajima, E.W. Fitopatol.bras. 15: 145.1990; (7) Santos, A.A. et al. Fitopatol.bras. 20: 506. 1995; (8) Meissner Fo., P.E. & Santana, E.N. Fitopatol.bras. 22: 342. 1997.

***Matayba ealeagnoides* Radlk. Sapindaceae**

Tobamovirus

***Pepper mild mottle virus* (PMMoV)**

PMMoV was detected by serological assays in seedlings of *M. ealeagnoides* in a nursery of the Univ. Brasília, DF (1).
Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40 (supl): 354.2. 2015.

***Matthiola incana* (L.) W. T. Aiton.(Hoary stock) Brassicaceae**

Caulimovirus

***Cauliflower mosaic virus* (CaMV)**

A possible isolate of CaMV was found associated with mosaic symptoms in the ornamental hoary stoch in the state of Rio Grande do Sul. Identification was based on symptoms and aphid (*Myzus persicae* and *Brevicoryne brassicae*) transmission (1).
Ref.: (1) Siqueira, O. & Dionelo, S.B. Fitopatologia (Lima) 8: 19. 1973

***Melochia* sp. Malvaceae**

Begomovirus

***Melochia mosaic virus* (MelMV); *Melochia yellow mosaic virus* (MelYM)**

Melochia sp., a wild malvaceae, was found with yellow mosaic symptoms on leaves in Corumbá, MS. Molecular assays indicated the presence of two, possibly new species of begomovirus, tentatively named MelMV and MelYMV (1).
Ref.: (1) Fiallo-Olivé, E. et al. Arch. Virol. 160: 3161. 2015.

***Mendicago sativa* L. (Alfafa) Fabaceae**
Alfamovirus
***Alfalfa mosaic virus* (AMV)**
AMV was first reported in Brazil infecting alfafa in Campinas and Araçoiaba da Serra, SP, causing typical symptoms of yellow mosaic with yellow rings or sinuous lines. The virus was identified by biological and morphological properties (1), and it was also found in alfalfa, in an experimental area in Piracicaba, SP (2).
Ref.: (1) Costa, A.S. et al. Summa Phytopathol. 6: 30. 1980; (2) Oliveira, P.R.D. et al. Fitopatol.bras. 11: 310. 1986.

***Mimosa sensitiva* L. Fabaceae**
Isometric virus, unclassified
***Mimosa sensitiva* mosaic virus (MiMV)**
During plant viruses survey, *M. sensitiva* plants, part of spontaneous vegetation nearby Belém, PA, was found showing conspicuous mosaic symptoms. The causal virus was identified as an isometric virus, ca. 30 nm in diam., transmissible by mechanical means and by the chrysomelis beetle *Diabrotica speciosa* (Oliv.), but only to the same species (1). The virus was purified and a specific antiserum produced. Serological tests against 31 isometric viruses were all negative (2).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 9: 394. 1984; (2) Marinho, V.L.A. et al. Fitopatol.bras 10: 308. 1985.

***Mirabilis jalapa* L. (Four o'clock) Nyctaginaceae**
Orthotospovirus
***Tomato chlorotic spot virus* (TCSV)**
The ornamental four o'clock is commonly present in residential gardens and city parks in Brazil. Mosaic bearing plants were found in a park in São Paulo, SP. Transmission and RT-PCR assays indicated that the causal agent of the symptoms was an isolate of TCSV (1).
Ref.: (1) Duarte, L.M. et al. Australasian Plant Disease Notes 11: 6. 2016.

***Momordica charantia* L. (Bitter melon) Cucurbitaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
An isolate of CMV coud be recovered from bitter melon plants with mosaic symptoms in the state of São Paulo (1, 2).
Ref.: (1) Barradas, M.M. et al. Arq.Inst.Biol.. 46: 117. 1979; (2) Brioso, P.S.T. & Lin, M.T. Fitopatol.bras. 9: 395. 1984.
Gemycircularvirus
Odonata associated gemycircularvirus 1 (OaGmV-1)
Molecular assays detected a gemycircularvirus in bitter melon, with high sequence identity with OaGmV-1 (1).
Ref.: (1) Rezende, R.R. et al. Arch.Virol. 163: 3163. 2018.

***Monstera deliciosa* Liebm. (Swiss cheese plant) Araceae**
Dichorhavirus
***Dichorhavirus* unidentified**
M. deleciosa plants with ringspot on their leaves were found nearby Manaus, AM. Tissues from these ringspots revealed cytopathic effects typical of dichorhavirus by electron microscopy (1).
Ref.: (1) Rodrigues, J.C.V. et al. Trop.Plt.Pathol. 33: 12. 2008.

***Musa* spp. (Banana) Musaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Infection of banana plants by CMV has been reported in Brazil since the 1930's (1). Symptoms are characterized by dark and clear streaks, continuous or not, originating from the main leaf vein. These streaks may evolve to necrosis, and wrinkling and reduction in leaf size may occur. CMV is aphid borne, being transmitted from other infected banana plants or from other host plants, mostly invasive. However, commonly, infection by CMV occurs by the use of shoots from infected mother plant. Original description was made in the state of São Paulo (1), but CMV is present in most of the banana producing areas of Brazil such as the states of Rio de Janeiro, Minas Gerais, Bahia, Pará, Paraná) (2-6, 7, 9, 10, 12,13). CMV group IA was identified in the state of São Paulo (7). Use of plants derived from massive multiplication of virus-free plantlets, obtained from tissue culture eliminates the initial infection. However, this practice requires rigorous control of the matrix plants, for cases of contamination with BSV has been reported, resulting in plants double infected by CMV and BSV in the field (11).
Ref.: (1) Deslandes, J. Rodriguesia 2 (no.esp.): 199. 1936; (2) Silberschmidt, K. & Nobrega, N.V.R. O Biológico 7: 216. 1941; (3) Medeiros, A.G. Bol.Tecn.IPA 4: 1. 1963; (4) Robbs, C.F. Agronomia 22: 127. 1964; (5) Rbeiro, M.I.S.D. et al. Fitopatologia (Lima) 10: 62. 1975; (6) Lima, J.A.A. & Gonçalves, M.F.B. Fitopatol. bras. 13: 101. 1988; (7)Eiras, M. et al. Fitopatol.bras. 25: 440. 2000; (8) Maciel-Zambolim, E. et al. Fitopatol.bras. 19: 483. 1994; (9) Barbosa, C.J. et al. Res. XIV Cong.Bras.Frutic.: 73. 1996; (10) Trindade, D.R. et al. Fitopatol.bras. 23: 185. 1998; (11) Brioso, P.S.T. et al. Summa Phytopathol. 26: 254. 2000; (12) Nunes, A.M.L. et al. Fitopatol.bras. 26: 512.2001; (13) Carnelossi, P.R. et al. Trop.Plant Pathol. 36 (Supl.) CDRom. 2011.
Badnavirus
***Banana streak virus* (BSV-OL)**
A disease of banana plants characterized by necrotic streaks on leaves is caused by BSV, whose genome is dsDNA and particles are bacilliform. It is spread in the field by mealybugs or through shoots of infected mother plant. It was first recorded in Brazil, in a case of co-infection with CMV, and detected by electron microscopy and PCR in the state of São Paulo (1). BSV has been detected in most of banana growing regions as states of Acre, Amazonas, Pará, Roraima, Bahia, Ceará., Goiás, Minas Gerais, Piauí, Rio de Janeiro, Santa Catarina, Pará, Amapá (2, 3, 7, 9). ICTV recognizes three species of BSV, Mysiore, OL and GF. The BSV present in Brazil is OL (4). In the state of Amazon, necrotic lesions were found in fruits, associated with infection by BSV (5). BSV was experimentally transmitted by the mealybug *Planococcus citri* from banana to banana (8).
Ref.: (1) Brioso, P.S.T. et al. Summa Phytopathol. 26: 254. 2000; (2) Figueiredo, D.V. et al. Fitopatol.bras. 32: 118. 2006. (3) Poltronieri, L.S. et al. Summa Pahytopathol. 35: 74. 2009.(4) Lombardi, R. et al. Pesq.Agrop.Bras. 45: 811. 2010; (5) Brioso, P.S.T. et al. Rev.Bras. Frutic. 33: 1353. 2011; (6) Brioso, P.S.T. Rev.Anual Patol. Planta 20: 64. 2012; (7) Bijora, T. et al. Trop.Plant Pathol. 38 (supl.) 2013; (8) Colariccio, A. et al Trop.Plt.Pathol. 33 (supl): S9.2008; (9) Colariccio, A. et al. Res.439, 50º Cong.Bras.Fitopat. 2017.

***Mussaenda erythrophylla* Schumach. & Thonn. (Ashanti blood) Rubiaceae**
Dichorhavirus
***Dichorhavirus* unidentified**
Ashanti blood plants were found with chlorotic spots on leaves nearby Manaus, AM. Electron microscopy of tissues from lesions revealed cytopathic effects of dichorhavirus, still unidentified (1).
Ref.: (1) Rodrigues, J.C.V. et al. Trop Plt Pathol 33: 12. 2008.

N

***Nasturtium officinale* R.Br. (Water crest) Brassicaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
A report of possible infection of water crest by CMV was made on samples collected in the state of Minas Gerais (1).
Ref.: (1) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econo. do Estado, Sec.Agric.Abast., RJ. 84p. 1978
Potyvirus
***Turnip mosaic virus* (TuMV)**
Water crest plants showing mosaic symptoms were found in Campos de Goytacazes, RJ. Biological assays and electron microscopy associated the disease with a potyvirus, tentatively identified as TuMV (1). A similar situation was found in high incidence in a commercial plantation at Marechal Floriano, ES. Elisa and RT-PCR experiments identified the causal virus as TuMV (2).
Ref.: (1) Boari, A.J. et al. Fitopatol.bras. 27: S200. 2002; (2) Costa, H. et al. Plant Dis.94: 1066. 2010.
Caulimovirus
***Cauliflower mosaic virus* (CaMV)**
A case of infection of water crest by CaMV was reported in the state of Paraná (1).
Ref.: (1) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9:403. 1984.

***Neonotonia wightii* (Perennial soybean) Fabaceae**
Begomovirus
***Bean golden mosaic virus* (BGMV)**
Perennial soybean plants showing characteristic symptoms of infection by begomovirus were found in Santo Antonio de Goiás, GO. Molecular assays indicated that these plants were infected by an isolate of BGMV (1).
Ref.: (1) Bertholdo, N.M. et al. Res.29 Cong.Bras.Virol. 2018.

***Nematanthus* sp. (= *Hypocyrta nervosa*) Gesneriaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was detected on *Nemantathus* sp. plants with chlorotic spots and rings on their leaves in Ibiúna, SP. Identification of CMV was based on biological and serological assays (1).
Ref.: (1) Duarte, L.M.L. et al. Fitopatol.bras. 21: 424. 1996.

***Nicandra physaloides* (L) Gaertn. (Shoo-fly plant) Solanceae**
Potyvirus
***Potato virus Y* (PVY)**
Natural infection of *N. physaloides* by PVY was noticed in the state of Minas Gerais (1)
Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.
***Papaya ringspot virus W* (PRSV)**
***Watermelon mosaic virus* (WMV)**
***Zucchini yellow mosaic virus* (ZYMV)**
A survey was carried out in weeds surrounding cucurbit fields in the state of Tocantins. PRSV-W and ZYMV were found in *N. physaloides* in Lagoa da Confusão, while in Formoso de Araguai, WMV was also found, besides these two viruses (1).
Ref.: (1) Aguiar, R.W.S. et al. Planta Daninha 36: :e018171593. 2018.
Begomovirus
***Tomato severe rugose virus* (ToRSV); *Tomato yellow vein streak virus* (ToYVSV)**
Molecular tools detected a begomovirus infecting shoo-fly plants in Brasília, DF, showing leaf deformation, without further information (1). There are also reports of begomovirus infecting *N. physaloides* in the states of São Paulo (2) and Minas Gerais (3). On the other hand, begomovirus found infecting shoo-fly plants in Sumaré, SP, was identified as ToRSV. Another isolate found in the states of Goiás and Distrito Federal was identified as ToYVSV (5).
Ref.: (1) Inoue-Nagata, A.K. et al. Virus Rev.& Res. 8: 186. 2003; (2) Andrade,G.P. et al. Fitopatol.bras. 32 (supl): 322. 2007; (3). Fernandes, J.J. et al. Plant Pathol. 55: 513. 2006; (4) Barbosa, J.C. et al. Plant Pathology 75: 440.2009; (5) Fonseca, M.E.N. et al. Trop.Plt. Pathol. 34 (supl): S267. 2009.

***Nicotiana tabacum* L. (Tobacco) Solanaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
***Tomato spotted wilt virus* (TSWV)**
"Vira-cabeça" (bent head) was a name given by growers to a condition they observed in tobacco fields, in which many plants had their tops bent as a consequence of one side being more necrotic than the other. First records were made in the state of São Paulo (1-3, 7). This name also has been extended to other crops as tomato. However, the complete symptomatology is more varied. In the beginning, affected plants show vein clearing and wrinkling, followed by necrosis on leaves, which extends to the stem. Plants had their growth delayed and in many cases die. Sometimes the diseased plant may recover. It was shown that the disease is transmitted by thrips, mechanical means and grafting (6). The causal virus was identified *Tomato spotted wilt virus*, described in Australia (4), which has a large range of hosts, either natural or experimental. At this time, TSWV was the only species recognized in the genus Orthotospoviruses (5). After the discovery that Orthotospoviruses comprises many other species, TCSV was found infecting tobacco plants in the state of São Paulo, and GRSV (10) as well as TSWV (9), in the state of Alagoas.
Ref.: (1) Silberschmidt, K. O Biologico 3: 183. 1937; (2) Forster, R. & Costa, A.S. Rev.Agric. (Piracicaba) 13: 69. 1938; (3) Costa, A.S. & Forster, R. Bol. Tec. Inst. Agron. Campinas. 1939; (4) Bragantia 1: 491. 1941; (5) 2: 83. 1942; (6) Forster, R. Bragantia 2: 499. 1942; (7) Costa, A.S. Bol. Min. Agric. 82p. 1948; (8) Colariccio, A. et al. Fitopatol.bras. 20: 347. 1995; (9) Silva, J.N. et al. Fitopatol.bras. 24: 360.1999; (10) Lima, G.S.A. et al. Summa Phytopathol. 29: 196. 2003.
Tymovirus
***Tomato blistering mosaic virus* (ToBMV)**
A tymovirus was found infecting field tobacco plants in the state of Santa Catarina, and considered as an isolate of *Eggplant mosaic virus* (EMV) by biological, morphological and serological assays (1). However, a reassessment of its identity by molecular tools revealed that this virus was an isolate of ToBMV (2).
Ref.: (1) Ribeiro, S.G. et al. Plant Dis. 80: 446. 1996; (2) Melo, F.L. et al. Virus Gene Annouc.2: e00701-14-e00701-14. 2014.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV causes intense mosaic in tobacco leaves, but it is of sporadic occurrence. This virus was reported for the first time in Brzsil in the state of São Paulo (1), and has been found in most of tobacco producing regions in the states of Sergipe (2), Santa Catarina (3), Alagoas (4), Minas Gerais (5). Some CMV isolates found in the state of Minas Gerais were accompanied by satellite RNA (6).
Ref.: (1) Costa, A.S. Bragantia 4: 489. 1944; (2) Oliveira, G.H. & Kitajima, E.W.- pers.comm. (3) Brioso, P.S.T. Tese Dr.,UnB. 1986; (4) Silva, J.N. et al. Fitopatol.bras. 24: 360. 1999; (5) Boari, A.J. et al. Fitopatol.bras. 25:49. 2000; (6) 25: 143. 2000.
Ilarvirus
***Tobacco streak virus* (TSV)**
A tobacco disease characterized by a white necrosis (white necrotic lines, running parallel to the veins) was observed in 1937/1938

in the state of São Paulo. Young leaves emerging after these initial symptoms are asymptomatic, but are followed by a phase coined "couve" (kale), because they are thicker, with dented borders and narrowed. Flowers may exhibit separated and thinner petals, with acute ends. Incidence of the disease in tobacco fields is very low. It is mechanically transmissible, with a wide host range. The causal agent was identified as an isolate of TSV, described in the USA (1-3). There is only one experiment showing that thrips may transmit TSV from infected *Ambrosia polystachya* to tobacco and soybean (5). TSV has been purified and a specific antiserum was obtained (4).
Ref.: (1) Costa, A.S. et al. J.Agronomia (Piracicaba) 3: 1. 1940; (2) Phytopathology 35: 1029. 1945; (3) Costa, A.S. & Carvalho, A.M.B. Phytopathol.Zeit. 42: 113. 1961; (4) Silva, D.M. et al. Bragantia 20:777. 1961; (5) Lima No., V.C. et al. Rev. Setor Cien.Agr.UFPr 4:1. 1982.

Potyvirus

Potato virus Y **(PVY)**

First mention of PVY infecting tobacco was made in cv.'Virginia', grown in Tremembé, SP, in an experimental field of the Instituto Biológico in 1939. Infected plants exhibited chlorotic spots usually accompanying veins, without deforming leaves. It was transmitted mechanically (1) and identified as an isolate of PVY (2).
Ref. (1) Kramer, M. & Silberschmidt, K. Arq.Inst.Biol. 11: 165. 1940; (2) Costa, A.S. & Forster, R. Bragantia 2: 55. 1942.

Alphanecrovirus

Tobacco necrosis virus **(TNV)**

TNV was recovered from tobacco and *Nicotiana clevelandii* grown under greenhouse conditions in the Instituto Agronomico, Campinas, SP (1).
Ref.: (1) Costa, A.S. & Carvalho , A.M.B. Bragantia 19: CXLVII. 1960.

Tobamovirus

Tobacco mosaic virus **(TMV)**

TMV was first described in Brazil infecting tobacco in the state of São Paulo in 1936. Infected plants showed systemic mosaic and reduction in size (1). The virus was recovered from several brands of commercial cigarrets and roll smoke (2). TMV was found infecting tobacco in the state of Alagoas (3).
Ref.: (1) Silberschmidt, K. O Biologico 2: 381. 1936; (2) Costa, A.S. & Forster, R. O Agronômico 1: 252. 1941; (3) Silva, J.N. et al. Fitopatol.bras. 24: 360.1999.

Begomovirus

Sida micrantha mosaic virus **(SimMV)**

Tobacco plants showing severe yellow mosaic were found in Cachoeirinha, RS. The disease was attributed do SimMV infection based on molecular analysis, although Koch's postulate has not been completed (1). This virus was also found infecting tobacco in the state of Paraná (2).
Ref.: (1) Barros, D.R. et al. Virus Rev.& Res. 13 (supl.2): 272. 2008; (2) Sawazaki, H.E. et al. Summa Phytopathol. 39 supl.CDRom. 2013.

Tomato severe rugose virus **(ToSRV)**

A case of natural infection of tobacco by ToSRV was registered in Cascavel, PR (1).
Ref.: (1) Souza Dias, J.A.C. et al. Summa Phytopathol. 36: (supl) #211. CDRom 2010.

Curtovirus, putative

Brazilian tomato curly top virus (BrCTV)

Two types of wrinkling, rough and curled, have been observed in tobacco plants in the state of São Paulo. Curling type was considered of genetic origin, while the rough, of possible viral cause (1). Subsequent works showed that the rough type was caused by the same virus that cause curly top in tomato, transmitted by hoppers *Agallia*, possibly related to the *Beet curly top* virus, described in the USA (2).
Ref.: (1) Costa, A.S. & Forster, R. J.Agronomia (Piracicaba) 2: 295. 1939; (2) Bennett, C.W. & Costa, A.S. J.Agric.Res. 78: 675. 1949.

O

****Ocimum basilicum*** **L. (Basel) Lamiaceae**

Tobamovirus

Tobamovirus **unidentified**

Rod-like particles were found by electron microscopy in extracts of basel showing chlorotic spots, in São Paulo, SP. The putative viral agent was not identified (1).
Ref.: (1) Chagas, C.M. & Colariccio, A. Fitopatol.bras. 18: 278. 1993.

****Ocimum campechianum*** **Willd. (Alfavaca) Lamiaceae**

Cucumovirus

Cucumber mosaic virus **(CMV)**

Alfavaca with mosaic symptoms were found nearby Belém, PA. Causal agent was identified as an isolate of CMV after biological and molecular tests (1).
Ref.: (1) Carvalho, T.P. et al. Trop.Plt.Pathol. 38 (supl.):CDRom 286-2. 2013.

***Orchid (several genera) Orchidaceae**

Cytorhabdovirus

Cytorhabdovirus **unidentified**

Unidentified cytorhabdovirus was detected by electron microscopy in *Laelia tenebrosa* with necrotic ringspots (1).
Ref.: (1) Chagas, C.M. et al. Fitopatol.bras. 13: 132.1988

Dichorhabdovirus

Orchid fleck virus **(OFV)**

Though the term "orchid fleck" refers to spots on leaves, symptoms caused by OFV are varied: chlorotic or necrotic spots, streaks and ringspots. They depend on species and/or genus of the infected orchids. First reported in Japan in 1969, the virus was found to be dispersed in the world, almost certainly due to the intense international exchange, either legal or illegal. Virus particles are short, rod-like (ca. 40nm x 100-110nm) which in infected cells may occur in the nucleus or cytoplasm; a characteristic electron-lucent inclusion (viroplasm) is noticeable in the nucleus. OFV has been reported naturally infecting many orchid genera (*Aspasia, Bifrenaria, Brassia, Cattleya, Coelogyne, Cymbidium, Dendrobium, Encyclia, Hormidium, Maxillaria, Miltonia, Odontoglossum, Oncidium, Oncidium x Odontoglossum, Pahiopedilum, Phalaenopsis, Stanhopea* e *Trigonidium, Xylobium,* etc.). In Brazil, first report of occurrence of OFV was made in several orchid types, maintained in the collection of the Genetic Department, ESALQ/USP, Piracicaba, SP, which were showing mostly chlorotic and/or necrotic spots and ringspots. Electron microscopy showed the typical cytopathic effects described originally for OFV (1). A survey made on several commercial orchid growers found several cases of OFV infection (2). Immunoelectron microscopic studies confirmed that rod-shaped particles are OFV and that viroplasm contains OFV-coded proteins (3). Transmission of OFV by *B. californicus* was also confirmed in Brazil (4). Further surveys found OFV-infected orchids in the states of Rio Grande do Sul, Paraná, Santa Catarina, Minas Gerais, Mato Grosso do Sul, Rio Grande do Sul (5, 6).
Ref.: (1) Kitajima, E.W. et al. Phytopathol.Zeit. 81: 280. 1974; (2) Freitas-Astua, J. et al. Fitopatol. Bras. 24: 125. 1999. (3) Kitajima, E.W. et al. J.gen.Plant Pathol. 67 (3):231. 2001; (4) Ferreira, P.T.O. et al. Fitopatol.bras. 28: S250. 2003; (5) Kubo, K.S. Tese Dr. USP. 2009; (6) Kubo, K.S. et al. J gen. Plt. Pathol. 75: 250. 2009.

Orthotospovirus

Orthotospovirus **unidentified**

An unidentified Orthotospovirus was detected by electron

microscopy in *Oncidium* sp. with mosaic and chlorotic spots on leaves and necrosis in the floral stem, in the state of São Paulo (1). Presence of Orthotospovirus was confirmed by by RT-PCR (2).
Ref.: (1) Alexandre, M.A.V. et al. Bol. Téc. Inst. Biol., nº25: 69-82, 2012; (2) Rivas et al. Res. do 13º Congr. Bras. de Floricult. e Plantas Ornam., p. 138. 2001.
Potexvirus
***Cymbidium mosaic virus* (CymMV)**
Cases of infection of *Cymbidium sp.* and *Laelia purpurata* by CymMV, resulting respectively in mosaic and necrotic spot symptoms were registered in the state of São Paulo. Identification of the causal virus was base on serology and electron microscopy (1). In the state of Paraná, CymMV was found infecting *Cattleya* and *Cymbidium* orchids (2). In a survey made on the orchid collection of the Dept.Genética, ESALQ/USP, Piracicaba, SP, CymMV was found infecting the following orchid genera *Anselliia, Cattleya, Coelogyne, Cymbidium, Dendrobium, Dendrochilum, Laelia, Oncidium, Phalaenopsis, Psychopsis* and hybrids such as *Brassolaeliocattleya, Laeliocattleya* e *Sophrolaeliocattleya* (3). CyMV was detected in the state of Rio de Janeiro infecting *Arundina* (4). In a survey made in the state of Paraíba, CyMV was found infecting *Cattleya* (5).
Ref.: (1) Chagas, C.M. et al. O Biológico 43: 72. 1977; (2) Souto, E.R. et al. Fitopatol. Bras. 16: XXV.1 991. (3); Freitas-Astua, J. et al. Fitopatol. Bras. 24: 125. 1999; (4) Klein, E.H.S. et al. Trop.Plt Pathol 33(supl): S285. 2008; (5) Vilar, L.P. et al. Res.14, 40 CPFitop. 2017.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was identified infecting *Dendrobium nobile* causing chlorosis, mottling, whitish spots and stunting, in Santos, SP. Biological assays based this identification, although this orchid species could not be infected experimentally by CMV (1).
Ref.: (1) Nóbrega, N.R. O Biológico 13: 62. 1947.
Cilevirus
***Cilevirus* unidentified**
During orchid viruses survey in the collection maintained at the Dept. Genética, ESALQ/USP, Piracicaba, SP, *Phaius* and *Xylobium* orchids were showing symptoms essentially similar to those caused by OFV. However, electron microscopy demonstrated cytopathic effects characteristic of cilevirus which could not be identified (1). Similar finding was made in orchid samples from commercial growers of the state of São Paulo (2) and in a sample of *Arundina,* collected in Manaus, AM (3).
Ref.: (1) ; Freitas-Astua, J. et al. Fitopatol. Bras. 24: 125. 99; (2) Kubo, K.S. et al. Fitopatol. bras. 31 (upl): S377. 2006. (3) Rodrigues, J.C.V. et al. Trop Plt Pathol 33: 12. 2008.
Tobamovirus
***Odontoglossum ringspot virus* (ORSV)**
ORSV was detected by serology and electron microscopy in plants of *Laelia tenebrosa* exhibiting necrotic ringspots in the state of São Paulo (1). Similar findings were made in *Cattleya* in the state of Minas Gerais (2) and DF (4). In a large survey for orchid viruses made in commercial nurseries and in the collection of Dept. Genética, ESALQ/USP, Piracicaba, SP, ORSV was found in the following orchid genera: *Cattleya, Cymbidium, Encyuclia, Epidendrum, Laelia, Laeliacattleya, Phalaenopsis*, *Oncidium* e *Xylobium* (3). ORSV was found infecting *Cattleya* and *Spathoglottes* orchids (5).
Ref.: (1) Chagas, C.M. et al. Res.IV Enc.Nac.Virol.p. 217. 1988; (2) Gonzales-Segana,LR. et al. Fitopatol.bras. 15: 152.1990; (3) Freitas-Astua, J. et al. Fitopatol. bras. 24: 125. 1999; (4) Alves, D.M.T. et al. Virus Rev.& Res. 9: 253. 2004.; (5) Vilar, L.P. et al. Res.14, 40 CPFitop. 2017.

***Oryza sativa* L. (Rice) Poaceae**
Benyvirus
***Rice stripe necrosis virus* (RSNV)**
Rice plants with stripe necrosis symptoms were observed in the central region of the state of Rio Grande do Sul. Samples were sent to CIAT in Colombia, in which RSNV was detected by molecular analysis (1).
Ref (1) Maciel, J.L.N. et al. Fitopatol.bras. 31: 209. 2006.

***Oxalis latifolia* Kunth (Garden pink-sorrel) Oxalidaceae**
Begomovirus
***Sida micrantha mosaic virus* (SiMMV)**
Oxalis sp. plants, showing a conspicuous yellow mosaic and leaf distortion and colonized by whiteflies, were found to be infected by an isolate of SiMMV, based on PCR assays (1, 2).
Ref.: (1) Fonseca, M.E.N. et al. Summa Phytopathol. 30: 106. 2004; (2) Lamas, N.S. et al. Virus Rev. & Res. 21: 129. 2016.

***Oxalis oxyptera* Progel Oxalidaceae**
Begomovirus
Infectious chlorosis of malvaceae complex (ICMC)
Yellow net symptoms were observed in *O. oxyptera* growing in the state of São Paulo. Causal virus was identified as a whitefly *Bemisia tabaci*-transmitted begomovirus of ICMC (1). Similar case was noticed in the state of Paraná (2).
Ref.: (1) Costa, A.S. Summa Phytopathol. 4: 3. 1978; (2) Lima No., V.C. et al. Rev.Setor Cien.Agr.UFPr 4: 1. 1982.

***Oxalis* spp., Oxalidaceae**
Begomovirus
***Sida micrantha* mosaic virus (SiMMV)**
Oxalis spp. plants with yellow mosaic and golden spots symptoms were found in the Federal District, Formosa, GO and Londrina, PR. Molecular assays indicated a case of infection of these plants by an isolate of SiMMV (1).
Ref.: (1) Fontenele, R.S. et al. Plant Dis. 102: 1862. 2018.

P

***Panicum maximum* Jacq. Poaceae**
Potyvirus
***Johnson grass mosaic virus* (JGMV)**
JGMV was detected infecting *P. maxium* samples showing mosaic symptoms, collected in São Luis de Paraitinga, SP. Its identification was based in electron microscopy and RT-PCR. Complete genome sequence of this isolated was obtained, revealing 82% identity with an Australian isolate deposited in the GenBank. Mechanical transmission assays showed that this isolate of JGMV can infect many poaceae hosts (2). An unidentified potyvirus in *P. maximum* reported in the state of Mato Grosso may represent a case of infection by JGMV (1)
Ref.: (1) Silva, M.S. et al. Fitopatol.bras. 31(supl):S192. 2006; (2) Camelo-Garcia, V.M. et al. Arch.Virol. 161: 1335. 2016.

***Panicum* sp. Poaceae**
Waikavirus
***Maize chlorotic dwarf virus* (MCDV)**
Mosaic symptoms were observed in *Panicum* sp. being assayed at Embrapa Gado de Corte, Campo Grande, MS. Molecular assays detected MCDV associated to the symptoms (1).
Ref.: (1) Silva, K.N. et al. Virus Rev & Res.20 (supl.): 211.2015.

**** Parthenium hysterophorus* (Santa Maria) Asteraceae**
Begomovirus
***Euphorbia yellow mosaic Virus* (EuYMV)**

EuYMV was detected by molecular assays infecting *P. hysterophorus* plants, with typical symptoms of infection by begomovirus in Santo Antonio de Goiás, GO (1).
Ref.: (1) Bertholdo, N.M. et al. Res.29 Cong.Bras.Virol. 2018.

***Paspalum conjugatum* Bergius (Sour paspalum) Poaceae**
Potyviruis
***Potyvirus* unidentified**
Chlorotic stripes sometimes followed by reddening of the leaves were observed in 100% of plants at the Experimental Station of Instituto Agronomico, in Capão Bonito, SP. Electron microscopy detected an unidentified potyvirus, which could not be transmitted mechanically, by seed or by aphids (1).
Ref.: (1) Vega, J. & Costa, A.S. Fitopatol.bras. 13: 101.1988.

***Passiflora alata* Curtis. Passifloraceae**
Vitivirus
***Grapevine virus A* (GVA)**
Electron microscopy detected closterovirus-like particles in asymptomatic plants of *P.* alata in the states of São Paulo and Minas Gerais (1). These particles reacted with anti-GVA serum in immunoelectron microscopic assays. RT-PCR confirmed the presence of GVA in these samples (2).
Ref.: (1) Chagas C.M. et al., Fitopatol. Bras.17:218, 1992; (2) Galleti, S.R. Fitopatol.bras.31:S373.2006.

***Passiflora edulis* Sims. (Purple granadilla)**
Isometric virus, unclassified
Purple granadilla mosaic virus (PGrMV)
Light mosaic, vein clearing of line pattern type, smaller plant size and occasional hardening of fruits was observed in purple granadilla in a backyard plantation at Cotia, SP (1). It is mechanically transmissible, and the unidentified causal virus is isometric (30 nm diam) occurring in high concentration in infected tissues, and induces a peculiar cytopathic effect- fibrous inclusions in mitochondria (2). The chrysomelid beetle *Diabrotica speciosa* transmitted this virus. Coat protein of virions are made up by a single protein of 35,5 kDa, and the genome is a ssRNA of 1,8 mDa. It was purified and a specific antiserum, produced. No serological relationship could be established with 33 isometric viruses assayed, and its identity still remains obscure (3).
Ref.: (1) Chagas, C.M. et al. Fitopat.Bras. 9: 241. 1984; (2) Vega, J. & Chagas, C.M. Fitopatol.bras. 8: 621. 1983; (3) Oliveira, C.R.B. et al. Fitopatol.bras. 19:455. 1994.

***P. edulis* Sims. f. *flavicarpa* DEG. (Yellow passion fruit); *P. coccínea* Aubl. *x P. setacea* D.C. Passifloraceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
A condition known locally as "enfezamento", characterized by passion flower plants with short internodes, leaves with reduced size, coriaceus, with vein clearing, few flowers and fruits has been reported in production areas of the state of Sergipe (1). It was also observed in the states of Rio de Janeiro (2), Rio Grande do Sul (3), Paraná (4), São Paulo (6), Bahia (7) and Pará (8). This disease is graft transmissible and is associated with the presence of an unidentified nucleorhabdovirus (5).
Ref.: (1) Batista, F.A.S. et al. Anais VI Cong.Bras.Frutic. 1408.1981; (2) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (3) Prata, C.H.S. Diss.Mest.UFRGS75p. 1984; (4) Souza, V.B.V. et al. Rev.Setor Cien.Agr.UFPR 6: 101. 1984; (5) Kitajima, E.W. & Crestani, O.A. Fitopatol.bras. 10: 681. 1985; (6) Chagas, C.M. et al. Fitopatol.bras. 12: 275. 1987; (7) Barbosa, C.J. et al. Fitopatol. bras. 24: 350. 1999; (8) Nogueira, M.S.R. et al. Virus Rev. & Res 11(supl): 187. 2006
Tymovirus
***Passionfruit yellow mosaic virus* (PFYMV)**
During a plant virus survey in the state Rio de Janeiro, passion flower plants showing bright yellow mosaic on leaves were found in Cachoeira do Macacu, RJ. Incidence was very low, and besides leaf symptoms, affected plants looked normal and yield apparently is not affected. The causal agent was identified as a new species of tymovirus, named PFYMV. It was easily transmitted mechanically and by the chrysomelid beetle *Diabrotica speciosa*. Host range of PFYMV was restricted to passifloraceae species. There is no additional report of its occurrence in Brazil, but it was detected in Colombia, where molecular tools confirmed that PFYMV is a distinct species in the genus tymovirus.
Ref.: (1) Crestani, O.A. et al. Phytopathology 76: 951.1986.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Infection of passion flower by CMV was first reported in the state of São Paulo (1, 2), and later in Bahia (3), Paraná (4) and Sergipe (5). This virus is commonly present where passion flower is cultivated, but in very low incidence. Leaf symptoms are represented by bright yellow spots and rings; fruits become smaller and deformed. It is spread in the field by aphids, and experimentally *Myzus persicae* was able to transmit CMV to passion flower. CMV seems to have limited movement in infected plants, and commonly recovery of infection occurs. New shoots after the infected portion are symptomless (6).
Ref.: (1) Cereda, E. Summa Phytopathol. 9: 30. 1983, (2) Colariccio, A. et al. Summa Phytopathol. 10: 118. 1984; (3) Chagas, C.M. et al. Fitopatol.bras. 9: 402.1984; (4) Barbosa, C.J. et al. Fitopatol. bras. 24:193. 1999; (5) Gonçalves, L.O. et al. Fitopatol.bras. 31 (supl): S340. 2006. (6) Gioria, R. et al. Plant Pathol. 51: 127. 2002;

Cilevirus
Passionfrut green spot virus (PFGSV)
Vera Cruz, SP was a traditional coffed growing region, but in last decades yellow passion flower was considered another option, especially for small producers. In the 1990's a serious problem affected these plantations. It was characterized by green spots in ripe fruits and senescent leaves, as well as necrotic lesions in the stems, which when fused caused annealing and as a result, death of the plant. In some fields, losses were 100%. Investigations revealed that this disease, coined "green spot", is caused by a *Brevipalpus*-mite transmitted cilevirus by biological assays and electron microscopy. The virus was named PFGSV, and chemical control of mite infestation was recommended as basic control measure, which worked fine (1). Later green spot of passion flower was also observed in the states of Bahia (2), Minas Gerais (3), Maranhão (4), Mato Grosso do Sul (7). It was also found infecting sweet passion fruit, *P. alata* in the state of São Paulo (5). Genome of PFGSV was partially sequenced, being distinct from *Citrus leprosis virus C* (CiLV-C) (6).
Ref.: (1) Kitajima, E.W. et al., Fitopatol.bras. 22: 555. 1997; (2) Santos Fo., H.P. et al. Virus Rev.&Res. 4: 150. 1999; (3) Takatsu, A. et al. Fitopatol.bras. 25: 332. 2000; (4) Moraes, F.H.R. et al. Fitopatol.bras. 31: 100. 2006; (5) Chagas, C.M. et al. Fitopatol.bras. 29 (supl.): S148. 2004 (6) Antonioli-Luizon, R. Tese MS ESALQ. 2010.; (7) Chabi-Jesus, C. et al. Res.#189, 28º Cong.Bras.Virol. 2017.
Polerovirus
***Cucurbit aphid-borne yellows virus* (CABYV)**
Passion flower plants showing mosaic and leaf deformation were collected in Lençois and Jussiape, BA. Molecular assays carried out on extracted dsRNA followed by sequencing demonstrated that these plants were infected by CABYV (1).
Ref.: (1) Vidal, A.H. et al. Plant Dis. 102: 2665. 2018.
Potyvirus

***Cowpea aphid-borne mosaic virus P* (CABMV-P)**

A condition essentially similar to "woodiness" previously described in Australia, being caused by a potyvirus, *Passion fruit woodiness virus* (PWV) was observed in Feira de Santana, BA. Symptoms were a severe mosaic and leaf deformation, short internodes, witches' broom, floral abortion and woody and deformed fruits (1). Indeed a potyvirus serologically related to PWV was detected by serology. Thus causal agent was thought to be an isolate of PWV. Similar diseases were later reported in a collection of *Passiflora* of UNESP, Jaboticabal, SP (3, 4) and also in commercial plantations in the states of Alagoas (6), Distrito Federal (7), Minas Gerais (5), Ceará (8). Paraná (9), Pará (12), Maranhão (14), Sergipe (16), Santa Catarina (18), Mato Grosso do Sul (20), Amazonas (20), Piauí (24). The virus was experimentally transmitted by several aphid species (*Myzus persicae, A. solanella, Toxoptera citricidus, Uroleucon ambrosiae,U. sonchii*) (10). Molecular analysis of the coat protein gene of this potyvirus revealed a larger homology to CABMV than to PWV (11, 13), thus the causal agent of woodiness symptoms in Brazil was considered an isolate of CABMV (CABMV-P). Transgenic plants expressing coat protein and replicase were resistant to CABMV-P under experimental conditions (12, 19). A mild isolate of CABMV-P which cause mottling was able to infect cucurbits experimentally (15). *P. suberosa* revealed to be immune to infection by CABMV-P (17). In the state of São Paulo a natural infection of the hybrid *P. coccínea x P. setacea* (Cerrado's star) was reported (20). Epidemiological studies showed predominance of aphids of the genus *Aphis* in passion flower fields in the Eastern state of São Paulo, being probably main vectors of CABMV-P (23).

Ref.: (1) Yamashiro, T. & Chagas, C.M. Na. 5º Cong.Bras.Frutic.: 915. 1979; (2) Chagas, C.M. et al. Fitopatol.bras. 6: 259. 1981; (3) Cereda, E. Summa Phytopathol. 9: 30. 1983; (4) Chagas, C.M. et al. Rev.Bras. Fruticult. 14: 187. 1992; (5) São José, A.R. et al. An. 13o Cong.Bras. Frutic.: 797. 1994; (6) Costa, A.F. et al. Fitopatol.bras. 19: 226. 1994; (7) Inoue,A.K. et al. Fitopatol.bras. 20: 479. 1995; (8) Bezerra, D.R. & Lima, J.A.A. Fitopatol. bras. 20: 553. 1995; (9) Barbosa, C.J. et al. Fitopatol. bras. 20: 302. 1995; (10) Costa, A.F. et al. Fitopatol.bras. 20: 376. 1995; (11) Santana, E.N. et al. Virus Rev. & Res. 4: 156. 1999; (12) Trindade, D.R. et al. Fitopatol.bras. 24: 196. 1999; (12) Torres, L.B. et al. Virus Rev.& Res. 6: 161. 2001; (13) Nascimento, A.V.S. et al. Fitopatol.bras. 29: 378. 2004 (14) Belo, R.F. et al. Fitopatol. bras. 29: S87. 2004; (15) Gioria, R. et al. Summa Phytopathol. 30: 256. 2004. (16) Gonçalves, LO et al. Fitopatol.bras.31 (supl): S340. 2006. (17) Nakano, DH et al. Fitopatol.bras. 31(supl):S325. 2006. (18) Colariccio,A . et al. Trop.Plt.Pathol. 33 (supl): S300. 2008; (19) Trevisan, F. et al. Plant Dis. 90: 1016. 2006; (20) Stangarlin, AP et al. Summa Phytopathol. 37 (supl.) CDRom. 2011; (21) Mello, A.P.O.A. et al. Summa Phytopathol 38 (supl.) CDRom 2012; (22) Costa, C.R.X. et al. Trop.Plant Pathol. 37 (supl.) CDRom 2012; (23) Garcez, R.M. et al. Hemipteran-Plant Interactions Symposium. Anais... Res.#39. p.11. 2011.; (24) Beserra Jr., J.E.A. et al. Summa Phytopathol. 39(supl) CDRom 2013.

Begomovirus

Passion flower little leaf mosaic virus (PLLMV)

100% incidence of a condition characterized by yellow mosaic, wrinkling, reduction of size of leaves, and limited development of plants, associated with a severe infestation with whiteflies was observed in passion flower plantations in Livramento de Nossa Senhora, BA. Subsequent works involving biological, serological and molecular assays, and electron microscopy, demonstrated that these plants had a double infection with CABMV and a begomovirus (1). Begomovirus was isolated by whitefly transmission and caused mosaic and small leaves in infected passion flower plants. It was characterized by molecular means and considered as a new species and named PLLMV. Partial sequence of DNA-A showed similarities with other begomoviruses from the New World. A similar begomovirus was found infecting passion flower in S. Fidelis, RJ which had 89% identity with *Sida mottle virus* (SiMoV) (2, 3). Further works carried out in begomoviruses isolated from passion flower in Paragominas (PA) and São Fidelis (RJ) showed that DNA-A had 90% similarity with SiMoV, while another isolate from Araguari (MG) had 96% de similarity SimMV. It was not possible to transmit these isolates with *Bemisia tabaci* biotype B, though they had acquired the virus (3).

Ref.: (1) Novaes, Q.S. et al. Plant Pathology 52: 648. 2003.(2) Moreira, A.G. et al. Fitopatol.bras. 31 (supl): 2006; (3) Alves, A.C.C.N. et al. Virus Rev.&Res. 16 (supl.) CDRom. 2011.

Passion fruit chlorotic mottle virus (PCMoV)

During surveys carried out on passion flower fields in the state of Mato Grosso do Sul, plants showing chlorosis, leaf crinkling and deformation were observed. Molecular analysis on these samples detected a begomovirus distinct from other previously known and tentatively named PCMoV. An infectious clone of PCMoV was produced (1).

Ref.: (1) Fontenele, R.S. et al. Viruses 10: 169. 2018.

***Passionfruit severe leaf distortion virus* (PSLDV)**

Another begomovirus was isolated from passion flower in the state of Bahia. Analysis of the DNA-A sequence indicated 77% similarity with that of *Tomato chlorotic mottle virus*, while with DNA– B the largest identity was found with *Tomato* yellow spot *virus* (74%) (1).

Ref.: (1) Ferreira, S.S. et al. Plant Pathology 59: 221. 2010.

****Pavonia* spp. (Swampmallows) Malvaceae**

Begomovirus

***Pavonia yellow mosaic virus* (PavYMV)**

***Pavonia mosaic virus* (PavMV)**

Pavonia sp. with mosaic symptoms were found in Albuquerque and Corumbá, MS. Molecular studies indicated that these plants were infected by two new begomovirus species, designated PavYMV and PavMV (1).

Ref.: (1) Pinto, V.B.et al. Arch.Virol. 161: 735. 2016.

Infectious chlorosis of malvacea complex (ICMC)

Mosaic bearing swampmallows plants were found in Araruama, RJ and Louveira, SP. The causal agent was considered as part of the infeccious chlorosis of malavacea complex (1).

Ref.: (1) Silberschmidt,K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

****Pelargonium hortorum* L.H. Bailey (Zonal geranium) Geraniaceae**

Cilevirus

***Cilevirus* unidentified**

Ringspots on the leaves of *P. hortorum* were noticed in the state of São Paulo, associated with infestation by *Brevipalpus* mites. Electron microscopy indicated the occurrence of cytopathic effects typical of cilevirus in tissues of the lesions (1).

Ref.: (1) Nogueira et al. Summa Phytopathol. 29: 278. 2003.

****Pennisetum purpureum* Schum. (Elephant grass) Poaceae**

Potyvirus

***Johnson grass mosaic virus* (JGMV)**

Elephant grass plants were found showing mosaic symptoms in the state of Bahia. Biological and molecular assays detected JGMV in these plants (1). A complete genome sequence of this isolate of JGMV was obtained (2). Maize was infected by a JGMV isolate obtained in the state of Minas Gerais (3). Ref.: (1) Silva, K.N. et al. Plant Dis. 97: 1003. 2013; (2) Silva, K.N. et al. Arch.Virol. 161: 1981. 2016; (3) Souza, J.M. et al. Virus Rev. & Res. 21: 123. 2016.

Potyviridae unclassified

Elephant grass mosaic virus (EGMV)

Symptoms of mosaic were observed in elephant grass from a pasture in Sta. Helena, PR associated with infection by a potyvirus. This virus was mechanically transmissible to elephant grass and some other poaceae hosts, but not by aphids, suggesting that it does not belong to the genus *Potyvirus.* The virus, named EGMV was purified and a specific antiserum was produced. Serological assays could not demonstrate relationship with other poaceae potyviruses (1).
Ref.: (1) Martins, C.R.F. & Kitajima, E.W. Plant Dis. 77: 726. 1993

***Peperomia caperata* Yunck (Emerald ripple peperomia) Piperaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV was detected infecting *P caperata* in Lavras, MG, showing deformed apical leaves, chlorotic or mottled leaves, and partial vein necrosis. Identification was made through biological, serological assays and electron microscopy (1).
Ref.: (1) Boari, A.J. et al. Fitopatol. Bras. 21: 422. 1996

***Peperomia obtusifolia* A.Dietrich (Baby rubberplant, Pepper face) Piperaceae**
Tymovirus
***Eggplant mosaic virus* (EMV)**
Concentric reddish rings were noticed in baby rubberplant growing in a residential garden in the city of São Paulo, SP. Further works indicated that the causal agent was a mechanically and chrysomelid beetle- transmissible virus. Electron microscopy suggested that this virus was a tymovirus, and serological assays revealed that it was an isolate of EMV. Molecular assays confirmed this identification (1).
Ref.: (1) Rivas, E.B. et al. Summa Phytopathol. 29: 313. 2003.

***Petroselinum sativum* L. (Parsley) Apiaceae**
Potyvirus
***Cerely mosaic virus* (CeMV)**
Natural infection of parsley by CeMV was registered in the state of São Paulo, resulting in yellow mosaic symptoms. Identification of the virus was made by biological and serological assays, and electron microscopy (1).
Ref. : (1) Novaes, Q.S. et al. Fitopatol.bras. 22:340. 1997.

***Petunia x hybrida* Hort. Ex-Vilm. (Petunia) Solanaceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Chlorotic spots and vein clearing was noticed in petúnia plants in São Paulo, SP, associated with an unidentified Orthotospovirus (1).
Ref.: (1) Alexandre, M.A.V. et al. Rev. Bras. Hortic. Ornamental 11: 49-57, 2005.
Caulimovirus
***Cauliflower mosaic virus* (CaMV)**
The caulimovirus-like virus found in petunia co-infected with PetVB from Gramado, RS, was tentatively considered as an isolate of *Petunia vein banding* virus, but later identified as CaMV, based on serological assays (2, 3).
Ref.: (1) Alexandre, M.A.V. et al. Summa Phytopathol. 19: 48. 1993; (2) Fitopatol. Bras. 22: 330, 1997; (3) Virus Reviews & Research 2: 189, 1997.
Tymovirus
***Petunia vein banding virus* (PetVBV)**
Petunia plants collected in Gramado, RS, showing vein banding, mosaic and blistering revealed to be co-infected by a caulimovirus-like and tymovirus-like viruses, based on electron microscopy. Vein banding symptoms was attributed to the tymovirus, which was characterized as a new species and named PetVBV (1).
Ref.: (1) Alexandre, M.A.V. et al. Plant Dis. 84: 739-742. 2000.
Tobamovirus
***Tobacco mosaic virus* (TMV)**
Symptoms of yellow mosaic and leaf deformation was observed in petunia plants sampled in the state of São Paulo. Causal agent was transmitted mechanically to *Petunia integrifolia, Gomphrena globosa,* tomato and *Zinnia elegans.* Nucleotide sequence of the coat protein indicated that these petunia were nfected by an isolate of TNV (1).
Ref.: (1) Alexandre, M.A.V. et al. J. Phytopath. 148: 601-607, 2000.

***Pfaffia glomerata* (Spreng.) Pedersen (Brazilian ginseng) Amaranthaceae**
Potyvirus
***Pfaffia mosaic virus* (PfMV)**
Pfaffia glomerata is cultivated for its pharmaceutical properties, and some plants of the germplasm collection kept at the Universidade Estadual Norte Fluminense in Campos de Goitacazes, RJ, exhibited mosaic symptoms. Further works demonstrated that the condition was a result of infection by a potyvirus with restricted host range and transmitted by aphids. This potyvirus was purified and a specific antiserum, produced. Analysis of the genome sequence indicated that it was a distinct species of potyvirus, and named PfMV (1). (1).
Ref. : (1) Mota, L.D.C. et al. Plant Pathology 53: 368. 2004.

***Phaseolus lunatus* L. (Lima bean) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**
One of the seeds of Lima bean, from Jataí, GO produced mild mosaic symptoms in primary leaves, upon germination. CPSMV, serotype IV, was identified as the causal agent (1). CPMSV was also found infecting Lima bean associated with mosaic symptoms in the state of Piauí (2).
Ref.: (1) Costa, C.L. et al. Fitopatol. Bras. 16: XXV. 1991; (2) Beserra Jr., J.E.A. et al. Trop.Plt.Pathol. 41 (supl.). 2016.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Mosaic induced by CMV infection of Lima bean was observed in the state of Ceará (1).
Ref.: (1) Lima, J.A.A. & Santos, C.D.G. Fitopatol.bras.10: 304. 1985*.
Potyvirus
***Cowpea aphid-borne mosaic virus* (CABMV)**
Occurrence of Lima bean plants possibly infected by CABMV was registered in Brasília, DF, showing yellow mosaic symptoms on leaves. Bean cv. 'Rosinha' was experimentally infected by this isolate and found to be infected by a potyvirus (1). A similar case of detection of CABMV in symptomatic Lima beans was registered in Itambé and Terezinha, PE, the virus being identified by biological and serological assays (2).
Ref.: (1) Costa, C.L. et al. Fitopatol. Bras. 16: XXVII. 1991/ (2) Andrade, G.P. et al. Fitopatol.bras. 26: 511. 2000.
Begomovirus
***Bean golden mosaic virus* (BGMV)**
BGMV infecting Lima bean was first recorded in the state of São Paulo, a situation quite common in commercial plantations of this legume, resulting symptoms very similar to that caused on beans by this virus. It is whitefly borne (1). Lima bean infection by BGMV was also reported in the state of Ceará (2), Alagoas and Pernambuco (3).
Ref.: (1) Ref.: Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972; (2) Lima, J.A.A. Fitopatol.bras. 10: 301. 1985; (3) Silva, S.J.C. et al. Fitopatol.bras. 31 (supl): S249. 2006.

***Phaseolus vulgaris* L. (Common bean) Fabaceae**

Cytorhabdovirus

***Cytorhabdovirus* unidentified**

A yet to be characterized cytorhabdovirus was found by NSG in transgenic bean variety, resistant to BGMV, which was exhibiting mosaic symptoms in an experimental area in the state of Goiás, co-infecting the plant with CPMMV and BRMV and endornavirus (1,3). This cytorhabdovirus was successfully transmitted to bean, soybean and cowpea by the whitefly *Bemisia tabaci* (2).

Ref.: (1) Alves-Freitas, D.M.T. et al. Virus Rev.&Res. 20 (supl): 42. 2016; (2) Lima, B.P. et al. Res.397, Cong.Bras.Virol., 2017; (3) Alves-Freitas, D.M.T. et al. Viruses 11:90 .2019.

Orthotospovirus

***Bean necrotic mosaic virus* (BNMV)**

BNMV is of rare occurrence. First described in the state of São Paulo in the 1950's, and later in Distrito Federal (5) and in the state of Rio de Janeiro (4). Causal virus was identified as an Orthotospovirus as deduced by electron microscopy (3), but considered distinct from until known species of Orthotospovirus, because upon mechanical inoculation on bean cv. 'Manteiga', caused systemic infection rather than local lesions (2). This virus causes mosaic symptoms resembling those caused by *Bean common mosaic virus*, but without blistering or rugosity. The systemic leaf necrosis is formed by small spots and rings resembling injuries caused by friction. Pods might become spotted and infected plants have lower yields (1). With the advent of molecular techniques its genome was completely sequenced and characterized as a new species among Orthotospoviruses, with some similarities with another Orthotospovirus characterized almost simultaneously in the USA, associated with vein necrosis in soybean (6).

Ref.: (1) Costa, A.S. Bragantia 16: XV. 1957; (2) Costa, A.S. et al. Anais I Simp. Bras. Feijão (Campinas). P. 305. 1972; (3) Kitajima, E.W. & Costa, A.S. Ciencia e Cultura 25: 1174.1973; (4) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (5) Costa, C.L. et al. Fitopatol. bras. 11: 370. 1986; (6) Oliveira, A.S. et al., Virus Gene 43: 385. 2011

Comovirus

***Bean rugose mosaic virus* (BRMV)**

Field infection of bean plants by BRMV is rare, and first description was made in the state of São Paulo (1). Symptoms of vein banding forming symmetric figures appear on the leaves, without rugosity or wrinkling, and plants do not seem seriously affected. BRMV as other comoviruses occurs in high concentration in the tissues, the virions frequently aggregating in crystalline formation in the cytoplasm (2). It is transmitted in the field by by chrysomelid beetles and experimentally, without difficulty, by mechanical means; no seed transmission was observed (1). BRMV has been purified and specific antiserum is available. Immunological assays clearly indicated that Brazilian isolates of BRMV is essentially identical to those found in Central America (4). It was found infecting bean plants in Distrito Federal (3), and in the states of Paraná (6), Goiás (7) and Minas Gerais (8). Precocious infection may reduce yields up to 60% (5).

Ref.: (1) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972; (2) Camargo, I.J.B. et al. Fitopatol.bras. 1:207. 1976; (3) Kitajima, E.W. et al. Fitopatol.bras. 5: 408. 1980; (4) Lin, M.T. et al. Fitopatol.bras. 6: 293.1981; (5) Sperandio, C.A. Diss.Mestr., UnB, 57p. 1982; (6) Bianchini, A. et al. Fitopatol.bras. 10: 307. 1985; (7) Anjos, J.R.N. et al., Fitopatol.bras. 11: 391. 1986; (8) Torres, L.B. et al. Virus Rev.& Res. 8: 195.2003.

***Cowpea severe mosaic virus* (CPSMV)**

CPSMV was found infecting bean, producing vein clearing and systemic chlorotic spots, blistering of young leaves in Distrito Federal. This virus was identified as CPSMV by serology, as being serotyp IV (1).

Ref.: (1) Cupertino, F.P. et al. Fitopatol.bras. 7: 275. 1982.

Carlavirus

***Cowpea mild mottle virus* (CPMMV)**

CPMMV was first described infecting cv. 'Jalo'bean plants in Campinas, SP and Londrina, PR, causing symptoms defined as angular mosaic on leaves. In younger leaves, infection results in vein chlorosis or interveinal chlorosis, followed by green vein banding. In older leaves, yellow mosaic angular in shape, limited by veins is observed. The causal virus was identified as a carlavirus transmitted by the whitefly *Bemisia tabaci*, and identified as an isolate of CPMMV (1, 2). Serological assays confirmed this diagnosis (3). It has been purified (4). CPMMV was detected in bean fields of the state of Pernambuco (5). Sensitive qRT-PCR assays demonstrated seed transmission of CPMMV in experimentally infected bean plants (6).

Ref.: (1) Costa, A.S. et al. Res.1º Sem.Pragas e Doenças Feijoeiro.p.8. 1980; (2) Costa, A.S. et al. Fitopatol.bras. 8: 325.1983; (3) Gaspar, J.O. et al. Fitopatol.bras 10: 195. 1985; (4) Gaspar, J.O. et al. Fitopatol. bras. 18: 554. 1993; (5) Lamas, N.S. et al. Plant Dis. 101: 1828. 2017; (6) Felix, GP et al. Res.29 Cong.Bras.Virol. 2019.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Smooth and small leaves, showing mosaic symptoms were observed in bean plants from Cruzeiro d`Oeste, PR. Causal agent of this condition was identified as an isolate of CMV (1). This virus was also reported infecting bean in the state of São Paulo, causing vein banding and leaf malformation, without affecting growth (2). CMV infection of bean plants was also recorded in Caruarú, PE (3).

Ref. (1) Silberschmidt, K. O Biológico 29: 117. 1963; (2) Costa, A.S. et al. Fitopatologia (Lima) 11: 10. 1976; (3) Costa, C.L. et al. Fitopatol.bras. 11: 359. 1986.

Ilarvirus

***Tobacco streak virus* (TSV)**

Red knot of bean plants is a rare disease, and caused by a Brazilian isolate of TSV. It was reported in the state of São Paulo. Infected plants exhibit several kinds of necrosis (points, rings, streaks) on leaves, petioles and stem. A reddening occurs in the nodes and may cause the death of the plant (1).

Ref.: (1) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972.

Alphaendornavirus

***Phaseolus vulgaris endorna virus 1* (PvEV-1) e *2* (PvEV-2)**

NSG technique revealed the presence of these two endornaviruses in transgenic, BGMV resistant bean cultivars, in an experimental field in the state of Goiás. These plants were also co-infected by BRMV and CPMMV (1).

Ref.: (1) Alves-Freitas, D.M.T. et al. Virus Rev. & Res. 20 (2): 42. 2016.

Potyvirus

***Bean common mosaic virus* (BCMV)**

The first formal description of bean infection by BCMV was made in experimental fields of bean in the Instituto Agronomico, Campinas, SP, in 1936. Most of bean varieties being studies revealed susceptibility (1). BCMV causes on infected plants conspicous mosaic, commonly with chlorotic areas between veins and wrinkling of leaves. This virus is seed and aphid borne, and experimentally is mechanically transmissible. Hypersensitive bean lines which are practically immune tp BCMV, if exposed to a very high inoculum potential, may show upon infection, tip necrosis followed by death (2). BCMV occurs in most of bean producing areas (1,3,5). A BCMV recovered from *Senna occidentalis* induce aracnoid yellow spots on inoculated leaves and also upon systemic infection. It was not seed-borne (4).

Ref.: (1) Costa, A.S. & Forster, R. O Biologico 7: 177. 1941. (2) Costa, A.S. et al. Res.1º Simp.Feijao. 1971; (3) Siqueira,O. et al. Rev.Bras. Fitopat. 4: 69. 1971; (4) Costa, A.S. et al. Anais I Simp.Bras.Feijão

(Campinas). P. 305. 1972; (5) Boari, A.J. & Figueira, A.R. Fitopatol. bras. 17: 178. 1992.

***Bean yellow mosaic virus* (BYMV)**

First mention of BYMV was made in a cytological study, comparing cytopathic effects of bean leaf tissues infected by BCMV and BYMV. BYMV induces a characteristic crystalline nuclear inclusion (2), but the disease has been noted together with dwarf mosaic in 1941 (1). Mosaic caused by BYMV is of bright yellow, not as much as golden mosaic, roughness and wrinkling of leaves, smaller size of infected plant. Infection by BYMV is quite rare in fields. It may infect naturally plants as groundnut, soybean and gladiolus. There are severe isolates as those necrotic type found in groundnut (3).

Ref.: (1) Costa, A.S. & Forster, R. O Biológico 7: 177. 1941; (2) Camargo, I.J.B. et al. Bragantia 27: 409. 1968; (3) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972.

***Cowpea aphid-borne mosaic virus* (CABMV)**

Natural infection of bean cv. 'BT2' by CABMV-P, was reported in the state of Minas Gerais, resulting in mosaic symptoms, close to a passion flower field. This virus was identified by biological and serological assays (1).

Ref.: (1) Maciel, S.C. et al. Summa Phytopathol. 30: 110.2004.

***Potyvirus* unidentified**

Bean plants from Tremembé, SP, were found showing mosaic in young and médium leaves, formed by irregular chlorotic plates. It was considered that the disease was caused by a potyvirus of the *Pisum* group (1).

Ref.: (1) Silberschmidt, K. & Nobrega, N.R. O Biologico 8: 129. 1943.

Sobemovirus

***Southern bean mosaic virus* (SBMV)**

SBMV was first detected in Brazil, infecting bean cv. 'Rico 23' causing mosaic symptoms, in Brasília, DF. Identification was made by biological and serological assays, complemented by electron microscopy (1). Its transmission by chrysomelid beetle *Diabrotica speciosa* (Germ) and *Cerotoma arcuata* (Oliv.) was demonstrated (2). SBMV was found infecting commercial bean fields in the state of Paraná (3). Genome sequences comparisons indicated that an isolate of SBMV from the state of São Paulo was essentially similar to USA isolate (4, 5).

Ref.: (1) Cupertino, F.P. et al. Plant Dis. 66: 741. 1982; (2) Silveira Jr., W.G. et al. Fitopatol. bras. 8: 625. 1983; (3) Gasparin, M.D.G. et al. Fitopatol.bras. 27: S205. 2002; (4) Moreira, A.E. & Gaspar, J.O. Fitopatol.bras. 27: 292. 2002.(5) Ozato Jr., T. et al. Virus Rev. & Res. 11 (supl):190. 2006.

Begomovirus

***Bean golden mosaic virus* (BGMV)**

BGMV was described around 1960's in the state of São Paulo as causing marginal disease in bean fields (1). However it became the limiting factor for common bean production in the next decade, as a consequence of the rapid expansion of the soybean culture. Soybean is an excelent host for the whitefly *Bemisia tabaci*, which freely migrated to nearby bean fields, spreading BGMV, destroying in several occasions entire bean fields resulting in significative losses in most of the bean producing states (3). Brazil became from bean exporter to importer in few years. BGMV-infected bean plants show conspicuous golden yellow mosaic or yellow net on leaves, and bean plants if infected early, remains stunted without producing bean grains. No varietal resistance exists. It is not mechanically transmissible as a Central America isolate. However, transmission by biolistic means was successful (5). Many cultivated or wild legumes may serve as source of inoculum (2). Control has been made through the use of tolerant varieties and zoning of the culture (far from soybean fields, or planted offseason of soybean) (4). Experimentally it was shown that infection by BGMV promotes effective cross-protection against infection by AbMBV (3). Bean lines more resistant have been selected (5). Genetic engineering has produced transgenic bean plants immunes to BGMV, through the expression of some viral genes, and commercial lines are ready to be distributed (6).

Ref.: (1) Costa, A.S. FAO Plant Protection Bull. 13: 1. 1965; (2) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). P. 305. 1972; (3) Costa, C.L. & Cupertino, F.P. Fitopatol. bras. 1: 18. 1976; (3) Costa, A.S. Summa Phytopathol. 9: 53. 1983; (4) Vicente, M. et al. O Biológico 51: 147. 1985; (5) Bianchini, A. Fitopatol.bras. 19: 329. 1994; (6) Aragão, F.J.L. et al. J.Biotechnology 166: 42. 2013..

***Euphorbia yellow mosaic virus* (EupMV)**

Infection of bean plants by EuYMV is a rare event. It was first reported in the state of São Paulo. Leaf distortion caused by chlorotic spots result from natural infection of EupMV (1).

Ref.: Costa, A.S. FAO Plant Protection Bull. 13: 1. 1965.

***Macroptilium yellow spot virus* (MaYSV)**

Isolates of MayYSV were found infecting bean plants, causing a golden mosaic, and were characterized by biological and molecular means in the states of Pernambuco, Sergipe and Alagoas (1).

Ref.: (1) Almeida, K.C. et al. Abst.7th Intl.Geminivirus Symp. P.60. 2013.

***Sida micrantha mosaic virus* (SimMV)**

A variant of SmMV was found causing golden mosaic symptoms on bean in the state of Goiás (1).

Ref: (1) Fernandes, N.A.N. et al. Trop Plt Pathol 34 (supl): S270. 2009.

***Tomato severe rugose virus* (ToSRV)**

A case of asymptomatic infection of bean plants by ToSRV was observed in commercial field in Central Brazil. Detection of this virus was made by PCR. Agroinfection of infectious clones of ToSRV also caused asymptomatic infection of bean (1).

Ref.: (1) Macedo, M.A. et al. Plant Dis. 101: 261. 2017.

