

Richness of insect galls on shrub-tree restinga of a coastal plain of southern Brazil

Riqueza de galhas de insetos em restinga arbustivo-arbórea de uma planície costeira do sul do Brasil

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ABSTRACT

The *restingas* are coastal ecosystems over the sandy Quaternary plains. Their vegetation present flora and structure conditioned mainly by edaphic factors. They vary from grasslands, shrub lands up to woody forests. Their environmental conditions, such as water stress and high solar irradiance, may be associated to a high richness of galling. This study aims to identify the insect-plant interactions of the gall type, in a shrub-tree *restinga* formation at the Acaraí State Park, situated in São Francisco do Sul, Santa Catarina State. The survey was conducted in four plots of 250 x 5 m (5,000 m²) of the PELD/PPBio module, with a sample effort of 32 hours. There were found 56 morphospecies of galls in 31 species of host plants. Lauraceae, Myrtaceae, Melastomataceae, Nyctaginaceae and Calophyllaceae showed the highest number of interactions. *Guapira opposita* (Nyctaginaceae) and *Calophyllum brasiliense* (Calophyllaceae) were the major super-hosts. There was a predominance of isolated globose galls on leaves, induced by Diptera – Cecidomyiidae. Galls on stems were less abundant. The focus of this inventory was restricted to the aerial parts of the plants, which limited the galls records on roots, for which there were records only in adventitious roots of the epiphyte *Philodendron surinamense*. The richness of galls seems to be proportional to the richness of plant species in this *restinga* formation.

Keywords: Cecidomyiidae; coastal vegetation; plant-insect interaction; super-hosts.

RESUMO

As restingas são ecossistemas costeiros que ocupam as planícies quaternárias arenosas. Sua vegetação apresenta flora e estrutura condicionada por fatores edáficos em maior grau. Variam de formações herbáceas, arbustivas, arbustivo-arbóreas a florestas. Suas características ambientais estressantes, como a baixa disponibilidade hídrica e a alta radiação solar, propiciam uma elevada riqueza de insetos galhadores. O objetivo deste estudo foi reconhecer as interações inseto-planta, do tipo galha, na formação arbustivo-arbórea da restinga do Parque Estadual Acaraí, situado em São Francisco do Sul, Santa Catarina. O levantamento foi realizado em quatro parcelas de 250 x 5 m (5.000 m²) do módulo PELD/PPBio, com esforço amostral de 32 horas. Encontraram-se 56 morfoespécies de galhas em 31 espécies de plantas hospedeiras. As famílias com maior número de interações foram Lauraceae, Myrtaceae, Melastomataceae, Nyctaginaceae e Calophyllaceae. As espécies *Guapira opposita* (Nyctaginaceae) e *Calophyllum brasiliense* (Calophyllaceae) foram as principais super-hospedeiras. Houve predominância de galhas globoides isoladas em folhas, induzidas por Diptera – Cecidomyiidae. Galhas em caules foram menos abundantes. O foco do inventário restringiu-se às partes aéreas das plantas, o que limitou o registro de galhas em raízes, sendo registradas apenas em raízes adventícias da epífita *Philodendron surinamense*. A riqueza de galhas parece ser proporcional à riqueza de espécies vegetais nessa formação de restinga.

Palavras-chave: Cecidomyiidae; interação inseto-planta; super-hospedeiras; vegetação costeira.

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INTRODUCTION

The *restingas*, ecosystems in the domain of the Atlantic Forest, show in their composition mosaics of distinct plant communities that vary according to the edaphic gradient. They range from herbaceous and shrubby formations on sandy soils to forests associated with hydromorphic and/or organic soils, whose canopy can reach 15-20 m in height (SCARANO, 2002; MELO JÚNIOR & BOEGER, 2015). The shrub-tree formations fit in the *restingas* as vegetation installed on sandy soils of low fertility and more distant from the sea, being composed of plants with habits mainly shrubby and arboreal and 2-5 m height (MELO JÚNIOR & BOEGER, 2016). In addition to these characteristics, other environmental factors considered to be adverse, such as high salinity, soil acidity, water scarcity, high incidence of winds and solar irradiation, render *restingas* extremely fragile environments as regards their conservation (ROCHA, 2003).

The characteristics of the *restinga* environments make these local ecosystems propitious to the concentration of a great richness of galling insects, which are endophytic herbivores inducing neoplasias in vegetal tissues, characterized by hypertrophy and/ or cell hyperplasia (MANI, 1964; SHORTHOUSE *et al.*, 2005). Through this interaction, these insects obtain shelter, food and protection against adverse environmental conditions and natural enemies (FERNANDES & PRICE, 1988; PRICE *et al.*, 1987; PRICE, 2005). In these relationships, the specificity of insect-plant systems generates phenotypes capable of indicating taxonomically the organisms involved (ISAIAS *et al.*, 2013; 2014), even when there are different interactions induced on the same host species, the so-called "super host plants" (ARAÚJO *et al.*, 2013). This diversity of gall phenotypes may be used as an indicator of the local richness of galling insects (FLOATE *et al.*, 1996; CARNEIRO *et al.*, 2009), as well as of the diversity of organisms of other associated trophic levels (MAIA, 2001; STONE & SCHONROGGE, 2003).

Studies done in the southeastern region of Brazil have shown the richness of entomogenic galls in *restingas* (Bregonci *et al.*, 2010; MAIA *et al.*, 2008; MAIA *et al.*, 2014; RODRIGUES *et al.*, 2014) and have described a large diversity of galling insects (MAIA, 1995, 2001, 2007). In general, there are few studies with a focus on richness of gall-inducing insect in the coastal region of southern Brazil, except the articles of Mendonça Jr. *et al.* (2010), performed in *restingas* of Rio Grande do Sul, and Arriola *et al.* (2016), in *restinga* formations occurring on dunes in the northeastern portion of the state of Santa Catarina.

In addition, anthropogenic pressures such as urbanization of coastal lines, construction of roads, trampling and car traffic over the vegetation of *restinga*, garbage disposal and other actions, make these environments a significantly threatened portion of the rain forest (ROCHA, 2003; THOMAZI *et al.*, 2013), opposing to their importance as a kind of vegetation that controls the effects of erosive processes of coastal regions and as an ecosystem that maintains the local biodiversity (KUKI *et al.*, 2008).

