DISTRIBUTION AND MORPHOLOGY OF INSECT GALLS OF THE RIO DOCE VALLEY, BRAZIL

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■ ABSTRACT: We studied the distribution and richness of gall-forming insects on their host plants in xeric and mesic habitats, as well as in understory of *Eucalyptus* spp forests in 5 localities of the Rio Doce Valley, in Southeastern Brazil. We found 273 different morphospecies of galling insects on 139 host plant species belonging to 40 families. The majority of galls (75.1%) were induced by Cecidomyiidae (Diptera). Galls occurred most frequently on stems (40.7%), had elliptical shape and had absence of trichomes on the external walls. The highest diversity of gall-forming insects was found in the locality that showed the highest diversity of plant species on the sclerophyllous vegetation of the Parque Natural do Caraça. We found no trends in richness of galling insects between the three habitats types studied

■ KEYWORDS: Gall richness; insect galls; insect-plant interaction; Rio Doce Valley.

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Introduction

Galls are tumorous structures induced by an increased number and/or volume of plant tissues or cells, caused by bacteria, virus, fungus, nematode, and mainly insects.[3,18] From an ecological point of view, galls are adaptations of some taxa of insects developed under selective pressures caused by both biotic and abiotic factors.[6,7,19] Insects are the most common gall inducers and are widely distributed in all biogeographical areas, and among plant families.[14,15,18] Strong global patterns have been described in the distribution of insect galls on host plant families and galled organs.[9,20]

The diversity and distribution of galling insects are influenced by factors such as plant resistance, chemistry, diversity, and historical aspects of their host plants, natural enemies, and finally the physical and climatic properties of the habitat,[1,2,5,7,18] as well as human disturbances.[10,16] Several studies have shown a high diversity of galling insects in sites that suffer water and nutrient deficiency,[7,8,17,21] (but see Blanche & Westoby).[1] Besides, this sclerophyllous vegetation seems to have a higher diversity of insect galls than riparian and mesic forests.[7,17,20]

For the first time, we describe the insect galls found in the Rio Doce Valley, in Southeastern Brazil, and provide some information on the external morphology of galls, their occurrence on host organs, and plant species affected. We also illustrate all galls found and describe the distribution patterns of gall-forming insects in the sampled habitats. Data were collected to enable further testing of the "harsh environment hypothesis" which predicts that dry sites with high degrees of hygrothermal and nutrient stress would support a greater richness of gall-forming species.[7] To our knowledge, this is the first time the hypothesis is tested in the Atlantic forest of Brazil.

Material and methods

Study sites

The study was performed in Rio Doce basin in Brazil from June 1994 to June 1995. The area is covered primarily by Atlantic forest, hillside forests, cerrado vegetation, and crops of several *Eucalyptus* species. We also sampled a drier locality with highly sclerophyllous vegetation (Caraça reserve) to further test the harsh environment hypothesis. The follow-

ing localities were studied: 1. Parque Natural do Caraça; 2. Parque Estadual do Rio Doce; 3. Antônio Dias County; 4. Ipatinga County, and 5. Belo Oriente County. In each locality we sampled sites of native Atlantic forests where xeric habitats (habitats far from water sources) and mesic habitats (habitats along rivers, streams, lakes, ponds and springs) could be easily distinguished.[7] Whenever possible, we also sampled understory of *Eucalyptus* spp forests, when available in the sample sites, as these are very common plantations in the region.

Methods

Samples of galling insects were made by 12 walks along trails (transects) of one hour each;[20] for a total of 6 hours in xeric habitats and 6 in mesic habitats. In the understory of *Eucalyptus* spp samples consisted of 6 transects of one hour each. In these areas no attempt was made to distinguish xeric from mesic habitats given the high human disturbance and land use. During each sample walk, plants which presented insect galls were recorded and collected. Galls were identified to morphospecies level and each gall type was recorded only once. Host plants were classified to morphospecies for later identification at the species level, and incorporated into the Gall Collection of the Herbarium of Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.

In the laboratory, galls were characterized by the presence or absence of trichomes (glabrous or pubescent), type of occurrence (isolated or grouped/coalescent), galled organ of the host plant, and also illustrated with hand-made drawings (Table 1, Figures 1-273). Gall-forming insects were separated into morphospecies and identified at the family level. Data were analyzed using analysis of variance (ANOVA) and when differences were found we used Tukey's test a posteriori. Comparisons within sites were done by Student t test.

Results

We found 273 morphologically different morphospecies of gall-forming insects. The most frequent were Cecidomyiidae (Diptera) (75.1%), followed by Hymenoptera (8.1%), Lepidoptera (4.0%), Curculionidae (3.3%), Tephritidae (Diptera) 2.2%, other Coleoptera (1.8%), Psyllidae (Homoptera) (1.5%), Thysanoptera (1.1%), and other Homoptera (0.7%). Galls where we could not identify the galling organism represented only 2.2% of all galls found (Table 2).

Table 1 – Host plant family and species, galling insect families, gall characterization and sampled localities in Rio Doce Valley, State of Minas Gerais, Brazil (PNC: Parque Natural do Caraça; PERD: Parque Estadual do Rio Doce; AD: Antônio Dias; BO: Belo Oriente; IPAT: Ipatinga)

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
Asteraceae	*Acanthospermum australe* (L.) Loefling	1	Hymenoptera	Leaf	Discoidal	Green	Glabrous	Single	IPAT	Xeric	Fig. 1
	Baccharis dracunculifolia D.C.	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	IPAT BO AD	Mesic, Xeric *Eucalyptus* Mesic, Xeric	Fig. 2
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Single	AD IPAT	Mesic, Xeric Mesic, Xeric	Fig. 3
		3	Cecidomyiidae	Stem	Cylindrical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 4
		4	Cecidomyiidae	Apical stem	Flower-like	Green	Pubescent	Single	IPAT AD	Mesic Mesic, Xeric	Fig. 5
		5	Neopelma baccharides	Leaf	Elliptical	Green	Glabrous	Single	AD	Xeric	Fig. 6
		6	Cecidomyiidae	Leaf	Discoidal	Green	Pubescent	Single	AD BO	Mesic *Eucalyptus*	Fig. 7
	Baccharis serrulata (Lam.) Pers.	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 8
		2	Lepidoptera	Stem	Elliptical	Brown	Pubescent	Single	IPAT	Mesic, Xeric	Fig. 9
		3	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	IPAT	Mesic, Xeric	Fig. 10
		4	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 11
	Eremanthus erythropappus (D.C.) MacLeish	1	Cecidomyiidae	Leaf	Spherical	Pale	Pubescent	Group	PNC	Mesic	Fig. 12
		2	Tephritidae	Stem	Elliptical	Brown	Glabrous	Group	PNC	Mesic, Xeric	Fig. 13
		3	Tephritidae	Stem	Globular	Brown	Glabrous	Single	PNC	Mesic, Xeric	Fig. 14
	Eremanthus sp	1	Tephritidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 15
		2	Tephritidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 16
		3	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	PNC	Xeric	Fig. 17
		4	Cecidomyiidae	Leaf petiole	Spherical	Green	Glabrous	Single	PNC	Xeric	Fig. 18

continuation

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		5	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	Single	PNC	Xeric	Fig. 19
		6	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 20
		7	Cecidomyiidae	Leaf	Spherical	Pale	Pubescent	Group	PNC	Xeric	Fig. 21
		8	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Group	PNC	Xeric	Fig. 22
	Mikania cf. *acuminata* D.C.	1	Cecidomyiidae	Leaf	Discoidal	Black	Glabrous	Single	PNC	Mesic	Fig. 23
	Mikania hirsutissima D.C.	1	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Group	BO IPAT AD	*Eucalyptus* Mesic Mesic	Fig. 24
		2	Cecidomyiidae	Leaf	Discoidal	Green	Pubescent	Single	AD PERD	Mesic *Eucalyptus*	Fig. 25
		3	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Group	BO	*Eucalyptus*	Fig. 26
		4	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	BO	*Eucalyptus*	Fig. 27
		5	Thysanoptera	Leaf	Spot-like	Green	Pubescent	Group	PNC	Mesic	Fig. 28
	Mikania campos-portoana Barroso	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	AD	Mesic	Fig. 29
	Mikania sp 1	1	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Single	PNC	Mesic	Fig. 30
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 31
	Mikania sp 2	1	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Single	PNC	Mesic	Fig. 32
	Mikania sp 3	1	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Single	PNC	Mesic	Fig. 33
	Piptocarpha sp	1	Coleoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 34
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Pubescent	Group	PNC	Mesic	Fig. 35
	Vernonia cf. *condensata* Baker	1	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Group	AD	Xeric	Fig. 36
	Vernonia polyanthes Less	1	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	AD BO	Mesic, Xeric Mesic	Fig. 37
		2	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	BO IPAT AD PNC	*Eucalyptus*, Mesic, Xeric Mesic, Xeric Xeric Mesic	Fig. 38

continuation

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		3	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Group	IPAT	Mesic, Xeric	Fig. 39
									AD	Xeric	
									BO	Mesic, Xeric, *Eucalyptus*	
									PERD	*Eucalyptus*	
		4	Cecidomyiidae	Leaf petiole	Spherical	Brown	Glabrous	Group	IPAT	Mesic, Xeric	Fig. 40
									BO	Mesic	
		5	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	Group	AD	Xeric	Fig. 41
									PNC	Mesic	
									PERD	*Eucalyptus*	
		6	Tephritidae	Stem	Fusiforme	Brown	Glabrous	Single	AD	Mesic, Xeric	Fig. 42
									IPAT	Xeric	
		7	Cecidomyiidae	Leaf vein	Spherical	Green	Pubescent	Group	IPAT	Xeric	Fig. 43
		8	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Single	IPAT	Mesic	Fig. 44
									BO	Mesic	
									AD	Xeric	
		9	Cecidomyiidae	Leaf vein	Elliptical	Brown	Pubescent	Single	BO	*Eucalyptus*	Fig. 45
										Mesic, Xeric	
									AD	Xeric	
	Vernonia scorpioides (Lam.) Pers.	1	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	AD	Mesic, Xeric	Fig. 46
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Group	AD	Xeric	Fig. 47
	sp 1	1	Coleoptera	Stem	Elliptical	Brown	Pubescent	Single	PNC	Xeric	Fig. 48
	sp 2	1	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Group	PNC	Mesic	Fig. 49
Apocynaceae	*Tabernaemontana* sp	1	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	Single	PERD	Xeric	Fig. 50
		2	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PERD	Xeric	Fig. 51
Aquifoliaceae	*Ilex ceracifolia* Reiss.	1	Thysanoptera	Leaf	Spherical	Green	Glabrous	Group	PNC	Mesic	Fig. 52
Anacardiaceae	*Tapirira guianensis* Aubl.	1	Psyllidae	Leaf	Elliptical	Green	Glabrous	Single	PERD	Mesic	Fig. 53
		2	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Single	PERD	Mesic	Fig. 54
		3	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PERD	Mesic	Fig. 55

