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Gall-inducing insects of an Araucaria Forest in southern Brazil

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ABSTRACT. Gall-inducing insects of an Araucaria Forest in southern Brazil. Diversity of galling insects is reported for the first time in an Araucaria Forest site. We address gall characteristics, host plant identification and the inducer identification and provide additional information about sites of gall occurrence in a mosaic of continuous forest and natural forest patches. After 40h of sampling we found 57 species of five insect orders, the majority of them Diptera (Cecidomyiidae), galling 43 host plant species, which in turn belonged to 18 host plant families. Stem and buds together, compared to leaves, harbored more galls, which were mostly glabrous, isolated, fusiform and green. Myrtaceae, Asteraceae and Melastomataceae were the most representative host families. Similarities in gall characteristics to what has been reported in the literature probably result from spatial correlation in a larger scale driven by ecological and evolutionary processes.

KEYWORDS. Diversity; forest patch; host plant; insect galls; Insecta.

Galls are the result of an abnormal growth induced on plants by different organisms, most of them insects, such as Diptera, Hymenoptera and Coleoptera (Mani 1964; Dreger-Jauffret & Shorthouse 1992; Shorthouse *et al.* 2005). The formation of a gall is essential to the inducers and is part of their life cycle, most of them being host-specific, especially those belonging to the dipteran family Cecidomyiidae (Shorthouse *et al.* 2005; Carneiro *et al.* 2009a).

Gall inventories in Brazil increased in number in the last decades, and most biomes of the country were surveyed at least once (Santos *et al.* 2011 and references therein). However, due to the concentration of taxonomists and research groups, most surveys were conducted at sites in southeastern Brazil, including areas under cerrado (*e.g.*, Fernandes *et al.* 1988; Gonçalves-Alvim & Fernandes 2001; Urso-Guimaraes & Scarelli-Santos 2006), Atlantic forest (*e.g.*, Fernandes *et al.* 2001; Moreira *et al.* 2007) and specific ecosystems within these biomes (*e.g.*, rupestrian fields, Maia & Fernandes 2004; Carneiro *et al.* 2009b, and restinga, Oliveira & Maia 2005; Maia *et al.* 2008).

In southern Brazil the first studies on gall-inducing insects were conducted by Tavares (1906, 1909) and Kieffer (1913), and since then they have been sparse. Lately, there were studies on the diversity of subtropical forests of the region (Dalbem & Mendonça 2006; Mendonça 2007; Mendonça *et al.* 2010) with a single new gall-midge genus and two species described from there (Maia *et al.* 1996; Maia *et al.* 2009). Despite the Araucaria forest being a relatively well-studied and very characteristic landscape (Ribeiro *et al.* 2009), its galling insect fauna remains unknown. Araucaria forest is a formation within the South American Atlantic forests, extending its domain several kilometers into the continent (Oliveira-Filho & Fontes 2000). As with all Atlantic forests, plant and animal richness is high, with the biogeographic value of the vegetation residing in its defining canopy species *Araucaria angustifolia*, a conifer that dominates the landscape and gives a temperate character to a mainly tropical biota (Oliveira-Filho & Fontes 2000). At higher altitudes there is a marked presence of *Campos* grasslands forming mosaics with Araucaria forests, with forests tending to expand over grasslands under conditions of fire and grazing exclusion (Oliveira & Pillar 2004). We report for the first time the diversity of galling insects in an Araucaria Forest site, addressing gall morphological characteristics, host plant and inducer identification, investigating the occurrence of galls within both continuous stands of Araucaria forest and smaller natural forest patches surrounded by grasslands.

MATERIAL AND METHODS

Study site. This research was carried out in the Pró-Mata Research and Nature Conservation Center (29°28'S, 50°13'W, henceforth PM) and two farms at the PM vicinity (Três Estrelas Farm 29°28'08"S, 50°12'38"W, TE; and Três Cachoeiras Farm, 29°26'21"S, 50°16'21"W, TC), all located at the municipality of São Francisco de Paula, Rio Grande do Sul State, southern Brazil. The study sites are located on a plateau at ca. 900 m a.s.l. with vegetation characterized by *Campos* grassland and Araucaria forest. PM has no cattle grazing or burning practices since 1994, a singular situation in the region, but still commonly practiced in the nearby farms. Hence, forests have been regenerating in the former (Oliveira & Pillar 2004) while management practices are still adopted constantly in the latter farms. The regional climate is classified according to Köppen as Cfb (Moreno 1961), which is a subtropical rainy climate, with a uniformly distributed precipitation throughout the year, and warm summers. The annual mean temperature is 15 °C, and annual mean rainfall is 2086 mm (Hijmans *et al.* 2005).

