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Gall-inducing insects of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil

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ABSTRACT. Galls are specific changes induced by insects on plant organs mainly through increases in plant cell number and/or size. Gall diversity is easy to recognize in the field because gallers are mostly species-specific, and thus each gall morphotype can be a proxy for a galling species. Insect galls are virtually unknown in Seasonal Deciduous and Semi-Deciduous forests of southern Brazil. Here, galls and host plants were surveyed between 2015 and 2017 in four forest fragments of Rio Grande do Sul State in these two vegetation types, in secondary-growth and areas under restoration. We recorded 89 gall morphotypes, with gallers belonging to Lepidoptera and Diptera, with the latter represented mainly by Cecidomyiidae. Galls were associated to 46 plant species in 27 families. Asteraceae, Piperaceae, Fabaceae, Myrtaceae and Lauraceae were the richest families in terms of galls, whilst *Piper aduncum* and *Mikania glomerata* were superhosts. Most galls occurred in leaves and shoots. The most common shapes were fusiform, globoid and lenticular. Forty-eight gall morphotype records are new for both Rio Grande do Sul and Brazil, an expressive number considering only two seasonal forest types sampled and few sampling points, showing how important surveys still are for these little know fauna both in taxonomic and ecological terms.

KEYWORDS. Insect-plant interaction, host plant, morphotype, gall richness.

RESUMO. Insetos indutores de galhas das florestas decidual e semidecidual no Estado do Rio Grande do Sul, Brasil. Galhas são alterações específicas induzidas por insetos sobre órgãos das plantas principalmente através de aumento no número e/ou tamanho das células vegetais. A diversidade de galhas é reconhecível em campo porque os galhadores são na sua vasta maioria espécie-específicos e assim cada morfotipo de galha serve como *proxy* para uma espécie de galhador. Insetos galhadores são virtualmente desconhecidos nas florestas estacionais deciduais e semideciduais do sul do Brasil. Galhas e plantas hospedeiras foram inventariadas entre 2015 e 2017 em quarto fragmentos florestais do Estado do Rio Grande do Sul nestas duas formações vegetacionais, em áreas com sucessão secundária e sob restauração. Foram encontrados 89 morfotipos de galhas, com galhadores pertencentes a Lepidoptera e Diptera, com os últimos representados principalmente por Cecidomyiidae. As galhas estiveram associadas a 46 espécies de plantas em 27 famílias. Asteraceae, Piperaceae, Fabaceae, Myrtaceae e Lauraceae foram as famílias mais ricas em termos de galhas, sendo *Piper aduncum* e *Mikania glomerata* considerados super-hospedeiras. A maioria das galhas ocorreu em folhas e ramos. As formas mais comuns foram fusiforme, globoide e lenticular. Dos morfotipos de galhas registrados, 48 são novos para o Rio Grande do Sul e o Brasil, um número expressivo considerando que somente dois tipos de florestas foram amostradas em um número restrito de pontos amostrais, demonstrando a importância de levantamentos para esta fauna quase desconhecida tanto em termos taxonômicos quanto ecológicos.

PALAVRAS-CHAVE. Interação inseto-planta, planta-hospedeira, morfotipo, riqueza de galhas.

Insect-induced galls are anomalous growth on plant organs originating from increases in plant cell number (hyperplasia) and/or size (hypertrophy) (Mani, 1964). Galling insect species can even be separated and identified based on gall morphology along with host plant organ and species (Price *et al.*, 1998). Each galling insect species is responsible for inducing a unique structure, a gall with distinct anatomy and physiology compared to other such species (Shorthouse *et al.*, 2005). Most gallers are species-specific relative to the plant host, with the latter usually belonging to specific plant clades as well, with clear evolutionary associations (Mendonça, 2007). New surveys of these gall-based plant-herbivore trophic networks on unexplored sites and vegetation types can work as repeated tests for these ecological and phylogenetic patterns, with regional preferences either confirmed or revised by new knowledge.

Since the end of the 1980s decade, studies on galling insects increased considerably in Brazil, mainly related to natural history and distribution (Fernandes *et al.*, 2014). Nowadays, work is being carried out in all different regions of this country: North (e.g. ALMADA & FERNANDES, 2011), Northeast (e.g. NOGUEIRA *et al.*, 2016), Central-West (e.g. ARAÚJO *et al*,. 2015) and Southeast (e.g. MAIA & CARVALHO-FERNANDES, 2016). In Southern Brazil, studies on galling insect diversity are still scarce, however there are recent records for Paraná (CARVALHO *et al.*, 2015; SANTOS & RIBEIRO, 2015) and Rio Grande do Sul States (e.g. DALBEM & MENDONÇA, 2006, MENDONÇA, 2007, 2011; MENDONÇA *et al.*; 2010, TOMA & MENDONÇA, 2013). MENDONÇA *et al.* (2014) listed insect galls known from the two biomes occurring in Rio Grande do Sul (RS), Atlantic forest and Pampas. Surveys covered different vegetation types, mostly subtropical gallery forests and subtropical moist forests, without being able to represent Seasonal forests, a rather common vegetation type in the region.

This study aims to increase the present knowledge on galling insects and their host plants by surveying Deciduous and Semideciduous Seasonal forests in Rio Grande do Sul State and comparing with already established ecological and evolutionary patterns on gall occurrence.

MATERIAL AND METHODS

This study was carried out in forest fragments of Semideciduous Seasonal (SS) and Deciduous Seasonal (DS) forest formation types, in two localities of Rio Grande do Sul State, Brazil. SS samples took place in Canela municipality, in an area belonging to the State Electric Company (Companhia Estadual de Energia Elétrica, CEEE-RS). Samples in DS occurred in Santa Tereza municipality, in private property areas with authorisation granted for scientific research.

