

## Metadata of the chapter that will be visualized online

Chapter Title	<i>Baccharis</i> : A Neotropical Model System to Study Insect Plant Interactions	
Copyright Year	2014	
Copyright Holder	Springer Science+Business Media Dordrecht	
Corresponding Author	Family Name	<b>Fernandes</b>
	Particle	
	Given Name	<b>G. Wilson</b>
	Suffix	
	Division	Ecologia Evolutiva de Herbívoros Tropicais/DBG
	Organization	Universidade Federal de Minas Gerais (UFMG)
	Address	Campus Pampulha, CP 486, CEP 31270-901, Belo Horizonte, MG, Brazil
	Email	gw.fernandes@gmail.com
	Author	Family Name
Particle		
Given Name		<b>Jhonathan O.</b>
Suffix		
Division		Departamento de Ecologia
Organization		Universidade de Brasília (UnB)
Address		Campus Darcy Ribeiro, Asa Norte, CEP 70910-900, Brasília, DF, Brazil
Author	Family Name	<b>Espírito-Santo</b>
	Particle	
	Given Name	<b>Mário M.</b>
	Suffix	
	Division	Departamento de Biologia Geral
	Organization	Universidade Estadual de Montes Claros
	Address	Campus Universitário Darcy Ribeiro, CP 126, CEP 39401-089, Montes Claros, MG, Brazil
Author	Family Name	<b>Fagundes</b>
	Particle	
	Given Name	<b>Marcílio</b>
	Suffix	

Division Departamento de Biologia Geral  
 Organization Universidade Estadual de Montes Claros  
 Address Campus Universitário Darcy Ribeiro, CP 126, CEP 39401-089, Montes Claros, MG, Brazil

Author

Family Name **Oki**

Particle

Given Name **Yumi**

Suffix

Division **Ecologia Evolutiva de Herbívoros Tropicais/DBG** change to: Ecologia Evolutiva & Biodiversidade

Organization Universidade Federal de Minas Gerais (UFMG)

Address Campus Pampulha, CP 486, CEP 31270-901, Belo Horizonte, MG, Brazil

Author

Family Name **Carneiro**

Particle

Given Name **Marco Antônio A.**

Suffix

Division Instituto de Ciências Exatas e Biológicas

Organization Universidade Federal de Ouro Preto (UFOP)

Address Campus Morro do Cruzeiro, CEP 35400-000, Ouro Preto, MG, Brazil

Abstract

The genus *Baccharis* is composed of ca. 500 species which are distributed primarily in tropical America. It is dioecious and highly diverse in chemistry, architecture, phenology and occupy many different niches across several gradients of light, temperature, humidity, altitude and succession. It is host to the most speciose galling fauna, with more than 121 galling species on 40 host plant. This system **provide** an ideal scenario to test several ecological hypotheses, including the long standing plant sexual differences on timing and intensity of energy allocation, vigor, architecture and herbivore attack. Moreover its wide distribution enables to test latitudinal and altitudinal gradients on gall attack. We review the studies performed on these Neotropical shrubs related to galling insects. These studies have been crucial for the establishment of generalities and testing of ecological and evolutionary theories across the Americas, as well as to generate new ideas and hypotheses. For these reasons and power of the field and experimental observations we suggest that the galling insects on their *Baccharis* hosts

change to provides

may represent a Neotropical model system for studies on insect plant interactions.

---

# Chapter 13

## *Baccharis*: A Neotropical Model System to Study Insect Plant Interactions

1  
2  
3

GWF is the corresponding author

[AU1] G.Wilson Fernandes, Jhonatanan O. Silva, Mário M. Espírito-Santo, Marcílio Fagundes, Yumi Oki, and Marco Antônio A. Carneiro

4  
5

**Abstract** The genus *Baccharis* is composed of ca. 500 species which are distributed primarily in tropical America. It is dioecious and highly diverse in chemistry, architecture, phenology and occupy many different niches across several gradients of light, temperature, humidity, altitude and succession. It is host to the most speciose gall-forming species on 40 host plant. This system provides an ideal scenario to test several ecological hypotheses, including the long standing plant sexual differences on timing and intensity of energy allocation, vigor, architecture and herbivore attack. Moreover its wide distribution enables to test latitudinal and altitudinal gradients on gall attack. We review the studies performed on these Neotropical shrubs related to galling insects. These studies have been crucial for the establishment of generalities and testing of ecological and evolutionary theories across the Americas, as well as to generate new ideas and hypotheses. For these reasons and power of the field and experimental observations we suggest that the galling insects on their *Baccharis* hosts may represent a Neotropical model system for studies on insect plant interactions.

6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20

---

G.W. Fernandes (✉) • Y. Oki

Ecologia Evolutiva de Herbívoros Tropic

change to: Ecologia Evolutiva &amp; Biodiversidade/DB

Campus Pampulha, CP 486, CEP 31270-901 Belo Horizonte, MG, Brazil

e-mail: [gw.fernandes@gmail.com](mailto:gw.fernandes@gmail.com)

J.O. Silva

Departamento de Ecologia, Universidade de Brasília (UnB),

Campus Darcy Ribeiro, Asa Norte, CEP 70910-900 Brasília, DF, Brazil

M.M. Espírito-Santo • M. Fagundes

Departamento de Biologia Geral, Universidade Estadual de Montes Claros,

Campus Universitário Darcy Ribeiro, CP 126, CEP 39401-089 Montes Claros, MG, Brazil

M.A.A. Carneiro

Instituto de Ciências Exatas e Biológicas, Universidade Federal de Ouro Preto (UFOP),

Campus Morro do Cruzeiro, CEP 35400-000 Ouro Preto, MG, Brazil

G.W. Fernandes and J.C. Santos (eds.), *Neotropical Insect Galls*,

DOI 10.1007/978-94-017-8783-3\_13, © Springer Science+Business Media Dordrecht 2014

[AU2] 21

## 13.1 Introduction

22 There are <sup>change to: ...world, but</sup> ~~only some~~ <sup>most</sup> and species of galling insects throughout  
 23 the world. But some of them offer unique opportunities for the study of galling  
 24 insects. The inspiration they provide to the scientists may originate from a <sup>...by the divers</sup>  
 25 economic <sup>...the</sup> ~~shape~~ <sup>by diver</sup>sity of galls. Some plants attract the attention <sup>by diver</sup>  
 26 <sup>complexity..</sup> ~~of~~ <sup>complexity</sup> of the interactions between the gall and the host plant or even with the  
 27 <sup>complexity</sup> of the interactions between the gall and the host plant or even with the  
 28 galler's natural enemies. But whatever the fascination is, some genera or species  
 29 have been selected to bring to light the curiosities and peculiarities of this interaction  
 30 throughout the world. For instance, in the Nearctic and Palearctic regions an  
 31 astonishing amount of work have been developed on the genera *Quercus* (Felt  
 32 1940), *Salix* (Price et al. 1995), *Populus* (Floate and Whitham 1995), *Rose*  
 33 (Shorthouse and Rohfritsch 1992; Stone et al. 2002), and *Solidago* (Abrahamson  
 34 and Weis 1997), to cite perhaps the most known ones. From the continued study of  
 35 the interactions among the galling organisms and their host plants and associated  
 36 fauna emerged many classical studies on the ecology of insect-plant interactions.  
 37 Consequently, many hypotheses were tested, as well as raised, in modern ecology  
 38 by the study of galling insects (e.g., Askew 1960; Cornell 1983; Price 1991;  
 39 Fernandes and Price 1988, 1991, 1992; Fernandes 1990; Hartley and Lawton 1992;  
 40 Hawkins and Compton 1992; Stone and Schönrogge 2003; Espírito-Santo et al.  
 41 2007, 2012; Inbar et al. 2010).

42 In the Neotropics no other single taxa of galling host plants has been studied in  
 43 such detail. <sup>add: Baccharis De Candole (Aster</sup> <sup>small cap</sup> ~~and~~ <sup>l</sup> on a web of Science  
 44 search <sup>and</sup> ~~the~~ words insect galls, galls, <sup>C</sup>ecidia, galling insects, galhas, gall-  
 45 mucken, <sup>agarias</sup> we were able to record at least 47 studies on galling insects on eight  
 46 species of *Baccharis* in the last 25 years <sup>delete</sup> (2012). Clearly, many other studies  
 47 were developed on the genus *Baccharis*, <sup>owing to</sup> the interest generated by the study  
 48 of their galling insects, but this escapes the purpose of this chapter.

49 Due to the accumulated knowledge and long term studies done so far, we show  
 50 that the system *Baccharis*-galling insects serves as an excellent model where one  
 51 could construct the basis for understanding patterns of adaptation, biodiversity and  
 52 evolution in insect-plant relationships, as well as to test hypotheses on galling  
 53 insects in the Neotropics at different scales.

### 54 13.1.1 Genus *Baccharis*

55 The genus *Baccharis* belongs to the Baccharidinae subtribe (Asteraceae), which is  
 56 restricted to the American continent (Barroso 1976). The Baccharidinae probably  
 57 appeared during the Middle Miocene when South America and Africa continents  
 58 were totally separated by the Atlantic Ocean (Cox and Moore 1993), justifying its  
 59 natural occurrence just in the New World. *Baccharis* is the largest genus of the

Baccharidinae subtribe, with more than 500 species distributed from south United States to Argentina (Boldt 1989). Interestingly, this number of species does not consider the hybrids that may be widespread in the genus (GWF, pers. observ.). Of the hundreds of species, 90 % occur in South America and most species are found in the south and southeastern regions of Brazil, suggesting that this region is the center of the genus origin (Jarvis et al. 1991). More than 120 species are known to occur in southeastern Brazil alone (Barroso 1976). All *Baccharis* species are perennial and dioecious shrubs, excepting *Baccharis monoica*, a species found in Mexico (Nesom <sup>add: present...</sup> many species of *Baccharis* disperse <sup>add: are</sup> seeds over long distances, <sup>optional demand</sup> of light for the germination <sup>add: has the</sup> tolerant with wide adaptability to soil nutrient concentration and ability to sprout after fire. All these traits favor their establishment and development in nutritionally poor and disturbed areas (Gomes and Fernandes 2002).

*Baccharis* species are known in traditional culture for treatment of diseases as female infertility and male impotence, gastrointestinal and liver disorders, anemia, diabetes, diarrhoea, infections, cancer, gout, rheumatism, ulcers, skin problems and others (Abad and Bermejo 2007). Currently, about 120 *Baccharis* species are being investigated for production of phytochemicals for pharmaceutical, cosmetic and other applications (Verdi et al. 2005). According to Abad and Bermejo (2007), over 150 compounds have been isolated and identified from this genus. Many substances isolated from *Baccharis* have been used as medicine (e.g. trichothecenes from *B. coridifolia*, used as antiviral), perfumes (essential oils of *B. dracunculifolia*, *B. uncinella*, *B. genistelloides*, *B. trimera*) and repellents (terpenoids and flavonoids found in many species), among other products (Jarvis et al. 1988; Argandoña and Faini 1993; Ferracini et al. 1995; Agostini et al. 2005; Verdi et al. 2005; Wollenweber et al. 2006). The *Baccharis* species more deeply studied chemically are *B. megapotamica*, *B. incarum*, *B. trimera*, *B. trinervis*, *B. salicifolia*, *B. crispa*, *B. coridifolia*, *B. dracunculifolia*, *B. grisebachii* and *B. tricuneata* (Verdi et al. 2005).

