Bulletin of Insectology

Research Article
Bulletin of Insectology 78 2025, 137–140
DOI 10.3897/bull.insectology.171229

New ichneumonid (Hymenoptera) parasitoids of the fig-tree skeletoniser moth, *Choreutis nemorana* (Hubner, 1799) (Lepidoptera, Choreutidae), an invasive pest to Central Europe

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Academic editor: Serena Magagnoli ♦ **Received** 5 September 2025 ♦ **Accepted** 29 October 2025 ♦ **Published** 25 November 2025

Abstract

The fig-tree skeletoniser moth, *Choreutis nemorana* (Hubner, 1799), in the course of spreading from the Mediterranean Region towards Central Europe, was first detected as a pest in Hungary in 2011. Established populations threaten fig cultivation, a newly increasing branch of horticulture, lacking any licensed pesticides. In order to investigate whether local parasitoids of the native microlepidopterous species have started to accept *C. nemorana* as a new host, we collected *C. nemorana* larvae and cocoons from various sites in Hungary and reared them on fig leaves. Levels of parasitization were recorded and emerged parasitoids were collected for identification. The overall levels of parasitization ranged from 9.4% to 52.6%. Three ichneumonid (Hymenoptera: Ichneumonidae) parasitoid species were found as new associations for *C. nemorana*: *Oiorhinus pallipalpis* Wesmael, 1845 (Ichneumoninae), *Scambus inanis* (Schrank, 1802) (Pimplinae), and *Encrateola laevigata* (Ratzeburg, 1848) (Cryptinae); the latter species is also known as a facultative pseudohyperparasitoid. *Mesochorus vittator* (Zetterstedt, 1838) (Ichneumonidae, Mesochorinae), a true hyperparasitoid, was also reared presumably from a koinobiont larval parasitoid such as *Diadegma* sp. Apart from those two already known parasitoids of *C. nemorana* were also found: *Scambus elegans* (Woldstedt, 1877) (Pimplinae) and *Diadegma* sp. (Campopleginae). These results are discussed in terms of the potential future role of local parasitoids in affecting populations of *C. nemorana*. Many parasitoids belonging to groups other than Ichneumonidae were also reared and will be the subject of later papers.

Key Words

Alien pest, beneficial parasitoids, biological control agents, *Ficus carica*, new host-parasitoid relationship

Introduction

Fig trees (*Ficus carica* L.) (Moraceae) have been planted in Hungary since the 16th century. In the past decades its popularity increased due to milder winters and relatively few known pathogens and pests. Recently, some of its pests started to appear in Hungarian orchards and gardens, like the fig-tree skeletonizer moth (also called as fig-leaf skeletonizer, or fig-leaf roller; EPPO Global Database), *Choreutis nemorana* (Hubner, 1799) (Lepidoptera: Choreutidae) (Bodor et al. 2011), the black fig fly, *Silba adipata* McAlpine, 1956 (Diptera: Lonchaeidae) (Kontchán and Medve 2024), the fig leafhopper, *Ficocyba ficaria* (Horvath, 1897) (Hemiptera: Cicadellidae) (Koczor et al. 2025a, 2025b), and the Mediterranean fig psyllid, *Homotoma ficus* (Linnaeus, 1758) (Hemiptera: Homotomidae) (Fazekas et al. 2022).

Established populations of these pests threaten fig cultivation, a newly increasing branch of horticulture in Hungary, lacking any licensed pesticides. Parasitoids, which may regulate populations of pests within the native range of occurrence, only exceptionally follow the spread of pests. More likely, some native parasitoids may accept the newly arrived alien pest as a host. In the case of the above-mentioned incoming pests of the fig, *C. nemorana* may represent the highest chance for this, regarding the longest time from settlement. Therefore, we started a survey to reveal whether local parasitoids of the native microlepidopteran species have started to accept *C. nemorana* as a new host. The first results of this survey, selecting ichneumon wasps (Hymenoptera: Ichneumonidae) are presented in this paper. The many other parasitoids reared are still under analysis (see Discussion).

