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ARTICLE

What do we know about Neotropical trap-nesting bees? Synopsis about their nest biology and taxonomy

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Abstract. Cavity-nesting bees are enigmatic because they are difficult to observe in the wild, hence trap-nests (man-made cavities) provide the means by which these bees may be studied. Trap-nests is an efficient methodology to study these bees and are common worldwide. These traps have been used for a variety of reasons, including inventories, to examine pollen load, to study habitat disturbance, and bee conservation. However Neotropical trap-nesting bees' taxonomy and biology are still poorly known and here we provide a review about these subjects. We searched for trap-nest bee studies in the Neotropical Region using Google Scholar and ISI Web of Science at any time in the past to December 2017. We found 109 independent studies, most of which were from Brazil (87 studies), followed by Argentina (10 studies), and other countries had fewer than five studies each. A total of 140 species, 24 genera, 10 tribes and three subfamilies were reported in trap-nests. Nest architecture was described for only 49 species. Taxonomy is only well-known for 14 genera, somewhat known for seven and is essentially unavailable for three genera. Construction material, closing plug and cell shape are similar among species in the same tribes and genera. Vestibular and intercalary cells, and the preliminary plug are variable, even at the specific level. Apinae is the most studied group with available data for all genera recorded in trap-nests. Colletinae is the least-studied group and nothing is known for their nesting biology. Megachilinae is intermediate, with some studies of taxonomy and nesting. We suggest that further trap-nest studies should provide more detailed information on nest architecture and construction materials, including explicit mention of structures that are absent. All Neotropical bees need more taxonomic studies, but some, such as *Hylaeus* and *Megachile,* require more attention since *Hylaeus* is essentially unknown and *Megachile* is very common on trap-nests.

Key-Words. Bee hotels; Diversity; Methodology; Nesting behavior; Systematics.

INTRODUCTION

Bee nests ordinarily comprises brood cells and associated structures and are often in burrows in the soil, aboveground cavities or free-standing (Michener, 2007). Most bees and apoid wasps excavate underground nests and this form of nesting is primitive in the superfamily (Melo, 1999; Hedtke *et al.,* 2013; Branstetter *et al.,* 2017). While we do not yet have a phylogenetic reconstruction of substrate preference for all bee species, apparently aboveground nesting arose independently several times. Four of the seven bee main lineages have species that nest in cavities and there are some reversals to soil nesting (Almeida, 2008).

Aboveground substrates are variable and cavity-nesting bees are likely to be an artificial ecological grouping. The use of existing tunnels in deadwood is common and bees often excavate decomposing wood and soft pith in stems and galls for nests (Sheffield *et al.,* 2011). Other examples of natural substrates include snail shells (Gess & Gess, 2008), rock surfaces (Eickwort, 1975) and man-made cavities, such as in brick walls (Santos *et al.,* 2016), metal frames (Sheffield *et al.,* 2011), farm tractor radiators (Sheffield, 2017) and door locks (RBG *pers. obs.*).

As a consequence of the wide variety of nesting substrates, artificial nesting substrates (trap-nests, nest-boxes, bee hotels) can be used to trap these cavity nesting bees and wasps (Krombein, 1967; MacIvor & Packer, 2015). These traps are often made of bundles of hollow stems, paper or cardboard tubes (Camillo *et al.,* 1995; Araújo *et al.,* 2016) and holes drilled in wood (Krombein, 1967; Buschini, 2006; see MacIvor, 2017 for a review). Characteristics of the entrance diameter, nest length, color and also placement of nests all influence bee selection and use of traps-nest (Krombein, 1967; MacIvor & Packer, 2015). Also, traps can be placed in aggregates of greater density to improve the likelihood of use. Studies tend

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to develop their own type of trap and so a wide variety of traps and their dispositions have been used, making comparisons of these studies very difficult.

As a consequence of the successful use of traps, studies are common worldwide, with over 1,300 results in Google (January 2018). Traps are used for many reasons, including to sample and monitor cavity nesting species and their predators (Araujo *et al.,* 2017; Oliveira & Gonçalves, 2017), to compare habitats among different regions (Araújo *et al.,* 2016), to examine altitudinal gradients (Perillo *et al.,* 2017) and vertical stratification (Morato, 2001b; Stangler *et al.,* 2015, 2016), to detect responses to fragmentation (Stangler *et al.,* 2015, 2016; Rocha-Filho *et al.,* 2017) and urbanization (Pereira-Peixoto *et al.,* 2014), to promote pollination and pollinator conservation (MacIvor & Packer, 2015) and to study the nest biology and behavior of particular groups (Rocha-Filho & Garófalo, 2016a,b; Moure-Oliveira *et al.,* 2017).

Despite of the large number of trap-nest studies, the Neotropical bee fauna taxonomy and diversity is still poorly known (Silveira *et al.,* 2002). Here we summarize the available information on biology and taxonomy of trap-nesting bees in this region. A synopsis is important to provide direction for future studies because further coordinated efforts will be important to produce comparable data and robust advances in this research field.

MATERIAL AND METHODS

To summarize the trap-nesting studies, we searched using Google Scholar and ISI Web of Science through the end of 2017. We used the following search terms: (Ninhos armadilha OR Nidos trampa OR Trap-nest OR Trap-nest bees) AND (Neotropical OR *countries names*). We included all countries from Chile to Mexico as search terms. The literature cited along any retrieved study was also used to find additional references. The following criteria was used to select the studies for this work: (1) used trap-nesting methods (understood here as any artificial cavity that was built by the researcher in which bees nested); (2) a primary reference, revision studies were not included; and (3) published in a peer reviewed journal or as an academic thesis or dissertation (other gray literature such as abstracts and conference reports were not included).

Data for nesting behavior, other biological details at higher taxonomic levels and the number of species in the world follow Michener (2007). The number of Neotropical species follows the online version of Moure's Bee Catalogue (Moure *et al.,* 2013). Nesting behaviors of species and genera were gathered from the original studies. Terminology for nest architecture follows Krombein (1967) as illustrated in Fig. 1. Trap-nest biology knowledge is considered "available" when there is at least one published description with details on the architecture using the trap-nest methodology, and "unavailable" in the absence of this information. Species identification was taken from the original studies and, if necessary, revised following Moure's Bee Catalogue (Moure *et al.,* 2013). We adopt the single-family classification for bees following Melo & Gonçalves (2005). Identification at morphospecies ("spp.") was also included in Table S1 but not counted in Table 1 except for the genera only recorded for undetermined species. We opted to include all records of primary references except for a single morphospecies of *Neofidelia* (Veddeler *et al.,* 2010). This refers to soil nesting species that are probably incorrectly identified. Taxonomy for each genus was evaluated at the species level and was considered "sufficient" when published taxonomical revision with identification keys is available, "moderate" when species are relatively well known and partial (regional or subgeneric) revisions are available, but much of the identification relies on taxonomists, and "insufficient" otherwise. Identification resources were gathered from Michener (2007), Moure *et al.* (2013) and

Table 1. A summary of trap-nesting bee genera from the Neotropical region. Notes: [1]morphospecies are excluded for most genera; [2]only recorded as morphospecies; [3]available for nest description of at least one species; [4]sufficient for taxa with published taxonomical revision, moderate for taxa only identified by taxonomists, insufficient when no revision is available.

