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Richness of hymenopterous galls from South America

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ABSTRACT

An overview of hymenopterous galls from South America is presented here based on literature as well as on data from the insect gall collection of the Museu Nacional/UFRJ. Seventy-three galls have been recorded on 71 host plants. Myrtaceae and Fabaceae are the plant families with the greatest number of galled species and gall morphotypes. Gall richness per plant species varied from one to two. The stem and bud were the most galled plant organs. The gallers comprise eight hymenopteran families, the best-represented being Eulophidae, Eurytomidae, and Cynipidae. Geographic records are restricted to six countries, and the majority is from Brazil.

Key-Words: Diversity; Geographical distribution; Insect plant interaction.

INTRODUCTION

Galls are predictable and consistent plant deformations that occur in response to feeding or other stimuli by foreign organisms (Gagné, 1994). The gall formation is characterized by abnormal growth of plant tissues by cell hypertrophy and hyperplasia (Price, 2005). Insect galls are considered the most sophisticated herbivore interactions of nature (Shorthouse *et al.,* 2005). Galling insects have the ability to manipulate the development of plant tissue and promote its growth (Stone & Schönrogge, 2003). The development of these structures has resulted from an adaptive strategy of many insects to obtain food and even protection against predators (Stone & Schönrogge, 2003). Among the insects, Diptera, Lepidoptera, Hemiptera, Coleoptera, Hymenoptera and Thysanoptera include galling species (Mani, 1964).

Gall midges (Diptera, Cecidomyiidae) are the most common galling insects in all biogeographic regions (Felt, 1940). In the Neotropical region, Hemiptera are the second most diversified and frequent gallers, followed by Lepidoptera and Coleoptera, being responsible for about 135, 110 and 80 gall morphotypes (Maia, 2006 and 2012). Thysanoptera are the least frequent ones with only 14 records in the Neotropics (Maia, 2006). Hymenopteran gallers are very frequent in Europe and North America, where records of galls induced by Tenthredinidae (sawflies), Cynipidae (gall wasps), Agaonidae (fig wasps), Braconidae, Eurytomidae, Eulophidae, and others families are found (Felt, 1940; Wehrmaker, 1998; Zinovjev, 1998).

Nevertheless, little is known about the diversity of hymenopterous galls in South America, as data are scattered in several insect gall inventories. There is a single previous compilatory study, published by Houard in 1933, which includes Hymenopterous galls. This author organized a catalog of galls induced by arthropods and nematodes. But even in Houard, 1933, the information about Hymenopteran gallers is pulverized. The present work is the first attempt to gather and upgrade this information.

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This paper aims to answer the following questions: (1) How many hymenopterous galls have been recorded in South America? (2) How many plant families are galled by Hymenoptera? (3) Which plant families are the most galled? (4) Is there a preference for any plant organ? (5) What is known about the taxonomy of these gallers? (6) Which hymenopteran families induce galls in this region? (7) Among them, which are the most common? and (8) What is known about the geographic distribution of these gallers?

MATERIAL AND METHODS

Data on hymenopterous galls were compiled based on data from the insect galls collection of Museu Nacional/UFRJ as well as on literature. The catalog of Houard, 1933 was used as a starting point and reference to previous publications. From 1933 to 2010, the research was based on the Web of Science, focusing upon host plant, galled plant organ, galling wasp and locality. The following papers were examined: Rübsaamen (1899, 1907, 1908), Tavares (1909, 1914), Kieffer & Jörgensen (1910), Brèthes (1915, 1918, 1922), Ferriére (1924), Houard (1933), Gomes (1943), Costa-Lima (1962), Fernandes *et al.* (1988), Arduin *et al.* (1989), Monteiro *et al.* (1993), Kraus *et al.* (1998), Kraus & Tanque (1999), Gonçalves-Alvim & Fernandes (2001), Ronquist & Liljeblad (2001), DalMolin *et al.* (2004), Maia & Fernandes (2004), Urso-Guimarães & Scareli-Santos (2006), Gates & Delvare (2008), Ros-Farré & Pujade-Villar (2009), Penteado-Dias & Carvalho (2008), Coelho *et al.* (2009), Pereira (2010) and Leite *et al.* (2011).

