Gall inducing arthropods from a seasonally dry tropical forest in Serra do Cipó, Brazil

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ABSTRACT. Gall inducing arthropods from a seasonally dry tropical forest in Serra do Cipó, Brazil. Highly diverse forms of galling arthropods can be identified in much of southeastern Brazil's vegetation. Three fragments of a Seasonally Dry Tropical Forest (SDTF) located in the southern range of the Espinhaço Mountains were selected for study in the first survey of galling organisms in such tropical vegetation. Investigators found 92 distinct gall morphotypes on several organs of 51 host plant species of 19 families. Cecidomyiidae (Diptera) was the most prolific gall-inducing species, responsible for the largest proportion of galls (77%) observed. Leaves were the most frequently galled plant organ (63%), while the most common gall morphotype was of a spherical shape (30%). The two plant species, *Baccharis dracunculifolia* (Asteraceae) and *Celtis brasiliensis* (Cannabaceae), presented the highest number of gall morphtypes, displaying an average of 5 gall morphotypes each. This is the first study of gall-inducing arthropods and their host plant species ever undertaken in a Brazilian SDTF ecosystem. Given the intense human pressure on SDTFs, the high richness of galling arthropods, and implied floral host diversity found in this study indicates the need for an increased effort to catalogue the corresponding flora and fauna, observe their intricate associations and further understand the implications of such rich diversity in these stressed and vulnerable ecosystems.

KEYWORDS. Biodviersity; biogeography; host plant family; herbivory; Insect galls; Richness.

RESUMO. Artrópodes indutores de galhas em Floresta Sazonal Tropical Seca da Serra do Cipó, Brasil. Artrópodes indutores de galhas são muito ricos em espécies nas formações vegetais no sudeste do Brasil. Três fragmentos de Floresta Sazonal Tropical Seca (FSTS) foram selecionados nas montanhas do sudeste da cadeia do Espinhaço para a primeira pesquisa de organismos indutores de galhas nesse tipo de vegetação. Encontramos 92 morfotipos distintos de galhas em vários órgãos de 51 espécies de plantas hospedeiras pertencentes à 19 famílias. A maioria das galhas (77%) foi induzida pela família Cecidomyiidae (Diptera). A folha foi o órgão mais atacado (63%), enquanto o morfotipo mais comum foi a forma esférica (30%). As espécies hospedeiras que apresentaram um maior número de morfotipos de galhas foram *Baccharis dracunculifolia* (Asteraceae) e *Celtis brasiliensis* (Cannabaceae), cada uma com cinco morfotipos de galha. Este é o primeiro estudo com galhas induzidas por artrópodes em áreas FSTS no Brasil. Dada a intensa pressão antrópica nas áreas de FSTS, a alta riqueza encontrada nesse estudo de artrópodes indutores de galhas aponta a necessidade de um maior esforço para se compreender a diversidade desses ecossistemas.

PALAVRAS-CHAVE. Biodiversidade; biogeografia; família de plantas hospedeiras; herbivoria; insetos galhadores; riqueza.

Galls are produced by an abnormal increase in the number and/or size of plant cells resulting in the formation of a symmetrical structure(s) on one or more organs of a host plant (Mani 1964; Raman 2007). Three influences give rise to the specific gall phenotype, namely: the genotype of the arthropode, the genotype of the host plant and general environmental factors such as heat, drought, soil composition, etc. (Weis *et al.* 1988). From an evolutionary perspective, insect galls can be regarded as extended phenotypes of the inducers, unique in that the parasitic arthropod induces a characteristic adaptation within the host plant that benefits itself and its offspring. Galls developed by host plants provide gall-inducers a refuge for their larvae that supplies tissues of high nutritional quality and protection from harsh environmental conditions and from natural enemies (Price *et al.* 1986; 1987; Nyman & Julkunen-Tiitto 2000; Stone & Schönrogge 2003).

Galls are induced by an enormous array of organisms, but those induced by insects are the most speciose (Mani 1964). Recent galling richness estimates suggest a low of 21,000 to as many as 211,000 gall-inducing arthropod species on earth (Espírito-Santo & Fernandes 2007). Only a very small fraction of these phenotypes have been catalogued in a systematic manner. Galls induced by insects are argued to be especially abundant in plant species found in hot and dry habitats, and also are numerous in as sclerophyllous host plants in both tropical and temperate regions (Fernandes & Price 1988, 1991; Lara & Fernandes 1996; Price *et al.* 1998).

