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Biological notes on *Ceranisus menes* (Hymenoptera: Eulophidae: Entedoninae), a biological control agent of thrips, in Ukraine

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Gumovsky, A.V. Biological notes on *Ceranisus menes* (Hymenoptera: Eulophidae: Entedoninae), a biological control agent of thrips, in Ukraine. — Habitat association, ovipositing behaviour and early stages of development of an asexual (parthenogenetic) strain (yellow color-type) of entedonine *Ceranisus menes* (Walker, 1839), were studied. *Ceranisus menes* is an endoparasitoid species associated with thrips, likely of tropical origin. In Central Ukraine, this species is associated with flowers of knapweeds, in particular the greater knapweed, *Centaurea scabiosa* ssp. *apiculata*, where it hunts for immature thrips. The oviposition, egg and embryo of the larva of *C. menes* are described and illustrated. Traits of immature development are discussed.

Key words: Chalcidoidea, Entedoninae, Thysanoptera, *Centaurea scabiosa*.

Гумовський, О.В. Нотатки з біології *Ceranisus menes* (Hymenoptera: Eulophidae: Entedoninae), агента біологічної боротьби з трипсами, в Україні. — Досліджено прив'язку до оселища, поведінку при відкладанні яйця та ранні стадії розвитку безстатевої (партеногенетичної) лінії (жовта кольорова форма) ентедоніна *Ceranisus menes* (Walker, 1839) — ендопаразитоїдного виду, пов'язаного з трипсами, що ймовірно має тропічне походження. У Центральній Україні цей вид пов'язаний, зокрема з суцвіттями волошок, а саме волошки гострокінцевої, *Centaurea scabiosa* ssp. *apiculata*, де нападає на личинок трипсів. Описано та проілюстровано відкладання та структуру яйця, а також ембріон личинки *C. menes*; обговорюється ембріональний розвиток цього виду.

Ключові слова: Chalcidoidea, Entedoninae, Thysanoptera, *Centaurea scabiosa*.

Introduction

The subfamily Entedoninae (Hymenoptera: Chalcidoidea: Eulophidae) encompasses several representatives associated with thrips. These entedonines are distributed between the genera allied to *Ceranisus* (also *Goetheana*, *Thripobius* and *Entedonomphale*), all species of which are thripsivorous, and the genus *Pediobius*, just a couple of species of which are associated with thrips. Doğanlar & Doğanlar (2013) proposed even a separate subfamily, Ceranisinae, for the former group of genera: the erection of such taxon was regarded unconvincing though (Triapitsyn, 2015). *Ceranisus menes* is a representative of this thrips-associated lineage. This Cosmopolitan species is among most established biocontrol agents of thrips worldwide, if not the most established (Loomans et al., 1995; Loomans & van Lenteren, 1995; Loomans, 2006); it is represented by sexual (mostly in tropical areas) and asexual strains (mostly in temporary areas), also different color types (yellow, brown and buff) occur (Loomans & van Lenteren, 1995, Castineiras et al., 1996; Loomans, 2006). This may suggest also biological variation and necessitates local biological records and surveys.

Most biological peculiarities of *C. menes* were summarized and illustrated by Loomans & van Lenteren (1995), and Loomans et al. (2006), but immature stages remained poorly studied or undescribed for this species. The purpose of this paper was to document and illustrate key ecological and developmental traits of this thrips-associated entedonine in Ukraine, so to supplement the life history data and collection approaches for *C. menes*.

Material and methods

The field research was conducted at an abandoned air stripe of the former 'air town' near Hlobyne (Poltava Region, Hlobyne District: 49.41088ºN, 33.26132ºE, Fig. 1C) in July–August 2020. Initially, some specimens of *C. menes* were found together with numerous immature and adult thrips (unidentified, possibly *Haplothrips reuteri*) in plastic bags with collected plant stems of knapweeds

(*Centaurea scabiosa* ssp. *apiculata*) and thistles (mostly *Cirsium arvense*) at the abovementioned site. After selective observations and shaking the plants into white plastic trays (following in part recommendations described by Marzo (2004) and Loomans (2006)), the parasitoid adults were discovered only in the knapweed inflorescence.

Active females of *C. menes* were isolated from the plant debris and other flower inhabitants by tiny brush, and then moved to an Eppendorf tube (Fig. 1F). Then active second instar thrips and knapweed florets were added, and the tube was sealed either by its lead, or by cotton. The oviposition was observed in the tube and the parasitized thrips larvae were tagged, and then used for dissections. Some parasitoid females, thrips larvae and knapweed florets were put into small Petri dishes for oviposition observations and imaging (Fig. 1E). All photos were made with the camera Canon PowerShot A650 IS and the Optika SZM-2 7×-45× stereomicroscope.

