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Representativity of the genus *Asphondylia* Loew, 1850 (Diptera, Cecidomyiidae) in Brazil

Ismael Cividini Flor[1,2]
Valéria Cid Maia[1,3]

ABSTRACT

Representativity of the genus Asphondylia *Loew, 1850 (Diptera, Cecidomyiidae) in Brazil. This cosmopolitan genus includes 272 galling species described, of which about 100 occur in the Neotropical Region. The present study goal to evaluate the richness of* Asphondylia *in Brazil, to provide an updated list of the host plant species, to determine the plant organs where galls are induced, to update the geographic distribution of the genus, to verify it distribution in the Brazilian biomes, and to the list the associated fauna. The survey data was carried out by consulting the Cecidomyiidae collection of the Museu Nacional/UFRJ, the database "Web of Science" using* Asphondylia *and Brasil/Brazil as keywords, 51 Brazilian inventories and two catalogues.* Asphondylia *is represented by 58 species in Brazil, among them, twenty are already known and 38 are still undetermined. The Brazilian described species represent 8% of the total of known species of* Asphondylia *in the world and 21% of species of the Neotropical fauna. This genus is associated with 51 plant species and 20 plant families in Brazil. Asteraceae comprise the greatest richness of* Asphondylia *species. This genus was found in five biomes, among them the Atlantic forest has the highest species richness. The associated fauna comprises parasitoids (Hymenoptera) and inquilines (Lepidoptera, Coleoptera and Diptera).*

Key-Words: Gall; Insect-plant interaction; Geographic distribution; Host plant.

INTRODUCTION

Asphondylia Loew, 1850 belongs to the tribe Asphondyliini, currently with 505 described species, subtribe Asphondyliina, which is the most diverse in the Neotropics (Gagné & Jaschhof, 2014). This cosmopolitan genus includes 272 described galling species, of which about 100 occur in the Neotropical Region (Gagné, 2004). Carneiro *et al.,* (2009a) reports the importance of genera as one of the dominant among galling found in Brazil, represented by 20 species. *Asphondylia* species have been recorded on 66 plant families in the world, being most frequent on Asteraceae, Fabaceae and Chenopodiaceae (Maia *et al.,* 2009).

The genus is morphologically characterized by a needlelike ovipositor, two-toothed gonostylus, three-segmented palpi and presence of upper and lower horns on the pupal frons (Gagné, 1994; Maia *et al.,* 2009). *Asphondylia* taxonomy is challenging because

[1.] Universidade Federal do Rio de Janeiro (UFRJ), Museu Nacional (MNRJ), Departamento de Entomologia, Laboratório de Diptera. Quinta da Boa Vista, São Cristóvão, CEP 20940-040, Rio de Janeiro, RJ, Brazil.
[2.] ORCID: 0000-0002-5173-4210. E-mail: ismaelcflor@gmail.com
[3.] ORCID: 0000-0001-9396-5618. E-mail: maiavcid@acd.ufrj.br
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adult morphology differs little among species. All species share the neckless, cylindrical antennal flagellomeres in both sexes, the needle-like ovipositor and conspicuously enlarged seventh sternite in the female, and the compact male genitalia with the spherical gonostyli positioned dorsally rather than apically (Gagné, 1994; Dorchin *et al.,* 2015). The third-instar larvae possess a well-developed, usually four-toothed spatula on the first thoracic segment. The pupation in all *Asphondylia* species takes place inside the gall rather than in the soil (Gagné, 1989, 1994). The pupae are characterized by well-developed horn-like antennal bases, a varying number of facial horns, and transverse dorsal rows of spines on the abdominal segments (Gagné, 1989, 1994) that assist in breaking out of the galls just before adults' emergence.

Constant assessment of biodiversity knowledge is essential to guide future efforts inventories in poorly studied areas, so that they can conserve endangered species (Toma & Maia, 2012). Moreover, considering the great diversity in the Neotropics, little is known about the fauna of Cecidomyiidae in this region, especially compared to other parts of the world, getting to be around six times smaller than the Palaearctic fauna (Gagné, 2007; Toma & Maia, 2012).

The present study goal to evaluate the richness of *Asphondylia* in Brazil, to determine the plant organs where galls are induced, to give an updated list of the host plant species, highlighting the their endemism and categories of conservational status, as well as to verify the species richness in each Brazilian biome, to update the geographic distribution of the genus and the respective associated fauna.

MATERIAL AND METHODS

The survey data on the species of *Asphondylia* was carried out by consulting the collection of Cecidomyiidae the Museu Nacional/UFRJ (the only reference collection to the family in Brazil) and, concomitantly, a literature review was performed on the database "Web of Science" using *Asphondylia* and Brasil/Brazil as keywords. Furthermore, the catalog of Cecidomyiidae of the world (Gagné & Jaschhof, 2014) was used to check all described Brazilian *Asphondylia* species until 2014. Besides, all insect galls Brazilian inventories were examined, as well as the catalog of galls of the Central and South Americas (Houard, 1933), which comprises data on Brazilian galls.