Taxon	Number of recorded species[1]	Trap-nest description[3]	Taxonomic knowledge[4]
Apinae			
Centridini			
Centris	14	Available	Moderate
Euglossini			
Eufriesea	8	Available	Sufficient
Euglossa	14	Available	Moderate
Tetrapediini			
Tetrapedia	7	Available	Insufficient
Xylocopini			
Xylocopa	6	Available	Moderate
Colletinae			
Colletini			
Colletes	1	Unavailable	Insufficient
Rhynchocolletes	1[2]	Available	Sufficient
Hylaeini			
Hylaeus	1	Unavailable	Insufficient
Megachilinae			
Anthidiini			
Anthidium	4	Available	Sufficient
Anthidulum	1[2]	Unavailable	Sufficient
Anthodioctes	5	Available	Sufficient
Carloticola	1	Available	Sufficient
Ctenanthidium	1	Available	Sufficient
Dicranthidium	3	Unavailable	Sufficient
Duckeanthidium	1	Available	Moderate
Epanthidium	5	Available	Sufficient
Hypanthidium	1	Unavailable	Moderate
Loyolanthidium	1[2]	Unavailable	Moderate
Nananthidium	1	Unavailable	Sufficient
Saranthidium	2	Unavailable	Sufficient
Lithurgini			
Microthurge	1	Unavailable	Sufficient
Trichothurgus	1	Available	Sufficient
Megachilini			
Megachile	33	Available	Insufficient
Osmiini			
Heriades	1[2]	Unavailable	Moderate

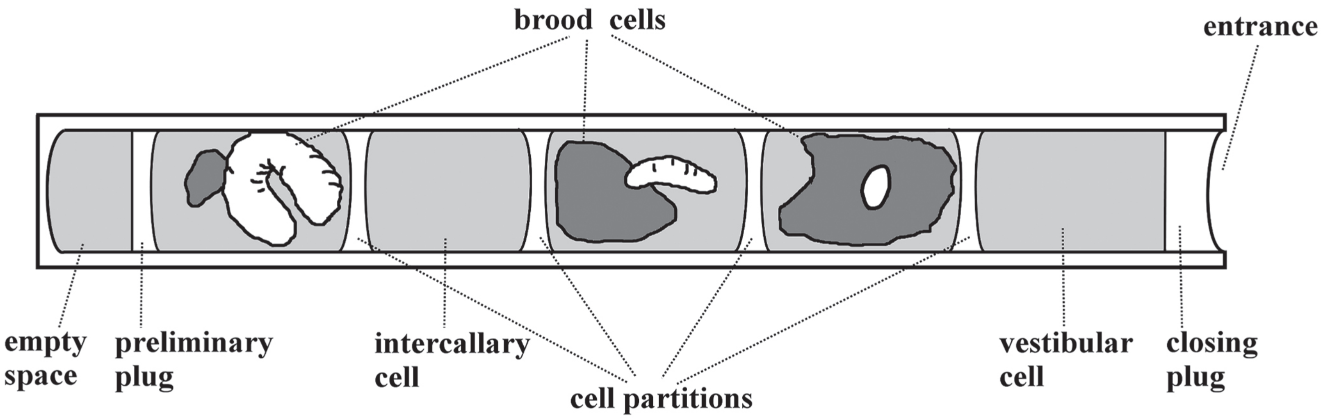

Figure 1. A generalized bee trap-nest architecture. At the left is the first cell made. The dark grey indicates food objects for the larvae (white). On the right is the last cell built with presence of a vestibular cell being variable.

published studies as described above. For the distributions of genera we followed Moure *et al.* (2013) and for species we used information from the original trap-nest studies (Table S1). States or provinces are informed of Argentina, Brazil and Mexico.

RESULTS

Our literature search resulted in a total of 109 independent studies, 87 from Brazil followed by Argentina (10), Costa Rica (5), Ecuador (2), Colombia (2), Mexico (1), Jamaica (1) and Trinidad and Tobago (1) (Table S1 summarizes trap-nesting bee literature). These studies comprised 140 species, 24 genera, 10 tribes and three subfamilies of trap-nesting bees in the Neotropical region. Nest architecture was described for 49 species and another 65 species were reported without descriptions (Tables 1 and 2). Fourteen genera had sufficient taxonomic descriptions, seven moderate and three insufficient.

APINAE. Although this group lacks a phylogenetic consensus (Cardinal *et al.,* 2010; Hedtke *et al.,* 2013; Martins *et al.,* 2014; Bossert *et al.,* 2019), wood nesting arose from soil nesting at least seven times following those topologies. All tribes of wood cavity nesting bees except the Tapinotaspidini were sampled using trap-nests, and Centridini, Euglossini and Tetrapediini were often found in these Neotropical studies.

Centridini. Traditionally the tribe comprised *Centris* and *Epicharis* (Bossert *et al.,* 2019), but it can be paraphyletic (*e.g.,* Martins & Melo, 2016). *Centris* included 251 species (Michener, 2007), mostly Neotropical (224 species) (Moure *et al.,* 2013), use floral oils mixed with other material for nest construction and protection (Vinson *et al.,* 1996). Nesting in existing cavities arose two times in this tribe in *C. (Xanthemisia)* and the clade *C. (Hemisiella)* + *C. (Heterocentris)* (Martins & Melo, 2016) and according with Moure *et al.* (2013) they comprise 35 described species. Only *C. (Hemisiella)* and *C. (Heterocentris)* were reported using trap nests (Vinson *et al.,* 2010; Vélez *et al.,* 2017). These subgenera use different material for nest construction; for example, *Heterocentris* use wood chips and *Hemisiella* use sand (Vinson *et al.,* 2010). Otherwise, nest characteristics are similar among these subgenera (Table 2).

Centris nests entrance diameter varies from 4.8-14 mm (Drummont *et al.,* 2008; Vinson *et al.,* 2010; Carvalho *et al.,*

Table 2. A summary on nest architecture of trap-nesting bee genera from Neotropical region. Data was summarized through the end of 2017. (?) There is not information or is dubious; (P) present, (O) occasional, (A) absent. The genera without published information about nest architecture we did not list in table.