The species of the genus *Baccharis* also harbors many ecological associations. One of the most known interactions is the relationship between *B. dracunculifolia* and africanized honey bee *Apis mellifera* (Kumazawa et al. 2003). This bee collects resin from apical buds of *B. dracunculifolia* and uses it to produce a resinous layer inside the hive, known as green propolis (Teixeira et al. 2005). This resinous mass, due to the antiseptic, anti-inflammatory, anti-cancer and healing properties, is widely studied, commercialized and used primarily by pharmaceutical and cosmetics industry (Banskota et al. 2001; Chan et al. 2012). Among the chemicals isolated from propolis, it is worth noticing the presence of flavonoids, phenylpropanoids, phenolic acids and essential oils (Kumazawa et al. 2003; Teixeira et al. 2005). In

this way, due to great ecological importance and associated <sup>delete this entire sentence</sup> as Neotropical model system to study insect-plant interactions.

A large number of galls induced by insects have been studied on many species of the genus *Baccharis*. The genus *Baccharis* likely support the highest galling insect fauna of the Neotropical region, with more than 121 galling species reported on 40 host plants more than a decade and half ago (Fernandes et al. 1996). Probably no other Neotropical galling community and host plant genus has been studied in such

105 detail as this one. These studies vary from simple description of the gall morphotypes  
 106 to anatomical descriptions of the galls to more detailed and/or long term ecological  
 107 studies. Here we provide some ecological background information on the system  
 108 *Baccharis*-galling herbivores.

109 The largest majority of the studies on galling insects on *Baccharis* were done on  
 110 Brazilian species. Likely, the system comprised by *Baccharis dracunculifolia* DC  
 111 and *Baccharopelma dracunculifoliae* (Hemiptera: Psyllidae) was the best studied  
 112 single system in the Neotropics, with more than 15 publications (Araújo et al. 1995;  
 113 Collevatti and Sperber 1997; Espírito-Santo and Fernandes 1998, 2002; Faria and  
 114 Fernandes 2001; Fagundes et al. 2001, 2005; Ribeiro-Mendes et al. 2002; Espírito-  
 115 Santo et al. 1999, 2003, 2004, 2007, 2012; Fagundes and Fernandes 2011). Studies  
 116 on other species of *Baccharis* also deserve to be mentioned due to their relatively  
 117 high numbers, such as *B. concinna*, *B. pseudomyriocephala*, and *B. ramosissima*  
 118 (Madeira et al. 1997; Araújo et al. 2003, 2006; Carneiro et al. 2005, 2006; Espírito-  
 119 Santo et al. 2007, 2012; See Table 13.1 for more details). In this chapter we review  
 120 the studies performed primarily on *B. dracunculifolia*, *B. concinna*, and  
 121 *B. ramosissima*.

## 122 13.2 The Diversity of Galling Insects on *Baccharis*

123 The highest number of galling species in the Neotropics has been recorded on spe-  
 124 cies of the genus *P* <sup>add: tropical</sup> must recognize, however, the high galling species  
 125 richness on other systems, such as on the speciose genera *Quercus* (135–200 spp.)  
 126 in Mexico and southeastern US (Manos et al. 1999), *Copaifera* (23 spp.) south-east-  
 127 ern Brazil (Costa et al. 2010), *Protium* (17 spp.) in the Amazonian region (Maia  
 128 2011), *Eucalyptus* (12 spp.) in Australia (Blanche 2000), and *Chrysothamnus*  
 129 (39 spp.) in southwestern North America (Fernandes et al. 2000). Fernandes et al.  
 130 (1996) reviewed the galling insects on *B. dracunculifolia*, *B. ramosissima* and  
 131 *B. concinna* during four consecutive years, and extracted data from literature from  
 132 other 37 species of *Baccharis*. The review resulted in the discovery of 121 species  
 133 of gall inducing insects on 40 different *Baccharis* species. Gallers were not evenly  
 134 distributed across host plant species while only four species of *Baccharis* (10 %  
 135 of the species studied) supported 46 % of the total galling fauna (56 galling  
 136 species). The host plants that supported the highest numbers of gallers were  
 137 *B. dracunculifolia* (17 spp.), *B. concinna* (15 spp.), *B. salicifolia* (13 spp.), and  
 138 *Baccharis* sp. 1 (11 spp.).

139 In the southeastern mountains of Brazil, the Mantiqueira and Espinhaço moun-  
 140 tains, we have recorded 106 galling species on 17 *Baccharis* species (Table 13.2;  
 141 Figs. 13.1, 13.2, and 13.3). In this study, the highest richness of galling insects (13  
 142 galling species) was recorded on *B. dracunculifolia*. The study also recorded a large  
 143 richness of galling insects on *B. minutiflora* (12 spp.), *B. cognate* (10 spp.), *B. retic-  
 144 ularia* (9 spp.), *B. intermixta* (8 spp.), and *B. concinna* (7 spp.). Six galling species  
 145 each was recorded on *B. ramosissima*, *B. helychrysoides*, and *B. truncata*, with

t1.1 **Table 13.1** Summary of studies that tested ecological hypotheses on galling insects on *Baccharis*  
t1.2 species in Neotropical America

t1.3	References	Ecosystem, country	Host	Tested hypotheses
t1.4	Araújo et al. (1995)	Cerrado (savanna), Brazil	<i>B. dracunculifolia</i>	(1) Sex-mediated herbivory
t1.5				
t1.6	Collevatti and		<i>B. dracunculifolia</i>	(1) Plant architecture
t1.7	Sperber (1997)			(2) Host plant patch size
t1.8	Madeira et al.	Cerrado (savanna), Brazil	<i>B. concinna</i>	(1) Vigor hypothesis
t1.9	(1997)			
t1.10	Espírito-Santo and	Cerrado (savanna), Brazil	<i>B. dracunculifolia</i>	(1) Gall abundance seasonality
t1.11	Fernandes (1998)			(2) Sex-mediated differences in tannin gall abundance and mortality rates
t1.12				(3) Tannin concentration on gall abundance
t1.13				
t1.14				
t1.15				
t1.16				
t1.17				
t1.18	Faria and	Ecotone Atlantic	<i>B. dracunculifolia</i>	(1) Vigor hypothesis
t1.19	Fernandes	rainforest and		(2) Sex-mediated gall abundance
t1.20	(2001)	cerrado (savanna), Brazil		
t1.21				
t1.22	Fagundes et al.	Rupestrian fields	<i>B. dracunculifolia</i>	(1) Resource concentration
t1.23	(2001)			
t1.24	Espírito-Santo	Dry forest	<i>B. dracunculifolia</i>	(1) Sex-mediated gall survivorship
t1.25	and Fernandes	and cerrado		
t1.26	(2002)	(savanna), Brazil		
t1.27	Ribeiro-Mendes	Atlantic rainforest,	<i>B. dracunculifolia</i>	(1) Hygrothermal stress hypothesis
t1.28	et al. (2002)	cerrado and		(2) Sex-mediated gall survivorship
t1.29		rupestrian field, Brazil		
t1.30				
t1.31	Araújo et al. (2003)	Semi-deciduous forest	<i>B. pseudomyriocephala</i>	(1) Vigor hypothesis
t1.32				(2) Meristems availability
t1.33				(3) Sex-mediated gall abundance
t1.34				
t1.35	Espírito-Santo et al.	Cerrado (savanna), Brazil	<i>B. dracunculifolia</i>	(1) Parasitoid attack on gall growth dynamics
t1.36	(2004)			
t1.37	Fagundes et al.	Semi-deciduous	<i>B. dracunculifolia</i>	(1) Ant effects on galling growth, Performance and parasitoidism
t1.38	(2005)	forest, Brazil		
t1.39				
t1.40	Carneiro et al.	Cerrado (savanna)	<i>B. concinna</i>	(1) Hygrothermal stress hypothesis
t1.41	(2005)	and rupestrian		(2) Atitudinal <b>gradient</b> <span style="color: yellow;">change to gradient</span>
[AU3] t1.42		field, Brazil		(3) Sex-mediated herbivory
t1.43				
t1.44				
t1.45	Carneiro et al.	Rupestrian filed, Brazil	<i>B. concinna</i>	(1) Intersexual differences
t1.46	(2006)			(2) Sex-mediated herbivory
t1.47				
t1.48	Araújo et al. (2006)	Semi-deciduous forest	<i>B. pseudomyriocephala</i>	(1) Plant architecture on gall abundance and performance
t1.49				
t1.50				

(continued)



Table 13.1 (continued)

References	Ecosystem, country	Host	Tested hypotheses
t1.51 t1.52 t1.53	Espírito-Santo et al. (2007)	Canga, rupestrian field and Cerrado (savanna), Brazil	17 <i>Baccharis</i> species (1) Plant architecture (2) Meristem availability
t1.55 t1.56 t1.57	Fagundes and Fernandes (2011)	Canga, rupestrian field and Cerrado (savanna), Brazil	<i>B. dracunculifolia</i> (1) Latitudinal gradient
t1.58 t1.59 t1.60 t1.63	Espírito-Santo et al. (2012)	Cerrado (savanna) and rupestrian field, Brazil	<i>B. dracunculifolia</i> <i>B. concinna</i> <i>B. ramosissima</i> (1) Intersexual differences (2) Sex-mediated herbivory (3) Plant phenology and gall synchronism

146 three galling species each recorded on *B. serrulata*, *B. ligustrina*, and *B. medullosa*.  
 147 Only one galling species was recorded on *B. oreophila*. These galls were all ascribed  
 148 to insects after the analysis of internal remains. Among the 106 galling species, 47  
 149 species (44 %) were not previously reported, hence representing new species and  
 150 records. Among the 59 identified ones, the majority (68 %) was induced by  
 151 Cecidomyiidae, followed by Lepidoptera (17 %), Psyllidae (12 %), Tephritidae  
 152 (1.7 %), and Curculionidae (1.7 %). The high number of galls induced by the  
 153 Cecidomyiidae is a trend already reported on several other faunal studies in the trop-  
 154 ics (see Mani 1992; Fernandes et al. 1996; Carneiro et al. 2009a; Coelho et al. 2009;  
 155 Santos et al. 2011). Carneiro et al. (2009b) studying the galling insects in the  
 156 Espinhaço mountain range supported the assertion that rupestrian fields present are  
 157 one world hotspot for galling insects (Lara and Fernandes 1996) and that the  
 158 *Baccharis* is the most speciose genus (see Fernandes et al. 1996). These mountains  
 159 are extremely species rich and harbor one of the most spectacular flora of the world  
 160 (see Safford 1999).