The Hymenopteran species names were checked in the Universal Chalcidoidea Database (Noyes, 2011). The botanical names and authors were checked in the websites Tropicos® (Tropicos.org) and Angiosperm Phylogeny Group III.

RESULTS AND DISCUSSION

Seventy-three hymenopterous galls have been recorded in South America. These galls occurred on 71 plant species distributed among 21 plant families of angiosperms. No galls were recorded on gymnosperms. The great majority of the host plants (about 90%) belong to dycotiledons. Only two families of monocotyledons were galled: Araceae and Orchidaceae. Myrtaceae and Fabaceae are the plant families with the greatest number of host plant (18 and 16, respectively) and gall morphotypes (18 and 19, respectively). These two families comprise about 50% of the recoded galls (Table 1).

The gall richness per plant species varied little (from one to two). The great majority (97%) presented only one gall morphotype; the only exceptions are *Prosopis alba* Griseb and *P. campestris* Griseb (Fabaceae) with two morphotypes respectively (Table 1). The plant genera with the greatest number of galled species are *Eugenia* L. (Myrtaceae) (09 spp.), *Erythroxylum* P. Browne (Erythroxylaceae) (05 spp.) and *Psidium* L. (Myrtaceae) (04 spp.) (Table 1).

TABLE 1: Distribution of hymenopterous galls from South America per host plant families and species.

Host family (n = 21)	Host plant (n = 71)	Number of Hymenopterous galls (n = 73)
Anacardiaceae	*Schinus dependens* Ortega	01
	S. weinmanniaefolia Engl.	01
Annonaceae	*Duguetia furfuracea* (St. Hil.) Benth. & Hook.	01
Araceae	*Philodendron selloum* C. Koch	01
	P. dubium Chodat & Vischer	01
	P. petraeum Chodat & Vischer	01
	Philodendron sp.	01
Boraginaceae	*Cordia curassavica* (Jacq.) R. & S.	01
Caryocaraceae	*Caryocar brasiliense* Camb.	01
Erythroxylaceae	*Erythroxylum campestre* St. Hill.	01
	E. citrifolium A.St.-Hil.	01
	E. frangulifolium St. Hill.	01
	E. ovalifolium Peyr	01
	E. vaccinifolium Mart.	01
Euphorbiaceae	*Colliguaya brasiliensis* Müll. Arg.	01
	Colliguaya odorifera Mol.	01
	Sapium sp.	01
	Tragia volubilis L.	01

Continuation of Table 1.