Infectious chlorosis of malvaceae complex (ICMC)

First report of bean infection by begomoviruses was reported in the state of São Paulo in the 1940's (1). Affected young plants were stunted and showed basal leaves in a dark green color, and the younger leaves became smaller occasionally with mosaic symptoms and curved down. Infection of adult plants causes mosaic, wrinkling and reduction in size of leaves and size of internodes. Seed transmission was observed but mechanical transmission was not achieved. The causal agent was considered as a member of ICMC, spread by the whitefly *Bemisia tabaci* (2-3). Natural infection of bean by ICMS was estimated in 2-5% (4). A witches' broom symptoms were observed associated with infection by this begomovirus (5).

Ref.: (1) Costa, A.S. & Forster, R. O Biologico 7: 177. 1941; (2) Costa, A.S. Phytopathol. Zeit. 24: 97. 1955; (3) Costa, A.S. FAO Plant Protection Bull. 13: 1. 1965; (4) Costa, A.S. et al. Anais I Simp.Bras. Feijão (Campinas). P. 305. 1972; (5) Costa, A.S. Summa Phytopathol. 9: 76.1983.

***Phenax sonneratii* (Poir) Wedd. (Asian ghostweed) Urticaceae**

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

Vein clearing and angular chlorotic spots were observed in leaves of *P. sonneratii* growing nearby the city of Santos, SP. The symptoms could be graft transmitted and the causal agent was identified as a possible member of the group of ICMC (1).

Ref.: (1) Silberschmidt, K. Phytopathology 38: 395. 1948.

***Physalis angulata* L. (Cutleaf groundcherry) Solanaceae**

Orthotospovirus

***Zucchini lethal chlorosis virus* (ZLCV)**

During a survey of viruses present in weeds surrounding cucurbit

fields in the state of Tocantins, ZLCV was found naturally infecting *P. angulata* in Formoso do Araguaia (1).
Ref.: (1) Aguiar, R.W.S. et al. Planta Daninha 36: :e018171593. 2018.
Crinivirus
***Tomato chlorosis virus* (ToCV)**
P. angulata plants showing interveinal chlorosis on their leaves were found in Capão Bonito, SP. These symptoms could be reproduced by whitefly transmission assays and RT-PCR confirmed the infection by ToCV (1).
Ref.: (1) Fonseca, M.E.N. et al. Plant Dis. 97: 692. 2013.
Potyvirus
***Papaya ringspotvirus W* (PRSV)**
***Watermelon mosaic virus* (WMV)**
***Zucchini yellow mosaic virus* (ZYMV)**
PRSV-W, WMV and ZYMV were found infecting *P. angulata* in Lagoa da Confusão, TO, during a survey for cucurbit viruses in spontaneous vegetation (1).
Ref.: (1) Aguiar, R.W.S. et al. Planta Daninha 36: :e018171593. 2018.
***Potato virus virus* (PVY)**
A case of infection of *P. angulata* by PVY was reported in samples collected at Mairiporã, SP (1**).**
Ref.: (1) Chaves, A.L.R. et al. Summa Phytopathol 36(supl): 047. CDRom.2010.
Tobamovirus
***Tobamovirus* unidentified**
During a plant virus survey in the Amazon basin, *P. angulata* plants, part of the spontaneous vegetation nearby Manaus, AM, were found showing conspicuous mosaic symptoms. Electron microscopy detected possible infection by a tobamovirus, which remains unidentified (1).
Ref.: (1) Cupertino, F.P. et al. Fitopatol.bras. 6: 532. 1981.
Begomovirus
***Begomovirus* unidentified**
Mottling was observed on *P. angulata* plants in an experimental field of Embrapa Hortaliças, Brasília, DF. A still unidentified begomovirus was detected by PCR tests (1).
Ref.: (1) Boiteux, L.S. et al. Fitopatol.bras. 28 (supl.): S2437. 2003.

***Physalis floridana* Rydberg. Solanaceae**
Polerovirus
***Potato leafroll virus* (PLRV)**
An isolate of PLRV, which causes tomato yellow top, was recovered from chlorotic *P. floridana* plants. These plants may serve as virus reservoir in the epidemiology of PLRV in tomato crops (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Coopercotia 148 fev.62,p.34. 1962.

***Physalis peruviana* L. (Peruvian groundcherry) Solanaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
P. peruviana plants showing chlorotic and ringspots on their leaves were found in an experimental field in Piracicaba, SP. GRSV was identified as the causal agent based on biological, morphological, serological and molecular assays. Presence of the thrips *Frankliniella schultzei,* its possible vector, on diseased plants was determined (1). GRSV was also found infecting *P. peruviana* in Central Brasil (2).
Ref.: (1) Esquivel, A.F. et al. Plant Dis. 102 (7): 1469. 2018; (2) Lima, M.F. et al. Res. 29 Cong.Bras.Virol. 2018.
***Tomato chlorotic spot virus* (TCSV)**
Mosaic symptoms were observed in a commercial plantation of Peruvian groundcherry in Santa Maria, RS. The causal agent was identified as TCSV (1).
Ref. (1) Eiras, M. et al. New Disease Rept. 25: 25. 2012.
Potyvirus
***Potato virus Y* (PVY)**
P. peruviana was found infected by PVY in the state of Santa Catarina (1).
Ref.: (1) Gonçalves, M.J. et al. Trop.Plt.Pathol. 39 (supl): CD Rom. 2014.
Sobemovirus
***Velvet tobacco mottle virus* (VTMoV)**
P. peruviana plants with mosaic, yellowing, leaf crinkling and fruit deformation were noticed in commercial fields in the state of Santa Catarina. Biological, serological and molecular assays identified the causal agent as an isolate of VTMoV. Infection of *P. peruviana* by VTMoV promoted yield losses and affected fruit quality (1).
Ref.: (1) Gorayeb, E.S. et al. Res. 29 Cong.Bras.Virol. 2018.

***Physalis* sp., Solanaceae**
Begomovirus
***Physalis* yellow spot virus (PhYSV)**
A begomovirus was found infecting *Physalis* sp. in the state of Alagoas, possibly a distinct species and named PhYSV, but further characterization is still pendent (1).
Ref.: (1) Nascimento, L.D. et al. Trop.Plt.Pathol. 38 (supl.): 195. 2013.

***Phytolacca decandra* L. (Pokeweed) Phytolaccaceae**
Potyvirus
***Potato virus Y* (PVY)**
Natural infection of field pokeweed plants by PVY was observed in the state of Minas Gerais. No reference to symptoms was made (1).
Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

***Piper callosum* Ruiz & Pav. Piperaceae**
Dichorhavirus
***Dichoravirus* unidentified**
P. callosum plants with chlorotic spots on their leaves were found nearby Manaus, AM. Electron microscopy revealed cytopathic effects similar to those caused by dichorhaviruses in tissues of lesions (1).
Ref.: (1) Rodrigues, J.C.V. et al. Trop.Plt.Pathol 33: 12. 2008.

***Piper nigrum* L. (Black pepper) Piperaceae**
Dichorhavirus
***Dichorhavirus* unidentified**
Chlorotic spots were observed on the leaves of some cultivated black pepper plants in Tome-Açú, PA. Electron microscopy revealed cytopathic effects similar to those caused by dichorhaviruses (1).
Ref.: (1) Yamashita, S. et al. Summa Phytopathol. 30: 68. 2004.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Black pepper plants cultivated in the state of Pará were found with mosaic symptoms on their leaves, reduced internode size, stunting, smaller and deformed bunches and yield reduction. The causal agent was identified as an isolate of CMV. Tha aphid *Aphis gossypii* was able to experimentally transmit CMV to black pepper. (1, 2). Later, similar problems were found in black pepper planted in the state of São Paulo (3) and Espirito Santo (ES). A satellite RNA was found associated with CMV found in black pepper in ES (5).
Ref.:(1) Caner, J. O Biológico 35: 185. 1969; (2) Costa, A.S. et al. IPEAN, Ser. Fitotecnia 1: 1. 1970; (3) Caner, J. & Ikeda, H. O Biológico 38: 93. 1972; (4) Maciel-Zambolin, E. et.al. Fitopatol.bras. 15: 220. 1990; (5) Boari, A.J. et al. Fitopatol.bras. 25: 143. 2000.
Badnavirus
***Piper yellow mottle virus* (PYMoV)**
Some black pepper plants maintained in the germplasm collection at Embrapa Amazonia Oriental, Belém, PA, showed chlorotic mottle and vein clearing symptoms on their leaves. Electron microscopy

revealed badnavirus like particles in the tissues (1). Molecular assays confirmed that this badnavirus is PYMoV, which is mealybug-transmitted (2). The mealybug *Planococcus minor* experimentally transmitted PYMoV to healhy black pepper plants (3).
Ref.: (1) Albuquerque, F.C. et al. Fitopatol.bras. 25: 36. 1999; (2) Brioso, P.S.T. et al. Fitopatol.bras. 25: 438. 2000; (3) Sousa, C.M. et al Virus Rev.Res. 15 (supl):309. 2010.

***Pisum sativum* L. (Pea) Fabaceae**
Cytorhabdovirus
***Cythorhabdovirus* unidentified**
Pea plants with chlorotic mottle and reduced growth were found in Itapecerica da Serra, SP. Co-infection of an unidentified potyvirus and cytorhabdovirus was verified. The latter was mechanically transmitted to *Nicotiana glutinosa* and *Datura stramonium*. No further works were made to complete the identification of these viruses (1).
Ref.: (1) Caner, J. et al. Summa Phytopathol. 2: 264.1976.
Orthotospovirus
***Goundnut ringspot virus* (GRSV)**
Pea plants with apical chlorosis, foliar necrosis and deformation were found in Brasília, DF. Causal agent was identified as an isolate of GRSV based on serological and molecular assays (1).
Ref,: (1) Fontes, MG et al. Plant Dis. 102: 457. 2018.
***Tomato spotted wilt virus* (TSWV)**
In Brasília, DF, TSWV was found infecting pea plants causing tip blight and brown spots on the pod; lower leaves exhibited mottling, and necrotic streaks appeared on stems. Symptoms were more severe on the cv. 'Triofin' than on 'Mikado' (1).
Ref.: (1) Reifschneider, F.J.B. et al. Trop.Pest Managem. 35: 304.1989.
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Pea plants were found in a commercial cv. 'Mikado' pea plantation in Dourados, MS, showing mosaic and rosette symptoms. Biological, serological and molecular assays, and electron microscopy, revealed that the causal agent was an isolate of CMV, similar to that found infecting black pepper (1).
Ref.: (1) Dusi, A.N. et al. Fitopatol.bras 17: 286. 1992.
Potyvirus
***Bean yellow mosaic virus* (BYMV)**
Mosaic symptoms were observed in cultivated pea in the state of Paraná, associated with infection by BYMV(1).
Ref.: (1) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984.
***Bidens mosaic virus* (BiMV)**
Occurrence of a yellow mosaic was noticed in a commercial plantation of pea cv.'Torta de Flor Roxa' in Brasília, DF. Causal agent was identified as an isolate of BiMV (1).
Ref.: Nagata, T. et al. Fitopatol. Bras. 20: 473. 1995.
***Pea seed-borne mosaico virus* (PSbMV)**
PSbMV was found infecting pea plants cv. 'Triofin', causing mosaic and leaf deformation in Dourados, MS and Brasília, DF. Identification was based on biological and serological asaays, and electron microcopy (1).
Ref.: (1) Dusi, A.N. et al. Fitopatol. bras. 19: 219. 1994.

***Plumbago auriculata* Lam. (Blue plumbago) Plumbaginaceae**
Cilevirus
***Cilevirus* unidentified**
Blue plumbago plants showing chlorotic spots on leaves were observed in a residential garden in Atibaia, SP, associated with *Brevipalpus* mite infestation. Electron microscopy revealed cytopathic effects similar to those caused by cilevirus in tissues of the lesions, but causal virus still reamains unidentified (1).
Ref.: (1) Freitas-Astua, J. et al. Summa Phytopathol. 30: 80. 2004.

***Pogostemum patchouly* Pellet (Patchouli) Lamiaceae**
Cytorhabdovirus
***Cytorhabdovirus* unidentified**
A possible *Cytorhabdovirus* was detected by electron microscopy in patchouli plants with mosaic symptoms, in a germplasm collection of Seção de Plantas Aromáticas, Instituto Agronomico, Campinas, SP. Similar finding was made in a sample collected in the state of Sergipe, in patchouli clones received from Embrapa Amazonia Oriental (2).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Fitopatol.bras. 4: 55. 1979; (2) Boari, AJ et al. Fitopatol.bras. 31 (supl): S322. 2006.
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
Electron microscopic analysis detected a possible infection by so far unidentified nucleorhabdovirus in patchouli plants collected in the state of São Paulo, showing chlorosis and leaf distortion (1).
Ref.: (1) Lombardi, R. & Galleti, S.R. Summa Phytopathol. 34 (supl.): S68-69. 2008.
Potexvirus
Patchouli X virus (PatVX)
Some patchouli plants with mosaic symptoms from the germplasm collection of Seção de Plantas Aromáticas, Instituto Agronomico, Campinas, SP, were found to have suffered a mixed infection by unidentified poty- and cytorhabdovirus, and by a potexvirus. This potexvirus, possibly causing latent infection, was characterized and found to be a new species, based upon partial sequences of the coat protein and named PatVX. It might be related to Argentine plantago virus. Mechanically inoculated tobacco and *Datura stramonium* became systemically infected, while *Gomphrena globosa* reacted with local lesions (1, 2).
Ref.: (1) Meissner Fo., P.E. et al. Fitopatol.bras.22: 569. 1997; (2) Ann.Appl.Biol. 141: 267. 2002.
Potyvirus
***Potyvirus* unidentified**
Unidentified potyvirus was detected in patchouli, from germplasm collection of Seção de Plantas Aromáticas, Instituto Agronomico, Campinas, SP, and samples from Belém, PA, sometimes in co-infection with other viruses (1). It was also detected in plants collected in the state of Sergipe (2). It seems to be an isolate of BiMV (E.W. Kitajima, pers.comm.).
Ref.: (1) Gama, M.I.C.S. et al. Fitopatol.bras. 4: 113. 1979; (2) Boari, A.J. et al. Fitopatol.bras. 31 (supl): S322. 2006.
Alphanecrovirus
***Tobacco necrosis virus* (TNV)**
TNV was found in some patchouli samples from the germplasm collection of Seção de Plantas Aromáticas, Instituto Agronomico, Campinas, SP, apparently in an asymptomatic infection (1).
Ref.: (1) Gama, M.I.C.S. et al. Phytopathology 72: 529. 1982.
Tobravirus
***Pepper ringspot virus* (PepRSV)**
Virus-free plants of patchouli were obtained by tissue culture. Some of them were planted on unsterilized soils in the experimental field of the Universidade de Brasília, DF. Chlorotic rings and yellow lines appeared in some of these plants, and the causal agent was identified as PepRSV. Probably natural infection of this virus was mediated by a nematode vector (1).
Ref.: (1) Gama, M.I.C.S. et al. Fitopatol.bras. 8: 395. 1983.

***Porophyllum ruderale* (Jacq.) Cass. (Bolivian coriander) Asteraceae**
Nucleorhabdovirus
***Nucleorhabdovirus* unidentified**
Bolivian coriander plants with yellow mottle symptoms were found in

Nova Odessa, SP. Electron microscopy detected a nucleorhabdovirus, which remains unidentified (1).
Ref. (1) Alves, A.C.C.N. et al. Summa Phytopathol. 34: 375. 2008.

***Portulaca oleracea* L. (Purslane) Portulacaceae**
Orthotospovirus
***Orthotospovirus* unidentified**

Purslane is a common invasive weed in Brazil, and some plants growing in the state of São Paulo were observed showing chlorotic and necrotic on their leaves, associated to stunting. Recovery assays demonstrated the presence of an unidentified Orthotospovirus, indicating that these infected purslane plants may serve as virus reservoir for cultivated plants (1). Similar finding is reported in the state of Paraná (2).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: XXI. 1960; (2) Lima No., V.C. et al. Rev. Setor Cien. Agr. UFPr 4: 1. 1982.
Potexvirus
***Alternanthera mosaic virus* (AltMV)**

A potexvirus (1), identified as AltMV (2), was found infecting purslane in São José do Rio Preto, SP, resulting in mosaic symptoms (1). This virus was later identified as AltMV (2).
Ref: (1) Tomomitsu, A.T. et al. Virus Rev. & Res. 11 (supl.): 192. 2006; (2) Alexandre, M.A.V. et al. Rev. Bras. Hort. Ornam. 16: 95, 2010.
Curtovirus
***Brazilian tomato curly top virus* (BrCTV)**

Swelling and protuberances on the veins, curved leaves and stunting were described in purslane growing in Campinas, SP, and the causal agent identified as BrCTV. No mechanical transmission was achieved, but the virus was transmitted by the hopper *Agallia albidula* (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: XIX. 1960.

***Prunus persica* (L) Batsch. (Peach) Rosaceae**
Ilarvirus
***Prunus dwarf virus* (PDV)**

Peach plants infected by PDV were detected in commercial orchards and in the germplasm collection of Embrapa/CAPACT in the state of Rio Grande do Sul, through TAS-ELISA (1).
Ref.: (1) Daniels, J. et al. Fitopatol. bras. 19: 329. 1994.
***Prunus necrotic ringspot virus* (PNRSV)**

Serological assays detected PNRSV and PDV in peach plants showing ringspot on their leaves, in commercial plantations in several regions of the state of Rio Grande do Sul (1).
Ref.: (1) Maciel, S.C. et al.. Fitopatol.bras. 27 (supl.): S209. 2002.

***Prunus persica* (L.) Batsch. var. *nucipersica* (Suckow) C.K. Schneid (Nectarine) Rosaceae**
Ilarvirus
***Prunus dwarf virus* (PDV)**

PDV was detected in nectarines in the state of Rio Grande do Sul, during a matrix plant certification program (1).
Ref.: (1)) Daniels, J. Fitopatol.bras. 24: 195. 1999.

***Prunus salicina* Lindl. (Plum) Rosaceae**
Ilarvirus
***Prunus necrotic ringspot virus* (PNRSV)**

PNRSV was detected in 100% of asymptomatic plum plants, cvs. Roxa de Itaquera and Satusuma in the state of São Paulo. This virus could be graft transmitted to other plum and peach plants, resulting in slight chlorotic lines forming symmetric figures. The virus could be mechanically transmitted to cucumber, *Chenopodium quinoa, Nicotiana glutinosa* and cowpea (1). The same virus was detected in the state of Rio Grande do Sul, by immuno assays, during a plum certification program (2).
Ref.: (1) Betti, J.A. et al. Fitopatologia (Lima) 9: 44. 1974; (2) Daniels, J. Fitopatol.bras. 24: 195. 1999.

***Psycothria mapourioides* DC Rubiaceae**
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**

PMMoV was detected in seedlings of *P. mapourioides* by immunoassays in the Universidade de Brasília, DF, without mention of symptoms and further experiments for viral characterization (1).
Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40 (supl): 354.2. 2015.

***Psidium guajava* L. (Guava) Myrtaceae**
Caulimovirus
Caulimovirus unidentified

Caulimovirus-like particles were observed in tissue sections of guava leaves, with yellow mosaic, in samples collected at Monte Aprazível, SP. Symptoms were reproduced in graft-inoculated plants. However no further works to characterize this unidentified virus were carried out (1).
Ref.: (1) Gaspar, J.O. et al. Fitopatol.bras. 18: 289. 1993.

***Psiguria triphylla* (Miq.) C. Jeffrey- Cucurbitaceae**
Potyvirus
***Papaya ringspot virus* W (PRSV-W)**

P. triphylla plants with mosaic and foliar deformation were found in an experimental field of passion fruit in Embrapa Cerrados, Planaltina, DF. Further assays revealed that these plants were infected by an isolate of PRSV-W (1).
Ref.: (1) Nakano, D.H. et al. Plant Pathology 57: 398. 2008.

***Psilanthus ebracteolatus* Hiern. Rubiaceae**
Dichorhabdovirus
***Coffee ringspot virus* (CoRSV)**

During surveys for CoRSV in a germplasm collection of the Centro de Café, Instituto Agronomico, Campinas, SP, ringspots were observed on the leaves of plants of *P. ebracteolatus*, a rubiaceae close to the genus *Coffea.* RT-PCR and electron microscopy concluded that the symptoms were due to infection by CoRSV (1).
Ref.: (1) Kitajima, EW et al. Sci.Agric. 68: 503. 2012.

***Psophocarpus tetragonolobus* (L.) DC (Winged bean) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**

In a experimental plot of winged bean, for introduction assessment in the Instituto Nacional de Pesquisas da Amazonia, Manaus, AM, some of the plants exhibited conspicous mosaic symptoms. The causal agent was identified as an isolate of CPSMV (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 4: 519. 1979.

***Pueraria* sp. (Kudzu) Fabaceae**
Comovirus
***Cowpea severe mosaic virus* (CPSMV)**

Kudzu plants showing mosaic symptoms were found in Igararé-Açú, PA. Biological and serological assays indicated that it was a case of natural infection by CPSMV, sorotype I (1).
Ref.: (1) Nogueira, M.S.R. et al. Virus Rev.& Res. 7: 156. 2002.

***Pyrus communis* L. (Pear), Rosaceae**
Foveavirus
***Apple stem pitting virus* (ASPV)**

ASPV was detected in pear plants, by qRT-PCR in the state Rio Grande do Sul (1).
Ref.: (1) Nickel, O. & Fajardo, T.V.M. Trop.Plt.Pathol. 39: 28. 2013.

Unclassified ssDNA virus

Temperate fruit decay associated virus (TFDaV)

Stunted pear plants with weak budding and dried twigs were found in Viçosa, MG. Molecular tools detected still unclassified ssDNA virus (TFDaV), associated to the condition (1). See more detail in *Vitis vinifera.*

Ref.: (1) Basso, M.F. et al. Virus Research 210: 27, 2015.

R

***Raphanus raphanistrum* L. (Wild radish) Brassicaceae**

Polerovirus

***Beet western yellows virus* (BWYV)**

Yellowing of lower leaves and marginal chlorosis on wild radish were observed in the state of São Paulo. Causal agent was transmitted in a persistent manner by the aphid *Myzus persicae* Sulz., and was identified as an isolate of the *Beet western yellows virus* (BWYV) (1, 2).

Ref.: (1) Costa, A.S. Fitopatologia (Lima) 9: 47. 1974; (2) Costa, A.S. Summa Phytopathol. 6: 28. 1980.

Potyvirus

***Turnip mosaic virus* (TuMV)**

Wild radish with conspicuous mosaic symptoms were found in the state of São Paulo. The causal virus was identified as an isolate of TuMV, aphid transmissible (1).

Ref.: (1) Costa, A.S. Fitopatologia (Lima) 9: 47. 1974.

***Raphanus* sp. Brassicasseae**

Nucleorhabdovirus

***Nucleorhabdovirus* unidentified**

An unidentified *Raphanus,* part of spontaneous vegetation with yellowing was collected in Limeira, SP. Among mechanically inoculated plants, a nucleorhabdovirus was found by electron microscopy in *Datura stramonium*, considered as an isolate of *Brocolis necrotic yellow nucledorhabdovirus*- BNYV). No further information is available (1).

Ref.: (1) Kitajima,E.W. & Costa, A.S. Fitopatol.Bras.4: 55. 1979.

Crinivirus

***Tomato chlorosis virus* (ToCV)**

Unidentified *Raphanus* with internerval chlorosis in lower leaves were collected in Mauá, PR. RT-PCR assays detected ToCV in this sample (1).

Ref. (1) Boiteux, L.S. et al. Plant Dis. 100: 1027. 2016.

***Rhoe discolor* (L'Her) Hance (=*Tradescantia spathacea* Sw.) (Moses-in-the-cradle) Commelinaceae**

Potyvirus

***Potyvirus* unidentified**

Mottled plants of Moses-in-the-cradle were found in a residential garden of Brasília, DF. Electron microscopy detected potyvirus, but no experimental transmission was achieved (1).

Ref.: (1) Rodrigues, M.G.R. & Kitajima, E.W. Fitopatol. Bras. 6: 533. 1981.

Tobamovirus

***Tobamovirus* unidentified**

Unidentified tobamovirus was detected in Moses-in-the-cradle plant in São Paulo, SP (1).

Ref. (1) Alexandre, M.A.V. et al. Rev.Bras.Hort.Ornam. 16: 95. 2010.

***Rosa* spp. (Roseira) Rosaceae**

Ilarvirus

***Apple mosaic virus* (ApMV) (= *Rose mosaic virus*)**

Mosaic symptoms in rose was first described around 1940 in the states of São Paulo and Rio de Janeiro, either in rootstocks or grafted commercial varieties. Observed symptoms were chlorotic bands along the veins and sometimes vein clearing. The condition was transmitted by grafting, but not mechanically. Rose plants of the group Tea, with yellow mosaic, conspicuous chlorotic spots, and elongated and discontinuous yellow streaks in stems were observed in the Instituto Biológico. The disease was considered caused by ApMV (1, 2).

Ref.: (1) Kramer, M. Rev.Agric. 15: 301. 1940; (2) Kramer, M. O Biológico 6: 365. 1940.

***Prunus necrotic ringspot virus* (PNRSV)**

PRNSV was detected in leaves and petals of rose exhibiting mosaic symptoms in samples collected at Atibaia and São Paulo, SP (1). Another isolate of PNRSV was found infecting rose plants in Lagoa Vermelha, RS, being identified by molecular means, and considered belonging to the group PV32 (2).

Ref: (1) Alexandre, M.A.V. et al. Trop. Pl. Pathol. 34(supl): S274. 2009; (2) Fajardo, T.V.M. et al. Ciência Rural 45: 2197. 2015

***Rubus* spp. (Blackberry) Rosaceae**

Nepovirus

***Tomato ringspot virus* (ToRSV)**

An isolated of ToRSV was identified infecting blackberry in Vacaria, RS, associated with mosaic symptoms. Transmission and serological assays were used for the identification. (1).

Ref.: (1) Nickel, O. et al. Virus Rev.& Res. 8: 189. 2003.

***Ruellia chartacea* (T. Anderson) Wash. (Peruvian wild petunia) Acanthaceae**

Dichorhavirus

***Dichorhavirus* unidentified**

During plant virus survey in Manaus, AM, *R. chartacea* plants with green spots on senescent leaves were found. Electron microscopy of the lesion tissues revealed cytopathic effects characteristics of those caused by dichorhaviruses (1).

Ref.: (1) Rodrigues, J.C.V. et al. Trop. Plant Pathol. 33: 12. 2008.

***Ruta graveolens* L. (Rue) Rutaceae**

Virus, unidentified

During transmission assays of citrus triteza carried out in the Instituto Biológico, São Paulo, SP, in the 1940's, one of the inoculated rue plants showed ringspot symptoms. About the same time, rue cuttings introduced from the Botanical Garden of Buenos Aires, Argentina, presented similar symptoms. Further experiments showed that the causal agent was transmissible to other rue plants, with inactivation temperature of 60º C, suggesting viral etiology. However characterization of this presumed virus was not concluded (1).

Ref.: (1) Silberschmidt, K. O Biológico 12: 219. 1946.

S

***Saccharum officinarum* L. (Sugar cane) Poaceae**

Polerovirus

***Sugarcane yellow leaf virus* (ScYLV)**

A disease, coined "amarelinho" (yellowing) caused concern on sugar cane culture at the end of 1990's, especially affecting the variety SP 71-6163 in which this condition caused significative losses in the state of São Paulo. Symptoms were variable depending upon the infected variety (1). In highly susceptible varieties as SP 71-6-6163, main vein showed yellowing on the abaxial side; older leaves, 6th to 7th from the tip, presented main, central vein with reddish color in the adaxial face, followed by color loss and tissue necrosis. Roots and stem had reduced growth resulting in significative yield losses (7, 8). Causal agent was identified as a new species of aphid-borne

polerovirus and named ScYLV (1, 2, 4, 5). This virus was purified and demonstrated to be isometric ca. 30 nm in diameter (3, 9), being phloem restricted and affecting maize plant metabolism (10). This viral disease was controlled through the use of resistant varieties (1, 6, 12). ScYLV is now endemic in sugar cane fields in Brazil, but there is no data on possible losses caused by its infection (8, 11).

Ref.: (1) Vega, J. et al. Plant Dis. 81: 21. 1997; (2) Maia, I.G. et al. Arch.Virology 145: 1009. 2000; (3) Gonçalves, M.C. & Vega, J. Fitopat.Bras. 22: 335. 1997; (4) Lopes, J.R.S. et al. Fitopatol.bras. 22: 335. 1997; (5) Gonçalves, M.C. et al. European Journal of Plant Pathology, 108: 401. 2002; (6) Gonçalves, M.C. et al. Virus Rev.& Res. 7: 26. 2002; (7) Gonçalves, M.C. et al. Fitopatol.bras. 30: 10. 2005; (8) Gonçalves, M. C. Doenças causadas por virus. In: Dinardo-Miranda, L.L. et al. (Org.). Cana-de-Açúcar. 1 ed. Campinas: Instituto Agronômico de Campinas, 2008, v. 1, p. 450. 2008; (9) Gonçalves, M.C. & Vega, J. Fitopatol.bras. 32: 50. 2007; (10) Vasconcelos, A.C.M. et al. Functional Plant Sci. & Biotechnol. 3: 31. 2009; (11) Gonçalves, M.C. Trop.Plant Pathol. 35: 54. 2010; (12) Gonçalves et al. Functional Plant Science & Biotechnology 6: 108. 2012.

Potyvirus

***Sugarcane mosaic virus* (SCMV)**

Mosaic symptoms (light green, yellow, white areas alternated with normal green) in sugarcane of viral origin was one of the first viral diseases described in Brazil in the 1920's. The disease, caused by SCMV, possibly was introduced in this period, in the varieties POJ 36, 213 and 218. It is present in all sugar cane growing regions of Brazil (states of São Paulo, Paraná, Goiás, Pernambuco, Alagoas, Rio de Janeiro (1-5, 11, 14, 16). Maize and sorghum are natural hosts for SCMV and serve as well as indicator plants (7). SCMV causes significative losses in the so called noble varieties, but resistance obtained by classical breeding programs solved the problem and presently this virus is not considered important (8, 12,13). However, due to the appearance of new severe isolates of SCMV both for sugarcane and maize, replacement of varieties and hybrids had been made quite frequently. SCMV is an aphid-borne potyvirus, and several isolates of SCMV have been found infecting other poaceae species (6, 10). Genome comparison has shown that Brazilian isolates of SCMV are very similar to the Australian isolate Brisbane (1, 16, 17).

Ref.: (1) Costa Lima, A. Chácaras e Quintais 34: 30. 1926; (2) Bitancourt, A.A. Rev.Agricult. (Piracicaba) 1: 22. 1926; (3) Camargo, T.A.O. Casa Genoud, Campinas. 1926; (4) Vizioli, J. Officinas da Gazeta, Piracicaba. 1926; (5) Caminha, A.F. Brasil Assucareiro 7: 209. 1936; (6) Costa, A.S. et al. Bragantia 10: 301. 1950; (7) Costa, A.S. & Penteado, M.P. Phytopathology 41: 114. 1951; (8) Matsusoka, S. & Costa, A.S. Pesq.Agropec.Bras. 9: 89. 1974; (9) Sanguino, A. & Moraes, V.A. Bol.Tecn.Coopersucar 27: 32. 1984; (10) Pinto, F.J.A. & Bergamin Fo., A. Fitopatol.bras. 10: 300. 1985; (11) Gonçalves, M. C. Fitopatol.bras. 29: S129. 2004; (12) Gonçalves, M.C. et al. . Fitopatol. bras. 32: 32..2007; (13) Barbosa, A.A.L. et al. Fitopatol.bras. 32:345. 2007; (14) Gonçalves, M.C. Summa Phyopathol. 36 (supl.) CDRom. 2010; (15) Gonçalves, M.C. et al. Trop.Plant Pathol. 35: 54. 2010; (16) Gonçalves, M.C. et al. Pesq.Agropec.Bras. 46: 362. 2011; (17) Gonçalves, M.C. et al. Functional Plant Sci. & Biotechnol. 6: 108. 2012.

Badnavirus

***Sugar cane bacilliform virus* (SCBV) Guadelupe A, IM, MO [BB, Kerala]**

Immunosorbent electron microscopy permitted the detection of badnavirus-like, bacilliform particles in asymptomatic sugarcane plants in the state of São Paulo (1, 2) and Alagoas (3). A systematic survey made on near 300 samples from a germplasm collection indicated an incidence of 36% of badnavirus. Molecular analysis based on partial sequencing of these detected badnaviruses indicated presence of six species SCBV Guadelupe A and D, IM, MO, besides SCBV BB (unclassified), one of them possible new species (Kerala) Some of these species seemed to be closely related to banana badnavirus (4)

Ref.: (1) Vega, J. et al. Fitopatol.Bras.16: XXVI.1991.(2) Gonçalves, M. C. Doenças causadas por virus. In: Dinardo-Miranda L.L. et al. (Org.). Cana-de-Açúcar. 1 ed. Campinas: Instituto Agronômico de Campinas, 2008, v. 1, p. 450; (3) Jordão, L.J. et al. Trop.Plt. Pathol. 39: 198. 2013; (4) Silva, J.M. et al. Trop. Plant Path.40, p. 151, 2015.

***Salvia leucantha* Cav. (Mexican bush sage) Lamiaceae**

Cilevirus

***Cilevirus* unidentified**

Green spots on senescent leaves were observed on *S. leucantha* growing in a residential garden in Piracicaba, SP, associated with infestation by tenuipalpid mite *Brevipalpus*. Electron microscopy of tissues from these lesions revealed cytopathic effects similar to those caused by cileviruses (1). This condition was reproduced through experiments of transmission with these mites which were identified as *B. phoenicis s.l.* (2).

Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 29: 53. 2003; (2) Kitajima, E.W. & Ferreira, P.T.O. et al. Fitopatol.bras. 28 (supl.): S250. 2003.

***Salvia splendens* Ker Gawl. (Scarlet sage) Lamiaceae**

Potexvirus

***Althernanthera mosaic virus* (AltMV)**

Mosaic symptoms were observed in Scarlet sage collected in São José do Rio Preto, SP, and the causal agent identified as AltMV (1, 2).

Ref.: (1) Alexandre, M.A.V. et al. Trop. Pl Pathol. 33 (supl): S231. 2008; (2) Alexandre, M.A.V. et al. Rev.Bras.Hort.Orn. 16: 95-100. 2010

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV was identified causing stunting, mosaic and leaf deformation in Scarlet sage in the state of São Paulo (1).

Ref. (1) Kudamatsu, M. et al. Summa Phytopathol. 7: 3. 1981.

Begomovirus

***Begomovirus* unidentified**

A begomovirus, still unidentified, distinct from other known species were detected by molecular means infecting Scarlet sage in Viçosa, MG. Preliminary assays failed to transmit mechanically this virus (1).

Ref.: (1) Krause-Sakate, R. et al. Fitopatol.bras. 23: 318. 1998.

***Schefflera actinophylla* (Endl.) Harms (Umbrella tree) Araliaceae**

Cilevirus

***Cilevirus* unidentified**

Green spots and ringspots were observed in senescent leaves of umbrella tree growing in the campus of Escola Superior de Agricultura Luiz de Queiroz/USP, Piracicaba, SP (1). Cytopathic alterations typical of cileviruses were observed in these lesions by electron microscopy (2). Reproduction of symptoms was achieved by mite transmission experiments (3).

Ref.: (1) Kitajima, E.W.et al. Virus Rev. & Res. 4: 148. 1999; (2) Kitajima, E.W. et al. Expt. Appl. Acarol. 30: 135. 2003; (3) Ferreira, P.T.O. et al. Fitopatol. bras. 28: S250. 2003.

Badnavirus

***Schefflera ringspot virus* (SRV)**

Some umbrella tree used for shading the parking lot of the Guarulhos International Airport (Guarulhos, SP) were found with chlorotic ringspot on their leaves. Electron microscopy detected badnavirus-like particles in the cytoplasm of cells from these lesions. PCR confirmed the presence of a badnavirus, which was considered

identical to previously described SRV (1). This virus was also detected in umbrella trees collected in the states of Rio de Janeiro, Rio Grande dos Sul and Rio Grande do Norte (2).
Ref.: (1) Brioso, P.S.T. et al. Fitopatol. bras. 28: S247. 2003; (2) Brioso, P.S.T. & Pozzer, L. . Summa Phytopthol. 36 (supl.) res. 214.2010.

***Sclerolobium melinonii* Harms Fabaceae**
Tobamovirus
***Pepper mild mottle virus* (PMMoV)**
PMMoV was detected by serological assays in seedlings of *S. melinonii* in a nursery of the Universidade de Brasília, DF (1).
Ref.: (1) Batista,J.G. et al. Trop.Plt.Pathol. 40(supl): 354-2. 2015.

***Scutellaria* sp. (Skull caps) Lamiaceae**
Potexvirus
***Alternanthera mosaic virus* (AltMV)**
A case of mosaic in skull cap caused by AltMV was reported in São José do Rio Preto, SP (1, 2).
Ref.: (1) Alexandre, M.A.V. et al. Trop. Plt Pathol. 33(supl): S231. 2008; (2) Alexandre, M.A.V. et al. Rev.Bras.Hort.Orn. 16: 95-100. 2010.

***Senecio douglasii* DC (Threadleaf ragwort) Asteraceae**
Orthotospovirus
***Chrysanthemum stem necrosis virus* (CSNV); *Tomato spotted wilt virus* (TSWV)**
S. douglasii plants were found infected by TSWV, showing vein chlorosis, leaf deformation, tip necrosis and arching in São Roque, SP (1). In another sampling, double infection by TSWV and CSNV of threadleaf ragwort was verified (2).
Ref.: (1) Rivas, E.B. et al. Fitopatol. bras. 20: 346. 1995; (2) Alexandre, M.A.V. et al. Summa Phytopathol. 25: 353.1999

***Senna occidentalis* (L.) Link (=*Cassia occidentalis* L.) (Coffee weed) Fabaceae**
Potexvirus
***Senna* Virus X (SeVX)**
Coffee weed plants showing conspicuous mosaic symptoms were collected in Tupã, SP. Preliminary electron microscopy indicated possible infection by a potexvirus. Mechanical transmission assays succeeded in transmitting the unidentified virus to several indicator plants (*Chenopodium quinoa, C. amaranticolor* e *Nicotiana benthamiana*). No seed transmission was observed. Serological assays indicated distant relationship with PVX and WCMV (1). The complete genome sequence of this virus was obtained, revealing that it is a new species of potexvirus and designated SeVX (2).
Ref.: (1) Giampan, J.S. et al. Fitopatol.bras. 29: S211. 2004; (2) Rezende, J.A.M et al. Arch.Virol. 162: 529, 2017.
Potyvirus
Bean common mosaic virus (BCMV)
Isolate of BCMV, which causes chlorotic spot type mosaic in bean, was isolated from field coffee weed plants in the state of São Paulo (1).
Ref.: (1) Costa, A.S. et al. Anais I Simp.Bras.Feijão (Campinas). p.305. 1972.
***Cowpea aphid-borne mosaic virus* (CABMV)**
A mosaic in coffee weed, observed in the state of Ceará, was identified as being caused by an isolate of CABMV (1).
Ref.: (1) Lima, J.A.A. & Gonçalves, M.F.B. Fitopatol.bras. 13: 365. 1988.
***Soybean mosaic virus* (SMV)**
A potyvirus was found infecting coffee weed in Brasília, DF (1), and possibly represents an isolate of SMV as reported in Paraná, PR (2).
Ref.: (1) Santos, O.R. et al. Fitopatol.bras. 16: XXXVIII. 1991; (2) Almeida, A.M.R. et al. Fitopatol.bras. 27: 151. 2002.

***Sesamum indicum* L. (Sesamum) Pedaliaceae**
Orthotospovirus
***Orthotospovirus* unidentified**
An isolate of Orthotospovirus was found infecting field sesamum plants in the state of São Paulo (1).
Ref.: (1) Costa, A.S. & Forster, R. Bragantia 2: 83. 1942.
Potyvirus
***Cowpea aphid-borne mosaic virus* (CABMV)**
A mosaic in sesamum was attributed to infection by CABMV in the state of Ceará (1).
Ref.: (1) Lima, J.A.A. et al. Fitopatol.bras. 16: 60. 1991.

***Sicana odorifera* Naudin (Musk cucumber) Cucurbitaceae**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
Musk cucumber plants from an experimental field of Univ. Fed. Minas Gerais, were found with blistering, light mosaic and deformation of leaves. Biological and serological assays concluded that the disease was caused by ZYMV (1).
Ref.: (1) Rocha, F.D.S. et al. Trop.PltPathol. 38 (supl.): 376-1. 2013.

***Sida* spp.: *Sida acuta* Burm., *S. carpinifolia* (L.) K.Schum.; *S. rhombifolia* L., *S. glaziovii* K.Schum., *S. cordifolia* L. *S. micrantha* St.Hill., *S. urens* L., *S. Bradei* Ulbricht, *S. spinosa* L. Malvaceae**
Orthotospovirus
***Orthotospovirus* unidentified**
Natural infection of *S. spinosa* by an unidentified toposvirus, resulting in irregular chlorotic spots and leaf deformation was reported in the state of São Paulo (1).
Ref.:(1) Pavan, M.A. et al. Fitopatol.bras. 17: 186. 1992.
Begomovirus
Infectious chlorosis of malvaceae complex (ICMC)
The first description of a golden mosaic in *Sida* sp. was registered in the 1940's in the state of São Paulo (1). The unidentified causal virus was not mechanically transmissible or by seeds, but it was transmitted by grafting. Experimental transmission using whitefly *Bemisia tabaci* was achieved (2,3). Later, successful mechanical transmission from *S. rhombifolia* and *S. micrantha* to *Malva parvifolia* was obtained (4,5). These mosaics in *Sida* spp. and wild malvaceae was considered as being caused by a member of ICMC. These conditions were also observed in the state of Pernambuco (6).
Ref.: (1) Silberschmidt, K. Arq.Inst.Biol. 14: 105. 1943; (2) Orlando, A. & Silberschmidt, K. Arq.Inst.Biol. 16: 1. 1946; (3) Costa, A.S. Phytopathol.Zeit. 24: 97. 1955; (4) Silberschmidt,K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955; (5) Costa, A.S. & Carvalho, A.M.B. Phytopathol.Zeit. 37: 259. 1960; (6) Lima, G.S.A. et al. Virus Rev.& Res. 6: 158.B 2001.
***Sida angular mosaic virus* (SiAMV)**
***Sida chlorotic vein virus* (SiCVV)**
***Sida golden mosaic virus Brazil* (SiGMV-BZ)**
***Sida micrantha mosaic virus* (SimMV)**
***Sida mosaic Alagoas virus* (SiMAlV)**
***Sida mottle virus* (SiMoV)**
***Sida mottle Alagoas virus* (SiMoAV)**
***Sida* golden yellow mosaic virus (SiGYMV)**
***Sida yellow mosaic virus Alagoas* (SiMV AL)**
***Sida* yellow spot virus (SiYSV)**

With molecular tools it has been possible to detect and identify a large number of begomovirus species not only in *Sida* spp., but also in other species. Several of these species were accepted by ICTV, while others still are waiting for the official recognition. In most of cases of begomovirus described before the advent of molecular techniques, precise species identification was not feasible. Most of them were considered isolates of AbMBV or ICMC, and for historical records, such identification are registered as such. In the era of molecular technology, several distinct begomoviruses have been identified infecting *Sida* spp., based on the sequence of their genomes (1-3). An isolate of SmMV recovered from tomato was shown to be mechanically transmissible to some assay plants, but not to *Sida* (4). This virus was found infecting tomato in the state of Rio de Janeiro (5). A begomovirus infecting naturally passion flower and causing mosaic and little leaf had 98% similarity with SiMoV (6). Begomoviruses (SiCSV and Si1gYMV) resembling those present in the old world were recovered from *Sida acuta*, in Viçosa, MG (7). SiMoV was recognized in the state of Paraíba (8). SiMoAV was described infecting *Sida* spp. in Viçosa, MG and Maragogi, AL (9). SiMAlV was found in the state of Alagoas (10). In the state of Piauí, two possible new species of begomovirus (SiAMV and SiCVV) were found infecting *Sida* spp. in Esperantina, Piracuruca and Teresina, state of Piauí (11).
Ref.: (1) Fernandes, A.V. et al. Fitopatol.Bras.23: 316; (2) Virus Rev.& Res. 4(supl.1): 148. 1999; (3) Contin, F.S. et al. Virus Rev.& Res. 8: 194. 2003; (4) Calegario, R.F. et al. Fitopatol.bras. 29: S150. 2004.(5) Paula, M.B. et al. Fitopatol.Bras.32 (supl): S197. 2007 (6) Moreira, A.G. et al. Fitopatol.bras. 31 (supl): 2006; (7) Xavier, C.A.D. et al. Virus Rev & Res.20 (supl.): 26. 2015; ; (8) Ferro, M.M.N. et al. Trop. Plant Pathol. 42:39. 2017; (9) Tavares, S.S. et al. Planta Daninha 30: 395. 2012; (10) Wyant, P.S. et al. Virology 427: 151. 2012; (11) Passos, L.S. et al. Arch.Virol. 162: DOI 10.1007/s00705-017-3283-7. 2017.

***Sida yellow leaf curl virus* (SiYLCV)**

SiYLCV was isolated from *Sida rhombifolia* in Coimbra, MG (1).
Ref.: (1) Castillo Urquiza, GP et al. Arch.Virol. 153: 1985. 2008.

***Sida common mosaic virus* (SiCmMV)**

SiCmMV was recovered from *Sida micrantha* in Coimbra, MG (1)
Ref.: (1) Castillo-Urquiza, G.P. et al. Arch.Virol. 153: 1985. 2008.

***Sida chlorotic mottle virus* (SiCMoV)**

A begomovirus isolalted from *Sida* sp. showing mosaic symptoms was found in the state of Rio Grande do Sul. Genome analysis indicated that it is a new begomovirus species. The closest known begomovirus is Tomato leaf dwarf virus (TLDV), sharing with it 81,5% of identity (1).
Ref.: (1) Ferro, C.G. et al. Virus Rev.Res. 19 (supl.): 209. 2014.

***Begomovirus* unidentified**

S. rhombifolia and *S. spinoa* were found infected with still unidentified begomovirus in the state of Alagoas (1). Similar case involving *S. cordifolia* was reported in the state of São Paulo (2).
Ref.:(1) Assunção, L.P. et al. Planta Daninha 24: 239. 2006. (2) Barbosa, J.C. et al. Summa Phytopathol. 33 (supl): 92. 2007.

***Sidastrum micranthum* (St.Hill.) Fryxel Malvaceae**

Begomovirus

***Begomovirus* unidentified**

An unidentified begomovirus was associated with mosaic symptoms of *S. micranthum* in the state of Alagoas (1).
Ref (1) Assunção, L.P. et al. Planta Daninha 24: 239.2006.

***Sinapsis alba* L. (Mustard) Brassicaceae**

Potyvirus

***Turnip mosaic virus* (TuMV)**

Mustard plants with mosaic symptoms were found in Vassouras and Itaguai, RJ, during a plant virus survey. Further assays indicated that these plants were infected by TuMV (1). Similar case was reported in the state of Paraná (2).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (2) Lima, M.L.R.Z.C. et al. Fitopatol. bras. 9:403. 1984.

Caulimovirus

***Cauliflower mosaic virus* (CaMV)**

CaMV causing mosaic in mustard was reported in the state of Paraná (1).
Ref.: (1) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9 :403. 1984.

***Sinningia speciosa (*Lodd.) Hiern. (Gloxinia) Gesneriaceae**

Orthotospovirus

***Chrysanthemum stem necrosis virus* (CSNV)**

CSNV was found infecting gloxinia in samples collected at Arujá, SP, exhibiting chlorotic and necrotic ringspot symptoms on their leaves, and flower deformation and discoloration. Identification was made by biological and serological assays (1).
Ref.: (1) Yuki, V.A. et al. Fitopatol.bras. 26: 517. 2001.

***Tomato spotted wilt virus* (TSWV)**

Infection of gloxinia by TSWV was registered in the state of São Paulo (1).
(1) Alexandre, M.A.V. et al. Rev. Bras. Hortic. Ornam. 11: 49. 2005.

***Solanum aculeatissimum* Jacq.(= *S. ciliatum* LAM.) (Dutch eggplant) Solanaceae**

Nucleorhabdovirus

Joa yellow blotch virus (JoaYBV)

During surveys of plant viruses in the Amazon basin, dutch eggplant, part of spontaneous vegetation in a citrus orchard, were found showing chlorotic spots on their leaves, near Manaus, AM. Electron microscopy indicated the presence of a nuclerhabdovirus in infected tissues. Graft, but not mechanical transmission was achieved. Molecular assays confirmed the presence of a nucleorhabdovirus with 75% identity in the sequence of the polymerase gene with *Potato yellow dwarf virus* (PYDV) and *Eggplant mottled dwarf virus* (EMDV). This virus was tentatively named JoaYBV (1).
Ref.: (1) Mei, Y. et al. Summa Phytopathol. 42 (supl): res.128. 2016.

Polerovirus

***Potato leafroll virus* (PLRV)**

Natural infection of dutch eggplant by PLRV was reported in the state of São Paulo, and considered as a natural reservoir for this virus, thus linked to its epidemiology for cultivated solanaceous crops (1,2).
Ref.: (1) Souza Dias, J.A.C. et al. Fitopatol. bras. 17: 156. 1992; (2) Souza Dias, J.A.C. & Costa, A.S. Res. VI Enc.Nac.Virol. 176.1992.

Potyvirus

***Potato virus Y* (PVY)**

PVY was found infecting dutch eggplant in the state of São Paulo (1,2).
Ref.: (1) Kudamatsu, M. & Alba, A.P.C. Summa Phytopathol. 5: 15. 1979; (2) Vicente, M. et al. Fitopatol.bras. 4: 73. 1979.

***Solanum aethiopicum* Jacq. (Jiló) Solanaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

Jiló plants exhibiting ringspots on leaves and fruits were found in a commercial plantation in Itapólis, SP. Biological and molecular assays indicated that the symptoms were due to infection by GRSV (1).
Ref.: (1) Cruciol, G.C.D. et al. Res. 29 Cong.Bras.Virol. 2018.

***Tomato chlorotic spot virus* (TCSV)**

Jiló were found in S. José dos Campos, SP, with symptoms of "vira cabeça". TCSV was considered the causal agent (1). A high incidence

of such a disease in jiló was reported in commercial plantations in Taiaçú, SP (2).
Ref.: (1) Chaves, A.L.R. et al. Fitopatol.bras. 25: 439. 2000; (2) Rabelo, L.C. et al. Fitopatol.bras. 27: 105. 2002.
Comovirus
***Andean potato mottle virus* (APMoV)**
Mottling in jiló observed in the state of Rio de Janeiró was found to be caused by an isolate of APMoV (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984.
Crinivirus
***Tomato chlorosis virus* (ToCV)**
Symptoms of interveinal chlorosis were observed in jiló cultivated commercially in Venda Nova, ES, Bragança Paulista, SP and Distrito Federal associated with infestation by the whitefly *Bemisia tabaci.* ToCV was detected in these plants by RT-PCR, and the virus was whitefly transmitted to susceptible tomato lines (1).
Ref.: (1) Fonseca, M.E.N. et al. Plant Dis. 100: 867. 2016.

***Solanum americanum* Mill. (Glossy nightshade) Solanaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Potyvirus
***Potato virus Y* (PVY)**
Glossy nightshade plants, growing close to a pepper culture, were found exhibiting mosaic symptoms in Lins, SP. Laboratory analysis indicated that these plants were either infected by PVY alone, or co-infected with CMV. Thus, this species, part of spontaneous vegetation, may serve as natural reservoir of these viruses for pepper and other crops (1).
Ref. (1) Moura, M.F. et al. Summa Phytopathol. 40: 78. 2013

***Solanum atropurpureum* Schrank (Purple devil) Solanaceae**
Potyvirus
***Potato virus Y* (PVY)**
Vein banding, chlorotic punctuations and bending were notice on leaves of purple devil in the campus of the Universidade de São Paulo, São Paulo, SP. Further assays identified the causal agent as an isolate of PVY (1).
Ref.: (1) Chagas, C.M. et al. Phytopathol.Zeit. 90: 147. 1977.

***Solanun commersonii* Dan. (Commerson's nightshade) Solanaceae**
Begomovirus
***Tomato severe rugose virus* (ToSRV)**
A survey made on the germplasm collection of Embrapa Hortaliças, Brasília, DF, revealed plants of Commerson's nightshade with yellow mosaic and leaf deformation of upper leaves and stunting. Molecular assays associated these symptoms with infection by ToSRV (1).
Ref.: (1) Lima, M.F & Vieira, D.C. 28º Cong.Bras.Virol.: Res.400, 2017.

***Solanum jamaicense Mill.* (Jamaican nightshade) Solanaceae**
Crinivirus
***Tomato chlorosis virus* (ToCV)**
S. jamaicense plants were found naturally infected by ToCV in Brasília, DF. Identification was made by RT-PCR (1).
Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673. 2018.

***Solanum lycocarpum* St.Hill. (Wolf apple) Solanaceae**
Potyvirus
***Potato virus Y* (PVY)**
A report of Wolf Apple infected by PVY was made in the state of Minas Gerais, without further details (1).
Ref.: (1) Oliveira, C.D. et al. Fitipatol.Bras. 21: 427. 1996.

***Solanum lycopersicum* L. (Tomato) Solanaceae**
Orthotospovirus
***Chrysanthemum* stem necrosis virus (CSNV)**
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
***Tomato spotted wilt virus* (TSWV)**
The syndrome known as "vira-cabeça" in tomato is one of the most destructive viral disease of tomato in Brazil and elsewhere. The name was given by the producers because of the bending of tip of young plants following necrosis. If susceptible varieties are infected in high incidence, the disease may destroy totally the plantation. Early report of this disease were made in 1930's in the state of São Paulo (1, 2). Symptomatology may vary depending upon the age of infected plant, variety, environment, isolate/species of the Orthotospovirus. In young plants, development is arrested and the green color becomes pale; young leaves of the tip show necrotic lines and rings and curve downwards. In severe infection, the tip dies. In older plants, symptoms are similar, progressing downwards. Necrotic streaks may appear in the stems. Green fruits may present internal and external necrosis., while mature fruits may show discolored spots or concentric rings. The disease is transmitted in a persistent manner by several species of thrips (3-5). At that time, the causal agent of "vira cabeça" was identified as TSWV, previously described in Australia. Electron microscopy revealed that the viral particles were membrane-bound, 80-100 nm in diameter, present within cisternae of the endoplasmic reticulum of infected cells (6, 7). In the 1990's, thanks to intense researches carried out at the Virus Department, Agricultural University of Wageningen, the Netherlands, with participation of several Brazilians, it became evident that the now *Orthotospovirus* genus did not comprise a single species (TSWV), but included many distinct species, several of them present in Brazil, infecting naturally many plant species, tomato being one of the most affected culture (8, 9). It should mentioned that the type species of *Orthotospovirus* genus, TSWV, was recovered from tomato at Embrapa Hortaliça em Brasília, DF. In Brazil, the following Orthotospovirus species were detected in tomato: TSWV, GRSV, TCSV and CNSV (12). Defective and interfering forms of TSWV may form after seqüencial mehanical transmission. Surveys have shown presence of GRSV in the states of Pernambuco, TSWV in Distrito Federal, TSWV, TCSV and GRSV in Minas Gerais, TSWV and GRSV in São Paulo, TSWV and TCSV in Paraná, TCSV in Rio Grande do Sul (12). CSNV was found infecting tomato in the state of Minas Gerais (11), Rio de Janeiro (13) and São Paulo (15). GRSV was the only Orthotospovirus found in a survey in commercial tomato fields in the "submédio São Francisco", state of Pernambuco (14). Sequences of viral glycoprotien genes of GRSV and TCSV showed to be almost identical (16). TCSV was found in Belém, PA (17).
Ref.: (1) Azevedo, N. Rodriguesia, 6: 209. 1936; (2) Bitancourt, A.A. O Biológico 2: 98. 1936; (3) Costa, A.S. Bragantia 4: 480. 1944; (4) Costa, A.S. & Forster, R. Bragantia 1: 491. 1941; (5) Costa, A.S. Bol. Min.Agric. 82p. 1948; (6) Kitajima, E.W. et al. Bragantia 22: XXXV. 1963; (7) Kitajima, E.W. Virology 26: 89. 1965; (8) de Ávila, A.C. et al. J.gen.Virol. 71: 2807.1990; (9) 74: 153. 1993; (10) Resende, R.O. PhD thesis, Agric. Univ. Wageningen 115p. 1993; (11) Resende, R.O. et al. Fitopatol.bras. 20: 299. 1995; (12) Nagata, T. et al. Fitopat. Bras. 20: 90. 1995; (13) Brioso, P.S.T. et al. Fitopatol.bras. 22: 332. 1997; (14) Lima, M.F. et al. Fitopatol.bras. 22: 340. 1997; (15) Colariccio, A. et al. Summa Phytopathol. 26: 252. 2000; (16) Lovato, F.A. et al. Fitopatol.bras. 29: S101. 2004; (17) Carvalho,T.P. et al. Trop.Plt. Pathol. 40 (supl.): 44-2. 2015.
Tymovirus
***Eggplant mosaic virus* (EMV)**

Tomato plants showing wrinkling, chlorotic mottling and whitish necrosis on leaves were noticed in Itaquaquecetuba, SP. Causal agent was identified as an isolate of EMV (1), which was purified (2) and analyzed serological and molecularly (3). This virus was experimentally transmitted by the beetle species *Epitrix fallada* (4), *Diabrotica speciosa* (5), *Epicauta atomaria* (6). EMV was also detected in commercial tomato fields in Caxias do Sul, RS (7).

Ref.: (1) Chagas, C.M. et al. Arq.Inst.Biol. 42: 157. 1975; (2) Alba, A.P.C. et al. Summa Phytopathol. 3: 131. 1977; (3) Barradas, M.M. Tese Dr., USP. 161p. 1983; (4) Salas, F.J.S. et al. Res.6ª Reuní.An.Inst. Biol.. p.34. 1993; (5) Res.Virologica PO-4-02. 1993; (6) Res.5º Enc. Nac.Virol.p.85. 1990 (7) Colariccio, A et al. Summa Phytopathol. 34 (supl): S80. 2008.

Tomato blistering mosaic virus (ToBMV)

Tomato plants showing severe mosaic and leaf deformation were noticed in a commercial plantation in the state of Santa Catarina. A mechanically transmissible virus was associated with the disease, which was identified as a tymovirus by RT-PCR assays. Sequence analysis of the genome of this virus revealed that it was a new species of tymovirus, being designated as ToBMV (1,2).

ef.: (1) Oliveira, V.C. et al. Virus Genes 46: 190. 2013; (2) Nicolini, C. et al. Arch.Virol. 160: 609. 2014.

Amalgavirus

***Amalgavirus* unidentified**

A still unidentified amalgavirus (dsRNA Ca. 3.5 kb, seed transmitted) was detected in surveys made in tomato fields of Campinas, SP and Brazlândia, DF. The virus was detected by molecular tools, but there is no additional information (1).

Ref.: (1) Martins, T.P. et al. Virus Rev.& Res. 20: 124. 2016

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Aphid-borne, CMV infection in tomato has low incidence. Infected plants show leaves of reduced size, stunting and lower yields (1, 2).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948; (2) Summa Phytopathol. 9: 37. 1983

Ilarvirus

***Tobacco streak virus* (TSV)**

Natural infection of tomato plants by TSV was first reported in Itatiba, SP, resulting in leaf malformation (1). Seed transmission was verified (2).

Ref.: (1) Costa, A.S. et al. Bragantia 20: CVII. 1961; (2) Cupertino, F.P. Rev.Soc.Bras.Fitopatol. 3: 50. 1969.

Crinivirus

***Tomato chlorosis virus* (ToCV)**

ToCV was first reported in Brazil, in tomato fields at Sumaré, SP, in the agricultural year of 2006/7 causing interveinal chlorosis (1), and a similar case previously reported in 1999, in Campinas, SP, was possibly caused by ToCV (3). Presence of ToCV was subsequently made in several parts of Brazil: states of Espirito Santo (2), Bahia, Goias, Minas Gerais and Rio de Janeiro (4), Distrito Federal (5). Experimental transmission by the whitefly *Trialeurodes vaporariorum* was achieved (6). Molecular analysis of the genome sequence indicates that Brazilian isolates of ToCV are closer to those described in Greece (7). Surveys made in Central Brazil, states of Goias and Distrito Federal revealed a frequent co-infection of ToCV and the begomovirus ToRSV in commercial tomato fields (8). ToCV was detected in tomato plants in the state of Pará (9).

Ref. (1) Barbosa, J.C. et al. Plant Dis.92, 1709. 2008; (2) Costa, H.S. et al. Trop.Plt.Pathol. 35(supl): S185, 2010; (3) Pavan, M.A. et al. Summa Phytopathol. 25: 36. 1999; (4) Barbosa, J.C. et al. Trop.Plant Pathol. 36: 256. 2011; (5) Nogueira, I. et al. Trop.Plant Pathol. 36 (Supl.) CDRom. 2011; (6) Freitas, D.M.S. et al. Summa Phytopathol. 37 (supl.) CD Rom. 2011; (7) Albuquerque L.C. et al. Trop.Plt.Pathol. 38(supl.):332. 2013; (8) Macedo, M.A. et al. Trop.Plt.Pathol. 39: 449. 2014; (9) Carvalho, T.P. et al. Trop.Plt.Pathol. 40 (supl): res.44-2. 2015.

Polerovirus

***Potato leafroll virus* (PLRV)**

Isolates of PLRV may cause distinct symptoms in tomato. **Lower leaf yellows**: chlorosis and leafroll symptoms in medial to lower leaves. This condition has been commonly seen in tomato grown in the state of São Paulo, being aphid-borne. Causal agent was identified as an isolate of PLRV by biological (1), serological (4) and molecular assays (5). The disease was officially reported in Distrito Federal (2) and in the state of Rio de Janeiro (3).

Ref.: (1) Costa, A.S. et al. Boletim do Campo 183: 8. 1964; (2) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 50. 1974; (3) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das culturas econômicas do Estado, Sec.Agric.Abast., RJ. 84p. 1978; (4) Souza Dias, J.A.C. & Costa, A.S. Summa Phytopathol. 20: 50. 1994; (5) Souza Dias, J.A.C. et al. Summa Phytopathol. 27: 104. 2001.

Yellow top: a condition also common in tomato fields, but in low incidence. Symptoms are represented by chlorosis on leaves of the top, followed by small size of leaflets and marginal chlorosis. Lower leaves have normal appearance. Affected plants have lower yields. Transmitted by the aphid *Myzus persicae* and grafting. It is caused by an isolate of PLRV and experimentally infected other solanaceous plants as *Datura stramonium, Physalis floridana*, pepper, tobacco and potato and was described in the states of São Paulo (1-3) and Rio de Janeiro (4). Serological relationship was demonstrated between the yellow top agent and PLRVC (5).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948; (2) Costa, A.S. O Biológico 15: 179. 1949; (3) Costa, A.S. & Carvalho, A.M.B. Arq.Inst. Biol. 28: 71. 1961; (4) Robbs, C.F. & Viegas, E.C. Guia de Controle às pragas e doenças das Cult.Econo. do Estado, Sec. Agric. Abast., RJ. 84p. 1978; (5) Souza Dias, J.A.C. et al. Summa Phytopathol. 20: 50. 1994.

Potyvirus

***Pepper yellow mosaic virus* (PepYMV)**

Yellow mosaic and leaf deformation in tomato plants were found to be caused by a potyvirus, identified as a new species by biological and molecular assays, and named PepYMV. It is reported in the states of São Paulo, Distrito Federal (1), and also in Espirito Santo, where it reached epidemical level in the "Zona Serrana" (2).

Ref: (1) Inoue-Nagata, A.K. et al. Virus Rev.& Res. 8: 186. 2003; (2) Maciel-Zambolin, E. et al. Fitopatol. Bras. 29: 325. 2004.

***Potato virus Y* (PVY)**

Wrinkled, small and thin leaflets, with thickened veins were observed in tomato plants grown in Piedade, SP. Causal agent was identified an isolate of PVY (1). A severe PVY isolate was described in several tomato growing areas in the state of São Paulo in the 1950's. Infected plants had smaller leaves and were stunted. Leaflets were arched downwards and necrotic streaks, parallel to veins in some medial leaves, and referred to as "risca" (streak). Mosaic may appear in youger leaves (2). Breeding program produced resistant tomato varieties (3).

Ref.: (1) Silberschmidt, K. Arq.Inst.Biol. 23: 125. 1956; (2) Costa, A.S. et al. Bragantia 19: 1111. 1960; (3) Nagai, H. & Costa, A.S. Bragantia 28: 219. 1969.

***Tobacco etch virus* (TEV)**

Mottling and wrinkling of leaves were observed in the state of São Paulo, and the symptoms attributed to infection by an isolate of TEV, based on biological and serological assays (1).

Ref.: (1) Pavan, M.A. & Kurozawa, C. Summa Phytopathol. 21: 49. 1995.

Alphanecrovirus

***Tobacco necrosis virus* (TNV)**

TNV was recovered from roots of tomato plants grown in greenhouse in the Instituto Agronomico, Campinas, SP (1).

Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Bragantia 19: XLCVII. 1960.