### 161 13.3 Super Host *Baccharis* Species

162 Some Neotropical families of plants are notably rich in galling insects including  
 163 Leguminosae *sensu lato*, Asteraceae, Myrtaceae, Malpighiaceae, Rubiaceae, and  
 164 Bignoniaceae (Fernandes 1992; Fernandes et al. 1988, 1997; Julião et al. 2002;  
 165 Carneiro et al. 2009b). One of the main determinants of galling species richness is  
 166 the taxonomic composition of the flora. This conclusion is supported by the fact that  
 167 a few taxa of host plants concentrate a large number of insect species, regardless of  
 168 the sample (Fernandes 1992; Hawkins and Compton 1992). Host plants with high  
 169 gall diversity have been named super host (Fernandes and Price 1988; Veldtman and  
 170 McGeoch 2003; Espírito-Santo et al. 2007; Costa et al. 2010, 2011). The presence  
 171 of “super hosts” is common in some tropical regions; hence contributing to the  
 172 increase of the local and regional gall richness in the communities. *Baccharis* is  
 173 certainly a super host genus.

**Table 13.2** Insect taxa and morphological characteristics of the galls found on 17 species of *Baccharis* (following the definitions from Fernandes et al. 1996)

	Host plant	Insect taxa	Organ	Shape	Color	Pubescence	Chambers	Reference	
t2.1	<i>B. ramosissima</i> Gardner	Cecidomyiidae sp.1	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.1a	
t2.2		Cecidomyiidae sp.2	Lateral bud	Tubular	Green	Glabrous	One	Fig. 13.1b	
t2.3		<i>Geraldnesia</i> sp.2 (Cecidomyiidae)	Leaf	Discoid	Green	Glabrous	One	Fig. 13.1c	
t2.4		Cecidomyiidae sp.3	Apical bud	Globulous	Green	Glabrous	One	Fig. 13.1d	
t2.5		Cecidomyiidae sp.4	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.1e	
t2.6		<i>Baccharopelma</i> <i>brasiliensis</i> (Psyllidae)	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.1f	
t2.7		<i>B. cognata</i> DC	Psyllidae	Leaf	Elliptical	Green	Glabrous	One	
t2.8			Cecidomyiidae	Leaf	Discoid	Green	Glabrous	One	
t2.9			Leptoptera	Stem	Elliptical	Green	Glabrous	One	
t2.10			Unidentified	Stem	Globulous	Brown	Glabrous	Several	
t2.11	Unidentified		Apical bud	Globulous	Green	Glabrous	One		
t2.12	Unidentified		Apical bud	Rosette	Green	Glabrous	One		
t2.13	Unidentified		Apical bud	Tubular	Green	Glabrous	One		
t2.14	Unidentified		Apical bud	Elliptical	Brown	Glabrous	One		
t2.15	Unidentified		Stem	Globulous	Brown	Glabrous	One		
t2.16	Unidentified		Lateral bud	Globulous	Brown	Glabrous	One		
t2.17	<i>B. helvchrysooides</i> DC	Unidentified	Stem	Globulous	Brown	Glabrous	One		
t2.18		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.19		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.20		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.21		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.22		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.23		Unidentified	Stem	Elliptical	Brown	Glabrous	One		
t2.24		Unidentified	Apical bud	Cylindrical	Brown	Glabrous	One		
t2.25		Unidentified	Apical bud	Tubular	Brown	Glabrous	One		
t2.26		Unidentified	Stem	Spherical	Brown	Glabrous	One		
t2.27	Unidentified	Stem	Elliptical	Brown	Glabrous	One			
t2.28	<i>B. serrulata</i> Cecidomyiidae	Stem	Spherical	Green	Glabrous	One			

(continued)

Table 13.2 (continued)

Host plant	Insect taxa	Organ	Shape	Color	Pubescence	Chambers	Reference
Person	Unidentified	Leaf/Petiole	Elliptical	Green	Glabrous	One	
	Unidentified	Stem	Elliptical	Brown	Glabrous	One	
<i>B. platypoda</i>	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	One	
DC	Unidentified	Stem	Globulous	Brown	Glabrous	Several	
	Unidentified	Leaf	Tubular	Green	Glabrous	One	
	Unidentified	Petiole	Elliptical	Green	Glabrous	One	
	Unidentified	Stem	Spherical	Brown	Glabrous	One	
<i>B. dracunculifolia</i>	Cecidomyiidae sp.8	Leaf bud	Spherical	Green	Glabrous	One	
DC	Cecidomyiidae sp. 9	Apical bud	Rosette	Green	Hairy	One	Fig. 13.1g
	<i>Asphondylia</i> sp. 1 (Cecidomyiidae)	Apical bud	Rosette	Green	Glabrous	One	Fig. 13.1h
	<i>Roasphondylia</i> <i>friburguensis</i> (Cecidomyiidae)	Stem	Globulous	Brown	Glabrous	One	
	Cecidomyiidae sp. 10	Stem	Elliptical	Brown	Glabrous	Several	
	Cecidomyiidae sp. 11	Stem	Tubular	Green	Glabrous	One	
	Cecidomyiidae sp. 12	Leaf	Conical	Green	Glabrous	One	
	Cecidomyiidae sp. 13	Apical bud	Rosette	Green	Glabrous	One	Fig. 13.1i
	<i>Genaldesia</i> sp. 1 (Cecidomyiidae)	Leaf	Discoid	Green	Glabrous	One	Fig. 13.1j
	Cecidomyiidae sp. 14	Stem	Globulous	Green	Hairy	One	Fig. 13.1k
	Tephritidae sp. 2	Apical bud	Globulous	Green	Glabrous	One	
	Lepidoptera sp. 2	Stem	Spherical	Green	Hairy	One	Fig. 13.1l
	<i>Baccharopelma</i> <i>dracunculifoliae</i> (Psyllidae)	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.1m

12.55	<i>B. concinna</i>	Cecidomyiidae sp. 16	Apical bud	Tubular	Yellow	Glabrous	One	Fig. 13.1n
12.56	Barroso	Cecidomyiidae sp. 17	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.1o
12.57		Cecidomyiidae sp. 18	Apical bud	Globulous	Purple	Glabrous	Several	Fig. 13.2a
12.58		<i>Geraldesia</i> sp. 3	Leaf	Discoid	Green	Glabrous	One	Fig. 13.2b
12.59		(Cecidomyiidae)						
12.60		Curculionidae sp. 1	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.2c
12.61		Lepidoptera sp. 3	Stem	Elliptical	Red	Glabrous	One	Fig. 13.2d
12.62		<i>Baccharopelma concinnae</i>	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.2e
12.63		(Psyllidae)						
12.64	<i>B. trimeria</i>	Cecidomyiidae	Stem	Elliptical	Green	Glabrous	Several	
12.65	DC	Unidentified	Stem	Elliptical	Brown	Glabrous	One	
12.66		Unidentified	Stem	Cylindrical	Brown	Glabrous	Several	
12.67		Unidentified	Lateral bud	Conical	Brown	Glabrous	One	
12.68		Unidentified	Lateral bud	Tubular	Brown	Glabrous	One	
12.69	<i>B. tarchoanthoides</i>	Lepidoptera	Stem	Elliptical	Brown	Glabrous	One	
12.70	DC	Unidentified	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.2f
12.71		Unidentified	Stem	Cylindrical	Brown	Glabrous	One	
12.72		Unidentified	Leaf	Spherical	Green	Glabrous	One	
12.73		Unidentified	Stem	Globulous	Brown	Glabrous	One	
12.74	<i>B. trinervis</i>	Lepidoptera	Stem	Elliptical	Green	Glabrous	One	
12.75	Person	Cecidomyiidae	Leaf	Blister	Green	Glabrous	One	
12.76		Unidentified	Apical bud	Tubular	Green	Glabrous	One	Fig. 13.2g
12.77		Unidentified	Stem	Cylindrical	Brown	Glabrous	One	
12.78	<i>B. ligustrina</i>	Lepidoptera	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.2h
12.79	DC	Cecidomyiidae	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.2i
12.80		Unidentified	Stem	Tubular	Brown	Glabrous	Several	Fig. 13.2j
12.81	<i>B. reticularia</i>	Lepidoptera	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.2k
12.82	DC	Psyllidae	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.2l
12.83		Cecidomyiidae	Apical bud	Tubular	Green	Glabrous	One	Fig. 13.2m
12.84		Cecidomyiidae	Leaf	Discoid	Green	Glabrous	One	Fig. 13.2n

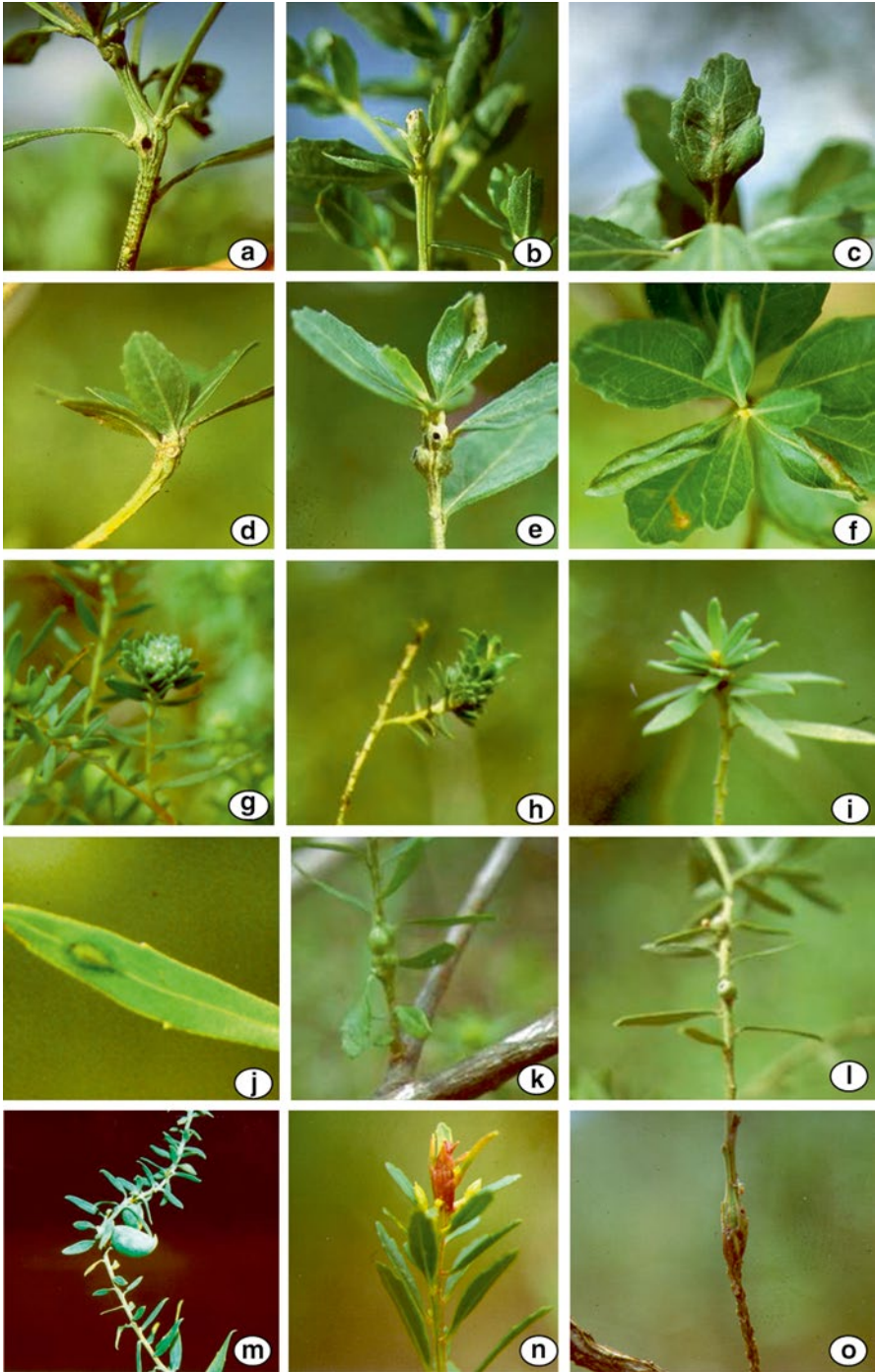
(continued)

