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The coccid-tending ant genus *Acropyga* Roger and its obligate associated myrmecophilous scale insect genus *Eumyrmococcus* Silvestri new to Italy (Hymenoptera: Formicidae; Hemiptera: Xenococcidae)

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Abstract
The ant genus *Acropyga* Roger, 1862 (Hymenoptera: Formicidae) and its associated myrmecophilous scale insect genus *Eumyrmococcus* Silvestri, 1926 (Hemiptera: Xenococcidae) are reported from Italy for the first time. These records are based on some alates of *Acropyga paleartica* Menozzi, 1936 with females of *Eumyrmococcus corinthiacus* Williams, 1993 carried in their mandibles, collected in Salento area (Apulia region, South Eastern Italy) in 2020.

Key words: ant, Coccomorpha, first record, root mealybug, Italy, trophophoresy.

Introduction

The ant fauna of southern Italy is notoriously poorly studied, despite this territory being a hotspot of myrmecological novelty, particularly in the southernmost parts. The discovery of the Balcanic ants *Aphaenogaster finzii* Müller, 1921 in Crotone province (Calabria region) (Schifani & Alicata 2019) and *Aphaenogaster ovaticeps* (Emery, 1898) in southern Salento (Apulia region) (Scupola 2017, as *A. muelleriana* Wolf, 1915), are the most recent discoveries. The new records stimulated the Natural History Museum of Salento to begin a series of myrmecological investigations in southern Apulia, aimed at reducing these data gaps.

During field work, some interesting small formicine ants were recorded at Calimera (Lecce province) in the Salento area (Apulia region). They were identified as *Acropyga paleartica* Menozzi, 1936 (Formicinae: Plagiolepidini), a rare ant species so far known only from Crete and mainland Greece. In addition, a few specimens of *Eumyrmococcus* Silvestri 1936 (Hemiptera, Coccomorpha: Xenococcidae), each carried in the mandibles of an *Acropyga* gyne, were found; this record supports and confirms the ant identification, as it is known that *Eumyrmococcus* species are obligate symbionts of *Acropyga* ants (Williams 1998; Johnson et al. 2001).

In this paper the first record in Italy of both the ant *Acropyga paleartica* and its associated root mealybug *Eumyrmococcus corinthiacus* Williams, 1983 are reported and discussed.

Material and methods

The specimens studied are deposited in the following collections:

ASPC Antonio Scupola personal collection, Verona, Italy
MSNS Museo di Storia Naturale del Salento, Calimera, Italy
DAFNAE University of Padua, Deparment DAFNAE, Legnaro, Italy

All the specimens are labelled: Calimera (Lecce province, Salento, Apulia region), 4 oct 2020, 40.240500 N, 18.292111 E, leg. A. Durante. They are preserved as follows:

Acropyga paleartica – dry mounted: 1 ♀ (gyne) (ASPC #488) and 2 ♂ (ASPC #486, #487); in 70% alcohol: 1 ♀ (gyne), 1 ♂ (ASPC); 4 ♂, 4 ♀ (gynes) (MSNS).

Eumyrmococcus corinthiacus – in 70% alcohol: 3 ♀ (1 in the mandibles of a gyne) (MSNS); 1 ♀ mounted on a microscope slide #1936 (DAFNAE).

The *E. corinthiacus* female was mounted on a slide using the procedure reported in Williams & Watson (1988). Its identification was based on the original description of the species (Williams 1993) and the identification key by Williams (1998).

The study and measurements of the ant specimens were carried out at magnifications 60X using Leica-Wild M3B stereomicroscope. All measurements are given in millimetres. The morphological abbreviations used are as follows:

CL cephalic length; maximum head length in full-face view, measured in a straight line from mid-point of anterior clypeal margin to mid-point of posterior margin
CW cephalic width; the maximum head width in full-face view, measured directly above the eyes
CI cephalic index: CW/CLx100
SL scape length; maximum straight-line length of scape excluding the basal condylar bulb;
SI scape index: SL/CWx100
EL eye length; maximum diameter of the compound eye
EW eye width; minimum diameter of the compound eye
ML mesosomal length; length of mesosoma measured from anteriormost point of pronotum to posteriormost point of metapleuron in lateral view
GL gaster length; the approximate length of the gaster measured from anterior margin of first abdominal segment to apex of genital capsule in lateral view
TL the approximate total body length (CL+ML+GL) (the petiole length is not considered because surmounted by first abdominal segment).