continuation

Host plant		Galling insect		Gall description					Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
	Tapirira sp	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 56
Annonaceae	*Guatteria villosissima* St. Hil.	1	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Group	PNC	Mesic	Fig. 57
	sp 1	1	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 58
Aristolochiaceae	*Aristolochia galeata* Mart. & Zucc.	1	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	BO	Xeric	Fig. 59
Bignoniaceae	*Anemopaegma* sp	1	Tephritidae	Stem	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 60
		2	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Group	PERD	Xeric	Fig. 61
		3	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 62
		4	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 63
	Arrabidaea chica (H. & B.) Verlot	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	BO	*Eucalyptus*	Fig. 64
		2	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 65
		3	Cecidomyiidae	Leaf petiole	Spherical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 66
		4	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Pubescent	Single	BO	*Eucalyptus* ssp	Fig. 67
		5	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Glabrous	Group	IPAT	Mesic	Fig. 68
		6	Cecidomyiidae	Leaf	Elliptical	Brown	Pubescent	Single	BO	*Eucalyptus*	Fig. 69
		7	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 70
	Arrabidaea cf. *formosa* (Bureau) Sandw.	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 71
	Arrabidaea cf. *sceptrum* (Cham.) Sandw.	1	Not identified	Leaf	Discoidal	Brown	Glabrous	Single	PERD	*Eucalyptus*	Fig. 72
	Arrabidaea sp 1	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 73
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PERD	Xeric	Fig. 74
	Arrabidaea sp 2	1	Not identified	Stem	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 75
	Arrabidaea sp 3	1	Not identified	Leaf	Discoidal	Green	Glabrous	Single	BO	Xeric	Fig. 76
	Clytostoma sp	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Group	PNC	Mesic	Fig. 77
	Fridericia speciosa Mart.	1	Cecidomyiidae	Leaf	Elliptical	Green	Pubescent	Single	BO	Xeric	Fig. 78
	Sparattosperma leucanthum (Vell.) K. Schum	1	Cecidomyiidae	Leaf vein	Elliptical	Green	Glabrous	Single	BO	*Eucalyptus* ssp	Fig. 79
		2	Cecidomyiidae	Leaf petiole	Elliptical	Green	Glabrous	Single	BO	*Eucalyptus* ssp	Fig. 80

continuation

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		3	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	Single	BO IPAT	Mesic Mesic, Xeric	Fig. 81
	Tabebuia ochraceae (Cham.) Standley	1	Curculionidae	Stem	Elliptical	Pale	Glabrous	Single	AD	Xeric	Fig. 82
	sp 1	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	BO	*Eucalyptus*	Fig. 83
		2	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Group	IPAT BO	Mesic, Xeric Mesic, *Eucalyptus*	Fig. 84
	sp 2	1	Cecidomyiidae	Leaf	Discoidal	Pale	Glabrous	Single	IPAT	Mesic	Fig. 85
		2	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	IPAT	Mesic	Fig. 86
	sp 3	1	Not identified	Stem	Globular	Brown	Glabrous	Group	BO	*Eucalyptus*	Fig. 87
		2	Coleoptera	Stem	Elliptical	Brown	Glabrous	Group	BO	*Eucalyptus*	Fig. 88
	sp 4	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	BO	*Eucalyptus*	Fig. 89
		2	Cecidomyiidae	Leaf petiole	Globular	Brown	Pubescent	Single	BO	*Eucalyptus*	Fig. 90
		3	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Group	BO	*Eucalyptus*	Fig. 91
	sp 5	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 92
Burseraceae	*Protium heptaphyllum* (Aubl.) March.	1	Psyllidae	Stem	Elliptical	Brown	Glabrous	Group	PNC	Mesic, Xeric	Fig. 93
		2	Psyllidae	Leaf	Spherical	Green	Glabrous	Group	PNC	Mesic, Xeric	Fig. 94
	Protium spruceanum (Benth.) Engl.	1	Cecidomyiidae	Leaf	Conical	Green	Glabrous	Single	PERD	Mesic	Fig. 95
Boraginaceae	*Cordia verbenacea* D.C.	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 96
	Tournefortia cf. *villosa* Salzm.	1	Cecidomyiidae	Leaf	Discoidal	Gray	Pubescent	Group	AD	Xeric	Fig. 97
Bombacaceae	sp 1	1	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PERD	Xeric	Fig. 98
Celastraceae	*Maytenus gonoclada* Mart.	1	Lepidoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 99
		2	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	PNC	Xeric	Fig. 100
Clusiaceae	*Vismia* sp	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	PNC	Mesic	Fig. 101
Crysobalanaceae	sp 1	1	Cecidomyiidae	Leaf	Spot-like	Brown	Glabrous	Single	PERD	*Eucalyptus*	Fig. 102
Dilleniaceae	*Davilla rugosa* St. Hil.	1	Cecidomyiidae	Apical stem	Flower-like	Brown	Pubescent	Single	PERD	Mesic	Fig. 103

continuation

Host plant		Galling insect			Gall description				Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Group	PERD	Mesic	Fig. 104
		3	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Single	PERD	Mesic	Fig. 105
Dryopteridaceae	*Tectaria* sp	1	Not identified	Leaf	Discoidal	Green	Glabrous	Single	PERD	Xeric	Fig. 106
Erythroxylaceae	*Erythroxylum gonocladum* (Mart.) O. E. Shulz.	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 107
Euphorbiaceae	*Croton* sp	1	Not identified	Leaf	Discoidal	Pale	Pubescent	Single	IPAT	Xeric	Fig. 108
	Croton migrans Casar	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 109
	Pera sp 1	1	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PERD	Mesic	Fig. 110
		2	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PERD	Mesic	Fig. 111
	Pera sp 2	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	PNC	Mesic	Fig. 112
		2	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 113
	Pera sp 3	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	AD	Xeric	Fig. 114
Fabaceae	*Andira* sp	1	Homoptera	Leaf	Discoidal	Green	Glabrous	Group	BO	Eucalyptus	Fig. 115
	Bauhinia sp	1	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	IPAT	Mesic	Fig. 116
	Dalbergia miscolobium Benth.	1	Hymenoptera	Stem	Globular	Brown	Glabrous	Single	PNC	Xeric	Fig. 117
	Dalbergia nigra Benth.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 118
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Single	IPAT	Mesic	Fig. 119
	Dioclea sp	1	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 120
	Machaerium angustifolium Vog.	1	Anadiplosis sp	Stem	Elliptical	Brown	Glabrous	Single	AD	Mesic	Fig. 121
	Machaerium sp	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	AD	Mesic	Fig. 122
	sp 1	1	Hymenoptera	Stem	Globular	Brown	Glabrous	Single	PERD	Xeric	Fig. 123
		2	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Glabrous	Single	PERD	Xeric	Fig. 124
		3	Cecidomyiidae	Leaf petiole	Spherical	Brown	Glabrous	Single	PERD	Xeric	Fig. 125
	sp 2	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	BO	Mesic	Fig. 126
		2	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 127
	sp 3	1	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	Single	PERD	Xeric	Fig. 128

continuation

Host plant		Galling insect			Gall description				Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		2	Cecidomyiidae	Leaf vein	Elliptical	Green	Glabrous	Single	PERD	Xeric	Fig. 129
		3	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PERD	Xeric	Fig. 130
Lauraceae	*Ocotea dispersa* (Nees) Mez.	1	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Group	PNC	Mesic	Fig. 131
	Ocotea macropoda Mez.	1	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Group	PNC	Mesic	Fig. 132
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PNC	Mesic	Fig. 133
Malpighiaceae	*Byrsonima intermedia* A. Juss.	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Group	PERD	Mesic, *Eucalyptus*	Fig. 134
	Byrsonima variabilis A. Juss.	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 135
		2	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 136
		3	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 137
	Stigmaphyllon sp	1	Cecidomyiidae	Leaf	Cylindrical	Pale	Pubescent	Group	IPAT	Mesic	Fig. 138
Melastomataceae	*Clidemia urceolata* D.C.	1	Curculionidae	Stem	Globular	Brown	Pubescent	Single	PNC AD	Mesic Mesic	Fig. 139
	Leandra cf. lacunosa Cogn.	1	Lepidoptera	Stem	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 140
		2	Lepidoptera	Leaf	Spherical	Brown	Pubescent	Single	PNC	Mesic	Fig. 141
		3	Lepidoptera	Leaf petiole	Spherical	Green	Pubescent	Single	PNC	Mesic	Fig. 142
	Leandra melastomoides Raddi	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Group	PNC	Mesic	Fig. 143
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Group	PNC	Mesic	Fig. 144
		3	Cecidomyiidae	Stem	Elliptical	Green	Pubescent	Single	PNC	Mesic	Fig. 145
		4	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 146
		5	Cecidomyiidae	Leaf vein	Discoidal	Green	Pubescent	Single	PNC	Mesic, Xeric	Fig. 147
	Miconia chartacea Triana	1	Lepidoptera	Stem	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 148
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Group	PNC	Mesic	Fig. 149
		3	Cecidomyiidae	Leaf vein	Spherical	Brown	Pubescent	Single	PNC	Mesic	Fig. 150
		4	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Single	PNC	Mesic	Fig. 151
		5	Cecidomyiidae	Leaf vein	Spherical	Brown	Pubescent	Single	PNC	Mesic	Fig. 152