Tobamovirus

***Tobacco mosaic virus* (TMV)**

***Tomato mosaic virus* (ToMV)**

***Tomato mottle mosaic virus* (ToMMV)**

Conspicuous mosaic symptoms in tomato cultures is of common occurrence in tomato plantations at the end of developmental cycle. Infected plants become smaller with wrinkling on leaflets, with upward rolling. The condition has been demonstrated to be caused either by TMV or ToMV. Some isolates induce yellow mosaic. Original description was made in the state of São Paulo (1). Resitant varieties have been bred (2). Internal brown spot in fruits may occur (3). First infection of tomato by ToMV was reported in the state of Minas Gerais, and identification was based in biological and serological assays (4). This virus was also registered in the state of São Paulo (5). One way to distinguish TMV from ToMV is to inoculate *Nicotiana siylvestris* in which TMV becomes systemic, while ToMV only causes localized lesions (5). Inner brown spots in tomato fruits was reported in the state of Paraná (6). Tobamovirus in tomato was recorded in the state of Rio Grande do sul (7). Tomato plants resistant to TMV and ToMV were found showing mosaic and thin leaf symptoms in Uberlândia, MG. Transmission assays and RT-PCR confirmed that the causal virus was an isolate of ToMMV (8), whose genome was entirely sequenced (9).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948; (2) Nagai, H. & Costa, A.S. Rev.Oleric.5. 1965; (3) Costa, A.S. et al. Rev.Oleric. 11: 77. 1971; (4) Fernándes, J.J. et al. Fitopatol.bras. 8: 625. 1983; (5) Caner, J. et al. Fitopatol.bras. 15: 347. 1990; (6) Lima No., V.C. et al. Rev. Set.Cien.Agr.UFPr 9: 34. 1987; (7) Daniels, J. et al. Fitopatol.bras. 19: 296.1994; (8) Marubayashi, J.M. et al. Res. 191. 40º Cong.Paul. Fitopatol. 2017; (9) Nagai, A et al. Genome Announc. 6: e00427-18, 2018.

Tobravirus

***Pepper ringspot virus* (PepRSV)**

PepRSV was first recorded in tomato grown Itaquaquecetuba, SP, showing chlorotic, interveinal lines, and considered being soil borne via nematodes (1). The virus was also found in Distrito Federal, infecting tomato plants (2).

Ref.: (1) Silberschmidt, K. Phytopathol.Zeit. 46: 209. 1962; (2) Cupertino, F.P. et al. Fitopatol.bras. 16: 251. 1991.

Begomovirus

Recent works on begomoviruses, found in several plant species, particularly in tomato, are strongly biased toward molecular aspects, frequently overlook the pioneer researches, which started in the 1930's, by Silberschmidt's group in the Instituto Biológico, São Paulo, and Costa, in Instituto Agronomico, Campinas, SP. Indeed, first case of whitefly transmission was reported by Silberschmidt and co-workers, while the first begomovirus molecularly characterized, TGMV, was isolated by Costa, who also described BGMV, the most devastating begomovirus in Brazil. The recent introduction into Brazil, of more aggressive type, the biotype B of *Bemisia tabaci*, resulted in more frequent problems with begomoviruses, particularly in tomato. And the use of more sensitive molecular tools and involvement of more research groups in Brazil, dealing with begomoviruses resulted in the description of an ever increasing number of new species. Begomoviruses has a great variability resulting from mutation and pseudo-recombination, and it is not rare the finding of two or more distinct species in a single plant. Costa (1) had already noted that, what is now known as begomoviruses, had a high adaptability to new hosts, because of their high genetic variability, quickly evolving and new species are continuously replacing the old ones.

Ref.:(1) Costa, A.S. Fitopatologia 9: 47. 1974.

Begomovirus

Tomato viruses transmitted by the whitefly *Bemisia tabaci*

In the following lines, reports of begomoviruses anterior to their molecular characterization, are presented.

Infectious chlorosis of malvaceae complex (ICMC)

A diffuse chlorotic spots and interveinal chlorosis on leaves were noticed in an experimental tomato field of the Instituto Biológico, São Paulo, SP. Graft and whitefly transmission experiments resulted in the transmission of the causal agent to tomato, tobacco and *Sida rhombifolia*, suggesting that it would belong to the group of ICMC (1, 2).

Ref.: (1) Flores, E. et al. O Biológico 26: 65. 1960; (2) Costa, A.S. Fitopatologia (Lima) 9: 47. 1974.

"Encarquilhamento"

Wrinkling and curling of leaves, referred to as "encarquilhamento" by tomato growers, were commonly observed in tomato fields of the states of São Paulo, Minas Gerais and Paraná, sometimes inducing yield losses. The condition was found to be whitefly-transmitted.

"Engrujo"

"Engrujo" describes a syndrome characterized by intense wrinkling of leaves of affected tomato plants. It is whitefly-borne and occurred in industrial tomato fields in Pesqueira, PE (1).

***Euphorbia mosaic virus* (EuMV)**

Infection of tomato plants by EuMV is rare, and may result in vein mosaic. It was first described in the state of São Pauo (1). Might correspond to the virus presently identified in Brazil as *Euphorbia yellow mosaic virus.*

Yellow net

Leaves showing intense yellowing of veins, in a reticular fashion was noticed in the state of São Paulo. The causal agent was transmitted by the whitefly *B. tabaci*, and was not characterized (1).

Ref.: (1) Costa, A.S. Fitopatologia (Lima) 9: 47. 1974.

***Begomovirus* detected by molecular means**

The introduction and use of molecular tools in the studies with begomoviruses resulted in an explosion of new species in this genus. PCR techniques, using universal primers, permitted to "fish" without difficulty these viruses, and comparison of genome sequence quickly distinguished new species, according to ICTV criteria. More than 1,000 new species were listed, but a small increase in stringency of criteria do define species, resulted in significant reduction of new species. Unfortunately, the same willingness to describe molecularly these viruses was not followed to complete the biological characterization, and in many cases the basic Koch's postulate has not been completed. It is expected that further works will do so. As above mentioned begomoviruses are highly variable due to several factors (1-3) and such a situation make breeding programs in susceptible cultures, as most of cultivated solanacea and malvacea, extremely complex (4).

Ref.: (1) Andrade, E.C. et al. Virus Rev. & Res. 7: 155. 2002; (2) Virus Rev.& Res 9: 240. 2004; (3) Albuquerque, L.C. et al. Virus Rev.& Res. 9: 289. 2004.(4) Inoue-Nagata, A.K. et al. Pesq. Agropec. Bras. 41: 1329. 2006.

***Begomovirus* of tomato, ICTV recognized species** (in 2018)

Chino del tomate virus Amazonas

Tomato plants showing interveinal chlorosis and yellow tip were found in Silves, metropolitan Manaus, AM. Molecular studies indicated that the causal begomovirus is distinct from known species. Because the virus with most closer sequence was Chino del tomato virus Mexico, the name Chino del tomate virus Amazonas was proposed (1).

Ref.: (1) Fernandes-Acioli, N.A.N. et al. Trop.Plant Pathol. 36 (Supl.):CDRom. 2011.

***Okra mottle virus* (OkMoV)**

A unidentified isolate of OkMoV was found in the state of Tocantins (1).
Ref: (1) Lima No., A.F. et al. Trop.Plt.Pathol 34 (supl): 275. 2009.

***Sida micrantha mosaic virus* (SimMV)**

A begomovirus was recovered from tomato plants in Bicas, MG, causing chlorosis and foliar deformation It is mechanically transmissible to solanacea and amaranthacea hosts, and was demonstrated to have genome sequence close to SmMV (1). Similar case was registered in the state of Rio de Janeiro (2).
Ref.; (1) Calegario, R.F. et al. Fitopatol.bras. 29: S150. 2004; (2) Paula, M.B. et al. Fitopatol.bras. 32 (supl): 197. 2007.

***Sida mottle virus* (SiMoV)**

SiMoV was detected infecting tomato plants in the state of São Paulo (1).
Ref.: (1) Cotrim, M.A.A. et al. Summa Phytopathol 33:300. 2007.

***Sida yellow net virus* (SiYNV)**

Tomato plants with small chlorotic spots on leaves were collected in tomato fields from two municipalities of the state of Rio de Janeiro. Molecular tools detected a begomovirus, similar to SiYNV, previously described in the state of Minas Gerais, infecting *Sida micrantha* (1).
Ref.: (1) Acioli, N.A.N.E. et al. Trop.Plt.Pathol. 38 (supl) : 847. 2013.

***Tomato chlorotic mottle virus* (ToCMoV)**

Yellow mottling on tomato leaves were noticed in samples collected in Seabra, BA. Molecular assays revealed that it was a begomovirus distinct from previously described and named ToCMoV. It was transmitted by *B. tabaci* biotype B and by DNAs A+B (1). This virus was also detected in the state of São Paulo (2)
Ref.: (1) Ribeiro, S.G. et al. Fitopatol.bras. 27: S 211. 2002; (2) Paula, D.F. et al. Virus Rev. &Res 11(supl): 189. 2006;

***Tomato common mosaic virus* (ToCmMV)**

ToCmMV was isolated from tomato plants in Coimbra, MG (1) and was also detected in the state of Espirito Santo (2).
Ref. : (1) Castillo-Urquiza, G.P. et al. Arch.Virol. 153: 1985. 2008; (2) Barbosa, J.C. et al. Tropical Plant Pathology 41: 62. 2016.

***Tomato golden leaf distortion virus* (TGLDV)**

Tomato plants showing intense chlorosis, leaf deformation, mosaic and vein clearing on leaves was collected in Gurupi, TO. A begomovirus was found by molecular means, and its sequence showed that it was a new species named TGLDV. (1).
Ref.: (1) Fernandes-Acioli, N.A.N. et al. Trop.Plant Pathol. 36 (Supl.): CDRom. 2011.

***Tomato golden mosaic virus* (TGMV)**

This was the first begomovirus recognized in Brazil, being referred to as “chita” by Costa (1). It is of rare occurrence in the state of São Paulo. Its infection is characterized by an intense yellow/golden mosaic. It is mechanically transmissible (1-3). It was purified and the geminated shape of virions visualized (2).
Ref.: (1) Costa, A.S. Fitopatologia (Lima) 9: 47. 1974; (2) Matys, J.C. et al. Summa Phytopathol. 1: 267. 1975; (3) Costa, A.S. et al. Summa Phytopathol. 3: 194. 1977.

***Tomato golden vein virus* (ToGVV)**

During tomato virus survey in the states of Goias and Distrito Federal, a begomovirus was recovered, causing yellow vein symptoms. Molecular studies showed that it was a new begomovirus species and named ToGVV (1). It was later detected in the state of São Paulo (2).
Ref.: (1) Albuquerque, L.C. et al. Fitopatol.bras. 29: S218. 2004; (2) Paula, D.F. et al. Virus Rev. &Res 11 (supl): 189. 2006.

***Tomato interveinal chlorosis virus* (ToICV)**

Two begomovirus isolates were recovered from tomato plants in Juazeiro and Bezerros, PE. Their DNA-A were completely sequenced revealing that it represented a new species (1).
Ref.: (1) Albuquerque, LC et al. Arch.Virol. 157: 747. 2012.

***Tomato leaf distortion virus* (ToLDV)**

***Tomato mild mosaic virus* (ToMiMV)**

ToLDV and ToMiMV were found infecting tomato plants in Paty de Alferes, RJ (1)
Ref.: (1) Castillo-Urquiza, G.P. et al. Arch.Virol. 153: 1985. 2008.

***Tomato mottle leaf curl virus* (ToMoLCV)**

A begomovirus found in Novo Lino, AL, causing chlorosis and leaf deformation was identified as a new species, based on molecular techniques, and named ToMoLCV, but no biological assays were performed (1). A similar virus was detected in the state of São Paulo (2) and Paraíba (4). Complete sequence of its genome was obtained (3).
Ref.: (1) Assunção, I.P. et al. Summa Phytopathol. 30: 504. 2004. (2) Paula, D.F. et al. Virus Rev.&.Res. 11(supl): 189. 2006; (3) Albuquerque, LC et al. Arch.Virol. 157: 747. 2012; (4) Ferro, M.M.M. et al. Trop.Plt.Pathol. 42: 39. 2017.

***Tomato rugose mosaic virus* (ToRMV)**

A whitefly-borne begomovirus causing a rough mosaic in tomato was isolated in the state of Minas Gerais (1). Similar isolates were found in the state of São Paulo (2), Goiás (3) and Paraná (5). The isolate from Goiás was used to study virus-vector relationship (3). Additional molecular works confirmed that ToRMV is a new begomovirus species (4).
Ref.: (1) Fernandes, J.J., et al.. Fitopatol. Bras. 25: 440. 2000; (2) Colariccio, A. et al. Virus Rev.& Res. 8: 191. 2003; (3) Santos, C.D.G. et al. Fitopatol.bras. 28: 664. 2003. (4) Fernandes, J.J. et al. Plant Pathology 55: 513. 2006. (5) Boiteux, L.S. et al. Trop.Plt.Pathol 34.(supl): S266. 2009.

***Tomato severe rugose virus* (ToSRV)**

ToSRV is a begomovirus which causes wrinkling of tomato leaves, and was detected in the states of Minas Gerais, Goiás, Pernambuco (1), Santa Catarina (2), São Paulo (3), Paraná and Rio Grande do Sul (4). An isolate of ToSRV isolated in Piracicaba, SP had its genome analyzed, indicating an evolutionary relationship with ToRMV (5).
Ref: (1) Fernandes, N.A.N. Tese Dr. Univ.Brasília, 2010; (2) Lima,A.T.M. et al. Fitopatol.bras. 31(supl):S224. 2006. (3) Paula, D.F. et al. Virus Rev.&Res. 11(supl): 189. 2006. (4) Boiteux, LS et al. Trop.Plt.Pathol. 34.(supl): S266. 2009; (5) Barbosa, J.C. et al. J. Phytopathology 159: 644. 2011.

***Tomato yellow spot virus* (ToYSV)**

A begomovirus found infecting tomato in the states of Rio de Janeiro and Espirito Santo, causing yellow spots on leaves was considered a new species and name ToYSV. Molecular studies indicated that it originated as a recombination of a begomovirus from *Sida* and another unidentified (1). A similar virus was found in Argentina (2).
Ref: (1) Andrade, EC. et al. J.gen.Virol. 87:3687. 2006.(2) Lima No., A.F. et al. Trop.Plt.Pathol. 34 (supl): S275. 2009.

***Tomato yellow vein streak virus* (ToYVSV)**

Veinal yellow streaks in apical leaflets were observed in tomato plants growing in the region of Campinas, SP. Whitefly (*Bemisia tabaci*) transmission experiments reproduced the symptoms in assayed tomato plants (1). Molecular studies indicated that it represented a new begomovirus species and named ToYVSV (2, 3).
Ref.: (1) Souza Dias, J.A.C. et al. Summa Phytopathol. 22: 57. 1996; (2) Faria, J. et al. Plant Dis. 81: 423. 1997; (3) Ribeiro, S.G. et al. Plant Pathology 55:569. 2006.

***Begomovirus* found in tomato, still unclassified**

Tomato chlorotic leaf curl virus (ToCLCV)

A begomovirus, with divided genome, distinct from those previously described was found infecting tomato, causing a chlorotic leaf curling, in Altamira, PA (1).
Ref.: (1) Quadros, AFF et al. Res.29 Cong.Bras.Virol. 2018.

Tomato chlorotic vein virus (ToCVV)

ToCVV was found infecting tomato plants in Distrito Federal (1) and state of Ceará (2). No further information available.
Ref.: (1) Ribeiro, S.G. et al. Fitopatol.bras.19: 330. 1994; (2) Acioli,N.A.N.E. et al. Trop.Plt.Pathol. 38 (supl): 847-2. 2013.

Tomato crinkle virus (ToCrV)

Tomato crinkle yellow leaf virus (ToCYLV)

Tomato infectious yellows virus (ToIYV)

These viruses were quoted in (1), without additional information.
Ref.: (1) Fernandes, N.A.N. Tese Dr. Univ.Brasília. 2010.

Tomato leaf curl purple vein virus (ToLCPVV)

Upward curling of leaves and purple veins were observed in tomato plants, in a comercial field in the state of Piauí, during surveys made in 2014/2016. Molecular assays detected a monopartite begomovirus, distinct from previously described. Symptoms were reproduced in tomato infected experimentally by agroinfection (1).
Ref.: (1) Macedo, MA et al. Arch.Virol. 163: 737. 2018.

Tomato mild leaf curl virus (TMLCV)

This unassigned begomovirus was found infecting tomato plants in the state of Rio de Janeiro (1).
Ref. (1) Colariccio,A. et al. Fitopatol.bras. 32 (supl): S306. 2007.

Tomato mosaic Barbados

This begomovirus was found in tomato plants with mosaic symptoms and foliar deformation by PCR assays, in Medicilandia, PA (1).
Ref.: (1) Quadros, A.F.F. et al. 40º Cong.Paul.Fitopat. Res.40. 2017.

Tomato severe mosaic virus (TSMV)

This begomovirus, found infecting tomato in Bicas, MG, causes mosaic and severe yellowing. It is mechanically transmissible to *Nicotiana benthamiana* and *N. glutinosa*. No mention on its transmission by whitefly. Molecular studies indicated that this was a new begomovirus, and named TSMV (1). Its complete genome sequence was obtained (2).)
Ref.: (1) Calegario, R.F. et al. Virus Rev.& Res. 8: 193. 2003; (2) Hallwass, M. et al.Virus Rev& Res 11 (suppl): 189. 2006.

Tomato yellow mosaic virus (ToYMV)

Quoted in (1) without further information.
Ref.: (1) Albuquerque, L.C. et al. Virus Genes 40: 140. 2010.

Curtovirus

Brazilian tomato curly top virus (BrTCTV)

Curly top disease in tomato is common, but with low incidence, and is not considered economically important. It was first described in the state of São Paulo (1-5), but tomato curly top has been observed in most regions where tomato is cultivated. Two different types of curly top are described though on symptoms standpoint they are undistinguishable. One is transmitted by the hopper *Agallia albidula,* infecting experimentally several plant species. The other is transmitted by hoppers *Agalliana ensigera* and *A. sticticollis* with a more restricted host range. The causal virus has similarities with *Beet curly top* described in the EUA. *Acantospermum hispidum* is considered a reservoir for BrTCTV (6). The virus has yet to be molecularly characterized to confirm its identity and taxonomical position.
Ref.: (1) Costa, A.S. & Forster, R. J.Agron. 2: 295. 1939; (2) Sauer, H.F.G. O Biológico 12: 176. 1946; (3) Kramer, M. O Biológico 13: 44. 1947; (4) Bennett, C.W. & Costa, A.S. J.Agric.Res. 78: 675. 1940; (5) Costa, A.S. Phytopathology 42: 396. 1952; (6) Costa, A.S. III Semin.Bras.Herbicidas e Ervas Daninhas p.69. 1960.

***Solanum mammosum* L (Nipplefruit) Solanaceae**

Orthotospovirus

***Orthotospovirus* unidentified**

Nipplefruit is commonly used as rootstocks for tomato in the Amazon basin, to overcome soilborne fungal problems, and plants showing bronzing on leaves and concentric rings in fruits were observed in an experimental field of Embrapa Hortaliça, Brasília, DF. A yet to be identified Orthotospovirus was considered the causal agent (1).
Ref.: (1) Madeira, M.C.B. et al. Fitopatol.bras. 14: 163.1989.

Crinivirus

***Tomato chlorosis virus* (ToCV)**

ToCV was found by RT-PCR assay, infecting naturally plants of *S. mammosum* in Brasília, DF (1).
Ref.: (1) Boiteux, L.S. et al. Plant Dis. 102: 1673. 2018.

***Solanum melongena* L. (Eggplant) Solanaceae**

Orthotospovirus

***Groundnut ringspot virus* (GRSV)**

***Tomato chlorotic spot virus* (TCSV)**

***Tomato spotted wilt virus* (TSWV)**

Natural infection of eggplants by two distinct Orthotospoviruses (TSWV and GRSV) was reported in Brasília, DF resulting in leaf distortion and ringspots (1). TSWV was found infecting commercially grown eggplants in Sorocaba, SP (2). An isolate of TCSV was detected infecting eggplant in Limeira, SP (3).
Ref.: (1) Boiteux, L.S. et al. Capsicum and Eggplant Newsletter 12: 75. 1993; (2) Colariccio, A. et al. Fitopatol..Bras. 29: S148. 2004; (3) Gouvêa, M.M.et al. Trop.Plant Pathol. 39 (supl.): CD ROM. 2014.

Comovirus

***Andean potato mottle virus* (APMoV)**

Eggplants grown in the "Vale do Paraíba", state of SãoPaulo, exhibiting mosaic symptoms were found to be infected by a mechanically transmissible isometric virus. Infected cells shows cytopathic effect typical of comoviruses, and was tentatively identified as eggplant mosaic virus (1, 2). Following works identified the virus as a strain of APMoV (3, 4). It was also found infecting potato in the state of São Paulo (5).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Bragantia 27: 5. 1968; (2) Kitajima, E.W. & Costa, A.S. Phytopathol. Zeit. 79: 289. 1974; (3) de Ávila, A.C. et al. Plant Dis. Reptr. 68: 397. 1984; (4) Brioso, P.S.T. et al. Fitopatol.bras. 18: 526. 1993; (5) Souza Dias, J.A.C. et al. Fitopatol.bras. 19: 322. 1994.

Crinivirus

***Tomato chlorosis virus* (ToCV)**

Eggplants showing interveinal chlorosis was observed in commercial fields in Canguçu,RS, and Formosa, GO. Dot-blot and RT-PCR assays demonstrated that these plants were infected by ToCV, which was whitefly transmitted to susceptible tomato lines (1).
Ref.: (1) Fonseca, M.E.N. et al. Plant Dis. 100: 867. 2016.

Polerovirus

***Potato leafroll virus* (PLRV)**

An isolate of PLRV, which causes yellow top in tomato, was recovered from chlorotic eggplants in the state of São Paulo, suggesting that they may serve as source of inoculum for PLRV to tomato crops (1).
Ref.: (1) Costa, A.S. & Carvalho, A.M.B. Coopercotia fev.62,p.34. 1962.

Potyvirus

***Potato virus Y* (PVY)**

Mosaic bearing eggplants were found to be infected by PVY in Distrito Federal (1), in the state of Rio de Janeiro (2) and Inhumas, Go (4). Some resistant lines of the cv. 'Campinas' were obtained (3).
Ref.: (1) Cupertino, F.P. et al. Fitopatologia (Lima) 9: 39. 1974; (2) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (3) Brioso, P.S.T. et al. Fitopatol.bras. 12: 144. 1988; (4) Mesquita, L.C. et al. Fitopatol. bras. 15: 127. 1990.

Begomovirus

***Tomato mottle leaf curl virus* (ToMoLCV)**

***Tomato severe rugose virus* (ToSRV)**

Eggplants collected from commercial fields in Lins and Itapólis, SP, were found to be infected by ToSRV and ToMoLCV, which were

detected by PCR assays. ToSRV was successfully transmitted by whiteflies to some assay plants (1,2).
Ref.: (1) Gotardi, G.A. et al. Summa Phytopathol. 42 (supl.) res.119. 2016; (2) Moura, M.F. et al. J.Phytopathology 100: 599. 2018.

***Solanum nigrum* L. (European nightshade) Solanaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Natural infection of *S. nigrum* by CMV, resulting in conspicuous mosaic symptoms, was noticed in plants growing nearby pepper fields in the state of São Paulo. CMV was identified by biological, serological, molecular assays and electron microscopy (1).
Ref.: (1) Moraes, C.A.P. et al. Summa Phytopathol. 30: 127. 2004.
Polerovirus
***Potato leafroll virus* (PLRV)**
PLRV isolate causing yellow top on tomato was recovered from *S. nigrum* with chlorosis, in the state of São Paulo, and considered as part of the epidemiological cycle of this virus to other solanaceous crops (1).
Ref.: Costa, A.S. & Carvalho, A.M.B. Coopercotia fev.62,p.34.
Potyvirus
***Potato virus Y* (PVY)**
A case of natural infection of *S. nigrum* by PVY was reported in the state of Minas Gerais, without additional information (1).
Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

***Solanum palinacanthum* Dunal Solanaceae**
Potyvirus
***Potato virus Y* (PVY)**
S. palinacanthum with mosaic symptoms were found in several regions of the state of São Paulo. Laboratory analysis of collected samples revealed that these plants were infected by common and necrotic isolates of PVY (1).
Ref.: (1) Barradas, M.M. et al. Ciencia e Cultura 30 (supl.): 416. 1976.

***Solalnum paniculatum* L. Solanaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
Mosaic symptoms observed in *S. paniculatum* plants in the state of Pará was attributed do CMV infection (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 5: 407. 1980.
Polerovirus
***Potato leafroll virus* (PLRV)**
Potyvirus
***Potato virus Y* (PVY)**
Presence of PLRV and PVY, infecting *S. paniculatum* was reported in the state of Minas Gerais (1).
Ref.: (1) Oliveira, C.D. et al. Fitipatol.Bras. 21: 427. 1996.

**** Solanum scuticum* M. Nee (Jurubeba) Solanaceae**
Crinivirus
***Tomato chlorosis virus* (ToCV)**
S. scuticum plants were found naturally infected by ToCV in Brasília, DF. Identification was based on RT-PCR assays (1).
Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673. 2018.

***Solanum sessiliflorum* Dunal (= *Solanum topiro* Humb. & Bonpl.) Solanaceae**
Orthotospovirus
***Groundnut ringspot virus* (GRSV)**
***Tomato chlorotic spot virus* (TCSV)**
S. sessiliflorum plants showing mosaic symptoms were found in Campos, RJ. Biological, serological, morphological and molecular tests indicated that these plants were infected by an isolate of GRSV (1). A similar case in Angatuba, SP, was found also to be a case of infection by a Orthotospovirus, but the agent was identified as TCSV (2).
Ref.: (1) Boari, A.J. Virus Rev. & Res. 4: 154. 1999; (2) Colariccio, A. et al. Summa Phytopathol. 29: 348. 2003.
Crinivirus
***Tomato chlorosis virus* (ToCV)**
During a survey for spontaneous plants being infected by ToCV in Brasília, DF, by RT-PCR assays, *S. sessiflorum* plants were found as a natural host (1).
Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673.2018.

***Solanum sisymbriifolium* Lam.(Sticky nightshade) Solanaceae**
Comovirus
***Andean potato mottle virus* (APMoV)**
APMoV was identified by biological and serological tests infecting sticky nightshade plants in the state of São Paulo (1).
Ref.: (1) Souza Dias, J.A.C. et al. Fitopatol. Bras. 19: 322. 1994.

**** Solanum stramoniifolium Jacq.* Solanaceae**
Crinivirus
***Tomato chlorosis virus* (ToCV)**
S. stramoniifolium plants were found naturally infected by ToCSV. Identification was made by RT-PCR assays (1).
Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673.2018.

**** Solanum subinerme Jacq.* Solanaceae**
Crinivirus
***Tomato chlorosis virus* (ToCV)**
S. subinerme was another native plant found naturally infected by ToCV in Brasília, DF. Identification was made by RT-PCR assay (1).
Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673. 2018.

***Solanum tuberosum* L. (Potato) Solanaceae**
Orthotospovirus
***Tomato spotted wilt virus* (TSWV)**
Infection of potato by Orthotospovirus was originally reported in experimental plots in Instituto Agronomico, Campinas, SP, in 1936/1937. Characteristic symptoms were represented by small chlorotic spots or specks which evolved to necrotic rings causing leaflet death and fall, when they fused. Necrosis may appear in the main vein of the leaves, progressing downwards. Biological assays identified the causal agent as TSWV, the same virus inducing "vira cabeça" in tomato, and spread by thrips (1). TSWV was also reported infecting potato in the state of Rio Grande do Sul (2, 3).
Ref.: (1) Costa, A.S. & Kiehl, J. J.Agronomia (Piracicaba) 1: 193. 1938; (2) Siqueira, O. et al. Rev.Soc.Bras.Fitopat. 4: 92. 1971; (3) Siqueira, O. et al. Rev.Soc.Bras.Fitopat. 4: 92. 1971.
Comovirus
***Andean potato mottle virus* (APMoV)**
APMoV was found infecting potato and inducing mottling symptoms on leaves in the state of São Paulo, being of rare occurrence, without causing serious losses (1, 8). This virus was also found infecting cv. "Delta S" in Canoinhas, SC, being detected by serology. The isolate was considered essentially similar to that described infecting eggplant (3, 4). Experimentally APMoV was succesfully transmitted by the chrysomelid beetle *Diabrotica speciosa* (5). APMoV was the first virus to be entirely sequenced in Brazil (6), and served as basis of pionneer works with transgenic plant expressing viral genes (7).
Ref.: (1) Kitajima, E.W. & Costa, A.S. Bragantia 27: 5. 1968; (2) de Ávila, A.C. et al. Fitopatol.bras. 8: 624. 1983; (3) Plant Dis. Reptr. 68: 997. 1984; (4) Sá, C.M. et al. Fitopatol.bras. 3: 105. 1978; (5)

Costa, C.L. & de Avila, A.C. Fitopatol. bras. 9: 401. 1984; (6)Shindo, N. et al. Plant Mol.Biol.. 19: 505. 1992; (7)Vicente, A.C.P. et al. Res. XXI Reun. An. Soc.Bras.Bioq.Biol.Mol, p.113.1992; (8) Souza Dias, J.A.C. et al. Fitopatol.bras. 19: 322. 1994.

Nepovirus

Tobacco ringspot virus **(TRSV)**

TRSV was first detected in Brazil in imported cv. 'Anett' tubers in the state of São Paulo (1), and later in cv. 'Olimpia" grown in Canoinhas, SC (2).

Ref.: (1) Silberschmidt, K. O Biológico 31: 176. 1965; (2) Cupertino, F.P. & Costa, A.S. Bragantia 28: IX. 1969.

Potexvirus

Potato aucuba mosaic virus **(PAMV)**

PAMV causes a mosaic with bright chlorotic areas on leaves of infected plants. It was first recorded in the state of São Paulo, in some varieties imported from Europe. This virus is mechanically transmissible but has no known vector (1).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948.

Potato virus X **(PVX)**

First detection of PVX in Brazil was made in a seed potato field in S.João da Boa Vista, SP. Infection of potato plants by PVX usually is latent, but in some varieties it may cause severe necrosis and death. This virus is mechanically transmissible and has no vector (1, 2). PVX has been detected in potato fields wherever this tuber is grown, as in the states of Rio Grande do Sul (3), Minas Gerais (4, 5), Pernambuco (5). A study made in 2005/2006 has shown that PVX occurs in low frequency in seven surveyed Brazilian states (6).

Ref.: (1) Silberschmidt, K. et al. Rev.Agricultura (Piracicaba) 21: 23. 1941; (2) Silberschmidt, K. et al. Arq.Inst.Biol. 12: 27. 1941; (3) Siqueira, O. et al. Rev.Soc.Bras.Fitopat. 4: 92. 1971; (3) Figueira, A.R. et al. Fitopatol.bras. 10: 303. 1985; (5) Paz, C.D. et al. Fitopatol. bras. 17: 154. 1992. (6) Ávila, A.C. et al. Hort. Bras. 27: 490. 2009.

Carlavirus

Potato virus M **(PVM)**

An unidentified isolate of PVM was found infecting potato in the state of Rio Grande do Sul. Identification was based on transmission assays and electron mciroscopy (1).

Ref.: (1) Daniels, J. et al. Fitopatol.bras. 18: 287. 1993.

Potato virus S **(PVS)**

Infection of potato by PVS results in latent infection, but it may cause yield losses. In Brazil, its first detection was made by the use of indicator plants and serology in a large number of local or imported seed potatoes, in the state of São Paulo (1). In a comprehensive survey made in 2005/2006 about 6% of analyzed samples were found infected by PVS (5). PVS has been detected in the states of Rio Grande do Sul (2), Minas Gerais (3), Pernambuco (4), Bahia, Paraná and Santa Catarina (5).

Ref.: (1) Cupertino,F.P. et al. Bragantia 29: XVII. 1970; (2) Siqueira, O. et al. Rev.Soc.Bras.Fitopat. 4: 92. 1971; (3) Figueira, A.R. et al. Fitopatol.bras. 10: 303. 1985; (4) Paz, C.D. et al. Fitopatol. Bras. 17: 154. 1992. (5) de Ávila, A.C. et al. Hort. Bras. 27: 490. 2009.

Alfamovirus

Alfalfa mosaic virus **(AMV)**

AMV-infected potato was first reported in the state of São Paulo, in cv. 'Konsuragis'. Observed symptoms were cream yellow blotches of irregular shape on adult leaves. Presence of AMV in poatoes is rare (1). A similar case was registered in cv. 'Hydra', planted in Poços de Caldas, MG (2).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948; (2) Souza Dias, J.A.C. Summa Phytopathol. 8: 45. 1982.

Ilarvirus

Tobacco streak virus **(TSV)**

Natural infection of potato by TSV was registered in Bragança, SP and Andradas, MG, resulting in necrotic rings or vein necrosis on leaves and necrosis in the stem (1).

Ref.: Costa, A.S. et al. Bragantia 23: I. 1964; Boletim do Campo 190: 68. 1965.

Crinivirus

Tomato chlorosis virus **(ToCV)**

Presence of ToCV infecting potato was first observed in Cristalina, GO, detection being made by RT-PCR (1). Similar findings were made in Brasília, DF (2) and in the regions of "Triângulo Mineiro", state of Minas Gerais and in Southeast state of São Paulo (3).

Ref.: (1) Freitas, D.M.S. et al. Virus Rev.&Res. 16 (supl.) CDRom. 2011; (2) Lima, M.F. & Barriolli, C. Trop.Plt.Pathol.39: 208. 2013; (3) Souza Dias, J.A.C. et al. Summa Phytopathol. 39 (supl.): CDRom. 2013.

Polerovirus

Potato leafroll virus **(PLRV)**

PLRV is considered the most important virus for potato crops. Yield losses may be up to 50% and even 80% in highly susceptible varieties (12-14). Degenerescence of potato crops caused by PLRV was known in Brazil since the 1930's, as well as that transmission of the causal agent was made by aphids and tubers from infected plants. First official record of PLRV in potato was made by Bitancourt in 1934 (1). Infection by PLRV causes leaf rolling in the running year, and affected plants produce small tubers. This virus is phloem limited and not mechanically transmitted, and dissemination is made by several aphid species, in a persistent-ciculative manner. Control of the disease has been made by the use of virus-free seed potatoes, multiplied in suitable conditions and an efficient system of seed certification. Though a good deal of seed potatoes are imported, Brazil is producing its own seeds based on epidemiological information generated by Costa and co-workers (2-5). Serological works showed that *Beet western yellows virus* (BWYV) is not associated with potato leaf roll symptoms in Brazil (6). PLRV was found in potato fields of the state of Pernambuco (7). Surveys made in seven Brazilian states in 2005/2006 (8) in the Southern region of the state of Minas Gerais and Alto Parnaíba, in 2010 (9) revealed very low incidence (8) of PLRV, or even its absence (9).

Ref.: (1) Bitancourt, A.A. Arch.Inst.Biol. 5: 185. 1934; (2) Costa, A.S. & Krug, C.A. Bol. Tecn. IAC 514. 1937; (3) Costa,A.S. & Carvalho, A.M.B. Coopercotia fev.62. p.34.1962; (4) Cupertino, F.P. & Costa, A.S. Bragantia 29: 337. 1970; (5) Cupertino, F.P. Tese Dr., ESALQ;USP 59p. 1972; (6) Souza-Dias, J.A.C. et al. Summa Phytopathol. 20: 50. 1994; (7) Assis Fo., F.M. et al. Summa Phytopathol. 22: 57. 1996. (8) de Ávila, A.C. et al. Hort. Bras. 27: 490, 2009. (9) Lima, M.F. et al. ALAP/ENB. ABBA. CD-ROM. N.0119. 2012. (10) Câmara, F.L.A. et al. Fitopatol. bras. 11: 711. 1986. (11) Filgueira, F.A.R. & Câmara F.L.A. Hort.Bras. 4: 29., 1986. (12) Daniels, J. Summa Phytopathol.: 269. 1995. (13) Figueira, A.R. Summa Phytopathol. 268. 1995. (14) Souza-Dias, J.A.C. Summa Phytopathol. 21: 264. 1995.

Potyvirus

Potato virus A **(PVA)**

Mild mosaic and slight wrinkling of potato leaves were observed in the state of São Paulo. These symptoms may disappear in very warm periods. The causal agent was identified as an aphid-borne potyvirus, identified as PVA (1). Yield loss evaluation experiments have shown that with a 25% infection, losses may reach 37% (2).

Ref.: (1) Costa, A.S. Bol.Min.Agric. 82p. 1948; (2) Cupertino, F.P. et al. Bragantia 32: I. 1973.

Potato virus Y **(PVY)**

Incidence of PVY in Brazilian potato fields was first reported in a seed potato production field in S.João da Boa Vista, SP. The virus was found infecting var. 'Serrana Negra', introduced from Peru, and this

isolated caused severe necrosis in mechanically or aphid inoculated tobacco plants (1, 2, 5). When potato plants are co-infected by PVY and PVX, necrosis and death of lower leaves may occur, while leaves at the top show wrinkling and mosaic, and the condition is known as rough mosaic (3). Three strains of PVY are known to infect potatoes-PVYO, PVYN e PVYC; the last one is not registered in Brazil yet (15,16). PVY infection often results in yield losses, and it has been found in most of potato growing regions in Brazil as the state of Rio Grande do Sul (5), Minas Gerais (6), Pernambuco (7). The isolate NTN of PVY which causes necrotic rings on the surface of tubers was found in the state of São Paulo (8), as well as in other states [Minas Gerais, Paraná, Bahia, Goias (10), Santa Catarina (11)]. This isolate was recognized based on molecular tools (9). A leaf wrinkling in the cv.'Mona Lisa', in the state of São Paulo was attributed to an isolate of PVY^{N} (12). The presence of the necrotic subgroup PVY^{NTN} in most of potato producing areas in seven surveyed Brazilian states (Espirito Santo, Goiás, São Paulo, Minas Gerais, Bahia, Paraná, Santa Catarina) confirms how disseminated is this PVY strain in the country (13). Surveys made on potato viruses throughout Brazil in 2005/2006 (13) and 2010 (14) identified PVY as the main virus in potato culture, indicating that it is the main cause of the seed potato degenerescence (13). There is a report of transmission of PVY^{NTN} by the leafminer fly *Lyriomiza huidobrensis* in tomato (14).

Ref.: (1) Silberschmidt, K. et al. Rev.Agricultura (Piracicaba) 21: 23. 1941; (2) Nobrega, N.R. & Silberschmidt, K. Arq.Inst.Biol. 15: 307. 1944; (3) Costa, A.S. Bol.Min.Agric. 82p. 1948; (4) Silberschmidt et al. Amer.Potato J. 31: 213. 1954; (5) Siqueira, O. et al. Rev. Soc. Bras. Fitopat. 4: 92. 1971; (6) Figueira, A.R. et al. Fitopatol.bras. 10: 302. 1985; (7) Paz, C.D. et al. Fitopatol. bras. 17: 154. 1992; (8) Souza Dias, J.A.C. et al. Summa Phytopathol. 25: 36. 1999; (9) Sawazaki, H. et al. Fitopatol.bras. 28: S253. 2003; (10) Souza Dias, J.A.C. et al. Summa Phytopathol. 30: 99. 2004; (11) Souza Dias, JAC et al. Summa Phytopathol. 31(supl): S78. 2006; (12) Souza Dias, JAC et al. Summa Phytopathol. 32 (supl): S95. 2007; (13) de Ávila, A.C. et al. *Hort. Bras.* 27: 490. 2009; (14) Lima, M.F. et al. ALAP/ENB. ABBA. CD-ROM. N.0119. 2012; (15) Salazar, L.F., 1996. Peru: CIP. 214p; (16) Singh, R.P. et al. Arch. Virol. 153: 1. 2008; (14) Salas, F.J.S. et al. Trop.Plt.Pathol. 38 (supl.): 582-1. 2013.

Tobravirus

***Pepper ringspot virus* (PepRSV)**

Natural infection of potato by PepRSV was registered in Guará, SP. This virus induced yellow spots and lines forming concentric rings, sometimes followed by necrosis in adjoining tissues (1).

Ref.: (1) Souza Dias, J.A.C.et al. Summa Phytopathol. 5: 21. 1979.

***Tobacco rattle virus* (TRV)**

Potato tubers with rings on the surface and also in the pulp were found in Aguaí, SP. Initially it was considered a possible case of infection by *Potato moptop virus* (PMTV), but subsequent works indicated that the causal agent was TRV (1).

Ref.: (1) Souza Dias, J.A.C. et al. Summa Phytopathol. 29: 95. 2003.

Begomovirus

***Tomato severe rugose virus* (ToSRV)**

***Tomato yellow vein streak virus* (ToYVSV)**

First mention on the presence of begomovirus in potato fields was made in early 1980's in the state of Rio Grande do Sul. Infection by begomovirus resulted in leaf deformation and yellow mosaic without defined borders (1), and it was considered similar to the deforming mosaic reported in Argentina (2). Transmission by the whitefly *Bemisia tabaci* was demonstrated (3). Similar condition was observed in the state of São Paulo (4), where a high % of virus perpetuation through the tubers was observed, contrary to what was known for another begomovirus, AbMBV (5). The virus was partially purified and an antiserum suitable for immunodiagnosis, obtained (6). Potato plants experimentally infected by a begomovirus producing yellow streaks on leaves resulted in deforming mosaic symptoms (7). Molecular analysis of the begomovirus isolated in the State of Rio Grande do Sul revealed high homology with ToYVS (8, 9). This isolate was also isolated in Pouso Alegre, MG (10). Potato plants showing deforming mosaic symptoms were found to be infected by an isolate of ToRSV in the state of São Paulo (11, 12) and in Central Brazil (13). ToRSV has also high rate of transmission through the tubers of infected plants (14).

Ref.: (1) Daniels, J. & Castro, L.A. Fitopatol.bras. 9: 398. 1984; (2) Daniels, J. & Castro, L.A.S. Fitopatol.bras. 10: 306. 1985; (3) Daniels, J. et al. Res.Io Enc.Oleric.Cone Sul, Pelotas, p. 30. 1985; (4) Costa, A.S. et al. Summa Phytopathol. 14: 35. 1988; (5) Costa, A.S. & Vega, J. Fitopatol.bras. 13: 115. 1988; (6) Daniels, J. & Castro, L.A.S. Fitopatol. Bras. 17: 214. 1992; (7) Souza Dias, J.A.C. et al. Fitopatol.bras. 22: 17. 1996; (8) Ribeiro, S.G. et al. Fitopatol.bras. 25: 447. 2000; (9) Ribeiro, S.G. et al. Plant Pathology 55: 569. 2006; (10) Figueira, A.R. et al. Summa Phytopathol. 32 (supl.): S58. 2006; (11) Souza Dias, J.A.C. et al. Summa Phytopathol. 33(supl): S43. 2007; (12) Souza Dias, J.A.C. et al. *Plant Disease*, v.92, n.3, p.487, 2008; (13) Lima, M.F. et al. Virus Rev. & Res. 16 (sup.1): 225. 2011; (14) Lima, M.F. et al. Acta Hort. (ISHS) p.83, 2012.

Curtovirus

Brazilian tomato curly top virus (BrCTV)

Cases of potato tubers of cvs. 'Baronesa' and 'Sto. Amor' producing thinned buds, weak plants with short internodes, internerval chlorosis on leaves were observed in the state of Rio Grande do Sul. It is assumed that the causal agent is an isolate of BrCTV because of the symptoms shown by graft-inoculated tobacco and *Datura stramonium* (1).

Ref.: (1) Siqueira, O. Fitopatologia (Lima) 8: 19. 1973.

****Solanum variabile* Mart. Solanaceae**

Polerovirus

***Potato leafroll virus* (PLRV)**

Natural infection of *S. variable* growing nearby potato fields by PLRV was noticed in the state of São Paulo, indicating that this plant may serve as natural reservoir for this virus, which infects many cultivated plants, and is one of the most important pathogen for potato crop (1,2).

Ref.: (1) Souza Dias, J.A.C. et al. Fitopatol. Bras. 17: 156. 1992; (2) Souza Dias, J.A.C. & Costa, A.S. Res. VI Enc.Nac.Virol. 176.1992.

**** Solanum velleum* Roem & Schul. Solanaceae**

Crinivirus

***Tomato chlorosis virus* (ToCV)**

In Brasília, DF, *S. velleum* plants were found naturally infected by ToCV, as revealed by RT-PCR assays (1).

Ref.: (1) Boiteux, LS et al. Plant Dis. 102: 1673.. 2018.

****Solanum viarum* Dun. (Tropical soda apple) Solanaceae**

Polerovirus

***Potato leafroll virus* (PLRV)**

PLRV was reported infecting tropical soda apple plants in the state of Minas Gerais, without further information (1).

Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

Potyvirus

***Potato virus Y* (PVY)**

Isolates of PVY was naturally infecting *S. viarum* plants, causing mosaic symptoms, in the states of São Paulo (1, 2) and Minas Gerais (3).

Ref.: (1) Kudamatsu, M. & Alba, A.P.C. Summa Phytopathol. 5: 15. 1979; (2) Vicente, M. et al. Fitopatol.bras. 4: 73. 1979; (3) Oliveira,

C.D. et al. Fitipatol.bras. 21: 427. 1996.

***Solanum violifolium* Schott. (=*Lyciantes asarifolia* Kunth & Bouch.) Solanaceae**

This plant has been miswritten as *Solanum violaefolium*, being *violifolium* the correct form.

Dichorhavirus

***Dichorhavirus* unidentified**

Chlorotic spots on leaves of *S. violifolium,* associated with infestation by *Brevipalpus* mites, were observed in the garden of Instituto Agronômico, Campinas, SP. Mites (*Brevipalpus obovatus*) collected from symptomatic plants reproduced the chlorotic spots on healthy *S. violifolium.* Electron microscopy detected cytopathic effects typical of those caused by dichorhavirus (1).

Ref.: (1) Kitajima, E.W. et al. Fitopatol. bras. 29 (supl.): S65. 2004

Tymovirus

***Tomato blistering mosaic virus* (ToBMV)**

Conspicuous mosaic symptoms were observed on *S. violifolium* growing in the central park of Piracicaba, SP. The causal agent was easily transmitted to some assay plants; serology and electron microscopy pointed to an unidentified tymovirus as the causal agent, initially considered close the *Eggplant mosaic virus*- EMV, but possibly a new species (1-3). However, after complete sequencing of its genome, it was concluded that this *S. violifolium* tymovirus is an isolate of ToBMV (4).

Ref.: (1) Kitajima, E.W. et al. Fitopatol. Bras. 25: 441. 2000; (2) Pinto, Z.V. et al. Summa Phytopathol. 29: 79. 2003; (3) Raelo, F.A.C. et al. Summa Phytopathol 38 (supl.) CDRom 2012; (4) Blawid, R. et al. Virus Genes 52: 294. 2016.

Cilevirus

***Solanum violifolium* ringspot virus (SvRSV)**

Chlorotic spots and ringspots were observed on leaves of *S. violifolium* leaves in public parks and residential gardens in Piracicaba, SP, associated with infestation by the tenuipalpid mite *Brevipalpus obovatus.* Ultrastructural studies on leaf lesions revealed cytopathic effects typical of those caused by cytoplasmic type of *Brevipalpus*-transsmitted viruses (1). This virus, named SvRSV, was experimentally transmitted to a large number of experimental hosts by *B. obovatus* (2). Partial sequence of its genome was obtained after extraction of dsRNA, revealing to be distinct from that of *Citrus leprosis C virus* (3).

Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 26: 133. 2000; (2) Summa Phytopathol. 27: 105. 2001. (3) Ferreira, P.T.O. et al. Summa Phytopathol. 33:264. 2007.

Tobravirus

***Pepper ringspot virus* (PepRSV)**

A case of co-infection of SvRSV and PepRSV in *S. violifolium* in the garden of Clube de Campo, Piracicaba, SP, producing large chlorotic spots on leaves. PepRSV was identified based on biological, serological, morphological and molecular studies (1).

Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 28: 106. 2002.

***Sonchus asper* (L) Hill. (Prickly sowthistle) Asteraceae**

Potyvirus

***Lettuce mosaic virus* (LMV)**

Samples of prickly sowthistle exhibiting mosaic symptoms were collected in Guarulhos, SP. Infection by LMV was considered responsible for the symptoms based on biological, serological and morphological analysis (1).

Ref.: (1) Chaves, A.L.R. et al. Summa Phytopathol. 29: 61. 2003.

***Sonchus oleraceus* L. (Sowthistle) Asteraceae**

Varicosavirus

***Lettuce big vein virus* (LBVV)**

Sowthistle plants showing vein clearing and chlorotic spots on leaves were found in Guarulhos, SP. Further laboratory studies showed that these plants were co-infected by LBVV and *Lettuce mosaic virus* (LMV), but not by *Mirafiori lettuce virus* (MiLV), the other member of the lettuce big vein complex (1).

Ref.: (1) Chaves, A.L.R. et al. Fitopatol.bras. 29 (supl.): S138. 2004.

Potyvirus

***Lettuce mosaic virus* (LMV)**

In an experimental field for vegetable crops in São Paulo, SP, mosaic bearing sowthistle plants were found growing nearby. Biological morphological and serological assays demonstrated that these sowthistles were infected by an isolate of LMV (1).

Ref.: (1) Chaves, A.L.R. et al. Summa Phytopathol. 29: 61. 2003.

***Potato virus Y* (PVY)**

Natural infection of sowthistle by PVY, without reference to symptoms, was reported in the state of Minas Gerais (1).

Ref.: (1) Oliveira, C.D. et al. Fitipatol.Bras. 21: 427. 1996.

***Sorghum bicolor* L. (Sorghum) Poaceae**

Potyvirus

***Johnson grass mosaic virus* (JGMV)**

Maize plants collected in Felixlandia e Paracatú, MG, showing mosaic symptoms were found to be infected by an isolate of JGMV, according to RT-PCR assays (1).

Ref.: (1) Souza, I.R.P. et al. . International Journal of Current Research 9 : 63415, 2017

***Sugar cane mosaic virus* (SCMV)**

Mosaic and red stripes on leaves of sorghum were observed in the state of São Paulo. SCMV was identified as the causal agent, which was able to be transmitted by the aphid *Rhopalosiphum maidis* (Fitch.) (1).

Ref.: (1) Costa, A.S. et al. Fitopatologia (Lima) 8: 7. 1973.

***Spathiphyllum wallisii* Regel (Peace lily) Araceae**

Dichorhavirus

***Clerodendrum* chlorotic spot virus (ClCSV)**

Peace lily growing nearby glory bower (*Clerodendrum x speciosum*) infected by ClCSV, exhibited chlorotic spots on their leaves. Subsequent assays on collected samples demonstrated that these symptoms were due to a natural infection by ClCSV (1).

Ref. (1) Kitajima, E.W. et al. Scientia Agricola 67: 348. 2010.

***Coffee ringspot virus* (CoRSV)**

A case of natural infection of peace lily plant by CoRSV was observed in a residential garden in Araras, SP (1).

Ref.: (1) Novelli, V.M. et al. Trop Plt Pathol. 34 (supl.): S274. 2009.

Cilevirus

***Cilevirus* unidentified**

Ringspots were noticed on leaves of peace lily plants in a residential garden in Piracicaba, SP, associated with infection by *Brevipalpus* mites. Cytological studies showed cell alterations typical of those induced by cilevirus infection (1).

Ref.: (1) Kitajima, E.W. et al. Scientia Agricola 67: 348. 2010.

***Spinacia oleracea* L. (Spinach) Amaranthaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

A high incidence of severe wilting occurred in a commercial field of spinach was observed in 2015, at the Fazenda Monte Deste, Campinas, SP. Biological, serological, molecular and morphological studies indicated that the causal agent was an isolate of CMV (1).

Ref.: (1) Yuki, V.A. et al. Plant Dis. 101: 2157. 2017.

Potyvirus

***Turnip mosaic virus* (TuMV)**

A mosaic in spinach was registered in the state of Paraná and attributed to infection by TuMV (1).

Ref.: (1) Lima, M.L.R.Z.C. et al. Fitopatol.bras. 9: 403. 1984.

****Spylanthes oleracea* L. (Toothache plant) Asteraceae**

Orthotospovirus

***Tomato chlorotic spot virus* (TCSV)**

Ringspot on leaves were observed in commercial fields of toothache plant in Sta.Isabel, PA. Biological, morphological and molecular studies identified the causal agent as an isolate of TCSV (1).

Ref.: (1) Boari, A.J. et al. Trop.Plt.Pathol. 38 (supl): 466-2. 2013.

***Orthotospovirus* unidentified**

Unidentified Orthotospovirus was found infecting toothache plants in the state of São Paulo (1).

Ref.: (1) Nozaki, D.N. Fitopatol.bras. 31(supl):S170. 2006.

****Stizolobium aterrimum* Piper & TracyI (Black mucuna) Fabaceae**

Alfamovirus

***Alfalfa mosaic virus* (AMV)**

A yellow mosaic was found in high incidence (50%) of black mucuna plants in an experimental field of the Instituto Agronomico, Campinas, SP. Causal agent was identified as an isolate of AMV (1).

Ref.: (1) Costa, A.S. et al. Summa Phytopathol. 12: 30. 1986.

****Strelitzia reginae* Aiton (Crane flower) Strelitziaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

RT-PCR assays detected CMV in crane flower samples showing mottling and thickening of the leaf blade in Seropédica and Rio de Janeiro, RJ (1).

Ref.: (1) Almeida, C.M. & Brioso, P.S.T. Summa Phytopathol. 42 (supl) res.17. 2016.

****Stylosanthes guianensis* (Aubl.) Sw. (Brazilian stylo) Fabaceae**

Brambivirus putative

***Stylosanthes* mosaic associated virus 1 (StyMAV-1)**

***Stylosanthes* mosaic associated virus 2 (StyMAV-2)**

***Stylosanthes* mosaic associated virus 3 (StyMAV-3)**

A survey made in an experimental field of Brazilian stylo maintained by Embrapa Gado de Corte, Campo Grande, MS, plants were found with mosaic symptoms. Molecular analysis detected at least three possible new brambiviruses (StyMAV 1, 2 e 3) (1). StyMAV 1 e 2 was able to infect soybean experimentally. Complete genome sequences of StyMAV 1, 2 e 3 were obtained. It is suggested that StyMAV 1 and 2 would form a new genus "Stylomovirus", while StyMAV-3 would be a Rymovirus (2).

Ref.: (1) Souza, J.M. et al. Res. 28º CongBras.Virol. #401. 2017; (2) Res. 29 Cong.Bras.Virol. 2018.

Potyvirus

***Potyvirus* unidentified**

An unidentifed potyvirus was found associated with mosaic symptoms in Brazilian stylo, in the state of Mato Grosso do Sul (1).

Ref.: (1) Silva, M.S. et al. Fitopatol.bras. 31 (supl): S102. 2006.

****Stylosanthes scabra* Vogel (Shrubby stylo) Fabaceae**

Potyvirus

***Potyvirus* unidentified**

Plants of shrubby stylo with mosaic, small leaflets, short internod and stunting were found in an experimental field of Embrapa Gado de Corte, Campo Grande, MS. Preliminary studies by electron microscopy identified presence of a potyvirus in tissues from symptomatic leaves (1), which was confirmed by molecular assays (2). NGS revealed three species of potyviruses, still unidentified (3).

Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 22: 336. 1997; (2) Silva, K.N. et al. Virus Rev. & Res.20 (supl.): 211.2015; (3) Souza, J.M. et al. Virus Review & Res. 21: 132. 2016.

****Syngonium wendlandii* Schott. (Arrowhead vine) Araceae**

Potyvirus

***Dasheen mosaic virus* (DsMV)**

Mosaic and leaf deformation were noticed on arrowhead vine plants in Brasília, DF. Causal agent was identified as DsMV (1).

Ref.: (1) Rodrigues, M.G.R. et al. Fitopatol. bras 9: 291. 1984.

T

****Talinum patense* L. Portulacaceae**

Ilarvirus

***Tobacco streak virus* (TSV)**

Plants of *T. patense* showing stunting, leaf wrinkling, necrotic specks and rings on leaves were observed in Arapoti, PR, and attributed to natural infection by TSV (1).

Ref.: (1) Lima No., V.C. et al. Fitopatol.bras. 9: 637. 1984.

****Tapeinochilus ananassae* (Hassk.) K. Schum. (Pineapple-ginger) Costaceae**

Cytorhabdovirus

***Cytorhabdovirus* unidentified**

Plants of the ornamental pineapple-ginger showing chlorotic stripes and stunting were found in a commercial nursery near Recife, PE. Electron microscopy of leaf tissues demonstrated the presence of cytorhabdovirus, which is still unidentified. Graft and mechanical transmission assays were unsuccessful (1).

Ref.: (1) Coelho, R.S.B. et al. Fitopatol. bras. 27: S 201. 2002.

****Tetragonia expansa* Murray (New Zealand spinach) Aizoaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Ringspot symptoms were observed on leaves of New Zealand spinach in a green market of Piracicaba, SP. Further biological, serological, molecular assays and electron microscopy demonstrated that these symptoms were caused by an isolate of CMV subgroup A (1).

Ref.: (1) Kitajima, E.W. et al. Summa Phytopathol. 42: res.127. 2016.

****Thunbergia alata* Sims (Black-eyed Susan vine) Acanthaceae**

Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

A case of infection of *T. alata* by CABMV was observed in "Zona da Mata", state of Pernambuco (1).

Ref: (1) Nicolini, C. et al. Trop. Plt Pathol. 34 (supl): S271. 2009.

****Thunbergia erecta* (Benth.) T. Anderson (King's mantle) Acanthaceae**

Cilevirus

***Cilevirus* unidentified**

Ringspot symptoms were observed on leaves of king's mantle plants in the state of São Paulo, associated with *Bevipalpus* mites infestation. Electron microscopy detected unidentified cilevirus cytopathology (1).

Ref.: (1) Nogueira et al. Summa Phytopathol. 29: 278. 2003.

****Torenia* sp. (Blue wings) Scrophulariaceae**

Potexvirus

***Alternanthera mosaic virus* (AltMV)**

AltMV was detecting causing a latent infection in blue wings plants in São Paulo, SP (1).
Ref.: (1) Duarte, L.M.L. et al. Rev. Bras. Hortic. Ornam. 14: 59. 2008.
Tobamovirus
***Tobamovirus* unidentified**
Unidentified tobamovirus was detected in blue wings plants in São Paulo, SP (1).
Ref. (1) Alexandre, M.A.V. et al. Rev. Bras. Hortic.Ornam. 16: 95.2010.

***Tradescantia diuretica* (Mart.) Handlos (=*T. elongata* G. Meyer) Commelinaceae**
Cucumovirus
***Cucumber mosaic virus* (CMV)**
CMV infection was reported in *T. diuretica* in São Paulo, SP, resulting in symptoms of mosaic and chlorotic rings (1).
Ref.: (1) Duarte, L.M.L. Fitopatol. Bras. 19: 248. 1994.

***Trichosanthes cucumerina* L. (Snake gourd) Cucurbitaceae**
Potyvirus
***Zucchini yellow mosaic virus* (ZYMV)**
Mosaic and leaf deformation were observed in snake gourd plants in Piracicaba, SP, and the causal agent was identified as ZYMV (1).
Ref.: (1) Jadão, A.S. et al. Plant Dis. 94: 789. 2010.

***Trifolium* sp. (Clover) Fabaceae**
Potexvirus
***White clover mosaic virus* (WClMV)**
Trifolium sp. plants showing conspicuous mosaic symptoms were found in a pasture near Guarapuava, PR. Biological, serological assays and electron microscopy on collected samples detected an isolate of WClMV (1).
Ref.: Mulder, J.G. et al. Fitopatol.bras. 12: 263. 1987.
Alfamovirus
***Alfalfa mosaic virus* (AMV)**
AMV was found co-infecting WClMV in mosaic bearing *Trifolium* sp. plants found Guarapuava, PR. This virus was detected by transmission assays to test plants, immunotechniques and cytopathological observations (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 12: 284. 1987.

***Triticum aestivum* L. (Wheat) Poaceae**
Cytorhabdovirus
***Cytorhabdovirus* unidentified**
Electron microscopy made in leaf tissues of wheat plants with chlorotic spots found in the Embrapa Cerrados, Planaltina, DF, detected a case of infection by still unidentified cytorhabdovirus (1).
Ref.: (1) Kitajima, E.W. et al. Fitopatologia (Lima) 11: 16. 1976.
Tenuivirus, putative
Wheat white spike virus (WWSV)
Symptoms of white-yellow, large and empty spikes, accompanied by chlorotic streaks on leaves and tillering in wheat plants were first observed in the state of Rio Grande do Sul (1), and later in experimental fields of Embrapa Cerrado, Planaltina, DF (4). Precocious infection may lead to the death of plant (1). It is transmitted by the hopper *Sogatella kolophon* (3). Electron microscopy associated the disease with a threadlike particles, which form large whorled inclusions in the cytoplasm (2). The available evidences suggest a case of infection by a putative *Tenuivirus*, tentatively named WWSV.
Ref.: (1) Caetano, V.R. et al. Bragantia 29: XLI. 1970; (2) Kitajima, E.W. et al. Bragantia 30: 101. 1971; (3) Costa, A.S. et al. Fitopatologia (Lima) 8: 6. 1973; (4) Silva, A.R. et al. Fitopatol.bras. 4: 152. 1979.
Benyviridae
Wheat stripe mosaic virus (WhSMV)
Wheat plants of several varieties, showing symptoms similar to those caused by co-infection by SBWMV and WSSMV were found in Passo Fundo, RS. Molecular assays did not detect any of these viruses. When extracts were analyzed by NGS, a possible member of the family *Beniviridae* was detected, but possibly distinct from members of the genus *Benivirus*, considering the divergence in the genome sequence. This virus was associated with the presence of the plasmodiophorid *Polymyxa graminis* in the roots (1). It is likely that the virus previously identified, based on symptoms and morphology, as Soil-borne wheat mosaic virus (2,3), was indeed WhSMV.
Ref.: (1) Valente, JB et al. Plant Pathology 68: 588. 2019; (2) Caetano, V.R. et al. Indic.Pesq.XIII. IPEAS, DNPEA. Mimeog.12p. 1971; (3) Issa, E. 3ª.Reun.Na.Conj.Pesq.Trigo (mimeog.). 1971.
Bromovirus
***Brome mosaic virus* (BMV)**
BMV was first described occurring in experimental wheat fields of Embrapa Trigo. Passo Fundo, RS, in lines resistant to SBWMV, showing mild mosaic symptoms. Identification of this virus was based on biological assays [mechanical and beetle (*Diabrotica speciosa*) transmission], serology and electron microscopy (1).
Ref.: (1) Caetano, V.R. et al. Fitopatol.bras. 15: 363. 1990.
Luteovirus
***Barley yellows dwarf virus* PAV (BYDV)**
Yellowing, reduced tillering, stunting associated to low yields in wheat plantations were known in the state of Rio Grande do Sul since 1920's, with controversial etiology, including viral (1-3). Confirmation that the causal agent of such a condition was BYDV was only made in 1968 (4). In these works a more precise evaluation of losses was made, estimated in 20-30%. It was demonstrated that BYDV is transmitted by several aphid species, being *Acyrthosiphum dirhodum* the most important. This virus is not mechanically transmitted nor seed-borne, and has a wide host range among poaceae, infecting several other winter cereals. BYDV-resistant or tolerant wheat varieties are known (4, 5). It was found that BYDV-susceptible lines are less prone to be infected by rust fungi (6). BYDV was reported infecting wheat in the states of Paraná (7) and Mato Grosso do Sul (8). A review updating these data can be seen in (9).
Ref.: (1) Deslandes, J. Agros 2 (2): 88. 1949; (2) von Perceval, M. Bol. 76 Sec.Agric.RS.1939; (3) Dischinger, R. Supl.Rural Correio do Povo (17/6). 1966; (4) Caetano, V.R. Rev.Soc.Bras.Fitopatol. 2: 53. 1968; (5) Tese Doutorado, ESALQ/USP, 75p. 1972; (6) Caetano,V.R. et al. Rev.Soc.Bras.Fitopatol. 5: 156. 1972; (7) Caetano,V.R. & Golo, R.S. Fitopatol.Bras.5: 389.1980; (8) Paiva, F.A. & Goulart, A.P.C. Fitopatol. Bras. 17: 179. 1992; (9) Lau, D. et al. Rev. Plantio Direto (março/abril) 31: 2011.
Bymovirus
***Wheat spindle streak mosaic virus* (WSSMV)**
Symptoms of diffuse chlorotic bands and/or speckes were observed in wheat planted in several regions of the states of Rio Grande do Sul, Santa Catarina and Paraná. It was demonstrated that the disease was caused by WSSMV by DAS-ELISA (1). Brazilian isolates were close to that reported in Argentina, and was able to infect other cereals (2)
Ref.: (1) Schons, J. et al. Trop.Plt.Pathol. 36 (supl.): CDRom 2011; (2) Mar, T.B. et al. Int.J.Agron.2013:1. 2013.

***Triumfetta* sp. (Burbark) Malvaceae**
Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

Mosaic symptoms observed in *Triumfetta* sp. plants collected in São Paulo and São Vicente, SP and Brotas, BA, were attributed to infection by a member of ICMC (1).

Ref.: (1) Silberschmidt, K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

***Triumfetta semitriloba* Jacq. (Burbark) Malvaceae**

Begomovirus

***Triumfetta yellow mosaic virus* (TrYMV)**

Infection by a begomovirus was observed in burbark plants in the state of Pernambuco (1). This begomovirus was considered, by molecular tools, as a new species and tentatively named TrYMV (2).

Ref. (1) Assunção, L.P. et al. Planta Daninha 24: 239. 2006; (2) Nascimento, L.D. et al. Arch.Virol. 161: 1735. 2016.

***Tropaeolum majus* L. (Garden nasturtium) Tropaeolaceae**

Orthotospovirus

***Orthotospovirus* unidentified**

Infection of garden nasturtium plants by an unidentified Orthotospovirus was reported in São Paulo, SP (1).

Ref.: (1) Costa, A.S. & Forster, R. Bragantia 2: 83. 1942.