Table 13.2 (continued)

Host plant	Insect taxa	Organ	Shape	Color	Pubescence	Chambers	Reference
12.85	Cecidomyiidae	Apical bud	Globulous	Brown	Glabrous	Several	
12.86	Cecidomyiidae	Leaf	Discoïd	Green	Glabrous	One	
12.87	Unidentified	Stem	Spherical	Green	Glabrous	One	
12.88	Unidentified	Inflorescence	Conical	Yellow	Glabrous	One	
12.89	Unidentified	Apical bud	Conical	Brown	Glabrous	One	Fig. 13.2o
12.90	Lepidoptera	Stem	Elliptical	Brown	Glabrous	One	
12.91	Cecidomyiidae	Apical bud	Tubular	Green	Glabrous	One	
12.92	Unidentified	Lateral bud	Spherical	Green	Glabrous	One	Fig. 13.3a
12.93	Unidentified	Stem	Elliptical	Brown	Glabrous	One	
12.94	Unidentified	Apical bud	Conical	Brown	Glabrous	One	
12.95	Unidentified	Stem	Elliptical	Brown	Glabrous	One	
12.96	Psyllidae	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.3b
12.97	Cecidomyiidae	Leaf	Discoïd	Green	Glabrous	One	
12.98	Cecidomyiidae	Apical bud	Tubular	Green	Glabrous	One	
12.99	Cecidomyiidae	Apical bud	Globulous	Purple	Glabrous	Several	
12.100	Lepidoptera	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.3c
12.101	Cecidomyiidae	Stem	Globulous	Brown	Glabrous	Several	
12.102	Unidentified	Apical bud	Conical	Brown	Glabrous	Several	
12.103	Unidentified	Stem	Elliptical	Brown	Glabrous	One	Fig. 13.3d
12.104	Psyllidae	Leaf	Elliptical	Green	Glabrous	One	Fig. 13.3e
12.105	Cecidomyiidae	Leaf	Discoïd	Green	Glabrous	One	
12.106	Cecidomyiidae	Apical bud	Tubular	Green	Glabrous	One	Fig. 13.3f
12.107	Cecidomyiidae	Apical bud	Globulous	Purple	Glabrous	Several	Fig. 13.3g
12.108	Lepidoptera	Stem	Elliptical	Brown	Glabrous	Several	Fig. 13.3h
12.109	Cecidomyiidae	Stem	Spherical	Brown	Glabrous	One	Fig. 13.3i
12.110	Cecidomyiidae	Stem	Spherical	Green	Glabrous	One	
12.111	Unidentified	Stem	Elliptical	Brown	Glabrous	Several	

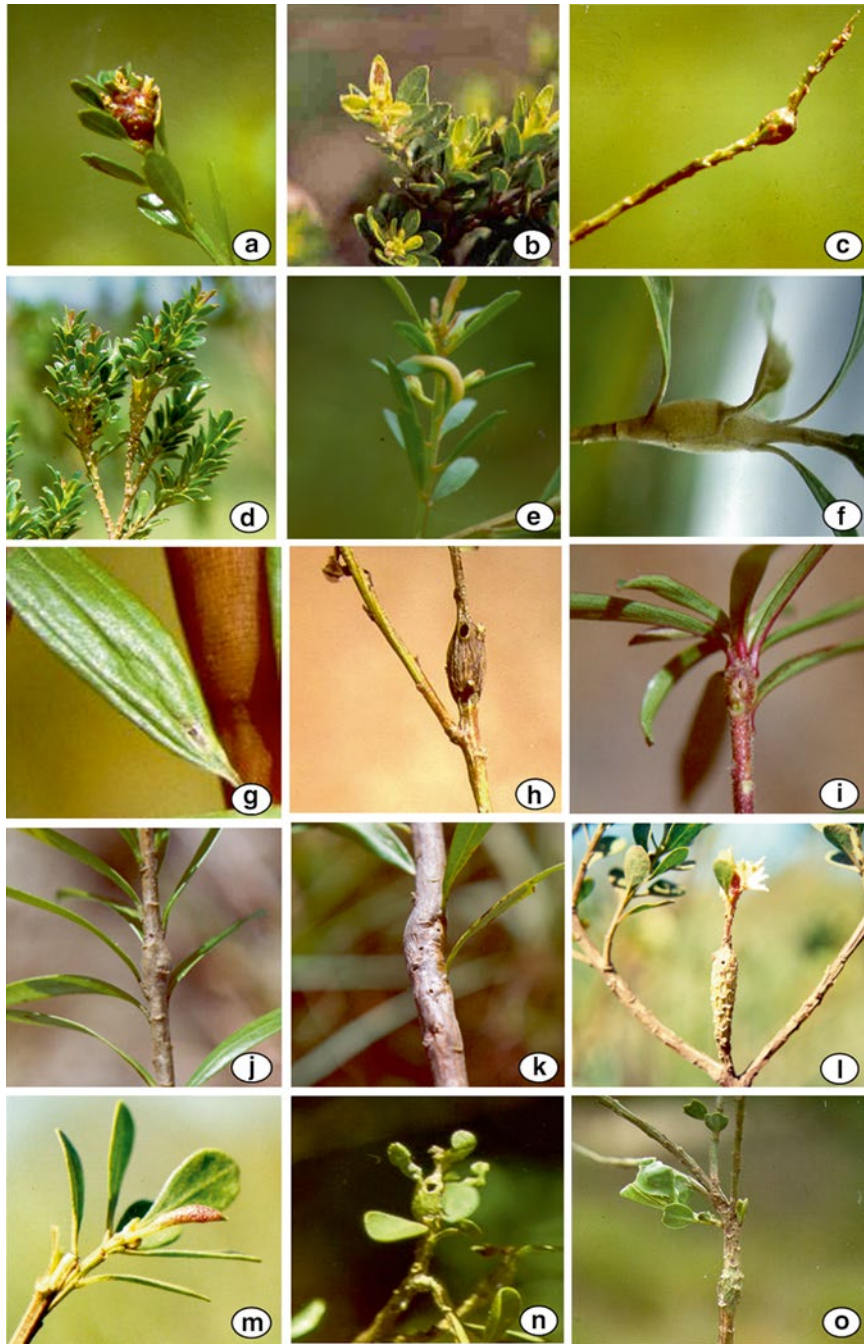
12.112	Unidentified	Stem	Cylindrical	Brown	Glabrous	One
12.113	Unidentified	Stem	Elliptical	Brown	Glabrous	One
12.114	Unidentified	Stem	Elliptical	Brown	Glabrous	Several
12.115	Unidentified	Inflorescence	Conical	Yellow	Glabrous	One
12.116	Cecidomyiidae	Leaf	Discoid	Green	Glabrous	One
12.117	Unidentified	Stem	Spherical	Brown	Glabrous	One
12.118	Unidentified	Stem	Cylindrical	Brown	Glabrous	One
12.119	Unidentified	Apical bud	Tubular	Brown	Glabrous	One
12.120	Malme					

Uncorrected Proof



**Fig. 13.1** Galling insect morphospecies found on *Baccharis* genus in Brazil. *Baccharis ramosissima* (a–f), *B. dracunculifolia* (g–m) and *B. concinna* (n–o)





**Fig. 13.2** Gall-forming insect morphospecies found on *Baccharis* genus in Brazil. *Baccharis concinna* (a–e), *B. tarchonanthoides* (f), *B. trinervis* (g–h), *B. ligustrina* (i–k), *B. reticularia* (l–n) and *B. truncata* (o)





**Fig. 13.3** Gallling insect morphospecies found on *Baccharis* genus in Brazil. *Baccharis truncata* (a), *B. intermixta* (b–d), *B. minutiflora* (e–i)

174 Two galling insect genera are commonly found on the species of *Baccharis*  
 175 throughout the Espinhaço mountains. The genus *Geraldesia* (Diptera: Cecidomyiidae)  
 176 was recorded on nine species of *Baccharis*, while the genus *Baccharopelma*  
 177 (Hemiptera: Psyllidae) was recorded on seven *Baccharis* species (Table 13.2).  
 178 These genera may have experienced a large radiation inside this host genus, such as  
 179 the genus *Asphondylia* (Cecidomyiidae) on *Larrea tridentata* (Waring and Price  
 180 1990). This similarity could lead to a convergence in community structure of gall-  
 181 ing insects. Host shift followed by subsequent reproductive isolation, adaptation,  
 182 and ultimately speciation and radiation through sympatric speciation seems a plau-  
 183 sible hypothesis (see also Craig et al. 1997). But while galling species radiations  
 184 can be seen in some species of *Baccharis*, another interesting evolutionary aspect  
 185 in this system is the distinct communities of galling insects attacking single host  
 186 species. *Baccharis* tend to host gallers of different and unrelated taxa, such as

dipterans, lepidopterans, hemipterans, coleopterans, thysanopterans, and even mites and mistletoes. Therefore, a peculiar or singular feature of the galling community on *Baccharis* spp. is the broad range of species composition. While in some galling speciose systems around the world we primarily see a diversification of a single taxon of gallers within the hosts, such as in *Quercus* (Cynipidae) (Shorthouse and Rohfritsch 1992; Stone et al. 2002), and *Larrea tridentata* (*Asphondylia*) (Waring and Price 1990), for instance, in *Baccharis* we observe many unrelated insect taxa attacking a single host species (see Fernandes et al. 1996; Espírito-Santo et al. 2007, 2012).

Curiously, we also observe each *Baccharis* host plant species having its own galling species of the genus *Baccharopelma* (Burckhardt et al. 2004). Based on gall abundance, *Baccharopelma* (Hemiptera: Psyllidae) (Burckhardt et al. 2004) has been shown to be the most abundant galling genus on *Baccharis* (Espírito Santo et al. 2007, 2012). *Baccharopelma dracunculifoliae* represents 80 % of the galls found on *B. dracunculifolia*, whereas *Baccharopelma concinnae* represents 56 % of the galls on *B. concinna*, and *Baccharopelma brasiliensis* responsible for 53.5 % of the galls on *B. ramosissima*. The reasons for the dominance of these galling hemipteran species on their hosts awaits further investigation.