The SS sites face a *Cfb* climate (Köppen classification) with average temperatures for the hottest month at 22°C and for the coldest month from -3°C and 18°C (MORENO, 1961). This type of forest formation is characteristic of regions with temperature climatic seasonality and has a percentage of deciduous trees between 25 and 50%, evident in the winter (IBGE, 2012). The DS sites are under a *Cfa* climate with average temperatures for the hottest month above 22°C and for the coldest month from -3°C and 18°C (MORENO, 1961). As with the SS forests, DS occurs in seasonal environments, having however at least 50% of trees losing leaves in the cold season (ESPÍRITO-SANTO *et al.*, 2006).

Eight seasonal samples were done during 2015 and 2017 (one yearly sample for autumn and winter and three yearly samples for summer and spring) in four forest fragments (two for each vegetation type) in two distinct successional stages. For the SS forests in Canela, two fragments had advanced secondary growth (29°22'58.1"S, 50°44'08.1"W and 29°22'50.4"S, 50°44'11.9"W) and two others had 10 years since restoration actions were undertaken (29°22'50.2"S, 50°44'03.2"W and 29°22'44.1"S, 50°43'49.8"W). For the DS forests in Santa Tereza, there were also fragments being the first two at an advanced secondary succession (29°09'27.5"S, 51°41'34.6"W and 29°09'45.8"S, 51°42'33.2"W), as well as two areas with eight years since restoration took place (29°09'44.8"S, 51°42'32.8"W and 29°09'47.8"S, 51°42'40.5"W). Each fragment was explored by two persons during 60 min in search for galls in all plant species. Overall there were 64 h of sampling in each locality.

All galls were collected and took to the lab, where they were separated in morphotypes according to external morphology in combination with galled organ and host plant species. Galls were photographed, dissected under stereoscopic microscope to obtain immature galling inducers and characterize and describe galls (shape, colour and number of chambers) according to ISAIAS *et al.* (2013).

Part of the sampled galls was kept in sealed plastic bags to obtain adult galling insects. These were preserved in 70% ethanol and identified to the lower taxonomic level possible. However, some gall morphotypes were found empty, which made inducer identification impossible, although there is no doubt these galls were insect-induced. Host plant shoots, reproductive when possible, were identified with the help of taxonomic literature and/or botanical specialists. Biological material is deposited in the scientific collection of the Laboratório de Ecologia de Interações, UFRGS. Host plant taxa were organised according to Angiosperm Phylogeny Group IV classification (APG, 2016).

RESULTS

Overall 89 gall morphotypes were found, with most insect inducer species being Diptera, and Cecidomyiidae having 55% of all galling species. Lepidoptera represented only 3.3% of galling species and 38.2% of the morphotypes could not be identified, either coming from empty galls or only found occupied by parasitoids (Hymenoptera and Diptera). Among all gall morphotypes found here, 48 are considered as new records for the host plant species (Tab. I), comparing with pertinent literature – that is, no mention of a gall on a given plant, with the structure and inducer reported here, could be found.

Galls were associated to 27 host plant families, including 40 genera and 46 nominated species (e.g. Tab. I - Figs 1-89). The most representative families were Asteraceae, with 18 gall morphotypes (20.2%), Piperaceae with 11 (12.3%), Fabaceae with seven (7.8%), Myrtaceae with six (6.7%) and Lauraceae with five (5.6%). These families comprised 52.6% of all recorded gall morphotypes. Asteraceae also had the highest number of galled plant species (n = 7), while other families had four or five species. The most representative genera in gall morphotype numbers were *Piper* L., with 11 (12.3%) and *Mikania* Willd., with 10 (11.2%). Among species, those with most galls were *Piper aduncum* L. (n = 8) and *Mikania glomerata* Spreng. (n = 6).

Most galls were found on leaves (48.3%) and shoots (43.8%). Buds and fruits represented only 8.9% and 2.2%, respectively. There were no galls on flowers. The most common gall shape was fusiform (51.6%), followed by globoid (26.9%), lenticular (10.11%), amorphous (3.3%), conical (3.3%), cylindrical (1.1%), leaf fold (1.1%), rosette (1.1%) and marginal roll (1.1%).

Tab. I. Host plants, morphological characters and inducers for galls sampled in Semideciduous Seasonal (S) and Deciduous Seasonal (D) forest formation types, in two localities of Rio Grande do Sul State, Brazil, from 2015 to 2017. Number of chambers in the gall: ^{M}, monothalamous; ^{P}, polythalamous; $^{N.O.}$, not observed. Gall color: ^{B}, Brown; ^{G}, green; ^{LB}, light brown; ^{LG}, light green; ^{RE}, red; ^{RO}, rosy; ^{Y}, yellow; ^{W}, white. For each forest formation type galls could have been recorded in areas of: ^{S}, secondary sucession and/or ^{R}, restoration. Yearly season gall was recorded (SP, spring; A, autumn; SU, summer; W, winter). * indicates an insect galler on a plant species never mentioned as galled by an insect of this family before.

