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Gall-inducing insects of restinga areas (Atlantic Forest) in Brazil: economic importance

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Abstract. Many gall-inducing insects have been reported as pests in the Old World and North America, although few such examples are known from South America. A list of gall-inducing insects of potential economic importance, with a focus on those of restinga environments, was compiled using Maia (2013a) as starting point and updated with the database "Thompson ISI", using 'Insect (title) and gall (topic)' as keywords. Botanical names were updated using the site "Flora do Brasil, 2020", while potential economic significance of host plant species was acquired from Santos *et al.* (2009) and the site "Useful Tropical Plants". Fifty-eight galling species were associated with 29 economically important plant species of 18 families in Brazilian restingas. The gallers were found to belong to Diptera (Cecidomyiidae and Agromyzidae) and Hemiptera (Eriococcidae and Psyllidae), among which Cecidomyiidae were the most important, with 55 gall-inducing species distributed among 28 genera. Six of the found genera are endemic to the Atlantic Forest and, until now, have been exclusively reported in restingas. About 78% of the gallers have been recorded only in Southeast Brazil and about 64% only in the state of Rio de Janeiro. Most gallers were found to be mainly associated with edible and/or medicinal plant species. Data on natural enemies are scarce with most records having been published at the taxonomic level of family or genus. Natural enemies were found associated with 43 gall-inducing species and included parasitoids, predators and inquilines. The first were the most diverse, being represented by 13 hymenopteran families, but the impacts of all of these guilds on galler populations are poorly known. Although 58 gall-inducing species were identified in the present study, the number of insect galls associated with plants of economic interests in restinga environments is about three times greater, since a total of 186 gall morphotypes have been reported. Nonetheless, many gallers are still undetermined, thus revealing how deficient their taxonomical knowledge remains.

Key-Words. Cecidomyiidae; Diptera; Hemiptera; Natural enemies; Geographic distribution.

INTRODUCTION

Galls induced by insects are pathological neoplasms on a plant (Mamaev & Krivosheina, 1993), which provide offspring with nutritionally better food and protection against extreme environmental conditions and several natural enemies (Price *et al.,* 1987; Fernandes & Price, 1992). Although gallers benefit from this relationship, host plants are negatively impacted (Price *et al.,* 1986; Guimarães *et al.,* 2014). Gall induction reduces leaf-water potential and photosynthetic and transpiration rates. It also affects mineral concentrations, such as that of boron, chloride, magnesium, and zinc (Florentine *et al.,* 2005). Physiologically, galls may act as nutrient sinks for their host plants, because nutrients are redirected from ungalled tissues and neighboring plant parts to the gall itself (McCrea *et al.* 1985; Larson & Whitharn, 1991; Marini-Filho & Fernandes, 2012). Furthermore, many studies have shown gall formation to cause reduced flower, fruit, seed, and biomass production, suggesting that galling insects have the potential to reduce fitness of susceptible host plants (Sacchi *et al.,* 1988; Fernandes & Ribeiro, 1990; Souza *et al.,* 1998). In this sense, cecidogenous insects are considered parasites (Larson, 1998).

Several plants of economic interest are vulnerable to damage by gall-inducing insects, including ornamental (*e.g., Laelia* spp., Orchidaceae), *edible* (*e.g., Manihot* spp., Euphorbiaceae), medicinal and pesticidal plants (*e.g., Melissa officinalis* L., Lamiaceae, as well as species used in carpentry, cosmetics, cabinet making, and agroforestry (Gagné & Jaschhof, 2017). However, the most well-known galling pests are those associated with edible plants, such as *Apiomyia bergenstammi* (Wachtl, 1882) (Diptera, Cecidomyiidae), a pear pest (*Pyrus communis* L.) (Rosaceae) in Europe; *Orseolia oryzae* Wood-Mason, 1889 (Cotes, 1889) (Diptera, Cecidomyiidae), a major endemic rice pest throughout Asia (Kalode & Bentur, 1989); *Lasioptera rubi* Heeger, 1851 (Diptera, Cecidomyiidae), a blackberry, raspberry, dewberry (*Rubus* spp.) (Rosaceae) pest in Europe; and *Ficiomyia perarticulata* Felt, 1922 (Diptera, Cecidomyiidae), a fig pest in the USA (Barnes, 1948). Most galling pests have been reported from the Old World and North America,

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whereas few examples are known from South America, such as *Iatrophobia brasiliensis* (Rübsaamen, 1908a) (Diptera, Cecidomyiidae), a manioc pest (EMBRATER/CIAT, 1982).

Due to the negative impact that gall-inducing insects have on their hosts they can be employed as biological control agents of invasive plants. For example, *Spurgia esulae* Gagné, 1990 (Cecidomyiidae, Diptera), *Kochiomyia stackelbergi* (Mamaev, 1972) (Cecidomyiidae, Diptera), and *Urophora cardui* (Linnaeus, 1758) (Tephritidae, Diptera) have been used to control *Euphorbia esula* L. (Euphorbiaceae) in the USA (Hansen *et al.,* 1997), *Salsola tragus* L. (Chenopodiaceae) in the USA and Uzbekistan (Sobhian *et al.,* 2003), and *Cirsium arvense* (L.) Scop. (Asteraceae) in Canada (Peschken & Harris, 1975), respectively.

Although several cecidogenous species have been associated with plants of economic interest in Brazil, only *Iatrophobia brasiliensis* Rübsaamen, 1915 has been recognized as a pest (EMBRATER/CIAT, 1982). Nevertheless, there are other examples, such as *Clinodiplosis* sp. on panicles of hog plum, *Anacardium mombium* L. (Anacardiaceae) (Moura *et al.,* 2010), and *Contarinia* sp. on leaves of the cashew tree, *Anacardium occidentale* L. (Anacardiaceae) (Tavares *et al.,* 2011), but these species are still unidentified.

Several insect gall inventories in Brazil have been carried out in areas of restinga (Bregonci *et al.,* 2010; Carvalho-Fernandes *et al.,* 2016; Maia, 2001a, 2013a; Maia & Oliveira, 2010; Maia & Silva, 2016; Maia *et al.,* 2008; Monteiro *et al.,* 1994, 2004; Oliveira & Maia, 2005; Rodrigues *et al.,* 2014), one of the most threatened physiognomies of the Atlantic Forest (MMA, 2018). These inventories have recorded great richness of insect galls, but none have focused on their economic importance. The restinga consists of a mosaic of plant communities (Rizzini, 1997) that grow on sandy and chemically-poor soils, with sea spray as the main source of nutrients (Araújo & Lacerda, 1987). They comprise several plant species of local or widespread economic importance, and so the gallers that are associated with them are also of economic significance, since they are generally species-specific and can cause severe damage to their hosts. Since the restinga is the best investigated Brazilian physiognomy with respect to insect galls, it is an ideal ecosystem for studying the economic significance of galling insects.

Thus, the objectives of the present study were to compile a list of gall-inducing insects in restingas that have potential economic significance, and to present the current state of knowledge regarding their biology and geographical distribution.