Thus, the present study aims to contribute to the knowledge about the richness of insect galls of southern Brazil *restingas*, employing the concept of "morphospecies" used by Portugal-Santana and Isaias (2014), as a tool for the record of these interactions in the shrub-tree restinga physiognomy of the Acaraí State Park (PEA), in São Francisco do Sul, Santa Catarina State, Brazil.

MATERIAL AND METHODS

The study area comprises a *restinga* remnant located in the municipality of São Francisco do Sul, in the coastal plain of Santa Catarina State, Brazil (48°33 'W – 26°17' S). Considered as a priority area for biodiversity conservation (PROBIO, 2003), the PEA region was transformed into a conservation unit in 2005 and covers a total area of 6,667 ha (FATMA, 2008; figure 1).

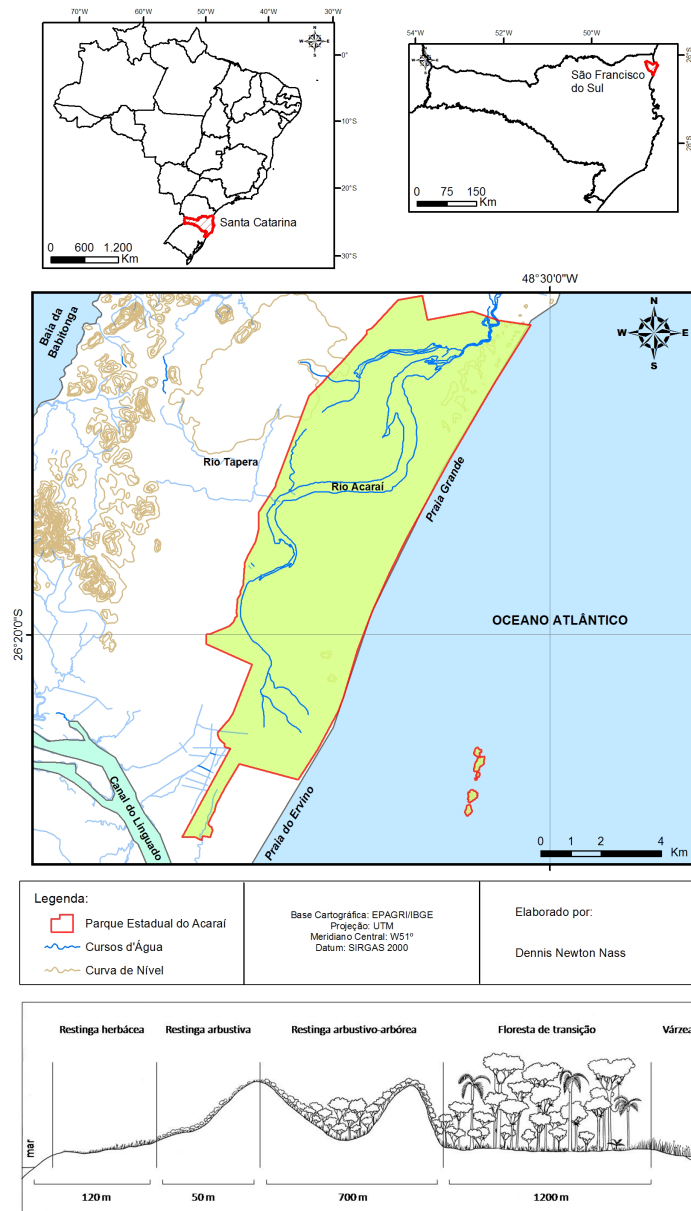


Figure 1 – Restinga of Parque Estadual Acaraí and yours formations, São Francisco do Sul municipality, Santa Catarina, Brazil.

The PEA is characterized by the presence of *restingas*, which vary as herbaceous formations (figure 1B) in the post-beach region and dunes, shrubs, shrubs-trees (figure 2) and transitional forests, as well as other less expressive formations such as floodplains, mangroves and submontane forest (FATMA, 2008).

The local flora covers 319 species, distributed in 215 genera and 82 families.

Among these, the most representative families in number of species are: Asteraceae (35), Fabaceae (30), Myrtaceae (20), Rubiaceae (18) and Poaceae (13) (MELO JÚNIOR & BOEGER, 2015). The climate of the region is classified as Cfa de Köppen (subtropical climate, with hot summer), influenced by the maritime humidity, with annual average temperature of 20.3°C and relative humidity of 1.874 mm/ year (KNIE, 2002). Soil is classified as a ferrihumiluvic spodosol in the shrub-arboreal formation of *restinga* (OLIVEIRA & VIEIRA, 2008).



Figure 2 – Vegetation of shrub-tree *restinga* of Parque Estadual Acaraí (São Francisco do Sul municipality, Santa Catarina, Brazil). Credits: João Carlos F. de Melo Júnior.

Samplings were carried out in four plots of 1,250 m² each (250 x 5 m), inserted in the Long-Term Ecological Research Module (PELD, PPBio-MA) installed in the PEA, totaling a sample area of 5,000 m². The plants of each plot were inspected during 8 hours in search of galls, totaling 32 sample hours, a pattern similar to the standardization of sample hours used by Maia *et al.* (2008) in *restingas* of the southeastern region. Branches of the plants ($n \geq 5$) with galls were collected and stored in plastic bags. Host plants were identified through the list of PEA flora species (MELO JÚNIOR & BOEGER, 2015) and classified by the APG IV system (2016). The vouchers were registered in the Herbarium of the University of the Region of Joinville (JOI). Galls were described according to the standardization of nomenclature for neotropical galls proposed by Isaias *et al.* (2013), and photographed with a Samsung ES68 digital camera. The identification of the gallers was based on the *restinga* galls review of the southeastern region of Brazil (MAIA, 2013) and on the world catalog of Diptera: Cecidomyiidae (GAGNÉ & JASCHHOFF, 2014).

RESULTS

The present work registered a total of 56 gall morphospecies in 31 plant species from 21 botanical families (table 1, figures 3 to 58).

