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Vermileo immaculatus sp. n.: a new vermileonid species from Malta (Diptera: Vermileonidae).

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Abstract: A new vermileonid species collected in Malta, *Vermileo immaculatus* **sp. n.**, is described in this paper. *Vermileo vermileo* (Linnaeus, 1758) and *Vermileo balearicus* Wheeler, 1930 are its most similar species. *V. balearicus* is confirmed as a valid species. Finally, a revision of previous records of *Vermileo* Macquart, 1834 in Malta and its current distribution is given.
Key words: Diptera, Vermileonidae, *Vermileo immaculatus* **sp. n.**, Malta.

Resumen: *Vermileo immaculatus* sp. n.: una especie nueva de vermileónido de Malta (Diptera: Vermileonidae). En este trabajo se describe una especie nueva de vermileónido, *Vermileo immaculatus* **sp. n.**, capturada en Malta. Sus especies más parecidas son *Vermileo vermileo* (Linnaeus, 1758) y *Vermileo balearicus* Wheeler, 1930. Se confirma la validez de *V. balearicus* como especie. Finalmente, se aporta una revisión de las citas previas de *Vermileo* Macquart, 1834 en Malta y su distribución actual.
Palabras clave: Diptera, Vermileonidae, *Vermileo immaculatus* **sp. n.**, Malta.

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Introduction

The Vermileonidae include long and slender flies of small to medium size (5-18 mm). The larvae are known as wormlions, as they make pitfall traps in the dust or sand to prey on other small insects, as the larvae of Myrmeleontidae (Neuroptera) do, the so-called antlions. The larvae live mainly in sunny and arid regions at rain-protected sites. The adults feed on nectar (Nagatomi, 1997).

Only two genera are known from Europe: *Lampromyia* Maccquart, 1835 and *Vermileo* Macquart, 1834 (Beuk & Pape, 2013).

Up to now, 11 species of *Vermileo* are known worldwide (GBIF, 2019; Eiseman & Schusteff, 2020), four of which have been recorded from western Palaearctic: *V. ater* Stuckenberg, 1965 (Greece: Creta), *V. balearicus* Wheeler, 1930 (Spain: Balearic Islands), *V. nigriventris* Strobl, 1906 (Portugal, Spanish mainland, and Morocco), and *V. vermileo* (Linnaeus, 1758) (Austria, Bulgaria, Croatia, Egypt?, French mainland, Greece (Thasos), Italy (mainland, Sardinia, and Sicily), Malta, Morocco, Portugal, Slovenia, Spanish mainland and Switzerland) (Wheeler, 1930; Edwards, 1935; Stuckenberg, 1965; Ebejer, 1995; Carles-Tolrá & Báez, 2002; Devetak, 2008; Beuk & Pape, 2013; Carles-Tolrá, 2016; Ebejer *et al.*, 2019; and Papp & Soltész, 2019).

The record of *V. vermileo* from Egypt by Wheeler (1930) may likely belong to *V. niloticus* Edwards, 1935, a species described from Sudan (Edwards, 1935; Stuckenberg, 1965).

The Maltese Archipelago is a group of three small islands (Malta, Gozo, and Comino) and some islets in the Central Mediterranean. Its geological composition, almost entirely of marine sedimentary rocks, its Mediterranean climate, and the great anthropic influence on the landscape (Mifsud, 2000) are ideal for promoting microhabitats where wormlions live. The first record for the family Vermileonidae in the Maltese Archipelago was published by Zammit-Maempel (1985) as *Vermileo* sp., identified from several larvae. A decade later, Ebejer (1995) recorded the presence of *V. vermileo* from adult specimens, indicating that they often fly indoors. This was the last record from Malta that we could find in the scientific literature.

Material and methods

In April 2009 the second author visited the Maltese Archipelago for the first time, in an entomological trip looking for heteropteran bugs and aphids (Cuesta Segura *et al.*, 2010; Mifsud *et al.*, 2011). In the summer of 2018 he came back during conventional holidays. In the visit to Valletta, the capital, the typical wormlion/antlion funnel traps were found in the debris accumulated on the window sills of several streets. After realising that they contained wormlions, traps were actively looked for in all the sites visited during the following days. The largest larvae were caught and kept alive in individualized vials, and pictures of the microhabitats where they lived were taken for the record (Fig. 1). Once at home, the larvae were fed with ants and *Drosophila* flies. Altogether, 25 larvae were collected, 18 of which survived and became adults in the spring of 2019 and, once dead, were then preserved in 70% alcohol.

The study of these 18 adult specimens has revealed they belong to a new species for science, which is described in this paper. Furthermore, previous records of Vermileonidae from Malta are discussed and corrected.