continuation

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
	Miconia corallina Spring	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 153
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Pubescent	Single	PNC	Mesic	Fig. 154
		3	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Group	PNC	Xeric	Fig. 155
	Miconia cf. *dodecandra* (Desr.) Cogn.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 156
	Miconia cf. *latecrenata* Naud.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	PNC	Mesic	Fig. 157
	Tibouchina martiusiana Cogn.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 158
		2	Lepidoptera	Leaf	Spherical	Brown	Pubescent	Group	PNC	Xeric	Fig. 159
	sp 1	1	Lepidoptera	Stem	Elliptical	Brown	Pubescent	Single	PNC	Xeric	Fig. 160
		2	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Group	PNC	Mesic, Xeric	Fig. 161
		3	Lepidoptera	Leaf	Spherical	Brown	Pubescent	Group	PNC	Xeric	Fig. 162
	sp 2	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	PNC	Mesic	Fig. 163
		2	Lepidoptera	Leaf	Spherical	Green	Pubescent	Single	PNC	Mesic	Fig. 164
Meliaceae	*Guarea guidonia* (L.) Sleumer	1	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 165
		2	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 166
	sp 1	1	Coleoptera	Stem	Elliptical	Brown	Glabrous	Single	PERD	Xeric	Fig. 167
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Group	PERDAD	XericMesic	Fig. 168
		3	Cecidomyiidae	Leaf	Discoidal	Pale	Glabrous	Single	PERD	Xeric	Fig. 169
Monimiaceae	*Siparuna arianeae* V. Pereira	1	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PERD	Mesic	Fig. 170
Myrsinaceae	*Myrsine* sp 1	1	Coleoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 171
		2	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PNC	Mesic, Xeric	Fig. 172
	Myrsine sp 2	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Single	PNC	Mesic	Fig. 173
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Pubescent	Group	PNC	Mesic	Fig. 174
Myrtaceae	*Eugenia* cf. *glazioviana* Kiaerskou	1	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PNC	Xeric	Fig. 175
	Eugenia sphenophylla Berg.	1	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 176
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PNC	Xeric	Fig. 177

continuation

Host plant		Galling insect		Gall description					Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
	Gomidesia sp 1	1	Hymenoptera	Stem	Elliptical	Brown	Pubescent	Group	PNC	Mesic	Fig. 178
	Gomidesia sp 2	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 179
		2	Hymenoptera	Leaf	Spherical	Green	Glabrous	Group	PNC	Xeric	Fig. 180
	Myrcia cf. *fallax* (Rich.) D.C.	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 181
		2	Hymenoptera	Leaf vein	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 182
	Myrcia cf. formosiana A.P. de Candole	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	PERD	Mesic	Fig. 183
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PERD	Mesic	Fig. 184
		3	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Group	PERD	*Eucalyptus*	Fig. 185
		4	Cecidomyiidae	Leaf vein	Spherical	Brown	Glabrous	Group	PNC	Mesic	Fig. 186
	Myrcia cf. *tomentosa* (Aubl.) D.C.	1	Hymenoptera	Stem	Globular	Brown	Glabrous	Group	AD	Xeric	Fig. 187
	Myrcia multiflora (Lam.) D.C.	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 188
		2	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 189
		3	Cecidomyiidae	Leaf vein	Elliptical	Green	Glabrous	Single	IPAT	Mesic	Fig. 190
		4	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PNC	Mesic	Fig. 191
		5	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 192
		6	Thysanoptera	Leaf	Spherical	Green	Glabrous	Group	PNC	Mesic	Fig. 193
		7	Cecidomyiidae	Leaf	Spherical	Yellow	Glabrous	Single	PNC	Mesic	Fig. 194
		8	Cecidomyiidae	Leaf	Discoidal	Black	Glabrous	Group	PNC	Xeric	Fig. 195
		9	Homoptera	Leaf	Elliptical	Green	Glabrous	Single	PNC	Xeric	Fig. 196
	Myrcia subcordata D.C.	1	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Group	PNC	Xeric	Fig. 197
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Pubescent	Single	PNC	Xeric	Fig. 198
	Myrcia sp 1	1	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Single	PNC	Mesic	Fig. 199
	Myrcia sp 2	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 200
		2	Cecidomyiidae	Leaf	Spherical	Yellow	Glabrous	Single	PNC	Mesic, Xeric	Fig. 201
		3	Cecidomyiidae	Leaf	Elliptical	Green	Glabrous	Single	PNC	Xeric	Fig. 202

continuation

Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
	Myrciaria sp	1	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	AD	Mesic	Fig. 203
	sp 1	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 204
	sp 2	1	Cecidomyiidae	Leaf	Spherical	Black	Glabrous	Group	PNC	Mesic	Fig. 205
	sp 3	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	PNC	Xeric	Fig. 206
		2	Cecidomyiidae	Leaf petiole	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 207
	Psidium guineense Sw.	1	Hymenoptera	Stem	Globular	Brown	Glabrous	Single	PERD BO	Mesic Mesic	Fig. 208
		2	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PERD	Mesic	Fig. 209
Piperaceae	*Piper aduncum* L.	1	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 210
Proteaceae	*Roupala* sp 1	1	Curculionidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 211
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 212
		3	Cecidomyiidae	Leaf	Discoidal	Pale	Glabrous	Group	PNC	Xeric	Fig. 213
	Roupala sp 2	1	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 214
Polygonaceae	*Triplaris brasiliana* Cham.	1	Cecidomyiidae	Leaf	Conical	Brown	Glabrous	Group	PNC	Mesic	Fig. 215
Rhamnaceae	*Reissekia smilacina* (J.H. Smith) Seud.	1	Cecidomyiidae	Leaf vein	Elliptical	Brown	Pubescent	Single	BO	*Eucalyptus*	Fig. 216
		2	Cecidomyiidae	Leaf	Discoidal	Green	Pubescent	Single	BO	*Eucalyptus*	Fig. 217
	sp 1	1	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Single	BO	Mesic, *Eucalyptus*	Fig. 218
Rubiaceae	*Borreria verticilatta* (L.) Mey.	1	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Group	AD	Mesic	Fig. 219
	Palicourea cf. *rigida* H.B.K.	1	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PNC	Mesic	Fig. 220
	Palicourea sp	1	Cecidomyiidae	Leaf	Spherical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 221
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Group	PERD	Mesic	Fig. 222
	Psychotria cephalantha (Muell. Arg.) Standl.	1	Cecidomyiidae	Leaf	Conical	Green	Glabrous	Single	PNC	Mesic	Fig. 223
	Psychotria cf. *harstisepala* Muell. Arg.	1	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	PERD	*Eucalyptus*	Fig. 224
	Psychotria stachyiodes Benth.	1	Cecidomyiidae	Leaf	Discoidal	Black	Glabrous	Group	PNC	Mesic	Fig. 225
		2	Cecidomyiidae	Leaf	Elliptical	Pale	Pubescent	Single	PNC	Mesic, Xeric	Fig. 226

continuation

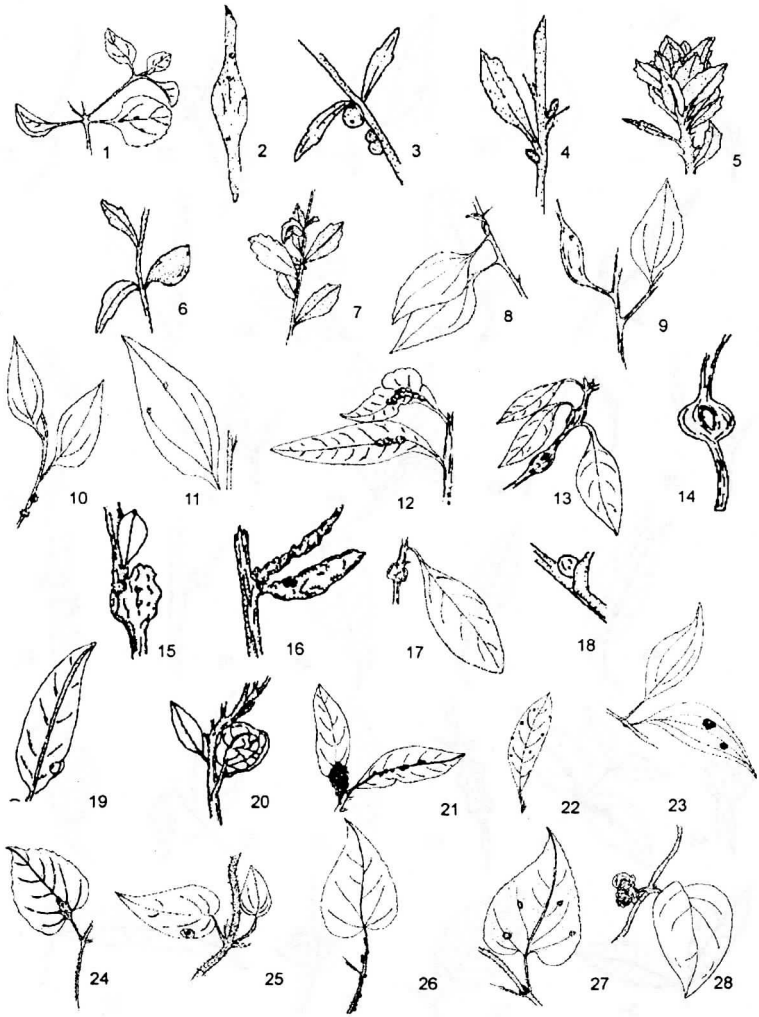
Host plant		Galling insect		Gall description					Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
	Psychotria tetraphylla Muell. Arg.	1	Cecidomyiidae	Leaf	Conical	Green	Pubescent	Group	PNC	Mesic	Fig. 227
	Psychotria triphylla Muell. Arg.	1	Cecidomyiidae	Leaf	Conical	Green	Pubescent	Group	PNC	Mesic	Fig. 228
	Psychotria sp	1	Cecidomyiidae	Leaf	Spherical	Brown	Pubescent	Group	PNC	Xeric	Fig. 229
Rutaceae	*Galipea* sp	1	Cecidomyiidae	Leaf vein	Spherical	Brown	Glabrous	Single	PERD	Xeric	Fig. 230
	Hortia arborea Engl.	1	Cecidomyiidae	Leaf vein	Elliptical	Green	Glabrous	Single	BO	Xeric	Fig. 231
	sp 1	1	Cecidomyiidae	Stem	Globular	Brown	Glabrous	Group	PERD	Xeric	Fig. 232
Sapindaceae	*Matayba guianensis* Aubl.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 233
		2	Hymenoptera	Stem	Elliptical	Brown	Glabrous	Group	BO	Xeric	Fig. 234
	Paullinia rubiginosa Camb.	1	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Single	PERD	*Eucalyptus*	Fig. 235
	Paullinia sp	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	PERD	Xeric	Fig. 236
		2	Cecidomyiidae	Leaf	Discoidal	Green	Pubescent	Group	PERD	*Eucalyptus*	Fig. 237
	Serjania caracasana Wild	1	Cecidomyiidae	Leaf	Spherical	Green	Glabrous	Single	IPAT	Mesic	Fig. 238
		2	Cecidomyiidae	Leaf petiole	Elliptical	Green	Glabrous	Single	IPAT	Mesic	Fig. 239
		3	Cecidomyiidae	Leaf petiole	Spherical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 240
		4	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 241
	Serjania lethalis St. Hil.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	IPAT	Mesic	Fig. 242
		2	Cecidomyiidae	Leaf vein	Elliptical	Brown	Glabrous	Single	PERD IPAT	Xeric Mesic	Fig. 243
	Serjania sp	1	Cecidomyiidae	Leaf	Discoidal	Pale	Glabrous	Group	IPAT PERD	Mesic Xeric	Fig. 244
		2	Cecidomyiidae	Leaf	Elliptical	Brown	Glabrous	Single	PERD	Xeric	Fig. 245
Sapotaceae	*Pouteria* sp	1	Cecidomyiidae	Leaf	Conical	Pale	Pubescent	Single	PERD	Mesic	Fig. 246
		2	Cecidomyiidae	Leaf vein	Elliptical	Parda	Pubescent	Single	PERD	Mesic	Fig. 247
Solanaceae	*Solanum cernuum* L.	1	Lepidoptera	Stem	Elliptical	Brown	Pubescent	Single	PERD	Mesic, *Eucalyptus*	Fig. 248
		2	Cecidomyiidae	Leaf vein	Elliptical	Pale	Pubescent	Single	PERD	Mesic	Fig. 249