Potyvirus

***Turnip mosaic virus* (TuMV)**

A mosaic in *T. majus* was first reported in São Paulo, SP. Symptoms include vein clearing, vein banding, chlorotic spots and interveinal rings. It is mechanically transmissible to several assay plants, and was considered similar to a virus described in this ornamental in the USA (1.2). Potyvirus-like particles were found in some experimentally infected hosts (3). The disease was also found in the state of Paraná, being mechanically and aphid-transmitted. Electron microscopy detected potyvirus-like particles and cytopathology typical of potyviruses (4). An isolate found in Brasília, DF was characterized as TuMV based on biological and molecular assays (5). In São Paulo, SP, TuMV also was detected in mosaic bearing garden nasturtium by RT-PCR (6).

Ref.: (1) Silberschmidt, K. Phytopathology 43: 304. 1953; (2) Liu, S.C.Y & Silberschmidt, K. Phytopathology 51: 413. 1961; (3) Kudamatsu, M. et al. Summa Phytopathol. 4: 3. 1978; (4) Costa Lima No., V.C. & de Souza, V.B.V. Rev.Setor Cien.Agr. UFPr 3: 66. 1981; (5) Amaral, P.P.R. et al. Virus Rev. & Res. 6: 151. 2001; (6) Duarte, L.M.L. et al. J.Plant Pathol. 96: 609. 2014.

***Tulipa* sp. (Tulip) Liliaceae**

Potyvirus

***Potyvirus* unidentified**

A still unidentified potyvirus detected by electron microscopy in tulips sold commercially in São Paulo, SP, showing breaking in flowers (1).

(1) Rivas, E.B. et al. Arq. Inst. Biol. 76: 501. 2009.

U

***Unxia kubitzki* H. Robinson Asteraceae**

Cilevirus

***Solanum violifolium* ringspot virus (SvRSV)**

Natural infection of *U. kubitzki*, growing nearby SvRSV-infected *S. violifolium*, by *Brevipalpus* mite-transmitted SvRSV, resulting in chlorotic lesions on leaves, was reported in Piracicaba, SP (1).

Ref. (1) Kitajima, EW et al. Scientia Agricola 67: 348. 2010.

V

***Vanilla planifolia* Jack. ex-Andrews (Vanilla) Orquidaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Tip blight of vanilla plants caused by CMV infection was reported in the state of São Paulo. This virus was mechanically transmitted to vanilla, but not by aphids (1).

Ref.: (1) Costa, A.S. & Robbs, C.F. Rev.Soc.Bras.Fitopatol. 4: 36. 1971.

***Verbena* sp. (Verbena) Verbenaceae**

Tobamovirus

***Tobamovirus* unidentified**

Unidentified tobamovirus was found infecting verbena in São Paulo, SP (1).

Ref. (1) Alexandre, M.A.V. et al. Rev. Bras. Hortic.Ornam. 16: 95.. 2010.

***Vernonia polyantes* Less. Asteraceae**

Polerovirus

***Potato leafroll virus* (PLRV)**

Potyvirus

***Potato virus Y* (PVY)**

A report has been made of infection of *V. polyantes* by PLRV and PVY, without further details In the state of Minas Gerais (1).

Ref.: (1) Oliveira, C.D. et al. Fitopatol.bras. 21: 427. 1996.

***Vigna luteola* (Jacq.) Benth. (Hairy cowpea) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

Symptoms of bright yellow mosaic and leaf distortion was observed in *V. luteola*, in Praia Grande, SP, and the causal agent identified as an isolate of CPSMV (1).

Ref.: (1) Salas, F.J.S. et al. Res.VII Enc.Nac.Virol. 280. 1996.

Begomovirus

***Begomovirus* unidentified**

Hairy cowpea plants exhibiting golden mosaic symptoms were found in Peruíbe, SP. Preliminary studies showed that the disease is transmitted by the whitefly *Bemisia tabaci*, being however distinct from BGMV, and it still remains unidentified (1).

Ref.: (1) Barradas, M.M. & Chagas, C.M. Arq.Inst.Biol. 49: 85. 1982.

***Vigna mungo* (L.) Hepper (Mungo bean) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

CPSMV was found infecting *V. mungo* in Brasília, DF, causing mosaic symptoms (1).

Ref.: (1) Lin, M.T. et al. Plant Dis. 66: 67. 1982.

***Vigna radiata* (L) R. Wilcz. (Mung bean) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

Mung bean plants showing mosaic symptoms were found in Brasília, DF (1) and Itaguaí, RJ (2). The causal agent was a serotype I CPSMV.

Ref.: (1) Lin, M.T. et al. Plant Dis. 66: 67. 1982 ; (2) Brioso, P.S.T. et al. Fitopatol.bras. 19: 420. 1994.

Potyvirus

***Bean common mosaic virus* (BCMV)**

Mosaic and blistering on leaves of mung bean were observed in an experimental field of the Universidade Federal do Ceará, Fortaleza, CE, associated with infection by a potyvirus, which was identified as an isolate of BCMV, based on biological and serological assays (1).

Ref.: (1) Lima, J.A.A. et al. Fitopatol.bras. 10: 303. 1985.

***Vigna unguiculata* (L.) Walp. (Cowpea) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

CPSMV is an isometric virus, ca. 30 nm diam., of high concentration in the tissues, transmitted in the nature by chrysomelid beetles, and easily transmitted by mechanical means. It is endemic in most of the cowpea producing areas in Brazil, commonly inducing yield losses. It often causes a blistering mosaic on the leaves of infected cowpea plants. CPSMV was first registered in Brazil in the state of Rio Grande do Sul in 1947, but in samples collected in the Brazilian Northeast (1), and subsequently in several other regions of the states of São Paulo (2, 3), Distrito Federal, Ceará, Amazonas, Pernambuco, Piauí, Rio Grande do Norte ,Paraíba and Pará (5-7, 10, 16, 17, 18, 19, 20). Yield losses have been evaluated, which in many cases are considerable (9). Initially considered as an isolate of another comovirus, *Cowpea mosaic virus* (CPMV), but it is now considered as being distinct species (8). CPSMV was purified and specific antiserum, produced (4). At least four serotypes of CPSMV have been identified in Brazil (11, 12). *Cerotoma arcuata* (Oliv.) (13) and *Diabrotica speciosa* were identified as transmitting CPSMV (14). Screening for varietal resistance found that there are some highly resistant and even immune varieties, as 'Macaibo' and 'FP 7733-2'(15).

Ref.: (1) Oliveira, M.A.Bol.Tecn.Inst.Agron.Sul (Pelotas) No.1. 1947; (2) Caner, J. et al. O Biológico 35: 13. 1969; (3) Costa, A.S. et al. Rev.Soc.Bras.Fitopatol. 3: 56. 1969; (4) Oliveira, A.R. et al. Rev.Soc. Bras.Fitopatol. 3: 26. 1969; (5) Cupertino, F.P. et al. Fitopatologia (Lima) 9:51. 1974; (6) Lima, J.A.A. & Nelson, M.R. Plant Dis. Reptr.61: 964. 1977; (7) Kitajima, E.W. et al. Acta Amazonica 9: 633. 1979; (8) Pio Ribeiro, G. & Paguio, O. Fitopatol.bras. 5: 375. 1980; (9) Gonçalves, M.F.B. & Lima, J.A.A. Fitopatol. Bras. 7: 547. 1982; (10) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (11) Lin, M.T. et al. Phytopathology 71: 435. 1981; (12) 74: 581. 1984; (13) Costa, C.L. et. al. Fitopatol. Bras. 3: 81. 1978; (14) Fitopatol.bras. 6: 523. 1981; (15) Rios, G.P. & das Neves, B.P. Fitopatol.bras. 7: 175. 1982; (16) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (17) Bertacini, P.V.et al. Fitopatol.bras. 19: 271. 1994; (18) Silva, S.P. et al. Fitopatol. bras. 26: 520. 2001;(19) Cezar, M.A. et al. Summa Phytopathol 36(supl)#097.CDRom.2010; (20) Rodrigues, E.C.S. et al. Trop.Plt. Pathol. 40 (supl.): CD Rom Res. 254.1. 2015.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

CMV has been found in cowpea alone, or co-infecting other viruses, in Brazil (5, 6). It causes mosaic symptoms, but distinct from those induced by CPSMV, and aphid transmission was demonstrated (1). CMV was detected in seeds of infected plants (1). This virus has been detected in the states of Goiás (1), Pernambuco (5), Ceará (4), Pirauí (3) and Pará (4).

Ref.: (1) Lin, M.T. et al. Fitopatol.Bras.5: 419. 1980; (2) 6: 193. 1981; (3) Res. 1ª Reun.Nac. Pesq. Caupi, p.101. 1982; (4) Silveira, L.F.S. & Lima, J.A.A. Fitopatol. Bras.11. 369. 1986; (5) Assis Fo., F.M. & Paz, C.D. Fitopatol.bras. 18: 287. 1993; (6) Paz, C.D. Et al. Fitopatol. bras. 20: 325. 1995; (7) Rodrigues, E.C.S. et al. Trop. Plant Pathol. 40 (supl.): CD Rom Res. 254.1. 2015.

Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

CABMV produces a mosaic pattern distinct from that caused by CPSMV. It is also quite frequent in cowpea fields in Brazilian territory, especially Northeast. First record of CABMV was made in the state of Pernambuco (1). It is likely that some other potyviruses reported on cowpea as green vein banding, rugose mosaic and severe mottling in samples collected in the Northeaster Brazil were isolates of CABMV 2-8, 11). Some isolates of potyviruses found in cowpea were also referred to as *Blackeye cowpea mosaic potyvirus* (BCPMV) (2-8), which is now considered as an isolate of CABMV based on molecular criteria. There are reports of the presence of CABMV in cowpea seeds (9). CABMV was reported in the state of Rio de Janeiro (10), Paraíba (13) and Pará (14). Potyvirus infecting cowpea has been reported in RJ (10). Varietal resistance for CABMV was reported in works conducted at Embrapa Meio Norte, in the state of Piauí (12).

Ref.: (1) Paguio, O. Fitopatol.bras. 3: 125. 1978; (2) Lin, M.T. et al. Fitopatol.bras. 4: 120. 1979; (3) Lima, J.A.A. & Lima, M.G. Fitopatol. bras. 5: 415. 1980; (4) Lin, M.T. et al. Fitopatol.bras. 5: 419. 1980; (5) Santos, A.A. et al. Fitopatol.bras. 5: 457. 1980; (6) Lima, J.A.A. et al. Fitopatol.bras. 6: 205. 1981; (7) Lin,M.T. et al. Fitopatol.bras. 6: 73. 1981; (8) 6: 193. 1981; (9) Silveira, L.F.S. & Lima, J.A.A. Fitopatol.bras. 11: 369. 1986; (10) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (11) Santos, A.A. et al. Fitopatol.bras. 9: 567. 1984; (12) Nogueira, M.S.R. et al. Summa Phytopathol. 32(supl):S 50. 2006.13) Cezar, M.A. et al. Summa Phytopathol 36 (supl.): #097.CDRom.2010; (14) Rodrigues, E.C.S. et al. Trop. Plt.Pathol. 40 (supl.): CD Rom Res. 254.1. 2015.

Begomovirus

***Cowpea golden mosaic virus* (CPGMV)**

This begomovirus was first found nearby São Luis, MA, being transmitted by the whitefly *Bemisia tabaci*, and is commonly present in cowpea field in the Brazilian Northeast. (1,3). CPGMV- resistant genotypes have been identified (4). It seems to be close to a virus causing golden mosaic in *Macroptilium lathyroides* in CE (5,6). CPGMV was detected in the state of Paraíba (7).

Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 7: 537. 1982; (2) Santos, A.A. & Freire Fo., F.A. Fitopatol.bras. 9: 406; (3) 407. 1984; (4) 11: 288. 1986; (5) Lima, J.A.A. et al. Virus Rev.& Res. 3 (supl.1): 143. 1998; (6) Fitopatol.Bras.23: 319. 1998.(7) Freitas, A.S. et al. Trop.Plt. Pathol. 35 (supl.): S214. 2010.

***Vigna unguiculata* (L.) Walp. Subsp. *sesquipedalis* (L.) Verdc. (Yardlong bean, Asparagus bean) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

Blistering mosaic as that seen in cowpea, is quite common in yardlong bean cultivated in Brazil. First report of CPSMV infection in this plant, has been made in Brasília, DF (1).

Ref.: (1) Lin, M.T. & Anjos, J.R.N. Plant Dis. 66: 67. 1982.

Potyvirus

***Cowpea aphid-borne mosaic virus* (CABMV)**

Vein banding mosaic in yardlong bean was observed in the state of Pará. It was associated with a potyvirus, tentatively identified as CABMV (1). Recent redetection of this virus in Embrapa Amazonia Oriental, confirmed its identity as CABMV (2).

Ref.: (1) Kitajima, E.W. et al. Fitopatol.bras. 5: 407. 1980; (2) Rodrigues, E.C.S. et al. Trop.Plt.Pathol. 39 (supl.): CD Rom. 2014.

***Vigna vexillata* (L) A. Rich. (Wild cowpea) Fabaceae**

Comovirus

***Cowpea severe mosaic virus* (CPSMV)**

Natural infection of wild cowpea by CPSMV was reported in the state of Pernambuco, based on biological and serological assays (1).

Ref.: (1) Gueiros Jr., F. et al. Res.III Cong.Inic.Cient.UFRPe p.55. 1993.

***Viola odorata* L. (Violet) Violaceae**

Potyvirus

***Potato virus Y* (PVY)**

An isolate of PVY was found naturally infecting ornamental violet in the state of São Paulo (1).

Ref.: (1) Colariccio, A. et al. Summa Phytopathol. 34 (supl): S47.

2008.

***Vitis vinifera* L., *Vitis labrusca* L., *Vitis* spp. (Grapevine) Vitaceae**

Nepovirus

***Grapevine fanleaf virus* (GFLV)**

Grapevine rootstoch 106-8 ("Traviú") presented symptoms of mosaic, irregular and sparse chlorotic spots, chlorotic bands in zig-zag, and occasionally smaller and deformed leaves. Such condition was first noticed in the state of São Paulo, being graft transmitted (1). The disease, also known as "fanleaf" is caused by GFLV, a *Xiphinema* nematode-borne, nepovirus. The virus was seen by electron microscopy (3). In the state of Rio Grande do Sul, some morphological changes in stems, as short internodes, double knots, flattening and bud proliferation were observed in cvs. 'Pirovano 54" and "Pirovano 149", and considered to be caused by the fanleaf, or "Court Noué" agent (4). Kuniyuki et al. (5) demonstrated the identity of "Mosaico do Traviú" and fanleaf. Another isolate of GFLV is considered responsible for a symptom variation known as grapevine yellow vein mosaic, characterized by intense yellow spots mainly on primary veins. It was observed initially in the cv. 'Niagara rosada' in Jundiaí, Louveira and Valinhos, SP, and in the cv. 'Pirovano' in São Roque, SP (7). This GFLV isolate is mechanically transmissible to some assay plants (2, 7). Some isolates were characterized serological and molecularly (6, 9). GFLV was also detected in Zona da Mata, MG and in the São Francisco Valley, PE (9).

Ref.: (1) Kuniyuki, H. Rev.Soc.Bras.Fitopatol. 5: 123. 1972; (2) Kuniyuki, H. Rev.Soc.Bras.Fitopatol. 5: 121. 1972; (3) Vega, J. & Kuniyuki, H. Summa Phytopathol. 4: 15. 1978; (4) Kuhn, G.B. & Siqueira, O. Fitopatologia (Lima) 9: 56. 1974; (5) Kuniyuki, H. et al. Fitopatol.bras. 19: 224.1994; (6) Fajardo et al. Fitopatol.bras 25: 505. 2000; (7) Fajardo, T.V.M. et al. In Fajardo, T.V.M. ed. Uva para processamento-Fitossanidade. Embrapa Inf. Tecnol. p.45. 2003; (8) Radaelli, P. et al. Trop. Plant Path. 34: 297. 2009; (9) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015.

Foveavirus

***Grapevine rupestris stem pitting-associated virus* (GRSPaV)**

Grapevines infected by GRSPaV has reduced growth, weaker stems, younger leaves with reddening or yellowing, thick bark (the reason of the popular name for the disease in Brazil- "cascudo"). In advanced stages, stem pitting may occur. Thes symptoms are similar to those referred as "legno riccio" and "rugose wood". It was first recorded in the states of São Paulo in cvs. as 'Itália' and 'Rupestris du Lot' (1), and also in rootstock varieties, with less intense symptoms, as 'Golia' and 'Kober 5BB' (3). Similar condition are registered in the states of Paraná (2) and Rio Grande do Sul (4). The virus can be detected by graft assay on 'Rupestris du Lot' (3). An isolate, severe in 'Kober 5BB', but very mild in 'Rupestris du Lot' was found in the state of São Paulo (5). The causal agent of these diseases were attributed to GRSPaV, and confirmation was made by molecular methods (6-9). The virus was detected in the states of Pernambuco, Paraíba, and Bahia (10) in the Zona da Mata, MG and São Francisco Valley, PE (11) and Mato Grosso do Sul (12).

Ref.: (1) Kuniyuki, H. Rev.Soc.Bras.Fitopatol. 5:137. 1972; (2) Kuniyuki, H. Fitopatol.bras. 6: 300. 1981; (3) Kuniyuki, H. & Muller, G. Summa Phytopath. 13: 26. 1987; (4) Kuhn, G.B. Fitopatol. Bras. 17: 194. 1992; (5) Kuniyuki, H. & Costa, A.S. Summa Phytopathol. 18: 13. 1992; (6) Espinha, L.M. et al. Fitopatol.bras. 26 (supl.): 533. 2001; (7) Espinha, L.M. et al. Fitopatol. bras. 28: 206. 2003; (8) Fajardo, T.V.M. et al. Fitopatol. bras. 29: 209. 2004; (9) Radaelli, P. et al. Trop. Plant Pathol. 34: 297. 2009; (10) Catarino,A.D.M. et al. Trop. Plt.Pathol. 38 (supl): CDRom 371-1.2013; (11) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015; (12) Stangarlin, O.S. et al. Summa Phytopathol. 42 (supl): res.06. 2016.

Trichovirus

***Grapevine Pinot gris virus* (GPGV)**

GPGV was found during a survey made in the grapevine germplasm collection of Embrapa Uva e Vinho, Bento Gonçalves, RS By RT-PCR indexing. About 20% of the tested samples were infected (1).

Ref.: (1) Fajardo, TVM et al. Australasian Plt.Dis.Notes 12: 45. 2017.

Vitivirus

***Grapevine virus A* (GVA)**

Stem pitting of cv. 'Kober' is part of a complex of at least four viruses causing alterations in the grapevine wood. Causal agent is identified as GVA, an elongated and ssRNA virus, naturally spread by mealybugs. It is mechanically transmitted, with difficulty, to some assay plants. In Brazil, GVA was detected in grapevines grown in the states of Rio Grande do Sul, São Paulo and Pernambuco. Stem pitting caused by GVA characterizes by grooving in the wood, below the bark of susceptible varieties as 'Kober 5BB', used as indicator plant. Infection by GVA may cause vigor reduction, delay in budding, and in susceptible combinations, decline and yield losses and early death (1-5), GVA was detected in PE and PB (6) and also found in the Zona da Mata, MG and São Francisco Valle, PE (7).

Ref.**:** (1) Kuhn, G.B. et al. Fitopatol.bras. 25(supl.): 442. 2000; (2) Kuniyuki, H. et al. Summa Phytopathol. 27: 116-117. 2001; (3) Fajardo, T.V.M. et al. Fitopatol.bras. 28: 521-527. 2003; (4) Kuniyuki, H. et al. Fitopatol.bras. 28:323. 2003; (5) Moreira, A.E. et al. Fitopatol. bras. 29: 205. 2004; (6) Catarino,A.D.M. et al. Trop.Plt.Pathol. 38 (supl) CDRom 371-1.2013; (7) Catarino, A.D.M. et al. Ciência Rural 45: 379. 2015.

***Grapevine virus B* (GVB)**

GVB was found in grapevine cultivars 'Niagara Branca' and 'Niagara Rosada' in the state of São Paulo (2), in cv. 'Isabel' in the state of Rio Grande do Sul (3,7) and Santa Catarina (4). In infected plants there is a delay in the spring budding and a lesser vegetative development; during flowering, symptoms as mild interveinal chlorosis, swelling in the internodes of the stem of the year with longitudinal fissures, and presence of corticous tissues become evident (1). This condition is also known as "corky bark". Diagnosis is based on the detection of GVB grafting on the indicator 'LN33', which when infected, presents symptoms of severe fissures in the stem bark (5). There are GVB isolates which do not cause symptoms in American grapevines (6, 11). GVB was identified by the morphology of its virion (elongated, ca. 800 nm long), size of capsidal protein (23 kDa) and indexation (9, 10, 12, 14). It was found in "submédio São Francisco" and "Zona da Mata", state of Pernambuco (8, 15), Mato Grosso do Sul (16). In the state of São Paulo, transmission of GVB by the mealybug *Pseudococcus longispinus* was achieved (13).

Ref.: (1) Kuniyuki, H. Fitopatologia (Lima) 8: 10. 1973; (2) Kuniyuki, H. Fitopatol.bras. 6: 153. 1975; (3) Kuhn, G.B. Fitopatol.bras. 6: 536.1981 (4) Kuniyuki, H. Fitopatol.bras. 6: 300. 1981; (5) Kuniyuki, H. & Costa, A.S. Fitopatol.bras. 7: 71. 1982; (6) Kuniyuki, H. & Costa, A.S. Summa Phytopathol.17: 38.1991; (7) Kuhn, G.B. Fitopatol.bras. 17: 399. 1992; (8) Kuhn, G.B. et al. Fitopatol.bras. 25: 442. 2000; (9) Kuniyuki, H. et al. Fitopatol.bras. 25: 443. 2000; (10) Nickel, O. et al. Fitopatol. bras. 27: 279. 2002; (11) Moreira, A.E. Fitopatol. bras. 29: 75. 2004; (12) Moreira, A.E. et al. Fitopatol. bras. 30:538. 2005; (13) Kuniyuki, H. et al. Summa Phytopathol. 32:151. 2006; (14) Radaelli, P. et al. Pesq. Agropec. Bras. 43: 1405. 2008; (15) Pio Ribeiro, G. et al. Trop Plt Pathol. 34(supl.): S276. 2009; (14) Catarino,A.D.M. et al. Trop.Plt.Pathol. 38 (supl.): CDRom 371-1.2013; (15) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015; (16) Stangarlin, O.S. et al. Summa Phytopathol. 42 (supl.): res.06. 2016.

***Grapevine virus D* (GVD)**

The "rugose wood complex" affects grapevine's wood resulting in swelling, stem pitting below the bark. Most of the rootstock

combination express symptoms when affected, and the disease is of economic concern in the whole world. Viruses associated to this coplex are GVA, GVB and GRSPA. Another member of the complex is GVD, detected in symptomatic grapevines, may cause reduction of growth in some rootstock varieties, being the less studied so far. Two isolates of GVD were detected and molecularly characterized in the state of Rio Grande do Sul (1, 2).

Ref.: (1) Dubiela, C.R. et al. *In* Girardi, C.L. et al. eds. Resumos, 9º Encontro de IC e 5° Encontro de Pós-Grad. Embrapa Uva e Vinho, Bento Gonçalves. p. 26, 2011; (2) Fajardo, T.V.M. Ciência Rural 42: 2127. 2012.

Maculavirus

***Grapevine fleck virus* (GFkV)**

GFkV causes latent infection in commercial varieties, but induces translucent spots in the veins (vein mosaic) in the indicator 'Rupestris du Lot'. It was found in Brazilian grapevines (1,2,7,8). In the state of São Paulo GFkV is present in most of the main cultivated varieties, and incidence may reach 100% (3). It has been reported to be present in grapevines cultivated in the states of Goias, Minas Gerais, Paraná and Santa Catarina (4), Rio Grande Sul (6), "submédio São Francisco" (9), Paraíba and Bahia (13), "Zona da Mata" and São Francisco valley, Minas Gerais (14), Mato Grosso do Sul (15). GFkV identity was confirmed by serological (10) and molecular (11, 12) techniques . It was detected in cvs. 'Kyoho' and 'Olimpina', imported from Japan (5).

Ref.: (1) Kuniyuki, H. Rev.Soc.Bras.Fitopatol. 5: 189. 1972; (2) Kuniyuki, H. Fitopatologia (Lima) 11: 17. 1976; (3) Kuniyuki, H. & Costa, A. S. Summa Phytopathol. 5: 24. 1979; (4) Kuniyuki, H. Fitopatol.bras. 6: 300. 1981; (5) Kuniyuki, H. & Suzukawa, Y. Fitopatol.bras. 6: 533. 1981; (6) Kuhn, G.B. Fitopatol.bras. 17: 435. 1992; (7) Kuniyuki, H. & Costa, A.S. Summa Phytopathol. 20:152. 1994; (8) Kuniyuki, H. et al. Fitopatol. bras. 20:618. 1995; (9) Kuhn, G.B. et al. Fitopatol.bras. 25: 442. 2000; (10) Kuniyuki, H. et al. Fitopatol.bras. 27: 635. 2002; (11) Fajardo, T.V.M. et al. Fitopatol. Bras. 29: 460. 2004; (12) Fajardo, T.V.M. et al. Ciência Rural 42: 2127. 2012; (13) Catarino,A.D.M. et al. Trop.Plt.Pathol. 38 (supl) CDRom 371-1.2013; (14) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015; (15) Stangarlin, O.S. et al. Summa Phytopathol. 42 (supl.): res.06. 2016.

Marafivirus, unclassified

Grapevine rupestris vein feathering virus (GRVFV)

GRVFV was detected and identified by RT-qPCR in 8% of the collected samples from the state of Pernambuco (1). This virus is also present in the states of Bahia and Paraíba (2), and in the "Zona da Mata" and São Francisco valley in the state of Minas Gerais (3).

Ref.: (1) Catarino, A.M. et al. Trop.Plt.Pathol. 38 (supl.): CDRom 371-2. 2013; (2) Catarino,A.D.M. et al. Trop.Plt.Pathol. 38 (supl): CDRom 371-1.2013; (3) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015.

***Grapevine Syrah virus* 1 (GSyV-1)**

Surveys made on in São Roque, SP, GSyV-1 was found infecting grapevines. Detection was made by molecular assays (1).

Ref.: (1) Moura, CJM et al. Scientia Agricola 75: 43. 2018.

Ampelovirus

***Grapevine leafroll-associated virus -1, -3, -4, -5, -6* (GLRaV-1,-3,-4,-5,-6)**

Closterovirus

***Grapevine leafroll-associated virus 2* (GLRaV-2)**

Grapevine leafroll, also known as reddening or yellows in the state of São Paulo, is considered one of the most important grapevine viral disease. Symptoms become visible in midsummer. Leaf rolling appears initially in basal leaves and proceeds until the end of fall, when most of leaves are rolled, reddish (still with green veins) or yellowish, rough and brittle. The disease is graft transmissible. First reported in the state of São Paulo (1), the disease is present in the states of Rio Grande do Sul (2), Goias, Minas Gerais, Paraná and Santa Catarina (3) and "submédio São Francisco", PE (7). Grapevine leafroll is caused by a complex of distinct viruses as the closterovirus GLRaV-2, and the ampeloviruses subgroup 1 (GLRaV-1,-3), subgroup II (GLRaV-4,-5,-6,-9,-Car, -Pr), velarivirus (GLRaV-7). In Brazil, the following members of the complex have been found: GLRaV -1,-2,-3 (8, 9, 11, 14, 15), GLRaV-4 (17), GLRaV-5, -6 (10, 16). Possible elongated, closterovirus-like particles were detected in callus tissue of grapevine (4). *Vitis labrusca* varieties and American hybrids produces little or no symptoms, but European grapevines (*Vitis vinifera*) usually show severe symptoms (5). GLRaV -1,-3,-4,-5,-6,-9 are mealybug-transmitted. Mechanical transmission is only reported to *Nicotiana* spp. by GLRaV-2 (10). Indexation is made by grafting onto indicator plants, and more recently by serological or molecular assays (11, 13, 16). GLRaV-1, -3 were found in "submédio São Francisco", PE (6), GLRaV-5 in the state of São Paulo (12), GLRaV-4 in Pernambuo (18), GLRaV -3,-4 in the states of Paraíba and Bahia (19), GLRaV-2,-3,-4 in "Zona da Mata" and São Francisco valley, Minas Gerais (2), GLRaV-3, in Mato Grosso (21).

Ref.: (1) Kuniyuki, H. Rev.Soc.Bras.Fitopatol. 5:165. 1972; (2) Kuhn, G.B. & Siqueira, O. Fitopatologia 9:56. 1974; (3) Kuniyuki, H. Fitopatol.bras. 6: 300. 1981; (4) Vega, J. et al. Fitopatol.bras. 14: 137. 1989; (5) Kuhn, G.B. & Nickel, O. Informe Agropecuário 19 (194): 85. 1998; (6) Kuhn, G.B. et al. Fitopatol.bras. 25: 442. 2000; (7) Lima, M.F. *In* Lima, M.F. & Moreira, W.A. eds. Uva de mesa. Fitossanidade. Embrapa Inf.Tecnol. p.35. 2002; (8) Fajardo, T.V.M. et al. Fitopatol. bras. 27: 58. 2002; (9) Kuniyuki, H. et al. Summa Phytopathol. 28: 311. 2002; (10) Fajardo, T.V.M. et al. *In* Fajardo, T.V.M. ed. Uva para processamento-Fitossanidade. Embrapa Inf. Tecnol. p.45. 2003; (11) Fajardo, T.V.M. et al. Fitopatol.bras. 32: 335. 2007; (12) Kuniyuki, H et al. Summa Phytopathol. 34:366. 2008; (13) Radaelli, P. et al. Pesq. Agrop.Bras. 43:1405. 2008; (14) Radaelli, P. et al. Trop.Plt.Pathol. 34: 297. 2009; (15) Fajardo, T.V.M. et al. Ciência Rural 41:5. 2011; (16) Fajardo, T.V.M. et al. Ciência Rural 42:2127. 2012; (17) Catarino, A.D.M. et al. *In* Girardi, C.L. et al. eds. Resumos, 10º Encontro IC e 6° Encontro de Pós-Grad. Embrapa Uva e Vinho. p. 47, 2012; (18) Catarino, A.D.M. et al. Trop.Plt.Pathol. 38 (supl.): 371. 2013.; (19) Catarino, A.D.M. et al. Trop.Plt.Pathol. 38 (supl.): CDRom 371-1.2013; (20) Catarino, A.D.M. et al. Ciência Rural 45: 379, 2015; (21) Stangarlin, O.S. et al. Summa Phytopathol. 42 (supl.): res.06. 2016.

Enamovirus

Grapevine enamovirus-1

A molecular survey of grapevine viruses was carried out in experimental fields of Embrapa Uva e Vinho, Bento Gonçalves, RS. From plants cv. 'Cabernet Sauvignon', showing severe leafroll and reddening, a virus was detected with 50% identity with *Pea enation mosaic virus 1* (PEMV-1). This virus was graft transmissible. Subsequent tests detected the same virus in at least three other varieties, and it is tentatively name Grapevine enamovirus-1 (1,2,3).

Ref.: (1) Silva, J.M.F. et al. Virus Rev.& Res. 20 (2): 27. 201; (2), Virus Genes 53: 667. 2017; (3) Silva, J.M.F. Diss.MS, UnB. 2018.

Apscaviroid

***Grapevine yellow speckle viroid 1* (GYSVd-1)**

Yellow spots or specks were observed on leaves of grapevine cv. 'Niagara rosada' and 'Semillon' grown in an experimental field of Embrapa Uva e Vinho, B.Gonçalves, RS. Molecular assays detected the viroid GYSVd in these plants (1, 2). This viroid was also found in grapevines cultivated in the state of Mato Grosso do Sul (3).

Ref.: (1) Fajardo, T.V.M. et al. Anais do XIII Congresso Brasileiro de Viticultura e Enologia e XV Congresso Latino-Americano de Viticultura e Enologia. Bento Gonçalves: Associação Brasileira de

Enologia e Embrapa Uva e Vinho, 2015. v. 1. p. 287; (2) Fajardo, T.V.M. et al. Trop.Plt.Pathol.41: 246. 2016; (3) Stangarlin, O.S. et al. Summa Phytopathol. 42 (supl.): res.06. 2016.

Pospiviroid

***Citrus exocortis viroid* (CEVd)**

***Hop stunt viroid* (HSVd)**

The *Citrus exocortis viroid* (CEVd - *Pospiviroid*) and *Hop stunt viroid* (HSVd - *Hostuviroid*) were detected in grapevines in Bento Gonçalves, RS (1-3). In surveys made in grapevine fields in the states of Rio Grande do Sul, São Paulo and Pernambuco, HSVd was found both in cultivated and wild species of *Vitis* (*V. flexuosa* e *V. tillifolia*- RS*, V. gigas*- SP). Detection was made by molecular assays (4).

Ref.: (1) Ferreira, A.P.M. et al. Fitopatol.bras. 17:154. 1992; (2) Fonseca, M.E.N. & Kuhn, G. Fitopatol.bras. 19:285. 1994; (3) Eiras, M. et al. Fitopatol.bras. 31: 440. 2006; (4) Fajardo, T.V.M. et al. Australasian Plt.Dis.Notes 13: 3. 2018.

Reoviridae, unclassified

Grapevine Cabernet sauvignon virus (GCSV)

A severe leafroll was observed in cv. Cabernet Sauvignon in an experimental field of Embrapa Uva e Vinho, Bento Gonçalves, RS. Molecular assays detected a reovirus yet to be characterized, tentatively named GCSV (1).

Ref.: (1) Fajardo T.V.M. et al. Virus Rev & Res.20 (supl.): 188. 2015.

Nanovirus

Unclassified ssDNA

Temperate fruit decay associated virus (TFDaV)

A still unclassified ssDNA virus, named Temperate fruit decay associated virus (TFDaV), was found associated with reddish, coriaceous and rolled up leaves in Embrapa Uva e Vinho, Bento Gonçalves, RS, though molecular analysis. Transmission was achieved by infectious clones (1).

Ref.: (1) Basso, M.F. et al. Virus Research 210: 27. 2015.

Uncharacterized virus

Grapevine LN33 stem grooving virus

This virus was found in grapevine cultivars from "Serra Gaúcha", as part of the rugose wood complex. When graft transmitted to the indicator host 'LN33', this virus induce stem pitting (1).

Ref.: (1) Kuhn, G.B. et al. Fitopatol.bras. 27(supl.): S207. 2002.

Obs.: "Grapevine rugose wood complex" seems to be caused by co-infection of at least four viruses, which results in wood alteration of infected plants, impairing the genesis of xylem and phloem vessels. These viruses are: "Corky bark", "Rupestris stem pitting","Kober stem grooving", "LN33 stem grooving". These viruses can be separated using proper indicator plants, specific for each virus.

Grapevine vein necrosis virus

Vein necrosis on the grapevine rootstock cv. 'R110' was observed in the state of Rio Grande do Sul (1,2). The problem is graft transmissible and infected scions show chlorotic leaves. This condition is similar to "grapevine vein necrosis" reported in other grapevine growing countries (5), and it was also noticed in the rootstock cv. 'Solferino' and some others imported from USA and Europe. It seems to be quite widespread, without causing obvious symptoms (2). Vein necrosis was also observed in the state of São Paulo (3) and in the Submédio São Francisco, Pernambuco and Paraíba (4). Causal agent is not well characterized yet, but there are reports association vein necrosis with a specific isolate of *Grapevine rupestris stem pitting-associated virus* (GRSPaV).

Ref.: (1) Kuhn, G.B. Fitopatol.bras. 17: 154. 1992; (2) Kuhn, G.B. et al. Fitopatol.bras. 19:79. 1994; (3) Kuniyuki, H. et al. Fitopatol.bras. 22: 186.1997; (4) Kuhn, G.B. et al. Fitopatol.bras. 25:442. 2000; (5) Fajardo, T.V.M. et al. *In* Fajardo, T.V.M. ed. Uva para processamento-Fitossanidade. Embrapa Inf. Tecnol. p.45. 2003.

W

***Waltheria indica* L (= W. *americana* L) (Sleepy morning) Sterculiaceae**

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

Sleepy morning plants were found with mosaic symptoms in the state of São Paulo. Viral etiology was suggested, being the causal agent considered a member of ICMC (1).

Ref.: (1) Silberschmidt, K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

Begomovirus unidentified

A begomovirus, yet to be identified, was found infecting sleepy morning with mosaic symptoms in the state of Alagoas (1).

Ref: (1) Assunção, L.P. et al. Planta Daninha 24: 239.2006.

***Wissadula* sp. Malvaceae**

Begomovirus

Infectious chlorosis of malvaceae complex (ICMC)

A whitefly transmitted virus was found in *Wissadula* sp. with mosaic symptoms, from Alagoinha, PB and Brotas, BA. Causal agent was considered as a member of ICMC (1).

Ref.: (1) Silberschmidt, K. & Tommasi, L.R. Ann.Acad.Bras.Cien. 27: 195. 1955.

X

***Xanthosoma atrovirens* Koch & Bouche (Malanga) Araceae**

Potyvirus

***Dasheen mosaic virus* (DsMV)**

DsMV was found infecting *X. atrovirens* causing mosaic symptoms in Brasília, DF (1).

Ref.: (1) Rodrigues, M.G.R. et al. Fitopatol. bras. 9: 291. 1984.

Y

***Yucca elephantipes* Regel ex.Trel (Spineless yucca) Agavaceae**

Badnavirus

***Badnavirus* unidentified**

Chlorotic spots and rings were noticed in spineless yucca in the state of São Paulo. A still unidentified badnavirus was found in tissues of the infected plant, by electron microscopy (1).

Ref.: (1) Rivas, E.B. et al. Fitopatol.bras. 19: 479. 1994.

Z

***Zamioculcas zamiifolia* (Lodd.) Engl. (ZZ plant) Araceae**

Potyvirus

***Konjac mosaic virus* (KoMV)**

A ZZ plant acquired from a florist in São Paulo, SP, presented mosaic and deformation on the leaves. A potyvirus was found associated with symptoms, which was identified as KoMV by RT-PCR and sequence analysis of the amplicon (1).

Ref.: (1) Alexandre, M.A.V. et al. Plant Dis. 97: 1517. 2013.

***Zantedeschia aethiopica* (L.) Spreng (Cara lily) Araceae**

Potyvirus

***Dasheen mosaic virus* (DsMV)**

DsMV was detected in Cara lily plants showing diffuse chlorotic spots on their leaves, using serology and electron microscopy (1).

Ref.: 1) Galleti, S.R. et al. Res. VI Enc. Nac. Virol. p.137. 1992.

***Zanthosylum rhoifolium* Lam. (Prickly ash) Rutaceae**

Potyvirus

***Potato virus Y* (PVY)**

Serological detection of PVY was made in seedlings of *Z. rhoifolium* in a nursery of the Universidade de Brasília, Brasília, DF (1).

Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40 (supl): 354.2. 2015.

***Zea mays* L. (Maize) Poaceae**

Cytorhabdovirus

Maize chlorotic vein banding virus (MCVBV)

A disease characterized by broad chlorotic bands along the veins was found to be caused by a cytorhabdovirus in the state of São Paulo. If infection is early, plants remain stunted, and yield is seriously affected. It is transmitted in a persistent manner by the hopper *Peregrinus maidis* Ashm. (1) The virus was named MCVBV and has been purified (2). Virus particles were visualized both in infected plants and viruliferous vector (3). MCVBD was also found in Distrito Federal and in the states of Amazonas (4), Rio de Janeiro (5), Rio Grande do Norte (6) and Piauí (7). It may be related to the Maize yellow striate virus (MYSV) described in Argentina (8).

Ref.: (1) Costa, A.S. et al. Rev.Soc.Bras.Fitopatol. 4: 39. 1971; (2) Kitajima, E.W. et al. Fitopatol.bras. 1: 34. 1976; (3) Kitajima, E.W. & Costa, A.S. Fitopatol.bras. 7: 247. 1982; (4) Kitajima, E.W. & van der Pahlen, A. Fitopatol.bras. 2: 83. 1977; (5) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; (6) Oliveira, F.C. et al. Fitopatol.bras. 17: 339. 1992; Beserra Jr., JEA et al. Trop.Plant Pathol. 36 (supl) CDRom. 2011; (8) Maurino, F. et al. Arch.Virol. 163: 291. 2018.

Marafivirus

***Maize rayado fino virus* (MRFV)**

Symptoms of small linear necrotic lesions along the veins is quite common in maize crops in Brazil, referred to as "risca" by local growers. It has been proved to be caused by a marafivirus, MRFV, previously described in Central America. In Brazil apparently is not related to yield losses in single infections, but may affect productivity if present in mixed infections with other pathogens as phytoplasma, spiroplasma and potyviruses, being part of the syndrome known as corn stunt (1, 2, 8, 9). It is transmitted by the hopper *Dalbulus maidis,* but not mechanically (1). MRFV infect parenchymal and vascular tissues of maize. Particles are isometric, ca. 30 nm in diameter and could be purified (3). Virions were detected in tissues of the viruliferous vector (5). Besides state of São Paulo, where it was first reported (1), MRFV has also been reported in the states of Ceará (4), Rio de Janeiro (6), Paraná (7), Minas Gerais (8).

Ref.: (1) Costa, A.S. et al. Rev.Soc.Bras.Fitopatol. 4: 39. 1971; (2) Kitajima, E.W. et al. Proc.Amer.Phytopathol.Soc. v.2, C-15. 1975; (3) Kitajima, E.W. et al. Ciencia e Cultura 28: 427. 1976: (4) Lima, J.A.A. & Gamez, R. Fitopatol.bras. 7: 535. 1982; (5) Kitajima, E.W. & Gamez, R. Intervirology 19: 129. 1983; (6) Kitajima, E.W. et al. Fitopatol.bras. 9: 607. 1984; ; (7) Kitajima, E.W. & Nazareno, N.R.X. Fitopatol.bras. 10: 613. 1985; (8) Melo, P.R. et al. Fitopatol.bras. 25: 444. 2000. (9) Gonçalves, M.C. et al. Summa Phytopathol. 33: 22. 2007.

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Chlorotic streaks and mosaic on leaves, associated to stunting were observed in maize in the state of São Paulo. This disease is of rare occurrence. Causal agent was identified as an isolate of CMV (1).

Ref.: Costa, A.S. & Kitajima, E.W. Rev. Soc.Bras.Fitopatol. 5: 159, 1972.

Polerovirus

***Maize yellow mosaic virus* (MaYMV)**

Yellow mosaic and stunting symptoms were noticed in commercial fields of maize in Casa Branca, SP. Molecular analysis identified the causal virus as an isolate of MaYMV with >90% identity in the sequences (1).

Ref.: (1) Gonçalves, M.C. et al. Plant Dis. 101: 2156. 2017

Potyvirus

***Johnson grass mosaic virus* (JGMV)**

Serodiagnosis suggested infection of maize, grown in Ribeirão Preto, SP, by an isolate of JGMV (1).

Ref.: (1) Chaves, A.L.R. et al. Fitopatol.bras. 25: 514. 2001.

***Maize dwarf mosaic virus* (MDMV)**

***Sugar cane mosaic virus* (SCMV)**

Infection of maize by potyvirus is common in Brazil. Possible cases of presence of potyviruses in maize were made in the state of Rio Grande do Sul in the 1960's (1,2). SCMV was identified in maize in the state of São Paulo, by biological assays, including aphid transmission (3). MDMV was considered present in Brazil (4) and reported in the state of Paraná (5). Recent surveys made on maize in the states of São Paulo, Paraná, Minas Gerais and Goias, have shown that only SCMV was recovered (M.C. Gonçalves, pers.comm.). The expansion of maize culture, once a year before the 1970's, to 2-3x a year ("safrinha"), and the growth in the planted area of sugar cane, seem to have favored the increase in the incidence of SCMV and the appearance of new isolates, as being observed after the 2000's (6). Some of these isolates seems to be peculiar to Brazil (7).

Ref.: (1) Caetano,V.R. & Siqueira, O. Rev.Soc.Bras.Fitopatol. 3: 82. 1969; (2) Hagedorn, D.J. et al. Plant Dis.Reptr. 53: 165. 1969; (3) Costa, A.S. et al. Rev. Soc. Bras. Fitopatol. 4: 39. 1971; (4) Kitajima, E.W. & Costa, A.S. Proc.2nd Int.Colloq.Workshop Maize Virus and Mycopl. p.100. 1983; (5) Kitajima, E.W. & Nazareno, N.R.X. Fitopatol.bras. 10: 613. 1985; (6) Gonçalves, M.C. et al. Summa Phytopathol. 33: 22. 2007; (7) Gonçalves,M.C. et al. Pesq.Agrop. Bras. 46: 362. 2011.

Fijivirus

***Mal de Rio Cuarto virus* (MRCV)**

Mal de Rio Cuarto is a serious viral disease occurring mainly in Cordoba, Argentina, characterized by leaf enation along veins in the adaxial face of leaves, stunting and anomalies in ears. Despite land continuity between this region and Brazil, the disease was considered absent in Brazil. The first and only report occurred in maize planted in Cascavel and Foz do Iguaçú, PR in 1986, based on symptoms and detection of reovirus-like particles by electron microscopy (1). No further cases have been registered so far.

Ref.: (1) Trevisan, W.L. et al. Fitopatol.bras. 11: 265. 1986.

***Zeyheria tuberculosa* (Vell.) Bureau ex. Verl. Bignoniaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Potyvirus

***Papaya ringspot virus* (PRSV)**

***Potato virus Y* (PVY)**

CMV, PVY e PRSV were detected by serology in seedlings of *Z. tuberculosa* in a nursery of the Universidade de Brasíllia, DF (1).

Ref.: (1) Batista, J.G. et al. Trop.Plt.Pathol. 40 (supl): 354.2. 2015.

***Zingiber officinale* Roscoe (Ginger) Zingiberaceae**

Cucumovirus

***Cucumber mosaic virus* (CMV)**

Ginger plants with stunting, small rhizomes, and general chlorosis were found in the state of São Paulo, SP. Following biological and serological assays and electron microscopy identified the causal agent of the disorder as an isolate of CMV (1).

Ref.: (1) Colariccio, A. et al. Res. VI Enc. Nac. Virol. p. 182. 1992.

***Zinnia elegans* JACQ. (Zinnia) Asteraceae**

Potyvirus

***Bidens mosaic virus* (BiMV)**

Zinnia plants showing mosaic symptoms were found in a residential garden in Brasília, DF. The causal agent of the symptoms was identified as an isolate of BiMV (1).

Ref.: (1) Kitajima, E.W. & Lima, M.I. Fitopatol.bras. 16: XXVI. 1991.

***Sunflower chlorotic mottle virus* (SuCMoV)**

Potyvirus causing mosaic symptoms in *Zinnia* was registered in the Northwest of the state of São Paulo. Biological and molecular assays identified this virus as an isolate of SuCMoV, originally described in Argentina (1).

Ref.: (1) Maritan, A.C. et al. Fitopatol. bras. 29: 28. 2004.

Tobamovirus

***Tobacco mosaic virus* (TMV)**

In São José do Rio Preto, SP, zinnia plants were found with mosaic symptoms. Further assays indicated that they were co-infected by a potyvirus, possibly BiMV, and an isolate of TMV

Ref.: (1). Maritan, C. & Gaspar, J.O. Fitopatol.bras. 26: 533. 2001.

Conclusions

This annotated list reports plant viruses described naturally infecting plants, cultivated or from spontaneous vegetation, in the Brazilian territory from the early reports in the 1920' to 2018. Most of them were possibly introduced, but there are several autochthonous viruses. The large majority cause marginal diseases which result in minor but consistent losses. Few of them, however, caused and may cause major outbreaks with severe yield losses, due to favorable epidemiological conditions and lack of natural resistance in host plants.

Author Contributions

Elliot W. Kitajima: Substantial contribution in the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intelectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Article

Taxonomic diversity of *Biomphalaria* (Planorbidae) in São Paulo state, Brazil

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Abstract: Morphological and molecular identifications were carried out for *Biomphalaria occidentalis, Biomphalaria oligoza, Biomphalaria peregrina, Biomphalaria schrammi, Biomphalaria straminea* and *Biomphalaria tenagophila* collected from 55 sites located along the upper basin of Tietê River in the Southeast Region of Brazil. Morphological analysis considered aspects of the shell, mantle, excretory organs and reproductive system. Molecular data included 122 sequences of Cytochrome C Oxidase I gene (COI). Our results showed that some shell characters, as well as other characters related to the mantle and the reproductive system, are fundamental for the identification of the six *Biomphalaria* species included in this study. The use of DNA barcoding together with morphological taxonomy generated more reliable results, proving to be a very useful approach, even for malacological surveillance services.
Keywords: *COI; DNA Barcoding; Morphology; Schistosomiasis; Intermediate Host Snail.*

Diversidade taxonômica de *Biomphalaria* (Planorbidae) no estado de São Paulo, Brasil

Resumo: Foi realizado estudo morfológico e molecular de *Biomphalaria occidentalis, B. oligoza, B. peregrina, B. schrammi, B. straminea* e *B. tenagophila* coletados em 55 pontos situados ao longo da bacia hidrográfica do Alto Rio Tietê a sudoeste do Brasil. A análise morfológica levou em consideração aspectos da concha, manto, órgãos excretores e sistema reprodutor. Os dados moleculares incluíram 122 sequências do gene mitocondrial Citocromo C Oxidase I (COI). Nossos resultados mostram que alguns caracteres da concha, bem como outros relacionados ao manto e ao sistema reprodutor foram aqui considerados fundamentais na determinação das seis *Biomphalaria* tratadas neste estudo. A utilização do DNA Barcode simultaneamente com a taxonomia morfológica gerou resultados mais fidedignos, demonstrando ser uma abordagem bastante útil, inclusive, para os serviços de vigilância malacológica.
Palavras-chave: *COI; DNA Barcode; Morfologia; Esquistossomose; Caramujos Hospedeiros Intermediários.*

Introduction

Schistosomiasis is a neglected disease that affects regions with precarious sanitary infrastructure, such as those found in endemic areas of Brazil (Baracho 2013). The transmission of schistosomiasis is closely linked to a population's contact with freshwater and the presence of mollusks of the genus *Biomphalaria* Preston, 1910, which host trematode larvae of *Schistosoma mansoni* Sambon, 1907, the etiological agent of schistosomiasis.

The planorbid chart of the metropolitan region of São Paulo, presented by Piza et al. (1972) and Ohlweiler & Rossignoli (2016), indicate the presence of *Biomphalaria occidentalis* Paraense, 1981, *Biomphalaria oligoza* Paraense, 1975, *Biomphalaria peregrina* (d'Orbigny, 1835), *Biomphalaria schrammi* (Crosse, 1846), *Biomphalaria straminea* (Dunker, 1848) and *Biomphalaria tenagophila* (d'Orbigny, 1835) in water bodies of the upper basin of Tietê River in state of São Paulo, located in the southeast of Brazil. *Biomphalaria straminea* and *B. tenagophila* were naturally found infected with *S. mansoni* in Brazil (Ohlweiler et al. 2010). *Biomphalaria straminea* is widely geographically distributed in Brazil, especially in northeastern states, where it is an important intermediary host of *S. mansoni* (Figueiredo 1989, Ohlweiler et al. 2010). *Biomphalaria tenagophila,* albeit it presents low rates of *S. mansoni* infection both in the field and in the laboratory, is responsible for the schistosomiasis outbreaks in the state of São Paulo (Paraense & Corrêa 1978).

The risk of schistosomiasis expansion in the upper basin of Tietê River is notorious in view of the presence of *B. tenagophila* in its hydrographic complex. Studies involving morphological and molecular identification of *Biomphalaria* occurring in the upper basin of Tietê River are extremely important for defining areas that are prone to schistosomiasis, as well as for understanding disease transmission in the region.

The morphological identification of *Biomphalaria* is carried out based on anatomical characters especially of the reproductive system

and renal tube (Paraense 1966a, 1975). However, phenotypic plasticity has been reported in *Biomphalaria* by Paraense (1966a, 1974, 1975, 1988), Paraense & Deslandes (1962), Spatz et al. (1999), Caldeira et al. (2000), Vidigal et al. (2000a, b), Carvalho et al. (2008) and Silva (2012).

The classification of *Biomphalaria* based on morphological characters presents difficulties in determining discrete taxonomic units, such as subspecies and the cryptic species that form complexes. For *Biomphalaria,* the tenagophila species complex (*B. tenagophila*, *B. tenagophila guaibensis* Paraense, 1984 and *B. occidentalis*) (Spatz et al. 1999) and straminea species complex (*B. straminea*, *B. kuhniana* (Clessin, 1883) and *B. intermedia* (Paraense & Deslandes, 1962) (Paraense 1988) are described. Aside from these two complexes, other *Biomphalaria* species, also registered in Brazil, have very similar characteristics to each other, such as *B. peregrina* and *B. oligoza* (Paraense 1974, 1975), and *B. cousini* Paraense, 1966 and *B. amazonica* Paraense, 1966 (Paraense 1966b).

In Neotropical gastropod groups, Cytochrome C Oxidase I (COI) helps to identify morphologically similar taxa and cryptic species (Tuan et al. 2012, Collado et al. 2016, Palasio et al. 2017). However, no molecular method should be applied in the taxonomic classification of *Biomphalaria* without support of morphological analysis, given that the anatomical characters are still the gold standard for identifying *Biomphalaria* at the species level.

This paper aims to understand the biodiversity of *Biomphalaria* in floodplain areas of the upper basin of Tietê River, in order to determine the extent of *S. mansoni* transmission risk areas. For this purpose, morphological and molecular identification methods were applied to *Biomphalaria* snails collected in freshwater bodies associated with the upper basin of Tietê River.

Materials and Methods

Planorbid snails of the genus *Biomphalaria* were collected from 55 points in freshwater bodies located along a 5,720 Km^2 line of the upper basin of Tietê River, in 18 municipalities of São Paulo (Brazil), from September 2015 to July 2016 (Figure 1 and Table 1).

Geocoding of collection points and elaboration of illustrative distribution maps of *Biomphalaria* in the upper basin of Tietê River were carried out in the program QGIS version 3.4.11 (QGIS 2019) using the coordinates of the georeferenced localities (latitude/longitude). The data referring to the geographic coordinates of the collection points were obtained through the Global Positioning System (GPS) Garmin

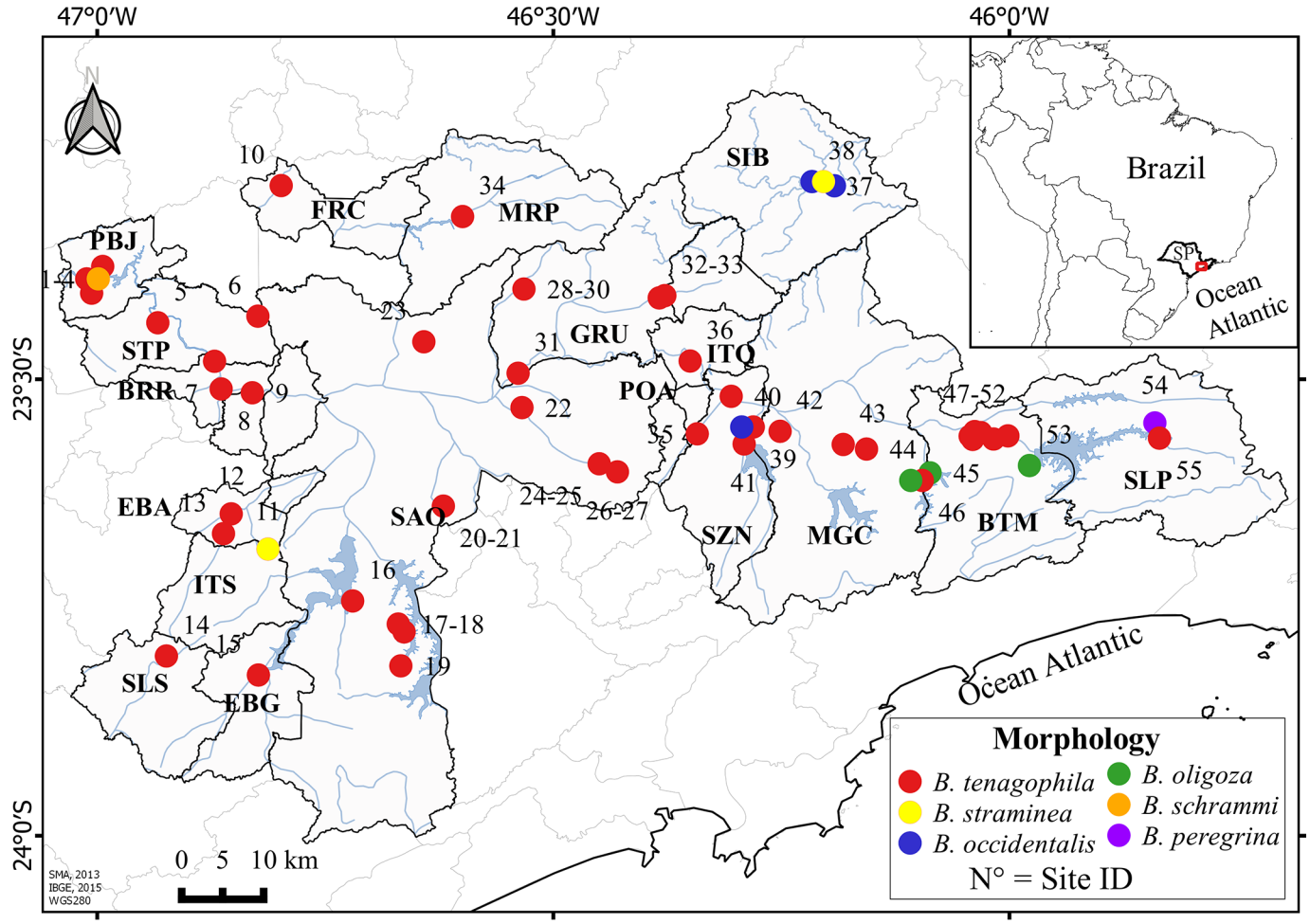

Figure 1. Maps of the distribution of *Biomphalaria* spp. collected in the Upper Tietê River Basin, São Paulo/Brazil. BRR, Barueri; BTM, Biritiba Mirim; EBA, Embú das Artes; EBG, Embu Guaçu; FRC, Franco da Rocha; GRU, Guarulhos; ITQ, Itaquaquecetuba; ITS, Itapecerica da Serra; MGC, Mogi das Cruzes; MRP, Mairiporã; PBJ, Pirapora do Bom Jesus; POA, Poá; SAO, São Paulo; SIB, Santa Isabel; SLP, Salesópolis; SLS, São Lourenço da Serra; STP, Santana de Parnaíba; SZN, Suzano;*, Codes of collection points (Site ID) in Table 1.

Table 1. *Biomphalaria* collected in municipalities of the Upper Tietê River Basin, São Paulo/Br and Genbank access numbers for 122 COI sequences used in this study.

Lot Number	*Biomphalaria*	CD	Municipality	NM	Latitude	Longitude	Codes for COI sequence	Genbank accession number
615	*B. occidentalis*	37	Santa Isabel	0	23º17´17" S	46º12´16" W	sti 1	KF926174
		38		0	23º17´00" S	46º12´59" W	sti 5	KF926195
3035		39	Suzano	15	23º33´08" S	46º16´51" W	szn 3,5	MH593417,419
2939	*B. oligoza*	46	Biritiba Mirim	10	23º36´38" S	46º05´43" W		
2989		45		10	23º36´09" S	46º05´13" W		
2927		53	Salesópolis	9	23º35´40" S	45º58´41" W		
2926	*B. peregrina*	54	Salesópolis	2	23º32´51" S	45º50´29" W		
2991		54		9	23º32´52" S	45º50´26" W	slp 1-5	MH593410-412,428,429
2971	*B. schrammi*	1	Pirapora do Bom Jesus	10	23º23´22" S	46º59´56" W	pbj 1- 4	MH593405,406, 408,409
2990		1		4	23º23´22" S	46º59´56" W		
2645	*B. straminea*	11	Itapecerica da Serra	4	23º41´09" S	46º48´46" W		
2649		11		6	23º41´09" S	46º48´46" W		
2661		11		2	23º41´09" S	46º48´46" W		
579		38	Santa Isabel	0	23º17´00" S	46º12´59" W	sti 2-4	KF926177, KF926189-190
3000	*B. tenagophila*	8	Barueri	14	23º30´38" S	46º51´51" W	brr 1-5	MH593423-427
3002		7		16	23º28´49" S	46º52´17" W	brr 6-10	MH593429-433
3015		7		15	23º28´50" S	46º52´17" W		
3019		9		14	23º30´53" S	46º49´48" W	brr 11-15	MH593434-438
2931		47	Biritiba Mirim	11	23º33´26" S	46º02´17" W	brt 6,7	MH593398, 399
2932		49		8	23º33´44" S	46º02´35" W	brt 1,2	KF926203,205
2933		48		7	23º33´30" S	46º01´53" W	brt 4,8, 9	MH593396, 400,401
2938		46		2	23º36´39" S	46º05´44" W		
2959		51		8	23º33´55" S	46º01´03" W		
2996		51		1	23º33´54" S	46º01´03" W		
*		52		0	23º33´43" S	46º00´06" W	brt 3	KF926204
2933		50		0	23º33´57" S	46º02´25" W	brt 5	MH593397
1779		12	Embu das Artes	0	23º38´50" S	46º51´11" W	ebt 1	KF926197
		13		0	23º40´08" S	46º51´42" W	ebt 2	KF926198
3054		15	Embu Guaçu	5	23º49´26" S	46º49´24" W	emg 1-4	MH593494,495 MH593503,504
3055		10	Franco da Rocha	5	23º17´16" S	46º47´54" W	frr 1-7	MH593496-502
3056		10		5	23º17´16" S	46º47´54" W		
2936		30	Guarulhos	3	23º24´05" S	46º31´56" W	**	
3021		32		10	23º24´30" S	46º22´40" W	gru 4-6	MH593452-454
3022		33		15	23º24´39" S	46º23´02" W	gru 1-3	MH593449-451
3025		31		15	23º29´36" S	46º32´19" W	gru 7-9	MH593455-557
3034		28		5	23º24´04" S	46º31´56" W	gru 10,11	MH593477, 478
3036		29		5	23º24´17" S	46º31´56" W	gru 12,13	MH593479,480
3023		36	Itaquaquecetuba	13	23º28´48" S	46º21´01" W	itq 1,5	MH593444,448
2918		34	Mairiporã	17	23º19´18" S	46º35´58" W		
2968		42	Mogi das Cruzes	15	23º33´25" S	46º15´05" W	mgc 2-4	MH593402,404
2992		43		15	23º34´18" S	46º10´56" W		
3001		43		0	23º34´17" S	46º10´56" W	mgc 5-7	MH593420,422
*		44		0	23º34´35" S	46º09´24" W	mgc 1	KF926202

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2970	2	Pirapora do Bom Jesus	15	23º23´22" S	46º59´56" W	pbj 3	MH593407
3047	4		4	23º22´35" S	46º59´38" W		
3057	3		5	23º24´20" S	47º00´22" W		
3053	35	Poá	5	23º33´35" S	46º20´32" W	poa 1,2	MH593505,506
3051	55	Salesópolis	5	23º33´52" S	46º50´08" W	slp 6	MH593493
3052	55		5	23º33´52" S	45º50´02" W		
3027	6	Santana de Parnaíba	6	23º25´51" S	46º49´26" W	stp 5-7	MH593496-498
3030	5		7	23º26´17" S	46º56´01" W	stp 1-4	MH593458-461
2148	14	São Lourenço da Serra	0	23º48´11" S	46º55´27" W	sls 1	KF926201
3042	16	São Paulo	5	23º44´35" S	46º43´13" W	**	
3046	17		0	23º46´05" S	46º40´12" W	sao 20-24	MH593488-492
3054	18		0	23º46´36" S	46º39´49" W	sao 13,14	MH593481,482
3037	19		3	23º48´50" S	46º40´02" W		
3043	20		5	23º38´20" S	46º37´14" W	sao 15,16	MH593483,484
3044	21		5	23º38´21" S	46º37´09" W	sao 17-19	MH593485-487
3033	22		2	23º31´52" S	46º32´04" W		
3041	23		5	23º27´32" S	46º38´31" W	**	
3032	24		10	23º35´33" S	46º26´59" W	sao 5-9	MH593474-478
3031	25		16	23º35´38" S	46º26´59" W	sao 10-12	MH593469-471
3028	26		15	23º36´05" S	46º25´47" W	sao 3,4	MH593464,465
3029	27		10	23º36´09" S	46º25´45" W	sao 1,2	MH593462,463
2997	41	Suzano	3	23º34´15" S	46º17´27" W	szn 1,2	MH593415,416
3001	39		1	23º33´08" S	46º16´51" W	szn 4	MH593418
3016	40		15	23º31´07" S	46º18´18" W	szn 6-10	MH593439-443
Total			452				122

*; COI sequences, from the Molecular Biology Laboratory of SUCEN, of malacological material not included in the collection of the Divisão de Programas Especiais (DPE) of SUCEN, **; species without COI sequences, CD; Code of the numbers of the collection sites in Figure 1, NM; Number of specimens used in the morphological study.

Etrex 10. The cartographic materials were collected from the web sites of the Instituto Brasileiro de Geografia e Estatística (IBGE 2015) and Secretaria de Meio Ambiente do Estado de São Paulo (SMA 2013).

Snails were collected manually with tweezers and a perforated metal ladle attached to a wooden handle, according to the technique used during the Schistosomiasis Surveillance and Control Program by the Ministry of Health (Brasil 2008). To standardize the samples, collections lasted for 1 hour at each collection point, with a sampling effort of three collectors (Brasil 2008).

In the laboratory, the live snails were subjected to parasitological examination by exposure to artificial light for up to 4 hours, to verify if they were infected with trematodes larvae (Ohlweiler et al. 2013). Infection free snails with intact anatomical structures were used in the morphological and molecular study.