The images were taken with a pink background, which later was removed with Adobe Photoshop for easier viewing. However, in some of the pictures we can still see a pinkish halo, which has not been removed to avoid losing details of the pilosity or generate a false clear edge. Likewise, some images may have pink tones seen through transparent structures or reflected in some parts.

Description

***Vermileo immaculatus* sp. n.** (Figs. 2-33)

Male (Figs. 2, 8-10). Head black. Frons and face dark, grey tomentose; ocellar tubercle black. Occiput black, with paler short setae. Antenna (Fig. 11): scape and pedicel yellow; flagellomere 1 brown, yellow basally; style dark brown. Antennal proportions: scape:pedicel:flagellomere 1:style = 1:0.5:1.2:3.5. Palpus and proboscis yellow.

Thorax (Figs. 13-14) mainly yellow. Scutum (Fig. 13) with 4 dark brown longitudinal stripes; median stripes mostly shorter and fused anteriorly, or they may be completely fused reaching the scutellum; scutum more or less brown in front of scutellum; scutum with small black setae. Postpronotum with small black setae. Scutellum brownish to brown, yellow laterobasally, with small black setae. Anepisternum (Fig. 14) with a large dark brown spot. Katepisternum (Fig. 14) yellow, brownish basally; sometimes brownish anteriorly. Meron (Fig. 14) yellow, brownish basally. Mediotergite (Fig. 14) yellow, brown posteriorly. All other pleural sclerites yellow. Laterotergite with small black setae.

Wing (Fig. 12) transparent, grey tinged, with a diffuse spot below at the beginning of R2+3. Cell m3 open, or closed with a very short petiole. Halter brownish.

Fore and mid legs (Figs. 9-10) yellow, only tarsomeres 2 (distally) to 5 brown. Hind leg (Figs. 9-10) dirty yellow, brownish; coxa dark brown posteriorly; femur apically and tibia apically brown; tarsomere 1 whitish, brownish apically; tarsomere 2 whitish, brown apically, or completely brown;

tarsomeres 3-5 brown. Hind femur (Figs. 9-10) swollen apically. All tibiae with ventroapical spurs (1:2:2).

Abdomen yellow, with distinct brown markings (Figs. 2, 8, 16-17). Tergites 1-2 each with a median brown transverse stripe; tergite 2 brownish anteriorly; median transverse stripe on tergite 3 complete or interrupted, and on tergite 4 interrupted; tergites 5-8 with only a pair of small mediolateral brown spots, spots on tergite 8 distinctly larger. Tergites 2-3(4) concave in lateral view. Tergites bare anteriorly, posteriorly with small black setae. Sternites 1-6 yellow, at most sternites 6-8 brown laterally in variable extension. All sternites with small black setae.

Genitalia (Figs. 19-31) with small black setae: epandrium (tergite 9) rectangular, convex laterally and concave anterior and posteriorly (Figs. 19-20); gonocoxites (Figs. 20-23) fused, rounded; synsternite with a distinct posterior incision connecting a desclerotised triangular central zone (Figs. 22-23); gonostylus (Figs. 24-25) J-shaped, abruptly tapered apically. Aedeagus (Figs. 26-28) very long, reaching sixth segment interiorly, base strongly pointed (Figs. 27-28), bifid apically (Fig. 28). Dorsal bridge (Figs. 27, 29) H-shaped, anterior arms short, parallel, posterior arms longer, divergent. Associated structures to the aedeagus (Fig. 30) with variable number and size of spikes (Fig. 31, arrows).

Female (Figs. 3-7). As the male. Scutum: median stripes completely fused and reaching scutellum or very short and only touching anteriorly. Scutellum dark brown, yellow laterobasally. Brown parts on katepisternum and meron usually distinctly darker (Fig. 15) than in males.

Fore and mid tarsi: tarsomere 1 yellow, brownish apically, tarsomeres 2-5 brown. Hind tarsus: tarsomere 1 whitish, brownish apically, tarsomeres 2-5 brown.

Abdomen mainly yellow (Figs. 6, 18): only tergite 1 with a complete median transverse brown stripe. Tergite 2 brownish anteriorly. Tergites 2-8 mostly with only mediolateral brown spots, without transversal stripes. Median transverse stripes may be present on some tergites, but they are incomplete: tergites 2-5 (1 specimen), tergites 3-4 (1 specimen) and tergites 3-5 (1 specimen). Sternites (Fig. 7) 1-5 yellow, sternites 6-7 brownish to brown laterally (only 1 specimen with sternite 6 completely yellow), anterior half of sternite 7 desclerotised (Fig. 32), sternite 8 trifid anteriorly (Fig. 32). Three spermathecae (Fig. 33), oval, narrower basally.

Total body length: males = 8.4-10.2 mm; females = 10.3-12 mm.