The Neotropics, rupestrian fields and Cerrado (savanna) were identified as vegetation types with the highest richness of galling insects in the world (Lara & Fernandes 1996). Although many surveys were performed in various Brazilian biomes [e.g., Atlantic Rainforest (Fernandes *et al.* 2001; Mendonça 2007), Cerrado (Fernandes *et al.* 1988; Gonçalves-

Alvim & Fernandes 2001; Maia & Fernandes, 2004), Pantanal (Juliao *et al.* 2002), Amazonian rain forest (Julião *et al.* 2005), Subtropical Seasonal Forest (Dalbem & Mendonça (2006); Restinga (Maia 2001, 2005; Maia *et al.* 2002; Mendonça 2007; Oliveira & Maia 2005)] we are not aware of any studies performed in the Brazilian Seasonally Tropical Dry Forest (STDF). These forests are essentially tree-dominated, closed canopy, fertile soil ecosystems, dominated by the Fabaceae and Bignoniaceae families (Pennington *et al.* 2000). It should be noted that patterns of composition and species dominance can vary even among STDFs limited to the Minas Gerais state (Meguro *et al.* 2007). Dry forests shed at least 50% of their leaves during the dry season, depending upon soil conditions (Ribeiro & Walter 1998; Sánchez-Azofeifa *et al.* 2005). Brazilian dry forests occur in the Cerrados of central Brazil in areas of fertile soils (Ratter *et al.* 1978), and in the Brazilian states of Minas Gerais, Goias, Bahia and border regions of the Amazon (Rizzini 1997; Nascimento *et al.* 2004). When on limestone, the dry forests are called Seasonally Deciduous Forest of Slope (Nascimento *et al.* 2004). Refer to Prado (2000) for a review of the origin and distribution of this unique South American ecosystem.

In this study we will describe the galls induced in host plants by arthropods (insects and mites) inherent to the natural fragments (or islands) of dry forests rooted in a limestone substrate and located in southeastern Brazil at the base of Serra do Cipó mountain. This work is part of our efforts to describe 1) the natural history of galling insects; 2) the galls produced by these insects and their host plants in different Brazilian vegetations, particularly in the Seasonally Tropical Dry Forests of the Americas.

MATERIAL AND METHODS

Samples were obtained from various plant specimens found in dry forests covering limestone outcrops in Serra do Cipó, Municipality of Santana do Riacho, MG, in southeastern Brazil. The Serra do Cipó is located in the southern portion of the Espinhaço Range and is dominated by Cerrado and rupestrian field vegetation (Eiten 1978; Giulietti *et al.* 1987). Because most of the dry forests in the region have been subject to disturbances induced by man (cattle, fire, logging, mining), only three fragments of the selected STDF were deemed acceptable for this study: Rancho Cipó (1) coordinates 43º 36’23.0’’W, 19º 19’44.6’’S; Pedreira Mountain (2) coordinates 43º 36’42.3’’W, 19º 18’ 24.1’’S and IBAMA (3) coordinates 43º 36’09.3’’W, 19º 20’24.0’’S. The three fragments are all of similar size, comparable intermediate successional stage with respect to conservation, and are equivalently isolated by anthropic areas as roads, hotels and pasturelands.

Sampling methods used in this study followed those described by Fernandes & Price (1988) and Price *et al.* (1998), specifically, sampling along the trajectory of an “imaginary line,” traveled at a natural walking pace over the course of one hour in each of the three forest fragments. Three field-trained personnel carried out the sampling. Samples were acquired during the wet season, Fevereiro (2007), with plants in full leaf. Only lower branches (within 2.0 m of the forest floor) were sampled. Gall morphospecies were identified based upon their external morphology in combination with the host plant species in which they were found. Usually, galling arthropods induce one or more galls on only one preferred organ of a host plant (Dreger-Jauffret & Shorthouse 1992; Floate *et al.* 1996). For example, 95% of the described cecidomyiid species may be recognized by the gall morphotype formed by their associated host plants (Carneiro *et al.* 2009). The use of morphospecies to represent the richness of gall-inducing arthropods is widely accepted with numerous applications in the literature [e.g., Price *et al.* (1998); Cuevas-Reyes *et al.* (2004); for a review see Carneiro *et al.* (2009)]. Hence, hereinafter in this article we refer to gall morphotypes as true species.

Host plants and galls were collected and brought back to the laboratory for detailed analysis. All plants and galls were mounted and deposited in the Herbarium (BHCB) of the Departamento de Botânica of the Universidade Federal de Minas Gerais. The collected plants were separated into families and were identified to the lowest taxonomic level possible by specialists. The classification of host plants species followed the classification system proposed by the “Angiosperm Phylogeny Group” (APGII 2003, see too Souza & Lorenzi 2005). Galls were separated into species and each species was recorded only once in each area to estimate the gall richness. In the laboratory, galls were photographed and categorized according to color, shape, presence or absence of trichomes (glabrous or pubescent), and organ of the host plant in which they were found. Identification of the gall inducer was made whenever possible.