Taxon	Material	Entrance diameter (mm)	Cell arrangement	Number of brood cells	Brood cells shape	Vestibular cells	Closing plug	Empty space	Preliminary plug	Intercallary cells
Anthidium	trichomes, plants parts, detritus	5-11	linear	1-19	?	?	P	?	?	?
Anthodioctes	resin, mud, wood chips	5-11	linear	2-11	?	0	P	0	0	0
Carloticola	resin, clay, sand	6-10	?	3-6	?	P	?	?	P	?
Centris	oil, wood chips or sand	4.8-14	linear or irregular	1-16	cylindrical or oval	0	P	P	?	0
Ctenanthidium	resin	4	linear	?	?	?	P	P	?	?
Duckeanthidium	resin, saliva	11-13	?	1-3	?	?	?	?	?	?
Epanthidium	resin, mud, sand	?	linear	2-9	?	0	?	?	?	?
Eufriesea	resin, wood chips	15-25	linear or irregular	2-4	oval	0	?	A	A	A
Euglossa	resin	11-22	linear or cluster	2-14	oval	?	P	P	A	A
Megachile	leaves, petals, mud rocks	6-27	linear	1-16	cylindrical	0	?	?	0	?
Tetrapedia	oil, soil, sand	3-12	linear	1-9	?	P	P	P	P	?
Trichothurgus	wood chips, pollen	8-11	?	no partition	?	?	A	?	?	?
Xylocopa	wood particles	12-23	linear	1-6	barrel	?	A	?	?	?

2016; Vélez *et al.,* 2017). Nests usually comprise linear brood cells (Drummont *et al.,* 2008; Vinson *et al.,* 2010; Carvalho *et al.,* 2016; Vélez *et al.,* 2017), with two rows of cells in *Centris tarsata* Smith, 1874 (Aguiar & Garófalo, 2004). Nests have from one to 16 circular to oval brood cells (Aguiar & Garófalo, 2004; Aguiar *et al.,* 2006; Buschini & Wolff, 2006; Drummont *et al.,* 2008; Vinson *et al.,* 2010; Carvalho *et al.,* 2016; Moure-Oliveira *et al.,* 2017; Vélez *et al.,* 2017). Vestibular and intercalary cells are occasionally found (Buschini & Wolff, 2006; Vinson *et al.,* 2010; Vélez *et al.,* 2017). A closing plug and an empty space in the distal end of the cell rows are common (Aguiar & Garófalo, 2004; Aguiar *et al.,* 2006). The genus is mostly Neotropical with few species reaching North America (Moure *et al.,* 2013). Subgenera of *Centris* may be identified by Silveira *et al.* (2002) and Michener (2007). Some *C. (Hemisiella)* and *C. (Heterocentris)* species may be identified by Thiele (2003) and Vivallo & Vélez (2016). Keys to *Centris* species from Central and North America and for species from Argentina are available Snelling (1984) and Roig-Alsina (2000), respectively.

Euglossini. Orchid bees are mostly Neotropical, comprising five genera: *Aglae* (1 Neotropical species), *Eufriesea* (67 Neotropical species), *Euglossa* (128 Neotropical species and 6 subgenera), *Eulaema* (33 Neotropical species and 2 subgenera), and *Exaerete* (8 Neotropical species). This tribe is unique in its elongate tongue and males collect orchid fragrances. *Aglae* and *Exaerete* are cleptoparasites of *Eufriesea* and *Eulaema.* Most species nest in existing cavities in which they do not build storage cells, unlike the other corbiculate bees (Michener, 2007). Taxonomy of the group is mostly based on males while females are identified by experts.

Eufriesea nests are built with wood chips and plant resins (Viana *et al.,* 2001; Kamke *et al.,* 2008). Entrance diameter varies from 15-25 mm (Viana *et al.,* 2001; Kamke *et al.,* 2008). Cell orientation may be horizontal as in *Eufriesea mussitans,* (Fabricius, 1787) (Viana *et al.,* 2001) to irregular as in *Eufriesea smaragdina* (Perty, 1833) (Kamke *et al.,* 2008). In the latter, cells are still built sequentially (Kamke *et al.,* 2008). Usually 2-4 oval and smooth brood cells are built having internal divisions of resin, with occasional vestibular cells (Viana *et al.,* 2001; Kamke *et al.,* 2008). *Eufriesea* is distributed from Argentina to Mexico (Moure *et al.,* 2013). Kimsey (1982) provided a key to the males.

Euglossa have nest architecture in the subgenera *Euglossa s.s.* and *Glossura* similar to *Eufriesea,* with brood cell divisions and closing plugs of resins only (Garófalo *et al.,* 1998; Peruquetti, 1998; Augusto & Garófalo, 2004; Parra-H & Nates-Parra, 2009). Entrance diameters varied from 11-22 mm. Brood cells may be linear (vertical or horizontal) or clustered (Garófalo *et al.,* 1998; Peruquetti, 1998; Augusto & Garófalo, 2004, 2009), and the usually oval cells vary from 4-14 per nest (Garófalo *et al.,* 1998; Peruquetti, 1998; Augusto & Garófalo, 2004). Preliminary plugs were not mentioned, while a distal empty space is typical (Parra-H & Nates-Parra, 2009). Females may nest alone or with other, usually sister, females, and may reuse empty cells (Silva *et al.,* 2016). If with others, a dominant female remains at the nest while others forage (Augusto & Garófalo, 2004, 2009, 2011; Freiria *et al.,* 2017). *Euglossa* is found from Mexico to Argentina (Moure *et al.,* 2013). Most subgenera can be identified using Silveira *et al.* (2002), while no complete revision of the genus is available. Males from São Paulo (Brazil) can be identified using keys provided by Rebêlo & Moure (1995), males and females of *E. (Glossura)* from Atlantic forest with Faria-Jr. & Melo (2007) and *E. (Euglossa)* in the *E. analis* group using Faria & Melo (2012).

Tetrapediini. Traditionally including two genera, the cleptoparasite *Coelioxoides* Cresson and *Tetrapedia* (Michener, 2007), recent phylogenetic hypotheses place *Coelioxoides* within the cleptoparasitic clade of Apinae (Cardinal *et al.,* 2010; Hedtke *et al.,* 2013). The *Tetrapedia* position in Apinae is uncertain, Martins *et al.* (2014) suggested that the genus is related to Ctenoplectrini, and Bossert *et al.* (2019) consider both as related with Xylocopini. In both genera include species that nest aboveground. *Tetrapedia,* comprising 28 species, is found from Mexico to Argentina (Moure *et al.,* 2013). There is no available key for species identification. They collect floral oils and nest in existing cavities (Alves-dos-Santos *et al.,* 2002). Cell partitions and closing plug are of soil or sand mixed with floral oils (Alves-dos-Santos *et al.,* 2002; Camillo, 2005; Menezes *et al.,* 2012; Rocha-Filho & Garófalo, 2016a). Entrance diameter varies between 3-12 mm (Alves-dos-Santos *et al.,* 2002; Camillo, 2005; Menezes *et al.,* 2012; Rocha-Filho & Garófalo, 2016a). Cells are linear and horizontal (Alves-dos-Santos *et al.,* 2002; Camillo, 2005; Menezes *et al.,* 2012; Rocha-Filho & Garófalo, 2016a), or linear and vertical (Camillo, 2005). Brood cells vary from 1-9 (Alves-dos-Santos *et al.,* 2002; Camillo, 2005; Menezes *et al.,* 2012; Rocha-Filho & Garófalo, 2016a). Vestibular cells, preliminary plugs and distal empty spaces are present (Rocha-Filho & Garófalo, 2016a).

