DOI: 10.17387/BULLENTSOCMALTA.2015.10

Aphidiinae (Hymenoptera, Braconidae) aphid parasitoids of Malta: review and key to species

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ABSTRACT. This paper brings an annotated list of the 16 aphid parasitoids detected up to 2015 in Malta. All the species were reared from identified aphid-plant associations. An illustrated key to the identification of the recorded species from Malta is provided. Taxonomy and peculiarities of the individual taxa are discussed and research outlines are also presented. Two species, *Aphidius absinthii* and *Trioxys pallidus* are newly recorded for the Maltese fauna, in association with *Uroleucon inulae* and *Hoplocallis picta*, respectively. The first host association has never been reported so far. The documented aphid fauna of the Maltese Islands indicates the probable existence of other species of aphid parasitoids that may be present in the archipelago, especially those already known in nearby Mediterranean territories.

KEY WORDS. Biological control, invasive species, intraspecific variation, tritrophic association, *Aphidius absinthii*, *Trioxys pallidus*.

INTRODUCTION

All members of the braconid subfamily Aphidiinae are solitary endoparasitoids of aphids (Starý, 1970). They are among the most important natural enemies of aphids, which can effectively regulate the aphid populations and prevent serious outbreaks (Hughes, 1989; Hagvar & Hofsvang, 1991). As a representative model of food webs in an ecosystem (Starý, 2006), the Aphidiinae have widely been considered in the tritrophic (parasitoid-aphid-plant) approach (Kavallieratos *et al*., 2004), which gives the useful ecological data as well as a good background for subsequent biological control programmes against aphid pests.

Given their position in the central Mediterranean, the Maltese Islands provide a good example of the range and variety of Mediterranean vegetation, supplemented by the agricultural complexity (Schembri, 1997). Among other things it can be viewed as a reservoir of very diverse, but poorly known groups of indigenous, endemic and invasive organisms (Mifsud & Pérez Hidalgo, 2011).

The first records on the aphid parasitoids of Malta have been presented by Farrugia (1995) and Mifsud (1997). Subsequent studies (Mifsud & Starý, 2009; 2011; 2012; Mifsud *et al*., 2013; Stanković *et al*., 2015) on aphid parasitoids were undertaken in order to evaluate which Aphidiinae were present in the Maltese Islands and to understand better the composition of the existing tritrophic associations.

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The present assemblage of the Maltese aphid parasitoids belongs to nine genera, including *Adialytus* Förster, *Aphidius* Nees, *Binodoxys* Mackauer, *Diaeretiella* Starý, *Ephedrus* Haliday, *Lipolexis* Förster, *Lysiphlebus* Förster, *Pauesia* Quilis and *Praon* Haliday. Of these, some constitute genera having very few species (e.g. *Adialytus*) whereas others such as *Aphidius* and *Praon*, are species rich genera. All recorded genera are widely distributed in the Holarctic region.

Despite the economic importance of aphids, these insects were poorly studied in Malta (Mifsud, 2008; Mifsud *et al.*, 2009) and it was only in recent years that some 100 different species were recorded for the mentioned territory (Mifsud *et al*., 2011). For the successful biological control of aphids, it is necessary to search for effective natural enemies, particularly those that can be used to control aphids on crops (van Steenis, 1995; Burgio *et al*., 1997). The aim of this work was to review the scattered and sporadic information available on Maltese aphid parasitoids, as well as to present the new species records and host associations. The general distribution and species diversity for the Aphidiinae species so far recorded from the Maltese archipelago are discussed.

MATERIAL AND METHODS

The aphid parasitoid data has been extracted from recently published data pertaining to biodiversity studies carried out in Malta. The reference material, deposited in the collections of the second and fourth authors were examined. Additional material which was collected during 2014 is also included and marked with an asterisk (*). The principal sampling approach followed the rearing of parasitoids from identified aphids and associated aphid-host plant data, locality names and sampling data. Parts of host plants bearing the aphid colonies were cut with scissors and placed in a small plastic container or tube covered with nylon netting. The samples were transferred from the field to the laboratory, where they were kept under room temperatures (approx. 20–25°C). The emerging parasitoids were captured soon after emergence using a suction collector, and preserved in 70% ethanol. Live aphids were preserved in 90% ethanol and 75% lactic acid in a ratio of 2:1 (Eastop & van Emden, 1972) for identification at a later stage.

The external morphology of the aphid parasitoids was studied using a Nikon™ SMZ645 Stereomicroscope. Line drawings were traced in Adobe Illustrator CS5, based on the photographs captured using a digital camera attached to a Nikon™ Eclips E200 microscope. They were subsequently assembled in Adobe Photoshope CS5. An original key for the identification of the known aphid parasitoids of Malta is provided. Aphid nomenclature follows Remaudière & Remaudière (1997). The morphological terminology used in this paper follows Sharkey & Wharton (1997). Distribution data follows Yu *et al*. (2012).

The identity of two species, *Aphidius absinthi* Marshall and *Adialytus ambiguus* (Haliday) was confirmed using the partial sequence of COI. DNA extraction, amplification and sequencing of the barcoding region of the mitochondrial cytochrome oxidase subunit I (COI) gene was carried out following Tomanović *et al*. (2014).

ANNOTATED SPECIES LIST

Adialytus ambiguus (Haliday, 1834)

Host records: *Rhopalosiphum padi* (L.) on *Phalaris canariensis* (Stanković *et al.*, 2013).
General distribution: Eastern Palaearctic, Nearctic, Oriental, Western Palaearctic.

Aphidius absinthii Marshall, 1896*

Material examined: Malta, Wied Qirda, 5.vi.2014, 10 ♂♂ and 29 ♀♀ emerged from *Uroleucon inulae* Ferrari on *Dittrichia viscosa*, leg. M. Zammit.

General distribution: Eastern Palaearctic, Nearctic, Oriental, Western Palaearctic.