The morphological and molecular study was performed on healthy snails free from parasite larvae, which were anesthetized with menthol crystals for 24 to 48 hours at a temperature of 4ºC. Afterwards, their bodies were separated from their shells according to the methodology described by the Ministry of Health (Brasil 2008).

1. *Morphological study*

Snail bodies were fixed for at least 48 hours in a Railliet-Henry solution, where they were kept permanently, and the shells were dry conditioned. The morphological analyses are based on 35 characters: 10 related to the shell, 2 to the mantle, 3 to the excretory system and 20 to the reproductive system. A minimum of 11 adult specimens were analyzed per species under a stereoscopic microscope, according to the available bibliography. The shells were measured with a DE MEO analogue caliper with scale in millimeters (0.05 mm).

2. *Molecular Study*

The mitochondrial DNA segment corresponding to the COI gene was amplified using the primers LCO1498 and HCO2190 (Folmer et al. 1994), which allow the 658 bp-region of the COI gene to be amplified (Hebert 2003). At least one snail from each sampled site was used for molecular identification, except for Mairiporã and Itapecerica da Serra, as DNA extraction was not possible for such material. The morphology of specimens used for molecular identification were previously identified (Table 1). In the PCR-COI amplification reaction, 25 µl of Master Mix solution, 2 µl of 0.1 µM of each Primer (HCO and LCO), 2 µl of 10-100 ng of DNA, and 19 µl of water were used. Amplifications (Biometra Thermo Cycler) were performed according to the following protocol: 95ºC for 3 minutes; 25 cycles of 95ºC for 1 minute, 47ºC for 1 minute and 72ºC for 1 minute and 30 seconds.

Samples with at least 20 ng of DNA/µL were sequenced. Sequencing reactions were made in an ABI 3100 automatic sequencer

(Applied Byosistems®) at the Molecular Biology Laboratory in the Biotechnology Center at the Butantan Institute.

The sequences were aligned using MAFFT version 7 (Katoh et al. 2017) under the Q-INS-I parameter to restrict the formation of gaps. The aligned sequences were visually corrected in BioEdit 7.2.5 (Hall 1999) and individually analyzed in the NCBI (2018) using Basic Local Alignment Search Tool – Nucleotídeo (BLASTn) (Benson et al. 2012) data base to obtain the highest similarity values between the target sequence and the sequences previously deposited in the GenBank®. The values of interspecific and intraspecific genetic divergence by distance matrix were generated in MEGA X (Kumar et al. 2018). Genetic polymorphism indexes were calculated using the software DnaSP version 6.12 (Rozas et al. 2017).

For the phylogenetic analysis, a known sequence of the North American snail *Planorbella trivolvis* (Say, 1817) was used as the out group (Genbank accession number MG4229211). The Model generator program (Keane et al. 2006) was used to determine the most suitable nucleotide substitution model for the sequences submitted to phylogenetic analysis based on ML (Maximum likelihood) in the program PhyML 3.2 (Guindon & Gascuel 2003). The reliability values of the tree branches were obtained using a LRT (Approximate Likelihood Ratio Test) associated with non-parametric correction based on the Shimodaira-Hasegawa (SH) algorithm for tree comparison (Shimodaira & Hasegawa 1999, Anisimova et al. 2011).

For analysis of species delimitation methods in molecular operational taxonomic units (MOTUs), the following statistical tests were applied: A) ABGD (Automatic Barcode Gap Discovery) (Puillandre et al. 2012), which considers distances as parameters to infer Barcoding gaps; B) bPTP (Zhang et al. 2013), which calculates the highest probability of branches through Bayesian analysis. The file containing the tree data calculated under ML, GTR+G+I as an evolutionary model, was used for the calculations in bPTP (Zhang et al. 2013). C) GMYC (General mixed Yule Coalescent) (Fujisawa & Barraclough 2013), which uses speciation models (interspecific relations) and coalescence (intraspecific relations) to infer identified species. The GTR+G+I evolution model was used as the basis of calculation for the construction of an ultrametric tree in MEGA X (Kumar et al. 2018), which served as input file for calculating the cluster number (Zhang 2015).

The 112 sequences obtained in this study were deposited in GenBank, with accession number MH593395 to MH593506. We also used other 12 sequences (Palasio et al. 2017) deposited in GenBank under the not consecutive accession numbers KF926174 to KF926204, as described in Table 1. The vouchers, along with the snails used for the morphological study, were catalogued according to their collection sites and deposited in the Malacological Collection at the Division of Special Programs of the Superintendence of Control of Endemic Diseases of the State of São Paulo – SUCEN under the numbers DPE1779 to DPE3057 (not necessarily consecutive) (Table 1).

Results

1. Morphological study

The 35 morphological characters observed in the 452 snails *Biomphalaria* (15 specimens of *Biomphalaria occidentalis*, 29 *Biomphalaria oligoza*, 11 *Biomphalaria peregrina*, 14 *Biomphalaria schrammi*, 12 *Biomphalaria straminea* and 371 *Biomphalaria tenagophila*) are presented in the Tables 2 and 3.

Morphological analysis shows that 26 out of the 35 characters examined indicate significant anatomical differences among the six species of *Biomphalaria*: five shell characters – shape of the turns, carenas, internal lamellas on the last turn of the shell, opening shape and opening position – two of the mantle – pattern of mantle pigmentation and stain pattern – and nineteen reproductive system

Table 2. Morphological characters of the shell of *Biomphalaria* from the Upper Tietê River Basin, São Paulo-Brazil.

Shell characters	*B. tenagophila*	*B. occidentalis*	*B. oligoza*	*B. peregrina*	*B. schrammi*	*B. straminea*
Color	Brown	Brown	Brown	Brown	Brown	Brown
Diameter (mm)						
Average	12,5	7,8	4,2	7	5	6,4
Minimum-Maximum	3,4 - 22,5	6,2 - 13,6	3,3 - 5,2	6,2 - 8,4	4,6 - 5,4	5,2 - 7,0
Width (mm)						
Average	5,1	3,5	1,7	2,5	1,7	2,9
Minimum-Maximum	0,7 - 9,6	2,3 - 4,7	1,4 - 2,1	2,0 - 3,0	1,5 - 2,0	2,4 - 3,0
Number of turns	4 1/4 to 7	5 to 6 1/4	4 to 4 1/2	4 1/4 to 4 1/2	4 to 4 3/4	4 1/2 to 5
Aspect of sutures	Defined	Defined	Well defined	Defined	Well defined	Well defined
Shape of the turns*	Angular	Angular	Rounded	Rounded	Rounded	Rounded
Carenas*	Present	Present	Absent	Absent	Absent	Absent
Internal lamellas on the last turn of the shell*	Absent	Absent	Absent	Absent	Present (0 to 6)	Absent
Opening shape*	Transverse or deltoid	Transverse or deltoid	Rounded	Rounded	Rounded	Rounded
Opening position*	Front	Front	Front	Lightly deflected to the left	Heavily deflected to the left	Lightly deflected to the left

*morphological characters with expressive anatomical characteristics

Table 3. Morphological characters of the mantle, excretory system and reproductive system of *Biomphalaria* from the Upper Tietê River Basin, São Paulo/Brazil.

	B. tenagophila	***B. occidentalis***	***B. oligoza***	***B. peregrina***	***B. schrammi***	***B. straminea***
Morphological characters of the mantle						
Pattern of mantle pigmentation*	Tends to be homogeneous	Tends to be homogeneous	Spots or scores	Spots or scores	Spots or scores	Spots or scores
Stain Pattern*	Inapplicable	Inapplicable	Rounded or misshapen	Rounded or misshapen	elongated, transversely disposed	Rounded or misshapen
Morphological characters of excretory system						
Pigmented line in the renal tube	Present in some specimens	Absent	Absent	Absent	Absent	Absent
Oblique salience in the renal tube	Present in some specimens	Absent	Absent	Absent	Absent	Absent
Renal tube	Flat	Flat	Flat	Flat	Flat	Flat
Morphological characters of reproductive system						
Number of ovotestis diverticula*	101 to 429	124 to 176	16 to 38	80 to 113	19 to 30	109 to 143
Aspect of the ovotestis diverticula*	Little differentiated	Little differentiated	Well differentiated	Well differentiated	Well differentiated	Well differentiated
Shape of the ovotestis diverticula*	Elongated	Elongated	Bulging	Elongated	Bulging	Elongated
Configuration of the ovotestis diverticula*	Subdivided and simple	Subdivided and simple	Simple (some subdivided)	Subdivided and simple	Simple (some subdivided)	Subdivided and simple
Aspect of the seminal vesicle*	Bulky	Reduced	Reduced	Bulky	Reduced	Bulky
Constitution of the conglomerate portion of the seminal vesicle*	Digitiform expansions	Digitiform expansions	Nodular formations	Digitiform expansions	Digitiform expansions	Digitiform expansions
Aspect of the oviduct pouch*	Clearly defined	Clearly defined	Bulky	Clearly defined	Discreet	Bulky
Vaginal pouch in the ventral wall of the posterior region of the vagina*	Present	Absent	Present	Present	Absent	Absent
Aspect of the vaginal pouch*	Clearly defined	Inapplicable	Discreet	Clearly defined	Inapplicable	Inapplicable
Shape of the vaginal pouch*	Bulging	Inapplicable	Elongated	Elongated	Inapplicable	Inapplicable
Dilation in the ventral wall of the posterior region of the vagina	Absent	Present in some specimens	Absent	Absent	Absent	Absent
Corrugation on the dorsal wall of the posterior region of the vagina*	Absent	Absent	Absent	Absent	Absent	Strongly undulated
Extension of the spermatheca in relation to its duct *	Approximate to the duct	Approximate to the duct	Approximate to the duct	Approximate to the duct	Below the duct	Approximate to the duct
Route of the spermioduto from the genital crossroads to the prostate*	Winding	Winding	Rectilineal	Rectilineal	Rectilineal	Winding
Shape of the prostate diverticula*	Tree-like	Tree-like	Simple or subdivided	Tree-like	Tree-like	Tree-like
Number of prostate diverticula*	10 to 29	18 to 23	0 to 4	14 to 17	12 to 18	12 to 18
Aspect of the penial complex (sheath and prepuce)*	Robust	Slender	Robust	Robust	Slender	Robust
Width of the penial sheath in relation to the prepuce*	Narrow (less than 50%)	Narrow (less than 50%)	Wide (greater than 50%)	Wide (greater than 50%)	Wide (greater than 50%)	Wide (greater than 50%)
Extension of the penial sheath in relation to the prepuce*	Approximate length to the prepuce	Approximate length to the prepuce	Approximate length to the prepuce	Approximate length to the prepuce	Length longer than the prepuce (2 to 4 times)	Length longer than the prepuce
Dimension of the prepuce*	Wider free termination	Same diameter along its whole length	Same diameter along its whole length	Wider free termination	Subtly wider free termination	Wider free termination

*morphological characters with expressive anatomical characteristics

(Tables 2 and 3, Figures 2 to 8, Appendix 1 and 2). The morphological differences found in the reproductive system are related to the following structures: ovotestis diverticula, seminal vesicle, oviduct pouch, vaginal pouch, vaginal corrugation, spermatheca duct, spermatheca, spermiduct, prostate diverticula and penial complex.

Some of the morphological characters are intrinsic to four out of the six species studied, which are from *Biomphalaria oligoza* (Figures 4 and 6): 1- conglomeration portion of the seminal vesicle consisting of nodular formations, 2- discrete aspect of the vaginal pouch, 3- simple prostate diverticula, bifurcated or trifurcated and 4- reduced number of prostate diverticula; *Biomphalaria schrammi* (Appendix 1, Figures 2 and 6)*:* 1- presence of internal lamellae on the last suture of the shell, 2- opening of the shell strongly reflected to the left, 3- elongated and transversely arranged stains on the mantle, 4- discrete aspect of the oviduct pouch, 5- spermatheca with inferior extension to the duct; *Biomphalaria tenagophila* (Figure 8): 1- bulging shape of the vaginal pouch; *Biomphalaria straminea* (Figure 5)*:* 1- strongly undulated corrugation on the dorsal wall of the posterior region of the vagina. *Biomphalaria peregrina* and *B. occidentalis* have important characters in the specific determination, which are not necessarily inherent in each one of them (Tables 2 and 3).

A larger number of morphological characters, with expressive anatomical specificities, are shared exclusively among species of pairs *B.*

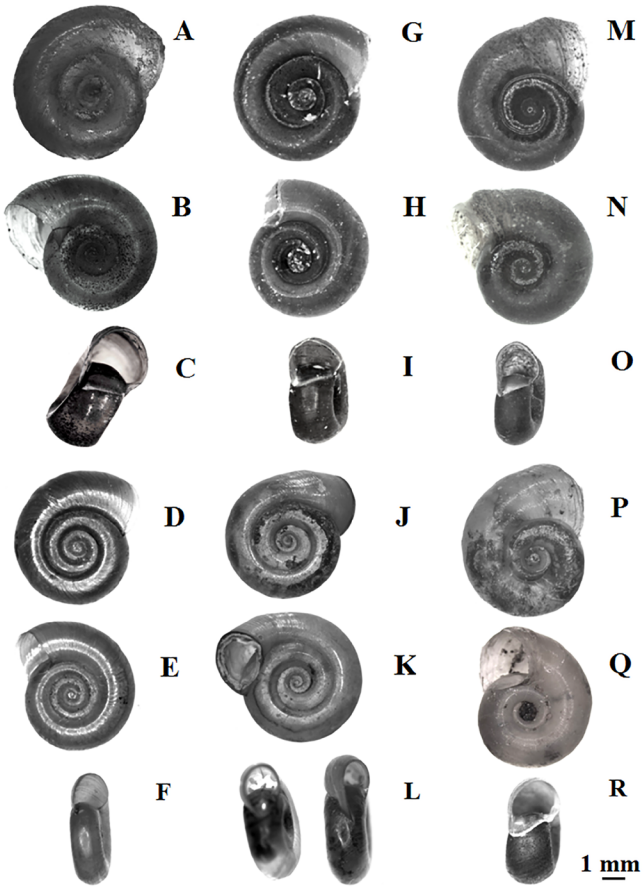

Figure 2. Right lateral views, left and front of shells of the *Biomphalaria* spp. A-C, *Biomphalaria tenagophila*; D-F, *Biomphalaria peregrina*; G-I, *Biomphalaria occidentalis*; J-L, *Biomphalaria schrammi*; M-O, *Biomphalaria oligoza*; P-R, *Biomphalaria straminea*.

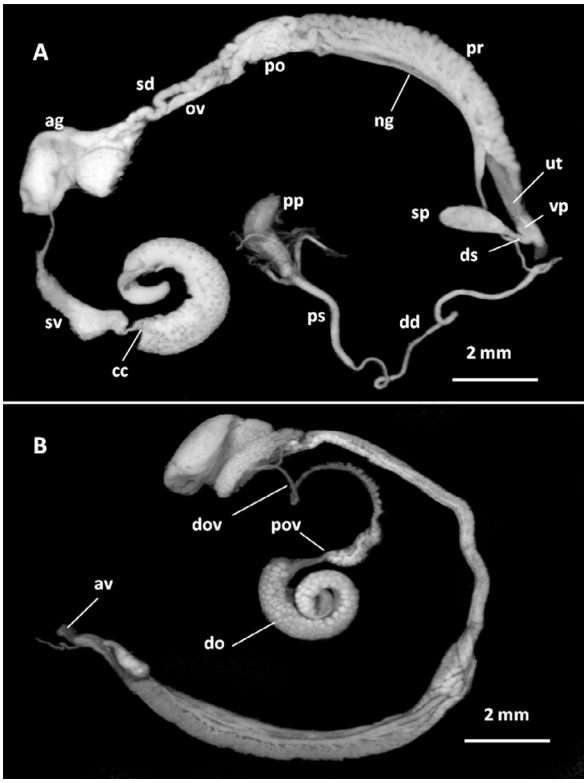

Figure 3. Genital organs. A, *Biomphalaria tenagophila*; *B, Biomphalaria occidentalis;* ag, albumen gland; av, anterior vagina; cc, free portion of the collector channel; dd, duct deferens; do, diverticula of ovotestis; dov, distal ovispermiduct; ds, duct of spermatheca; ng, nidamental gland; ov, oviduct; po, pouch of oviduct; pov, proximal ovispermiduct; pp, prepuce; pr, prostate; ps, penial sheath; sd, spermiduct; sp, spermatheca; sv, seminal vesicle; ut, uterus; vp, vaginal pouch.

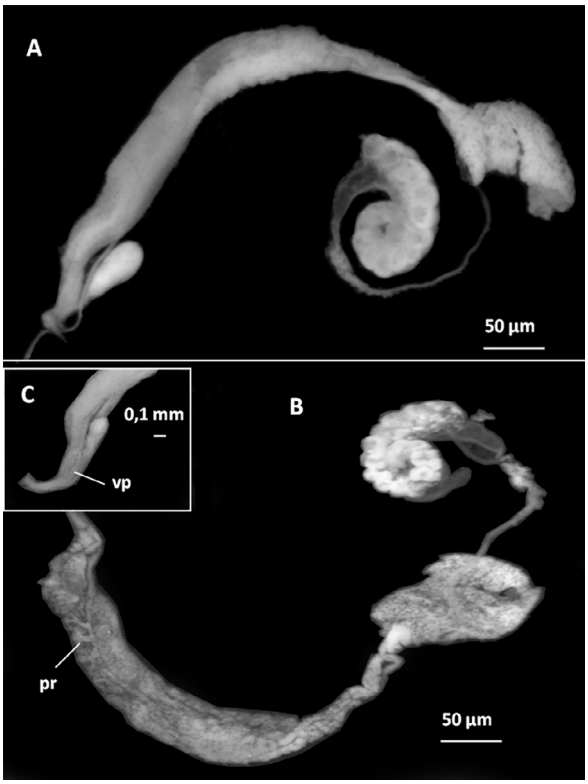

Figure 4. *Biomphalaria oligoza*. A and B, genital organs; C, detail of the vagina showing the vaginal pouch; vp, vaginal pouch; pr, prostate.

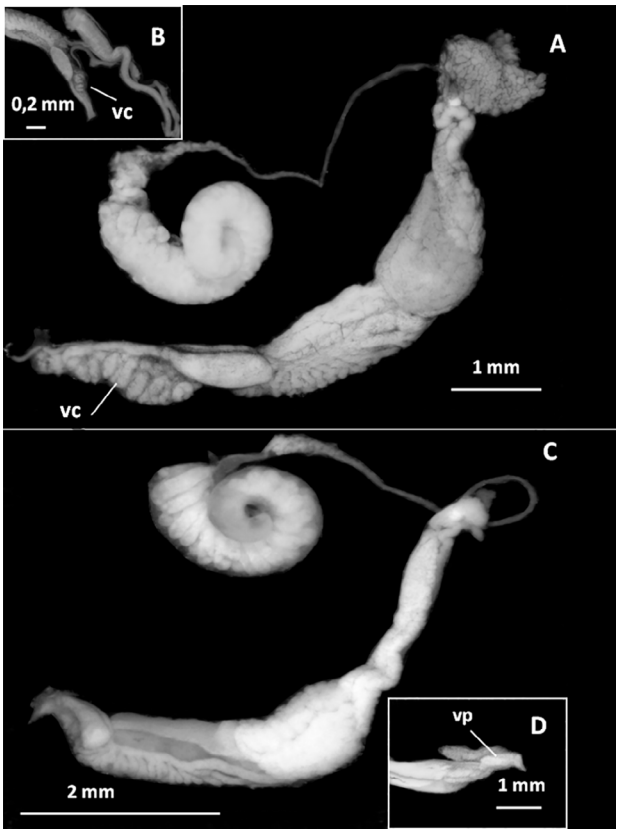

Figure 5. Genital organs. A and B, *Biomphalaria straminea* with detail of the vagina region showing corrugation; C and D, *Biomphalaria peregrina* with detail of the vagina showing the vaginal pouch; vc, vaginal corrugation; vp, vaginal pouch. Absent or partially absent albumen gland in both figures.

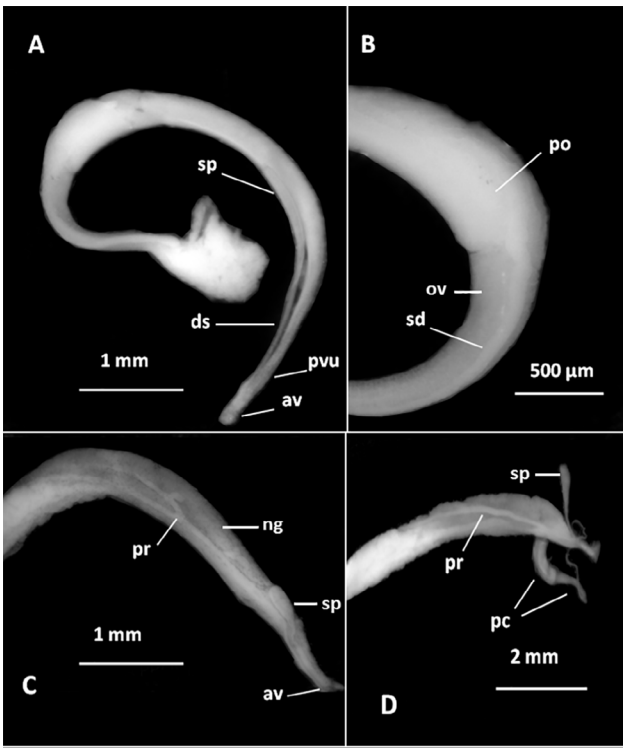

Figure 6. Genital organs. A and B, *Biomphalaria schrammi*; C and D, *Biomphalaria oligoza*; av, anterior vagina; ds, duct of spermatheca; ng, nidamental gland; ov, oviduct; pc, penial complex; po, pouch of oviduct; pr, prostate; pvu, region of the posterior vagina and uterus; sd, spermiduct; sp, spermatheca.

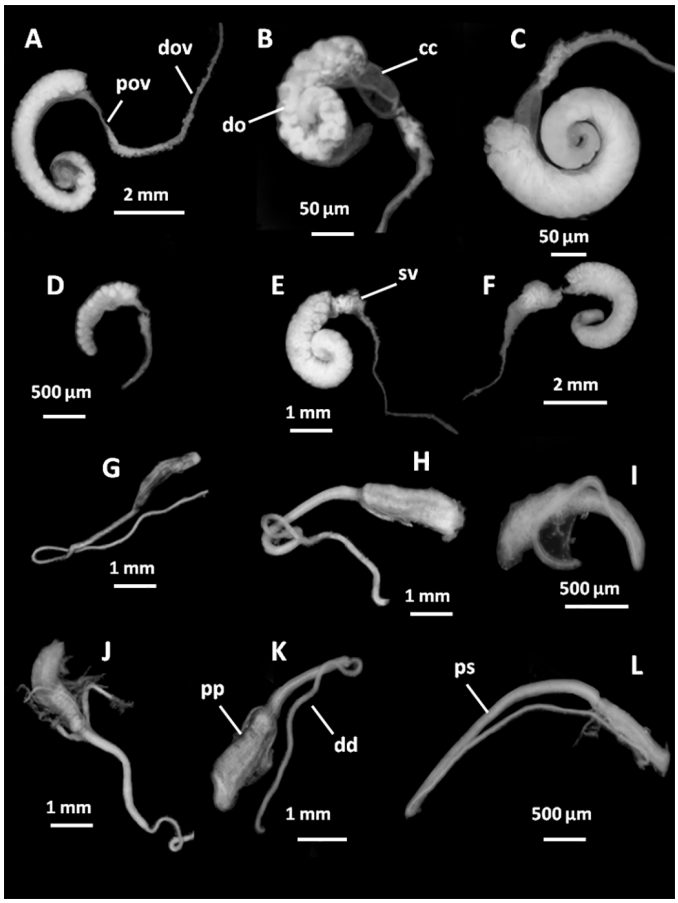

Figure 7. Ovotestis (A to F) and penial complex (G to L). A and G, *Biomphalaria occidentalis*; B and I, *Biomphalaria oligoza*; C and K, *Biomphalaria peregrina*; D and L, *Biomphalaria schrammi*; E and H, *Biomphalaria straminea*; F and J, *Biomphalaria tenagophila*; cc, free portion of the collector channel; dd, duct deferens; do, diverticula of ovotestis; dov, distal ovispermiduct; pp, prepuce; ps, penial sheath; pov, proximal ovispermiduct; sv, seminal vesicle.

tenagophila vs *B. occidentalis* (6/26) and *B. oligoza* vs *B. schrammi* (3/26) (Table 4). The other pairs of species share one or none morphological character with significant anatomical specificity (Table 4).

2. *Molecular analysis*

Molecular data consisted of an alignment of 567 pb of 124 specimens derived from the study area. The 122 COI sequences obtained in this study are presented in Table 1. Molecular results do not include two sequences of *B. oligoza*, due to the low quality of the sequences resulting from the amplification of genomic DNA with the COI-Folmer primers.

The number of COI sequences of the species reflects directly their population size in the study region. The total genetic variation in the set of 122 COI sequences is 3.0%, due to the genetic polymorphism in *B. tenagophila* and *B. straminea*, each species with 1.0% genetic variation (Table 5). Although low, the value obtained for *B. tenagophila* and *B. straminea* contrasts with null values obtained from sequences related to the species *B. occidentalis*, *B. peregrina* and *B. schrammi*, in which no intraspecific genetic variations were observed (Table 5).

The lowest interspecific genetic divergence values were observed in the *B. tenagophila* and *B. occidentalis* (5%) (Table 6), a pair of species which belongs to a species complex. In pair of species with

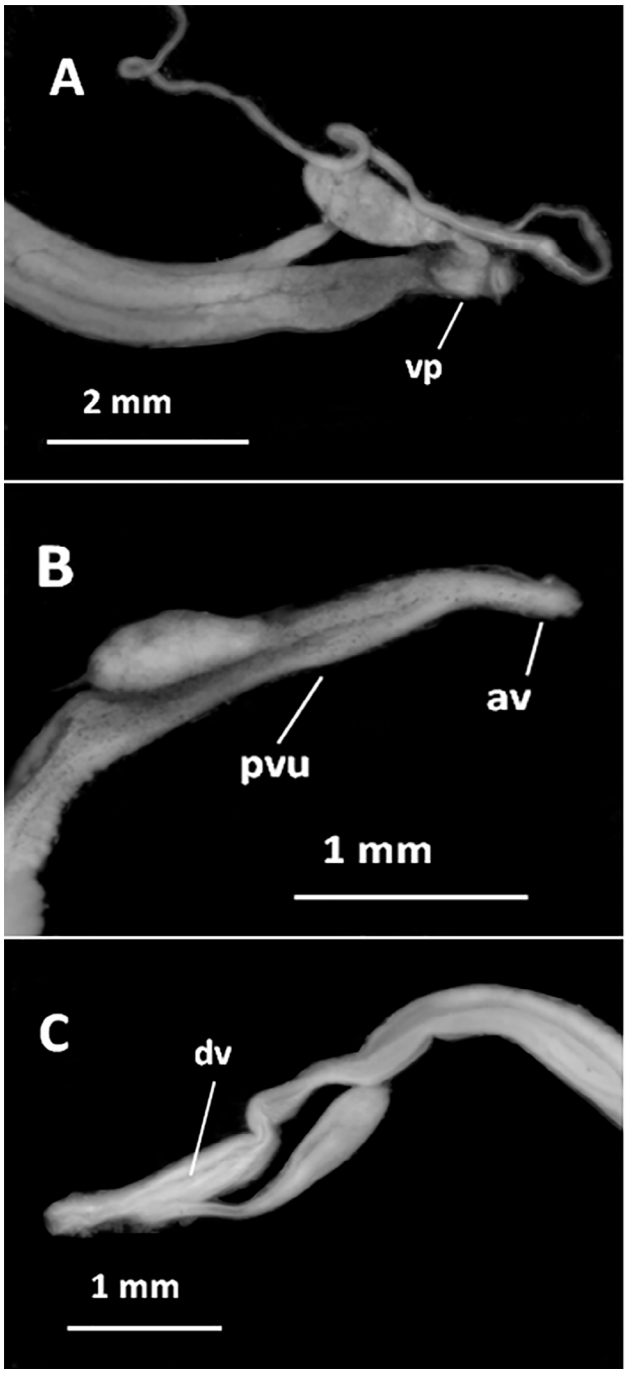

Figure 8. Region of the vagina. A, *Biomphalaria tenagophila*; B and C, *Biomphalaria occidentalis*; av, anterior vagina; dv, dilation of the vagina; pvu, region of the posterior vagina and uterus; vp, vaginal pouch.

high dissimilar morphology, the interspecific values vary from 9% to 13%.

Table 7 shows the results obtained through the analysis of the sequences in ABGD, bPTP and GMYC. The highest values of similarity indices between sequences of this study and sequences found in the Genbank correspond to the sequences of the specimens identified as *B. tenagophila, B. straminea*, and *B. occidentalis*. The similarity values between 97-98% were observed in the sequences from species identified as *B. peregrina*. A group of four sequences, whose specimens were identified as *B. schrammi*, showed lower similarity value (Table 7).

The results of the analysis of COI sequences by sequence delimitation methods in taxonomic units are the following:

For the range of intraspecific genetic divergence values (ABDG) of 0.013-0.021 there is high statistical probability of partitioning for 122 sequences in five groups of putative species (Group 1: *B. tenagophila*, Group 2: *B. occidentalis*, Group 3: *B. straminea*, Group 4: *B. schrammi* and Group 5: *B. peregrina*), the same was identified in bPTP method. There is a range of Barcoding Gap between these analyzed sequences (Figure 9).

The GMYC model which combines algorithms that consider constant speciation rates and coalescence identified 9 differentiated clusters, being 1 cluster with the sequences of *B. schrammi*, 1 cluster with the sequences of *B. peregrina*, 1 cluster with 2 sequences of *B. straminea*, 1 cluster with the sequences of *B. occidentalis* and five differentiated clusters resulting from the partitioning of *B. tenagophila* sequences, besides 1 undifferentiated sequence of *B. straminea* (Figure 10). The higher Likelihhod Score (LR) of the GMYC model that splits the sequences into 9 clustres (LR=1832.949) has a better fit on our data than for the null hypothesis, that considers that all the sequences belong to the same species (LR=1367.263).

The phylogenetic tree represented in Figure 10 shows high statistical support values for COI sequences, which come to an agreement with delimitation methods and the all specimens identified by morphology.

Discussion

1. Morphological taxonomy

Anatomical characters are the basis for identifying different species of the genus *Biomphalaria*. The shell and soft tissue structures, identified in the six studied taxa, are generally in accordance with the descriptions provided by Paraense (1966a, 1970, 1974, 1975, 1981) and Paraense et al. (1964). However, in our material, we observed morphological structures in the shell, mantle and vagina with different aspects from those available in the bibliography:

Table 4. Morphological characters with expressive anatomical specificities shared, exclusively, among *Biomphalaria* species. Total number of morphological characters considered = 26.

Morphological species	*B. tenagophila*	*B. occidentalis*	*B. oligoza*	*B. peregrina*	*B. schrammi*
B. tenagophila	26				
B. occidentalis	6	26			
B. oligoza	0	1	26		
B. peregrina	1	0	1	26	
B. schrammi	0	1	3	0	26
B. straminea	0	0	1	1	1

Table 5. COI-Folmer gene polymorphism in *Biomphalaria* spp. and in the five species from the Upper Tietê River Basin, calculated in DnaSP. (N= number of sequences, H = number of haplotypes, Hd= haplotypic diversity and variance (VHd), π= average number of differences between two sequences, K = average number of differences).

Morphological species	N	H	Hd	π	K
B. tenagophila	106	6	0.52±0.05	0.01	5.564
B. straminea	3	2	0.66±0.31	0.01	8
B. occidentalis	4	1	0	0	0
B. peregrina	5	1	0	0	0
B. schrammi	4	1	0	0	0
Biomphalaria spp.	122	11	0.64±0.04	0.03	16.34

Table 6. Values of Kimura-2p genetic divergence calculated for the intra and interspecific species in the Upper Tietê River Basin.

Morphological species	*B.tenagophila*	*B.occidentalis*	*B.straminea*	*B.schrammi*	*B.peregrina*
B.tenagophila	0-0.03				
B.occidentalis	0.05	0-0.00			
B.straminea	0.09	0.09	0-0.01		
B.schrammi	0.12	0.11	0.12	0-0.00	
B.peregrina	0.12	0.11	0.10	0.13	0-0.00

Table 7. Similarity indices between the 122 COI sequences of the *Biomphalaria* obtained in this study, sequences provided by the Genbank and taxonomic molecular units (MOTUs) estimated following the ABGD, bPTP and GMYC methods. (NS= Number of Specimens, NH= Number of Haplotypes, NPS= Number of Putative Species).

Morphological species	NS	GenBank sequences	GenBank best-fit	GenBank similarity	NH	ABGD	bPTP	GMYC
B. tenagophila	106	106	*B. tenagophila*	99-100%	6	1	1	5
B. straminea	3	96	*B. straminea*	99-100%	2	1	1	1
B. occidentalis	4	21	*B. occidentalis*	99-100%	1	1	1	1
B. peregrina	5	14	*B. peregrina*	97-98%	1	1	1	1
B. schrammi	4	0	Planorbidae	91%	1	1	1	1
NPS						5	5	9

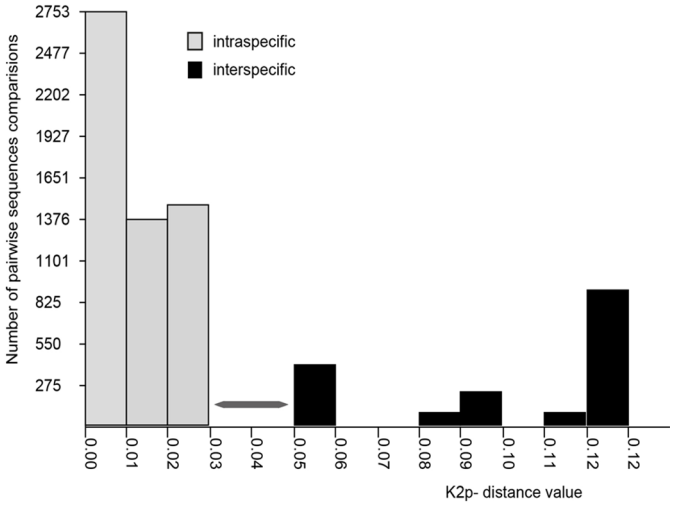

Figure 9. Frequency distribution of K2p-distances within the 122 COI sequences as calculated by ABGD. Gap (-).

1- *Biomphalaria schrammi* with up to 4 mm shell diameter are characterized by Paraense (1975) with shells devoid of lamellae and openings directed forward, suggesting that the opening of the shell leans to the left only after the appearance of the lamellae. Unlike what is mentioned by Paraense (1975), in our material, we verified specimens of *B. schrammi* with shell diameter greater than 4 mm, with and without lamellae, and the opening was deflected to the left in all of them (Figure 2).

Notwithstanding, we observed variation in the degree of deflection between shells with and without internal lamellae. In shells without lamellae, deviation is lower than in those that present lamellae. These are intra-population variations of *B. schrammi* that may be associated with a greater adaptation that some snail species present in the face of environmental adversity (Medeiros et al. 2015).

Nevertheless, we consider that the degree of deflection of the *B. schrammi* shell opening is visually stronger than in *B. peregrina* and *B. straminea*, in which the shell opening has a slight inclination, although it also faces to the left (Figure 2).

2-The diameter of the shell, according to Paraense (1970), is related to the pigmentation of the mantle. Adult individuals of species with greater shell diameter, such as *B. tenagophila* and *B. occidentalis*, have a homogeneous mantle pigmentation pattern differing from species of snails with smaller shell diameter, such as *B. oligoza*, *B. peregrina*, *B. schrammi* and *B. straminea* that have mantles with stains and punctuation at any age (Appendix 1). PAHO (1968) and Paraense (1966a, 1970, 1974) do not mention differences in the mantle pigmentation pattern of these last four species.

In our material, we observed that the pigmentation pattern of *B. schrammi* mantle is mostly with elongated patches transversely

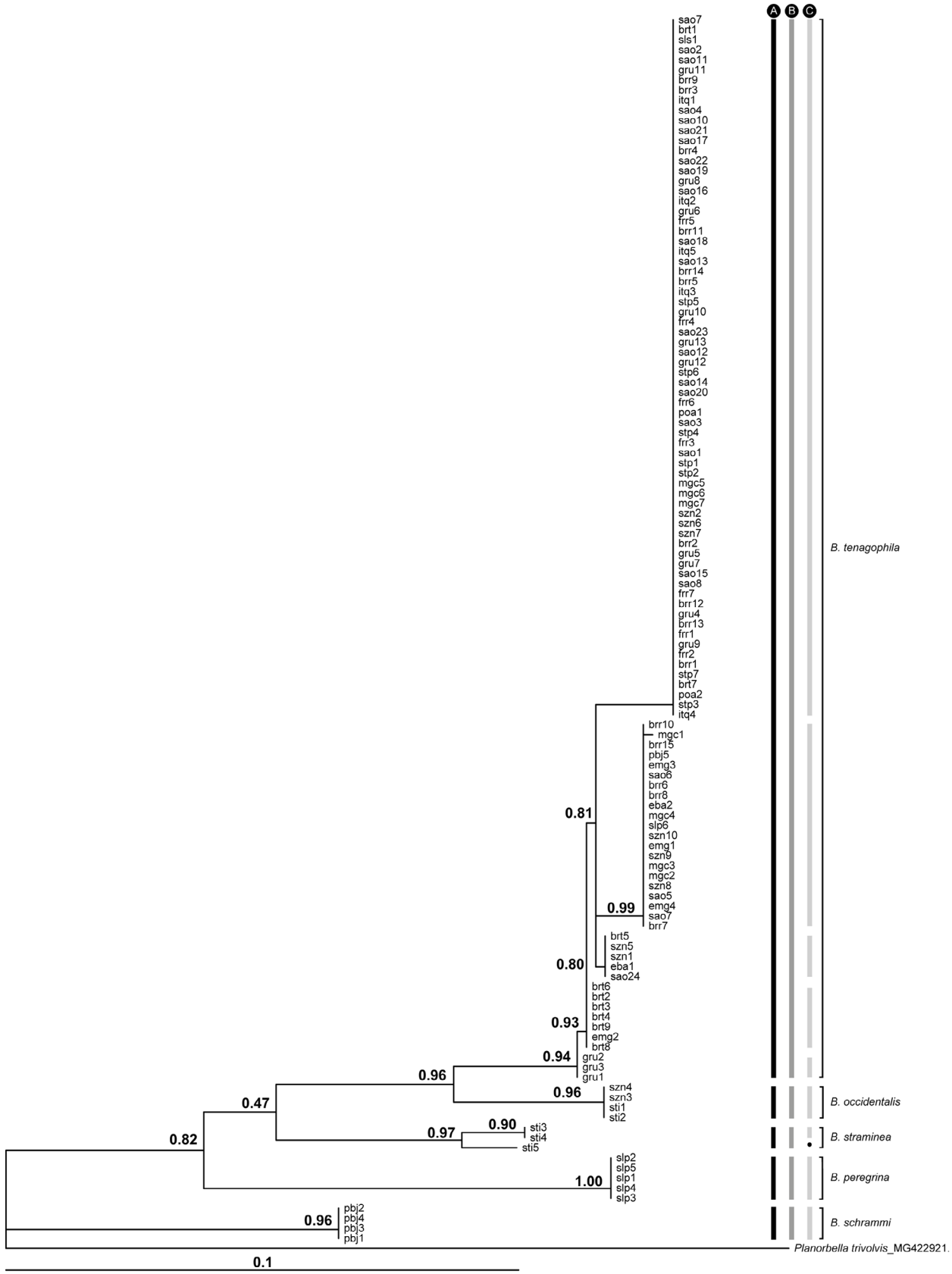

Figure 10. Maximum Likelihood phylogenetic tree of the 122 *Biomphalaria* COI sequences, plus one sequence of *Planorbella trivolvis* used as outgroup. Grey bars represent the putative species as inferred by ABGD distance-method (A) and tree-based methods bPTP (B) and GMYC (C). All 122 sequences are assigned to named taxa by morphology-based identification. The tree was constructed on PHYML based on GTR + I model and branch support values calculated by Shimodaira-Hasegawa [SH]-aL.RT. brr, Barueri; brt, Biritiba Mirim; eba, Embu das Artes; emg, Embu Guaçu; frr, Franco da Rocha; gru, Guarulhos; itq, Itaquaquecetuba; mgc, Mogi das Cruzes; pbj, Pirapora do Bom Jesus; poa, Poá; sao, São Paulo; slp, Salesópolis; sls, São Lourenço da Serra; sti, Santa Isabel; stp, Santana de Parnaíba; szn, Suzano.

distributed on the mantle. This stain pattern gives the *B. schrammi* mantle a brindled appearance, which differs from the pattern presented by *B. oligoza*, *B. peregrina* and *B. straminea*, whose rounded or misshapen patches give the mantle a marbled appearance (Appendix 1).

3- The posterior region of the vagina has taxonomic relevance by the presence of a strongly corrugated area, as in *B. straminea* (Paraense 1975, 1988, Palasio et al. 2017), or a vaginal pouch, as in *B. tenagophila*, *B. oligoza* and *B. peregrina* (Paraense 1974, 1975, Paraense et al. 1964).

In our material, we observed a phenotypic difference as to the shape of the vaginal pouch, being possible to distinguish the bulged vaginal pouch of *B. tenagophila* (Figures 3 and 8) from the elongated vaginal pouch of *B. oligoza* (Figure 4) and *B. peregrina* (Figure 5). However, this difference is very subtle in young specimens, which may hinder the correct determination of the aforementioned species and, consequently, may generate false diagnoses.

Biomphalaria occidentalis (Figure 8B), like *B. schrammi* (Figure 6), has the posterior region of the smooth vagina, devoid of vaginal pouch or corrugated area (Paraense 1975, 1981, 1988).

Some specimens of *B. occidentalis* from Suzano presented a small and elongated dilatation on the ventral wall of the posterior region of the vagina (Figure 8C) that is confused with the conspicuous vaginal pouch found in *B. tenagophila* (Figure 8A). Findings such as these were also observed by Paraense (1981) in *B. occidentalis* from Campo Grande, Mato Grosso do Sul. In this case, histological studies are needed to clarify the microanatomy of the posterior region of the vagina, as morphological variations within the same species can lead to diagnostic errors.

Biomphalaria oligoza, *B. schrammi*, *B. straminea* and *B. tenagophila* have inherent morphological characters to the taxa themselves. Already, the determining morphological characters to *B. peregrina* and *B. occidentalis* are common also to one or another of the other studied taxas.

The exclusive sharing of a larger number of morphological characters, with expressive anatomical specificities, as verified between *B. tenagophila* vs *B. occidentalis* (6/26 characters) and *B. oligoza* vs *B. schrammi* (3/26 characters), indicates that these are pairs of closest species. The closeness between *B. tenagophila* and *B. occidentalis* is expected, once both species are members of a complex. The common characters among the species of the two pairs make it difficult to delimit the taxas involved and, consequently, can generate false diagnoses.

This differed from what was observed in the relationships between other species (Table 4), which have low or zero amounts of morphological characters, with expressive anatomical specificities, common among paired species, showing that they are pairs whose species are better defined morphologically, with anatomical variations that may be intrinsically related to their evolutionary histories.

2. *Molecular taxonomy*

The molecular results are in agreement to specimens morphologically identified as *B. occidentalis*, *B. peregrina*, *B. straminea* and *B. tenagophila*. The COI-FOLMER sequences also obtained high similarity values in relation to the nominal species deposited in GenBank. In the case of *B. schrammi*, the sequences resulted in the lowest similarity value in the GenBank, which is why these sequences were identified in a supra-specific taxonomic group (Planorbidae Family). It is important to emphasize that, in relation to *B. schrammi*, the DNA Barcode sequences of this species obtained in our study are unique and unpublished in the GenBank.

In *B. tenagophila*, differences were found in relation to the statistical methods employed for the delimitation of MOTUs; ABGD and bPTP that gather the sequences of *B. tenagophila* in a single taxonomic unit, while in GYMC the sequences are divided into five molecular units (Figure 10). Among the three methods used, in GYMC the sampling, population size, and speciation rate are aspects that may interfere when estimating taxonomic molecular units (Fujisawa & Barraclough 2013, Fontaneto et al. 2015). In the Upper Tietê River Basin, of the six *Biomphalaria* represented in this study, *B. tenagophila* is the most abundant species. The population size and the intraspecific diversity of *B. tenagophila*, represented by numerous mitochondrial haplotypes (H = 6) herein (Table 5), are aspects that may have caused decreased accuracy of GYMC in comparison to ABGD and bPTP.

The statistical methods employed in this work by DNA Barcode determine, with robustness, the limits of each species belonging to the pairs aforementioned in the morphological study (*B. tenagophila* vs *B. occidentalis*). The maximum likelihood analysis recovered *B. tenagophila* and *B. occidentalis* in differentiated branches, with high values of statistical support, which indicates the high resolution potential of the phylogenetic analysis in the delimitation of these morphologically similar species. For that reason, in the case of *B. tenagophila* and *B. occidentalis*, molecular characters may be more resolutive in taxonomic terms than morphological taxonomy.

The pairs of species with the most significant degrees of morphological differentiation (*B. tenagophila* vs *B. schrammi*, *B. tenagophila* vs *B. straminea*, *B. tenagophila* vs *B. peregrina*, *B. occidentalis* vs *B. peregrina*, *B. occidentalis* vs *B. straminea*, *B. occidentalis* vs *B. schrammi*, *B. straminea* vs *B. schrammi*, *B. straminea* vs *B. peregrina* and *B. schrammi* vs *B. peregrina*) also have high genetic distance values (9 a 13%) (Table 6). Their genetic divergence values are high enough to delimit these species by DNA Barcode (Hebert et al. 2013), indicating that this is an accurate molecular method for these species pairs.

3. *Morphological taxonomy integrated with molecular taxonomy in specific determination*

Traditional taxonomy, when associated with more sophisticated study methods, such as the use of molecular markers, makes diagnoses more consistent. Among the advantages of using the traditional taxonomy is the low cost, especially in areas with high species diversity and lack of financial resources for research, and the fact that the classification of species is fast, didactic, and understandable for people and professionals who have no prior knowledge of molecular methods (Barros 2015).

Using taxonomic surveys of freshwater organisms as reference, Stein et al. (2014) calculated that the total cost of identifying 200 molecular taxonomic units made by DNA barcode and Sanger sequencing is approximately 1.7 times greater than the cost of obtaining results through morphology.

The molecular approach is similar to the morphological approach when using delimitation methods for species based on distance (ABGD) and phylogeny (bPTP). Due to its high resolution in ABGD and BPTP, the DNA barcode has the potential to impart greater objectivity to the morphological identification and can be used as a control for the characterization of *Biomphalaria* species. The disparity between molecular and morphological results in GMYC is expected, because of a

higher probability of coalescence of *B. tenagophila* and *B. straminea* in differentiated lineages over time and is therefore an important indicator of the evolutionary factors of these species.

In *Biomphalaria*, the number of COI sequences deposited in the GenBank is significantly higher for intermediate host species of the *S. mansoni* (Figure 11). The extension of the database in Genbank or BOLD with the insertion of COI sequences for all *Biomphalaria* species is fundamentally important to a solid analysis of the application limits of the molecular approach in the delimitation of taxonomic units.

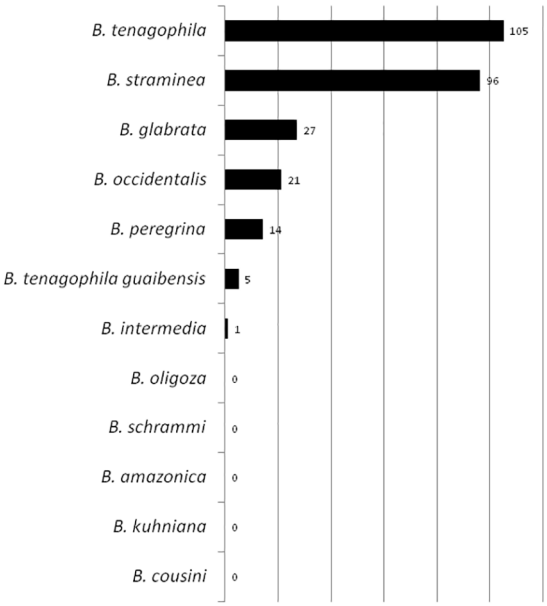

Figure 11. Number of partial sequences of the mitochondrial COI gene deposited in GenBank for different *Biomphalaria* species found in Brazil.

Conclusions

1. Our results show that the fundamental morphological characters in determining the six *Biomphalaria* studied relate to shell (shape of turns, shape and position of the opening, carenas and lamellae), to mantle (pigmentation pattern of the mantle and stains), and to the reproductive system, which has the greatest number of diagnostic characters, related to ovotest, seminal vesicle, oviduct pouch, vaginal pouch, vaginal corrugation, spermatheca duct, spermatheca, spermoduct, prostate and penial complex.

2. *Biomphalaria oligoza, B. schrammi*, *B. straminea* and *B. tenagophila*, which presented inherent morphological characters, are considered species with decisive characteristics for diagnostic classification of taxa. In contrast, specific determination of *B. peregrina* and *B. occidentalis* is based on a sum of morphological characters.

3. The high number of common morphological traits among the pairs of species *B. tenagophila vs B. occidentalis* and *B. oligoza* vs *B. schrammi* indicates that there is a close relationship between these taxa.

4. In the following pairs of species *B. tenagophila* vs *B. oligoza*, *B. tenagophila* vs *B. schrammi*, *B. tenagophila* vs *B. straminea*, *B. tenagophila* vs *B. peregrina*, *B. occidentalis* vs *B. oligoza*, *B. occidentalis* vs *B. peregrina*, *B. occidentalis* vs *B. schrammi*, *B. occidentalis* vs *B. straminea*, *B. oligoza vs B. peregrina, B. oligoza vs B. straminea, B. peregrina vs B. schrammi, B. peregrina vs B. straminea* and *B. schrammi* vs *B. straminea*, the low or nonexistent sharing of morphological characters indicates that the relationship between the taxa of each pair is weak.

5. Resoluteness and effectiveness are two of the critical characteristics of DNA Barcoding for taxonomic biodiversity studies in *Biomphalaria*. The use of DNA Barcoding combined with morphological taxonomy can help to solve some taxonomical problems, resulting in advantages to geographically extensive malacological surveys.

6. The presence of *B. tenagophila*, the intermediate host of *S. mansoni* in the hydrographic network of the Upper Tietê River Basin indicates that this region is a hot-spot for the transmission of schistosomiasis. The occurrence of *B. peregrina* and *B. straminea* in the Upper Tietê River Basin requires attention. The former is a potential intermediate host of *S. mansoni* (Paraense & Corrêa 1973) and the latter an intermediate host of the parasite in nature (Paraense 2001). *Biomphalaria straminea* is the main intermediate host for *S. mansoni* in the northeast of Brazil (Figueiredo 1989, Ohlweiler et al. 2010). Its high capacity to spread through new water collections (Pointier et al. 2005, Palasio et al. 2019) may facilitate the expansion of the species in the state of São Paulo. This poses a challenge to control the disease, which requires monitoring and constant mapping of water bodies and the snails associated with them.

Supplementary material

The following online material is available for this article:

Appendix 1 - Pigmentation of the mantle. A, adult specimen of *Biomphalaria tenagophila*; B, young specimen of *Biomphalaria tenagophila*; C, *Biomphalaria oligoza*; D, *Biomphalaria straminea*; E, adult specimen of *Biomphalaria. occidentalis*; F, young specimen of *Biomphalaria occidentalis*; G, *Biomphalaria peregrina*; H, *Biomphalaria schrammi*.

Appendix 2 - Kidney tube of *Biomphalaria tenagophila*. A and B, salience that runs obliquely along the kidney tube; C, salience of the kidney tube in cross-section; D, smooth kidney tube. s, salience; k, kidney tube.

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Author Contributions

Fernanda Pires Ohlweiler: Obtaining financial resources from Fapesp. Conceptual and design of the study. Collection, analysis and interpretation of morphological data. Preparation and critical review of the manuscript, including the morphological and molecular study.

Thays de Jesus Rossignoli: Collection and analysis of morphological data. Extraction and amplification of genomic material to obtain COI sequences. Preparation of the manuscript.

Raquel Gardini Sanches Palasio: Performed the DNA Barcoding experiments. Analysis and interpretation of molecular data. Geospatial mapping. Preparation of the manuscript.

Roseli Tuan: Conceptual and practical framework for DNA Barcoding analysis, critical revision, adding intellectual content to molecular analysis.

Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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Article

Major range extensions for three species of porcupines (Rodentia: Erethizontidae: *Coendou*) from the Brazilian Amazon

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Abstract: We report range extensions for three species of Amazonian erethizontids, *Coendou bicolor*, *C. ichillus*, and *C. nycthemera*. We record *C. ichillus* for the first time in Brazil, from Rio Japurá, state of Amazonas. We record *C. bicolor* for the first time in the state of Amazonas, which represents a range extension of approximately 905 km. We also extend the occurrence of *C. nycthemera* 620 km to the south into Mato Grosso state. All records are based on museum specimens, highlighting the importance of scientific collections as biodiversity databases and emphasizing the lack of research on Amazonian porcupines.
Keywords: Coendou bicolor, Coendou ichillus, Coendou nycthemera, museum specimens, new record.

Extensão de distribuição de três espécies de porcos-espinhos, gênero *Coendou* (Rodentia: Erethizontidae) da Amazônia brasileira.

Resumo: Aqui nós relatamos ampliação de distribuição de três espécies de eretizontídeos amazônicos: *Coendou bicolor, C. ichillus* e *C. nycthemera*. Nós registramos pela primeira vez *C. ichillus* no Brasil, no Rio Japurá, estado do Amazonas. Registramos *C. bicolor* pela primeira vez no estado Amazonas, o que representa uma ampliação de distribuição de aproximadamente 905 km. Também estendemos a ocorrência de *C. nycthemera* 620 km ao sul, no estado de Mato Grosso. Todos os registros são baseados em espécimes de museu, enfatizando a importância das coleções científicas como bancos de dados da biodiversidade e a destacando ausência de pesquisas para porcos-espinhos amazônicos.
Palavras-chave: Coendou bicolor, Coendou ichillus, Coendou nycthemera, espécime de museu, novo registro.

Introduction

New World porcupines (family Erethizontidae) are nocturnal and arboreal rodents with prehensile tails and with hairs modified into sharped quills (Emmons 1997). Erethizontids are distributed from Canada to Uruguay and Argentina (Emmons 1997, Voss 2015). There are 17 species recognized in the family Erethizontidae of which 15 belong to the genus *Coendou* Lacépède, 1799 (Voss 2015, Feijó & Langguth 2013, Mendes Pontes et al. 2013). Brazil is the country with the highest diversity of erethizontids, which includes the Atlantic forest endemic, *Chaetomys subspinosus*, together with nine species of *Coendou,* of which five are endemic to the country: *C. nycthemera, C insidiosus, C. roosmalenorum, C. baturitensis* and *C. speratus* (Feijó & Langguth 2013, Voss 2015, Mendes Pontes et al. 2013, de Freitas et al. 2013).

As cryptic animals, rarely observed in the wild and underrepresented in collections, there are several gaps in the knowledge about the distribution of most porcupine species (Leite et al. 2011, Voss et al. 2013, Feijó & Langguth 2013, Mendes Pontes et al. 2013). The records for many species are limited to a small number of specimens (e.g. *Coendou melanurus* as pointed by Voss et al. 2001) or biased towards the surroundings of urban centres and river margins (see maps 405-417 in Voss 2015). Several new distributional records of porcupine species were made recently: *Coendou bicolor* had new records from Brazil (de Freitas et al. 2013) and a possible record for Colombia (Ramírez-Chaves et al. 2016), *Coendou speratus* had a distributional gap filled in northeastern Brazil (Nascimento & dos Santos 2014), *Coendou ichillus* had new records from Peru (Gregory et al. 2015) and Colombia (Ramírez-Chaves et al. 2016), and *Coendou rufescens* had new records for Ecuador (Narváez-Romero et al. 2018).

In this report, we present new geographical records and updated distribution maps of three species of Amazonian *Coendou*, with the first records of *C. ichillus* for Brazil and major range extensions of *C. bicolor* and *C. nycthemera*.

Material and Methods

Specimens (skin, crania, and partial skeletons) of erethizontids were examined in the scientific collections of the American Museum of Natural History (AMNH) in New York, USA; Universidade do Estado de Mato Grosso, campus Alta Floresta (CZAF) in Alta Floresta, Brazil; the Field Museum of Natural History (FMNH) in Chicago, USA; Universidade Federal da Paraíba (UFPB) in João Pessoa, Brazil; Museu Nacional (MNRJ) in Rio de Janeiro, Brazil; Museu Paraense Emílio Goeldi (MPEG) in Belém, Brazil; Museu de Zoologia da Universidade de São Paulo (MZUSP) in São Paulo, Brazil; Universidade de Brasília (UnB) in Brasília, Brazil.

A total of 130 porcupine specimens representing species that occur in the Amazonia were examined (Appendix 1), including the types of *C. baturitensis, C. ichillus,* and *C. prehensilis*. Taxonomic determination was based on published studies (Feijó & Langguth 2013, Handley & Pine 1992, Voss & Angermann 1997, Voss & da Silva 2001, Voss et al. 2001, Voss 2011, 2015). The external measurements are the length of head-and-body (HBL) and length of tail (LT) following the protocol in Voss & Angermann (1997). External measurements were extracted from specimen labels. We estimated the area (in km^2) of species distribution range based on the minimum convex polygon using ArcMap software version 10.2.

Results

Figure 1 shows the updated distribution map of *Coendou bicolor, C. ichillus,* and *C. nycthemera*, and Table 1 has the detailed localities. We did not map the record of "*Coendou* cf. *bicolor*" for Boyacá, Colombia (Ramírez-Chaves et al. 2016) because it is based on a cranium without an associated skin, and the authors did not consider *C. bicolor* distinguishable from *C. prehensilis* by cranial characters alone.

The new records of *Coendou nycthemera* are based on three specimens (CZAF-MA 9, 10, 11, stuffed skins without associated skulls – Figure 2b), an adult male and a female from the right bank of the Rio Teles Pires, and a juvenile (sex undetermined) from the opposite bank of the same river (Table 1). All three records were made in the vicinity of a hydroelectric power plant, the Usina Hidrelétrica Teles Pires, Mato Grosso state, and were previously identified as *"Coendou melanurus*". Brandão et al. (2019) identified one of these CZAF specimens as "*Coendou* cf. *nycthemera*", but those authors could not confirm the identity of the specimen. These new records extend the known geographic range of *C. nycthemera* approximately 620 km from the closest locality to the northwest (Igarapé Auará, on the left bank of Rio Madeira) and 950 km from the closest locality to the northeast (Capitariquará, on Rio Tocantins), representing a southward area extension of about 41% (Figure 1).

Coendou nycthemera can be externally diagnosed from its congeners by its size, length of soft hairs relative to quills, and color pattern of dorsal quills (Table 2). *Coendou nycthemera* is slightly smaller than *C. melanurus* and significantly smaller than *C. baturitensis* and the Amazonian populations referred to *C. prehensilis* (Table 2). The distal band of the tricolored quills of *C. nycthemera* is very short, inconspicuous or absent, and its colour may be whitish, yellowish or orangish (Figure 3d). Furthermore, *Coendou nycthemera* differs from the similar-sized *C. melanurus* and *Coendou roosmalenorum* by lacking a long, soft fur covering its quills (Voss & Angermann 1997, Handley & Pine 1992). The distal band of the guard hairs of *C. melanurus* are always long and pale yellowish (Voss et al. 2001). *Coendou nycthemera* has only bicolored quills on its rump whereas *C. baturitensis* and Amazonian *C. prehensilis* have tricolored and bicolored quills on rump. It also differs from *C. baturitensis* by the dark brownish or black short medial band of the tricolored quills and distal band of bicolored quills (Figure 3). In *C. baturitensis* the medial band of the tricolored quills and the distal band of the bicolored quills are light brownish (Feijó & Langguth 2013).

The range extension of *Coendou bicolor* is based on two specimens previously identified as *Coendou prehensilis*, a juvenile of unknown sex (MPEG 24574, stuffed skin and skull) and an adult female (MPEG 37122, stuffed skin without associated skull – Figure 2a), both from Estação Ecológica Mamirauá, Uarini, in Amazonas State (Table 1). These records expand the known distribution of *C. bicolor* approximately 905 km northeast from Senador Guimard, Acre, Brazil, the closest record in Brazil (de Freitas et al. 2013) and approximately 1,250 km northeast from Río Alto Ucayali, Ucayali, Peru, the closest record outside Brazil (Voss 2015). The new record comprises an eastward area extension of 53% (Figure 1). *Coendou bicolor* is a large porcupine (Table 2) and has no distal bands on its quills (Figure 3c) and no tricolored quill on the rump, differing from the Amazonian *C. prehensilis* and the northeastern Brazil *C. baturitensis*, both of which have tricolored quills (Figure 3a-b). *Coendou bicolor* does not have soft fur covering its quills (Voss 2011) differing from *C. melanurus*

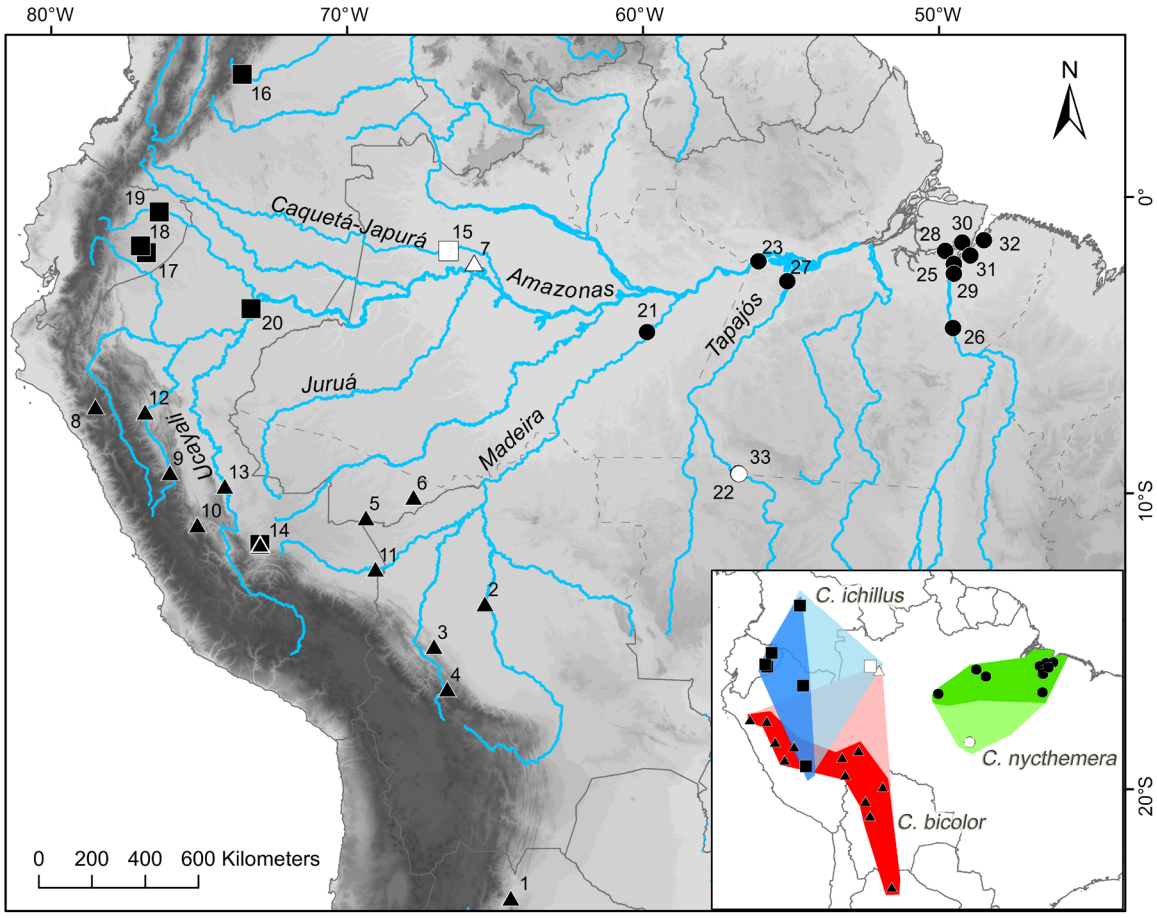

Figure 1. Updated distribution map of *Coendou bicolor* (triangles), *C. ichillus* (squares), and *C. nycthemera* (circles). New records are represented by white symbols. Detailed locality data is in Table 1. Inset map shows the previous distribution (darker shades) and the updated polygon (lighter shades) of *C. bicolor* (red), *C. ichillus* (blue), and *C. nycthemera* (green).

(Voss et al. 2001) and *C. roosmalenorum* (Voss & da Silva 2001). We compared specimen MPEG 24574 with juveniles of other species housed in the visited collections. It has dorsal tricolored quills with a very short orangish distal band and a very wider medial blackish band. Its rump and tail lack tricolored quills and have a soft ventral pelage. These characteristics are more similar to the adult MPEG 37122 than to the juveniles of other species.