Type material

Holotype ♂: MALTA: Qrendi, 2.08.2018 (larva), Il-Kabiri Street, in stone wall holes, N35°49'57.9" E14°27'18.1", 103 m, A.D. Cuesta-Segura leg.

Paratypes: MALTA: Dingli, 3.08.2018 (larvae), 4 males, 5 females, Il-Buskett Street, houses in front of the entrance of the Verdala Palace, under a doorless shed and in stone wall holes of the Verdana Palace complex, N35°51'43.8" E14°23'51.5", 192 m; Qrendi, 2.08.2018 (larvae), 2 females, Il-Kabiri Street, in stone wall holes, N35°49'57.9" E14°27'18.1", 103 m; Qrendi, 2.08.2018 (larva), 1 male, Il-Maqluba Natural Reserve, in soil protected by rocks, N35°49'51.6" E14°27'25.5", 85 m; Siggiewi, 3.08.2018 (larvae), 1 male, 3 females, pine forest close to Il-Buskett Street, in a hole in the base of stone wall, N35°51'34.0" E14°23'50.9", 218 m; Valletta, 29.07.2018 (larvae), 1 female, Merchants Street and Old Mint Street, in accumulated sediments at the base of low windows, N35°53'46.78" E14°30'41.26", 53 m. All A.D. Cuesta-Segura leg.

Holotype, 4 male and 9 female paratypes deposited in the collection of the first author, and 2 male and 2 female paratypes deposited in the collection of the second author. All material preserved in alcohol (70%).

Discussion

The most similar species to *Vermileo immaculatus* sp. n. are *V. vermileo* and *V. balearicus*.

Vermileo vermileo: 5 males and 27 females collected in the province of Barcelona (Spain) and published in Carles-Tolrá (2001) have been studied again.

Additional material: Barcelona: Badalona, 2.06.2019 (larvae), 4 males, 3 females (Can Ruti Campus); Barcelona, 3.06.2019 (larva), 1 male (Museo de Arte stairs); Sant Martí de Centelles, 1.06.2019 (larvae), 1 male, 1 female (Sant Joan Street); all A.D. Cuesta-Segura leg.

Regarding to *V. balearicus*, Wheeler (1930) collected specimens (he didn't indicate how many) in the Balearic Islands, from Mallorca and Menorca, and wrote "*…the specimens from the Balearic Islands probably represent a distinct variety, for which I propose the name balearicus var. nov. The general yellow color of the body and appendages seems to be paler or duller. Other slight differences will probably be revealed by careful comparison with typical continental specimens*". Some decades later, Carles-Tolrá in Carles-Tolrá & Báez (2002), after having looked in vain for those Wheeler's specimens and considering that they were found in an isolated region (isles), included *V. balearicus* as a valid species. This new taxonomic level was later followed by Beuk & Pape (2013).

In July 2019 the second author travelled to the Balearic Islands for the aim of finding specimens of *V. balearicus*. Fortunately, 166 larvae were found and later reared at his home obtaining 101 adult specimens of both sexes so far: Mallorca (65 specimens), Menorca (16 specimens), and Cabrera (20 specimens). These new Balearic specimens have now avoided to confirm the actual taxonomic status of *V. balearicus*, stating that it is a valid species.

Back to *V. immaculatus* sp. n., a detailed study of the male genitalia of the three species compared has revealed that there are not differences among them, not even on the internal parts (dorsal bridge and other associated structures enclosing the aedeagus). According to Stuckenberg (1965: Fig. 10), *V. vermileo* has the synsternite completely sclerotised, but all the males studied for this paper have a distinct desclerotised zone on the synsternite, like *V. balearicus* and *V. immaculatus* sp. n. (Figs. 22-23). Furthermore, the gonostyli drawn by Stuckenberg (1965: Fig. 9) seemed distinctly different from those of *V. balearicus* and *V. immaculatus* sp. n. (Figs. 24-25), but this was due to differences in view angles, while in reality they are identical. Likewise, the number and size of spikes (Figs. 30-31) on the associated structures to the aedeagus are also very variable and even lack in some cases. All in all, no distinct and constant genital differences have been found among these three species in any sex. Consequently, the three species are only distinguishable by external morphological characters, mostly those of the abdominal pattern on tergites and sternites (see Table I).

Table I.- Main features to distinguish *Vermilio immaculatus* sp. n. of its two more similar species: *V. vermileo* and *V. balearicus*. Each tergite may have 1 stripe (transversal), or 2 spots (lateral), or 3 spots (1 median and 2 lateral).

