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## REPRESENTATIVITY OF THE GENUS *ASPHONDYLIA* LOEW, 1850 (DIPTERA, CECIDOMYIIDAE) IN BRAZIL

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### 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 its 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 inquiline (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 domi-

nant 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

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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 Palaeartic 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 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 Brazil/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; Rübbsaamen, 1907; Rübbsaamen, 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 <i>Asphondylia</i> species
		Endemic	Native	Exotic	
Apocynaceae	<i>Oxypetalum banksii</i> R.Br. ex Schult.	x			1
	<i>Peplonia asteria</i> (Vell.) Fontella & E.A. Schwarz	x			1
	<b>Total</b>				<b>2</b>
Araliaceae	<i>Didymopanax morototoni</i> (Aubl.) Decne. & Planch.		x		1
	<b>Total</b>				<b>1</b>
Asteraceae	<i>Baccharis anomala</i> DC.	x			1
	<i>Baccharis conyzoides</i> (Less.) DC.	x			1
	<i>Baccharis concinna</i> G.M. Barroso	x			1
	<i>Baccharis dracunculifolia</i> DC.		x		1
	<i>Baccharis pseudomyriocephala</i> Malag.	x			1
	<i>Calea pinnatifida</i> (R.Br.) Less.		x		1
	<i>Calea serrata</i> Less.	x			2
	<i>Eremanthus polycephalus</i> (DC.) MacLeish	x			1
	<i>Gochnatia polymorpha</i> (Less.) Cabrera		x		1
	<i>Mikania glomerata</i> Spreng.		x		2
	<i>Mikania</i> sp.1		x		1
	<i>Mikania</i> sp.2		x		1
	<i>Mikania</i> sp.3		x		1
	<i>Mikania</i> sp.4			x	1
	<i>Pentacalia desiderabilis</i> (Vell.) Cuatrec.	x			1
	<i>Piptocarpha</i> cf. <i>cinerea</i> (Sch. Bip.) Baker	x			1
	<i>Piptocarpha notata</i> (Less.) Baker	x			1
	<i>Porophyllum ruderale</i> (Jacq.) Cass.		x		1
	<i>Vernonia discolor</i> (Spreng.) Less.		x		1
	<i>Vernonia rufogrisea</i> Saint-Hilaire			x	1
Not determined				1	
	<b>Total</b>				<b>23</b>
Bignoniaceae	<i>Zeyheria montana</i> Mart.	x			1
	<b>Total</b>				<b>1</b>
Boraginaceae	<i>Varronia curassavica</i> Jacq.		x		1
	<i>Tournefortia membranacea</i> (Gardner) DC.		x		1
	<i>Tournefortia</i> sp.		x		1
	<b>Total</b>				<b>3</b>
Bursaceae	<i>Protium ovatum</i> Engl.	x			1
	<b>Total</b>				<b>1</b>
Dilleniaceae	<i>Davilla brasiliiana</i> DC.		x		1
	<b>Total</b>				<b>1</b>

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*.

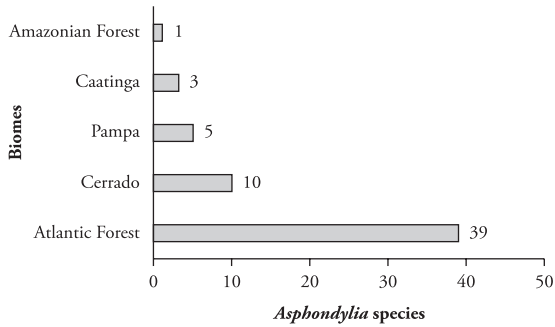
TABLE 1: Continued.

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

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 <i>Asphondylia</i> 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: Espírito 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 polyccephalus* (Asteraceae).

