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Natural enemies of the oil-collecting bee *Centris analis* (Fabricius, 1804) with notes on the behavior of the cleptoparasite *Coelioxys nigrofimbriata* Cockerell, 1919 (Hymenoptera, Apidae)

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Abstract

This work presents a review of natural enemy species associated with *Centris analis* and summarizes the available information on life history, behavior, diversity, and specialization of these taxa. Records include over 20 species in ten genera from seven distinct families of Hymenoptera, Diptera and Coleoptera. These species are cleptoparasites or parasitoids of immature stages or adults. Some species seem to be occasional parasitoids, while others seem to be more frequent and responsible for significant mortality rates of immatures in nests. Three families of Hymenoptera represent the majority of natural enemy taxa found in *C. analis* nests: Apidae, Chrysididae, and Leucospidae. The most frequent parasitoid reared from nests was the wasp *Leucospis cayennensis* Westwood, followed by cleptoparasitic bee species of the genus *Coelioxys* Latreille. Vouchers of trap nest studies are identified for the first time and refer to *Coelioxys nigrofimbriata* Cockerell, which seems to have a strong association with nests of *C. analis*. Further direct observation notes about biology and behavior of *C. nigrofimbriata* are also provided.

Keywords

Centridini, host, Neotropical region, nesting, parasite

Introduction

Centris analis (Fabricius) is a solitary, oil-collecting bee with a broad geographic range that extends from central Mexico to southern Brazil (Moure and Melo 2012). It is often recorded in trap-nest surveys in various Brazilian biomes such as the Atlantic rainforest, caatinga, and cerrado (Jesus and Garófalo 2000; Aguiar and Martins 2002; Aguiar et al. 2005; Oliveira and Schlindwein 2009; Dórea et al. 2010; Rabelo et al. 2014; Moure-Oliveira et al. 2017). These bees are multivoltine, polylectic, and effective pollinators of native plants as well as crops (Dórea et al. 2010; Vilhena et al. 2012). These features led *C. analis* to be considered as a manageable pollinator in cultures such as acerola (*Malpighia emarginata*, Malpighiaceae), increasing orchard productivity and reducing pollination deficit (Oliveira and Schlindwein 2009; Magalhães and Freitas 2013). However, studies necessary to make its commercial use feasible are still lacking, including aspects of its life history, physiology, nesting preferences, population genetics, and natural enemies (Bosch and Kemp 2002; Oliveira and Schlindwein 2009; Alonso et al. 2012). This work aims to contribute an overview of the parasitoid and cleptoparasitic species known to attack *C. analis*, including data about distribution, biology and behavior of natural enemies, and direct observation notes on the behavior of the cleptoparasite *Coelioxys nigrofimbriata* attacking *C. analis* trap nests in Pernambuco, northeastern Brazil.

Material and methods

Field observations

Weekly observations of behavior of adults of *Coelioxys nigrofimbriata* were conducted on trap nests set up at commercial orchard Acerolândia, municipality of Paudalho, Pernambuco, Brazil, from November 2016 to December 2017. Two models of trap nests were used: compact and observation trap-nests. The compact nests were constructed with black cardboard with one end closed and inserted in wood blocks (modified from Garófalo et al. 1989). Each set contained 30 tubes, for a total of 240 cavities distributed in eight blocks. The observation trap nests consisted of linear cavities in wood blocks covered with a transparent plastic sheet fixed with a screw (modified from Cane 2004). Five sets were constructed with 30 tubes each, for a total of 150 cavities. The adult specimens that emerged from these nests were deposited in the entomological collection of the Department of Agronomy, Universidade Federal Rural de Pernambuco (CERPE), Recife, Brazil.

Natural enemies of *Centris analis*

The many natural enemies of bees include parasites, commensals, predators, or scavengers of various organism groups including fungi, nematodes, mites and insects (Wcislo

and Cane 1996). There are only records of cleptoparasite or parasitoids species (ectoparasitoids of immature stages or endoparasitoids of adults) attacking *C. analis*. The cleptoparasite females lay eggs in nest cells, and their larvae consume both the host bee's food provision and the host egg or larva (Michener 2007; Groulx and Forrest 2018). Parasitoids lay eggs within or adjacent to bee larvae or eggs and their larvae develop and consume the bee larva or adult (Yeates and Greathead 1997).

Results and discussion

The literature survey results indicate there are at least 22 species of natural enemies of *C. analis* in three orders of insects: Hymenoptera (3 families and 5 genera), Diptera (3 families and 3 genera) and Coleoptera (1 family and 2 genera) (Table 1). These species can produce 1 to 30% mortality rates in trap-nest studies and can be significant especially in aggregation nests (Aguiar and Martins 2002; Gazola and Garófalo 2003; Alonso et al. 2012). Besides parasitism, Jesus and Garófalo (2000) and Alonso et al. (2012) registered high mortality rates for immature *C. analis* in artificial trap-nests, with up to 60% due to unknown causes. A summary of general information and distribution records of natural enemies is presented below.

APIDAE
Ericrocidini

The tribe Ericrocidini includes 11 genera and 44 species, known only from the New World. All species of this tribe are cleptoparasites, most of them on *Centris* spp. (Rocha-Filho et al. 2009; Martins et al. 2017; Michener 2007), although *Mesoplia* Lepeletier also occurs in nests of *Epicharis* Klug (Rocha-Filho et al. 2008). Host associations are still poorly documented, sometimes only known from indirect observations (Michener 2007). Two species have been recorded in *C. analis* nests: *Aglaomelissa duckei* Snelling & Brooks, 1985 and *Mesocheira bicolor* Lepeletier & Serville, 1825.

Aglaomelissa Snelling and Brooks is a monotypic genus known from Costa Rica and northern South America (Michener 2007, Moure and Melo 2012). Rocha-Filho et al. (2009) reported that *A. duckei* emerged from nests of two species of *Centris* (*Heterocentris*) in the Brazilian Amazon: *Centris analis* and *C. terminata*. Considering the abundance and distribution of *C. analis*, *A. duckei* may be an important parasite in the Amazon region. However, because of the scarcity of information on *A. duckei* hosts, it is not possible to indicate how often this parasitic species attacks *C. analis*, or whether it is specific to *Centris* (*Heterocentris*).

Mesocheira Lepeletier and Serville is also a monotypic genus that occurs throughout the Neotropics, from Mexico to Paraguay. *Mesocheira bicolor* is frequently reported in trap nest studies but little is known about its cleptoparasitic behavior, biology and specificity. This species was recorded parasitizing both *Centris* (*Hemisiella*) and

Centris (*Heterocentris*) species, as follows: *C. dichrootricha* Moure, 1945, *C. nitida* Smith, 1874, *C. tarsata* Smith, 1874, *C. trigonoides* Lepeletier, 1841 and *C. analis* Fabricius, 1804 (Parker 1977; Morato et al. 1999; Jesus and Garófalo 2000; Aguiar and Martins 2002; Gazola and Garófalo 2002; Aguiar and Garófalo 2004; Aguiar et al. 2005). *Centris analis* is the only species of this list in subgenus *Centris* (*Heterocentris*), and the parasitism rates were low considering the wide distribution and the relative frequency of *M. bicolor* in trap-nesting bee studies. In observations performed in trap-nests set in the municipality of Paudalho, *Mesocheira bicolor* females only attacked nests of *C. tarsata*, even though the abundance of *C. analis* nests was much higher in the studied area. Similar patterns were reported by Araújo et al. (2018) and Oliveira-Rebouças et al. (2018). The apparent preference of *M. bicolor* for *C.* (*Hemisiella*) nests may be due to the type of material used by female hosts to construct and/or provision the brood cells. The species of this subgenus are known to use a mixture of sand and oils (Vinson et al. 1996; Morato et al. 1999; Pereira et al 1999) while *C.* (*Heterocentris*) females tend to use plant material and oils (Jesus and Garófalo 2000; Aguiar and Garófalo 2004; Oliveira and Schlindwein 2009). The low rates of parasitism could also be due to the differences in larval foods stored in brood cells. The cell provisions of *C. analis* consist of pollen and nectar without floral oils, which may be a characteristic of the subgenus (Jesus and Garófalo 2000; Aguiar and Garófalo 2004), while *C. tarsata* females use a mixture of pollen, nectar, and oil (Aguiar and Garófalo 2004). Based on the available information, it seems *M. bicolor* is not an effective parasite of *C. analis*, with only occasional occurrence in nests of this species.

Megachilini

The tribe Megachilini includes a large number of taxa with great morphological and behavioral diversity. Most of the cleptoparasitic species belong to the cosmopolitan genus *Coelioxys*, which includes over 200 species in South America (Moure et al. 2012, Michener 2007). Most *Coelioxys* spp. are cleptoparasites of *Megachile*, although there are records of parasitism of other genera of both Megachilinae and Apinae, including *Centris* (Rocha-Filho and Packer 2015; Michener 2007).

Coelioxys spp. have often been recorded as parasites of *C. analis* in samples with trap nests (Table 1). In most of these studies, one single species of *Coelioxys* was observed parasitizing *C. analis* nests, but in several of them the species is not identified due to the lack of taxonomic studies of the genus (Rocha-Filho 2015). The present work reports on vouchers identified to species level for the first time. All specimens examined belonged to *Coelioxys nigrofimbriata* (see references in Table 1). Only Aguiar and Martins (2002) and Gazola and Garófalo (2009) found more than one *Coelioxys* species attacking *C. analis* nests in the same area; two and three, respectively. The material from Gazola and Garófalo (2009) identified as *Coelioxys* aff. *uhleri* from Estação Ecológica de Paulo de Faria actually corresponds to *C. nigrofimbriata*. The other two species reported by Gazola and Garófalo (2009), the material of Aguiar and Martins

Table 1. Summary of records of *Centris analis* natural enemies.

Taxa	Locality	References
HYMENOPTERA		
APIDAE		
Ericrocidini		
Aglaomelissa duckei	BRAZIL: Acre	Rocha-Filho et al. 2009
Mesocheira bicolor	BRAZIL: São Paulo	Jesus and Garófalo 2000; Gazola and Garófalo 2002; Couto and Camillo 2007
Megachilini		
Coelioxys nigrofimbriata	BRAZIL: Pernambuco,	This study
	BRAZIL: São Paulo	Jesus and Garófalo 2000; Gazola and Garófalo 2002; Couto and Camillo 2007; Gazola and Garófalo 2009
Coelioxys spp.	BRAZIL: Minas Gerais	Araújo et al. 2018
	BRAZIL: Paraíba	Aguiar and Martins 2002
	BRAZIL:Paraná	Oliveira and Gonçalves 2017
	BRAZIL: São Paulo	Gazola and Garófalo 2009; Araújo et al. 2018;
CHRYSIDIDAE		
Chrysidini		
Chrysis sp.	BRAZIL: Paraná	Oliveira and Gonçalves 2017
LEUCOSPIDAE		
Leucospis bulbiventris	COSTA RICA: Guanacaste	Cooperband et al. 1999
Leucospis cayennensis	COSTA RICA: Guanacaste	Cooperband et al. 1999
	BRAZIL: São Paulo	Jesus and Garófalo 2000; Gazola and Garófalo 2002, 2003, 2009; Couto and Camillo 2007; Alonso et al. 2012; Moure-Oliveira et al. 2017
Leucospis spp.	BRAZIL: Paraná	Oliveira and Gonçalves 2017
	BRAZIL: São Paulo	Gazola and Garófalo 2009
	BRAZIL: Bahia	Oliveira-Rebouças et al. 2018
DIPTERA		
BOMBYLIIDAE		
Anthracini	BRAZIL: São Paulo	Rocha-Filho et al. 2017
Anthrax oedipus	BRAZIL: São Paulo	Gazola and Garófalo 2009
Anthrax macquarti	BRAZIL: São Paulo	Gazola and Garófalo 2009; Moure-Oliveira et al. 2017; Araújo et al. 2018
Anthrax spp.	BRAZIL: Minas Gerais	Araújo et al. 2018
CONOPIDAE		
Conopini		
Physocephala aurifrons	BRAZIL: São Paulo	Santos et al. 2008; Couto and Camillo 2014
Physocephala benneti	BRAZIL: São Paulo	Santos et al. 2008; Couto and Camillo 2014
Physocephala bipunctata	BRAZIL: São Paulo	Couto and Camillo 2014
Physocephala cayennensis	BRAZIL: São Paulo	Santos et al. 2008; Couto and Camillo 2014
Physocephala inhabilis	BRAZIL: São Paulo	Couto and Camillo 2014
Physocephala rufithorax	BRAZIL: São Paulo	Santos et al. 2008; Couto and Camillo 2014
Physocephala soror	BRAZIL: São Paulo	Santos et al. 2008
Physocephala spheniformis	BRAZIL: São Paulo	Santos et al. 2008; Couto and Camillo 2014
Physocephala sp.	BRAZIL: São Paulo	Santos et al. 2008
PHORIDAE		
Melaloncha sp.	São Paulo: BRAZIL	Ament et al. 2014
COLEOPTERA		
MELOIDAE		
Nemognathini		
Nemognatha sp.	São Paulo: BRAZIL	Gazola and Garófalo 2009
Tetraonycini		
Tetraonyx sp.	Amazonas: BRAZIL	Morato et al. 1999

(2002) and also the other surveys listed in Table 1 as *Coelioxys* spp. could not be examined to confirm the identification at this time.

Behavior of *Coelioxys nigrofimbriata*. This species was described from the state of Amazonas, Brazil, but the observation of specimens in trap-nest studies demonstrated that it is widely distributed in Brazil, occurring from Amazonas to Paraná. *Coelioxys nigrofimbriata* females usually hover in front of the trap nests to locate a nest that is being provisioned. Often, only one or two females of the cleptoparasite bee were seen at the same time in the wooden blocks. The parasite enters, inspects and deposits an egg when the host female is absent. When the amount of larval food is not sufficient, the parasite leaves the nest, lands near the nest entrance and waits for the host to deposit more pollen (up 70 min, according to Gazola and Garófalo 2002). This behavior of ovipositing into open cells, and waiting near the entrance agrees with the general patterns described for the genus (Scott et al. 2000, Michener 2007, Vinson et al. 2011). The females of *C. nigrofimbriata* were observed within 3 to 20 cm of the nest, with the head directed towards the nest entrance, similar to what was described for *Coelioxys chichimeca* Cresson, 1878 (Vinson et al. 2011). Females of *C. analis* that returned from foraging trips expelled parasites that were close to their nests. However, the parasites would return a few minutes later and repeat the behavior. The observations described here agree with the remarks made by Gazola and Garófalo (2002) (cited as *Coelioxys* sp.).

Centris analis was active throughout the year, with nest construction recorded in every month except June and July, while the *C. nigrofimbriata* attacks occurred between November and May. *Centris analis* built 116 nests during the study period, of which 28 were attacked by *C. nigrofimbriata*. Of the 116 nests, 97 were built during the hot and wet season, with the highest frequency occurring in March (n=46). These nests produced 274 individuals of the host species and 32 *C. nigrofimbriata*. The number of brood cells constructed by *C. analis* per nest ranged from one (n= 19) to nine cells (n= 1), with four (n=22) and five (n= 22) cells being the most abundant. Of the 28 nests attacked by cleptoparasite bees, 24 produced only one parasite, and four produced two parasites. The highest frequencies of attacks occurred in the months that *C. analis* had the highest nesting frequencies (January, March and April) (Figure 1). *Coelioxys nigrofimbriata* parasitized exclusively nests of *C. analis* even though there were also nests of *C. tarsata* in the same area. These data demonstrated that parasitism activities of *C. nigrofimbriata* were strongly synchronized and dependent on the construction of nests by *C. analis*.

CHRYSIDIDAE

Chrysididae is a diverse and cosmopolitan family that includes about 3000 species in 80 genera. The biology of chrysidids is still poorly known, with few studies about their hosts (Tormos et al. 1996). The group is classified in four subfamilies known for attacking Phasmatodea as well as other Hymenoptera such as Diprionidae, Tenthredinidae, bees and solitary wasps (Soon and Sarma 2011; Melo et al. 2012). Most species of the subfamily Chrysidinae are parasites of bee and wasp larvae or are cleptoparasites

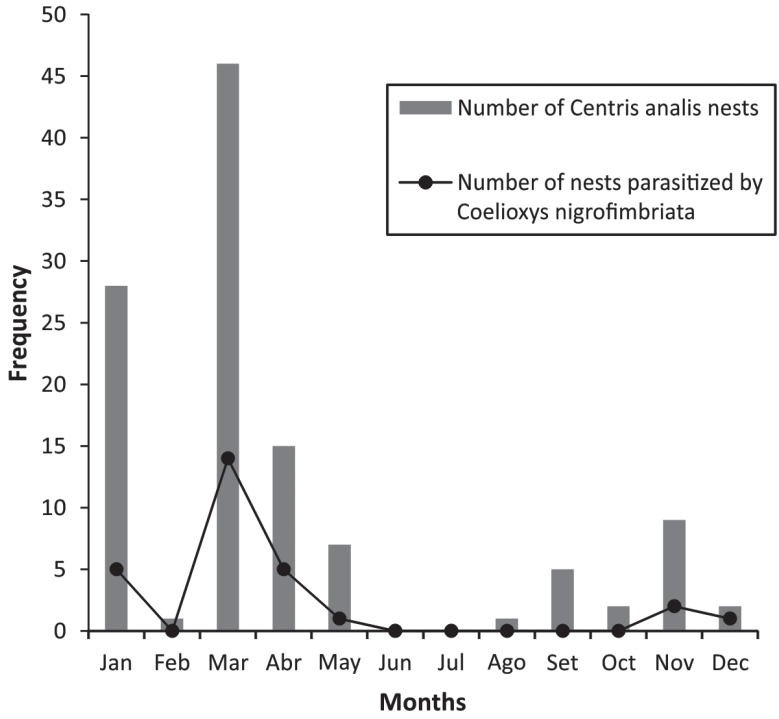

Figure 1. Number of *Centris analis* nests built and number of nests attacked by *Coelioxys nigrofimbriata* from January to December 2017.

of larval provisions of their hosts (Morgan 1984; Melo et al. 2012). Most hosts are solitary wasps that build mud-pot nests or that use preexisting cavities in soil or wood, such as Vespidae, Sphecidae, Crabronidae, and Megachilinae (Pärn et al. 2015; Kimsey 2006; Torretta 2015). The genus *Chrysis* L. is largest genus of the group, but there is little information about their host species. Species of *Chrysis* are known to have various levels of host specialization (Pärn et al. 2015). The only record of a *Chrysis* species parasitizing a nest of *C. analis* was recently published by Oliveira and Gonçalves (2017) in southern Brazil. The data indicates that this species is a non-specific parasite in *C. analis* nests, as these authors also recorded the same species of *Chrysis* attacking nests of *Megachile susurrans* Haliday, 1836 and three species of Vespidae – *Monobia angulosa* Saussure, 1852, *Pachodynerus guadulpensis* (Saussure, 1853) and *Pachodynerus grandis* Willink & Roig-Alsina, 1998.

LEUCOSPIDAE

This family of chalcidoid parasitoids includes four genera and about 141 species distributed worldwide (Lima and Dias 2018; Melo et al. 2012; Noyes 2017), most of them in the genus *Leucospis* Fabricius, with approximately 120 described species

and 45 known to occur in the Neotropical Region (Noyes 2017). These wasps are larval parasitoids of solitary bees (Apidae and Megachilidae) and less frequently aculeate wasps (Sphecidae and Vespidae) (Torreta et al. 2017). Females usually use their ovipositor to drill through the cell walls of the host nest and the immature develops as an ectoparasite feeding on the fluids of the host larva. Hosts are known only for about 30 species (Grissell and Cameron 2002), four of which were reported from nests of *C. analis*: *Leucospis bulbiventris*, *L. cayennensis*, *L. manaica*, and *L.* sp. (Table 1). Among these species, *L. cayennensis* is the most common natural enemy of *C. analis* (Boucek 1974; Gazola and Garófalo 2003). This species also was reported in nests of *Centris tarsata* Smith, 1874 (Chandler et al. 1985), *Centris bicornuta* Mocsáry, 1899, *Centris nitida* Smith, 1874, *Centris vittata* Lepeletier, 1841 (Cooperband et al. 1999), *Centris labrosa* Friese, 1899 (Gazola and Garófalo 2003), *Tetrapedia diversipes* Klug, 1810 (Camillo 2000) and *Tetrapedia curvitarsis* Friese, 1899 (Gazola and Garófalo 2003).

Leucospis cayennensis is widely distributed from Mexico to Argentina. However, the frequency of attacks on nests of *C. analis* is not homogeneous throughout this distribution. This species was associated with nests of *C. analis* only in Costa Rica and the states of Paraná and São Paulo in Brazil (Table 1). The highest rates were observed in studies conducted in São Paulo (Gazola and Garófalo 2002, 2003), with 25% of cell parasitism by *L. cayennensis.* This variation, in addition to the records of *L. cayennensis* in nests of many others species (Torreta et al. 2017), suggests that this wasp is not specific to *C. analis.* However, *Leucospis cayennensis* may still have an important role as natural enemy of *C. analis* in aggregations of trap-nests due to their behavior. Gazola and Garófalo (2003) reported that the parasitoid females may repeatedly return to the nesting area for several days and that a single female can attack up to 24 nests. More details about the biology of this species can be found in Gazola and Garófalo (2002, 2003).

DIPTERA
BOMBYLIIDAE

Bombyliidae is one of the largest families of true flies with over 5000 described species. Their representatives are most abundant and diverse in arid and semiarid regions of the world, with about 450 species in the Neotropical Region (Ávalos-Hernández et al. 2014; Yeates and Greathead 1997; Carvalho et al. 2012). *Anthrax* Scopoli is also a diverse taxon, with 248 species worldwide, whose immature stages are all ectoparasitoids of larvae and pupae of holometabolous insects living in tubular nests or cells (Marston 1970, Ávalos-Hernández et al. 2014). Yeates and Greathead (1997) listed 70 species as ectoparasitoids of larvae and pupae of bees and wasps, and over 300 host records, but available information about host preferences and specificity for the genus is still scarce (Marston 1970). Among the bees, six studies recorded three species of

Anthrax in nests of *C. analis* (Table 1). In all these trap-nest studies, *Anthrax* species seemed to be generalist, emerging from nests of *C. analis* as well as other species of bees and wasps. No additional data was found on the parasitic behavior of *Anthrax* in nests of *C. analis*.

CONOPIDAE

Conopidae is a widespread family of flies with about 780 species and 56 genera (Carvalho et al. 2012). The larvae of species for which biology is known are obligatory endoparasitoids of other insects. Representatives of three subfamilies (Conopinae, Myopinae and Dalmanniinae) are known as internal parasites of aculeate Hymenoptera, and some species may have a negative effect on populations of pollinators (Gibson et al. 2013; Melo et al. 2008). Females attack adult bees, inserting an egg on or within the bee's abdomen while they are foraging, or in flight. The larva develops inside the abdomen of the host, feeding on internal tissue and hemolymph, and pupates in situ, killing the host (Santos et al. 2008).

Species of the genus *Physocephala* Schiner are solitary koinobiont endoparasitoids of several genera of bees such as *Anthidium* Fabricius, *Anthophora* Latreille, *Apis* Linnaeus, *Bombus* Latreille, *Centris* Fabricius, *Epicharis* Klug, *Eulaema* Lepeletier, *Euglossa* Latreille, *Halictus* Latreille, *Megachile* Latreille, and *Xylocopa* Latreille (Rasmussen and Cameron 2004; Melo et al. 2008; Santos et al. 2008; Couto and Camillo 2014). Santos et al. (2008) reported on conopid flies attacking *C. analis* and recorded nine species of *Physocephala* in southeastern Brazil (Table 1). Couto and Camillo (2014) also recorded eight *Physocephala* species emerging from dead specimens of *C. analis*. Couto and Camillo (2014) also observed that parasitized females present behavioral changes, and deposited extra oil on the nest occlusion or closed empty nests. These parasitic associations do not appear to be specific, but impact the behavior of the female bees. Behavior data for *C. analis* are still scarce, but these parasitic flies can have a high incidence of attacks and decrease bee populations as reported for *Bombus* spp. by Abdalla et al. (2014) and Malfi et al. (2014).

PHORIDAE

Phoridae is a cosmopolitan family of flies with over 4000 described species (Brown and Smith 2010). Many species are well known as parasitoids of corbiculate bees such as stingless bees, bumblebees and honey bees (Lucia et al. 2013; Ament et al. 2014). There are also records of species of *Melaloncha* Brues attacking Augochlorini (Halictidae) (Wcislo et al. 2004), Centridini (Apidae) and Euglossini (Apidae) species (Ament et al. 2014). The genus occurs only in the Neotropical Region and comprises the largest group of bee-killing parasitoids, with 167 described species. Female flies attack bees

by injecting an egg into their body through the membrane between sclerites and the larvae develop as internal parasitoids, consuming and killing the hosts (Brown 2004; Brown and Smith 2010; Brown 2016). The record is exceptional and it is based on the observation of a puparium removed from the mesosoma of a *Centris analis* (Ament et al. 2014).

COLEOPTERA
MELOIDAE

Meloidae is a family of beetles that includes almost 2500 species in approximately 120 genera. Meloid larvae are known as parasites of grasshoppers and larvae of Apoidea or other aculeate Hymenoptera (Bologna and Pinto 2001; Lückmann and Assmann 2006). The family has a distinctive form of metamorphosis, with the presence of a triungulin first instar in most taxa. This first instar, depending on the group, feeds on eggs of Acridoidea or provisions and larvae of Apoidea or other aculeate Hymenoptera. In the taxa that attack apoid hosts, the triungulin is phoretic, and is taken to the larval food indirectly by the adult bees that visit flowers (Bologna and Pinto; 2001). Some species have been documented as parasites of *Melitoma* Lepeletier and Serville (Roubik 1989), *Epicharis* Klug (Gaglianone 2005), *Monoeca* Lepeletier and Serville (Rozen et al. 2006) and *Eufriesea* Cockerell (Kamke et al. 2008). *Tetraonyx* Latreille (Morato et al. 1999) and *Nemognatha* Illiger (Gazola and Garófalo 2009) were recorded in *C. analis* nests trap-nest surveys, but without species-level identification, information about the biology or parasitic behavior.

Conclusion

Although there are many studies about the life history of *C. analis* (see Jesus and Garófalo 2000; Alonso et al. 2012; Couto and Camillo 2014), much still needs to be described, especially regarding interactions with natural enemies. With the exception of the detailed observations made by Gazola and Garófalo (2003) about *L. cayennensis*, little is known about behavioral strategies of species attacking *C. analis*. Most records are scattered, and lack information about biology and parasitism rates (Wcislo and Cane 1996). Aspects such as parasite-host synchronicity and the effects of the presence of multiple natural enemies on the same populations of *C. analis* need to be better investigated. In addition, up to 70% of the mortality rates in immature stages of the trap nests are due to unknown causes (Oliveira and Schlindwein 2009; Alonso et al. 2012). Bacteria, fungi, mites and viruses may be responsible for part of this mortality in *C. analis*, but are still unknown. Pathogenic fungi, for example, are known to cause diseases in solitary bees (*Megachile rotundata* and *Osmia* spp.) leading to high levels of mortality in managed populations (Bosch and Kemp 2002).

The present work aimed to summarize available information on natural enemies and contribute to the taxonomic identification of the *Coelioxys* spp. that attack *C. analis* (Table 1). The new data about distribution, biology and behavior of *Coelioxys nigrofimbriata* provide a new perspective on the intricate relationships between host and cleptoparasitic bees. The other species of natural enemies of *C. analis* listed here do not seem to have this strong association. However, some of them can also reach high parasitism rates, such as *Leucospis cayennensis*. Therefore advanced studies about natural enemies of *Centris analis* are necessary to make commercial rearing feasible. As pointed out by Bosch and Kemp (2002) the mortality levels often decrease as knowledge on the developmental biology of the pollinator increases, and rearing methods are improved.

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References

Abdalla FC, Sampaio G, Pedrosa M, Sipriano TP, Domingues CEC, Silva-Zacarin ECM, Camargo DA (2014) Larval development of *Physocephala* (Diptera, Conopidae) in the bumble bee *Bombus morio* (Hymenoptera, Apidae). Revista Brasileira de Entomologia 58: 343–348. https://doi.org/10.1590/S0085-56262014000400003

Aguiar AJC, Martins CF (2002) Abelhas e vespas solitárias em ninhos-armadilha na Reserva Biológica Guaribas (Mamanguape, Paraíba, Brasil). Revista Brasileira de Zoologia 19: 101–116. https://doi.org/10.1590/S0101-81752002000500005

Aguiar CML, Garófalo CA (2004) Nesting biology of *Centris* (*Hemisiella*) *tarsata* Smith (Hymenoptera, Apidae, Centridini). Revista Brasileira de Zoologia 21: 477–486. https://doi.org/10.1590/S0101-81752004000300009

Aguiar CML, Garófalo CA, Almeida GF (2005) Trap-nesting bees (Hymenoptera, Apoidea) in areas of dry semideciduous forest and caatinga, Bahia. Brazil. Revista Brasileira de Zoologia 22: 1030–1038. https://doi.org/10.1590/S0101-81752005000400031

Alonso J, Silva J, Garófalo C (2012) The effects of cavity length on nest size, sex ratio and mortality of *Centris* (*Heterocentris*) *analis* (Hymenoptera, Apidae, Centridini). Apidologie 43: 436–448. https://doi.org/10.1007/s13592-011-0110-0

Ament D, Freiria G, Rocha-Filho LC, Lama M, Garófalo CA (2014) A scientific note on the first records of *Melaloncha* Brues, 1904 (Diptera: Phoridae) parasitizing Euglossini and Centridini bees. Apidologie 45: 266–268. https://doi.org/10.1007/s13592-013-0246-1

Araújo GJ, Fagundes R, Antonini Y (2018) Trap-nesting Hymenoptera and their network with parasites in recovered riparian Forests Brazil. Neotropical Entomology 47: 26–36. https://doi.org/10.1007/s13744-017-0504-4

Ávalos-Hernández O, Kits J, Trujano-Ortega M, García-Vázquez UO, Cano-Santana Z (2014) New records of bee flies (Diptera, Bombyliidae) from Cuatro Ciénegas, Coahuila, Mexico. ZooKeys 422: 49–85. https://doi.org/10.3897/zookeys.422.7598

Bologna MA, Pinto JD (2001) Phylogenetic studies of Meloidae (Coleoptera), with emphasis on the evolution of phoresy. Syst Entomol 26: 33–72. https://doi.org/10.1046/j.1365–3113.2001.00132.x

Bosch J, Kemp WP (2002) Developing and establishing bee species as crop pollinators: the example of Osmia spp. (Hymenoptera: Megachilidae) and fruit trees. Bulletin of Entomological Research 92: 3–16.

Boucek Z (1974) A revision of the Leucospidae of the World. Bulletin of the British Museum (Natural History), Entomology, Supplement 23: 1–24.

Brown B (2016) Two new bee-killing flies from Brazil (Insecta: Diptera: Phoridae: Melaloncha). Biodiversity Data Journal 4: e7715. https://doi.org/10.3897/BDJ.4.e7715

Brown BV, Smith PT (2010) The bee-killing flies, genus *Melaloncha* Brues (Diptera: Phoridae): a combined molecular and morphological phylogeny. Systematic Entomology 35: 649–657. https://doi.org/10.1111/j.1365-3113.2010.00540.x

Brown BV (2004) Revision of the subgenus *Udamochiras* of *Melaloncha* bee-killing flies (Diptera: Phoridae: Metopininae). Zoological Journal of Linnean Society, London 140: 1–42. https://doi.org/10.1111/j.1096-3642.2004.00086.x

Camillo E (2000) Biologia de quatro especies de Tetrapedia em ninhos armadilha (Hymenoptera, Apidae, Tetrapediini). PHD Thesis, Universidade de São Paulo.

Cane JH (2004) Exposing their progeny: using X-rays and observation nests to study and manipulate cavity-nesting bees. In Proceedings of the 8th IBRA International Conference on Tropical Bees and VI Encontro sobre Abelhas. Ribeirão Preto, SP, 99–100.

Carvalho CJB, Rafael JAR, Couri MS, Silva VC (2012). Diptera. In: Rafael J, Melo GAR, Carvalho CJB, Casari AS, Constantino R (Eds) Insetos do Brasil. Diversidade e Taxonomia. Holos. Ribeirão Preto, 701–743.

Chandler L, Barrigosi JAF, Diaz EBS (1985) The first definitive host record for *Leucospis cayennensis* Westwood (Hymenoptera: Leucospidae). Revista Ceres 32: 170–174.

Cooperband MF, Wharton RA, Frankie GW, Vinson SB (1999) New host and distribution records for *Leucospis* (Hymenoptera: Leucospidae) associated primarily with nests of *Centris* (Hymenoptera: Anthophoridae) in the dry forests of Costa Rica. Journal of Hymenoptera Research 8: 153–164.

Couto RM, Camillo E (2014) Deposições de óleo por fêmeas de *Centris analis* (Fabricius) (Hymenoptera: Apidae: Centridini) parasitadas por *Physocephala* spp. (Diptera: Conopidae). EntomoBrasilis 7: 81–85. https://doi.org/10.12741/ebrasilis.v7i2.382

Couto RM, Camillo E (2007) Influência da temperatura na mortalidade de imaturos de *Centris* (*Heterocentris*) *analis* (Hymenoptera, Apidae, Centridini). Iheringia 97: 51–55. https://doi.org/10.1590/S0073-47212007000100008

Dórea MC, Aguiar CML, Figueroa LER, Lima LCL, Santos FAR (2010) Residual pollen in nests of *Centris analis* (Hymenopera, Apidae, Centridini) in an area of Caatinga vegetation from Brazil. Oecologia Australis: 14: 232–237. https://doi.org/10.4257/oeco.2010.1401.13

Garófalo CA, Camillo E, Serrano JC (1989) Espécies de abelhas do gênero *Centris* (Hymenoptera, Anthophoridae) nidificando em ninhos armadilhas. Ciência Cultural 41: 799

Gaglianone MC (2005) Nesting biology, seasonality, and flower hosts of *Epicharis nigrita* (Friese, 1900) (Hymenoptera: Apidae: Centridini), with a comparative analysis for the genus. Studies of Neotropical Fauna and Environment 40: 191–200. https://doi.org/10.1080/01650520500250145

Gazola AL, Garófalo CA (2009) Trap-nesting bees (Hymenoptera: Apoidea) in forest fragments of the State of São Paulo, Brazil. Genetics and Molecular Research 8: 607–622. https://doi.org/10.4238/vol8-2kerr016

Gazola AL, Garófalo CA (2003) Parasitic behavior of *Leucospis cayennensis* Westwood (Hymenoptera, Leucospidae) and rates of parasitism in populations of *Centris* (*Heterocentris*) *analis* (Fabricius 1804) (Hymenoptera: Apidae: Centridini). Journal of Kansas Entomological Society 76: 131–142.

Gazola AL, Garófalo CA (2002) Comportamento dos inimigos naturais de *Centris* (*Heterocentris*) *analis* (Hymenoptera: Apidae). In Del Claro K (Ed.) Anais do II Simpósio de Ecologia Comportamental e de Interações. Uberlândia, Brasil: 0–17.

Gibson JF, Skevington JH (2013) Phylogeny and taxonomic revision of all genera of Conopidae (Diptera) based on morphological data. Zoological Journal of Linnean Society, London: 167: 43–81. https://doi.org/10.1111/j.1096-3642.2012.00873.x

Grissell EE, Cameron SA (2002) A new *Leucospis* Fabricius (Hymenoptera: Leucospidae), the first reported gregarious species. Journal of Hymenoptera Research 11: 271–278.

Groulx AF, Forrest JRK (2018) Nesting aggregation as a predictor of brood parasitism in mason bees (*Osmia* spp.). Ecological Entomology 43: 182–191. https://doi.org/10.1111/een.12484

Jesus MBV, Garófalo CA (2000) Nesting behaviour of *Centris* (*Heterocentris*) *analis* in southeastern Brazil (Hymenoptera, Apidae, Centridini). Apidologie 31: 503–513. https://doi.org/10.1051/apido:2000142

Kamke R, Zillikens A, Heinle S, Steiner J (2008) Natural enemies and life cycle of the orchid bee *Eufriesea smaragdina* (Hymenoptera: Apidae) reared form trap nests. Journal of the Kansas Entomological Society 82: 202–209. https://doi.org/10.2317/JKES-703.26.1

Kimsey LS (2006) Chrysididae. In: Handson PE, Gauld ID Hymenoptera de la región Neotropical. The American Entomologial Institute, Gainesville 77: 544–550.

Lima AR, Dias PG (2018) The New World species of Leucospis Fabricius, 1775 (Hymenoptera, Chalcidoidea, Leucospidae): an update of Bouček's revision with description of two new species from Brazil. Zootaxa 4441: 1–45. https://doi.org/10.11646/zootaxa.4441.1.1

Lucia M, Alvarez LJ, Abrahamovich AH (2013) First record of Melaloncha (Diptera: Phoridae) parasitoid associated with Bombus (Apidae: Bombini) in Argentina. Journal of Apicultural Research 52: 72–73. https://doi.org/10.3896/IBRA.1.52.2.15

Lückmann J, Assmann T (2006) Reproductive biology and strategies of nine meloid beetles from Central Europa (Coleoptera: Meloidae). Journal of Natural History 39: 4101–4125. https://doi.org/10.1080/00222930500533823

Magalhães CB, Freitas BM (2013) Introducing nests of the oil-collecting bee *Centris analis* (Hymenoptera: Apidae: Centridini) for pollination of acerola (*Malpighia emarginata*) increases yield. Apidologie 44: 234–239. https://doi.org/10.1007/s13592-012-0175-4

Malfi RL, Roulston TAH (2014) Patterns of parasite infection in bumble bees (*Bombus* spp.) of Northern Virginia. Ecological Entomology 39: 17–29. https://doi.org/10.1111/een.12069

Marston N (1970) Revision of New World species of *Anthrax* (Diptera: Bombyliidae), other than the *Anthrax albofasciatus* group. Smithsonian Institution Press, Washington, DC.: 1–149. https://doi.org/10.5479/si.00810282.43

Martins AC, Luz DR, Melo GAR (2017) Palaeocene origin of the Neotropical lineage of cleptoparasitic bees Ericrocidini-Rhathymini (Hymenoptera, Apidae). Systematic Entomology 43: 510–521. https://doi.org/10.1111/syen.12286

Melo GAR, Aguiar AP, Garcete-Barrett BR (2012) Hymenoptera. In: Rafael J, Melo GAR, Carvalho CJB, Casari AS, Constantino R (Eds) Insetos do Brasil. Diversidade e Taxonomia. Holos, Ribeirão Preto, 553–612.

Melo GAR, Faria-Junior LRR, Marchi P, Carvalho CJB (2008) Small orchid bees are not safe: parasitism of two species of *Euglossa* (Hymenoptera: Apidaea: Euglossina) by conopid flies (Diptera: Conopidae). Revista Brasileira de Zoologia 25: 573–575. https://doi.org/10.1590/S0101-81752008000300028

Michener CD (2007) The Bees of the World. The John Hopkins University Press, Baltimore.

Morato EF, Garcia MVB, Campos LAO (1999) Biologia de *Centris* Fabricius (Hymenoptera, Anthophoridae,Centridini) em matas contínuas e fragmentos na Amazônia Central. Revista Brasileira de Zoologia 16: 1213–1222. https://doi.org/10.1590/S0101-81751999000400029

Morgan D (1984) Cuckoo-Wasps (Hymenoptera, Chrysididae). Handbooks for the Identification of British Insects. Vol. 6. Royal Entomological Society of London, London.

Moure JS, Melo GAR (2012) Centridini Cockerell and Cockerell, 1901. In: Moure JS, Urban D, Melo GAR (Eds) Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region – Online Version. http://moure.cria.org.br/index

Moure JS, Melo GAR, DalMolin A (2012) Megachilini Latreille, 1802. In: Moure JS, Urban D, Melo GAR (Eds) Catalogue of Bees (Hymenoptera, Apoidea) in the Neotropical Region – Online Version. http://moure.cria.org.br/index. [Accessed 20 October 2017]

Moure-Oliveira D, Rocha-Filho LC, Ferreira-Caliman MJ, Garófalo CA (2017) Nesting dynamic and sex allocation of the oil-collecting bee *Centris* (*Heterocentris*) *analis* (Fabricius, 1804) (Apidae: Centridini), Journal of Natural History. https://doi.org/10.1080/00222933.2017.1324052

Noyes JS (2017) Universal Chalcidoidea Database. World Wide Web electronic publication. http://www.nhm.ac.uk/chalcidoids. [Accessed 25 October 2018]

Oliveira-Rebouças P, Aguiar CML, Ferreira VS, Sodré GS, Carvalho CAL,Gimenes M (2018) The cavity-nesting bee guild (Apoidea) in a Neotropical sandy coastal plain. Sociobiology 65: 706–713. https://doi.org/10.13102/sociobiology.v65i4.3339

Oliveira OS, Gonçalves RB (2017) Trap-nesting bees and wasps (Hymenoptera, Aculeata) in a Semidecidual Seasonal Forest Fragment, Southern Brazil. Papéis Avulsos de Zoologia 57: 149–156. https://doi.org/10.11606/0031-1049.2017.57.13

Oliveira R, Schlindwein C (2009) Searching for a manageable pollinator for acerola orchards: The solitary oil-collecting bee *Centris analis* (Hymenoptera: Apidae: Centridini). Journal of Economic Entomology 102: 265–273. https://doi.org/10.1603/029.102.0136

Parker FD (1977) Biological notes on some Mexican bees (Hymenoptera: Megachilidae, Anthophoridae), Pan-Pac Entomologist 53: 189–192.