Aphidius colemani Viereck, 1912

Host records: *Aphis nerii* Boyer de Fonscolombe on *Nerium oleander* and *Stephanotis floribunda* (Mifsud *et al*., 2013); *Aphis* sp. on *Setaria* sp. (Mifsud *et al*., 2013); *Rhopalosiphum padi* (L.) on *Triticum* sp. (Mifsud & Starý, 2011).
General distribution: Afrotropical, Australasian, Eastern Palaearctic, Nearctic, Neotropical, Oriental, Western Palaearctic.

Aphidius funebris Mackauer, 1961

Host records: *Uroleucon sonchi* (L.) on *Sonchus* sp. (Mifsud & Starý, 2011).
General distribution: Eastern Palaearctic, Oriental, Western Palaearctic.

Aphidius matricariae Haliday, 1834

Host records: *Myzus persicae* (Sulzer) on *Capparis* sp. and on *Brassica oleracea* var. *botrytis* (Farrugia, 1995; Mifsud & Starý, 2011).
General distribution: Afrotropical, Eastern Palaearctic, Nearctic, Neotropical, Oriental, Western Palaearctic.

Binodoxys angelicae (Haliday, 1833)

Host records: *Aphis nerii* Boyer de Fonscolombe on *Nerium oleander* (Mifsud *et al*., 2013); *Aphis rumicis* L. on *Rumex conglomerates* (Mifsud *et al*., 2013); [?] *Lipaphis pseudobrassicae* (Davis) on *Brassica oleracea* var. *botrytis* (Farrugia, 1995).
General distribution: Eastern Palaearctic, Oriental, Western Palaearctic

Diaeretiella rapae (M´Intosh, 1855)

Host records: *Brevicoryne brassicae* (L.) on *Brassica oleracea* var. *botrytis* (Farrugia, 1995); *Lipaphis erysimi* (Kaltenbach) on *Diplotaxis* sp.; *Melanaphis donacis* (Passerini) on *Arundo donax* (Mifsud & Starý, 2011); *Myzus persicae* (Sulzer) on *Brassica oleracea* var. *botrytis* (Farrugia, 1995); *Rhopalosiphum padi* (L.) on *Phalaris canariensis* (Stanković *et al.*, 2013).
General distribution: Afrotropical, Australasian, Eastern Palaearctic, Nearctic, Neotropical, Oceanic, Oriental, Western Palaearctic.

Ephedrus persicae Froggatt, 1904

Host records: *Melanaphis donacis* (Passerini) on *Arundo donax* (Mifsud & Starý, 2011).
General distribution: Afrotropical, Australasian, Eastern Palaearctic, Nearctic, Neotropical, Oriental, Western Palaearctic.

Lipolexis gracilis (Förster, 1862)

Host records: *Aphis* sp. on *Papaver* sp. (Mifsud & Starý, 2012).
General distribution: Eastern Palaearctic, Europe, Oriental, Western Palaearctic.

Lysiphlebus confusus Tremblay & Eady, 1978

Host records: *Dysaphis pyri* (Boyer de Fonscolombe) on *Pyrus communis* (Mifsud & Starý, 2011).
General distribution: Eastern Palaearctic, Europe, Oriental, Western Palaearctic.

Lysiphlebus fabarum (Marshall, 1896)

Host records: *Aphis craccivora* Koch on *Ceratonia siliqua* (Mifsud & Starý, 2009); *Aphis euphorbiae* Kaltenbach on *Euphorbia* sp. (Mifsud & Starý, 2012); *Aphis nerii* Boyer de Fonscolombe on *Nerium oleander*; *Aphis* sp. on *Foeniculum vulgare* (Mifsud *et al*., 2013); [?] *Myzus persicae* (Sulzer) on *Brassica oleracea* var. *botrytis* (Farrugia, 1995).
General distribution: Australasian, Eastern Palaearctic, Oriental, Western Palaearctic.

Lysiphlebus testaceipes (Cresson, 1880)

Host records: *Aphis nerii* Boyer de Fonscolombe on *Nerium oleander* (Mifsud *et al*., 2013).
General distribution: Afrotropical, Australasian, Eastern Palaearctic, Nearctic, Neotropical, Oriental, Western Palaearctic.

Pauesia silana Tremblay, 1969

Host records: *Cinara palestinensis* Hille Ris Lambers on *Pinus halepensis* (Mifsud & Starý, 2009).
General distribution: Western Palaearctic.

Praon volucre (Haliday, 1833)

Host records: *Brevicoryne brassicae* (L.) on *Brassica oleracea* var. *botrytis*; *Myzus persicae* (Sulzer) on *Brassica oleracea* var. *botrytis* (Farrugia, 1995).
General distribution: Eastern Palaearctic, Neotropical, Oriental, Western Palaearctic.

Praon yomenae Takada, 1968

Host records: *Uroleucon* (?) *aeneum* on *Carthamus lanatus* (Mifsud *et al*., 2013).
General distribution: Eastern Palaearctic, Oriental, Western Palaearctic.

Trioxys pallidus (Haliday, 1833)*

Material examined: Malta, St. Thomas Bay, 14–24.ii.2014, 4 ♂♂ and 9 ♀♀ emerged from *Hoplocallis picta* (Ferrari) on *Quercus ilex*, leg. D. Mifsud.

General distribution: Eastern Palaearctic, Nearctic, Oriental, Western Palaearctic.