	***Vermilio immaculatus* sp. n.**	***Vermileo vermileo***	***Vermileo balearicus***
Notopleural setae	Small and dark	Longer and light	Small and dark (only a bit long and light in very few specimens)
		Males	
Tergites	1-3 with stripes; 4-8 with 2 spots	1-4 with stripes; 5-8 with 3 spots	1-4 with stripes; 5-8 with 3 spots
Sternites	Yellow; at most 6-8 brown laterally	2-3 brown; 4-8 yellow, brown laterally; or 2-8 yellow, brown laterally	Yellow, 6-8 brown laterally
		Females	
Tergites	2-8 with 2 spots	2-7(8) with 3 spots	2-8 with 3 spots
Sternites	2-5 yellow; 6-7 yellow, brown laterally	2 brown; 3-4 brown, yellow anteriorly; 5-7 yellow, brown laterally	2-5 yellow; 6-7 yellow, brown laterally

Biology

The larvae were found and collected in summer (2018) in their typical conical pitfall traps at rain protected sites (Fig. 1), and then they were reared at home fed with ants and *Drosophila* flies till their emergence in spring (2019). We highlight that at the doorless shed in Dingli there was a colony of about 500 individuals, mostly composed of tiny traps. According to Ebejer (1995), adults often fly indoors.

Conservation

Because the Maltese Archipelago is under great anthropic pressure (Mifsud, 2000), native species might be expected to need some form of protection. However, *Vermileo immaculatus* sp. n. uses many human constructions for its larval development, which protect the substrate from rain, being found only in the Il-Maqluba Natural Reserve in completely natural microhabitats (Fig. 1). The islands are full of natural stone walls built without using cement, and as long as this continues, we consider that the species will have enough suitable places to carry out its life cycle.

Etymology

The specific name *immaculatus* (from Latin = not stained) refers to the absence of median spots on tergites.

Distribution

Hitherto only known from the isle of Malta (Fig. 34), although quite possibly it is also present in Gozo and Comino islands. It is most likely an endemism.

The Maltese records from Birzebbuga (Ghar Dalam Cave) as larvae of *Vermileo* sp. by Zammit-Maempel (1985), and from Balzan (adults) and Guardamangia (adults) as *V. vermileo* by Ebejer (1995) should be assigned to *Vermileo immaculatus* sp. n., considering it the only species present in the archipelago so far.