Literature data were compiled from six papers retrieved from the Web of Science (Carneiro *et al.,* 2009a; Maia, 2013a; Maia *et al.,* 2009; Maia *et al.,* 2008b; Maia & Fernandes, 2005; Gagné *et al.,* 2001), 51 Brazilian gall inventories (Almada & Fernandes, 2011; Araújo *et al.,* 2011; Araújo *et al.,* 2014; Bregonci *et al.,* 2010; Carneiro *et al.,* 2009b; Coelho *et al.,* 2009; Coelho *et al.,* 2013a; Coelho *et al.,* 2013b; Costa *et al.,* 2014; Dreger-Jauffret & Shorthouse, 1992; Fernandes & Negreiros, 2006; Fernandes *et al.,* 1988; Fernandes *et al.,* 1997; Fernandes *et al.,* 2001; Gagné *et al.,* 2001; Gagné, 1994; Gagné, 2004; Gonçalves-Alvim & Fernandes, 2001; Julião *et al.,* 2002; Maia & Carvalho, 2016; Maia & Fernandes, 2004; Maia & Fernandes, 2005; Maia & Oliveira, 2010; Maia & Souza, 2013; Maia *et al.,* 1992; Maia *et al.,* 2008a; Maia *et al.,* 2009; Maia *et al.,* 2014; Maia, 2001; Maia, 2004; Maia, 2011; Maia, 2013b; Maia, 2014; Mendonça *et al.,* 2014; Oliveira & Maia, 2005; Pamplona *et al.,* 2000; Rodrigues *et al.,* 2014; Rübsaamen, 1907; Rübsaamen, 1916; Saito & Urso-Guimarães, 2012; Santos *et al.,* 2010; Santos *et al.,* 2011a; Santos *et al.,* 2011b; Tavares, 1909; Tavares, 1916; Tavares, 1917; Tavares, 1918; Toma & Mendonça, 2013; Urso-Guimarães & Amorim 2002; Urso-Guimarães & Scareli-Santos, 2006; Urso-Guimarães *et al.,* 2003), and two catalogues (Houard, 1933; Gagné & Jaschhof, 2014).

Information about the host plant (botanical species and family), galled plant organs, shape and type of gall, and geographical distribution for each species were provided, whenever possible. Biomes were defined from the collection locations. Data on origin and categories of the conservational status of the host plants were found in the Lista da Flora do Brasil 2016 website (Flora do Brasil, 2020).

According to Carneiro *et al.,* (2009a) the gall morphology associated with the identification of host-plant species is a reliable richness indicator of the gall-inducing insects. About 95% of described species of cecidomyiids from Brazil can be identified based on these two data together (Coelho *et al.,* 2013a). In the present study, we adopted both information to evaluate the richness of the genus *Asphondylia.*

Considering the high host specificity of the gall midges, the undetermined species probably belong to new species, as they are associated with new records of plants. Based on this specificity, we included also the undetermined species of *Asphondylia* in the following discussion (Maia & Silva, 2013).

RESULTS

Asphondylia is represented by 58 species in Brazil (21 from the papers retrieved from the Web of Sci-

TABLE 1: Distribution of the number of *Asphondylia* species (Diptera, Cecidomyiidae) per host plant families and species with information on their origin in Brazil. Note: Three botanical names were updated: *Vanillosmopsis erythropappa* (DC.) Sch. Bip. was replaced by *Eremanthus polycephalus* (DC.) MacLeish (Asteraceae), and *Cordia curassavica* Jacq. and *Cordia verbenacea* DC. were replaced by *Varronia curassavica* Jacq. (Boraginaceae).

Family	Host plants	Origin of host plants			Number of *Asphondylia* species
		Endemic	Native	Exotic	
Apocynaceae	*Oxypetalum banksii* R.Br. ex Schult.	x			1
	Peplonia asteria (Vell.) Fontella & E.A. Schwarz	x			1
	Total				**2**
Araliaceae	*Didymopanax morototoni* (Aubl.) Decne. & Planch.		x		1
	Total				**1**
Asteraceae	*Baccharis anomala* DC.	x			1
	Baccharis conyzoides (Less.) DC.	x			1
	Baccharis concinna G.M. Barroso	x			1
	Baccharis dracunculifolia DC.		x		1
	Baccharis pseudomyriocephala Malag.	x			1
	Calea pinnatifida (R.Br.) Less.		x		1
	Calea serrata Less.	x			2
	Eremanthus polycephalus (DC.) MacLeish	x			1
	Gochnatia polymorpha (Less.) Cabrera		x		1
	Mikania glomerata Spreng.		x		2
	Mikania sp.1		x		1
	Mikania sp.2		x		1
	Mikania sp.3		x		1
	Mikania sp.4		x		1
	Pentacalia desiderabilis (Vell.) Cuatrec.	x			1
	Piptocarpha cf. *cinerea* (Sch. Bip.) Baker	x			1
	Piptocarpha notata (Less.) Baker	x			1
	Porophyllum ruderale (Jacq.) Cass.		x		1
	Vernonia discolor (Spreng.) Less.		x		1
	Vernonia rufogrisea Saint-Hilaire		x		1
	Not determined				1
	Total				**23**
Bignoniaceae	*Zeyheria montana* Mart.	x			1
	Total				**1**
Boraginaceae	*Varronia curassavica* Jacq.		x		1
	Tournefortia membranacea (Gardner) DC.		x		1
	Tournefortia sp.		x		1
	Total				**3**
Burseraceae	*Protium ovatum* Engl.	x			1
	Total				**1**
Dilleniaceae	*Davilla brasiliana* DC.		x		1
	Total				**1**