Pärn M, Soon V, Vallisoo T, Hovi K, Luig J (2015) Host specificity of the tribe Chrysidini (Hymenoptera: Chrysididae) in Estonia ascertained with trap-nesting. European Journal of Entomology 112: 91–99. https://doi.org/10.14411/eje.2015.012

Pereira M, Garófalo CA, Camillo E, Serrano, JC (1999) Nesting biology of *Centris* (*Hemisiella*) *vittata* Lepeletier in southeastern Brazil (Hymenoptera, Apidae, Centridini). Apidologie 30: 327–338. https://doi.org/10.1051/apido:19990409

Rabelo LS, Vilhena AMGF, Bastos EMAF, Augusto SC (2014) Differentiated use of pollen sources by two sympatric species of oil-collecting bees (Hymenoptera: Apidae). Journal of Natural History 48: 25–26. https://doi.org/10.1080/00222933.2014.886342

Rasmussen C, Cameron SA (2004) Conopid Fly (Diptera: Conopidae) Attacking Large Orchid Bees (Hymenoptera: Apidae: Eulaema). Journal of Kansas Entomological Society 77: 61–62. https://doi.org/10.2317/0306.16.1

Rocha-Filho LC, Packer L (2015) Revision of the Neotropical subgenera *Coelioxys* (*Platycoelioxys*) Mitchell and *C.* (*Rhinocoelioxys*) Mitchell (Hymenoptera; Megachilidae) with the description of one new species. Zootaxa 3941: 151–203. https://doi.org/10.11646/zootaxa.3941.2.1

Rocha-Filho LC (2015) A contribution to the taxonomy of the cleptoparasitic bee subgenus *Cyrtocoelioxys* Mitchell of Coelioxys Latreille (Hymenoptera: Megachilidae). Annales Zoologici 65: 687–703. https://doi.org/10.3161/00034541ANZ2015.65.4.011

Rocha-Filho LC, Morato EF, Melo GAR (2009) New host records of *Aglaomelissa duckei* and compilation of host associations of Ericrocidini bees (Hymenoptera: Apidae). Revista Brasileira de Zoologia 26: 299–304. https://doi.org/10.1590/S1984-46702009000200012

Rocha-Filho LC, Silva CI, Gaglianone MC,Augusto SC (2008) Nesting behavior and natural enemies of *Epicharis* (*Epicharis*) *bicolor* Smith (Hymenoptera: Apidae). Tropical Zoology 21: 227–242.

Roubik DW (1989) Ecology and natural history of tropical bees, Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511574641

Rozen Jr JG, Melo GAR, Aguiar AJC, Alves-dos-Santos IA (2006) Nesting biologies and immature stages of the Tapinotaspidine bee genera *Monoeca* and *Lanthanomelissa* and of their Osirine Cleptoparasites *Protosiris* and *Parepeolus* (Hymenoptera: Apidae: Apinae). American Museum Novitates 3501: 1–60. https://doi.org/10.1206/0003-0082(2006)501[0001:NBAISO]2.0.CO;2

Santos AM, Serrano JC, Couto RM, Rocha LSG, Mello-Patiu CA, Garófalo CA (2008) Conopid flies (Diptera: Conopidae) parasitizing *Centris* (*Heterocentris*) *analis* (Fabricius) (Hymenoptera: Apidae, Centridini). Neotropical Entomology 37: 606–608. https://doi.org/10.1590/S1519-566X2008000500018

Scott VL, Kelley ST, Strickler K (2000) Reproductive biology of two *Coelioxys* cleptoparasites in relation to their *Megachile* hosts (Hymenoptera: Megachilidae). Annales of Entomological Society of America 93: 941–948. https://doi.org/10.1603/0013-8746(2000)093[0941:RBOTCC]2.0.CO;2

Soon V, Sarma U (2011) Mitochondrial phylogeny of the *Chrysis ignita* (Hymenoptera: Chrysididae) species group based on simultaneous Bayesian alignment and phylogeny reconstruction. Molecular Phylogenetics and Evolution 60: 13–20. https://doi.org/10.1016/j.ympev.2011.04.005

Torretta JP, Molina GAR, Aquino DA (2017) Life cycles and host-parasitoid relationships of five species of *Leucospis* wasps in Argentina (Hymenoptera: Leucospidae). Journal of Natural History. https://doi.org/10.1080/00222933.2017.1353151

Torretta JP (2015) Host-parasite relationships and life cycles of cuckoo wasps in agro-ecosystems in Argentina (Hymenoptera: Chrysididae: Chrysidini). Journal of Natural History 49:1641–1651. https://doi.org/10.1080/00222933.2015.1005710

Tormos J, Asis JD, Gayubo SF, Mingo E (1996) Description of the mature larvae of *Chrysis gracillima* and *Omalus biaccinctus* and new data on the biology of *Trichrysis cyanea* (Hymenoptera: Chrysididae). Florida Entomologist 79: 56–63. https://doi.org/10.2307/3495754

Vilhena AMGF, Rabelo LS, Bastos EMAF, Augusto SC (2012) Acerola pollinators in the savanna of Central Brazil: temporal variations in oil-collecting bee richness and a mutualistic network. Apidologie 43: 51–62. https://doi.org/10.1007/s13592-011-0081-1

Vinson SB, Frankie GW, Willians HJ (1996) Chemical ecology of bees of the genus *Centris* (Hymenoptera: Apide). Florida Entomologist 79: 109–129. https://doi.org/10.2307/3495809

Vinson SB, Frankie G, Rao A (2011) Field behavior of parasitic *Coelioxys chichimeca* (Hymenoptera: Megachilidae) toward the host bee *Centris bicornuta* (Hymenoptera: Apidae). Apidologie 42: 117–127. https://doi.org/10.1051/apido/2010041

Wcislo WT, Arneson L, Roesch K, Gonzalez V, Smith A, Fernández H (2004) The evolution of nocturnal behaviour in sweat bees, *Megalopta genalis* and *M. ecuadoria* (Hymenoptera: Halictidae): an escape from competitors and enemies? Biological Journal of Linnean Society 83: 377–387. https://doi.org/10.1111/j.1095-8312.2004.00399.x

Wcislo WT, Cane JH (1996) Floral resource utilization by solitary bees (Hymenoptera: Apoidea) and exploitation of their stored foods by natural enemies. Annual Reviews of Entomology 41: 257–286. https://doi.org/10.1146/annurev.en.41.010196.001353

Yeates DK, Greathead D (1997) The evolutionary pattern of host use in the Bombyliidae (Diptera): a diverse family of parasitoid flies. Biological Journal of Linnean Society 60: 149–185. https://doi.org/10.1111/j.1095-8312.1997.tb01490.x

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First contribution to the study of the genus *Micatagla* Argaman, 1994 (Hymenoptera, Bradynobaenidae, Apterogyninae) in the fauna of Saudi Arabia, with the description of four new species

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Abstract

The species of the genus *Micatagla* Argaman (Bradynobaenidae: Apterogyninae) in Saudi Arabia are reviewed. A single species, *M. antropovi* Pagliano, 2002, has previously been reported from Abu Arish (Jazan region, Saudi Arabia). Four new species based on females are described and illustrated in the present paper: *M. fuscogaster* **sp. nov.** and *M. reemae* **sp. nov.** (Garf Raydah Natural Reserve, Asir region), *M. saudita* **sp. nov.** (Wadi Hanifah, Riyadh region) and *M. similis* **sp. nov.** (Shada Al-Ala Natural Reserve, Al-Baha region). An illustrated key to the females and an annotated faunistic list of all *Micatagla* species of Saudi Arabia are also provided.

Keywords

faunistic list, females, *Micatagla*, new species, Saudi Arabia

Introduction

The genus *Micatagla* Argaman, 1994 is one of the largest genera of Bradynobaenidae and the most speciose in the subfamily Apterogyninae (Pagliano 2002). It currently comprises 54 species (Pagliano 2002, Pagliano and Romano 2013, Gadallah and Soliman 2014, Lo Cascio and Pagliano 2014, Pagliano and Romano 2018). Almost all of them are found in the Afrotropical Region (Pagliano 2002, Lo Cascio and Pagliano 2012). Only four species, *M. antropovi* Pagliano, 2002, *M. ezzati* Gadallah & Soliman, 2014, *M. klugi* (André, 1899), and *M. pseudorainerii* Gadallah & Soliman, 2014, are Palearctic (Pagliano 2002, Gadallah and Soliman 2014).

The genus *Micatagla* was first proposed by Argaman (1994) in his generic synopsis of Apterogyninae, represented by a single species, *M. schultzei* (André, 1909). Species of this genus are usually small to medium-sized (4.0–18 mm in length). They are entirely red (*M. schultzei*), red mixed with dark ferruginous, or black. Only a few species are entirely black (Pagliano 2002, Pagliano and Romano 2012, Gadallah and Soliman 2014, Lo Cascio and Pagliano 2014). They are characterized by the following: eyes small in female, distant from occipital carina by at least its own diameter; female third metasomal tergite (T3) without yellow spots at base; male hind trochanter with ventral lamella, and brachial cell of fore wing closed, except open in *M. noorti*. Nothing is known about the biology of *Micatagla* species (Pagliano 2002).

No study has so far focused on the taxonomy of *Micatagla* in Saudi Arabia. Only two species are known to occur in the whole Arabian Peninsula: *M. antropovi* (Saudi Arabia, Yemen) (Pagliano 2002), and *M. hejeki* (Yemen) (Lo Cascio and Pagliano 2014). Four new species are described herein: *M. fuscogaster* (Asir), *M. reemae* (Asir), *M. saudita* (Riyadh) and *M. similis* (Al-Baha). An illustrated key to females of all *Micatagla* species from Saudi Arabia, as well as a faunistic list are also provided.

Material and methods

The specimens were collected from Riyadh region (Riyadh – Wadi Hanifah), Al-Baha region (Al-Mukhwah – Shada Al-Ala Natural Reserve; Mandaq – Amadan) and Asir region (Abha – Garf Raydah Natural Reserve) (Fig. 1A–C). Sampling was done by means of pitfall trap and some specimens were hand collected around light trap; the collected specimens were pinned directly for identification and further studies. The type materials of the new species are deposited in Efflatoun Bey Collection (EFC), Entomology Department, Faculty of Science, Cairo University, Egypt, and King Saud University Museum of Arthropods (KSMA), Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia.

Morphological terms as well as descriptions follow Pagliano (2002). Body sculpture terminology follows Harris (1979).

Photographic images were taken using a Canon EOS 70D attached to LEICA MZ 125 stereomicroscope. Individual source images were then stacked using HeliconFocus

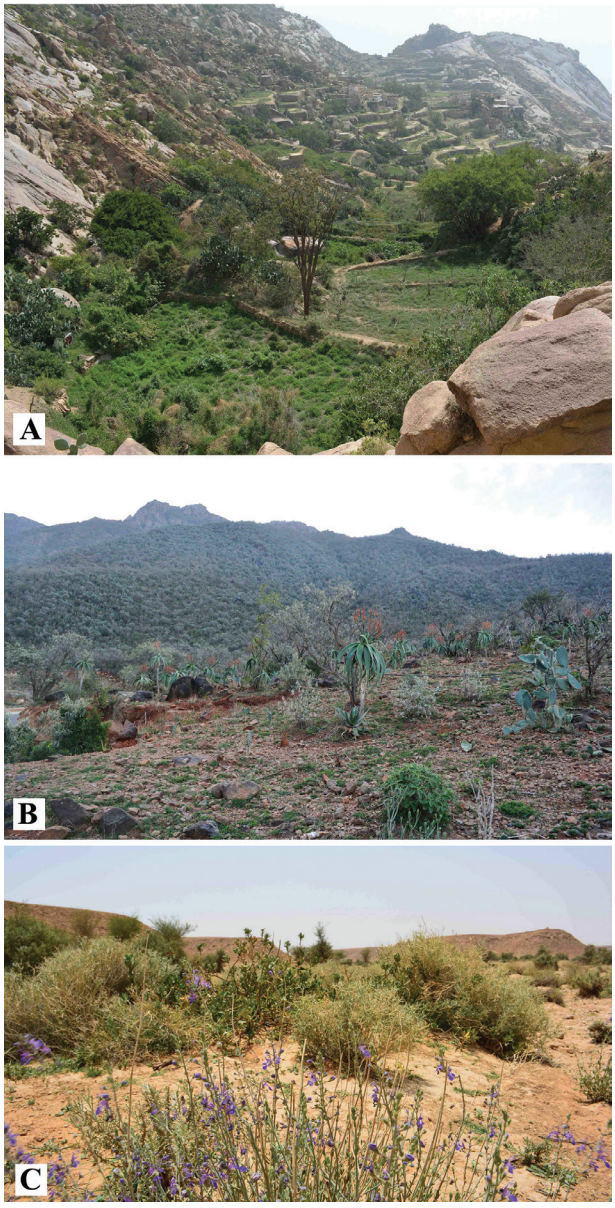

Figure 1. Examples of habitat where specimens of *Micatagla* species (females) were collected. **A** Shada Al-Ala Natural Reserve (Al-Baha) **B** Garf Raydah Natural Reserve (Asir) **C** Wadi Hanifah (Riyadh).

v6.22 (HeliconSoft LTD) extended depth of field software. Further image processing done by using the software Adobe Photoshop Lightroom 5.2 final [ChingLiu]. Measurements were made using an ocular micrometer. The distribution of the collecting sites (Fig. 2) is plotted using DIVA-GIS (v. 7.17).

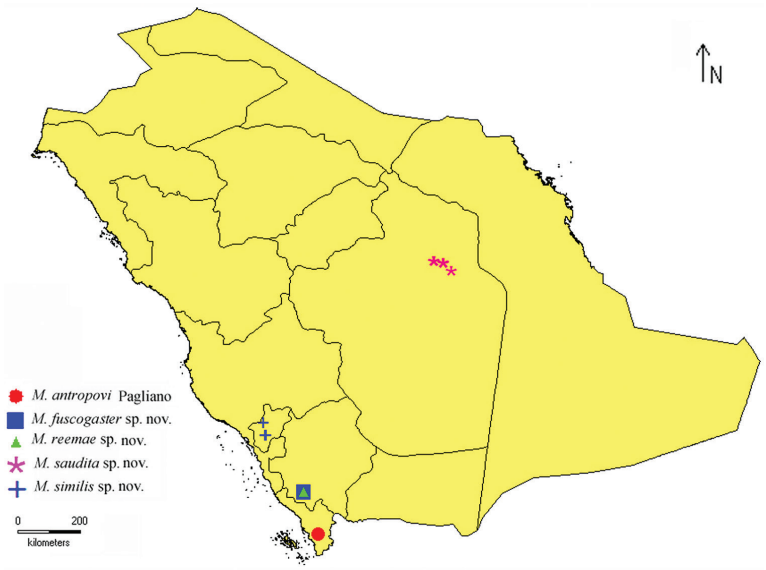

Figure 2. Distributional map of collection localities of *Micatagla* species in Saudi Arabia.

Collection sites

Al-Baha Region: Amadan [20°12'09"N, 41°13'54"E, alt. 1881m]. **Shada Al-Ala Natural Reserve** (Fig. 1A): Cactus 2 [19°50'24"N, 41°18'41"E, alt. 1611m]; Cactus 3 [19°50'20"N, 41°18'36"E, alt.1563m]; Acacia 1 [19°50'42"N, 41°18'16"E, alt. 1474m]; Acacia 2 [19°51'04"N, 41°18'02"E, alt.1325m].

Asir Region: Garf Raydah Natural Reserve (Fig. 1B): Juniper 2 [18°12'19"N, 42°24'36"E, alt. 2761m]; Juniper 3 [18°12'06"N, 42°24'32"E, alt. 2578m]; Olive 1 [18°11'53"N, 42°24'26"E, alt. 2387m]; Olive 3 [18°11'42"N, 42°23'49"E, alt. 1897m].

Riyadh Region: Wadi Hanifah (Fig. 1C): WHN01 [24°54'19"N, 46°11'19"E, alt. 698m]; WHN05 [24°53'56"N, 46°10'32"E, alt. 818m]; WHS01 [24°52'12"N, 46°27'24"E, alt. 707m]; WHS02 [24°52'08"N, 46°27'27"E, alt. 698m]; WHS03 [24°52'03"N, 46°27'30"E, alt. 646m]; WHS05 [24°51'53"N, 46°27'40"E, alt. 693m]; WHU02 [24°36'40"N, 46°41'18"E, alt. 584m].

Abbreviations:

F	antennal flagellomere;	T	metasomal tergite;
GRNR	Garf Raydah Natural Reserve;	WHN	Wadi Hanifah, natural habitat;
HP	hand picking;	WHS	Wadi Hanifah, semi-natural habitat;
LT	light trap;		
PT	pitfall trap;	WHU	Wadi Hanifah urbanization habitat.
S	metasomal sternite;		
SANR	Shada Al-Ala Natural Reserve;		

Systematic account

Key to the species of *Micatagla* (females) in Saudi Arabia

1 T4 & T5 dark reddish brown to blackish brown (Fig. 12A, B); T3 with or without apical faint yellow band (Fig. 12A, B); T2 with sparse posteromedial row of silver setae, absent laterally (Figs 11A, B, 12A, B); eyes weakly bulged laterally when seen from dorsal or frontal views (Figs 6A, B, 7A, B) **2**

– T4 & T5 bright red to yellow (Fig. 12C, D); T3 with distinct apical yellow band (Fig. 12C, D); T2 with row of dense silver setae, extending along the whole length of posterior margin (Figs 11C, D, 12C, D); eyes clearly bulged laterally (Figs 6C, D, 7C, D) **3**

2 Face covered with dense pale setae (Fig. 6A); vertex broadly convex (Fig. 6A); mandible with two, very small teeth subapically; T2 and T3 with coarse ridges between ellipsoid punctures (Fig. 12A); T6 with 10–12 longitudinal close ridges (Fig. 14A)..... ***M. fuscogaster*** **Soliman & Gadallah, sp. nov.**

– Face asetose (Fig. 6B); vertex narrowly convex, semi-rounded (Fig. 6B); mandible edentate (Fig. 6B); T2 & T3 with fine ridges between ellipsoid punctures (Fig. 12B); T6 with eight longitudinal ridges widely spaced (Fig. 14B)..... ..... ***M. reemae*** **Gadallah & Soliman, sp. nov.**

3 Mesosomal dorsum beyond pronotum striatofoveate (Fig. 9C); metasomal T2 & T3 with dense, fine close longitudinal ridges, impunctate (Fig.12C); T6 reddish, with darker red lateral and posterior margins, and sparse superficial widely interrupted ridges especially laterally and posteriorly (Fig. 14C); S2 & S3 reddish, especially apically (Fig. 13C) ..... ***M. saudita*** **Soliman & Gadallah, sp. nov.**

– Mesosomal dorsum beyond pronotum foveate-reticulate (Figs 3A, 9D); metasomal T2 & T3 with dense, opened ellipsoid punctures, ridged in between (Figs 3D, 12D); T6 entirely dark reddish brown, with black longitudinal ridges (either continuous or narrowly interrupted) (Figs 3E, 14D); S2 & S3 brownish (Fig 13D) **4**

4 Face with bright red to golden setae (Fig. 6D); metasomal tergites with rows of sparse setae apically (Fig. 12D); malar space about 1.3 × as long as eye height (Fig. 8D); T2 & T3 with broad yellow bands (Fig. 12D); T6 with broadly triangular lateral teeth (Fig. 14D) ..... ***M. similis*** **Gadallah & Soliman, sp. nov.**

– Face with white setae (Fig. 3B); metasomal tergites with rows of dense setae apically (Fig. 3D); T2 & T3 with narrow yellow bands apically (Fig. 3D); malar space as long as eye height (Fig. 3C); T6 with sharp lateral teeth (Fig. 3E) .... ***M. antropovi*** **Pagliano, 2002**

Micatagla antropovi Pagliano, 2002

Figure 3A–E

Diagnosis. Body clothed with dense white setae (Fig. 3A); mandible bidentate sub-apically (Fig. 3B); metasomal segments with row of dense silvery setae along posterior margins

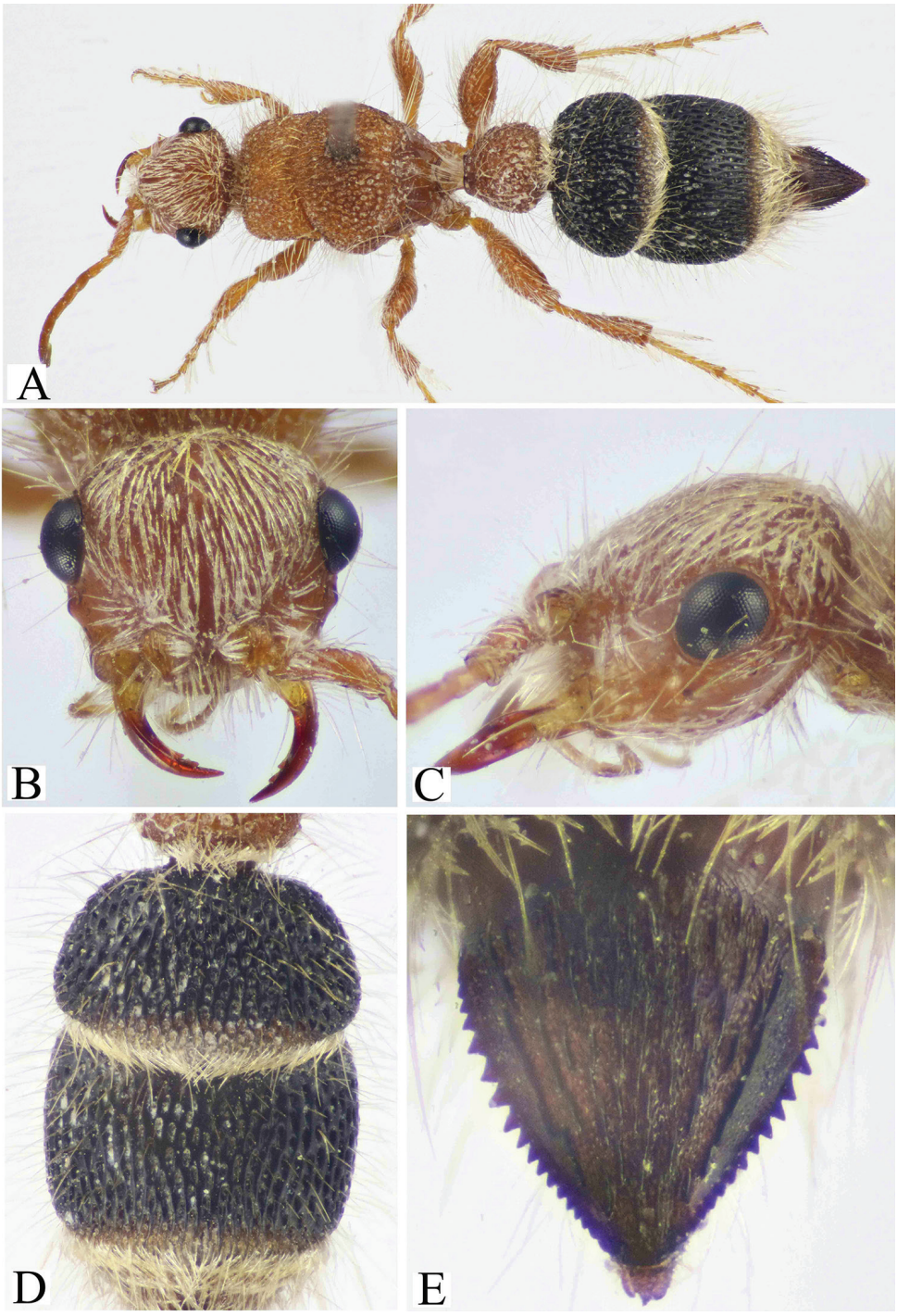

Figure 3. *Micatagla antropovi* Pagliano, 2002. **A** Dorsal habitus **B** frontal view of head **C** lateral view of head **D** metasomal T2 and T3 **E** matasomal T6.

(Fig. 3D); T2 and T3 black, with interrupted ridges forming deep widely spaced ellipsoid punctures, with thin yellow bands (Fig. 3D); T4 and T5 light yellow; T6 dark brown to black, bordered with large and sharp teeth (Fig. 3E); S2 and S3 deeply punctate-reticulate.

This species is closely related to the new species *M. similis* Gadallah & Soliman, from which it may be differentiated by the colour of setae covering face, length of the malar space, the setal density of posterior margin of metasomal tergites, the thickness of the yellow bands on metasomal tergites, and the shape of lateral setae of T6 characters given in the key. It may also be confused with the Egyptian species, *M. ezzati* Gadallah & Soliman (Fig. 15) in which the body is smaller in size; mandible edentate (bidentate in *M. antropovi*); colour and sculpturing of T2 and T3, in which they are blackish red (both tergites are black in *M. antropovi*), T2 with ellipsoid punctures and with longitudinal shiny ridges in between, while T3 with fine longitudinal regular ridges (both tergites with interrupted ridges forming deep, widely spaced ellipsoid punctures in *M. antropovi*); S2 and S3 with widely spaced punctures (deeply punctate-reticulate in *M. antropovi*).

Material examined. 1♀: Egypt: Fayoum (Kom Osheim), 30.v.2013, leg. Ahmed M. Soliman [EFC].

Previous records from Saudi Arabia. Abu Arish (Jazan region) (Pagliano 2002).

Micatagla fuscogaster Soliman & Gadallah

Figures 4A, 5A, 6A, 7A, 8A, 9A, 10A, 11A, 12A, 13A, 14A

Material examined. Holotype ♀: Saudi Arabia, Asir (Abha, GRNR), 31.vii.2015, PT4 (Olive 1), leg. Al Dhafer et al. [KSMA]; **Paratypes**: 1♀ Saudi Arabia: Asir (Abha, GRNR), 28.iv.2014, PT6 (Olive 3), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Asir (Abha, GRNR), 8.vi.2014, PT6 (Olive 3), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Asir (Abha, GRNR), 5.iii.2015, PT3 (Juniper 3), leg. Al Torkey et al. [KSMA]; 1♀ Saudi Arabia: Asir (Abha, GRNR), 31.vii.2015, PT2 (Juniper 2), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Asir (Abha, GRNR), 31.vii.2015, PT4 (Olive 1), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Asir (Abha, GRNR), 31.vii.2015, PT6 (Olive 3), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Asir, (Abha, GRNR), 26.viii.2014, PT (Olive 3), leg. Al Dhafer et al. [EFC]; 1♀ Saudi Arabia: same data, 31.vii.2015 [EFC].

Diagnosis. Metasomal segments 2–6 dark reddish brown (Figs 12A, 13A, 14A); T2 with obscured yellow streak (narrow yellow band) posteromesally (Figs 11A, 12A); T1–5 with apical row of sparse setae (Fig. 12A); row of setae on T2 restricted to mesal part along the yellow band, absent laterally (Fig. 12A); T2 and T3 largely ellipsoid punctate, punctures open posteriorly and closer on T2, separated by coarse ridges in between (Fig. 12A).

The new species *M. fuscogaster* Soliman & Gadallah resembles the South African species *M. ellipsigera* (Invrea) in having T2 and T3 with greatly reduced apical yellow bands, and T4 and T5 dark reddish brown to black. However, it differs from it in having T2 bell-shape, 1.45 × as wide as long (T2 very transverse in *M. ellipsigera*, 2.5 × as wide as long); metasomal tergites with apical row of sparse setae (lacking in

M. ellipsigera); T2 and T3 on disc strongly and irregularly ridged, with large ellipsoid setiferous puncture in between (in *M. ellipsigera* T2 and T3 finely longitudinally striated, denser and more parallel on T3).

Description. Female (Holotype). Body length 6.6 mm.

Colour (Figs 4A, 5A, 12A, 14A): Head (including antenna), mesosoma, legs and first metasomal segment red, head significantly dark red; remaining metasoma dark reddish brown, with faint yellow band restricted to posteromesal part of T2; S2 with red tint; T6 with black longitudinal ridges; maxillary and labial palpi yellowish red; mandible reddish brown, red basally; fore tibial spur red, mid and hind ones waxy white.

Pubescence (Figs 6A, 7A, 10A, 12A): Body including scape of antenna and legs clothed with long erect white setae that are procumbent on face; T1–5 with row of weak silvery setae, directed towards middle; row of setae of T2 restricted to mesal part along the yellow band only, absent laterally.

Head (Figs 6A, 7A, 8A): Dorsally scarcely wider than the pronotum (about 1.1 ×), nearly as wide as the maximal width of mesosoma at mesopleuron, with thin and sharp occipital carina; face and vertex with relatively large, deep setiferous punctures, about 0.5–1.0 diameter apart, denser near inner margin of eyes; vertex broadly convex; eye relatively small, weakly bulged laterally when seen in dorsal or frontal views, located slightly above mid line between clypeus and vertex when seen in front view; distance between antennal tubercles slightly less than tubercle length; malar space about as long as eye height; scape of antenna about 2.3 × as long as F1; F1 slightly longer than F2 (about 1.15 ×). Clypeus broad, densely punctate basally, with slightly emarginate free margin; mandible relatively thick, with very small two teeth subapically.

Mesosoma (Figs 9A, 10A): Pronotum distinctly wider than long at its maximum width (1.65 ×), densely setiferous foveate dorsally, rugose or faintly wrinkled laterally, with anterior margin gently declivous, humeral angle rounded and posterior margin broadly concave; remainder of mesosomal dorsum densely setiferous foveate-reticulate, foveae larger than those on pronotum; posterior face of propodeum gently declivous (oblique), somewhat smooth and impunctate; mesopleuron superficially foveolate especially anteriorly; metapleuron smooth above, and weakly transversely ridged below; outer hind tibial spur about 0.65 × as long as related hind basitarsus.

Metasoma (Figs 11A, 12A, 13A, 14A): T1 pear-shape, scarcely wider than long (1.1 ×), densely setiferous foveate; T2 bell-shape, about 1.45 × as wide as long, with faint yellow band posteromedially, slightly widened medially; T2 and T3 on disc longitudinally ridged, more distinct on T2, with large ellipsoid setiferous puncture in between, punctures are opened posteriorly, both tergites are densely foveate laterally; T4 and T5 finely alutaceous, with rows of coarse and very close setiferous punctures posteriorly; T6 basally with 10–12 longitudinal widely spaced ridges, roundly pointed at apex, with relatively large and blunt teeth laterally, gradually smaller from base to apical end of the tergum. S2 and S3 with dense punctures mainly laterally and medially, leaving posterior margins smooth and shiny pre-apically, S2–5 with row of long setae along posterior margins; S4–6 smooth and shiny.

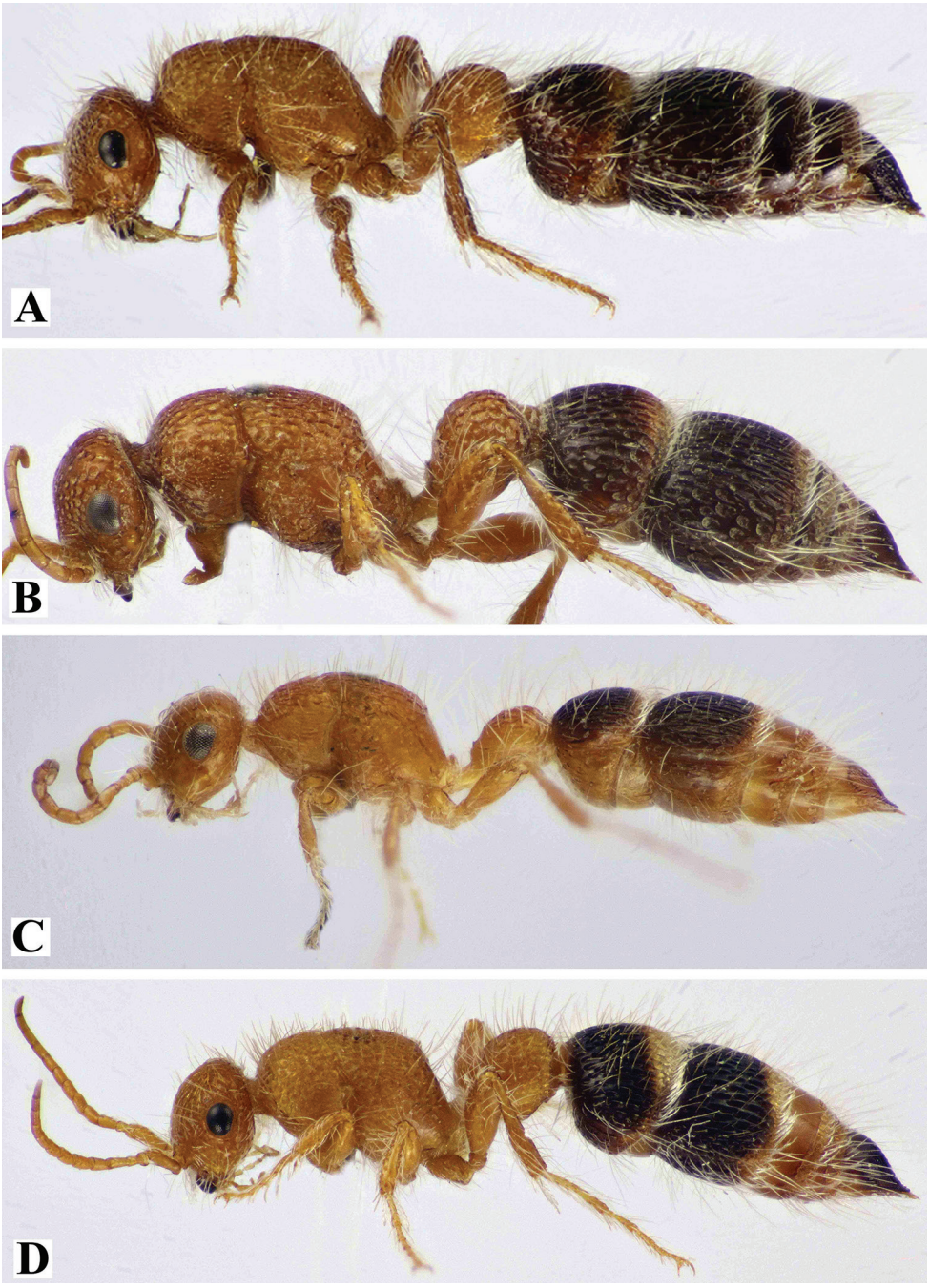

Figure 4. Lateral habitus. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

Variation. In one paratype specimen T3 with greatly reduced apical yellow band; some specimens shorter than the holotype specimen in length (4.3–6.0 mm).

Distribution. Saudi Arabia (Asir region, Garf Raydah Natural Reserve).

Etymology. The specific name '*fuscogaster*' refers to the dark reddish brown colour of most of the metasoma.

Micatagla reemae Gadallah & Soliman

Figures 4B, 5B, 6B, 7B, 8B, 9B, 10B, 11B, 12B, 13B, 14B

Material examined. Holotype ♀: Saudi Arabia, Asir (Abha, GRNR), 30.vii.2015, Hp4 (Olive 1), leg. Al Dhafer et al. [KSMA].

Diagnosis. Metasomal segments 2–6 dark brown to black (Figs 12B, 13A, 14B); head and mesosomal dorsum greatly bare (Figs 6B, 7B, 9B); T2 with setal row restricted to posteromesal part along the yellow band, absent laterally (Fig. 12B); T2 and T3 ellipsoid punctate, punctures are opened posteriorly, with strong longitudinal ridges in between (Fig. 12B).

This species resembles *M. fuscogaster* Soliman & Gadallah in having the same body colour, apical rows of setae and yellow bands of metasomal tergites, but differs in the following: face asetose (Fig. 6B) (face covered with dense pale setae in *M. fuscogaster* (Fig. 6A)); vertex narrowly convex, semi-rounded (broadly convex in *M. fuscogaster*); mandible edentate (Fig. 6B) (with very small two teeth subapically in *M. fuscogaster*); ridges between ellipsoid punctures on T2 and T3 fine (Fig. 12B) (coarse in *M. fuscogaster* (Fig. 12A)); T6 with eight longitudinal ridges, widely separated (Fig. 14B) (10–12 and closer in *M. fuscogaster* (Fig. 14A)).

Description. Female (Holotype). Body length 6.0 mm.

Colour (Figs 4B, 5B, 12B, 14B): Head (including antennae), mesosoma, legs and first metasomal segment bright red; remaining metasoma dark brown to black, with yellow bands posteromesal margin of T2 and posterior margin of T3; mandible dark reddish brown, red basally. Eye gray; fore tibial spur yellow, mid and hind ones waxy white; T6 with black longitudinal ridges.

Pubescence (Figs 7B, 9B, 10B, 11B, 12B): Posterior margin of head, anterior margin of pronotum, as well as lateral margins of mesosoma and metasoma clothed with fine whitish setae that are short and erect at head and pronotum; anterior margin of T1 with fine, long upwardly directed setae, posterior margin of metasomal tergites with rows of silvery setae, that are somewhat less dense on T1 and restricted to the yellow area on T2, absent laterally.

