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Gall-inducing insects from Atlantic forest of Pernambuco, Northeastern Brazil

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SANTOS, J.C., ALMEIDA-CORTEZ, J.S. & FERNANDES, G.W. **Gall-inducing insects from Atlantic forest of Pernambuco, Northeastern Brazil**. Biota Neotrop. 12(3): http://www.biotaneotropica.org.br/v12n3/en/abstract?inventory+bn00812032012

Abstract: An inventory of gall inducing insects and their host plants in the Atlantic forest of Pernambuco, northeastern Brazil is presented. Samples of galls and their host plants were taken in six fragments of Atlantic forest. One hundred thirty-six different morphotypes of insect galls on 79 host plant species belonging to 35 plant families and 53 genera were recorded. The host plant families most attacked by galling insects were: Lecythidaceae, Myrtaceae, and Nyctaginaceae. The most frequent galling taxa were Diptera of the Cecidomyiidae family (95%), followed by Lepidoptera and Coleoptera. Galls occurred most frequently on leaves and stems, had globoid and elliptical shapes, green color and absence of trichomes on the external walls. The data indicate an intermediary richness of gall inducing insects when compared to other Brazilian Atlantic forests.
Keywords: *biodiversity, Cecidomyiidae, host plants, insect galls, herbivory.*

SANTOS, J.C., ALMEIDA-CORTEZ, J.S. & FERNANDES, G.W. **Insetos indutores de galhas da floresta Atlântica de Pernambuco, Nordeste do Brasil**. Biota Neotrop. 12(3): http://www.biotaneotropica.org.br/v12n3/pt/abstract?inventory+bn00812032012

Resumo: Um inventário de insetos galhadores e suas plantas hospedeiras foi realizado para a Mata Atlântica de Pernambuco, Nordeste do Brasil. As galhas e suas plantas hospedeiras foram amostradas em seis fragmentos de Mata Atlântica. Cento e trinta e seis diferentes morfotipos de galhas de insetos em 79 espécies de plantas hospedeiras pertencentes a 35 famílias de plantas e 53 gêneros foram registrados. As famílias de plantas mais atacadas por insetos galhadores foram: Lecythidaceae, Myrtaceae e Nyctaginaceae. O grupo mais frequente de galhador foi Diptera da família Cecidomyiidae (95%), seguido por Lepidoptera e Coleoptera. Galhas ocorreram mais frequentemente sobre as folhas e caules, possuíam um formato globoso e formas elípticas, de cor verde e ausência de tricomas nas paredes externas. Os dados indicam uma riqueza intermediária de insetos indutores de quando comparado com outras florestas atlânticas brasileiras.
Palavras-chave: *biodiversidade, Cecidomyiidae, plantas hospedeiras, insetos galhadores, herbivoria.*

Introduction

Gall-inducing insects are a special guild of endophytic and specialist plant herbivores (Shorthouse et al. 2005) with most galling species restricted to one specific host plant (see Carneiro et al. 2009a). This species-specific relationship between galling insects and host plants suggests that these herbivores can be used to test broad ecological concepts (Fernandes & Price 1988, 1991, Price et al. 2004), such as, hypotheses to explain latitudinal and altitudinal patterns (e.g., Fernandes & Price 1988, Carneiro et al. 2005). A study on global richness of gall-inducing insects estimated the existence of 21,000 to 211,000 species (see Espírito-Santo & Fernandes 2007). This inaccuracy is probably due to the lack of more studies throughout the many vegetation types and biomes around the globe.

In the Brazilian Atlantic Forest, studies addressing inventories of galling insects have been concentrated in south and southeastern regions of Brazil (e.g. Fernandes et al. 2001, Maia 2005, Dalbem & Mendonça 2006, Fernandes & Negreiros 2006, Mendonça 2007, Moreira et al. 2007, see also the Brazilian Atlantic costal ecosystem called restinga, Maia 2001, Oliveira & Maia 2005, Maia & Oliveira 2010). Up to the present date, only two local studies (see Fernandes et al. 2009, Silva et al. 2011) reported insect gall richness in the northeastern Brazilian Atlantic Forest, an important area of endemism [Pernambuco Center of Endemism (*sensu* Silva & Casteleti 2003)]. Therefore, we present the inventory of galling insects and their host plants in the Atlantic forest of Pernambuco as an attempt reduce the lack of knowledge of the gall inducer insects in this region.

Materials and Methods

Study area – This study was conducted in six fragments of Atlantic forests in the state of Pernambuco, Brazil, specifically in the Reserva Ecológica de Saltinho (city of Tamandaré) (8° 43' 30" S and 35° 10' 40" W), Parque Estadual de Dois Irmãos (city of Recife) (8° 7' 30" S and 34° 52' 30" W), Reserva Ecológica de Carnijó - Reserva Particular do Patrimônio Natural (RPPN) de Carnijó (city of Moreno) (08° 08' 42" S and 35° 04' 34" W), Reserva Ecológica Mata de Duas Lagoas (city of Cabo de Santo Agostinho) (8° 18' 16" S and 34° 58' 17" W), Refúgio Ecológico Charles Darwin (city of Igarassu) (7° 48' 37" S and 34° 27' 25" W), and Engenho Monjolo (city of Abreu e Lima) (7° 54' 32" S and 34° 57' 25" W). These areas were chosen arbitrarily to cover the maximum of environmental heterogeneity in the Atlantic Forest state of Pernambuco (Figure 1).

Sampling galling insect richness – The Brazilian Atlantic Forest were investigated for galls over a period of seven months from January to September of 2008, once for each area over the sample period. In each site, galling insect richness were sampled by two people following the adapted methodology of random walking (see Julião et al. 2002, Fernandes & Negreiros 2006), where instead of an hour, five hours were spent in each area (total hours