DICHOTOMOUS KEY FOR THE IDENTIFICATION OF MALTESE APHIDIINAE (females)

1.Forewing venation with 8 cells. 3RSb vein reaching the margin of the wing (Fig. 1a) .... ***Ephedrus persicae***

- Forewing venation with less than 8 cells (Figs. 1b, 1c). 3RSb vein (Fig. 1c) or r&RS vein (Fig. 1b) not reaching the wing margin **2**

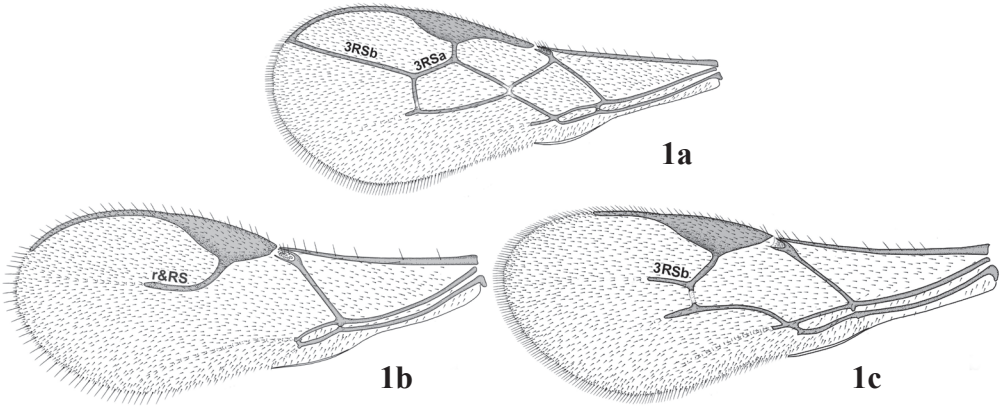

Figure 1: Forewings. **a**: *Ephedrus persicae*; **b**: *Adialytus ambiguus*; **c**: *Aphidius absinthii*.

2. RS+M vein present in forewing (Figs. 2a). Notaulices well developed and distinct (Fig. 3a) **3**

- RS+M vein absent (Fig. 2b). Notaulices incomplete or absent (Fig. 3b) **4**

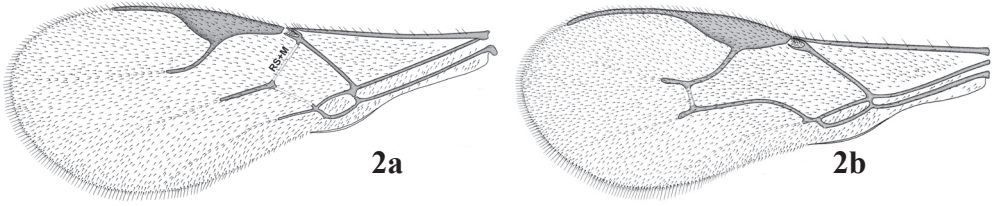

Figure 2: Forewings. **a**: *Praon yomenae*; **b**: *Aphidius matricariae*.

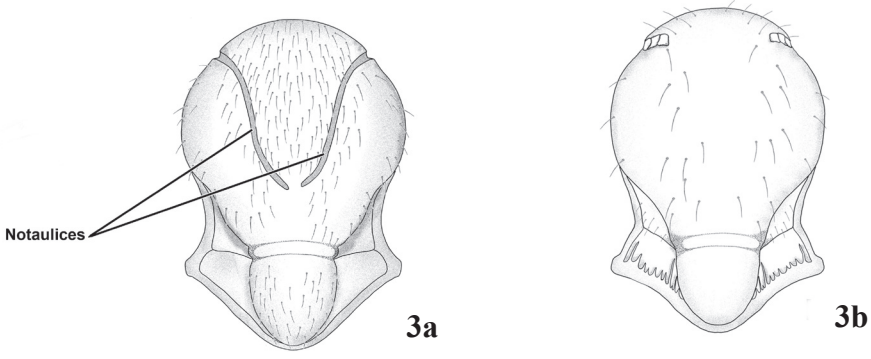

Figure 3: Mesonotum. **a**: *Praon yomenae*; **b**: *Aphidius matricariae*.

3. Forewing m-cu colourless throughout (Fig. 4a). Lateral lobes of mesonotum with large hairless areas (Fig. 5a). Flagellomere I entirely yellow ..... ***Praon yomenae***

- Forewing m-cu vein coloured throughout (Fig. 4b). Lateral lobes of mesonotum pubescent (Fig. 5b). Flagellomere I dark brown, only yellowish at base ..... ***Praon volucre***

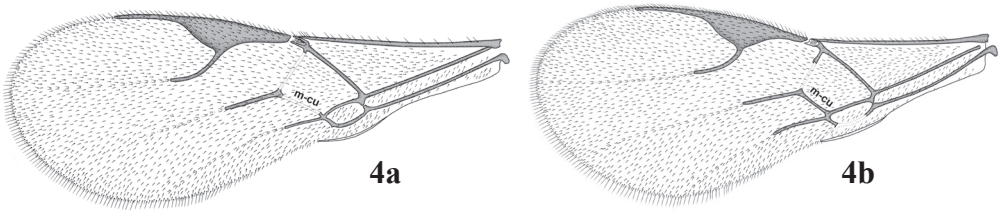

Figure 4: Forewings. **a**: *Praon yomenae*; **b**: *Praon volucre*.

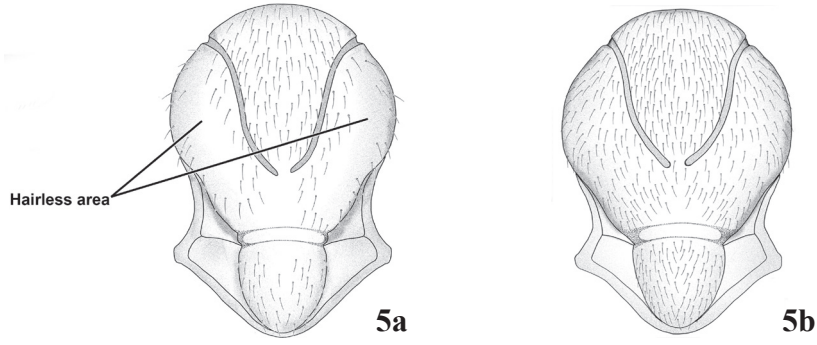

Figure 5: Mesonotum. **a**: *Praon yomenae*; **b**: *Praon volucre*.