MATERIAL AND METHODS

A comprehensive list of gall-inducing insects reported for Brazilian restingas was compiled starting with Maia (2013a). More recent data were then obtained by searching the Thompson ISI database for papers published from 2013 through 2017 using 'Insect (title) and gall (topic)' as key-words (performed November 2017). Among the resulting papers, those with a focus on restingas were verified. Botanical names were updated using the site "Flora do Brasil, 2020" and a list of synonyms was developed to aid in the search of host plants, while plant common names were obtained from Zanith & Scarano (2004). The potential economic significance of host plant species was acquired from Santos *et al.* (2009) and the site Useful Tropical Plants (2014). Data on gallers, gall morphology, natural enemies and geographical distributions were also compiled.

RESULTS AND DISCUSSION

Fifty-eight (58) gall-inducing species were found in association with 29 economically important plant species of 18 families in Brazilian restingas (Table 1). Since these gallers are species-specific (Carneiro *et al.,* 2009), they are considered economically important, at least potencially. The inducers found belong to Diptera (n = 56) and Hemiptera (2), with each order being represented by two families: the former by Agromyzidae (n = 1) and Cecidomyiidae (n = 55), and the latter by Eriococcidae and Psylidae (Table 1).

The economically important Cecidomyiidae found in the present study are distributed among 28 genera, of which seven are wide spread (*Asphondylia* Loew, 1850, *Bruggmanniella* Tavares, 1909, *Clinodiplosis* Kieffer, 1894, *Contarinia* Rondani, 1860, *Dasineura* Rondani, 1840, *Lopesia* Rübsaamen, 1908b, and *Schizomyia* Kieffer, 1889), three occur in more than one zoogeographic region (*Youngomyia* Felt, 1908 in the Nearctic, Neotropical and Oriental regions; and *Neolasioptera* Felt, 1908 and *Stephomyia* Tavares, 1916 in the Nearctic and Neotropical regions) and 18 are restricted to the Neotropics (*Alycaulus* Rübsaamen, 1915, *Arrabiadaeamyia* Maia, 2001b, *Clusiamyia* Maia, 1997, *Cordiamyia* Maia, 1996a, *Costadiplosis,* Viceconte & Maia, 2009, *Dactylodiplosis* Rübsaamen, 1915, *Epihormomyia* Felt, 1915, *Eugeniamyia* Maia, Mendonça & Romanowski, 1997, *Jorgenseniella* Maia, 2005, *Liodiplosis* Gagné, 2001, *Manilkaramyia* Maia, 2001b, *Mayteniella* Maia, 2001b, *Myrciamyia* Maia, 1996c, *Myrciariamyia* Maia, 1995, *Neomitranthella* Maia, 1996c, *Parazalepidota* Maia, 2001b, *Paulliniamyia* Maia, 2001b, and *Perasphondylia* Möhn, 1960). Fourteen have been reported only from Brazil (*Arrabidaeamyia, Clusiamyia, Cordiamyia, Costadiplosis, Dactylodiplosis, Eugeniamyia, Jorgenseniella, Liodiplosis, Mayteniella, Myrciamyia, Myrciariamyia, Neomitranthella, Manilkaramyia,* and *Parazalepidota*) (Gagné & Jaschhof, 2017), of which eight can be considered endemic to the country because they occur exclusively on Brazilian endemic host plant species (*Clusiamyia, Costadiplosis, Jorgenseniella, Mayteniella, Myrciamyia, Neomitranthella, Manilkaramyia,* and *Parazalepidota*). Six of these are endemic to the Atlantic Forest and, until now, have been exclusively reported for restingas (*Clusiamyia, Costadiplosis, Jorgenseniella, Neomitranthella, Manilkaramyia,* and *Parazalepidota*).

Table 1. Gall-inducing species of potential economic interest in Brazilian restingas (Atlantic Forest), including their host plants (scientific and common names), gall morphology (galled organ and gall shape), economic importance, natural enemies, geographic distribution, and references.

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Diptera, Agromyzidae:						
Japanagromyza inferna Spencer, 1973	*Centrosema virginianum* (L.) Benth. (Fabaceae)/jetirana	Leaf/globoid	Agroforestry (erosion control)	No data	Bahamas, Guadeloupe, Brazil (RJ: Mangaratiba, Saquarema, Arraial do Cabo, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Sousa & Couri (2014), Spencer & Stegmaier (1973), Useful Tropical Plants (2014)
Diptera, Cecidomyiidae:						
Alycaulus globulus Gagné, 2001	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Leaf/lenticular	Edible (as tea), medicinal (treatment of asthma and bronchitis)	Parasitoids: Platygastridae (Hymenoptera)	Brazil: RJ (Itatiaia, Rio de Janeiro, Silva Jardim)	Gagné *et al.* (2001), Maia (2013a), Maia & Mascarenhas (2017), Maia *et al.* (2008), Oliveira & Maia (2005), Skuhravá (1989), Teske & Trentini (1997)
Arrabidaeamyia serrata Maia, 2001	*Fridericia conjugata* (Vell.) Mart. (Bignoniaceae)/Cipó bugi	Leaf/conical	Manufacture of rope	Parasitoids: *Eurytoma* sp. (Eurytomidae, Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Carapebus, Mangaratiba, Maricá, Rio de Janeiro)	Carvalho-Fernandes *et al.* (2016), Maia (2001a, b, 2013a), Maia & Azevedo (2009), Monteiro *et al.* (1994, 2004), Oliveira & Maia (2005), Rodrigues *et al.* (2014), Santos *et al.* (2009)
Asphondylia communis Maia & Couri, 1992	*Ximenia americana* L. (Olacaceae)/ameixa-do-brasil	Stem/fusiform	Edible, medicinal (laxative, treatment for fevers, colds, toothaches, headaches, angina), agroforestry, manufacture of soap, body lubrication, and hair oil	Parasitoids: Encyrtidae (Hymenoptera)	RJ (Maricá)	Maia (2001a, 2013a), Maia & Azevedo (2009), Maia *et al.* (1992), Useful Tropical Plants (2014)
Asphondylia cfr. cordiae Möhn, 1959	*Varronia curassavica* Jacq. (Boraginaceae)/erva-baleeira	Flower bud/ovoid	Medicinal (as anti-inflammatory) manufacture of rope, mosquito repellent	Parasitoids: *Eurytoma* sp. (Eurytomidae), Eulophidae, Elasmidae (Hymenoptera)	El Salvador Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Maricá, Saquarema, São Francisco de Itabapoana, São João da Barra), SP (Bertioga)	Carvalho-Ferdandes *et al.* (2016), Maia (1996a, 2001a, 2013a), Maia & Carvalho-Fernandes (2016), Maia & Azevedo (2009), Maia *et al.* (2008), Möhn (1959), Santos *et al.* (2009), Useful Tropical Plants (2014)
Asphondylia moehni Skuhravá, 1989	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Stem/globoid	Edible (as tea), medicinal (treatment of asthma and bronchitis)	Parasitoids: Hymenoptera	Brazil: RJ (Itatiaia, Poço das Antas, Silva Jardim, Rio de Janeiro)	Gagné *et al.* (2001), Maia (2013a), Maia & Mascarenhas (2017), Maia *et al.* (2008), Oliveira & Maia (2005), Skuhravá (1989), Teske & Trentini (1997)
Bruggmanniella byrsonimae (Maia & Couri, 1992)	*Byrsonima sericea* DC. (Malpighiaceae)/murici da praia	Flower bud/ovoid	Edible, ornamental, carpentry, source of tannins, textile dyes	Parasitoids: Encyrtidae (Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Carapebus, Mangaratiba, Maricá, São Francisco de Itabapoana, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Maia (2001a, b, 2013a), Maia *et al.* (1992), Maia & Carvalho-Fernandes (2016), Maia & Azevedo (2009), Monteiro *et al.* (1994, 2004), Rodrigues *et al.* (2014), Santos *et al.* (2009), Useful Tropical Plants (2014)
Bruggmanniella maytenuse (Maia & Couri, 1992)	*Maytenus obtusifolia* Mart. (Celastraceae)/papagaio, carne de anta, congonha brava de folha miúda, lenha branca	Fruit/ovoid	Edible (as tea), medicinal (treatment of diarrhea, serious ulcers, general inflammations, cancer and external ulcers on the skin), carpentry, rural construction work	Parasitoids: Eulophidae (Hymenoptera)	Brazil: RJ (Maricá, São Francisco de Itabapoana, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Maia (1999b, 2001a, b, 2013a), Maia & Azevedo (2009), Maia & Carvalho-Fernandes *et al.* (2016), Maia *et al.* (1992), Santos *et al.* (2009), Useful Tropical Plants (2014)