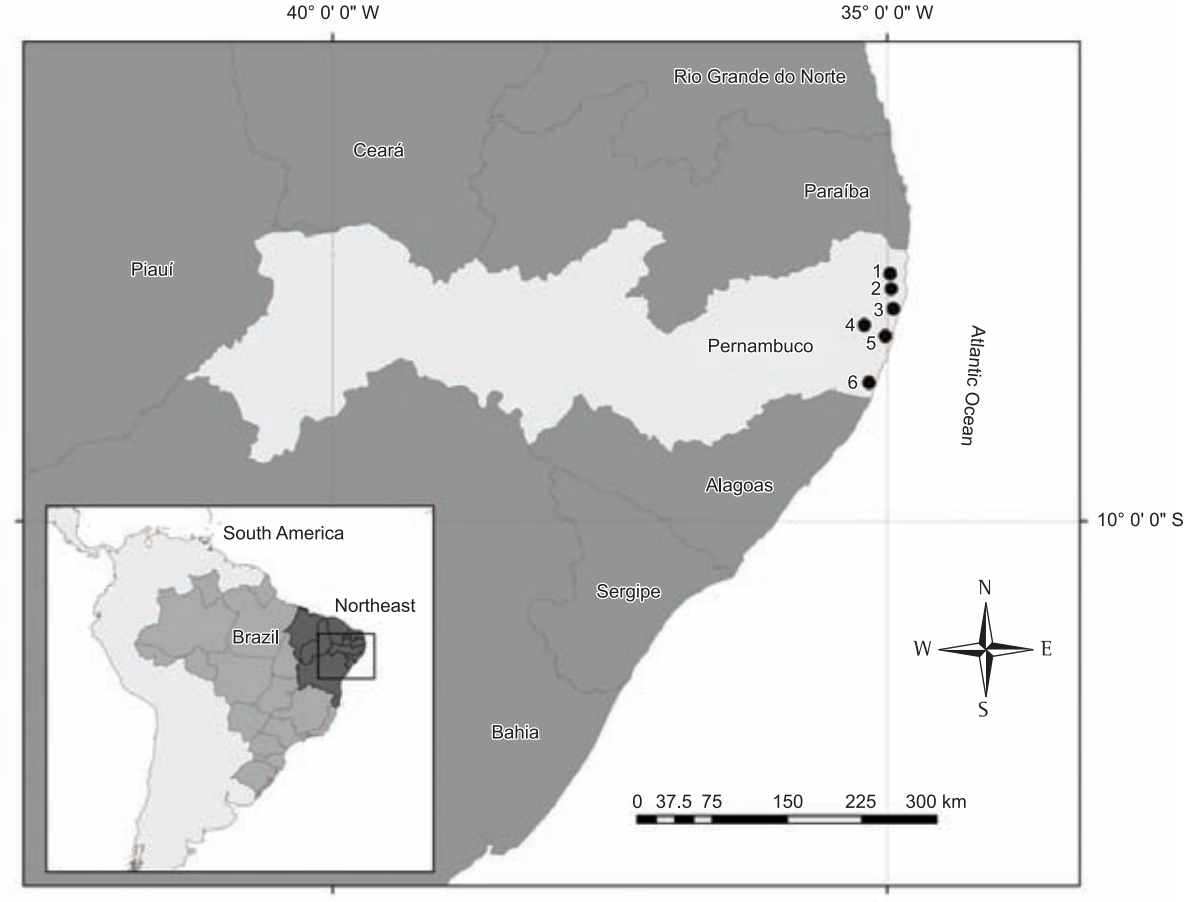

Figure 1. Location of the studied sites of Atlantic forests (number) in Pernambuco state (detail), northeast region (light grey) of Brazil (dark grey): 1 - Refúgio Ecológico Charles Darwin; 2 - Engenho Monjolo; 3 - Parque Estadual Dois Irmãos; 4 - Reserva Particular do Patrimônio Natural (RPPN) de Carnijó; 5 - Reserva Ecológica Mata de Duas Lagoas; 6 - Reserva Ecológica de Saltinho.

of survey = 30 hours). To maximize the sampling of richness, a distance of at least 500 m was established among the sites sampled inside the areas (Fernandes & Price 1988). All plant organs, except root, were investigated, and each gall and host plants (up to 3 m high) found were collected, placed into plastic bags, and then taken to a laboratory for photographic registration and description of the external morphology of the galls. Host plants were identified into morphospecies in the field, and later at the species level in the in the Herbarium Geraldo Mariz of the Universidade Federal de Pernambuco (UFPE). The classification of species of host plants followed the system proposed by Angiosperm Phylogeny Group III (Angiosperm… 2009), and the authors and scientific host plant names were checked in the Plantminer, a web tool designed to check seed plants species data (Carvalho et al. 2010). Voucher specimens were deposited in a reference collection do Museu de Biodiversidade do Cerrado (MBC) of Universidade Federal de Uberlândia (UFU).

In this study, the gall morphospecies was identified based upon their external morphology in combination with their host plant species, because, in general, 95% species of Cecidomyiidae induce a gall on a specific tissue of a certain plant species (Carneiro et al. 2009a). Therefore, the gall morphotypes were considered as true species (see also Coelho et al. 2009). The use of gall morphotype as surrogate of galling species richness is acceptable both ecologically and taxonomically (see Carneiro et al. 2009a) and it has been used in several studies in different ecosystems (e.g. Price et al. 1998, Cuevas-Reyes et al. 2004, Fernandes & Negreiros 2006, Moreira et al. 2007, Carneiro et al. 2009b, Coelho et al. 2009). Therefore, galls were characterized as reported by Fernandes & Price (1988): host plant species, number of types of galls by host plant, type of host tissue attacked, shape of galls, color of galls, presence or absence of pubescence, and number of chambers in the gall, occurrence on the galled organ: isolated or grouped/coalescent. A list only with the likely inducers of galls was chosen to be showed because many galls were naturally damaged during the study period, without the presence of the inducing larvae, or parasitized.

Results

Altogether 136 morphologically distinct types of insect galls were found in the Brazilian Atlantic Forest of Pernambuco. These galls were found on 79 species of host plants belonging to 35 families and 53 genera (Table 1, Figure 2). The greatest richness of galling insects was found in the Reserva Ecológica de Saltinho (59 morphospecies), followed by Parque Estadual de Dois Irmãos (50 morphospecies), Reserva Particular de Carnijó (46 morphospecies), Reserva Ecológica Mata de Duas Lagoas (17 morphospecies), Refúgio Ecológico Charles Darwin (15 morphospecies), and Engenho Monjolo with 13 morphospecies.

Compiling the results from all areas, the majority of galls induced by insects belonged to the family Cecidomyiidae (94.85%) (Diptera), followed by Lepidoptera (1.47%), and Coleoptera (0.74%), while 2.94% were undetermined. The host plant families with the largest number of galling species were: Lecythidaceae, Myrtaceae, and Nyctaginaceae, with 6.62% (9 morphotypes) each; Burseraceae with 5.88% (8 morphotypes); Clusiaceae, Fabaceae, Lauraceae, Melastomataceae and Polygonaceae with 5.15% (7 morphotypes) each; and Rubiaceae with 4.41% (6 morphotypes) (Table 2). Together these plant families supported approximately 56% (76 morphotypes) of all galls found. The host plant families with the larger number of host plant species were: Myrtaceae with 8.86% (7 species); Polygonaceae with 7.59% (6 species); Melastomataceae with 6.33% (5 species); and Fabaceae, Lauraceae, Rubiaceae with 5.06% (4 species) each (Table 2). Together these plant families supported approximately 38% (30 species) of all host plants found. The genera with the largest number of gall morphotypes were: *Guapira* (nine), *Protium* (seven), and *Coccoloba*, *Miconia*, *Ocotea*, and *Eschweilera* with six morphotypes each. Most galls were induced on leaves (74.26%) and stems (19.85%). The most frequent shape of galls was globoid (29.41%) followed by the elliptical shape (20.59%). Ninety-one percent of galls were glabrous, 66.18% were predominantly green, while 69.12% did not form clusters.

Discussion

This study represented an important contribution to the understanding on the galling insect guild distribution in the Brazilian Atlantic Forest of northeast Brazil. A comparison of present study with that from other areas of Brazilian Atlantic Forests showed the richness of the insect galls in the Brazilian Atlantic Forest of Pernambuco (136 morphospecies) was intermediary. The highest diversity (282 morphospecies) was reported by Mendonça (2007) in the Brazilian Atlantic Forest and Pampas of south Brazil and Fernandes et al. (2001) that reported on 273 galling species in several areas of Brazilian Atlantic Forest of the southeast Brazil. To Atlantic Forest in northeastern Brazil, Silva et al. (2011) reported 50 morphospecies along a secondary successional gradient, and Fernandes et al. (2009) reported 32 morphospecies in an urban remnant. Mendonça (2007) argues that the result of highest diversity of insect galls is in function of larger plant families which have more galls, such as Asteraceae. This is in agreement with the hypothesis proposed by Fernandes (1992) in which the higher richness of galling insects should be found on the most speciose host families, the plant richness hypothesis. One likely explanation for the low richness of galling insects in comparison to other forests of the southern Brazilian Atlantic Forest is the fact that the Brazilian Atlantic Forest in the north of the São Francisco River (e.g. Pernambuco's forest) have lower species richness of plants species (Tabarelli et al. 2006) in comparison with other Atlantic forests. Other likely explanation is that most of the remaining forests studied are small and have strong changes in floristic composition and structure due to edge effects and fragmentation habitat (see Tabarelli et al. 2005), reducing the availability of host plants for galling insects and, therefore, reducing galling richness too. Otherwise, many factors, e.g. historical factors, could also be important in explaining the results in this study. Unfortunately, the low number of studies does not permit broader generalizations. More sampling of galls at local and regional scales are needed in order to verify the existence of a regional pattern or even to make generalizations on the differences between northern and southern areas of Brazilian Atlantic Forest based on the diversity patterns of galling insects.