Head (Figs 6B, 7B, 8B): In dorsal view as wide as pronotum, with thin, sharp occipital carina; face with relatively large, deep punctures, that are dense along inner margin of eyes and antennal tubercles, becoming reduced in number above, with smooth and shiny integument between punctures; face just behind vertex nearly bare medially;

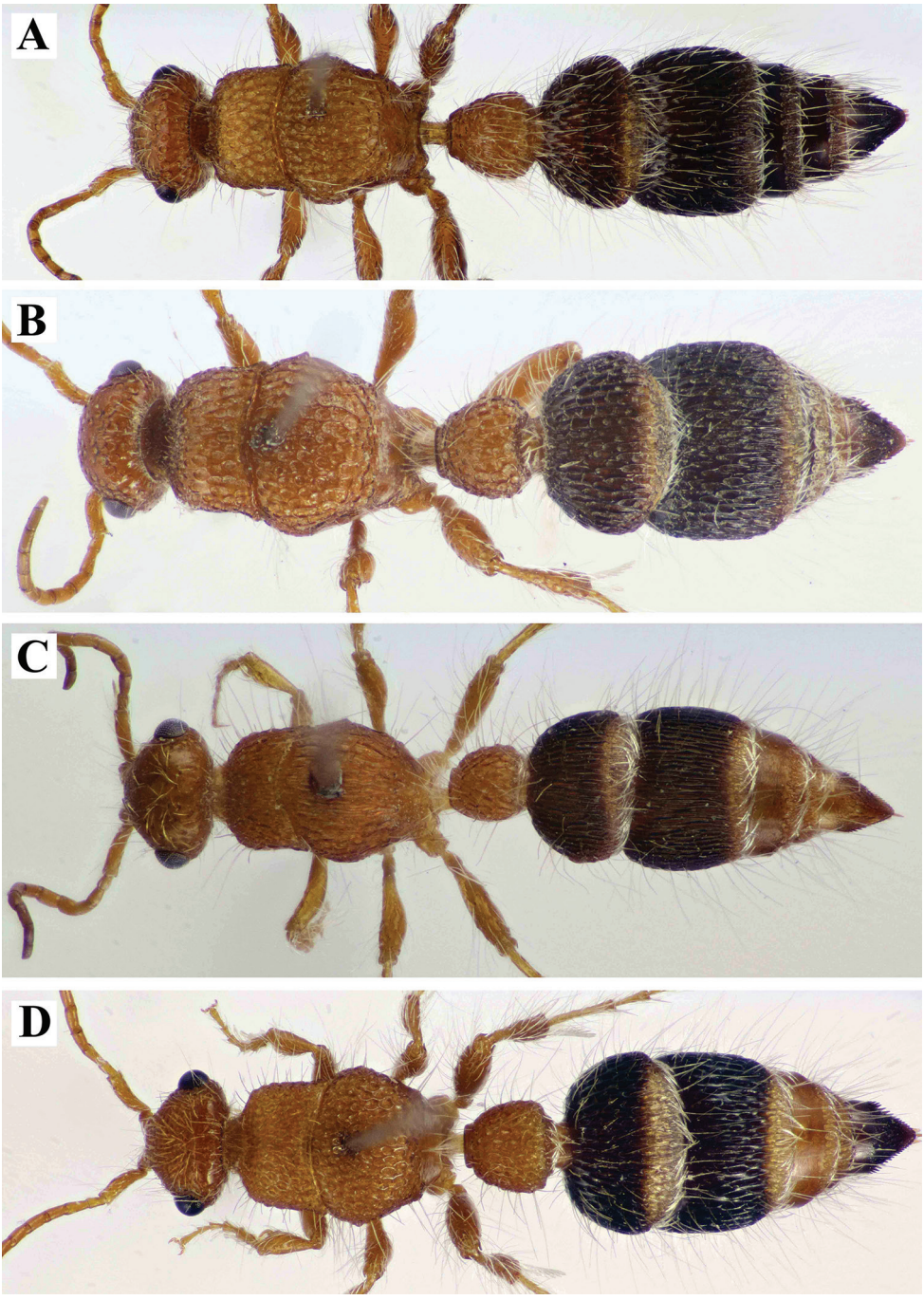

Figure 5. Dorsal habitus. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

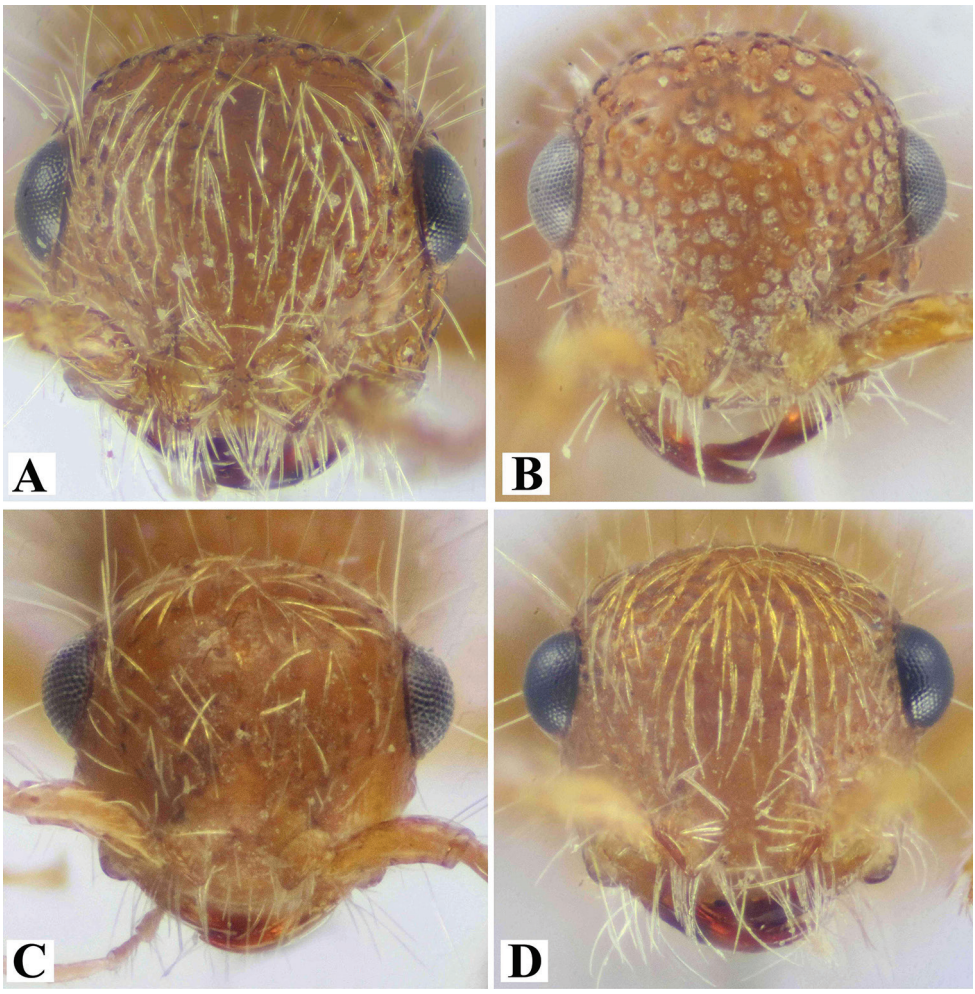

Figure 6. Frontal view of head. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

vertex somewhat semi-rounded (narrowly convex); eye small, weakly bulged laterally when seen in dorsal or frontal view, located above mid line between clypeus and vertex when seen in frontal view; distance between antennal tubercles about as long as tubercle length; malar space about as long as eye height; scape of antenna about 2.5 × as long as F1; F1 slightly longer than F2. Clypeus thin and broad, slightly emarginate at free margin; mandible relatively thick, edentate.

Mesosoma (Figs 9B, 10B): Pronotum about 1.7 × as wide as long at its maximum width, densely foveate dorsally, with anterior margin gently declivous, humeral angle rounded and posterior margin slightly concave; remainder of mesosomal dorsum densely foveate-reticulate, fovea larger than those on pronotum; posterior face

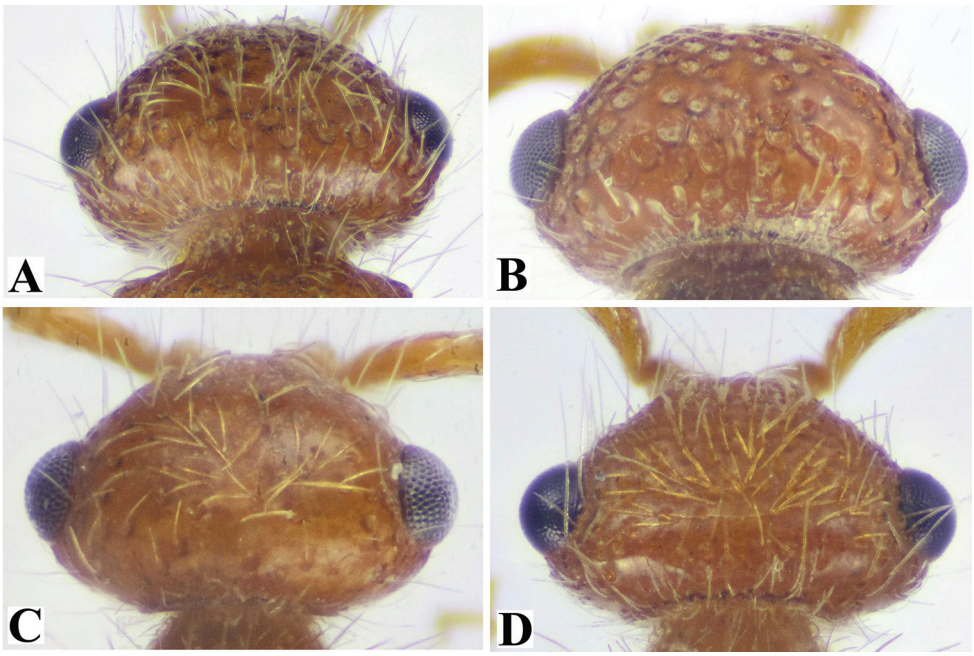

Figure 7. Dorsal view of head. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

of propodeum gently declivous, somewhat smooth and impunctate; pronotal lateral face faintly wrinkled; mesopleuron superficially foveolate; metapleuron nearly smooth. Outer hind tibial spur about 0.5 × length of hind basitarsus. Mesosternum with two parallel-sided, very close lobes enclosing a thin-carinated oval area, extending in the middle just above bases of mesocoxae and reaching bases of metacoxae straightly. Mesosternum punctate, punctures about 1 diameter apart.

Metasoma (Figs 11B, 12B, 13B, 14B): T1 pear-shape, about as long as maximal width, densely and closely foveate; T2 bell-shape, about 1.3 × as wide as long, with yellow band widened medially and absent laterally; T2 and T3 on disc longitudinally strigate, with large ellipsoid puncture in between, punctures are closed on T2 and opened posteriorly on T3, contiguous with each other , laterally both tergites are densely foveate; T4 and T5 with rows of coarse and very close setiferous punctures; T6 basally with about eight longitudinal, widely separated ridges, broadly rounded at apex, with sharp spaced teeth laterally, extending from near base to upper two thirds, becoming minute to serrate, and very close posteriorly. S2 and S3 with scattered punctures mainly laterally and medially, leaving posterior margin smooth and shiny pre-apically, S2–5 with row of fine setae along posterior margins, arise from large sockets, S4–6 smooth and shiny.

Distribution. Saudi Arabia (Asir region, Garf Raydah Natural reserve).

Etymology. This species is named in honour of the daughter "Reem" of Ahmed M. Soliman.

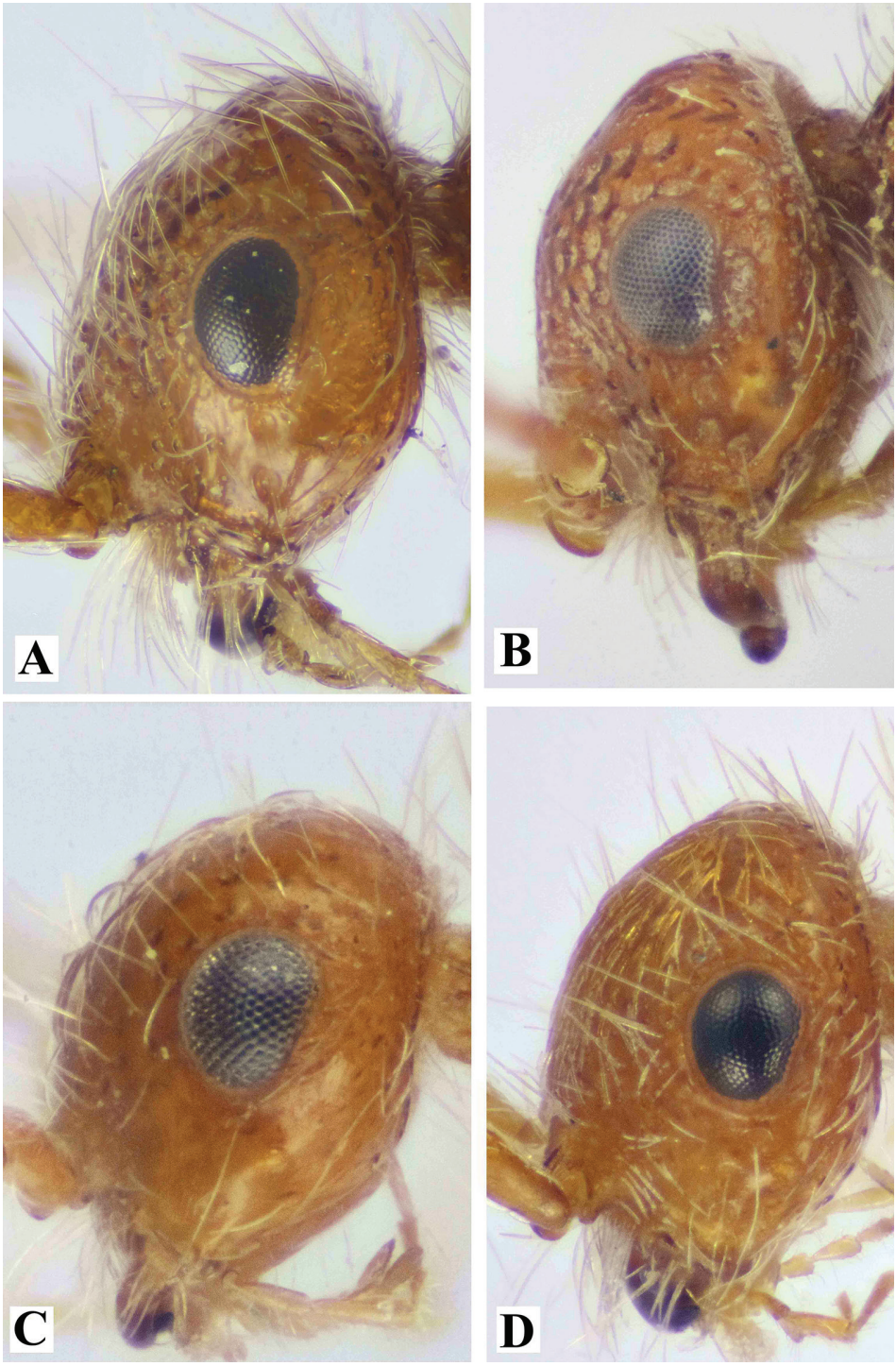

Figure 8. Lateral view of head. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

***Micatagla saudita* Soliman & Gadallah**
Figures 4C, 5C, 6C, 7C, 8C, 9C, 10C, 11C, 12C, 13C, 14C

Material examined. Holotype ♀: Saudi Arabia, Riyadh (Wadi Hanifah, WHN05), 27.viii.2015, PT, leg. Abdeldayem et al. [KSMA]; **Paratypes**: 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHS02), 27.viii.2015, PT, leg. Abdeldayem et al. [KSMA]; 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHS03), 27.viii.2015, PT, leg. Abdeldayem et al. [KSMA]; 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHS05), 27.viii.2015, PT, leg. Abdeldayem et al. [KSMA]; 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHU02), 12.x.2015, PT, leg. Abdeldayem et al. [KSMA]; 5♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHS01), 12.x.2015, PT, leg. Abdeldayem et al. [KSMA]; 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHS02), 12.x.2015, PT, leg. Abdeldayem et al. [KSMA]; 1♀ Saudi Arabia: Riyadh (Wadi Hanifah, WHN01), 12.x.2015, PT, leg. Abdeldayem et al. [KSMA]; 2♀ Saudi Arabia: Riyadh (Wadi Hanifa WHS02), 12.x.2015, PT, leg. Abdeldayem, M. et al. [EFC].

Diagnosis. Body slender; head, mesosoma and the first and 4–6th metasomal segments uniformly red (Figs 4C, 5C); T1 pear-shape (Fig. 11C); T2 and T3 dark brown, longitudinally closely strigate, both tergites with distinct yellow bands and compact (dense) setal rows along the whole posterior margins (Fig. 12C); T6 laterally with relatively small but sharp teeth, a little spaced in the middle, posterior ones minute and rounded at the apex (Fig. 14C).

The new species may be confused with *M. ezzati* Gadallah & Soliman, 2014 (Egypt) (Fig. 15) in having the same body colour, T6 red with lateral teeth not excessively large and a little spaced in the middle, but differs from it by having body very slender, mesosoma striatopunctate (Fig. 9C) and T2 and T3 longitudinally strigate (Fig. 12C) (body robust, mesosoma densely punctate (Fig. 15B) and T2 and T3 ellipsoid punctate with ridges in between (Fig. 15C) in *M. ezzati*).

Description. Female (Holotype). Body slender, 4.0 mm in length.

Colour (Figs 4C, 5C, 12C, 14C): Head including antenna, mesosoma, legs and the first and 4th –6th (except lateral margins of T6, including teeth, slightly brownish); metasomal segments as well as S2 red; T2 and T3 dark brown, both tergites with well-developed yellow bands along posterior margin that are widened medially; S3 reddish brown; maxillary and labial palpi yellow; mandible reddish brown, red basally; fore tibial spur red, mid and hind ones waxy white.

Pubescence (Figs 6C, 10C, 11C, 12C): Body including scape of antenna and legs clothed with scattered fine and erect white setae; face with scattered procumbent pale-golden setae, denser and inwardly directed on vertex, dorsum of mesosoma with similar but erect setae; posterior margin of T1–5 with row of dense silvery setae, directed towards middle.

Head (Figs 6C, 7C, 8C): In dorsal aspect scarcely wider than the maximal width of pronotum (about 1.1 ×), with thin occipital carina; face and vertex with scattered setiferous punctures, vertex broadly convex; gena and malar area nearly smooth; eye small, somewhat bulged laterally when seen in front or dorsal view, located above mid line between clypeus and vertex when seen in front view; distance between antennal

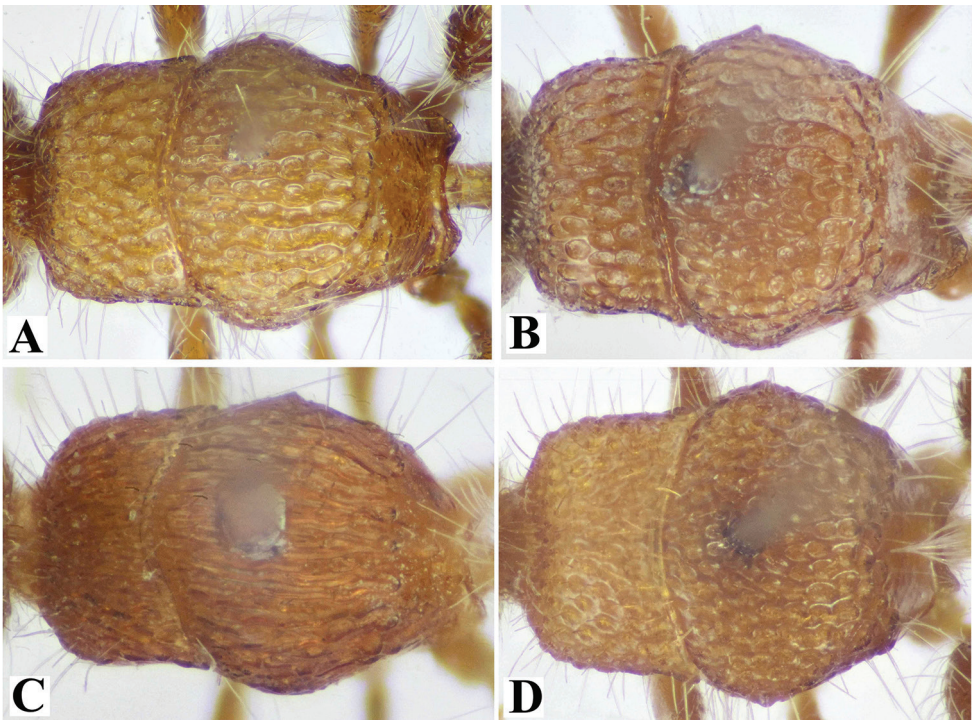

Figure 9. Dorsal aspect of mesosoma. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov. **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

tubercles about as long as tubercle length; malar space hardly longer than eye height (about 1.1 ×); scape of antenna about 2.5 × as long as F1; F1 as long as F2. Clypeus broad, with apical half nearly smooth and gently bent toward the mouth, basal part of clypeus with scattered setiferous punctures; mandible edentate.

Mesosoma (Figs 9C, 10C): Pronotum shallowly foveate dorsally, weakly rugose laterally, rectangular (about 1.65 × as wide as long at maximum width), with anterior margin gently declivous, humeral angle rounded and posterior margin broadly concave; remainder of mesosomal dorsum setiferous striatofoveate; posterior face of propodeum gently declivous, smooth and impunctate; mesopleuron superficially foveolate; metapleuron smooth above, and weakly transversely ridged below. Inner hind tibial spur about 0.65 × as long as hind related basitarsus.

Metasoma (Figs 11C, 12C, 13C, 14C): T1 pear-shape, as long as its maximal width, shallowly setiferous foveate; T2 semicircular, about 1.5 × as wide as long, with yellow band remarkably widened medially; T2 and T3 longitudinally strigate; ridges on T3 more regular and closer than those of T2; T4 and T5 posteriorly with row of very close ellipsoid punctures; T6 with weak, scattered and widely interrupted brown ridges, narrowly rounded at apex, laterally with small but sharp teeth, becoming minute towards apex. S2 and S3 smooth except laterally with scattered setiferous punctures, with row of long scat-

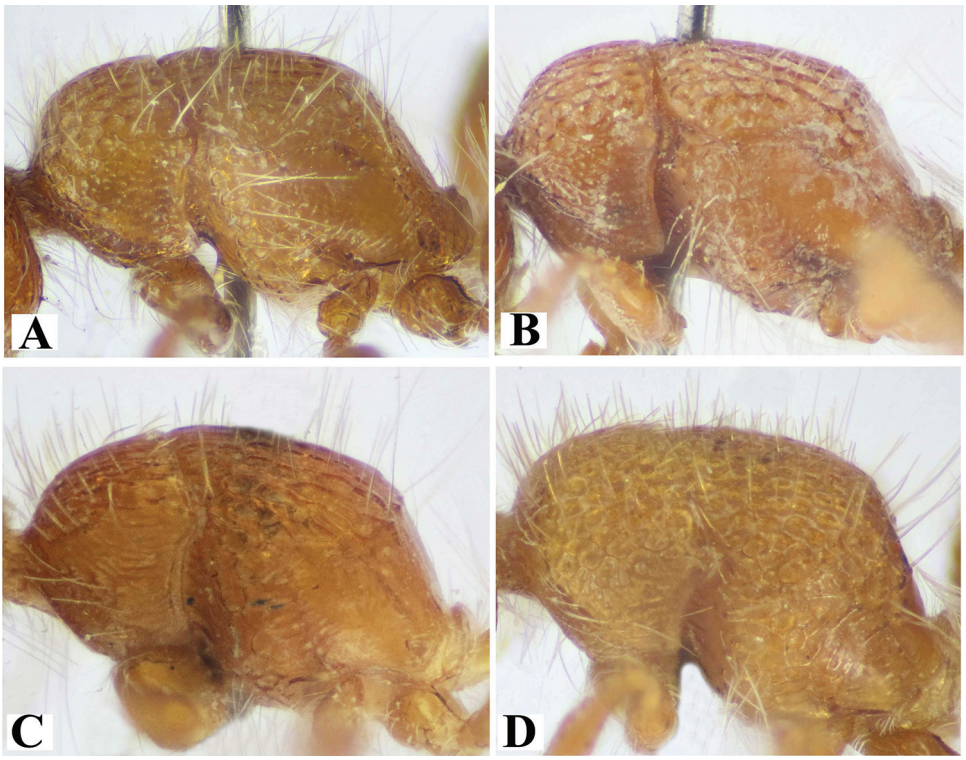

Figure 10. Lateral aspect of mesosoma. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov. **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

tered setae along posterior margins; S4–5 smooth and shiny except posteriorly with row of setiferous punctures; hypopygium with setiferous punctures on posterior half.

Variation. Some paratype specimens are longer, about 4.8–5.5 mm. In some specimens T6 slightly darker, yellow-brown; face with darker golden setae.

Distribution. Saudi Arabia (Riyadh region).

Etymology. The specific name '*saudita*' is a Latinized adjective in the feminine gender derived from the country of the type locality, Saudi Arabia.

Micatagla similis Gadallah & Soliman

Figures 4D, 5D, 6D, 7D, 8D, 9D, 10D, 11D, 12D, 13D, 14D

Material examined. Holotype ♀: Saudi Arabia, Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 31.vii.2015, PT4 (Acacia 2), leg. Al Dhafer et al. [KSMA]. **Paratypes:** 1♀ Saudi Arabia: Al-Baha (Amadan Madaq), 19.v.2010, leg. M.R. Sharaf [KSMA]; 1♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 23.iv.2014, PT2 (Cactus 2), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Al-Baha, (Al-Mukhwah,

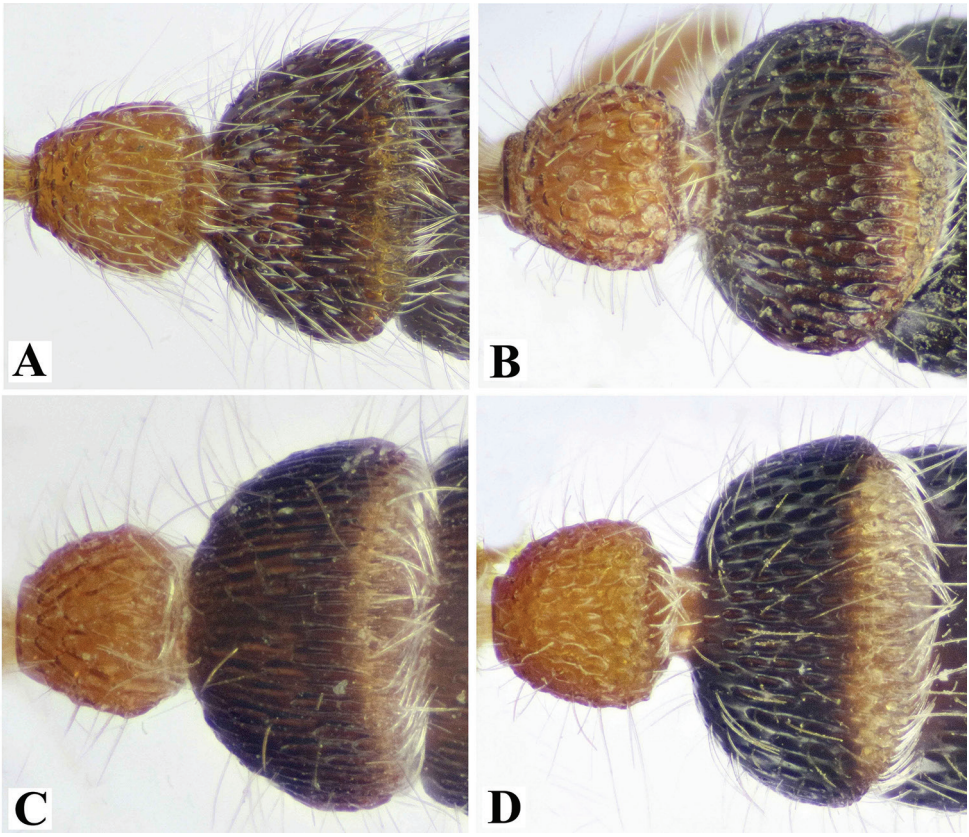

Figure 11. Metasomal T1 and T2. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov. **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

Shada Al-Ala Natural Reserve), 23.iv.2014, PT4 (Acacia 1), leg. Al Dhafer et al. [KSMA]; 5♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 23.viii.2014, PT4 (Acacia 1), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 2.iii.2015, PT2 (Cactus 2), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 2.iii.2015, PT5 (Acacia 2), leg. Al Dhafer et al. [KSMA]; 2♀ Saudi Arabia, Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 3.v.2015, PT2 (Cactus 2), leg. Al Dhafer et al. [KSMA]; 4♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 3.v.2015, PT3 (Cactus 3), leg. Al Dhafer et al. [KSMA]; 2♀ Saudi Arabi: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 31.vii.2015, PT2 (Cactus 2), leg. Al Dhafer et al. [KSMA]; 3♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 31.vii.2015, PT4 (Acacia 1), leg. Al Dhafer et al. [KSMA]; 4♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 31.vii.2015, PT5 (Acacia 2), leg. Al Dhafer et al. [KSMA]; 1♀ Saudi Arabia: Al-Baha, (Al-Mukhwah, Shada Al-Ala Natural Reserve), 15.xi.2015, PT4 (Acacia 2), leg. Al Dhafer et al. [KSMA].

Figure 12. Metasomal T2–T5. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov. **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

Diagnosis. Body relatively slender; face with bright red setae (Fig. 6D); mesosomal dorsum slightly longer than wide; propodeum with posterior face gently declivous, oblique (Fig. 10D); T2 and T3 with relatively broad yellow bands along their posterior margins (Fig. 12D); T1 globular, as long as wide (Fig. 11D); T2 and T3 with closed ellipsoid punctures bordered with coarse ridges, with broad yellow band, maximal thickness of yellow band on T2 about 1.3 × as long as eye height (Fig. 12D); T6 with broad triangular lateral teeth, becoming minute to meaningless posteriorly (Fig. 14D).

This species may be confused with *M. zavattarii* (Invrea, 1950) (Fig. 16) (examined material received from Guido Pagliano, labelled: Rosso Mauritanie, leg. Amiet, 26.i.1964, RO59) in having the same body colour and sculpture, but it differs by the following characters: body relatively slender, with mesosomal dorsum longer than wide, covered on head and mesosoma with bright red setae (Figs 5D, 6D, 9D, 10D) (robust, with mesosomal dorsum as long as broad, covered with white setae in *M. zavattarii* (Fig. 16A, B)); propodeal posterior face oblique (Fig. 10D) (vertical in *M. zavattarii* (Fig. 16B)); T2 bell-shape, with lateral side broadly curved (Fig. 12D) (semicircular, with lateral side sharply curved in *M. zavattarii* (Fig. 16D)); T2 with coarse ridges (Fig. 12D) (fine in *zavattarii* (Fig. 16D)); T6 with broad triangular lateral teeth (Fig. 14D) (with minute (meaningless) teeth in *zavattarii* (Fig. 16E)).

Description. Female (Holotype). Body length 6.0 mm.

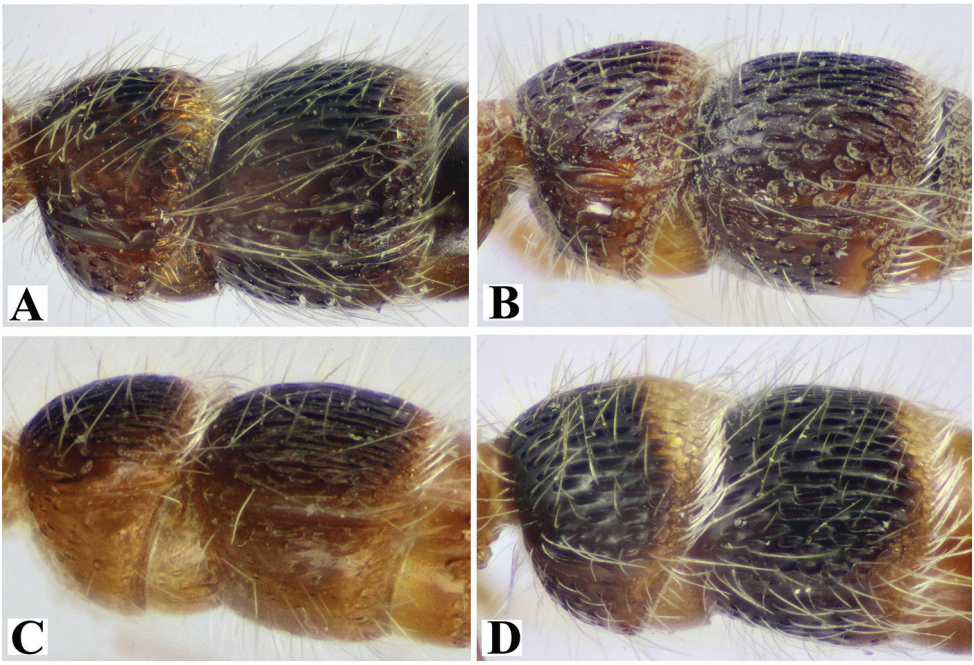

Figure 13. Lateral aspect of second and third mesosomal segments. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

Colour (Figs 4D, 5D, 14D): Head (including antenna), mesosoma, legs and first metasomal segment red, head distinctly dark red; second and third metasomal segments black, with well-developed yellow bands at posterior margins of T2 and T3 (that widened medially in T2); S2 reddish; T4 and T5 reddish brown, with faint yellow posterior margins; T6 dark ferruginous, with black longitudinal ridges. Eye black; mandible dark reddish brown, red basally; maxillary and labial palpi yellow; fore tibial spur red, mid and hind ones waxy white.

Pubescence (Figs 6D, 10D, 11D, 12D): Face densely covered with radiated, bright red, long fine adpressed setae, such setae (but less bright) covering mesosoma, shorter and erect laterally as well as T1; remainder of metasoma clothed with whitish, erect to semi-erect fine setae especially laterally; posterior margin of metasomal tergites with rows of silvery setae; legs as well clothed with such fine setae. Posterior margin of metasomal S1 with dense fine, relatively long setae; S2–5 with a row of fine adpressed setae.

Head (Figs 6D, 7D, 8D): In dorsal view slightly wider than pronotum, setiferous punctate (except smooth malar space), with thin and sharp occipital carina; vertex broadly convex; eye relatively small, but distinctly bulged laterally when seen in front or dorsal view, located above mid line between clypeus and vertex when seen in front view; malar space relatively long, about 1.3 × as long as eye height; antennal tubercles away from each other by a distance shorter than tubercle length; antenna with scape about 2.5 × as long as F1, distinctly elbowed; F1 as long as F2 (that is slightly widened

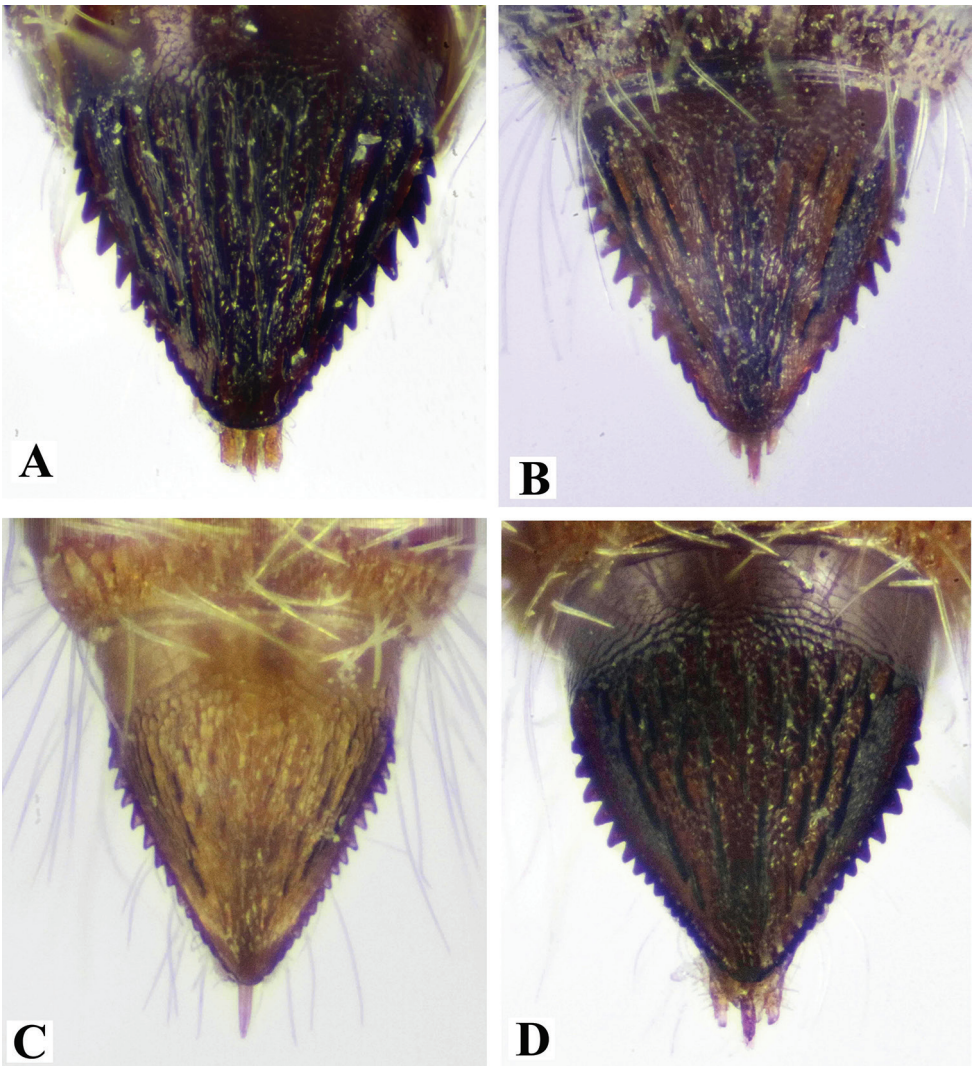

Figure 14. Metasomal T6. **A** *Micatagla fuscogaster* Soliman & Gadallah, sp. nov. **B** *M. reemae* Gadallah & Soliman, sp. nov. **C** *M. saudita* Soliman & Gadallah, sp. nov. **D** *M. similis* Gadallah & Soliman, sp. nov.

apically). Clypeus broad, setiferous punctate basally, with smooth and bent apical portion; mandibles somewhat thin, edentate.

Mesosoma (Figs 9D, 10D): Mesosomal dorsum slightly longer than wide at mesopleuron; pronotum about 1.7 × as wide as long, with gently declivous anterior margin, rounded humeral angle and broadly concave posterior margin; pronotum with dense rounded setiferous foveolae dorsally, superficially foveolate laterally; rest of mesosoma setiferous foveate-reticulate; propodeal posterior face gently declivous, smooth. Mesopleuron superficially foveolate; metapleuron superficially foveolate above, and weakly transversely ridged below; mesosternum smooth basally, punctate laterally, leaving an

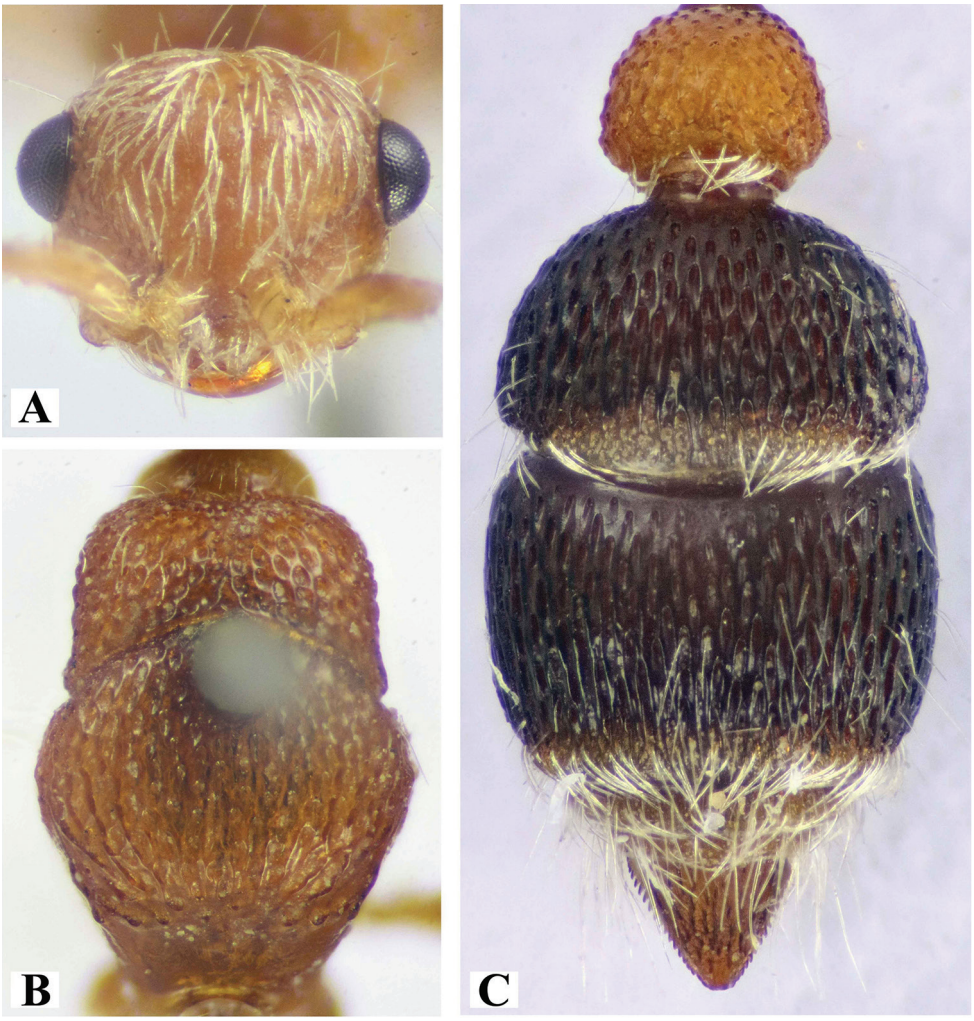

Figure 15. *Micatagla ezzati* Gadallah & Soliman, 2014. **A** Frontal view of head **B** dorsal aspect of mesosoma **C** dorsal aspect of metasoma.

oval smooth and shiny area medially. Hind outer tibial spur about 0.6 × as long as related basitarsus.

Metasoma (Figs 11D, 12D, 13D, 14D): T1 globular, slightly wider than long, densely foveate; T2 bell-shape, with closed ellipsoid punctures; T3 longitudinally ridged, with ellipsoid punctures in between [as in T2 but punctures more elongate here]; T4 and T5 smooth to very finely sculptured, with dense close longitudinal sockets posteriorly; T6 densely ridged, ridges are interrupted, rounded apically, laterally with relatively short and dense, very close teeth at basal two thirds, becoming minute and meaningless posteriorly. S1 nearly smooth; S2 and S3 (except smooth and shiny posterior margin) with moderately scattered punctures that are irregularly separated.

Etymology. The Latin name *similis* (adjective) refers to the similarity of this species with *Micatagla zavattarii* (Invrea).