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Clinodiplosis conica Oliveira & Maia, 2008	*Microstachys corniculata* (Vahl) Griseb. (Euphorbiaceae)/ falsa-guanxuma, guanxuma-de-chifre	Bud/conical	Medicinal (treatment of headaches, heart problems, sores, thrush, wounds and cuts)	Parasitoids: Eulophidae (Hymenoptera)	Brazil: RJ (Carapebus, Maricá)	Maia (2001a, 2013a), Maia & Azevedo (2009), Oliveira & Maia (2008), Useful Tropical Plants (2014)
Clinodiplosis costai Maia, 2005	*Paullinia weinmanniifolia* Mart. – (Sapindaceae)/cipó-sangue	Leaf/leaf roll	Ornamental	Predator: *Lestodiplosis* sp. (Cecidomyiidae, Diptera)	Brazil: RJ (Arraial do Cabo, Carapebus, Maricá)	Maia (2001a, 2005a, 2013a), Monteiro *et al.* (1994, 2004), Santos *et al.* (2009)
Clinodiplosis profusa Maia, 2001	*Eugenia uniflora* L. (Myrtaceae)/pitangueira	Leaf/conical	Edible, medicinal (head colds, influenza, chest colds, coughs and fever), carpentry, insect repellent	Parasitoids: *Chrysonotomyia* sp., *Aprostocetus* sp. (Eulohidae, Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Carapebus, Mangaratiba, Maricá, Rio de Janeiro, São João da Barra, Saquarema), RS (Pelotas)	Bierhals *et al.* (2012), Diez-Rodríguez *et al.* (2011), Maia (1993, 2013a), Maia & Azevedo (2009), Santos *et al.* (2009), Useful Tropical Plants (2014)
Clusiamyia granulosa Maia, 2001	*Clusia hilariana* Schltdl. (Clusiaceae)/clúsia-baiana	Leaf/lenticular	Edible, medicinal (treatment of diarrhea), carpentry, ornamental, fuel source or charcoal manufacture	Parasitoids: Eupelmidae (Hymenoptera)	Brazil: ES (Guarapari), RJ (Arraial do Cabo, Carapebus)	Bregonci *et al.* (2010), Maia (2001a, b, 2013a), Maia & Azevedo (2009), Santos *et al.* (2009), Useful Tropical Plants (2014)
Clusiamyia nitida Maia, 1997	*Clusia lanceolata* Camb. (Clusiaceae)/cebola-da-praia	Leaf/globoid	Used as fuel	Parasitoids: *Encarsia* sp. (Aphelinidae), *Innostemma* p. (Platygastridae) Hymenoptera)	Brazil: RJ (Arraial do Cabo, Maricá)	Maia (1997, 2001a, 2013a), Maia & Azevedo (2009), Useful Tropical Plants (2014)
Contarinia gemmae Maia, 2003	*Calophyllum brasiliense* Cambess. (Calophyllaceae)/ guanandi	Bud/globoid	Carpentry, medicinal (antidiabetic and vermifuge, headache), agroforestry (to stabilize soils and to relieve soil compaction in degraded pastures), general construction	No data	Brazil: AM (Reserva de Desenvolvimento Sustentável Amanã), BA (Parque Estadual da Serra dos Montes Altos), GO (Pirenópolis), MG (Januária, São Tomé das Letras), RJ (Carapebus), SP (Bertioga)	Arriola *et al.* (2016), Madeira *et al.* (2003), Maia (2013a), Maia *et al.* (2008), Proença & Maia (2015), Santos *et al.* (2009), Useful Tropical Plants (2014)
Cordiamyia globosa Maia, 1996	*Varronia curassavica* Jacq. (Boraginaceae)/erva-baleeira	Leaf/globoid	Medicinal (as anti-inflammatory) Rope manufacture, mosquito repellent	Parasitoids: *Galeopsomyia* sp. and *Cirrospilus* sp. (Eulophidae), *Eurytoma* sp. (Eurytomidae), *Lyrcus* sp. (Pteromalidae), *Synopeas* sp. (Platygastridae), *Torymoides* sp. and *Torymus* sp. (Torymidae) (Hymenoptera)	Brazil: ES (Guarapari), RJ (Arraial do Cabo, Cabo Frio, Carapebus, Maricá, São Francisco de Itabapoana, São João da Barra), Saquarema), SP (Bertioga)	Bregonci *et al.* (2010), Carvalho-Fernandes *et al.* (2016), Maia (1996a, 2001a, 2013a), Maia & Azevedo (2009), Maia & Tavares (2000), Maia *et al.* (2008), Möhn (1959), Santos *et al.* (2009) Useful Tropical Plants (2014)
Costadiplosis maricaensis Viceconte & Maia, 2009	*Psittacanthus dichroos* (Mart.) Mart. (Loranthaceae)/erva-de-passarinho	Leaf/lenticular	Medicinal (treatment of haemorrhoids)	Parasitoids: *Aprostocetus* sp. (Eulophidae, Hymenoptera)	Brazil: RJ (Maricá)	Maia (2001a, 2013a), Maia & Azevedo (2009), Santos *et al.* (2009), Viceconte & Maia (2009)
Dactylodiplosis heptaphylli Maia, 2004	*Protium heptaphyllum* (Aublet.) March. (Burseraceae)/almecega	Leaf/globoid	Edible, medicinal (treatment of spine problems, asthma and bronchitis), carpentry, agroforestry (excellent shade) used for incense and in varnishes	No data	Brazil: RJ (Carapebus, São Francisco de Itabapoana, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Maia (2013a), Maia & Carvalho-Fernandes (2016), Narahara *et al.* (2004), Santos *et al.* (2009), Useful Tropical Plants (2014)
Dactylodiplosis icicaribae Maia, 2002	*Protium icicariba* (DC.) March. (Burseraceae)/insenso	Leaf/conical	Edible, medicinal (treatment of spine and skin problems, antirheumatic, haemostatic, expectorant, and stimulant)	No data	Brazil: RJ (Carapebus, Mangaratiba)	Maia (2001a, 2002, 2013a), Maia *et al.* (2002), Rodrigues *et al.* (2014), Santos *et al.* (2009), Useful Tropical Plants (2014)
Dasineura byrsonimae Maia, 2010	*Byrsonima sericea* DC. (Malpighiaceae)/murici da praia	Leaf/lenticular	Edible, ornamental, carpentry, source of tannins, textile dyes	Parasitoids: Hymenoptera	Brazil: ES (Guarapari), RJ (Angra dos Reis, Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Mangaratiba, Maricá, Rio de Janeiro, São Francisco de Itabapoana, São João da Barra, Saquarema)	Bregonci *et al.* (2010), Carvalho-Fernandes *et al.* (2016), Maia (2001a, 2010, 2013a), Maia & Carvalho-Fernandes (2016), Maia & Oliveira (2010), Oliveira & Maia (2005), Monteiro *et al.* (2004), Rodrigues *et al.* (2014), Santos *et al.* (2009) Useful Tropical Plants (2014)