The parasitized thrips larvae were dissected immediately after oviposition and within each 7–10 hours afterwards to trace immature development of *C. menes* (Fig. 3A–C). Thirty two larvae were dissected in total. Unfortunately, the parasitized larvae did not survive more than a week after oviposition, so developmental observations were limited to the fully-formed first instar's embryo.

Fig. 1. A, B — habitat of *Ceranisus menes*: abandoned air stripe near Hlobyne (Poltava Region); C — the locality on map; D — the host plant, greater knapweed (*Centaurea scabiosa* ssp. *apiculata*); E — florets of host plant in Petri dish; F — experiments on oviposition: host thrips (yellow arrowed) and females of *C. menes* (red arrowed) in an Eppendorf tube with isolated knapweed florets.

Results

Ceranisus menes (Walker, 1839)

For full list of synonymies see: Triapitsyn, 2005.

Material. 16 ♀ (all yellow color-type), Ukraine, Poltava Region, Hlobyne, abandoned air stripe of the former 'air town' near Hlobyne (Poltava Region, Hlobyne District: 49.41088ºN, 33.26132ºE), 07–08.2020 (Gumovsky) (SIZK).

Host. Various thrips on wide range of plants (Loomans & van Lenteren, 1995; Triapitsyn, 2005; Noyes, 2019); associated with a thrips (Fig. 3A) on *Centaurea scabiosa* ssp. *apiculata* in Central Ukraine (here).

Distribution. Cosmopolitan, likely originates from tropical areas (where sexual strains are common). In Ukraine: Cherkasy Region, Khmelnytsky Region, Kyiv Region, Crimea (Doğanlar et al., 2011), Poltava Region (**first record**).

Tri-trophic narration and behavioral observations

In Poltava Region of Ukraine, the adults of *Ceranisus menes* occur in the research plot (Fig. 1A, B) at least from mid-July to beginning of August. Its occurrence coincides with the blossoming of the host plant, the greater knapweed *Centaurea scabiosa* ssp. *apiculata* (Fig. 1D). The host