These morphospecies were classified into seven gall morphotypes, of which the most abundant was the globule with 37.5% of occurrences, followed by lenticular (26.79%) and fusiform (23.21%). The least frequent morphotypes were conical (5.36%), rosette (3.57%), foliar winding and nailing (1.79% each). Galls occurring in isolation were more frequent (87.5% of cases) than the coalescing morphotypes (12.5%). Galls morphotypes occurred predominantly in leaves (71.43%), occurring with a lower incidence in stems (25%). Galls in roots were also observed (3.57%) but, due to the focus of work in the aerial parts of the plants, they show a low proportion of records. The galls varied in color, with predominantly green morphotypes (67.86%), followed by brown (23.21%), yellow (5.36%), white and red (1.79% each). Galls exhibiting ornamentation/ pubescence occurred in about 22% of the morphotypes found. The most representative botanical families in gall morphotypes were: Lauraceae (10), Myrtaceae

(7), Melastomataceae (4), Nyctaginaceae (4) and Calophyllaceae (4). The species diagnosed as the main local super host were *Calophyllum brasiliense* Cambess. (Calophyllaceae) and *Guapira opposita* (Vell.) Reitz (Nyctaginaceae), each hosting four distinct morphotypes of galls. The galling insects were identified at least at the order level in about 60% of the cases. The Diptera: Cecidomyiidae taxon was the most representative, with 48.21% of occurrences. Other less representative groups were Hemiptera (7.14%), Lepidoptera (3.57%) and Coleoptera (1.79%). The remaining 40% remained undetermined.

Table 1 – Characterization of gall morphotypes and their respective host-plants occurring in the shrub-tree restinga of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil.

Family	Plant species	Morphotype	Host organ / Oviposition site	Color	Pubescence	Gall-inducer*
Anacardiaceae	<i>Schinus terebinthifolius</i> Raddi	extralaminar lenticular	leaf / median vein	green	no	<i>Calophya terebinthifolii</i> Burckhardt & Basset, 2000 (Psylloidea, Hemiptera)
		fusiform	stem	brown	yes	Unknown
Annonaceae	<i>Guatteria australis</i> A.St.-Hil.	globoid	leaf / secondary vein	green	no	Unknown
		lenticular	leaf / secondary vein	green	no	Unknown
		fusiform	root / adventitious root grampiform	green	no	Unknown
Araceae	<i>Philodendron surinamense</i> (Miq.) Schott.	fusiform to coalescent	root / adventitious root	green	no	Cecidomyiidae (Diptera)
		lenticular extralaminar	leaf / secondary vein	green	no	Unknown
Asteraceae	<i>Mikania trinervis</i> Hook. & Arn.	conical	leaf / median vein	green	no	<i>Liodiplosis cylindrica</i> Gagné, 2001 (Cecidomyiidae, Diptera)
		globoid to coalescent	leaf / median vein-petiole	green	no	<i>Liodiplosis</i> sp. (Cecidomyiidae, Diptera)
			stem	green / red	no	<i>Mikaniadiplosis</i> sp. (Cecidomyiidae, Diptera)

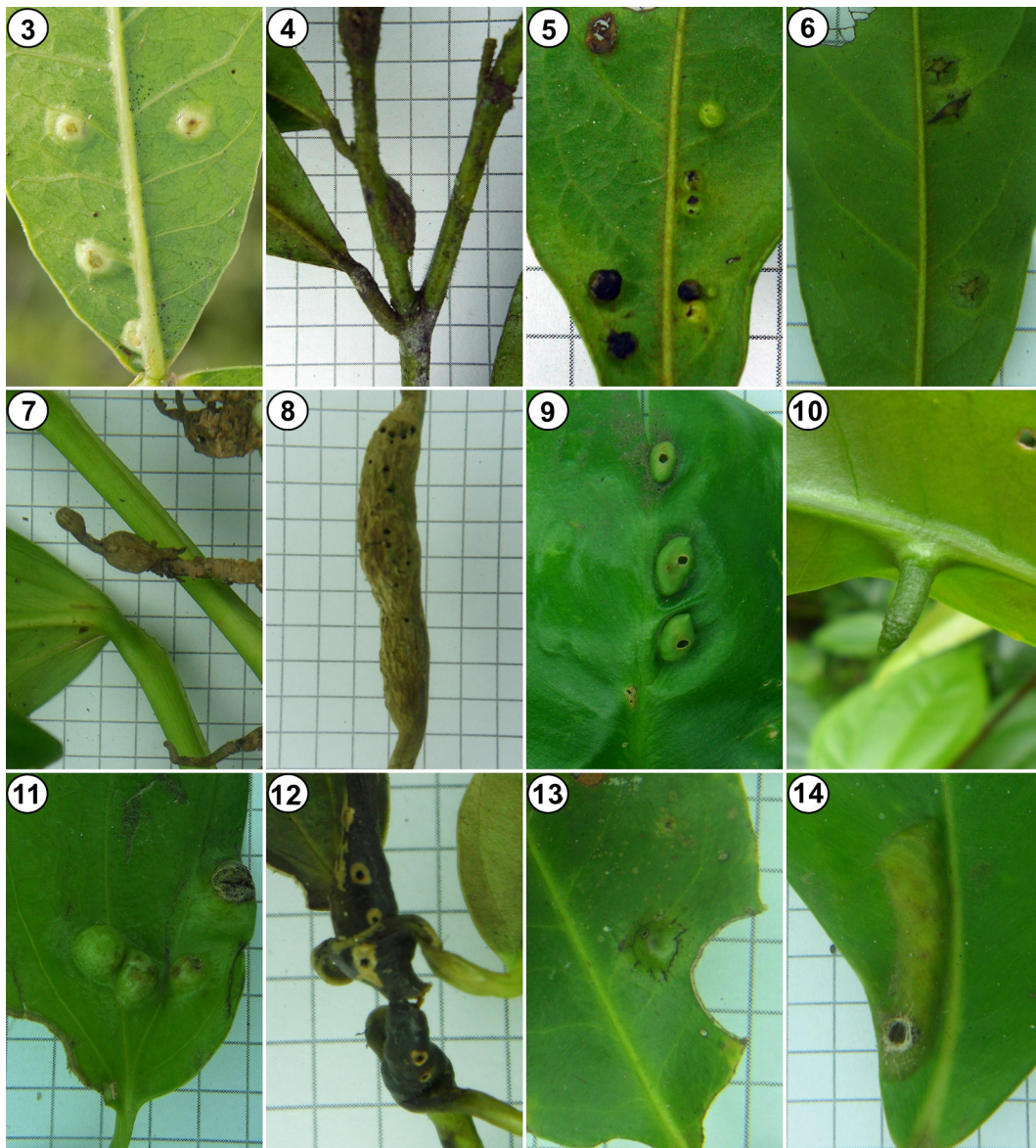
Family	Plant species	Morphotype	Host organ / Oviposition site	Color	Pubescence	Gall-inducer*
Calophyllaceae	<i>Calophyllum brasiliense</i> Cambess.	leaf rolling	leaf / leaf lamina	green	no	Cecidomyiidae (Diptera)
		fusiform	leaf / leaf lamina	green	no	<i>Lopesia linearis</i> Maia, 2003 (Cecidomyiidae, Diptera)
		globoid to coalescent	stem	brown	no	<i>Lopesia caulinaris</i> Maia, 2003 (Cecidomyiidae, Diptera)
		intralaminar lenticular	leaf / leaf lamina	green	no	<i>Lopesia elliptica</i> Maia, 2003 (Cecidomyiidae, Diptera)
Celastraceae	<i>Maytenus glazioviana</i> Loes.	lenticular	leaf / secondary vein	green	no	<i>Mayteniella robusta</i> Maia, 2001 (Cecidomyiidae, Diptera)
Clusiaceae	<i>Clusia criuva</i> Cambess.	fusiform intralaminar	leaf / leaf lamina	green	no	Lepidoptera
		fusiform	leaf / leaf lamina	green	yes	<i>Lopesia</i> sp. (Cecidomyiidae, Diptera)
Fabaceae	<i>Andira fraxinifolia</i> Benth.	globoid	leaf / secondary vein	yellow	no	<i>Asphondyliina</i> sp. (Cecidomyiidae, Diptera)
		clavate	leaf / secondary vein	green	yes	<i>Lopesia grandis</i> Maia, 2001 (Cecidomyiidae, Diptera)
Lauraceae	<i>Aiouea saligna</i> Meisn.	lenticular	leaf / leaf lamina	green	no	Unknown
		fusiform, isolated or coalescent	stem	brown	no	Unknown
		globoid	leaf / leaf lamina	brown	yes	Unknown
		lenticular	leaf / leaf lamina	green	no	Unknown