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Dasineura gigantea Angelo & Maia, 1999	*Psidium cattleyanum* Sabine (Myrtaceae)/Araçá	Bud/leaf rosette	Edible, flowers used as a garnish, medicinal (treatment for haemorrhages), agroforestry, ornamental, used for lathe work, tool handles and for objects that require much resistance, fuel and charcoal	Parasitoids: *Leptacis* sp. (Platygastridae, Hymenoptera), Alysiini sp. (Braconidae)	Brazil: PR (Piraquara, Pontal do Paraná), RS (Pelotas), SP (Bertioga), SC (Itapoá)	Angelo (2007), Angelo & Maia (1999), Diez-Rodríguez *et al.* (2011), Maia (2013a), Maia *et al.* (2008), Santos *et al.* (2009), Useful Tropical Plants (2014)
Dasineura globosa Maia, 1996	*Eugenia astringens* Cambess. (Myrtaceae)/aperta-goela	Leaf/lenticular	Medicinal (treatment of diarrhea)	Parasitoids: Eulophidae (Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Mangaratiba, Maricá, Rio de Janeiro, São João da Barra, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (1996b, 2001a, 2013a), Maia *et al.*: 2005, Maia & Azevedo (2009), Oliveira & Maia (2005), Santos *et al.* (2009), Tavares (1920)
Dasineura marginalis Maia, 2005	*Eugenia astringens* Cambess. (Myrtaceae)/aperta-goela	Leaf/marginal roll	Medicinal (treatment of diarrhea)	Parasitoids: Eulophidae (Hymenoptera) Predator: *Lestodiplosis* sp. (Cecidomyiidae, Diptera)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Mangaratiba, Maricá, Rio de Janeiro, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (1993,2013a), Maia *et al.*: 2005, Oliveira & Maia (2005), Rodrigues *et al.* (2014), Santos *et al.* (2009), Tavares (1920)
Dasineura myrciariae Maia, 1996	*Myrciaria floribunda* (H. West ex Willd.) Legrand (Myrtaceae)/cambuí-amarelo	Leaf/marginal roll	Edible fruit	Parasitoids: *Proacrias* sp. (Eulophidae), Aphelinidae (Hymenoptera) Predator: *Lestodiplosis* sp. (Cecidomyiidae, Diptera)	Brazil: ES (Guarapari), RJ (Carapebus, Maricá, Rio de Janeiro, São Francisco de Itabapoana)	Bregonci *et al.* (2010), Maia (1996b, 1994, 2001a, 2013a), Maia & Azevedo (2009), Maia & Carvalho-Fernandes (2016)
Dasineura ovalifoliae Maia & Carvalho-Fernandes, 2011	*Erythroxylum ovalifolium* Peyr. (Erythroxylaceae)/fruta-de-pomba	Leaf/triangular	Medicinal (spine problems)	Parasitoids: Eulophidae, Eupelmidae, Mymaridae, Pteromalidae (Hymenoptera) Modifier: Tetrastichinae (Eulophidae, Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Maricá, Rio de Janeiro, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (2001a, 2013a), Maia & Azevedo (2009), Maia & Fernandes (2011), Santos *et al.* (2009)
Dasineura tavaresi Maia, 1996 (inquiline or gall maker)	*Neomitranthes obscura* (DC.) N.J.E. Silveira (Myrtaceae)/ cambuí-preto	Leaf/marginal roll	Edible fruit, medicinal (treatment of diarrhea), fuel and charcoal	Parasitoids: Encyrtidae (Hymenoptera) Free living phytophagous: *Stenoma annosa* (Butler, 1877) (Oecophoridae, Lepidoptera)	Brazil: ES (Guarapari), RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Maricá, Saquarema)	Bregonci *et al.* (2010), Carvalho-Fernandes *et al.* (2016), Maia (1996b, 1995, 2001a, 2013a), Maia & Azevedo (2009), Santos *et al.* (2009), Useful Tropical Plants (2014)
Epihormomyia miconiae Maia, 2001	*Miconia cinnamomifolia* (DC.) Naudin. (Melastomataceae)	Stem/ovoid	Carpentry, agroforestry (pioneer in reforestation projects), ornamental	Inquiline: *Reseliella* sp. (Cecidomyiidae, Diptera)	Brazil: RJ (Carapebus)	Maia (2001a, b, 2013a), Santos *et al.* (2009), Useful Tropical Plants (2014)
Eugeniamyia dispar Maia, Mendonça & Romanovski, 1996	*Eugenia uniflora* L. (Myrtaceae)/Pitangueira	Leaf/globoid	Edible, medicinal (head colds, influenza, chest colds, coughs and fever), carpentry, insect repellent	Parasitoids: *Rileya hegeli* Girault, 1916 (Eurytomidae, Hymenoptera) Predator: *Pseudomyrmex* sp. (Formicidae, Hymenoptera) Phytophagous: *Pheidole* sp. (Formicidae, Hymenoptera)	Brazil: SP (Bertioga), SC (Florianópolis), RS (Pelotas, Porto Alegre, Ijuí, Parque Florestal de Nonoai)	Bierhals *et al.* (2012), Diez-Rodríguez *et al.* (2011), Maia (1993, 2013a), Maia *et al.* (1996, 2008), Maia & Nava (2011), Mendonça & Romanovski, 2002a, b, Santos *et al.* (2009), Useful Tropical Plants (2014)
Eugeniamyia triangularis Maia & Nava, 2001	*Eugenia uniflora* L. (Myrtaceae)/Pitangueira	Leaf/triangular	Edible, medicinal (head colds, influenza, chest colds, coughs and fever), carpentry, insect repellent	No data	Brazil: RJ (Maricá)	Maia (1993, 2013a), Maia *et al.* (1996), Maia & Nava (2011), Santos *et al.* (2009), Useful Tropical Plants (2014)
Jorgenseniella eugeniae Maia, 2005	*Eugenia astringens* Cambess. (Myrtaceae)/aperta-goela	Leaf/lenticular	Medicinal (treatment of diarrhea)	No data	Brazil: RJ (Arraial do Cabo, Macaé)	Maia (1993, 2013a), Maia *et al.*: 2005, Santos *et al.* (2009), Tavares (1920)
Liodiplosis conica Gagné, 2001	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Leaf/conical	Edible (as tea), medicinal (treatment of asthma and bronchitis)	No data	Brazil: RJ (Itatiaia, Rio de Janeiro, Silva Jardim)	Gagné *et al.* (2001), Maia (2013a), Maia & Mascarenhas (2017), Oliveira & Maia (2005), Skuhravá (1989), Teske & Trentini (1997)

