**Stenomesius japonicus** (Ashmead) (Hymenoptera: Eulophidae): a new parasitoid of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Syria

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**ABSTRACT.** *Stenomesius japonicus* (Ashmead, 1904) (Hymenoptera: Eulophidae) was collected for the first time from larvae of the tomato leaf-miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) infesting *Lycopersicon esculentum* Mill. in Syria. Diagnostic morphological characters, biology and distribution of the newly recorded species are provided. Its role in the biological or integrated control of *T. absoluta* remains to be evaluated. A list of all eulophid wasps recorded from Syria is also provided.

**Key words:** Eulophidae, parasitoid, *Tuta absoluta*, Syria

**INTRODUCTION**

The tomato leaf-miner, *Tuta absoluta* (Meyrick, 1917) (Lepidoptera: Gelechiidae) is a Neotropical oligophagous pest of cultivated and wild plants with a high preference for Solanaceae, especially tomato (Nurul Huda et al., 2020). This pest also attacks other cultivated plants including potato (*Solanum tuberosum* L.), eggplant (*Solanum melongena* L.), sweet pepper (*Solanum muricatum* Aiton), tobacco (*Nicotiana tabacum* L.), bean (*Phaseolus vulgaris* L.) and cape gooseberry (*Physalis peruviana* L.) (Desneux et al., 2010). On wild plant species, the larvae of *T. absoluta* was found on *Datura stramonium* L., *Datura ferox* L., *Lycium chilense* Bertero, *Lycopersicum hirsutum* L., *Nicotiana glauca* (Graham), *Solanum lyratum* Thunberg, *Solanum puberulum* Nuttal ex Seemann, and *Solanum nigrum* L. (EPPO, 2009).

*Tuta absoluta* is originated from South America, but it was introduced to Spain in 2006 (Urbaneja et al., 2007), then spread throughout the Mediterranean Basin, Central Europe and the Middle East (Devetak et al., 2015). The subsequent invasion into the Middle East have been recorded from Syria (Almatni, 2010; Ibrahim et al., 2012; Mofleh et al., 2014), Iraq (Abdul Razzak et al., 2010), Iran (Banamieri & Cheraghian, 2011), and Jordan (Al Antary & Al Shaalan, 2013). It caused serious damages....
to tomato cultivations in invaded areas (Ferracini et al., 2019), may be responsible for the losses of up to 80–100% in tomato crops (Desneux et al., 2010). All aerial parts of the host plant including leaves, stems and fruits may be attacked by the pest. *Tuta absoluta* is a difficult pest to manage because of the larval feeding habits in the mines and its ability to build up insecticide resistance (Abdelmaksoud et al., 2020).

Together with the chemical control of this pest, and mating disruption technique has given encouraging results (Filho et al., 2000). Many species of natural enemies are attacking this insect, some of them are considered as important biological control agents. A list of new recorded enemies for Europe is summarized by Desneux et al. (2010). Several braconid species including, *Pseudoapanteles dignus* (Muesebeck) (Cardona & Oatman, 1971; Sanchez et al., 2009) and *Agathis fuscipennis* (Zetterstedt) (Loni et al., 2011) were found attacking the tomato leaf-miner in its original distribution area. Many eulophid species were also reared in association with this insect, including *Neochrysocharis formosa* (Sohrabi et al., 2014) and genus *Elachertus* spp. (Yarahmadi et al., 2016) in Iran, *Closterocerus clara* (Zeleny), *Ratzeburgiola christatus* (Ratzburg), *R. incompleta* Bouček, *Baryscapus bruchophagi* (Gahan) in Turkey (Doğanlar & Yiğit, 2011). Other parasitoids belonging to Chalcididae (*Brachymeria secundaria* (Ruschka) and *Hockeria unicolor* (Walker)), *Pteromalidae* (*Pteromalus intermedius* (Walker)), and *Braconidae* (*Bracon hebetor* Say and *Bracon didemie* Beyarslan) were also recorded from Turkey (Doğanlar & Yiğit, 2011).