Materials and methods

Timing of collections

In 2023 and 2024 fifth instar larvae of *C. nemorana* were collected from both generations, in the stage just before pupation, as well as pupae in cocoons from fig leaves in several localities of Hungary and were reared in the laboratory. As for seasonal development in Hungary, the species develops two generations. Overwintering adults became active in spring, when milder weather arrives. Females soon lay their eggs on the fig leaves, where larvae complete their development under a web. They spin a cocoon and then pupate in a fold on the leaves. The adults of the first generation are on the wing from the end of June until the end of July. The second generation's larvae feed on the host plant from July until October (Fazekas 2015); then, overwintering adults emerge from August until October. For comparison, more to the south, in Croatia, there are three generations (Maceljski 2002) and depending on latitude and climate in Russia and Central Asia there are records of three, or even four, generations per year (Aizpurúa 1997).

Collection sites

We collected larvae and pupae from fig trees situated mostly in private gardens in Pilisvörösvár (GPS: 47°61'70"N, 18°89'15"E), Gödöllő (GPS: 47°58'15"N, 19°37'56"E), Kistarcsa (GPS: 47°54'78"N, 19°25'62"E) (Pest County) and Debrecen (GPS: 47°50'69"N, 21°63'57"E) (Hajdú–Bihar County). The largest numbers, however, were collected at the experimental farm of the Hungarian University of Agriculture and Life Sciences in Szárítópuszta (Gödöllő; GPS: 47°58'16"N, 19°37'56"E). Parasitized larvae and pupae were only found in Gödöllő and Pilisvörösvár.

Handling of samples

Cocoons attached to fig leaves containing either mature larva or pupa were collected along with leaf cuttings and placed into transparent plastic containers of 30 mL at the sites, then transported to the laboratory. Leaf cuttings were kept fresh with moistened filter paper attached to the vein or stem. The surrounding web was gently dissected and the pupae were individually placed in small glass sample containers of 12 mL until hatching. The emerged parasitoids were preserved in 96% ethanol.

Taxonomy and nomenclature of Ichneumonidae follow Yu et al. (2016). The collected specimens were mounted on pinned triangular cards and were identified by the second author using a Nikon SMZ645 stereoscopic microscope. Ichneumon wasp specimens mentioned in this paper are deposited in the Hymenoptera Collection of the Hungarian National Museum Public Collection Centre – Hungarian Natural History Museum, Budapest. Host-parasitoid relationships were checked mainly through Yu et al. (2016), as well as in Shaw (2006, 2017), and Shaw et al. (2016).

Results and discussion

In the first generation of *C. nemorana* in 2023, a total of 192 cocoons were collected in Gödöllő, of which 18 were parasitized (9.4%), 3 of them were ichneumonid species which is 16.7% of the parasitized cocoons. During the second generation of the same year, 343 cocoons were collected from the same site, of which 41 were parasitized (12%), one of them was an ichneumon wasp which is 2.4% of the parasitized cocoons. From the first generation in 2024, a total of 208 cocoons were collected in Gödöllő, of them 53 were parasitized (25.5%) 9 of them were ichneumonid species which is 17% of the parasitized cocoons. During the second generation out of 38 cocoons collected in Gödöllő, 20 were parasitized (52.6%) none of them were ichneumonid species; additionally, 12 cocoons were collected in Pilisvörösvár, of them 5 were parasitized (42%), none of them were ichneumonid species. Thus, prevalence of parasitization varied by sites and years, ranged from 9.4% to 52.6%. The overall of total parasitation across all sites in course of the entire survey was 8%, while the overall parasitation accounted for ichneumonids was 1.64%.