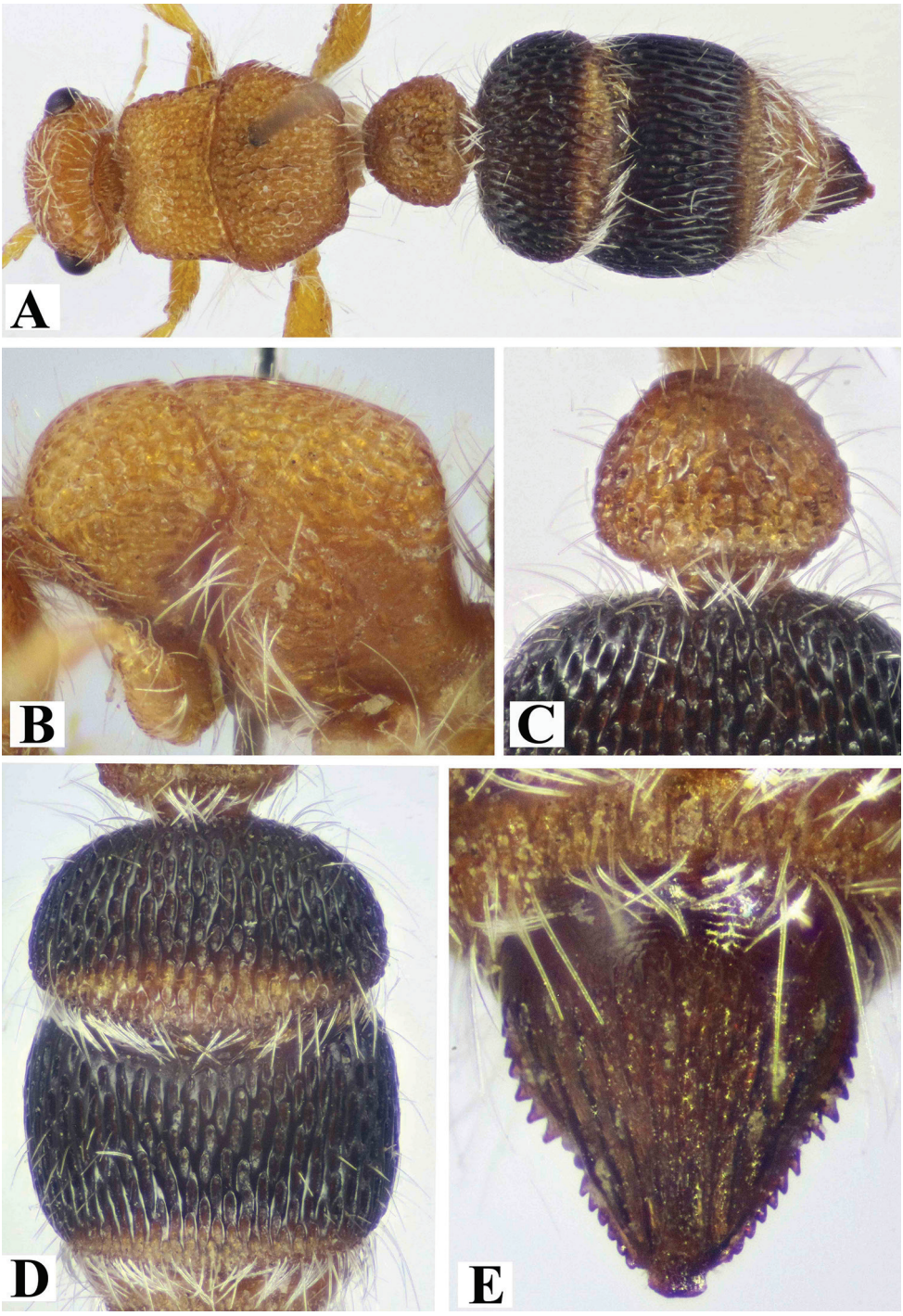

Figure 16. *Micatagla zavattarii* (Invrea, 1950). **A** Dorsal habitus **B** lateral aspect of mesosoma **C** metasomal T1 and part of T2 **D** metasomal T2 and T3 **E** matasomal T6.

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Sincere gratitude to Guido Pagliano for sending us a *Micatagla zavattarii* specimen to examine. Also, many thanks to Prof. Lynn Kimsey (reviewer) for her valuable comments and criticisms on the manuscript. We thank members of the King Saud University Museum of Arthropods for their help in collecting the specimens. Sincere appreciation extended to the Deanship of Scientific Research at King Saud University for funding this research group number RGP-1437-009.

References

Argaman Q (1994) Generic synopsis of Apterogyninae (Hymenoptera: Apterogynidae). Folia Entomologica Hungarica 55: 41–48.

Gadallah NS, Soliman AM (2014) The genus *Micatagla* Argaman, 1994 in Egypt, with three new species and a new record (Hymenoptera, Bradynobaenidae, Apterogyninae). ZooKeys 397: 71–81. https://doi.org/10.3897/zookeys.397.6768

Harris RA (1979) A glossary of surface sculpturing. Occasional Papers in Entomology 28: 1–31.

Lo Cascio P, Pagliano G (2014) A new species of *Micatagla* from Socotra Island (Hymenoptera: Bradynobaenidae: Apterogyninae). Acta Entomologica Musei Nationalis Pragae 54 (supplementum): 423–427.

Pagliano G (2002) Revisione della sottofamiglia Apterogyninae (Hymenoptera: Bradynobaenidae). Museo Regionale di Scienze Naturali di Torino, Monografie 34: 1–387.

Pagliano G, Romano M (2012) Three new species of African Apterogyninae from Kenya, Namibia and Senegal (Insecta, Hymenoptera, Bradynobaenidae). Naturalista Valtellinese, Atti Museo Civico Storia naturale Morbegno 23: 15–41.

Pagliano G, Romano M (2018) World list of all known species of Bradynobaenidae (Hymenoptera). Atti Museo Civico Storia natural Morbegno 28: 15–46.

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Revision of the south Asian amisegine genus *Cladobethylus* Kieffer, 1922 (Hymenoptera, Chrysididae, Amiseginae)

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Abstract

The south Asian genus *Cladobethylus* Kieffer, 1922, is reviewed, with a key to the species. Five new species are described, one from the island of Borneo (*Cl. darlingi*), two from Thailand (*Cl. densepunctatus* and *Cl. thailandicus*), one from Korea (*Cl. koreensis*), and one from Sumatra (*acehensis*).

Keywords

Vietnam, *Eurycantha insularis*, Phasmatodea, Phasmatidae

Introduction

Cladobethylus Kieffer, 1922, is one of the most widespread and speciose of the south Asian amisegine genera, with 11 species, including the ones newly described below. There are undoubtedly more species to be discovered and it would not be surprising to find species in southern China, Cambodia and other islands in Indonesia, such as Sulawesi. The current distribution of the genus is probably more a reflection of where collecting has been done and the techniques used than the actual distribution. Based on personal observation, as with most other amisegines, males are more commonly collected, particularly in Malaise traps and by sweep netting. Females are rarer in collections, and are more likely to be collected in bowl and pitfall traps. This may have

more to do with the environments the two sexes typically inhabit than any actual differences in numbers. Females may spend most of their time searching in and on leaf litter for walking stick eggs, whereas males fly and sit on vegetation above the ground searching for females, and are more likely to be caught in a Malaise trap.

The majority of *Cladobethylus* species are moderate-sized amisegine wasps ranging from 2–4 mm long. However, one species, *Cl. insularis* Kimsey & Dewhurst, from Papua New Guinea is much larger, ranging from 5–7 mm in length. This is also the only species, where a host is known. It parasitizes the eggs of *Eurycantha insularis* Lucas (Phasmatodea: Phasmatidae) (Kimsey et al. 2012).

Materials and methods

Specimens were borrowed from and/or types are deposited in the following institutions, which are given in the descriptions below using their acronyms: AEI – American Entomological Institute, Logan, Utah, USA; BME – Bohart Museum of Entomology, University of California, Davis, USA; BMNH – The Natural History Museum, London, U.K.; BPBM – B.P. Bishop Museum, Honolulu, Hawaii, USA; MZB – Museum Zoologi Bogor, Chibinong, Indonesia; QSBG – Queen Sirikit Botanical Garden, Chiang Mai, Thailand; ROM – Royal Ontario Museum, Toronto, Ontario, Canada; USNM – U. S. National Museum of Natural History, Washington, D. C., USA.

Morphological terminology follows that used by Kimsey and Bohart (1991). The acronym MOD is used for midocellus diameter, which is the width of the midocellus from side to side in front view. The interocular distance is measured across the narrowest part of the face in front view, using the greatest width of the eye in front view for comparison. Antennal articles are measured at the point of greatest breadth and compared with the total length of the article. Postocular distance is measured across the greatest width of the head laterally behind the eye margin in dorsal view.

Systematics

Genus *Cladobethylus* Kieffer, 1922

Cladobethylus Kieffer, 1922: 67. Type species: *Cladobethylus cruciger* Kieffer, 1922:69. Original designation.

Diagnosis. The most distinctive feature of the genus *Cladobethylus* is the impunctate welt that extends along the midline of the vertex from near the midocellus to the occipital carina. This feature is only shared with species of *Magdalium* Kimsey and *Senesega* Kimsey, although it is less well developed in these genera. *Cladobethylus* can be distinguished from those genera by the lack of an omaulus on the mesopleuron and the usually biangulate genal area, which is evenly curved in *Magdalium* and *Senesega*.

In addition, *Cladobethylus* species have at most a weakly defined scrobal sulcus. The scrobal sulcus in *Magdalium* and *Senesega* is well defined.

Description. Vertex with low impunctate welt along midline from midocellus to occiput; eye with short sparse setulae; scapal basin usually with at least some cross-ridging; malar space with vertical sulcus extending from ventral eye margin to mandibular articulation; occipital carina present; posterior margin of head behind eye usually biangulate in side view; male flagellum elongate and cylindrical; female flagellum short, fusiform and usually flattened on one surface; pronotum with narrow posteromedial groove; mesopleuron without scrobal sulcus or omaulus; scutum with notauli and parapsides; both sexes fully winged, forewing Rs extended by evenly curved dark streak, costal cell widest medially, stigma large and broad, R_1 not indicated, medial vein arising before cu-a; propodeum with long dorsal surface and abrupt posterior declivity, lateral propodeal angle undeveloped; hindcoxa with dorsobasal carina; tarsal claws edentate in females, with one small subbasal tooth and subbasal angle in males.

Distribution (Fig. 1). Tropical Asia: Sri Lanka, New Guinea, Malaysia, Vietnam, Sarawak, Philippines, Indonesia (Sumatra), Borneo, South Korea and Japan.

Hosts. *Cladobethylus insularis* was reared from eggs of the oil palm stick insect, *Eurycantha insularis* Lucas (Phasmatodea: Phasmatidae), in Papua New Guinea (Kimsey et al. 2012).

Key to the Species of *Cladobethylus**

1 Four visible metasomal segments; flagellum tapering, broadest submedially; females..... **2**

– Five visible metasomal segments; flagellum slender, parallel-sided; males..... **11**

Females

2 Metasomal tergum II with punctures 0–2 puncture diameters apart **3**

– Metasomal tergum II with tiny punctures 5–10 or more puncture tiny diameters apart **6**

3 Flagellomeres I–III whitish **4**

– Flagellomeres I–III dark brown..... **5**

4 Malar space 3.5 MOD wide; femoral apices whitish, contrasting with rest of femur; body with bluish metallic highlights, particularly dorsally; Papua New Guinea ..... ***Cl. insularis*** **Kimsey**

– Malar space 4.5 MOD wide; femoral apices not whitish or contrasting with rest of femur; body without bluish metallic highlights; Papua New Guinea ... . ***Cl. aquilus*** **Kimsey**

* Females are unknown for *Cl. acehensis* and *Cl. ceylonicus*, and males are unknown for *Cl. japonicus* and *Cl. koreensis*.

5 Underside of head with occipital fovea on either side of occipital suture; body with bluish metallic highlights, particularly dorsally; Philippines ..... ***Cl. cruciger* Kieffer**

– Underside of head with occipital fovea on either side of occipital suture; body with bluish metallic highlights, particularly dorsally; Thailand, Viet Nam .... ***Cl. densepunctatus* Kimsey, sp. nov.**

6 Underside of head without occipital fovea on either side of occipital suture; metapleuron and propodeal side cross-ridged or wrinkled..... **7**

– Underside of head with occipital fovea on either side of occipital suture; metapleuron and propodeal side smooth without cross-ridges or wrinkles **8**

7 Malar space less than 4 MOD wide; ocular setulae less than 1 MOD long; Thailand ..... ***Cl. thailandicus* Kimsey, sp. nov.**

– Malar space more than 4.5 MOD wide; ocular setulae 1 MOD long or longer; body with bluish metallic highlights, particularly dorsally; Korea..... ***Cl. koreensis* Kimsey, sp. nov.**

8 Flagellomere I less than 1.5× as long as broad; flagellomere II broader than long **9**

– Flagellomere I twice as long as broad or longer; flagellomere II as long as broad or longer **10**

9 Malar space more than 4 MOD wide; flagellomere X twice as long as broad; Malaysia..... ***Cl. gilbus* Kimsey**

– Malar space less than 4 MOD wide; flagellomere X 1.5–1.6× as long as broad; Borneo..... ***Cl. sarawakensis* Kimsey, sp. nov.**

10 Legs and antennae yellow; malar space less than 4.5 MOD wide; body without metallic highlights; Borneo ..... ***Cl. darlingi* Kimsey, sp. nov.**

– Legs and antennae brown; malar space more than 4.5 MOD wide; body with metallic highlights; Japan..... ***Cl. japonicus* Kimsey**

Males

11 Metasomal tergum II with punctures 0–2 puncture diameters apart **12**

– Metasomal tergum II with tiny punctures 10 or more puncture diameters apart **15**

12 Malar space less than 3 MOD wide; post ocular distance 2 MOD wide; body length 5–7 mm; Papua New Guinea..... ***Cl. insularis* Kimsey & Dewhurst**

– Malar space 3 MOD wide or wider; post ocular distance less than 2 MOD wide; body length less than 4.5 mm..... **13**

13 Face and malar space coarsely punctate; head dorsolaterally strongly angulate behind eye in lateral view; Thailand, Viet Nam..... ***Cl. densepunctatus* Kimsey, sp. nov.**

– Face and malar space largely impunctate, with few scattered punctures; head dorsolaterally rounded or obtusely angulate behind eye in lateral view..... **14**

14 Malar space more than 3.5 MOD wide; postocular distance 1.5 MOD wide or wider; Sri Lanka. ..... ***Cl. ceylonicus* Krombein**

– Malar space 3 MOD wide; postocular distance less than 1.5 MOD wide; Papua New Guinea ..... ***Cl. aquilus* Kimsey**

15 Postocular distance more than 2 MOD wide; scapal basin without cross ridging; flagellomere X less than 5.5× as long as broad; Thailand .... ***Cl. thailandicus* Kimsey, sp. nov.**

– Postocular distance less than 1.6 MOD wide; scapal basin with zones of cross-ridging; flagellomere X more than 5.5× as long as broad **16**

16 Malar space less than 3 MOD wide; postocular distance less than 1 MOD wide; Malaysia. ..... ***Cl. gilbus* Kimsey**

– Malar space 3 or more MOD wide; postocular distance 1 MOD wide or wider **17**

17 Flagellomere I 4× as long as broad or longer; Sumatra..... ..... ***Cl. acehensis* Kimsey, sp. nov.**

– Flagellomere I 3.5× as long as broad or shorter **18**

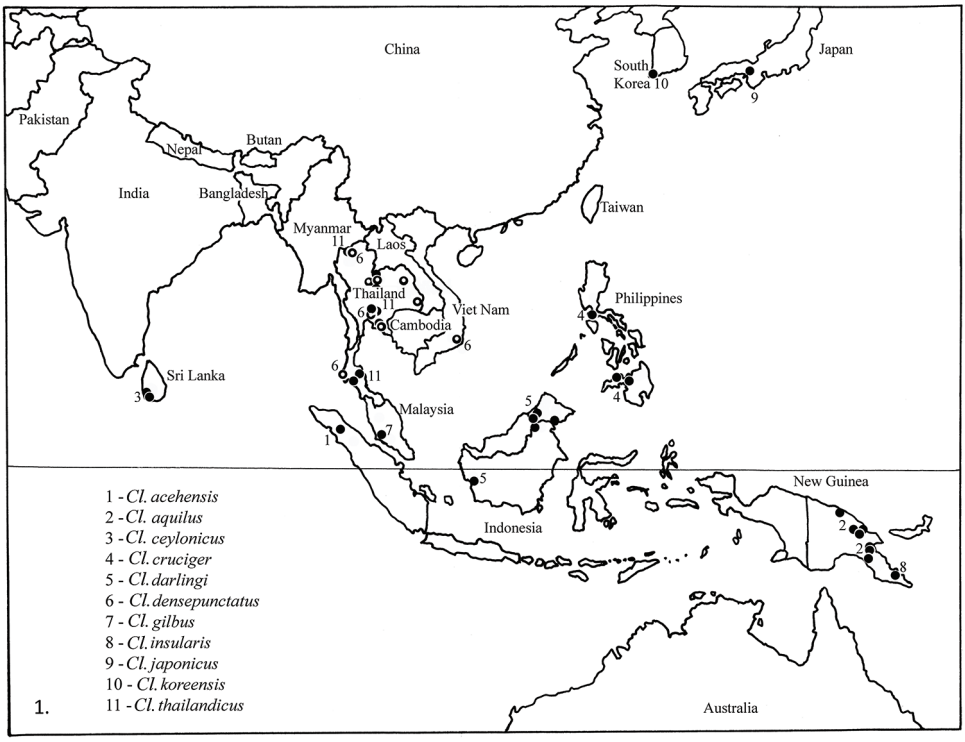
18 Least interocular distance twice greatest eye width or more in front view; Borneo..... ***Cl. darlingi* Kimsey, sp. nov.**

– Least interocular distance 1.5× greatest eye width or less, in front view; Philippines..... ***Cl. cruciger* Kieffer**

***Cladobethylus acehensis* Kimsey, sp. nov.**
http://zoobank.org/9F6DC8C1-143A-4F1B-9B6E-9FCFA5C9A98B
Figs 2, 3

Diagnosis. This species is part of the group that has a nearly impunctate second metasomal tergum, including *Cl. darlingi*, *Cl. densepunctatus*, *Cl. gilbus* and *Cl. philippinensis*. It can be distinguished from these and other species by the combination of the pale antenna, flagellomere I 4× as long as broad or longer, flagellomere II 1.5× as long as broad or shorter, flagellomere XI 6.5× as long as broad, and flagellomeres VII–X asymmetrical. Other diagnostic features include the long malar space, slightly less than 4 midocellar diameters wide, and body with bluish highlights.

Male description. Body (Figs 2, 3) length 3.0–4.0 mm. *Head*. frons with punctures 2–4 puncture diameters apart; scapal basin polished and impunctate, with short, sublateral group of transverse ridges; clypeal apicomedial margin slightly concave; subantennal distance 1 MOD long; malar space 3.8 MOD long; head slightly broader than long, interocular distance twice eye width in front view; postocular distance 1.5 midocellar diameters wide; vertex rounded posterolaterally in dorsal view; midocellus 2 MOD from ocular margin; ocelli arranged in equilateral triangle; hindocelli separated from ocular margin by 1.0–1.1 diameters; apical flagellomeres asymmetrical, broadest medially, appearing slightly lobed on one side; flagellomere I 4.2× as long as



Cl. acehensis

Figures 1–3. 1 Distribution map of *Cladobethylus* species **2, 3** *Cladobethylus acehensis* male **2** Lateral view **3** dorsal view.

broad, setae 0.5× as long as flagellomere breadth; flagellomere II 2.4× as long as broad; flagellomere IX 6.5× as long as broad; flagellomeres VIII-X slightly lobate submedially. *Mesosoma*. Pronotum 0.9× as long as scutum in dorsal view; mesopleural punctures 1 puncture diameter apart; metapleuron polished, impunctate; propodeal side polished impunctate, posteriorly with subrectangular medial enclosure. *Metasoma*. Tergum I nearly impunctate; terga II–IV with tiny punctures, 5–10 puncture diameters apart or

more, with impunctate apical margin. *Color*. Body black, with metallic blue highlights on dorsum of head, pronotum and scutum; legs and antennae yellow; wing membrane brown tinted, with dark brown veins.

Female. Unknown.

Type material. Holotype male: Indonesia: Sumatra, **Aceh**, Gunung Lauser Natl. Pk., Ketambe Res. Sta. xi/1989, IIS890004, D.C. Darling (MBZ). Paratypes: 24 males same locality data as holotype; 8 males: 5 Sept. 1989, screen sweep, B. Hubley and D. C. Darling, ROM893044; 1 male: 22–30 Sept. 1989, D. C. Darling, Malaise trap with pans, IIS890003; 1 male: 1–30 Oct. 1989, Malaise trap with pans, D.C. Darling, IIS890007; 3 males: Nov. 1989, Malaise trap, D. C. Darling, IIS890006; 1 male: Nov. 1989, D. C. Darling, IIS890005; 1 male: 1–30 Nov. 1989, D.C. Darling, Malaise trap with pans, IIS890012; 1 male: 1–31 Dec. 1989, Malaise trap with pans, D.C. Darling, IIS890013; 1 male: 1–31 Jan. 1990, Malaise trap, D.C. Darling, IIS900001; 2 males: 1–31 Jan. 1990, Malaise trap, D.C. Darling, IIS900005; 2 males: 1–28 Feb. 1990, Malaise trap, D.C. Darling, IIS900009; 1 male: 1–28 Feb. 1990, Malaise trap, D.C. Darling, IIS900011; 2 males: 1–31 Mar. 1990, Malaise trap, D.C. Darling, IIS900021 (BME, MBZ, ROM).

Distribution. Indonesia: Sumatra, Aceh, Gunung Lauser National Park.

Etymology. The species is named after Aceh Province on the island of Sumatra, Indonesia, where it was collected.

Cladobethylus aquilus **Kimsey**

Figs 4–7

Cladobethylus aquilus Kimsey 1986: 157. Holotype male; New Guinea: Bulolo (AEI).

Diagnosis. *Cladobethylus aquilus* males most closely resemble those of *Cl. ceylonicus* and *Cl. insularis* based on flagellomere I 4.0–4.5× as long as broad, the dark brown antenna, nearly impunctate metasomal tergum II, and reduced cross ridging in the scapal basin. However, *Cl. aquilus* can be distinguished from those and other species by the combination of the longer subantennal distance, lack of metallic blue highlights, slightly medially lobate apical flagellomeres, and flagellomere XI 6× as long as broad. Females most closely resemble those of *Cl. insularis* and *Cl. thailandicus* based on the bicolored antenna and flagellomere II about as long as broad. They can be distinguished from these and other species by the scapal basin lacking cross ridges, bicolored legs and densely punctate metasomal tergum II.

Male description. Body (Figs 4, 5). Length 3.0–4.0 mm. *Head*. Frons with punctures 0.5–1.0 puncture diameter apart; scapal basin impunctate, with narrow band of cross-ridges sublaterally; clypeus long and subtruncate apicomedially; subantennal distance 1 MOD long; malar space 3.4 MOD long; gular area flattened, without depression or pits; head 0.9× as long as broad, interocular distance twice eye width in front view; postocular distance 1.4 midocellar diameters wide; vertex

broadly rounded posterolaterally in dorsal view; midocellus 2.2 MOD from ocular margin; ocelli arranged in isosceles triangle; hindocelli separated from ocular margin by 1.0 diameters; flagellomere I 4× as long as broad, setae 0.5× as long as flagellomere breadth; flagellomere II 2.8× as long as broad; flagellomere IX 6× as long as broad; flagellomeres VIII–X slightly lobate submedially. *Mesosoma*. Pronotum medially 0.8× as long as scutum in dorsal view; mesopleural punctures contiguous to 0.5 puncture diameter apart; metapleuron polished, impunctate; propodeum laterally polished, impunctate, posteriorly with posteromedial subrectangular enclosure. *Metasoma*. Tergum I punctures 5–10 puncture diameters apart; tergum II with punctures, 1–2 puncture diameters apart, separated medially by impunctate medial stripe; tergum III–IV punctures 1–2 puncture diameters apart. *Color*. Body black, without metallic highlights; legs yellow; antenna brown to blackish; wing membrane light brown-tinted, with dark brown veins.

Female description. *Body* (Figs 6, 7). Length. 4.0 mm. *Head*. Frons punctures contiguous to 0.5 puncture diameter apart; scapal basin impunctate, with narrow vertical band of cross-ridges submedially; clypeus short in front view, projecting ventrally, projection truncate apicomedially; subantennal distance 0.8 MOD wide; malar space 4.5 MOD long; head 0.9× as long as broad, interocular distance 1.2× eye width in front view; postocular distance 1 midocellar diameter; vertex rounded angulate posterolaterally in dorsal view; midocellus 2.3 MOD from ocular margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by 1 diameter; flagellomeres appearing somewhat bead-like, broader medially than apically; flagellomere I twice as long as broad; flagellomere II as long as broad; flagellomere X twice as long as broad. *Mesosoma*. Mesopleural punctation contiguous; metapleuron polished with metapleural-propodeal suture foveate; propodeum polished below wing. *Metasoma*. Tergum I punctures 2–5 puncture diameters apart with impunctate medial stripe; tergum II with punctures, 1–2 puncture diameters apart, separated medially by impunctate medial stripe; tergum III–IV punctures 1–2 puncture diameters apart. *Color*. Body black, without metallic highlights; coxae and tarsi brown, femora and tibia basally brown, apically white; scape, pedicel brown to dark brown, flagellomeres I–III at least partly white, remainder of flagellomeres dark brown; wing membrane light brown tinted, with dark brown veins.

Distribution. Papua New Guinea: **Morobe Prov**., Bulolo, 900 m, 13/ii/-13/iii/1979, J. Sedlacek; Tekadu, 100m, i/1–17/2000, Sears & Binatung brigade; 7–9/ii/2010, T. Sears & Binatung brigade, 7°38'S, 146°34'E; Lakekamu Basin, Ivimka Research Sta., 120 m 7°7'44"S, 146°30'E, MT; 20/ii-2/iii/2000, T. Sears, MT iv/1–20/2000, T. A. Sears; xi/2–8/1999, Heydon, Schiff & Sears; Wau; 1100 m, 15/ix/1964, J. Sedlacek, MT; Baiyer River, 6–25/ii/1979, 1100m, J. Sedlacek; **Madang Prov.**, Mt. Wilhelm, 200m, 16–25/v/2013; 700m, 5°43'55.596"S, 145°15'7.9194"E; 23–24/v/2013, 1200m, 5°43'15.1464"S, 145°16'10.1994"E; Wanang, ix/16–22/2012, 5°13'39.6114"S, 145°4'46.92"E; **East Sepik Prov**., Amboin Patrol Post, Karawar Lodge, ii/1983 A. C. Messer; 19 males and 3 females were examined (AEI, BME, BPBM).

Cl. aquilus

Cl. ceylonicus

Cl. aquilus

Cl. cruciger

Figures 4–11. 4, 5, 8–11 Male *Cladobethylus* **6, 7** Female *Cladobethylus* **4, 6, 8, 10** Lateral view **5, 7, 9, 11** dorsal view.

Cladobethylus ceylonicus Krombein

Figs 8, 9

Cladobethylus ceylonicus Krombein 1980: 253. Holotype male; Sri Lanka: Central Prov., Kandy Dist., Adams Peak (USNM).

Diagnosis. The most distinctive features of *Cl. ceylonicus* are the long first and second flagellomeres, a characteristic shared with *Cl. acehensis* and *Cl. densepunctatus*. Howev-

er, *Cl. ceylonicus* can be distinguished from these and other species by the combination of these features, along with the densely punctate second metasomal tergum, asymmetrical apical male flagellomeres and short subantennal distance.

Male description. *Body* (Figs 8, 9). Length 4.0 mm. *Head*. Scapal basin impunctate, with short strip of cross-ridges on either side of narrow medial stripe; clypeus short and subtruncate apically, subantennal distance 0.4 MOD long; malar space 3.8 MOD long wide; head about as long as wide; interocular distance 1.9× eye width in front view; midocellus 2.2 MOD from ocular margin; ocelli arranged in isosceles triangle; hindocelli separated from ocular margin by 1 diameter; postocular distance 1.6 MOD wide; flagellomere I 4.5× as long as broad, setae 0.5× as long as flagellomere breadth; flagellomere II 3.3× as long as broad; flagellomere XI 5× as long as broad; flagellomeres VIII–X asymmetrically bulging submedially. *Mesosoma*. Pronotum about 1.1× as long as scutum; mesopleural punctures contiguous; metapleuron dorsally cross-ridged, ventrally polished, impunctate; propodeum laterally cross-ridged dorsally, ventrally polished, impunctate, with subrectangular posteromedial enclosure. *Metasoma*. Tergum I with few, widely scattered tiny punctures; tergum II with large patch of punctures 1–2 puncture diameters apart, separated by medial longitudinal stripe; terga III–V with dense, tiny, nearly contiguous punctures, with impunctate apical margin. *Color*. Body black, with metallic blue highlights; legs yellow; antenna orange; wing membrane brown-tinted, veins dark brown.

Female. Unknown.

Distribution. Sri Lanka: Rat Dist., Gilimale, Induruwa Jungle, **Central Prov**., Kandy Dist., Adams Peak. The holotype and one male paratype were examined.

Cladobethylus cruciger Kieffer

Figs 10, 11

Cladobethylus cruciger Kieffer 1922: 69. Syntype males; Philippines: Mindanao, Butan; Luzon, Laguna, Mt. Maquiling (Lost?).

Cladobethylus cruciger var. *antennalis* Kieffer 1922: 71. Holotype male; Philippines: Luzon, Tayabas, Mt. Banahao (Lost?). Synonymized by Kimsey and Bohart 1991.

Cladobethylus coeruleus Kieffer 1922: 71. Holotype female; Philippines: Mindanao, Butan (Lost?), syn. nov.

Diagnosis. *Cladobethylus cruciger* males most closely resemble male *Cl. darlingi* based on the cylindrical apical flagellomeres, nearly impunctate metasomal tergum II, and flagellomere I less than 3.5× as long as broad. It can be distinguished from *Cl. darlingi* and other *Cladobethylus* species by the combination of the male least interocular distance equal to the eye width in front view, postocular distance one midocellar diameter wide, brown antenna and body with bluish highlights dorsally. There are insufficient characters given by Kieffer to distinguish female "*Cl. coeruleus*" from other female *Cladobethylus*.

Male description. Body (Figs 10, 11): length 4.0 mm. *Head*. frons punctures 0.2–0.5 puncture diameters apart; scapal basin primarily smooth with short strip of cross-

ridges on either side of broad medial stripe; clypeus long and truncate apically in front view, subantennal distance 1 MOD; malar space 3.6 MOD long; head 1.1× as long as wide in front view, interocular distance equal to eye width in front view; midocellus 2 MOD from ocular margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by 1 diameter; postocular distance 1 MOD; flagellomere I 3.3–3.5×, setae half as long as flagellomere breadth; flagellomere II 2.7–3.0×; flagellomere IX 6×; apical flagellomeres cylindrical. *Mesosoma*. Pronotum about as long as scutum; mesopleural punctures 0.5–1.0 puncture diameters apart; metapleuron smooth, impunctate; propodeum laterally smooth and impunctate, with posteromedial enclosure parallel-sided, subrectangular. *Metasoma*. Tergum I essentially impunctate; tergum II with few, tiny, widely scattered punctures; terga III-V with dense, contiguous to narrowly separated tiny punctures, with impunctate apical rim. *Color*. Body black, except dorsum of head, pronotum, scutum and scutellum with faint metallic blue highlights; legs including coxae yellow; antenna brown; wing membrane brown tinted; veins dark brown.

Female description (based on Kieffer's description of *Cl. coeruleus*). *Body length* 4.0 mm. *Head*. Flagellomere I 2.5× as long as broad; flagellomere II 1.5× as long as broad; flagellomere X more than twice as long as broad. *Metasoma*. Third tergum closely and rather finely punctured. *Color*. Body black, except mesosomal dorsum with metallic blue highlights; legs including coxae yellow.

Distribution. Philippines: **Mindanao**: Misamis Or., Dinawehan Gingoong, 26 km e Gingoong City, 100–300m, 12/viii/1965, L. Torrevillas; **Butan**; Luzon, Laguna, Mt. Maquiling; one non-type male has been seen (BPBM).

Discussion. The description above is based on Kieffer's descriptions of *Cl. coeruleus* and *Cl. cruciger*, plus a single male specimen from the island of Mindanao that fits Kieffer's description.

Kieffer's *Cladobethylus coeruleus* is synonymized here with *Cl. cruciger* as his description of *coeruleus* matches the shared characteristics between male and female *Cladobethylus* seen in other species where both sexes are known. Both specimens are from Mindanao. In the female description, Kieffer refers to punctation of the third tergum, but it is not clear whether he counted the propodeum as the first tergum.

The subspecies *Cl. antennalis* might be a valid species based on the differences in flagellomere dimensions and collection location on a separate island. In Kieffer's description flagellomere I is 3.5× along as broad and flagellomere II 3× as long as broad in *Cl. cruciger s. s*., but in *Cl. antennalis* flagellomere I is 3× as long as broad and II twice as long as broad. However, without access to the types it is impossible to be certain.

***Cladobethylus darlingi* Kimsey, sp. nov.**
http://zoobank.org/71BED8B5-7E81-4C25-AA13-4E850E01A370
Figs 12–15

Diagnosis. Males of this species most closely resemble those of *Cl. cruciger* as discussed under that species. It can be distinguished from *Cl. cruciger* and other male

Cladobethylus by the combination of the malar space 3.5 midocellar diameters wide or wider, interocular distance more than twice eye width in front view, flagellomere I less than 3.5× as long as broad, flagellomere II less than 2.5× as long as broad, and flagellomere XI more than 6.5× as long as broad.

Male description. *Body* (Figs 12, 13). Length 3.0–5.0 mm. *Head*. Frons with punctures 1–2 puncture diameters apart; scapal basin primarily smooth with narrow strip of cross-ridges on either side of broad medial stripe and scattered punctures laterally along eye margins; clypeus long, projecting ventrally, projection apicomedially irregularly truncate; subantennal distance 1.2 MOD long; malar space 3.8 midocellar diameters wide; head about as long as wide; interocular distance 2.2× eye width in front view; midocellus 2.4 diameters from ocular margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by 1.0–1.2 diameters; flagellomere I 3.5–3.8× as long as broad, setae length 0.3× flagellar width; flagellomere II 2.3–2.5× as long as broad; flagellomere XI 6.7× as long as broad; apical flagellomeres asymmetrically slightly bulging medially. *Mesosoma*. Pronotum slightly shorter than scutum; mesopleural punctures 0.5 puncture diameters apart; metapleuron polished with 1–3 irregular transverse ridges; propodeum laterally polished, with subrectangular posteromedial enclosure. *Metasoma*. Tergum I with medial transverse zone of widely separated tiny punctures, otherwise impunctate; tergum II highly polished, with tiny punctures 2–10 puncture diameters apart, with impunctate longitudinal medial band and posterior margin; terga III-IV with tiny punctures, 1–3 puncture diameters apart, posterior margins impunctate. *Color*. Body black, except head vertex with purplish highlights and dorsum of pronotum, scutum, scutellum and metanotal triangle with metallic blue highlights; metasomal tergum I reddish basally, apically black, often with bluish highlights, terga II–V black, often with bluish highlights; legs including coxae yellow; antenna orange to light brown; wing membrane light brown-tinted, with dark brown veins.

Female description. Body (Figs 14, 15). Length 3.0 mm. *Head*. Frons punctures contiguous to 0.5 puncture diameter apart; scapal basin impunctate, with narrow band of cross-ridges submedially; clypeus short, truncate apicomedially; subantennal distance 0.4 MOD wide; malar space 4 MOD long; head 0.9× as long as broad, interocular distance 1.1× eye width in front view; postocular distance 0.4 MOD; vertex rounded angulate posterolaterally in dorsal view; midocellus 2.2 MOD from ocular margin; ocelli arranged in isosceles triangle; hindocelli separated from ocular margin by 1 hindocellar diameter; flagellomere I 2.3× as long as broad; flagellomere II as long as broad; flagellomere X 1.8× as long as broad. *Mesosoma*. Mesopleural punctation contiguous; metapleuron polished with metapleural-propodeal suture foveate; propodeum smooth, impunctate below wing. *Metasoma*. Tergum I and II with tiny widely separated punctures, 10 puncture diameters apart or more; terga III and IV punctures 1–3 puncture diameters apart, with impunctate apical rim. *Color*. Body black, without metallic highlights; legs brown; antenna brown; wing membrane light brown tinted, with dark brown veins.

Type material. Holotype male: Indonesia: Borneo, **West Kalimantan**, Gunung Palung Nat. Park, Cabang Panti Res. Sta., 100m, Malaise trap, rainforest alluvial, 1°15'S, 110°5'E, 15 Jun-15 Aug, 1991, Darling, Rosichon, Sutrisno, IIS910122

Cl. darlingi

Cl. densepunctatus

Figures 12–19. 12, 13, 16, 17 Male *Cladobethylus* **14, 15, 18, 19** Female *Cladobethylus* **12, 14, 16, 18** Lateral view **13, 15, 17, 19** dorsal view.

(ROM). Paratypes: 8 males, 2 females; 3 males: same data as holotype; 2 males: same data, except rainforest sandstone, IIS910119; 1 male: rainforest sandstone, light gap, IIS910116; 1 male: 100–400m, rainforest sandstone, IIS910129; 1 male: 29/vi/1991, rainforest alluvial, screen sweep, IIS910165; 1 female: rainforest sandstone, Malaise trap pans, IIS9310134; 1 male: rainforest peat swamp, Malaise trap pans, IIS910132; 1 female: rainforest granite, Malaise trap pans, IIS910115; 1 male: 17–29/vi/1991, rainforest sandstone, Malaise trap, IIS910135 (BME, MZB, ROM).

Distribution. Borneo. Additional non-type material from Borneo includes three males: **East Kalimantan**, Kac. Pujungan, Kayan-Mentarang Nat. Res., 21/iii/-4/iii/1992, 2°52'N, 115°49'E, lowland Dipt. Forest, Lalut Birai riparian vegetation 378m, screen sweep, DC Darling, IIS930008; 4 males: **Brunei**, Kuala Belalong, FSC, 4°34'N, 115°7'E, 18/v/1991, Malaise, N. Mawdsley, BMNH(E)1991-173; 1 male: iii/1991, BMNH(E)1991-173; 1 male: Brunei, Ulu Temburong base camp, 300m, 16/ii-9/iii/1982, M.C. Day; 1 male: **North Borneo** (SE), 19 km n, forest camp, 60 m, 21/xi/1962, K.J. Kuncheria; 1 male: 7/xi/1862; 1 male: **Sarawak**, 4th div., Gn. Mulu, RGS Exp. 17/xi/1923, D. Hollis, BM77-543; 1 male: British N. Borneo, Gomantong Caves, 22–26/xi/1958, TC Maa; 2 males: Borneo, Sarawak, sw Gunung Buda, 64km s Limbang, 4°13'N, 114°56'E, 22–28/xi/1996, MT, SL Heydon & S Fung; 1 male: 8–15/xi/1996.

Etymology. The species is named after Chris Darling who not only collected this species, but also has collected many other *Cladobethylus* species in Southeast Asia.

Cladobethylus densepunctatus Kimsey, sp. nov.

http://zoobank.org/B76A5F6E-B578-401C-B63B-02F5171E7070
Figs 16–19

Diagnosis. This is the most distinctive of the *Cladobethylus* species. The coarse punctation and long, strongly angulate vertex will immediately separate *Cl. densepunctatus* from all other species in both sexes. In addition, males have the apical flagellomeres asymmetrical, and females have the longest first flagellomere (2.5×), widest interocular distance (more than twice eye width), longest subantennal distance (more than 1.3 midocellar diameters), lack occipital fovea (shared with *Cl. thailandicus*) and have an entirely brown antenna.

Male description. Body (Figs 16, 17). Length 2.0–4.0 mm. *Head*. Scapal basin coarsely punctate, at most with small number of wrinkles basomedially; clypeus long and gently convex apicomedially; subantennal distance 1.2 MOD; malar space 3.5 MOD long; head slightly shorter than broad, interocular distance 2.4× eye width in front view; postocular distance 2.3 midocellar diameters; vertex strongly angulate posterolaterally in dorsal view; midocellus 2 MOD from ocular margin; ocelli arranged in isosceles triangle; hindocelli separated from ocular margin by 1.2 diameters; flagellomere I 3.5× as long as broad, setae 0.4× as long as flagellomere breadth; flagellomere II 2.6× as long as broad; flagellomere IX 5× as long as broad; apical five flagellomeres slightly lobate submedially. *Mesosoma*. Pronotum about as long as scutum; mesopleu-

ron with punctures contiguous t 0.5 puncture diameters apart; metapleuron polished, impunctate; propodeum laterally polished, impunctate, with posteromedial enclosure subrectangular. *Metasoma*. Tergum I with small submedial patch of punctures, 1–2 puncture diameters apart, otherwise impunctate; tergum II basal half with punctures, 1–2 puncture diameters apart, separated by impunctate medial stripe, apical part impunctate; terga III-V with dense basal band of punctures separated by impunctate longitudinal band, posterior margin impunctate. *Color*. Body black, without metallic highlights; legs including coxae orange to red; antenna dark reddish brown; wing membrane light brown tinted, with dark brown veins.