The family Eulophidae with over 4500 species and 332 genera have been known as parasitoids of many insect families, including several species the leaf-miners both in Lepidoptera and Diptera (Noyes, 2021). Eulophidae are either ectoparasitoids or endoparasitoids and mostly parasitize the larvae of other insects, specifically those belonging to the orders Lepidoptera, Coleoptera, Diptera and Hymenoptera. They are environmentally and economically important (Yefremova et al., 2007), and some species are considered as biological control agents for a wide spectrum of pest insects. Little is known about Eulophidae of Syria (only 26 species on different hosts) (Noyes, 2021), with no records as parasitoids of the tomato leaf-miner. This survey revealed the existence of an active eulophid parasitoid that heavily attacks the population of *T. absoluta*.

**MATERIAL AND METHODS**

The samples of infested tomato plants by tomato leaf-miner, *T. absoluta* were collected from a greenhouse and fields from March to October of the years 2019 to 2021. Collections were done from four localities in Latakia (Jableh-Bet Yashowt, Alaamronie, Jableh-Snouber Jableh) and Tartus provinces (Baniyas-Hrison) (Fig. 1). All the collected samples were transferred to the laboratory (Agricultural Research Centre in Latakia) for rearing and further studies. The parasitized larvae of *T. absoluta* were placed in glass tubes and closed with cotton until the emergence of adult parasitoids. Obtained parasitoids were identified using the available keys (Askew, 1968; Bouček, 1988; Khan et al., 2005). The identification was confirmed by Alex Gumovsky (National Academy of Sciences of Ukraine, I. Schmalhausen Institute of Zoology). The percentage of parasitism was calculated using the following formula (Qureshi et al., 2009).

\[
\text{Parasitism rate (％)} = \frac{\text{no of Emerged parasitoids}}{\text{no of Emerged host} + \text{no of Emerged parasitoids}} \times 100
\]

The voucher specimens are deposited in the collection of the General Commission of Scientific Agricultural Research (GCSAR), Damascus, Syria. Twenty specimens were dissected and mounted in Canada balsam on slides following the method of Noyes (1982). Images were taken with a stereomicroscope equipped with a computer-attached camera, and a Nikon-Eclipse 80i Digital microscope (40X) equipped with Camera Nikon E8800.
RESULTS
Order Hymenoptera
Family Eulophidae
Subfamily Eulophinae
Genus *Stenomesius* Westwood, 1833

Diagnosis (Female). Funicle 4 -segmented, club 2 or 3 -segmented; mandible developed; pronotum without transverse carina; mesoscutellum with sublateral grooves; propodeum medially with X- or H-shaped carinate; hind tibial spurs normal; petiole shorter than hind coxa, gaster usually elongate.

*Stenomesius japonicus* (Ashmead, 1904)

*Sympiesomorpha japonica* Ashmead, 1904:163, Holotype ♀, USNM, Japan.

**Material examined:** 200♀, 200♂, Syria, Latakia province, 20♀, 10♂, Bet Yashowt (35°19′01″N, 36°07′49″E), 50♀, 10♂, Alaamronie (35°47′N, 35°31′E), 150♀, 75♂, Snouber Jableh (35°53′12″N, 35°28′31″E); Tartus province, 50♀, 35♂, Hrison (35°55′N, 35°08′E), in May to August of the years 2019 to 2021, ex *Tuta absoluta* on Tomato, leg.: R. Muhsen Youssef.

**Diagnostic morphological characters. Female.** Body length 1–1.5 mm.

**Colour:** Face yellow; vertex black; scape yellow, pedicel and flagellum dark brown; antenna 9 -segmented with two anelli, four funiculurs, and three clavomeres; funiculurs subequal in length; mandibles, gena, pronotum, mesoscutum, and axillae yellow, mesoscutellum black; propodeum yellow, with carina blackish brown (Fig. 2); wings hyaline, legs yellow, gaster yellowish with apex, lateral margins, lateral sides dark brown, and with dark brown spot on median part, ovipositor dark brown (Fig. 2).

**Head.** Frons and vertex smooth and shiny, malar sulcus present and straight, fronto-facial suture absent, antenna inserted at above the lower eye margins and on the middle distance between anterior ocellus and lower clypeus margin, scape exceeding level of vertex.

Figure 1. Collection localities for Eulophid specimens in Syria: Latakia and Tartus provinces.
Stenomesius japonicus in Syria

Figure 2. Stenomesius japonicus (Ashmead, 1904). A. Pupa; B. Larve of S. japonicus on larve of Tomato leaf-miner, T. absoluta; C. Adult, general habitus, dorsal view; D. Propodeum, dorsal view (Slide mounted in Canada Balsam), indicating a double X- or H-shaped carinae.