Host family (n = 21)	Host plant (n = 71)	Number of Hymenopterous galls (n = 73)
Fabaceae	*Acacia cavenia* Bert.	01
	Calliandra bicolor Benth.	01
	Canavalia ensiformis (L.) DC.	01
	Copaifera sp.1	01
	Copaifera sp.2	01
	Copaifera langsdorfii Desf.	01
	Cratylia mollis Mart. ex Benth	01
	Gourliea decorticans Gill.	01
	Inga sp.	01
	Machaerium sp.	01
	Mimosa biuncifera Benth.	01
	Peltogyne sp.	01
	Prosopis alba Griseb	02
	P. alpataco Phil.	01
	P. campestris Griseb	02
	Swartzia sp.	01
Fagaceae	*Nothofagus antarctica* Oerst	01
Lauraceae	*Nectandra lanceolata* Ness	01
	Ocotea opifera Mart	01
Loranthaceae	*Struthanthus vulgaris* Mart.	01
Malpighiaceae	*Byrsonima coccolobifolia* H.B. & K.	01
Moraceae	*Ficus doliaria* Mart.	01
	Ficus noronhae Oliver	01
	Ficus sp.	01
Myrsinaceae	*Cybiantus* sp.	01
Myrtaceae	*Blepharocalyx salicifolium* (Kunth) O. Berg.	01
	Corymbia citriadora Hill & Johnson (introduced species)	01
	Eucalyptus camaldulensis Dehn. (introduced species)	01
	Eugenia acuminatissima Berg.	01
	E. axillaris (Willd.)	01
	E. copacabanensis Kiaersk	01
	E. jaboticaba (Vell.) Kiaersk	01
	E. ovalifolia Camb.	01
	E. punicifolia (H.B. e K.) DC	01
	Eugenia sp.1	01
	Eugenia sp.2	01
	Eugenia sp.3	01
	Myrcia torta DC.	01
	Neomitranthes obscura (DC) N.J.E. Silveira	01
	Psidium cattleyanum Sab.	01
	P. cinereum Mart. ex DC	01
	P. guayava L.	01
	Psidium sp.	01
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz.	01
Orchidaceae	*Cattleya gutata* Lindl.	01
	Cattleya sp.	01
	Laelia sp.	01
Rhamnaceae	*Scutia buxifolia* Reiss.	01
Sapindaceae	*Paullinia elegans* Camb.	01
	Serjania sp.	01
	Urvillea uniloba Radlk.	01
Vochysiaceae	*Qualea parvifolia* Mart.	01
Winteraceae	*Drymis brasiliensis* Miers.	01

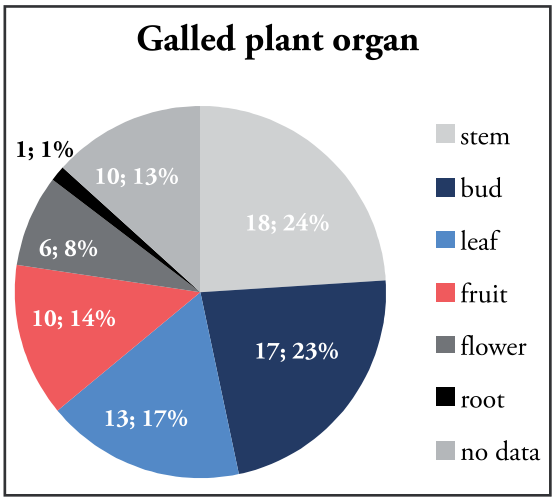

FIGURE 1: Distribution of Hymenopteran gallers from South America per plant organ.

The galls were recorded on several plant organs, such as stem, bud, leaf, fruit, flower and aerial root. Stem and bud were the most galled plant organs (around 48%), and flower and aerial root were the least galled (around 9.4%) (Figure 1).

The taxonomy of the galling wasps is still incipient. Only 28 gallers (about 38%) are identified at species level (Tables 2 and 3). The majority of the records are in wider categories. The gallers comprise eight hymenopteran families (Agaonidae, Cynipidae, Eulophidae, Eurytomidae, Figitidae, Pteromalidae, Scelionidae, and Tanaostigmatidae), the best-represented being Eulophidae, Eurytomidae, and Cynipidae with 13, 08 and 06 species, respectively. They also comprise 14 genera: *Aditrochus* Rübsaamen, 1902, *Chrysocharis* Förster, 1856, *Eurytoma* Illiger, 1807, *Neohyperteles* De Santis, 1957, *Proseurytoma* Kieffer, 1910, *Tanaostigma* Howard, 1890, and *Tetrastichus* Haliday, 1844 (all represented by only one species), *Minapis* Brèthes, 1916, and *Tanaostigmodes* Ashmead, 1896 (each represented by two species), *Eschatocerus* Mayr, 1881, *Myrtopsen* Rübsaamen, 1908, *Prodecatoma* Ashmead, 1904, and *Rileya* Ashmead, 1888 (each represented by three species). *Aprostocetus* Westwood, 1833 the best represented genus, has five galling species in South America (Table 2).