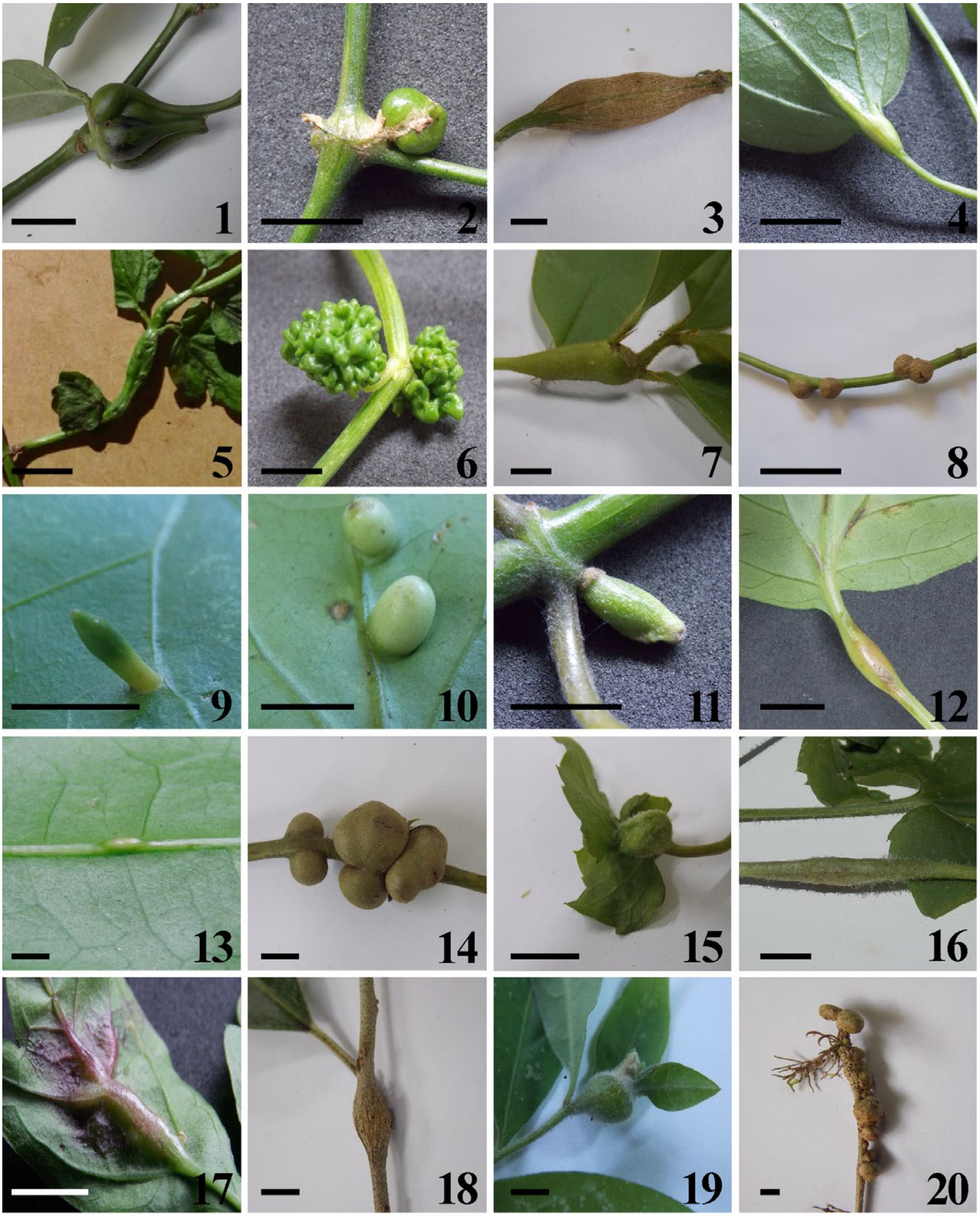
Host plant	Organ	Shape	Gall inducer	Fig.	Forest type	Season
Acanthaceae						
Justicia brasiliana Roth	Bud	Fusiform^{M,G}	Cecidomyiidae	1	D$^{R/S}$	A/SP
Asteraceae						
Calea serrata Less.	Stem	Globoid^{M,G}	Cecidomyiidae	2	S/D^{R}	W/SP/SU
Calea serrata Less.	Stem	Fusiform^{M,LB}	Cecidomyiidae	3	S^{R}	SU
Calea serrata Less*	Leaf (petiole)	Fusiform^{M,G}		4	S^{R}	SP
Calea serrata Less*	Stem	Fusiform^{P,G}		5	D^{R}	SU
Calea serrata Less*	Leaf	Amorphous^{M,G}		6	D^{S}	SP
Dasyphyllum spinescens (Less.) Cabrera*	Stem	Fusiform$^{N.O.,G}$		7	S^{S}	SP
Mikania glomerata Spreng.	Stem	Globoid^{P,B}	*Asphondylia moehni* Skuhravá, 1989	8	S/D$^{R/S}$	A/W/SP/SU
Mikania glomerata Spreng.	Leaf	Cylindrical^{M,G}	*Liodiplosis cylindrica* Gagné 2001	9	S^{R}	W
Mikania glomerata Spreng.	Leaf	Globoid^{M,G}	*Liodiplosis spherica* Gagné, 2001	10	S^{R}	W
Mikania glomerata Spreng.	Stem/Leaf	Conical^{M,G}	*Liodiplosis conica* Gagné, 2001	11	S^{S}	W
Mikania glomerata Spreng.	Leaf (petiole)	Fusiform^{M,G}	*Mikaniadiplosis annulipes* Gagné, 2001	12	D^{S}	W/SU
Mikania glomerata Spreng.	Leaf (vein)	Fusiform^{M,G}		13	S^{R}	SU
Mikania micrantha Kunth*	Stem	Globoid$^{N.O.,B}$		14	D^{R}	S
Mikania micrantha Kunth*	Leaf (petiole)	Globoid^{M,G}		15	D^{R}	S
Mikania micrantha Kunth*	Stem	Fusiform^{M,G}		16	D^{R}	SP
Mikania ternata (Vell.) B.L. Rob.*	Leaf	Fusiform$^{M,G/RO}$		17	S^{S}	SP
Moquiniastrum polymorphum (Less.)	Stem	Fusiform^{M,B}	Cecidomyiidae	18	S^{R}	SP
Trixis praestans (Vell.) Cabrera*	Bud	Globoid^{M,G}		19	D^{S}	A
Bignoniaceae						
Dolichandra unguis-cati (L.) L.G.Lohmann	Stem	Globoid^{P,LB}	Cecidomyiidae	20	S/D$^{R/S}$	A/SP/SU
Cordia ecalyculata Vell.*	Stem	Fusiform^{P,B}	Cecidomyiidae	21	S$^{R/S}$	W/SP
Cordia americana (L.) Gottshling & J.E.Mill.	Leaf	Globoid^{M,G}	Diptera	22	D$^{R/S}$	SP/SU
Cannabaceae						
Celtis iguanaea (Jacq.) Sarg.	Leaf (vein)	Fusiform^{M,G}	Cecidomyiidae	23	S$^{R/S}$	A/W/SP/SU
Celtis iguanaea (Jacq.) Sarg.*	Stem	Fusiform$^{N.O.,LB}$		24	S$^{R/S}$	A/W
Trema micrantha (L.) Blume*	Stem	Fusiform^{P,LB}	Cecidomyiidae	25	S$^{R/S}$	A/W/SP
Cardiopteridaceae						
Citronella gongonha (Mart.) R.A.Howard*	Stem	Fusiform^{M,G}		26	S^{R}	SU
Citronella gongonha (Mart.) R.A.Howard*	Stem	Fusiform$^{N.O.,G/LB}$	Cecidomyiidae	27	S^{R}	SP
Dioscoreaceae						
Dioscorea scabra Humb. & Bonpl. ex Willd.*	Leaf (petiole)	Fusiform^{M,G}	Cecidomyiidae	28	D^{S}	W/SU
Dioscorea scabra Humb. & Bonpl. ex Willd.*	Stem (aculeus)	Fusiform^{M,G}	Cecidomyiidae	29	D^{R}	SU
Dioscorea scabra Humb. & Bonpl. ex Willd.*	Stem	Fusiform^{M,G}		30	D^{R}	W/SU
Dioscorea scabra Humb. & Bonpl. ex Willd.*	Bud	Fusiform^{P,G}	Cecidomyiidae	31	D^{R}	W/SU