While no evolutionary studies on the host relations with the galling fauna were developed so far in this genus, speciation through host shifting, species radiation within single hosts, plus colonization by different taxa are all taking place. The combination of these phenomena may account for such high and unprecedented diversity. In spite the fact that studies phylogenetic studies on the genus *Baccharis* are still underway, its species present similar architecture (see Table 13.3), and biology what could select for similar chemistry, physical and physiological traits (Espírito-Santo et al. 2007, 2012). The only system most similar to that found in *Baccharis* is perhaps that of *Chrysothamnus* spp. (Asteraceae) in southwestern United States, where at least dozens of still undescribed species of galling insects belonging to Tephritidae, Cecidomyiidae, and Lepidoptera are observed on hybrids and sub-species of *Chrysothamnus* (e.g. Floate et al. 1996; Fernandes et al. 2000).

## **13.4 Global and Regional Patterns of Gall Diversity on *Baccharis***

### **13.4.1 Latitudinal Gradient**

Fagundes and Fernandes (2011) tested the spatial heterogeneity hypothesis in galling insects by evaluating the variation in richness of galling herbivores associated with 17 populations of a single species of host plant, *Baccharis dracunculifolia*. Habitats were maintained somehow homogeneous along the distributional limits of the host plant, near the Brazilian sea coast (for details see Fagundes and Fernandes 2011).

**Table 13.3** Architectural traits and gall richness and abundance of the 17 species of *Baccharis*

	Species	Number of ramifications	Level of ramification	Number of fourth-level shoots	Height (m)	Biomass (g)	Gall richness (total)	Gall abundance
t3.1	<i>B. ramosissima</i>	21.9±1.32	5.12±0.15	138.7±9.79	1.99±0.05	273.8±45.2	6	11.28±1.29
t3.2	<i>B. cognata</i>	17.4±1.43	4.46±0.09	87.4±9.32	0.97±0.02	56.5±9.08	10	3.95±1.09
t3.3	<i>B. helychrysoides</i>	1.62±0.13	2.96±0.13	4.47±0.84	1.46±0.03	30.4±4.33	6	0.98±0.18
t3.4	<i>B. serrulata</i>	3.34±0.22	3.74±0.16	8.72±1.35	0.78±0.04	37.7±10.2	3	1.15±0.37
t3.5	<i>B. platypoda</i>	4.72±0.37	3.06±0.11	6.13±1.57	1.22±0.06	150.5±28.3	5	3.15±1.20
t3.6	<i>B. dracunculifolia</i>	10.7±0.59	5.18±0.16	141.1±13.0	1.84±0.06	253.5±23.1	13	54.1±7.23
t3.7	<i>B. concinna</i>	11.5±0.66	5.25±0.20	92.8±9.98	1.05±0.04	81.5±12.7	7	15.63±3.34
t3.8	<i>B. trimera</i>	1.62±0.13	4.01±0.12	22.4±2.29	0.85±0.03	56.2±11.9	5	3.02±0.61
t3.9	<i>B. tarchonanthoides</i>	2.13±0.14	3.91±0.14	12.5±1.93	1.17±0.04	150.4±23.9	5	0.85±0.20
t3.10	<i>B. trinervis</i>	3.11±0.24	3.88±0.14	27.1±8.15	0.97±0.04	84.2±23.7	4	1.83±0.35
t3.11	<i>B. ligustrina</i>	2.42±0.18	3.13±0.12	4.81±0.77	0.54±0.02	37.5±7.97	3	2.11±0.44
t3.12	<i>B. reticularia</i>	17.4±1.26	5.45±0.17	86.9±8.09	1.65±0.04	305.0±26.8	9	16.08±1.87
t3.13	<i>B. truncata</i>	4.82±0.39	4.15±0.15	26.5±3.79	0.67±0.03	37.8±6.16	6	1.07±0.26
t3.14	<i>B. minutiflora</i>	25.2±2.14	5.47±0.15	119.3±11.0	1.00±0.03	68.7±9.56	12	30.97±4.82
t3.15	<i>B. intermixta</i>	10.1±0.49	5.09±0.15	79.2±8.27	1.34±0.04	184.6±24.7	8	36.32±5.27
t3.16	<i>B. medullosa</i>	3.05±0.26	3.86±0.11	27.1±3.51	1.95±0.06	201.0±36.1	3	9.35±1.57
t3.17	<i>B. oreophila</i>	2.78±0.38	2.88±0.08	6.03±1.39	1.89±0.04	66.6±8.26	1	0.08±0.04

The authors did not find support for the spatial heterogeneity hypothesis; indicated 226  
 by the lack of variation of galling insect richness associated with *B. dracunculifolia* 227  
 along the latitudinal gradient studied. This result associated with the fact that the 228  
 genus *Baccharis* is more species-rich in the southern region of Brazil (see Jarvis 229  
 et al. 1991) and the narrow host plant requirements of gall-inducing insects (special- 230  
 ists) (see Carneiro et al. 2009a) support the hypothesis that galling insect associated 231  
 with the genus *Baccharis* radiated into the southern region of Brazil (Fagundes and 232  
 Fernandes 2011). 233

**13.4.2 Altitudinal Gradient** 234

Galling insect species diversity is generally negatively correlated with altitude 235  
 (Fernandes and Price 1988, 1991; Fernandes and Lara 1993), whereas in some cases 236  
 galling insect diversity peaks at intermediate altitudes (Waring and Price 1990). 237  
 Fernandes and Price (1991) observed that the negative relationship between altitude 238  
 at regional scale and galling species richness was heavily dependent on xeric habitat 239  
 than mesic habitat, suggesting that altitude is a spurious correlate, and environmen- 240  
 tal harshness is the key factor determining galling species richness. Such a conclu- 241  
 sion is supported by the latitudinal pattern. 242

Carneiro et al. (2005) verified the effects of the altitudinal gradient (800–1,400 m) 243  
 on the galling insect community on *Baccharis concinna* within the same latitude. 244  
 The total number of galling species and the richness of galling cecidomyiids showed 245  
 a peak at intermediate altitudes (= 1,100 m). The richness of all galling species and 246  
 galling cecidomyiids were strongly influenced by habitat. A similar peak has been 247  
 reported for *Asphondylia* spp. (Cecidomyiidae) on *Larrea tridentata* by Waring and 248  
 Price (1990) in North America. Since Carneiro et al. (2005) used a system nearly 249  
 void of confounding effects (effects of latitude, plant species richness, and plant 250  
 architecture controlled as only a single host taxon was studied), the results indicate 251  
 that local factors were more important than regional factors structuring the galling 252  
 insect community on *B. concinna*. 253

**13.5 Local Patterns of Gall Diversity on *Baccharis*** 254

**13.5.1 Architecture and Galling Insects** 255

Among the plant traits known to affect herbivorous insects, architecture is probably 256  
 the least studied (Marquis et al. 2002). According to Lawton (1983), plant architec- 257  
 ture has five components: size, growth form (mainly herbs, shrubs, and trees), sea- 258  
 sonal development, variety of above-ground parts, and the persistency of these 259  
 parts. *Baccharis* represents an ideal system to verify architectural features effects on 260  
 gall attack since interspecific variation in architecture is high, with species varying 261

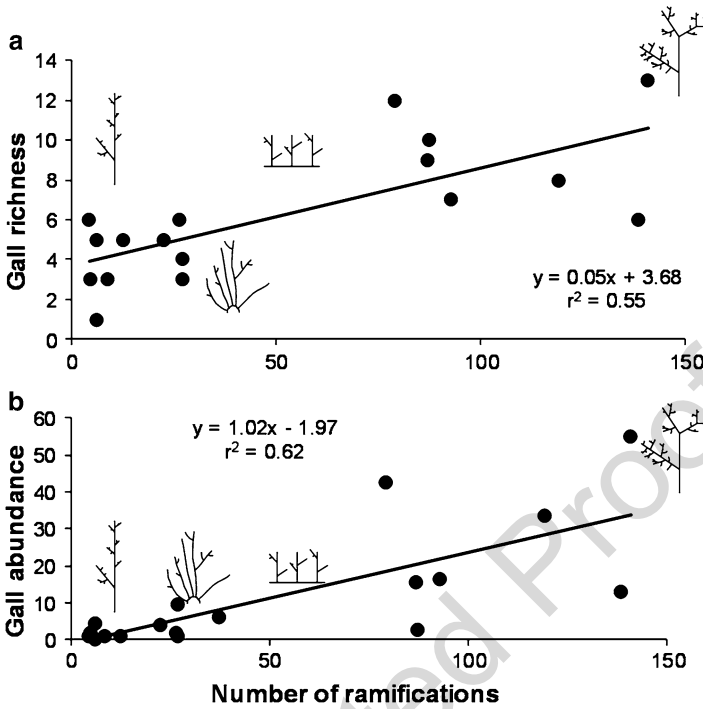
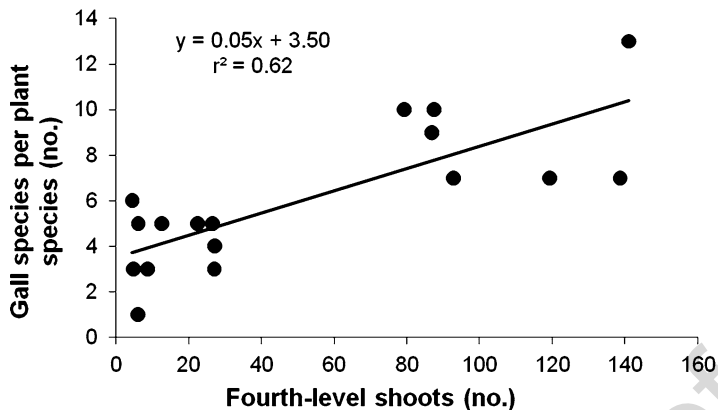


Fig. 13.4 Relationship between total (a) gall richness and (b) abundance and number of ramifications for 17 species of *Baccharis*

262 from 0.3 to 4 m in height, and with very distinct ramification patterns (see Barroso  
 263 1976); thus allowing comparisons between species with great discrepancy in architecture  
 264 and gall richness.

265 Espírito-Santo et al. (2007) investigated the influence of plant architecture on the  
 266 speciose fauna of gall-inducing insects associated with the 17 species of *Baccharis*  
 267 previously cited (Table 13.3). Five architectural variables were evaluated: plant  
 268 height, number of fourth-level shoots, biomass, average level, and number of rami-  
 269 fications (Table 13.3). Fourth-level shoots are usually young and possess many  
 270 sprouting leaves, therefore being a natural indicator of the amount of active meri-  
 271 stems in a given individual. Higher-level shoots (e.g., fifth and sixth level) are  
 272 encountered only in few architecturally complex individuals of some *Baccharis*  
 273 species and hence were not considered here for clarity (for details see Espírito-  
 274 Santo et al. 2007).