One *E. corinthiacus* female was mounted on slide using the method reported in Williams & Watson (1988). Its identification was based on the original description of the species (Williams 1993) and the identification key provided by Williams (1998).

Discussion

Acropyga paleartica Menozzi, 1936

The subterranean ant genus *Acropyga* Roger, 1862 (Formicinae: Plagiolepidini Forel, 1886) occurs in warm temperate and tropical areas, and contains about 40 species (LaPolla 2004). An ecological and ethological characteristic of *Acropyga* is the obligate mutualistic relationship with root-feeding scale insects, mostly in the family Xenococcidae, genus *Eumyrmococcus* but also including a few Rhizoecidae species such as *Ishigakicoccus shimadai* Tanaka, 2016 and *Williamsrhizoecus udzungwensis* (Johnson et al. 2001; LaPolla et al. 2002; Schneider & LaPolla 2011, 2020) and Ortheziidae, namely *Acropygorthezia williamsi* LaPolla & Miller, 2008 (LaPolla et al. 2008).

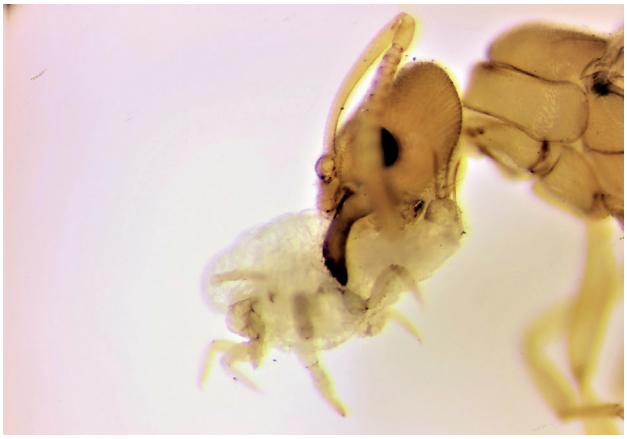

Fig. 1 – An *Acropyga paleartica* gyne carring one *Eumyrmococcus corynthiacus* female.

Fig. 2 – *Acropyga paleartica*, known distribution.

According to Schneider & LaPolla (2011), all Xenococcidae are obligate trophobionts with *Acropyga* ants. The ants feed mainly on honeydew excreted by the xenococcids, and the xenococcids live in ant nests, attended by the ants and protected from their natural enemies. It is known that, during the nuptial flight, each virgin *Acropyga* gyne carries a female of the associated scale insect in her mandibles (Fig. 1), so ensuring a source of food for the offspring in the new nest.

This behaviour, known as trophophoresy (LaPolla et al. 2002), is attested by fossils in Dominican amber from the Miocene (dated to at least 20 Ma) of the fossil

Tab. 1 – Comparison of measurement ranges for alates of *Acropyga palearctica* from Salento, with those from Greece recorded by LaPolla (2004, 2006). The data from both localities are similar, particularly in the males.

	Gyne from Salento, (n.1)	Gyne (LaPolla 2004)	Males from Salento, (n.2)	Males (LaPolla 2006)
CL	0.62	0.591	0.48 – 0.51	0.47 – 0.548
CW	0.60	0.577	0-44 – 0.46	0.423 – 0.501
SL	0.57	0.515	0-46 – 0.49	0.439 – 0.470
ML	0.94	0.952	0.70 – 0.76	0-782 – 0.923
EL	0.19	--	0.17 – 0.19	--
EW	0.12	--	0.12 – 0.16	--
GL	1.45	1.23	1.12 – 1.15	0.892 – 0.939
TL	3.03	2.77	2.30 – 2.42	2.14
CI	96	97.63	90 – 91	90 – 91
SI	91	89.25	104 – 106	94 – 104

ant *†Acropyga glaesaria* LaPolla, 2005, associated with three Xenococcid species related to the genus *Eumyrmococcus*, described in the extinct genus *†Electromyrmoccus* Williams, 2001 (Johnson et al., 2001; LaPolla 2005; Williams, 2001). This obligate ant/scale insect symbiosis is a classic case of co-evolution between two organisms that determined their survival and success (LaPolla et al. 2002; LaPolla 2004).

Acropyga paleartica is known thus far only from SE Europe (continental and insular Greece) (Fig. 2). Hitherto, it had been recorded only from Karpathos island (type locality) (Menozzi 1936), Crete and the nearest Gavdos island (Seifert & Heller 1999; Salata et al. 2020), Perachora (in the Corinth channel; Bushinger et al. 1987 as *Plagiolepis* sp; Williams 1993), and Meteora (Thessaly) (LaPolla 2006).