Tab. I. Cont.

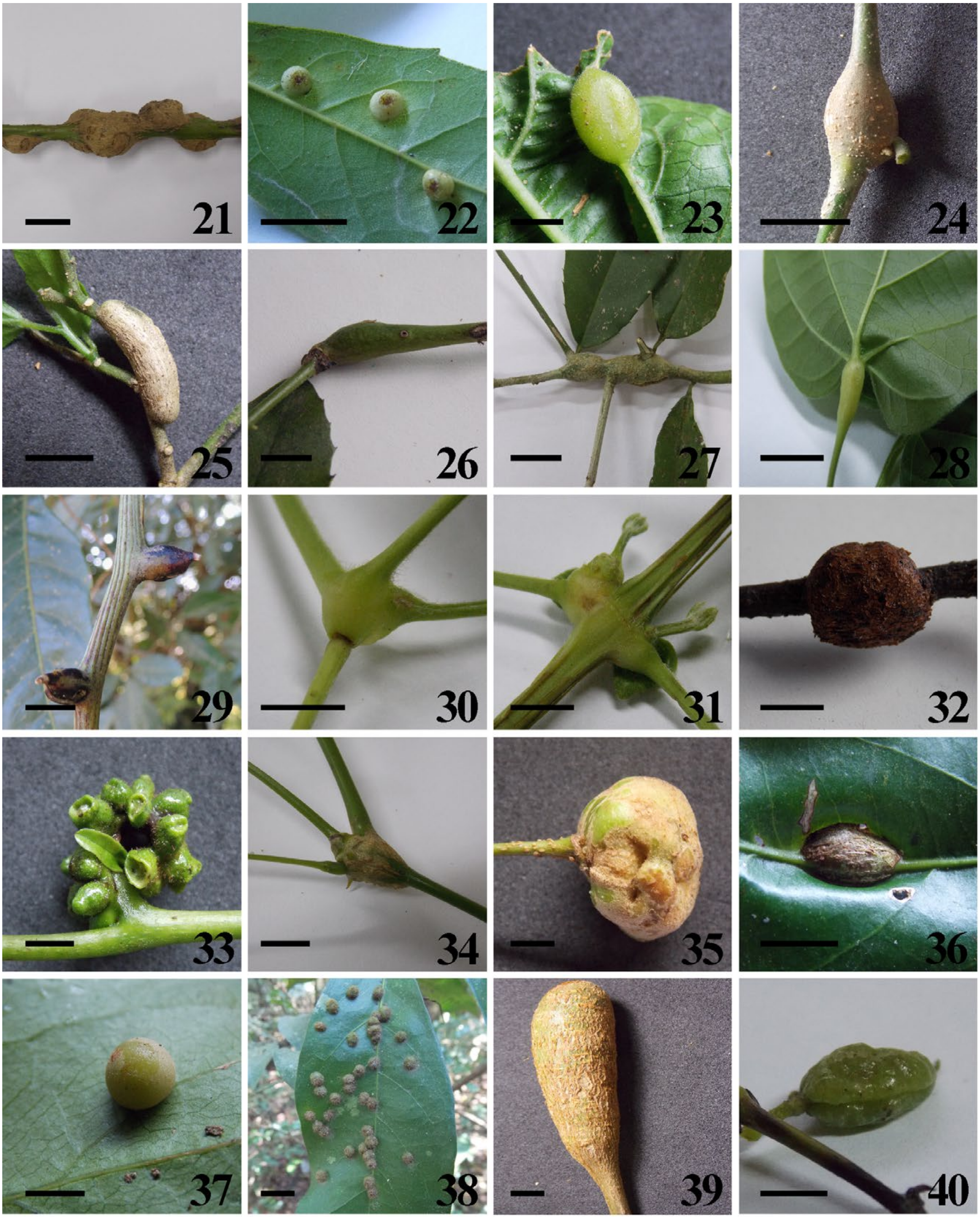
Host plant	Organ	Shape	Gall inducer	Fig.	Forest type	Season
Elaeocarpaceae						
Sloanea monosperma Vell.*	Stem	Globoid^{P,B}		32	S^{R}	SU
Euphorbiaceae						
Sebastiania sp.	Leaf	Globoid^{M,G}		33	S^{S}	SP
Fabaceae						
Bauhinia forficata Benth.*	Stem	Fusiform$^{M,G/B}$		34	D^{R}	S
Inga marginata Willd.	Stem	Globoid$^{P,G/LB}$	Cecidomyiidae	35	S/D$^{R/S}$	A/W/SP/SU
Inga marginata Willd.	Leaf (vein)	Fusiform^{M,LB}	Cecidomyiidae	36	S/D$^{R/S}$	A/W/SP/SU
Inga marginata Willd.*	Leaf	Globoid$^{M,B/Y}$		37	S$^{R/S}$	W/SP
Inga marginata Willd.*	Leaf	Globoid^{M,LB}	Cecidomyiidae	38	S^{S}	A/SP
Inga marginata Willd.*	Stem	Fusiform$^{N.O.,/LB}$		39	S^{R}	SP
Machaerium paraguariense Hassl.*	Leaf	Leaf Fold^{M,LG}	Cecidomyiidae	40	D^{R}	A
Lauraceae						
Ocotea puberula (Rich.) Nees*	Stem/Leaf	Globoid^{M,LG}	Cecidomyiidae	41	S/D$^{R/S}$	W/SP
Nectandra megapotamica (Spreng.) Mez	Stem	Fusiform^{P,B}	Cecidomyiidae	42	S/D$^{R/S}$	A/W/SP/SU
Nectandra megapotamica (Spreng.) Mez*	Leaf	Globoid$^{M,G/RO}$	Cecidomyiidae	43	S/D$^{R/S}$	A/W/SP
Nectandra megapotamica (Spreng.) Mez *	Leaf	Fusiform^{M,G}	Cecidomyiidae	44	D$^{R/S}$	A/SU
Nectandra megapotamica (Spreng.) Mez *	Leaf	Lenticular$^{M,Y/LG}$		45	D^{S}	SP
Malvaceae						
Luehea divaricata Mart. & Zucc.	Leaf	Conical$^{M,G/W}$	Cecidomyiidae	46	S/D	SP/SU
Luehea divaricata Mart. & Zucc.	Leaf	Fusiform^{M,LB}		47	D$^{R/S}$	SP/SU
Luehea divaricata Mart. & Zucc.	Leaf	Globoid^{M,G}		48	D^{S}	SU
Melastomataceae						
Leandra regnellii (Triana) Cogn.*	Leaf	Globoid^{M,RO}	Cecidomyiidae	49	S/D$^{R/S}$	A/W/SP/SU
Leandra regnellii (Triana) Cogn.*	Stem	Fusiform^{P,LB}	Cecidomyiidae	50	S$^{R/S}$	A/W/SP/SU
Meliaceae						
Trichilia claussenii C.DC.*	Stem/Bud	Rossette^{M,G}		51	S$^{R/S}$	SU
Monimiaceae						
Mollinedia elegans Tul.*	Stem	Fusiform^{M,LB}	Cecidomyiidae	52	S$^{R/S}$	A/W/SP/SU
Mollinedia schottiana (Spreng.) Perkins*	Bud	Conical^{M,LB}		53	S^{R}	SP
Moraceae						
Sorocea bonplandii (Baill.) W.C. Burger, Lanjouw & Boer*	Stem	Fusiform^{M,LB}		54	S^{R}	SU
Myrtaceae						
Campomanesia xanthocarpa O. Berg	Leaf	Lenticular^{M,LG}	Cecidomyiidae	55	D^{R}	SP/SU
Eugenia uniflora L.	Leaf	Fusiform$^{M,RE/G}$	*Clinodiplosis profusa* Maia, 2001	56	D$^{R/S}$	A
Eugenia uniflora L.*	Leaf	Lenticular^{M,LG}		57	D^{R}	A
Myrcianthes pungens (O.Berg) D. Legrand*	Bud	Fusiform^{M,LG}	Cecidomyiidae	58	D^{R}	SP
Myrcianthes pungens (O.Berg) D. Legrand*	Leaf	Marginal roll^{M,G}		59	D^{R}	SU
Psidium cattleyanum Sabine*	Stem	Fusiform^{M,LG}		60	D^{R}	SP
Nyctaginaceae						

Tab. I. Cont.