continuation

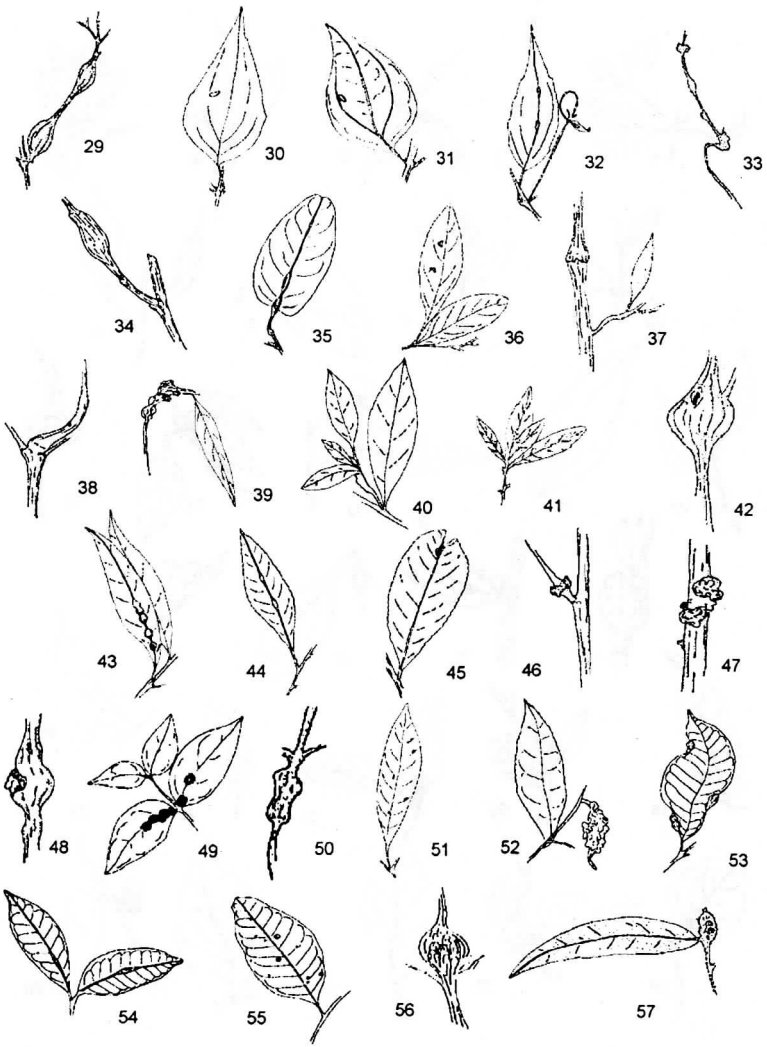
Host plant		Galling insect		Gall description					Loca-lities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
		3	Cecidomyiidae	Leaf vein	Spherical	Pale	Pubescent	Group	PERD	Mesic	Fig. 250
	Solanum cladotrichum Dunal	1	Cecidomyiidae	Stem	Elliptical	Green	Pubescent	Single	PNC	Mesic	Fig. 251
		2	Cecidomyiidae	Leaf	Conical	Green	Pubescent	Group	PNC	Mesic	Fig. 252
	Solanum sartizianum Roem et Shult.	1	Cecidomyiidae	Leaf vein	Spherical	Green	Glabrous	Single	IPAT	Mesic	Fig. 253
		2	Cecidomyiidae	Leaf	Discoidal	Green	Glabrous	Single	AD	Mesic	Fig. 254
Sterculiaceae	*Waltheria communis* St. Hil.	1	Cecidomyiidae	Stem	Globular	Green	Pubescent	Group	IPAT BO	Xeric Mesic	Fig. 255
		2	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Group	BO	Mesic, Xeric, *Eucalyptus*	Fig. 256
									IPAT	Mesic, Xeric	
		3	Cecidomyiidae	Leaf vein	Elliptical	Green	Pubescent	Single	AD	Mesic	Fig. 257
Trigoniaceae	*Trigonia paniculata* Warm.	1	Cecidomyiidae	Leaf vein	Spot-like	Brown	Glabrous	Single	BO	*Eucalyptus*	Fig. 258
Tiliaceae	*Luehea divaricata* Mart.	1	Cecidomyiidae	Leaf	Spherical	Pale	Pubescent	Single	IPAT	Mesic	Fig. 259
		2	Curculionidae	Leaf vein	Elliptical	Brown	Pubescent	Single	BO	*Eucalyptus*	Fig. 260
Verbenaceae	*Lantana camara* L.	1	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Single	ADIPAT	MesicMesic	Fig. 261
		2	Cecidomyiidae	Stem	Globular	Brown	Pubescent	Single	IPAT	Mesic	Fig. 262
		3	Cecidomyiidae	Leaf	Cylindrical	Brown	Pubescent	Single	IPAT	Mesic	Fig. 263
		4	Cecidomyiidae	Leaf	Spherical	Pale	Pubescent	Group	AD IPAT	Mesic Mesic, Xeric	Fig. 264
	Lantana sp	1	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Group	BO	Mesic, *Eucalyptus*	Fig. 265
									AD	Mesic, Xeric	
		2	Cecidomyiidae	Leaf	Spherical	Green	Pubescent	Single	BO	Mesic, Xeric, *Eucalyptus*	Fig. 266
		3	Cecidomyiidae	Stem	Elliptical	Brown	Pubescent	Group	BO AD	Mesic Xeric	Fig. 267
		4	Cecidomyiidae	Stem	Globular	Pale	Pubescent	Group	BO	Xeric	Fig. 268
	Lippia cf. *velutina* Senaw	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	AD	Xeric	Fig. 269

continuation

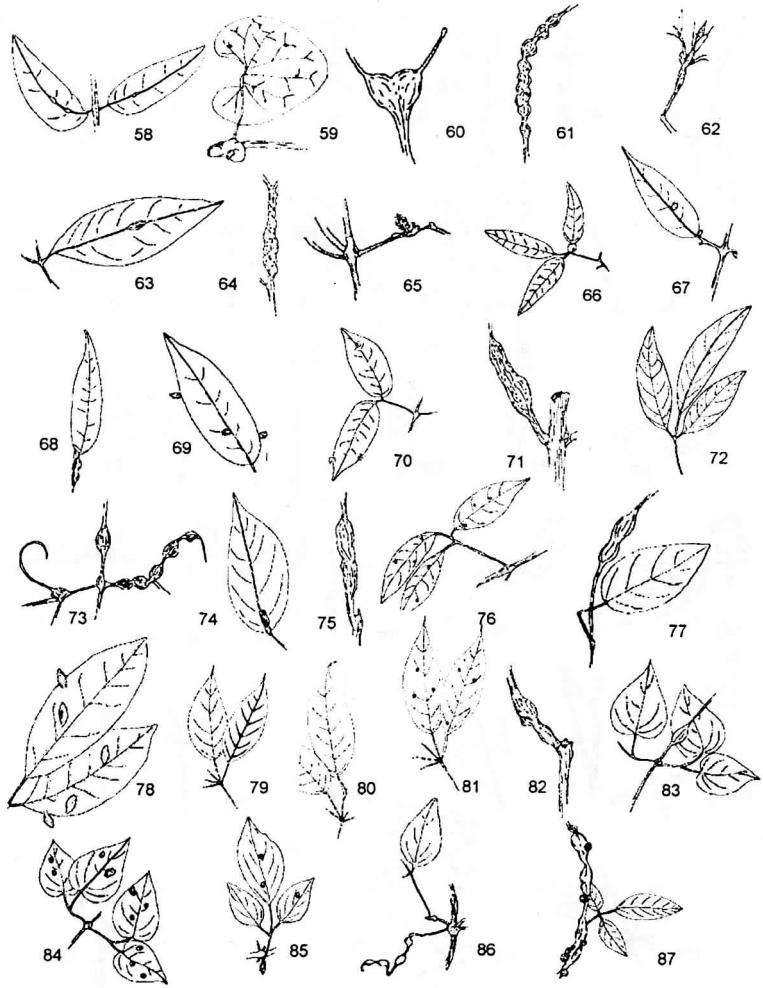
Host plant		Galling insect		Gall description					Localities	Habitat	Figure
Family	Species	Gall	Family	Organ	Shape	Color	Pubescence	Occurrence			
Vochysiaceae	*Vochysia* sp	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Mesic	Fig. 270
	Vochysia tucanorum Mart.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Single	PNC	Xeric	Fig. 271
		2	Cecidomyiidae	Leaf	Discoidal	Brown	Glabrous	Group	PNC	Xeric	Fig. 272
Ulmaceae	*Celtis* cf. *brasiliensis* Planch.	1	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	Group	PERD	Xeric	Fig. 273