RESULTS

We recorded 92 galling species induced by arthropods in 19 families, 37 genera and 51 species of host plants in the three fragments of dry forest (Table 1, Figure 1- 6). The family with the highest occurrence of galling species was Fabaceae (24%, Figure 2-3), followed by Myrtaceae (12%, Figure 4-5), and Asteraceae (9%, Figure 1). The genera that supported the highest number of galling species were: *Bauhinia* (Fabaceae), *Myrcia* (Myrtaceae), *Baccharis* (Asteraceae), *Celtis* (Cannabaceae), and *Serjania* (Sapindaceae), which combined, hosted 37% of all galls found. *Baccharis dracunculifolia* (Asteraceae) and *Celtis brasiliensis* (Cannabaceae), exhibited the highest number of galling species residing on any single host plant, with both reaching a maximum of five galling species. The number of galling species differed significantly among arthropod taxa. Cecidomyiidae (Diptera) was the most common galling taxa (77%), followed by Homoptera (6%), Hymenoptera (4%), Lepidoptera (4%), Acarina (2%), and Coleoptera (1%). Galls were mainly induced on leaves (63%) and the most common shape was spherical (30%). Most galls were found in Fragment 3, which concentrated 54% of all galling species, followed by Fragment 2 (40%), and Fragment 1 (35%).

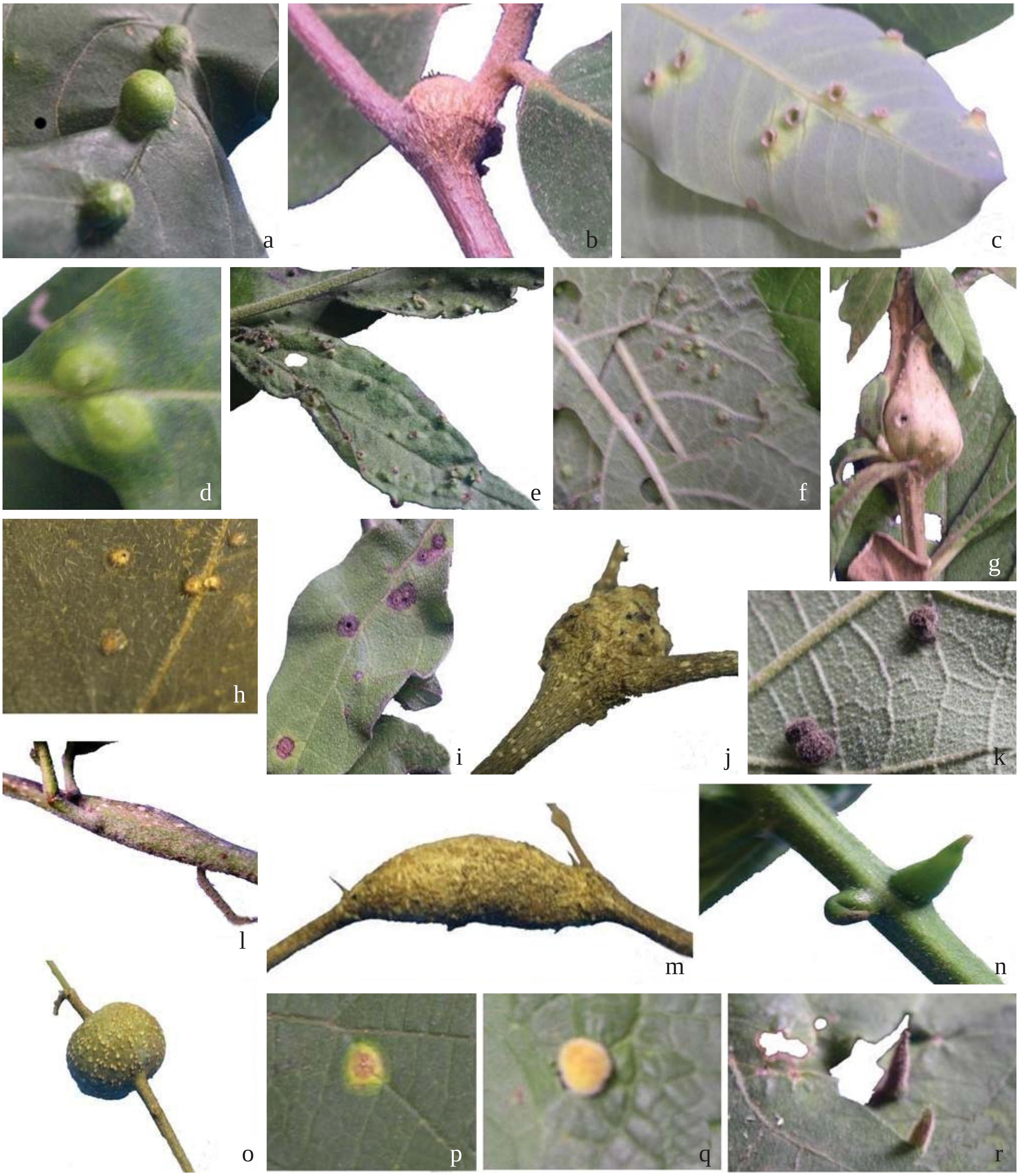

Fig. 1. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Annonaceae (*Rollinia laurifolia* (a) *Rollinia sylvatica* (b), Apocynaceae (*Aspidosperma cylindrocarpon* (c), *Aspidosperma pyrifolium* (d) Asteraceae (*Baccharis* sp. (e), *Vernonanthura phosphorica* (f-g), Boraginaceae (*Cordia trichotoma* (h-l), Cannabacea (*Celtis brasiliensis* (m-q), *Celtis iguanaea* (r).