Female description. *Body* (Figs 18, 19). Length. 3.0–6.0 mm. *Head*. Scapal basin coarsely punctate, with band of wrinkles basomedially; clypeus long and rounded apically, subantennal distance 1.8 MOD long; malar space 5.2 MOD long; head slightly broader than long; midocellus 3.6 MOD from ocular margin; ocelli arranged in isosceles triangle; hindocelli separated from ocular margin by 2 diameters; flagellomeres rounded, broadest submedially; flagellomere I 2.6× as long as broad; flagellomere II as long as broad; flagellomere X twice as long as broad. *Mesosoma*. Pronotum slightly shorter than scutum; mesopleural punctures large, contiguous; metapleuron with coarse cross ridging; propodeum laterally wrinkled, with posteromedial enclosure subrectangular. *Metasoma*. Tergum I impunctate, except for narrow transverse band of punctures separated by 0.5–1.0 puncture diameters; tergum II with large ovoid basal punctate areas, with punctures 0.5–1.0 puncture diameters apart, separated medially by impunctate longitudinal stripe, laterally and posteriorly nearly impunctate; terga III-V with punctures 0.5–1.0 puncture diameters apart, with impunctate apical margin. *Color*. Body black, without metallic highlights; legs including coxae yellow; antenna: scape, pedicel red, flagellum dark brown becoming red ventrally toward apex; wing membrane light brown tinted, veins dark brown.

Type material. Holotype male: Thailand: **Lampang Prov**., Chae Son NP, Huai Yen, 18°50'012"N, 99°28'656"E, 419m, pan trap, 7–8/v/2008, Kwannui & Sukpeng, T5304 (QSBG). Paratypes: 6 males, 9 females: 1 male: **Bangkok**, Khao Yai NP, 15/iv/1990, Black light, B.V. Brown; 1 female; **Chiang Mai Prov.**, Doi Chang Dao NP, Pha Tang substation, 19°25'N, 98°55'E, 526 m, Songkran & Apichart, 21–28.x.2007, MT, T3180; 1 female: Jugeau & Watwanich, 8–15/iv/2008, T5791; 1 female: Doi Inthanon NP, Vachiratharn Falls, 18°32.311'N, 98°36.048'E, 700m, Malaise trap, 2–8.vii.2006, Y. Areeluck. T51; 1 female: Chiang Mai Botanic Garden, 18.8955N, 98.8636E, 11–25/vii/2013, M. Hauser; 1 female: **Chaiyaphum Prov.**, Pa Hin Ngam NP, Thepana waterfall, 15°38.948'N, 101°25.625'E, 604m, Malaise trap, 7–13.x.2006, Sa-nog & Adnafai, T660; 1 male: **Chanthaburi Prov.**, Khao Khitchatkut NP, 12°50.2'N, 102°7.3'E, 46m, 10–17/IV/2009, S. Charoenchai, MT, T4878; 1 female: **Loei Prov.**, Phu Ruea NP, 17°27.901'N, 101°21.301'E, 700m, Malaise trap, 5–12.xii.2006, Patikom Tumtip, T1263; 1 male, 1 female: Phu Kradeung NP, 273m, 16°56.589'N, 101°42.074'E, 21/x/2006, S. Glonglasae, T786; 1 male: 16°49.9'N, 101°47.6'E, 273m, Malaise trap, 14–21/v/2008, T. Phatai, T5011; 1 female: **Sakon Nakhon Prov.**, Phu Phan NP, 16°48.628'N, 103°53.591'E, 522m, Malaise trap, 3–9.

xii.2006, S. Kongnara, T1241; 1 male: Surat Thani, Khao Sok NP, Ban Huaraed, 8°54.555'N, 98°30.522'E, 122m, MT, 6–13/I/2009, Pongphan, T3913; 1 male: **Trang Prov.**, Khaophappha Khaochang, 200–400m, 10.1.1964, W. Samuelson; 1 female: **Ubon Ratchathani Prov.**, Pha Taem NP, 15°37.321'N, 105°36.982'E, 419m, Malaise trap, 13–20.x.2006, T723 (BME, CHIANG MIA).

Distribution. Thailand: Bangkok, Chiang Mai, Chaiyaphum Chanthaburi, Loei, Sakon Nakhon, Surat Thani, Trang, Ubon Ratchathani Provinces. One additional male was seen from Viet Nam: 6 km s Dalat, 1400–1500 m, 9/vi-7/vii/1961, N. R. Spencer.

Etymology. The species is named for the unusually dense, coarse punctation on the head and thorax.

Cladobethylus gilbus Kimsey

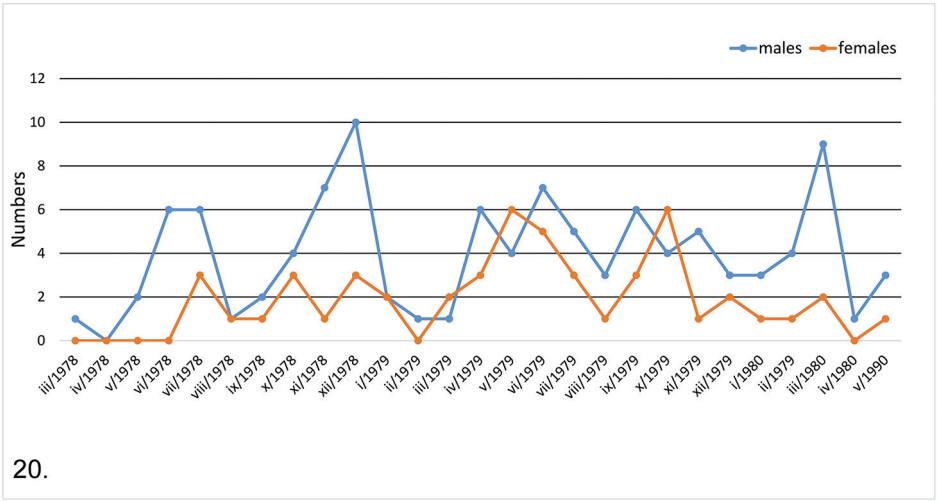
Figs 20–25

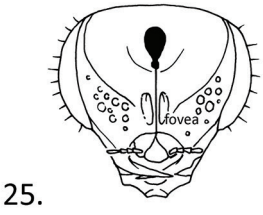
Cladobethylus gilbus Kimsey 1986:157. Holotype male; Malaysia: Pasoh Forest Res., Negri Sembilan (AEI).

Diagnosis. *Cladobethylus gilbus* shares the nearly impunctate second metasomal tergum with *Cl. darlingi*, *Cl. acehensis* and *Cl. densepunctatus*. In males it can be distinguished from those species by the narrow malar space (less than 2.8 midocellar diameters), flagellomere I less than 4× as long as broad, flagellomere II more than 2.5× as long as broad, flagellomere XI 7× as long as broad and postocular distance less than 1 MOD. Females have the basal three flagellar segments paler than the rest of the flagellum, very short flagellomeres I and II and malar space 4.5 midocellar diameters wide (shared with *Cl. aquilus*).

Male description. *Body* (Figs 21, 22). Length 3.5–4.0 mm. *Head*. Scapal basin with narrow band of cross-ridges separated by smooth medial band; head venter without ovoid foveae along midline of gular area, gular area punctate; malar space 2.6 MOD long; head as wide as long; interocular distance 1.5× eye width in front view; midocellus 1.4 MOD from ocular margin; ocelli arranged in a nearly equilateral triangle; hindocelli separated from ocular margin by 1 diameter; subantennal distance 0.6 MOD; clypeal apex truncate to slightly concave; flagellomere I 3.6× as long as broad, setae length 0.4× flagellomere breadth; flagellomere II 2.6× as long as broad; flagellomere IX 7× as long as broad; flagellomeres VIII–X slightly lobate submedially. *Mesosoma*. Pronotum 0.9× as long as scutum; mesopleural punctures 0.2–0.5 puncture diameters apart; metapleuron with zone of cross ridging below hindwing base; propodeum laterally cross-ridged, posteromedially with subrectangular enclosure. *Metasoma*: terga I and II impunctate; terga III–V with basal band of dense, minute, contiguous punctures. *Color*: body black, except pronotum, scutum, scutellum and metanotal triangle with metallic blue highlights; antenna and legs including coxae yellow; wing membrane light brown tinted, with brown veins.

Female description. *Body* (Figs 23, 24). Length. 4.0–5.0 mm. *Head*. Frons punctures contiguous to 0.5 puncture diameters apart; scapal basin primarily smooth with





Figures 20–25. *Cladobethylus gilbus* 20 graph of seasonal abundance of males and females in Malaysia **21, 22** males **23–25** females **21, 23** lateral view **22, 24** dorsal view **25** ventral view of head.

short strip of cross-ridges on either side of broad medial stripe; head venter with ovoid fovea on either side of gular midline (Fig. 25), gular area punctate; clypeus subtruncate apically; subantennal distance 0.8 midocellar diameter; malar space 4.5 midocellar diameters long; head about as long as wide; midocellus 2× midocellar diameters from ocu-

lar margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by one diameter; flagellomere I as long as broad; flagellomere II 0.6× as long as broad; flagellomere X twice as long as broad. *Mesosoma*. Pronotum about as long as scutum; mesopleuron with irregular scrobal sulcus, punctures contiguous to 0.5 puncture diameter apart; metapleuron smooth and impunctate; propodeum laterally polished, impunctate, posteromedially with subrectangular enclosure smooth but somewhat irregular. *Metasoma*. Tergum I impunctate; tergum II punctures 10 puncture diameters apart becoming slightly denser laterally; terga II–IV punctures 1–2 puncture diameters apart with impunctate rim. *Color*. Body black, except head and pronotum with faint metallic blue highlights; legs including coxae yellow; scape yellowish brown becoming darker ventrally; pedicel and flagellomeres I–III yellow, remaining flagellomeres brown dorsally becoming yellow ventrally; wing membrane brown-tinted, veins dark brown.

Distribution. MALAYSIA: **Negeri Sembilan**, Pasoh Forest Res.; 106 males and 50 females were examined (AEI, BME). Males and females were found in nearly every month over a two-year period of Malaise trap collecting at this site (Fig. 20).

Cladobethylus insularis Kimsey & Dewhurst

Figs 26–29

Cladobethylus insularis Kimsey, Dewhurst & Nyaure, 2012: 3. Holotype male; Papua New Guinea, Northern Prov., Higaturu (BMNH).

Diagnosis. This is the largest bodied species of *Cladobethylus*, with males averaging about 1.5× the length of the known other species. Male *Cl. insularis* can be distinguished from *Cl. aquilus*, the only other species known from New Guinea by the pronotum without blue tints, a much broader zone of cross-ridging in the scapal basin, legs brown instead of yellow (*Cl. aquilus*) flagellomere I shorter (4× as long as broad versus 5× in *Cl. aquilus*), and flagellomere XI shorter (5× as long as broad versus 6× in *Cl. aquilus*). Features of female *Cl. insularis* not shared with other *Cladobethylus* include the bicolored antenna and legs, long clypeus (1 MOD long versus 0.3–0.6 MOD in other species), and narrow distance between the midocellus and nearest eye margin (up to 2 MOD versus 2.6–2.7 MOD in the others).

Male description. *Body* (Figs 26, 27). Length 5.0–7.0 mm. *Head*. Face about as long as broad across the eyes; genal area without foveae; midocellus 1.8 diameters from ocular margin; hindocellus 0.9 diameters from ocular margin; scapal basin with narrow, longitudinal submedial band of cross-ridges; malar space 3.5–3.8 MOD; subantennal distance 1 MOD long; interocular distance twice as wide as eye width in front view; postocular distance from ocular margin 1.8 MOD wide, postocular margin sharply angulate posterolaterally; flagellomere I 4.0–4.2× as long as broad; flagellomere II 2.6–3.0× as long as broad, setae length 0.5× as flagellomere breadth; flagellomere IX 5.5–5.7× as long as broad; ocular setulae 0.4 MOD long. *Mesosoma* (Fig 9). Pronotum about as long as scutum; punctation on pronotum, scutum and mesopleuron large,

Figures 26–33. 26, 27 Male *Cladobethylus* **28–33** female *Cladobethylus* **26, 28, 30, 32** lateral view **27, 29, 31, 33** dorsal view.

deep and nearly contiguous; with scutellum polished with scattered tiny punctures; metapleuron polished, impunctate; propodeum laterally polished and impunctate with several cross ridges ventrally, posteromedial enclosure broadly rectangular, polished and impunctate medially. *Metasoma*. Tergum I with transverse medial band of tiny punctures 2–4 puncture diameters apart, impunctate otherwise; tergum II with two large ovoid patches of small punctures, contiguous to 1 puncture diameter apart, separated medially by impunctate band, with broad apical impunctate band; terga III–IV with tiny punctures 1 puncture diameter apart, becoming sparser toward apical margin. *Color*. Body black, with metallic bluish green highlights dorsally on head, pro-

notum and scutellum, sometimes faintly on metasomal terga; mandible and antenna dark brown; legs light reddish brown, except coxae dark brown to black basally; wing membrane brown-tinted, darkest in vicinity of stigma; wing veins dark brown.

Female description. *Body* (Figs 28, 29). Length. 4.5–5.5 mm. *Head*. Malar space 3.6–3.8 MOD wide; subantennal distance 0.6 MOD wide; interocular distance 1.2× as wide as eye in front view; postocular distance 1.1 MOD wide, posterolateral margin broadly angulate; midocellus 2 diameters from ocular margin; hindocellus 1 diameter from ocular margin; flagellum fusiform, flagellomeres broadest apically, flagellomere I 2.2–2.4× as long as broad, flagellomere II as long as broad, flagellomere X 1.3–1.5× as long as broad. *Mesosoma*. Pronotum 1.2× as long as scutum medially; mesopleural punctures contiguous; metapleuron smooth, impunctate; propodeum laterally smooth, impunctate, posteromedial enclosure subrectangular. *Metasoma*: tergum I with transverse medial band of scattered tiny punctures, otherwise impunctate; tergum II punctures 0.5–1.0 puncture diameters apart, with impunctate medial longitudinal band and posterior margin; tergum III–V punctures tiny, 0.5–1.0 puncture diameter apart with impunctate margin. *Color*: scape, pedicel black; flagellomeres I–III white, remaining flagellomeres black; coxae, femora, mid and hindtibiae black basally, whitish apically; foretibia and tarsi brown; wing membrane brown-tinted with dark brown veins.

Distribution. Papua New Guinea, **Northern (Oro) Province**, Higaturu; 18 males, 6 females; ex *Eurycantha insularis* eggs (BME, BMNH).

Cladobethylus japonicus Kimsey

Figs 30, 31

Cladobethylus japonicus Kimsey 1986: 158. Holotype female; Japan: Kyoto (AEI).

Diagnosis. This species has several unusual diagnostic female features. The eye has very long dense setulae, the hindocelli are very close to the ocular margins and the malar space is very long. In addition, the pronotum is longer than the scutum, and the metapleuron is cross-ridged from wing base to coxa.

Male. Unknown.

Female description. *Body* (Figs 30, 31). Length: 2.5 mm. *Head*. Scapal basin smooth with short strip of cross-ridges on either side of broad medial stripe; clypeus short, broadly rounded; subantennal distance 0.6 MOD; malar space 5 MOD long; interocular distance 1.5–1.7× eye width in front view; face about as broad as long in front view; ocular setulae 1 MOD long or longer; midocellus 2.6 MOD from ocular margin; hindocellus separated from ocular margin by one diameter; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by 1 hindocellar diameter; flagellomere I 2.3× as long as broad; flagellomere II 1.4× as long as broad. *Mesosoma*. Mesopleural punctures larger than on pronotum; metapleuron cross-ridged from hindwing base nearly to midcoxa; propodeum with posteromedial enclosure rough, subrectangular. *Metasoma*: terga I–V with tiny scattered punctures at least 4–6 PD apart laterally, nearly impunctate medially. *Color*: body black with bluish tints on vertex and

pronotum; legs including coxae yellow; scape dark brown becoming paler distally; pedicel and flagellomeres I–III yellow, remaining flagellomeres brown; mandibles brown.

Distribution. JAPAN: **Kyoto**; 1 female (the holotype) examined (AEI).

***Cladobethylus koreensis* Kimsey, sp. nov.**
http://zoobank.org/3B10AB85-C52F-4AD8-A2F7-DD6EC718CFE5
Figs 32, 33

Diagnosis. This species has several unusual female features. The eye has very long dense setulae, the hindocelli are very close to the ocular margins and the malar space is very long. In addition, the pronotum is longer than the scutum, and the metapleuron is cross-ridged from wing base to coxa.

Male. Unknown.

Female description. *Body* (Figs 32, 33). Length. 2.5–3.0 mm. *Head*. Scapal basin smooth, polished with narrow strip of cross-ridges on either side of broad medial stripe; clypeus short, broadly convex apicomedially; subantennal distance 0.5 MOD wide; malar space 5 MOD long; interocular distance 1.2× eye width in front view; face about 3× as long as broad across midocellus in front view; ocular setulae 1.5 MOD long or longer; midocellus 3 MOD from ocular margin; hindocellus separated from ocular margin by 1 hindocellar diameter; ocelli arranged in isosceles triangle; postocular distance 0.5 MOD; flagellomere I 2.3× as long as broad; flagellomere II as long as broad; flagellomere X 1.5× as long as broad. *Mesosoma*. Mesopleural punctures larger than on pronotum, 0.2–1.0 puncture diameters apart; metapleuron impunctate medially, transversely ridged, with smooth area medially; propodeum laterally impunctate and irregularly wrinkled, posteromedial enclosure ovoid. *Metasoma*: terga I–V with tiny scattered punctures at least 10 PD apart laterally, nearly impunctate medially. *Color*: body black without bluish tints; legs including coxae yellow; scape dark brown becoming paler distally; pedicel and flagellomeres I–III white, remaining flagellomeres brown; mandibles brown; wing base white, rest of wing membrane and veins brown.

Type material. Holotype female: South Korea: **Jeollanam-Do**, Wando Arboretum, 34.3585N, 126.6685E, 10/viii/2015, T-S. Kwan, forest Malaise trap (BME). Paratype female: same data as holotype.

Distribution. South Korea: South Jeolla Prov.

Etymology. The species is named for the country of collection.

***Cladobethylus thailandicus* Kimsey, sp. nov.**
http://zoobank.org/6ECB75D0-B471-4061-BDBA-27E048EB3C68
Figs 34–37

Diagnosis. This is a distinctive species. Males can be distinguished by flagellomere XI 5× as long as broad (shared with *Cl. ceylonicus* and *Cl. densepunctatus*), scapal basin without cross-ridging, subantennal distance more than 1 midocellar diameter long and

body lacking metallic bluish highlights. Females have a bicolored antenna, with the basal segments whitish and the apical segments dark brown, the postocular distance is less than one midocellar diameter, and the gular bridge lacks occipital foveae.

Male description. *Body* (Figs 34, 35). Length 2.5–4.0 mm. *Head*. Frons punctures 1–2 puncture diameters apart; scapal basin primarily smooth with short strip of cross-ridges on either side of broad medial stripe; clypeus long and truncate or slightly emarginate apically; subantennal distance 1.2 midocellar diameters; malar space 3.5 midocellar diameters long; head about as long as wide; midocellus 1.7 diameters from ocular margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by one diameter; postocular distance 2.5 midocellar diameters; flagellomere I 4× as long as broad, setae 0.5× as long as flagellomere breadth; flagellomere II 3.2× as long as broad; flagellomere IX 5× as long as broad. *Mesosoma*. Pronotum about 0.9× as long as scutum; mesopleural punctures 0.5–1.0 puncture diameters apart; metapleuron smooth, impunctate; propodeum laterally wrinkled, with posteromedial enclosure subrectangular. *Metasoma*. Tergum I essentially impunctate; tergum II with few, widely scattered, tiny punctures; terga III–V with dense, tiny punctures 0–0.5 puncture diameters apart, with impunctate apical margin. *Color*. Body black, except pronotum, scutum, scutellum and medial triangle of metanotum with metallic blue highlights; legs including coxae yellow to orange; antenna brown; wing membrane brown, veins dark brown.

Female description. *Body* (Figs 36, 37). Length 2.5–4.0 mm. *Head*. Frons punctures contiguous to 0.5 puncture diameters apart; scapal basin primarily smooth with short strip of cross-ridges on either side of broad medial stripe; clypeus long and apically truncate or slightly emarginate; subantennal distance 0.8 midocellar diameter long; malar space 3.8 midocellar diameters long; head as long as wide; midocellus 2 diameters from ocular margin; ocelli arranged in nearly equilateral triangle; hindocelli separated from ocular margin by 0.5–0.8 diameters; postocular distance 0.5 MOD; flagellum fusiform; flagellomere I 2.4× as long as broad; flagellomere II 0.7–0.9× as long as broad; flagellomere X twice as long as broad. *Mesosoma*. Pronotum about as long as scutum; mesopleural punctures contiguous to 0.5 puncture diameter apart; metapleuron entirely cross-ridged; propodeum laterally wrinkled, with posteromedial enclosure subrectangular. *Metasoma*. Terga I and II largely impunctate with narrow lateral band of tiny punctures, 3–6 puncture diameters apart; tergum III with tiny punctures 1–2 puncture diameters apart, separated medially by impunctate longitudinal stripe and apical impunctate rim; tergum IV punctures tiny, separated by 0.5–1.0 puncture diameters with narrow impunctate rim. *Color*. Body black, except pronotum and scutum with faint blue highlights; legs including coxae yellow; scape, pedicel and flagellomeres I–III pale orange to whitish, remaining flagellomeres brown, except tip of apical flagellomere whitish; wing membrane brown tinted, with dark brown veins.

Type material. Holotype male: Thailand: **Nakon Nayok Prov.**, Khao Yai NP, Lam Takong view point, 14°25.762'N, 101°23.527'E, 732m, 5–12/x/2006, W. Sook Kho, T741 (QSBG). **Paratypes**. 7 males, 10 females. 1 female: **Nakhon Nayok Prov.**, Khao Yai, 14°24.619'N, 101°22.708'E, MT, 19–26/vii/2006, P. Sandao, T148; 1 female:

Figures 34–37. 34, 35 Male *Cladobethylus thailandicus* **36, 37** Female *Cladobethylus* **34, 36** lateral view 35, 37 dorsal view.

Khao Yai NP, 6/vi/1965, P. D. Ashlock; 1 males, 2 females: 180 km NE **Bangkok**, Khao Yai NP, 780m, 11–18/iv/1990, MT, B.V. Brown; 2 males, 1 female: **Nakhon Si Prov.**, Thammarat, Namtok Yong NP, 8°14.3'N, 99°48.3'E, 952m, Malaise trap, Paiboon, 30/iii-6/iv/2009, T4658; 1 male: Thammarat, Namtok Yong NP, road to Khao Mhen 150m from Nern 499, 8°16.959'N, 99°39.149'E, Malaise trap, 8–15/vi/2008, S. Samnaokan, T3095; 1 male: **Trang Prov.**, Khaophappha Khaochang, 200m, 1–3/i/1964, GA Samuelson, Malaise trap, Bishop; 1 male: **Chanthaburi Prov.**, Khao Khitchakut NP, Khao Prabaht Peak, 875m, 12°50.4'N, 102°10'E, MT, S. Charoenchai, 6–13/iii/2009, T4060; 1 male: **Phetchabun Prov.**, Nam Nao NP, 16°43.695'N, 101°33.797'E, 921m, YPT, 25–26/x/2006, N. Hongyothi, T1006; 1 female: **Petchaburi Prov.**, Kaeng Krachan NP, 320m, 12°47.9'N, 99°27.2'E, 27/vi-4/vii/2008, MT, Sirichai, T4338; 1 female: **Nakhon Ratchasima Prov.**, Khao Yai NP, 700–800m, 18–24/iv/1990, MT, E. Fuller; 1 female; Tiger trail, 760m, MT, 14°27.5'N, 101°22'E, 26/vi-2/vii/2007, P. Sandao, T2232; 1 female: **Chiang Mai Prov.**, Doi Chiangdao NP, Huai Na Lao, 500m, 19°24.731'N, 98°55.315'E, MT, 3–9/v/2008, Jugsu & Watwanich, T5803; P. Sandao, T2232; 1 female: **Surat Thani Prov.**, Khao Sok NP, Bang Huaraed, 122m, 8°54.6'N, 98°30.5'E, 5–12/v/2009, MT, Pongphan, T4861 (BME, QSBG).

Distribution. Thailand: Chanthaburi, Chiang Mai, Nakhon Nayok, Nakhon Si, Nakhon Ratchasima, Phetchabun, Phetchaburi, Surat Thani, and Trang Provinces.

Etymology. The species is named after the country of collection.

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References

Kieffer JJ (1922) Philippine Serphidae (Proctotrupidae). Philippine Journal of Science 20: 65–103.

Kimsey LS (1986) New species and genera of Asian Amiseginae. Psyche 93: 153–165. https://doi.org/10.1155/1986/31631

Kimsey LS, Bohart RM (1991 [1990]) The Chrysidid Wasps of the World. Oxford Science Publications, New York, 652 pp.

Kimsey LS, Dewhurst CF, Nyaure S (2012) New species of egg parasites from the Oil Palm Stick Insect (*Eurycantha insularis*) in Papua New Guinea (Hymenoptera: Chrysididae; Phasmatodea: Phasmatidae). Journal of Hymenoptera Research 30: 19–28. https://doi.org/10.3897/jhr.30.4010

Krombein KV (1980) Biosystematic studies of Ceylonese wasps, I. A preliminary revision of the Amiseginae. PEP Deraniyagala Commemorative Volume (Sri Lanka): 246–260.

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RESEARCH ARTICLE

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The ants of Ohio (Hymenoptera, Formicidae): an updated checklist

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Abstract

I update the last published list of Ohio ants to include 26 new species records and 38 name changes in species already on the list based on literature records, institutional collections, and contemporary collections made by the author or colleagues. At present, 143 species and morphospecies representing 30 native and 5 exotic genera and 7 subfamilies have been recorded for the state. Another seven species are removed from the Ohio ant fauna as they represent distribution anomalies, or are based on erroneous records. Known distribution data suggest that there is still a considerable potential for the discovery of more ant taxa in Ohio.

Keywords

ant diversity, new records, distribution, eastern United States, Nearctic

Introduction

In 2005, Coovert published the first comprehensive account of the ant fauna of Ohio and listed 118 species and subspecies from the state based on literature, museum records, and extensive collecting in the state in the period 1996–2002 (Coovert 2005). The list included 14 taxa recorded for the first time from Ohio. A few earlier records were overlooked (i.e., *Paratrechina longicornis* (Latreille) (Hedges 1998), *Strumigenys hyalina* (Bolton) (Bolton 2000), *Tetramorium bicarinatum* (Nylander) (Bolton 1979)),

or excluded from the list (i.e., *Formica incerta* Buren (Wesson and Wesson 1940; Amstutz 1943; Headley 1943, 1949, 1952; Talbot 1945), *Myrmica incompleta* Provancher (Weber 1950), *Proceratium crassicorne* Emery (Wesson and Wesson 1940)) based on contemporary understanding of the group. *Formica nitidiventris* Emery was later synonymized with *Formica pallidefulva* Latreille and dropped from Ohio's list (Trager et al. 2007), bringing the total number of species known from the state to 117.

In the past fourteen years, a substantial amount of information from survey work, biodiversity and ecological studies, and taxonomic revisions (Francoeur 2007; Rabeling et al. 2007; Snelling and Snelling 2007; Trager et al. 2007; Trager 2013; Mackay and Mackay 2010, 2017; Kallal and Lapolla 2012; Pacheco and Mackay 2013; DeMarco and Cognato 2015, 2016; Morgan and Mackay 2017) has become available. As a result, the 2005 list is much out of date necessitating the current update. Contemporary knowledge of the state's ant fauna may be beneficial in providing support to future ecological, conservation, behavioral, and taxonomic studies in Ohio and the surrounding areas.

Materials and methods

Data reported herein are based on information gathered from the following sources: 1) review of published records; 2) examination of materials in the collections of the Cleveland Museum of Natural History and the Virginia Museum of Natural History; 3) online records from digitized personal and museum collections, iDigBio (https://www.idigbio.org/), SCAN (http://scanbugs.org/portal), and AntWeb (https://antweb.org/); and 4) newly collected material.

Abbreviations of entomological collections used in this study are as follows:

CMNH	Cleveland Museum of Natural History, Cleveland, Ohio.
FMNH	Field Museum of Natural History, Chicago, Illinois.
INHS	Illinois Natural History Survey, Champaign, Illinois.
MCZ	Louis Agassiz Museum of Comparative Zoology, Cambridge, Massachusetts.
MEM	Mississippi Entomological Museum, Starkville, Mississippi.
OSUC	C.A. Triplehorn Insect Collection at Ohio State University, Columbus, Ohio.
TTU-Z	Texas Tech University Invertebrate Collection, Lubbock, Texas.
UAIC	University of Arizona Insect Collection, Tucson, Arizona.
UCMC	University of Colorado Museum of Natural History Insect Collection, Boulder, Colorado.
VMNH	Virginia Museum of Natural History, Martinsville, Virginia.

To the best of my knowledge, all species names presented herein are the currently valid names according to the fourth edition of the International Code of Zoological Nomenclature (ICZN 1999). Taxon names and concepts used in this work are gleaned from an interpretation of the contemporary literature and follow Bolton (2019) with

the exception of *Myrmica emeryana* Forel which is based on an ongoing revision of North American *Myrmica* by André Francoeur. Known morphospecies bear the names assigned to them by the relevant taxonomic specialists (e.g., André Francoeur's "*Myrmica* AF-*smi*"). These names are unavailable according to the zoological code (ICZN 1999). Unless otherwise noted, all identifications were made by the author. Vouchers of all newly collected material are deposited in the invertebrate collections at CMNH and VMNH.

The species included in this checklist can be identified using the keys in Coovert (2005), Francoeur (2007), Trager et al. (2007), Ellison et al. (2012), Kallal and Lapolla (2012), and Sarnat et al. (2015). Additionally, representative high-resolution photographs of at least the worker's caste of Ohio's species can be found on AntWeb, AntWiki (www.antwiki.org) and on Discover Life (www.discoverlife.org).

In the species accounts presented herein, all taxa are listed alphabetically by subfamily, tribe, genus, and species. County-level distributions (new data in bold) are provided only for the published Ohio records not appearing in Coovert (2005) and for species previously known from only one or two records which are herein presented as "Rare", although I acknowledge that they may be more abundant and widespread outside the boundaries of Ohio. Detailed locality data are given only for the unpublished Ohio records. Material from institutional and personal collections is given first, followed by literature records, which are presented in chronological order. An asterisk (*) marks taxa absent from the 2005 list and superscript ^{E} denotes exotic species. General within-state distribution follows Coovert (2005) with adjustments for new records and recent taxonomic changes.

Appended is a list of questionable Ohio records based on published accounts or unpublished records appearing in online databases. These taxa are excluded from the Ohio fauna as they are based on erroneous records, mislabeled specimens, or misidentifications.

Results and discussion

A total of 143 species and morphospecies representing 30 native and 5 exotic genera and 7 subfamilies comprise the known ant fauna of Ohio, USA. These include 26 additions to the checklist provided in Coovert (2005) and 38 name changes in species already on the list. The new Ohio records are based on: 1) records published prior to 2005 but previously omitted from the list (6 taxa), 2) records published since 2005 (10 taxa), and 3) unpublished records (10 taxa). The majority of Ohio's new additions are known species whose populations were only recently discovered in the state with the remainder representing recently described (*Myrmica semiparasitica* Francoeur) or yet undescribed (*Myrmica* AF-*eva*, *Myrmica* AF-*scu*, *Myrmica* AF-*smi*) species.

Ohio's ant fauna is dominated by cool-climate *Camponotus*, *Formica*, *Lasius*, and *Myrmica*, whereas taxa with austral affinities are largely restricted to the southern, unglaciated region of the state. The overall composition of Ohio's myrmecofauna much

resembles that of other Midwestern and northeastern states for which contemporary checklists exist (e.g., Indiana (Carroll 2011), Michigan (Wheeler et al. 1994), New England (Ellison et al. 2012), and Pennsylvania (Butler and Coulter 2019)). The most species-rich genera in the state include *Formica* (26 spp.), *Strumigenys* (15 spp.), *Myrmica* (11 spp. and morphospp.), *Camponotus* (10 spp.), *Lasius* (10 spp.), *Temnothorax* (10 spp.), *Aphaenogaster* (7 spp.), and *Nylanderia* (6 spp.). These eight genera include two-thirds of Ohio's ant species and morphospecies. Conversely, 16 genera are represented in Ohio by a single species (Table 1).

Many of Ohio's ant taxa are widespread, both in the state and in Eastern North America, with nearly a quarter of the species having an essentially statewide distribution. The most widely distributed of these are the forest-dwelling *Camponotus pennsylvanicus* (De Geer) and *Lasius americanus* Emery, which have been recorded in all of Ohio's 88 counties. Other species that have been collected in a large proportion of the state include *Lasius neoniger* Emery (87 counties), *Formica subsericea* Say (>80 counties), *Formica pallidefulva* Latreille (>75 counties), and the non-native *Tetramorium immigrans* Santschi (>75 counties), (distribution from Coovert 2005 and new data). Other taxa exhibit restricted within-state distribution as a result of associations with rare/unusual habitats (*Dorymyrmex grandulus* (Forel), *Nylanderia arenivaga* Wheeler, W.M., *Myrmica lobifrons* Pergande), or because they reach the northern (e.g., *Neivamyrmex carolinensis* (Emery), *Aphaenogaster lamellidens* Mayr, *Crematogaster pilosa* Emery, *Pheidole tysoni* Forel, *Strumigenys laevinasis* Smith, M.R., *Temnothorax pergandei* (Emery), *Trachymyrmex septentrionalis* (McCook)), or southern (e.g., *Formica aserva* Forel, *Formica ulkei* Emery, *Harpagoxenus canadensis* Smith, M.R., *Leptothorax canadensis* Provancher) limits of their distributional ranges. Yet others, have been infrequently collected in the state due to their socially parasitic lifestyle (*F. aserva*, *Temnothorax americanus* (Emery), *T. duloticus* (Wesson L.G.), *T. minutissimus* Smith M.R., *Tetramorium atratulum* (Schenck)), or simply because standard ant collecting techniques do not pick them very well (e.g., *Colobopsis*, *Strumigenys*, *Proceratium*). Undoubtedly, there are other, equally rare, species, which have not been detected yet in Ohio.

Recently, Ivanov (2016) reviewed the exotic ant fauna of Ohio and listed ten non-native taxa from the state. Earlier Ohio records of *Tetramorium bicarinatum* (Bolton 1979; Wetterer 2009) were overlooked and not included in the list. With the addition of this species, and the recent report of *Brachyponera chinensis* (Emery) from Cincinnati (Guénard et al. 2018), there are now 12 ant exotics known to occur in the state. Half of Ohio's non-native species belong to the subfamily Myrmicinae (6 species) with Dolichoderinae, Formicinae, and Ponerinae represented by two species each. While the native ant fauna predominates in intact forest ecosystems, grasslands, old fields, and prairie remnants, exotic species are more commonly associated with disturbed areas and are frequently encountered indoors in the large metropolitan areas of Cincinnati, Cleveland, and Columbus.

Although the updated list presented herein likely contains a large proportion of the taxa that exist in the state, there is still a considerable potential for the discovery of more species. There are at least 44 species likely to occur in the state by virtue of their

Table 1. Taxonomic composition of Ohio's ant fauna. Genera are ordered by the total number of (morpho-)species in each. Superscript [E] denotes exotic genera.

Genus	Number of species	% of Ohio fauna	Genus	Number of species	% of Ohio fauna
Formica	26	18.2	*Tapinoma*	2	1.4
Strumigenys	15	10.5	*Brachymyrmex*	1	0.7
Myrmica	11	7.7	[E]*Brachyponera*	1	0.7
Camponotus	10	7.0	[E]*Cardiocondyla*	1	0.7
Lasius	10	7.0	*Dorymyrmex*	1	0.7
Temnothorax	10	7.0	*Forelius*	1	0.7
Aphaenogaster	7	4.9	*Harpagoxenus*	1	0.7
Nylanderia	6	4.2	*Leptothorax*	1	0.7
Pheidole	5	3.5	[E]*Linepithema*	1	0.7
Stenamma	4	2.8	*Myrmecina*	1	0.7
Crematogaster	3	2.1	*Neivamyrmex*	1	0.7
Dolichoderus	3	2.1	[E]*Paratrechina*	1	0.7
Proceratium	3	2.1	*Polyergus*	1	0.7
Solenopsis	3	2.1	*Ponera*	1	0.7
[E]*Tetramorium*	3	2.1	*Prenolepis*	1	0.7
Colobopsis	2	1.4	*Stigmatomma*	1	0.7
Hypoponera	2	1.4	*Trachymyrmex*	1	0.7
Monomorium	2	1.4			

presence in neighboring areas (Appendix 1), any and all of which may turn up in Ohio in the future. Targeting these taxa, however, will require a more systematic approach and more intensive collecting throughout the state. Nonetheless, future collecting efforts are certain to add new taxa and provide additional locality records of known species building upon our knowledge of Ohio's myrmecofauna.

List of Ohio ants

Subfamily Amblyoponinae [1 genus; 1 species]
Tribe Amblyoponini
***Stigmatomma* Roger**
pallipes (Haldeman). Common, but inconspicuous element of the local fauna throughout Ohio. Under *Amblyopone* in Coovert (2005).

Subfamily Dolichoderinae [5 genera; 8 species]
Tribe Dolichoderini
***Dolichoderus* Lund**
plagiatus (Mayr). Widespread.
pustulatus Mayr. Widespread
taschenbergi (Mayr). Champaign and Hocking Cos. in southcentral Ohio. Rare.

Tribe Leptomyrmecini

***Dorymyrmex* Mayr**

grandulus (Forel). Literature records: **Lucas** (Friedrich 2010). Only known from a small number of collections in prairie remnants of the globally rare Oak Openings Region of northwestern Ohio. Rare.

***Forelius* Emery**

pruinosus (Roger). Literature records: **Lucas**, **Preble** (Uno et al. 2010; Campbell and Crist 2017). Previously reported from areas with full sun and hot, dry conditions in Adams and Erie Cos. Rare.

***Linepithema* Mayr**

[E]***humile*** (Mayr). Ohio's only confirmed record of this notorious invasive species is from a greenhouse in Cleveland (Ivanov 2016). Coovert (2005) includes an unspecified Ohio record in Arnett (1993). Indoors, in heated buildings.

Tribe Tapinomini

***Tapinoma* Foerster**

*, [E]***melanocephalum*** (Fabricius). Literature records: **Butler**, **Cuyahoga**, **Franklin** (Ivanov 2016). In Ohio, this widely distributed tramp species is currently confined to indoor situations and can be abundant in greenhouses, conservatories, and zoo buildings.

sessile (Say). Statewide and in most habitats including disturbed sites and inside buildings.

Subfamily Dorylinae [1 genus; 1 species]

***Neivamyrmex* Borgmeier**

carolinensis (Emery). Unspecified Ohio records in M.R. Smith (1967), Watkins (1972, 1976), and D.R. Smith (1979). Rare. No definitive Ohio records of this southeastern army ant exist, but it may occur in suitable habitats in the southern part of the state along the northern fringes of its distribution (see Snelling and Snelling 2007).

Subfamily Formicinae [9 genera; 58 species]

Tribe Camponotini

***Camponotus* Mayr**

americanus Mayr. Widespread. Majority of the records from unglaciated southern Ohio, with disjunct records from Columbiana, **Lucas** (Uno et al. 2010) and **Summit** (VMNH110593) Cos. in the north.

caryae (Fitch). Widespread.

castaneus (Latreille). A number of scattered records from southern Ohio, north to Franklin and Muskingum Cos.

chromaiodes Bolton. Statewide.

discolor (Buckley). Gallia and Muskingum Cos. in unglaciated southwestern Ohio. Rare.