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

<i>Asphondylia</i> species	Host plant	Plant organ	Gall	Biome	State	Reference
<i>Asphondylia</i> sp.7	<i>Baccharis pseudomyricophala</i>			Cerrado	MG	
<i>Asphondylia</i> sp.8	<i>Bauhinia cheilantha</i>	Stem	Spherical	Caatinga	SE	Mendonça <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.9	<i>Calea pinnatifida</i>	Stem	Drop-shaped, green	AF	RS	Mendonça <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.10	<i>Calea serrata</i>	Stem	Fusiform, green	Pampa	RS	Mendonça <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.11	<i>Calea serrata</i>	Stem		Pampa		
<i>Asphondylia</i> sp.12	<i>Croton</i> sp.	Bud		AF (restinga)	SP	
<i>Asphondylia</i> sp.13	<i>Davilla brasiliiana</i>	Bud	Rosette	AF	MG	Maia & Fernandes, 2004.
<i>Asphondylia</i> sp.14	<i>Erythroxylum ovalifolium</i>	Flower bud	Ovoid, green, glabrous and one-chambered	AF (restinga)	RJ	Maia, 2001.
<i>Asphondylia</i> sp.15	<i>Eugenia binarginata</i>	Leaf	Cylindrical, cream and one-chambered	Cerrado	SP	Urso-Guimarães & Scareli-Santos, 2006.
<i>Asphondylia</i> sp.16	<i>Lantana lilacina</i>	Leaf	Globose, green, hairy, one-chambered	AF (restinga)	RJ	Rodrigues <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.17	<i>Mikania</i> sp.2	Bud		AF	ES	Maia <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.18	<i>Mikania</i> sp.3			AF	ES	Maia <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.19	<i>Mikania</i> sp.4	Stem	Fusiform	AF	ES	Maia <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.20	<i>Pentacalia desiderabilis</i>	Bud	Conical and green	AF	RS	
<i>Asphondylia</i> sp.21	<i>Piptocarpha</i> cf. <i>cinerea</i>	Leaf	Globose	AF (restinga)	SP	Maia <i>et al.</i> , 2008a.
<i>Asphondylia</i> sp.22	<i>Piptocarpha</i> cf. <i>cinerea</i>	Stem	Fusiform	AF (restinga)	SP	Maia <i>et al.</i> , 2008a.
<i>Asphondylia</i> sp.23	<i>Piptocarpha notata</i>			AF	RS	
<i>Asphondylia</i> sp.24	<i>Porophyllum ruderale</i>	Flower bud		AF	RJ	Pamplona <i>et al.</i> , 2000.
<i>Asphondylia</i> sp.25	<i>Protium ovatum</i>			Cerrado	MG	
<i>Asphondylia</i> sp.26	<i>Psychotria carthagenensis</i>	Bud	Aggregate	AF	ES/SP	Maia <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.27	<i>Psychotria vellosiana</i>	Leaf	Globose	AF	ES	Maia <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.28	<i>Solanum</i> sp.2			AF	MG	Maia, 2013a.
<i>Asphondylia</i> sp.29	<i>Solanum</i> sp.3	Stem	Globose and hairy	AF	RS	
<i>Asphondylia</i> sp.30	<i>Syrax leprosus</i>		Amorphous	AF	RS	
<i>Asphondylia</i> sp.31	<i>Tournefortia membranacea</i>	Flower bud	Globose, green and glabrous	Pampa	RS	
<i>Asphondylia</i> sp.32	<i>Vernonia discolor</i>	Stem		AF	RJ	Maia & Souza, 2013.
<i>Asphondylia</i> sp.33	<i>Vernonia rufovirgata</i>	Stem	Spherical	AF	RS	
<i>Asphondylia</i> sp.34	<i>Zeyheria montana</i>		Globose, yellow, glabrous and multi-chambered	AF (restinga)	RJ	Rodrigues <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.35	Asteraceae			Cerrado	MG	
<i>Asphondylia</i> sp.36	<i>Tournefortia</i> sp.	Fruit	Globose	AF	MG	Maia, 2013a.
			Globose, green, glabrous and multi-chambered	AF (restinga)	RJ	Rodrigues <i>et al.</i> , 2014.
<i>Asphondylia</i> sp.37	No data		Globose	AF	ES	
<i>Asphondylia</i> 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
<i>Andira fraxinifolia</i>	AL, BA, CE, PB, PE, PI, RN, SE, DF, GO, MS, ES, MG, RJ, SP, PR, SC and RS	SP, ES
<i>Aureliana fasciculata</i>	AC, PA, AL, BA, PE, ES, MG, RJ, SP, PR, SC and RS	SP
<i>Baccharis anomala</i>	MG, SP, PR, SC and RS	RS
<i>Baccharis concinna</i>	MG	MG
<i>Baccharis conyzoides</i>	All states	SP
<i>Baccharis dracunculifolia</i>	Cerrado, Atlantic Forest and Pampa	MG
<i>Baccharis pseudomyriocephala</i>	MG, RJ, SP and PR	MG
<i>Bauhinia brevipes</i>	All states	MG
<i>Bauhinia cheilantha</i>	AL, BA, CE, MA, PB, PE, PI, RN, SE, MS, MT, MG and SP	SE
<i>Borreria verticillata</i>	All states	RJ
<i>Calea pinnatifida</i>	DF, ES, MG, RJ, SP, PR, SC and RS	RS
<i>Calea serrata</i>	DF, MG and SP	RS
<i>Davilla brasiliiana</i>	PA, BA, MG, RJ, SP, PR, SC and RS	MG
<i>Didymopanax morototoni</i>	All states less SC and RS	SP
<i>Emeranthus polycephalus</i>	DF, GO, ES, MG, RJ and SP	MG
<i>Erythroxylum ovalifolium</i>	RJ	RJ
<i>Eugenia bimarginata</i>	BA, GO, MS, MT, MG, SP and PR	SP
<i>Gochmatia polymorpha</i>	BA, GO, MS, MG, RJ, SP, PR, SC and RS	MG
<i>Lantana lilacina</i>	AL, BA, CE, MA, PB, PE, PI, GO, MS, SC and RS	RJ
<i>Mikania glomerata</i>	BA, ES, MG, RJ, SP, PR, SC and RS	SP, RJ, RS
<i>Oxypetalum banksii</i>	BA, SE, ES, MG, RJ, SP, PR, SC and RS	RJ
<i>Pentacalia desiderabilis</i>	BA, ES, MG, RJ, SP, PR, SC and RS	RS
<i>Peplonia asteria</i>	BA, ES and RJ	RJ
<i>Piptocarpha cf. cinerea</i>	ES, MG, RJ and SP	SP
<i>Piptocarpha notata</i>	ES, MG, RJ and SP	RS
<i>Porophyllum ruderale</i>	AC, AM, AP, PA, RO, BA, CE, PE, RN, DF, GO, MS, MT, ES, MG, RJ, SP, PR, SC and RS	RJ
<i>Protium ovatum</i>	RO, TO, BA, DF, GO, MT, MG and SP	MG
<i>Psychotria carthagenensis</i>	All states less RN	ES, SP
<i>Psychotria vellosiana</i>	BA, PE, DF, GO, ES, MG, RJ, SP, PR and SC	ES
<i>Senna bicapsularis</i>	Exotic	RJ
<i>Struthanthus maricensis</i>	RJ	RJ
<i>Styrax leprosus</i>	MG, RJ, SP, PR, SC and RS	RS
<i>Tournefortia membranacea</i>	BA, CE, PE, ES, MG, RJ, SP, PR, SC and RS	RJ
<i>Varronia curassavica</i>	AM, AP, PA, TO, AL, BA, CE, PB, PE, PI, SE, GO, MS, MG, RJ, SP, PR, SC and RS RJ, SP	
<i>Vernonia discolor</i>	BA, DF, ES, MG, RJ, SP, PR, SC and RS	RS
<i>Vernonia rufogrisea</i>	BA, DF, GO, MT and MG	RJ
<i>Ximения americana</i>	All states less AM, RR, AP and RS	RJ
<i>Zeyheria montana</i>	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: Espírito 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.