We recorded 24% galling species occurring in at least two of the forest fragments, while only 6 % occurred in all three fragments. Only 10 % of galling species identified in this study have had been previously reported. Previously reported galling species include *Baccharis dracunculifolia* (Table 1) with 5 galls (Fernandes *et al.* 1996); *Celtis brasiliensis* (Fig. 1 (o), Table 1 with 1 gall (Fernandes *et al.* 1997); *Terminalia argentea* (Fig. 2(c), Table 1 with 1 gall (Fernandes *et al.* 1997); *Bauhinia brevipes* (Fig. 3(b), Fig. 3(d), Table 1 with 2 galls (Fernandes, 1998); all found in Cerrado biomes.

DISCUSSION

A majority of the research on galling organisms occuring in Brazil focuses on two prominent ecosystems, specifically the Cerrado (Fernandes *et al.* 1988; Gonçalves-Alvim &

Fig. 2. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Combretaceae (*Buchenavia tomentosa* (a), *Terminalia argentea* (b-c), Erythroxylaceae (*Erythroxylum citrifolium* (d-e), *Erythroxylum vacciniifolium* (f-g), Fabaceae (*Acacia martii* (h-i), *Acacia* sp.1 (j-k), *Anadenanthera colubrina* (l-m).

Fernandes 2001; Urso–Guimarães *et al.* 2003; Urso–Guimarães & Scarelli-Santos 2006) and the Atlantic coastal vegetation called "restinga" (Maia 2001, 2005; Maia *et al.* 2002). A limited number of studies evaluated galling organisms in Atlantic Rain Forest areas (Fernandes *et al.* 2001), Pantanal (Julião *et al.* 2002), and the Amazonian Rain Forest (Julião *et al.* 2002). Our research represents the first survey of galling organisms performed in areas of STDF. This study reported 92 galling species on 51 species of host plants. Gall-inducers are speciose in the Neotropical region, but despite their richness, little is known about their taxonomy, distribution, host plant and galls. In this study, only 10% of galling species had already been reported in previous surveys of Cerrado vegetation. Despite high seasonality and consequent leaf loss, and the small, fragmented nature of the sampled STDF, the number of galls found may be considered high when compared with the number of galls reported in surveys performed in other Brazilian biomes (e.g., Fernandes *et al.* 2001; Gonçalves-Alvim & Fernandes 2001; Julião *et al.* 2002; Maia 2001, 2005; Maia *et al.* 2002; Urso–Guimarães & Scarelli-Santos 2006). The distribution of galling insects among different herbivore taxa and host plants in this study confirm the Cecidomyiidae as the most common galling taxa in the neotropics (Gagné 1994; Fernandes *et al.* 2001; Julião *et al.* 2002; Cuevas-Reyes *et al.* 2004).

Fig. 3. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Fabaceae - *Bauhinia brevipes* (a-d), *Bauhinia longifolia* (e-g), *Bauhinia rufa* (h), *Bauhinia* sp (i-j), *Copaifera langsdorffii* (k), *Piptadenia gonoachanta* (l-n), *Stylosanthes* sp. (o), Flacourtiaceae - *Casearia rupestris* (p).

In recent study carried out in an area characterized by calcareous rocks flanking the Espinhaço, Meguro *et al.* (2007) found 296 species of vascular plants were found Fabaceae (33 spp.), Euphorbiaceae (18 spp.), Bignoniaceae (13 spp.), Malvaceae (13 spp.), Apocynaceae (11 spp.) and Sapindaceae (11 spp.) as the most representative families. In our survey, the most representative plant families were also the families that supported the most diverse galling. The Fabaceae family possesses the highest variety of subsidiary species detected in STDFs (Pennington *et al.* 2000; Meguro *et al.* 2007) and, not unexpectedly, was the taxon with the highest number of plant species sampled (n= 10) and with the highest number of

Fig. 4. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Flacourtiaceae - *Prockia crucis* (a), Lamiaceae - *Hyptis* sp. (b), sp. 1 (c), Malpighiaceae - *Banisteriopsis* sp. (d-e), *Heteropteris* sp. (f-g), Malvaceae - *Guazuma ulmifolia* (h), *Sida* sp. (i), sp. 1 (j), Myrtaceae - *Blepharocalyx salicifolius* (k-l), *Eugenia sondeliana* (m), *Myrcia splendens* (n-p), *Myrcia tomentosa* (q).

Table I. Insec t galls from tropical dry forests, Serra do Cipó, MG.