These hymenopteran genera differ in species richness as well as in geographic distribution. *Eurytoma, Aprostocetus,* and *Tetrastichus* are very large and cosmopolitan genera, with about 700, 750 and 500 described species (Gates & Delvare, 2008; Noyes, 2011). *Chrysocharis, Tanaostigmodes, Rileya,* and *Prodecatoma* are also worldwide, but less diversified with about 140, 65, 65, and 50 known species (Hanson, 1987, Noyes, 2011). The others (*Tanaostigma, Myrtopsen, Aditrochus, Minapis, Eschatocerus, Neohyperteles,* and *Proseurytoma*) comprise few species (about 11, 09, 03, 03, 02 and 01 species, respectively), and are mainly or exclusively Neotropical genera (Noyes, 2011; Ronquist & Liljeblad, 2001; Ros-Farré & Pujade-Villar, 2009).

Regarding the families of Hymenoptera, Eulophidae are associated with 10 plant families (Araceae, Euphorbiaceae, Myrtaceae, Sapindaceae, Lauraceae, Annonaceae, Boraginaceae, Caryocaraceae, Erythroxylaceae, and Winteraceae), Araceae being the plant family with the greatest number of galled species (04), followed by Euphorbiaceae (03), Lauraceae, Myrtaceae and Sapindaceae (02 each). Only one species of the other plant families was galled. The majority of the Eulophidae galling species was monophagous. Only three were oligophagous: *Chrysocharis gallicola* (Costa-Lima, 1930) which induced galls on two species of *Psidium* L. (Myrtaceae), *Aprostocetus gallicola* (Ferrière, 1924) on four species of *Philodendron* Schott (Araceae), and *A. verticillata* (Brèthes, 1913) on two genera of Euphorbiaceae (Table 2). Eurytomidae are associated with four plant species: Fabaceae, Orchidaceae, Myrtaceae, and Euphorbiaceae, galling two species of each family, except Euphorbiaceae, with a single host plant (Table 2). Cynipidae are associated mainly with Fabaceae, but there is a single species associated with Anacardiaceae. Four species of Cynipidae are monophagous, and two are oligophagous, namely: *Eschatocerus myriadeus* Kieffer & Jörgensen, 1910, and *E. niger* Kieffer & Jörgensen, 1910, both inducing galls on two species of *Prosopis* L., (Fabaceae) (Table 2). Tanaostigmatidae are associated with two plant species: Fabaceae (three galling species) and Rhamnaceae (a single galling species). All Tanaostigmatidae gallers are monophagous, except for *Tanaostigma chapadae* (Ashmead, 1904), which induce galls on three genera of Fabaceae.

The South American fauna of hymenopteran gallers differ from Holarctic fauna, mainly by the absence of gall forming sawflies (Tenthredinidae) and by the higher diversity of gall-forming Eulophidae, Eurytomidae and Cynipidae. The geographic records are restricted to six countries, and the majority is from Brazil (around 68%; Figure 2), where most of the surveys have been developed.

CONCLUSIONS

Hymenoptera galls are less diversified in South America than in Nearctic and Palearctic regions. The

TABLE 2: Distribution of Hymenopteran gallers from South America per plant, plant organ and country.