Host plant	Organ	Shape	Gall inducer	Fig.	Forest type	Season
Guapira opposita (Vell.) Reitz	Leaf	Globoid^{M,G}	Cecidomyiidae	61	S$^{R/S}$	A/SP
Guapira opposita (Vell.) Reitz	Leaf	Globoid^{M,RO}	*Bruggmannia robusta* Maia & Couri, 1993	62	S$^{R/S}$	SP
Guapira opposita (Vell.) Reitz	Leaf	Lenticular^{M,G}	*Bruggmannia elongata* Maia & Couri, 1 993	63	S$^{R/S}$	A/SP/SU
Guapira opposita (Vell.) Reitz	Stem	Fusiform^{M,G}	Cecidomyiidae	64	S^{R}	SU
Phytolaccaceae						
Seguieria aculeata Jacq. *	Leaf	Lenticular$^{M,G/LB}$		65	S^{S}	SU
Piperaceae						
Piper aduncum L.	Stem	Fusiform^{P,G}	Cecidomyiidae	66	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.	Stem	Fusiform^{M,G}	Cecidomyiidae	67	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.	Leaf (vein)	Globoid^{M,G}	Cecidomyiidae	68	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.	Leaf (petiole)	Fusiform^{M,G}	Cecidomyiidae	69	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.*	Leaf (vein)	Fusiform^{M,G}	Cecidomyiidae	70	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.*	Leaf	Globoid$^{M,G/W}$	Cecidomyiidae	71	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.	Stem/Leaf	Amorphous^{P,G}	Cecidomyiidae	72	S/D$^{R/S}$	A/W/SP/SU
Piper aduncum L.*	Fruit	Amorphous^{P,G}	Cecidomyiidae	73	D$^{R/S}$	SP
Piper mikanianum (Kunth) Steudel	Stem	Fusiform^{P,B}	Cecidomyiidae	74	S/D$^{R/S}$	A/W/SP/SU
Piper mikanianum (Kunth) Steudel*	Leaf	Lenticular^{M,G}		75	S/D$^{R/S}$	W/SP/SU
Piper mikanianum (Kunth) Steudel*	Fruit	Globoid^{M,B}	Cecidomyiidae	76	S/D$^{R/S}$	SP/SU
Primulaceae						
Myrsine coriacea (Sw.) R.Br.	Stem	Fusiform^{M,LB}	Lepidoptera	77	D^{R}	A
Myrsine umbellata Mart.	Bud	Fusiform^{M,G}	Lepidoptera	78	S$^{R/S}$	A/W/SU
Rubiaceae						
Psychotria carthagenensis Jacq.*	Leaf (vein)	Fusiform^{M,G}	Cecidomyiidae	79	S/D$^{R/S}$	SU
Psychotria carthagenensis Jacq.	Leaf	Lenticular^{M,G}	Cecidomyiidae	80	S/D$^{R/S}$	A/W/SP/SU
Rudgea parquioides (Cham.) Müll.Arg.*	Stem	Fusiform^{P,B}		81	D^{R}	W
Rudgea parquioides (Cham.) Müll.Arg.	Leaf	Lenticular^{M,G}	Cecidomyiidae	82	S^{S}	SP
Salicaceae						
Xylosma pseudosalzmanii Sleumer*	Bud	Globoid^{M,B}		83	S^{R}	W
Sapindaceae						
Allophylus edulis (A.St.-Hil., Cambess. & A. Juss.) Radlk.	Stem	Fusiform^{M,B}	Lepidoptera	84	D$^{R/S}$	SP/SU
Allophylus edulis (A.St.-Hil., Cambess. & A. Juss.) Radlk.	Leaf (vein)	Lenticular$^{M,Y/LG}$	Diptera	85	D$^{R/S}$	SP/SU
Serjania sp.	Stem	Fusiform$^{M, LB/G}$		86	D^{R}	SU
Smilacaceae						
Smilax sp.	Stem	Fusiform$^{N.O.,G}$		87	S^{S}	SP
Solanaceae						
Cestrum strigillatum Ruiz & Pav.	Bud	Globoid^{M,LG}		88	D^{R}	S
Vitaceae						
Cissus striata Ruiz & Pav.*	Stem	Fusiform$^{P,RO/Y}$	Cecidomyiidae	89	S^{R}	W/SP