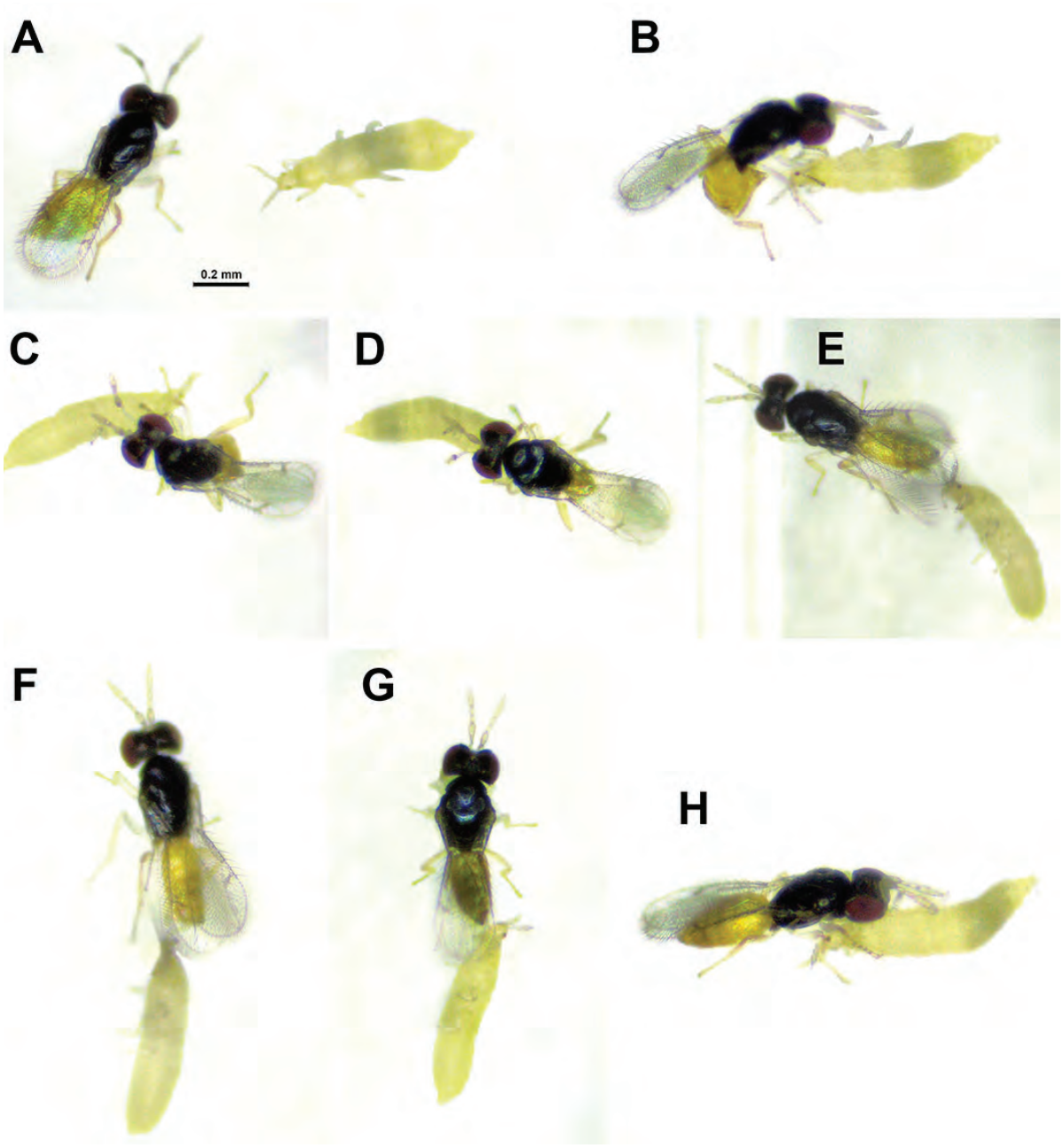

Fig. 2. Interactions between *C. menes* and the 2nd instar of host thrips: A — before attack; B–D — initial penetration; E–G — tailing and dragging; H — host feeding.

thrips inhabit the flowers of knapweeds, in particular the nectar-containing florets of the host plant. Both, adults and larvae of thrips occur in the same host plant. Females of *C. menes* walk along knapweed florets, attempting to locate the host thrips. The parasitoid females do not respond to adult thrips, but being nearly always interested in the second thrips larva. In general, the oviposition corresponds to that described by Loomans (1991) and Loomans & van Lenteren (1995). As long as the parasitoid female locates the thrips larva, the former bends its gaster and quickly stings the latter (Fig. 2B–D) until the ovipositorial saw is anchored in thrips' body (Fig. 2E). Often, immediately after that the thrips runs away and eventually drags the parasitoid female. Eventually the parasitoid turns and both insects appear in a characteristic "tale-to-tale" or "tale-to-head"