Host plant	Gall maker	Organ	Shape	Colour	Pubescence	Chambers	Fragment	Reference
Annonaceae								
Rollinia laurifolia Schltdl.	Homoptera	Leaf	Spherical	Green	Glabrous	1	2	Fig. 1(a)
Rollinia sylvatica (A. St.-Hil.)	Homoptera	Stem	globulous	brown	Glabrous	1	1,3	Fig. 1(b)
Apocynaceae								
Aspidosperma cylindrocarpon Müll. Arg.	Homoptera	Leaf	Cylindric	Green	Glabrous	1	2,3	Fig. 1(c)
Aspidosperma pyrifolium Mart	Cecidomyiidae	Stem	Conical	Green	Glabrous	1	3	Fig. 1(d)
Asteraceae								
Baccharis dracunculifolia DC.	*Neopelama baccharidis* Buckhardt	Leaf	Legume	Green	Glabrous	1	3	Fernandes *et al.* (1996)
	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	Various	3	Fernandes *et al.* (1996)
	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	3	Fernandes *et al.* (1996)
	Cecidomyiidae	Stem	Spherical	Green	Hairy	1	3	Fernandes *et al.* (1996)
	Lepidoptera	Stem	Elliptical	Green	Glabrous	1	3	Fernandes *et al.* (1996)
Baccharis sp.	Acarina	Leaf	Conical	Green	Glabrous	1	3	Fig. 1(e)
Vernonanthura phosphorica (Vell.) H. Rob.	Cecidomyiidae	Leaf	Spherical	Green	Hairy	1	3	Fig. 1(f)
	Cecidomyiidae	Stem	Globulous	Brown/Green	Glabrous	1	3	Fig. 1(g)
Boraginaceae								
Cordia trichotoma (Vell.) Arráb. ex Steud.	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	1	3	Fig. 1(h)
	Cecidomyiidae	Leaf	Discoid	Brown	Glabrous	1	3	Fig. 1(i)
	Cecidomyiidae	Stem	Globulous	Brown	Glabrous	Various	3	Fig. 1(j)
	Cecidomyiidae	Leaf	Spherical	Brown	Hairy	1	3	Fig. 1(k)
	Lepidoptera	Stem	Elliptical	Green	Glabrous	Various	1,2,3	Fig. 1(l)
Cannabacea								
Celtis brasiliensis (Gardner) Planch.	Lepidoptera	Stem	Elliptical	Brown	Glabrous	1	1,2,3	Fig. 1(m)
	Cecidomyiidae	Thorn	Conical	Green	Glabrous	1	1	Fig. 1(n)
	Cecidomyiidae	Stem	Globulous	Brown	Glabrous	1	1,2	Fig. 1(o)
	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	1	2,3	Fig. 1(p)
	Cecidomyiidae	Leaf	Spherical	Yellow	Hairy	1	1,2	Fig. 1(q)
Celtis iguanaea (Jacq.) Sarg.	Cecidomyiidae	Leaf	Conical	Green	Hairy	1	2	Fig. 1(r)
Combretaceae								
Buchenavia tomentosa Eichler	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	1	2	Fig. 2(a)
Terminalia argentea Mart.	Cecidomyiidae	Leaf	Discoid	Brown	Glabrous	1	1	Fig. 2(b)
	Cecidomyiidae	Leaf	Spherical	Brown	Hairy	1	3	Fig. 2(c)
Erythroxylaceae								
Erythroxylum citrifolium A. St.-Hil.	Hymenoptera	Apical bud	Globulous	Green/Brown	Glabrous	Various	1,2	Fig. 2(d)
	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	1	2	Fig. 2(e)
Erythroxylum vacciniifolium Mart.	Hymenoptera	Stem	Spherical	Green	Glabrous	1	1	Fig. 2(f)
	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	1	1,3	Fig. 2(g)
Fabaceae								
Acacia martii Benth.	Cecidomyiidae	Leaf	Conical	Brown	Glabrous	1	3	Fig. 2(h)
	Cecidomyiidae	Leaf	Spherical	Yellow	Glabrous	1	3	Fig. 2(i)
Acacia sp. 1	Cecidomyiidae	Leaf	Spherical	Brown/Green	Glabrous	1	2	Fig. 2(j)
	Cecidomyiidae	Leaf	Cylindric	brown	Glabrous	1	1,2	Fig. 2(k)
Anadenanthera colubrina (Vell.) Brenan	Cecidomyiidae	Stem	Spherical	Brown	Glabrous	1	3	Fig. 2(l)
	Cecidomyiidae	Leaf	Conical	Brown	Glabrous	1	3	Fig. 2(l)
	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	1	3	Fig. 2(m)
Bauhinia brevipes Vogel	Lepidoptera	Stem	Elliptical	Brown	Glabrous	Various	1,2,3	Fig. 3(a)
	Cecidomyiidae	Leaf	Elliptical	Green	Glabrous	1	1	Fig. 3(b)
	Cecidomyiidae	Stem	Globulous	Brown	Glabrous	Various	2	Fig. 3(c)
	Cecidomyiidae	Leaf	Spherical	Red	Hairy	1	2	Fig. 3(d)
Bauhinia longifolia (Bong.) Steud.	Homoptera	Leaf	Discoid	Green	Glabrous	1	1,2	Fig. 3(e)
	Cecidomyiidae	Leaf	Spherical	Red	Hairy	1	1,2	Fig. 3(f)
	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	1	1	Fig. 3(g)

Table I. Cont.