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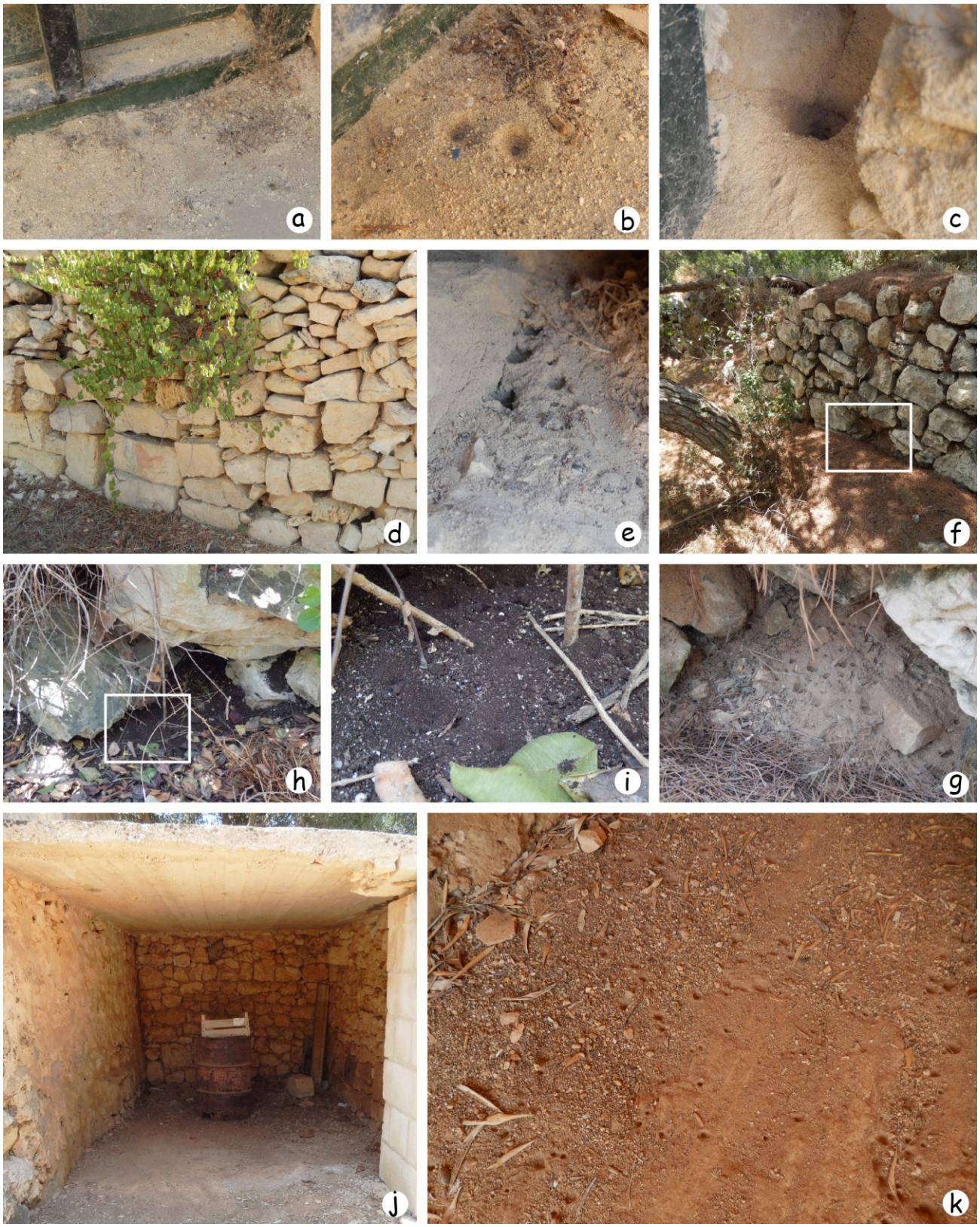
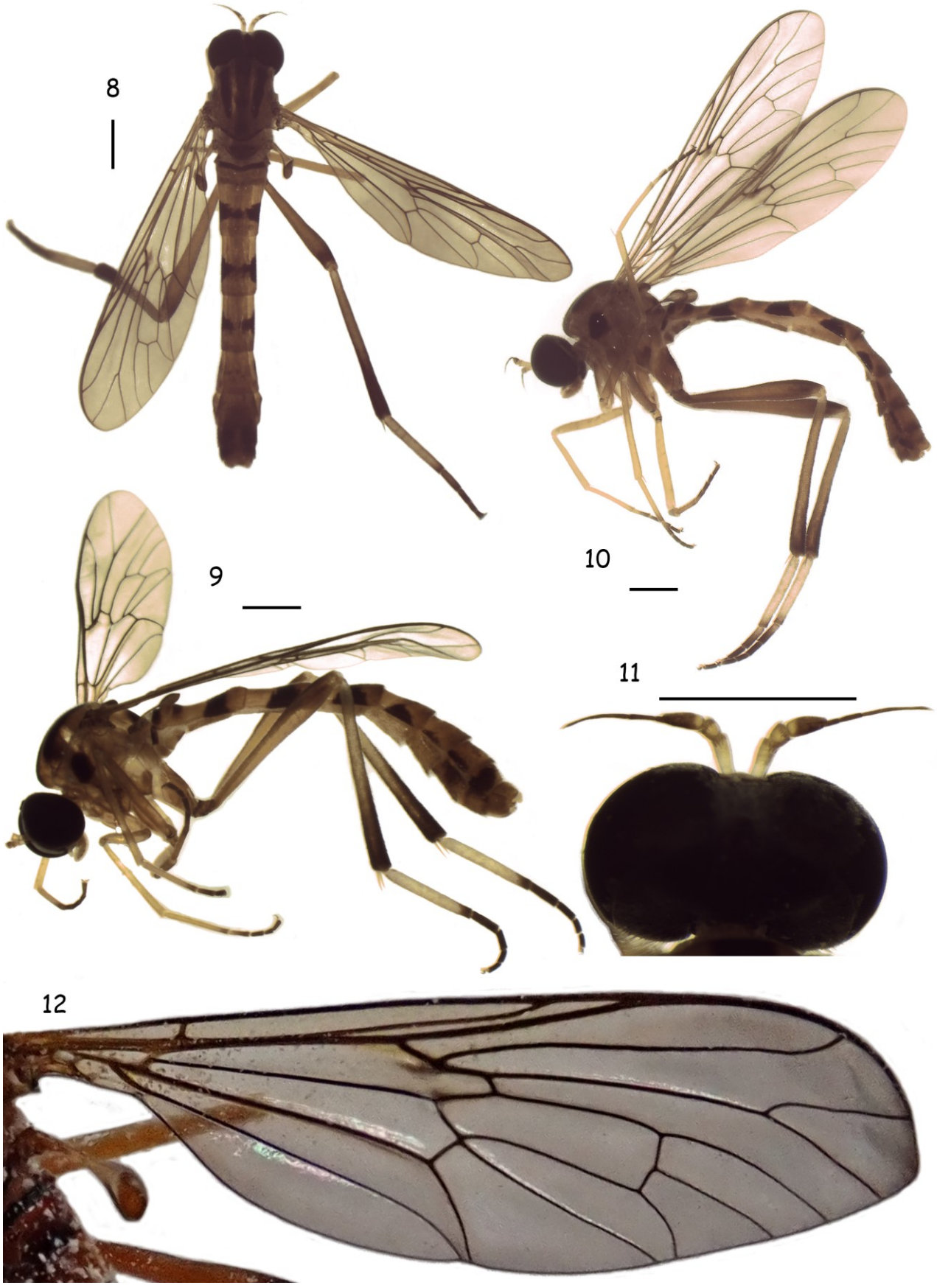


Fig. 1.- Microhabitats where wormlion's traps were found.

a-c.- Windows sills in Valletta.
d-e.- Stone wall holes in Qrendi.
f-g.- Hole in the base of stone wall in Siggiewi.
h-i.- Soil protected by rocks in Il-Maqluba Natural Reserve.
j-k.- Doorless shed in Dingli, colony of about 500 individual, mostly tiny traps.