With the majority of galls induced by insects belonged to the family Cecidomyiidae (94.85%), the results of this study also reinforce the importance of the family Cecidomyiidae as the major taxonomic group among galling in the Neotropical region, accounting for more than 90% of gall morphotypes (Carneiro et al. 2009a). The composition of the main families of host plants was also distinct from that found in other studies in Atlantic Forest (see Fernandes et al. 2001, Dalbem & Mendonça 2006, Fernandes & Negreiros 2006, Mendonça 2007, Moreira et al. 2007, Santos et al. 2011). For instance, in Brazilian Atlantic Forest remnants of Minas Gerais State the families with more galling were Asteraceae, Myrtaceae, Bignoniaceae and Melastomataceae (Fernandes et al. 2001), and in Atlantic Forest from southern Brazil the families with more galling were Asteraceae, Myrtaceae and Sapindaceae (Mendonça 2007). To other studies in the Atlantic Forest from northeast Brazil, the most important plant families were Melastomataceae followed by

Table 1. Galling insect morphospecies and host plants found in the Atlantic forests of Pernambuco, Brazil. The host plants and description of gall morphotypes are presented below, with the number of galls found on each host plant, plant organ where the gall was induced, area where the gall was induced on the sheet in the form galls, predominant color, presence or no hair, number of chambers (if it is grouped or isolated) and the likely group of the gall inducer. Each gall morphotype of this table is depicted in Figure 1 below. Legends: Reserva Ecológica de Saltinho (SA), Parque Estadual Dois Irmãos (DI), Reserva Ecológica de Carnijó (CA), Reserva Ecológica Mata de Duas Lagoas (DL), Refúgio Ecológico Charles Darwin (CD), and Engenho Monjolo (EM).

Host plant family	Host plant species	Galls number	Organ	Side	Shape	Color	Pubescense	Chambers	Likely gall maker	Figs.	Sites
Anacardiaceae	*Anacardium occidentale* L.	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.1	DI
	Thyrsodium spruceanum Benth.	1	Leaf	Both	Globoid	Brown	No	Isolated	Cecidomyiidae	2.2	CD
		2	Leaf	Abaxial	Conical	Brown	No	Isolated	Cecidomyiidae	2.3	SA
Annonaceae	*Anaxagorea dolichocarpa* Sprague & Sandwith	1	Leaf	Both	Discoid	Green/Brown	No	Isolated	Cecidomyiidae	2.4	CA, CD
Apocynaceae	*Mandevilla* cf. *scabra* (Hoffmanns. ex Roem. & Schult.) K. Schum.	1	Leaf	Abaxial	Cylindrical	Green	Yes	Isolated	Cecidomyiidae	2.5	DL
Araceae	*Philodendron lundii* Warm.	1	Leaf	Adaxial	Globoid	Green	No	Isolated	Cecidomyiidae	2.6	DI
Araliaceae	*Schefflera morototoni* (Aubl.) Maguire	1	Leaf (rib)	Both	Globoid	Green	No	Grouped	Cecidomyiidae	2.7	DI, DL
Apocynaceae	*Schubertia grandiflora* Mart.	1	Leaf	Abaxial	Cylindrical	Brown	Yes	Isolated	Cecidomyiidae	2.8	CA
		2	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.9	CA
Asteraceae	*Mikania duckei* G.M. Barroso	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.10	SA
Bignoneaceae	*Adenocalymma* sp.1 Mart. ex Meisn.	1	Stem	-	Elliptical	Green	No	Grouped	Cecidomyiidae	2.11	CA, SA
	Adenocalymma sp.2 Mart. ex Meisn.	1	Meristem	-	Amorphous	Green	No	Grouped	Cecidomyiidae	2.12	CA
		2	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.13	CA, SA
		3	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.14	CA, SA
Boraginaceae	*Cordia multispicata* Cham.	1	Stem	-	Elliptical	Green	No	Grouped	Cecidomyiidae	2.15	SA
	Cordia nodosa Lam.	1	Leaf (rib)	Abaxial	Elliptical	Green	Yes	Grouped	Cecidomyiidae	2.16	SA
Burseraceae	*Protium aracouchini* Marchand	1	Leaf	Both	Conical	Brown	No	Isolated	Cecidomyiidae	2.17	CA, SA, EM
	Protium heptaphyllum (Aubl.) Marchand	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.18	SA
		2	Leaf	Both	Conical	Brown	No	Isolated	Cecidomyiidae	2.19	SA
		3	Leaf (edge)	-	Elliptical	Green	No	Isolated	Unidentified	2.20	DI, SA
		4	Leaf	Adaxial	Amorphous	Green	No	Isolated	Unidentified	2.21	DI, SA
		5	Leaf	Both	Spherical	Brown	No	Isolated	Cecidomyiidae	2.22	SA
		6	Leaf	Adaxial	Discoid	Green	No	Isolated	Cecidomyiidae	2.23	SA
	Tetragastris catuaba Soares da Cunha	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.24	SA
Chrysobalanaceae	*Hirtella ciliata* Mart. & Zucc.	1	Leaf	Adaxial	Discoid	Green	No	Isolated	Cecidomyiidae	2.25	DI
Clusiaceae	*Clusia nemorosa* G. Mey.	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.26	DL
		2	Leaf	Adaxial	Globoid	Green	No	Isolated	Cecidomyiidae	2.27	DL
	Tovomita brevistaminea Engl.	1	Leaf	borda	Spherical	Brown	No	Isolated	Cecidomyiidae	2.28	SA
		2	Leaf	Abaxial	Globoid	Green	No	Isolated	Cecidomyiidae	2.29	SA
		3	Leaf	Adaxial	Conical	Green	No	Isolated	Cecidomyiidae	2.30	SA
		4	Leaf (rib)	Both	Elliptical	Green	No	Isolated	Cecidomyiidae	2.31	SA
		5	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.32	SA

Table 1. Continued...