The record of *Coendou ichillus* is based on an adult male (MZUSP 11465, Figure 2c), collected on November 21, 1977, on the margins of Rio Japurá, at Limoeiro in Amazonas State (Table 1). The specimen is preserved as an open skin with the cranium and skeleton removed and was previously identified as "*Coendou prehensilis"* by P.E. Vanzolini. This is the first record of *C. ichillus* in Brazil and extends its distribution eastwards approximately 790 km from Iquitos, Peru, the closest known record (Voss & da Silva 2001), representing an increase of 55% on its estimated distribution area (Figure 1). The specimen matches the *C. ichillus* description given by Voss & da Silva (2001) and it is a medium-sized porcupine (Table 2) that differs from the similar *C. melanurus* and *C. roosmalenorum* by the absence of long hairs covering its quills and from *C. nycthemera* by the presence of tricolored bristle-quills on its dorsum (Voss & da Silva 2001). It is also distinct from the larger *C. prehensilis* and *C. baturitensis* by the lack of tricolored quills on the rump and the presence of bristle-like quills on the dorsum (Figure 3g).

Discussion

Natural history information on *Coendou* species is scant in the literature, especially for the Amazonian taxa (Voss, 2015). Even their distribution ranges are poorly defined. For example, Voss (2015) considered *C. nycthemera* associated with the lower Amazonas, Madeira, and Tocantins rivers. With the new record presented here, we demonstrate that *C. nycthemera* occurs further south, along the banks of the Rio Teles Pires in Mato Grosso (Figure 1). Considering the new potential distribution of *C. nycthemera*, it is plausible that it also occurs in the Amazon of the state of Maranhão, as suggested by de Oliveira et al. (2007), and in the northern tip of the state of Tocantins.

Coendou bicolor was previously thought to occur exclusively along the Andean foothills and in adjacent lowland forest (Voss, 2015), our record from the Brazilian state of Amazonas expands its potential distribution area in about 53% towards central Amazon. Similarly, *C. ichillus* had a restricted distribution limited to east Ecuador, north Peru, and Colombia, and the record from Rio Japurá increases by 55% its potential range (Figure 1). Altogether, our findings contribute

Table 1. Locality records of *Coendou bicolor*, *C. ichillus*, and *C. nycthemera*. Localities are ordered by species, country, state/department, and locality, and the #ID refers to map in Figure 1.

#ID	Species	Country	Department/ State/Province	Locality	Coordinates	Source
1	*C. bicolor*	Argentina	Jujuy	Yuto	23°39'S 64°28'W	Lucero (1987)
2	*C. bicolor*	Bolivia	Beni	Puerto Caballo	13°43'S 65°21'W	Voss (2015)
3	*C. bicolor*	Bolivia	Beni	Yucumo	15°10'S 67°04'W	Voss (2015)
4	*C. bicolor*	Bolivia	Cochabamba	Charuplaya	16°36'S 66°37'W	Voss (2015)
5	*C. bicolor*	Brazil	Acre	Brasiléia	10°48'38"S 69°22'05"W	Freitas et al. (2013)
6	*C. bicolor*	Brazil	Acre	Senador Guimard, on AC-040 road	10°07'12"S 67°45'15"W	Freitas et al. (2013)
7	*C. bicolor*	Brazil	Amazonas	Reserva de Desenvolvimento Sustentável Mamirauá	2°12'54.43"S 65°42'35.53"W	MPEG 24574, 37122
8	*C. bicolor*	Peru	Cajamarca	2.5 km N of Monte Seco	7°03'51.32"S 78°30'25.80"W	Voss (2015)
9	*C. bicolor*	Peru	Huánuco	Tingo María	9°17'38.07"S 75°59'39.02"W	Voss (2015)
10	*C. bicolor*	Peru	Junín	Chanchamayo	11°03'25.73"S 75°03'39.99"W	Voss (2015)
11	*C. bicolor*	Peru	Madre de Dios	Reserva Cuzco Amazónico	12°33'00"S 69°02'60"W	Voss (2015)
12	*C. bicolor*	Peru	San Martín	Área de Conservación Municipal Mishquiyacu-Rumiyacu y Almendra	7°14'40.16"S 76°49'33.47"W	Voss (2015)
13	*C. bicolor*	Peru	Ucayali	Río Alto Ucayali	9°45'00"S 74°07'59.99"W	Voss (2015)
14	*C. bicolor* and *C. ichillus*	Peru	Cusco	Confluence of Ríos Camisea and Urubamba	11°43'16.80"S 72°56'31.20"W	Gregory et al. (2015)
15	*C. ichillus*	Brazil	Amazonas	Limoeiro, Japurá, Rio Japurá	1°49'S 66°35'W	MZUSP 11465
16	*C. ichillus*	Colombia	Meta	Villavicencio, km 30 carretera a Caños Negros	4°09'25"'N 73°33'21"W	Ramírez-Chaves et al. (2016)
17	*C. ichillus*	Ecuador	Pastaza	Río Conambo	1°52'S 76°46'60"W	Voss and da Silva (2001)
18	*C. ichillus*	Ecuador	Pastaza	Río Yana Rumi	1°38'S 76°59'W	Voss and da Silva (2001)
19	*C. ichillus*	Ecuador	Sucumbíos	La Selva Jungle Lodge	0°30'S 76°21'60"W	Voss and da Silva (2001)
20	*C. ichillus*	Peru	Loreto	Iquitos	3°45'60"S 73°15'W	Voss and da Silva (2001)
21	*C. nycthemera*	Brazil	Amazonas	Igarapé Auará, Rio Madeira, left bank	4°33′S 59°52′W	Voss (2015)
22	*C. nycthemera*	Brazil	Mato Grosso	Teles Pires Hydroelectric Reservoir, left bank of Rio Teles Pires	9°19′S 56°47′W	CZAF-MA 10
23	*C. nycthemera*	Brazil	Pará	ALCOA harbor, Juruti	2°10′S 56°06′W	MPEG 38377
24	*C. nycthemera*	Brazil	Pará	Belém	1°27′S 48°29′W	Voss (2015)
25	*C. nycthemera*	Brazil	Pará	Cametá	2°15′S 49°30′W	Voss (2015)
26	*C. nycthemera*	Brazil	Pará	Capitariquará, extreme South of Ilha Tocantins, rio Tocantins, 78 km S and 16 km E, Tucuruí	4°25′S 49°32′W	MPEG 12496
27	*C. nycthemera*	Brazil	Pará	Caxiricatuba	2°50′S 55°08′W	MZUSP 5035
28	*C. nycthemera*	Brazil	Pará	Curralinho, Marajó island	1°48′S 49°47′W	Voss (2015)
29	*C. nycthemera*	Brazil	Pará	Mocajuba	2°34′S 49°30′W	Voss (2015)
30	*C. nycthemera*	Brazil	Pará	Muaná	1°31′S 49°13′W	Voss (2015)
31	*C. nycthemera*	Brazil	Pará	Rio Meruú, left margin, PA-151, Km 18. Igarapé-Miri	1°58′S 48°57′W	MPEG 24191
32	*C. nycthemera*	Brazil	Pará	Santa Teresinha, Km 87-94 of the BR-010 road	1°16′S 48°05′W	MZUSP 25591
33	*C. nycthemera*	Brazil	Pará	Teles Pires Hydroelectric Reservoir, right bank of Rio Teles Pires	9°20′S 56°46′W	CZAF-MA 9, CZAF-MA 11.

Figure 2. Skins in dorsal view of **a)** *Coendou bicolor* (MPEG 37122), **b)** *C. nycthemera* (CZAF-MA 10), and **c)** *C. ichillus* (MZUSP 11465).

significantly to a better delimitation of the range of these three Amazonian porcupines.

Our study also suggests broader patterns of sympatry among *Coendou* species. Approximately 100 km south to the new localities of *C. nycthemera* reported here, we (GSTG and TBFS) observed a larger species of *Coendou*, here identified as *C. prehensilis* (ca. 10°20'S 56°58'W – Figure 4), suggesting that these two taxa are sympatric in the region, as has been recorded elsewhere (Handley & Pine 1992). The new localities for *C. bicolor* (locality 7 in Figure 1) and *C. ichillus* (locality 15 in Figure 1) are just 100 km apart in the north-western region of Amazonas state and support the hypothesis that the two taxa occur in sympatry throughout much of their range, as observed by Gregory et al. (2015), who photographed both species using the same branches of a tree in southwestern Peru.

The three species reported here can be differentiated from their congeners based on external traits, particularly the morphology of the quills, which can be assessed in the field or in museums (Table 2, Figure 3). Nevertheless, cranial characters and molecular sequence data are important to provide unequivocal identification of some taxa. It is noteworthy that all the new records presented here are based on misidentified museum specimens. Some individuals, as the *C. ichillus* from MZUSP, were collected about 40 years ago. These results highlight both the importance of scientific collections in preserving a still unknown biodiversity and how poor is our current knowledge about the taxonomy and distribution of Neotropical porcupines.

From a conservation viewpoint, the areas where *Coendou nycthemera* was recorded, in southern (localities 22, 33 in Figure 1) and eastern Amazonia (localities 25, 26, and 28–32, in Figure 1) are under intense pressure from cattle ranching, agricultural developments, and selective logging (Gascon et al. 2001, Yoshikawa & Sanga-Ngoie 2011, Silva & Lima 2018). Therefore, our new record documents an arboreal mammal that is likely being affected by intense deforestation in the southern Amazon of Mato Grosso, in the same manner as monkeys such as *Mico emiliae, Saguinus niger*, and the recently described *Callicebus grovesi*, all of which occur in the region (Garbino et al. 2015, Boubli et al. 2019).

Our paper provides new data on the geographical distribution of *Coendou* species, recording for the first time *C. ichillus* for Brazil and reporting major range extensions for *C. bicolor* and *C. nycthemera*. With the new record of *C. ichillus* for Brazil, there are now 10 species of *Coendou* confirmed in the country (de Freitas et al. 2013, Voss 2015). Considering the most up-to-date catalogue of the Brazilian mammals (Quintela et al. in press), there are now 744 species of mammals in the country.

All records presented herein are based on scientific collections, reinforcing their importance as repositories of still unknown mammalian diversity, even for large species such as erethizontids. We would like to point out that due to the science cuts imposed by the Brazilian federal government (de Oliveira Andrade 2019), it is likely that biodiversity studies based on scientific collections will be severely impacted.

Supplementary material

The following online material is available for this article:
Appendix 1

Acknowledgements

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Author Contributions

Fernando Heberson Menezes - Substantial contribution in the concept and design of the study, Contribution to data collection, Contribution to data analysis and interpretation, Contribution to manuscript preparation.

Guilherme Siniciato Terra Garbino - Substantial contribution in the concept and design of the study, Contribution to data collection, Contribution to data analysis and interpretation, Contribution to manuscript preparation.

Table 2. External diagnostic characters of the Brazilian Amazonian porcupines. See Materials and Methods for measure abbreviations.

	Size	Soft hair	Long dorsal quills/bristle-quills/guard hairs	Short dorsal quills
C. nycthemera	Small (HBL: 344±22mm; LT: 313±25mm) (Voss & Angermann 1997)	Does not cover the quills	Tricolored or bicolored. Basal band short and yellowish, medial band blackish and long. Distal band, when present, very short. May be whitish, yellowish or orangish	Bicolored. Short basal band yellowish and long distal band blackish
C. bicolor	Large (Mean HBL: 457mm; Mean LT: 422 mm) (Voss 2011)	Does not cover the quills	Bicolored. Short basal band slightly yellowish; long distal band blackish	Bicolored. Short basal band yellowish; long distal band blackish
C. ichillus	Small (HBL: 275mm; LT: 245mm)*	Does not cover the quills	Substituted by Tricolored bristle-quills. Basal band is yellowish, medial band is blackish and distal band is whitish. All bands above the same length	Bicolored. Yellowish basal band and blackish distal band, above the same length
Amazonian *C. prehensilis*	Large (HBL: 451±25mm; LT: 453±31mm (Voss 2011)	Does not cover the quills	Bicolored and tricolored. Tricolored quills have basal band slightly yellowish, long blackish medial band and short whitish distal band. Bicolored quills have slightly yellowish basal band and the blackish distal band	Bicolored and tricolored. Tricolored quills have basal band yellowish, long blackish medial band and short whitish distal band. Bicolored quills have yellowish basal band and the blackish distal band
C. melanurus	Small (Mean HBL: 385mm; Mean LT: 373mm) (Voss et al. 2001, p.136)	Covers the quills	Guard hairs. Long yellowish basal band, blackish medial band and long pale yellowish distal band	Bicolored. Long strongly yellowish basal band with an inconspicuous blackish distal band
C. roosmalenorum	Small (HBL ~290mm; LT ~250mm) (Voss & da Silva 2001)	Covers the quills	Substituted by bristle-quills. Long yellowish basal band, blackish medial band and slightly yellowish distal band	Bicolored. Long strongly yellowish basal band with a short blackish distal band
C. baturitensis	Large (HBL: 500mm; LT: 460mm) (Feijó & Langguth 2013)	Does not cover the quills	Bicolored and tricolored. Tricolored quills have whitish basal band, long brownish medial band and short whitish distal band. Bicolored quills have short whitish basal band and long brownish distal band	Bicolored and tricolored. Tricolored quills have whitish basal band, long brownish medial band and short whitish distal band. Bicolored quills have short whitish basal band and long brownish distal band

* based on measurements of the examined specimens.

Thiago Borges Fernandes Semedo - Substantial contribution in the concept and design of the study, Contribution to data collection, Contribution to data analysis and interpretation, Contribution to manuscript preparation.

Mendelson Lima - Contribution to data collection, Contribution to critical revision, adding intelectual content.

Anderson Feijó - Substantial contribution in the concept and design of the study, Contribution to data collection, Contribution to data analysis and interpretation, Contribution to manuscript preparation.

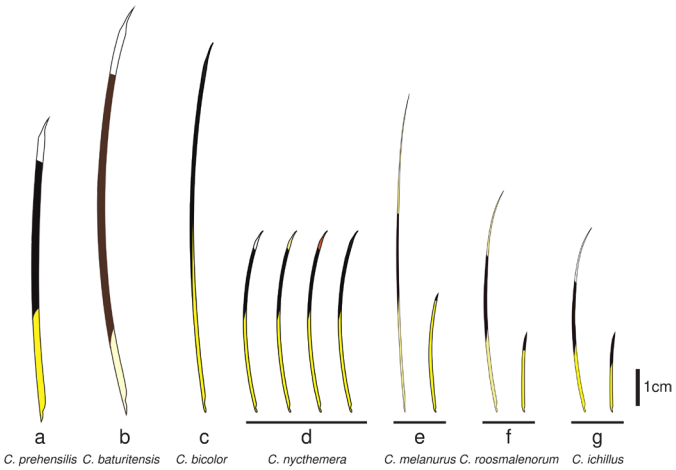

Figure 3. Quills and bristle-quills of selected species of Brazilian porcupines. **a)** Amazonian *C. prehensilis* long tricolored quill, **b)** *C. baturitensis* long tricolored quill, **c)** *C. bicolor* long bicolored quill, **d)** *C. nycthemera* long quills with different distal band colors, **e)** *C. melanurus* tricolored guard hair and bicolored quill, **f)** *C. roosmalenorum* tricolored bristle-quill and bicolored quill, and **g)** *C. ichillus* tricolored bristle-quill and bicolored quill.

Figure 4. *Coendou prehensilis* observed close to Nova Monte Verde, Mato Grosso, Brazil.

Pedro Cordeiro-Estrela - Contribution to critical revision, adding intelectual content .

Itayguara Ribeiro da Costa - Contribution to critical revision, adding intelectual content.

Conflicts of Interest

On behalf of the co-authors, I declare that there is no conflict of interest related to the publication of this manuscript

Ethics

This study did not involve animal experimentation or collecting, as the analyzed specimens were already deposited in scientific collections.

Data Availability

Every information necessary to replicate this study is present in the manuscript text

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article

Population and reproductive traits of a freshwater amphipod (Crustacea, Peracarida, Hyalellidae) from northwest of the state of Rio Grande do Sul, Brazil

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Abstract: The study of population and reproductive traits provides information about the ecological structure of natural populations. This study aimed to characterize dynamics and reproductive traits of *Hyalella palmeirensis* from a natural pond from southern Brazil. The amphipods were sampled monthly (August 2012 to July 2013) by a person with the aid of a hand net for 20 minutes. Ovigerous females and pre-copulatory pairs were individualized in the field. A total of 12,325 individuals were sampled, being 1,421 males, 6,983 females (including 215 ovigerous females) and 3,921 juveniles. Paired and unpaired males were significantly greater in size than females. There was a positive correlation between body size (CL) of paired males and females. Males and females showed bimodal distribution. Total sex ratio favored females, and these were more frequent in almost all months. Ovigerous females and precopulatory pairs were found throughout the year, but with high frequency in winter and autumn, respectively, characterizing a seasonal reproduction. Juveniles were sampled throughout the year, with greater intensity in the spring. The mean fecundity was 19.6 ± 4.34 eggs. No reduction in the number of eggs was observed during embryonic development. The results observed in *H. palmeirensis* demonstrate that this species has a population and reproductive dynamics very similar to other species of *Hyalella* already analyzed in southern Brazil. Moreover, it can be seen that although the *H. palmeirensis* occurs in an environment with anthropic influence (soy cultivation,) the population is managing to remain in the area, with reproduction and recruitment in most months of year.
Keywords: *fecundity, body size, Hyalella palmeirensis, sex ratio, reproduction, recruitment.*

Características populacionais e reprodutivas de um anfípodo de água doce (Crustacea, Peracarida, Hyalellidae) do noroeste do estado do Rio Grande do Sul, Brasil

Resumo: O estudo dos aspectos populacionais e reprodutivos providenciam informações sobre a estrutura ecológica das populações naturais. Este estudo teve como objetivo caracterizar aspectos populacionais e reprodutivos de *Hyalella palmeirensis* de uma lagoa do sul do Brasil. Os anfípodos foram amostrados mensalmente (agosto/2012 a julho/2013) por uma pessoa com o auxílio de puçá por 20 minutos. Fêmeas ovígeras e casais em comportamento pré-copulatório foram individualizados no campo. Um total de 12.325 indivíduos foram amostrados, sendo 1.421 machos, 6.983 fêmeas (incluindo 215 fêmeas ovígeras) e 3.921 juvenis. Machos pareados e não pareados são significativamente maiores em tamanho do que as fêmeas. Houve uma correlação positiva entre o tamanho do corpo (CC) de machos e fêmeas pareados. Machos e fêmeas apresentaram distribuição bimodal. A proporção sexual total favoreceu as fêmeas, e estas foram mais frequentes em quase todos os meses. Fêmeas ovígeras e casais em pré-cópula foram amostrados ao longo do ano, mas com elevada frequência no inverno e outono, respectivamente, caracterizando uma reprodução sazonal. Os juvenis foram amostrados ao longo do ano, com maior intensidade na primavera. A fecundidade média foi de 19,6 ± 4,34 ovos. Não houve redução no número de ovos durante o desenvolvimento embrionário. Os resultados observados em *H. palmeirensis* demonstram que esta espécie possui uma dinâmica populacional e reprodutiva muito similar a outras espécies de *Hyalella* já analisadas no sul do Brasil. Além disto, apesar de *H. palmeirensis* ocorrer num ambiente com influência antrópica (cultivo de soja), sua população está conseguindo se manter na área, com reprodução e recrutamento na maioria dos meses do ano..
Palavras-chave: *fecundidade, tamanho corpóreo, Hyalella palmeirensis, razão sexual, reprodução, recrutamento.*

Introdution

The freshwater amphipods of the genus *Hyalella*, Smith, 1874 inhabit a wide variety of aquatic environments of the Americas, as streams, lakes, rivers and some species are found in subterranean environments (Bousfield 1996; González & Watling, 2002; Bueno et al. 2014; Cardoso et al. 2014; Rodrigues et al. 2017). These crustaceans and have a great ecological importance, since they provide and facilitate the matter and energy transfer between trophic levels, convert detritus into the final particulate organic matter and serve as food for many waterfowl, macroinvertebrates, fish, amphibians, birds (Swanson 1984; Wen 1992; Wellborn 2002; Wellborn & Cothran 2007). Besides, *Hyalella* are crustaceans most commonly used as freshwater quality bioindicators and test organisms in ecotoxicological studies in mainly due to their high sensitivity to contaminants and environments impacts (Morris et al. 2003; Wilcoxen et al. 2003; Gust 2006; Ding et al. 2011; Lasier & Urich 2014; Javidmehr et al. 2015).

Ecological studies of the *Hyalella* genus in South America are mainly focused on the abundance, body size, sex ratio, reproduction, fecundity, recruitment and, pairing success (Lopretto 1983; Casset et al. 2001; Poretti et al. 2003; Galassi et al. 2006; Castiglioni & Bond-Buckup 2007, 2008a, 2008b, 2009; Castiglioni et al. 2007; Torres et al. 2015; Bastos-Pereira & Bueno 2016a, 2016b; Castiglioni et al. 2016; Ozga & Castiglioni 2017; Ozga et al. 2018; Colla & César 2019). The knowledge of these ecological traits of its populations are crucial for long-term conservation plans, the evaluation of its extinction risk as well as its potential use as bioindicators in ecotoxicological studies (Cooper 1965; Hutchinson 1981; Muskó 1992; Castiglioni et al. 2016).

In the South America, Brazil has the greatest number of *Hyalella* species described, 28 in total (Bastos-Pereira & Bueno 2013; Bueno et al. 2014; Cardoso et al. 2014; Rodrigues et al. 2014; Streck et al. 2017; Bastos-Pereira et al. 2018; Streck-Marx & Castiglioni 2020). According to Bueno et al. (2014), Streck et al. (2017) and Streck-Marx & Castiglioni (2020), the state of Rio Grande do Sul (Southern Brazil) is the region with the highest species diversity in the country, counting 12 described species. Among the species that occur in Brazil, *Hyalella palmeirensis* Streck-Marx & Castiglioni, 2019 was recently described (Streck-Marx & Castiglioni 2020), but its biology and ecology are unknown. Thus, this study aimed to characterize the population and reproductive traits of the freshwater amphipod *H. palmeirensis* from southern Brazil, and for this the abundance, body size, frequency distribution, body size, sexual maturity, sex ratio, reproductive period, fecundity and recruitment were analyzed.

Material and Methods

The specimens of *H. palmeirensis* were sampled monthly from August 2012 to July 2013 in a natural pond (Figure 1A) by a person with the aid of a hand net (mesh of 250 µm) for 20 minutes. The natural pond is located in the municipality of Palmeira das Missões (27º56'57.30" S - 53º 19'35.46" W), state of Rio Grande do Sul, Brazil. The natural pond is located in a rural property where soybeans, wheat and oats are grown throughout the year (Figure 1B), and is surrounded by a narrow strip of native shrubs and has macrophytes of the genus *Egeria*.

During the sampling period, the sediment and macrophytes were removed of the natural pond with a hand net and placed on plastic trays for separation of ovigerous females (females carrying eggs or juveniles inside the brood pouch) and pre-copula pairs. These amphipods were preserved in 70% ethanol in microtubes. The sediment and macrophytes contained in the plastic trays were placed in plastic bags, transported in a refrigerated container and, in the laboratory, washed in a 0.177 mm mesh to obtain the remaining organisms that were subsequently preserved in 70% ethanol.

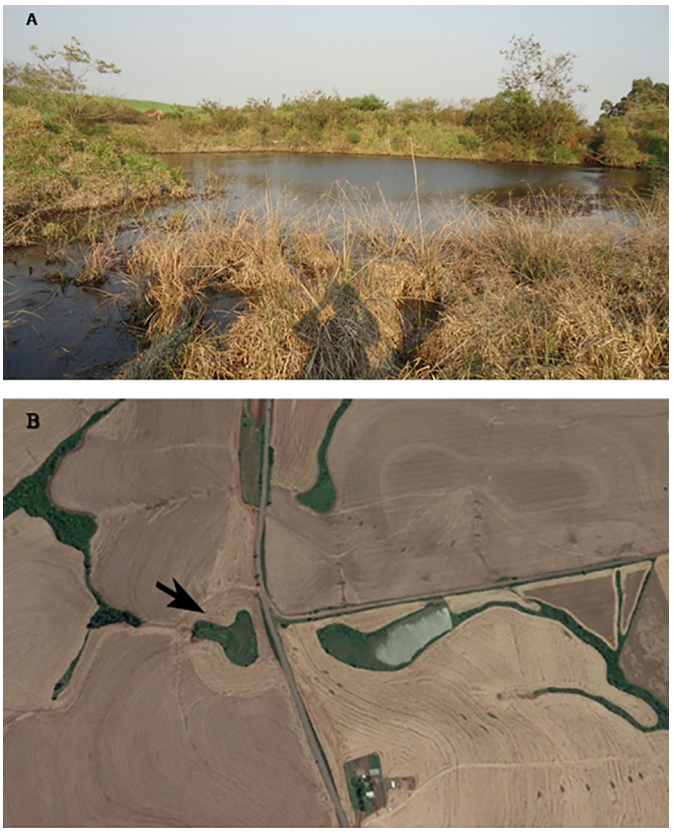

Figure 1. A. Pond where specimens of *Hyalella palmeirensis* were sampled, municipality of Palmeira das Missões, state of Rio Grande do Sul, Brazil. **B.** Overview of the pond, showing the crops in its surroundings. The arrow indicates the location where *H. palmeirensis* were sampled.

Later, individuals were identified and grouped into four categories: juveniles (specimens with undeveloped secondary sexual character), males (individuals with a well-developed gnathopod 2), females (individuals with oostegites and a small gnathopod 2), and ovigerous females (females carrying eggs or juveniles in the brood pouch) (Borowsky 1991; Castiglioni & Bond-Buckup 2008a; Castiglioni et al. 2016). These amphipods were measured from the anterior margin of the rostrum until the posterior margin of the cephalothorax (head), in lateral view (cephalothorax length, CL in mm) using a micrometer eyepiece in a stereoscopic microscope.

The total and monthly abundances of juveniles, males, females and ovigerous females were estimated.

The minimum, maximum and mean CL values of males and females (including ovigerous females and non-ovigerous females) and ovigerous females were evaluated. The mean sizes are given with their standard deviations. The mean size was compared between sexes using the *t* test ($\alpha = 0.05$; Zar 1996). Moreover, the mean body size of paired and unpaired males and females were compared, to assess whether pairing success was influenced by body size (*t* test; $\alpha = 0.05$; Zar 1996).

The sexual maturity of *H. palmeirensis* was estimated through two methods - based on the CL of the smallest ovigerous female found in the population and based on the CL of the smallest male and female

found in precopulatory behavior (Borowsky 1991; Wellborn et al. 2005; Castiglioni & Bond-Buckup 2008a; Ozga & Castiglioni 2017).

Total frequency distribution in size classes (CL) of juveniles, males and females (including ovigerous females) was estimated. The width of the size classes was calculated using the value of ¼ of the standard deviation from the values of cephalothorax length (Markus 1971). Later, the normality of the frequency distributions was analyzed using Shapiro-Wilk test (α= 0.05) (Zar 1996).

The total, monthly, seasonal, and size-class (CL) sex proportions were expressed as the total number of males divided by the total number of females (including the ovigerous females). The goodness of fit test (chi-Square test -χ^2) with a significance level of 5% was used to verify if the sex ratio followed the 1:1 ratio (Zar 1996).

The reproductive period was estimated by seasonal frequency of ovigerous females and pre-copula pairs. The seasonal frequency of ovigerous females in relation to that of adult females (females that were as large as or larger than smallest female found in pre-copula pairs – i.e. estimated size at sexual maturity) was calculated. Later, the ovigerous females proportion was compared among seasons using the multinomial proportions test (MANAP; $\alpha = 0.05$) (Curi & Moraes 1981). In addition, the relative frequency of pairs in precopulatory behavior per season was estimated and compared using the multinomial proportion test (MANAP; $\alpha = 0.05$) (Curi & Moraes 1981).

In order to verify if males and females choose mating pairs according to their size, the correlation between CL of paired males and females was estimated with a Person correlation (r) ($\alpha = 0.05$; Zar 1996).

Ovigerous females were individualized in field to estimate fecundity. In the laboratory, eggs and/or juveniles were removed from the brood pouch of each female and classified according to the stage of embryonic development: 1) initial stage - egg completely filled with yolk, no visible embryonic formation; 2) intermediate stage - initial decrease of yolk, start of embryonic development; 3) final stage - yolk completely consumed by the embryo, which is visible; the eyes are present; 4) juvenile stage - the juveniles hatched and are visible inside the brood pouch (Subida et al. 2005; Castiglioni & Bond-Buckup 2009; Ozga & Castiglioni 2017). Later, eggs and juveniles were counted under the stereomicroscope.

The total fecundity of *H. palmeirensis* was estimated (minimum, maximum, and mean ± standard deviation), as well as the numbers of eggs and juveniles per embryonic stage. Additionally, the fecundity index (FI) was estimated (number of eggs/cephalothorax length). To compare fecundity between the embryonic stages and between seasons, the analysis of variance (ANOVA) was used, followed by the Tukey test ($\alpha = 0.05$) (Zar 1996). Besides, the mean body size (CL) of ovigerous females containing egg in each embryonic development stage or juveniles in the brood pouch was compared by analysis of variance (ANOVA), followed by the Tukey test ($\alpha = 0.05$) (Zar 1996). The relationship between ovigerous females CL (x) and the number of eggs per embryonic stage and number of juveniles (y) was estimated through a regression analysis ($y = ax - b$) and a Pearson correlation (r) was calculated for each embryonic stage and for the total egg production (considering all stages) ($\alpha = 0.05$) (Zar 1996).

To estimate the recruitment period was calculated the juvenile proportion in relation to adults for each season and we used a goodness of fit test (chi-Square test -χ^2) (α=0.05) in order to verify if the proportion follows the pattern 1:1 ratio (juveniles: adults). Besides, the seasonal juvenile frequency was compared using the multinomial proportion test (MANAP; $\alpha = 0.05$) (Curi & Moraes 1981). For the recruitment analysis, we considered juveniles those individuals with CL smaller than 0.27 mm (individuals where the enlargement of the second pair of gnathopods or oostegites could not be observed (Borowsky 1991; Castiglioni et al. 2016) and those individuals smaller than the values estimated at sexual maturity (see values in results).

Results

During the sampling period, 12,325 individuals were collected, being 1,421 males, 6,983 females (including 215 ovigerous females) and 3,921 juveniles. In the Table I are present the number of males, females, ovigerous females and juveniles sampled by month. The population of *H. palmeirensis* showed the highest abundances in November and January. The lowest abundances were recorded in May and June (Table 1).

Table 1. Number of specimens sampled monthly for a year, monthly sex ratio and goodness of fit analysis (χ^2) of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil.

	Males	Females	Ovigerous Females	Pairs	Juveniles	Total	M:F	χ^2
Aug/12	171	225	28	5	44	468	0.68: 1	15.86*
Sep/12	133	368	95	11	47	643	0.29: 1	182.72*
Oct/12	28	736	27	0	221	1,012	0.04: 1	682.96*
Nov/12	415	2,695	25	0	2,934	6,069	0.15: 1	1694.74*
Dec/12	119	736	6	0	57	918	0.16: 1	450.79*
Jan/13	403	1,736	0	0	471	2,610	0.23: 1	830.71*
Feb/13	19	74	0	0	4	97	0.26: 1	32.53*
Mar/13	82	78	12	10	0	172	0.91: 1	0.37
Apr/13	39	24	11	8	0	74	1.11: 1	0.22
May/13	3	2	0	3	0	5	1.50: 1	0.20
Jun/13	2	8	2	4	1	13	0.20: 1	5.33*
Jul/13	7	86	9	4	142	244	0.07: 1	75.92*
Total	1421	6,768	215	45	3,921	12,325	0.20: 1	3681.09*

Note: The "*" indicates a significant difference in the proportion of males and females ($p < 0.05$).

The cephalothorax length of males ranged from 0.27 to 0.74 mm and that of females from 0.27 to 0.72 mm. The mean CL of unpaired and paired males and females are show in Table 2. Unpaired and paired males were larger than their respective females (t = 16.77 for unpaired and t = 8.14 for paired; $p < 0.05$). The mean CL of paired males was greater than that of unpaired males (t= 15.80; $p< 0.05$; Table 2). Besides, the mean CL of paired females was greater than that of unpaired females (t= 8.56; p <0.05; Table 2). There was a positive correlation between body size (CL) of paired males and females (r= 0.73; p<0.05).

Table 2. Mean body size (cephalothorax length - CL in mm) of unpaired and paired males and females of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil.

	Paired	***Unpaired***
Males	0.52 ± 0.0.5 a	0.37 ± 0.10 b
Females	0.44 ± 0.04 a	0.33 ± 0.08 b

Note: Different lowercase letters indicate significant difference in mena boby size between males and females (p<0,05).

The size at sexual maturity estimated as the CL of the smallest individual found in pre-copula pairs was 0.45 in males and 0.37 mm in females. Besides, considering the size of smallest ovigerous female sampled, the size at sexual maturity of females was 0.27 mm.

Size frequency distribution patterns were non-normal in both sexes (p<0.05) (males W = 0.86 and females W = 0.91). Males and females showed bimodal distribution, being divided into two groups (immatures and adults) (Figure 2).

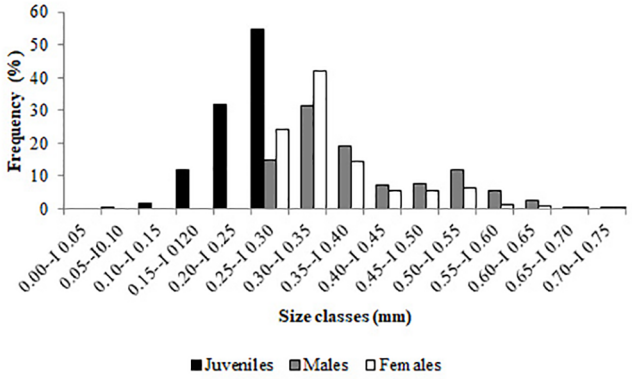

Figure 2 . Frequency distribution in size classes of cephalothorax length (CL in mm) for juveniles, males and females of *Hyalella palmeirensis***,** Palmeira das Missões, state of Rio Grande do Sul, Brazil.

The overall male: female sex ratio was 0.20:1 and differ significantly from the expected 1:1 proportion ($\chi 2$ = 3681.09; p<0.05). Sex ratio favored females in most months (p<0.05), with the exception of March, April and May, in which there was no significant difference in proportion (p>0.05) (Table 1). Regarding the sex ratio by size classes, it was observed that proportions favored females in intermediate classes and males in larger classes (p<0.05) (Figure 3).

Ovigerous females of *H. palmeirensis* were sampled throughout year but was observed greater fluctuations in the abundance (Table 1). In the analysis of the seasonal frequency of ovigerous females, it was observed greater frequency in winter (61.4%) (Figure 4). The number of

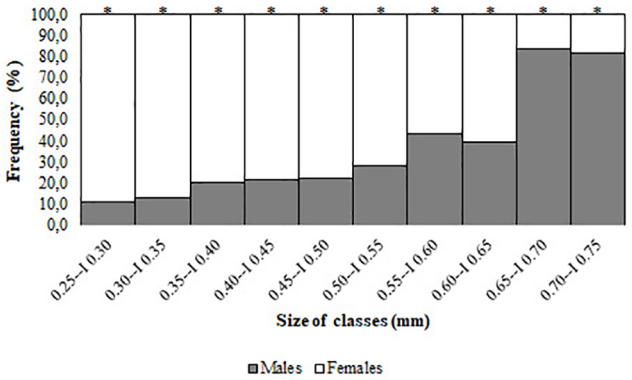

Figure 3. Sex ratio by size classes of cephalothorax length (CL in mm) of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil. "*" indicates significant difference in sex ratio (p<0.05).

pairs in pre-copulatory behavior was low, when compared to unpaired males and females (Table 1). Pairs in pre-copulatory behavior were found throughout all the year, except spring, being more frequently in autumn (33.3%) and winter (48.9%) (Figure 4).

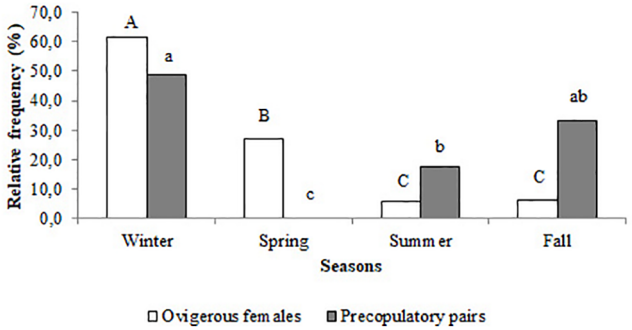

Figure 4. Seasonal relative frequency (%) of ovigerous females and pairs in pre-copulatory behaviour of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil. The capital letters represent to the comparison of the frequency of ovigerous females among season and small letters correspond to the comparisons of the frequency of precopulatory pairs. Columns with at least one letter in common did not differ statistically (p>0.05).

The body size (CL) of ovigerous females ranged from 0.27 to 0.67 mm (mean ± standard deviation – 0.48 ± 0.06 mm). Total fecundity varied from 10 to 28 eggs and mean fecundity was 19.6 ± 4.34 eggs. The fecundity index (number eggs/cephalothorax length) was 40.43 ± 5.92 eggs. There was a positive correlation between body size (CL) of ovigerous females and egg production (r= 0.79; p<0.05) (Figure 5).

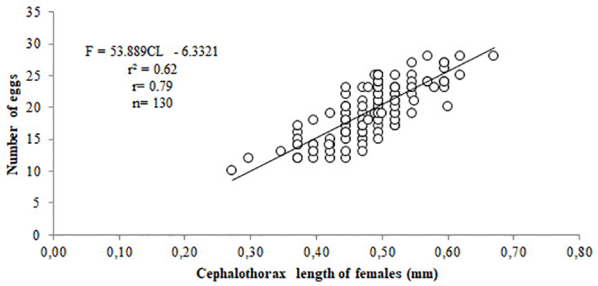

Figure 5. Regression analysis between body size (CL) of ovigerous females and number of eggs produced by *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul.

There was no significantly decrease in the number of eggs and juveniles throughout development in *H. palmeirensis* (p>0.05) (Table 3). In addition, there was no difference in mean body size between females containing eggs at each embryonic development stage or juveniles in the brood pouch (p>0.05; Table 3). Additionally, there was a positive correlation between the body size (CL) of ovigerous females and the number of eggs at each development embryonic stage, and the number of juveniles contained in the brood pouch (p<0.05; Table 3). In the analysis of seasonal fecundity, there was also no significant difference in the mean eggs or juvenile's production (p>0.05; Table 4).

Juveniles were sampled in all seasons, but the greater relative frequency was observed in spring (72.7%; p<0.05) and lower in autumn (0.20%; p<0.05) (Figure 6). The overall juvenile: adult ratio was 4.76:1 and differ significantly from the expected 1:1 proportion ($\chi2 = 5257.38$; p<0.05). The ratio of juveniles was superior to the adult ratio in spring ($\chi2 = 5809.66$; p<0.05) and summer ($\chi2 = 931.61$; p<0.05) (Figure 7). However, adults predominated in autumn ($\chi2 = 29.39$; p<0.05) and winter ($\chi2 = 91.96$; p<0.05) (Figure 7).

Discussion

Species of the genus *Hyalella* can be found mainly along the aquatic vegetation of the banks of streams, lakes, wetlands, springs and underground aquatic environments (Grosso & Peralta 1999; Bueno et al. 2014). Besides, some species of *Hyalella* were found associated with macrophytes, which can be used as shelter and/or food by these amphipods (Bueno et al. 2014). In the present study, it was observed that *H. palmeirensis* adheres to macrophyte roots, with abundance peak occurring from spring to summer (October to January), season where there also a high abundance of macrophytes. Colla & César (2019) reported similar results in *H. pampeana* where amphipods increased their numbers together with the macrophyte development in warmers months. Aquatic vegetation cover is an important factor influencing invertebrate community structure, presumably because the vegetation creates structural heterogeneity and it can provide refuges and food resources (Hargrave 1970; Waterkeyn et al. 2008). Spring and summer temperatures are ideal for the reproduction of the amphipods, since with the greater food availability, they performed the molt more often, grow and reach the sexual maturity earlier, and shortened the intervals between ovipositions and increased reproductive rate (Cooper 1965; Kruschwitz 1978; Panov & Mcqueen 1998). In addition, higher temperatures stimulate the production of larger broods and eggs (Siegfried 1985) and increasing juvenile's survival rates

Table 4. Fecundity for the season in *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil.

Seasons	Min - max	Mean ± sd
Summer	12- 25	18.5 ± 4.27 a
Autumn	12 - 24	18.3 ± 4.21 a
Winter	12 - 28	20.5 ± 4.01 a
Spring	10 - 25	18.7 ± 4.75 a

Note: Different lowercase letters indicate significant difference in mean number of eggs (p<0,05).

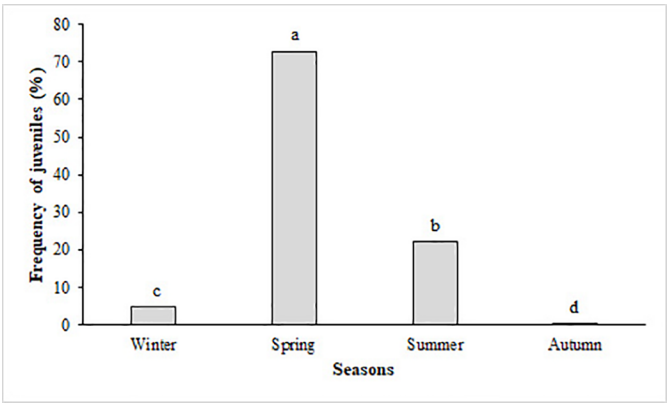

Figure 6. Seasonal relative frequency (%) of juveniles of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil. Columns with at least one letter in common did not differ statistically (p>0.05).

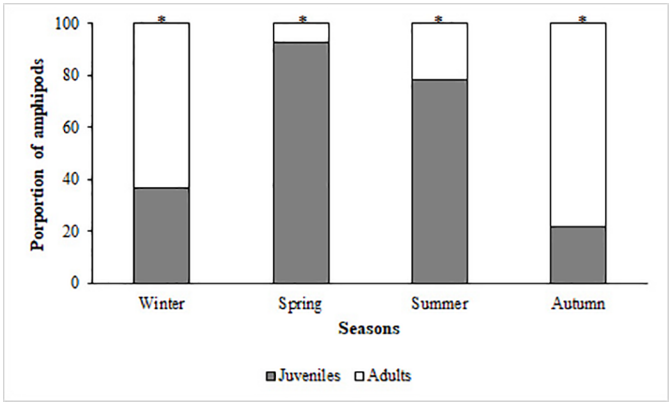

Figure 7. Proportion of juvenile and adults of *Hyalella palmeirensis*, Palmeira das Missões, state of Rio Grande do Sul, Brazil. "*" indicates significant difference in proportion between juveniles and adults (p<0.05).

Table 3. Number of eggs and juveniles and minimum, maximum and mean (± SE) cephalothorax length (CL) of the females of *Hyalella palmeirensis* in different stages of embryonic development and number of juveniles within the brood pouch, Palmeira das Missõe, State of Rio Grande do Sul, Brazil.

Development stage	N	CL of ovigerous females		Eggs		r
		Min-max	Mean ± sd	Min-max	Mean ± sd	
Initial	53	0.35 - 0.67	0.48 ± 0.06 a	12 - 28	19.4 ± 4.75 a	0.80
Intermediate	53	0.37 - 0.62	0.49 ± 0.05 a	12 - 28	19.3 ± 3.92 a	0.82
Final	20	0.47 - 0.62	0.52 ± 0.05 a	15 - 25	18.5 ± 3.31 a	0.87
Juvenile	16	0.40 - 0.52	0.51 ± 0.04 a	14 - 23	18.3 ± 1.30 a	0.85

Note: CL= cephalothorax length; Min= minimum; Max= maximum, r = correlation coefficient. Different lowercase letters indicate significant differences in mean body size (CL) and mean number of eggs.

(Panov & Mcqueen 1998). This could explain the high abundances in natural populations of *Hyalella* during warmer months, as it has been reported by others authors (Casset et al. 2001; Poretti et al. 2003).

Males of *H. palmeirensis* reached sexual maturity at larger sizes and are greater than females. Generally, males reach larger body size than females in freshwater amphipods, as for examples, in *H. azteca* Saussure, 1858 (Pickard & Benke 1996), *H. pleocuta* González, Bond-Buckup & Araújo, 2006 and *H. castroi* González, Bond-Buckup & Araújo, 2006 (Castiglioni & Bond-Buckup 2008), *H. longistila* Faxon, 1876 (Bastos-Pereira & Bueno 2016), *H. bonariensi*s Bond-Buckup, Araujo & Santos, 2008 (Castiglioni et al. 2016), *H. georginae* Streck & Castiglioni, 2017 and *H. gauchensis* Streck & Castiglioni, 2017 (Ozga et al. 2018), and *H. pampeana* Cavalieri, 1968 (Colla & César 2019). Crustacean growth is similar between sexes until reproductive maturity, and after that, males and females present different ecological and/or reproductive demands resulting in distinct growth rates between sexes (Low 1978). Males invest most of their energy in reproduction, especially in searching for a female and copulation, while in female's energy effort is invested in gamete production and parental care (Wen 1992; Castiglioni & Bond-Buckup 2007). In addition, females usually grow more slowly due to the prolongation of intermolt period while producing and incubating the embryos, since they do not molt during this period (Hartnoll 1982; Wen 1992; Cardoso & Veloso 1996). Sexual dimorphism seems essential for crustaceans that have a precopulatory behavior, as *Hyalella* species (Wen 1992; Castiglioni & Bond-Buckup 2008; Ozga & Castiglioni 2017; Castiglioni et al. 2018), because, a large male-to-female size ratio may allow the male carry the female more easily during this phase (Adams & Greenwood 1983; Adams et al. 1985).

The bimodal frequency distribution of *H. palmeirensis* was marked by the presence of two distinct groups, juveniles and adults. This feature may be related to the seasonal reproduction and, consequently, to the recruitment peaks in the population. This pattern of population frequency distribution is common in other species of *Hyalella* such as *H. azteca* (Pickard & Benke 1996), *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buckup 2008a), *H. bonariensis* (Castiglioni et al. 2016) and *H. georginae* and *H. gauchensis* (Ozga et al. 2018). According to Appadoo & Myers (2004), bimodal distributions are apparently advantageous since recruitment occurs in warmer months, when food availability is higher, increasing the survival rate.

Females of *H. palmeirensis* are almost 5 times more frequent than males in total and in most months of the year. Sexual deviations in favor of females have already been observed in *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buckup 2008a), *H. bonariensis* (Castiglioni et al. 2016), *H. longistila* (Bastos-Pereira & Bueno 2016), *H. georginae* and *H. gauchensis* (Ozga et al. 2018). Deviations in sex ratio appear to be related to reproductive behavior of species of *Hyalella*, because males spend more time exposed in the environment by choosing, holding and carrying the female and thus the males are more susceptible to predators (Moore 1981; Poweel & Moore 1991; Wellborn 1994; Wellborn & Cothran 2007; Kevrekids 2005; Castiglioni & Bond-Buckup, 2008b; Castiglioni et al., 2016). According to Wellborn (1994) deviations in sex ratio may be due to differential predation by fish and larvae of Odonata, which prefer to feed on larger specimens, such as males, and, therefore, females will be more numerous in the population.

The sex ratio of *H. palmeirensis* favored females in intermediary classes and males in the upper classes, which characterizes an anomalous sex ratio pattern (Wenner 1972). Similar results were found in other species of *Hyalella* from Brazil (Castiglioni & Bond-Buckup 2008a; Castiglioni et al. 2016; Bastos-Pereira & Bueno 2016; Ozga et al. 2018). These results could be related to the same reasons used to explain sexual dimorphisms in relation to body size. The predominance of males in upper size classes which could be related to differences in energy consumption and investment between sexes, being that female's amphipods expend most of their energy and time in reproduction (egg production), while males do so in pairing (Cardoso & Veloso 1996; Castiglioni & Bond-Buckup 2007). Besides, the females' prolonged parental behavior, in which they carry the offspring attached to their bodies (Borowski 1991; Thiel 2003; Castiglioni & Bond-Buckup 2007). Due to this behavior, females direct their energetic budget towards the offspring care instead of molting; therefore, the molt is delayed, limiting the females' body size when in comparison to males (Aoki & Kikuchi 1991; Thiel 2003).

The reproduction of *H. palmeirensis* occurred more intensely in the colder months of the year, and ovigerous females were more frequent in winter and in pre-copulatory pairs in autumn and winter, indicating a seasonal reproduction. The number of ovigerous females has decreased dramatically in summer and pairs in spring and summer, with this period coinciding with the soybean-growing season around the weir. Probably the use of fertilizers and pesticides may have had a negative effect on *H. palmeirensis* population, causing the mortality of many individuals (see Table 1). It is noteworthy that amphipod species are considered sensitive to pollutants, herbicides and heavy metals, as shown by Kruschwitz (1978), Duan et al. (1997), and Dutra et al. (2008, 2009, 2011). Dutra et al. (2008) observed that carbofuran pesticide induces significant decreases in glycogen, proteins, lipids, triglycerides, and Na+/K+ATPase, as well as a significant increase in lipoperoxidation levels in *H. pleoacuta* and *H. curvispina*. Besides, these authors suggested that the reproductive parameters (formation of pre-copulatory pairs, ovigerous females and mean number of eggs) might provide sensitive criteria for assessing ecotoxicological effects. Results similar were observed in *H. castroi* that were exposed to carbofuran at a dose of 5 or 50 microg/L for a period of 7 days (Dutra et al. 2009). Besides, Dutra et al. (2011) observed que concentrations of Roundup® (glyphosate formulation) induced significant decreases in all biochemical parameters and Na+/K+ATPase activity, and significant increase in lipoperoxidation levels in *H. castroi*. According to Dutra et al. (2011), very low concentrations of Roundup® have a potentially toxic effect in *H. castroi* and this can lead to significant changes in trophic structure of limnic environments because these amphipods are important links in food chain in these habitats. Dutra et al 2011.

The more intense reproduction in the colder months of the year in *H. palmeirensis* can be explained by the fact that this time of the year presents a greater abundance of macrophytes on the dam margin (personal observation), and these plants can be used as shelter and food (Castiglioni et al. 2008a; Castiglioni et al. 2016). In addition, the most intense breeding in the colder months should probably be to avoid competition with other spring and summer breeding aquatic invertebrates and thus to ensure the survival of juveniles of *Hyalella* species. A reproductive peak during the colder months (autumn and/or winter) has been observed in other species of *Hyalella* found in Brazil (Castiglioni & Bond -Buckup 2008; Castiglioni et al. 2016; Bastos-Pereira & Bueno 2016; Ozga et al. 2018).

Paired males and females were larger than unpaired. Similar results were already recorded for *H. azteca* (Saussure, 1858) (Wen 1992; Wellborn et al. 2005), *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buckup 2008b), *H. longistila* Faxon, 1876 (Bastos-Pereira & Bueno 2016), *H. gauchensis* and *H. georginae* (Ozga & Castiglioni 2017) and *H. bonariensis* (Castiglioni et al. 2018). Larger males may be less likely to lose their female during the precopulatory behavior and may be more likely to succeed in attempts to take over a guarded female (Ward 1983; Dick & Elwood 1990).

The species *H. palmeirensis* exhibited significant positive assortative mating, which was indicated by a correlation between the size of paired males and females, with large males carrying larger females during the precopulatory behavior, and small males carrying small females. This is common among species of *Hyalella*, such as *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buckup 2008b), *H. longistila* (Bastos-Pereira & Bueno (2016), *H. gauchensis* and *H. georginae* (Ozga & Castiglioni 2017) and *H. bonariensis* (Castiglioni et al. 2018). Several hypotheses proposed by explain the assortative pairing by size in amphipods (Birkhead & Clarkson 1980; Ward 1984; Elwood et al. 1987; Crespi 1989; Elwood & Dick 1990; Dick & Elwood 1996; Ward & Porter 1993; Cornet et al. 2012; Yu & Chen 2013). However, the most widely accepted is male-male competition hypothesis (Ward 1983; Elwood et al. 1987; Castiglioni & Bond-Buckup 2008), which can explain the results observed in *H. palmeirensis* in the present study. According to the male-male competition hypothesis the larger males are better competitors, pairing with larger and more fecund females, because they are better able to affect a takeover, and they are able to resist takeover attempts while in precopulatory behavior (Ward 1983; Ward 1986).

The number of pairs in precopulatory mate-guarding behavior in the population of *H. palmeirensis* was slightly low, when compared to unpaired adults. The same was observed in *Hyalella castroi* and *H. pleoacuta* (Castiglioni & Bond-Buckup 2008b), *H. carstica* (Torres et al. 2015) and *H. bonariensis* (Castiglioni et al. 2018). The low occurrence of pairs in this population can be related to the fact that the individuals stay in precopulatory mate-guarding for a short time, approximately 3-4 days (personal observation), since this behavior can make individuals more vulnerable to predation (Strong 1972; Wellborn 1995; Castiglioni & Bond-Buckup 2008b). Moreover, the sampling procedures may have led to the separation of individuals (Wellborn 1995; Castiglioni & Bond-Buckup 2008b).

In the present study, it was observed that there is no reduction in the number of eggs during embryonic development in *H. palmeirensis* probably because the number of eggs produced is relatively low and thus there is enough space in the brood pouch for the development of all eggs until the end of embryo incubation, with no loss of embryos. However, there has been a reduction in egg numbers throughout embryonic development in some species of *Hyalella* from Brazil (Castiglioni & Bond-Buckup 2009; Bastos-Pereira & Bueno 2016; Ozga & Castiglioni 2017; Castiglioni et al. 2018). Usually there is an increase in embryo volume throughout embryonic development and thus the space inside the brood pouch decreases, leading to a premature loss of a few embryos (Koch 1990). In addition, the reduction of eggs/juveniles may be a consequence of the presence of parasites (Sheader 1983; Kuris 1991) or maternal cannibalism, which may occur when food resources are scarce (Sheader 1983; Castiglioni & Bond-Buckup 2009).

The mean fecundity of *H. palmeirensis* is relatively lower than other species of *Hyalella* that occur in the state of Rio Grande do Sul, such as *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buclup 2009), and *H. gauchensis* and *H. georginae* (Ozga & Castiglioni 2017) and similar to *H. bonariensis* (Castiglioni et al. 2018). Castiglioni et al. (2018) observed for *H. bonariensis* greater fecundity compared to other Brazilian tropical species, such as *H. carstica* (Torres et al. 2015) and *H. longistila* (Bastos-Pereira & Bueno 2016) and one North American species, *H. azteca* (Othman & Pascoe 2001; Wellborn et al. 2005). Probably, this difference in fecundity between species of the genus *Hyalella* may be associated with differences in habitats and microclimate in which species live, a fact already verified by Poweel (1992) and Appadoo & Myers (2004) for other amphipod species.

In the present study, it was observed that there is no difference in *H. palmeirensis* fecundity throughout the seasons. On the other hand, Ozga & Castiglioni (2017) found differences in the number of eggs production for *H. georginae* with lower production in autumn and *H. gauchensis* with lower egg production in spring demonstrating that for these species the environmental conditions were related to reproduction. A reduction in the number of eggs produced in the summer was observed in *H. pleocuta* and *H. castroi* (Castiglioni & Bond-Buckup 2009), in *H. bonariensis* (Castiglioni et al. 2018) and in *H. pampeana* (Colla & Cesar 2019). Reduction in the number of eggs in summer may be associated with decreased macrophyte coverage and consequently shelter and food during the warmer months where specimens were sampled suggesting what may be related to a reproductive strategy of this amphipod (Castiglioni & Bond Buckup 2009; Castiglioni et al.2018). Already results obtained by Torres et al. (2015) for *H. carstica* showed that higher egg production peaked in summer after a long drought period suggesting that females produced more eggs at this time to recover and recolonize the habitat. Differences in seasonal fertility fluctuations observed in these species demonstrate that environmental conditions can directly interfere with reproductive biology as already observed by Maranhão et al. (2001), that cites temperatures and rainfall as factors that may influence the reproduction of amphipods.

The positive correlation between the body size of ovigerous females and the number of eggs in the brood pouch in *H. palmeirensis* is similar to the results observed for *H. azteca* (Strong 1972; Othman & Pascoe 2001), *H. pleoacuta e H. castroi* (Castiglioni & Bond-Buckup 2007; Castiglioni & Bond-Buckup 2009), *H. carstica* (Torres et al. 2015), *H. gauchensis* e *H. georginae* (Ozga et al. 2017), *H. bonariensis* (Castiglioni et al. 2018) and *H. pampeana* (Colla & César 2019). According to Castiglioni & Bond-Buckup (2009), body size of females may be related to the number of eggs produced, being that larger females are capable of producing more embryos and carry them in the brood pouch during the all embryonic development. Furthermore, in each species the great variability of the body shape can be interfere in the volume available for gonadal development and, consequently, in the brood size (Hines 1988).

The juvenile frequency of *H. palmeirensis* was high in spring and summer due to the peak of reproduction in the colder months of the year. Similar results were observed for other species such as *H. pleoacuta* and *H. castroi* (Castiglioni & Bond-Buckup 2008a) where juveniles were sampled in all seasons, being higher than the proportion of adults in most months, but showing frequency peaks in spring. Castiglioni et al. (2018) reported that adults of *H. bonariensis* outnumbered juveniles in the autumn, winter, and summer, showing only that juveniles represented only 25% of the total population. Juvenile peaks occurred in winter and

spring. Results observed in this study for *H. palmeirensis* regarding the high frequency of juveniles compared to adults in the warmer months of the year may be related to a reproductive strategy to ensure species survival as seasonal changes may interfere with food availability and possibly cause mortality (Price 1974; Smith & Fretwell 1974).

Conclusions

The results observed in *H. palmeirensis* demonstrate that this species has a population and reproductive dynamics very similar to other species of *Hyalella* already analyzed in southern Brazil. Moreover, it can be seen that although the species occurs in an environment with anthropic influence (soy cultivation), the population is managing to remain in the area, with formation of pre-copulatory pairs and release of juveniles in most months of year. Future studies might increase the knowledge about the biology and the relation between population of *H. palmeirensis* and their habitat, as well as their possible use as test in ecotoxicological test.

Moreover, it can be seen that although the *H. palmeirensis* occurs in an environment with anthropic influence (soy cultivation,) the population is managing to remain in the area, with reproduction and recruitment throughout the year.

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Authors' contributions

Daniela da Silva Castiglioni: contribution to data collection, concept and design of the study, data analysis and interpretation, and critical revision.

Marcio Limberger: contribution to data analysis and interpretation, and critical revision.

Vanessa da Silva e Castro: contribution to data collection, manuscript preparation, and data analysis.

Francieli Ubessi: contribution to data collection, manuscript preparation, and data analysis.

Conflicts of interest

There is no conflict of interest.

Ethics

The sampling was made with authorizations of the Instituto Chico Mendes de Conservação da Biodiversidade (MMA; ICMBio; SISBIO n° 32726-1).

Data Availability

The individuals are deposited in the Laboratório de Zoologia e Ecologia, Campus de Palmeira das Missões, Universidade Federal de Santa Maria.

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Dalechampia (Euphorbiaceae, Acalyphoideae): synopsis of species from Northeast Brazil

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Abstract: A synopsis of the *Dalechampia* from Northeastern Brazil is presented here, with discussions of their diagnostic features. The study was based on the analysis of herbarium material (including historical collections and types), specimens collected in the field, and bibliographic documentation. Twenty-eight species distributed among five sections were recognized, 19 of them endemic to Brazil. Most of the species are found in Caatinga and Atlantic Forest vegetation. A key for species identifications is provided, together with illustrations, and information on their geographic distributions and conservation statuses.
Keywords: *Dalechampiinae; Flora; Plukenetieae; Taxonomy.*

Dalechampia (Euphorbiaceae, Acalyphoideae): sinopse das espécies do Nordeste do Brasil

Resumo: Uma sinopse da *Dalechampia* do Nordeste do Brasil é apresentada aqui com uma discussão sobre as características diagnósticas. O estudo foi baseado na análise de materiais de herbário (incluindo coleções históricas e tipos), espécimes coletados durante o trabalho de campo, além de documentação bibliográfica. Vinte e oito espécies distribuídas em cinco seções foram reconhecidas, 19 delas endêmicas no Brasil. A maioria das espécies está distribuída na Caatinga e na Mata Atlântica. Uma chave para a identificação de espécies é fornecida juntamente com ilustrações, informações sobre as distribuições geográficas e status de conservação.
Palavras-chave: *Dalechampiinae; Flora; Plukenetieae; Taxonomia.*

Introduction

Dalechampia L. comprises approximately 130 species distributed pantropically, 90 of which are found in the tropical Americas, with its center of diversity being in South America (Armbruster et al. 1993). Brazil stands out for its diversity of species, with 72 taxa widely disseminated throughout the country in different vegetation types (Maya-Lastra et al. 2015). Southeastern Brazil holds 47.2% of the country's *Dalechampia* diversity (34 spp.), although Bahia State (located in the northeastern region) has the largest number of species (23 spp.), followed by the states of Minas Gerais and São Paulo, with 20 species each (both in the southeastern region), and Amazonas State (northern region) with 19 species. Neotropical savanna (Cerrado) and Atlantic Forest regions hold the largest numbers of genera (32 and 31 respectively), while the northeastern region holds 29 species, representing 39% of the species richness of the country (Flora do Brasil 2020, under construction). The Caatinga and Atlantic Forest phytogeographic domains concentrate the highest representivity of *Dalechampia* (Flora do Brasil 2020, under construction).

The inflorescences and flowers of *Dalechampia* provide the best morphological features for characterizing the genus. The inflorescence is a pseudanthium, distinguishable from the other genera of Euphorbiaceae by having two large involucral bracts varying in color from whitish, yellowish-greenish, pink, to magenta; those bracts can be entire, 3–lobed, or deeply 3–5-lobed, and are inserted below a pistillate cymule of 1–3 flowers, with staminate pleiochasium that can range from 4 to almost 50 flowers (Webster & Armbruster 1991 Armbruster, 2017). Most species have resiniferous secretory glands, or emit volatile aromatic compounds from the staminate subflorescence (Armbruster & Webster 1979, Webster & Armbruster, 1991). From a vegetative point of view, they are mostly herbaceous and climbing plants. Subshrub species are occasionally encountered, but almost exclusively in central-western Brazil (Pax & Hoffmann 1919, Webster & Armbruster 1991, Flora do Brasil 2020, under construction). The leaves can be extremely variable within a single species, and even on the same individual (Webster & Armbruster 1991).

The treatment by Webster & Armbruster (1991), which included the South American species of *Dalechampia,* is still the most recent and most complete. Although those authors did not provide descriptions of the species, they detailed morphological aspects and rearranged the sections and subsections. Some floristic studies involving *Dalechampia* (or part of the genus) have been conducted in Brazil (Alves 1998, Sales et al. 1998, Maya-Lastra 2015, Barbosa et al. 2006, Rodrigues 2007, Sátiro & Roque 2008, Pereira-Silva et al. 2015, Pereira-Silva et al. 2016, Souza et al. 2016), although they have been limited in scope and have not covered the entire northeastern region. *Dalechampia* diversity in northeastern Brazil is relevant, being the third highest richest region of the country (28 spp.), behind only the southeast (34 spp.) and central-west (30 spp.). Additionally, the northeastern region holds three of the four ecosystems with high representivities for the genus (Atlantic Forest, Cerrado, and Caatinga) (Flora do Brasil 2020, under construction). Bahia, the state with the highest recorded number of *Dalechampia* species in Brazil, is inserted in that region. At least six new occurences (*D. fernandesii* Webster, *D. armbrusteri* Webster, *D. viridissima* Webster, *D. allemi* Webster, *D. purpurata* Cordeiro, and *D. erythrostyla* R. A. Pereira-Silva & A. L. Melo) have been discovered in Bahia in recent decades, as well as *D. erythrostyla* in Pernambuco State, also in the northeast (Flora do Brasil 2020, under construction). As such, the present work updates the geographical distribution of *Dalechampia* in northeastern Brazil, reports three new occurrences for that country, and provides a key to the identification, with illustrations and comments of all of its species.

Materials and Methods

Northeastern Brazil comprises nine states (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe), and covers an area of more than 1,500,000 km^2, equivalent to approximately 20% of the area the country (IBGE 2004).

The main geological features found in the northeastern region are Great Depressions (e.g., the mid-São Francisco depression), interspersed with plateaus and other mountain ranges with elevations often above 800 m a.s.l. (e.g., Chapada do Araripe, Chapada do Apodi, and Chapada Diamantina). The phytophysiognomies there reflect the different environmental conditions in those distinct geomorphological regions – being principally Caatinga (a low, deciduous, thorny vegetation), Cerrado (neotropical savanna, characterized by low woody and herbaceous plants, and small trees having thick bark), and Atlantic Forest (characterized by tall perennial and broad-leaved plants) (Queiroz 2009).

The regional climate in northeastern Brazil is semiarid (BSh), with mean annual temperatures between 23 and 27 ºC, mean annual rainfall levels of less than 800 mm, and relative humidity of 50% (EMBRAPA 1993). The most frequently occurring soils in the region are: Argisols, Latosols, Neosols, Litholic, Quartzeneic Neosols, Planosols, and Vertisols (Cunha et al. 2010).

Periodic field excursions were undertaken since 2015 until 2018 to observe natural populations and make botanical collections, following the methodology described by Mori et al. (1989). The collected materials, after processing, were deposited in the Professor Vasconcelos Sobrinho Herbarium (PEUFR) of the Federal Rural University of Pernambuco.

The identifications of the taxa were based mainly on Webster & Armbruster (1991). Exsiccates from the following herbaria were examined to analyze intraspecific morphological variations: ASE, BHCB, CEN, CEPEC, CESJ, DAV, ESA, FURB, G, HBR, HRCB, HST, HUEFS, HVASF, IAN, IBGE, INPA, IPA, K, M, MAC, MBML, NY, P, PEUFR, R, RB, S, SJRP, SP, SPF, TEPB, UB, UCR, UEC, UPCB, W (acronyms according to Thiers 2017). The standardization of vegetative and reproductive structural terminology was based on Radford (1974) and Webster & Armbruster (1991). Comments on geographic distributions, habitats, and phenological data were based on field collections, information available in the literature, and exsiccate labels.