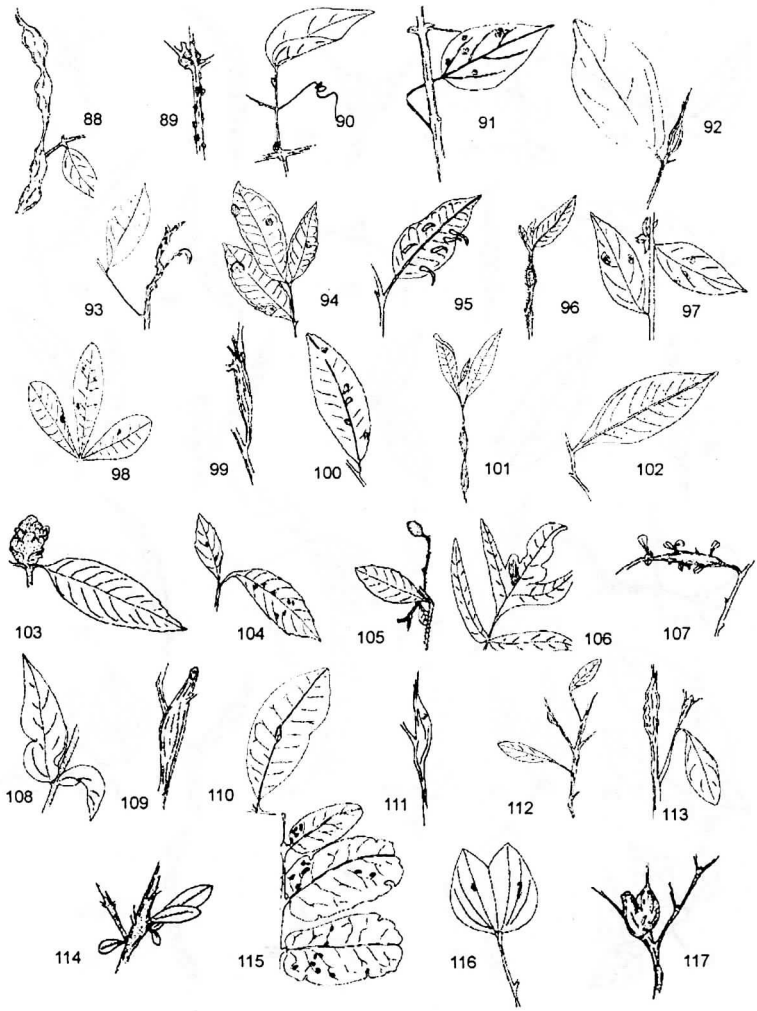
FIGURES 1-28 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (1: *Acanthospermum australe;* 2-7: *Baccharis dracunculifolia*; 8-11: *B. serrulata*; 12-14: *Eremanthus erythropappus*; 15-22: *Eremanthus* sp; 23: *Mikania* cf. *acuminata*; 24-28: *M. hirsutissima*).



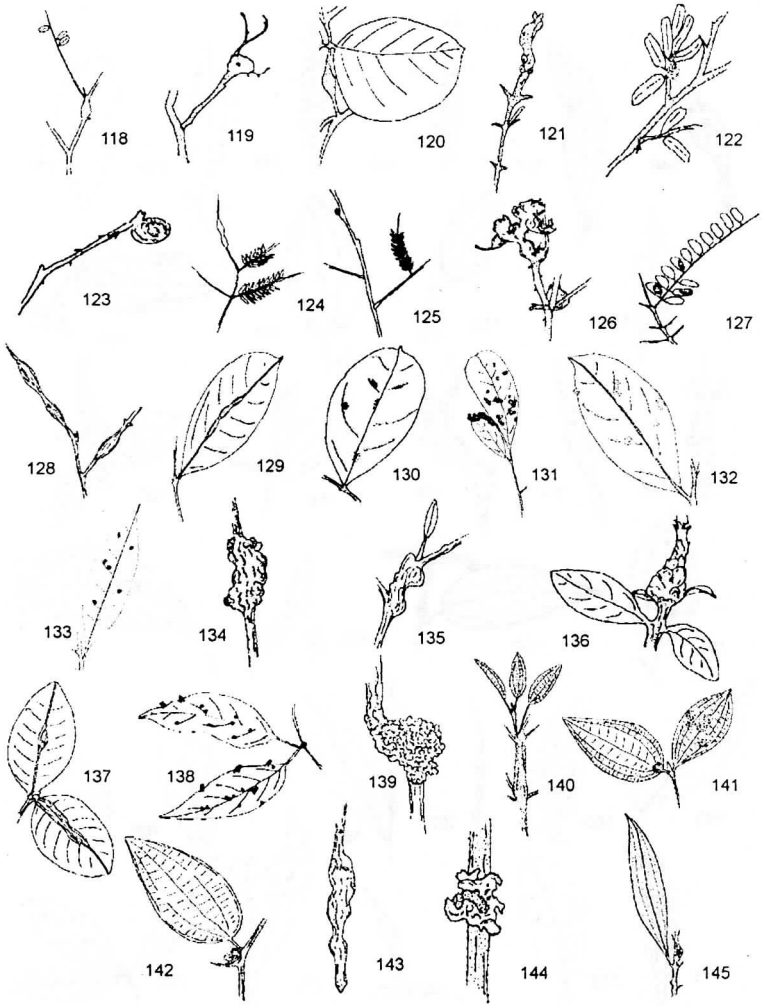
FIGURES 29-57 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (29: *Mikania campos-portoana*; 30-31: *Mikania* sp 1; 32: *Mikania* sp 2; 33: *Mikania* sp 3; 34-35: *Piptocarpha* sp 36: *Vernonia* cf. *condensata*; 37-45: *V. polyanthes*; 46-47: *V. scorpioides*; 48: unindentified species (sp 1) of Asteraceae; 49: unindentified species (sp 2) of Asteraceae; 50-51: *Tabernaemontana* sp; 52: *Ilex ceracifolia*; 53-55: *Tapirira guianensis*; 56: *Tapirira* sp 57: *Guatteria villosissima*).



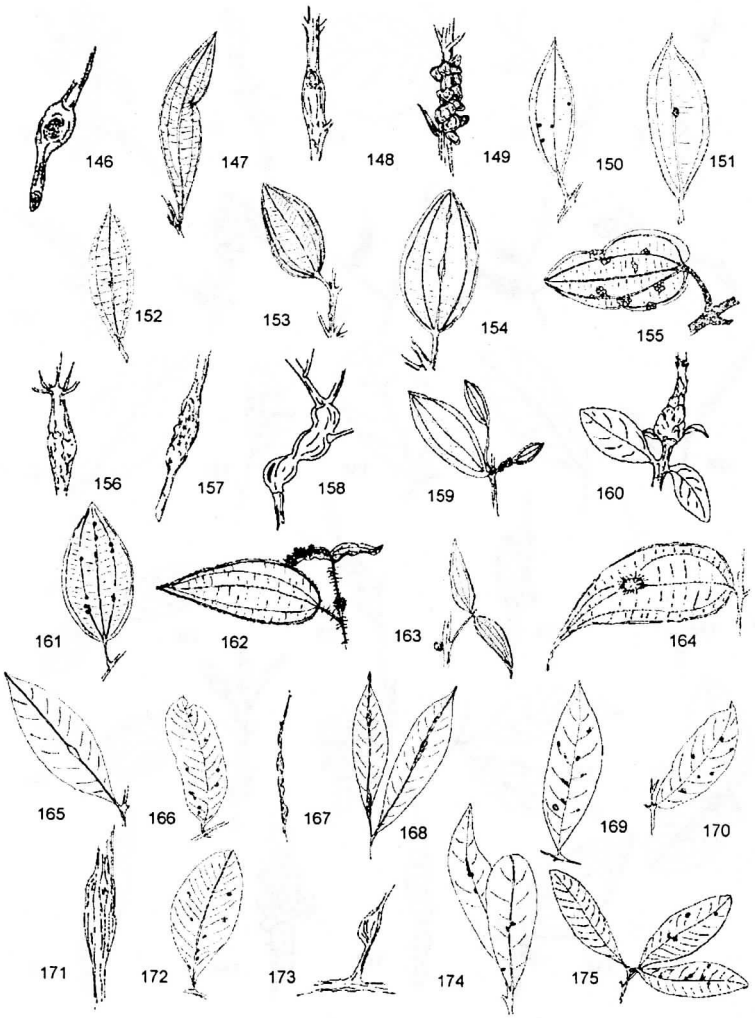
FIGURES 58-87 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (58: unindentified species (sp 1) of Annonaceae; 59: *Aristolochia galeata*; 60-63: *Anemopaegma* sp; 64-70: *Arrabidaea chica*; 71: *A.* cf. *formosa*; 72; *A.* cf. *sceptrum*; 73-74: *Arrabidaea* sp 1; 75: *Arrabidaea* sp 2; 76: *Arrabidaea* sp 3; 77: *Clytostoma* sp; 78: *Fridericia speciosa*; 79-81: *Sparattosperma leucanthum*; 82: *Tabebuia ochraceae*; 83-84: unindentified species (sp 1) of Bignoniaceae; 85-86: unindentified species (sp 2) of Bignoniaceae; 87: unindentified species (sp 3) of Bignoniaceae).