Host plant family	Host plant species	Galls number	Organ	Side	Shape	Color	Pubescense	Chambers	Likely gall maker	Figs.	Sites
Hypericaceae	*Vismia guianensis* (Aubl.) Pers.	1	Leaf	Abaxial	Conical	Green	No	Isolated	Cecidomyiidae	2.33	CA
		2	Leaf (rib)	-	Amorphous	Brown	No	Isolated	Cecidomyiidae	2.34	CA
		3	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.35	CA, DI
		4	Floral bud	-	Amorphous	Brown	Yes	Isolated	Cecidomyiidae	2.36	DI, EM
Connaraceae	*Connarus blanchetii* Planch.	1	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.37	DI
Dioscoreaceae	*Dioscorea* sp. L.	1	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.38	SA
Erythroxylaceae	*Erythroxylum squamatum* Sw.	1	Leaf (petiole/rib)	-	Globoid	Green	No	Isolated	Cecidomyiidae	2.39	DI
		2	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.40	DI
Peraceae	*Chaetocarpus myrsinites* Baill.	1	Meristem	-	Globoid	Green	Yes	-	-	2.41	DI, SA
	Pogonophora schomburgkiana Miers ex Benth.	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.42	DI, DL, SA
		2	Leaf (edge)	-	Elliptical	Green	No	Isolated	Unidentified	2.43	SA
Fabaceae	*Andira fraxinifolia* Benth.	1	Stem	-	Globoid	Brown	No	Isolated	Cecidomyiidae	2.44	SA
		2	Leaf (rib)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.45	SA
	Chamaecrista ensiformis (Vell.) H.S. Irwin & Barneby	1	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.46	DI
	Inga capitata Desv.	1	Leaf	Abaxial	Spheral	Brown	No	Isolated	Cecidomyiidae	2.47	DL
		2	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.48	DL
	Inga thibaudiana DC.	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.49	CA, EM
		2	Leaf (rib)	Both	Elliptical	Green	No	Grouped	Cecidomyiidae	2.50	DI, CA, EM
Salicaceae	*Casearia javitensis* Kunth	1	Leaf (rib)	Both	Amorphous	Green	No	Isolated	Cecidomyiidae	2.51	CA, SA, DI
		2	Leaf (petiole)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.52	CA, EM
	Casearia sylvestris Sw.	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.53	SA
		2	Leaf (edge)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.54	SA
Celastraceae	*Hippocratea volubilis* L.	1	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.55	SA
Lauraceae	*Nectandra cuspidata* Nees & Mart.	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.56	DI
	Ocotea cf. *glomerata* (Nees) Mez	1	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.57	CD
	Ocotea glomerata (Nees) Mez	1	Leaf (edge)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.58	DI
		2	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.59	DI
	Ocotea opifera Mart	1	Leaf (rib)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.60	DI
		2	Leaf	Both	Conical	Brown	Yes	Isolated	Cecidomyiidae	2.61	DI
		3	Leaf (rib)	Both	Discoid	Brown	No	Isolated	Cecidomyiidae	2.62	DI
Lecythidaceae	*Eschweilera ovata* (Cambess.) Miers	1	Leaf/Stem	Both	Globoid	Green	No	Grouped	Cecidomyiidae	2.63	CA, DI, DL, EM, CD, SA
		2	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.64	CA, SA, DL
		3	Leaf	Abaxial	Conical	Green	No	Isolated	Cecidomyiidae	2.65	DL, EM
		4	Leaf	Abaxial	Globoid	Yellow	No	Isolated	Cecidomyiidae	2.66	DI, CA, EM, CD
		5	Leaf	Abaxial	Discoid	Green/Brown	No	Isolated	Cecidomyiidae	2.67	DI, CA

Table 1. Continued...

Host plant family	Host plant species	Galls number	Organ	Side	Shape	Color	Pubescense	Chambers	Likely gall maker	Figs.	Sites
		6	Leaf	Abaxial	Globoid	Green	No	Isolated	Cecidomyiidae	2.68	CA
	Lecythis cf. *chartacea* O. Berg	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.69	DI
		2	Stem/Leaf (petiole)	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.70	DI
	Lecythis sp. Loefl.	1	Leaf	Both	Globoid	Green	No	Grouped	Cecidomyiidae	2.71	DI
Malpighiaceae	*Byrsonima sericea* DC.	1	Leaf (edge)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.72	SA
	Byrsonima verbascifolia (L.) Rich. ex Juss.	1	Leaf	Abaxial	Conical	Green	Yes	Isolated	Cecidomyiidae	2.73	DL
	Mascagnia psilophylla (A. Juss.) Griseb.	1	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.74	CA
Melastomataceae	*Henriettea succosa* (Aubl.) DC.	1	Meristem	-	Rosette	Green	No	Isolated	Lepidoptera	2.75	SA
	Miconia cinnamomifolia (DC.) Naudin	1	Leaf (petiole)	-	Globoid	Green	No	Isolated	Coleoptera	2.76	CA
	Miconia hypoleuca (Benth.) Triana	1	Leaf	Abaxial	Conical	Green	Yes	Isolated	Cecidomyiidae	2.77	SA
	Miconia prasina (Sw.) DC.	1	Leaf	Both	Elliptical	Green	No	Isolated	Cecidomyiidae	2.78	CA, CD, SA
		2	Leaf (petiole)	-	Elliptical	Green	No	Isolated	*Prospoliata bicolorata* (Coleoptera) Almeida-Cortez *et al* (2006)	2.79	CA, CD, SA
		3	Floral bud	-	Cylindrical	Green	No	Isolated	Cecidomyiidae	2.80	CA, CD, EM
	Miconia sp. Ruiz & Pav.	1	Leaf/Stem	Both	Amorphous	Green	No	Grouped	Cecidomyiidae	2.81	SA
Meliaceae	*Guarea* sp. F. Allam. ex L.	1	Leaf	Adaxial	Conical	Green	No	Isolated	Cecidomyiidae	2.82	SA
	*Trichilia quadrijuga (*Miq.*) Kunth*	1	Leaf (edge)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.83	CA
Siparunaceae	*Siparuna guianensis* Aubl.	1	Leaf	Both	Spheral	Brown	No	Isolated	Cecidomyiidae	2.84	CA, DL, SA
		2	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.85	CA
		3	Stem	-	Elliptical	Green	No	Grouped	Cecidomyiidae	2.86	SA
Myrtaceae	*Calyptranthes* sp. Sw.	1	Leaf	Both	Spheral	Green	No	Isolated	Cecidomyiidae	2.87	CA
		2	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.88	CA
	Calyptranthes widgreniana O. Berg	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.89	CD
	Eugenia sp. L.	1	Leaf	Both	Spheral	Brown	No	Isolated	Cecidomyiidae	2.90	DI
	Myrcia cf. *guianensis* (Aubl.) DC.	1	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.91	CA
	Myrcia cf. *splendens* (Sw.) DC.	1	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.92	DI
	Myrcia sp. DC.	1	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.93	DL
	Myrcia sylvatica (G. Mey.) DC.	1	Meristem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.94	CA, DI, DL, SA
		2	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.95	SA
Nyctaginaceae	*Guapira opposita* (Vell.) Reitz	1	Leaf	Both	Star	White	No	Isolated	Cecidomyiidae	2.96	SA
		2	Leaf	Adaxial	Spheral	Brown	No	Isolated	Cecidomyiidae	2.97	SA

Table 1. Continued...