Map with the geographic distributions of the species was prepared using QGIS® 2.18 software, based on the geographic coordinates provided on the herbarium labels (Figure 1). When geographical coordinates were not noted on the those labels, georeferencing was based on the GeoLoc tool of the speciesLink network (http://splink.cria.org.br/tools).

Conservation status assessments were primarily based on EOO (the extent of occurrence) and AOO (area of occupancy), using the Geocat web tool (http://geocat.kew.org/), following Bachman et al. (2011). Conservation statuses were subsequently determined based on criterion "B1" proposed by the IUCN red list, Version 3.1 (IUCN 2001).

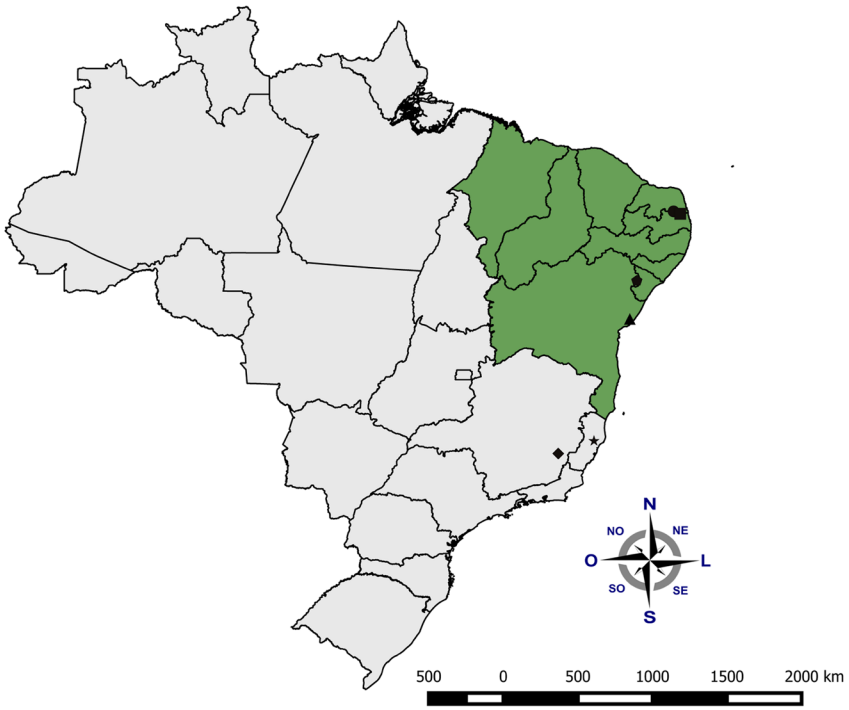

Figure 1. Map of Brazil with area of study highlighted including the distribution of the occurrences of *Dalechampia* .. (●) *D. leandri*; (■) *D. subintegra;* (⬟) *D. erythrostyla;* (▲) *D. affinis*; (♦) *D. allemii; D. alata* (★).

The habits of the *Dalechampia* plants from the Northeast, Brazil, were illustrated in Naquin (Figures 2-7). Regarding to Figures 8-10, we have opted for colorful illustration which has been useful for identification and classification of plants during centuries (Kur, 2018). It is possible to find many colorful botanical illustrations for *Dalechampia* since the end of 18th and-beginning of 19th century (see http://plantillustrations.org/species.php?id_species=319482). In that period, this style of illustrations used to be realistic representations (Hickman et al. 2017). We rescued the technique of colorful illustration reproduced by hand with adjustment of actual softwares to represent faithfully the species in the field in two dimensions, detaching the form of their pseudanthia. Some of the pseudanthia were illustrated based on photos available on the internet, these are indicated by the name of their authors; we do not intend to infringe copyright.

Results and Discussion

Dalechampia from Northeastern Brazil is represented by 28 species: *D. affinis* Mull. Arg., *D. alata* Mull. Arg., *D. allemii* Webster, *D. arciana* Baill., *D. armbrusteri* Webster, *D. brasiliensis* Lam., *D. convolvuloides* Lam., *D. coriacea* Klotzsch ex Müll. Arg., *D. erythrostyla* R. A. Pereira-Silva & A. L. Melo, *D. fernandesii* Webster, *D. ficifolia* Lam., *D. ilheotica* Wawra, *D. leandri* Baill., *D. linearis* Baill., *D. luetzelburgii* Pax & K. Hoffm., *D. olfersiana* Müll. Arg., *D. peckoltiana* Müll. Arg., *D. pentaphylla* Lam., *D. pernambucensis* Baill., *D. purpurata* Cordeiro, *D. scandens* L., *D. schenckiana* Pax & K.Hoffm., *D. stipulacea* Mull. Arg., *D. subintegra* Müll. Arg., *D. sylvestris* S. Moore, *D. tiliifolia* Lam., *D. triphylla* Lam., and *D. viridissima* Webster. They form a group morphologically very diverse which differ in habit, type of leaves, color of involucral bracts and shape of stylar column. Here each species is

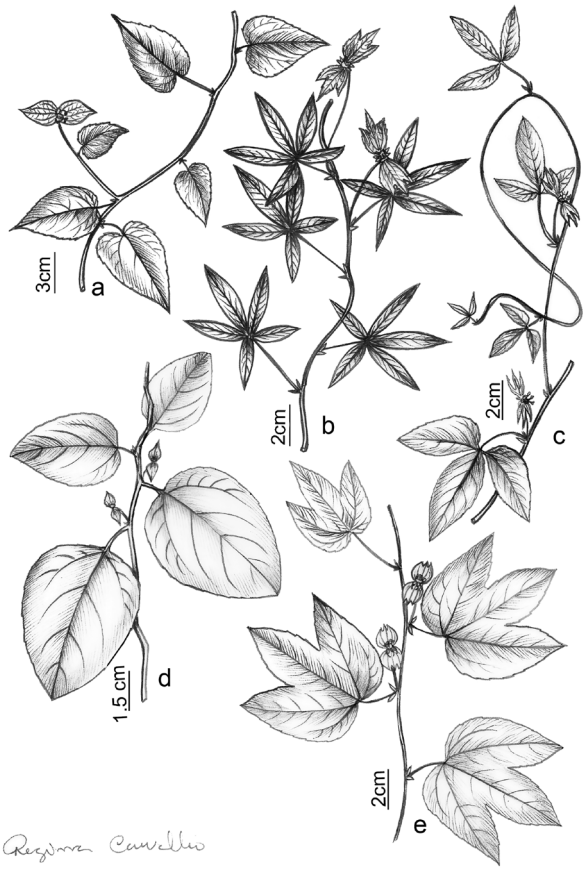

Figure 2. Habits of *Dalechampia* species. a. *D. affinis* (*M.G. Silva & R. Bahia 3591*). b. *D. alata* (*L. Kollmann et al. 2376*). c. *D. allemii* (*A.C. Allem et al. 2980*). d. *D. arciana* (*S.G. Resende & E.G. Resende 1699*). e. *D. armbrusteri* (*Hage & L.A.M. Silva 317*).

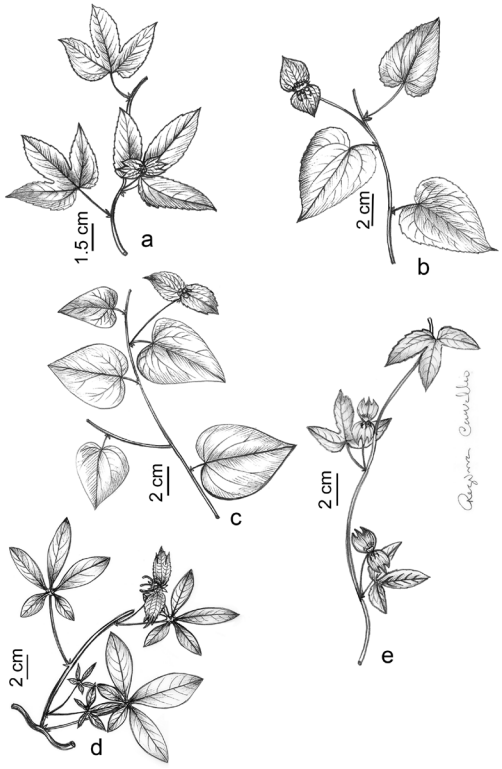

Figure 3. Habits of *Dalechampia* species. a. *D. brasiliensis* (*L.R. Noblick 3565*). b. *D. convolvuloides* (*F.S. Santos Filho 007*). c. *D. coriacea* (*Allem et al. 2949*). d. *D. erythrostyla* (*R. A. Pereira-Silva & A. L. Melo 16*). e. *D. fernandesii* (*A.M. Fernandes & E. Matos s.n. EAC 12725*).

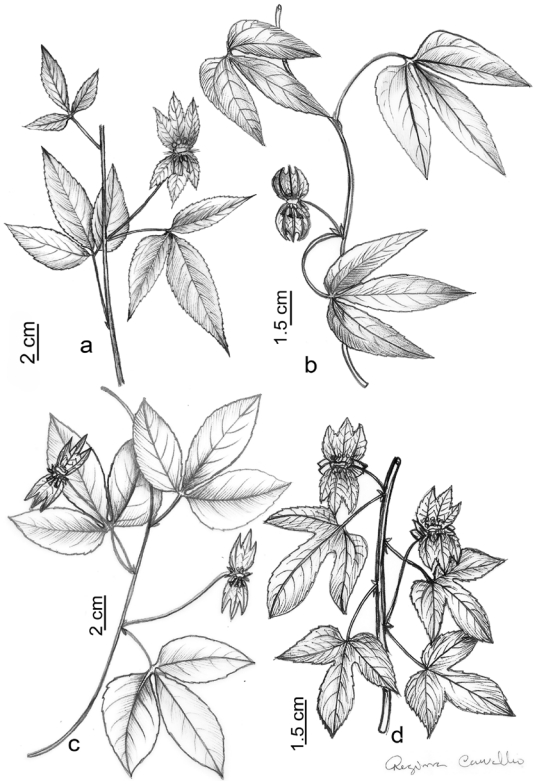

Figure 5. Habits of *Dalechampia* species. a. *D. luetzelburgii* Pax & Hoffm. (*M.R.L. Oliveira 59*). b. *D. olfersiana* Müll. Arg. (*K.R.B. Leite 212*). c. *D. peckoltiana* (*F.R. Nonato et al. 877*). d. *D. pernambucensis* (*A.S. Fernandes s.n.*, EAC 20877).

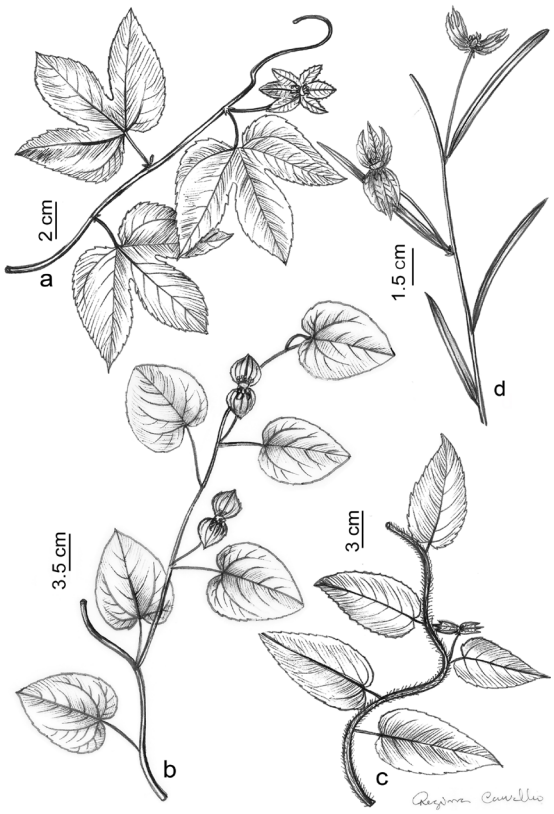

Figure 4. Habits of *Dalechampia* species. a. *D. ficifolia* (*A. Korte 669*). b. *D. ilheotica* (*M.L. Guedes* et al. 1198). c. *D. leandri* (*G.L. Webster et al. 25429*). d. *D. linearis* Baill. (*T.S. Figueiras 1289*).

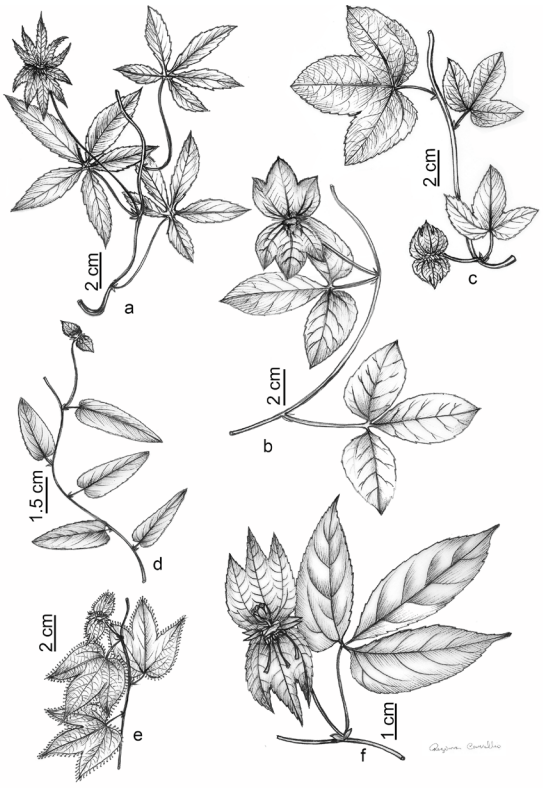

Figure 6. Habits of *Dalechampia* species. a. *D. pentaphylla* (*L.P. de Queiroz et al. 9402*). b. *D. purpurata* (*B. Stannard et al. H51654*). c. *D. scandens* L. (*A.C. Allem et al. 3010*). d. *D. schenckiana* (*Pereira-Silva 37*). e. *D. stipulacea* (*A.M. Miranda* et al. *2695*). f. *D. sylvestris* (A.M Giulietti & R. M Harley 2055).

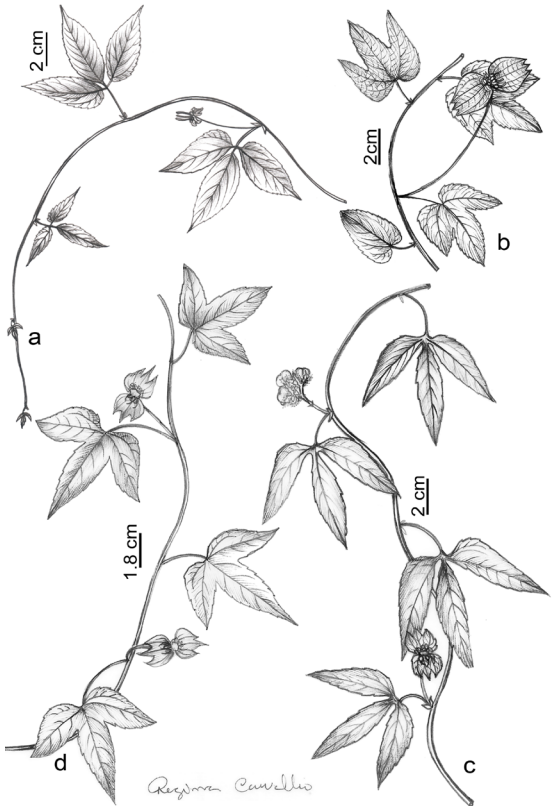

Figure 7. Habits of *Dalechampia* species. a. *D. subintegra* (*P.C. Fevereiro 170*). b. *D. tiliifolia* (*M.J. Ballck et al. 1490*). c. *D. triphylla* (*K. Santos s.n.,* SJRP 30272). d. *D. viridissima* (*A.M. Amorim et al. 2466*).

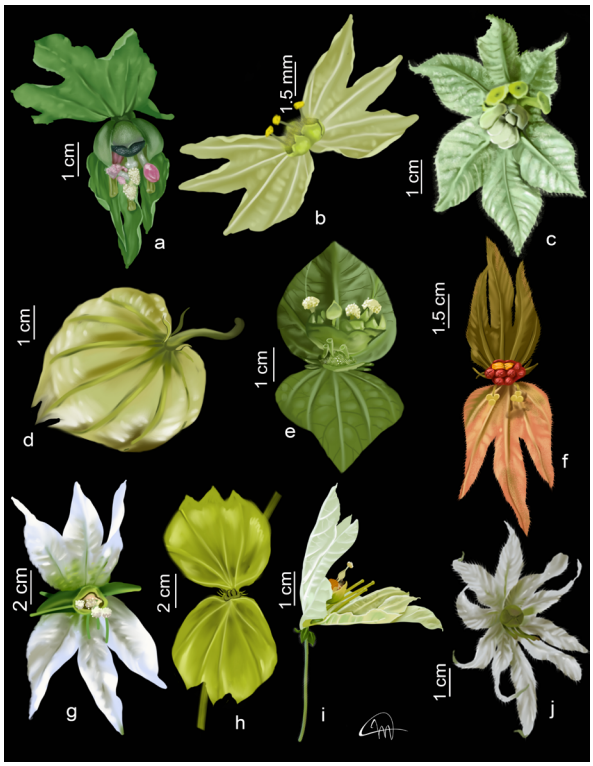

Figure 9. Pseudanthia of *Dalechampia* in northeastern Brazil. a. *D. erythrostyla.* b. *D. fernandesii*. c. *D. ficifolia* (Photo: Marcia Stefani). d. *D. ilheotica*. e. *D. leandri.* f. *D. linearis* (Photo: Marcelo F. Simon). g. *D. luetzelburgii* (Photo:Daniela Zappi). h. *D. olfersiana* Müll. Arg. i. *D. peckoltiana* (Photo: Alex Popovkin). j. *D. pentaphylla* (Photo: pybio.org).

Figure 8. Pseudanthia of *Dalechampia* in northeastern Brazil. a. *Dalechampia affinis* (Photo: Alex Popovkin). b. *Dalechampia alata*. c. *D. allemii* d. *D. arciana*. e. *D. armbrusteri.* f. *D. brasiliensis*. g. *D. convolvuloides*. h. *D. coriacea*.

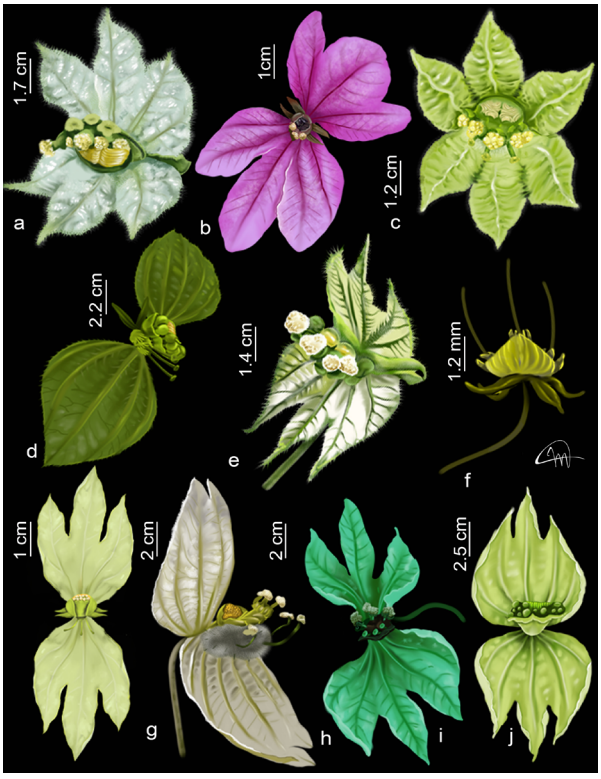

Figure 10. Pseudanthia of *Dalechampia* in northeastern Brazil. a. *D. pernambucensis* (Photo: Roberto Guerra). b. *D. purpurata* (Photo: Eduardo Saar). c. *D. scandens* (Photo: W.J. Hayden). d. *D. schenckiana*. e. *D. stipulacea*. f. *D. subintegra*. g. *D. sylvestris*. h. *D. tiliifolia* (Photo: Andres Hernandez). i. *D.* aff. *triphylla* (Photo: Eduardo Lozano). j. *D. viridissima*.

characterized and compared with related taxa, being a great contribution for identification of more than 37% of the genus from Brazil. In addition, we present a key more complete for the group until the moment.

From those species listed, seven are new occurrences identified in this work, five in northeastern Brazil and one in the southeast (Figure 1). Where *Dalechampia erythrostyla* is reported here for the first time for Sergipe State, *D. leandri* for Paraíba State, *D. pernambucensis* for Piauí State, *D. affinis* and *D. linearis* for Bahia State, *D. allemii* for Minas Gerais (southeast) and *D. alata* for Espírito Santo (southeast). Among these 28 species identified in the northeastern Brazil, five of the six sections are represented (*Coriaceae*, *Dalechampia, Dioscoreifoliae*, *Tiliifoliae,* and *Triphyllae*) (Table 1).

Table 1. Species from northeastern Brazil in their respective sections.

Sections	Species
Coriaceae Pax & K. Hoffm	D. coriacea
Dalechampia L.	*D. allemii, D. armbrusteri, D. brasiliensis, D. convolvuloides, D. ficifolia, D. leandri, D. linearis, D. olfersiana, D. pernambucensis, D. scandens, D. schenckiana, D. stipulacea, D. triphylla, D. viridissima*
Dioscoreifoliae Pax & K. Hoffm.	*D. alata, D. arciana, D. erythrostyla, D. luetzelburgii, D. peckoltiana, D. pentaphylla, D.purpurata, D. subintegra, D. sylvestris*
Tiliifoliae G. L. Webster & Armbruster	*D. affinis, D. fernandesii, D. ilheotica, D. tiliifolia*

Most of them from northeastern were observed to occur in Bahia (25 spp.), followed by Pernambuco (16 spp.) and Sergipe (9 spp.). Occurring mainly in Atlantic Forest phytophysiognomies (coastal and montane vegetations), and preferably in sunny areas (such as forest fragment edges). In Bahia, the species preferentially occur in ecotone areas of seasonal, caatinga, and cerrado forests. To other genera of Euphorbiaceae from Brazil such as *Acalypha*, *Croton* and *Euphorbia*, this occurrence for Atlantic forest also is predominant (Flora do Brasil 2020, in construction).

Dalechampia L., Sp. Pl. 2: 1054. 1753.

Type: *Dalechampia. scandens* L. Species Plantarum: 105: 1753. Type: West Indies. Plantarum Americanarum fasciculus, 5: pl. 101 (original plate at P!, illustrated by Plumier).

Vine, liana or subshrub, monoecious; branches with tector trichomes, usually stinging. Leaves alternate, simple or compound, with petiolar stipules, and stipels at the base of leaf blade; lamina entire, 3–5-lobed or 3–5-foliolate, cordiform, linear, ovate, lanceolate; margins entire, slightly serrated, sinuate, serrulate or dentate, usually with glands, sometimes with stipitate glandular trichomes. Pseudanthium axillary, rarely terminal, bisexual, with 2 pairs of bracteal stipules, 2 involucral bracts; staminate pleiochasium and pistillate cymule centrally located; resiniferous glands formed by a set of bracteoles located next to the staminate pleiochasium. Involucral bracts entire to lobed, usually not unguiculate, magenta, yellowish, greenish or whitish. Staminate pleiochasium with 6–16 flowers; 1–5 bracteoles. Staminate flowers apetalous, pedicelate; sepals 4–6, free, lanceolate; stamens 4–100, filaments united in a column, anthers showing longitudinal dehiscence. Pistillate cymule with 3 flowers; bracteoles 1–4. Pistillate flowers apetalous, pedicelate; sepals 6–12, free, lanceolate or ovate, entire, pinnatifid or laciniate; ovary globoid, 3-locular, 3-carpelar, 1 ovule per locule; stylar column cylindrical, stigma lobed, crateriform, clavate, discoid, cylindrical to peltate. Capsule with persistent stylar column, sepals, and involucral bracts. Seeds usually globoid, smooth or rugose, ecarunculate.

Identification key to species of *Dalechampia* in northeastern Brazil

1. Subshrub; staminate bracteoles and staminate sepals reddish.....14. *D. linearis*
1. Liana or vine; staminate bracteoles greenish and staminate sepals pinkish or greenish 2
2. Leaves simple, unlobed and/or lobed 3
3. Leaves unlobed.....4
4. Leaves with margins sinuate, apex rounded, slightly apiculate; involucral bracts lanceolate .....4. *D. arciana*
4. Leaves with margins entire or dentate, apex acute, not apiculate; involucral bracts ovate to widely ovate 5
5. Leaves coriaceous .....8. *D. coriacea*
5. Leaves membranaceous 6
6. Involucral bracts widely ovate, with 7 primary veins; ovary hispidous.....1. *D. affinis*
6. Involucral bracts ovate, with 3–5 primary veins; ovary pubescent.....7
7. Leaves cordiform; apex of the stylar column discoid.....7. *D. convolvuloides*
7. Leaves lanceolate to ovate; apex of stylar column discreetly crateriform to moderately lobed 8
8. Branches and veins on the adaxial face of the leaves hirsute; involucral bracts 1.5-2 cm wide; pistillate sepals laciniate .....13. *D. leandri*
8. Branches densely villous, and veins on the abaxial side of the leaves pubescent; involucral bracts 0.6–1 cm wide; pistillate sepals pinnatifid .....22. *D. schenckiana*
3. Leaves lobed.....9
9. Leaves 3-lobed or varing between unlobed to 3-lobed.....10
10. Involucral bracts 3-toothed.....11
11. Leaves exclusively 3-lobed.....5. *D. armbrusteri* 11. Leaves varying between unlobed to 3-lobed.....12
12. Branches tomentose; apex of the stigma discoid to peltate; resiniferous gland fimbriate .....26. *D. tiliifolia*
12. Branches pubescent; apex of the stigma crateriform, resiniferous gland lacerate .....12. *D. ilheotica*

10. Involucral bracts 3-lobed…..……13
13. Pistillate sepals 6–7, discreetly glandular at tip…….....28. *D. viridissima*
13. Pistillate sepals 8–12, copiously glandular at tip.....…….....14
14. Margins of leaves with capitate glandular trichomes; parastipule present on the petiolar stipule .....24. *D. stipulacea*
14. Margins of leaves with papiliform glands; parastipule absent on the petiolar stipule 15
15. Liana; petiolar stipule ferruginous; bracteal stipule oblong…. ……11.*D. ficifolia*
15. Vine; petiolar stipule greenish; bracteal stipule linear, lanceolate or deltoid…….....16
16. Involucral bracts chartaceous; stigma peltate to discoid……..……....17
17. Margins of involucral bracts ciliate; involucral bracts white at anthesis; bracteal stipule deltoid.....19. *D. pernambucensis*
17. Margins of involucral bracts not ciliate; involucral bracts yellowish at anthesis; bracteal stipule linear ……..……10. *D. fernandesii*
16. Involucral bracts membranaceous; stigma crateriform to lobed……18
18. Involucral bract greenish; bracteal stipule lanceolate; stigma slightly crateriform; resin of gland yellowish .....22. *D. scandens*
18. Involucral bract pale green; bracteal stipule linear; stigma slightly lobed, resin of gland white .....6. *D. brasiliensis*
9. Leaves 5-lobed…….20
19. Branches greenish; pistillate sepals laciniate; upper half of the stylar column greenish after pollination; stigma clavate .....2. *D. alata*
19. Branches vinaceous; pistillate sepals pinnatifid; upper half of the stylar column reddish after pollination, stigma lobate .....
.....……..9. *D. erythrostyla*
2. Leaves compound ……..……20
20. Staminate bracteole free; resin gland fimbriate.....…….....21
21. Leaf 5-foliolate; involucral bracts deeply 3-5-lobed; pistillate sepals 6 entire.....18. *D. pentaphylla*
21. Leaf 3-foliolate, involucral bracts exclusively 3-lobed; pistillate sepals 6-12 pinnatifid ……..22
22. Involucral bracts vinaceous; petiolar stipule and staminate bracteole vinaceous; pistillate sepals pink .....20. *D. purpurata*
22. Involucral bracts greenish, whitish or yellowish; petiolar stipule and staminate bracteole greenish; pistillate sepals greenish ….....23
23. Stigma slender.....…….....24. *D. subintegra*
23. Stigma cylindrical or moderately lobed.....…….....24
24. Pseudanthium 7–9 cm long; involucral bracts greenish to yellowish, stigma moderately lobed ……..……26. *D. sylvestris*
24. Pseudanthium 5–7 cm long; involucral bracts albido-virides or whitish, stigma cylindrical …..……..25
25. Bracteal stipule 1–1.3 cm; ovary pubescent; stylar column glabrescent, 1.4–1.5 cm long; pistillate bracteole glabrous, ciliat ……
…….....18. *D. peckoltiana*
25. Bracteal stipule ca. 8 mm long; ovary vellutinuos; stylar column pubescent, 1.2–1.3 cm long; pistillate bracteole pubescent, no ciliate …..
…….....15. *D. luetzelburgii*
20. Staminate bracteole connate at the base, resin gland laminar .....…….....28
27. Involucral bract unguiculate, 0.7–1 cm wide; pistillate sepals 3-fid..…….....3. *D. allemii*
27. Involucral bract not unguiculate, 1.3–1.9 cm wide; pistillate sepals laciniate or pinnatifid 28
28. Adaxial leaf face glabrous; apex of stigma slender to moderately lobed; sepals on fruit 3–4 mm wide.....27. *D. triphylla*
28. Adaxial leaf face sparsely hispidous; apex of stigma discoid; sepals on fruit 1–2 mm wide .....16. *D. olfersiana*

1. *Dalechampia affinis* Müll. Arg. Linnaea 34: 223. 1865. Lectotype (designated by Webster & Armbruster 1991): French Guyana, La Mana, 1856, *P.A. Sagot s.n.* (G!, isolectotype P! 2 sheets). Figure 2a & 8a.

Dalechampia affinis is distinguished by having pistillate cymule sessile, pistillate bracteole widely ovate, pistillate sepals, ovary hispidous, stigma peltate, and a discoid stylar column. It can be confused with *D. convolvuloides*, as they share cordate leaves and pinnatifid sepals. They can be differentiated, however, by the numbers of veins (seven in *D. affinis* vs. three to five in *D. convolvuloides*), ovary hispid (vs. pubescent)

Distribution, ecology, and conservation: *Dalechampia affinis* occurs in South America from Venezuela to Brazil in rainforest environments (Webster & Armbruster 1991). In Brazil, it is found in the northern (Amazonas, Amapá, Pará, Rondônia states), southeastern (Minas Gerais), and northeastern regions (Flora do Brasil, under construction 2020). In the northeast, it has been recorded in the states of Maranhão and Piauí in gallery forests. A new occurrence is recorded here for Bahia in an Atlantic Forest environment. The species is designated, using IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 5,947,112.590 km^2, and as endangered (EN) due to its AOO of 272.000 km^2.

Material examined: BRAZIL, BAHIA: Salvador, 12°58'S, 38°30'W, 18.VII.1951, fl., O. Travassos 206 (RB). PIAUÍ: Piripiri, Estrada para pedro II, 4°20'S, 41°46'W, 05.IV.2002, R.S. Rodrigues 1488 (TEPB). MARANHÃO: Viana, 03º13'S, 45º00'W, I.1960, fl., fr., O. Carvalho s.n. (RB 105148).

Additional material examined: BRAZIL, PARÁ: Jacundá, Rio Tocantins, 4°26'S, 49°6'W, 16.V.1978, fl., M.G. Silva & R. Bahia 3591 (UB); Oriximiná, Cachoeira Porteira, 1°45'S, 55°51'W, V.1981, fl., fr., *C. Davidson s.n.* (UB 117738). AMAPÁ: Macapá, Rodovia JK 2 km, Cerrado do campus Marco Zero da UNIFAP, 0°2'N, 51°4'W, 19.VI.2015, fl., *R.S.F.R. Sarquis 274* (IAN).

2. *Dalechampia alata* Müll.Arg. Linnaea 34: 220. 1865. Lectotype (designated by Webster & Armbruster 1991): Brazil, Rio de Janeiro, Tocaia, *Schott 4198* (W!). Figure 2b & 8b.

Dalechampia alata was distinguished from other congeners by having a cuneate foliole base, laciniate pistillate sepals, and stigma clavate. It resembles *D. erythrostyla,* as both have parted leaves, 5-lobed, but are differentiated by the shape of the pistillate sepals (laciniate or slightly lobed in *D. alata* vs. pinnatifid in *D. erythrostyla*) and by the shape of the stigma (clavate in *D. alata* vs. slightly lobed in *D. erythrostyla*).

Distribution, ecology, and conservation: *Dalechampia alata* is endemic to Brazil, having been recorded in the southeastern (Espírito Santo, Rio de Janeiro and São Paulo) and northeastern regions of that country (Flora do Brasil 2020, under construction). In the study area, it is recorded for Bahia and Pernambuco, occurring in the caatinga and Atlantic Forests. *Dalechampia alata* is designated as of least concern (LC) considering it's EOO of ca. 1,389,947.159 km^2, and as endangered (EN) due to its AOO of 40.000 km^2 (IUCN 2001).

Material examined: BRAZIL, PERNAMBUCO: São Lourenço da Mata, Tapera, 8°0'S, 35°1'W, 06.III.1925, fl., D.B. Pickel 886 (IPA). BAHIA: Maracás, 13º26'S, 40º25'W, 05.V.1979, fr., S.A. Mori & T.S. Santos s.n. (CEPEC 16131). ESPÍRITO SANTO: Santa Teresa, Estrada do 25 de Julho, 06.IV.1999, fr., L. Kollmann et al. 2376 (MBML); Santa Teresa, São João de Petrópolis, fl., fr., (fragmented), A. P. Fontana et al.21 (MBML).

3. *Dalechampia allemii* Webster, Ann. Missouri Bot. Gard. 78: 255-257. 1991. Holotype: Brazil, Bahia, Andaraí, 50 km NW of Andaraí, *A.C. Allem, G.L. Webster & W.L. Werneck 2980* (CEN, isotype DAV!). Figure 2c & 8c

Dalechampia allemii is easily differentiated from other congeners by having 3-foliolate leaves, unguiculate involucral bracts, and 3-fid pistillate sepals.

Distribution, ecology, and conservation: *D. allemii* is endemic to Brazil, and currently considered exclusive to Bahia (northeastern region), where it is found growing in Caatinga vegetation (Webster & Armbruster 1991). We have expanded the amplitude of its distribution, however, with a new record here for Minas Gerais State (southeast) in a semideciduous montane forest. According IUCN criteria (2001), the species is designated as least concern (LC) by having an EOO of ca. 225,678.370 km^2, and as endangered (EN) due to its AOO of 24.000 km^2 (IUCN 2001). Part of the area in which the species occurs is located within the Morro do Chapéu State Park.

Material examined: BRAZIL, BAHIA: Wagner, 12°16'S, 41°10'W, 15.XI.1984, fl., A.C. Allem et al. 2980 (CEN).

Additional material examined: BRAZIL, MINAS GERAIS: Jequeri, área de inundação da usina de providência, 20°27'S, 42°39'W, 19.XI.1997, fl., A. Salino 3752 (BHCB).

4. *Dalechampia arciana* Baill. Adansonia 5: 314. 1865. Lectotype: Brazil, Bahia, Jacobina, Pouço d'Areia, *J.S. Blanchet 3884* (P!, isolectotypes BM!, G! 3 sheets, G-DC!, UC!). Figure 2d & 8d.

Dalechampia arciana can be distinguished from other species in the group by having leaves chartaceous, ovate, with base subcordate to rounded, apex rounded, an involucral bract, and pistillate sepals entire.

Distribution, ecology, and conservation: The species is endemic to Brazil and can be found in the southeastern (Rio de Janeiro) and northeastern regions of that country (Flora do Brasil 2020, under construction). In the northeast, it is found only in Bahia State in caatinga environments. The species is designated, according IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 858,606.243 km^2, and as endangered (EN) due to its AOO of 36.000 km^2. The area of occurrence of *Dalechampia arciana* includes three protected areas in southern Bahia: the Descobrimento National Park, Pau Brasil National Park, and the Una Wildlife Refuge.

Material examined: BRAZIL, BAHIA: Prado, Fazenda Riacho das Ostras, 17°19'S, 39°13W, 28.XI.2006, fl., S.G. Resende & E.G. Resende 1699 (BHCB).

5. *Dalechampia armbrusteri* Webster, Brittonia 41:3. 1989. Holotype: Brazil, Bahia, grounds of CEPLAC, *G.L. Webster & S. Armbruster 25000* (CEPEC!, isotype DAV!). Figure 2e & 8e.

Dalechampia armbrusteri can be recognized by its 3-lobed, chartaceous leaves and obtuse to rounded base of involucral bracts. It can be confused, with *D. ilheotica* for sharing 3-cuspidate involucral bracts, velutinous, and 7–9 primary veins. Additionally, both were described from the same locality (Ilhéus, in Bahia State). *D. armbrusteri*, however, as leaves exclusively 3-lobed (vs. varying between entire and 3-lobed in *D. ilheotica*) and a 3-lobed stigma (vs. crateriform).

Distribution, ecology, and conservation: *Dalechampia armbrusteri* is endemic to Brazil, with records for the southeastern (Espírito Santo State) (Flora do Brasil 2020, under construction) and northeastern (Bahia) regions of that country, growing in ombrophilous forest environments.

Material examined: BRAZIL. BAHIA: Una, Serra Boa, 15°17'S, 39°4'W, 28.IX.1979, fl., J.L. Hage & L.A.M. Silva 317 (CEPEC).

6. *Dalechampia brasiliensis* Lam., Encycl. 2: 258. 1786. Lectotype (designated by Webster & Armbruster 1991): Brazil, Rio de Janeiro, *J. Dombey s.n.* (P!, isotype NY!). Figure 3a & 8f.

Dalechampia brasiliensis can be easily recognized by its linear bracteal stipules and pale green involucral bracts. The species has morphological affinities with both *D. scandens* and *D. pernambucensis* as they share 3-lobed leaves and pinnatifid pistillate sepals. They can be easily differentiated, however, by the shapes of their bracteal stipules, being linear in *D. brasiliensis* (vs. lanceolate in *D. scandens,* and deltoid in *D. pernambucensis*) and by the slightly lobed stigma in *D. brasiliensis* (vs. slightly crateriform in *D. scandens*, and peltate to discoid in *D. pernambucensis*).

Distribution, ecology, and conservation: *Dalechampia brasiliensis* is endemic to Brazil, growing in evergreen and seasonal forests (Webster & Armbruster 1991). According to Flora do Brasil (2020, under construction), the species is widely disseminated in the central-western (Mato Grosso do Sul and Mato Grosso states), southeastern (Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo), and northeastern regions of the country. *D. brasiliensis* is found in the states of Alagoas, Bahia, Ceará, Paraíba, Pernambuco, and Sergipe, growing in Caatinga and Atlantic Forest environments. The species is designated, according to IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 7, 836, 865. 094 km^2, and vunerable (VU) due to its AOO of 536. 000 km^2. *D. brasiliensis* occurs in protected areas in northeastern Brazil, such as: the Chapada

Diamantina National Park, Morro do Chapéu State Park, and the Raso da Catarina Ecological Station (all in Bahia), and in part of the Serra da Capivara National Park (Piauí State).

Material examined: BRAZIL, ALAGOAS: Matriz de Camaragibe, Santuário ecológico da Serra d'água, 9°5'S, 35°34'W, 26.VII.2003, fl., fr., R.P. Lyra-Lemos et al. 7805 (MAC). BAHIA: Senhor do Bonfim, Serra da Jacobina, 10°27'S, 40°11'W, 29.VII.2005, fl., V.J. Santos et al. 448 (HUEFS); Iaçu, 12°43'S, 39°52'W, 12.III.1985, fl., fr., L.R. Noblick 3565 (HUEFS). CEARÁ: Crato, Lameiro, 7°24'S, 39°41'W, 10.I.1982, fl., fr., A.L. Peixoto & O.L. Peixoto 1657 (UEC). PARAÍBA: Coremas, Área de tensão ecológica, próximo a Serra, 07°00'S, 37°56'W, 20.I.2010, fl., J.R. Andrade et al. 240 (PEUFR). PERNAMBUCO: Quipapá, Mata da Usina Água Branca, 8°49′S, 36°0′W, 10.I.1994, fl., A.M. Miranda 1170 (PEUFR). SERGIPE: Capela, RVS Mata do Junco, 10°32'S, 37°03'W, 30.IV.2013, fl, fr., L.A. Gomes et al. 1039 (ASE).

Additional material examined: BRAZIL, MINAS GERAIS: Itacarambi, 15°3'S, 44°8'W, 30.I.2010, fl., fr., E. Tameirão Neto & C. Vidal 4756 (BHCB).

7. *Dalechampia convolvuloides* Lam., Encycl. 2: 256.1786. Holotype: Brazil, *J. Dombey s.n.* (P!). Figure 3b & 8g.

Dalechampia convolvuloides can be recognized by having petiolar stipules sparsely hispid, involucral bracts entire, ciliated, with cordate bases, bracteal stipules ovate with obtuse bases, and ovary pubescent. It resembles *D. affinis*, but can be distinguished from it by characters discussed above in the comments concerning that species.

Distribution, ecology, and conservation: *Dalechampia convolvuloides* is restricted to Brazil where it can be found in northern (Acre, Rondônia), southeastern (Minas Gerais, Rio de Janeiro and São Paulo), and northeastern regions of that country (Flora do Brasil 2020, under construction). In the study area, the states of Bahia, Pernambuco, Sergipe, and Piauí are largely covered by Caatinga and Atlantic Forest vegetations. The species is designated, according IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 3,348,540.451 km^2, and as endangered (EN) due to its AOO of 96. 000 km^2. *D. convolvuloides* occurs in the Raso do Catarina Ecological Station (Bahia), Catimbau National Park (Pernambuco), Serra da Capivara National Park (Piauí), and the Araripe-Apodi National Forest (Ceará).

Material examined: BRAZIL, BAHIA: Salvador, Dunas de Itapuã, 12°56'S, 38°21'W, 12.XII.1985, fl., L.R. Noblick & I.C. Britto 4484 (HUEFS). PERNAMBUCO: Buíque, PARNA Catimbáu, 8°34'S, 37°15'W, 25.XI.2007, fl., B.S. Amorim & A. Melo 2373 (NY). PIAUÍ: Teresina, Pq. Zoobotânico, 5°5'S, 42°48'W, 03.02.1999, fl., F.S. Santos Filho 10 (PEUFR). SERGIPE: Mata do Crasto, Santa Luzia do Itanhy, 11°22'S, 37°25'W, 15.IX.1995, M.F. Landim 659 (HUEFS).

Additional material examined: BRAZIL, ESPÍRITO SANTO: Santa Teresa, Estrada para o Cruzeiro, 19°56'S, 40°35'W, 8.V.1984, fl., fr., R.M. Piziolo 52 (MBML); Santa Teresa, Estrada para o Canaã, 19°55'S, 40°37'W, 04.XII.1985, fl., J.M. Vimercat 322 (MBML). MINAS GERAIS: Santo Hipólito, 18°17'S, 44°11'W, 24.III.1997, fl., R.M. Silva et al. 1300 (BHCB).

8. *Dalechampia coriacea* Klotzsch ex Müll. Arg., Linnaea, 35: 223. 1865. Lectotype (designated by Webster & Armbruster 1991): Brazil, without locality, *F. Sellow s.n.* (G!, isolectotype P!, W!) Figure 3c & 8h.

Dalechampia coriacea can be recognized by having coriaceous leaves with dentate or entire margins, entire or 3-toothed involucral bracts, and pistillate sepals glabrous. It is morphologically similar to *D. ilheotica* in terms of the coriaceous consistency of their leaves, and *D. coriacea* can sometimes have entire leaves (similar to those of *D. ilheotica*). They can be differentiated, however, by having pubescent branches (vs. sparsely villous in *D. ilheotica*), lanceolate bracteal stipules (vs. linear), and a discoid stigma (vs. crateriform).

Distribution, ecology, and conservation: *D. coriacea* is endemic to Brazil (Webster & Armbruster 1991), with records only for the northeastern region (Bahia and Pernambuco), being found in Caatinga and Ombrophilous Forest environments. According to IUCN (2001) criteria, the species is classified as of least concern (LC) due to its EOO of ca. 1,700, 173. 391 km^2, and as endangered (EN) due to its AOO of 200.000 km^2. Populations of this species can be found within the Serra das Confusões and Serra da Capivara National Parks (Piauí), the Araripe-Apodi National Forest (Ceará), the Catimbau National Park (Pernambuco), the Murici Ecological Station (Alagoas), the Raso do Catarina Ecological Station, Sete Passagens State Park, Morro do Chapéu State Park, and the Chapada Diamantina National Park (Bahia).

Material examined: BRAZIL, BAHIA: Itiruçu, 13°31'S, 40°9'W, 12.XI.1984, fl., A.C. Allem & W.L. Werneck 2949 (CEN); Santa Terezinha, Serra da Jibóia, 12°46'S, 39°31'W, 08.VII.1999, F. França et al. 3201 (CEN). PERNAMBUCO: Igarassu, Usina São José, 7°46'S, 35°00'W, 1.XII.2011, fl., fr., B.S. Amorim et al. 1309 (NY).

9. *Dalechampia erythrostyla* R. A. Pereira-Silva & A. L. Melo, Syst. Bot. 41: 989–995. 2016. Holotype: Brazil, Pernambuco, Tracunhaém, engenho Trapuá, 27 May 2014, *R. Pereira-Silva & A. Laurênio 16* (IPA!, isotypes K!, NY!, P!, PEUFR!, RB!, SP!). Figure 3d & 9a.

Dalechampia erythrostyla can be recognized by having branches vinaceous, pistillate pinnatifid sepals, involucral bracts cuneate, resiniferous glands fimbriate, a reddish coloration on the upper half of the stigma following pollination, and cylindrical stigma. The taxon is often confused with *D. alata*, but can be differentiated by aspects discussed above in the comments on that species.

Distribution, ecology, and conservation: *D. erythrostyla* is currently known only to Brazil, in the states of Bahia, Pernambuco, and Sergipe in the northeast region of that country (Pereira-Silva et al. 2016). The record for Sergipe is presented here for the first time. *D. erythrostyla* was found in those areas in the Atlantic Forest and at the edges of sub-deciduous forests. The species was considered as least concern (LC) due to its EOO of ca. 51, 333. 737 km², and as endangered (EN) due to its AOO of 12. 000 km².

Material examined: BRAZIL, PERNAMBUCO: Tracunhaém, Engenho Trapuá, 7°48'S, 35°14'W, 1.II.2014, fl., R.A. Pereira-Silva & A. Laurênio 12 (PEUFR); idem, 13.II.2014, fl., R. A.Pereira-Silva 14 (PEUFR); idem, 27.V.2014, fr., R. A.Pereira-Silva & L. Lima-Santos 16 (PEUFR); idem, 27.VI.2014, fl., fr., R.A. Pereira-Silva 18 (PEUFR). BAHIA: Jacobina, 11°10'S, 40°30'W, 25.VIII.1980, fl., Orlandi, R. 219 (HBR). SERGIPE: Divina Pastora, Fazenda Vassouras, 10°40'S, 37°9'W, 18.XI.2014, fl., J.A. Santana Júnior, et al. 41 (ESA).

10. *Dalechampia fernandesii* Webster, Brittonia 41:1. 1989. Holotype: Brazil, Ceará, Chapada da Ibiapaba, *G.L. Webster, Fernandes & Matos 25598* (EAC!, isotypes DAV!, NY, R, UCR!). Figure 3e & 9b.

Dalechampia fernandesii can be distinguished from other congeners by havingbracteal stipules linear involucral bracts 3-lobed, yellowish, vellutinous with proeminent veins, pistillate bracteole widely ovate and stigma peltate to discoid *Dalechampia brasiliensis* share the shape of bracteal stipules, but they differ in multiple aspects such as texture, color and primary veins of involucral bracts, beyond the shape of stigma.

Distribution, ecology, and conservation: *D. fernandesii* is endemic to Brazil, being encountered only in the northeastern region of that country (the states of Ceará, Maranhão, and Piauí) in Caatinga vegetation. The species is categorized, according to IUCN (2001) criteria, as vulnerable (VU) due to its EOO of ca. 9, 462. 023 km^2, and as endangered (EN) due to its AOO of 12,000 km^2. One of its known populations occurs in the vicinity of the Aiuaba Ecological Station in Ceará state.

Material examined: BRAZIL, CEARÁ: Aracati, 4°33'S, 37°46'W, 30.V.1987, A. Fernandes & A. Nunes s.n. (EAC 15262); Jaburuna-Sul, Planalto do Iapaba-Ubajara, 3°53'S, 40°58'W, 06.VI.1994, F.S. Araújo 807 (EAC); Tianguá, Chapada da Ibiapara, 03º43' S, 40º59'W 01.XI.1986, fl., G.L. Webster et al. s.n. (EAC 14892). MARANHÃO: Timon, 05º05'S, 42º50'W, 29.IV.1978, fl., A. M. Fernandes & E. Matos s.n. (EAC 3832). PIAUÍ: Between Parnaíba and Piracuruca, 2°54'S, 41°46'W, 28.VI.1984, A. M. Fernandes & E. Matos s.n. (EAC 12725).

11. *Dalechampia ficifolia* Lam., Encycl. 2: 258.1786. Holotype: Brazil, without locality, *J. Dombey s.n.* (P!). Figure 4a & 9c.

Dalechampia ficifolia is characterized by having oblong bracteal stipules, ferruginous, velutinous, and a 3-lobed to clavate stylar column. The species is similar to *D. stipulacea*, but can be differentiated by the length of the bracteal stipules in *D. ficifolia* (0.4–0.2 cm vs. 1.3–1.5 cm in *D. stipulacea*) and by the shape of the stigma shape in *D. ficifolia* (discoid to crateriform vs. lobed in *D. stipulacea*).

Distribution, ecology, and conservation: *D. ficifolia* is considered endemic to Brazil, although widely disseminated in all of its regions, growing predominantly in rainforest areas (Webster & Armbruster 1991). It is encountered in the central-western (Distrito Federal, Goiás), southeastern (Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo), and southern (Paraná and Santa Catarina) regions of the country (Flora do Brasil 2020, under construction). It is found in Bahia, Pernambuco, and Sergipe in ecotone areas between forest and Caatinga zones. The species is designated, according IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 10, 552, 361. 913 km^2, and as vulnerable (VU) due to its AOO of 748. 000 km^2. One of its populations has been recorded in the Chapada Diamantina National Park (Bahia); the extent of occurrence of the species includes several protected areas, such as: the Araripe-Apodi National Forest (Ceará), Catimbau National Park (Pernambuco), Raso do Catarina Ecological Station, Morro do Chapéu State Park, the Brejo Grande Ecological Reserve (Bahia), Serra das Confusões National Park, and the Serra da Capivara National Park (Piauí).

Material examined: BRAZIL, BAHIA: Santa Tereza, Serra da Jibóia, 12°51'S, 39°28'W, 01.XI.1992, L.P. Queiroz et al. 20891 (BHCB). PERNAMBUCO: São Vicente Férrer, Mata do Estado, 7°35'S, 35°30'W, 29.X.1984, E.M.N. Ferraz et al. 602 (PEUFR). SERGIPE: Mata do Crasto, Santa Luzia do Itanhy, 11°22'S, 37°25'W, 30.X.1995, fl., fr., M.F. Landim 750 (ASE).

Additional examined material: BRAZIL, SANTA CATARINA: Blumenau, 26°54'S, 49°4'W, 05.XII.2012, fl., L.A. Funez 1299 (FURB); Bairro Ristow, 21.X.2009, fl., A. Korte 669 (FURB). SÃO PAULO: Ubatuba, Acesso ao Condomínio Laranjeiras, 23°25'S, 45°5'W, 31.I.1996. fl., H.F. Leitão Filho et al. 34413 (UEC). MINAS GERAIS: Descoberto, reserva Biológica da Represa do Grama, 21°27'S, 42°58'W, 10.XI.2001, fl., J.O. Augustin et al. s.n. (CESJ 35081).

12. *Dalechampia ilheotica* Wawra, Oesterr. Bot. Z. 13: 222. 1863. Holotype: Brazil, Bahia, Ilhéus, *Wawvra & Maly 365* (W!, isotype W!). Figure 4b & 9d

Dalechampia ilheotica resembles *D. coriacea* and *D. armbrusteri* by aspects already presented for those species. *D. ilheotica* is characterized by having simple leaves, coriaceous or membranous, it is possible find individuals with unlobed leaves or 3-lobed, or yet ranging from unlobed to 3-lobed even on the same individual, as well as the involucral bracts can be unlobed or 3-toothed and apex of stigma crateriform.

Distribution, ecology, and conservation: *D. ilheotica* has been recorded for Colombia and Brazil. In Brazil, it has been collected in the southeastern (Espírito Santo) and northeastern (Bahia and Pernambuco) regions, growing in Atlantic Forest environments such as restinga (Webster & Armbruster 1991, Flora do Brasil 2020, under construction). It is found in ombrophilous forest and restinga environments in the states of Bahia and Pernambuco, and is designated, according IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 4, 509, 418. 463 km^2, and as endangered (EN) due to its AOO of 268,000 km^2. The largest number of populations is found in Bahia, where the species is disseminated throughout the state, growing in the Cassurubá Extractive Reserve, the Una Wildlife Refuge, and Serra das Lontras National Park. Considering its extent of occurrence, however, it is probable that populations of *D. ilheotica* occur in other protected areas in Bahia, such as: the Pau Brasil National Park, Descobrimento National Park, Canavieiras Extractivist Reserve, Boa Nova National Park, Morro do Chapéu Park State, Raso do Catarina Ecological Station, and the Chapada Diamantina National Park.

Material examined: BRAZIL, PERNAMBUCO: Maraial, 8°48'S, 35°45'W, 10.II.1994, fr., A.M. Lourenço 1317 (PEUFR); São Vicente Ferrer, 7°35'S, 35°29'W, 20.I.1999, fl. E. M. N. Ferraz et al. 602 (PEUFR). BAHIA: Uruçuca, Distrito de Serra Grande, 14° 35'S, 39° 17'W, 07.IX.1991, A.M. Carvalho et al. 3646 (SP).

13. *Dalechampia leandri* Baill. Adansonia 5: 315. 1865. Lectotype (designated by Webster & Armbruster 1991): Brazil, Rio de Janeiro, *Leandro di Sacramento 110* (P!). Figure 4c & 9e.

Dalechampia leandri can be recognized by having hirsute trichomes on its branches, the veins of the abaxial surface of leaves, and on the pistillate laciniate sepals; leaf margins undulate, and laminar resiniferous glands. It resembles *D. schenckiana* as they share lanceolate leaves; they can be differentiated, however, by the hirsute branches of *D. leandri* (vs. densely villous in *D. schenckiana*), involucral bracts ranging between unlobed to 3-toothed (vs. always unlobed), laciniate sepals (vs. pinnatifid), and hirsute trichomes on the leaf veins (vs. pubescent).

Distribution, ecology, and conservation: *D. leandri* is endemic to Brazil, being known from the southern (Paraná) and southeastern (Rio de Janeiro and São Paulo) regions of the country (Flora do Brasil 2020, under construction). It is cited here for the first time in the study

area, occurring in Paraiba state. The species is designated, according IUCN (2001) criteria, as least concern (LC) due to its EOO of 344, 331.752 km² and as endangered (EN) due its AOO of 28. 000 km². A population of that species has been recorded in the Guaribas Biological Reserve (Paraíba State).

Material examined: BRAZIL, PARAÍBA: Mamanguape, Reserva ecológica Guaribas, 6°43'S, 35°8'W, 07.VII.2015, fl., R.A. Pereira-Silva, 32 (PEUFR).

Additional examined material: BRAZIL, SÃO PAULO: Pariquera-Açú, 24°42'S, 47°52'W, 16.II.1995, fl., H. F. Leitão Filho et al. 33192 (UEC); Estrada Pariquera-Açú para Cananéia, 24°42'S, 47°52'W, 07.II.1995, fl., H.F. Leitão Filho et al. 32727 (UEC). PARANÁ: Paranaguá, Morro do Meio, 25°30'S, 48°31'W, 13.XII.1986, fl., R.M. Britez 1257 (UPCB). RIO DE JANEIRO: Parque Nacional da Tijuca, 22°56'S, 43°17'W, 27.X.1984. fl., G.L. Webster et al. 25429 (UEC).

14. *Dalechampia linearis* Baill. Adansonia 5: 316-317. 1865. Lectotype (designated by Webster & Armbruster 1991): Brazil, Goiás, Rio Pilões, *St. Hilaire C*[*l*] *801* (P!, isotype P!). Figure 4d & 9f.

Dalechampia linearis can be distinguished from congeners by having a subshrub habit, simple and linear to lanceolate leaves, 3-lobed involucral bracts, lanceolate stipules, and a lobed stigma. This species can be confused with *D. caperonioides*, a species presently recorded for the central-western region of Brazil. *D. linearis*, however, has a 3-lobed, greenish to vinaceous bracteole (vs. entire, whitish, or pinkish in *D. caperonioides*), and 12 pistillate pinnatifid sepals (vs. 6 entire).

Distribution, ecology, and conservation: *D. linearis* has been recorded for Paraguay and Brazil. In Brazil, there are records for the northern (Pará and Tocantins), central-western (Distrito Federal, Goías, and Mato Grosso), and northeastern regions (Flora do Brasil 2020, under construction). In the latter region, the species is found in the states of Maranhão and Piauí. It is recorded here, for the first time, for Bahia, with occurrences in both caatinga and cerrado vegetation. The species is designated, according IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 1,769, 053. 532 km², and as endangered (EN) due to its AOO of 352. 000 km². None of the specimens analyzed came from protected areas in the two northeastern states. It is possible, however, that greater collection efforts will result in new findings in protected areas within the range of occurrence of the species, such as: the Parnaíba River National Park, the Uruçuí-Una Ecological Station, and the Serra das Confusões National Park (Piauí)

Material examined: BRAZIL, BAHIA: Cariparé, 11°30'S, 45°2'W, 17.XII.1987, fl., T.S. Figueiras 1289 (CEN). MARANHÃO: Balsas, 7°31'S, 46°2'W, 18.XI.1997, fl., R.C. Oliveira & G.P. da Silva 545 (CEN). PIAUÍ: Ribeiro Gonçalves, 7°32'S, 45°14'W, 17.X.1980, fl., A. Fernandes & A.J. Castro s.n. (EAC); Ribeiro Gonçalves, 7°32'S, 45°14'W, 10.XII.1980, fl., M.R. Del'Marco et al. s.n. (TEPB 1417).

Additional material examined: BRAZIL, GOIAS: Estrada em direção ao centro de Goias, 15°55'S, 50°07'W, 30.XI.2011, fl., fr., R.F. Monteiro et al. 437 (CEN); Colinas do Sul, Niquelânia, 14°16'S, 48°09'W, 22.IV.2010, fl., J.E.Q. Faria et al. 835 (CEN). TOCANTINS: Almas, Estrada para Natividade, 11°37'S, 47°23'W, 22.VII.2000, V.C. Souza et al. 24514 (CEN); Itacajá, Reserva Indígena Krahó, Aldeia Pedra Branca, 08°18'S, 47°38'W, 06.V.2000, fl., A.A. Santos et al. 650 (CEN); Parana, 3º parada após a ponte sobre o Rio São Domingos, 12°55'S, 47°41'W, 28.III.2004, fl., A.C. Sevilha et al. 3906 (CEN).

15. *Dalechampia luetzelburgii* Pax & Hoffm., Pflanzenr. IV. 147. XVII (Heft 68): 188 1924. Lectotype (designated by Athiê-Souza et al. 2018). Brazil, Bahia, São Bento das Lages, 1913, *von Lützelburg 132* (M! M0233664, isolectotype M! M0233665). Figure 5a & 9g.

Historically the species with 3-foliolate leaves form a complex of difficult identification as discussed by Allem and Waechter (1977) and commented by Armbruster & Webster (1991). *D.luetzelburgii*, *D. peckoltiana* and *D. sylvestris* are very close morphologycally due this kind of leaves and the shape of involucral bracts, deeply 3-lobed. Comparing the size and color of involucral bracts these are 5-6 cm long, whitish in *D. luetzelburgii* (vs. 5-6 cm long, albido viridis and 7-9 cm long, pale green in *D. peckoltiana* and *D. sylvestris,* respectively). The stylar column is 1.2–1.3 cm long (vs. 1.4–1.5 cm long and 0.8-1 cm long). The number of pistillate sepals is the same for *D. luetzelburgii* and *D. peckoltiana* (6) (vs. ca. 9 in *D. sylvestris*). In addition, pseudanthium of *Dalechampia luetzelburgii* and *D. peckoltiana* also is similar to *D. subintegra* in the shape of involucral bracts and number of pistillate sepals (6). But, they differ by the bracteal stipules deltoid to lanceolate (vs. linear in *D. subintegra*) and stigma cylindrical (vs. slender).

These species need more investigation as phylogenetic analyzes or other tools that may help in identifying.

Distribution, ecology, and conservation: *D. luetzelburgii* has been recorded from the northern (Pará) and northeastern regions of Brazil (Flora do Brasil 2020, under construction); the species in the latter region (in the states of Bahia and Ceará) occur in Atlantic Forest environments. *D. luetzelburgii* is included in the category of least concern, as its EOO is ca. 1, 125, 778. 391 km², and as endangered (EN) due to its AOO of 88.000 km². The species is found in protected conservation areas such as the Araripe National Forest (Ceará) and the Pau-Brasil Ecological Station (Bahia).

Material examined: BRAZIL. BAHIA: Santa Cruz Cabrália. Estação Ecológica do Pau-Brasil 7.V.1984, F.S. Santos 325 (CEPEC). CEARÁ. Crato, chapada do Araripe, 7°16'S, 39°32W, 19.I.1983, fl., fr., T. Plowman 12736 (NY); Guaramiranga, Serra de Baturité, 09.VIII.1993. fl., M. R. L. Oliveira 59 (EAC). PARÁ. Rio Tocantins: nella foresta Capuera Roca presso Itacayuna 1.VII.1899. L. Buscalioni 3650 (NY).

16. *Dalechampia olfersiana* Müll. Arg., Linnaea 34: 280. 1865. Lectotype (designated by Webster & Armbruster 1991): Brazil, without locality, *F. Sellow 636 ex p.* (G!, isolectotype F!). Figure 5b & 9h.

Dalechampia olfersiana is characterized by having compound leaves, 3-foliolate, pistillate sepals 7 to 8, pinnatifid, involucral bracts 1.3–1.5 × 1.3–1.8 cm, 3-lobed, green, with papilliform glands and a discoid stigma.

Distribution, ecology, and conservation: *D. olfersiana* is endemic to the southeastern (Minas Gerais, Rio de Janeiro, and São Paulo) and northeastern regions of Brazil (Flora do Brasil 2020, under construction). It occurs in the northeast in the states of Bahia and Pernambuco in caatinga, ombrophilous forest, semideciduous seasonal forest, and gallery forest environments. The species is designated,

according to IUCN (2001) criteria, as least concern (LC) due to its EOO of 1, 316, 190. 235km^2 , and as endangered (EN) due to its AOO 20. 000 km^2 (IUCN 2001).

Material examined: BRAZIL, BAHIA: Maracás, 13°31'S, 40°33'W, 22.IV.2002, fl., K.R.B Leiite et al 212 (HUEFS). PERNAMBUCO: Brejo da Madre de Deus, 8°8'S, 36°22'W, 04.II.1995, M.J.N. Rodal et al. 456 (PEUFR).

Additional material examined: BRAZIL, MINAS GERAIS: Serra do Cipó, Santana do Riacho, 19°10'S, 43°42'W, 27.IV.1993, fr., J.A. Lombardi & F.R.N. Toledo 189 (BHCB).

17. *Dalechampia peckoltiana* Müll. Arg., in Martius, Fl. Bras. 11(2): 647. 1874. Holotype: Brazil, Rio de Janeiro, Canta Gallo, *Peckolt 93* (M, isotypes BR!, G!). Figure 5c & 9i.

Dalechampia peckoltiana is distinguished by its pseudanthium with deeply 3-lobed, whitish, involucral bracts and deltoid to lanceolate bracteal stipules.It demonstrates morphological similarities with *D. subintegra* and *D. luetzelburgii* by sharing shape of involucral bracts and leaves. They can be distinguished by the characteristics noted in the comments above concerning *D. luetzelburgii*.

Distribution, ecology, and conservation: *D. peckoltiana* is endemic to Brazil, having originally been considered to be restricted to Rio de Janeiro (southeast) (Webster & Armbruster 1991). The species is currently known to the states of Espírito Santo and Minas Gerais (both in the southeastern region), and to the northeast (Flora do Brasil 2020, under construction). In the northeast, the species can be found in Alagoas, Bahia, Pernambuco, and Sergipe, in caatinga and ombrophilous forest environments. The species is designated, according to IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 987, 171. 633 km^2, and as endangered (EN) due to its AOO of 272.000 km^2 (IUCN 2001). Some populations occur in and around the Chapada Diamantina National Park (Bahia), and several populations have been recorded from the vicinity of the Sete Passagens State Park (Bahia). According to the geographic extension of the species, it is expected that some populations will be found in other protected areas in Bahia State, such as: the Canavieiras Extractivist Reserve, the Serras das Lontras National Park, and the Una Wildlife Refuge.