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Liodiplosis cylindrica Gagné, 2001	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Leaf/cylindrical	Edible (as tea), medicinal (treatment of asthma and bronchitis)	Parasitoids: Hymenoptera	Brazil: RJ (Itatiaia, Paraty, Silva Jardim)	Gagné *et al.* (2001), Maia (2013a), Maia & Mascarenhas (2017), Skuhravá (1989), Teske & Trentini (1997)
Liodiplosis spherica Gagné, 2001	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Leaf/spherical	Edible (as tea), medicinal (treatment of asthma and bronchitis)	Parasitoids: Hymenoptera	Brazil: RJ (Itatiaia, Parati, Silva Jardim)	Gagné *et al.* (2001), Maia (2013a), Maia & Mascarenhas (2017), Skuhravá (1989), Teske & Trentini (1997)
Lopesia caulinaris Maia, 2003	*Calophyllum brasiliense* Cambess. (Calophyllaceae)/ guanandi	Stem/globoid	Carpentry, medicinal (antidiabetic and vermifuge, headache), agroforestry (to stabilize soils and to relieve soil compaction in degraded pastures), general construction	Parasitoids: Hymenoptera	Costa Rica (Heredia), Bolivia (Santa Cruz), Brazil: AM (Reserva de Desenvolvimento Sustentável Amanã), Amapá (Oiapoque), BA (Parque Estadual da Serra dos Montes Altos), GO (Pirenópolis), MG (São Januária, São Tomé das Letras), RJ (Carapebus), SP (Bertioga), SC (São Francisco do Sul)	Arriola *et al.* (2016), Madeira *et al.* (2003), Maia (2013a, 2013b), Maia *et al.* (2008), Proença & Maia (2015), Santos *et al.* (2009), Useful Tropical Plants (2014)
Lopesia conspicua Maia, 2003	*Calophyllum brasiliense* Cambess. (Calophyllaceae)/ guanandi	Leaf/globoid	Carpentry, medicinal (antidiabetic and vermifuge, headache), agroforestry (to stabilize soils and to relieve soil compaction in degraded pastures), general construction	No data	Brazil: AM (Reserva de Desenvolvimento Sustentável Amanã), RN (Canguaretama), BA (Parque EstaduaL da Serra dos Montes Altos), GO (Pirenópolis), MG (Januária, São Tomé das Letras), RJ (Carapebus), PR (Paranaguá)	Arriola *et al.* (2016), Madeira *et al.* (2003), Maia (2013a, 2013b), Proença & Maia (2015), Santos *et al.* (2009), Useful Tropical Plants (2014)
Lopesia elliptica Maia, 2003	*Calophyllum brasiliense* Cambess. (Calophyllaceae)/ guanandi	Leaf/elliptical	Carpentry, medicinal (antidiabetic and vermifuge, headache remedy), agroforestry (to stabilize soils and to relieve soil compaction in degraded pastures), general construction	Parasitoids: Eurytomidae (Hymenoptera) Inquilines: Coleoptera	Mexico (Coaxaca), Guatemala (Santa Helena and San Francisco), Costa Rica (Heredia), Dominican Republic (Dajabón), Cuba, Guyana (Upper Takutu- Upper Essequibo), Bolivia (Santa Cruz), Peru (Loreta), Paraguay (Amambay), Brazil: AP (Oiapoque), AM (Reserva de Desenvolvimento Sustentável Amanã), PA (Moju), MA (São Luís), RO (Chupinguaia), RN (Canguaretama), BA (Parque Estadual da Serra dos Montes Altos), Pernambuco, GO (Pirenópolis), TO (Formoso do Araguaia), MT (Santa Terezinha), MG (São Tomé das Letras), RJ (Carapebus), SP (Bertioga), PR (Paranaguá), SC (São Francisco do Sul)	Arriola *et al.* (2016), Madeira *et al.* (2003), Maia (2013a), Maia *et al.* (2008), Proença & Maia (2015), Santos *et al.* (2009), Useful Tropical Plants (2014)
Lopesia erythroxyli Rodrigues & Maia, 2010	*Erythroxylum ovalifolium* Peyr. (Erythroxylaceae)/fruta-de-pomba	Bud/conical	Medicinal (spine problems)	Parasitoids: Eulophidae, Eupelmidae, *Eurytoma* sp. (Eurytomidae), Mymaridae, Pteromalidae (Hymenoptera) Modifier: Tetrastichinae (Eulophidae, Hymenoptera)	Brazil: RJ (Angra dos Reis, Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Maricá, Rio de Janeiro, São João da Barra, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (2013a), Maia & Azevedo (2009), Maia & Carvalho-Fernandes (2011), Maia & Oliveira (2010), Rodrigues & Maia (2010), Santos *et al.* (2009)
Lopesia linearis Maia, 2003	*Calophyllum brasiliense* Cambess. (Calophyllaceae)/ guanandi	Leaf/lineal	Carpentry, medicinal (antidiabetic and vermifuge, headache remedy), agroforestry (to stabilize soils and to relieve soil compaction in degraded pastures), general construction	No data	Costa Rica (Heredia), Cuba, Trinidad and Tobago (Saint George), Mexico (Coaxaca), Bolivia (Santa Cruz), Colombia (Antioquia), Guyana (Upper Takutu- Upper Essequibo), Peru (Loreta), Paraguay (Amambay), Brazil: AM (Reserva de Desenvolvimento Sustentável Amanã), PA (Moju), RO (Chupinguaia), RR (Caracaraí), RN (Canguaretama), MT (Santa Terezinha), MS (Corumbá), MG (São Tomé das Letras), ES (Linhares), RJ (Carapebus), SP (Bertioga), PR (Paranaguá), SC (São Francisco do Sul)	Arriola *et al.* (2016), Madeira *et al.* (2003), Maia (2013a and b), Maia *et al.* (2008), Santos *et al.* (2009), Useful Tropical Plants (2014)
Lopesia maricaensis Rodrigues & Maia, 2009	*Protium brasiliense* (Spr.) Engl.	Leaf/marginal roll	Edible (oil obtained from seeds), carpentry	Parasitoids: *Goniozus* sp. (Bethylidae, Hymenoptera)	Brazil: RJ (Maricá)	Maia (2013a), Maia & Azevedo (2009), Rodrigues & Maia (2010), Useful Tropical Plants (2014)