Host plant	Gall maker	Organ	Shape	Colour	Pubescence	Chambers	Fragment	Reference
Bauhinia rufa (Bong.) Steud.	Cecidomyiidae	Stem	Irregular	Brown	Glabrous	Various	1,2,3	Fig. 3(h)
Bauhinia sp.	Cecidomyiidae	Stem	Irregular	Brown	Glabrous	Various	3	Fig. 3(i)
	Cecidomyiidae	Leaf	Spherical	Red	Hairy	1	3	Fig. 3(j)
Copaifera langsdorffii (Vogel) Benth.	Cecidomyiidae	Leaf	Legume	Green	Glabrous	Various	2	Fig. 3(k)
Piptadenia gonoacantha (Mart.) J. F. Macbr.	Cecidomyiidae	Leaf	Spherical	Green	Hairy	1	2	Fig. 3(l)
	Cecidomyiidae	Leaf	Spherical	Green/Brown	Glabrous	1	2	Fig. 3(m)
	Cecidomyiidae	Leaf	Globulous	Yellow	Glabrous	Various	1,2,3	Fig. 3(n)
Stylosanthes sp.	Cecidomyiidae	Stem	Elliptical	Green	Hairy	Various	3	Fig. 3(o)
Flacourtiaceae								
Casearia rupestris Eichler	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	1	Fig. 3(p)
Prockia crucis P. Browne ex L.	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	1	1	Fig. 4(a)
Lamiaceae								
Hyptis sp.	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	1	3	Fig. 4(b)
sp. 1	Cecidomyiidae	Stem	Elliptical	Green	Hairy	1	2	Fig. 4(c)
Malpighiaceae								
Banisteriopsis sp.	Acarina	Leaf	Irregular	Green	Glabrous	Various	1,3	Fig. 4(d)
	Cecidomyiida	Leaf	Discoid	Green	Glabrous	Various	1,2	Fig. 4(e)
Heteropteris sp.	Cecidomyiidae	Stem	Spherical	Whitish	Hairy	1	2	Fig. 4(f)
	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	2	Fig. 4(g)
Malvaceae								
Guazuma ulmifolia K. Schum.	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	3	Fig. 4(h)
Sida sp.	Cecidomyiidae	Leaf	Spherical	Green	Hairy	1	2	Fig. 4(i)
Sp. 1	Cecidomyiidae	Stem	Elliptical	Brown	Hairy	Various	3	Fig. 4(j)
Myrtaceae								
Blepharocalyx salicifolius (Kunth) O. Berg	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Various	3	Fig. 4(k)
	Hymenoptera	Flower	Globolous	Green	Glabrous	1	3	Fig. 4(l)
Eugenia sonderiana O. Berg	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Various	1	Fig. 4(m)
Myrcia splendens (Sw.) DC.	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Various	1,2	Fig. 4(n)
	Cecidomyiidae	Leaf	Elliptical	Green	Glabrous	Various	1,2	Fig. 4(o)
	Cecidomyiidae	Leaf	Conical	Green	Glabrous	1	1	Fig. 4(p)
	Cecidomyiidae	Leaf	Globulous	Green	Glabrous	Various	1	Fig. 4(p)
Myrcia tomentosa (Aubl.) DC.	Cecidomyiidae	Leaf	Conical	Brown	Glabrous	1	1,2	Fig. 4(q)
	Cecidomyiidae	Leaf	Elliptical	Green	Hairy	1	3	Fig. 5(a)
	Cecidomyiidae	Leaf	Spherical	Brown	Hairy	1	3	Fig.5(b)
Psidium sp.	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	1	2	Fig. 5(c)
Rubiaceae								
Guettarda viburnoides Cham. & Schltdl.	Not identified	Leaf	Discoid	Green	Glabrous	1	3	Fig. 5(d)
	Not identified	Leaf	Elliptical	Green	Glabrous	1	3	Fig. 5(d)
Sp. 1	Not identified	Stem	Elliptical	Brown	Glabrous	Various	1	Fig. 5(e)
Sapindaceae								
Cupania vernalis Cambess.	Not identified	Stem	Irregular	Brown	Glabrous	Various	2	Fig. 5(f)
Serjania sp. 1	Cecidomyiidae	Leaf	Spherical	Green/Red	Glabrous	1	1,2,3	Fig. 5(g)
	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	1	1	Fig. 5(h)
Serjania sp. 2	Cecidomyiidae	Leaf	Elliptical	Green	Glabrous	1	1	Fig. 5(i)
	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	Various	3	Fig. 5(j)
	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	1	2,3	Fig. 5(k)
Serjania sp. 3	Cecidomyiidae	Leaf	Conical	Green	Hairy	1	2	Fig. 5(l)
Smilacaceae								
Smilax sp. 1	Cecidomyiidae	Leaf	Spherical	whitish	Glabrous	1	3	Fig. 5(m)
Smilax sp. 2	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	1	3	Fig. 5(n)
Smilax sp. 3	Cecidomyiidae	Stem	Globulous	brown	Glabrous	Various	3	Fig. 5(o)
Solanaceae								
Capsicum parvifolium Sendtn.	Coleoptera	Stem	Elliptical	brown	Glabrous	Various	3	Fig. 6(a)
Verbenaceae								
Lantana fucata Lindl.	Cecidomyiidae	Leaf	Spherical	Green	Hairy	1	1	Fig. 6(b)
Lippia sp.	Cecidomyiidae	Leaf	Cylindric	Green	Hairy	1	3	Fig. 6(c)
	Cecidomyiidae	Leaf	Spherical	Green	Hairy	1	3	Fig. 6(d)
Vochysiaceae								
Callisthene major Mart.	Homoptera	Leaf	Spherical	Green	Glabrous	1	2	Fig. 6(e)