4. Forewing M&m-cu vein present and complete (Figs. 6a, 6b) **5**

- Forewing M&m-cu vein incomplete (Fig. 7a) or absent (Fig. 7b) **9**

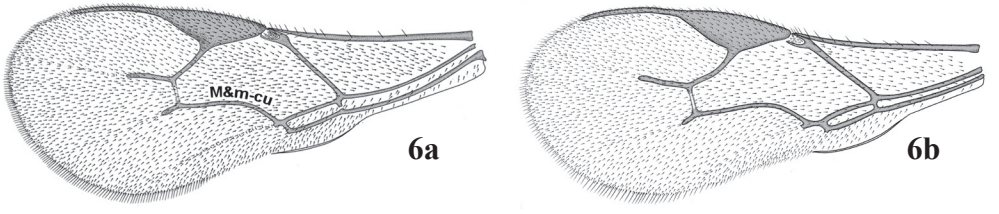

Figure 6: Forewings. **a**: *Aphidius funebris*; **b**: *Aphidius colemani*.

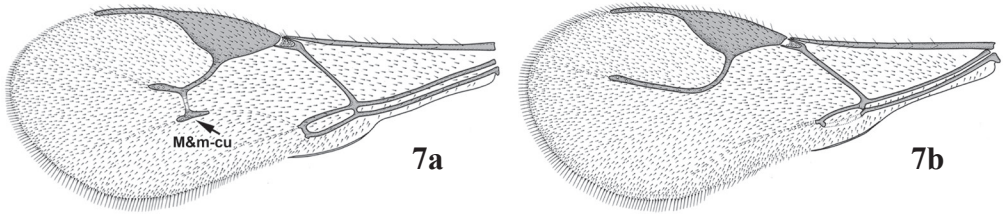

Figure 7: Forewings: **a**: *Lysiphlebus testaceipes*; **b**: *Binodoxys angelicae*.

5. Forewing stigma widely triangular (Fig. 8a). Propodeum smooth centrally, with only two strong transverse carinae extending laterally toward spiracles (Fig. 9a) ..... ***Pauesia silana***

- Forewing stigma elongate triangular (Fig. 8b). Propodeum with distinct central pentagonal areola (Fig. 9b) **7**

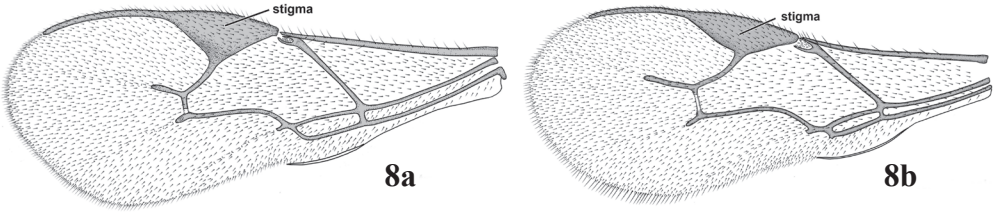

Figure 8: Forewings. **a**: *Pauesia silana*; **b**: *Aphidius colemani*.

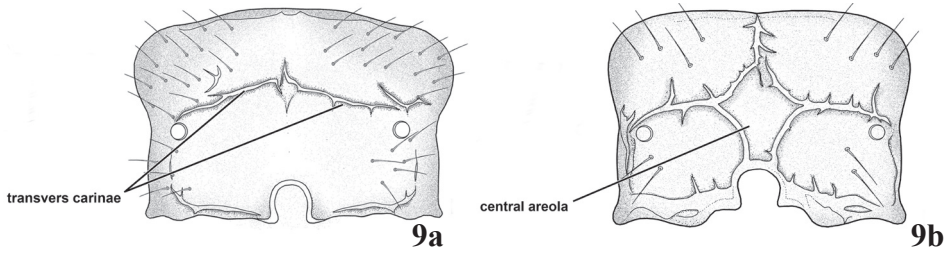

Figure 9: Propodeum. **a**: *Pauesia silana*; **b**: *Aphidius colemani*.

6. Anterolateral area of petiole costate (Fig. 10a) ..... ***Aphidius colemani***

- Anterolateral area of petiole finely costulated (Figs. 10b, 10c) **8**

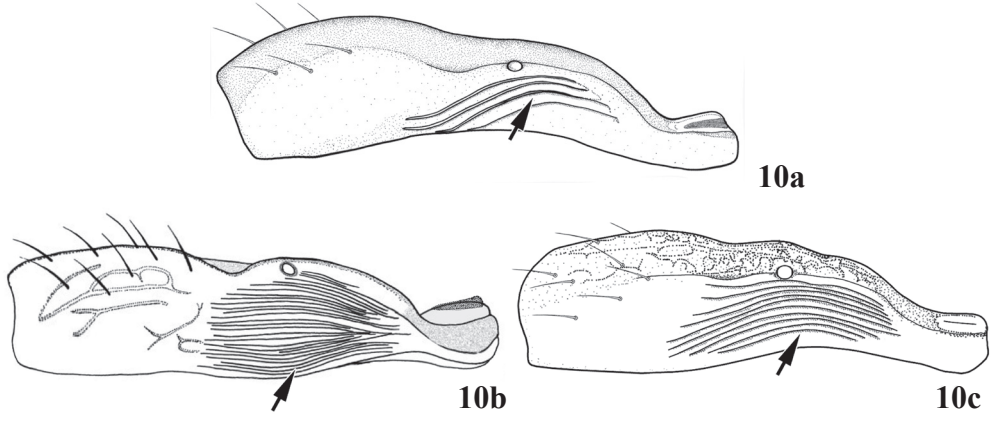

Figure 10: Anterolateral area of petiole. **a**: *Aphidius colemani*; **b**: *Aphidius funebris*; **c**: *Aphidius matricariae*.