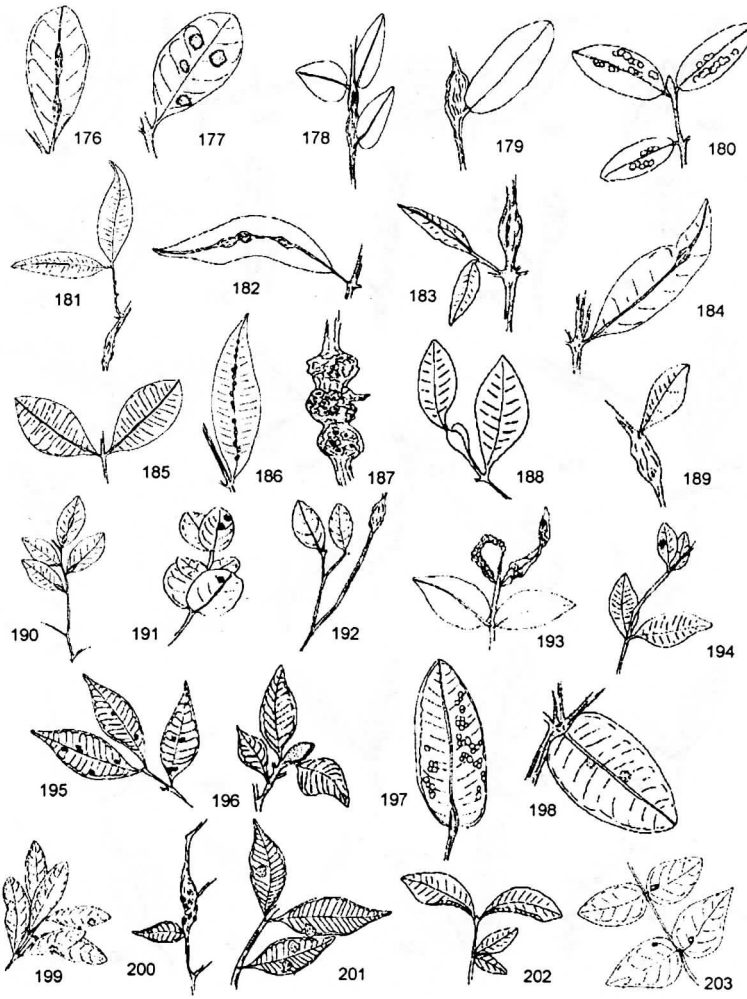
FIGURES 88-117 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (88: unindentified species (sp 3) of Bignoniaceae; 89-91: unindentified species (sp 4) of Bignoniaceae; 92: unindentified species (sp 5) of Bignoniaceae; 93-94: *Protium heptaphyllum*; 95: *P. spruceanum*; 96: *Cordia verbenacea*; 97: *Tournefortia* cf. *villosa*; 98: unindentified species (sp 1) of Bombacaceae; 99-100: *Maytenus gonoclada*; 101: *Vismia* sp 102: unindentified species (sp 1) of Chrysobalanaceae; 103-105: *Davilla rugosa*; 106: *Tectaria* sp 107: *Erythroxylum gonocladum*; 108: *Croton* sp 109: *C. migrans*; 110-111: *Pera* sp1; 112-113: *Pera* sp 2; 114: *Pera* sp 3; 115: *Andira* sp 116: *Bauhinia* sp; 117: *Dalbergia miscolobium*).



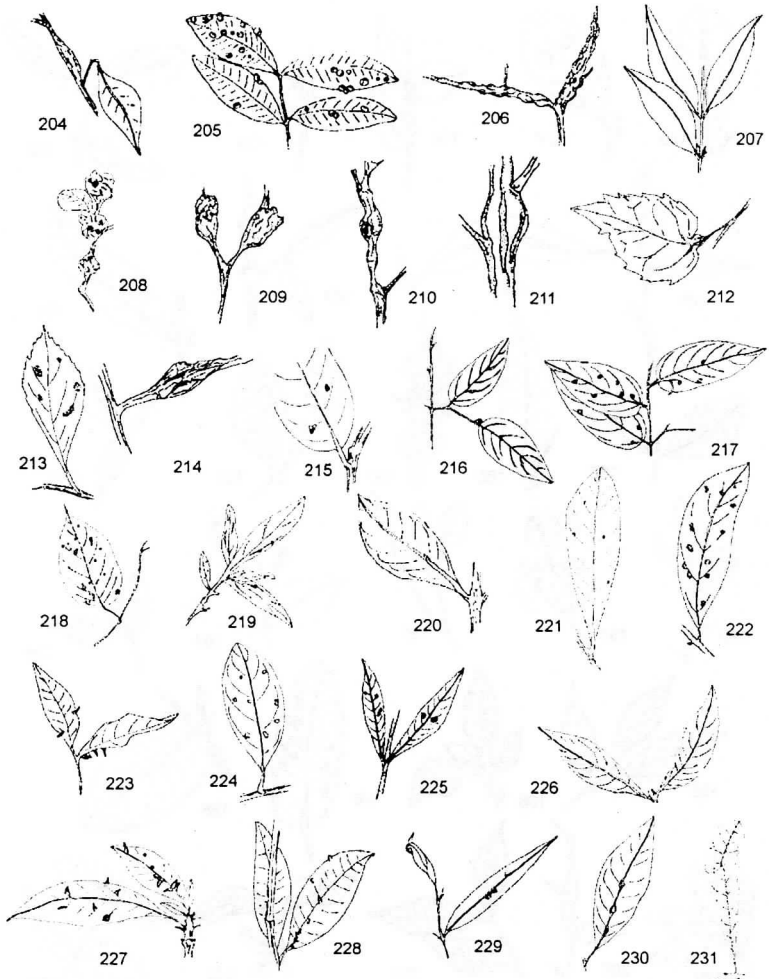
FIGURES 118-145 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (118-119: *Dalbergia nigra*; 120: *Dioclea* sp; 121: *Machaerium angustifolium*; 122: *Machaerium* sp; 123-125: unindentified species (sp 1) of Fabaceae; 126-127: unindentified species (sp 2) of Fabaceae; 128-130: unindentified species (sp 3) of Fabaceae; 131: *Ocotea dispersa*; 132-133: *O. macropoda*; 134: *Byrsonima intermedia*; 135-137: *B. variabilis*; 138: *Stigmaphyllon* sp 139: *Clidemia urceolata*; 140-142: *Leandra* cf. *lacunosa*; 143-145: *L. melastomoides*).



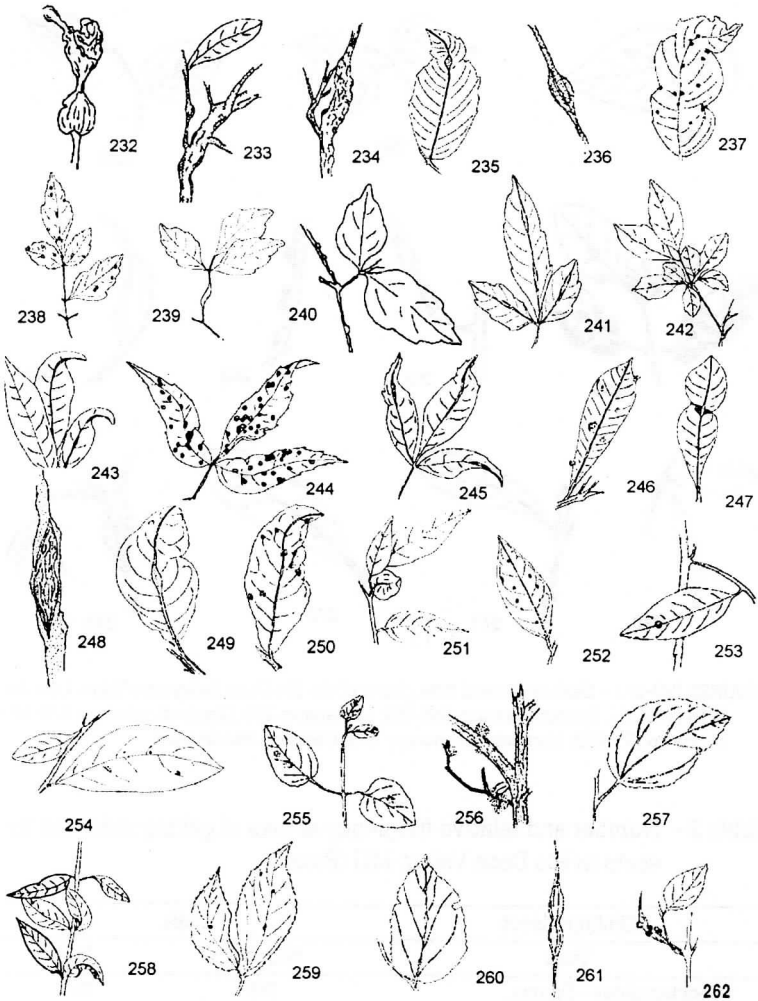
FIGURES 146-175 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (146-147: *Leandra melastomoides*; 148-152: *Miconia chartacea*; 153-155: *M. corallina*; 156: *M.* cf. *dodecandra*; 157: *M.* cf. *latecrenata*; 158-159: *Tibouchina martiusiana*; 160-162: unindentified species (sp 1) of Melastomataceae; 163-164: unindentified species (sp 2) of Melastomataceae; 165-166: *Guarea guidonia*; 167-169: unindentified species (sp 1) of Meliaceae; 170: *Siparuna arianeae*; 171-172: *Myrsine* sp 1; 173-174: *Myrsine* sp 2; 175: *Eugenia* cf. *glazioviana*).