Family	Plant species	Morphotype	Host organ / Oviposition site	Color	Pubescence	Gall-inducer*
		conical	leaf / median vein	green	yes	Unknown
	<i>Nectandra membanacea</i> (Sw.) Griseb.	globoid	leaf / secondary vein	green	no	Unknown
		globoid	leaf / secondary vein	brown	yes	Unknown
Lauraceae	<i>Ocotea catharinensis</i> Mez	globoid	leaf / median vein-secundária	red	no	<i>Neolasioptera</i> sp. (Cecidomyiidae, Diptera)
	<i>Ocotea pulchella</i> (Nees & Mart.) Mez	intralaminar lenticular	leaf / secondary vein	green	no	Coccidae (Hemiptera)
		rosette	stem / meristem	green	no	<i>Clinodiplosis</i> sp. (Cecidomyiidae, Diptera)
Malvaceae	<i>Pavonia</i> sp.	globoid	leaf / median and secondary vein	green	yes	Cecidomyiidae (Diptera)
	<i>Miconia pussilliflora</i> (DC.) Naudin.	fusiform	stem	brown	no	Unknown
		fusiform	leaf / median vein	green	no	Unknown
Melastomataceae	<i>Tibouchina pulchra</i> Cogn.	globoid to coalescent	stem	brown	no	Lepidoptera
		fusiform	leaf / median vein	green	yes	Curculionidae (Coleoptera)
		fusiform	stem	brown	no	Cecidomyiidae (Diptera)
Meliaceae	<i>Guarea macrophylla</i> Vahl	fusiform	leaf / median vein	green	yes	<i>Neolasioptera</i> sp. (Cecidomyiidae, Diptera)
		globoid	leaf / leaf lamina	green / yellow	yes	<i>Sphaeromyia flava</i> Maia, 2007 (Cecidomyiidae, Diptera)
	Myrtaceae sp. 01	lenticular	leaf / secondary vein	green	no	Unknown
		globoid	stem	brown	no	Unknown
Myrtaceae	<i>Myrcia pulchra</i> (O.Berg) Kiaersk.	lenticular	leaf / leaf lamina	yellow	yes	Unknown
		lenticular	leaf / secondary vein	branca	no	Unknown