7. Antennae 14–15-segmented ..... ***Aphidius matricariae***

- Antennae 16–19-segmented **9**

8. Ovipositor sheath elongate and strongly prominent (Fig. 11a). Labial palpi 3-segmented (Fig. 12a). Antennae 18–19-segmented ..... ***Aphidius funebris***

- Ovipositor sheath slightly elongated (Fig. 11b). Labial palpi 2-segmented (Fig. 12b). Antennae 16–(17)-segmented ..... ***Aphidius absinthii***

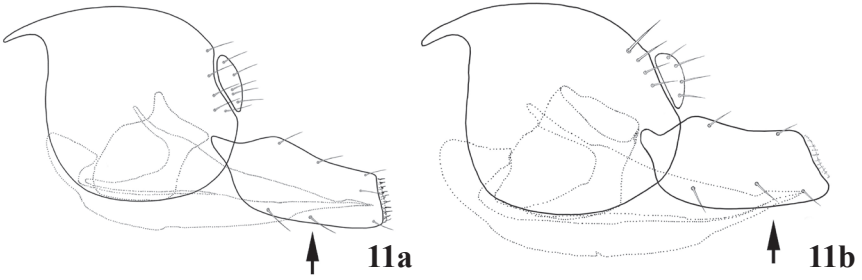

Figure 11: Female genitalia. **a**: *Aphidius funebris*; **b**: *Aphidius absinthii*.

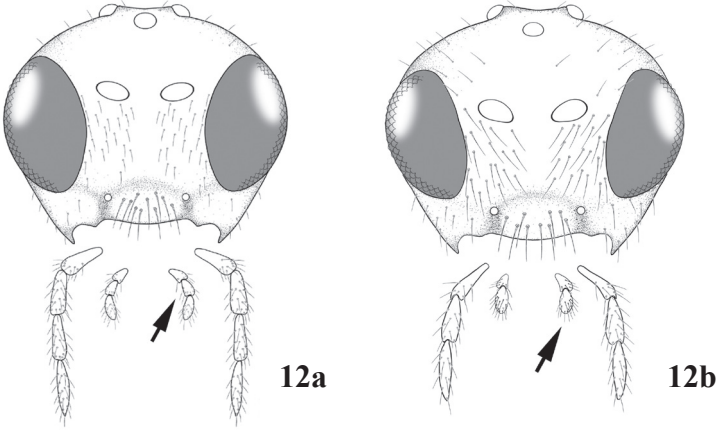

Figure 12: Head. **a**: *Aphidius funebris*; **b**: *Aphidius absinthii*.

9. Forewing M&m-cu vein incomplete, reduced in anterior part (Fig. 7a) **10**

- Forewing M&m-cu vein completely absent (Fig. 7b) **12**

10. Forewing stigma widely triangular, distinctly longer than R1 vein (Fig. 13a). Labial palpi 2-segmented (Fig. 14a) ..... ***Lysiphlebus testaceipes***

- Forewing stigma elongate triangular, distinctly shorter than R1 vein (Figs. 13b, 13c). Labial palps 1-segmented (Figs. 14b, 14c) **11**

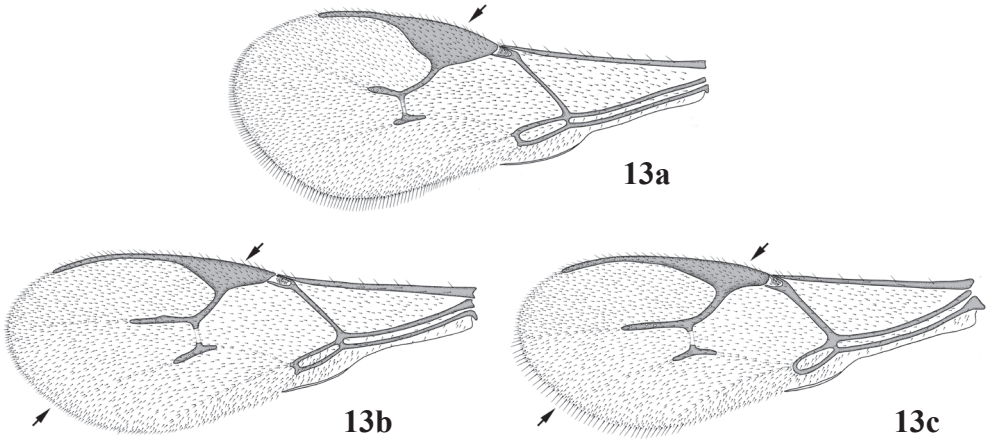

Figure 13: Forewings. **a**: *Lysiphlebus testaceipes*; **b**: *Lysiphlebus fabarum*; **c**: *Lysiphlebus confusus*.

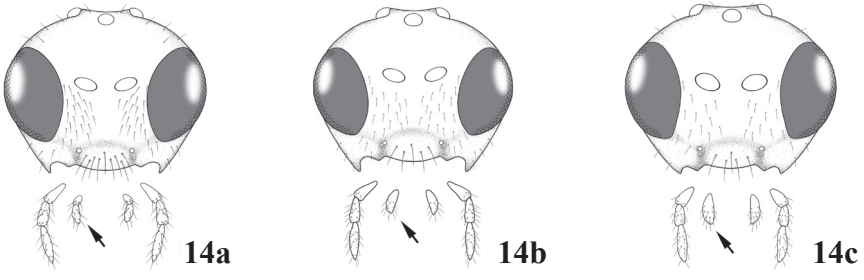

Figure 14: Head. **a**: *Lysiphlebus testaceipes*; **b**: *Lysiphlebus fabarum*; **c**: *Lysiphlebus confusus*.