****herculeanus*** (Linnaeus). **– Cuyahoga Co. •** Cuyahoga Valley National Park; 41.35597N, 81.56847W; alt. 259 m; 18 July 2009; W. & E. Mackay leg.; #23734; nest in solid log; hardwood forest; clay loam soil; W. Mackay det. 2009; MCZENT567833.

nearcticus Emery. Statewide.

novaeboracensis (Fitch). Widespread in northern Ohio, south to Franklin and Greene Cos.

pennsylvanicus (De Geer). Statewide.

subbarbatus Emery. Statewide.

***Colobopsis* Mayr**

impressa Roger. **Mahoning** (CMNHENT39502), **Warren** (K. Campbell unpublished data; pers. comm., February 2019). Previously reported from Henry and Muskingum Cos. Rare.

mississippiensis (Smith, M.R.). This infrequently collected arboreal species is known from only a few scattered Ohio sites.

Tribe Formicini

***Formica* Linnaeus**

argentea Wheeler, W.M. **Cuyahoga**, **Ottawa**, **Richland** (MCZENT551348, MCZENT551349, MCZENT551350, MCZENT551351, MCZENT551352, MCZENT551353, MCZENT551354, MCZENT551355, MCZENT551400, MCZENT551401, MCZENT551402, MCZENT551410, MCZENT551411, MCZENT551412, MCZENT551413). Until now, this species was only know Summit Co. in the northeastern part of the state. Rare.

aserva Forel. **Geauga** (VMNH110555; in a mixed colony with host *F. glacialis* Wheeler, W.M). Until present, this northern dulotic species was only known from neighboring Ashtabula Co. in the extreme northeastern part of the state. Rare.

dakotensis Emery. Scattered records from glaciated western Ohio.

difficilis Emery. Single record from Jackson Co. in southcentral Ohio (Wesson and Wesson 1940). Rare.

dolosa Buren. Scattered sites throughout Ohio. Records under *Formica schaufussi* Mayr in Coovert (2005) refer to this species.

exsectoides Forel. Statewide.

glacialis Wheeler, W.M. Widespread in glaciated northern Ohio, south to Champaign and Madison Cos.

****gynocrates*** Snelling, R.R. & Buren. Literature records: **Lucas** (Friedrich 2010). In Ohio, this species is only known from prairie remnants in the globally rare Oak Openings Region of northwestern Ohio.

****incerta*** Buren. **Ashland**, **Ashtabula**, **Athens**, **Erie**, **Geauga**, **Hardin**, **Huron**, **Madison**, **Morgan**, **Summit** (CMNHENT40013, CMNHENT40014, CMN-

HENT40015, CMNHENT40016, CMNHENT40017, CMNHENT40018, CMNHENT40019, CMNHENT40259, MCZENT672736, MCZENT672737, VMNH110556, VMNH110557, VMNH110558, VMNH110575, VMNH110576, VMNH110597, VMNH110601, VMNH110602). Literature records: **Adams**, **Ashtabula**, **Butler**, **Champaign**, **Delaware**, **Hamilton**, **Hocking**, **Jackson**, **Lucas**, **Montgomery**, **Seneca**, **Wyandot** (Amstutz 1943; Headley 1943, 1949, 1952; Talbot 1945; Trager et al. 2007; Friedrich 2010), **southcentral Ohio** (Wesson and Wesson 1940). The name *incerta* has a long and confusing history (see Coovert 2005; Trager et al. 2007) until finally revived from synonymy under *pallidefulva* (and its synonym *F. nitidiventris* Emery) by Trager et al. (2007). All Ohio records of this species in Coovert (2005) appear under *nitidiventris*. This species occurs in mesic, and dry-mesic grasslands, pastures, lawns, old fields, and other open habitats throughout the state. It is undoubtedly more widespread in Ohio than the current records indicate.

integra Nylander. Widespread with majority of the records from unglaciated southern Ohio.

lasioides Emery. Fulton and Lucas Cos. in northwestern Ohio. Rare

montana Wheeler, W.M. Few sites in northcentral Ohio, south to Madison Co.

neogagates Viereck. Scattered sites across northeastern Ohio.

obscuriventris Mayr. Few disjunct sites in extreme northern (Lucas Co.) and southern (Adams, Pike, and Scioto Cos.) Ohio in areas with the appropriate combination of dense woodlands and adjacent open prairie remnants and pastures.

pallidefulva Latreille. Statewide. Distribution of this widespread species in Ohio is confounded with *F. incerta* (see comments under *incerta*). A number of records under *F. nitidiventris* in Coovert (2005) also refer to this species.

pergandei Emery. Few scattered sites in southern and northwestern Ohio.

podzolica* Francoeur. **– Summit Co. • 30.57 km SW of Richfield; 41.20992N, 81.66797W; alt. 354 m, 26 July 2007; W. & E. Mackay leg.; W. Mackay det.; MEM221118.

postoculata Kennedy & Dennis. Butler and Hocking Cos. Rare

prociliata Kennedy & Dennis. In Ohio, this species is only known from Ottawa Co. (including type locality) in the extreme northern part of the state. Rare. It is a known inhabitant of glaciated tallgrass prairies and prairie remnants of the upper Midwest.

querquetulana Kennedy & Dennis. Few disjunct sites in extreme southern and northern Ohio where the appropriate combination of open oak woodlands, oak savannas, and associated prairie clearings occurs.

rubicunda Emery. Glaciated western Ohio, and just into the adjacent unglaciated area.

subaenescens* Emery. Literature records: **Lucas (Uno et al. 2010). The sole Ohio record appears under the name *Formica fusca* Linnaeus. As currently understood, true *fusca* is restricted to the Palearctic region and does not occur in North America (see Schär et al. 2018).

subintegra Wheeler, W.M. Statewide. This dulotic species is found throughout Ohio along with *Formica fusca*-group hosts.

subsericea Say. Statewide.
ulkei Emery. Widespread in northern Ohio.
vinculans Wheeler, W.M. Scattered sites in glaciated western Ohio, and just into the adjacent unglaciated area.

Polyergus **Latreille**
lucidus Mayr. This dulotic species is known from few scattered Ohio sites along with host *F. incerta*.

Tribe Lasiini
Lasius **Fabricius**
americanus Emery. Statewide. Records under *L. alienus* (Foerster) in Coovert (2005) refer to this species.
aphidicola (Walsh). Statewide. Records under *L. umbratus* (Nylander) in Coovert (2005) refer to this species.
brevicornis Emery. **Fairfield** (OSUC53785, OSUC53786, OSUS53787, OSUC53788). Literature records: **Lucas**, **Montgomery** (Uno et al. 2010; Campbell and Crist 2017). This species was previously only known from Summit Co. and an unspecified southcentral Ohio record in Wesson and Wesson (1940). Rare. Records under *L. flavus* (Fabricius) in Coovert (2005) refer to this species.
claviger (Roger). Widespread with majority of the records from glaciated western Ohio. Under *Acanthomyops* in Coovert (2005).
interjectus Mayr. Known from a number of scattered Ohio sites, predominantly in the western, glaciated, part of the state. Under *Acanthomyops* in Coovert (2005).
latipes (Walsh). **– Greene Co.** • Wright State University Woods; 39.7836N, 84.0636W; 28 July 1998; G.A. Coovert leg.; G.A.C. 2026 #9; G.A. Coovert det.; OSUC57890. Until now, this species was known only from Lucas Co. in glaciated northwestern Ohio (Wing 1968; material at MCZ: MCZENT557430, MCZENT557431, MCZENT557432). Rare. Interestingly, the single specimen in the OSU collection was collected and identified by Gary Coovert but not included in the 2005 list. Under *Acanthomyops* in Coovert (2005).
minutus Emery. Lucas Co. Rare.
nearcticus Wheeler, W.M. Statewide.
neoniger Emery. Statewide.
speculiventris Emery. Widespread.

Nylanderia **Emery**
****arenivaga*** (Wheeler, W.M.). **Lucas**: Toledo (S. Philpott unpublished data; pers. comm., June 2007). This distinctive yellow *Nylanderia* is a sand specialist associated with deep sand deposits in dry open areas with sparse vegetation.
faisonensis (Forel). Widespread. Under *Paratrechina* in Coovert (2005).
*, E***flavipes*** (Smith). Literature records: **Cuyahoga**, **Franklin**, **Lake**, **Lucas** (Ivanov and Milligan 2008; Ivanov et al. 2011; Ivanov 2016; Uno et al. 2010). This temperate introduced species is abundant in the urban and suburban areas of Cleveland,

Columbus, and Toledo including forested green spaces, gardens, yards, and vacant lots. It is also occasionally found indoors (see Ivanov 2016).

parvula (Mayr). Widespread with majority of the records from southern Ohio. Under *Paratrechina* in Coovert (2005).

****terricola*** (Buckley). **– Cuyahoga Co.** • Cleveland, Cleveland State University campus; 41.50236N, 81.67353W; alt. 202 m; 10 May 2007; K. Ivanov leg.; KI1731; single male on bare soil surface; landscaped flower bed surrounded by pavement; urban; VMNH110553. Workers of this species are nearly impossible to separate from those of *N. vividula* (Nylander) and males are required for proper identification (see Kallal and LaPolla 2012).

****vividula*** (Nylander). **Cuyahoga** (VMNH110554). Literature records: **Franklin** (Kallal and LaPolla 2012; material at MCZ: MCZENT565308, MCZENT565309, MCZENT565310).

Paratrechina **Donisthorpe**

*, E***longicornis*** (Latreille). Literature records: **Hamilton** (Hedges 1998). In Ohio, this notorious tramp species is currently confined to heated buildings. It is undoubtedly more widespread in the state than current records indicate.

Prenolepis **Mayr**

imparis (Say). Statewide.

Tribe Myrmelachistini

Brachymyrmex **Mayr**

depilis Emery. Statewide but uncommonly collected likely due to small worker and colony size, and its largely subterranean habits. This species has an enormous geographic range and may turn out to represent a complex of sibling species.

Subfamily Myrmicinae [15 genera; 65 species, 3 morphospecies]

Tribe Attini

Pheidole **Westwood**

bicarinata Mayr. Few disjunct sites in extreme northern (**Lucas** Co.; Friedrich 2010) and southern (Adams, Pike, and Jackson Cos.) Ohio.

E***bilimeki*** Mayr. The single Ohio record of this introduced species is from a greenhouse in Franklin Co. (Coovert 2005).

****dentata*** Mayr. **– Franklin Co.** • Columbus; 7 Apr. 1916; M.R. Smith leg. Single uncatalogued specimen at MCZ (D. Lubertazzi pers. comm., March 2019).

pilifera (Roger). Widespread in southern Ohio.

tysoni Forel. **Hocking**, **Scioto** (VMNH110560, VMNH110561, VMNH110596). Literature records: **Butler**, **Montgomery**, **Preble** (Campbell and Crist 2017). Until now, this species was known from Hocking and Gallia Cos. in the southern, unglaciated, part of Ohio.

***Strumigenys* Smith F.**

The perceived rarity of these cryptic litter and soil inhabitants can be explained, at least partly, by the fact that litter extraction techniques historically have been rarely used for the collection of soil and litter dwelling taxa in Ohio. At least some members of this genus (i.e., *S. ohioensis* Kennedy & Schramm, *S. ornata* Mayr, *S. rostrata* Emery) are among the most widespread and commonly encountered ants in the soil and litter layers of eastern deciduous forests. All taxa under *Smithistruma* in Coovert (2005).

abdita Wesson, L.G. & Wesson, R.G. Literature records: **Cuyahoga** (Ivanov and Keiper 2010). Until now, this species was known only from Jackson and Ottawa Cos. Rare.

bimarginata Wesson, L.G. & Wesson, R.G. Adams Co. Rare.

clypeata Roger. Literature records: **Butler**, **Montgomery**, **Preble** (Campbell and Crist 2017). Previously only known from Jackson Co. in southcentral Ohio.

dietrichi Smith, M.R. Few scattered sites throughout Ohio.

****hyalina*** (Bolton). **Cuyahoga**, **Greene** (VMNH110584, VMNH110585, VMNH110586, VMNH110587). Literature records: **Ottawa** (Bolton 2000). Until now, this rarely collected species was only known in Ohio from the type locality in Catawba Beach (Bolton 2000).

****laevinasis*** Smith, M.R. **Greene** (VMNH110559). Literature records: **Pike** (Campbell et al. 2013). This uncommonly collected woodland species is at the northern fringes of its distribution in Ohio.

missouriensis Smith, M.R. Pike Co. Rare.

ohioensis Kennedy & Schramm. Widespread in southern Ohio.

ornata Mayr. Pike Co. Rare.

pergandei Emery. Few scattered sites throughout Ohio.

pilinasis Forel. Pike Co. Rare.

pulchella Emery. Few scattered sites throughout Ohio.

reflexa Wesson, L.G. & Wesson, R.G. Few scattered sites throughout Ohio.

rostrata Emery. Few records from unglaciated southcentral Ohio.

talpa Weber. Few records from unglaciated southcentral Ohio.

***Trachymyrmex* Forel**

septentrionalis (McCook). In Ohio, this wide-ranging fungus-growing ant is known only from Adams and Jackson Cos. in the extreme southern part of the state along the northern fringes of its distribution. Rare.

Tribe Crematogastrini

***Cardiocondyla* Emery**

*, E***obscurior*** Wheeler, W.M. Literature records: **Hamilton** (Ivanov 2016). The single Ohio record of this introduced species is from a conservatory in Cincinnati.

Crematogaster **Lund**
cerasi (Fitch). Statewide.
lineolata (Say). Statewide.
pilosa Emery. Widespread in southcentral Ohio, north to Fairfield Co.

Harpagoxenus **Forel**
*****canadensis*** Smith, M.R. – **Jackson Co.** • 1938; L.G. Wesson leg.; FMNHINS113834. In Ohio, this boreal dulotic species is near the southern edge of its known distribution.

Leptothorax **Mayr**
canadensis Provancher. **Ashtabula**, **Franklin**, **Geauga** (UCMC94034, UCMC94036, VMNH110562, VMNH11563, VMNH110564). Previously only known from Ashtabula Co. in northernmost Ohio. Rare. Records under *L. muscorum* (Nylander) in Coovert (2005) refer to this species.

Myrmecina **Curtis**
americana Emery. Statewide.

Temnothorax **Mayr**

All *Temnothorax* records, except *T. americanus* (see below), appear under *Leptothorax* in Coovert (2005).
ambiguus (Emery). Statewide.
americanus (Emery). This dulotic species is known from a few scattered Ohio sites along with hosts *T. ambiguus*, *T. curvispinosus* (Mayr), and *T. longispinosus* (Roger). Under *Protomognathus* in Coovert (2005).
curvispinosus (Mayr). Statewide.
duloticus (Wesson, L.G.). This rarely collected dulotic species is known from a handful of scattered Ohio sites along with hosts *T. ambiguus*, *T. curvispinosus*, and *T. longispinosus*.
longispinosus (Roger). Statewide.
minutissimus (Smith, M.R.). In Ohio, this rarely collected workerless parasite of *T. curvispinosus* is known only from Delaware and Franklin Cos. Rare.
pergandei (Emery). Widespread in southern Ohio.
schaumii (Roger). Statewide.
smithi (Baroni Urbani). This species is only known from Hocking and Jackson Cos. in unglaciated southern Ohio along the northern edge of its distribution. Rare.
texanus (Wheeler, W.M.). Several disjunct records from Jackson (south) and Lucas (north) Cos. Rare.

Tetramorium **Mayr**
[E]***atratulum*** (Schenck). **Cuyahoga** (CMNHENT40727, CMNHENT40728), **Preble** (K. Campbell unpublished data; pers. comm., February 2019). Literature records:

Ashtabula, **Cuyahoga**, **Geauga** (Ivanov 2016). This introduced workerless social parasite of *Tetramorium immigrans* Santschi previously was only known from Shelby Co. in western Ohio. It is rarely observed in both its native and introduced ranges, presumably because of its parasitic lifestyle or simply because it is indeed rare. Under *Anergates* in Coovert (2005).

*,E***bicarinatum** (Nylander). Literature records: **Franklin**: Columbus, 1931, collector unknown, material at the US National Museum of Natural History (Wetterer 2009), **Ohio** (Bolton 1979). In temperate areas, this widely distributed tramp species is confined to greenhouses and other heated buildings.

E***immigrans*** Santschi. Statewide. This introduced species is abundant in disturbed habitats and urban settings throughout Ohio, and is also occasionally found indoors. Records under *T. caespitum* (Linnaeus) in Coovert (2005) refer to this species.

Tribe Myrmicini
***Myrmica* Latreille**

André Francoeur is working on a much-needed revision of the Nearctic members of this genus and I have chosen to follow his preliminary findings in my species accounts below including the recognition of a few as-yet-undescribed species (see also Ellison et al. 2012).

americana Weber. Distribution of this northerly species in Ohio is unclear, confounded with the undescribed and more widely distributed *M*. AF-*eva*. True *americana* appears to be a strict psammophile occurring in glaciated sand communities and probably does not occur outside of them (J. Trager pers. comm.). In Ohio, I have only collected this species in the sparsely vegetated fossil dune ridge of North Kingsville Sand Barrens in Ashtabula Co. in northernmost Ohio (VMNH110565). It likely also occurs in other sand based communities along the coast of Lake Erie in northern Ohio, however, its distribution in the state is much more restricted than indicated in Coovert (2005).

emeryana Forel. Distribution of this species in Ohio is unclear, confounded with the undescribed but widespread and abundant *M.* AF-*scu* and *M*. AF-*smi*. The distribution depicted in Coovert (2005) represents a composite of the distributions of these three taxa. Records under *Myrmica latifrons* Stärcke in Coovert (2005) refer to this species.

*AF-***eva**. **– Cuyahoga Co.** • Cleveland Heights, 3986 Bluestone Rd.; 41.52998N, 82.53670W; 30 Sep. 2004; H. Clebsch leg.; yellow pan traps; CMNHENT0038652. **– Hardin Co.** • Ada, Ohio Northern University campus; 40.76844N, 83.84341W; alt. 294 m; 8–9 Sep. 2017; A. Brooks & J. Isaak leg.; red pan traps; mowed grass at edge of a small woodlot; VMNH110577 • same collection data as for preceding; VMNH110578. **– Hocking Co.** • Hocking Hills, Deep Woods farm; 39.40812N, 82.57503W; alt. 215 m; 14 June 2008; K. Ivanov leg.; KI2042; ground foragers; open mowed grass field; VMNH110545. **– Madison Co.** • OPOTA tactical training center; 39.88028N, 83.48917W; alt. 338 m;

25–26 July 2016; J.B. Keiper leg.; old field; sweeping; VMNH110579 • same collection data as for preceding; VMNH110580. – **Summit Co.** • Sagamore Hills, Eaton estate; 20 Sep. 2002; M.R. Proffitt leg.; CMNHENT0038653 • Singer Lake Bog; 40.92288N, 81.48720W; alt. 356 m; 9 May 2008; K. Ivanov leg.; KI2019; ground foragers; edge of agricultural field; VMNH110546. This undescribed species is found in dry-mesic to mesic grasslands, pastures, and old fields (Ellison *et al.* 2012). Historically it has been commonly confused with *Myrmica americana*.

fracticornis Forel. Statewide, in moist open habitats. Historical records likely confounded with the undescribed *M*. AF-*scu*.

incompleta* Provancher. **Franklin** (OSUC270669; as *M. brevinodis* Emery, N.F. Johnson det. 1984). Literature records: **Adams** (Weber 1950). This species was prematurely excluded from the 2005 list without examination of Weber's specimens.

lobifrons* Pergande. – **Champaign Co.** • Cedar Bog Nature Preserve; 40.05785N, 83.79613W; 27– 28 May 2006; T. Jones leg.; sedge meadow; VMNH110548. – **Cuyahoga Co.** • Cleveland Metroparks, Acacia Reservation; 41.51039N, 81.49517W; alt. 313 m; 27 May 2013; K. Ivanov leg.; KI2333; sedge meadow; sweeping; VMNH110547. – **Stark Co.** • Jackson Township, Willow Dale Bog; 22 Sep. 2011; D. Kriska leg.; VMNH110549 • same collection data as for preceding; VMNH110550 • same collection data as for preceding; VMNH110551 • same collection data as for preceding; VMNH110552. In Ohio, this boreal bog-inhabiting species is rarely collected in the northern, glaciated, part of the state.

pinetorum Wheeler, W.M. Statewide.

punctiventris Roger. Statewide.

*AF-***scu***. – **Ashtabula Co.** • North Kingsville Sand Barrens; 30 Aug. – 24 Sep. 2007; T. Pucci leg.; Malaise trap; CMNHENT0038834 • same collection data as for preceding; 9– 19 Sep. 2008; VMNH110603 • Pymatuning Creek Fen; 41.56738N, 80.62710W; alt. 298 m; 13 Oct. 2008; K. Ivanov leg.; KI2192; soil nest under plant litter at the base of a small sumac (*Rhus* sp.); edge of agricultural field; VMNH110598. – **Cuyahoga Co.** • Strongsville, Cleveland Metroparks, nr. Greenbrier L.; 8 Aug. 2009; T. Pucci leg.; meadow; sweeping; CMNHENT0038835. – **Erie Co.** • Kelleys Island, Coleman Tract; 2–4 Aug. 2002; B. Coleman leg.; C1; pitfall trap; VMNH110571 • same collection data as for preceding; D2; VMNH110569 • same collection data as for preceding; 6–8 Sep. 2002; D2; VMNH110570 • Castalia, Rockwell Springs Trout Club; 41.39014N, 82.83646W; alt. 194 m; 17 July 2008; K. Ivanov leg.; KI2121; strays in grass litter; open grass field adjacent to riparian woods; VMNH110600 • Castalia, 0.25 mi N intersection Rt. 312 and Vickery Rd.; 41.38979N, 82.84770W; alt. 192 m; 17 July 2008; K. Ivanov leg.; KI2124; ground foragers; managed tallgrass prairie remnant; VMNH110599 – **Geauga Co.** • Burton Wetlands Nature Preserve; 41.44576N, 81.17723W; alt. 341 m; 21 Apr. 2006; K. Ivanov leg.; KI1228; foragers in grass litter at base of a large oak tree; edge of an open grass field; VMNH110590 • Fern Lake Bog; 41.44026N, 81.17262W; alt. 344 m; 16 May 2007; K. Ivanov leg.; KI1745; soil nest in clay loam under grass litter; edge of tamarack bog; VMNH110589 •

Taber Preserve; 18 May 2007; T. Pucci leg.; sweeping; CMNHENT0038833 • Soubusta; 41.57000N, 81.24000W; 28 July 2009; T.H. Webster leg.; scrap wood pile; CMNHENT0038816 – **Greene Co.** • Wright State University campus; 8 July 2009; B. Doane leg.; tuna baits; VMNH110605. – **Madison Co.** • OPOTA tactical training center; 39.88028N, 83.48917W; alt. 338 m; 25–26 July 2016; J.B. Keiper leg.; old field; sweeping; VMNH110581 • same collection data as for preceding VMNH110582. – **Medina Co.** • Wolf Creek Environmental Center; 2 July 2008; T. Pucci leg.; sweeping; CMNHENT0038815. – **Ottawa Co.** • Winous Point; 24 June 2004; T. Pucci leg.; sweeping; CMNHENT0038814 • Ottawa National Wildlife Refuge, Young Pond; 41.53649N, 83.00608W; alt. 175 m; 25 July 2008; K. Ivanov leg.; KI2147; ground foragers; open riparian woods; VMNH110568. – **Trumbull Co.** • Chamberlin Forest; 41.44773N, 80.98881W; alt. 311 m; 5 June 2009; K. Ivanov leg.; KI2201; ground foragers; small grass field surrounded by mesic woods; VMNH110567. – **Wyandot Co.** • Kildeer Plains Wildlife Area; 40.70234N, 83.24097W; alt. 271 m; 22 May 2009; K. Ivanov leg.; KI2197; ground foragers; open grass and gravel road at the edge of an open mixed mesic woodland; VMNH110591. This undescribed species is found in mesic grasslands, wood's edges, and open, remnant dry-mesic and mesic woodlands. Historically it has been confused with *M. emeryana* and *M. fracticornis*. It is undoubtedly more widespread in the state than the above records indicate.

****semiparasitica*** Francoeur. Literature records: **Cuyahoga** (Francoeur and Ivanov 2008; Ivanov and Keiper 2009, 2011; Ivanov et al. 2010). This recently described species has been rarely collected in the northern half of the eastern deciduous forest biome along with its suspected host *M. punctiventris*. Since the range of its host covers the southern half of the eastern deciduous forest biome as well, it is expected that *M. semiparasitica* will be discovered much further south in the future

*AF-***smi***. **Athens**, **Cuyahoga**, **Erie**, **Geauga**, **Greene**, **Hocking**, **Lake**, **Medina**, **Scioto**, **Summit** (CMNHENT0038654, CMNHENT0038655, CMNHENT0038656, CMNHENT0038657, CMNHENT0038658, CMNHENT0038659, CMNHENT0038660, CMNHENT0038661, CMNHENT0038662, CMNHENT0038663, CMNHENT0038664, CMNHENT0038665, CMNHENT0038666, CMNHENT0038667, CMNHENT0038668, CMNHENT0038669, CMNHENT0038670, CMNHENT0038671, CMNHENT0038672, CMNHENT0038673, CMNHENT0038674, CMNHENT0038675, CMNHENT0038676, CMNHENT0038677, CMNHENT0038678, CMNHENT0038679, CMNHENT0038680, CMNHENT0038681, CMNHENT0038682, CMNHENT0038683, CMNHENT0038684, CMNHENT0038685, CMNHENT0038687, CMNHENT0038688, CMNHENT0038811, CMNHENT0038812, CMNHENT0038813, CMNHENT0038817, CMNHENT0038819, CMNHENT0038820, CMNHENT0038838, CMNHENT0038839, CMNHENT0038840, VMNH110572, VMNH110573, VMNH110574, VMNH110583, VMNH110588, VMNH110592, VMNH110594,

VMNH110595, VMNH110604). Literature records: **Cuyahoga**, **Medina** (Ivanov and Keiper 2009, 2010, 2011; Ivanov et al. 2010). This undescribed species prefers dry to mesic deciduous woodlands and mixed forests (Ellison et al. 2012) and is also occasionally found in mesic grasslands and old fields. It is undoubtedly more widespread in the state than the above records indicate.

Tribe Solenopsidini

Monomorium **Mayr**

minimum (Buckley). Statewide but less common in northern Ohio.

[E]***pharaonis*** (Linnaeus). This notorious tramp species is known from a number of scattered indoor records across Ohio.

Solenopsis **Westwood**

Members of the *molesta* complex (sensu Pacheco and Mackay 2013) are minute in size and notoriously difficult to identify. Historical Ohio records of this complex (i.e., *S. carolinensis* Forel, *S. molesta* (Say), and *S. texana* Emery) are likely confounded with each other and should be viewed with caution. Presence of queens will aid in identification, but see discussion in Deyrup (2016).

carolinensis Forel. Single unspecified southcentral Ohio record in Wesson and Wesson (1940). Rare.

molesta (Say). Statewide.

texana Emery. Adams Co. Rare.

Tribe Stenammini

Aphaenogaster **Mayr**

While many eastern *Aphaenogaster* can be readily identified based on morphological characters, a number of taxa remain difficult, or impossible, to separate based on morphology alone. This is especially true for some members of the *rudis* clade although some progress has been recently made (DeMarco 2015; DeMarco and Cognato 2016). Historical records of *Aphaenogaster carolinensis* Wheeler, W.M. and *Aphaenogaster rudis* Enzmann from Ohio, and elsewhere, should be interpreted with caution.

fulva Roger. Statewide.

lamellidens Mayr. An unspecified southern Ohio record in Dennis (1938). Rare.

mariae Forel. A number of scattered sites in unglaciated southern Ohio.

picea (Wheeler, W. M.). Statewide.

rudis Enzmann. Statewide.

tennesseensis (Mayr). Statewide.

treatae Forel. Few scattered records from prairie remnants and old fields in extreme northern and southern Ohio.

***Stenamma* Westwood**

brevicorne (Mayr). Statewide.

****diecki*** Emery. – **Licking Co.** • Blackhand Gorge; 3–4 May 1989; P. Kovarik leg.; berlesate; leaf litter; S.P. Cover det. 1989; MCZ540382 • same collection data as for preceding; MCZ540383.

impar Forel. Widespread and likely more common than current records indicate.

schmitti Wheeler, W.M. Few scattered sites throughout Ohio.

Subfamily Ponerinae [3 genera; 4 species]

Tribe Ponerini

***Brachyponera* Emery**

*, E***chinensis*** (Emery). Literature records: **Hamilton**: Cincinnati, 2017, J Boggs leg., Ohio State University Extension (Guénard et al. 2018). This East Asian species has been spreading through the eastern United States since its original discovery in Georgia, North Carolina, and Virginia (Smith 1934). At present, Ohio lies along the northern edge of its known introduced range. Given its profound negative impacts on local insect populations, care should be taken in monitoring the future spread of this invasive species in Ohio and the adjacent areas.

***Hypoponera* Santschi**

opacior (Forel). Widespread in southern Ohio, north to Guernsey Co.

E***ragusai*** (Emery). This introduced species in known from a single locality in Jackson Co. (Wesson and Wesson 1940). Record under *H. gleadowi* (Emery) in Coovert (2005) refers to this species.

***Ponera* Latreille**

pennsylvanica Buckley. Statewide.

Subfamily Proceratiinae [1 genus; 3 species]

Tribe Proceratiini

***Proceratium* Roger**

****crassicorne*** Emery. Literature records: **southcentral Ohio** (Wesson and Wesson 1940). Rare. The single Ohio record is included under *P. silaceum* in Coovert (2005). This species was revived from synonymy under *P. silaceum* by Baroni Urbani and De Andrade (2003).

pergandei (Emery). Literature records: **Franklin** (Campbell et al. 2013). Until now, this species was only known from Adams and Greene Cos. Rare.

silaceum Roger. Few scattered sites throughout Ohio.

Doubtful Ohio records

Dorymyrmex insanus (Buckley) (Friedrich 2010; likely misidentification of *D. grandulus*), *Pheidole tepicana* Pergande (TTU-Z_075141), *Pogonomyrmex barbatus* (Smith F.) (OSUC50490), and *Leptogenys elongata* (Buckley) (INHS-INSECT-575849) are herein excluded from the Ohio list. These records represent stark distribution anomalies relative to the rest of their known western ranges and are likely based on misidentifications and/or mislabeled specimens. The record of *A. carolinensis* from Ottawa Co. reported in Mackay and Mackay (2017; p.238) seems rather surprising. The finding of this southern species in northern Ohio is doubtful and likely represents misidentification of the more common and widespread *A. rudis*. Workers from young *A. rudis* colonies can easily be mistaken for *A. carolinensis* and genetic data is needed for proper identification (see DeMarco and Cognato 2016). I provisionally exclude this species from the Ohio list awaiting future work on the *rudis* Complex of species. In addition, Mackay and Mackay (2017) erroneously cite Coovert (2005) as source of *Aphaenogaster ashmeadi* (Emery) (p. 211) and *A. flemingi* Smith, M.R. (p. 244) records from Ohio. To my knowledge, no Ohio records of these two southeastern taxa exist.

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References

Amstutz ME (1943) The ants of the Kildeer plain area of Ohio (Hymenoptera, Formicidae). Ohio Journal of Science 43: 165–173.

Antmaps (2019) http://antmaps.org [Accessed on 22 February 2019]

AntWeb (2019) http://www.antweb.org [Accessed on 20 February 2019]

Arnett RH (1993) American insects. A handbook of the insects of America north of Mexico. Sandhill Crane Press, Gainesville, 1024 pp.

Baroni Urbani C, De Andrade ML (2003) The ant genus *Proceratium* in the extant and fossil record (Hymenoptera: Formicidae). Museo Regionale di Scienze Naturali, Monografie 36: 1–480. https://doi.org/10.1002/mmnz.20040800210

Bolton B (1979) The ant tribe Tetramoriini (Hymenoptera: Formicidae). The genus *Tetramorium* Mayr in the Malagasy region and in the New World. Bulletin of the British Museum (Natural History) Entomology Series 38: 129–181.

Bolton B (2000) The ant tribe Dacetini. Memoirs of the American Entomological Institute 65: 1–1028.

Bolton B (2019) An online catalog of the ants of the world. http://antcat.org/ [Accessed on 30 January 2019]

Butler WB, Coulter B (2019) Ants of Pennsylvania on AntWeb.org. https://www.antweb.org/adm1.do?name=Pennsylvania&country=United+States [Accessed on 20 February 2019]

Campbell KU, Crist TO (2017) Ant species assembly in constructed grasslands is structured at patch and landscape levels. Insect Conservation and Diversity 10: 180–191. https://doi.org/10.1111/icad.12215

Campbell KU, Klompen H, Crist TO (2013) The diversity and host specificity of mites associated with ants: the roles of ecological and life history traits of ant hosts. Insectes Sociaux 60: 31–41. https://doi.org/10.1007/s00040-012-0262-6

Carroll TM (2011) The ants of Indiana (Hymenoptera: Formicidae). Master's Thesis. Purdue University (West Lafayette): 1–385.

Coovert GA (2005) The ants of Ohio (Hymenoptera: Formicidae). Bulletin of the Ohio Biological Survey 15: 1–202.

DeMarco BB (2015) Phylogeny of North American *Aphaenogaster* species (Hymenoptera: Formicidae) reconstructed with morphological and DNA data. PhD Dissertation. Michigan State University (Ann Arbor): 1–147.

DeMarco BB, Cognato AI (2015) Phylogenetic analysis of *Aphaenogaster* supports the resurrection of *Novomessor* (Hymenoptera: Formicidae). Annals of the Entomological Society of America 108: 201–210. https://doi.org/10.1093/aesa/sau013

DeMarco BB, Cognato AI (2016) A multiple-gene phylogeny reveals polyphyly among eastern North American *Aphaenogaster* species (Hymenoptera: Formicidae). Zoologica Scripta 45: 512–520. https://doi.org/10.1111/zsc.12168

Dennis CA (1938) The distribution of ant species in Tennessee with reference to ecological factors. Annals of the Entomological Society of America 31: 267–308. https://doi.org/10.1093/aesa/31.2.267

Deyrup M (2016) Ants of Florida: Identification and Natural History. CRC Press (Boca Raton): 1–423. https://doi.org/10.1201/9781315368023

Ellison AM, Gotelli NJ, Farnsworth EJ, Alpert GD (2012) A field guide to the ants of New England. Yale University Press, New Haven and London, 256 pp.

Francoeur A (2007) The *Myrmica punctiventris* and *M. crassirugis* species groups in the Nearctic region. In: Snelling RR, Fisher BL, Ward PS (Eds) Advances in ant systematic (Hymenop-

tera: Formicidae): homage to E. O. Wilson – 50 years of contributions. Memoirs of the American Entomological Institute 80: 153–185.

Francoeur A, Ivanov K (2008) The known range of *Myrmica semiparasitica* (Formicidae: Hymenoptera). Notes from Underground 13: 1–2.

Friedrich RL (2010) The short-term impacts of burning and mowing on prairie ant communities of the Oak Opening Region. Master's Thesis. University of Toledo (Toledo): 1–64.

Guénard B, Wetterer JK, MacGown JA (2018) Global and temporal spread of a taxonomically challenging invasive ant, *Brachyponera chinensis* (Hymenoptera: Formicidae). Florida Entomologist 101: 649–656. https://doi.org/10.1653/024.101.0402

Headley AE (1943) The Ants of Ashtabula County, Ohio (Hymenoptera, Formicidae). The Ohio Journal of Science 43: 22–31.

Headley AE (1949) A population study of the ant *Aphaenogaster fulva* ssp. *aquia* Buckley (Hymenoptera, Formicidae). Annals of the Entomological Society of America 42: 265–272. https://doi.org/10.1093/aesa/42.3.265

Headley AE (1952) Colonies of ants in a locust woods. Annals of the Entomological Society of America 45: 435–442. https://doi.org/10.1093/aesa/45.3.435

Hedges SA (1998) Field guide for the management of structure-infesting ants. 2nd ed. GIE Incorporated, Cleveland, 304 pp.

iDigBio (2019) Integrated Digitized Biocollections. http://www.idigbio.org [Accessed on 30 January 2019]

International Commission on Zoological Nomenclature (1999) International Code of Zoological Nomenclature. Fourth Edition. International Trust for Zoological Nomenclature, London, 306 pp.

Ivanov K (2016) Exotic ants (Hymenoptera: Formicidae) of Ohio. Journal of Hymenoptera Research 51: 203–226. https://doi.org/10.3897/jhr.51.9135

Ivanov K, Milligan J (2008) *Paratrechina flavipes* (Smith) (Hymenoptera: Formicidae), a new exotic ant for Ohio. Proceedings of the Entomological Society of Washington 110: 439–444. https://doi.org/10.4289/07-046.1

Ivanov K, Keiper JB (2009) Effectiveness and biases of Winkler litter extraction and pitfall trapping for collecting ground-dwelling ants in northern temperate forests. Environmental Entomology 38: 1724–1736. https://doi.org/10.1603/022.038.0626

Ivanov K, Keiper JB (2010) Ant (Hymenoptera: Formicidae) diversity and community composition along sharp urban forest edges. Biodiversity and Conservation 19: 3917–3933. https://doi.org/10.1007/s10531-010-9937-3

Ivanov K, Keiper JB (2011) Potential impacts of the invasive herb garlic mustard (*Alliaria petiolata*) on local ant (Hymenoptera: Formicidae) communities in northern temperate forests. Jeffersoniana 26: 1–14.

Ivanov K, Milligan J, Keiper JB (2010) Efficiency of the Winkler method for extracting ants (Hymenoptera: Formicidae) from temperate-forest litter. Myrmecological News 13: 73–79.

Ivanov K, Lockhart OM, Keiper JB, Walton BM (2011) Status of the exotic ant *Nylanderia flavipes* (Hymenoptera: Formicidae) in northeastern Ohio. Biological Invasions 13: 1945–1950. https://doi.org/10.1007/s10530-011-0021-z

Kallal RJ, Lapolla JS (2012) Monograph of *Nylanderia* (Hymenoptera: Formicidae) of the World, Part II: *Nylanderia* in the Nearctic. Zootaxa 3508: 1–64. https://doi.org/10.11646/zootaxa.3508.1.1

Mackay WP, Mackay E (2010) The systematics and biology of the New World ants of the genus *Pachycondyla* (Hymenoptera: Formicidae). Edwin Mellen Press, Lewiston, 648 pp.

Mackay WP, Mackay E (2017) The New World gypsy ants of the genera *Aphaenogaster* and *Novomessor* (Hymenoptera: Formicidae). Lambert Academic Publishing, Mauritius, 605 pp.

Morgan C, Mackay WP (2017) The North America acrobat ants of the hyperdiverse genus *Crematogaster*. Lambert Academic Publishing, Mauritius, 532 pp.

Pacheco JA, Mackay WP (2013) The systematics and biology of the New World thief ants of the genus *Solenopsis* (Hymenoptera: Formicidae). Edwin Mellen Press, Lewiston, 501 pp.

Rabeling C, Cover SP, Mueller UG, Johnson RA (2007) A review of the North American species of the fungus-gardening ant genus *Trachymyrmex* (Hymenoptera: Formicidae). Zootaxa 1664: 1–54.

Sarnat EM, Fischer G, Gúenard B, Economo EP (2015) Introduced *Pheidole* of the world: taxonomy, biology and distribution. ZooKeys 543: 1–109. https://doi.org/10.3897/zookeys.543.6050

SCAN (2019) Symbiota Collections of Arthropods Network (SCAN): A Data Portal Built to Visualize, Manipulate, and Export Species Occurrences. http://scanbugs.org/portal [Accessed on 21 February 2019]

Schär S, Talavera G, Espadaler X, Rana JD, Andersen AA, Cover SP, Vila R (2018) Do Holarctic ant species exist? Trans-Beringian dispersal and homoplasy in the Formicidae. Journal of Biogeography 45: 1917–1928. https://doi.org/10.1111/jbi.13380

Seifert B, Kleeberg I, Feldmeyer B, Pamminger T, Jongepier E, Foitzik S (2014) *Temnothorax pilagens* sp. n. – a new slave-making species of the tribe Formicoxenini from North America (Hymenoptera, Formicidae). ZooKeys 368: 65–77. https://doi.org/10.3897/zookeys.368.6423

Smith DR (1979) Superfamily Formicoidea. In: Krombein KV, Hurd Jr PD, Smith DR, Burks BD (Eds). Catalog of Hymenoptera in America North of Mexico. 2 Apocrita (Aculeata). Smithsonian Institution Press, Washington D.C., 1323–1467.

Smith MR (1934) Ponerine ants of the genus *Euponera* in the United States. Annals of the Entomological Society of America 27: 557–564. https://doi.org/10.1093/aesa/27.4.557

Smith MR (1967) Family Formicidae. In: Krombein KV, Burks BD (Eds). Hymenoptera of America North of Mexico. Synoptic Catalogue. Second Supplement. United States Department of Agriculture Agriculture Monograph 2: 343–374.