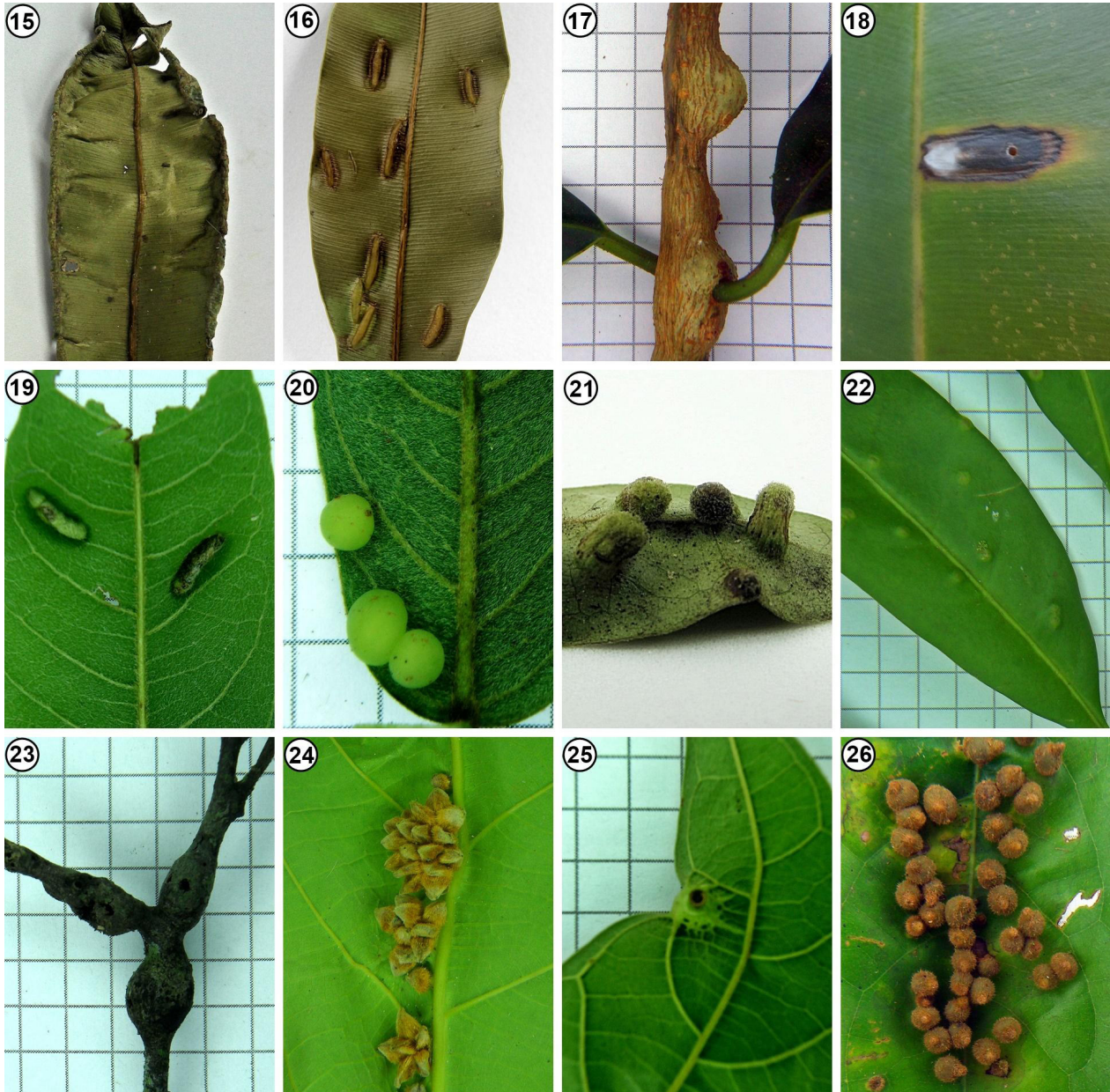
Family	Plant species	Morphotype	Host organ / Oviposition site	Color	Pubescence	Gall-inducer*
Myrtaceae	<i>Psidium cattleianum</i> Sabine	globoid extralaminar	leaf / secondary vein	yellow	no	<i>Nothotrioza cattleiani</i> Burckhardt, 2013 (Psylloidae, Hemiptera)
		intralaminar globoid with apical projection	leaf / median and secondary vein	green	no	<i>Tectococcus ovatus</i> Hempel., 1900 (Eriococcidae, Hemiptera)
		lenticular	leaf / leaf lamina	green	no	Cecidomyiidae (Diptera)
		fusiform	stem	brown	no	<i>Proasphondylia formosa</i> Maia, 1993 (Cecidomyiidae, Diptera)
Nyctaginaceae	<i>Guapira opposita</i> (Vell.) Reitz	globoid, predom. coalescent	stem	brown	no	<i>Proasphondylia guapirae</i> Maia & Couri, 1993 (Cecidomyiidae, Diptera)
		lenticular	leaf / leaf lamina	green	no	<i>Bruggmannia elongata</i> Maia & Couri, 1993 (Cecidomyiidae, Diptera)
		rosette	stem / meristem	green	no	<i>Pisphondylia braziliensis</i> Couri & Maia, 1992 (Cecidomyiidae, Diptera)
Orchidaceae	<i>Vanilla chamissonis</i> Klotzsch	globoid	leaf / leaf lamina	green	no	Unknown
Piperaceae	<i>Piper solmsianum</i> C.DC.	globoid	leaf / secondary vein	green	yes	Cecidomyiidae (Diptera)
Rubiaceae	<i>Psychotria carthagenensis</i> Jacq.	conical	leaf / median and secondary vein	green	no	Cecidomyiidae (Diptera)
Sapindaceae	<i>Paullinia trigonia</i> Vell.	globoid	leaf / leaf lamina	green	no	Cecidomyiidae (Diptera)
Sapotaceae	<i>Pouteria beaurepairei</i> (Glaz. & Raunk.) Baehni	globoid	stem	brown	no	Unknown
Smilacaceae	<i>Smilax campestris</i> Griseb.	lenticular	leaf / leaf lamina	green / black	no	<i>Smilasioptera</i> sp. (Cecidomyiidae, Diptera)

Family	Plant species	Morphotype	Host organ / Oviposition site	Color	Pubescence	Gall-inducer*
Solanaceae	<i>Solanum pseudoquina</i> A.St.-Hil.	globoid, coalescent	stem / meristem	brown	no	Unknown
		lenticular	leaf / leaf lamina	green	no	Unknown