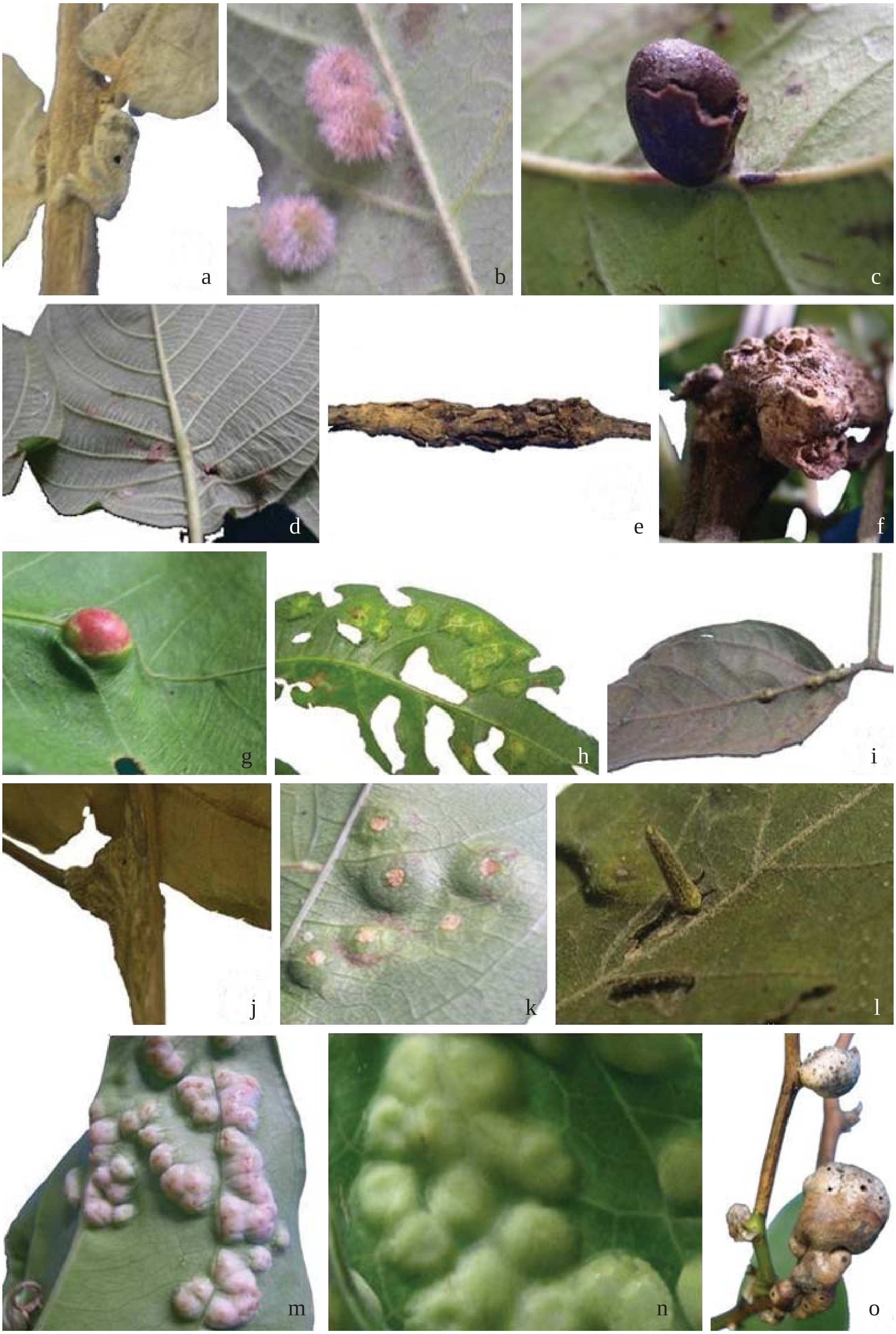

Fig. 5. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Myrtaceae - *Myrcia tomentosa* (a-b), *Psidium* (c), Rubiaceae - *Guettarda viburnoides* (d), sp.1 (e), Sapidaceae - *Cupania Vernalis* (f), Serjania sp. 1 (g, h), *Serjania* sp. 2 (i, k), *Serjania* sp. 3 (l), Smilacaceae - *Smilax* sp. 1 (m), *Smilax* sp. 2 (n), *Smilax* sp. 3 (o).