Sampling galling insects. We focused on sampling the existing forests in the landscape (forest types), distinguishing between a large forested area, here called 'continuous forest', and smaller 'natural forest patches' inserted in the grasslands. This was performed in order to account for possible differences since forest patches exhibit their own dynamics of expansion over grasslands (Oliveira & Pillar 2004). Sampling was carried out in five occasions cumulatively: December 2010, and April, May, June and September 2011; given the absence of seasonality for the gallers of this region (Dalbem & Mendonça 2006) and the sampling of both forest types in each occasion, gall seasonality is not expected to affect the results. Five sampling sites for each forest type were in a recovering area (PM) and five were in disturbed areas (three at TC and two at TE), totalizing ten sampling sites per forest type. For continuous forests, we considered portions of the forest adjacent to the grassland at least 500 m apart to guarantee independence. Forest patches were relatively small forest formations surrounded by grasslands ranging in size from 0.06 to 0.56 ha.

At each site we took one sample at the edge and one at the interior. In this study, we defined edge as the transition between the trees and grassland, following an imaginary line connecting the plant individuals over 2 m tall that touched the crown of at least another such plant. In order to standardize the samples in terms of range inspected at the interior for each forest type, these samples were restricted to a strip until 25 m away from the edge transect inspected on continuous forest portions, while at forest patches, they were situated at the center of the patch. We confirmed the difference between edge and interior in temperature and humidity during the day for some representative sites (data not shown).

Each sample was obtained in 60 min surveys actively searching for galls along the border of the entire forest patch for the edge samples or in short linear transects through the interior, following the methodology proposed by Julião *et al.* (2004). In their study, Julião *et al.* (2004) sampled structurally similar forest patches in Pantanal. Our total sampling effort was 40h. During the sampling period we collected galls and plant branches for identification of inducers and their hosts. Galls were separated in morphotypes (from now on called species; see Carneiro *et al.* 2009a) and later dissected under stereomicroscope. Galls were also placed in plastic pots to rear adult insects. Gall inducers were identified down to the lowest taxonomic level possible, including the help of specialists on each group when available.

RESULTS

We found 57 galling insect species from five insect orders, of which 14 remained undetermined. Galls occurred on 43 host plant species, belonging to 18 host families (Table I, Figs. 1–3). Most galls were induced by species of Diptera, all belonging to the family Cecidomyiidae (54.4%), followed by Lepidoptera (8.8%), Hemiptera (7.0%), Thysanoptera (3.5%) and Coleoptera (1.7%), and unidentified inducers (24.6%). The galls were induced almost equally on leaves (36.8%) and stems (33.3%), but also buds (28.1%), and on both leaves and stems (1.7%). Galls were mostly glabrous (78.9%) and occurred isolated from one another (80.7%). The most common shape was fusiform (43.9%), followed by globoid (26.3%), discoid (12.3%), conical (8.8%), cylindrical (5.3%) and amorphous (3.4%). The majority of galls were green (70.2%).

The most representative host plant families were Myrtaceae, with 20 gall morphotypes (35.0%), Asteraceae, with eight (14.0%), and Melastomataceae, with five (8.7%), totaling more than one half of all morphotypes (57.7%). The same families had the highest number of host plant species, 12 (27.9%), eight (18.6%) and four (9.3%), respectively, likewise comprising together more than one half of all host plant species (55.8%). The most representative genera in number of gall morphotypes were *Myrcia*, with seven (12.3%), *Myrceugenia*, with six (10.5%), and *Siphoneugena*, with four (7.0%), all three belonging to Myrtaceae. The host plant species that harbored more gall morphotypes were *Siphoneugena reitzii*, with four, and *Myrcia guianensis* and *Ilex microdonta*, with three morphotypes each.

Overall, 39 galling insect species occurred at the edge and 37 in the interior of forests, 19 occurring on both habitats (Table I). Recovering sites had 43 species, while disturbed ones had 31, with 17 common to both types. Portions of continuous forests had together 49 species, while forest patches totalized 33 and 25 occurred on both recovering and disturbed sites (Fig. 4A). Regarding the host plants: 30 were at the edge and 26 in the interior, with 13 species common to both habitats; 38 were in continuous forests and 23 in forest patches, with 18 in common to both forest types; 33 were in recovering sites and 24 in disturbed ones, with 14 in common to them (Fig. 4B).