ence, 38 from Brazilian gall inventories, 10 exclusively from Gagné & Jaschhof, 2014, 9 exclusively from the MNRJ, and 47 simultaneously from the MNRJ and literature). The MNRJ comprehended data on 11 determined and 36 undetermined species, all mounted on slide. The later comprised 14 new records. Among them, 20 are known and 38 are still undetermined. The last ones comprise 15 species found in the MNRJ and 23 retrieved from the literature (Maia, 2013a; Maia & Fernandes, 2004; Maia & Souza, 2013; Maia *et al.,* 2008a; Maia *et al.,* 2014; Mendonça *et al.,* 2014; Pamplona *et al.,* 2000; Rodrigues *et al.,* 2014; Urso-Guimarães & Scareli-Santos, 2006.) The described species represent 8% of the known species of *Asphondylia* in the world and 21% of Neotropical species.

Asphondylia is associated with 51 plant species and 20 plant families in Brazil. Asteraceae comprise the greatest richness of *Asphondylia* species (n = 23). Data on other families are shown in Table 1. *Baccharis* L. and *Mikania* Willd. (Asteraceae) were the plant genera that host the greatest number of *Asphondylia* species, both with five. *Mikania glomerata* (Asteraceae) was the unique plant species that comprised more than one species of *Asphondylia.*

TABLE 1: Continued.

Family	Host plants	Origin of host plants			Number of *Asphondylia* species
		Endemic	Native	Exotic	
Erythroxylaceae	*Erythroxylum ovalifolium* Peyr.	x			1
	Total				**1**
Euphorbiaceae	*Croton* sp.		x		1
	Total				**1**
Fabaceae	*Andira fraxinifolia* Benth.	x			1
	Bauhinia brevipes Vogel		x		1
	Bauhinia cheilantha (Bong.) Steud.		x		1
	Senna bicapsularis (L.) Roxb.			x	1
	Total				**4**
Lamiaceae	*Hyptis* sp.		x		1
	Total				**1**
Loranthaceae	*Struthanthus maricensis* Rizzini	x			1
	Struthanthus sp.		x		1
	Total				**2**
Myrtaceae	*Eugenia bimarginata* DC.		x		1
	Total				**1**
Olacaceae	*Ximenia americana* L.		x		1
	Total				**1**
Onagraceae	*Jussiaea* sp.		x		1
	Total				**1**
Rubiaceae	*Borreria verticillata* (L.) G. Mey.		x		1
	Psychotria carthagenensis Jacq.	x			1
	Psychotria vellosiana Benth.		x		1
	Not determined				1
	Not determined				1
	Total				**5**
Smilacaceae	*Smilax* sp.		x		1
	Total				**1**
Solanaceae	*Aureliana fasciculata* (Vell.) Sendtn.		x		1
	Solanum sp.1		x		1
	Solanum sp.2		x		1
	Solanum sp.3		x		1
	Total				**4**
Styracaceae	*Styrax leprosus* Hook. & Arn.		x		1
	Total				**1**
Verbenaceae	*Lantana lilacina* Desf.		x		1
	Total				**1**
	Not determined				1
	Not determined				1
	Total				**2**

Seventeen species of host plants are endemic in Brazil, thirty four are native, and one is exotic. The endemic plants host *Asphondylia maricensis* Maia & Couri, 1992, *A. peploniae* Maia, 2001, *A. serrata* Maia, 2004, and 13 undetermined species. Concerning the conservational status, *Baccharis concinna* was the single species categorized as a vulnerable, seven were categorized as less concerning (*C. serrata, G. polymorpha, M. glomerata, P.* cf. *cinerea, P. notata, Z. montana, A. fasciculata*), and the remaining have not been yet evaluated for threat of extinction. *Baccharis concinna* host a single species of *Asphondylia,*

TABLE 2: Distribution of the number of *Asphondylia* species (Diptera, Cecidomyiidae) per plant organs in Brazil.

Plant organ	Number of *Asphondylia* species	%
Leaves	14	24
Stems	13	22
Flower buds	6	11
Buds	4	7
Flower	3	5
Fruit	3	5
Inflorescence	2	3
Leaves and stem	1	2
No data	12	21

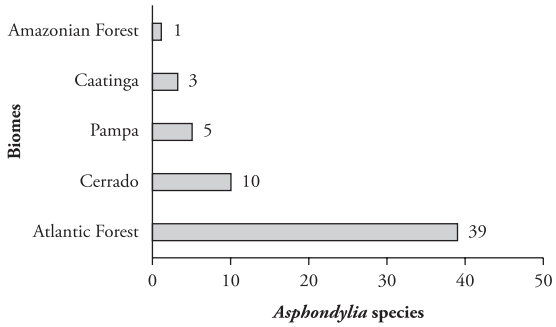

FIGURE 1: Distribution of the number of *Asphondylia* species (Diptera, Cecidomyiidae) per Brazilian biomes.

whereas the less concerning plants host nine species and the others 48.