275 The higher richness and abundance of galling insects was found on host species  
 276 that presented the higher number of ramifications (architecturally complex)  
 277 (Fig. 13.4). The most important architectural trait influencing gall richness at the  
 278 species level was the number of fourth-level shoots, which is indicative of the  
 279 availability of plant meristems, a fundamental tissue for gall induction and  
 280 development (Fig. 13.5). This variable also showed a positive correlation with gall



**Fig. 13.5** Relationship between total gall richness and the average number of fourth-level shoots per species for 17 species of *Baccharis* ( $y=0.05x + 3.50$ ,  $r^2=0.62$ )

richness and abundance at the individual level on *B. concinna*, *B. dracunculifolia*, 281  
 and *B. ramosissima* (see also Sect. 13.5.2). Hence, plant individuals and species 282  
 with a higher average number of fourth-level shoots may support a higher richness 283  
 of galling insects. 284

Galling insects require relatively undifferentiated tissues for the induction and 285  
 development of galls (Mani 1964; Weis et al. 1988; Rohfritsch 1992). In general, 286  
 apical dominance is reduced on shrubs (Steeves and Sussex 1989; Sussex and Kerk 287  
 2001) and the plants maintain a steady supply of young branches suitable for attack 288  
 by galling female (Price et al. 1996). Variations in gall richness among host species 289  
 may be driven by interspecific differences in plant architecture via availability of 290  
 young, undifferentiated tissue, which is genetically controlled by the strength of the 291  
 apical dominance. This is reinforced in our studies (see Espírito-Santo et al. 2007), 292  
 in which *Baccharis* species with higher meristem availability supported higher gall 293  
 richness and abundance. Corroborating this finding, Araújo et al. (2003) showed 294  
 that galling insect richness on *Baccharis pseudomyriocephala* was positively related 295  
 to host architectural complexity (height, biomass, and shoot size). Although many 296  
 factors influence the evolutionary radiation of galling species (e.g., plant chemistry, 297  
 physical defenses, phenology, gall competition and natural enemies), we must yet 298  
 untangle the role of resource availability and meristem dynamics in the system 299  
 (Espírito-Santo et al. 2007). 300

**13.5.2 Dioecy and Gall Attack** 301

Plants have limited resources for their physiological processes and there is a 302  
 trade-off between the various processes. Dioecious plants present different 303  
 adaptations related to each gender investing differentially their nutrients and 304  
 energy into reproduction, growth rates and production of chemical compounds. 305

306 Female plants growth rates are lower than in male plants, while male plants may  
307 experience greater damage by herbivores than female plant conspecifics (Ågren  
308 1987; Boecklen et al. 1990, 1994; Herms and Mattson 1992; Cornelissen and  
309 Stiling 2005). In dioecious species, where male and female plants have different  
310 growth rates, the resource availability hypothesis predicts that: (1) female plants  
311 (slow growth) invest more resources in the production of secondary compounds  
312 against herbivores than male plants (rapid growth); and that (2) female plants due  
313 to the high concentration of secondary compounds will be less attacked by her-  
314 bivores than males. Several studies have indeed indicated that female plants are  
315 less attacked by different guilds of herbivores, including free-feeding and galling  
316 herbivores (Boecklen et al. 1990; Boecklen and Hoffman 1993), other inverte-  
317 brate herbivores (Elmqvist et al. 1991), herbivorous mammals (Danell et al.  
318 1985, 1991; Hjaltén 1992), and fungi (Varga and Kytöviita 2008), while some  
319 exceptions were found (e.g., parasites, Gehring and Whitham 1992; and patho-  
320 gens, Lee 1981).

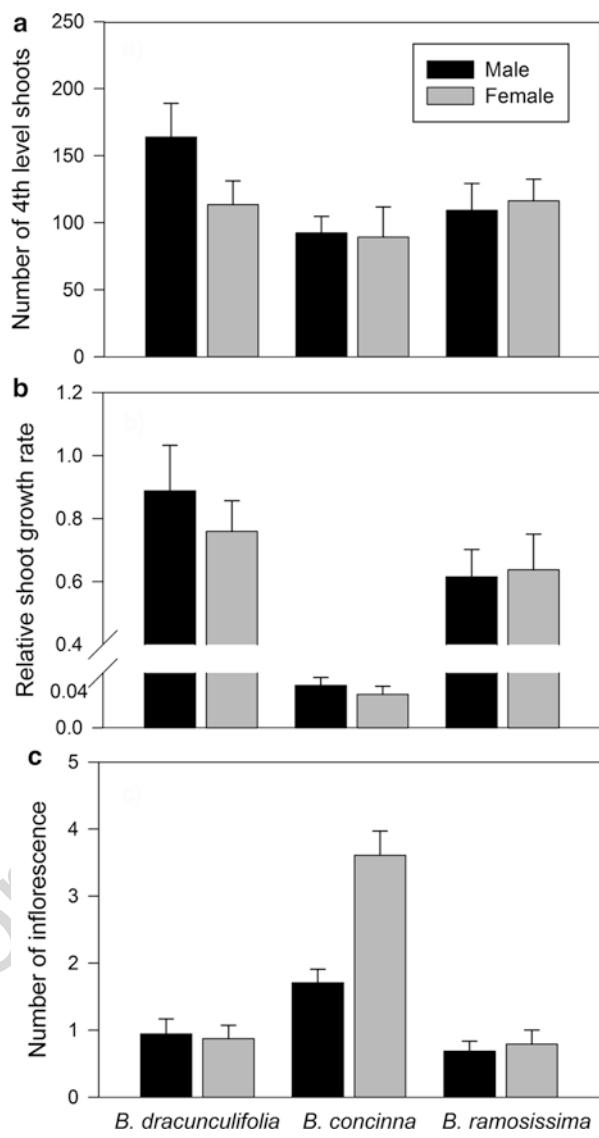
321 The system comprised of *Baccharis* species and their gall-inducing insects  
322 appears to provide an ideal scenario to test for plant sexual differences on timing  
323 and intensity of energy allocation and herbivory attack. The effects of vegetative  
324 (number of fourth-level shoots and relative shoot growth rate) and reproductive  
325 traits (inflorescence number) on gall attack on *Baccharis dracunculifolia*, *B. con-*  
326 *cinna*, and *B. ramosissima* was studied during a 1 year period. Intersexual differ-  
327 ences were only observed in inflorescence number on *B. concinna*, in which was  
328 male biased (Fig. 13.6). On the other hand, gall abundance did not differ between  
329 sexes of the three *Baccharis* species studied (Fig. 13.7).

330 Females of *B. concinna* produced a significantly higher number of inflorescences  
331 than males. However, this species is wind-pollinated (Barroso 1976) and has the  
332 smallest inflo~~delete~~ among the three species studied. Its low-cost flowers are  
333 produced during throughout the year by both gender (see Espírito-Santo et al. 2012).  
334 Thus, due to the absence of differences in relative shoot growth rate between gen-  
335 ders, a high female investment in flowering do not provoke a trade-off between  
336 reproduction and growth, ultimately resulting in the absence of difference of gall  
337 abundance between sexes. Furthermore, carbon-based defenses such as tannins do  
338 not vary between sexes in *B. dracunculifolia* (Espírito-Santo et al. 1999), although  
339 nothing is yet known for the chemistry of *B. concinna* and *B. ramosissima*. In gen-  
340 eral, plant sex does not seem to be an important variable that affects gall attack on  
341 *Baccharis*.

342 The findings in these three species corroborate the previous studies in this speci-  
343 ose genus (Espírito-Santo and Fernandes 1998; Faria and Fernandes 2001; Araújo  
344 et al. 2003; Carneiro et al. 2006; Espírito-Santo et al. 2012). On *B. dracunculifolia*,  
345 Faria and Fernandes (2001) did not find difference in relative growth rate and gall  
346 abundance between sexes, whereas Espírito-Santo and Fernandes (1998), and  
347 Ribeiro-Mendes et al. (2002) were not able to find any statistically significant dif-  
348 ference on gall performance (e.g. gall parasitoidism and predation) between sexes.  
349 In *B. pseudomyriocephala*, Araújo et al. (2003) also failed to verify any effect of



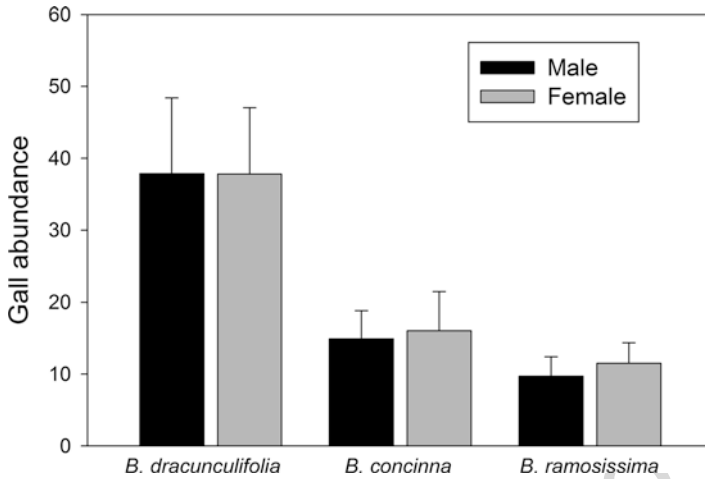
**Fig. 13.6** Average (a) number of fourth-level shoots, (b) relative shoot growth rate and (c) inflorescence number on male and female individuals *Baccharis dracunculifolia*, *B. concinna* and *B. ramosissima*. Data were measured every 3 weeks during 1 year and averaged per plant species (mean  $\pm$  s.e.)



host plant gender on shoot size, meristem availability or gall attack. Although the abundance of galling insects showed a positive correlation with shoot size, larval survivorship was not influenced by shoot size. Finally, although *B. concinna* male plants presented longer shoots and a lower average number of inflorescences than female plants, no statistically significant difference was found in the number of galls between male and female plants (Carneiro et al. 2006).

350  
351  
352  
353  
354  
355





**Fig. 13.7** Average number of galls (mean  $\pm$  s.e.) on male and female individuals of *Baccharis dracunculifolia*, *B. concinna* and *B. ramosissima*. Galls were counted every 3 weeks during 1 year and averaged per plant species

356 In spite of the intersexual differences in *B. concinna* (e.g., number of inflorescence),  
 357 the *Baccharis* species do not exhibit significant differences in growth rates, number  
 358 of shoots, nutritional status, and chemical properties between male and female  
 359 plants. At this moment, there is compelling evidence to the lack of differential gall  
 360 attack between host plant sexes. Our long-term data support the hypothesis that  
 361 shoot growth rate is an important variable influencing temporal variations in gall  
 362 attack, whereas the number of fourth-level shoots is responsible for spatial and indi-  
 363 vidual differences in plant susceptibility regardless of plant gender.