DISCUSSION

The total richness of galling insects found here (57) can be classified as intermediate considering the richness found by Araújo *et al.* (2011; 62 galling species) who themselves were comparing their result to other studies in terms of crude numbers. However it is important to account for differences among the studies, at least in terms of sampling effort. For instance, in a terra firme Amazon forest 309 gall morphotypes were recorded in 216 h of sampling (Almada & Fernandes 2011), and in natural forest patches of the Pantanal biome 133 gall morphotypes were recorded in 54 h of sampling (Julião *et al.* 2004). Other issues may also interfere and direct comparisons are certainly tentative, but scale is a likely factor influencing richness in gall surveys. Our samples, alternatively, were obtained in a more restricted area with the galling fauna of forest patches representing either subsets of the continuous forest or being very similar to them (Toma & Mendonça, unpubl.).

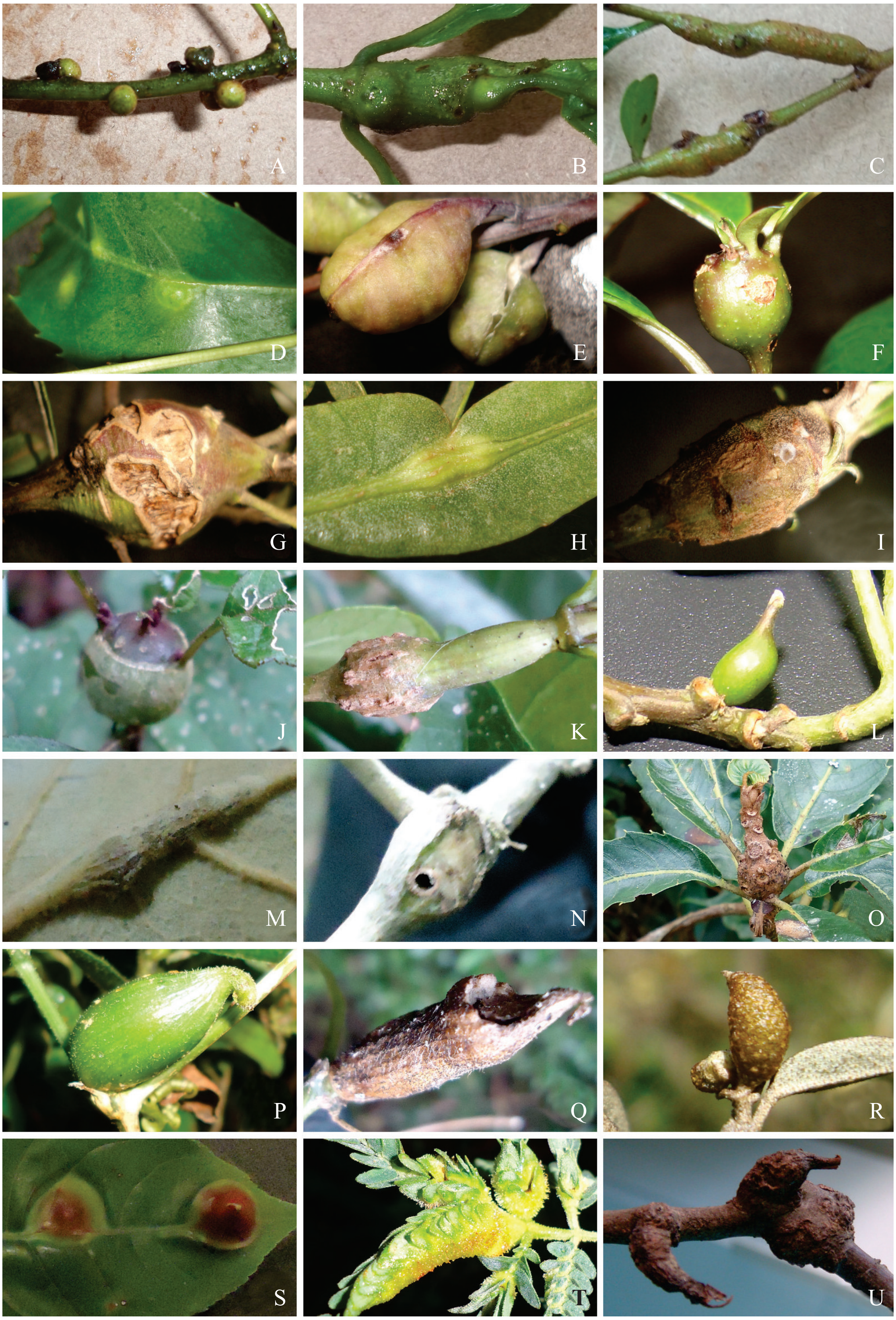

Fig. 1. Galling insect morphotypes of an Araucaria Forest site in southern Brazil. A-B) *Chamissoa altissima* (Amaranthaceae), C) *Lithraea brasiliensis* (Anacardiaceae), D-F) *Ilex microdonta* (Aquifoliaceae), G) *Baccharis semiserrata* (Asteraceae), H) *Baccharis* sp. (Asteraceae), I) *Eupatorium serratum* (Asteraceae), J) *Mikania campanulata* (Asteraceae), K) *Mikania paranensis* (Asteraceae), L) *Pentacalia desiderabilis* (Asteraceae), M) *Piptocarpha axillaris* (Asteraceae), N) *Piptocarpha notata* (Asteraceae), O) *Clethra uleana* (Clethraceae), P) *Cayaponia* sp. 1 (Curcubitaceae), Q) *Cayaponia* sp. 2 (Curcubitaceae), R) *Croton* sp. (Euphorbiaceae), S) *Sapium glandulosum* (Euphorbiaceae), T) *Mimosa scabrella* (Fabaceae), U) *Nectandra grandiflora* (Lauraceae).