11. Forewing marginal setae similar to those on surface or shorter (Fig. 13b) .... ***Lysiphlebus fabarum***

- Forewing marginal setae distinctly longer than to those on surface (Fig. 13c).. ***Lysiphlebus confusus***

12. Hypopygium with a pair of prongs (Figs. 15a, 15b) **13**

- Hypopygium without prongs (Figs.16a, 16b) **14**

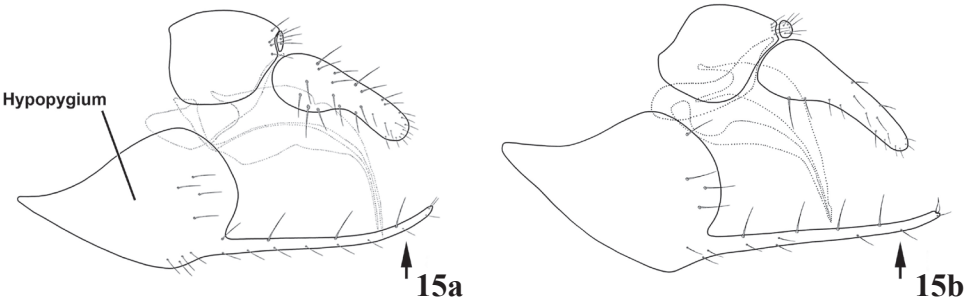

Figure 15: Female genitalia including hypopygium with prongs. **a**: *Binodoxys angelicae*; **b**: *Trioxys pallidus*.

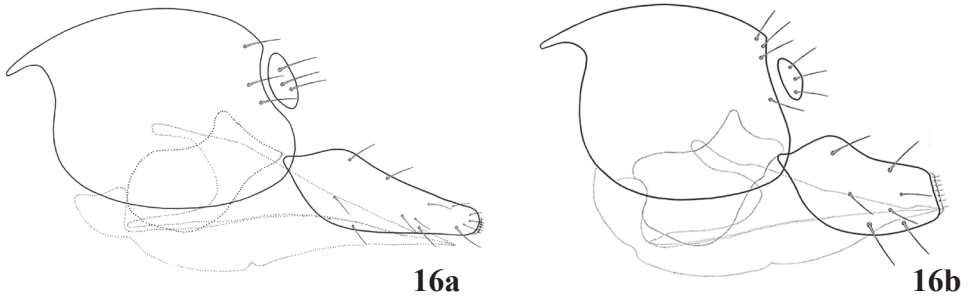

Figure 16: Female genitalia including hypopygium with prongs. **a**: *Adialytus ambiguus*; **b**: *Diaeretiella rapae*.

13. Petiole with only primary (=spiracular) tubercles (Fig. 17a). Apical portion of prong with a single ovoid shape bristle (Fig. 18a) ..... ***Trioxys pallidus***

- Petiole with primary and secondary tubercles (Figs. 17b). Apical portion of prong with a pair of normal bristles (Fig. 18b)..... ***Binodoxys angelicae***

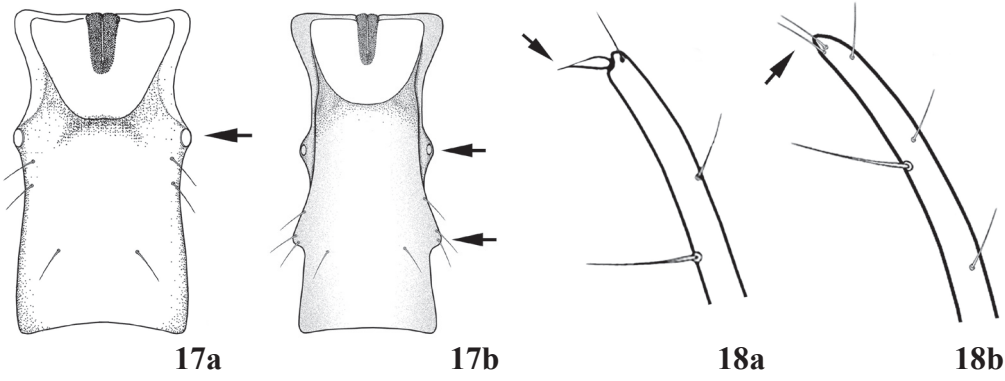

Figure 17: Dorsal aspect of petiole. **a**: *Trioxys pallidus*; **b**: *Binodoxys angelicae*.
Figure 18: Tip of prong. **a**: *Trioxys pallidus*; **b**: *Binodoxys angelicae*.

14. Propodeum smooth (Fig. 19a) ..... ***Adialytus ambiguus***

- Propodeum carinated (Figs. 19b, 19c) **15**

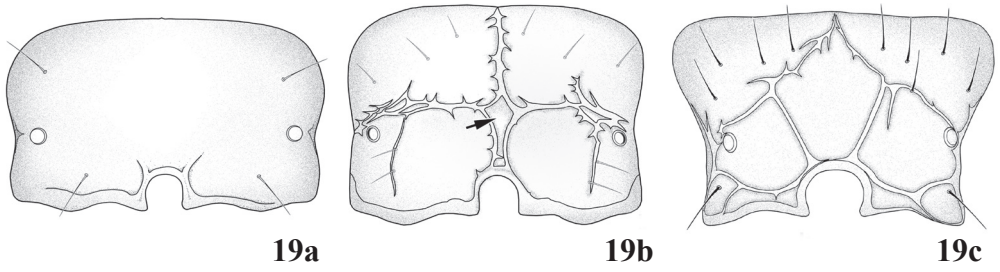

Figure 19: Propodeum. **a**: *Adialytus ambiguus*; **b**: *Diaeretiella rapae*; **c**: *Lipolexis gracilis*.