### 364 13.6 Concluding Remarks

365 *Baccharis* support the highest galling insect fauna in the Neotropics and is a super  
 366 host genus for gall inducing insects. Within single species or within the genus, many  
 367 insects belonging to different taxa succeeded, evolved and radiated to form one of  
 368 the most spectacular communities of gallers in the world. Their study has been cru-  
 369 cial for the establishment of generalities and testing of ecological and evolutionary  
 370 theories across the Americas, as well as to generate new ideas and hypotheses.  
 371 For these reasons and power of the field and experimental observations we suggest  
 372 that the galling insects on their *Baccharis* hosts may represent a Neotropical model  
 373 system for studies on insect plant interactions.

## References

374

- Abad MJ, Bermejo P (2007) *Baccharis* (Compositae): a review update. *Arkivoc* 7:76–96 375
- Abrahamson WG, Weis AE (1997) Evolutionary ecology across three trophic levels: goldenrods, gallmakers and natural enemies. Princeton University, Princeton 376
- Agostini F, Santos ACA, Rossato M, Pansera MR, Zattera F, Wasum R, Serafini LA (2005) Studies on the essential oils from several *Baccharis* (Asteraceae) from Southern Brazil. *Rev Bras Farmacogn* 15:215–219 378
- Ågren J (1987) Intersexual differences in phenology and damage by herbivores and pathogens in dioecious *Rubus chamaemorus* L. *Oecologia* 72:161–169 381
- Araújo AM, Fernandes GW, Bedê LC (1995) Influência do sexo e fenologia de *Baccharis dracunculifolia* DC. (Asteraceae) sobre insetos herbívoros. *Rev Bras Entomol* 39:347–353 382
- Araújo APA, Carneiro MAA, Fernandes GW (2003) Efeitos do sexo, do vigor e do tamanho da planta hospedeira sobre a distribuição de insetos indutores de galhas em *Baccharis pseudomyriocephala* Teodoro (Asteraceae). *Rev Bras Entomol* 47:483–490 383
- Araújo APA, Paula JD, Carneiro MAA, Schoederer JH (2006) Effects of host plant architecture on colonization by galling insects. *Austral Ecol* 31:343–348 384
- Argandoña VH, Faini F (1993) Oleanolic acid content in *Baccharis linearis* and its effects on *Heliothis zea* larvae. *Phytochemistry* 33:1377–1379 385
- Askew RR (1960) The biology of the British species of the genus *Olux* Förster (Hymenoptera: Eulophidae), with a note on seasonal colour forms in the Chalcidoidea. *Proc R Entomol Soc Lond* 36:103–112 386
- Banskota AH, Tezuka Y, Kadota S (2001) Recent progress in pharmacological research of propolis. *Phytother Res* 15:561–571 387
- Barroso GM (1976) Compositae-subtribo Baccharidinae-Hoffman: estudo das espécies ocorrentes no Brasil. *Rodriguesia* 40:3–273 388
- Blanche KR (2000) Diversity of insect-induced galls along a temperature–rainfall gradient in the tropical Savannah region of the Northern Territory, Australia. *Austral Ecol* 25:311–318 389
- Boecklen WJ, Hoffman MT (1993) Sex-biased herbivory in *Ephedra trifurca*: the importance of sex-by environment interactions. *Oecologia* 96:49–55 390
- Boecklen WJ, Price PW, Mopper S (1990) Sex and drugs and herbivores: sex-biased herbivory in arroyo willow (*Salix lasiolepis*). *Ecology* 71:581–588 391
- Boecklen WJ, Mopper S, Price PW (1994) Sex-biased herbivory in arroyo willow: are there general patterns among herbivores? *Oikos* 71:267–272 392
- Boldt PE (1989) *Baccharis* (Asteraceae), a review of its taxonomy, phytochemistry, ecology, economic status, natural enemies and the potential for its biological control in the United States. USDA, Agricultural Research Service. Grassland, Soil and Water Research Laboratory, Temple 393
- Burckhardt D, Espírito-Santo MM, Fernandes GW, Malenovský I (2004) Gall-inducing jumping plant-lice of the Neotropical genus *Baccharopelma* (Hemiptera, Psylloidea) associated with *Baccharis* (Asteraceae). *J Nat Hist* 38:2051–2071 394
- Carneiro MAA, Fernandes GW, De Souza OFF (2005) Convergence in the variation of local and regional galling species richness. *Neotrop Entomol* 34:547–553 395
- Carneiro MAA, Fernandes GW, De Souza OFF, Souza WVM (2006) Sex-mediated herbivory by galling insects on *Baccharis concinna* (Asteraceae). *Rev Bras Entomol* 50:394–398 396
- Carneiro MAA, Branco CSA, Braga CED, Almada ED, Costa MBM, Maia VC, Fernandes GW (2009a) Are gall midge species (Diptera, Cecidomyiidae) host-plant specialists? *Rev Bras Entomol* 53:365–378 397
- Carneiro MAA, Borges RAX, Araújo APA, Fernandes GW (2009b) Insetos indutores de galhas da porção sul da Cadeia do Espinhaço, MG. *Rev Bras Entomol* 53:570–592 398
- Chan GC, Cheung K, Sze DM (2012) The immuno modulatory and anticancer properties of propolis. *Clin Rev Allergy Immunol*. doi:10.1007/s12016-012-8322-2 399

- 425 Coelho MS, Almada ED, Fernandes GW, Carneiro MAA, Santos RM, Sánchez-Azofeifa A (2009)  
426 Gall inducing arthropods from a seasonally dry tropical forest in Serra do Cipó, Brazil. *Rev*  
427 *Bras Entomol* 53:404–414
- 428 Collevatti RG, Sperber CF (1997) The gall maker *Neopelma baccharidis* Burck. (Homoptera:  
429 Psyllidae) on *Baccharis dracunculifolia* DC. (Asteraceae): individual, local, and regional  
430 patterns. *Ann Soc Entomol Brasil* 26:45–53
- 431 Cornelissen T, Stiling P (2005) Sex-biased herbivory: a meta-analysis of the effects of gender on  
432 plant-herbivore interactions. *Oikos* 111:488–500
- 433 Cornell HV (1983) The secondary chemistry and complex morphology of galls formed by the  
434 Cynipidae (Hymenoptera): why and how? *Am Midl Nat* 136:581–597
- 435 Costa FV, Fagundes MF, Neves FS (2010) Arquitetura da planta e diversidade de galhas associadas  
436 à *Copaifera langsdorffii* (Fabaceae). *Ecol Aust* 20:9–17
- 437 Costa FV, Neves FS, Silva JO, Fagundes M (2011) Relationship between plant development,  
438 tannin concentration and insects associated with *Copaifera langsdorffii* (Fabaceae). *Arthropod*  
439 *Plant Interact* 5:9–18
- 440 Cox CB, Moore PD (1993) Biogeography: an ecological and evolutionary approach. Blackwell,  
441 Berlin
- 442 Craig TP, Horner JD, Itami JK (1997) Hybridization studies on the host races of *Eurosta solidaginis*:  
443 implications for sympatric speciation. *Evolution* 51:1552–1560
- 444 Danell K, Elmqvist T, Ericson L, Salomonson A (1985) Sexuality in willows and preference by  
445 bark-eating voles, defence or not? *Oikos* 44:82–90
- 446 Danell K, Hjältén J, Ericson L, Elmqvist T (1991) Vole feeding on male and female willow shoots  
447 along a gradient of plant productivity. *Oikos* 62:145–152
- 448 Elmqvist T, Cates RG, Harper JK, Garfjell H (1991) Flowering in males and females of a Utah  
449 willow, *Salix rigida* and effects on growth, tannins, phenolic glycosides and sugars. *Oikos*  
450 61:65–72
- 451 Espírito-Santo MM, Fernandes GW (1998) Abundance of *Neopelma baccharidis* (Homoptera:  
452 Psyllidae) galls on the dioecious shrub *Baccharis dracunculifolia* (Asteraceae). *Environ*  
453 *Entomol* 27:870–876
- 454 Espírito-Santo MM, Fernandes GW (2002) Host plant effects on the development and survivorship  
455 of the galling insect *Neopelma baccharidis* (Homoptera: Psyllidae). *Aust Ecol* 27:249–257
- 456 Espírito-Santo MM, Fernandes GW, Allain LR, Reis TRF (1999) Tannins in *Baccharis*  
457 *dracunculifolia* (Asteraceae): effects of seasonality, water availability and plant sex. *Acta Bot*  
458 *Bras* 13:167–174
- 459 Espírito-Santo MM, Madeira BG, Neves FS, Faria ML, Fagundes M, Fernandes GW (2003)  
460 Sexual differences in reproductive phenology and their consequences for the demography of  
461 *Baccharis dracunculifolia* (Asteraceae), a dioecious tropical shrub. *Ann Bot* 91:13–19
- 462 Espírito-Santo MM, Faria ML, Fernandes GW (2004) Parasitoid attack and its consequences to the  
463 development of the galling psyllid *Baccharopelma dracunculifoliae*. *Basic Appl Ecol*  
464 5:475–484
- 465 Espírito-Santo MM, Neves FS, Andrade-Neto FR, Fernandes GW (2007) Plant architecture and  
466 meristem dynamics as the mechanism determining the diversity of gall-inducing insects.  
467 *Oecologia* 153:353–364
- 468 Espírito-Santo MM, Neves FS, Fernandes GW, Silva JO (2012) Plant phenology and absence of  
469 sex-biased gall attack on three species of *Baccharis*. *Plos ONE* 7(10):e46896. doi:10.1371/  
470 journal.pone.0046896
- 471 Fagundes M, Fernandes GW (2011) Insect herbivores associated with *Baccharis dracunculifolia*  
472 (Asteraceae): responses of gall-forming and free-feeding insects to latitudinal variation. *Rev*  
473 *Biol Trop* 59:1419–1432
- 474 Fagundes M, Faria ML, Fernandes GW (2001) Efeitos da distribuição de *Baccharis dracunculifolia*  
475 (Asteraceae) na abundância e no parasitismo de galhas de *Neopelma baccharidis* (Homoptera:  
476 Psyllidae). *Unimontes Cientific* 1:1–7
- 477 Fagundes M, Neves FS, Fernandes GW (2005) Direct and indirect interactions involving ants,  
478 insect herbivores, parasitoids, and the host plant *Baccharis dracunculifolia* (Asteraceae). *Ecol*  
479 *Entomol* 30:28–35