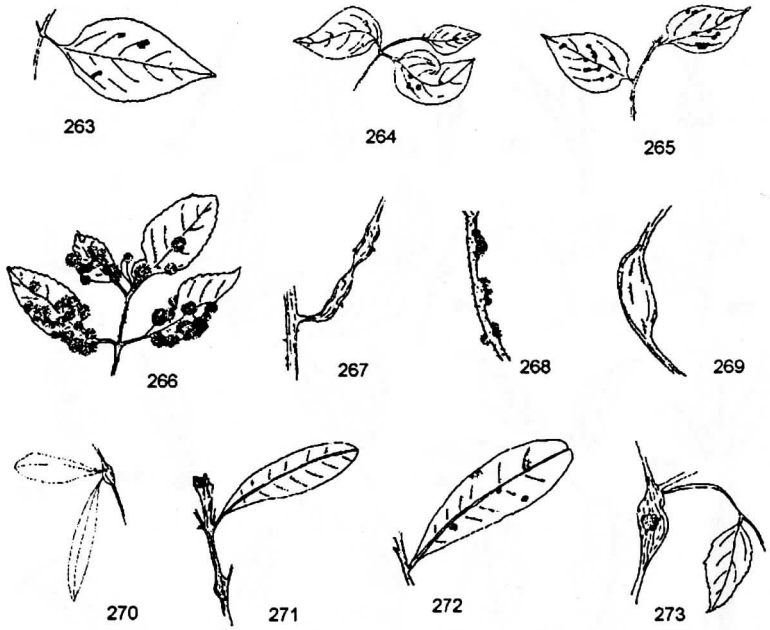
FIGURES 176-203 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (176-177: *Eugenia sphenophylla*; 178: *Gomidesia* sp 1; 179-180: *Gomidesia* sp 2; 181-182: *Myrcia* cf. *fallax*; 183-186: *M.* cf. *formosiana*; 187: *M.* cf. *tomentosa*; 188-196: *M. multiflora*; 197-198: *M. subcordata*; 199: *Myrcia* sp 1; 200-202: *Myrcia* sp 2; 203: *Myrciaria* sp).



FIGURES 204-231 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (204: unindentified species (sp 1) of Myrtaceae; 205: unindentified species (sp 2) of Myrtaceae; 206-207: unindentified species (sp 3) of Myrtaceae; 208-209: *Psidium guineense*; 210: *Piper aduncum*; 211-213: *Roupala* sp 1; 214: *Roupala* sp 2; 215: *Triplaris brasiliana*; 216-217: *Reissekia smilacina*; 218: unindentified species (sp 1) of Rhamnaceae; 219: *Borreria verticilatta*; 220: *Palicourea* cf. *rigida*; 221-222: *Palicourea* sp 223: *Psychotria cephalantha*; 224: *P.* cf. *harstisepala*; 225-226: *P. stachyiodes*; 227: *P. tetraphylla*; 228: *P. triphylla*; 229: *Psychotria* sp; 230: *Galipea* sp; 231: *Hortia arborea*).



FIGURES 232-262 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (232: unindentified species (sp 1) of Rutaceae; 233-234: *Matayba guianensis*; 235: *Paullinia rubiginosa*; 236-237: *Paullinia* sp; 238-241: *Serjania caracasana*; 242-243: *S. lethalis*; 244-245: *Serjania* sp 246-247: *Pouteria* sp 248-250: *Solanum cernuum*; 251-251: *S. cladotrichum*; 253-254: *S. sartizianum*; 255-257: *Waltheria communis*; 258: *Trigonia paniculata*; 259-260: *Luehea divaricata*; 261-262: *Lantana camara*).



FIGURES 263-273 – Galls on several host plants of the Rio Doce Valley (see Table 1 for details) (263-264: *Lantana camara*; 265-268: *Lantana* sp 269: *Lippia* cf. *velutina*; 270: *Vochysia* sp 271-272: *Vochysia tucanorum*; 273: *Celtis* cf. *brasiliensis*).

Table 2 – Number and relative frequency of taxa of galling inducing insects in Rio Doce Valley, MG (Brazil)

Galling insect	Galls	
Taxa	Number	(%)
Cecidomyiidae - Diptera	205	75.1
Hymenoptera	22	8.1
Lepidoptera	11	4.0
Curculionidae - Coleoptera	9	3.3
Tephritidae - Diptera	6	2.2
Other - Coleoptera	5	1.8
Psyllidae - Homoptera	4	1.5
Thysanoptera	3	1.1
Homoptera	2	0.7
Not identified	6	2.2

Galls were found on 139 host plant species belonging to 40 families (Table 1). Seventeen species of Asteraceae (12% of all species of plants) supported 49 species of galling insect (18% of all galls), while 16 species of Myrtaceae (11.5% of all species of plants) supported 35 galling species (13% of all galls), 16 species of Bignoniaceae (11.5%) supported 33 galling species (12%), and 10 species of Melastomataceae (7%) supported 26 galling species (7.5%) (Table 3). Together these plant families (42.4% of all plant species, n = 59) supported more than half of all galls found (52.4% of all galls, n = 143).

Table 3 – Family and number of host plants and number of galling insect species in Rio Doce Valley, Brazil

Host plant		Number galling
Family	Number of species	species
Asteraceae	17	49
Myrtaceae	16	35
Bignoniaceae	16	33
Melastomataceae	10	26
Fabaceae	10	16
Sapindaceae	06	13
Rubiaceae	09	11
Verbenaceae	03	09
Euphorbiaceae	05	07
Solanaceae	03	07
Malpighiaceae	03	05
Meliaceae	02	05
Anacardiaceae	02	04
Myrsinaceae	02	04
Proteaceae	02	04
Burseraceae	02	03
Dilleniaceae	01	03
Lauraceae	02	03
Rhamnaceae	02	03
Rutaceae	03	03
Sterculiaceae	01	03
Vochysiaceae	02	03
Apocynaceae	01	02
Annonaceae	02	02
Boraginaceae	02	02
Celastraceae	01	02
Sapotaceae	01	02
Tiliaceae	01	02
Aquifoliaceae	01	01
Aristolochiaceae	01	01
Bombacaceae	01	01

continuation

Host plant		Number galling species
Family	Number of species	
Clusiaceae	01	01
Chrysobalanaceae	01	01
Dryopteridaceae	01	01
Erythroxylaceae	01	01
Monimiaceae	01	01
Piperaceae	01	01
Polygonaceae	01	01
Trigoniaceae	01	01
Ulmaceae	01	01
Total	139	273

Eighteen species of host plants and 24 species of galling insects were found in both mesic and xeric habitats. Only one host plant species occurred in both xeric and *Eucalyptus* spp habitats, while no galling species was exclusive to these habitats. Seven species of host plants and 6 species of galling insect occurred in both mesic and *Eucalyptus* spp habitats, while 6 species of host plant species and 10 galling species were common to the three sampled habitats. Thus, more host plants and galling species were found in mesic and xeric habitats: 56 host plant species and 120 galling species were found only in mesic habitats, while 42 host plant species and 89 galling species were found only in xeric habitats (Figure 274).

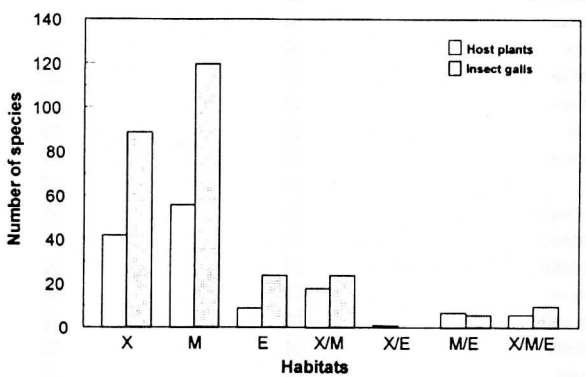


FIGURE 274 – Number of species of host plants and galls found exclusively in xeric (X), mesic (M) and Eucalyptus (E) habitats and number of species of host plants and galls commons in xeric and mesic (X/M), xeric and eucalyptus (X/E), mesic and eucalyptus (M/E) and xeric, mesic and eucalyptus (X/M/E) habitats of Rio Doce Valley, Brazil.

The most frequent shape of galls was elliptical (50.5%). Galls mostly frequenttly occurred isolated (66.7%) and were glabrous (63%) (Figure 275). The plant organ with the highest frequency of galls were stems (40.7%) and leaves (38.1%) (Table 4).

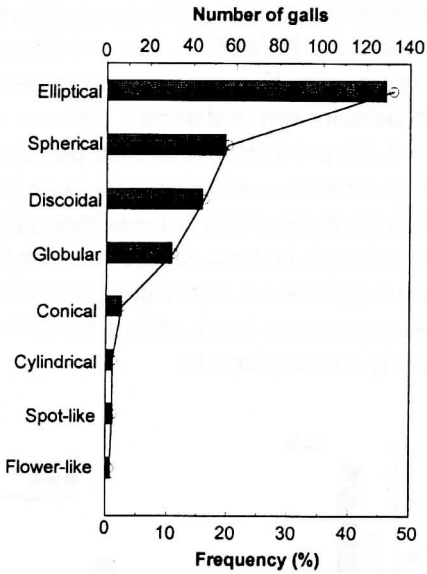


FIGURE 275 – Frequency (bars) and respective percentages (line) of external insect gall morphology of Rio Doce Valley, Brazil.

Table 4 – Total number and relative frequency of galls, pubescence, occurrence, and plant organ attacked

Gall traits		Number	Frequency (%)
Pubescence	Pubescent	101	37.0
	Glabrous	172	63.0
Occurrence	Group	91	33.3
	Single	182	66.7
Galled Organ	Stem	111	40.7
	Apical stem	02	0.7
	Leaf	104	38.1
	Leaf vein	41	15.0
	Leaf petiole	15	5.5

The highest diversity of gall-forming insects was found in the area that showed the highest plant diversity, in the sclerophyllous vegetation of the Parque Natural do Caraça (Figure 276). However, we did not find a significant difference in the mean richness of galls between the mesic and xeric habitats in this site ($t = 0,718$; $p > 0.05$). In the Atlantic forest of the Parque Estadual do Rio Doce gall richness did not differ between mesic and xeric habitats (ANOVA $F = 1, 09$; $p > 0.05$) nor between them and *Eucalyptus* spp. forests. However, mean richness of galls between xeric and mesic habitats was statistically different in Ipatinga and Antônio Dias ($t = 3, 87$; $p < 0.05$), but no clear pattern was found. The mean richness of gall insects was higher in the xeric habitat compared to the mesic habitat in Antônio Dias but was lower in the xeric habitat than in the mesic habitat in Ipatinga. On the other hand, in Belo Oriente the mean richness of galls did not differ significantly between the mesic habitat and the *Eucalyptus* spp forest, while xeric habitats differed from these two habitats ($p < 0.005$; Table 5).