Xylocopini. Among the most speciose lineages of aboveground nesting bees, most nest in cavities, with one reversal to ground-nesting in *X. (Proxylocopa)* (Leys *et al.,* 2002). The tribe has four lineages, of which only Allodapina is not Neotropical (Michener, 2007). *Ceratina,* with 199 species, has never been reported in trap-nests. Also, *Manuelia* (3 species) in Argentina and Chile has not been reported in trap-nests (see Daly *et al.,* 1987; Flores-Prado *et al.,* 2008 for detailed biology). *Xylocopa* (111 species) in the Neotropical region (Moure *et al.,* 2013) includes trap-nesting only in the subgenus *Neoxylocopa* (Table 1, Table S1). Phylogenetic relationships among these four lineages vary by study, yet Allodapina and Ceratinina are consistently considered to be sister groups (Flores-Prado *et al.,* 2008; Cardinal *et al.,* 2010; Martins *et al.,* 2014).

Xylocopa nests comprise fine wood particles that the bees excavate (Marchi & Melo, 2010; Pereira & Garófalo, 2010; Lucia *et al.,* 2017) and cell partitions are of wood particles mixed with saliva (Pereira & Garófalo, 2010; Lucia *et al.,* 2017). Females of *Xylocopa* and *Ceratina* remove nest partitions and the allodapines lack cell partitions (Michener, 2007). Entrance diameter varies from 12-23 mm (Marchi & Melo, 2010) with 1-6 brood cells (Marchi & Melo, 2010; Pereira & Garófalo, 2010). Brood cells are barrel-shaped (Pereira & Garófalo, 2010), as in species of *Manuelia* (Flores-Prado *et al.,* 2008). Cells are aligned (Marchi & Melo, 2010; Pereira & Garófalo, 2010). Females may reuse nests and nest cooperatively with sisters (Camillo & Garófalo, 1989). Guarding behavior, recognition and tolerance of nest males are found too in all xylocopines (Flores-Prado *et al.,* 2010). *Xylocopa* is distributed in all Neotropical region. Subgenera are identified following Silveira *et al.* (2002) and Michener (2007). Species from São Paulo (Brazil) are identified following the key in Marchi & Alves-dos-Santos (2013).

COLLETINAE. Known for polyester brood-cell lining, wood nesting probably arose once in the subfamily along with multiple reversals to soil nesting (Almeida, 2008). Of the Neotropical aboveground nesting lineages, only Xeromelissini was not sampled with trap-nests. Nesting behavior in this subfamily was revised by Almeida (2008).

Colletini. This tribe comprises three Neotropical genera, *Hemicotelles* (2 species), *Rhynchocolletes* (12 species) and *Xanthocotelles* (11 species) plus the cosmopolitan *Colletes* (330 species, 108 Neotropical species) (Michener, 2007). The nesting substrates of *Hemicotelles* and *Xanthocotelles* are unknown (Michener, 2007). One species of *Rhynchocolletes* was recently sampled with trap-nests (Diniz, 2010). *Colletes* was sampled only once with trap-nests in Neotropical region. Most species nests in soil, some in stem pith or existing cavities (Almeida, 2008). Soil nesting *Colletes* have linear cells and they lack basitibial and pygidial plates, for this the cavity nesting behavior may be primitive (Almeida, 2008). Otherwise, trap-nest biology in Neotropical species is unknown. Ferrari & Silveira (2015) provided a key to species of Colletini of Minas Gerais (Brazil) and Ferrari (2017) for *Colletes* of Chile.

Hylaeini. *Hylaeus* comprises 624 species worldwide of which 111 are Neotropical (Michener, 2007). They nest in existing cavities in a variety of substrates, including wood, pith, rock and soil (Michener, 2007; Almeida, 2008). Nothing is known of the Neotropical species and no identification key is available.

MEGACHILINAE. Most lineages of this subfamily include species that nest above ground, except near root lineages (Gonzalez *et al.,* 2012). Nests may be in the soil, in burrows in the wood, in plant stems, in other cavities, or may be free-standing constructs. Materials used to construct their nest are variable (petals and leaves, resin, nectar, saliva, others). The tribes Anthidiini, Megachilini and Osmiini have been observed carrying material for nesting (Michener, 2007) and all these tribes, along with the Lithurgini, used trap-nests in the Neotropical region.

Anthidiini. This tribe comprises 677 species worldwide and 339 Neotropical species, with 38 (Moure *et al.,* 2013) genera in the neotropics. See Martins *et al.* (2015) for a list of Danuncia Urban' publications that include comparative notes and keys to the species. Anthiidines nest in existing cavities or build exposed nests, while few species excavate soil nests (Michener, 2007). Nests comprise a wide variety of materials, including resin, leaf and flower pieces, plant fibers and pebbles (Michener, 2007). A total of 26 species and 12 genera were reported using trap-nests (Tables 1 and S1). Nest architecture is known for: *Anthidium* (50 Neotropical species), *Anthodioctes* (43 species), *Carloticola* (2 Neotropical species) *Ctenanthidium* (4 species), *Duckeanthidium* (4 species), *Epanthidium* (23 species), while nothing is known for half of the genera: *Anthidulum* (7 species), *Dicranthidium* (8 species), *Hypanthidium* (20 species), *Loyolanthidium* (8 Neotropical species), *Nananthidium* (13 species) and *Saranthidium* (10 species) (Moure *et al.,* 2013, Table 1, Table S1).

Anthidium nests partitions and plugs include plant trichomes and other material such as fruits, seeds, leaves, small rocks, wood chips and detritus (Vitale *et al.,* 2017). Entrance diameter varies from 5-11 mm (Vitale *et al.,* 2017). Brood cells are linear, except for *Anthidium vigintipunctatum* Friese, 1908, which cells were perpendicular or oblique. Brood cells vary from 1-19 (Vitale *et al.,* 2017). The genus occurs from Argentina to Mexico (Moure *et al.,* 2013). Gonzalez & Griswold (2013) provided a key to species.

Anthodioctes cells and closing plug are made with resins, sometimes mixed with mud or wood chips (Morato, 2001a; Alves-dos-Santos, 2004; Camarotti-de-Lima & Martins, 2005). Entrance diameter ranges from 5-11 mm (Morato, 2001a; Camarotti-de-Lima & Martins, 2005). The 2-11 brood cells are linear, some with vestibules and preliminary plugs (Morato, 2001a; Alves-dos-Santos, 2004; Camarotti-de-Lima & Martins, 2005). *Anthodioctes megachiloides* Holmberg 1903 nests sometimes have intercalary cells and distal empty space (Alves-dos-Santos, 2004). The genus occurs from Mexico to Argentina (Moure *et al.,* 2013). Identification of its species is possible following Urban (1999, 2002, 2003, 2004).