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Lopesia similis Maia, 2004	*Protium heptaphyllum* (Aublet.) March. (Burseraceae)/almecega	Leaf/marginal roll	Edible, medicinal (treatment of spine problems, asthma and bronchitis), carpentry, agroforestry (excellent shade) used for incense and in varnishes	Parasitoids: Eupelmidae (Hymenoptera)	Brazil: MG (Tiradentes), MS (Aquidauana), RJ (Arraial do Cabo, Carapebus, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Maia (2013a), Maia & Azevedo (2009), Maia & Fernandes (2004), Narahara *et al.* (2004), Santos *et al.* (2009), Silva & Maia (2014), Useful Tropical Plants (2014)
Lopesia simplex Maia, 2002	*Protium icicariba* (DC.) March. (Burseraceae)/Insenso	Leaf/marginal roll	Edible, medicinal (treatment of spine and skin problems, antirheumatic, haemostatic, expectorant, and stimulant)	Parasitoids: Hymenoptera	Brazil: ES (Guarapari), RJ (Araruama, Carapebus, Mangaratiba, São João da Barra)	Bregonci *et al.* (2010), Carvalho-Fernandes *et al.* (2016), Maia (2001a, 2002, 2013a), Maia *et al.* (2002), Rodrigues *et al.* (2014), Santos *et al.* (2009), Useful Tropical Plants (2014)
Lopesia singularis Maia, 2001	*Pouteria venosa* (Mart.) (Sapotaceae)/Sapota-preta	Leaf/lenticular	Edible fruit, medicinal (treatment for diarrhea and heartburn)	Parasitoids: Tetrastichinae (Eulophidae), Eupelmidae, Torymidae (Hymenoptera)	Brazil: RJ (Maricá, Carapebus), SP (Bertioga)	Maia (2001a, b, 2013a), Maia & Azevedo (2009), Maia *et al.* (2008), Monteiro *et al.* (1994), Useful Tropical Plants (2014)
Manilkaramyia notabilis Maia, 2001	*Manilkara subsericea* (Mart.) Dubard. (Sapotaceae)/ maçaranduba-da-praia	Bud/ovoid	Edible fruit, carpentry	Parasitoids: Torymidae (Hymenoptera)	Brazil: ES (Guarapari), RJ (Carapebus)	Bregonci *et al.* (2010), Maia (2001a, b, 2013a), Santos *et al.* (2009), Useful Tropical Plants (2014)
Mayeniella distincta Maia, 2001	*Maytenus obtusifolia* Mart. (Celastraceae)/papagaio, carne de anta, congonha brava de folha miúda, lenha branca	Leaf/globoid	Edible (as tea), medicinal (treatment of diarrhea, serious ulcers, general inflammations, cancer and also against external ulcers on the skin), carpentry, rural construction work	Parasitoids: *Xanthellum* (Eulophidae, Hymenoptera)	Brazil: RJ (Arraial do Cabo, Mangaratiba, Maricá, Rio de Janeiro, São Francisco de Itabapoana, São João da Barra)	Maia & Carvalho-Fernandes (2016), Maia (2001a, b, 2013a), Maia & Azevedo (2009), Maia & Silva (2016), Monteiro *et al.* (1994), Rodrigues *et al.* (2014), Santos *et al.* (2009), Useful Tropical Plants (2014)
Myrciamyia maricaensis Maia, 1996	*Myrcia amazonica DC.* and *M. ovata* Cambess. (Myrtaceae)/araçá-aiçara	Bud/ovoid	Edible fruit	Parasitoids: *Aprostocetus* sp. (Eulophidae), Platygastridae. Modifiers: Eulophidae (Hymenoptera)	Brazil: RJ (Arraial do Cabo, Carapebus, Maricá)	Ferraz & Monteiro (2003), Maia (1996c, 2001a, 2013a), Maia & Azevedo (2009), Monteiro *et al.* (1994), Santos *et al.* (2009)
Myrciariamyia bivalva Maia, 1994	*Myrciaria floribunda* (H. West ex Willd.) Legrand (Myrtaceae)/cambuí-amarelo	Bud/bivalve	Edible fruit	Parasitoids: Eulophidae, Encyrtidae, Pteromalidae (Hymenoptera)	Brazil: RJ (Arraial do Cabo, Carapebus, Maricá)	Maia (1993, 1994, 2001a, 2013a), Maia & Azevedo (2009), Monteiro *et al.* (1994, 2004)
Neolasioptera cerei Rübsaamen, 1905	*Hylocereus setaceus* (Salm-Dyck) R. Bauer (Cactaceae)/ cardeiro-trepador	Stem/fusiform	Edible fruit	No data	Brazil: RJ (Angra dos Reis, Cabo Frio, Carapebus, São João da Barra)	Carvalho-Fernandes *et al.* (2016), Maia (2013a), Maia & Oliveira (2010), Rübsaamen (1905), Useful Tropical Plants (2014)
Neolasioptera eugeniae Maia, 1993	*Eugenia uniflora* L. (Myrtaceae)/pitangueira	Leaf/lenticular	Edible, medicinal (head colds, influenza, chest colds, coughs and fever), carpentry, insect repellent	Parasitoids: Eulophidae, Eurytomidae (Hymenoptera)	Brazil: RJ (Angra dos Reis, Arraial do Cabo, Cabo Frio, Maricá, Rio de Janeiro)	Maia (1993, 2001a, 2013a), Maia & Azevedo (2009), Maia & Oliveira (2010), Monteiro *et al.* (1994), Oliveira & Maia (2005), Santos *et al.* (2009), Useful Tropical Plants (2014)
Neomitranthella robusta Maia, 1996	*Neomitranthes obscura* (DC.) N.J.E. Silveira (Myrtaceae)/ cambuí-preto	Bud/imbricated	Edible fruit, medicinal (treatment of diarrhea), fuel and charcoal	Inquiline: *Stenoma annosa* (Butler, 1877) (Oecophoridae, Lepidoptera)	Brazil: RJ (Araruama, Cabo Frio, Carapebus, Maricá, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (1996c, 2001a) Maia *et al.* (2013a), Santos *et al.* (2009), Useful Tropical Plants (2014)
Parazalepidota clusiae Maia, 2001	*Clusia fluminensis* Planch. & Triana (Clusiaceae)/abaneiro	Leaf/lenticular	Veterinary, medicinal, ornamental, agroforestry (reforestation near the coast) Fuel or charcoal	Parasitoids: *Rileya* sp. (Eurytomidae, Hymenoptera)	Brazil: RJ (Maricá, Rio de Janeiro)	Maia (2001a, b, 2013a), Maia & Azevedo (2009), Oliveira & Maia (2005), Useful Tropical Plants (2014)