Galling family	Galling species	Host plant	Plant organ	Country
Agaonidae (n = 01)	sp.	*Ficus* sp.	Flower	Brazil
Chalcidoidea (n = 03)	sp.1	*Acacia cavenia*	Bud	Paraguay
	sp.2	*Gourliea decorticans*	Bud and stem	Argentina
	sp.3	Not determined	Leaf	French Guyana
Cynipidae (n = 06)	*Eschatocerus acaciae* Mayr, 1881	*Acacia cavenia*	Stem	Uruguay
	E. myriadeus Kieffer & Jörgensen, 1910	*Prosopsis alpataco* and *P. campestris*	Stem Stem	Argentina Argentina
	E. niger Kieffer & Jörgensen, 1910	*P. alba* and *P. campestris*	Bud and stem Bud	Argentina Argentina
	sp.1	*Schinus weinmanniaefolia*	Stem	Argentina and Brazil
	sp.2	*Peltogyne* sp.	Leaf	Brazil
	sp.3	*Machaerium* sp.	Bud	Brazil
Eulophidae (n = 13)	*Aprostocetus bahiensis* (Costa-Lima, 1959)	*Ocotea opifera*	Fruit	Brazil
	A. colliguayae (Philippi, 1873)	*Colliguaya odorifera*	No data	Chile
	A. bondari (Costa-Lima, 1959)	*Paullinia elegans*	Fruit	Brazil
	A. gallicola (Ferrière, 1924)	*Philodendron selloum,* *P. petraeum,* *P. undulatum,* *Philodendron* sp.	Flower Flower Flower Flower	Paraguay Paraguay Paraguay Paraguay
	A. verticillata (Brèthes, 1913)	*Sapium* sp. *Colliguaya brasiliensis*	No data No data	Argentina Brazil
	Neohyperteles euplectriformis De Santis, 1957	*Nectandra lanceolata*	No data	Argentina
	Chrysocharis gallicola (Costa-Lima, 1930)	*Psidium guayaba* and *Psidium* sp.	No data No data	Brazil Brazil
	Tetratichus urvilleae (De Santis, 1957)	*Urvillea uniloba*	Fruit	Argentina
	sp.1	*Cordia curassavica*	Stem	Brazil
	sp.2	*Erythroxylum frangulifolium*	Stem	Brazil
	sp.3	*Drimys brasiliensis*	Stem	Brazil
	sp.4	*Duguetia furfuracea*	Leaf	Brazil
	sp.5	*Caryocar brasiliense*	Leaf	Brazil
Eurytomidae (n = 08)	*Rileya haumani* (Brèthes, 1918)	*Tragia volubilis*	Flower	Argentina
	R. nigra (Gomes, 1943)	*Cattleya gutata*	Root	Brazil
	R. cearae (Crawford, 1910)	Not determined	No data	Brazil
	Eurytoma orchideadrum (Westwood, 1869)	*Cattleya* sp.	Stem	Brazil
	Prodecatoma carpophaga DalMolin, Melo & Perioto, 2004	*Psidium cattleyanum*	Fruit	Brazil
	P. parodii Brèthes, 1922	*Prosopis alba*	Stem	Argentina
	P. petrodoma DalMolin, Melo & Perioto, 2004	*Psidium cinereum*	Fruit	Brazil
	Proseurytoma gallarum Kieffer, 1910	*Gourliea decorticans*	Bud	Argentina
Figitidae (n = 03)	*Myrtopsen mayri* Rübsaamen, 1907	*Eugenia acuminatissima* and *Eugenia* sp.	Leaf Leaf	Brazil Brazil
	M. luderwalti Dettmer, 1930	*Eugenia jaboticaba*	No data	Brazil
	M. rodovalhoi Dettmer, 1930	*Mimosa biuncifera*	No data	Brazil
Pteromalidae (n = 01)	*Aditrochus fagicolus* Rübsaamen, 1902	*Nothofagus antarctica*	Leaf	Argentina
Scelionidae (n = 01)	sp.	*Struthanthus vulgaris*	Leaf	Brazil
Tanaostigmatidae (n = 05)	*Minapis maculiventris* Gomes, 1941	*Inga* sp.	Leaf	Brazil
	M. nigra Brèthes, 1916	*Scutia baccifolia*	Leaf	Brazil
	Tanaostigma chapadae (Ashmead, 1904)	*Canavalia ensiformis,* *Cratylia mollis* and *Inga* sp.	Seed Seed Seed	Brazil Brazil Brazil
	Tanaostigmodes ringueleti (Brèthes, 1924)	*Calliandra bicolor*	Bud	Argentina
	T. kiefferi (Mayr, 1905)	Not determined	No data	Paraguay

TABLE 3: Distribution of Hymenopteran gallers (records at order category) from South America per plant, plant organ and country.