Fig. 2. Galling insect morphotypes of an Araucaria Forest site in southern Brazil. A-B) *Ocotea corymbosa* (Lauraceae), C) *Leandra* sp. (Melastomataceae), D) *Miconia hyemalis* (Melastomataceae), E) *Miconia pusilliflora* (Melastomataceae), F-G) *Tibouchina sellowiana* (Melastomataceae), H-I) *Calyptranthes concinna* (Myrtaceae), J) *Eugenia pluriflora* (Myrtaceae), K) *Myrceugenia euosma* (Myrtaceae), L) *Myrceugenia mesomischa* (Myrtaceae), M) *Myrceugenia miersiana* (Myrtaceae), N-O) *Myrceugenia myrcioides* (Myrtaceae), P) *Myrceugenia oxysepala* (Myrtaceae), Q-S) *Myrcia guianensis* (Myrtaceae), T-U) *Myrcia hartwegiana* (Myrtaceae).

Fig. 3. Galling insect morphotypes of an Araucaria Forest site in southern Brazil. A) *Myrcia palustris* (Myrtaceae), B) *Myrcia retorta* (Myrtaceae), C-F) *Siphoneugena reitzii* (Myrtaceae), G) *Podocarpus lambertii* (Podocarpaceae), H) *Myrsine coriacea* (Primulaceae), I) *Myrsine lorentziana* (Primulaceae), J-K) *Roupala montana* (Proteaceae), L) *Rubus erythrocladus* (Rosaceae), M) *Rudgea parquioides* (Rubiaceae), N) *Allophylus edulis* (Sapindaceae) (photography by Cristina R. Wenzel), O) *Solanum* sp. (Solanaceae).

The most representative taxon of gall inducers was the dipteran family Cecidomyiidae, a pattern common to other ecosystems worldwide (Espírito-Santo & Fernandes 2007). This might be expected given that the family Cecidomyiidae is the most speciose group of gall-inducing insects (Gagné 2010). The other taxa observed here also appear in many studies, but with clear differences between regions (Mani 1964; Espírito-Santo & Fernandes 2007). Additionally, most likely our study is the first one in Brazil to present detailed identification of Thysanoptera gall inducers, which are probably new species. It is important to stress that unidentified gallers were mostly from rare plants with few galls, which in turn were either open or attacked by parasitoids.