Carloticola nests and cells partitions are of clay or sand mixed with resin (Mello, 2014). Entrance diameter varies from 6-10 mm and nests have 3-6 brood cells. Vestibular cells are filled with flower buds (Asteraceae or Malpighiaceae) and a preliminary plug is present (Mello, 2014). The genus occurs in Argentina, Brazil and Paraguay (Moure *et al.,* 2013). Identification follows Moure & Urban (1990).

Ctenanthidium, a single nest of *Ctenanthidium bifasciatum* Urban, 1993 was described by Alvarez *et al.* (2015). Resin covered the inner walls, brood cells and partitions. The entrance was 4.0 mm in diameter. The nest had three serial brood cells between an empty space in the distal end of the nest and a closing plug. The genus is found in Argentina, Bolivia, Brazil and Uruguay (Moure *et al.,* 2013). Identification follows Urban (1991).

Duckeanthidium cells are made with glandular substance and plant resins (Thiele, 2002). Entrance diameter varies from 11-13 mm. Nests have 1-3 brood cells, 15-45 mm from the preliminary plug. Partitions and closing plug were extremely hard, with a resin-like material in the closing plug. The genus occurs from Costa Rica to Brazil (Moure *et al.,* 2013). Comparative notes about taxonomy of the species can be found in Michener (2002) and Urban (2004).

Epanthidium nests are of resin mixed with mud or sand (Gomes, 2016) with 2-9 linear brood cells, occasionally with vestibules. The genus occurs from Mexico to Argentina (Moure *et al.,* 2013) and information to identify its species can be found in Urban (1992, 2006, 2011).

Lithurgini. This tribe comprises two South American genera, *Microthurge* (4 species) and *Trichothurgus* (14 species) plus two genera with Neotropical species, *Lithurgopsis* (5 Neotropical species) and *Lithurgus* (1 Neotropical species), these species nest in dead, dry, decomposing wood, making nests without cell linings and often without partitions (Michener, 2007; Moure *et al.,* 2013). *Microthurge corumbae* (Cockerell, 1901) can reuse nests made by one or more females in which guarding occurs (Garófalo *et al.,* 1992). *Trichothurgus laticeps* (Friese, 1906) build nests with wood particles and pollen (Vitale & Vázquez, 2017). Entrance diameter varying from 8-11 mm and nests are without a closing plug and most are without cell partitions. Females excavate wood with mandibles (Vitale & Vázquez, 2017). *Trichothurgus* occurs in Argentina, Chile and Peru (Moure *et al.,* 2013), and an identification key is provided by Michener (1983).

Megachilini. This tribe has two Neotropical genera: *Megachile* and the cleptoparasite *Coelioxys*. *Megachile* comprises 1,093 species, of which 431 are Neotropical (Michener, 2007; Moure *et al.,* 2013), with 32 Neotropical subgenera. Nests are built, often with petals and leaves, in existing cavities in soil, wood, and man-made objects, while some may be free-standing construction (Michener, 2007). Seventeen subgenera and 33 species were studied using trap-nests. *Megachile* builds with leaves, petals, soil, mud and pebbles (Torretta & Durante, 2011; Torretta *et al.,* 2012, 2014, Marques & Gaglianone, 2013; Sabino & Antonini, 2017). Entrance diameter varies from 6-27 mm (Torretta & Durante, 2011; Torretta *et al.,* 2012, 2014; Marques & Gaglianone, 2013; Sabino & Antonini, 2017). One to 16 brood cells tend to be cylindrical and linear (Teixeira *et al.,* 2011; Cardoso & Silveira, 2012; Marques & Gaglianone, 2013; Rocha-Filho & Garófalo, 2016b; Sabino & Antonini, 2017). Preliminary plugs and vestibular cells are uncommon (Torretta & Durante, 2011; Teixeira *et al.,* 2011; Cardoso & Silveira, 2012; Torretta *et al.,* 2012, 2014; Marques & Gaglianone, 2013; Rocha-Filho & Garófalo, 2016b; Sabino & Antonini, 2017). Two species were observed sharing the same nest (Cardoso & Silveira, 2012). *Megachile* occurs from Mexico to Argentina (Moure *et al.,* 2013). The *Megachile* subgenera can be identified following Michener (2007) and Silveira *et al.* (2002). A key to the Neotropical species is not available.

Osmiini. Twenty genera are recognized in this tribe, four of which are found in Mexico and Central America (*Ashmeadiella, Atoposmia, Heriades* and *Osmia;* Michener, 2007). Osmiini nest in the soil and in existing cavities (Rozen *et al.,* 2010; Rozen-Jr. & Praz, 2016), using a variety of materials, including petals, mud, pebbles and resins (Praz *et al.,* 2008). Osmiini from the New World tend to nest aboveground more than those from the Old World (Praz *et al.,* 2008), however, the group lacks phylogenetic consensus which is necessary for a proper reconstruction of nesting behavior (Praz *et al.,* 2008; Gonzalez *et al.,* 2012). One *Heriades* morphospecies was reported in trap-nests in the Neotropical region without nest information (Roubik & Villanueva-Gutiérrez, 2009). An identification subgenera's key is provided by Michener (2007).

DISCUSSION

We reviewed 109 trap-nesting studies in the Neotropical region that included information for 140 species and 24 genera. Garófalo *et al.* (2004) listed 57 species for Brazil while we report 90 Brazilian species demonstrating rapid advancement in the study of this group of bees. Some of them are studied more often than others. The Apinae are the most studied, with data for all genera sampled in trap-nests. Conversely, trap-nesting Colletinae have not been reported, and the taxonomy of this subfamily has received little attention (see below). Megachilinae are intermediate, with many nests of the Anthidiini being properly described. Their taxonomy is relatively well-understood (Table 1).

We found that most studies were from Brazil and they were restricted to about half of the states, mostly southeastern (Freitas *et al.,* 2009). The other Neotropical countries continue to be very poorly studied. Argentina, Ecuador and Colombia have several studies and may be considered to have quite understanding of their trap-nesting bees biodiversity. In Central America, Costa Rica is better sampled (*e.g.,* Coville & Coville, 1980; Thiele, 2005; Vinson *et al.,* 2010), followed by Panama.