15. Forewing stigma elongate triangular (Fig. 20a). Propodeum with narrow pentagonal areola (Fig. 19b). Ovipositor sheath short, straight, apically truncated (Fig. 21a) ..... ***Diaeretiella rapae***

- Forewing stigma widely triangular (Fig. 20b). Propodeum with a wide areola (Fig. 19c). Ovipositor sheath elongated, downcurved (Fig. 21b) ..... ***Lipolexis gracilis***

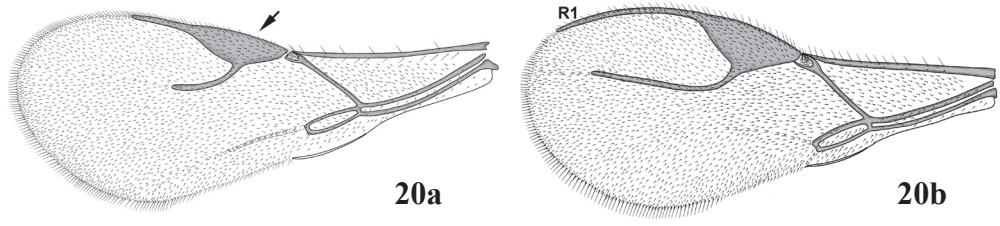

Figure 20: Forewings. **a**: *Diaeretiella rapae*; **b**: *Lipolexis gracilis*.

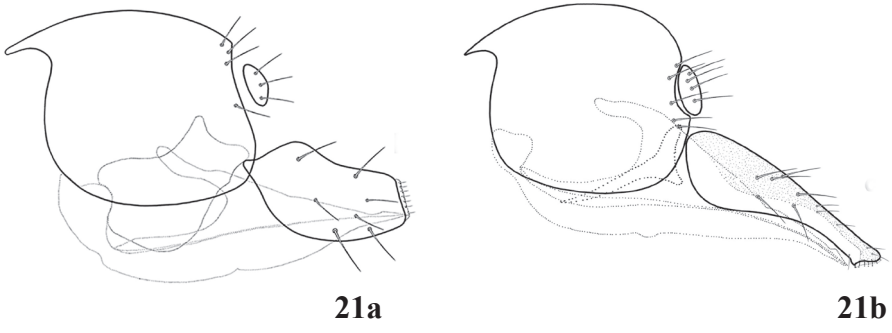

Figure 21: Propodeum. **a**: *Diaeretiella rapae*; **b**: *Lipolexis gracilis*.

DISCUSSION

Up-to 2013, 14 species of aphid parasitoids were documented from Malta which are now being augmented with two additional records and bringing a total number of 16 species. The whole complex of aphid parasitoids present in Malta represent well known and widely distributed species. Most of the species are numerous and abundant in ecosystems and some species have invaded other areas either naturally or deliberately via biological control programmes. For the Maltese aphid parasitoids, three centres of origin are distinguished, a western Palaearctic, a Far Eastern and a North American one (Starý *et al*., 2014).

Over the years, hundreds of non-native organisms have been introduced into the Maltese Islands. This is particularly so for many plants such as fruit trees, crops and ornamentals (Vogiatzakis *et al*., 2008). The geographical position of the Maltese Islands in the centre of the Mediterranean basin, favours the accidental introduction of various insects, including biological control agents (Schembri & Lanfranco, 1996). On the other hand, except for a few cases all aphid parasitoids recorded from the Maltese Islands, are widely distributed in the Palaearctic region, sometimes with extended distribution into the Oriental region. The presence of these species in the Nearctic and the Australasian regions is a matter of proposefull introduction (Yu *et al*., 2012).

Adialytus ambiguus is widely distributed throughout the Holarctic region. It was successfully introduced and established in Hawaii as a biological control agent of the sugarcane aphid, *Sipha flava* (Forbes) (Culliney *et al*., 2003). *Aphidius colemani* is commercially produced as a biocontrol agent against numerous aphid pests of greenhouses and open fields. The taxonomy of *A. colemani* and the closely related species, *A. platensis* Brethes and *A. transcaspicus* Telenga was discussed by Tomanović *et al*. (2014) and in the light of this work, the material collected from Malta was re-examined and was asserted to belong to *A. colemani*. Most likely, the three mentioned species originated in the Mediterranean and subsequently expanded their range to nearby areas with subtropical / tropical climates. They occur at least in a part of Sub-Saharan Africa, South-Eastern Asia and Australia but their precise geographical ranges need to be reviewed (Tomanović *et al*., 2014).

Diaeretiella rapae has been used as a biocontrol agent against *Diuraphis noxia* infesting cereal crops in many countries (Waterhouse & Sands, 2001; Elliott *et al*., 1995). Some biotypes of *E. persicae* have also been used as classical biocontrol agents, for example from Lebanon to California (Mackauer & Starý, 1967). In the New World and the Far East, *E. persicae* forms uniparental populations consisting solely of females whereas elsewhere the species exhibits biparental populations (Starý & Schlinger, 1967; Starý, 1995). *Lysiphlebus fabarum* was also deliberately introduced in Australia in 1982 for the biological control of aphid pests (Carver & Franzmann, 2001). *Lysiphlebus testaceipes* is native to South America and in 1973 the species was introduced from Cuba to Europe (southern France) as a biological control agent against two citrus aphid pests (Starý *et al*., 1988). The species managed to invade central and North America too and was also imported in 1982 in Australia for biological control of aphid pests (Carver, 1984).

The host range pattern for the Maltese aphid parasitoids, ranges from narrow oligophagous (*Adialytus ambiguus*, *Trioxys pallidus*) to species having rather wide host ranges (*Aphidius colemani*, *Aphidius matricariae*, *Diaeretiella rapae*, *Ephedrus persicae*, *Lysiphlebus fabarum*, *Lysiphlebus testaceipes*). *Adialytus ambiguus* is a specialised parasitoid of aphids of the genus *Sipha* which feed on Poaceae host plants (Rakhshani *et al*., 2012).