Snelling GC, Snelling RR (2007) New synonymy, new species, new keys to *Neivamyrmex* army ants of the United States. In: Snelling RR, Fisher BL, Ward PS (Eds) Advances in ant systematics (Hymenoptera: Formicidae): Homage to E.O. Wilson – 50 years of contributions. Memoirs of the American Entomological Institute 80: 459–550.

Talbot M (1945) A comparison of the flights of four species of ants. American Midland Naturalist 34: 504–510. https://doi.org/10.2307/2421139

Trager JC (2013) Global revision of the dulotic ant genus *Polyergus* (Hymenoptera: Formicidae, Formicinae, Formicini). Zootaxa 3722: 501–548. https://doi.org/10.11646/zootaxa.3722.4.5

Trager JC, MacGown JA, Trager MD (2007) Revision of the Nearctic endemic *Formica pallidefulva* group. In: Snelling RR, Fisher BL, Ward PS (Eds). Advances in ant systematics (Hymenoptera: Formicidae): Homage to E.O. Wilson – 50 years of contributions. Memoirs of the American Entomological Institute 80: 610–636.

Uno S, Cotton J, Philpott SM (2010) Diversity, abundance, and species composition of ants in urban green spaces. Urban Ecosystems 13: 425–441. https://doi.org/10.1007/s11252-010-0136-5

Watkins JF II (1972) The taxonomy of *Neivamyrmex texanus*, n. sp., *N. nigrescens* and *N. californicus* (Formicidae: Dorylinae), with distribution map and keys to the species of *Neivamyrmex* of the United States. Journal of the Kansas Entomological Society 45: 347–372.

Watkins JF II (1976) The identification and distribution of New World army ants (Dorylinae: Formicidae). Baylor University Press, Waco, 102 pp.

Weber NA (1950) A revision of the North American ants of the genus *Myrmica* Latreille with a synopsis of the Palearctic species. III. Annals of the Entomological Society of America 43: 189–226. https://doi.org/10.1093/aesa/43.2.189

Wesson LG, Wesson RG (1940) A collection of ants from southcentral Ohio. American Midland Naturalist 24: 89–103. https://doi.org/10.2307/2421055

Wetterer JK (2009) Worldwide spread of the Penny Ant, *Tetramorium bicarinatum* (Hymenoptera: Formicidae). Sociobiology 54: 811–830.

Wheeler GC, Wheeler JN, Kannowski PB (1994) Checklist of the ants of Michigan (Hymenoptera: Formicidae). The Great Lakes Entomologist 26: 297–310.

Wing MW (1968) Taxonomic revision of the Nearctic genus *Acanthomyops* (Hymenoptera: Formicidae). Cornell University Agricultural Experiment Station Memoir 405: 1–173.

Appendix 1

Alphabetical list of native ant taxa documented from surrounding areas but not yet recorded from Ohio. Data from Wheeler et al. (1994), Coovert (2005), Carroll (2011), Seifert et al. (2014), Butler and Coulter (2019), Antmaps (2019), and references therein.

Species	Indiana	Kentucky	Michigan	Pennsylvania	West Virginia
Camponotus decipiens Emery	√				
Crematogaster ashmeadi Mayr				√	
Crematogaster laeviuscula Mayr	√	√			
Crematogaster missouriensis Emery	√				
Dolichoderus mariae Forel	√		√	√	
Formica adamsi Wheeler, W.M.			√		
Formica creightoni Buren			√		
Formica ferocula Wheeler, W.M	√				
Formica fossaceps Buren			√		
Formica hewitti Wheeler, W.M.			√		
Formica impexa Wheeler, W.M.			√		
Formica indianensis Cole					
Formica neorufibarbis Emery			√	√	
Formica nepticula Wheeler, W.M.			√	√	
Formica obscuripes Forel	√		√	√	
Formica talbotae Wilson			√		
Formicoxenus hirticornis (Emery)	√		√		
Formicoxenus provancheri (Emery)			√		
Lasius murphyi Forel			√		
Lasius pallitarsis (Provancher)	√		√		
Lasius plumopilosus Buren			√		
Lasius subglaber Emery	√		√		
Lasius subumbratus Viereck	√		√		
Monomorium emarginatum DuBois	√			√	
Monomorium talbotae DuBois			√		
Myrmica alaskensis Wheeler, W.M.			√		
Myrmica brevispinosa Wheeler, W.M.			√		
Myrmica detritinodis Emery			√		
Myrmica monticola Creighton			√		
Myrmica nearctica Weber	√		√		
Myrmica spatulata Smith, M.R.	√		√	√	
Neivamyrmex nigrescens (Cresson)	√	√			√
Pheidole morrisii Forel	√				
Polyergus bicolor Wasmann	√		√		
Polyergus breviceps Emery	√		√		
Polyergus mexicanus Forel	√				
Polyergus montivagus Wheeler, W.M.	√		√		
Polyergus sanwaldi Trager	√				
Stenamma meridionale Smith, M.R.	√				√
Strumigenys angulata Smith, M.R.		√			
Strumigenys filitalpa (Brown)	√				
Strumigenys memorialis (Deyrup)		√			
Strumigenys metazytes (Bolton)		√			
Temnothorax pilagens Seifert et al.			√		

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Revision of the North American species of *Promicrogaster* (Hymenoptera, Braconidae, Microgastrinae), with an updated key to all described species in North and Meso America

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Abstract

The genus *Promicrogaster* (Hymenoptera, Braconidae, Microgastrinae) in North America is revised and seven new species are described: *floridakeys*, *gainesvillensis*, *huachuca*, *jaymeae*, *madreanensis*, *rondeau* and *virginianus*. All but one have so far been found in protected areas of Canada and the USA, with two species collected at rather high altitudes of over 1,600 m.a.s.l. (Arizona, southwestern USA), whereas the other five were found in Eastern North America (southern Ontario and several USA states) at relatively lower altitudes (less than 150 m.a.s.l.). A key to all 31 described species in North and Meso America is provided. A species from Costa Rica previously described in *Promicrogaster* is here transferred to a different genus as *Hypomicrogaster pablouzagai* (Fernandez-Triana & Boudreault, 2016), **comb. nov.**

Keywords

Microgastrinae, *Promicrogaster*, Nearctic, taxonomic key

Introduction

The genus *Promicrogaster* (Hymenoptera: Braconidae, Microgastrinae) comprises a very distinctive group of microgastrine wasps, on account of its very long, strongly curved ovipositor with its apex sinuate. It is widely distributed in the New World, with 32 currently described species (Fernandez-Triana et al. 2016), and a probable species-richness estimated by Mason (1981) to be over 100 species. In spite of that, specimens are rare in

collections, and very few details of its biology are presently known. All of the verified host records for *Promicrogaster* are from caterpillars of the Lepidoptera families Sesiidae and Tineiae living deeply inside more or less woody plant material (reviewed by Fernandez-Triana et al. 2016), suggesting than the sinuate ovipositor tip is an adaptation to steer it through fissures in harder/more woody structures than mere leaf rolls (e.g., Quicke 2015).

Until now, no species of *Promicrogaster* had been reported from North America, although Mason (1981) and Fernandez-Triana et al. (2016) mentioned a few undescribed specimens present in collections. Seven sp. nov. from Canada and the United States are described below, increasing the total of known *Promicrogaster* species in the New World to 38. A recent key to Meso American species by Fernandez-Triana et al. (2016) is updated and modified below to accommodate the new North American species.

Methods

Promicrogaster is a very rarely collected genus (Mason 1981, Fernandez-Triana et al. 2016), and it is poorly represented in collections. This study is based on 10 specimens available for study in the Canadian National Collection of Insects (CNC) in Ottawa, out of thousands of Nearctic Microgastrinae specimens that were examined.

Morphological terms and measurements of structures are mostly as used by Mason (1981), Huber and Sharkey (1993), Whitfield (1997), Karlsson and Ronquist (2012), and Fernández-Triana et al. (2014a). Mediotergites 1, 2, etc., are abbreviated as T1, T2, etc. Flagellomere 1 is the closest to the pedicel while flagellomere 16 is the apical one. Because the ovipositor in *Promicrogaster* is curved and crooked at the very apex, its length is difficult to measure accurately; the ovipositor length measurements provided for each sp. nov. are only intended as an approximation. In any case, the ovipositor and its sheaths are some of the longest observed in any Microgastrinae genera; they are usually two times longer than the metatibia length. The descriptions include characters that are commonly used in describing Microgastrinae (e.g., body measurements such as length of body and fore wing, ovipositor sheath; and also color of particular body areas). These characters follow a recent revision of the Mesoamerican *Promicrogaster* (Fernández-Triana et al. 2016), so as to facilitate future comparisons between species in the New World.

The dichotomous key is based on that provided by Fernández-Triana et al. (2016), expanded to accommodate the new North American species, and revised to correct some previous inaccuracies. In a few couplets of the key, some qualifiers ("***either***", "***and***", "***or***", "***and/or***") are shown in bold and italic to be explicit that in those cases more than one character state must be considered.

The key mostly uses morphological characters, but in one couplet molecular characters are provided to differentiate species that are morphologically similar to each other. In that case, characteristic loci in the DNA barcoding region are detailed. The bases are numbered from the start of the COI gene according to the reference sequence U37541 (*Drosophila melanogaster*), and are only diagnostic within that couplet. The letters A, C, G, and T correspond to adenine, cytosine, guanine, and thymine respectively.

Photos were taken with a Keyence VHX-1000 Digital Microscope, using a lens with a range of 13–130×. Multiple images through the focal plane were taken of a structure and these were combined to produce a single in-focus image, using the software associated with the Keyence System.

For two species molecular data was available (DNA barcodes, the 5' region of the cytochrome c oxidase I (CO1) gene, Hebert et al. (2003)). Information for those sequences can be retrieved from the Barcode of Life Data System (BOLD) (Ratnasingham and Hebert 2007).

Results

Detailed morphological characterization of *Promicrogaster* was provided in Fernández-Triana et al. (2016). It is a very distinctive genus defined by the combination of elongate and bilobate glossa, large polished areas on lateral face of scutellum, and ovipositor shape and length. Within Microgastrinae, it can only be confused with *Sendaphne*, but the later has a much less transverse mediotergite 2, the apex of the ovipositor is not sinuate, the propodeum is entirely or mostly smooth, and the first discal cell is much wider (e.g., Fernández-Triana et al. 2014b).

A total of seven *Promicrogaster* species, all new and described below, are here recognized for North America (Table 1). All but one have so far been found in protected areas of Canada and the USA. Two species were collected in Southwestern USA (Arizona) at rather high altitudes (over 1,600 m.a.s.l.); the other five were collected in Eastern North America (southern Ontario and several USA states), at relatively lower altitudes (less than 150 m.a.s.l.). Although a few additional species are expected to be found in North America, especially when other collections are studied as comprehensively as that of the CNC has been, most of the undescribed species in this genus will probably be found in South America.

Five of the seven sp. nov. described below are only represented by a single specimen, in spite of the studied region having tens of thousands of specimens of Microgastrinae in the CNC collection that were examined for this paper. The relative scarcity of *Promicrogaster* specimens from North America is similar to what was found when studying the Costa Rican fauna (Fernández-Triana et al. 2016), when very few specimens of the genus were available among tens of thousands of specimens of Microgastrinae examined. Whether *Promicrogaster* is indeed rare in nature or just not commonly collected is still unknown.

As was the case for species described from Costa Rica (Fernández-Triana et al. 2016), no biological information is available at present for the North American species.

Only two of the sp. nov. (*jaymeae* and *madreanensis*) have some molecular data associated (DNA barcodes), in one case only a minibarcode of 165 base pairs.

Further study revealed that one of the species from Costa Rica described in Fernández-Triana et al. (2016), the nominal *Promicrogaster pablouzagai* Fernandez-Triana & Boudreault, 2016, is better placed in *Hypomicrogaster*, with the comb. nov. proposed below (see section "Taxonomic treatment of species, in alphabetical order"), and it is excluded from the key.

Table 1. North American species of Promicrogaster and their known distribution. Data from present paper.

Species	Known distribution in North America (approximate altitude in m)
Promicrogaster floridakeys Fernandez-Triana, sp. nov.	USA, Florida, protected areas of the Lower and Middle Florida Keys, less than 5 m.a.s.l.
Promicrogaster gainesvillensis Fernandez-Triana, sp. nov.	USA: Florida, Gainesville, 50 m.a.s.l.
Promicrogaster huachuca Fernandez-Triana, sp. nov.	USA, Arizona, protected area in the Huachuca Mountains, 1830 m.a.s.l
Promicrogaster jaymeae Fernandez-Triana, sp. nov.	Canada, Ontario, Thousand Islands National Park, 120 m.a.s.l; USA: Massachusetts, Blue Hills Reservation State Park, 55 m.a.s.l.
Promicrogaster madreanensis Fernandez-Triana, sp. nov.	USA, Arizona, protected area in the Patagonia Mountains, 1680 m.a.s.l.
Promicrogaster rondeau Fernandez-Triana, sp. nov.	Canada, Ontario, Rondeau Provincial Park, 150 m.a.s.l.
Promicrogaster virginianus Fernandez-Triana, sp. nov.	USA, Virginia, no further data.

The updated key below covers all 32 species so far described from North America and Meso America and believed to be correctly placed in *Promicrogaster*. Detailed images and full descriptions of the Mesoamerican species are not repeated here as they can be freely accessed in Fernández-Triana et al. (2016). South America is the only remaining area in the New World pending study and description of its species, most of them undescribed.

Key to *Promicrogaster* species in North and Meso America (female specimens)

1 Lighter coloured species; clypeus entirely or mostly yellow to orange-yellow; all sternites and hypopygium yellow to orange-yellow; metasoma dorsally with T1–T4 entirely (rarely mostly) yellow, orange or red **2**

– Darker coloured species; most sternites (usually) and hypopygium (partially to entirely) dark brown; metasoma dorsally mostly dark brown to black (rarely some tergites with small areas orange to light brown); clypeus coloration variable, usually dark brown to black, rarely mostly yellow to orange-yellow **5**

2(1) Propodeum with complete, raised, and strongly defined median carina; ***and*** T1 entirely smooth; ***and*** malar line more than half eye length; ***and*** clypeus large and entirely orange-yellow [Panama, Trinidad] ..... ***Promicrogaster miranda* Muesebeck, 1958**

– Propodeum without a median carina but with central depression; ***either*** with T1 mostly rugose ***and*** with malar line less than half eye length; ***or*** with clypeus smaller and not entirely yellow-red [other Mesoamerican countries, mostly Costa Rica] **3**

3(2) Metasoma dorsally entirely yellow-orange; T1 with coarse sculpture on 0.7 or more of its length; T2 relatively narrow, its width at posterior margin more

than 3.0 × its length centrally; scape entirely to mostly black to dark brown [Costa Rica, Honduras, Mexico, Panama, mostly found at elevations over 1,000 m.a.s.l.] ..... ***Promicrogaster munda*** **Muesebeck, 1958**

– Metasoma dorsally with some red, brown or black coloration; T1 comparatively smoother, at most with sculpture on posterior 0.5 of its length; T2 broader, its width at posterior margin usually less than 3.0 × its length centrally; scape mostly yellow [Costa Rica (ACG), dry forest, under 300 m.a.s.l.] **4**

4(3) Posterior margin of clypeus strongly concave; lower face clearly elongate, malar line at least 1.5 × mandible width; fore wing vein 1M transparent; T1 shape more or less rectangular (width at middle length, anterior and posterior margins about the same); T1–T4 entirely orange-yellow, T5+ mostly dark brown to black ..... ***Promicrogaster fabriciocambroneroi*** **Fernandez-Triana & Boudreault, 2016**

– Posterior margin of clypeus very slightly concave, almost straight; lower face of normal length, malar line 1.0 × mandible width; fore wing with vein 1M brown; T1 narrowing towards posterior margin; T1 mostly red with black margins (posterior 0.3 of T1 sometimes black), T2–T4 red-orange or yellow-orange, T5+ yellow with small central band brown ..... ***Promicrogaster alexmartinezi*** **Fernandez-Triana & Boudreault, 2016**

5(1) Antenna with most of flagellomeres 10–16 yellow-white **6**

– Antenna entirely dark brown to black (rarely with flagellomeres 1–4 lighter in colour than rest of antenna) **7**

6(5) Antenna with flagellomeres 11–16 yellow-white; propleuron, anterior 0.5 of metacoxa, sternites and hypopygium dark brown; ovipositor strongly down curved on posterior 0.2 [Costa Rica (ACG), cloud forest over 1000m] ..... ***Promicrogaster leilycastilloae*** **Fernandez-Triana & Boudreault, 2016**

– Antenna with flagellomeres 1–8 and 15–16 dark brown, and flagellomeres 9–14 (sometimes only 10–14) yellow white; propleuron, metacoxa, sternites and hypopygium mostly yellow to orange-yellow; ovipositor relatively straight [Costa Rica (ACG), mid-elevation rain forests, 500–800m] ..... ***Promicrogaster daretrizoi*** **Fernandez-Triana & Boudreault, 2016**

7(5) Fore wing without areolet, ***and*** hypopygium and sternites almost always entirely dark brown (at most hypopygium with small pale spot basally, and/or anterior 2–3 sternites yellow), ***and*** smaller size (body length 1.8–2.4 mm, fore wing length 2.0–2.6 mm) **8**

– Fore wing with small areolet, ***and/or*** hypopygium and sternites usually mostly to entirely yellow, ***and/or*** larger size (body and fore wing lengths usually 3.0–4.0 mm) **16**

8(7) Propodeum mostly sculptured (except for polished areas postero-laterally) **9**

– Propodeum mostly smooth (except for small striae around nucha) **14**

9(8) Propodeum with almost complete areola (clearly defined posteriorly by carinae, definition anteriorly more obscured by surrounding sculpture); T2 mostly smooth [United States (Florida Keys), mangrove-hammock forest

transition, at around sea level]..... .....***Promicrogaster floridakeys*** **Fernandez-Triana, sp. nov.**

– Propodeum without defined areola (with longitudinal sculpture, mostly near posterior half of propodeum); T2 mostly sculptured, except for smooth central area [species either from Canada or from Costa Rica, found at much higher altitudes and/or completely different ecosystems]..... **10**

10(9) Ocelli comparatively smaller: ocular-ocellar line 2.8 × posterior ocellus diameter, ocular-ocellar line 2.0 × interocellar distance; ovipositor length 2.0 × metatibia length [Canada (Ontario), 42°N, sand dunes, at around 170 m.a.s.l.]..... ***Promicrogaster rondeau*** **Fernandez-Triana, sp. nov.**

– Ocelli comparatively larger: ocular-ocellar line 1.6–2.0 × (very rarely 2.3 ×) posterior ocellus diameter, ocular-ocellar line 0.9–1.6 × interocellar distance; ovipositor length more than 2.0 × metatibia length [Costa Rica (ACG), 10–11°N, rainforest, at 1,000–1,100 m.a.s.l.)]..... **11**

11(10) Smaller size, body length 2.0–2.1 mm, fore wing length 2.2 mm, metacoxa 0.45–0.46 mm; ocular–ocellar line 0.08–0.09 mm; T1 width/length 0.4–0.5 ×; ten diagnostic characters in the DNA barcoding region: 79C, 235C, 346C, 364C, 386A, 415A, 421G, 562A, 607G, 622C..... ..... ***Promicrogaster fabiancastroi*** **Fernandez-Triana & Boudreault, 2016**

– Larger size, body length 2.3–2.4 mm, fore wing length 2.4–2.6 mm, metacoxa 0.47–0.56 mm; ocular–ocellar line 0.11–0.15 mm (rarely 0.08); T1 width/length 0.5–0.7 ×; different base pairs in the barcoding region: 79A or 79T, 235T, 346A or 346T, 364A or 364T, 386T, 415G, 421A or 421T, 562G or 562T, 607A or 607T, 622A or 622T **12**

12(11) Ocular–ocellar line shorter than interocellar distance (0.9 ×); T1 posterior width 1.3 × T2 central length; T2 width 3.2 × its length centrally .... ***Promicrogaster luismendezi*** **Fernandez-Triana & Boudreault, 2016**

– Ocular–ocellar line longer than interocellar distance (1.4–1.6 ×); T1 posterior width 1.8–2.0 × T2 central length; T2 width 3.5–4.9 × (usually more than 4.0 ×) its length centrally **13**

13(12) T2 width 4.9 × its length centrally; T1 length 1.9 × its posterior width; larger species, fore wing length 2.6 mm, metacoxa length 0.6 mm, metafemur length 0.7 mm, metatibia 0.9 mm ....***Promicrogaster eddycastroi*** **Fernandez-Triana & Boudreault, 2016**

– T2 width 3.5–4.0 × its length centrally; T1 length 1.5–1.7 × its posterior width; smaller species, fore wing length 2.3–2.4 mm, metacoxa length 0.5 mm, metafemur length 0.5–0.6 mm, metatibia 0.7–0.8 mm..... ...***Promicrogaster naomiduarteae*** **Fernandez-Triana & Boudreault, 2016**

14(8) Pterostigma with anterior 0.3 or more white, most veins of fore wing transparent or white [Costa Rica (ACG), dry forest under 300 m.a.s.l.] ....***Promicrogaster daniellopezi*** **Fernandez-Triana & Boudreault, 2016**

– Pterostigma entirely brown or at most with anterior 0.1 pale, fore wing with veins mostly brown [Costa Rica (ACG), cloud forests over 1,000 m.a.s.l.] **15**

15(14) Posterior 0.6 of T1 sculptured; clypeus, procoxa, most of sternites and laterotergites brown .....
.....***Promicrogaster ronycastilloi*** **Fernandez-Triana & Boudreault, 2016**

– Posterior 0.6 of T1 mostly smooth (at most with sculpture restricted to margins); labrum yellow-orange, procoxa yellow, sternites and laterotergites mostly to partially yellow .....
...***Promicrogaster sebastiancambroneroi*** **Fernandez-Triana & Boudreault, 2016**

16(7) Posterolateral corners of anteromesoscutum orange; hypopygium and sternites dark brown; T1 hardly narrowing towards posterior margins; T1 relatively wide, its medial length barely longer than its width at anterior margin [Panama] ..... ***Promicrogaster polyporicola*** **Muesebeck, 1958**

– Anteromesoscutum entirely black; hypopygium and sternites usually mostly to entirely yellow; T1 usually narrowing towards posterior margin; T1 relatively narrower, its medial length much longer than its width at anterior margin [Brazil, Canada, Costa Rica, Mexico, United States] **17**

17(16) Propleuron almost entirely yellow, except for anterior 0.2 near head yellow-white (rarely propleuron partially yellow, partially light-brown); hypopygium, sternites and most laterotergites entirely yellow (hypopygium may have a dark spot on posterior 0.1 or less).....**18**

– Propleuron almost entirely dark brown to black, except for anterior 0.2 near head yellow; hypopygium, sternites and laterotergites at least partially dark brown **20**

18(17) Metacoxa dark brown on anterior 0.6; tegula brown; propleuron partially yellow, partially light-brown.....
... ***Promicrogaster kiralycastilloae*** **Fernandez-Triana & Boudreault, 2016**

– Metacoxa, tegula and propleuron entirely yellow (propleuron with anterior 0.2 near head yellow-white) **19**

19(18) T3 mostly yellow-white, with anterior 0.4 light brown, T4–7 brown anteriorly, white on posterior 0.3–0.5 [Costa Rica (ACG), cloud forest over 1,000 m.a.s.l.].....
...***Promicrogaster kevinmartinezi*** **Fernandez-Triana & Boudreault, 2016**

– All tergites dark brown to black [Costa Rica (ACG), mid-elevation rain forest, 500 m.a.s.l.].....
.... ***Promicrogaster eimyobandoae*** **Fernandez-Triana & Boudreault, 2016**

20(17) Fore wing without areolet .....
... ***Promicrogaster andreyvallejosi*** **Fernandez-Triana & Boudreault, 2016**

– Fore wing with small areolet **21**

21(20) Flagellomeres 1–4 yellow-brown, clearly paler than rest of entirely brown flagellomeres ; orange-yellow areas on metapleuron posterior 0.4, T1 anterior 0.6, T3 anterior 0.5 and small spot on mesopleuron posteriorly .....
Promicrogaster hillaryvillafuerteae **Fernandez-Triana & Boudreault, 2016**

– All flagellomeres same color (brown to dark brown); meso- and metapleuron entirely dark brown to black, coloration of T1 and T3 variable but not as above **22**

22(21) Tegula and wing base dark brown to black; clypeus black (same color as face); clypeus slightly protruding and labrum slightly depressed, giving the appearance of a circular opening between the margin of clypeus and mandibles..... ... ***Promicrogaster monteverdensis*** **Fernandez-Triana & Boudreault, 2016**

– Tegula and wing base yellow; clypeus entirely to partially orange-yellow or orange-brown (clearer than face); clypeus not protruding and labrum not depressed, not giving the appearance of a circular opening.....**23**

23(22) Flagellomere 15 length 1.6–1.7 × its width; ***and*** ovipositor tip strongly bent downwards; ***and*** clypeus entirely orange-yellow (different from dark brown to black face); ***and*** body length and fore wing length 4.0 mm; ***and*** T1 almost parallel-sided, very slightly narrowing towards posterior margin; ***and*** T2 mostly sculptured; ***and*** T3 with small yellow spot laterally [Brazil, Mexico]... ..... ***Promicrogaster apharea*** **Nixon, 1965**

– Flagellomere 15 length 1.0–1.3 × its width; ***and/or*** ovipositor tip less strongly bent downwards; ***and/or*** clypeus entirely to partially dark brown to black (same color as face); ***and/or*** body length and fore wing length less than 4.0 mm; ***and/or*** T1 clearly narrowing towards posterior margin; ***and/or*** T2 mostly smooth; ***and/or*** T3 entirely dark brown to black [Canada, Costa Rica, United States] **24**

24(23) Metacoxa with at least anterior 0.6 (usually more) dark brown to black [United States; Costa Rican specimens running through this couplet come from cloud forests over 1,000 m.a.s.l. in ACG] **25**

– Metacoxa mostly to entirely yellow (at most with small, dark spot on anterior 0.1–0.3 dorsally) [United States; Costa Rican specimens running through this couplet come from dry forest or mid-elevation rainforests at 300–500 m.a.s.l. in ACG] **26**

25(24) Smaller ocelli, ocular–ocellar line 2.6 × as long as posterior ocellus diameter; more rounded head, its maximum width 1.15 × its height; smaller body length (2.5 mm) and fore wing length (2.6 mm); tegula yellow [United States] .....***Promicrogaster virginianus*** **Fernandez-Triana, sp. nov.**

– Bigger ocelli, ocular–ocellar line 1.9–2.0 × as long as posterior ocellus diameter; more ovoid head, its maximum width 1.3 × its height; larger body length (3.3–3.5 mm) and fore wing length (3.7 mm); tegula brown [Costa Rica (ACG), cloud forests over 1,000 m.a.s.l.] ..... ***Promicrogaster brandondinartei*** **Fernandez-Triana & Boudreault, 2016**[*]

26(24) T3 with yellow spots laterally; T2 mostly sculptured (but sometimes smooth centrally) ***and/or*** T1 clearly narrowing towards posterior margin, its length at least 2.0 × its width at posterior margin **27**

– T3 entirely dark brown to black; T2 smooth ***and*** T1 usually barrel-shaped to almost parallel-sided, rarely slightly narrowing towards posterior margin, its length 1.7 × its width at posterior margin **30**

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* In the original description of this species the color of metacoxa was wrongly described as 'yellow' but after re-examining all specimens is evident that was an error, as all specimens have metacoxa with anterior 0.5–0.6 dark brown to black

27(26) Fore wing vein R1 pale (yellow-white); metasoma with T3+ yellow-orange on posterior 0.2–0.5 [Canada (ON); United States (Massachusetts); 42–44°N]. ..... ***Promicrogaster jaymeae*** **Fernandez-Triana, sp. nov.**

– Fore wing vein R1 dark brown; metasoma mostly dark brown to black, at most T3 with yellow spots laterally [Costa Rica (ACG); United States (AZ), 31°N] **28**

28(27) Clypeus almost entirely black (at most with very small yellow spots on postero-lateral margins); fore wing with most veins dark brown; hypopygium partially yellow; ovipositor length 2.50–2.60 × metatibia length; tip of antenna with shorter flagellomeres (flagellomere 14 1.3–1.4 × as long as wide, flagellomere 15 1.2 × as long as wide) [Costa Rica (ACG), 280–300 m.a.s.l.] .... ***Promicrogaster liagrantae*** **Fernandez-Triana & Boudreault, 2016**

– Clypeus entirely to mostly orange; fore wing with most veins light yellow to almost transparent; hypopygium dark brown to brown; ovipositor length 1.97–2.14 × metatibia length; tip of antenna (when known) with longer flagellomeres (flagellomere 14 1.6 × as long as wide, flagellomere 15 1.5 × as long as wide) [United States] **29**

29(28) Comparatively smaller species (body length: 3.10 mm, fore wing length: 3.00 mm); T1 length 1.9 × its width at posterior margin; T2 posterior margin width 3.2 × it length medially and slightly more sculptured; head and mesosoma mostly dark reddish-brown; fore wing areolet almost obliterated [Florida, 50 m.a.s.l.] .... ***Promicrogaster gainesvillensis*** **Fernandez-Triana, sp. nov.**

– Comparatively larger species (body length: 3.70 mm, fore wing length: 3.80 mm); T1 length 2.7 × its width at posterior margin; T2 posterior margin width 4.4 × its length medially and mostly smooth (except for sculpture near posterior margin); head and mesosoma mostly black; fore wing areolet clearly visible and defined [Arizona (Huachuca Mountains), 1830 m.a.s.l.] .... ***Promicrogaster huachuca*** **Fernandez-Triana, sp. nov.**

30(26) Clypeus with strong notch centrally on posterior margin; T1 and T2 almost entirely smooth; metapleuron relatively more sculptured on posterior 0.4; body and fore wing length over 4.5 mm [United States (AZ, Patagonia Mountains), 1,675 m.a.s.l.] .... ***Promicrogaster madreanensis*** **Fernandez-Triana, sp. nov.**

– Clypeus without notch centrally on posterior margin; T1 with some sculpture on posterior 0.4–0.5, T2 with some punctuation on margins; metapleuron relatively less sculptured, almost smooth on posterior 0.4; body and fore wing lengths 3.6–4.0 mm [Costa Rica (ACG), 400–520 m.a.s.l.] .... ***Promicrogaster tracyvindasae*** **Fernandez-Triana & Boudreault, 2016**

Taxonomic treatment of species, in alphabetical order

Hypomicrogaster pablouzagai (Fernandez-Triana & Boudreault, 2016), comb. nov.

Promicrogaster pablouzagai Fernandez-Triana & Boudreault, 2016.

Notes. A critical re-examination of the available specimens (including the holotype) as well as the numerous DNA barcodes available, clearly indicate that this species is better placed within *Hypomicrogaster*. The propodeum has an irregular pattern of carinae around the median longitudinal carina, but still it is possible to distinguish a partially defined areola (at least apically) which is similar to other known species of *Hypomicrogaster*. The head is also considerably transverse (i.e., significantly much wider than high in frontal view), another morphological feature that is typical in this genus. The DNA barcodes cluster close to many other species of *Hypomicrogaster* and relatively distant from *Promicrogaster*, further supporting transferring the species here.

Promicrogaster floridakeys Fernandez-Triana, sp. nov.

http://zoobank.org/24EBD28C-19D2-4FAE-8DA5-10E26CB39103
Fig. 1 A–G

Material examined. Holotype. UNITED STATES • ♀, CNC; Florida, Long Key State Park; 24.8127N, 80.8231W; 24 Aug-26 Oct 2016; J McIntosh leg; Malaise trap; CNC634252.

Paratypes. UNITED STATES • ♀, CNC; Florida, Monroe County, Middle Torch Key; 1–30 Jun 1985; S & J Peck leg; Malaise trap; mangrove-hardwood transition; CNC505706 • ♀, CNC; Florida, Monroe County, Big Pine Key; 1–30 Mar 1986; S & J Peck leg; Malaise trap; CNC526849.

Diagnosis. Among the darker coloured species with unicolorous (brown to black) flagellomeres, *P. floridakeys* is unique in having the propodeum with an almost complete areola (all other species lack an areola).

Description. Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): black to dark brown. Metacoxa: mostly black to dark brown (posterior 0.1–0.2 yellow). Malar distance: less than 0.2 × eye length. Fore wing areolet: absent. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly smooth. Body length: 2.30–2.50 mm. Fore wing length: 2.40–2.55 mm. Ovipositor length: 1.50–1.70 mm. Ocular–ocellar line: 0.12 mm. Interocellar distance: 0.09 mm. Posterior ocellus diameter: 0.06 mm. Metacoxa length: 0.51–0.56 mm. Metafemur length: 0.61–0.65 mm. Metatibia length: 0.71–0.77 mm. T1 length/width at posterior margin: 0.33–0.35 mm/ 0.14 mm. T2 length/width at posterior margin: 0.07–0.08 mm/ 0.30–0.32 mm.

Distribution. UNITED STATES, Florida, protected areas of the Lower and Middle Florida Keys (less than 5 m.a.s.l.). Specimens have been caught at mangrove or hardwood habitats.

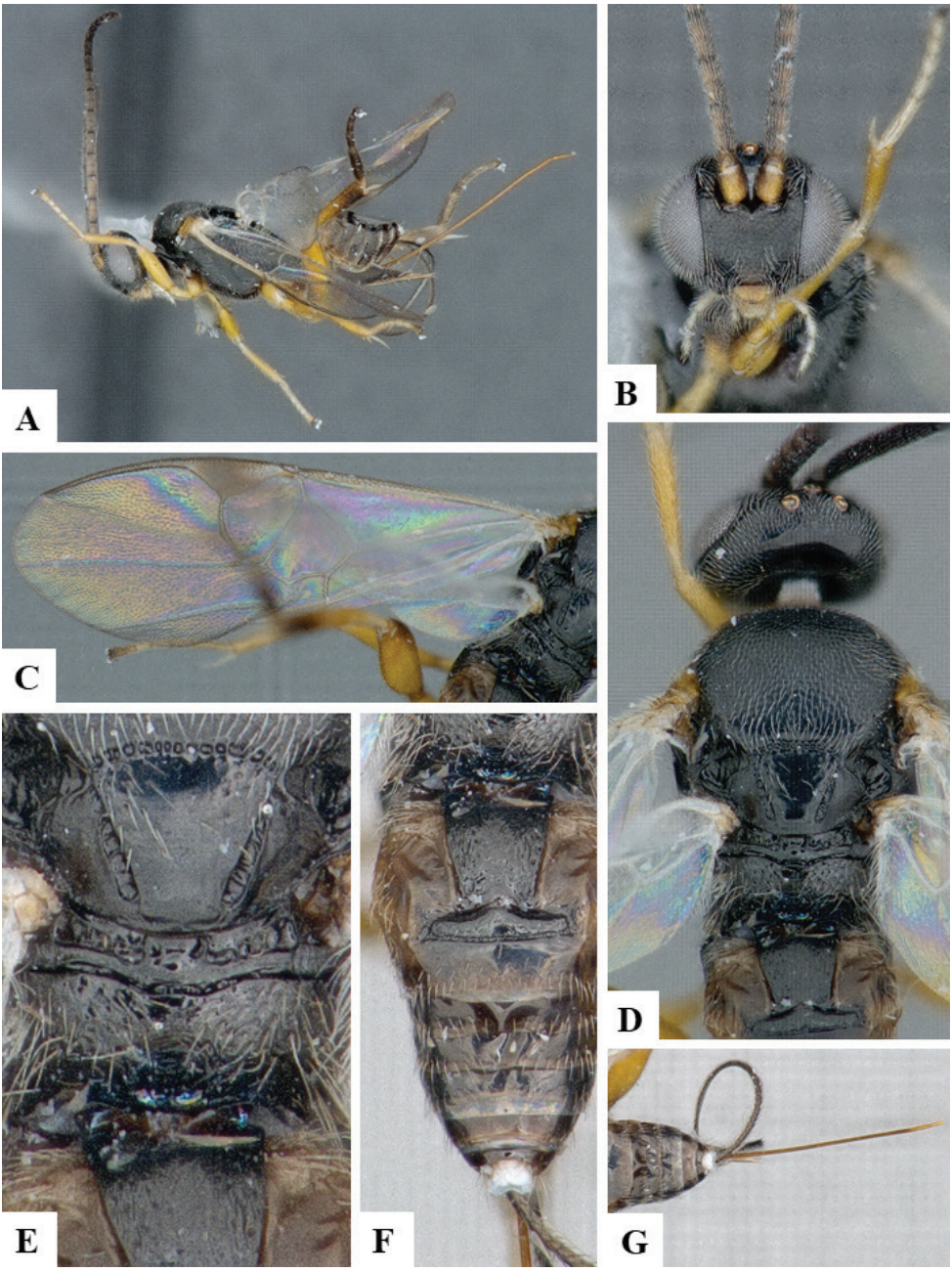

Figure 1. *Promicrogaster floridakeys*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** scutellar complex and propodeum, dorsal **F** metasoma, dorsal **G** ovipositor.

Biology. Unknown.

Molecular data. Not available.

Etymology. Named after the Florida Keys, with the intention to recognize the beautiful yet fragile ecosystems present there.

***Promicrogaster gainesvillensis* Fernandez-Triana, sp. nov.**
http://zoobank.org/9AD19A17-D8CB-411D-A150-D820C342AA18
Fig. 2 A–E

Material examined. Holotype. UNITED STATES • ♀, CNC; Florida, Gainesville, Doyle Conner Building; 09 Oct 1973; E.E. Grissell leg; Malaise trap; CNCHYM 01987.

Diagnosis. This species is morphologically similar to *P. huachuca* (Arizona), *P. jaymeae* (Canada), and *P. liagrantae* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different.

Description. Head: mostly dark reddish-brown, labrum and mandibles yellow, clypeus mostly dark reddish-brown but with comparatively large yellow spots on postero-lateral margins. Flagellomeres: dark brown. Mesosoma: mostly dark reddish-brown laterally, dorsally mostly black (but with faint reddish-brown spots on posterolateral margins of anteromesoscutum). Tegula: yellow. Metasoma (dorsally): mostly dark brown to black, T3 with yellow spots laterally. Metacoxa: yellow. Malar distance: less than 0.2 × eye length. Fore wing areolet: present. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly sculptured, except for smooth central area. Body length: 3.10 mm. Fore wing length: 3.00 mm. Ovipositor length: 2.25 mm. Ocular–ocellar line: 0.15 mm. Interocellar distance: 0.08 mm. Posterior ocellus diameter: 0.07 mm. Metacoxa length: 0.75 mm. Metafemur length: 0.85 mm. Metatibia length: 1.05 mm. T1 length/width at posterior margin: 0.48 mm/ 0.25 mm. T2 length/width at posterior margin: 0.12 mm/ 0.38 mm.

Distribution. UNITED STATES, Florida, Gainesville, 50 m.a.s.l.

Biology. Unknown.

Molecular data. Not available.

Etymology. Named after the type locality, as a recognition to the important insect collections hosted in that city and the vibrant entomological community living there.

***Promicrogaster huachuca* Fernandez-Triana, sp. nov.**
http://zoobank.org/4DE29D6C-4FBA-47F9-A345-A62300595942
Fig. 3 A–F

Material examined. Holotype. UNITED STATES • ♀, CNC; Arizona, Sierra Vista, Huachua Mountains, Ramsey Canyon; 1829 m.a.sl.; 07 Nov 1967; Sternitzky leg; CNCHYM 01988.

Diagnosis. This species is morphologically similar to *P. gainesvillensis* (Florida), *P. jaymeae* (Canada), and *P. liagrantae* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different.