The galls of *Asphondylia* were found on leaves, stems, flower buds, buds, flowers, fruits, inflorescences and simultaneously on leaves/stems. Leaves comprised the greatest richness of *Asphondylia* species (n = 14) (Table 2). Many gall shapes were found: globose, ovoid, rosette, spherical, elliptic, swollen, cylindrical, conical, drop-shaped, amorphous, aggregate and fusiform (the terminology used by each author was repeated in the present work). The majority of the analyzed morphotypes were glabrous and one-chambered. There was an evident predominance of green (n = 18) galls, the color of the most galled plant organ (leaf). But, yellow, brown, black and cream galls were also found (again, we repeat the color information given by each author) (Table 3).

The genus was found in five biomes, Atlantic forest, Cerrado, Caatinga, Pampa, and Amazonian forest (Fig. 1). The gall midges were found mainly in restingas (18 spp.), the most surveyed physiognomy of the Atlantic forest. As the restingas comprise several multivoltine gall midges, specimens are more easily

FIGURE 2: Distribution of the number of *Asphondylia* species (Diptera, Cecidomyiidae) per Brazilian states. Legends: AC: Acre; AM: Amazonas; AP: Amapá; MA: Maranhão; AL: Alagoas; BA: Bahia; CE: Ceará; PB: Paraíba; TO: Tocantins; PA: Pará; RO: Roraima; PE: Pernambuco; PI: Piauí; RN: Rio Grande do Norte; SE: Sergipe; DF: Distrito Federal; GO: Goiás; MT: Mato Grosso; MS: Mato Grosso do Sul; ES: Espirito Santo; MG: Minas Gerais; RJ: Rio de Janeiro; SP: São Paulo; PR: Paraná; SC: Santa Catarina and RS: Rio Grande do Sul.

TABLE 3: Host plants, gall characterization and geographic distribution of *Asphondylia* species (Diptera Cecidomyiidae) in Brazil (AF: Atlantic Forest). Note: Three botanical names were updated. *Cordia curassavica* and *Cordia verbenacea* were replaced by *Varronia curassavica* (Boraginaceae) and *Vanillosmopsis erythropappa* by *Eremanthus polycephalus* (Asteraceae).