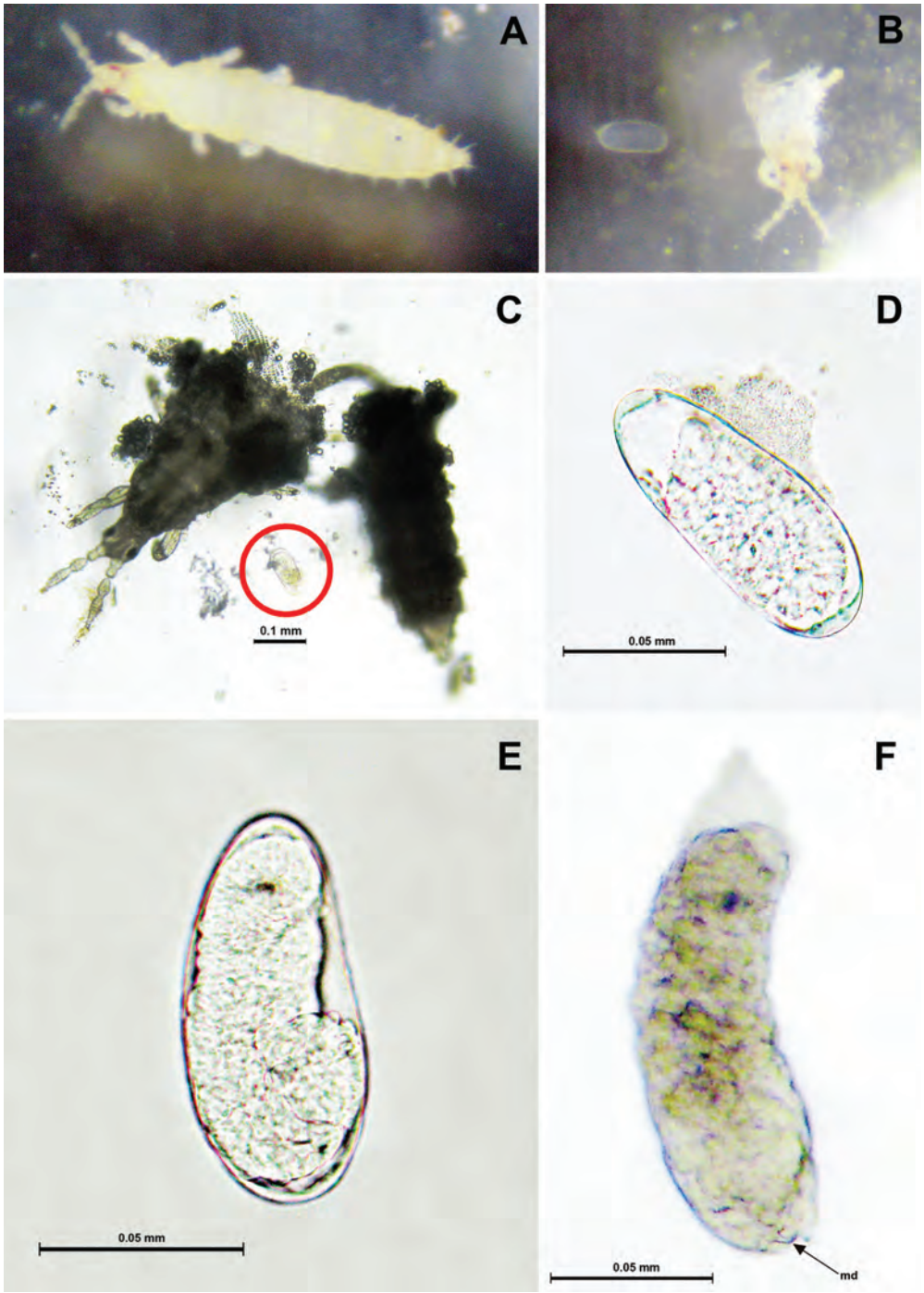

Fig. 3. A, B — freshly parasitized thrips larva before and after dissection: A, intact thrips; B, isolated egg of *C. menes* near the dissected thrips; C, D — dissected thrips after about 48 h: C, dissected thrips with an isolated egg of *C. menes* (red arrowed); D, the isolated egg from C; E — egg with fully formed larval embryo of *C. menes*; F — larva of *C. menes* ready to hatch.
md — mandible.

posture (Fig. 2E-G). This posture is generally associated with active movements of the host thrips. Occasionally the parasitoid is itself lifted on inserted ovipositor, while the thrips larva stands immobile. Duration of oviposition varies, generally about 20-30 seconds. The stung thrips becomes sedentary and maintains low mobility afterwards. Occasionally, the penetration of the host thrips with ovipositor is followed not by oviposition, but by the host feeding (Fig. 2H).

Immature stages of *C. menes*

Egg. The freshly laid egg is long-ovate, about 0.14-0.17 mm long and about 0.08 mm wide, nearly transparent, with evenly distributed yolk being visible as tiny granules (Fig. 3B). An intensive proliferation of cells starts about 48 hours later and the egg turns slightly smaller, nearly 0.1 mm long and 0.04 mm wide (Fig. 3D). Then some of the proliferating cells migrate peripherad, making the separation of internal cell mass and the outer cell layer distinct. Egg develops slowly, and separation of an embryo from egg chorion is traceable on 2nd-3rd day after oviposition: it has distinct body outlines (head capsule, in particular) at 4th day after the oviposition (Fig. 3E).

First instar larva (as discernible in egg-shell, before eclosion) is about 0.13 mm long (Fig. 3F), with head capsule bearing sharp mandibles (Fig. 3F, md) and traceable head sensoria, in particular pharyngeal palpi.

Discussion

The biology of *C. menes* has perhaps been the most comprehensively studied among thrips-attacking parasitoid species. Previous students revealed its life history traits (Loomans & van Lenteren, 1995), development duration under different conditions (Murai & Loomans, 1995), evaluated efficacy of its biotypes as biological control agents (Loomans, 2006), etc. Tagashira & Hirose (2001) reported the development of eggs and larvae, however they did not describe the egg and larval morphology. In general, the immature stages of this species have been remained very poorly described (e.g., Diop 1999).

As our preliminary data reveal, the egg development of *C. menes* is typical for Entedoninae: similar to what was described by Ivanova-Kazas (1952), Jackson (1969), Gumovsky (2008). The detailed description of the first instar larva of *C. menes* awaits for its completion due to short lifespan of the parasitized thrips larva in our experiments. The sharp mandibles suggest that the first instar of *C. menes* is involved in siblicide, similarly to other solitary entedonine species (Gumovsky, 2007, 2008). Although Loomans & van Lenteren (1995) suggested that only one egg is commonly laid, two eggs were laid per host at least once in our experiments. Also, Marzo (2004) and Loomans (2006) suggested that *C. menes* can control population of thrips. So, the population density of the parasitoid may be relatively high to promote superparasitism, and the siblicide may prevent rivalry between conspecific larvae.

The research plot, the former air stripe near Hlobyne, was cleared in late 1930s and remained so till late 1990s, when it started getting overgrown with indigenous and invasive vegetation. The described above association of the greater knapweed, the host thrips and its endoparasitoid *C. menes* was discovered there about 30 years after the start of the natural recovery of the plot. So, this association may serve as a model system for future studies on tritrophic interactions and natural or intentional restoration of biological communities.

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