Host plant family	Host plant species	Galls number	Organ	Side	Shape	Color	Pubescense	Chambers	Likely gall maker	Figs.	Sites
		3	Leaf	Both	Spheral	Brown	No	Isolated	Cecidomyiidae	2.98	SA
		4	Leaf	Both	Spheral	Brown	Yes	Isolated	Cecidomyiidae	2.99	SA
		5	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.100	SA
		6	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.101	CA
		7	Meristem	-	Amorphous	Green	No	-	Cecidomyiidae	2.102	CA
		8	Leaf	Both	Spheral	Pink/Yellow	Yes	Isolated	Cecidomyiidae	2.103	CD
		9	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.104	CD
Ochnaceae	*Ouratea* sp. Aubl.	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.105	CD
Piperaceae	*Piper aduncum* L.	1	Leaf/Stem	Abaxial	Amorphous	Green	Yes	Isolated	Cecidomyiidae	2.106	SA
Polygonaceae	*Coccoloba* cf. *ochreolata* Wedd.	1	Leaf	Both	Globoid	Brown	No	Isolated	Cecidomyiidae	2.107	SA
	Coccoloba ochreolata Wedd.	1	Leaf	Both	Globoid	Green	No	Isolated	Cecidomyiidae	2.108	DL
	Coccoloba sp.1 P. Browne	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.109	CA, EM
	Coccoloba sp.2 P. Browne	1	Leaf	Both	Conical	Brown	No	Isolated	Cecidomyiidae	2.110	CA, SA
	Coccoloba sp.3 P. Browne	1	Leaf	Both	Globoid	Brown	No	Grouped	Cecidomyiidae	2.111	DI
		2	Leaf (rib)	Both	Globoid	Brown	No	Isolated	Cecidomyiidae	2.112	DI
	Polygonaceae sp.1 Juss.	1	Leaf	Both	Globoid	Green	No	Isolated	Cecidomyiidae	2.113	CA
Rubiaceae	*Amaioua guianensis* Aubl.	1	Leaf (petiole/rib)	Both	Globoid	Green	No	Grouped	Cecidomyiidae	2.114	CA
		2	Leaf	Adaxial	Spheral	Brown	No	Isolated	Cecidomyiidae	2.115	SA
	Palicourea crocea (Sw.) Schult.	1	Leaf (rib)	-	Elliptical	Green	No	-	Cecidomyiidae	2.116	DL
		2	Leaf (petiole/rib)	-	Elliptical	Green	No	Grouped	Cecidomyiidae	2.117	DL
	Psychotria carthagenensis Jacq.	1	Leaf	Both	Globoid	Green	No	Isolated	Cecidomyiidae	2.118	EM
	Rubiaceae sp.1 Juss.	1	Leaf/Stem	Abaxial	Amorphous	Green	No	Isolated	Cecidomyiidae	2.119	SA
Sapindaceae	*Cupania racemosa* (Vell.) Radlk.	1	Leaf	Both	Conical	Green	No	Isolated	Cecidomyiidae	2.120	CA
		2	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.121	CA
	Paullinia pinnata L.	1	Stem	-	Globoid	Green	No	Isolated	Cecidomyiidae	2.122	CA
		2	Stem	-	Globoid	Brown	No	Grouped	Cecidomyiidae	2.123	SA
Sapotaceae	*Chrysophyllum splendens* Spreng.	1	Leaf (rib)	Adaxial	Amorphous	Green	No	-	Cecidomyiidae	2.124	SA
	Pouteria sp. Aubl.	1	Leaf	Abaxial	Cylindrical	Brown	No	Isolated	Cecidomyiidae	2.125	CA
		2	Stem	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.126	CA, SA
		3	Leaf (rib)	Both	Elliptical	Green	No	Grouped	Cecidomyiidae	2.127	CA, SA
Simaroubaceae	*Simarouba amara* Aubl.	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.128	CA
		2	Leaf	Abaxial	Globoid	Green	No	Isolated	Cecidomyiidae	2.129	SA
		3	Stem	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.130	SA
Violaceae	*Rinorea* cf. *guianensis* Aubl.	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.131	CD
		2	Leaf (edge)	-	Elliptical	Green	No	Isolated	Cecidomyiidae	2.132	CD
Not identified	Not identified sp.1	1	Stem	-	Elliptical	Brown	No	Grouped	Cecidomyiidae	2.133	CA
Not identified	Not identified sp.2	1	Leaf	Both	Spheral	Brown	Yes	Isolated	Cecidomyiidae	2.134	EM
Not identified	Not identified sp.3	1	Leaf	Both	Discoid	Green	No	Isolated	Cecidomyiidae	2.135	EM
Not identified	Not identified sp.4	1	Floral bud	-	Globoid	Green	No	Grouped	Cecidomyiidae	2.136	CD

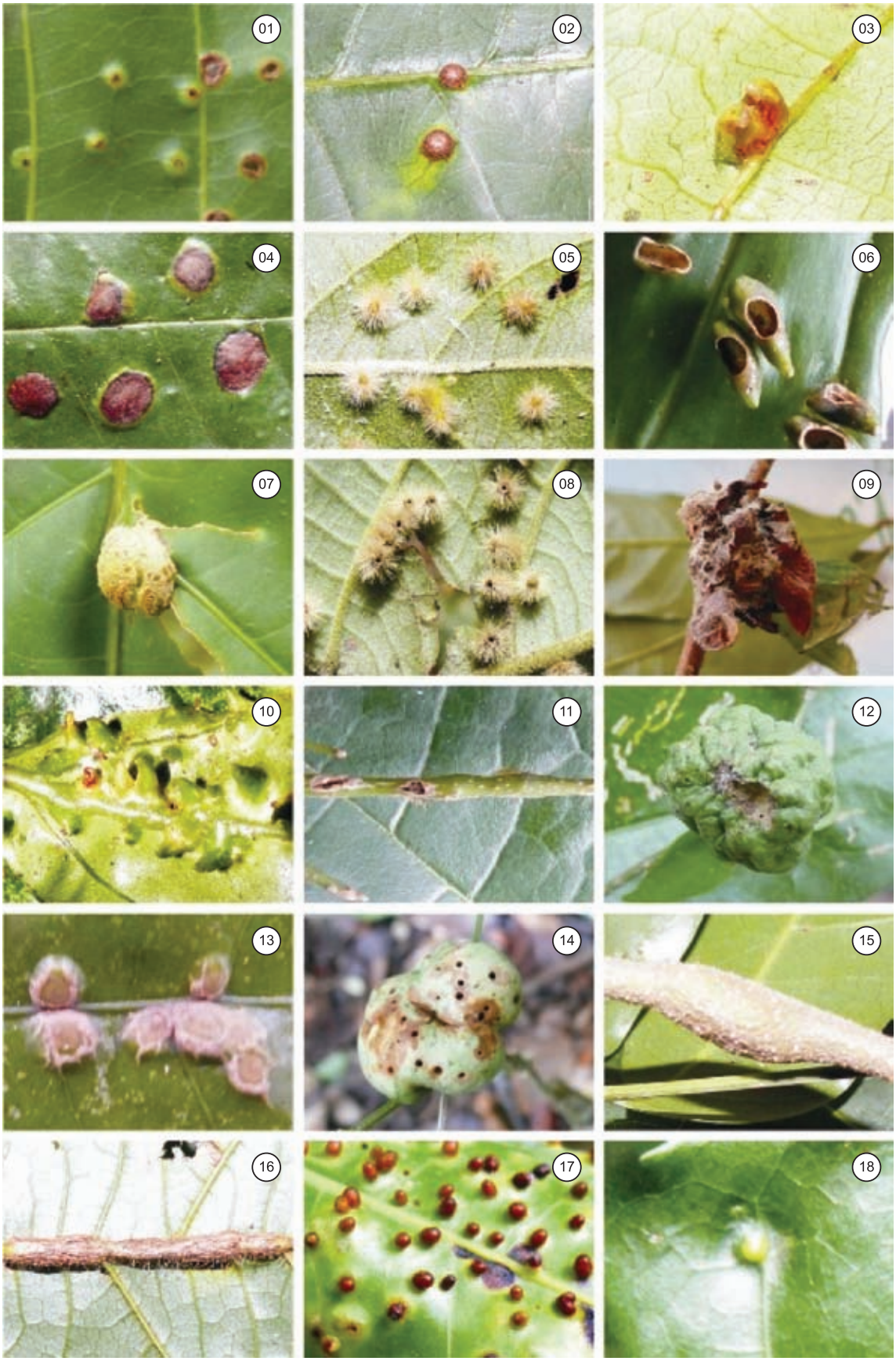

Figure 2. Galling insect morphospecies in Atlantic forests of Pernambuco, Brazil. 1 - *Anacardium occidentale*; 2 and 3 - *Thyrsodium spruceanum*; 4 - *Anaxagorea dolichocarpa*; 5 - *Mandevilla* cf. *scabra*; 6 - *Philodendron lundii*; 7 - *Schefflera morototoni*; 8 and 9 - *Schubertia grandiflora*; 10 - *Mikania duckei*; 11 - *Adenocalymma* sp.1; 12-14 - *Adenocalymma* sp.2; 15 - *Cordia multispicata*; 16 - *Cordia nodosa*; 17 - *Protium aracouchini*; 18 - *Protium heptaphyllum*;