***Asphondylia* species**	**Host plant**	**Plant organ**	**Gall**	**Biome**	**State**	**Reference**
Asphondylia bahiensis Tavares, 1917	Rubiaceae	Flower bud	Spherical and hairy	AF	BA	Tavares, 1917; Houard, 1933; Gagné, 1994, 2004.
Asphondylia borreriae Rübsaamen, 1905	*Borreria verticillata*	Inflorescence	Fusiform, green, glabrous and one-chambered	AF (restinga)	RJ	Gagné, 1994
Asphondylia canastrae Urso-Guimarães & Amorim, 2002	*Hyptis* sp.	Flower	Spherical	Cerrado	SP	Urso-Guimarães & Amorim, 2002; Gagné, 2004.
Asphondylia communis Maia & Couri, 1992	*Ximenia americana*	Stem	Ovoid, brown, glabrous and one-chambered	AF (restinga)	RJ	Maia *et al.,* 1992; Maia, 2001; Gagné, 2004.
Asphondylia cfr. *cordiae* Möhn, 1959	*Varronia curassavica*	Inflorescence	Ovoid, green/yellow, hairy and one-chambered	AF (restinga)	RJ/SP	Gagné, 1994; Maia *et al.,* 2008a.
Asphondylia fructicola Maia, 2009	*Solanum* sp.1	Fruit	Spherical and green	Amazonia	PA	Maia *et al.,* 2009.
Asphondylia glomeratae Gagné, 2001	*Mikania glomerata*	Leaf	Fusiform, green and glabrous	AF (restinga)	SP/RJ	Gagné *et al.,* 2001; Gagné, 2004.
Asphondylia gochnatiae Maia, 2008	*Gochnatia polymorpha*	Leaf	Spherical and yellow	Cerrado	MG	Gagné, 1994; Maia *et al.,* 2008b.
Asphondylia maricensis Maia & Couri, 1992	*Struthanthus maricensis*	Leaf/Stem	Ovoid, green, glabrous and one-chambered	AF (restinga)	RJ	Maia *et al.,* 1992; Gagné, 2004.
Asphondylia microcapillata Maia, 2005	*Bauhinia brevipes*	Leaf	Spherical and green	Cerrado	MG	Maia & Fernandes, 2005.
Asphondylia moehni Skuhravá, 1989	*Mikania glomerata*	Stem	Fusiform and one-chambered	AF/Pampa	RJ/RS/SP	Gagné, 1994
Asphondylia parva Tavares, 1917	Rubiaceae	Flower	Elliptic and green	AF	BA	Tavares, 1917; Gagné, 1994, 2004.
Asphondylia peploniae Maia, 2001	*Oxypetalum banksii*	Flower bud		AF (restinga)	RJ	Maia, 2001; Gagné, 2004.
	Peplonia asteria	Flower bud	Ovoid, green, glabrous and one-chambered	AF (restinga)	RJ	
Asphondylia rochae Tavares, 1918	*Jussiaea* sp.	Stem	Elliptic	Caatinga	CE	Tavares, 1918; Houard, 1933; Gagné, 1994, 2004.
Asphondylia sanctipetri Urso-Guimarães & Amorim, 2002	*Didymopanax morototoni*	Leaf	Swollen and green	Cerrado	SP	Urso-Guimarães & Amorim, 2002.
Asphondylia sennae Maia & Couri, 1992	*Senna bicapsularis*	Flower	Spherical and yellow	AF (restinga)	RJ	Maia *et al.,* 1992; Gagné, 2004.
Asphondylia serrata Maia, 2004	*Emeranthus polycephalus*	Leaf	Ovoid, yellow and glabrous	AF	MG	Maia, 2004; Maia & Fernandes, 2004.
Asphondylia struthanthi Rübsaamen, 1916	*Struthanthus* sp.	Fruit	Globose	Caatinga	CE	Rübsaamen, 1916; Gagné, 1994, 2004.
Asphondylia sulphurea Tavares, 1909	*Smilax* sp.	Leaf	Elliptic and green		RS	Tavares, 1909; Gagné, 1994, 2004.
Asphondylia ulei Rübsaamen, 1907	*Mikania* sp.1	Leaf	Spherical and green	AF	RJ	Rübsaamen, 1907; Gagné, 1994, 2004.
Asphondylia sp.1	*Andira fraxinifolia*	Leaf	Globose	AF (restinga)	SP	Maia *et al.,* 2008a.
Asphondylia sp.2	*Aureliana fasciculata*	Stem	Fusiform	AF (restinga)	SP	Maia *et al.,* 2008a.
Asphondylia sp.3	*Baccharis anomala*	Stem	Fusiform, green	Pampa		Mendonça *et al.,* 2014.
Asphondylia sp.4	*Baccharis conyzoides*	Leaf	Black	AF (restinga)	SP	Maia *et al.,* 2008a.
Asphondylia sp.5	*Baccharis concinna*			Cerrado	MG	
Asphondylia sp.6	*Baccharis dracunculifolia*			Cerrado	MG	

Asphondylia species	Host plant	Plant organ	Gall	Biome	State	Reference
Asphondylia sp.7	*Baccharis pseudomyriocephala*			Cerrado	MG	
Asphondylia sp.8	*Bauhinia cheilantha*			Caatinga	SE	
Asphondylia sp.9	*Calea pinnatifida*	Stem	Spherical	AF	RS	Mendonça *et al.,* 2014.
Asphondylia sp.10	*Calea serrata*	Stem	Drop-shaped, green	Pampa	RS	Mendonça *et al.,* 2014.
Asphondylia sp.11	*Calea serrata*	Stem	Fusiform, green	Pampa		Mendonça *et al.,* 2014.
Asphondylia sp.12	*Croton* sp.	Bud		AF (restinga)	SP	
Asphondylia sp.13	*Davilla brasiliana*	Bud	Rosette	AF	MG	Maia & Fernandes, 2004.
Asphondylia sp.14	*Erythroxylum ovalifolium*	Flower bud	Ovoid, green, glabrous and one-chambered	AF (restinga)	RJ	Maia, 2001.
Asphondylia sp.15	*Eugenia bimarginata*	Leaf	Cylindrical, cream and one-chambered	Cerrado	SP	Urso-Guimarães & Scareli-Santos, 2006.
Asphondylia sp.16	*Lantana lilacina*	Leaf	Globose, green, hairy, one-chambered	AF (restinga)	RJ	Rodrigues *et al.,* 2014.
Asphondylia sp.17	*Mikania* sp.2	Bud		AF	ES	Maia *et al.,* 2014.
Asphondylia sp.18	*Mikania* sp.3			AF	ES	Maia *et al.,* 2014.
Asphondylia sp.19	*Mikania* sp.4	Stem	Fusiform	AF	ES	Maia *et al.,* 2014.
Asphondylia sp.20	*Pentacalia desiderabilis*	Bud	Conical and green	AF	RS	
Asphondylia sp.21	*Piptocarpha* cf. *cinerea*	Leaf	Globose	AF (restinga)	SP	Maia *et al.,* 2008a.
Asphondylia sp.22	*Piptocarpha* cf. *cinerea*	Stem	Fusiform	AF (restinga)	SP	Maia *et al.,* 2008a.
Asphondylia sp.23	*Piptocarpha notata*			AF	RS	
Asphondylia sp.24	*Porophyllum ruderale*	Flower bud		AF	RJ	Pamplona *et al.,* 2000.
Asphondylia sp.25	*Protium ovatum*			Cerrado	MG	
Asphondylia sp.26	*Psychotria carthagenensis*	Bud	Aggregate	AF	ES/SP	Maia *et al.,* 2014.
Asphondylia sp.27	*Psychotria vellosiana*	Leaf	Globose	AF	ES	Maia *et al.,* 2014.
Asphondylia sp.28	*Solanum* sp.2		Globose and hairy	AF	MG	Maia, 2013a.
Asphondylia sp.29	*Solanum* sp.3	Stem	Amorphous	AF	RS	
Asphondylia sp.30	*Styrax leprosus*			Pampa	RS	
Asphondylia sp.31	*Tournefortia membranacea*	Flower bud	Globose, green and glabrous	AF	RJ	Maia & Souza, 2013.
Asphondylia sp.32	*Vernonia discolor*	Stem	Spherical	AF	RS	
Asphondylia sp.33	*Vernonia rufogrisea*	Stem	Globose, yellow, glabrous and multi-chambered	AF (restinga)	RJ	Rodrigues *et al.,* 2014.
Asphondylia sp.34	*Zeyheria montana*			Cerrado	MG	
Asphondylia sp.35	Asteraceae		Globose	AF	MG	Maia, 2013a.
Asphondylia sp.36	*Tournefortia* sp.	Fruit	Globose, green, glabrous and multi-chambered	AF (restinga)	RJ	Rodrigues *et al.,* 2014.
Asphondylia sp.37	No data		Globose	AF	ES	
Asphondylia sp.38	No data	Leaf	Fusiform	AF	ES	