Gall-inducing species	Host plant scientific/ common name	Galled organ/ gall shape	Economical importance	Natural enemies	Geographic distribution	References
Paulliniamyia ampla Maia, 2001	*Paullinia weinmanniifolia* Mart. (Sapindaceae)/cipó-sangue	Leaf/conical	Ornamental	Parasitoids: Braconidae, Eulophidae, Eurytomidae, *Dimeromicrus cecidomyiae* Ashmead, 1887 (Torymidae), Platygastridae (Hymenoptera) Gall modifier: Eulophidae (Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Maricá, São Francisco de Itabapoana, São João da Barra, Saquarema), SP (Bertioga)	Carvalho-Fernandes *et al.* (2016), Maia (2001a, b, 2013a), Maia & Azevedo (2009), Maia & Carvalho-Fernandes (2016), Maia *et al.* (2008), Santos *et al.* (2009)
Perasphondylia mikaniae Gagné, 2001	*Mikania glomerata* Spreng. (Asteraceae)/guaco	Bud/ovoid	Edible (as tea), medicinal (treatment of asthma and bronchitis)	Parasitoids: Hymenoptera	Brazil: RJ (Itatiaia, Silva Jardim), SP (Bertioga), RS	Gagné *et al.* (2001), Maia (2013a), Maia *et al.* (2008), Maia & Mascarenhas (2017), Mendonça *et al.* (2014), Skuhravá (1989), Teske & Trentini (1997), Useful Tropical Plants (2014)
Schizomyia spherica Maia & Oliveira, 2007	*Microstachys corniculata* (Vahl) Griseb. (Euphorbiaceae)/ falsa-guanxuma, guanxuma-de-chifre	Bud/spherical	Medicinal (treatment of headaches, heart problems, sores, thrush, wounds and cuts)	Parasitoids: Eulophidae (Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Carapebus, Maricá, Saquarema)	Maia (2013a), Maia & Azevedo (2009), Maia & Oliveira (2007), Useful Tropical Plants (2014)
Stephomyia clavata (Tavares, 1920)	*Eugenia astringens* Cambess. (Myrtaceae)/aperta-goela	Leaf/claviform	Medicinal (treatment of diarrhea)	Parasitoids: Eulophidae (Hymenoptera)	Brazil: RJ (Carapebus, Rio de Janeiro), BA (Madre de Deus)	Maia (1994, 2001a, 2013a), Maia *et al.*: 2005, Maia & Azevedo (2009), Maia & Silva (2016), Santos *et al.* (2009), Tavares (1920)
Stephomyia mina Maia, 1994	*Neomitranthes obscura* (DC.) N.J.E. Silveira (Myrtaceae)/ cambuí-preto	Leaf/elliptical	Edible fruit, medicinal (treatment of diarrhea), fuel and charcoal	Parasitoids: Braconidae (Hymenoptera)	Brazil: RJ (Araruama, Arraial do Cabo, Carapebus, Maricá)	Carvalho-Fernandes *et al.* (2016), Maia (1993, 1995, 2001a, 2013a), Maia & Azevedo (2009), Santos *et al.* (2009), Useful Tropical Plants (2014)
Stephomyia rotundifoliorum Maia, 1994	*Eugenia astringens* Cambess. (Myrtaceae)/aperta-goela	Bud/cylindrical	Medicinal (treatment of diarrhea)	Parasitoids: *Dimeromicrus cecidomyiae* (Torymidae), *Donquickeia* sp. (Braconidae), *Eurytoma* sp. and *Rileya* sp. (Eurytomidae), Eulophidae, Eupelmidae, Platygastridae, Scelionidae, Torymidae (Hymenoptera) Modifiers: Hymenoptera Predators: *Novohorus* sp. (Olpiidae, Pseudoscorpiones)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Carapebus, Maricá, São João da Barra, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (1994, 2001a, 2013a), Maia *et al.*: 2005, Maia & Azevedo (2009), Monteiro *et al.* (1994), Santos *et al.* (2009), Tavares (1920)
Youngomyia pouteriae Maia, 2001	*Pouteria caimito* (Ruiz &Pav.) Radlk. (Sapotaceae)/abil	Leaf/cylindrical	Edible, carpentry (construction and external work)	Parasitoids: *Dimeromicrus cecidomyiae* (Torymidae), *Xanthellum* (Eulophidae), Eupelmidae, Platygastridae, (Hymenoptera) Inquiline: *Trotteria quadridentata* Maia, 2001c (Cecidomyiidae, Diptera)	Brazil: RJ (Araruama, Arraial do Cabo, Cabo Frio, Maricá, Rio de Janeiro, São João da Barra, Saquarema)	Carvalho-Fernandes *et al.* (2016), Maia (2001a, c, 2013a), Maia & Azevedo (2009), Monteiro *et al.* (1994), Oliveira & Maia (2005), Useful Tropical Plants (2014)
Hemiptera, Eriococcidae:						
Nothotrioza tavaresi (Crawford, 1925) (Psyllidae)	*Psidium cattleianum*	Leaf/lenticular	Edible, flowers used as a garnish, medicinal (treatment for haemorrhages), agroforestry, ornamental, used for lathe work, tool handles and for objects that require much resistance, fuel and charcoal	No data	Brazil: BA, RS	Burckhardt & Queiroz (2012), Carneiro *et al.* (2012), Crawford (1925), Mendonça *et al.* (2014), Tavares (1921, 1922)
Tectococcus ovatus Hempel, 1990	*Psidium cattleyanum* Sabine (Myrtaceae)/araçá	leaf/biconvex	Edible, flowers used as a garnish, medicinal (treatment for haemorrhages), agroforestry, ornamental, used for lathe work, tool handles and for objects that require much resistance, fuel and charcoal	Parasitoids: *Metaphycus flavus* Howard, 1881 (Encyrtidae), *Aprostocerus* sp. (Eulophidae) (Hymenoptera) Predator: *Hyperaspis delicata* Massuti & Vittorino, 1997 (Coccinellidae, Coleoptera)	Brazil: RJ (Angra dos Reis), PR (Curitiba), RS	Angelo & Maia (1999), Hempel (1990), Maia (2013a), Maia & Oliveira (2010), Santos *et al.* (2009), Useful Tropical Plants (2014), Vittorino *et al.* (2007)

About 78% of the galling species compiled have been recorded only in Southeast Brazil, and about 64% only in the state of Rio de Janeiro, although their host plant species have broader geographic distributions. These inconsistencies between galler and host distributions are likely the result of a lack of data. For example, until two years ago *Lopesia caulinaris* Maia, 2003, *L. cylindrica* Maia, 2003 and *L. linearis* Maia, 2003 were known only from Southeast Brazil, but as the result of the examination of galled exsiccates deposited in several herbaria, the extent of their known distribution was greatly expanded, even to include other countries of South and Central America (Arriola *et al.,* 2016).