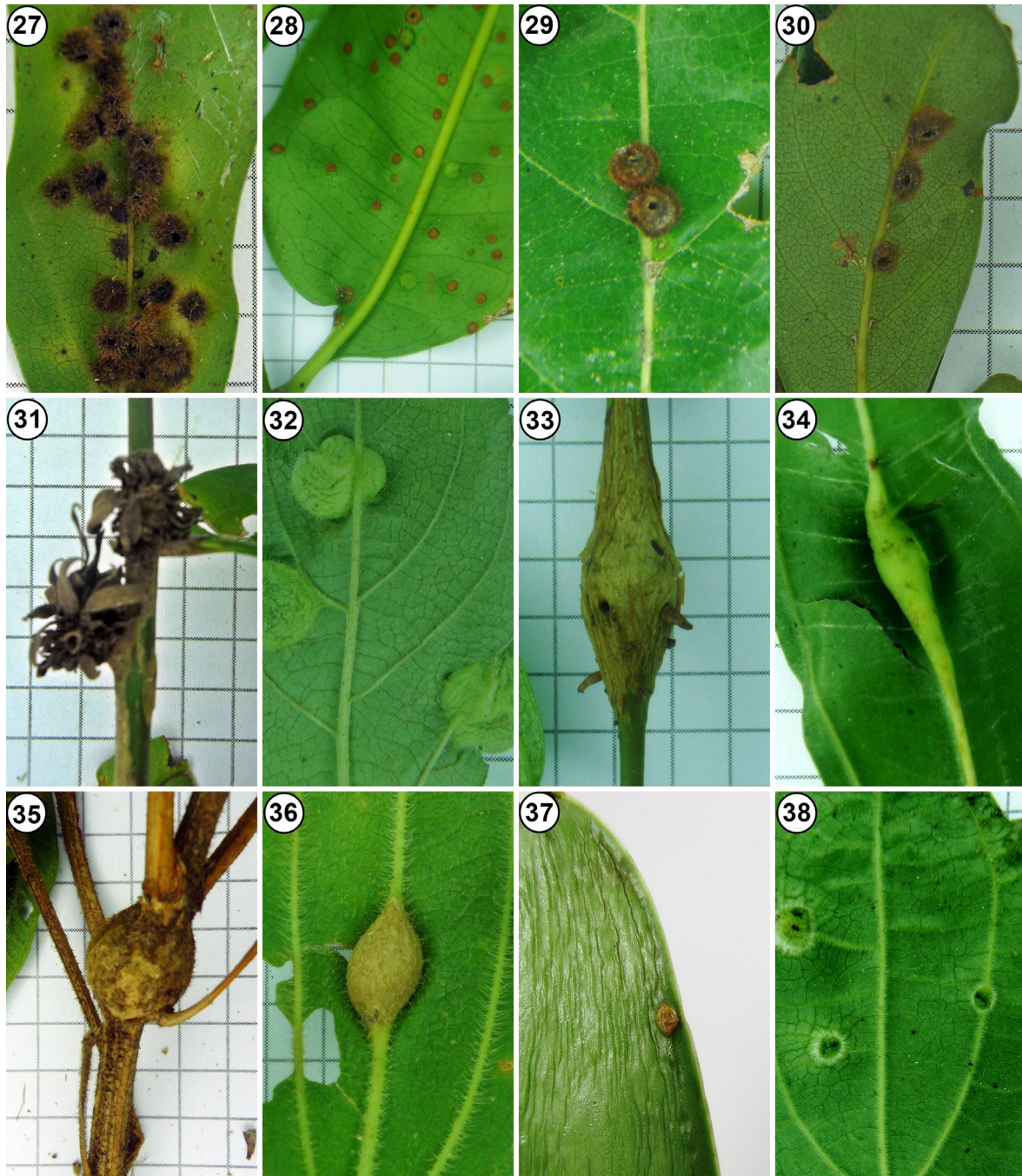
* Based on Maia (2013) and Gagné & Jaschhof (2014)



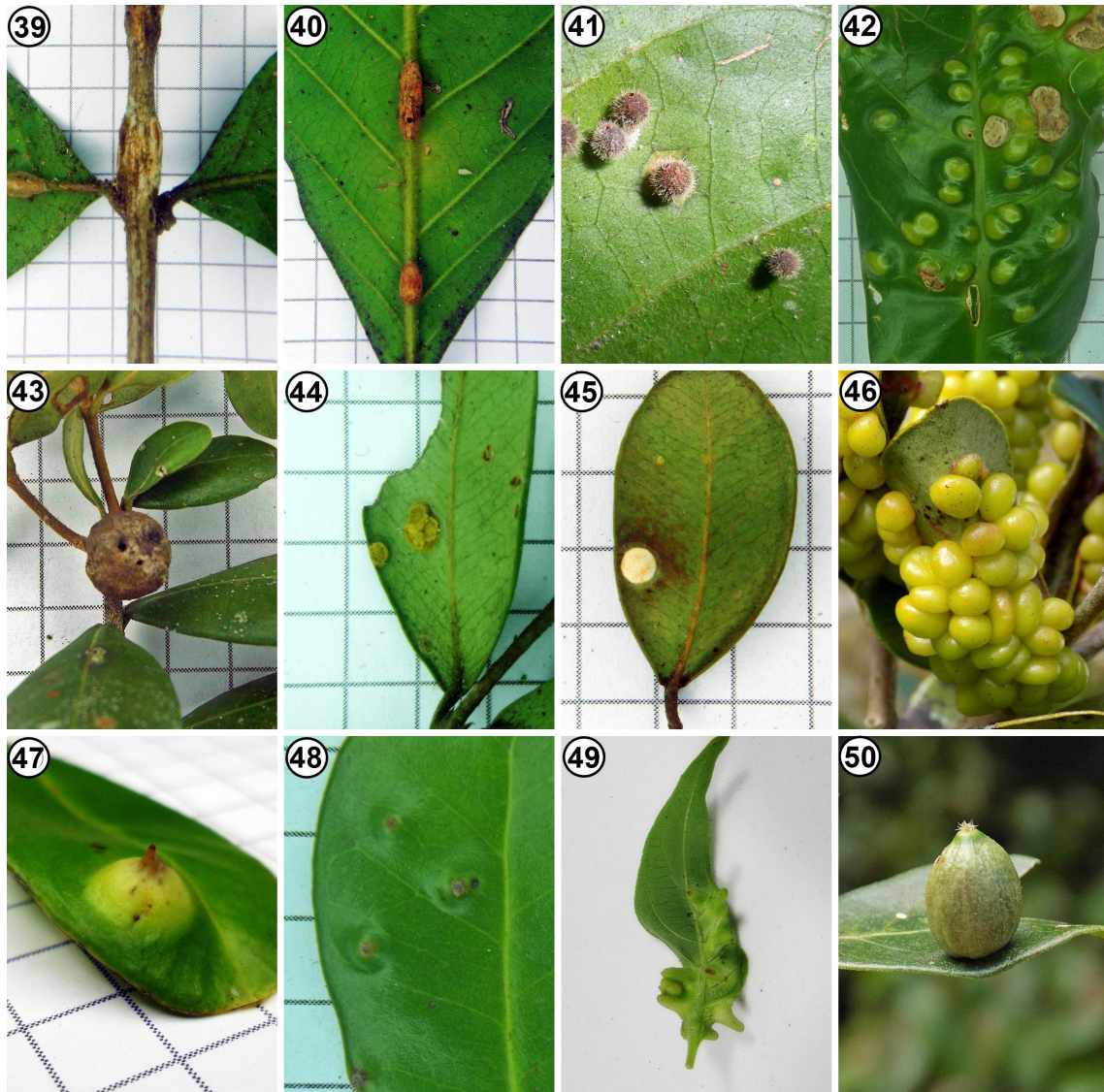
Figures 3-14 – Galls of shrub-tree restinga of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil. 3) *Schinus terebinthifolius* (Anacardiaceae): Extralaminar lenticular. 4-6) *Guatteria australis* (Annonaceae): (4) Fusiform on stem; (5) Globoid on leaf; (6) Lenticular on leaf. 7-9) *Philodendron surinamense* (Araceae): (7) Fusiform on adventitious root grampiform; (8) Coalescent fusiform on adventitious root; (9) Extralaminar lenticular. 10-12) *Mikania trinervis* (Asteraceae): 10) Conical; 11) Globoid on leaf; 12) Coalescent globoid on stem. 13) *Maytenus glazioviana* (Celastraceae): Lenticular. 14) *Clusia criuva* (Clusiaceae): Intralaminar fusiform.