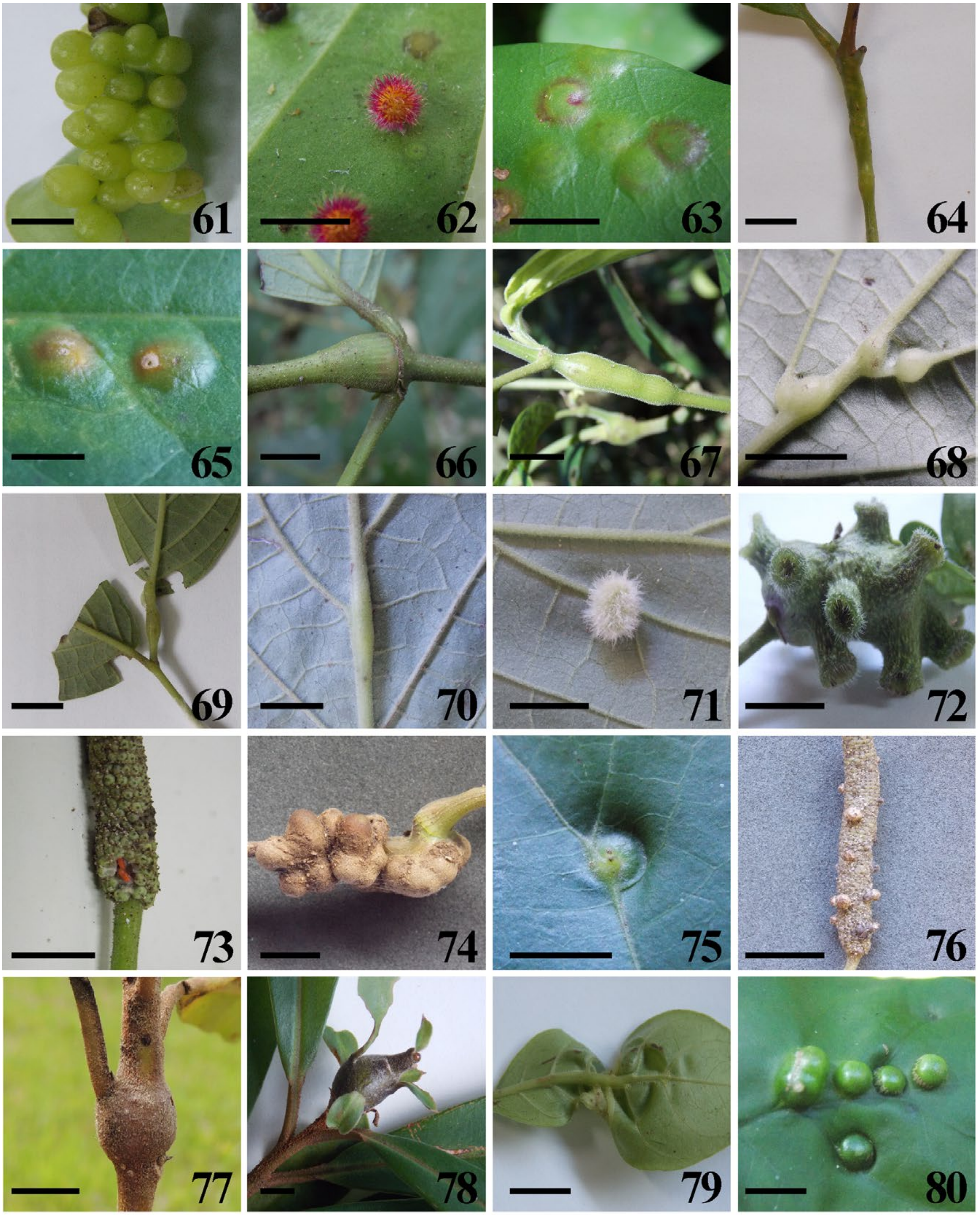


Figs 1-20. Insects galls of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil: 1, *Justicia brasiliana*; 2-6, *Calea serrata*; 7, *Dasyphyllum spinescens*; 8-13, *Mikania glomerata*; 14-17, *Mikania micrantha*; 18, *Moquiniastrum polymorphum*; 19, *Trixis praestans*; 20, *Dolichandra unguis-cati*. Scale bar: 1 cm.