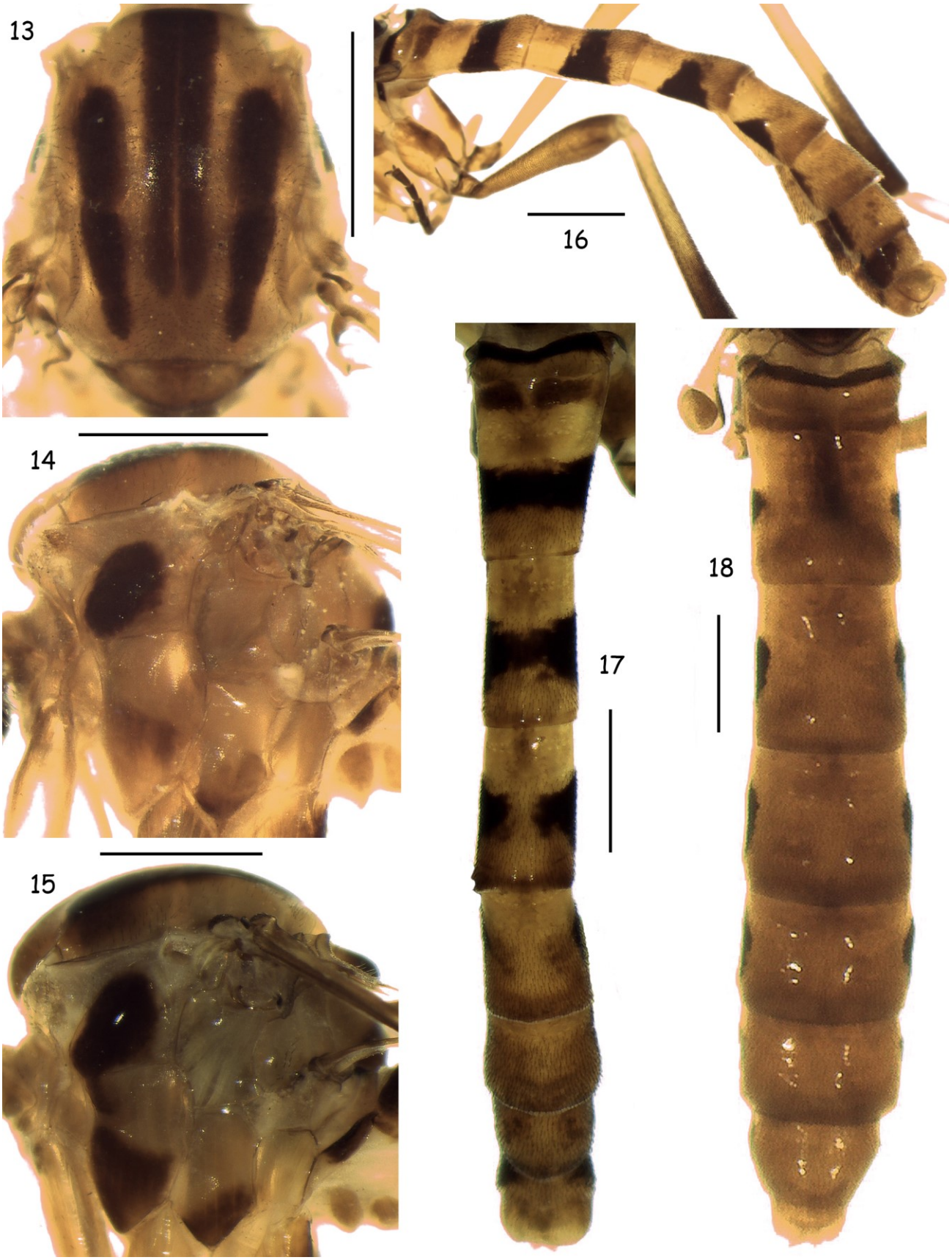
Figs. 2-7.- Habitus of *Vermileo immaculatus* **sp. n.**

2.- Male, dried. **3.-** Female, alive. **4-7.-** Females, dried.