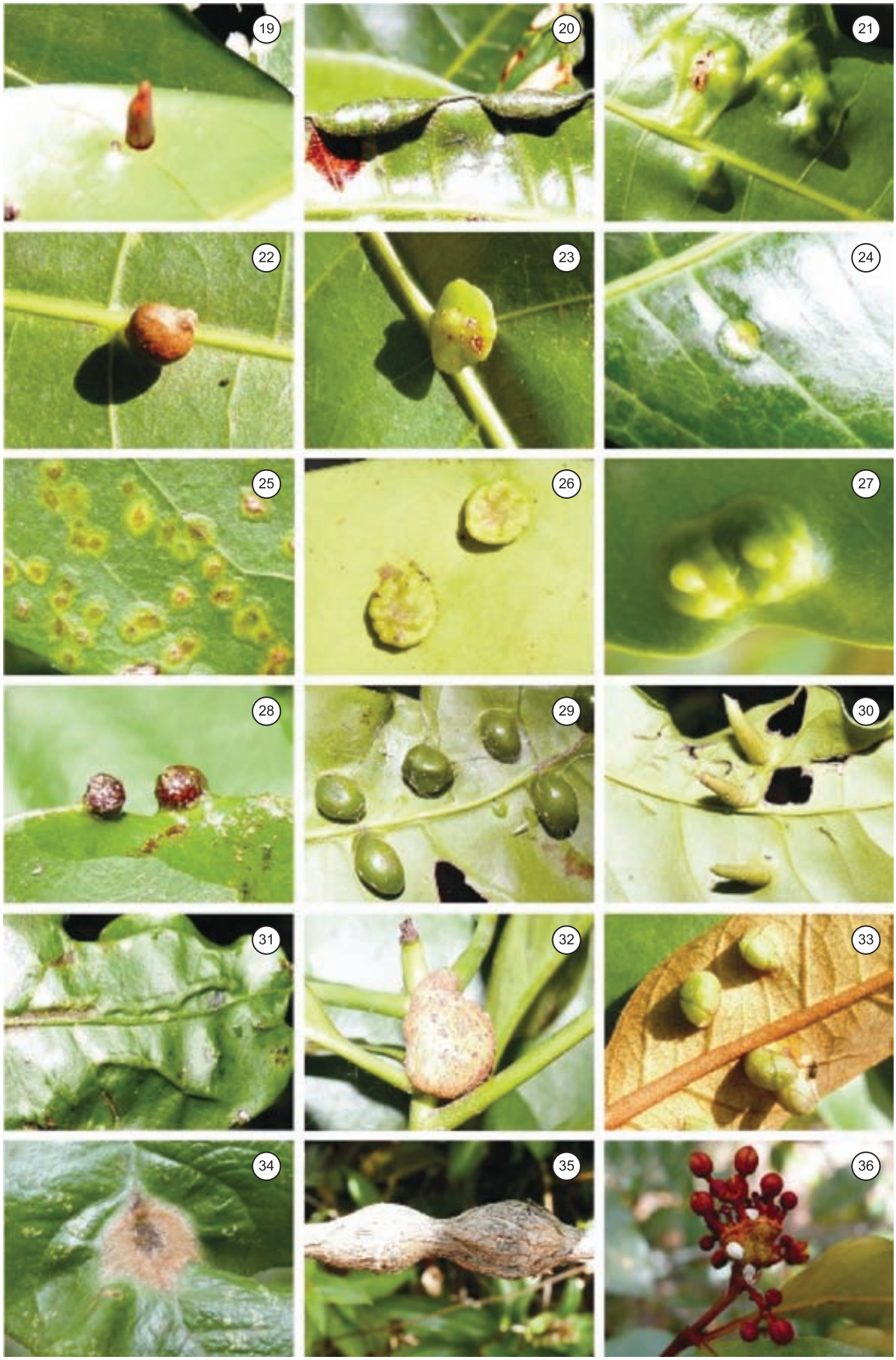

Figure 2. 19-23 - *Protium heptaphyllum*; 24 - *Tetragastris catuaba*; 25 - *Hirtella ciliata*; 26 and 27 - *Clusia nemorosa*; 28-32 - *Tovomita brevistaminea*; 24 - *Tetragastris catuaba*; 25 - *Hirtella ciliata*; 26 and 27 - *Clusia nemorosa*; 28-32 - *Tovomita brevistaminea*; 33-36 - *Vismia guianensis*;