The presence of *A. paleartica* and its associated symbiont *Eumyrmococcus corinthiacus* in Salento (South Italy) is of biogeographic significance because it is the first record from outside Greece, and the first for Italy of both species. Salata et al. (2020) considered *A. paleartica* as an Aegean corotype but, according to recent records from mainland Greece and the present one from the Apulia region in Italy, its pertinence to Eastern Mediterranean corotype (Vigna Taglianti et al. 1999) appears more consistent with the available data records.

The status of *Acropyga paleartica* as a species native to the Mediterranean region was recently questioned (Salata et al. 2020). The genus is pan-tropical so we cannot exclude that *A. paleartica* comes from the tropics (Africa?); the same argument applies to the associated *E. corinthiacus* mealybugs. However, additional tropical or subtropical records of either species corroborating this hypothesis are so far unknown. The genus *Acropyga* is known to have existed since the Miocene, when (mostly in the early periods) climatic conditions were hot and humid and the vegetation was typically tropical, even in Mediterranean areas. Later (during the Messinian period), dramatic climatic changes due to evaporation of the Mediterranean Sea led to a massive extinction of the tropical fauna and its replacement by species adapted to colder and dryer climates. It is then possible that *A. paleartica* survived these events as a biogeographic relict.

Acropyga, and the nearest genera *Lepisiota* and *Plagiolepis*, are the only Italian Formicinae with 11 antennal segments in the females (gynes and workers) and 12 in the males; in the other Italian Formicinae, the antennae have one extra segment: 12 in females, 13 in males. *Acropyga paleartica* (Figs 3-4) can be distinguished from species in the other two genera by having the palp formula 4:3

Fig. 3 – *Acropyga paleartica*, gyne: body, lateral view (Scale bar: 1 mm).

Fig. 4 – *Acropyga paleartica*, gyne: head, frontal view (Scale bar: 0,5 mm).

Fig. 5 – *Acropyga paleartica*, male: body, lateral view (Scale bar: 1 mm).

Fig. 6 – *Acropyga paleartica*, male: head, frontal view (Scale bar: 0.5 mm).

(vs 6:4 in the other two genera); pilosity profuse, with short suberect setae (very sparse and adpressed in the other two genera); and 6-8 uneven mandibular teeth (5-6 in the other two genera). In addition, *A. paleartica* workers are characterized by a quadrangular head with compound eyes strongly reduced, almost punctiform (diameter always less the maximum width of the scape); in contrast, workers of *Lepisiota* and *Plagiolepis* each have an oval head with compound eyes well developed (diameter > scape width).

The males of *A. paleartica* (Figs 5-6) were described by LaPolla (2006) based on specimens from central Greece; *Acropyga* males are distinguished from those of *Lepisiota* and *Plagiolepis* by possession of the palp formula 4:3 (vs 6:4), a massive mandible with 6-8 mandibular teeth (vs 5-6), and the subgenital plate with a denticulate posterior margin (Fig. 7). In addition, *Acropyga* males having TL >2.14 (Tab. 1) distinguishes them from *Plagiolepis* (1.5-2 mm), and the scape protrudes from the posterior head margin by only a third of its length, whereas in *Lepisota* the scape protrudes by more than half of its length.

Based on the morphological characters of workers and males, *A. paleartica* is close to the South African *A. arnoldi* Santschi, 1926 and is tentatively placed in the *A. arnoldi* species-group. *Acropyga arnoldi* is a symbiont of *Eumyrmococcus scorpioides* (De Lotto, 1977) (LaPolla 2006).

The biology and ecology of *A. paleartica* is scarcely known. Its nests were found in pine forests (LaPolla 2004) but also in moist soil at the bases of trees growing near riverbanks. Specimens were found in the soil (at a depth of 10 cm) near a tree growing alongside the stream Milo in Karpathos (Menozzi 1936), while recently Salata et al. (2020) found a nest in Crete in moist soil under a rock on a dry riverbank, surrounded by phrygana vegetation. In Salento the *A. paleartica* alates were collected at the boundary between olive groves and a *Quercus ilex* wood, during their nuptial flight, in the early afternoon (about 3.00 p.m.) on October 4th. It is interesting to note that alate *A. paleartica* carrying *E. corynthiacus* were collected near Corinth on almost the same date: October 7th (Williams 1993). This suggests that the swarming period occurs in early autumn. No nest has been found so far in Apulia.