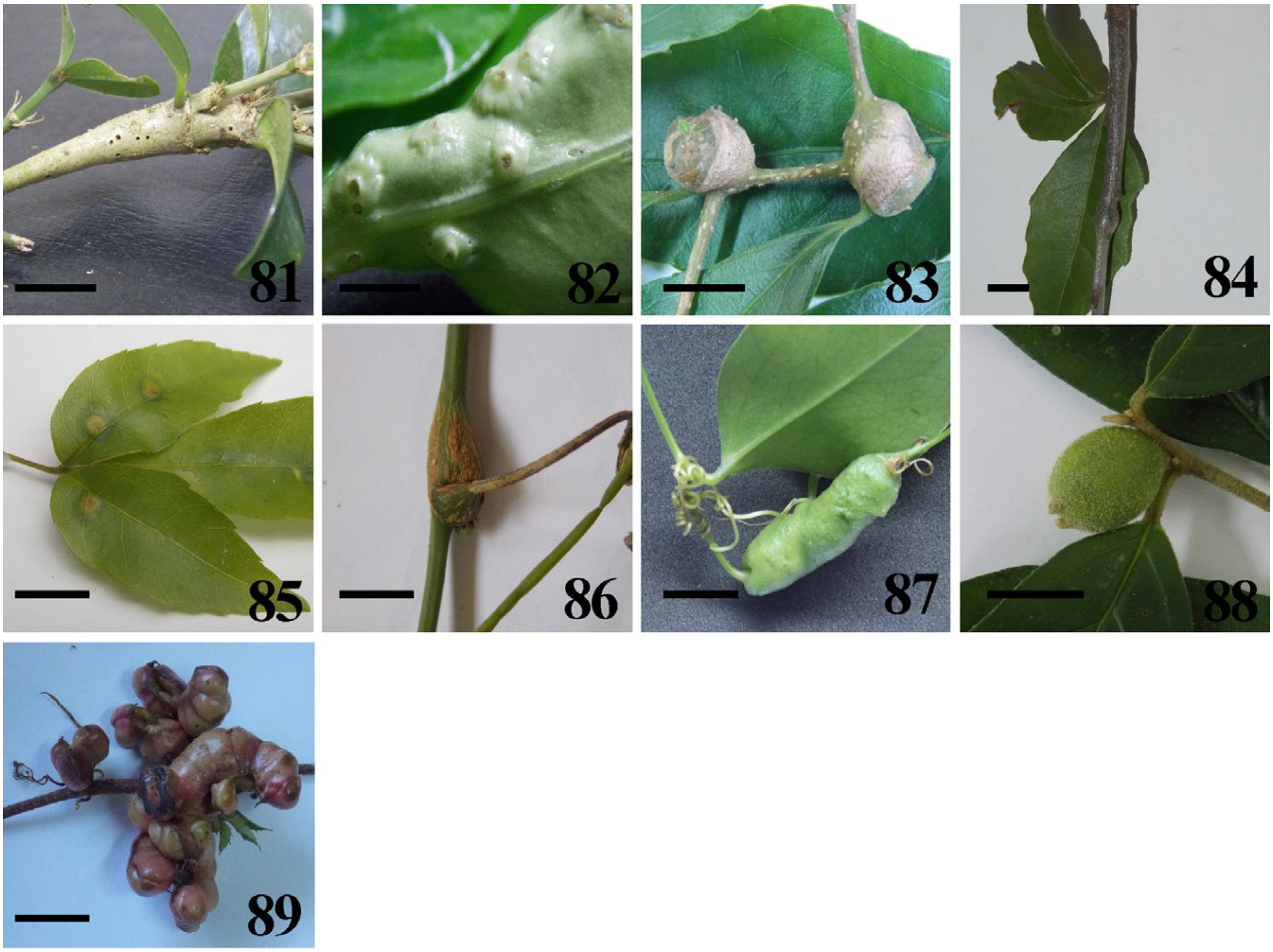


Figs 21-40. Insects galls of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil: 21, *Cordia ecalyculata*; 22, *Cordia americana*; 23-24, *Celtis iguanaea*; 25, *Trema micrantha*; 26-27, *Citronella gongonha*: 28-31, *Dioscorea scabra*; 32, *Sloanea monosperma*; 33, *Sebastiania* sp.; 34, *Bauhinia forficata*; 35-39, *Inga marginata*; 40, *Machaerium paraguariense*. Scale bar: 1 cm.

Figs 41-60. Insects galls of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil: 41, *Ocotea puberula*; 42-45, *Nectandra megapotamica*; 46-48, *Luehea divaricata*; 49-50, *Leandra regnellii*; 51, *Trichilia claussenii*; 52, *Mollinedia elegans*; 53, *Mollinedia schottiana*; 54, *Sorocea bonplandii*; 55, *Campomanesia xanthocarpa*; 56-57, *Eugenia uniflora*; 58-59, *Myrcianthes pungens*; 60, *Psidium cattleyanum*. Scale bar: 1 cm.



Figs 61-80. Insects galls of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil: 61-64, *Guapira opposita*; 65, *Seguieria aculeata*; 66-73, *Piper aduncum*; 74-76, *Piper mikanianum*; 77-78, *Myrsine coriacea*; 79-80, *Psychotria carthagenensis*. Scale bar: 1 cm.



Figs 81-89. Insects galls of deciduous and semideciduous forests in Rio Grande do Sul State, Brazil: 81-82, *Rudgea parquioides*; 83, *Xylosma pseudosalzmanii*; 84-85, *Allophylus edulis*; 86, *Serjania* sp.; 87, *Smilax* sp.; 88, *Cestrum strigillatum*; 89, *Cissus striata*. Scale bar: 1 cm.

DISCUSSION

The plant families with most galls in the Seasonal forests of Southern Brazil were Asteraceae, Fabaceae and Myrtaceae, all pointed out as the most common host taxa in Brazilian surveys from different regions (e.g. Maia *et al.*, 2014; Araújo *et al.*, 2015; Maia & Carvalho-Fernandes, 2016). Asteraceae as the family with most galled species also agrees with what was previously found for RS State, according to Mendonça (2007). These members of the daisy family were also recorded as those with the higher number of morphotypes in more recent surveys in RS (e.g. Toma & Mendonça, 2013; Mendonça *et al.*, 2014).

Records of galls on *Mikania* had the highest contribution to morphotype richness in Asteraceae (10 of the 18 morphotypes in this family), with this genus already known (Mendonça *et al.*, 2014) as a super-host (species or genera hosting many types of gall, Veldtman & McGeoch, 2003). *Piper aduncum* was the species attaining super-host status, followed by *M. glomerata*, a plant already considered as a super-host (Mendonça *et al.