obtained. The Cerrado was second biome in richness of species, followed by Pampa, Caatinga and Amazonian Forest, with 10, 5, 3 and 1 species, respectively.

All species were found in a single biome, excepting *Asphondylia moehni* Skuhravá, 1989, with occurrence in the Pampa and Atlantic forest. The species were collected in Para (PA), Sergipe (SE), Ceará (CE), Pernambuco (PE), Bahia (BA), Espírito Santo (ES), Minas Gerais (MG), Rio de Janeiro (RJ), São Paulo (SP), and Rio Grande do Sul (RS) (Fig. 2). The majority of the species were found in RJ, SP, MG, and RS, the best surveyed states. The other states have been less surveyed. All species were recorded in a single Brazilian state, with four exception, *A. moehni* (in RJ, SP and RS), *A. glomerata* (in RJ and SP) *A.* cfr. *cordiae* (in RJ and SP) and *Asphondylia* sp. (in ES and SP) (Table 3).

TABLE 4: Species of host plants, their distribution in Brazil and the galling species distribution.

Host plant species	Distribution in Brazil	Galling species distribution
Andira fraxinifolia	AL, BA, CE, PB, PE, PI, RN, SE, DF, GO, MS, ES, MG, RJ, SP, PR, SC and RS	SP, ES
Aureliana fasciculata	AC, PA, AL, BA, PE, ES, MG, RJ, SP, PR, SC and RS	SP
Baccharis anomala	MG, SP, PR, SC and RS	RS
Baccharis concinna	MG	MG
Baccharis conyzoides	All states	SP
Baccharis dracunculifolia	Cerrado, Atlantic Forest and Pampa	MG
Baccharis pseudomyriocephala	MG, RJ, SP and PR	MG
Bauhinia brevipes	All states	MG
Bauhinia cheilantha	AL, BA, CE, MA, PB, PE, PI, RN, SE, MS, MT, MG and SP	SE
Borreria verticillata	All states	RJ
Calea pinnatifida	DF, ES, MG, RJ, SP, PR, SC and RS	RS
Calea serrata	DF, MG and SP	RS
Davilla brasiliana	PA, BA, MG, RJ, SP, PR, SC and RS	MG
Didymopanax morototoni	All states less SC and RS	SP
Emeranthus polycephalus	DF, GO, ES, MG, RJ and SP	MG
Erythroxylum ovalifolium	RJ	RJ
Eugenia bimarginata	BA, GO, MS, MT, MG, SP and PR	SP
Gochnatia polymorpha	BA, GO, MS, MG, RJ, SP, PR, SC and RS	MG
Lantana lilacina	AL, BA, CE, MA, PB, PE, PI, GO, MS, SC and RS	RJ
Mikania glomerata	BA, ES, MG, RJ, SP, PR, SC and RS	SP, RJ, RS
Oxypetalum banksii	BA, SE, ES, MG, RJ, SP, PR, SC and RS	RJ
Pentacalia desiderabilis	BA, ES, MG, RJ, SP, PR, SC and RS	RS
Peplonia asteria	BA, ES and RJ	RJ
Piptocarpha cf. *cinerea*	ES, MG, RJ and SP	SP
Piptocarpha notata	ES, MG, RJ and SP	RS
Porophyllum ruderale	AC, AM, AP, PA, RO, BA, CE, PE, RN, DF, GO, MS, MT, ES, MG, RJ, SP, PR, SC and RS	RJ
Protium ovatum	RO, TO, BA, DF, GO, MT, MG and SP	MG
Psychotria carthagenensis	All states less RN	ES, SP
Psychotria vellosiana	BA, PE, DF, GO, ES, MG, RJ, SP, PR and SC	ES
Senna bicapsularis	Exotic	RJ
Struthanthus maricensis	RJ	RJ
Styrax leprosus	MG, RJ, SP, PR, SC and RS	RS
Tournefortia membranacea	BA, CE, PE, ES, MG, RJ, SP, PR, SC and RS	RJ
Varronia curassavica	AM, AP, PA, TO, AL, BA, CE, PB, PE, PI, SE, GO, MS, MG, RJ, SP, PR, SC and RS RJ, SP	
Vernonia discolor	BA, DF, ES, MG, RJ, SP, PR, SC and RS	RS
Vernonia rufogrisea	BA, DF, GO, MT and MG	RJ
Ximenia americana	All states less AM, RR, AP and RS	RJ
Zeyheria montana	PA, TO, BA, MA, PI, DF, GO, MS, MT, MG, SP and PR	MG