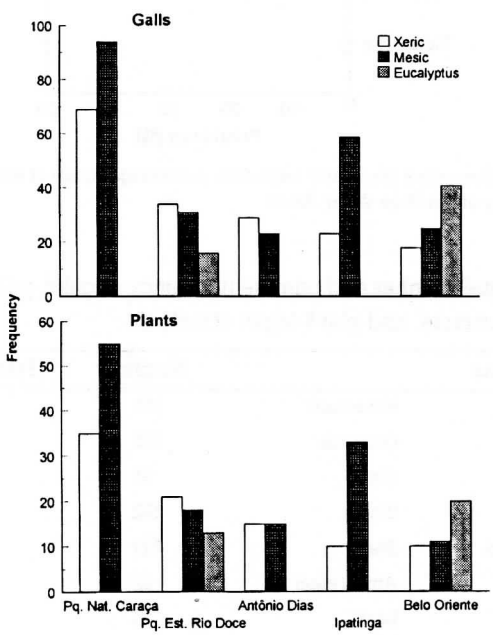


FIGURE 276 – Host plants and galling insect richness in xeric, mesic habitats, and Eucalyptus forest habitats in five localities in Rio Doce Valley, Brazil.

Table 5 – Mean richness of insect galls in xeric, mesic habitats, and *Eucalyptus* forest habitats in Rio Doce Valley, Brazil. Different letters indicate mean values statistically different ($p < 0.05$)

Localities	Habitats		
	Xeric	Mesic	*Eucalyptus*
Parque Natural do Caraça	18.7 ± 2.4 (a)	22.0 ± 3.8 (a)	-
Parque Estadual do Rio Doce	6.7 ± 1.7 (a)	8.5 ± 1.4 (a)	4.0 ± 0.7 (a)
Antônio Dias	9.2 ± 1.1 (a)	5.7 ± 0.5 (b)	-
Ipatinga	6.6 ± 0.9 (a)	11.0 ± 1.4 (b)	-
Belo Oriente	3.9 ± 0.9 (a)	9.1 ± 1.1 (b)	11.0 ± 1.4 (b)

Discussion

The highest richness of gall-forming insects occurred where host plant richness was higher. This pattern was also found in Rio Jequitinhonha Valley in the northern region of Minas Gerais where the families Fabaceae, Malpighiaceae, Asteraceae, and Myrtaceae presented the highest richness of gall-forming insects.[11] In that study, the authors observed that in areas of cerrado (savanna) Cecidomyiidae was responsible for approximately 70% of the galls recorded and that the most heavily galled organs on the host plants were leaves (53.7%), followed by stems (45%), and flowers (1.3%). The values obtained in our study correspond to the patterns found by Fernandes et al.[11] for gall frequency induced by a gall-forming taxon, but differed in the frequencies of galled host plant organs. The data also differed from the general pattern found elsewhere in the world[18] where most galls are found on leaves, while in the present study most galls were found on stems. We do not know the cause of this discrepancy, but at this moment we can only postulate that a different pattern of host organ use may have evolved in the Atlantic forests in coastal Brazil.

The high diversity of gall-forming insects in Parque Natural do Caraça can be related to the sclerophylly of the host plants as well as to plant species richness. Sclerophylly is a common feature in plants of this mountainous region, both in mesic and xeric habitats. The richest communities of galls are in habitats dominated by sclerophyllous plants such as chaparral vegetation in Arizona, cerrado and rupestrian vegetation in Minas Gerais, coastal scleromorphic vegetation in Australia,

campina areas in infertile sands along the Rio Negro, Amazônia, and Fynbos and Karoo vegetation in South Africa.[7,10,17,20,21,22,23]

Parque Estadual do Rio Doce is characterized by a continuous area of Atlantic forest. Hence, we believe that the homogeneity in vegetation, soil and climate condition may have led to little difference in the richness of galling insects between the study sites. In Rio Doce Valley, only in the locality of Antônio Dias did we find a higher galling species richness in the xeric habitat than the mesic habitat. The contrasting differences in gall richness found in Belo Oriente and Ipatinga can not be explained as these areas are also within the Atlantic forest domain, and present similar and homogenous climatic conditions perhaps not distinguishable between habitats. More sampling should be done in these areas to observe whether the pattern will hold. Comparisons of galling insect richness in different regions of Brazil will be done in the future in an attempt to broaden our knowledge of the patterns of gall richness among habitats and host plant families in the tropics.

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- *RESUMO: Estudamos a distribuição e a riqueza de insetos formadores de galhas e suas plantas hospedeiras em hábitats xéricos e mésicos, assim como em sub-bosque de florestas de* Eucalyptus *spp, em 5 localidades do Vale do Rio Doce, Sudeste do Brasil. Encontramos 273 morfoespécies diferentes de insetos galhadores em 139 espécies de plantas hospedeiras pertencentes a 40 famílias. A maioria das galhas (75,1%) foi induzida por insetos da família Cecidomyiidae (Diptera). Galhas ocorreram com maior freqüência em ramos (40,7%), tiveram forma elíptica e glabra. A maior diversidade de insetos formadores de galhas foi encotrada na localidade que apresentou maior diversidade de espécies de plantas, na vegetação esclerofila do Parque Natural do Caraça. Não encontramos nenhuma tendência na riqueza de insetos galhadores entre os três tipos de hábitats estudados.*

- *PALAVRAS-CHAVE: Riqueza de galhas; galhas de insetos; interação inseto-planta; Vale do Rio Doce.*

References

1 BLANCHE, K. R., WESTOBY, M. Gall-forming insect diversity is linked to soil fertility via host plant taxon. *Ecology*, v.76, p.2334-7, 1995.

2 CORNELL, H. V. The secondary chemistry and complex morphology of galls formed by the Cynipinae (Hymenoptera): why and how? *Am. Midl. Nat.*, v.110, p.225-34, 1983.

3 FERNANDES, G. W. Gall-forming insects: their economic importance and control. *Rev. Bras. Entomol.*, v.31, p.379-98, 1987.

4 _____. Hipersensivity: a neglected plant resistance mechanism against insect herbivores. *Environ. Entomol.*, v.19, p.1173-82, 1990.

5 _____. Plant historical and biogeographycal gradients effect on insular gall-forming species richness. *Glob. Ecol. Biogeogr. Lett.*, v.2, p.71-4, 1992.

6 FERNANDES, G. W., MARTINS, R. P. As galhas: tumores de plantas. *Cienc. Hoje.*, v.4, p.58-64, 1985.

7 FERNANDES, G. W., PRICE, P. W. Biogeographical gradients in galling species richness: tests of hypotheses. *Oecologia*, v.76, p.161-7, 1988.

8 _____. Comparisons of tropical and temperate galling species richness: the role of environmental harshness and plant nutrient status. In: PRICE, P. W. et al. *Plant-animal interactions*: evolutionary ecology in tropical and temperate regions. New York: Wiley, 1991. p.91-116.

9 FERNANDES, G. W., LARA, A. C. F., PRICE, P. W. The geography of galling insects and the mechanisms resulting in patterns. In: PRICE, P. W., MATTSON, W. J., BARACHIKOV, Y. *Gall-forming insects*: physiology, ecology and evolution. St. Paul: United States Department of Agriculture - Forest Service, 1994. p.42-8.

10 FERNANDES, G. W., PAULA, A. S., LOYOLA, R. O uso de insetos galhadores em estudos de impacto ambiental de empreendimentos hidrelétricos. *Vida Silv. Neotrop.*, v.4, p.133-9, 1995.

11 FERNANDES, G. W. et al. Insect galls from Jequitinhonha Valley, Minas Gerais, Brazil. *Naturalia (São Paulo)*, v.22, p.221-44, 1997.

12 FLOATE, K. D., FERNANDES G. W., NILSSON, J. A. Distinguishing intrapopulational categories of plants by their insect faunas: galls on rabbitbrush. *Oecologia*, v.105, p.221-9, 1996.

13 FONSECA, G. A. B. The vanishing brazilian Atlantic forest. *Biol. Conserv.*, v.34, p.17-34, 1985.

14 GAGNÉ, R. J. The geography of gall insects. In: ANANTHAKRISHNAN, T. N. *Biology of gall insects*. India: Oxford & IBH Publ. Co, 1984. p.305-22.

15 _____. *The gall midges of the neotropical region*. Ithaca: Comstock, 1984. 352p.

16 HELIÖVAARA, K. et al. Heavy metal levels in two biennial pine insects with sap-sucking and gall-forming life-styles. *Environ. Pollut.*, v.48, p.13-23, 1987.

17 LARA, A. C. F., FERNANDES, G. W. 1996. The highest diversity of galling insects: Serra do Cipó, Brazil. *Biodivers. Lett.*, v.3, p.111-4, 1996.

18 MANI, M. S. *The ecology of plant galls*. The Hague: Junk, 1964. 640p.

19 PRICE, P. W., FERNANDES, G. W., WARING, G. L. Adaptive nature of insect galls. *Environ. Entomol.*, v.16, p.15-24, 1987.

20 PRICE, P. W. et al. Global patterns in local number of insect galling species. *J. Biogeogr.*, v.25, p.581-92, 1998.

21 WARING, G. L., PRICE, P. W. Plant water stress and gall formation. (Cecidomyiidae: *Asphondylia* spp) on creosote bush. *Ecol. Entomol.*, v.15, p.87-95, 1990.

22 WRIGHT, M. G., SAMWAYS, M. J. Gall-insect species richness in African Fynbos and Karoo vegetation: the importance of plant species richness. *Biodivers. Lett.*, v.3, p.151-5, 1996.

23 _____. Insect species richness tracking plant species richness in a diverse flora: gall-insects in the Cape floristic region, South Africa. *Oecologia*, v.115, p.427-33, 1998.

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