The details of nest architecture are similar to most of the taxa with respect to construction material, closing plug and cell shape (Table 2), while other structures may vary among lineages and intraspecifically. For example, entrance diameter is correlated with female body size ensuring the fit of brood cells (Krombein, 1967; MacIvor, 2017). Diameter of trap-nests also seems to be due to female choice, in part, and varies widely among studies (Coville, 1982; MacIvor, 2017). The number of brood cells is also variable and associated with resource availability, sex ratio of progeny and of course, nest length (Coville, 1982; Morato & Martins, 2006). Vestibular and intercalary cells and the preliminary plug also vary widely among trap-nesting bees (Table 2). Vestibular cells vary from occasional to common (Krombein, 1967; Asís *et al.,* 2007), and while they have been suggested to be a defense against parasites (Krombein, 1967; Coville & Coville, 1980), their true purpose has not been experimentally tested (Asís *et al.,* 2007). Also, vestibular cells often remain unmentioned in studies and so their presence or absence in those studies is unclear. As an important nest feature, we recommend that presence and absence of the vestibular cells always be clearly stated. Intercalary cells and the preliminary plug are seldom observed, they may be used in the defense against parasites or to change the conformation of the inner end of the boring, respectively (Krombein, 1967; O'Neill, 2001).

Taxonomic information was sufficient for only 14 genera, more than half of which are in the Anthidiini. This well-known tribe was studied extensively by Urban (see bibliography in Martins *et al.,* 2015). Essentially all the remaining groups are poorly studied taxonomically (Table 1). Relatively well known genera include *Centris,* and *Xylocopa,* whose species can often be identified by specialists, but comprehensive keys are not yet available. *Hylaeus* and *Megachile* remain poorly studied with many unnamed species (Moure *et al.,* 2013). *Tetrapedia* is also poorly studied but not so diverse as *Hylaeus* and *Megachile* (Moure *et al.,* 2013).

Taxonomical impediment is an important issue in many insect studies (Oliveira *et al.,* 2011; Begum *et al.,* 2011; Jordaens *et al.,* 2013), including in trap-nesting bee studies Araujo *et al.,* 2017; Matos *et al.,* 2016; Iantas *et al.,* 2017). Reliable identification is necessary when using bees as ecological indicators (Tscharntke *et al.,* 1998) even if morphospecies can be used in some diversity metrics and analyses (Magurran, 2004; Tylianakis *et al.,* 2007; Pereira-Peixoto *et al.,* 2014; Araújo *et al.,* 2016; Iantas *et al.,* 2017). Studies of phylogenetic and beta diversity, temporal and spatial distribution patterns and nesting behaviors are all hampered by problems with species identification (Faith, 1992; Magurran, 2004; Mittelbach *et al.,* 2007; Faith, 2015).

CONCLUSIONS

Herein we summarized biological and taxonomic knowledge of trap-nest bees in the Neotropical region. Priorities for future research must be settled to fill the more important gaps. For example, researchers should clearly provide details of nest architecture, including clear statements about the presence and absence of structures that can be considered as characters. We propose that researchers provide details of building material, entrance diameter (if oval, diameter along both axes), cell arrangement, number and shapes of brood cells, presence/absence of vestibular and intercalary cells, preliminary and closing plugs and the back empty space. Some of Neotropical trap-nesting groups require further taxonomical work, but especially *Hylaeus* and *Megachile* seeing of the absence of modern taxonomic studies. *Megachile* has an additional requirement since its high abundance in trap-nests studies.

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APPENDICES

Table S1. A summary of trap nesting bee species from Neotropical region. Data was summarized through the end of 2017. (Available) It is when there is at least one published description with details on the architecture using trap-nest methodology; (unavailable) is when information is absence. Abbreviations follow: Argentina: BA = Buenos Aires, LP = La Pampa and MZ = Mendoza. Brazil: AC = Acre, AM = Amazonas, BA = Bahia, CE = Ceará, MA = Maranhão, MG = Minas Gerais, PB = Paraíba, PE = Pernambuco, PR = Paraná, RJ = Rio de Janeiro, RN = Rio Grande do Norte, SC = Santa Catarina and SP = São Paulo. Mexico: QR = Quintana Roo.