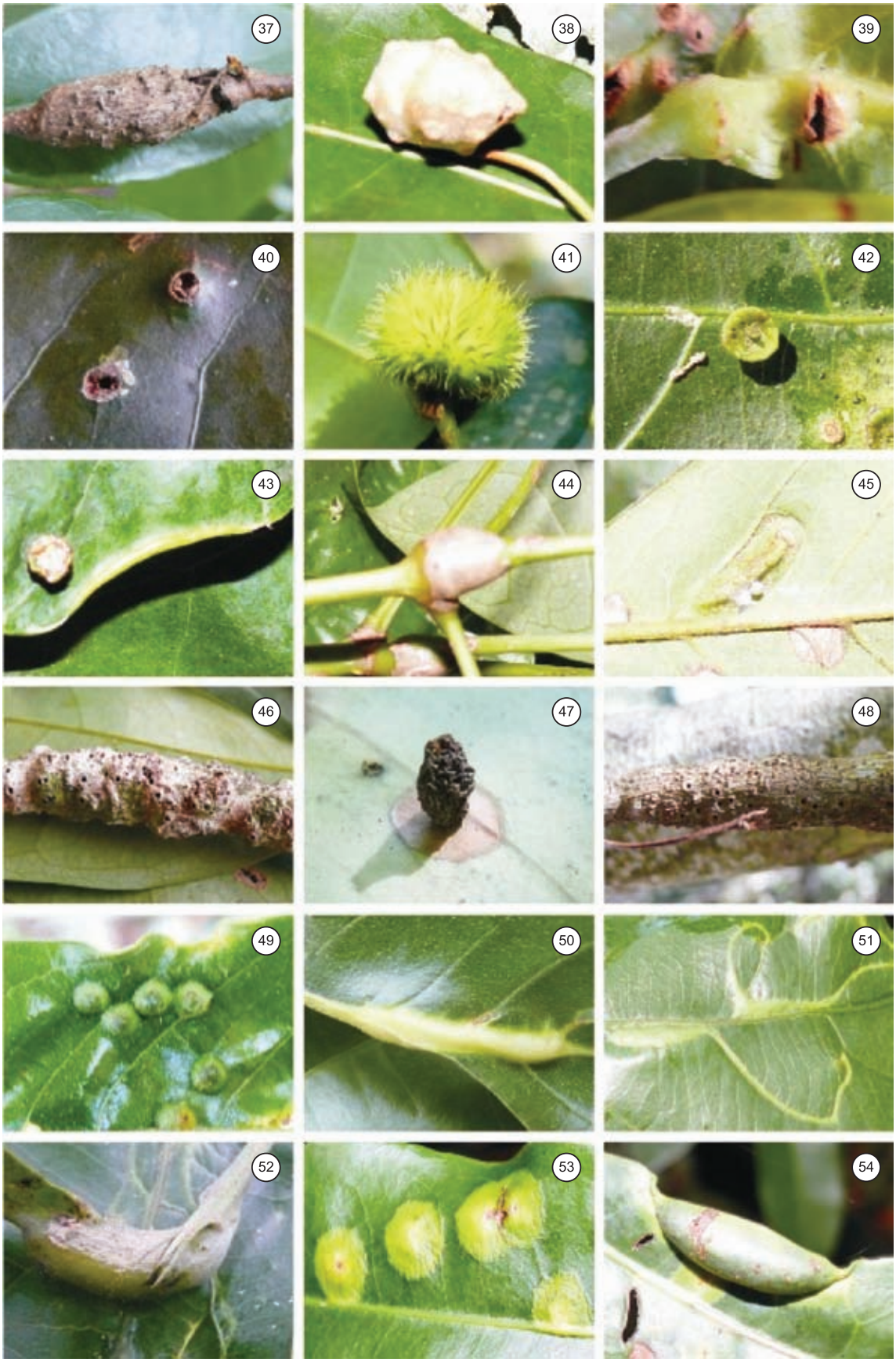

Figure 2. 37 - *Connarus blanchetii*; 38 - *Dioscorea* sp.; 39 and 40 - *Erythroxylum squamatum*; 41 - *Chaetocarpus myrsinites*; 42 and 43 - *Pogonophora schomburgkiana*; 44 and 45 - *Andira fraxinifolia*; 46 - *Chamaecrista ensiformis*; 47 and 48 - *Inga capitata*; 49 and 50 - *Inga thibaudiana*; 51 and 52 - *Casearia javitensis*; 53 and 54 - *Casearia sylvestris*;

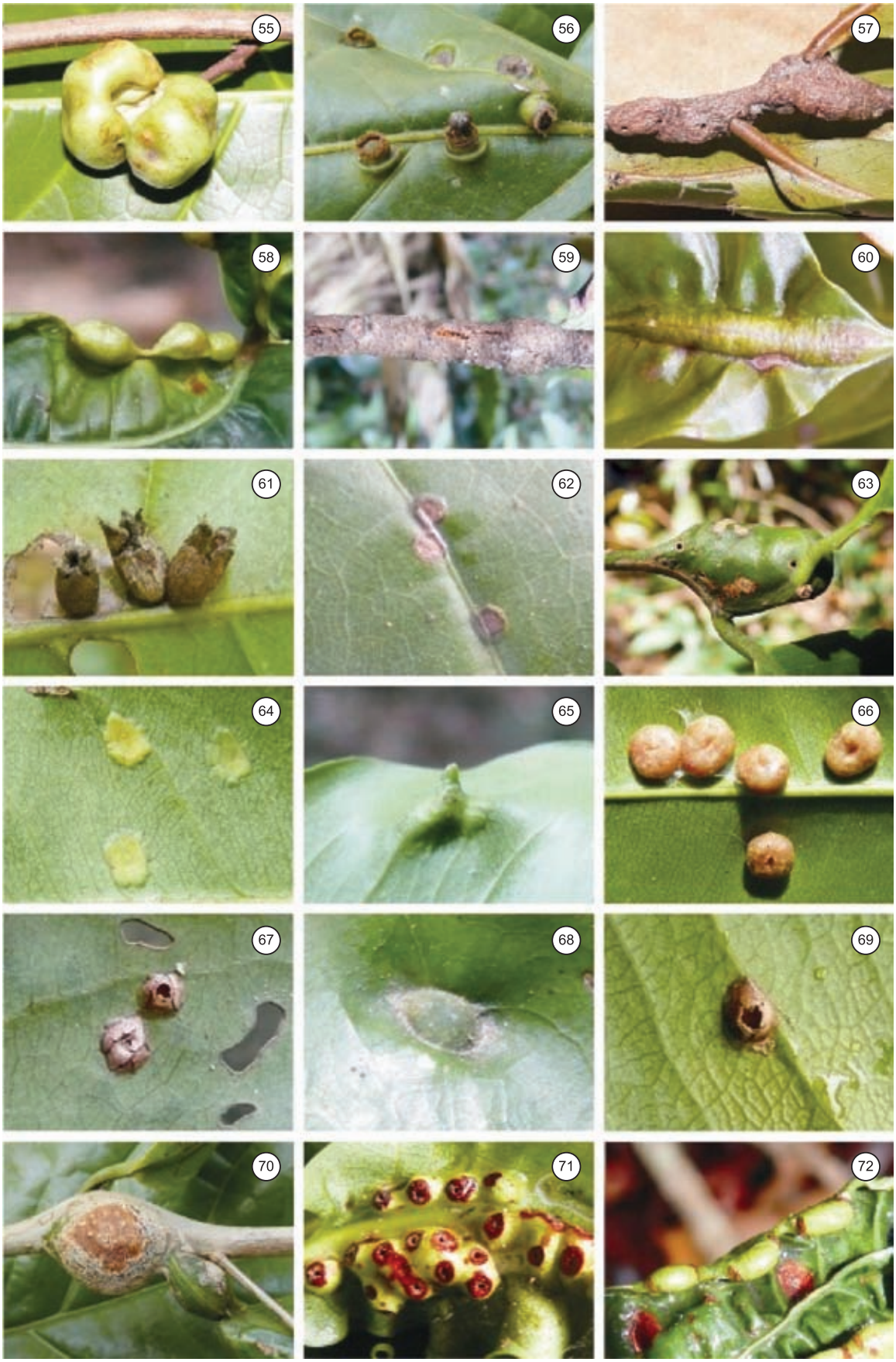

Figure 2. 55 - *Hippocratea volubilis*; 56 - *Nectandra cuspidata*; 57 - *Ocotea* cf. *glomerata*; 58 and 59 - *Ocotea glomerata*; 60-62 - *Ocotea opifera*; 63-68 - *Eschweilera ovata*; 69 and 70 - *Lecythis* cf. *chartacea*; 71 - *Lecythis* sp.; 72 - *Byrsonima sericea*;

Figure 2. 73 - *Byrsonima verbascifolia*; 74 - *Mascagnia psilophylla*; 75 - *Henriettea succosa*; 76 - *Miconia cinnamomifolia*; 77 - *Miconia hypoleuca*; 78-80 - *Miconia prasina*; 81 - *Miconia* sp.; 82 - *Guarea* sp.; 83 - *Trichilia quadrijuga*; 84-86 - *Siparuna guianensis*; 87 and 88 - *Calyptranthes* sp.; 89 - *Calyptranthes widgreniana*; 90 - *Eugenia* sp.;

Figure 2. 91 - *Myrcia* cf. *guianensis*; 92 - *Myrcia* cf. *splendens*; 93 - *Myrcia* sp.; 94 and 95 - *Myrcia sylvatica*; 96-104 - *Guapira opposita*; 105 - *Ouratea* sp.; 106 - *Piper aduncum*; 107 - *Coccoloba* cf. *ochreolata*; 108 - *Coccoloba ochreolata*;

Figure 2. 109 - *Coccoloba* sp.1; 110 - *Coccoloba* sp.2; 111 and 112 - *Coccoloba* sp.3; 113 - Polygonaceae sp.1; 114 and 115 - *Amaioua guianensis*; 116 and 117 - *Palicourea crocea*; 118 - *Psychotria carthagenensis*; 119 - Rubiaceae sp.1; 120 and 121 - *Cupania racemosa*; 122 and 123 - *Paullinia pinnata*; 124 - *Chrysophyllum splendens*; 125-126 - *Pouteria* sp.;