A strong predominance for leaves was not observed here in regard to galled organs, with galls evenly distributed among plant organs. This trend is uncommon for insect galls, which are usually reported to occur predominantly on leaves (Dreger-Jauffret & Shorthouse 1992; Fernandes *et al.* 1988; Maia & Fernandes 2004; Moreira *et al.* 2007; Maia *et al.* 2008). Only a few studies report more galls on stems (African savanna; Veldtman & McGeoch 2003) or stems and buds (rupestrian fields; Carneiro *et al.* 2009b). Interestingly, these studies were performed on areas geographically related to the Araucaria forest, either in terms of altitude (Carneiro *et al.* 2009b) or southern location (Veldtman & McGeoch 2003). However, their explanations, despite being valuable, did not account for this

Table I. Galling insect species and host plants of an Araucaria Forest site in southern Brazil. Host plants, gall morphology, gall maker and sites of occurrence (numbers represent sum of occurrences for the combination of factors, 10 is the maximum value).

Host plant	Gall morphology			Gall inducer	Site of occurrence					Figure
	Organ	Shape	Color		Recovering		Disturbed			
					Edge	Interior	Edge	Interior	Total	
Amaranthaceae										
Chamissoa altissima (Jacq.) Kunth	stem	globoid	green	Cecidomyiidae		1^{P}	1^{F}	6	8	1A
	leaf/stem	amorphous[1,2]	green	*Clinodiplosis* sp. (Cecidomyiidae)	1^{P}	2	6	10	19	1B
Anacardiaceae										
Lithraea brasiliensis Marchand	stem	fusiform[2]	brown	Unidentified				1^{P}	1	1C
Aquifoliaceae										
Ilex microdonta Reissek	leaf	discoid	green	Cecidomyiidae	6	4^{P}			10	1D
	leaf	globoid	green	Hemiptera	3		1^{F}		4	1E
	bud	globoid	green	Cecidomyiidae	5	8	1^{F}	2^{P}	16	1F
Asteraceae										
Baccharis semiserrata DC.	stem	globoid	green/brown	Unidentified	1^{P}				1	1G
Baccharis sp.	stem	fusiform[2]	green	Alycaulini (Cecidomyiidae)	3		8		11	1H
Eupatorium serratum Spreng.	stem	fusiform	green/brown	Unidentified	1^{F}				1	1I
Mikania campanulata Gardner	bud	globoid[2]	green/purple	*Contarinia* sp. (Cecidomyiidae)	1^{F}				1	1J
Mikania paranensis Dusén	stem	fusiform	green	Cecidomyiidae	1^{F}				1	1K
Pentacalia desiderabilis (Vell.) Cuatrec.	bud	conical	green	*Asphondylia* sp. (Cecidomyiidae)			1^{F}		1	1L
Piptocarpha axillaris (Less.) Baker	leaf (rib)	fusiform[1]	brown	Unidentified	2^{F}				2	1M
Piptocarpha notata (Less.) Baker	stem	globoid	green	*Resseliella* sp. (Cecidomyiidae)	1^{F}	3^{F}			4	1N
Clethraceae										
Clethra uleana Sleumer	bud	globoid	brown	Cecidomyiidae	2				2	1O
Curcubitaceae										
Cayaponia sp. 1	bud	fusiform[1]	green	Coleoptera	1^{F}				1	1P
Cayaponia sp. 2	bud	fusiform[1]	brown	Lepidoptera	1^{F}				1	1Q
Euphorbiaceae										
Croton sp.	bud	globoid	brown	Cecidomyiidae	2^{F}				2	1R
Sapium glandulosum (L.) Morong	leaf	conical	red	Psyllidae (Hemiptera)	3	1^{P}			4	1S
Fabaceae										
Mimosa scabrella Benth.	leaf	amorphous[1,2]	orange	Cecidomyiidae	1^{F}				1	1T
Lauraceae										
Nectandra grandiflora Nees	stem	fusiform[2]	brown	Unidentified		1^{F}			1	1U
Ocotea corymbosa (Meisn.) Mez	leaf	conical	brown	Unidentified		1^{F}			1	2A
	stem	fusiform	brown	Unidentified		1^{F}			1	2B
Melastomataceae										
Leandra sp.	leaf	globoid[1]	green	Cecidomyiidae		2^{F}		1^{F}	3	2C
Miconia hyemalis A.St.-Hil. & Naudin	stem	fusiform	brown	Unidentified			1^{F}		1	2D
Miconia pusilliflora (DC.) Naudin	leaf (rib)	fusiform	green	Cecidomyiidae		1^{P}			1	2E
Tibouchina sellowiana Cogn.	stem	globoid	green/red	Gelechioidea (Lepidoptera)	5		1^{P}	1^{F}	7	2F
	leaf/petiole	globoid[1]	green/red	*Lopesia* sp. (Cecidomyiidae)	5	1^{F}	1^{P}	3	10	2G
Myrtaceae										
Calyptranthes concinna DC.	bud	globoid[2]	green	Lasiopteridi (Cecidomyiidae)			4	6	10	2H
	leaf	discoid	green/brown	Cecidomyiidae			1^{P}	1^{F}	2	2I
Eugenia pluriflora DC.	leaf	cylindrical	green/red	*Stephomyia* sp. (Cecidomyiidae)				2^{F}	2	2J
Myrceugenia euosma (O.Berg) D.Legrand	stem	fusiform[2]	brown	Cecidomyiidae	8		10	5	23	2K
Myrceugenia mesomischa (Burret) D.Legrand & Kausel	bud	conical	green	Unidentified			1^{F}		1	2L
Myrceugenia miersiana (Gardner) D.Legrand & Kausel	bud	fusiform[1]	green/purple	Cecidomyiidae				2	2	2M
Myrceugenia myrcioides (Cambess.) O.Berg	leaf	fusiform	green	Unidentified		1^{P}			1	2N
	bud	fusiform	green	Cecidomyiidae				1^{F}	1	2O
Myrceugenia oxysepala (Burret) D.Legrand & Kausel	bud	fusiform	brown	*Clinodiplosis* sp. (Cecidomyiidae)		1^{F}			1	2P
Myrcia guianensis (Aubl.) DC.	leaf	fusiform	green/red	*Holopothrips* sp. (Thysanoptera)	2^{P}		1^{P}	1^{F}	4	2Q
	leaf (petiole)	fusiform	green	Cecidomyiidae		2			2	2R
	bud	globoid	green/red	Cecidomyiidae	2	1^{F}	3	3	9	2S