Aphidius absinthii represents a new record for Malta and its association with *Uroleucon inulae* (Ferrari) was never previously documented. It is regarded as a common parasitoid of *Macrosiphoniella* all over the Mediterranean basin and Europe (Rakhshani *et al*., 2011). Biotype *A. absinthii* from *U. inulae* show some variability in fore wing venation pattern, number of maxillary palps (3–4), narrow and sometimes incomplete propodeal areola and antennal segments (16-segmented antennae). Comparison of the sequences of COI barcoding gene for the Maltese population with specimens of *A. absinthii* from southeastern Europe showed an average difference of 0.04%. Since the identity of these specimens was confirmed using molecular analysis, the morphological differences encountered are considered as intraspecific variations which are acceptable for the Maltese population.

Trioxys pallidus is an oligophagous parasitoid on arboricolous Callaphidinae aphids (Starý, 1978) and its association with *Hoplocallis picta* (Ferrari) feeding on *Quercus ilex* is endemic to the Mediterranean basin. The presence of *Trioxys pallidus* in Malta represents a new record for this mentioned territory. *Aphidius funebris* and *Praon yomenae* are the oligophagous parasitoids of *Uroleucon* aphids feeding on different herbaceous plants. Both species are widely distributed in the Palaearctic (Rakhshani *et al*., 2011). *Praon volucre* was recorded from Malta by Farrugia (1995) but its presence was never confirmed during recent studies. *Pauesia silana* is generally known from southern Europe with records from Italy, Spain, Greece and Malta (Starý, 1976; Kavallieratos *et al*., 2001). This species seems to be an oligophagous parasitoid of *Cinara* aphids associated with pine trees (Starý, 1976).

Three species, *Diaeretiella rapae*, *Ephedrus persicae* and *Lysiphlebus testaceipes* seem to have the widest host range and distribution patterns. *Diaeretiella rapae* is a polyphagous aphid parasitoid known to parasitize some 100 different species of aphids feeding on more than 180 plant species (Singh & Singh, 2015). The main host aphids include *Brevicoryne brassicae* (L.), *Myzus persicae* (Sulzer), *Lipaphis erysimi* (Kaltenbach) and *Diuraphis noxia* (Kurdjumov). *Ephedrus persicae* is known to parasitizes over 150 aphid species worldwide (Gardenfors, 1986), with the main aphid hosts belonging to the Myzini, Aphidiini and Macrosiphini which include some of the most important pest aphid species worldwide. It represents the keystone parasitoid species of leaf-curling aphids in orchard agroecosystems and to a lesser degree in vegetable crops, alfalfa, soybean and cereals (Žikić *et al*., 2009). The host range of the third species, *Lysiphlebus testaceipes* exceed 100 aphid species (Pike *et al*., 2000). It was originally introduced into southern France (Starý *et al*., 1988), and gradually naturalised in a narrow coastal part of the Mediterranean region, competing with the local parasitoids, and within a relatively short period of time it established itself over the entire Mediterranean, and invaded continental Europe (Žikić *et al*., 2015), Iran (Rakhshani *et al*., 2005), Turkey (Satar *et al*., 2012), North Africa (Laamari *et al*., 2012; Ben Halima Kamel, 2011) and West Africa (Sæthre *et al*., 2011).

Aphis nerii feeding on the toxic plant *Nerium oleander*, may become protected from aphid parasitoids (Hajek, 2004). Despite this, in Malta it was successfully parasitized by a rich guild of four species, namely *Aphidius colemani, Binodoxys angelicae*, *Lysiphlebus fabarum* and *Lysiphlebus testeceipes*. This phenomenon was already observed in south-eastern Europe (Kavallieratos *et al*., 2004) and the Mediterranean (Starý, 1976), whereas in central Asia (e.g Iran) a more diverse complex of parasitoids was recorded (Talebi *et al*., 2009; Rakhshani *et al*., 2008; 2013).

In spite of the data recorded in the present work, there are still several missing items which might be discovered in future via appropriate research. Root aphids ought to be sampled as the whole associated parasitoid complex remain unknown for Malta. Gall-inducing Fordini aphids on *Pistacia*

represent the hosts of *Monoctonia pistaciaecola* Starý. The species is restricted to warmer parts of the Mediterranean region, Asia Minor and Central Asia but probably evolved in the European part of the Mediterranean (Rakhshani *et al*., 2015). Even though this aphid parasitoid was never collected in Malta, we are of the opinion that it should be present in Malta. This is due to the fact that Fordini aphid hosts are rather common in Malta (Mifsud *et al*., 2009). A common member of the *Urolecucon* aphid parasitoids guild, *Binodoxys centaureae* has also not yet been recorded from Malta.

The data obtained may clarify differences in the associated parasitoid complexes on the primary and secondary host plants of the Fordinae. This information would be a useful supplement to the Fordinae parasitoids in temperate areas of Europe where these aphids are anholocyclic and the respective associations reduced. At last, the detection of the parasitoid-aphid-plant associations in the different (agro) ecosystems should be studied, tracing the interactions between the systems as well as the role of parasitoids. On an island like Malta, such detections are important to spot and might be easy to identify. Although small in size, small field and gardens, apart from the urban agglomerations, should be also sampled. The latter approach was exemplified in *Phalaris canariensis* (Stankovic *et al*., 2013) and in *Aphis nerii* (Mifsud *et al*., 2013). Many other species of aphid parasitoids are expected to occur in Malta, especially those present in the southern and northern Mediterranean countries, where similar flora and aphid fauna is present.

ACKNOWLEDGMENTS

The contribution by E. Rakhshani was supported by the grant No. 89–9198, University of Zabol and the contribution of Ž. Tomanović and P. Starý was partially supported by the grant III43001 (The Ministry of Education, Science, Serbia) and by the institutional support RVO: 60077344, respectively. We also thank M. Zammit for donating the aphid parasitoids he collected.

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Received: January 10, 2015
Accepted: March 20, 2015