Mesosoma. Axillae and scutellum shiny, pronotum without transverse carina; mesoscutellum with sublateral grooves; propodeum smooth with a double X- or H-shaped carinae; mesoscutellum with one pair of setae; sublateral grooves meeting each other medially on posterior margin; forewing hyaline and speculum absent; stigma hyaline, with three setae or more on submarginal vein, cubital vein straight, length of postmarginal vein very long, more than two times the length of stigmal vein.

Legs. Yellow, tibial spurs short, with tarsus 4 tarsomeres, claws yellow.

Metasoma. Petiole short, gaster elongate and longer than mesosoma; ovipositor black brown, and exserted beyond apex of gaster.

Male. Body length is 0.5 mm, head black; antenna 9-segmented with two anelli, four funiculars, and two clavomers; mesosoma 2.5× as long as gaster.

Note on biology: Host-parasitoid association between T. absoluta (Fig. 2) and S. japonicus, is recorded for the first time from Syria. Adults of T. absoluta and S. japonicus started to emerge from the infested leaves during 2019, 2020 and 2021. 300 specimens of T. absoluta and 119 specimens of S. japonicus have been obtained in 2019; 350 adults of T. absoluta and 116 specimens of S. japonicus emerged in 2020 and finally, 400 adults of T. absoluta and 165 specimens of S. japonicus emerged in 2021. The larval parasitism rate was determined to be 35% of the larval population. Stenomesius japonicus was the only parasitoid emerged from our samples.

DISCUSSION

The discovery of Stenomesius japonicus in Syria represents a new generic and species record for Syria. It was reared from larvae of the tomato leaf-miner, Tuta absoluta (Meyrick, 1917) (Lepidoptera: Gelechiidae). So far 26 species of eulophid wasps are recorded from Syria (Table 1). Stenomesius japonicus was already recorded from some other countries in the Middle East including Egypt (Urbaneja et al., 2012), and Iran (Hesami et al., 2010; Yefremova et al., 2007), but widely distributed in the eastern Palearctic region to the Oceanic and Australasian regions (Noyes, 2021). It has also occurred in T. absoluta-infested tomato crops in various European Mediterranean basin countries (Desneux et al., 2010; Urbaneja et al., 2012; Zappalà et al., 2012, 2013). Stenomesius japonicus is a solitary idiobiont ectoparasitoids of the larva of leaf-mining lepidoptera of the families Gracillariidae, Gelechiidae, Pyralidae, Tortricidae and Noctuidae (Askew & Bouček, 1968; Bouček, 1988). Further research is needed to determine its potential and efficiency as a biocontrol agent of T. absoluta.
Table 1. The known eulophid species (Hymenoptera, Eulophidae) from Syria and their host associations.