Taxon	Distribution records (States or provinces from Argentina, Brazil and Mexico are indicated under parenthesis)	References for records	Trap nest description	References for nest descriptions
APINAE				
Centridini				
Centris (Hemisiella) crassipes Smith, 1874	Jamaica	1	Available	1
Centris (Hemisiella) dichrootricha (Moure, 1945)	Brazil (AC, AM, MA)	2–4	Available	4
Centris (Hemisiella) facialis Mocsáry, 1899	Colombia	5	Unavailable	
Centris (Hemisiella) merrillae Cockerell, 1919	Brazil (AC), Trinidad and Tobago	3, 6	Available	6
Centris (Hemisiella) nitida Smith, 1874	Brazil (AM), Costa Rica	7–9	Available	8, 9
Centris (Hemisiella) tarsata Smith, 1874	Argentina (BA); Brazil (BA, CE, MA, MG, PB, PE, PR, RJ, RN, SC, SP)	10–42	Available	33, 43, 44
Centris (Hemisiella) trigonoides Lepeletier, 1841	Brazil (AM, MG, RN); Costa Rica; Colombia	2, 5, 8, 16, 21	Available	8, 9, 45
Centris (Hemisiella) vittata Lepeletier, 1841	Brazil (MA, MG, SP); Costa Rica	3, 7, 8, 15, 19, 26, 28, 36, 46, 47	Available	8, 9, 47, 48
Centris (Hemisiella) sp.	Brazil (AC)	3	—	
Centris (Heterocentris) adunca Moure, 2003	Brazil (AC)	3	Unavailable	
Centris (Heterocentris) analis (Fabricius, 1804)	Brazil (AC, AM, BA, MG, PB, PE, PR, RJ, SP); Costa Rica; Colombia; Mexico (QR)	2, 3, 5, 7, 8, 12, 13, 15, 22, 24, 25, 27, 28, 32, 36, 38–40, 42, 46, 49–55	Available	8, 54
Centris (Heterocentris) bicornuta Mocsáry, 1899	Brazil (AM, MA); Costa Rica	2, 7, 8, 19, 46	Available	8, 9
Centris (Heterocentris) difformis Smith, 1854	Costa Rica	46	Unavailable	
Centris (Heterocentris) labrosa Friese, 1899	Brazil (SP); Costa Rica	25, 36, 46, 50	Unavailable	
Centris (Heterocentris) terminata Smith, 1874	Brazil (AC, AM, BA, MA, MG, PB)	2, 3, 12, 14, 18, 19, 22, 27, 56, 57	Available	58
Centris (Heterocentris) spp.	Brazil (AC, CE, MG, RJ)	3, 14, 18, 27	—	
Centris spp.	Brazil (SP); Ecuador	25, 59, 60	—	
Euglossini				
Eufriesea auriceps (Friese, 1899)	Brazil (SP)	25, 36	Unavailable	
Eufriesea mussitans (Fabricius, 1787)	Brazil (BA)	35	Unavailable	
Eufriesea purpurata (Mocsáry, 1896)	Brazil (AM)	2	Unavailable	
Eufriesea smaragdina (Perty, 1833)	Brazil (SC)	61	Available	62
Eufriesea surinamensis (Linnaeus, 1758)	Brazil (SP)	25	Unavailable	
Eufriesea theresiae (Mocsáry, 1908)	Brazil (AM)	2	Unavailable	
Eufriesea violacea (Blanchard, 1840)	Brazil (MG, SC, SP)	15, 37, 63	Available	63
Eufriesea violascens (Mocsáry, 1898)	Brazil (SP)	36	Unavailable	
Eufriesea sp.	Brazil (MG)	26	—	
Euglossa (Euglossa) amazonica Dressler, 1982	Brazil (CE)	18	Unavailable	
Euglossa (Euglossa) anodorhynchi Nemésio, 2006	Brazil (SP)	30, 64	Unavailable	
Euglossa (Euglossa) avicula Dressler, 1982	Brazil (AC, MG)	3, 65	Unavailable	
Euglossa (Euglossa) cordata (Linnaeus, 1758)	Brazil (BA, MA, MG, RN, SP)	17, 21, 32, 35, 36, 39, 65–67	Available	68
Euglossa (Euglossa) fimbriata Moure, 1968	Brazil (SP)	69	Unavailable	
Euglossa (Euglossa) gaianii Dressler, 1982	Brazil (AM, MA)	2, 17, 67	Unavailable	
Euglossa (Euglossa) hemichlora Cockerell, 1917	Colombia	70	Available	70
Euglossa (Euglossa) melanotricha Moure, 1967	Brazil (MG, SP)	12, 36, 65	Unavailable	
Euglossa (Euglossa) modestior Dressler, 1982	Brazil (AC)	3	Unavailable	
Euglossa (Euglossa) pleosticta Dressler, 1982	Brazil (CE, SP)	15, 18, 36	Unavailable	
Euglossa (Euglossa) townsendi Cockerell, 1904	Brazil (CE, MG, SP)	16, 19, 25, 26, 28, 36, 65, 66	Available	71
Euglossa (Euglossa) truncata Rebêlo & Moure, 1996	Brazil (SP)	36, 66	Unavailable	
Euglossa (Euglossa) variabilis Friese, 1899	Ecuador	59	Unavailable	
Euglossa (Glossura) annectans Dressler, 1982	Brazil (SC, SP)	61, 72, 73	Available	73
Euglossa spp.	Brazil (BA, MA)	35, 74	—	
Tetrapediini				
Tetrapedia amplitarsis Friese, 1899	Brazil (SP)	36	Available	75
Tetrapedia curvitarsis Friese, 1899	Brazil (BA, MG, SP)	15, 25, 28, 36, 39, 75	Available	75
Tetrapedia diversipes Klug, 1810	Brazil (BA, CE, MG, PB, PE, RJ, SP)	15, 22, 24, 25, 27, 28, 32, 36, 38, 42, 75, 76	Available	75, 77, 78
Tetrapedia garofaloi Moure, 1999	Brazil (SP)	36, 75	Available	75
Tetrapedia maura Cresson, 1878	Costa Rica	46, 50	Unavailable	
Tetrapedia ornata (Spinola, 1853)	Brazil (AM)	2	Unavailable	
Tetrapedia rugulosa Friese, 1899	Brazil (MG, SP)	25, 28, 36, 75	Unavailable	
Tetrapedia spp.	Argentina (BA); Brazil (AC, MG, PE, SP); Ecuador	3, 12, 14–16, 29, 36, 40, 41, 60	—	
Xylocopini				
Xylocopa (Neoxylocopa) augusti Lepeletier, 1841	Argentina (BA); Brazil (PR)	34, 79	Available	79
Xylocopa (Neoxylocopa) frontalis (Olivier, 1789)	Brazil (BA, MG, SP)	28, 35, 39, 80–82	Available	82, 83
Xylocopa (Neoxylocopa) grisescens Lepeletier, 1841	Brazil (BA, MG, SP)	28, 39, 80–82	Available	82