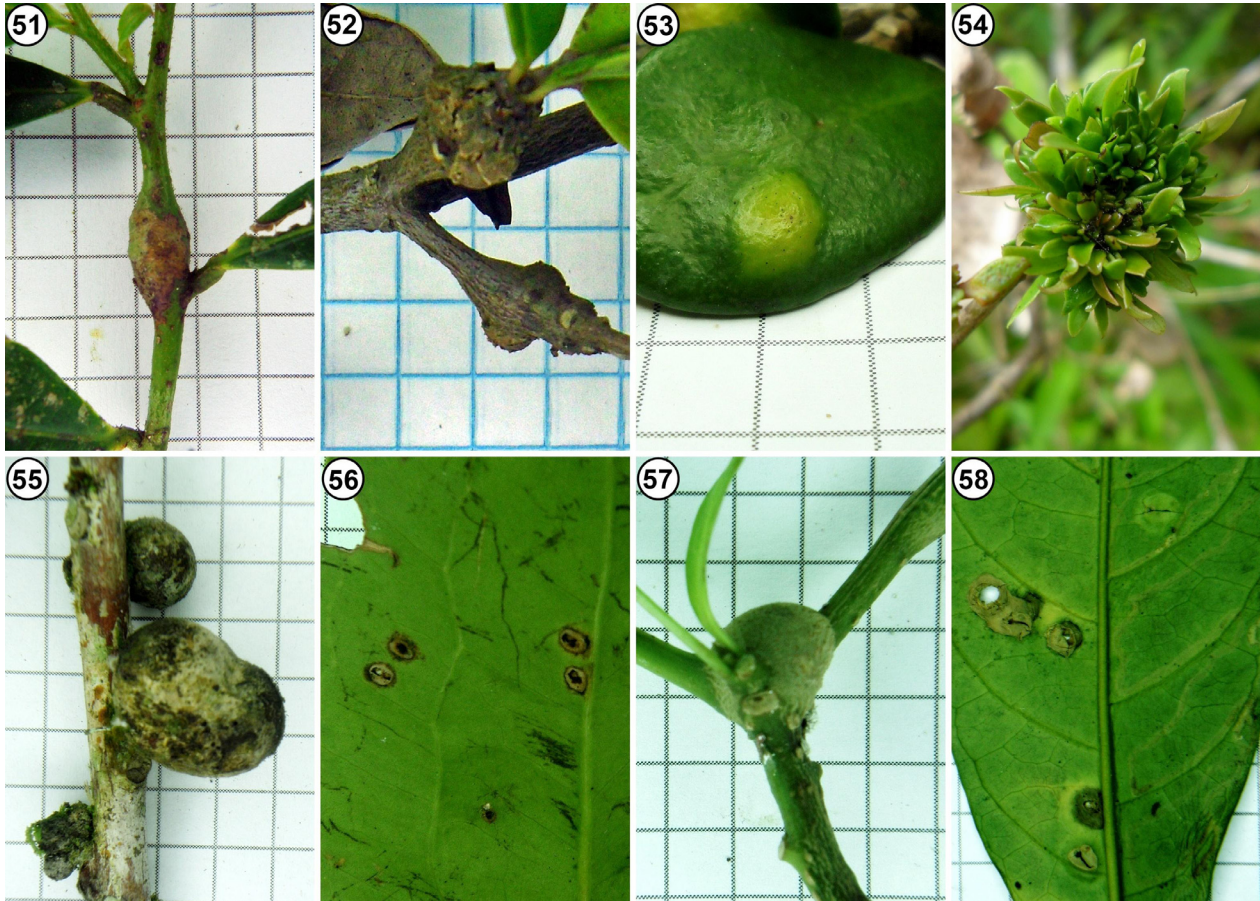
Figures 15-26 – Galls of shrub-tree *restinga* of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil. 15-18) *Calophyllum brasiliense* (Calophyllaceae): (15) Leaf rolling; (16) Fusiform on leaf; (17) Globoid on stem; (18) Intralaminar lenticular. 19-20) *Andira fraxinifolia* (Fabaceae): (19) Fusiform on stem; (20) Globoid on leaf. 21) *Dalbergia frutescens* (Fabaceae): Clavate. 22) *Aiouea saligna* (Lauraceae): Lenticular. 23) *Endlicheria paniculata* (Lauraceae): Fusiform on stem. 24-26) *Nectandra membranacea* (Lauraceae): (24) Conical; (25) Green globoid; (26) Brown globoid.



Figures 27-38 – Galls of shrub-tree restinga of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil. 27) *Nectandra grandifolia* (Lauraceae): Globoid. 28) *Nectandra oppositifolia* (Lauraceae): Lenticular. 29) *Ocotea catharinensis* (Lauraceae): Globoid. 30-31) *Ocotea pulchella* (Lauraceae): (30) Intralaminar lenticular; (31) Rosette. 32) *Pavonia* sp. (Malvaceae): Globoid. 33-34) *Miconia pussilliflora* (Melastomataceae): (33) Fusiform on stem; (34) Fusiform on leaf. 35-36) *Tibouchina pulchra* (Melastomataceae): (35) Globoid on stem; (36) Fusiform on leaf. 37) *Vanilla chamissonis* (Orchidaceae): Globoid. 38) *Piper solmsianum* (Piperaceae): Globoid.



Figures 39-50 – Galls of shrub-tree *restinga* of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil. 39-41) *Guarea macrophylla* (Meliaceae): (39) Fusiform on stem; (40) Fusiform on leaf; (41) Globoid. 42) Myrtaceae sp. 01: Lenticular. 43-45) *Myrcia pulchra* (Myrtaceae): (43) Globoid on stem; (44) Yellow lenticular; (45) White lenticular. 46-48) *Psidium cattleianum* (Myrtaceae): (46) Extralaminar globoide; (47) Intralaminar globoide, with apical projection; (48) Lenticular. 49) *Psychotria carthagenensis* (Rubiaceae): Conical. 50) *Paullinia trigonia* (Sapindaceae): Globoid.