Continues

Table I. Continued.

Host plant	Gall morphology			Gall inducer	Site of occurrence					Figure
	Organ	Shape	Color		Recovering		Disturbed			
					Edge	Interior	Edge	Interior	Total	
Myrcia hartwegiana (O.Berg) Kiaersk.	leaf	discoid	green	Coccoidea (Hemiptera)				1[F]	1	2T
	bud	globoid[1]	brown	Cecidomyiidae				1[F]	1	2U
Myrcia palustris DC.	leaf	discoid	green/yellow	Coccoidea (Hemiptera)				1[F]	1	3A
Myrcia retorta Cambess.	bud	fusiform[1,2]	green	Lasiopteridi (Cecidomyiidae)	1[F]	10	8	10	29	3B
Siphoneugena reitzii D.Legrand	stem	globoid	brown	Cecidomyiidae	1[P]	9	4	7	10	3C
	leaf	cylindrical	green/red	*Holopothrips* sp. 2 (Thysanoptera)	1[P]				1	3D
	leaf	cylindrical	green/yellow	Cecidomyiidae		1[F]			1	3E
	bud	conical	green	Cecidomyiidae			8	8	16	3F
Podocarpaceae										
Podocarpus lambertii Klotzsch ex Endl.	stem	fusiform	brown	Cecidomyiidae	3		3		6	3G
Primulaceae										
Myrsine coriacea (Sw.) R.Br. ex Roem. & Schult.	stem	fusiform	green	Lepidoptera	3	1[P]	2[F]		6	3H
Myrsine lorentziana (Mez) Arechav.	stem	fusiform	green/red	Lepidoptera	9	10	3	2	24	3I
Proteaceae										
Roupala montana Aubl.	leaf	discoid	green/brown	Unidentified	1[P]				1	3J
	stem	fusiform[2]	brown	Unidentified	1[P]				1	3K
Rosaceae										
Rubus erythrocladus Mart.	stem	fusiform[1,2]	green/brown	Unidentified			2		2	3L
Rubiaceae										
Rudgea parquioides (Cham.) Müll.Arg.	leaf	discoid	green	Cecidomyiidae		6	2[F]	9	17	3M
Sapindaceae										
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	stem	fusiform	green	Lepidoptera		1[F]			1	3N
Solanaceae										
Solanum sp. L.	leaf	discoid[1]	green	Unidentified		1[P]			1	3O

[1] pubescent gall, [2] gall with grouped chambers, [P] gall occurring only on forest patches, [F] gall occurring only on continuous forest.