Biological data for the economically important gallers cited in the present study are scarce. To date, the population dynamics of only nine species [*Clusiamyia nitida* Maia, 1997, *Cordiamyia globosa* Maia, 1996a, *Dasineura gigantea* Angelo & Maia, 1999, *Dasineura globosa* Maia, 1993b, *Eugeniamyia dispar* Maia, Mendonça & Romanovski, 1996, *Myrciamyia maricaensis* Maia, 1996c, *Stephomyia rotundifoliorum* Maia, 1994, *Nothotrioza tavaresi* (Crawford, 1925), and *Tectococcus ovatus* Hempel, 1990] have been studied (Maia, 1999a; Maia & Tavares, 2000; Angelo, 2007, 2008; Mendonça & Romanoswki, 2002a; Ferraz & Monteiro, 2003; Butignol & Pedrosa-Macedo, 2003; Vitorino *et al.,* 2000).

Data on natural enemies are also deficient, since most records have been published at the taxonomic levels of family and genus. Natural enemies include mainly parasitoids, which are associated with 43 galling species (about 74%) and are represented exclusively by Hymenoptera of 13 families: Aphelinidae, Bethylidae, Braconidae, Elasmidae, Encyrtidae, Eulophidae, Eupelmidae, Eurytomidae, Mymaridae, Platygastridae, Pteromalidae, Scelionidae, and Torymidae. Most records of natural enemies are at the taxonomic levels of family (n = 43; about 51%) and genus (n = 26; about 32%), with other categories totaling about 16% (order n = 7, tribe n = 1, subtribe n = 1 and species n = 5)

At least 16 cecidogenous species are attacked by more than one species of parasitoid. Among these, *Stephomyia rotundifoliorum, Cordiamyia globosa, Lopesia erythroxyli* Rodrigues & Maia, 2010, *Paulliniamyia ampla* Maia, 2001b, *Dasineura ovalifoliae* Maia & Carvalho-Fernandes, 2011 and *Youngomyia pouteria* e Maia, 2001c, host the greatest richness of parasitoids (9, 7, 5, 5, 4, and 4 species, respectively). However, the role of each of these species in controlling the population of their host remains unknown, as does their level of specificity, which are essential data for evaluating their potential effectiveness as biological control agents.

Predators, inquilines and even free-living larvae that feed on galls have also been reported. The first, represented by cecidomyiids, pseudoscorpions, beetles, and ants, have been associated with five galling species and include records mainly at the genus level (n = 5), but also at the family (n = 1) and species (n = 1) levels. Although the last two guilds are phytophagous, they can cause death to the galler by interfering with gall growth, changing its morphology (in this case, they are referred to as gall modifiers), destroying the gall or competing with the inducer for internal space and food. The inquilines are represented by cecidomyiids and beetles. The former have been associated with three gall-inducing species and their records are at the genus (n = 2) and species (n = 1) levels, while the latter were found in a single gall. Finally, the free living species, recorded only in galls of *Neomitranthes obscura* (DC.) N.J.E. Silveira, are represented by a single species of moth, *Stenoma annosa* (Butler, 1877) (Oecophoridae, Lepidoptera). This moth is a facultative inquiline, which feeds on leaves of species of Myrtaceae in restingas as well as on galled tissues. Since the caterpillar is highly voracious, it can destroy numerous galls, which always results in the galler's death (*personal observation*).

The impacts of all of these guilds on galler populations is poorly known since few studies on their biology have been published. In fact, data on parasitoidism and predation rates are known only for the nine cecidogenous species: *Clusiamyia nitida, Cordiamyia globosa, Dasineura gigantea, Dasineura globosa, Eugeniamyia dispar, Myrciamyia maricaensis, Stephomyia rotundifoliorum, Nothotrioza tavaresi,* and *Tectococcus ovatus* (Maia, 1999a; Maia & Tavares, 2000; Mendonça & Romanowski, 2002b; Bierhals *et al.,* 2012; Ferraz & Monteiro, 2003; Butignol & Pedrosa-Macedo, 2003; Vitorino *et al.,* 2000).

Most of the gallers found in the present study are associated with edible and/or medicinal plant species (about 59% and 68%, respectively), but there are also records of associations with plants used in agroforestry and carpentry, or as ornamentals and repellents, among others (Table 2). Some host plants have several uses, which explains the association percentages summing to more than 100%.

Although 58 gall-inducing species were identified in the present study, the number of insect galls associated with plants of economic interests in restinga environ-

Table 2. Number species host plants of economic importance and their gall-inducing insect species of Brazilian restingas (Atlantic Forest).

Host plant	Number of gall-inducing species	
	Use	Number species
Carpentry	24	19
Edible	34	34
Medicinal	33	39
Agroforestry	14	13
Fuel and charcoal	13	8
Ornamental/garnish	12	11
Cabinet making	9	0
Used to make ropes/whips	4	3
Ceramic	3	—
Pesticidal/repellent	3	4
Hair/body oil	2	1
Source of tannins	2	2
Aromatic baths	1	—
Soap manufacture and lubrication	1	1
Veterinary medicine	1	1
Weaving baskets	1	—
Textile dyes	1	2

ments is about three times greater, since a total of 186 gall morphotypes have been reported. Thus, 128 morphotypes were not included since the gall-inducing species remain undetermined. These data reveal the present deficiency of the taxonomical knowledge regarding galling taxa. Reasons for this scenario include: 1) a yet poorly understood Brazilian fauna; 2) few taxonomists focused on cecidogenous insects; 3) rearing gallers is difficult due to high mortality rates and little biological data, so there is often insufficient material for study; and 4) several studies have focused on ecological patterns, and do not consider galler identification.

This is the first list of cecidogenous insects of potential economic importance in Brazil, or in the Neotropical Region for that matter. Other areas of the world are better represented by such efforts, such as those of Barnes, 1946a, b, 1948, 1949, 1951, for the Nearctic Region, and Nijveldt, 1969; Harris, 1966; Jiang, 1994; and Skuhravá, 1997 in the Palearctic Region. However, it must be remembered that as far as the Neotropical Region and Brazil are concerned, the present list is partial, as it focuses only on restinga environments. Nonetheless, this work represents a starting point for future compilations.

CONCLUSIONS

Restinga environments harbor a great number of gall-inducing species of potential economic importance. Knowledge of their geographic distributions, biology and impacts on host plants remains deficient, and their role as pests needs to be evaluated. There remains a large number of undetermined cecidogenous species, so an effort to identify them, perhaps through rearing, is essential. Since this list is restricted to restingas, studies of other phytophysiognomies will certainly amplify knowledge regarding the gall-inducing insects of potential economic importance in Brazil.

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