AC: Acre; AM: Amazonas; AP: Amapá; MA: Maranhão; AL: Alagoas; BA: Bahia; CE: Ceará; PB: Paraíba; TO: Tocantins; PA: Pará; RO: Roraima; PE: Pernambuco; PI: Piauí; RN: Rio Grande do Norte; SE: Sergipe; DF: Distrito Federal; GO: Goiás; MT: Mato Grosso; MS: Mato Grosso do Sul; ES: Espirito Santo; MG: Minas Gerais; RJ: Rio de Janeiro; SP: São Paulo; PR: Paraná; SC: Santa Catarina and RS: Rio Grande do Sul.

TABLE 5: Brazilian species of *Asphondylia* (Diptera, Cecidomyiidae) and described life cycle phases. The letter "x" indicates known phase.

Asphondylia species	Life cycle stages			
	Larva	Pupa	Adult	
			Male	Female
Asphondylia bahiensis		x	x	x
A. borreriae	x			x
A. canastrae	x	x	x	x
A. communis	x		x	
A. cordiae		x		x
A. fructicola			x	
A. glomeratae		x	x	x
A. gochnatiae			x	
A. maricensis	x		x	x
A. microcapillata			x	
A. moehni	x	x	x	x
A. parva		x	x	x
A. peploniae	x	x	x	x
A. rochae		x	x	x
A. sanctipetri	x	x	x	x
A. sennae				x
A. serrata			x	
A. struthanthi			x	
A. sulphurea			x	
A. ulei	x			

As the geographical distribution of all host plant species is wider than that of the galler (Table 4), we expect that researches in less sampled states can result in an expansion of the galling species distribution.

Only five species from Brazil are known in the larval stage, pupa and adult of both sexes (Table 5). *Asphondylia ulei,* characterized only in the larval stage, is the described species that most lacks morphological information. The number of undescribed species to Brazil indicates that *Asphondylia* is more diverse than it seems.

The associated arthropod fauna comprises parasitoids and inquilines. The former are represented by three families of Hymenoptera: Eurytomidae, Braconidae and Pteromalidae, and the later by three insects orders: Lepidoptera, Coleoptera and Diptera. The beetles are represented by a single family, Curculionidae, whereas the flies are represented by three, Tephritidae, Sciaridae and Cecidomyiidae (Table 6). The taxonomical knowledge of the associated fauna is superficial, with most records at order or family level and only two in genus level.

Nine species of *Asphondylia* were attacked by Hymenoptera, the most important natural enemy of these midges in the world (Gagné, 1994). In Brazil, Eurytomidae and Pteromalidae are very frequent parasitoids in Cecidomyiidae galls; while Braconidae are less common (Maia & Azevedo, 2009). Five species of *Asphondylia* induce galls which are invaded by inquilines. Lepidoptera, Curculionidae, Tephritidae, Sciaridae, and Cecidomyiidae are frequent inquilines of Cecidomyiidae galls in Brazil.

DISCUSSION

This genus is one of the most frequent in Brazil, represented by 20 described species (Carneiro *et al.,* 2009a). All determined species reported in the present study were cited by Carneiro *et al.,* (2009a), except *Asphondylia gochnatiae* Maia, 2008.

According to Maia *et al.* (2009), *Asphondylia* is associated with 66 plant families in the world, being more frequent on Asteraceae, Fabaceae and Chenopodiaceae. In the present study, Asteraceae are also pointed out as an important host plant family, but this is not the case of Fabaceae and Chenopodiaceae. Another difference is the indication of Rubiaceae as an important host family.

Eighteen *Asphondylia* species are associated with these endemic hosts. Among them, three are identified at species level, *Asphondylia maricensis,*

TABLE 6: *Asphondylia* species (Diptera, Cecidomyiidae) and associated fauna in Brazil.