A total of 13 cocoons were parasitized by ichneumon wasps, representing 6 species, belonging to 5 subfamilies (Campopleginae, Cryptinae, Ichneumoninae, Mesochorinae, Pimplinae). Three of these parasitoid species are new to the host *C. nemorana*: *Oiorhinus pallipalpis* Wesmael, 1845 (Ichneumoninae, 1 female), *Scambus inanis* Schrank, 1802 (Pimplinae, 1 female), and *Encrateola laevigata* Ratzeburg, 1848 (Cryptinae, 4 females). Regarding these, *O. pallipalpis* is known from other species of Choreutidae such as *Choreutis pariana* (Clerck, 1759) and *Anthophila fabriciana* (Linnaeus, 1767) (Górska-Drabik 2007; Yu el al. 2016; Shaw 2017).

Scambus inanis is known to develop in several species of Lepidoptera (Shaw 2006; Yu el al. 2016). *Encrateola laevigata* is also known to parasitize several lepidopteran hosts such as *Prochoreutis sehestediana* (Fabricius, 1777) and *P. myllerana* (Fabricius, 1794) and is also a facultative pseudohyperparasitoid (parasitising Ichneumonidae and Braconidae cocoons) (Yu el al. 2016; Shaw 2017).

Furthermore, *Mesochorus vittator* (Zetterstedt, 1838) (Mesochorinae, 2 females), a true hyperparasitoid species, was also reared in this study from cocoons of *C. nemorana*; which is also a newly recorded relation to *C. nemorana*. However, *M. vittator* is a known true hyperparasitoid developing in several braconid and ichneumonid species, including *Diadegma* Förster, 1869, of which several species develop in choreutid moths (Mustaţă and Mustaţă 2007; Yu el al. 2016; Shaw 2017) Thus, *M. vittator* undoubtedly targeted the larva of the primary parasitoid rather than that of the moth.

Previously known parasitoids of *C. nemorana* were also indentified in our samples: 3 females of *Scambus elegans* (Woldstedt, 1877) (Pimplinae) (Aubert 1958) developed in the coccons, as well as 2 males of *Diadegma* sp. (Yu et al. 2016); unfortunately, the collected *Diadegma* specimens could not be reliably identified at species level due to the lack of any female specimen in the samples, although Shaw (2017) recorded *D. armillatum* (Gravenhorst, 1829) from *C. nemorana*.

Besides ichneumon wasps, there were several other parasitoid taxa found in this study, some in large numbers. Six specimens belonged to Diptera, while the vast majority to Hymenoptera: Proctotrupoidea sensu lato (1 specimen), Braconidae (3 specimens), Bethylidae (5 specimens), and Chalcidoidea (more than 100 specimens). The identification of these taxa is ongoing.

Previous studies documented several other parasitoids of *C. nemorana*, representing various taxa (see e.g., Bouček and Askew 1968; Cuscianna 1927; Kara et al. 2003; Luquet 2004; Papp 2015; Shaw et al. 2016, 2017; Abdinbekova et al. 2017; Fazekas 2019; Kavallieratos et al. 2019), not (or not yet) found or identified from our samples.

Summing up the results, several parasitoid species accept the invasive *C. nemorana* as host in Hungary. Some of these parasitoids were not known within the original range of distribution of *C. nemorana*, while some others were. Many parasitoids known from the Mediterranean area have not been found in the recent study. Further sampling will be needed to reveal their possible occurrence in Hungary. Although the highest parasitation level recorded in this study reached 50%, this value results from gradual accumulation over more than a decade following the pest's establishment. This suggests that parasitoids may not be expected to provide an efficient control of this upcoming pest in the future. In combination with new environmentally safe, species-specific control methods to be developed in the future, like those based on sex pheromones or host plant kairomones, parasitoids could make a contribution to control this pest, in the frame of integrated pest management.

Acknowledgements

We would like to express our thanks to the staff of the Hungarian University of Agriculture and Life Sciences experimental farm in Szárítópuszta for permitting us to collect experimental insects in their extensive fig plantation. Thanks are also due to several private garden owners for allowing us to make collections.

This research was funded partly by the stipendium from the Doctoral School of Plant Sciences at Hungarian University of Agriculture and Life Sciences and the Junior Researcher 2025 grant of HUN-REN Centre for Agricultural Research (0309B1431P) to A. Teski.

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