Host Plant		Nº of galls (n = 22)	Plant organ	Country
Family	**Species**			
Anacardiaceae	*Schinus dependens*	01	Bud	Brazil
Erythroxylaceae	*Erythroxylum campestre*	01	Bud	Brazil
		01	Leaf	Brazil
	E. ovalifolium	01	Stem	Brazil
Fabaceae	*Copaifera langsdorfii*	01	Bud	Brazil
	Copaifera sp.1	01	Leaf	Brazil
	Copaifera sp.2	01	Bud	Brazil
	Swartzia sp.	01	Bud	Brazil
Malpighiaceae	*Byrsonima coccolobifolia*	01	Bud	Brazil
Moraceae	*Ficus doliaria*	01	Fruit	Brazil
	F. noronhae	01	Leaf	Brazil
	Ficus sp.	01	Fruit	Brazil
Myrsinaceae	*Cybianthus* sp.	01	Bud	Brazil
Myrtaceae	*Eugenia copacabanensis*	01	Stem	Brazil
	E. ovalifolia	01	Stem	Brazil
	Eugenia sp.1	01	Bud	Brazil
	Eugenia sp.2	01	Bud	Brazil
	Myrcia torta	01	Bud	Brazil
	Neomitranthes obscura	01	Stem	Brazil
Nyctaginaceae	*Guapira opposita*	01	Stem	Brazil
Sapindaceae	*Serjania* sp.	01	Stem	No data
Vochysiaceae	*Qualea parvifolia*	01	Stem	Brazil

gallers are represented by eight families. The most common of these are Eulophidae, Eurytomidae, and Cynipidae. There is no record of Tenthredinidae galls. Hymenopteran galls were more frequent on stems and buds. The taxonomy of the galling species is still incipient.

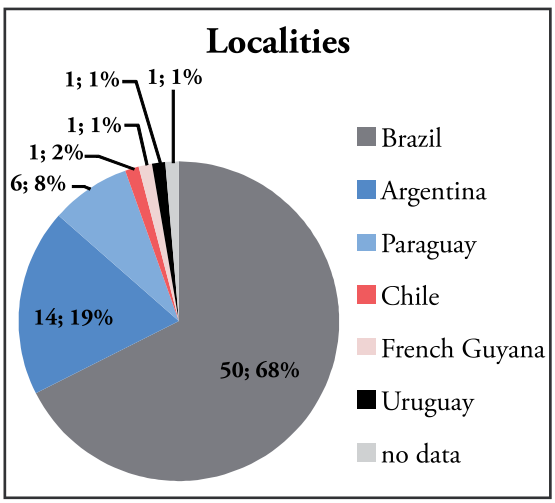

FIGURE 2: Distribution of the records of Hymenopteran gallers from South America per country.

RESUMO

Uma abordagem geral de galhas de himenópteros da América do Sul é apresentada aqui com base na literatura e na coleção de galhas de insetos do Museu Nacional/UFRJ. Setenta e três galhas estão registradas em 71 espécies de plantas hospedeiras. Myrtaceae e Fabaceae são as famílias de planta com maior número de espécies hospedeiras e de morfotipos de galhas. A riqueza de galhas por espécie botânica variou de um a dois. Caule e gema foram os órgãos da planta mais atacados. Os galhadores compreendem oito famílias de Hymenoptera, tendo Eulophidae, Eurytomidae, e Cynipidae maior representatividade. Os registros geográficos estão restritos a seis países, sendo a maioria do Brasil.

PALAVRAS-CHAVE: Diversidade; Distribuição geográfica; Interação inseto-planta.

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