Material examined: BRAZIL, ALAGOAS: Coruripe, Usina Coruripe, Mata do Riachão, 10°02'S, 36°16'W, 04.XI.2002, fl., W.W. Thomas et al. s.n. (NY 13268). BAHIA: Jacobina, Itaitu, Cachoeira do Véu da Noiva, 11°10' S, 40°31'W, 24.IV.1999, fl., R.C. Forzza, A.M. Amorim & Sant'Ana 1337 (SP); Lençois, Pai Inácio, 12°28'S, 41°27'W, 12.III.1997, P. Gasson & L. Natalino 6210 (SP). PERNAMBUCO: Tapera, 9º25'S, 40º45'W, 1936, fl., B. Pickel 4210 (IPA). SERGIPE: Nossa Senhora do Socorro, Floresta Nacional do Ibura, 10º83'S, 37º13'W, 02.X.2014, J.P. Santana 347 (ASE).

18. *Dalechampia pentaphylla* Lam. Encycl. Botanique 2: 258. 1786. Holotype: Brazil, probably near Rio de Janeiro, 1790, *Vandelli s.n.* (P). Figure 6a & 9j.

Dalechampia pentaphylla can be recognized by having compound leaves, 5-foliolate and deeply involucral bracts, 5-lobed, and six entire pistillate sepals. The species demonstrates morphological similarities with *D. alata* and *D. erythrostyla*. They can be easily differentiated, however, as *D. pentaphylla* has 5-foliolate compound leaves (vs. the pseudo-compound, deeply 5-lobed leaves of *D. alata* and *D. erythrostyla*), 5-lobed involucral bracts (vs. 3-lobed in *D. alata* and *D. erythrostyla*), and six entire pistillate sepals (vs. 12, laciniate or slightly lobed sepals in *D. alata* and 12 pinnatifid sepals in *D. erythrostyla*).

Distribution, ecology, and conservation: *D. pentaphylla* is not endemic to Brazil also occur in San Jose, Paraguay next to Mato Grosso do Sul. In Brazil, occurring in the central-western (Goiás and Mato Grosso do Sul), southeastern (Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo), southern (Paraná), and northeastern regions of that country (Flora do Brasil 2020, under construction). In the northeastern region, it only occurs in Bahia State, where it was found in transitional areas between seasonal caatinga and cerrado forests. The species is designated, according to IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 2,597, 337. 417 km^2, and as endangered (EN) due to its AOO of 196.000 km^2. Considering the geographic coverage of the species, individuals will probably be encountered in the Boa Nova National Park (Bahia).

Material examined: BRAZIL, BAHIA: Jaguaquara, Cascalheira, 13°31'S, 39°58'W, 13.X.2012, fl., W. Milliken et al. 5048 (HURB).

Additional examined material: BRAZIL, SÃO PAULO: São Pedro, Cachoeira da Peroba, 22°33'S, 47°55'W, 30.I.1992, fl., S. Gandolfi et al. s.n. (ESA 33223); Campinas, Santa Elisa, 22°55'S, 47°4'W, 15.IV.1992, fl., fr., J.A. Lombardi 15 (BHCB). ESPÍRITO SANTO: Alegre, Parque Nacional do Caparaó, 20°23'S, 41°44'W, 22.II.2000, fl., V.C. Souza et al. 23673 (ESA). MINAS GERAIS: Carandaí, Pedra do Sino Hotel Fazenda, 20°52'S, 43°48'W, 29.XII.2005, N.F.O. Mota & P.L. Viana 491 (ICB).

19. *Dalechampia pernambucensis* Baill., Adansonia 5: 311. 1865. Holotype: Brazil, Pernambuco, *G. Gardner 1130* (G!, isotypes BM, K! 2 sheets, P!). Figure 5d & 10a

Dalechampia pernambucensis is characterized by having deltoid bracteal stipules, involucral bracts that vary from whitish to greenish, with glandular trichomes on their margins, and the stylar column peltate to discoid. *D. pernambucensis* is commonly confused with *D. brasiliensis* and *D. scandens*, but can be differentiated by aspects already mentioned in the comments above concerning *D. brasiliensis*.

Distribution, ecology, and conservation: *D. pernambucensis* is endemic to Brazil, having been recorded in the northern (Amazonas, Pará, and Roraima) and northeastern regions of the country (Flora do Brasil 2020, under construction). In the northeastern region, *D. pernambucensis* can be found in Bahia, Ceará, Paraíba, and Pernambuco. In the study area, it has been identified in caatinga and Atlantic Forest vegetations. *Dalechampia pernambucensis* is considered of least concern (LC) due to its EOO of ca. 3, 051, 723. 353 km^2, and as endangered (EN) due to its AOO of 400.000 km^2. Populations of this species are widely disseminated in the study region and have been recorded in the Araripe-Apodi National Forest and Aiuaba Ecological Station (Ceará). Taking into account the extent of expected occurrence of the species, populations may be encountered in other protected areas in the region (Catimbau National Park in Pernambuco, Raso do Catarina Ecological Station, Boa Nova National Park, Serras das Lontras National Park, and Una Wildlife Refuge in Bahia, and the Parnaíba River National Park on the borders of the states of Piauí, Maranhão, Bahia, and Tocantins). In the study area, it was found here for the first time in Piauí state.

Material examined: BRAZIL, BAHIA: Caetité, 14°03'S, 42°28'W, 19.II.1992, fl., A.M. Carvalho et al. 3771 (CEPEC). CEARÁ: Meruoca, Sítio Santo Antônio dos Fernandes, 3°32'S, 40°27'W, 26.V.1994, fl., fr., A.S. Fernandes s.n. (EAC 20877); Caridade, 4°5'S, 39°3'W, 06.V.1990, fl., B. Freitas s.n. (EAC 16780); 11 km de Canindé pela BR 02, 4°21'S, 39°18'W, 27.I.1990, fl., I. Cordeiro & J.R. Pirani 520 (SP). PARAÍBA: Remígio, 6°55'S 35°53'W 17.III.1975, fl., V.P. Barbosa 231 (RB). PERNAMBUCO: Goiana, Itapirema, 07°33'S, 35°00'W, 06.IV.1983, fl., fr., A. Chiappeta & R. Barreto 497 (IPA). PIAUÍ: Cocal, Baixão, 3°28'S, 41°30'W, 29.III.2003, E.M.F. Chaves & E.M.S. Júnior s.n. (TEPB 19255).

20. *Dalechampia purpurata* Cordeiro, Kew Bulletin 53: 467. 1998. Holotype: Brazil, Bahia, Abaíra, *Stannard, Ganev & Queiroz H. 51654* (SPF!, isotypes K!, SP!). Figure 6b & 10b.

Dalechampia purpurata differs from the other species of *Dalechampia* in the Northeast, because among the species with compound leaves, 3-foliolate, it is the unique with 3-lobed involucral bracts magenta and slightly lobed stigma.

Distribution, ecology, and conservation: *D. purpurata* is endemic to Brazil (Flora do Brasil 2020, in constr.), and restricted to Bahia State in caatinga environments. In terms of conservation status, *Dalechampia purpurata* is included in the category of vulnerable (VU) species because of its EOO of ca. 10, 659. 277 km^2, and as endangered (EN) due to its AOO of 24,000 km^2.

Material examined: BRAZIL, BAHIA: Abaíra, 13°16'S, 41°44'W, 31.I.1992, fl., D.J.N. Hind et al. 51399 (K); Abaíra, 13°16'S, 41°44'W, 28.II.1992, fl., B. Stannard et al. 51654 (NY).

21. *Dalechampia scandens* L. Sp. Pl. 2: 1054. 175. Holotype: West Indies, illustrated by Plumier, *Plantarum Americanarum fascículos, 5: pl. 101* (original plate at P). Figure 6c & 10c.

Dalechampia scandens can be distinguished from its congeners mainly by having lanceolate bracteal stipules and a slightly crateriform stigma. *D. scandens* can be confused with *D. brasiliensis*, but differs from it by characteristics already mentioned above for the latter species.

Distribution, ecology, and conservation: *D. scandens* is not endemic to Brazil, occurring in Central America, the Antilles, and South America (Webster & Armbruster 1991). It is widely distributed in Brazil, occurring in the northern (Amazonas, Pará, Rondônia and Roraima), central-western (Mato Grosso do Sul and Mato Grosso), southeastern (Minas Gerais and São Paulo), and northeastern regions of the country (Flora do Brasil 2020, in constr.). In the study area, it has been recorded from Bahia, Ceará, Maranhão, Paraíba, and Pernambuco, growing in caatinga and Atlantic Forest vegetations. The species is herein designated as of least concern (LC), according to IUCN red list (IUCN 2001) criteria, because its populations are numerous and widespread throughout the study region.

Material examined: BRAZIL, BAHIA: Barra, Ibiraba, 10º47'S, 42°50'W, 22.II.1997, fl., L.P. Queiroz 4768 (TEPB). CEARÁ: Caridade, 04°13'S, 39°11'W, 08.IV.2002, A. Fernandes s.n. (EAC 31381). PARAÍBA: São José dos Cordeiros, RPPN Fazendo Almas, 7°28'S, 36°53'W, 15.VIII.2010, fl., R.M.T. Costa & M.F.M. Brito 151 (RB). PERNAMBUCO: Ouricuri, Tamboril, 07°52'S, 40°04'W, 10.III.1982, fl., V.C. Lima et al. 206 (IPA).

Additional material examined: BRAZIL, SÃO PAULO: Parque Estadual da Ilha Anchieta, 23°32'S, 45°4'W, 08.IX.2008, fl., V.B. Zipparro 2504 (HRCB). MATO GROSSO: Poconé, Fazenda Corizal, 16°15'S, 56°37'W, 21.XII.1980, C.N. Cunha & A. Prado 12129 (UEC).

22. *Dalechampia schenckiana* Pax & Hoffm., Pflanzenr. IV. 147. XII (Heft 68): 49 1919. Neotype (designated by Webster & Armbruster 1991): Brazil, Pernambuco, Garanhuns, *G.L. Webster et al. 25648* (R!, isoneotype DAV). Figure 6d e 10d.

Dalechampia schenckiana has densely villous branches and 6–12 pistillate pinnatifid sepals. Morphologically, it is similar to *D. leandri*, what can be differentiated by aspects already mentioned above in the comments concerning that species.

Distribution, ecology, and conservation: *D. schenckiana* is endemic to Brazil (Flora do Brasil 2020, under construction) and is known only from the northeastern region of the country. In the study area, it is known from the states of Bahia, Pernambuco, Sergipe, and Alagoas. It is recorded here for the first time in Alagoas, occurring in the caatinga (stricto sensu) and rock outcrop vegetation. The species is designated, according to IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 929, 920. 476 km^2 and endangered (EN) due to its AOO of 104. 000 km^2. Some specimens were collected in protected areas in the study region and some of the collections analyzed came from the Morro do Chapéu State Park and the Raso do Catarina Ecological Station (both in Bahia), and the Catimbau National Park (Pernambuco).

Material examined: BRAZIL, ALAGOAS: Olho d'água do Casado, Capelinha, 9°25'S, 37°49'W, 17.IX.2001. fl., fr., L.M. Cordeiro 484 (PEUFR). BAHIA: Feira de Santana, 12°13'S, 38°57'W, 22.XI.1986, fl., G.L. Webster 25846 (HUEFS). PERNAMBUCO: Buíque-Catimbau, 8°34'S, 37°15'W, 25.IV.2013*, R.A. Pereira-Silva 37* (PEUFR). SERGIPE: Canindé do São Francisco, Fazenda Poço Verde, 9°39'S, 37°47'W, 23.III.2000, fl., R.A. Silva & D. Moura 1405 (PEUFR).

23. *Dalechampia stipulacea* Müll. Arg., Linnaea 34: 221. 1865. Holotype: Peru, without locality, *R. Pavon s.n.* (G!). Figure 6e & 10e.

Dalechampia stipulacea stands out for having glandular stipitate trichomes on the margins of the leaf blade, staminate bracteole, and being the only species in the Northeast with parastipules at the base of the petiolar stipule. It resembles *D. ficifolia* by having 3-lobed leaves and bracts; they can be differentiated in the aspects commented in this latter species. **Distribution, ecology, and conservation:** *D. stipulacea* is found in South America growing in seasonal tropical and subtropical forest areas (Webster & Armbruster 1991). In Brazil, it occurs in the central-western (Mato Grosso do Sul), southeastern (Minas Gerais, Rio de Janeiro and São Paulo), Southern (Paraná, Rio Grande do Sul and Santa Catarina), and northeastern regions (Flora do Brasil 2020, in constr.). In the study area, there have been records of its occurrence only in the states of Maranhão and Pernambuco in Atlantic Forest vegetation. *D. stipulacea* is designated, according to IUCN (2001) criteria, as least concern (LC) due to its EOO 10, 411, 504. 087 km² and endangered (EN) due to its AOO of 632. 000 km².

Material examined: BRAZIL, PERNAMBUCO: Triunfo, 7.VI.1997, fl., fr., A.M. Miranda et al. 2695 (IPA). MARANHÃO: Buriti Bravo, Margem direita do Rio Itapecuru, 23.II.1983, fl., J.U. Santos et al. 684 (K).

Additional material examined: BRAZIL, PARANÁ: Tuneiras do Oeste, Reserva Biológica das Perobas, estrada interna, 23°51'S, 52°45'W, 27.X.2011, fl., M.G. Caxambu et al. 3615 (HCF); Goioerê, Parque Municipal Antônio Sestak, 24°9'S, 53°1'W, 18.VIII.2007, fl., E.M. Silva s.n (HCF 5838). SÃO PAULO: Piracicaba, Mata da Pedreira, ESALQ/USP, 22°42'S, 47°37'W, 27.IX.1985, fl., E.L.M. Catharine 432 (BHCB). MINAS GERAIS: Pedro Leopoldo, Lara Vermelha, 19°36'S, 44°2'W, 15.VI.1978, fl., J.M. Ferrari 145 (BHCB); Juiz de Fora, 21°45'S, 43°26'W, 02.IX.1981, fl., TSMG 749 (BHCB). SANTA CATARINA: Siderópolis, Barragem do Rio São Bento, 28°36'S, 49°33'W, 05.XI.2009, fl., M. Verdi, A.L. Tomazi & G. Klemz 3043 (FURB).

24. *Dalechampia subintegra* Müll. Arg., Flora Brasiliensis 11: 650. 1874. Holotype: Brazil, Bahia, without locality, *Blanchet s.n.* (G!). Figure 7a & 10f.

Dalechampia subintegra shares 3-foliolate leaves, a slender stigma, and 3-lobed involucral bracts with *D. peckoltiana*, but its stylar column is thinner than that of *D. peckoltiana*. The species, however, still needs to be further investigated. Other morphological comparisons can be found in the comments presented above concerning *D. peckoltiana*.

Distribution, ecology, and conservation: *D. subintegra* is endemic to Brazil (Flora do Brasil 2020, under construction), being recorded only from the northeastern region of the country in the states of Bahia and Pernambuco. It is found here for the first time in the study area for Paraiba State. *D. subintegra* is included in the category of endangered because of its EOO of 0.000 km^2 and as endangered (CR) due to its AOO of 8.000 km^2.

Material examined: BRAZIL, PARAÍBA: Areia, 6°57'S, 35°42'W, 15.VII.1976, P.C. Fevereiro 170 (RB).

25. *Dalechampia sylvestris* S. Moore, Trans. Linn. Soc. London, 2: 467–468. 1895. Holotype: Brazil Mato Grosso, between Santa Cruz and Tapirapuã 376 (BM!). Figure 6f & 10g.

Apparently, *Dalechampia sylvestris* seems morphologically with *D. peckoltiana* due the leaves 3-foliolate and involucral bracts deeply 3-lobed. However, they are differentiated in the comments of this last species. The taxon is referred to the northeast and Central region in the states of Bahia, Mato Grosso, Minas Gerais. *Dalechampia sylvestris* is included in the category of Least Concern species because an EOO of the 855, 412. 426 km^2 and as endangered (EN) due to an AOO of the 56. 000 km^2.

Material examined: BRAZIL, BAHIA: Macugê, 13°, 7',3" S, 41°, 29',13" W, 20.II.2002, A. M. Giulietti, & R. M. Harley 2055 (HUEFS). CEARÁ: Parque Nacional do Araripe, Crato, 19.I.1983, T. Plowman 12736 (EAC). MINAS GERAIS: without locality, 01.I.1816, Saint-Hilaire 1062 (P).

26. *Dalechampia tiliifolia* Lam. Encycl., 2: 257.1786. Holotype: possibly Peru, without locality, *Herb. Jussieu* (P). Figure 7b & 10h.

Dalechampia tiliifolia is easily recognized by having leaves varying from entire to lobed, linear bracteal stipules, involucral bracts entire to slightly 3-lobed, chartaceous, with 7–9 primary veins, and stigma discoid to peltate.

Distribution, ecology, and conservation: *D. tiliifolia* is widely distributed in South America (Webster & Armbruster 1991), and has been recorded in the northern (Acre, Amazonas, Amapá, Pará, Rondônia and Roraima), central-western (Goiás and Mato Grosso), and northeastern regions of Brazil (Flora do Brasil 2020, under construction). In the study area, it has been collected in Bahia, Ceará, Maranhão, Pernambuco, Piauí, and Sergipe in cerrado and Atlantic Forest vegetation. The species is included in the category of least concern because of its EOO of ca. 16, 304, 443.697 km^2 and as endangered (VU) due to its AOO of 1, 264. 000 km^2. None of the collections come from protected areas, but specimens may yet be found in protected areas within the extent of occurrence of the species such as the Chapada Diamantina National Park and Morro do Chapéu State Park (Bahia), Serra das Confusões National Park and Serra da Capivara National Park (Piauí), Araripe-Apodi National Forest (Ceará), Catimbau National Park (Pernambuco), and Chapada das Mesas National Park (Maranhão).

Material examined: BRAZIL, BAHIA: Entre Rios, Areial, 12°12'S, 37°57'W, 13.IV.2012, A.V. Popovkin 1094 (HUEFS). CEARÁ: Ubajara, Parna do Ubajara, 03°51'S, 40°55'W, 13.IX.1982, fl., A. Fernandes & P. Gibbs s.n. (EAC 15081). MARANHÃO: Loreto, Ilha de Balsas, 7°28'S, 45°3'W, 17.II.1970, fl., G. Eiten & L.T. Eiten 10657 (K). PERNAMBUCO: Recife, 8°3′S, 34°52′W, 30.V.1971, fl., E.P. Heringer et al. 1005 (IPA). PIAUÍ: Tamboril, 08°24'S, 42°54'W, 22.VII.1979, fr., F. Chagas & Silva 17 (K). SERGIPE: Siriri, Mata do Cipó, 10°35'S 37°08'W, 28.VIII.2013, fl., J.P. Santana et al. 206 (ASE).

Additional material examined: BRAZIL. TOCANTINS: Itacajá, 35 km após a aldeia Pedra Branca, 8°37'S, 47°31'W, 07.V.2000, fl., A.A. Santos et al. 686 (CEN). RONDÔNIA: Pimenta Bueno, 11°39'S, 61°11'W, 25.V.1990, fl., fr., L.A. Skorupa et al. 798 (CEN). RORAIMA: Boa Vista, Fazenda Quixabeira, 2°29'N, 60°40'W, 15.VIII.1977, fl., L. Coradin & M.R. Cordeiro s.n. (INPA 683). GOIÁS: Guarani, Fazenda Forquilha, 05.III.2001, fl., fr., M.L. Fonseca et al 2418 (IBGE).

27. *Dalechampia triphylla* Lam., Encycl. 2: 258. 1786. Holotype: Brazil, without locality, *J. Dombey s.n.* (P!, isotype NY). Figure 7c & 10i.

In the vegetative stage, *Dalechampia triphylla* can be quite easily confused with other species with 3-foliolate leaves. It is characterized, however, by its hispid fruits with pistillate sepals widely pinnatifid in fruits

Distribution, ecology, and conservation: *D. triphylla* is reported from Mexico and Brazil. It has been reported from the northern (Pará), southeastern (Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo), and northeastern region of Brazil (Flora do Brasil 2020, under construction). In the northeastern region, the species has been recorded from Pernambuco State in Atlantic Forest environments. *Dalechampia triphylla* is designated, according to IUCN (2001) criteria, as of least concern (LC) due to its EOO of ca. 13, 041, 354. 454 km², and endangered (EN) due to its AOO of 292. 000 km².

Material examined: BRAZIL, PERNAMBUCO: Maraial, 8°48'S, 35°45'W, 13.III.1994, A.M. Miranda et al. 8253 (HST).

Additional examined material: BRAZIL, SÃO PAULO: Bom Sucesso de Itararé, 24°19'S, 49°08'W, 19.VIII.1995, fl., V.C. Souza et al. 8891 (ESA); Apiaí, Estrada do Pinhalzinho, 24°30'S, 48°50'W, 13.VII.1997, fl., fr., F. Chung et al. 96 (ESA).

28. *Dalechampia viridissima* Webster, Brittonia 41:6. 1989. Holotype: Brazil, Bahia, CEPLAC grounds, *G.L. Webster & S. Armbruster 25165* (CEPEC!, isotypes DAV, GH, MO, NY, R. SP, UEC). Figure 7d & 10j.

Dalechampia viridissima is characterized by reduced pubescence, linear bracteal stipules, and an intense green color of the involucral bracts, beyond this the pistillate sepals are 6−7, minutely glandular at tip. This set of characters allows differentiate this species from other with 3-lobed leaves.

Distribution, ecology, and conservation: *D. viridissima* is endemic to Brazil (Webster & Armbruster) with records of occurrence in the southeast (Espírito Santo), and northeastern regions (Bahia) of the country, being found in ombrophilous forest environments. This species is included in the critically endangered category because of its AOO of 4,000 km^2

Material examined: BRAZIL, BAHIA: Jussari, 15°7'S, 39°30'W, 13.VIII.1998, fl., A.M. Amorim et al. 2466 (NY).

Author Contributions

Rafaela Alves Pereira-Silva: conceived the idea and structured the manuscript; contributed to the writing of the text, and the interpretation of the results.

Beatriz Rayrana de Araújo Gama: contributed with the descriptions of the species.

Sarah Maria Athiê-Souza: contributed to the writing of the text, and the interpretation of the results.

André Laurênio de Melo: contributed to the writing of the text, and the interpretation of the results.

Margareth Ferreira de Sales: designed the study and has contributed to the correction and discussion of the results, and to research funding.

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Conflicts of Interest

We, the authors, declare that we have no conflicts of interests related to the publication of this manuscript.

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Article

Using distribution models to estimate blooms of phytosanitary cyanobacteria in Brazil

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Abstract: The multiple uses of aquatic ecosystems by humankind and the continuous interference of their activities have contributed to the emergence of potentially toxic cyanobacteria blooms. Here, we firstly created a database of occurrences of cyanobacteria blooms in Brazil through a systematic review of the scientific literature available in online platforms (e.g. Web of Science, Capes Thesis Catalogue). Secondly, we carried out ecological niche models with occurrence data obtained from these studies to predict climatically suitable areas for blooms. We select 21 bioclimatic variables input environmental data. We used five modeling methods for the current climate scenario: (1) Maxent; (2) Support Vector Machines; (3) Random Forest; (4) Maximum Likelihood e (5) Gaussian. We found that the number of publications about bloom events was higher in 2009 with a decline in the years 2012, 2013 and 2017. Furthermore, the years with the higher records of blooms in freshwater environments were 2005, 2011 e 2014. These events occurring mainly in public supply reservoirs and are mostly of the genera *Microcystis* Lemmermann, 1907, *Dolichospermum* (Ralfs ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek, 2009 and *Raphidiopsis* F.E.Fritsch & F.Rich, 1929. Modeling the potential distribution of blooms, we found sampling gaps that should be targeting for future researches, especially in the Amazon biome. Overall, the models did not predict highly suitable areas in the /north of Brazil, while other regions were relatively well distributed with a higher number of occurrence records in the Southeast region.
Keywords: *freshwater ecosystems, species distribution models, bloom occurrence, cyanobacteria.*

Usando modelos de distribuição para estimar florações de cianobactérias fitossanitárias no Brasil

Resumo: Os múltiplos usos dos ecossistemas aquáticos pela humanidade e a contínua interferência das suas atividades têm contribuído para o surgimento de florações de cianobactérias potencialmente tóxicas. Aqui, primeiramente criamos um banco de dados de ocorrências de floração de cianobactérias no Brasil por meio de uma revisão sistemática da literatura científica disponível em plataformas on-line (por exemplo, Web of Science, Catálogo de Teses da Capes). Em segundo lugar, realizamos modelos de nicho ecológico com dados de ocorrência obtidos a partir desses estudos para prever áreas climaticamente adequadas para as florações. Selecionamos 21 variáveis bioclimáticas como dados ambientais de entrada. Usamos cinco métodos de modelagem diferentes para no cenário climático atual: (1) Maxent; (2) Support Vector Machines; (3) Random Forest; (4) Maximum Likelihood e (5) Gaussian. Encontramos que o número de publicações sobre eventos de floração foi maior em 2009 com um declínio nos anos de 2012, 2013 e 2017. Além disso, os anos com os registros mais altos de florescimento em ambientes de água doce foram 2005, 2011 e 2014. Esses eventos ocorrem principalmente em reservatórios de abastecimento público e são na sua maioria dos gêneros *Microcystis* Lemmermann, 1907, *Dolichospermum* (Ralfs ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek, 2009 e *Raphidiopsis* F.E.Fritsch & F.Rich, 1929. Modelando a distribuição potencial das florações, encontramos lacunas de amostragem que devem ser direcionadas para futuras pesquisas, especialmente no bioma Amazônia. Em geral, os modelos não previram áreas altamente adequadas no norte do Brasil, enquanto outras regiões estavam relativamente bem distribuídas com um número maior de registros de ocorrência na região Sudeste.
Palavras-chave: *ecossistema de água doce, modelos de distribuição de espécie, ocorrência de floração, cyanobacteria.*

Introduction

Freshwater ecosystems sustain much of Earth's biodiversity, providing multiple products and ecological services to humankind (Laurance et al. 2014). However, these ecosystems are suffering from several kinds of human pressures, such as changes in use and land cover (Huisman et al. 2018). Inadequate use of natural resources, as well as the different process of overexploitation, pollution, eutrophication, dam construction and silting, has intensified over recent decades (Hannah et al. 2013), causing negative impacts on the environment and the health of human populations (Green et al. 2015). Specifically, the broad degradation has generated a loss of species and habitats, threatening several biological communities of rivers, lakes and flood plains (Vitule et al. 2017).

Overgrowth of algae, especially cyanobacteria, is one of the problems in aquatic environments (Walls et al., 2018). Results from the interaction of physical, chemical and biotic factors (Behrenfeld & Boss, 2017), which is marked mainly by increased cyanobacterial density broadly geographically distributed, and that respond rapidly to environmental changes in aquatic environments (Padisák et al. 2016), such as light intensity, CO_2 accessibility, high pH and low N:P ratio (Genuário et al. 2016). The growth of harmful cyanobacteria in high densities, known as water-blooms or blooms (Paerl & Otten 2013), produces a variety of cyanotoxins (Kosten et al. 2012) that may cause liver, digestive and neurological diseases when ingested by birds or mammals (Mantzouki et al. 2018). Furthermore, they directly affect water quality, producing taste and odor, increased turbidity, decreased submerged aquatic vegetation (Merel et al. 2013), decreasing, and promoting the death of fish and benthic invertebrates (Josué et al. 2018). The problems tend to increase with the abundance, frequency, and extent of blooms (O'Neil et al. 2012). Thus, it is of great importance to know what determines the occurrence of these events in aquatic environments (Glibert et al. 2008).

Patterns that determine the spatial and temporal distributions of these organisms are environmental characteristics (Hernández-Fariñas et al. 2014), biological interactions and dispersal capacity of the species (Soberón & Peterson 2005, Soberón 2007). These species act as "refined sensors of environmental properties" because they respond quickly to variations in the availability of environmental resources (Mekonnen & Hoekstra 2018). However, lack of knowledge about the global distribution and abundance of algae restricts our ability to understand the mechanisms that determine its distribution (Flombaum et al. 2013). In general, geographic distributions are poorly known and have numerous information gaps (Moreira et al. 2013). The Wallacean shortfall refers to inadequate knowledge about the species' geographic distribution (Whittaker et al. 2005, Hortal et al. 2015) and is a constraint particularly important to improve understanding about cyanobacterial blooms events (Hortal et al. 2015). The predominance of studies close to traditional research centers (Newbold 2010) or uneven spatial distribution of infrastructure (Oliveira et al. 2016) may also generate a geographic bias about known cyanobacterial bloom events (Sastre & Lobo 2009).

To reduce the Wallacean shortfall it is necessary to find the potential geographic gaps of these organisms and fill them in. In this context, scientometrics studies can contribute significantly to a general analysis of the patterns found. This research method allows us to measure the available data on species geographic distribution and to assess existing citations (Carneiro et al. 2008), revealing trends and gaps in scientific production (Debackere et al. 2002). Additionally, scientometric analyzes can identify gaps in Cyanobacterial geographic distribution, helping to formulate new hypotheses about the mechanisms that determine these distributions. Thereby, it is possible to use Ecological Niche Models (hereafter ENMs) to fill these gaps (Jensen et al. 2017). ENMs are statistical procedures that use species occurrence records to estimate suitable areas through environmental similarity between different sites (Peterson 2017).These models assume the premise that species' ecological niche is fully known and never changes over time, being completely dependent on the amount observed and the distribution pattern of the occurrence records (Peterson 2011). Therefore, it is possible to estimate new environmentally similar areas for species to occur. These models are widely used to (i) define potential distributions (Flombaum et al. 2013); (ii) indicate suitable areas for future sampling (Jensen et al. 2017); (iii) test biogeographic and evolutionary hypotheses (Silva et al. 2014); (iv) suggest the establishment of conservation units (Loyola et al. 2008, Nóbrega & De Marco 2011); and (v) determine how species respond to climate change (Barton et al. 2016, Oliveira et al. 2015).

Assuming that the occurrence of toxic cyanobacterial blooms is a recurring problem in several freshwater reservoirs in many tropical countries and that these events make drinking water unfit for human consumption (Mowe et al. 2015), there is a strong interest in developing an ability to predict the occurrence of cyanobacterial blooms in freshwater environments. A major obstacle in attempting to reduce cyanobacterial growth events in freshwater ecosystems is a consequence of the lack of reliable data on the distribution of these species. From this perspective, we describe the number of publications collected in the scientific literature that documented the occurrence of cyanobacterial blooms over the years, as well as the responsible orders and the records of the Brazilian states where they occurred. Also, we used the occurrence data obtained in this scientometric investigation to estimate climatically suitable areas for the occurrence of cyanobacterial bloom events. For us, the pattern of the wide distribution of flowering events reflects the arrangement of their corresponding habitats, and the occurrence of these species is restricted to environments that correspond to specific adaptations of the species. As cyanobacterial bloom events are more common in lentic environments (e.g., reservoirs), we hypothesize that locations with higher intensity of use (e.g.: higher population density) and greater damming of rivers (e.g. reservoirs) will exhibit a higher frequency of blooms.

Material and Methods

1. Database of blooms events in freshwater environments

We created our database of cyanobacteria blooms occurrences in Brazil through a systematic review of the scientific literature available in the platforms Web of Science (WoS, http://apps.isiknowledge.com) maintained by Clarivate Analytics and Capes Thesis Catalogue (http://catalogodeteses.capes.gov.br), using the code of search: [("bloom*") AND ("Brasil" OR "Brazil") AND ("cyanobacteria" OR "cyanophyceae")] and "florações" (in Portuguese). The WoS database has the advantage of providing data on publications over a broad time, presenting detailed and accurate scientific articles data, and is widely used in systematic review articles (Falagas et al. 2007). The Capes Thesis Catalogue stores many dissertations and thesis published in Brazil, facilitating the compilation of blooms events that occurred in the Brazilian territory.

In both databases, we searched for articles and reviews that contained the search terms in the title, abstract and/or keywords (access date: May 22th, 2018). We established two criteria to select the occurrence records in the scientific articles: (1) cyanobacteria blooms classified according to the distribution of cells and individuals in the water column (accumulation of high concentrations of chlorophyll-a in the first centimeters of the water surface; accumulation of high concentrations of chlorophyll-a in water depth; and when the cells are dispersed in the water column); and (2) blooms according to the density of chlorophyll-a (minimum concentration of 10 $\mu g/L^{-1}$ of chlorophyll-a; and minimum density of 20.000 cells/mL of cyanobacteria) (De León & Chalar 2003). In our search, we obtained 208 scientific articles in the WoS database, selected 98 studies after reading the abstracts and included 47 in our study. At the Capes Thesis Bank, we found 385 records. However, not all records were made available for reading. Thus, according to the established criteria, we were able to include only 18 studies in our database. We also included 10 studies cited in the bibliographic review of Freitas et al., (2012), in which they present a synthesis of blooms events in Brazil. Finally, we added two other scientific studies found in two Brazilian repositories (Universidade Nacional de Brasília e Universidade Federal de Goiás). Of the 77 papers found in the scientific literature, five papers were of the same area and the same species or were located in marine water environments, therefore they were not included.

2. *Scientometric analysis*

We compiled a list of 72 scientific studies that mention cyanobacterial blooms in freshwater environments in Brazil. The species names were updated following information from the On-line Database of Cyanobacterial Genera (CyanoDB.cz, http://www.cyanodb.cz/) (Komárek et al. 2014). We classified the occurrence records according to the distribution of the taxa at the collection sites. We corrected possible georeferencing errors considering several quality criteria (latitude and longitude exchange; occurrence records outside of the freshwater environments; and duplicate records) (Giovanni et al. 2012). When the latitude and longitude were incorrect, but there was information about the sampling and collecting site, we used Google Earth to get surrogate information. Each event record in a given location was considered as a sample. Bloom events that occurred in distinct months were considered as different records. To estimate the sampling effort in Brazil, we counted the number of bloom events in 1-degree cells.

Then, we elaborated on a map demonstrating the total number of bloom events distributed in Brazil. Also, we produced bar charts evidencing the number of blooms events and the number of scientific studies published per year. To identify whether there is a relation between the number of blooms and the number of scientific studies, we performed a simple linear regression analysis between those variables. We verified the residues normality and used a transformation (log+1) to meet that basic premise based on the protocol for data exploitation provided by (Zuur et al. 2010). To identify if there was a relationship between the number of flowering in freshwater environments and the population density, we performed a simple regression analysis between the variables using the premise mentioned above. For this, we consider the population density per municipality and the year for each point where the flowering event occurred. For the collection of the population estimation data, we consider the information provided by the IBGE (https://cidades.ibge.gov.br/). We combined the same geographic coordinates, and then our N which was 90 points, resulted in 59 records of reports of bloom in freshwater environments.

3. *Environmental variables*

To produce the ENMs, we used the environmental variables obtained from WorldClim 1.4 (http://worldclim.org/current; Hijmans et al., 2005) and WorldClim 2.0 databases (http://worldclim.org/version2; Fick and Hijmans, 2017). We select all 19 bioclimatic variables from WorldClim 1.4, average altitude and solar radiation from WorldClim 2.0 as input environmental data. These variables have a spatial resolution of 5 arc-minutes (≈10 km of cell size). We considered the variables already reported in other studies. For example, the temperature variable is often considered the most important determinant of growth and metabolism in freshwater algae, including cyanobacteria, due in part to the fact that many of the enzymatic reactions involved in photosynthesis and respiration are temperature dependent. Solar radiation is justified because it is an essential resource for photosynthesis since these organisms are autotrophic (Walls et al. 2018). We used altitude as a variable because it is highly related to weather variables (Teittinen et al. 2017). Finally, we chose the precipitation variable, in the rainy season the highest nutrient transport takes place for the aquatic ecosystems, being observed the increase in the density of cyanobacteria. Furthermore, climate variations can modify from the community structure in freshwater ecosystems. For instance, the cyanobacteria presence may be strongly influenced by physical factors, such as the local climate conditions (Karadžić et al. 2013). The extreme precipitation in a reservoir cause increased nutrients concentration and, then, altered the composition of the phytoplankton community by cyanobacteria, evidencing the first bloom events after the suppression of other species (Simić et al. 2017).

To reduce the multicollinearity of the data, we performed the Principal Component Analysis (PCA) (Pearson 1901). This method calculates the mean of all variables and subtracts from the individual values. Then, the resulting values are divided by the standard deviation of each variable (z transformation). Thus, the cells of all variables range from -1 to 1, with zero mean. Thereby, we produced 21 orthogonal principal components (independent) and selected the first seven, which accounted for 96.4% of the variation of the original dataset (Table 1). This method allows the variables to have the same importance in the ENM predictions (Dormann et al. 2012). Consequently, it also avoids the overfitting of the models, which can result in unreliable predictions (De Marco & Nóbrega 2018).

4. *Modeling procedures*

We performed the ENMs only for orders of cyanobacteria that had a minimum of 10 occurrence points. For Phylum Cyanobacteria, we compiled a total of 109 occurrence records, where 47 belonged to Chroococcales, 44 to Nostocalles, 12 to Oscillatoriales and 6 to Synechoccales. We also included a general model for Cyanobacteria to represent the order Synechoccales in our study. To ensure independence in the dataset used to fit and evaluate the performance of the models, we chose to use geographic partitions in a grid format, similar to a checkerboard (Muscarella et al. 2014).

Table 1. Summary of the Principal Component Analysis performed from 21 environmental variables used in the Ecological Niche Modeling. Principal Component axes (PC) were selected until the cumulative explanation proportion reached 95% or more of the total variation of the original matrix. Loadings of PCs for each variable are presented, as well as PC's eigenvalues, the proportion of explained variance of each PC, and accumulated proportion of explained variance.

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Annual Mean Temperature (bio1)	-0.266	-0.240	-0.063	-0.015	-0.044	0.078	0.056
Mean Diurnal Range (bio2)	0.197	-0.206	0.026	0.456	-0.045	-0.052	0.539
Isothermality (bio3)	-0.225	0.018	0.370	0.030	0.064	0.263	0.382
Temperature Seasonality (bio4)	0.233	-0.053	-0.384	0.120	0.135	-0.130	0.107
Max Temperature of Warmest Month (bio5)	-0.157	-0.355	-0.262	0.112	0.038	-0.060	0.170
Min Temperature of Coldest Month (bio6)	-0.296	-0.111	0.049	-0.155	-0.001	0.104	0.016
Temperature Annual Range (bio7)	0.244	-0.138	-0.264	0.279	0.031	-0.175	0.152
Mean Temperature of Wettest Quarter (bio8)	-0.211	-0.290	-0.136	0.122	-0.107	0.157	0.037
Mean Temperature of Driest Quarter (bio9)	-0.270	-0.167	0.012	-0.117	0.078	-0.004	0.130
Mean Temperature Warmest Quarter (bio10)	-0.204	-0.304	-0.258	0.028	0.034	0.021	0.019
Mean Temperature of Coldest Quarter (bio11)	-0.286	-0.171	0.072	-0.057	-0.069	0.099	0.081
Annual Precipitation (bio12)	-0.268	0.190	-0.017	0.215	0.028	-0.183	0.034
Precipitation of Wettest Month (bio13)	-0.268	0.076	0.122	0.217	-0.014	-0.391	0.154
Precipitation of Driest Month (bio14)	-0.153	0.325	-0.233	0.188	0.147	0.307	0.088
Precipitation Seasonality (bio15)	0.057	-0.278	0.404	0.190	-0.056	-0.192	0.139
Precipitation of Wettest Quarter (bio16)	-0.269	0.087	0.116	0.212	-0.030	-0.395	0.105
Precipitation of Driest Quarter (bio17)	-0.163	0.324	-0.229	0.190	0.156	0.273	0.077
Precipitation of Warmest Quarter (bio18)	-0.165	0.174	-0.093	0.437	-0.539	0.162	0.270
Precipitation of Coldest Quarter (bio19)	-0.207	0.187	-0.016	0.035	0.583	-0.309	0.131
Radiation solar	0.047	-0.309	0.116	0.281	0.506	0.329	0.545
Altitude	0.178	0.091	0.399	0.335	0.105	0.217	0.123
Proportion explain by each PC %	0.490	0.205	0.115	0.062	0.038	0.034	0.020
Accumulated Proportion Explained by the PCs	0.490	0.695	0.811	0.872	0.910	0.944	0.964

This partition subdivides the study area equally and in a spatially independent manner, alternating between training (to perform the model) and testing (to evaluate the model). We used five ENM algorithms to model the distribution of bloom events: (1) Maximum Entropy (MXE) (Phillips et al. 2006); (2) Support Vector Machine (SVM) (Guo et al. 2005); (3) Random Forest (RDF) (Breiman 2001); (4) Maximum Likelihood (MLK) (Royle et al. 2012) e Gaussian (GAU) (Golding & Purse 2016).

The MXE algorithm is a technique of machine-learning that estimates the nearest probability distribution of the uniform distribution under constraint whose expected values for each variable are in agreement with empirical values observed in the occurrence records (Phillips et al. 2006). This technique constrains the possibilities of adjusting linear or quadratic functions, reducing the complexity of the models and producing better predictions in certain situations (Phillips et al. 2017, 2004). The SVM algorithm is a set of methods of supervised learning belonging to the family of generalized linear classifiers. This algorithm reduces the probability of misclassifying in patterns not observed by the distribution of data probabilities (Rangel & Loyola 2012). SVM creates hyperplanes to differentiate the occurrence records from absence sets (Guo et al. 2005). The RDF algorithm produces accurate predictions that do not overload data, fitting the models based on decision trees that use a subset of random predictors (Breiman 2001). The MLK algorithm predicts the species occurrence probability in a given location by estimating a distribution of occurrence probability based on observed environmental conditions (Royle et al. 2012). The GAU algorithm predicts the species occurrence probability based on adjustments made by Bayesian inference (Golding & Purse 2016).

We used a method to create pseudo-absence to meet some algorithms' requirements. Here, we used bioclimatic envelopes similar to the BioClim algorithm (Booth et al. 2014). This procedure constraints the occurrence points of the taxa in the geographical space using a bioclimatic envelope (VanDerWal et al. 2009, Lobo & Tognelli 2011). Then, the external area is considered as not suitable for the occurrence of species. In this area, pseudo-absences are created in a ratio of 1:1. We used a threshold that maximizes the sum of the sensitivity and specificity obtained from the Receiver Operating Characteristic (ROC) curve. This method is given by the graphical representation of True Positive Rate and True Negative Rate in several threshold settings. We measured the performance of the ENM algorithms by True Skill Statistics (TSS; Allouche et al., 2006). TSS is a threshold-dependent metric and ranges from -1 to 1. Predicted distributions with negative values and close to zero are not considered better than random models. 'Acceptable' projections for potential species distributions generally reach TSS values close to 0.5. 'Good' projections reach TSS values close to 0.7, while 'excellent' projections reach close to 0.9.

We represented the final distributions using consensus maps to reduce the uncertainties associated with each algorithm (Araújo & New 2007). We made the consensus maps using the average of the models that presented TSS values above the average. The idea of the consensus models considers that different errors may affect the final result (e.g. sensitivity of the models, lack of true absences). For this reason, it has been argued in the literature that the use of consensus maps as final distribution models may reduce the number of errors (Diniz Filho et al. 2010).

Results

1. Scientometric analysis

We found 72 scientific studies in the literature that mention the occurrence of bloom events in freshwater environments in Brazil. We detected that the orders Chroococcales, Nostocales, Oscillatoriales, and Synechococcales were the most reported. Species of the orders Chrococcales and Nostocales, represented by the genera *Microcystis*, *Raphidiopsis*, and *Dolichospermum* (old *Anabaena)*, occurred mainly in the states of São Paulo, Paraná, Rio Grande do Sul and Minas Gerais (Fig. 1). There were differences in the number of records distributed among Brazilian states. In some states we obtained a large number of blooms, while there were no records at all for others.

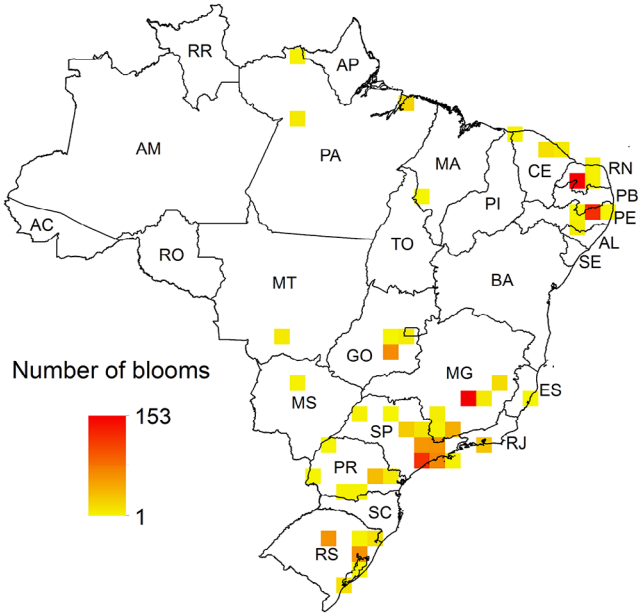

Figure 1. The number of events registered in the literature in freshwater environments. Each cell has a spatial resolution of 1 decimal degree. The number of bloom events was counted in each cell considering the entire time series for all occurrence records (evaluating the temporal consistency of the blooms). All records are of freshwater environments. The maximum value for each cell is 153 bloom events. Note: the initials for the twenty-six states and Federal District (in Portuguese, Distrito Federal) are, respectively: Acre-AC; Alagoas-AL; Amapá-AP; Amazonas-AM; Bahia-BA; Ceará-CE; Distrito Federal-DF; Espírito Santo- ES; Goiás-GO; Maranhão- MA; Mato Grosso- MT; Mato Grosso do Sul- MS; Minas Gerais-MG; Pará-PA; Paraíba- PB; Paraná- PR; Pernambuco- PE; Piauí- PI; Roraima- RR; Rondônia- RO; Rio de Janeiro-RJ; Rio Grande do Norte- RN; Rio Grande do Sul-RS; Santa Catarina-SC; São Paulo-SP; Sergipe-SE; Tocantins-TO.

The highest numbers of blooms found in the literature were obtained in the states of São Paulo, Minas Gerais, Pernambuco, and Rio Grande do Norte. On the other hand, we found the smallest amounts of bloom registered in the literature in the Amazon hydrographic basin. Mainly, bloom events were reported in sites of high human concentrations and with public supply reservoirs: Acarape do Meio Reservoir (Ceará), Armando Ribeiro Gonçalves Reservoir and Cruzeta Reservoir (Rio Grande do Norte), Carpina Reservoir (Pernambuco), Billings and Guarapiranga Reservoir (São Paulo), Utinga Reservoir (Belém do Pará) and Juturnaíba Reservoir (Rio de Janeiro).

We observed the first bloom events in 1982 (n = 2) and the highest number of bloom records in 2010 (n = 89) (Fig. 2A).

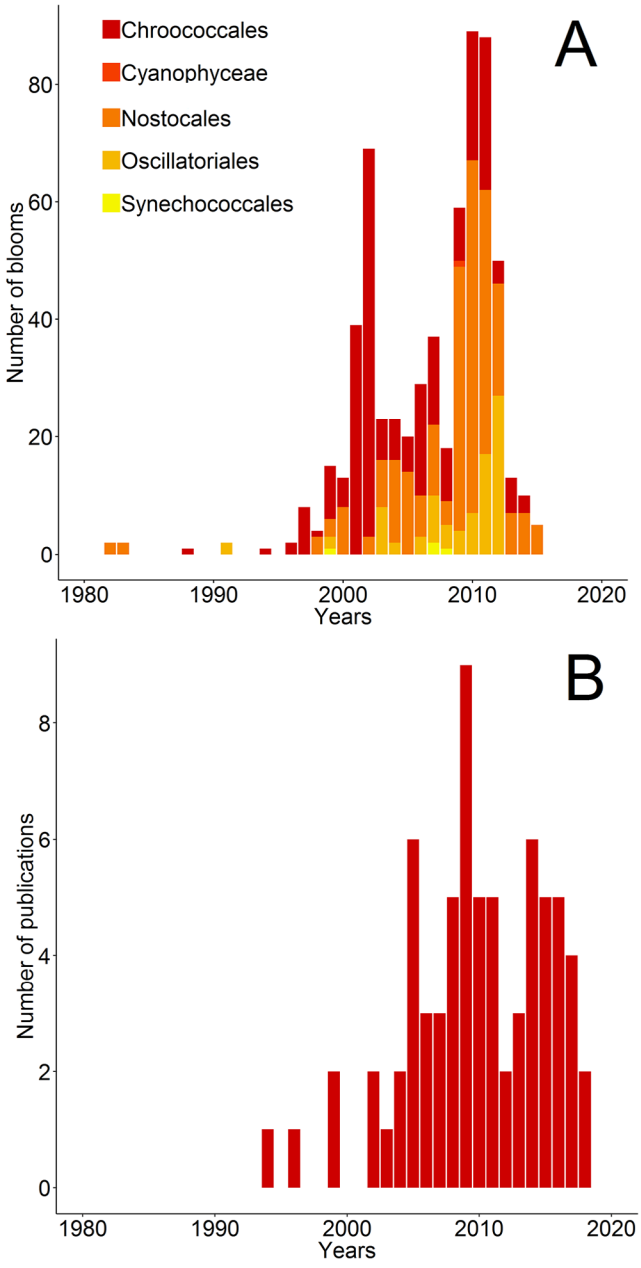

Figure 2. The number of occurrence records and number of publications (scientific studies) over the years. (A) The total number of cyanobacterial blooms per year in freshwater ecosystems in Brazil. (B) The number of scientific studies reporting blooming events in the Brazilian territory per year.

On the other hand, the year with the highest number of studies reporting blooms are 2009 (n = 9), 2005 and 2014 (n = 6), with the first study published in 1994 (n = 1) (Fig. 2B). We found no relationship between the number of blooms and the number the scientific studies (F = 3.231; R^2 = 0.076; p = 0.083). However, we must point out that since our database is composed of scientific studies and is not based on random sampling and probably does not have the same number of repetitions in each region, the sampling effort is an important factor in the frequency of occurrence of bloom. Thus, although the statistical relation has not been observed, it is difficult to consider that there is no relation between a number of blooms events and the numbers of scientific studies. We observed a relationship between the number of blooms in freshwater environments and population density (R^2 adjusted = 0.35; p = <0.001). Furthermore, we observed that the years with the relationship number of blooms are not necessarily the years with the relationship numbers of studies.

2. *Cyanobacteria potential distributions*

In general, TSS values obtained for the modeled taxa were considered acceptable (greater than 0.5) or excellent (greater than 0.7). TSS values for phylum Cyanobacteria (0.856) and the order Chrococcales (0.882) were the highest. For the orders Nostocales (0.743) and Oscilatoriales (0.657) the values indicate models with good adjustment (Table 2).

While the Phylum Cyanobacteria, the orders Chroococcales and Nostocales obtained wide potential distributions range among the Northeast, South, Southeast and Midwest regions, the order Oscillatoriales presented a restricted distribution between Northeast and Southeast regions (Fig. 3). Altogether, no model designed suitable areas in the Northern region, so that the distribution of the taxa was mainly concentrated in Southeastern Brazil. The prediction for the phylum Cyanobacteria showed that 52.5% of the Brazilian territory has highly suitable area for the occurrence of blooming events. The orders Chroococcales, Nostocalles and Oscillatoriales showed high suitability in 55.5%, 49.9% and 17.3% of the Brazilian territory.

Discussion

We observed that the number of publications on blooming events was higher in 2009, showing a decline in 2012, 2013 and 2017. However, the blooms have been reported in publications with data since 1982. Our results indicate the higher number of freshwater blooms in 2005, 2011 and 2014, and the vast majority of these records occurred in public supply reservoirs. We observed a relationship between the number of blooms in freshwater environments and population density (R^2 adjusted = 0.35; p = <0.001). Furthermore, we observed that the years with the relationship number of blooms are not necessarily the years with the relationship numbers of studies. For instance, 2009 presented the highest number of scientific studies and a median number of bloom events. Then, we also observed that species of potentially toxic genera, such as *Microcystis, Raphidiopsis*, and *Dolichospermum* have a wide geographic distribution.

The increase in publications during the years 2005, 2009 and 2014 indicates an increase in the number of researchers in this field of study, as well as its scientific and technological progress, considering that the number of publications is one of the most used measures to quantify the scientific production (Debackere et al. 2002). Between the years of 2010 and 2018, the publications did not exceed the number of five studies, demonstrating a small number of scientific studies mentioning the bloom occurrences. The lack of studies on the occurrence of cyanobacterial bloom events, as well as the concentration of records sampled in large cities and close to researches centers, were the main observed biases. The amount of published research over the years may indicate gaps to be filled in later studies since cyanobacteria are potentially toxin-producing organisms lethal to aquatic biota and humans. Our findings indicate that the occurrences are located where there is a greater human population density and in public supply reservoirs with historic of persistent blooms. What may justify the greatest number of events recorded in supply reservoirs is the existence of criteria related to the growth of cyanobacteria that are set out in the Ministry of Health Ordinance Nº. 2.914, dated December 12, 2011, and which, in turn, revoked the Ministry of Health Ordinance Nº. 518 of March 25, 2004. The federal law evidences the need to monitor cyanobacteria in all sources of public supply, thus contributing to the largest number of publications in supply reservoirs.

Since bloom events occur mainly in large urban centers favors the accumulation of pollutants and the accelerated growth of the phytoplankton community, causing a considerable increase in biomass (Behrenfeld & Boss 2018). This biomass has negative consequences on the efficiency and cost of water treatment, which can generate a loss of the resources destined to the public supply due to the economic unviability related to the water treatment (Lorenzi et al. 2018). The blooms were mostly of the genus *Microcystis*, which in turn provide great shading for the other phytoplankton species, hindering their development, reducing the competition rate and eventually reducing the richness and diversity of organisms (Cires et al. 2013). Also, morphological adaptations and the presence of gas vesicles allow buoyancy (van Gremberghe et al. 2011) and access to active photosynthetic radiation that facilitates its success in aquatic ecosystems (Padisák 1997). Yet, the dense mucilage in cyanobacteria (Reynolds 2007) ensures the increase in tolerance to high luminous intensities due to the acclimation by an increase in the production of photoprotective pigments (Paerl & Otten

Table 2. TSS values for the evaluation of the distribution models of the Phylum Cyanobacteria and of the orders Chroococcales, Nostocales and Oscillatoriales in different algorithms and for the ensemble map.

	TSS					
Taxonomic group	GAU	MLK	MXS	RDF	SVM	Ensemble
Phylum Cyanobacteria	0.769	0.595	0.828	0.725	0.798	0.856
Order Chroococcales	0.799	0.417	0.646	0.819	0.750	0.882
Order Nostocales	0.690	0.192	0.590	0.799	0.668	0.743
Order Oscillatoriales	0.343	0.271	0.586	0.486	0.243	0.657

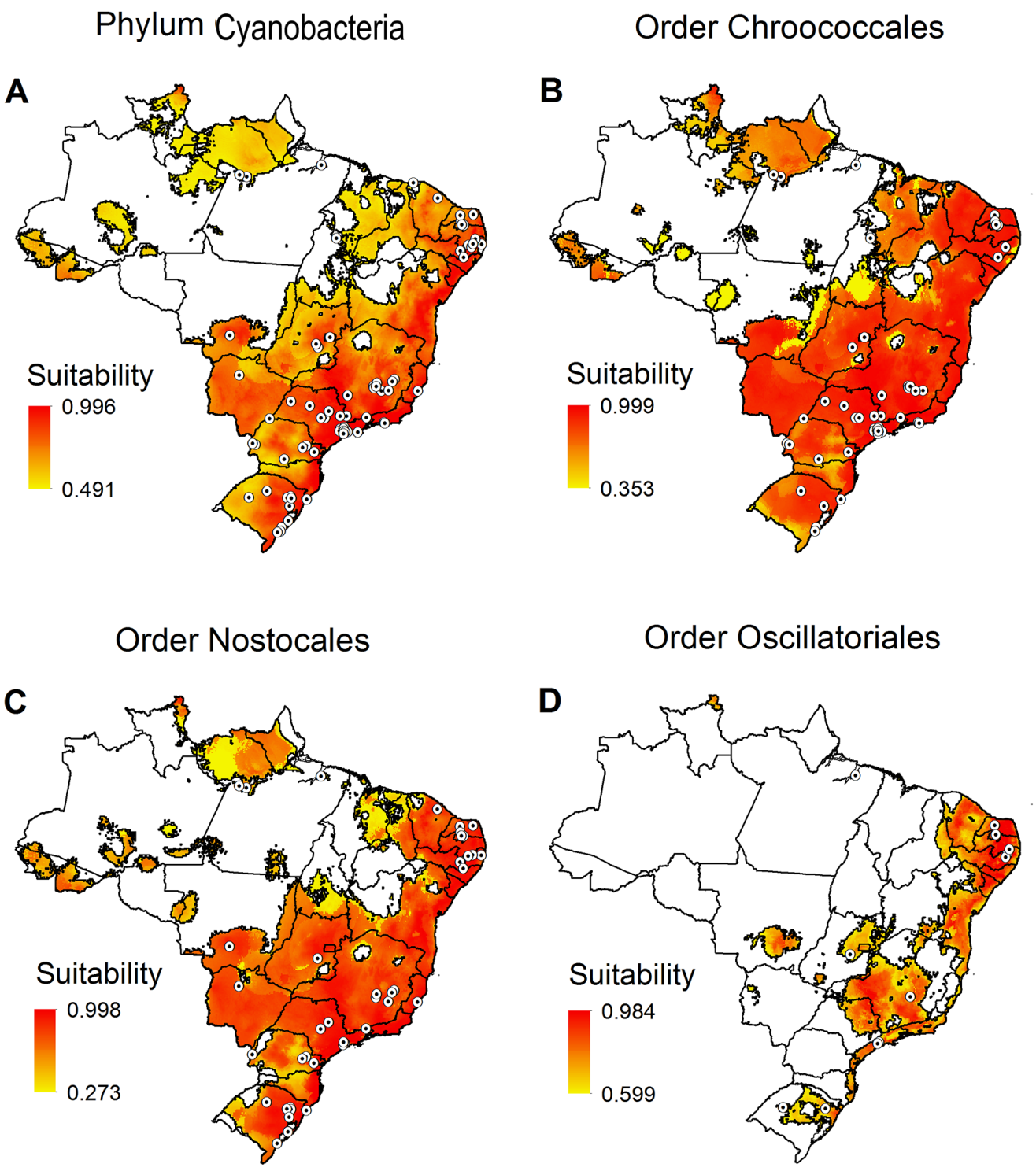

Figure 3. Potential distributions for the groups of modeled Cyanobacterial in the Brazilian territory. (A) Phylum Cyanobacteria; (B) order Chrococcales; (C) order Nostocales; and (D) Order Oscillatoriales. The most suitable areas are represented colors closer to red, while the less suitable regions have colors closer to yellow. The dark line spatially delimits the threshold obtained from the values that maximized the sum of the sensitivity and specificity of the models, selecting only areas of high suitability.

2013). In contrast, species of the genus *Raphidiopsis* can to adapt to low luminous intensity, being able to coexist with 'floating' genera, such as *Dolichospermum* and *Microcystis*, forming blooms in greater depths (Paerl & Huisman 2008). Also, the genera *Raphidiopsis* presents success in dispersal attributed, in large part, to its ability to tolerate journeys along with river courses (Rick et al. 2007, Moreira et al. 2015). In the genera *Dolichospermum* and *Microcystis*, the wind is an important dispersing agent for phytoplankton (Chrisostomou et al. 2009), as well as the animals that can also transport their vegetative forms on their body surface (Padisák et al. 2016). Cyanobacteria occur at environmentally suitable sites, where adequate dispersion rates are paramount for tracking changes in environmental conditions between localities (Heino et al. 2009).

Cyanobacterial dominance is associated with high temperatures, and the close relationship between temperature and the dominance in water bodies is evident (Cottingham et al. 2015).

The use of ENMs can estimate environmentally suitable areas where the knowledge about cyanobacterial geographic distribution is incomplete (Silva et al. 2013); guiding future field surveys (Jensen et al. 2017). In an attempt to reduce the lack of knowledge about the geographic distribution of cyanobacteria responsible for bloom events, also known as Wallacean shortfall (Cardoso et al. 2011, Whittaker et al. 2005), the data compilation from specialized literature, becomes an effective tool to mitigate such a problem. However, it is necessary not only to record the collection biases but also to identify the priority areas for inventories to overcome this problem (Sousa-Baena et al. 2014).

Our ensemble distribution maps revealed that the northern portion of Brazil does not have high suitability for bloom events, being that the blooms are distributed in greater number of occurrences in the Southeast region. This result is the same for all four models. The suitability observed in this region may be a reflection of the lack of information about bloom events due to the low human concentration. Another explanation for the low occurrence in the North is that in these environments there is still a large proportion of the rivers preserved and not converted into reservoirs. Lentic environments are more amenable to flowering than lotic. Also, these species that were more reported are more successful in reservoirs (Komárek et al. 2014). Incomplete data of geographic distribution are common in biological datasets from tropical regions (Ballesteros-Mejia et al. 2013, Kamino et al. 2012, Soberón 2007); with the Amazon region being generally sub-sampled (Freitas et al. 2012). The distribution data are overlapped to regions with high human density (Letters & Jan 2013) and the spatial patterns that we observed reflect the activities of the Brazilian researchers in reservoirs that show the historical persistence of blooms (Lorenzi et al. 2018). Sampling bias is quite common for several biological groups and can have a strong effect on ENMs results (Kramer-Schadt et al. 2013).

Although the sampling bias demonstrated here is one of the main reasons that may explain the fragmentary distributional patterns we observed, less appreciated factors may also explain this pattern, such as: (1) material sampled extensively in a given area, causing an accumulation of many data to be processed (Hortal et al. 2015); (2) Financial and/or human insufficient resources for the identification and curation of species (Fontaine et al. 2012); and (3) social and logistical variables (e.g., accessibility, number of inhabitants of a region, economy) (Whittaker et al. 2005). Even more subjective factors, such as the researcher's preference for certain organisms or regions, may leave incomplete the distribution and occurrence scenarios for cyanobacteria (Ficetola et al. 2014).

Our results indicate that the available data on the geographic distribution for cyanobacterial blooms in freshwater environments are far from complete and have obvious geographical biases. However, it is much more comprehensive than the information available in the literature, as also reported in Freitas et al. (2012). We are aware that many of the cyanobacterial bloom events in water environments were not accessible, which may have reduced our ability to assess bloom events in Brazil. In our study, we mapped the available biological data about cyanobacteria responsible for the bloom events and the sample effort invested in the Brazilian territory. Our results can provide useful information on current sampling gaps that need further research to improve distribution data on the occurrence of bloom events in public supply reservoirs and support the monitoring practices of these events.

Monitoring practices and risk assessments in water bodies include a proactive approach, encompassing inspection and monitoring programs with specific preventive actions (Huisman et al. 2018). However, although the enrichment of freshwater environments by nutrients is considered a major problem of pollution worldwide (Glibert et al. 2008), it is also one of the most important factors contributing to the increase in the number of bloom events (Glibert et al. 2008). In Brazil, eutrophication is still on the rise because of the increasing human population in many regions, which increases energy demands, increases the use of nitrogen fertilizers (N) and phosphorus (P) for agriculture, and increases the production of meat and animal waste. Nevertheless, we have noticed that the monitoring programs developed in Brazil are divided into four types of policies: prevention, restoration, improvement and no action (Caron et al. 2010). In other countries (e.g. the United States of America), advances are being made to detect bloom events and, in some cases, predict the occurrence and potentially reduce impacts. The rapid detection ability of phytosanitary cyanobacteria has progressed greatly from classical microscopic methods for detection involving specific molecules and genomes, which can be detected with a fluorescent signal (reviewed by Sellner et al., 2003). In addition, uses of remote images, packets and arrays that can detect and provide real-time information about species, as well as physical and chemical parameters have been enhanced (Stumpf & Tyler 1988, Lopes et al. 2016, Mishra & Mishra 2014). In Brazil, such advances and techniques are still far from being widely used, which may underestimating the actual bloom's occurrence in the country, affecting the data available on bloom events (Sellner et al. 2003).

Thus, we hope that this study will stimulate new cyanobacterial samplings and increase efforts to understand and predict algal blooms to reduce its occurrence or impacts in the future. The most effective way is to reduce the entry of nutrients into aquatic environments since blooms are a widespread problem affecting estuaries, coasts and freshwaters around the world with effects on ecosystems, human health, and economies.

Conclusions

Using a scientometric analysis and ENMs, we demonstrate that many of the bloom events of phytosanitary cyanobacteria reported in the Brazilian literature are of the toxic genera *Microcystis*, *Raphidiopsis*, and *Dolichospermum.* These genera are broadly distributed in Brazil and respond quickly to current environmental changes and should certainly occur in areas that were not currently detected in our scientometric and ENMs analyzes. Thus, we believe that there are still several sampling gaps to be filled to effectively unravel the geographic distribution of cyanobacterial that cause blooms in freshwater environments and, consequently, diminish the effect of the Wallacean shortfall in this group. For instance, the northern portion of Brazil, which still has low suitability for bloom events compared to the occurrences in other Brazilian regions with a large concentration of human centers and population, needs to be better sampled, especially, in large urban centers. The cyanobacteria overgrowth has been highlighted because of possible problems in aquatic ecosystems, and by ecological and sanitary interest.

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Author Contributions

Ariane Guimarães: Substantial contribution to the design and design of the work; Contribution to data acquisition; Contribution in the analysis and interpretation of data.

Pablo Henrique da Silva: Substantial contribution to the design of the work; Contribution in the analysis and interpretation of data.

Fernanda Melo Carneiro: Substantial contribution to the design of the work; Contribution to data acquisition

Daniel Paiva Silva: Substantial contribution to the design and design of the work; Contribution in the analysis and interpretation of data; Contribution in critical review adding intellectual content.

Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethics

Our study did not involve humans and / or clinical trials. The manuscript represents original and valid work and that neither this manuscript nor one with substantially similar content under the same authorship has been published or is being considered for publication elsewhere.

Data Availability

The data used were taken from the literature as mentioned in the materials and methods.

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Erratum

Erratum: Using distribution models to estimate blooms of phytosanitary cyanobacteria in Brazil

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