Figures 51-58 – Galls of shrub-tree *restinga* of Parque Estadual Acaraí, São Francisco do Sul municipality, Santa Catarina, Brazil. 51-54) *Guapira opposita* (Nyctaginaceae): (51) Fusiform on stem; (52) Globoid on stem; (53) Lenticular; (54) Rosette; (55) *Pouteria beaupairei* (Sapotaceae): Globoid on stem. 56) *Smilax campestris* (Smilacaceae): Lenticular. 57-58) *Solanum pseudoquina* (Solanaceae): (57) Globoid on stem; (58) Lenticular.

DISCUSSION

The flora of the shrub-tree physiognomy of the PEA restinga is composed of 110 species, distributed in 81 genera and 47 families (MELO JÚNIOR & BOEGER, 2015), of which 31 plant species, 28% of the floristic diversity of this formation accumulate a wealth of 56 morphospecies of galls. The families that added the most gall (51.8%) in the formation of restinga studied also stand out in the flora of the PEA as those with the greatest species richness, or with species of greater representativeness in the community structure of the restinga formations of this park (MELO JÚNIOR & BOEGER, 2015). In this way, the greater diversity presented or the greater abundance of a given taxon can be positively related to the supply of host plants (MENDONÇA JR., 2007; ARAÚJO, 2011). In the herbaceous formation of the PEA, 15 morphospecies of gall were recorded, occurring in 8 species of host plants (ARRIOLA *et al.*, 2015), a number considerably lower than that recorded in this study. This difference between gall richness formations can be explained by the difference in the local floristic richness, corroborating the hypotheses that relate the greatest plant richness to the greatest wealth of galling insects (MENDONÇA JR., 2007; ARAÚJO, 2011).

The globular morphotype occurred in 37.5% of the galls recorded in this *restinga* formation, standing out as the most common morphotype of Brazilian flora (ISAIAS *et al.*, 2013, 2014). In addition to this, the lenticular morphotype, one of the main morphotypes of local galls (ARRIOLA *et al.*, 2015), and the fusiform, a predominant morphotype in stems (FORMIGA *et al.*, 2015), were prominent in this *restinga* formation. Other less frequent morphotypes in Brazilian biomes were also recorded, such as the conical, rosette, foliar winding and nailing (ISAIAS *et al.*, 2013, 2014). In general, the dominance

pattern of globular, lenticular and fusiform gall morphotypes of this *restinga* is in agreement with the patterns found in other *restingas* of the Southeast region (MAIA, 2013), corroborating the neutrality of this environment in relation to its morphogenetic effects on the formation of galls (ARRIOLA *et al.*, 2015). It is a consensus in literature that the morphotypes are conditioned by the plastic capacity of the plant tissue and by the genetic interaction between insect-plant, and there is no environmental variable that determines the morphotypes (STONE & SCHONROGGE, 2003; FORMIGA *et al.*, 2015).

The occurrence of isolated gall morphotypes was greater than that of coalescing galls, the latter occurring exclusively in stems and roots. Isolated galls on leaves appear to be a guarantee for the development of the galler since there is a considerable reduction of the impact of the gall on the morphophysiological characteristics of the parasitized leaf. However, coalescent galls or the massive occurrence of galls on the same leaf can cause, by the leaf deformation, the reduction of the specific leaf area and an early leaf senescence (CONSTANTINO *et al.*, 2009).

The leaf, as the most frequent host organ, is considered the part of the plant that most houses galling insects in the flora in general (ISAIAS *et al.*, 2013, 2014). The lower frequency of galls in stems, as well as the smaller variety of morphotypes occurring in this organ, may be associated with the lower plastic response potential of the tissues to the stimulation of the galler (FORMIGA *et al.*, 2015). Galls in roots were recorded only in the epiphytic species *Philodendron surinamense* (Araceae), occurring in adventitious roots. In general, root-induced insect galls are poorly recorded, although they occur in roots of epiphytic species of other families such as Orchidaceae and Polypodiaceae (TANOUE *et al.*, 2004; MAIA & SANTOS, 2015). Underground roots aggregate gallers from other organisms, such as bacteria and nematodes (MANI, 1964) and are often the focus of agronomic science studies.

As to the coloration and ornamentation of the galls, the distinction in relation to the surrounding plant tissues confers alert signaling characteristics as protection against herbivory (IMBAR *et al.*, 2010). Thus, the predominance of green coloration (67.86%) indicates the variation in the accumulation of pigments during the senescence process of the gall, occurring the greater accumulation of chlorophyll in galls in later stages of development (DIAS *et al.*, 2013).

Superhosts families and species are those capable of harboring three or more gall morphotypes, indicating their ability to react to the stimulus of more than one inducer, which contributes to the increase of galling insects diversity in an ecosystem (ARAÚJO *et al.*, 2013). In the present study, the super-host species added around 16% of the total number of galls found, demonstrating their importance for the diversity of galling insects. Similarly, studies performed by Arriola *et al.* (2015, 2016) also indicated the species *Guapira opposita* (Nyctaginaceae) and *Calophyllum brasiliense* (Calophyllaceae) as important super host galls in the PEA flora.

The predominant group of inductors in this study was the Cecidomyiidae family (Diptera), which corroborates the assumption that it is the largest and most specialized group of forming galls herbivores (MAIA, 2013; GAGNÉ & JASCHHOF, 2014). The indeterminate taxa, which represented 40% of the total observed, can be considered, due to these species-specific interactions, to be new species of inductors to be described and known by science (ESPÍRITO-SANTO & FERNANDES, 2007; CARNEIRO *et al.*, 2009).

This first galls inventory focused on the shrub-arboreal vegetation of the PEA *restinga* showed the increasing diversity of specialized herbivory interactions (insect-plant) when compared to the inventories made in herbaceous vegetation of *restinga* (MENDONÇA JR. *et al.*, 2010, ARAÚJO, 2011; ARRIOLA *et al.*, 2015), as well as contributed to the design of research protocols linked to long-term ecological works developed within the PPBio Mata Atlântica network.

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