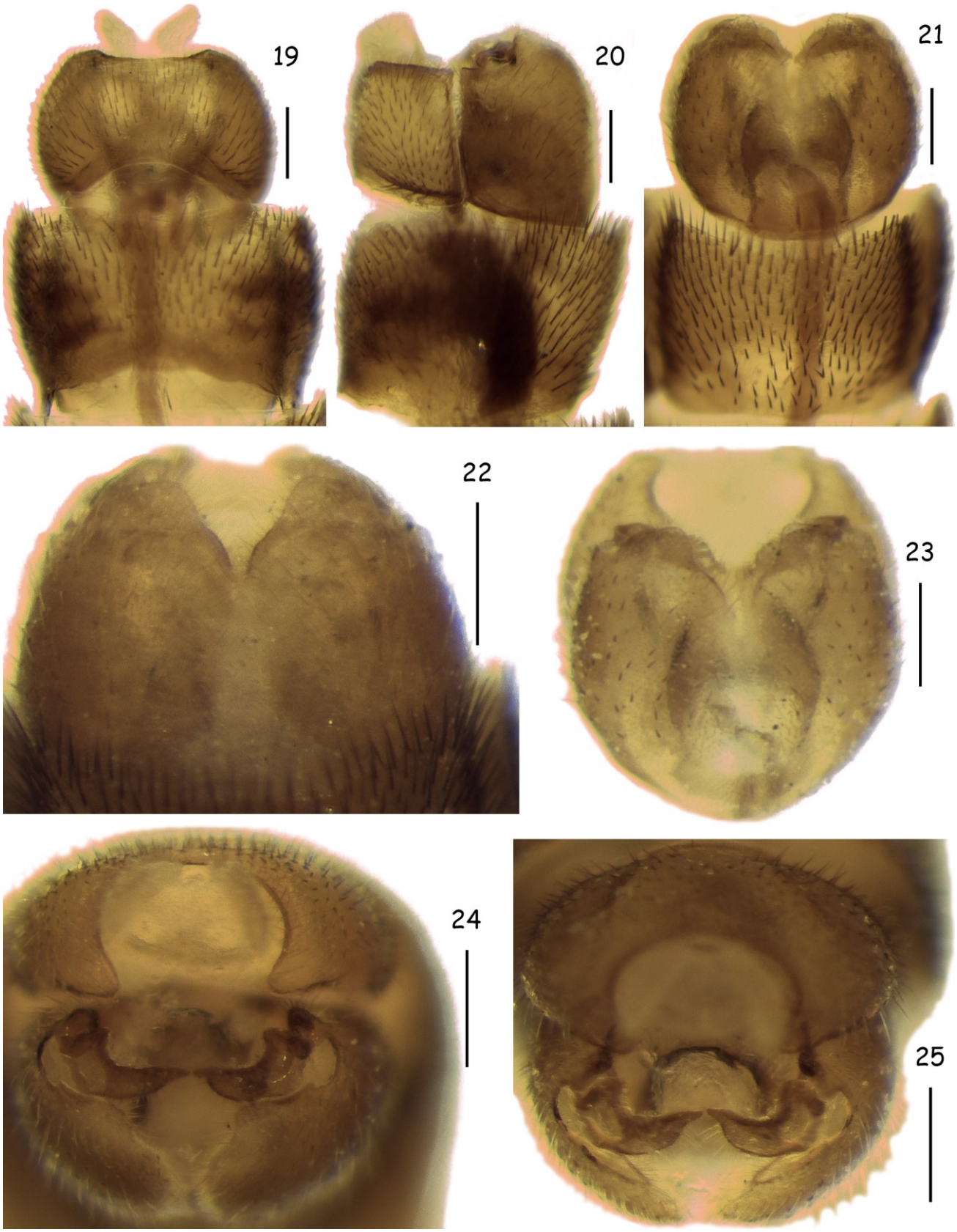
Figs. 8-12.- *Vermileo immaculatus* **sp. n.**

8-10.- Male habitus, alcohol. **10.-** Holotype. **11.-** Antennae, dorsally. **12.-** Wing (apex wrinkled). Scale bars = 1 mm.