Galling species	Associated fauna	
	Parasitoid	Inquiline
Asphondylia cfr. *cordiae*	Hymenoptera	
A. moehni	Eurytomidae	
A. serrata	Hymenoptera	Diptera: Tephritidae
Asphondylia sp.1		Coleoptera: Curculionidae
Asphondylia sp.13	Hymenoptera	
Asphondylia sp.16	Hymenoptera	
Asphondylia sp.22	Eurytomidae, Braconidae and Pteromalidae	Lepidoptera and Coleoptera: Curculionidae
Asphondylia sp.24		Diptera: Tephritidae (*Trypanea* sp.)
Asphondylia sp.31	Hymenoptera	
Asphondylia sp.33	Hymenoptera	Diptera: Sciaridae and Cecidomyiidae (*Resseliella* sp.)
Asphondylia sp.36	Hymenoptera	

A. peploniae and *A. serrata.* As they induce gall exclusively on endemic plants, they are proposed here as endemic too. The other 15 species, although still undetermined, probably are endemic based on the high specificity between the gallers and the host plants, but more comparative morphological studies among them are necessary before proposing it. Unfortunately, the available material is not enough, as the species are represented by different life cycle stages.

Baccharis concinna was categorized as a vulnerable species, so the undetermined galler which is associated with this host can be also vulnerable, if it occurs exclusively on it. It is important to highlight this situation, where a probably new species can be considered vulnerable. So, it can become extinct before being formally described, implying silent extinction.

The highest incidence of galling species on leaves confirmed the global pattern pointed out by Felt (1940), probably because the leaves represent an abundant and frequent resource (Maia *et al.,* 2008a).

The highest number of species (39 spp.) was recorded in the Atlantic forest, what corresponds to about 67% of the total, but this result does not necessarily indicate that the Atlantic forest comprises the greatest richness of *Asphondylia* species, as the highest number of inventories developed by taxonomists was carried out in this biome. In addition to that, there are more available specimens of the Atlantic forest for identification.

In spite of being one of the most surveyed biomes, the Cerrado comprises only 10 *Asphondylia* species. This can be explained by the low number of available specimens for identification. Differing from the multivoltine species of the restingas, the gall midges of the Cerrado are generally univoltine, with longer life cycles and consequently lower success of rearing. The other biomes have been little studied.

Considering all species (58 spp.), the genus in Brazil is quite representative of the Neotropical fauna, although the morphological knowledge of many species is partial due to the lack of knowledge of the life cycle phases or both sexes. The species described in the larval stage, pupal and adult male and female correspond to the more recently described, and indicate the current tendency to describe a new taxon only when all stages are shown (except egg, which contributes little to the taxonomy).

The records of inquilines exemplify some ecological interactions between *Asphondylia* species and other insects and suggest the role of these gall midges as ecosystem engineers. The importance of the parasitoid wasps as natural enemies of the cecidomyiids are confirmed. These can be evaluated as more data on the associated fauna are known.

CONCLUSIONS

The taxonomical knowledge of the Brazilian species of *Asphondylia* is still incipient. *Asphondylia maricensis, A. peploniae* and *A. serrata* are endemic based on their occurrence exclusively on endemic host plants. Asteraceae is confirmed as the botanical family which hosts the greatest richness of *Asphondylia* species. The geographic distribution of the Brazilian *Asphondylia* species is poorly known. The genus exhibits genetic plasticity to different environmental conditions, as it has been recorded in five Brazilian biomes. The associated fauna is little studied.

RESUMO

Representatividade do gênero Asphondylia *Loew, 1850 (Diptera, Cecidomyiidae) no Brasil. Este gênero cosmopolita inclui 272 espécies galhadoras descritas, das quais cerca de 100 ocorrem na Região Neotropical. O objetivo deste estudo foi avaliar a riqueza de* Asphondylia *no Brasil, fornecer uma lista atualizada das espécies de plantas hospedeiras, determinar os órgãos das plantas onde as galhas são induzidas, atualizar a distribuição geográfica do gênero, verificar sua distribuição nos biomas do Brasil e uma lista da fauna associada. Os dados da pesquisa foram realizados consultando a coleção de Cecidomyiidae do Museu Nacional/UFRJ, a base de dados "Web of Science", utilizando as palavras* Asphondylia *e Brasil/Brazil, 51 inventários brasileiros e dois catálogos.* Asphondylia *é representada por 58 espécies no Brasil, entre elas, 20 são já conhecidas e 38 ainda são indeterminadas. As espécies descritas no Brasil representam 8% do total de espécies conhecidas de* Asphondylia *no mundo e 21% das espécies da fauna Neotropical. Este gênero está associado a 51 espécies de plantas e 20 famílias de plantas no Brasil. As Asteraceae hospedam a maior riqueza de espécies de* Asphondylia. *Este gênero foi encontrado em cinco biomas, entre eles a Mata Atlântica obteve a maior riqueza de espécies. A fauna associada compreende parasitóides (Hymenoptera) e inquilinos (Lepidoptera, Coleoptera e Diptera).*

Palavras-Chave: Galhas; Interação inseto-planta; Distribuição geográfica; Planta hospedeira.

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