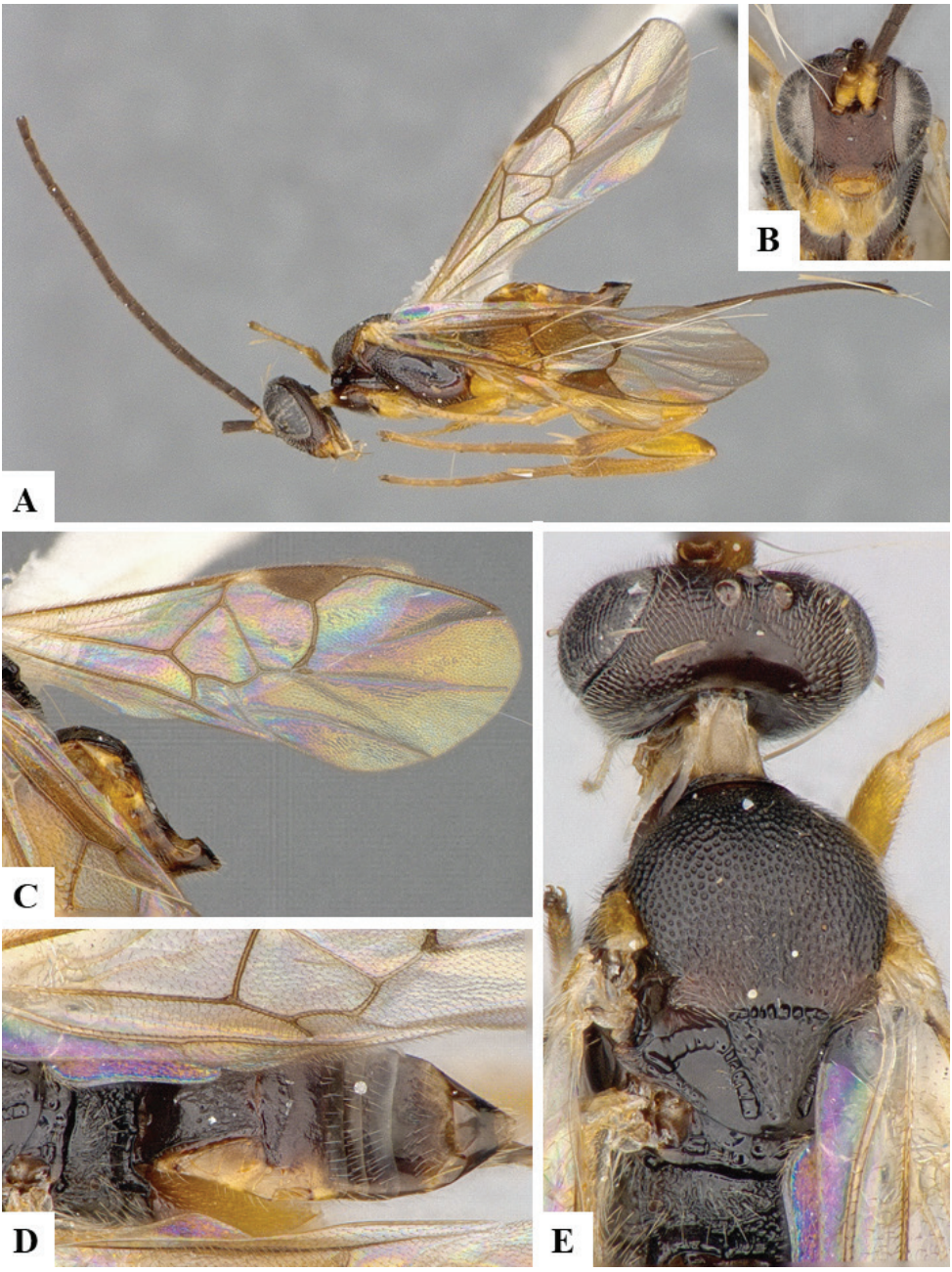

Figure 2. *Promicrogaster gainesvillensis*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** head and mesosoma, dorsal.

Description. Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): mostly dark brown to black, T3 with yellow spots laterally. Metacoxa: yellow. Malar distance: 0.3 × eye length.

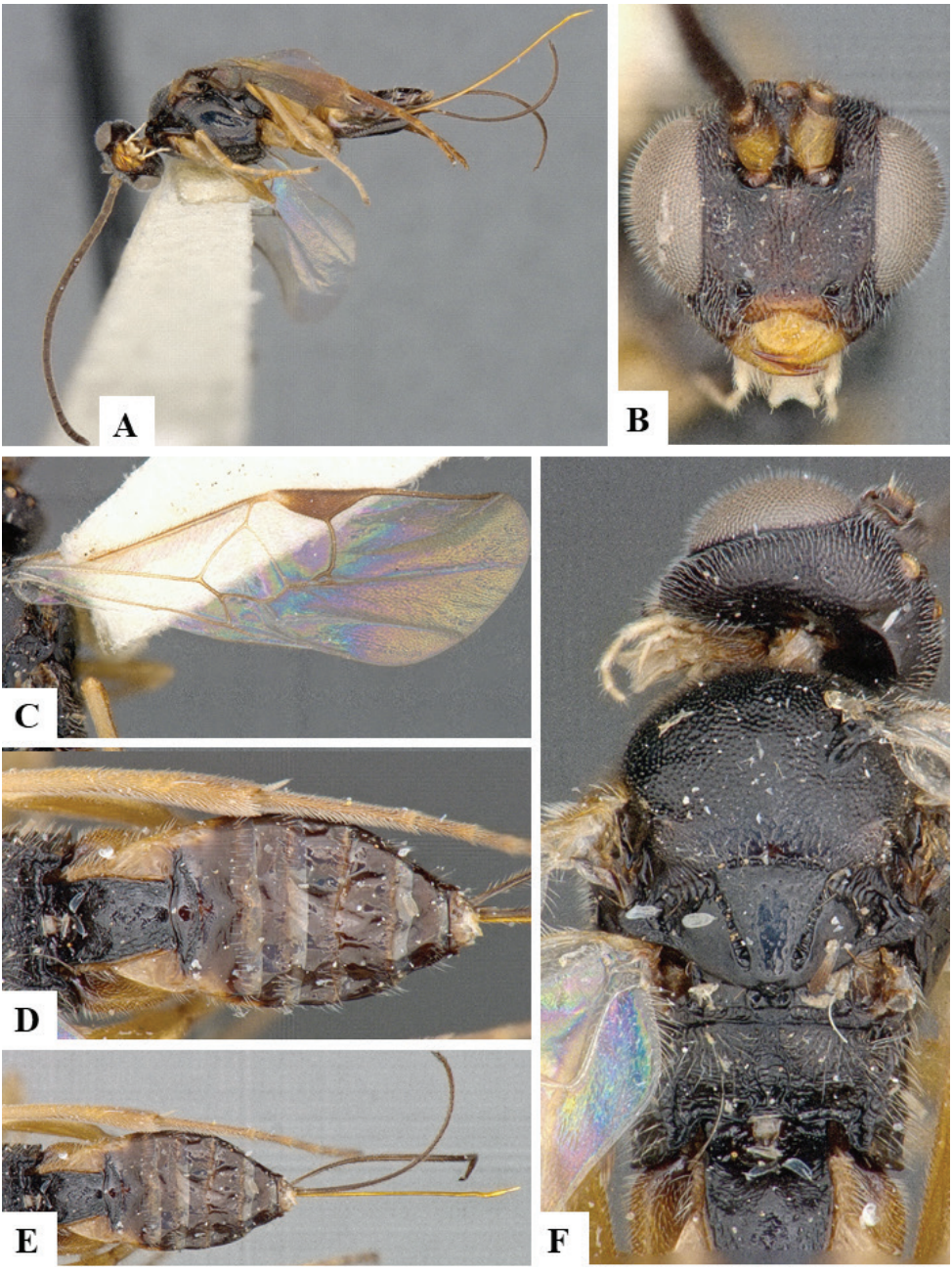

Figure 3. *Promicrogaster huachuca*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** ovipositor **F** head and mesosoma, dorsal.

Fore wing areolet: present. T1 sculpture: anterior 0.5 smooth, posterior 0.5 sculptured. T2 sculpture: mostly smooth but with sculpture near margins. Body length: 3.70 mm. Fore wing length: 3.80 mm. Ovipositor length: 2.40 mm. Ocular–ocellar line: 0.17 mm.

Interocellar distance: 0.10 mm. Posterior ocellus diameter: 0.09 mm. Metacoxa length: 0.85 mm. Metafemur length: 0.95 mm. Metatibia length: 1.22. T1 length/width at posterior margin: 0.60/ 0.22 mm. T2 length/width at posterior margin: 0.12 mm/ 0.53 mm.

Distribution. UNITED STATES, Arizona, Huachuca Mountains, 1,829 m.a.s.l.

Biology. Unknown.

Molecular data. Not available.

Etymology. Named after the Huachuca Mountains, one of the major Madrean sky island ranges in Arizona. The Madrean sky islands are pine-oak woodlands found at higher elevations in Mexico, Arizona and New Mexico (USA); they are surrounded at lower elevations by the Sonoran and Chihuahuan deserts, and are important because of their endemism, and relict populations.

Promicrogaster jaymeae **Fernandez-Triana, sp. nov.**
http://zoobank.org/D5ED2A45-7F43-4B1F-9813-88B7E73BB9E0
Figs 4 A–F, 5 A–G

Material examined. Holotype. CANADA • ♀, CNC; Ontario; St. Lawrence Islands National Park; Jones Creek by Mallory Town; Country Road 5; 44.4747N, 75.8652W; 117 m.a.s.l; 19 Sep 2012; Mixed forest - sugar maple and white birch; St. Lawrence Islands National Park leg; BIOUG03887-G02.

Paratype. UNITED STATES • ♀, MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, USA); Massachusetts, Blue Hills Reservation, Milton; 19 Aug 1963; H.E. Evans leg; CNC666703.

Diagnosis. This species is morphologically similar to *P. gainesvillensis* (Florida), *P. huachuca* (Arizona), and *P. liagrantae* (Costa Rica), but there are enough morphological differences (see key above for details on how to separate those four species) and disparate geographical distributions (including different ecosystems and considerable variation in altitude) to consider all of them as different. The Canadian species can be separated based on its fore wing vein R1 yellow-white, T3+ yellow-orange on posterior 0.2–0.5, metacoxa dark brown on anterior 0.3, and T2 mostly sculptured (fore wing vein R1 dark brown; metasoma mostly dark brown to black, metacoxa entirely yellow, and T2 mostly smooth on *P. liagrantae*).

Description. Head: mostly black, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: black. Tegula: yellow. Metasoma (dorsally): mostly dark brown, with T3+ yellow-orange on posterior 0.2–0.5. Metacoxa: mostly orange yellow, with black to dark brown spot on anterior 0.3 dorsally. Malar distance: less than 0.2 × eye length. Fore wing areolet: present. T1 sculpture: mostly sculptured. T2 sculpture: mostly smooth. Body length: 3.40–3.50 mm. Fore wing length: 3.40 mm. Ovipositor length: 2.10–2.30 mm. Ocular–ocellar line: 0.14 mm. Interocellar distance: 0.09–0.10 mm. Posterior ocellus diameter: 0.08–0.09 mm. Metacoxa length: 0.80–0.90 mm. Metafemur length: 0.90–1.02 mm. Metatibia length: 1.15–1.28. T1 length/width at posterior margin: 0.47–0.57/ 0.29 mm. T2 length/width at posterior margin: 0.11 mm/ 0.42–0.43 mm.

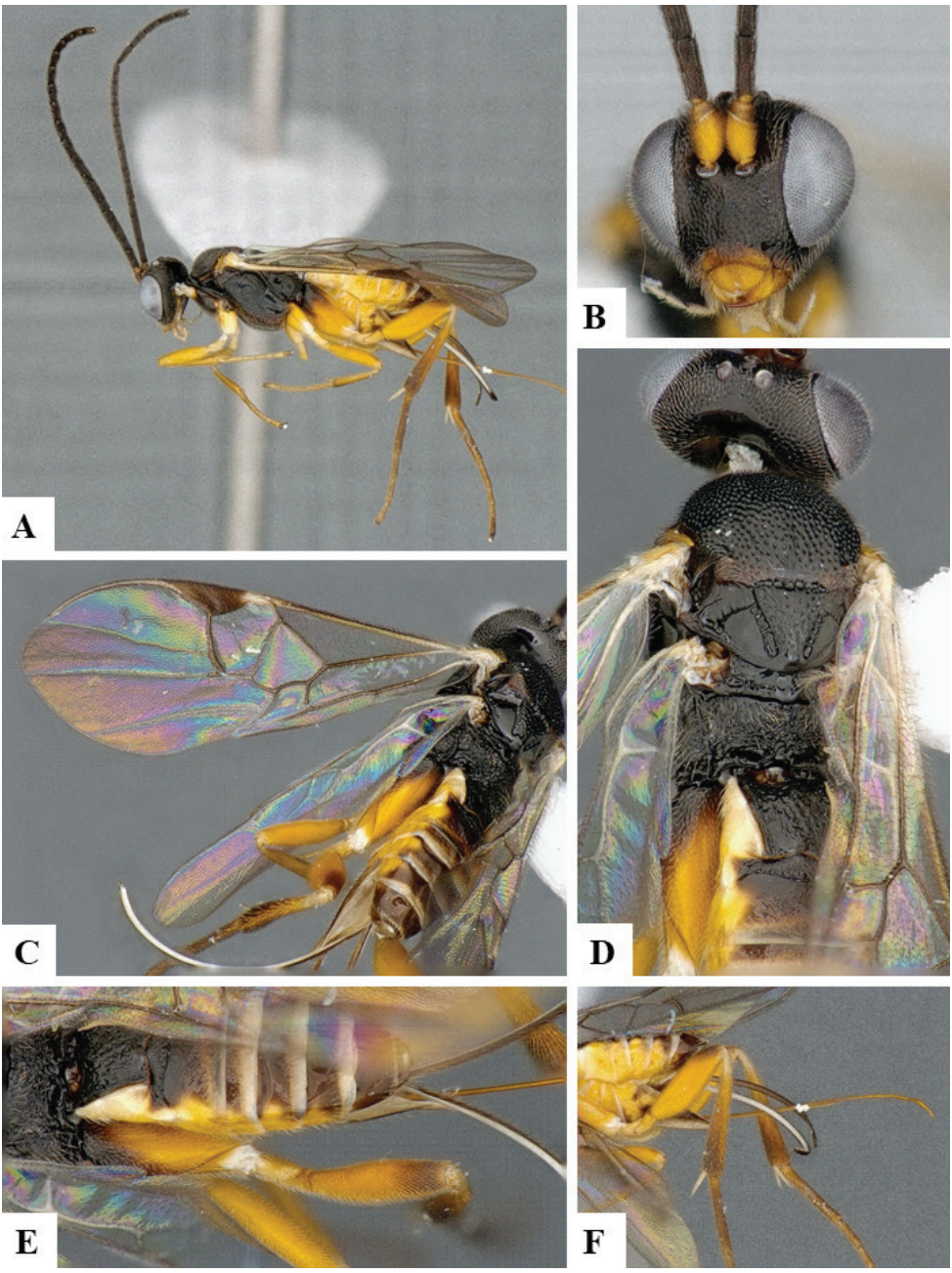

Figure 4. *Promicrogaster jaymeae*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** propodeum and metasoma, dorsal **F** ovipositor.

Distribution. CANADA, Ontario; UNITED STATES, Florida, Massachusetts. Collected between 55 and 117 m.a.s.l.

Biology. Unknown.

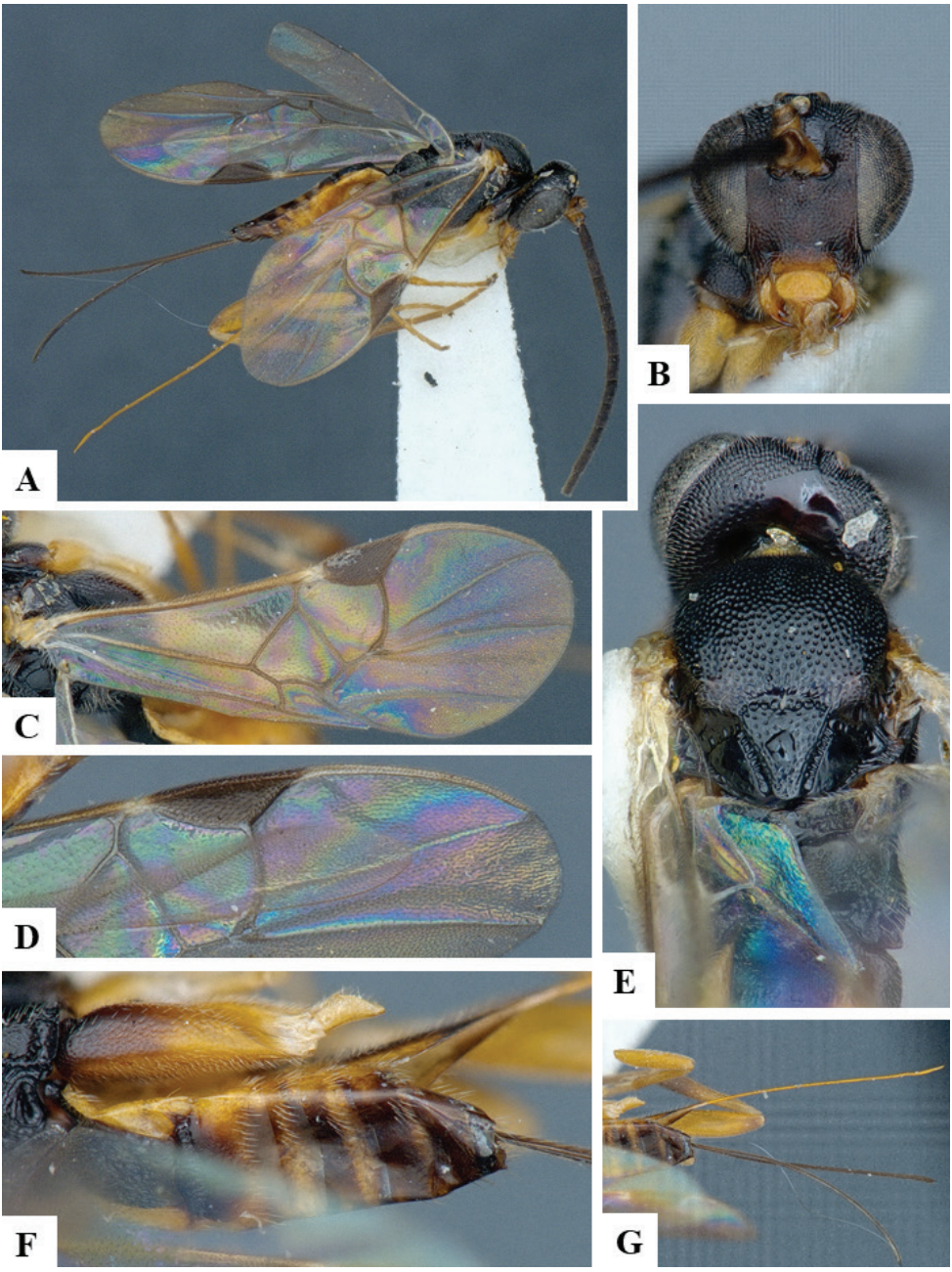

Figure 5. *Promicrogaster jaymeae*, female paratype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** details of pterostigma and fore wing areolet **E** head and mesosoma, dorsal **F** metasoma, dorsal **G** ovipositor.

Molecular data. The holotype rendered an almost complete DNA barcode (622 base pairs), the sequence page in BOLD is CNSLK014-12. It belongs to BIN BOLD:ADA9820, which contains another sequence, from *P. liagrantae* (Costa Rica).

The two sequences are rather similar (1.73% base pairs difference) but represent different species.

Etymology. Named after Jayme Sones, Collections Manager of the Centre for Biodiversity Genomics (CBG), University of Guelph, Canada, in appreciation of the extraordinary work she has done for the CBG during the past 15 years, and as a big thanks for her support and help with many braconid loans and other topics over the years.

***Promicrogaster madreanensis* Fernandez-Triana, sp. nov.**
http://zoobank.org/C3EE1313-A3D8-4865-96EA-3C5B9A620D38
Fig. 6 A–F

Material examined. Holotype. UNITED STATES • ♀, CNC; Arizona, Patagonia Mountains; 1676 m.a.sl.; 10 Jul 1962; H.E. Milliron leg; CNCHYM 01986.

Diagnosis. This species is morphologically similar to *P. tracyvindasae* (Costa Rica), but can be distinguished from it (and from all other described species of *Promicrogaster* from North and Meso America) because of its clypeus with a strong notch centrally on posterior margin.

Description. Head: mostly dark reddish-brown, labrum and mandibles yellow, clypeus orange-yellow. Flagellomeres: dark brown. Mesosoma: mostly black but ventrolaterally reddish-brown. Tegula: yellow. Metasoma (dorsally): mostly dark brown to black. Metacoxa: yellow. Malar distance: 0.3 × eye length. Fore wing areolet: present. T1 sculpture: mostly smooth. T2 sculpture: mostly smooth but with sculpture near margins. Body length: 4.90 mm. Fore wing length: 4.90 mm. Ovipositor length: approximately 2.90 mm. Ocular–ocellar line: 0.20 mm. Interocellar distance: 0.12 mm. Posterior ocellus diameter: 0.10 mm. Metacoxa length: 1.10 mm. Metafemur length: 1.20 mm. Metatibia length: 1.50. T1 length/width at posterior margin: 0.65/ 0.40 mm. T2 length/width at posterior margin: 0.21 mm/ 0.80 mm.

Distribution. UNITED STATES, Arizona, Patagonia Mountains, 1,676 m.a.s.l.

Biology. Unknown.

Molecular data. The holotype rendered a partial DNA barcode (164 base pairs), the sequence page in BOLD is HYCNE1802-11.

Etymology. Named after the Madrean sky island ranges in Arizona. The Madrean sky islands are pine-oak woodlands found at higher elevations in Mexico, Arizona and New Mexico (USA); they are surrounded at lower elevations by the Sonoran and Chihuahuan deserts, and are important because of their endemism and relict populations.

***Promicrogaster rondeau* Fernandez-Triana, sp. nov.**
http://zoobank.org/8064D59E-A217-48F9-BFB6-752078A4540F
Fig. 7 A–F

Material examined. Holotype. CANADA • ♀, CNC; Ontario; Rondeau Provincial Park; 12 Aug 1982; Sand dunes; M. Sharkey leg; CNC666701.

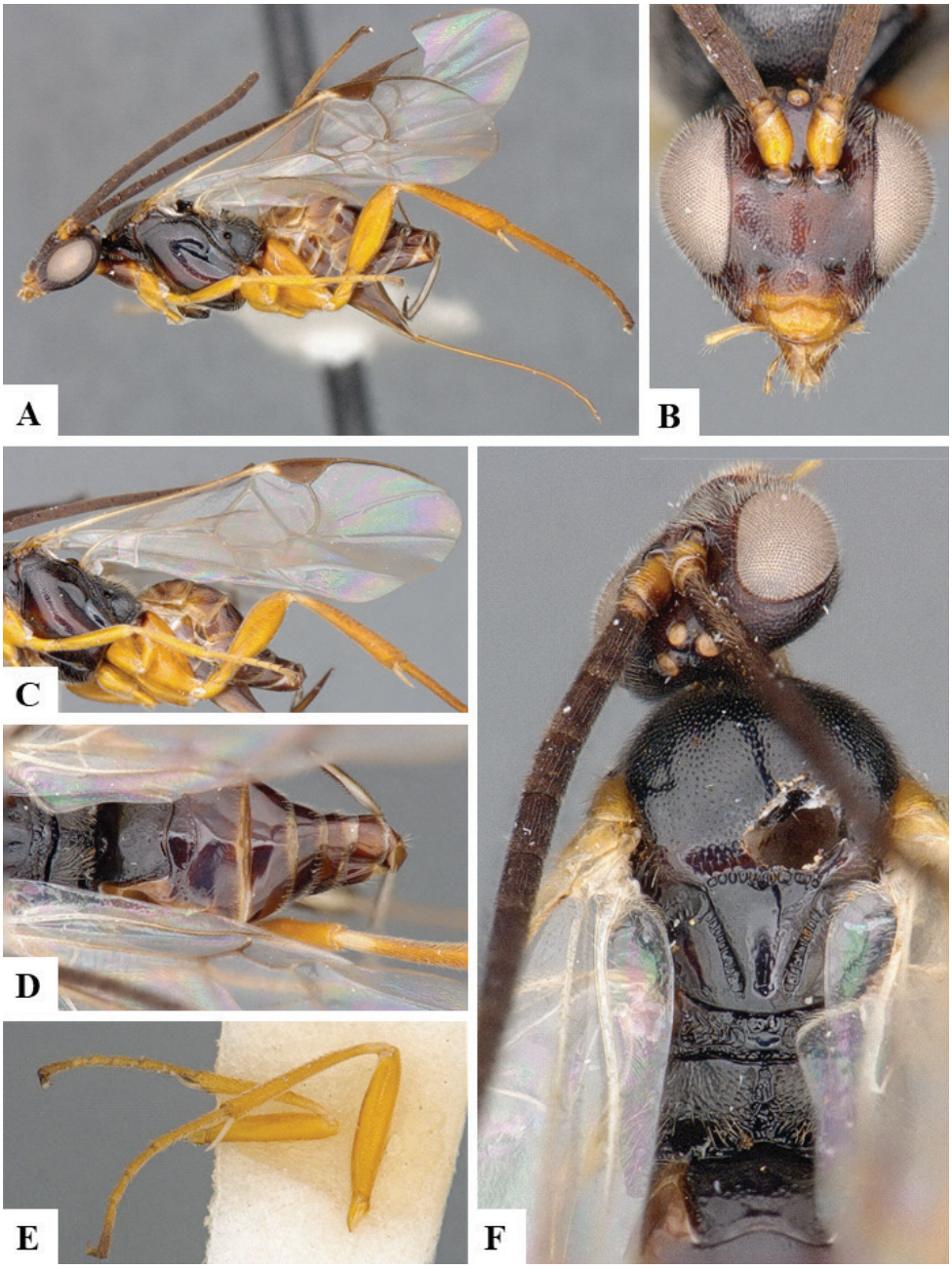

Figure 6. *Promicrogaster madreanensis*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** middle legs **F** head and mesosoma, dorsal.

Diagnosis. This species is morphologically similar to four species described from Costa Rica (ACG). Apart from the disparate geographical distribution, there are several differences between them, which are best shown in Table 2 below.

Table 2. Differences between *Promicrogaster rondeau* (from Canada) and four morphologically related species from Costa Rica. OOL- Ocular-ocellar line; POL- Posterior ocellar line; POD- Posterior ocellus diameter; L- Length. All measurements in mm.

Species	OOL	POL	POD	Meta-coxa L	Meta-femur L	Meta-tibia L	Body L	Fore wing L	Ovipositor L
P. rondeau	**0.14**	**0.07**	0.05	**0.44**	**0.51**	**0.65**	2.20	2.30	**1.30**
P. fabiancastroi	0.08–0.10	0.08	0.05	0.45–0.47	0.52–0.56	0.65–0.69	1.98–2.14	2.23–2.25	1.40–1.57
P. eddycastroi	0.11	0.08	0.06	0.56	0.68	0.89	2.29	2.65	1.77
P. luismendezi	0.08	0.09	0.05	0.50	0.58	0.76	2.33	2.37	1.67
P. naomiduarteae	0.11–0.14	0.07–0.9	0.06	0.47–0.53	0.52–0.61	0.66–0.79	2.33–2.39	2.31–2.47	1.41–1.92

Description. Head: mostly dark reddish-brown, labrum and mandibles yellow. Flagellomeres: dark brown. Mesosoma: mostly dark reddish-brown laterally, dorsally mostly black (but with faint reddish-brown spots on posterolateral margins of anteromesoscutum). Tegula: yellow. Metasoma (dorsally): mostly dark brown to black. Metacoxa: brown. Malar distance: less than 0.2 × eye length. Fore wing areolet: absent. T1 sculpture: mostly sculptured. T2 sculpture: mostly sculptured, except for small, smooth central area. Body length: 2.20 mm. Fore wing length: 2.30 mm. Ovipositor length: 1.30 mm. Ocular–ocellar line: 0.14 mm. Interocellar distance: 0.07 mm. Posterior ocellus diameter: 0.05 mm. Metacoxa length: 0.44 mm. Metafemur length: 0.51 mm. Metatibia length: 0.65 mm. T1 length/width at posterior margin: 0.31 mm/ 0.17 mm. T2 length/width at posterior margin: 0.08 mm/ 0.32 mm.

Distribution. CANADA, Ontario, Rondeau Provincial Park.

Biology. Unknown.

Molecular data. Not available.

Etymology. Named after the type locality, in recognition of the natural values and uniqueness of the Rondeau Provincial Park.

***Promicrogaster virginianus* Fernandez-Triana, sp. nov.**
http://zoobank.org/BF705DDC-8701-4A84-AB9F-38B737C9C39A
Fig. 8 A–E

Material examined. Holotype. UNITED STATES • ♀, USNM; Virginia; 28 Aug 1884; CNC666702.

Diagnosis. Among the darker coloured species (with uniformly dark antenna and entirely dark brown propleuron), with small areolet in the fore wing and tegula and wing base yellow, this species can be distinguished by its relatively small size (body and fore wing length 2.5–2.6 mm) and smaller ocelli (ocular–ocellar line 2.6 × as long as posterior ocellus diameter). All other species with dark colouration are either substantially larger (body and fore wing length at least 3.3 mm, usually more), and/or have larger ocelli, lack an areolet or have some other differences (as stated in the key above).

Description. Head: mostly reddish-brown, labrum and mandibles yellow. Flagellomeres: brown. Mesosoma: reddish-brown. Tegula: yellow. Metasoma (dorsally): mostly reddish-brown. Metacoxa: mostly brown. Malar distance: less than 0.2 × eye length. Fore

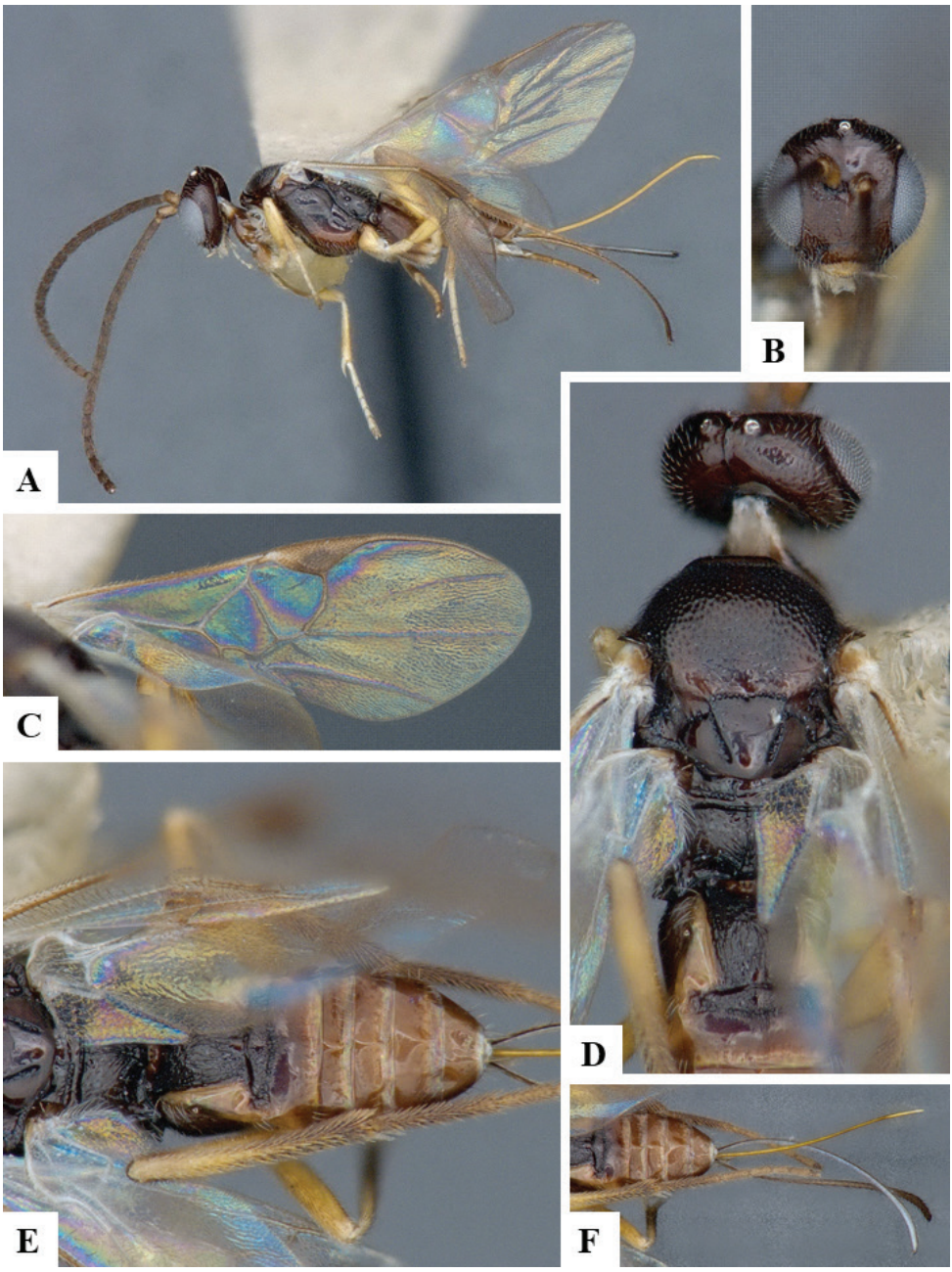

Figure 7. *Promicrogaster rondeau*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** head and mesosoma, dorsal **E** propodeum and metasoma, dorsal **F** ovipositor.

wing areolet: present. T1 sculpture: : anterior 0.4 smooth, posterior 0.6 sculptured. T2 sculpture: mostly sculptured. Body length: 2.60 mm. Fore wing length: approximately 2.80 mm. Ovipositor length: 2.30 mm. Ocular–ocellar line: 0.17 mm. Interocellar

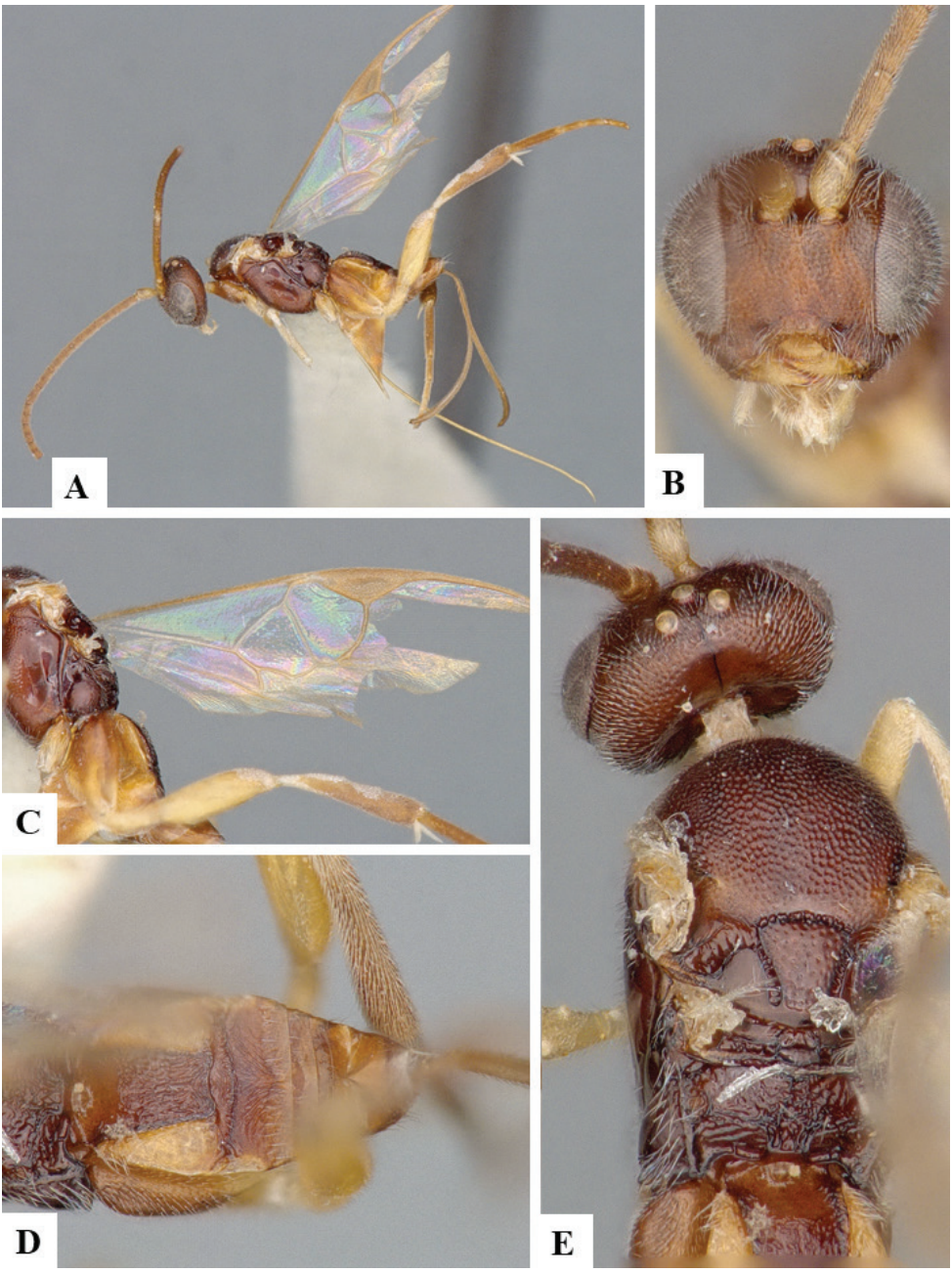

Figure 8. *Promicrogaster virginianus*, female holotype. **A** Habitus, lateral **B** head, frontal **C** fore wing **D** propodeum and metasoma, dorsal **E** head and mesosoma, dorsal.

distance: 0.08 mm. Posterior ocellus diameter: 0.07 mm. Metacoxa length: 0.65 mm. Metafemur length: 0.75 mm. Metatibia length: 0.90 mm. T1 length/width at posterior margin: 0.43 mm/ 0.18 mm. T2 length/width at posterior margin: 0.08 mm/ 0.38 mm.

Distribution. UNITED STATES, Virginia.
Biology. Unknown.
Molecular data. Not available.
Etymology. Named after the state where it was collected.
Notes. This is the oldest known specimen of *Promicrogaster*, having been collected 135 years ago.

Acknowledgements

I am very grateful for the editorial work of Gavin Broad (Natural History Museum, London, UK) and the review of Mark Shaw (National Museums of Scotland, Edinburgh) which significantly improved the final version of the manuscript. This work was supported by project 3199 "Systematics of beneficial arthropods in support of resilient agroecosystems", Agriculture and Agri-Food Canada.

References

Fernández-Triana J, Whitfield J, Rodriguez J, Smith M, Janzen D, Hajibabaei M, Burns J, Solis A, Brown J, Cardinal S, Goulet H, Hebert P (2014a) Review of *Apanteles sensu stricto* (Hymenoptera, Braconidae, Microgastrinae) from Area de Conservación Guanacaste, northwestern Costa Rica, with keys to all described species from Mesoamerica. ZooKeys 383: 1–565. https://doi.org/10.3897/zookeys.383.6418

Fernández-Triana JL, Whitfield JB, Smith MA, Hallwachs W, Janzen DH (2014b) Revision of the neotropical genus *Sendaphne* Nixon (Hymenoptera, Braconidae, Microgastrinae). Journal of Hymenoptera Research 41: 1–29. https://doi.org/10.3897/JHR.41.8586

Fernández-Triana J, Boudreault C, Dapkey T, Smith MA, Rodriguez J, Hallwachs W, Janzen DH (2016) Revision of the genus *Promicrogaster* (Hymenoptera, Braconidae, Microgastrinae) from Area de Conservación Guanacaste, Costa Rica, with a key to all species previously described from Mesoamerica. Journal of Hymenoptera Research 50: 25–79. https://doi.org/10.3897/JHR.50.8220

Hebert PDN, Cywinska A, Ball SL, deWaard JR (2003) Biological identifications through DNA barcodes. Proceedings of the Royal Society B 270: 313–321.https://doi.org/10.1098/rspb.2002.2218

Huber JT, Sharkey MJ (1993) Structure. In: Goulet H, Huber JT (Eds) Hymenoptera of the world: an identification guide to families. Agriculture Canada Research Branch, Monograph No. 1894E, Ottawa, Canada, 13–59.

Karlsson D, Ronquist F (2012) Skeletal morphology of *Opius dissitus* and *Biosteres carbonarius* (Hymenoptera: Braconidae), with a discussion of terminology. PLoS ONE 7(4): e32573. https://doi.org/10.1371/journal.pone.0032573

Mason WRM (1981) The polyphyletic nature of *Apanteles* Foerster (Hymenoptera: Braconidae): A phylogeny and reclassification of Microgastrinae. Memoirs of the Entomological Society of Canada, Ottawa, 147 pp. https://doi.org/10.4039/entm113115fv

Quicke DLJ (2015) The Braconid and Ichneumonid Parasitoid Wasps: Biology, Systematics, Evolution and Ecology. Willey-Blackwell, 704 pp. https://doi.org/10.1002/9781118907085

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System [www.barcodinglife.org]. Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Whitfield JB (1997) Subfamily Microgastrinae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication No. 1, International Society of Hymenopterists, Washington, DC, 333–364.