Regarding the association of *A. paleartica* with other Hemipteran species, Menozzi (1936) reported that *A. paleartica* specimens were found with aphids of the root-feeding genus *Forda* van Heyden, 1837 (Hemiptera: Aphididae, Fordini). Even if this observation had no further feedback, it is well known that *Forda* species live in *Pistacia* leaf galls (the primary host), then migrate to the roots of Poaceae (the secondary host) where they are attended by ants and often live in ants' nests; so it is possible that this occasional observation by Menozzi is correct. However, the first record of *Eumyrmococcus corinthiacus* was with *Acropyga paleartica* (Williams 1983), and the data presented herein fully confirm this association.

Eumyrmococcus corinthiacus Williams, 1993

Eumyrmococcus corinthiacus belongs to the family Xenococcidae Tang, 1992, a family of subterranean, obligate myrmecophilous mealybugs, characterized by unique morphological and biological traits.

The family is composed of 3 genera: *Eumyrmococcus* (20 species), *Neochavesia* (8 species), and *Xenococcus* (5 species). Their systematic position has been controversial because of their peculiar morphological and biological characteristics. For a long time, xenococcids were considered to belong to

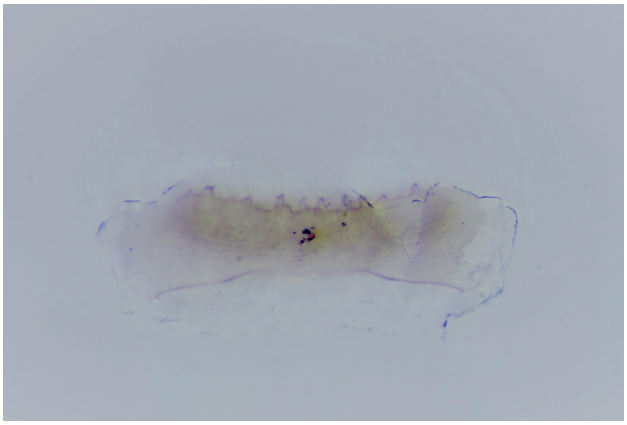

Fig. 7 – Subgenital plate of adult male *Acropyga paleartica.*

the Pseudococcidae, but they differ from pseudococcids in many morphological characters: e.g., the females do not have ducts, pores or ostioles; antennae have only 2 or 4 segments; eyes are absent; the anal ring lacks pores; the anal lobes have long setae; and the males are small, larva-like, apterous and without eyes, and the legs and antennae are strongly reduced (Hodgson 2012; Gavrilov Zimin 2018). Moreover, the female developmental cycle of some Xenococcinae (e.g., *Neochavasia* species and *E. smithi* Silvestri) is characterized by the presence of a quiescent pupal stage in the third instar (Williams 1987, 2004; Kishimoto-Yamada et al. 2015) whereas in other mealybug families this is a trophic stage.

Tang (1992) erected the tribe Xenococcini for these peculiar scale insects, in the subfamily Rhizoecinae (Pseudococcidae). Hodgson (2012), based on male morphology, concluded that Rhizoecinae mealybugs were separate from the Pseudococcidae and elevated them to family Rhizoecidae, containing two subfamilies: Rhizoecinae Williams and Xenococcinae Tang. Danzig & Gavrilov-Zimin (2014) subsequently elevated Xenococcinae to family rank (Xenococcidae). This position was explained in detail by Gavrilov-Zimin (2018), and the family was also recognised based on male morphology (Hodgson 2020; Garcia Morales et al. 2016).

Eumyrmococcus females have a large head and thorax, abdomen rather tapering and, in profile, curved upwards. *Eumyrmococcus* species feed on the phloem of plant roots and live underground in ant-nest tunnels of *Acropyga* spp. ants. As discussed above, the species *E. corinthiacus* is associated to the ant *Acropyga paleartica.*

Based on the description and key by Williams (1993, 1998), *Eumyrmococcus corinthiacus* is easily identified by having 4-segmented antennae and 3 thick setae on each anal lobe, with 2 setae longer and stouter than the other. The longer setae each have the apical part curved, like a hook.

So far, *E. corinthiacus* was known only from the type locality (Perachora, Corinth, Greece). The present record of *E. corinthiacus* in Apulia region is the first for Italy and the second in Europe. As it is known that *E. corinthiacus* and the ant *A. palearctica* are obligate symbionts, it is likely that *E. corinthiacus* is also present in Greek locations where only the ant *A. paleartica* has been recorded so far.

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