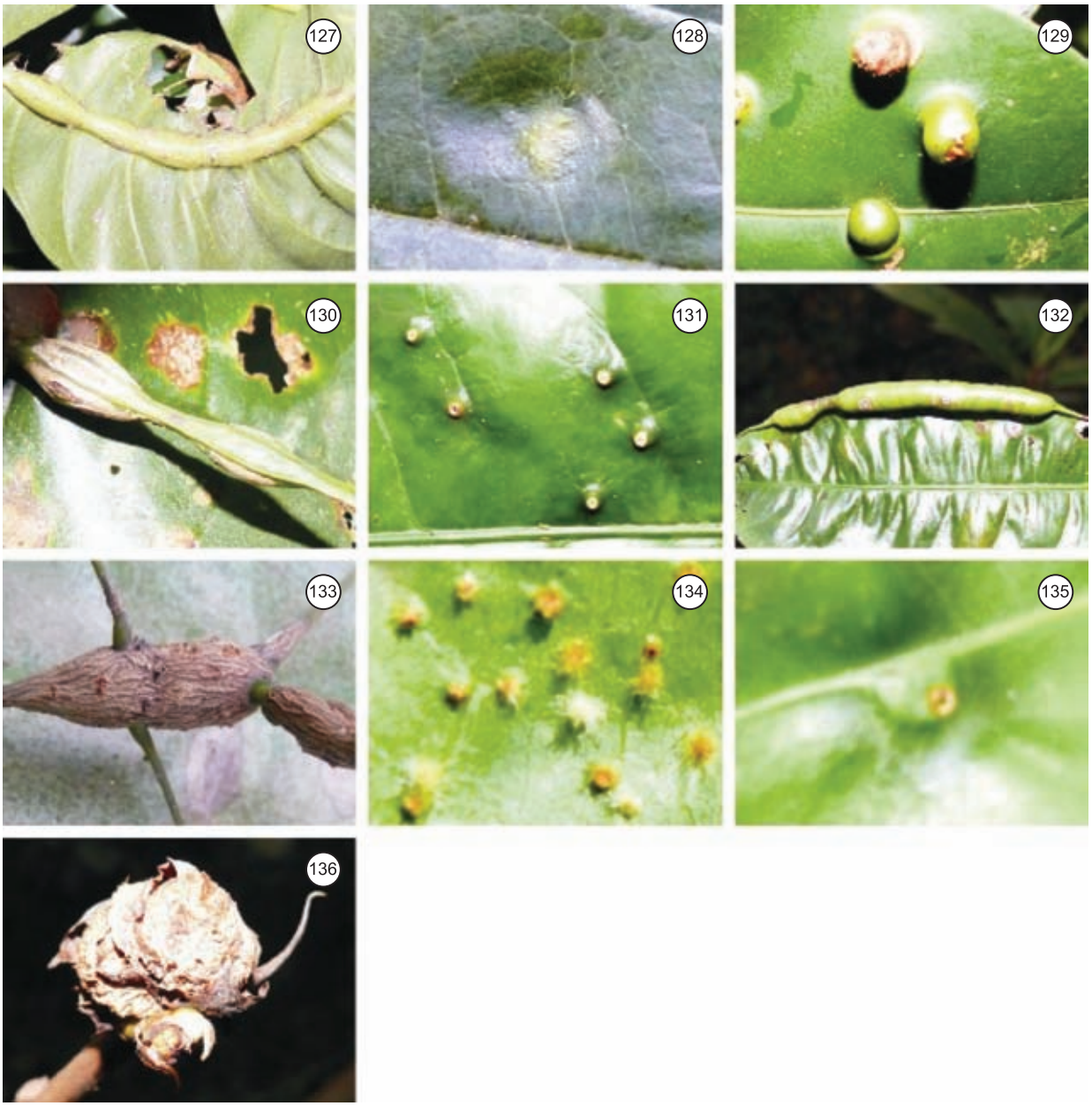

Figure 2. 127 - *Pouteria* sp.;128-130 - *Simarouba amara*; 131 and 132 - *Rinorea* cf. *guianensis*; 133 - Not identified sp.1; 134 - Not identified sp.2; 135 - Not identified sp.3; 136 - Not identified sp.4. For host plant identification and gall morphotypes description, see also Table 1.

Piperaceae in Usina Serra Grande, Alagoas state (Silva et al. 2011) and Burseraceae, Lecythidaceae, Annonaceaea and Melastomataceae in Parque Estadual de Dois Irmãos, Pernambuco state (Fernandes et al. 2009); while in this study Lecythidaceae, Myrtaceae, Nyctaginaceae, and Burseraceae were the families with more galling insects. This could be the consequence of the size of the host plant families in the region. In addition, as pointed out by some authors (e.g., Fernandes 1992, Fernandes & Price 1988), the presence of super-hosts can be an important element to determinate the composition of the community of galling insects. In this study, only *Guapira opposita* (Vell.) Reitz, *Eschweilera ovata* (Cambess.) Miers and *Protium heptaphyllum* (Aubl.) Marchand accounted for approximately 15% (21 morphotypes) of gall morphotypes. *Guapira opposita* was the host plant with more galling species (nine morphospecies). In other ecosystems, these species also is considered a super-host (Maia 2001, Maia et al. 2008, Maia & Oliveira 2010). Similar case can be found in savannah areas, where the genus *Baccharis* is a super-host (Fernandes et al. 1996, Espírito-Santo & Fernandes 2007).

In relation to shapes, pubescence, occurrence and plants organ attacked, the result obtained in this study correspond to those found by Fernandes et al. (2001) which shows a similarity in the life of this galling strategies for this type of forest. In this study, the galls were globoid and elliptical, glabrous, predominantly green, with one chamber per gall and that induce galls on leaves and stems. Whereas in Fernandes et al. (2001) the galls were elliptical and spherical, glabrous, predominantly green, with one chamber per gall and that induce galls on leaves and stems.

Table 2. Number species and proportion of galling insect morphospecies and host plants species for each host plant family found in the Atlantic forests of Pernambuco, Brazil.

Host plant family	Galling insect morphospecies		Host plant species	
	Number species	Proportion	Number species	Proportion
Anacardiaceae	3	2.21	2	2.53
Annonaceae	1	0.74	1	1.27
Apocynaceae	3	2.21	2	2.53
Araceae	1	0.74	1	1.27
Araliaceae	1	0.74	1	1.27
Asteraceae	1	0.74	1	1.27
Bignoneaceae	4	2.94	2	2.53
Boraginaceae	2	1.47	2	2.53
Burseraceae	8	5.88	3	3.80
Chrysobalanaceae	1	0.74	1	1.27
Clusiaceae	7	5.15	2	2.53
Hypericaceae	4	2.94	1	1.27
Connaraceae	1	0.74	1	1.27
Dioscoreaceae	1	0.74	1	1.27
Erythroxylaceae	2	1.47	1	1.27
Peraceae	3	2.21	2	2.53
Fabaceae	7	5.15	4	5.06
Salicaceae	4	2.94	2	2.53
Celastraceae	1	0.74	1	1.27
Lauraceae	7	5.15	4	5.06
Lecythidaceae	9	6.62	3	3.80
Malpighiaceae	3	2.21	3	3.80
Melastomataceae	7	5.15	5	6.33
Meliaceae	2	1.47	2	2.53
Siparunaceae	3	2.21	1	1.27
Myrtaceae	9	6.62	7	8.86
Nyctaginaceae	9	6.62	1	1.27
Ochnaceae	1	0.74	1	1.27
Piperaceae	1	0.74	1	1.27
Polygonaceae	7	5.15	6	7.59
Rubiaceae	6	4.41	4	5.06
Sapindaceae	4	2.94	2	2.53
Sapotaceae	4	2.94	2	2.53
Simaroubaceae	3	2.21	1	1.27
Violaceae	2	1.47	1	1.27
Not identified	4	2.94	4	5.06
All groups	136	100	79	100

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