| Parasitoids                  | Host                                           | References                                      |
|-----------------------------|-----------------------------------------------|------------------------------------------------|
| Aprostocetus invidus (Domenichini) | Coccus pseudomagnoliarum (Kuwana)              | Mohamed et al. (2012)                          |
|                             | Lasioptera berlesiana Paoli                   | Viggiani & Sasso (2008)                        |
| Baryscapus sp.              | Coccus pseudomagnoliarum (Kuwana)             | Basheer et al. (2014)                          |
|                             | Coccus hesperidum (L.)                        |                                                |
| Baryscapus servadeii (Domenichini) | Traumatocampa pityocampa (Denis & Schiffermüller) | Baur (2005)                                    |
| Cirrospilus ingenuus Gahan  | Phyllocnistis citrella Stainton               | Schaufl et al. (1998)                          |
| Cirrospilus nr. Lyncus (Walker) | Phyllocnistis citrella Stainton              | Almatni & Samara (2001)                        |
| Cirrospilus quadristriatus (Subba Rao & Ramamani) | Phyllocnistis citrella Stainton              | Almatni & Samara (2001)                        |
| Cirrospilus phyllocnistoides (Narayanan) | Phyllocnistis citrella Stainton              | Almatni & Samara (2001)                        |
| Chrysocharis latifossa Hansson | Liriomyza trifoli (Burgess)                  | Hansson (1985)                                 |
| Chrysocharis longitarsus Hansson | Liriomyza trifoli (Burgess)                  | Hansson (1985)                                 |
| Dicladocerus westwoodii Westwood | Prays oleae (Bernald)                      | Baur (2005)                                    |
|                             | Liriomyza cicerina (Rondani)                  | Almatni & Samara (2001)                        |
|                             | Liriomyza trifoli (Burgess)                  |                                                |
|                             | Liriomyza huidobrensis (Blanchard)           |                                                |
| Elasmus steffani Viggiani  | Phyllocnistis citrella Stainton               | Almatni & Samara (2001)                        |
|                             | Prays oleae (Bernald)                         | Baur (2005)                                    |
| Euplectrus flavipes (Fonscolombe) | Spodoptera exigua (Hübner)                  | Zhu & Huang (2003)                             |
| Hemiptarsenus ornatus (Nees) | Liriomyza huidobrensis (Blanchard)           | Almatni & Samara (2001)                        |
| Neochrysocharis sp.         | Phyllocnistis citrella Stainton               | Alkhateeb et al. (1999)                        |
| Neochrysocharis formosa (Westwood) | Liriomyza huidobrensis (Blanchard)           | Almatni & Samara (2001)                        |
|                             | Phyllocnistis citrella Stainton              |                                                |
| Oomyzus scaposus (Thomson)  | Coccinella septempunctata L.                  | Shahadi et al. (2002)                          |
| Pnigalo spp.                | Phyllocnistis citrella Stainton               | Almatni & Samara (2001)                        |
| Pnigalo agrauleus (Walker)  | Batrocera oleae (Gmelin)                      | Almatni & Samara (2001)                        |
| Pnigalo mediterraneus (Ferriere & Delucchi) | Batrocera oleae (Gmelin)                  | Almatni & Samara (2001)                        |
| Pediobius acanthi (Walker)  | Liriomyza huidobrensis (Blanchard)           | Almatni & Samara (2001)                        |
| Quadrastichus sajoi (Szelényi) | Dasineura oleae (Loew)                       | Doğanlar (1992)                                |
| Ratzeburgiola incompleta Bouček | Phyllocnistis citrella Stainton              | Alkhateeb et al. (1999)                        |
| Sympiesis sp.               | Phyllocnistis citrella Stainton               | Almatni & Samara (2001)                        |
| Semiacher petiolatus (Girault) | Phyllocnistis citrella Stainton              | Schaufl et al. (1998)                          |
| Tetrastichus sp.            | Coccus pseudomagnoliarum (Kuwana)             | Almatni & Samara (2001)                        |
|                             | Coccus hesperidum (L.)                        |                                                |
|                             | Ceroplastes rusc (L.)                         |                                                |
| Stenomesius japonicus Ashmead | Tuta absoluta (Meyrick)                      | Current study                                  |
AUTHOR'S CONTRIBUTION
The authors confirm contribution in the paper as follows: R.M.Y. performed the work, collecting and slide-mounting the parasitoid specimens, taking the photographs, identification of specimens, and drafting. N.H.A.K. was a major contributor in writing the manuscript, reviewing & editing the paper. R.A. reviewed and edited the paper. All author(s) read and approved the final manuscript.

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AVAILABILITY OF DATA AND MATERIAL
The mentioned specimens are deposited in the private collection of General Commission of Scientific Agricultural Research, Damascus, Syria.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE
Not applicable.

CONSENT FOR PUBLICATION
Not applicable.

CONFLICT OF INTERESTS
The authors declare that there is no conflict of interest regarding the publication of this paper.

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گونه (Hymenoptera: Eulophidae) _Stenomesius japonicus_ (Ashmead) در سوریه

(Rhopalopsylla japonicus) (Ashmead)

_Hymenoptera: Eulophidae_ (Lepidoptera: Gelechiidae) _absoluta_ (Meyrick)

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چکیده: گونه (1904) _Stenomesius japonicus_ (Ashmead) _Tuta absoluta_ برای اولین بار از روش مینوز برگ گوجه فرنگی (Eulophidae) (Meyrick, 1917) (Lepidoptera: Gelechiidae) (Meyrick, 1917) در سوریه، جمع‌آوری شد. صفات مورفولوژیک افتراقی، زیست‌شناسی و انتشار گونه گزارش شده، از این دو طریق اقتضایی بیولوژیکا و تلخیفی. _T. absoluta_ باید از دسته Eulophidae گزارش شده از سوریه اراپین شد.

واژگان کلیدی: _Tuta absoluta_, Eulophidae, پارازیتویدی