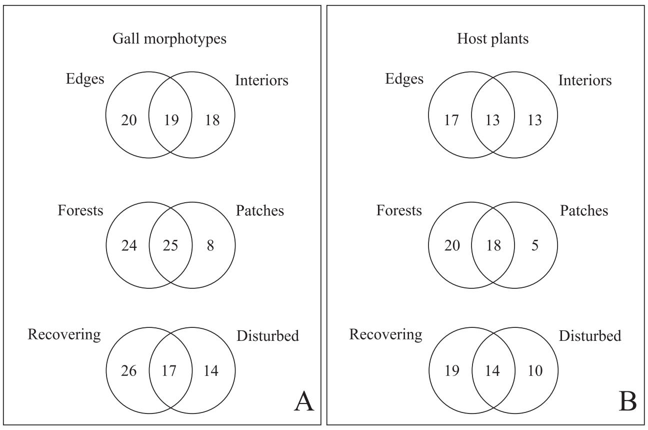

Fig. 4. Total numbers of gall morphotypes and host plants occurrence by habitat (edge and interior), forest type (continuous forests and patches) and type of disturbance (recovering and disturbed). A) Venn diagrams of the gall morphotypes, B) Venn diagrams of the host plants.

geographic trend and its ecological and evolutionary implications, which we consider worthy of further studies.

The predominance of glabrous galls has been widely reported. For instance, glabrous plants of the species *Arbutus xalapensis* (Ericaceae) had higher density of gallers compared to the hairy conspecifics (Ezcurra *et al.* 1987). Considering gall occurrence, isolated galls were more frequent, as reported by other studies. Fernandes *et al.* (1988) hypothesized that galls which occur isolated would be favored because parasitoid pressure would be diminished due to the greater searching time implied by isolation.

The two host plant families with more gall morphotypes, Myrtaceae and Asteraceae, figure as important taxa in other vegetation types in southern Brazil (Mendonça 2007; Mendonça *et al.* 2010), and even in other ecosystems throughout Brazil, as the cerrado (Gonçalves-Alvim & Fernandes 2001), rupestrian fields (Maia & Fernandes 2004) and restinga coastal forests (Maia *et al.* 2008). These two families are reported as very representative in the Araucaria forest, Myrtaceae among trees (Rambo 1956) and Asteraceae among non-arboreal species (Behling & Pillar 2007). The importance of Melastomataceae, ranked as the third most representative host family, and also an important plant family in Araucaria forests (Machado 2004), is not widespread, being more rarely found in Atlantic forest remnants (Fernandes *et al.* 2001) and in the Amazon forest (Almada & Fernandes 2011), despite being for a long time ranked as one of the richest in zoocecidea, along with the other two families (Houard 1933). Fabaceae hosted only one gall species in our study; it usually ranks high in most of the above cited gall inventories. This has been already pointed out by Mendonça (2007) based on another study conducted in southern Brazil, a pattern derived perhaps from a lack of legume plants in Araucaria forest relative to other Atlantic forest formations (Jarenkow & Waechter 2001).

At the genus level, *Myrcia* also appeared in another study as the most representative genus (Maia *et al.* 2008), but not *Myrceugenia* or *Siphoneugena*. The genera *Mikania* and *Eugenia*, accounting respectively for only two and a single gall species, were the genera with highest number of galls in another study in an area of Atlantic forest relatively close to our study sites, while *Myrcia* had only three galls and *Myrceugenia* and *Siphoneugena* did not have any (Mendonça 2007). This difference might reflect the absence of host species but also differences in these genera contribution to the flora of the region. For example, the genera *Myrcia* and *Myrceugenia* are very representative to the Araucaria forest (Behling & Pillar 2007). The presence of "super-hosts" belonging to the most representative family and genera was expected (Mendonça 2007) but even Myrtaceae with *Siphoneugena reitzii* and *Myrcia guianensis* had relatively low numbers of gall species.

This first report on the diversity of gall inducing insects from Araucaria forests constitutes an important contribution to the taxonomic knowledge of this group in the Neotropics. In general, gall characteristics follow trends already reported for the Neotropics and worldwide, sometimes more similar to studies performed in nearby ecosystems, probably reflecting a spatial correlation in a larger, biogeographical scale. We encourage more studies of gall-inducing insects in Araucaria forests in order to provide us with a clearer view of its biodiversity.

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