Taxon	Distribution records (States or provinces from Argentina, Brazil and Mexico are indicated under parenthesis)	References for records	Trap nest description	References for nest descriptions
Xylocopa (Neoxylocopa) suspecta Moure & Camargo, 1988	Brazil (MA, MG)	28, 74, 80	Unavailable	
Xylocopa (Schoenherria) subcyanea Pérez, 1901	Brazil (BA, MG)	23, 35	Unavailable	
Xylocopa (Schoenherria) varians Smith, 1874	Costa Rica	46	Unavailable	
Xylocopa sp.	Brazil (MG)	29	—	
Colletinae				
Colletini				
Colletes rufipes Smith, 1879	Brazil (SP)	25	Unavailable	
Colletes spp.	Brazil (PE, PR)	24, 34	—	
Rhynchocolletes sp.	Brazil (PR)	34	Available	34
Hylaeini				
Hylaeus transversus (Vachal, 1909)	Brazil (SP)	15	Unavailable	
Hylaeus spp.	Brazil (PB, RN, PR, SC, SP); Costa Rica	11, 21, 22, 37, 38, 50, 84	—	
Megachilinae				
Anthidiini				
Anthidium andinum Jörgensen, 1912	Argentina (MZ)	85	Available	85
Anthidium decaspilum Moure, 1957	Argentina (MZ)	85	Available	85
Anthidium rubripes Friese, 1908	Argentina (MZ)	85	Available	85
Anthidium vigintipunctatum Friese, 1908	Argentina (LP, MZ)	41, 85, 86	Available	85
Anthidium spp.	Costa Rica, Ecuador	7, 59	—	
Anthidulum sp.	Brazil (SP)	36	Unavailable	
Anthodioctes claudii Urban, 1999	Brazil (PR)	34	Unavailable	
Anthodioctes lunatus (Smith, 1854)	Brazil (AC, PE)	3, 24	Available	87
Anthodioctes manauara Urban, 1999	Brazil (AM)	88	Unavailable	
Anthodioctes megachiloides Holmberg, 1903	Brazil (MG, SP)	15, 25, 29, 30, 38	Available	89
Anthodioctes moratoi Urban, 1999	Brazil (AM)	2	Available	88
Anthodioctes spp.	Brazil (AC, BA, SP), Mexico (QR)	3, 36, 39, 49	—	
Carloticola paraguayensis (Schrottky, 1908)	Brazil (RJ, SP)	36, 90	Available	90
Ctenanthidium bifasciatum Urban, 1993	Argentina (BA)	91	Available	91
Dicranthidium arenarium (Ducke, 1907)	Brazil (BA, PB, PE, RN)	21, 22, 24, 39	Unavailable	
Dicranthidium luciae Urban, 1993	Brazil (BA)	39	Unavailable	
Dicranthidium seabrai Urban, 2002	Brazil (SP)	92	Unavailable	
Dicrantidium spp.	Brazil (MA, PE)	17, 40	—	
Duckeanthidium thielei Michener, 2002	Costa Rica	46, 50	Available	93
Duckeanthidium sp.	Brazil (AM)	2	Unavailable	
Epanthidium autumnale (Schrottky, 1909)	Brazil (PR, SC)	11	Unavailable	
Epanthidium erythrocephalum (Schrottky, 1902)	Brazil (SP)	36	Unavailable	
Epanthidium maculatum Urban, 1995	Brazil (MG)	26, 28	Unavailable	
Epanthidium nectarinioides (Schrottky, 1902)	Brazil (PR, SC, SP)	11, 34, 36	Unavailable	
Epanthidium tigrinum (Schrottky, 1905)	Brazil (CE, MG, PB, PE, RN, SP)	15, 16, 19, 21, 22, 24, 26, 32, 36, 92, 94	Available	94
Epanthidium spp.	Brazil (BA, MG, SP)	12, 36, 39	—	
Hypanthidium maranhense Urban, 1998	Brazil (MA, PE)	24, 74	Unavailable	
Loyolanthidium sp.	Mexico (QR)	49	Unavailable	
Nananthidium gualanense (Cockerell, 1912)	Costa Rica	50	Unavailable	
Saranthidium marginatum Moure & Urban, 1994	Brazil (SP)	25	Unavailable	
Saranthidium musciforme (Schrottky, 1902)	Brazil (SP)	36, 92	Unavailable	
Lithurgini				
Microthurge corumbae (Cockerell, 1901)	Brazil (SP)	95	Unavailable	
Trichothurgus laticeps (Friese, 1906)	Argentina (MZ)	96	Available	96
Megachilini				
Megachile (Acentron) sp.	Argentina (BA)	41	Unavailable	
Megachile (Austromegachile) facialis Vachal, 1909	Brazil (SP, MG)	15, 23, 29	Unavailable	
Megachile (Austromegachile) fiebrigi Schrottky, 1908	Brazil (PR)	13, 34	Unavailable	
Megachile (Austromegachile) orbiculata Mitchell, 1930	Brazil (AC, AM)	2, 3	Unavailable	
Megachile (Austromegachile) sejuncta Cockerell, 1927	Brazil (MA)	74	Unavailable	
Megachile (Austromegachile) susurrans Haliday, 1836	Brazil (PR)	13	Unavailable	
Megachile (Austromegachile) trigonaspis Schrottky, 1913	Brazil (PR)	97	Unavailable	
Megachile (Austromegachile) spp.	Argentina (BA), Brazil (AC, CE, MG, PR)	3, 14, 18, 41, 97	—	
Megachile (Callomegachile) rufipennis (Fabricius, 1793)	Jamaica	1	Available	1
Megachile (Chrysosarus) catamarcensis Schrottky, 1908	Argentina (LP)	41, 86, 98	Available	98
Megachile (Chrysosarus) guaranitica Schrottky, 1908	Brazil (PR, SP)	13, 15, 36	Available	99
Megachile (Chrysosarus) jenseni Friese, 1906	Argentina (BA)	41	Unavailable	
Megachile (Chrysosarus) pseudanthidioides Moure, 1943	Brazil (SC)	100	Available	100
Megachile (Chrysosarus) ruficornis Smith, 1853	Brazil (AC)	3	Unavailable	
Megachile (Chrysosarus) spp.	Argentina (BA), Brazil (AC, BA, CE, MG, PB, PE, PR, RN, SC, SP)	3, 11, 14, 21, 22, 24, 30, 37, 39, 41	—	
Megachile (Dasymegachile) sp.	Brazil (PR)	34	Unavailable	
Megachile (Eutricharaea) concinna Smith, 1879	Argentina (BA), Jamaica	1, 101	Available	1, 101

Taxon	Distribution records (States or provinces from Argentina, Brazil and Mexico are indicated under parenthesis)	References for records	Trap nest description	References for nest descriptions
Megachile (Grafella) sp.	Brazil (SC)	61	—	
Megachile (Melanosarus) brasiliensis Dalla Torre, 1896	Brazil (PR)	34	Unavailable	
Megachile (Melanosarus) nigripennis Spinola, 1841	Brazil (RJ)	102	Available	102
Megachile (Melanosarus) spp.	Brazil (MG, SC)	12, 61	—	
Megachile (Moureapis) benigna Mitchell, 1930	Brazil (MG, RJ)	103, 104	Available	104, 105
Megachile (Moureapis) maculata Smith, 1853	Brazil (MG, PR)	14, 97, 104, 106	Available	104, 106
Megachile (Moureapis) pleuralis Vachal, 1909	Brazil (PR, SC)	11	Unavailable	
Megachile (Moureapis) spp.	Brazil (AC, CE, MG, PR)	3, 14, 19, 34, 97, 107	—	
Megachile (Neochelynia) brethesi Schrottky, 1909	Brazil (MA, MG)	32, 74	Unavailable	
Megachile (Neochelynia) paulista (Schrottky, 1920)	Brazil (AC)	3	Unavailable	
Megachile (Pseudocentron) curvipes Smith, 1853	Brazil (AC, MA, SP)	3, 15, 74	Unavailable	
Megachile (Pseudocentron) gomphrenoides Vachal, 1909	Argentina (BA)	41, 108	Available	108
Megachile (Pseudocentron) inscita Mitchell, 1930	Brazil (BA)	39	Unavailable	
Megachile (Pseudocentron) nudiventris Smith, 1853	Brazil (SC)	61	Unavailable	
Megachile (Pseudocentron) spp.	Argentina (BA); Brazil (AC, MG, PE, RN, SP)	3, 21, 24, 25, 29, 32, 38, 41	—	
Megachile (Pseudomegachile) lanata (Fabricius, 1775)	Jamaica	1	Available	1
Megachile (Ptilosarus) bertonii Schrottky, 1908	Brazil (MG)	29	Unavailable	
Megachile (Ptilosarus) leucostomella Cockerell, 1927	Brazil (AC)	3	Unavailable	
Megachile (Ptilosarus) spp.	Brazil (AC, SP)	3, 30	—	
Megachile (Ptilosaroides) neoxanthoptera Cockerell, 1933	Brazil (SP)	25, 36	Unavailable	
Megachile (Rhyssomegachile) sp.	Brazil (AM)	2	Unavailable	
Megachile (Sayapis) cylindrica Friese, 1906	Brazil (MG, PB, PE)	24, 32	Available	24
Megachile (Sayapis) mendozana Cockerell, 1907	Argentina (BA)	109	Available	109
Megachile (Sayapis) planula Vachal, 1909	Brazil (SP)	15	Unavailable	
Megachile (Sayapis) zaptlana Cresson, 1878	Jamaica, Mexico (QR)	1, 49	Available	1
Megachile (Sayapis) spp.	Brazil (CE, PB, RN)	19, 21, 22, 57	—	
Megachile (Tylomegachile) orba Schrottky, 1913	Brazil (AC)	3	Unavailable	
Megachile spp.	Brazil (AM, BA, MA, MG, PR, SP); Costa Rica; Ecuador	2, 7, 12, 17, 25, 26, 36, 50, 59, 60, 74, 107	—	
Osmiini				
Heriades spp.	Mexico (QR)	49	—	

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