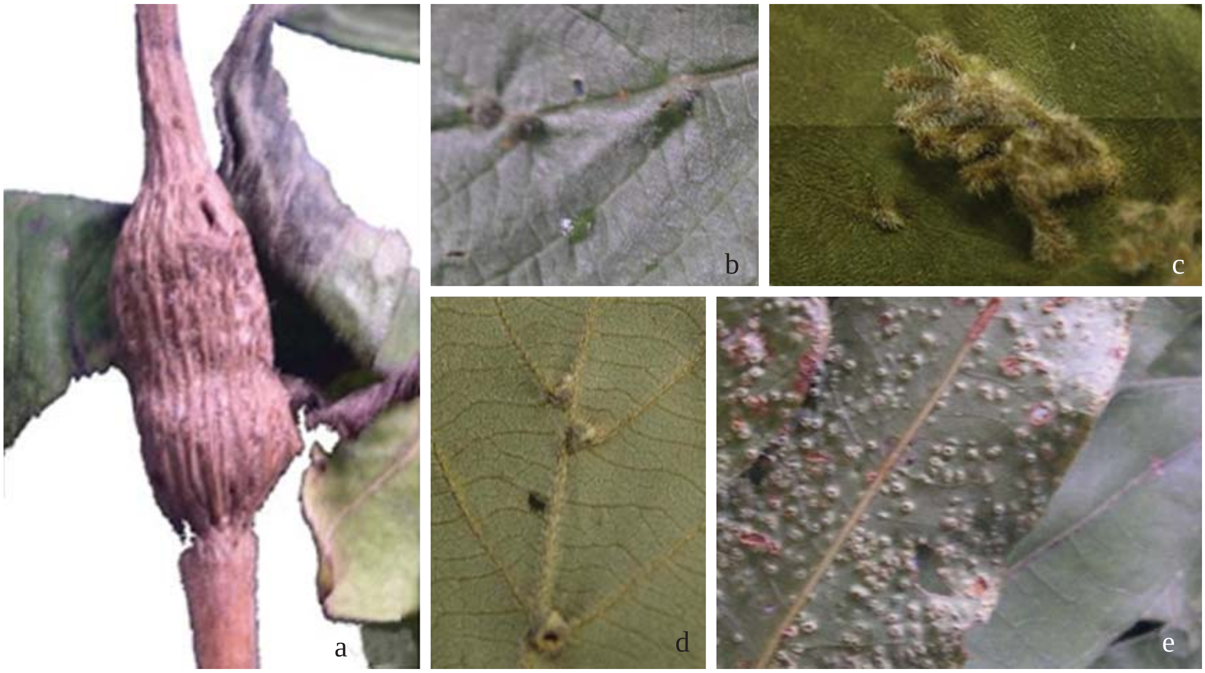

Fig. 6. Galling insect morphospecies in fragments of seasonally Dry Tropical Forest in Serra do Cipó, Minas Gerais, Brazil. Solanaceae - *Capisicum parvifolium* (a), Verbenaceae - *Lantana fucata* (b), *Lippia* sp. (c-d) Vochysiaceae - *Callisthene major* (e).

galling species (n= 23). The same pattern was observed for the a variety of biomes, including Cerrado (Gonçalves-Alvim & Fernandes 2001), rupestrian fields (Maia & Fernandes 2004), and Atlantic rain forests (Fernandes *et al.* 2001), where families with the highest number of plant species supported the highest number of galling species (see also Fernandes 1992; Mendonça 2007). This pattern did not hold for the Asteraceae and Myrtaceae families, respectively the second and third most productive galling species following Fabaceae found in this study. Future field studies on the ecological mechanisms that shape galling species richness within STDFs will allow us to better contrast the specific vegetations studied so far.

Given the intense human pressure on the SDTFs (Sánchez-Azofeifa *et al.* 2005), the high richness of galling arthropods and implied floral host diversity found in this survey indicates the need for an increased effort to understand the implications of such diversity in these vulnerable ecosystems. The distribution pattern of one host plant species and its availability to galling arthropods present in this study (*Anadenanthera colubrina*), as well as other arboreal species, follows the paradigm of the Pleistocenic arc. This concept uses mapping of the "Seasonal Tropical Forests Range", which suggests that the distribution of Brazilian STDFs arose during Pleistocene era (Prado 2005). Host species occur on a continental scale and range from the Brazilian Northeast to the Brazilian Pantanal (Prado 2005). Perhaps interesting avenues for research will be provided by the study of host plants and their associated galling arthropods widely distributed in the disjunct STDFs across the Americas.

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