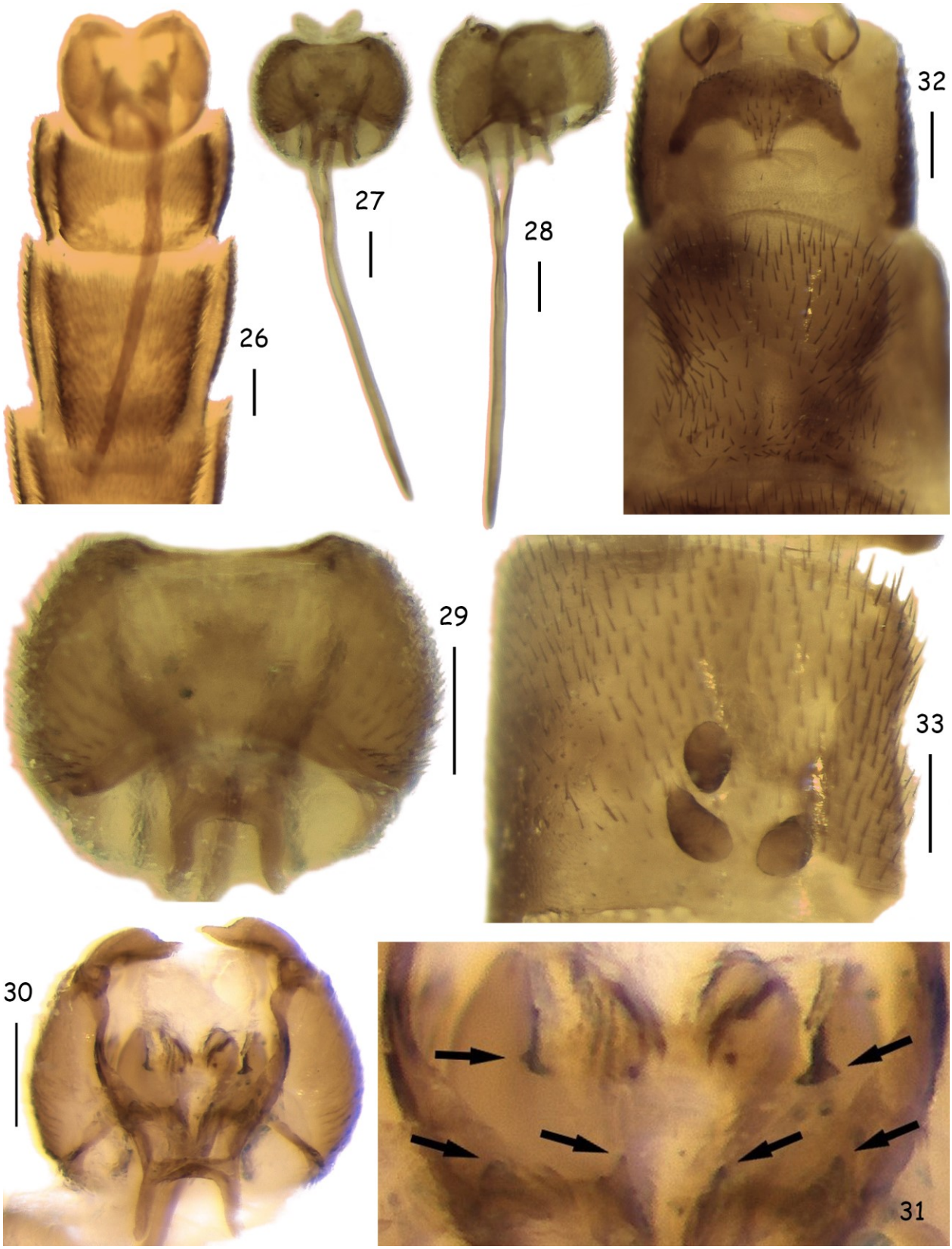
Figs. 13-18.- *Vermileo immaculatus* **sp. n.**

13.- Male thorax, dorsally. **14.-** Male thorax, laterally. **15.-** Female thorax, laterally.
16.- Male abdomen, dorsolaterally. **17.-** Male abdomen, dorsally. **18.-** Female abdomen, dorsally. Scale bars = 1 mm.



Figs. 19-25.- *Vermileo immaculatus* **sp. n.** (male).

19.- Tergite 8 and genitalia, dorsally. **20.-** Segment 8 and genitalia, laterally.
21.- Sternite 8 and genitalia, ventrally. **22.-** Genitalia, ventrally.
23.- Genitalia, posteroventrally. **24.-** Genitalia, posteriorly. **25.-** Genitalia, posterodorsally. Scale bars = 0.2 mm.



Figs. 26-33.- *Vermileo immaculatus* **sp. n.**

26.- Abdominal segments 6-8 and genitalia (tergite 9 removed) (macerated in KOH, aedeagus visible by transparency). **27.-** Genitalia dorsally (macerated in KOH). **28.-** Genitalia laterally (macerated in KOH). **29.-** Dorsal bridge, dorsally. **30.-** Associated structures to the aedeagus, dorsally. **31.-** Detail of the associated structures to the aedeagus with arrows showing the spikes. **32.-** Female sternites 7-8, ventrally. **33.-** Spermathecae. Scale bars = 0.2 mm.

Fig. 34.- Maltese Archipelago with the locations of *Vermileo immaculatus* **sp. n.** (red = this paper, white = bibliography). Map generated with Google Earth.