<i>Asphondylia</i> species	Life cycle stages			
	Larva	Pupa	Adult	
			Male	Female
<i>Asphondylia bahiensis</i>		x	x	x
<i>A. borrieriae</i>	x			x
<i>A. canastrae</i>	x	x	x	x
<i>A. communis</i>	x		x	
<i>A. cordiae</i>		x		x
<i>A. fructicola</i>			x	
<i>A. glomeratae</i>		x	x	x
<i>A. gochnatiae</i>			x	
<i>A. maricensis</i>	x		x	x
<i>A. microcapillata</i>			x	
<i>A. moehni</i>	x	x	x	x
<i>A. parva</i>		x	x	x
<i>A. peploniae</i>	x	x	x	x
<i>A. rochae</i>		x	x	x
<i>A. sanctipetri</i>	x	x	x	x
<i>A. sennae</i>				x
<i>A. serrata</i>			x	
<i>A. struthanthi</i>			x	
<i>A. sulphurea</i>			x	
<i>A. ulei</i>	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
<i>Asphondylia</i> cfr. <i>cordiae</i>	Hymenoptera	
<i>A. moehni</i>	Eurytomidae	
<i>A. serrata</i>	Hymenoptera	Diptera: Tephritidae
<i>Asphondylia</i> sp.1		Coleoptera: Curculionidae
<i>Asphondylia</i> sp.13	Hymenoptera	
<i>Asphondylia</i> sp.16	Hymenoptera	
<i>Asphondylia</i> sp.22	Eurytomidae, Braconidae and Pteromalidae	Lepidoptera and Coleoptera: Curculionidae
<i>Asphondylia</i> sp.24		Diptera: Tephritidae ( <i>Trypanea</i> sp.)
<i>Asphondylia</i> sp.31	Hymenoptera	
<i>Asphondylia</i> sp.33	Hymenoptera	Diptera: Sciaridae and Cecidomyiidae ( <i>Resseliella</i> sp.)
<i>Asphondylia</i> 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 inquiline 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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