*, 2014). Piperaceae, having this super-host species, ended up as the second most dominant family in this study, which is uncommon for gall surveys in Brazil. Cecidomyiidae as the most common inducer group was an expected result, since they comprise the richest family among galling arthropods (Gagné & Jaschhof, 2017), being also the most common in the Neotropical region (Gagné, 1994, Espírito-Santo & Fernandes, 2007).

Although leaves were the main galled organ, as is usual in other work (e.g. Araújo *et al.*, 2015; Maia & Mascarenhas, 2017), leaves and shoots had similar proportions, as was found by Toma & Mendonça (2013) for a nearby survey in araucaria forest in RS. Mendonça *et al.* (2014), considering different localities and vegetation types, pointed out that in RS there were even more galls on shoots than on leaves. This pattern of no high prevalence of galls on leaves might be related to forest deciduousness in more temperate vegetation types in Brazil, which by losing leaves during winter could represent a less lasting resource for gallers. This hypothesis, along with the geographic question of similar results on intermediate latitudes [African savanna, Veldtman & McGeoch (2003); Neotropical rupestrian fields, Carneiro *et al.* (2009)], as suggested by Toma & Mendonça (2013), needs more specific tests and more regional comparisons, however.

Fusiform galls were more frequent, differently from other sites where the globoid form is more common (Maia *et al.*, 2014; Nogueira *et al.*, 2016), the latter being the second most common. Again, this was also found previously for the RS State by Toma & Mendonça (2013) and Mendonça *et al.* (2014). This pattern might be correlated with the above-mentioned relatively higher frequency of shoot galls in these more meridional environments – shoot galls are usually fusiform (Isaias *et al.*, 2013; synonymized with elliptical).

The 48 new gall morphotype records (compared to the available literature, e.g. Almada & Fernandes, 2011; Toma & Mendonça, 2013; Mendonça *et al.*, 2014; Maia *et al.*, 2014; Araújo *et al.*, 2015; Maia & Carvalho-Fernandes, 2016; Nogueira *et al.*, 2016,), show how important survey work still is in this region, increasing our basic knowledge on galling insects. This expressive number of potentially new species of gallers reveals that especially in little explored different forest types (as seasonal Deciduous and Semi-deciduous forests), there is still much to be gained in terms of new data and new taxa.

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