Faria ML, Fernandes GW (2001) Vigour of a dioecious shrub and attack by a galling herbivore. <i>Ecol Entomol</i> 26:36–45	480 481
Felt EP (1940) Plant galls and gall makers. Comstock, Ithaca	482
Fernandes GW (1990) Hypersensitivity: a neglected plant resistance mechanism against insect herbivores. <i>Environ Entomol</i> 19:1173–1182	483 484
Fernandes GW (1992) Plant family size and age effects on insular gall-forming species richness. <i>Glob Ecol Biogeogr Letts</i> 2:71–74	485 486
Fernandes GW, Lara ACF (1993) Diversity of Indonesian gall-forming herbivores along altitudinal gradients. <i>Biodivers Letts</i> 1:186–192	487 488
Fernandes GW, Price PW (1988) Biogeographical gradients in galling species richness: tests of hypotheses. <i>Oecologia</i> 76:161–167	489 490
Fernandes GW, Price PW (1991) Comparison of tropical and temperate galling species richness: the role of environmental harshness and plant nutrient status. In: Price PW, Lewinsohn T, Fernandes GW, Benson WW (eds) <i>Plant–animal interactions: evolutionary ecology in tropical and temperate regions</i> . Wiley, New York, pp 91–115	491 492 493 494
Fernandes GW, Price PW (1992) The adaptive significance of insect gall distribution: survivorship of species in xeric and mesic habitat. <i>Oecologia</i> 90:14–20	495 496
Fernandes GW, Tameirão-Neto E, Martins RP (1988) Ocorrência e caracterização de galhas entomógenas na vegetação do Campus-Pampulha, UFMG, Belo Horizonte – MG. <i>Rev Bras Zool</i> 5:11–29	497 498 499
Fernandes GW, Carneiro MAA, Lara ACF, Allain LA, Andrade GI, Julião G, Reis TC, Silva IM (1996) Galling insects on neotropical species of <i>Baccharis</i> (Asteraceae). <i>Trop Zool</i> 9:315–332	500 501
Fernandes GW, Araújo RC, Araújo SC, Lombardi JA, Paula AS, Loyola R, Cornelissen TG (1997) Insect galls from Jequitinhonha Valley, Minas Gerais, Brazil. <i>Naturalia</i> 22:221–224	502 503
Fernandes GW, Saraiva C, Cornelissen TG, Price PW (2000) Diversity and morphology of insect galls on <i>Chrysothamnus nauseosus</i> (Asteraceae) in North Arizona. <i>Bios</i> 8:39–48	504 505
Ferracini VL, Paraiba LC, Leitão-Filho HF, Silva AGD, Nascimento LR, Marsaioli AJ (1995) Essential oils of seven Brazilian <i>Baccharis</i> species. <i>J Essent Oil Res</i> 7:355–367	506 507
Floate KD, Whitham TG (1995) Insects as traits in plant systematics: their use in discriminating between hybrid cottonwoods. <i>Can J Bot</i> 73:1–13	508 509
Floate KD, Fernandes GW, Nilsson JA (1996) Distinguishing intrapopulation categories of plants by their insect faunas: galls on rabbit brush. <i>Oecologia</i> 105:221–229	510 511
Gehring CA, Whitham TG (1992) Reduced mycorrhizae on <i>Juniperus monosperma</i> with mistletoe: the influence of environmental stress and tree gender on a plant parasite and a plant–fungal mutualism. <i>Oecologia</i> 89:298–303	512 513 514
Gomes V, Fernandes GW (2002) Germinação de aquênios de <i>Baccharis dracunculifolia</i> D. C. (Asteraceae). <i>Acta Bot Bras</i> 16:421–427	515 516
Hartley SE, Lawton JH (1992) Host-plant manipulation by gall-insects: a test of the nutrition hypothesis. <i>J Anim Ecol</i> 61:113–119	517 518
Hawkins BA, Compton SG (1992) African fig wasp communities: undersaturation and latitudinal gradients in species richness. <i>J Anim Ecol</i> 61:361–372	519 520
Hermes DA, Mattson WJ (1992) The dilemma of plants: to grow or defend. <i>Q Rev Biol</i> 67:283–335	521
Hjältén J (1992) Plant sex and hare feeding preferences. <i>Oecologia</i> 89:253–256	522
Inbar M, Izhaki I, Kopolovich A, Lupo I, Silanikove N, Glasser T, Gerchman Y, Perevolotsky A, Lev-Yadun A (2010) Why do many galls have conspicuous colors? A new hypothesis. <i>Arthropod Plant Interact</i> 4:1–6	523 524 525
Jarvis BB, Midiwo JO, Bean GA, Abdoul-Nasr MB, Barras CS (1988) The mystery of trichothecene antibiotics in <i>Baccharis</i> species. <i>J Nat Prod</i> 51:736–744	526 527
Jarvis BB, Mokhtari-Rejali N, Schenkel EP, Barros CS, Matzenbacher NI (1991) Trichothecene mycotoxins from Brazilian <i>Baccharis</i> species. <i>Phytochemistry</i> 30:789–797	528 529
Julião GR, Amaral MEC, Fernandes GW (2002) Galhas de insetos e suas plantas hospedeiras do Pantanal sul-mato-grossense. <i>Naturalia</i> 27:47–74	530 531
Kumazawa S, Yoneda M, Shibata I, Kanaeda J, Hamasaka T, Nakayama T (2003) Direct evidence for the plant origin of Brazilian propolis by the observation of honeybee behavior and phytochemical analysis. <i>Chem Pharm Bull</i> 51:740–742	532 533 534

- 535 Lara ACF, Fernandes GW (1996) The highest diversity of galling insects: Serra do Cipó, Brazil.  
536 Biodivers Letts 3:111–114
- 537 Lawton JH (1983) Plant architecture and the diversity of phytophagous insects. *Annu Rev Entomol*  
538 28:23–29
- 539 Lee JA (1981) Variation in the infection of *Silene dioica* (L.) by *Ustilago violacea* (Pers) in  
540 Northwest England. *New Phytol* 87:81–89
- 541 Madeira BG, Cornelissen TG, Faria ML, Fernandes GW (1997) Insect herbivore preference for sex  
542 and modules in *Baccharis concinna* (Asteraceae). In: Raman A (ed) Ecology and evolution of  
543 plant-feeding insects in natural and man-made environments. International Scientific  
544 Publications, New Delhi, pp 135–145
- 545 Maia VC (2011) Characterization of insect galls, gall makers, and associated fauna of Platô Bacaba  
546 (Porto de Trombetas, Pará, Brazil). *Biota Neotrop* 4. Available online at: [http://www.scielo.br/  
547 scielo.php?pid=S1676-6032011000400003&script=sci\\_arttext](http://www.scielo.br/scielo.php?pid=S1676-6032011000400003&script=sci_arttext). Accessed August 2012
- 548 Mani MS (1964) The ecology of plant galls. Junk, The Hague
- 549 Mani MS (1992) Introduction to cecidology. In: Shorthouse JD, Rohfritsch O (eds) Biology of  
550 insect-induced galls. Oxford University Press, Oxford, pp 3–7
- 551 Manos PS, Doyle JJ, Nixon KC (1999) Phylogeny, biogeography, and processes of molecular  
552 differentiation in *Quercus* subgenus *Quercus* (Fagaceae). *Mol Phylogenet Evol* 12:333–349
- 553 Marquis RJ, Lill JT, Piccini A (2002) Effect of plant architecture on colonization and damage by  
554 leaf-tying caterpillars of *Quercus alba*. *Oikos* 99:531–537
- 555 Nesom G (1988) *Baccharis monoica* (Compositae: Asteraceae), a monoecious species of the  
556 *B. salicifolia* complex from Mexico and Central America. *Phytologia* 65:160–164
- 557 Price PW (1991) The plant vigor hypothesis and herbivore attack. *Oikos* 62:244–251
- 558 Price PW, Craig TP, Roininen H (1995) Working toward theory on galling sawfly population  
559 dynamics. In: Cappuccino N, Price PW (eds) Population dynamics: new approaches and  
560 synthesis. Academic, San Diego, pp 321–338
- 561 Price PW, Fernandes GW, Floate RD (1996) Gall-inducing insect herbivores in multitrophic  
562 systems. In: Gange A, Brown VK (eds) Multitrophic interactions in terrestrial systems.  
563 Blackwell, England, pp 239–255
- 564 Ribeiro-Mendes HN, Marques ESA, Silva IM, Fernandes GW (2002) Influence of host-plant sex  
565 and habitat on survivorship of insect galls within the geographical range of the host plant. *Trop*  
566 *Zool* 15:5–15
- 567 Rohfritsch O (1992) Patterns in gall development. In: Shorthouse JD, Rohfritsch O (eds) Biology  
568 of insect-induced galls. Oxford University Press, Oxford, pp 60–86
- 569 Safford HD (1999) Brazilian páramos I. An introduction to the physical environment and vegetation  
570 of the campos de altitude. *J Biogeogr* 26:693–712
- 571 Santos JC, Almeida-Cortez JS, Fernandes GW (2011) Richness of gall-inducing insects in the  
572 tropical dry forest (Caatinga) of Pernambuco. *Rev Bras Entomol* 55:45–54
- 573 Shorthouse JD, Rohfritsch O (1992) Biology of insect-induced galls. Oxford University, New York
- 574 Steeves TA, Sussex IM (1989) Patterns in plant development. Cambridge University Press,  
575 Cambridge
- 576 Stone GN, Schönrogge K (2003) The adaptive significance of insect gall morphology. *Trends Ecol*  
577 *Evol* 18:512–522
- 578 Stone GN, Schönrogge K, Atkinson RJ, Bellido D, Pujade-Villar J (2002) The population biology  
579 of oak gall wasps (Hymenoptera: Cynipidae). *Annu Rev Entomol* 47:633–668
- 580 Sussex IA, Kerk NM (2001) The evolution of plant architecture. *Curr Opin Plant Biol* 4:33–37
- 581 Teixeira EW, Negri G, Meira RM, Message D, Salatino A (2005) Plant origin of green propolis:  
582 bee behavior, plant anatomy and chemistry. *Evid Based Complement Alternat Med* 2:85–92
- 583 Varga S, Kytöviita MM (2008) Sex-specific responses to mycorrhiza in a dioecious species. *Am J Bot*  
584 95:1225–1232
- 585 Veldtman R, McGeoch MA (2003) Gall-forming insect species richness along a non-scleromorphic  
586 vegetation rainfall gradient in South Africa: the importance of plant community composition.  
587 *Aust Ecol* 28:1–13

Verdi LG, Brighente MC, Pizzolatti MG (2005) Gênero <i>Baccharis</i> (Asteraceae): Aspectos químicos, econômicos biológicos. <i>Quim Nova</i> 28:85–94	588
Waring GL, Price PW (1990) Plant water stress and gall formation (Cecidomyiidae: <i>Asphondylia</i> spp.) on creosote bush. <i>Ecol Entomol</i> 15:87–95	589
Weis AE, Walton R, Greco CL (1988) Reactive plant tissue sites and the population biology of gall makers. <i>Annu Rev Entomol</i> 33:467–486	590
Wollenweber E, Valantvetschera KM, Fernandes GW (2006) Chemodiversity of exudate flavonoids in <i>Baccharis concinna</i> and three further South-American <i>Baccharis</i> species. <i>Nat Prod Commun</i> 1:627–632	591
	592
	593
	594
	595
	596

Uncorrected Proof

# Author Queries

Chapter No.: 13      0002107113

Queries	Details Required	Author's Response
AU1	Please confirm the corresponding author.	
AU2	Please provide keywords.	
AU3	Please check and confirm the term "Atitudinal gradiente" in Table 13.1.	

Uncorrected Proof