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Coleophoridae in the spotlight I. On some aspects of the biology of *Coleophora impalella* Toll, 1961 (Lepidoptera: Coleophoridae)

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Abstract – Eggs, larval stages and young cases of *Coleophora impalella* Toll, 1961, a little known East-European species of Coleophoridae (Lepidoptera), are documented for the first time based on a rearing experiment.

Key words – Microlepidoptera, host plant, *Galatella sedifolia*

INTRODUCTION

Coleophora Hübner, 1822 is one of the currently recognised three genera in the family Coleophoridae (Lepidoptera). A recent phylogenetic study (Bauer *et al.* 2012) downgraded two genera formerly recognised as valid, *Goniodoma* Zeller, 1849 and *Metriotes* Herrich-Schäffer, 1853, as its junior synonyms. With 643 described species it is by far the largest genus of the family in Europe, compared to the remaining genera: *Augasma* Herrich-Schäffer, 1853 with three species and *Isophanes* Meyrick, 1891 with four species included (Rennwald & Rodeland 2021).

Knowledge on the biology of *Coleophora* species is rather limited. The species in the genus utilise a broad spectrum of host plants in the families of Poaceae, Asteraceae, Fabaceae, Betulaceae, Lamiaceae, Rosaceae, Amarantheaceae, Caryophyllaceae, Rhamnaceae, Juncaceae, Ericaceae, and Cistaceae; however, the host plants of many species are still unknown (Baldizzone 2019).

First instars are generally endophagous, mining in the leaves, flowers and seeds of their host plants. Later the larvae build a case that is attached to the plant when the larvae are feeding, and it is replaced or enlarged during the development

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(Hering 1951). The larvae of some species leave their cases when preparing mines, whereas others mine without leaving the case. Leaf-miner species make patch mines, which are visible on both sides (Emmet *et al.* 1996). There is a small, round hole where the larva enters the leaf (Figs 1, 1a).

Cases of *Coleophora* species include spatulate leaf cases (Fig. 2), composite leaf-cases (Fig. 3), sheath cases (Fig. 4), tubular silk cases (Fig. 5), seed cases (Fig. 6), tubular leaf-cases, lobe cases, and pistol cases (Hering 1951, Szőcs 1977, Emmet *et al.* 1996). In many species, however, the cases have still not been observed and described. One of these is *Coleophora impalella* Toll, 1961, a rarely collected or observed species restricted to the south-eastern part of Europe and only recently discovered in Hungary (Baldizzone & Tokár 2008).

Coleophora impalella was described from southern Russia based on a male specimen (Toll 1961). The first female was found much later at the middle reaches of the Volga River and described by Anikin (2004). Another population was found in the Karadag Nature Reserve in the Crimea (Budashkin & Puzanov 2017). Outside of the former USSR this moth occurs in Hungary, where adults of both sexes and cases were found at Bélmegyer (Békés County), near Szabadkígyós (Békés County), and in the vicinity of the village Elek (Békés County), and also in Romania, in the surroundings of Grăniceri (Arad County). The adults (Figs 14–15) are diurnal and hardly attracted by artificial light. They fly from mid-April to mid-May in sunny weather (Szabóky *et al.* 2009). Recent studies found that the primary host plant of the species in Hungary is *Galatella sedifolia* (L.) Greuter 2003 (Asteraceae) (Takács *et al.* 2022). Copulation takes place usually between 11 a.m. and 1 p.m. Preliminary observations indicated that a few larvae may resume feeding following overwintering, when the first leaves of the host plants appear (A. Takács, unpublished). Further details of the life history of *Coleophora impalella* and its developmental stages including the egg and young cases have remained unknown.

The present paper reports on the larval development and phenology of the species. Different early stages and their characteristic morphological features as well as some aspects of the life history of the species are documented.

MATERIAL AND METHODS

We performed a rearing experiment in 2022 to examine and document all developmental stages of *Coleophora impalella*. Eggs were acquired from captured gravid females that were transferred to the experimental garden of one of the authors where host plants were cultivated. Larvae hatched from the same egg batch were reared on a separate host plant, protected from parasitoids by mesh bags attached to the plants, which also prevented the larvae from escaping.

Larvae on each plant were counted weekly by removing the mesh bags; the bags were cleaned before placing them back on the plants. Morphological features were recorded for each developmental stage; measurements were taken under using a dissecting microscope provided with a calibrated ocular micrometer; cases and leaf damages were photographed using a Canon 450 D camera attached to a Carl Zeiss Stemi-2000 binocular stereomicroscope.

Figs 1–6. Typical mine and case types in Coleophoridae, 1 = patch mine of *Coleophora badiipennella* (Duponchel, [1843]), 1a = small, round holes where the larva of *Coleophora spiraeella* Rebel, 1916 entered the leaf, 2 = spatulate leaf case of *Coleophora kroneella* Fuchs, 1899, 3 = composite leaf case of *Coleophora ochrea* (Haworth, 1828), 4 = sheath case of *Coleophora conspicuella* Zeller, 1849, 5 = tubular silk case of *Coleophora thymi* M. Hering, 1942, 6 = seed case of *Coleophora oriolella* Zeller, 1849. Scale bars = 0.3 mm (Fig. 1), 0.5 mm (Fig. 2), 0.8 mm (Figs 3–4), 0.6 mm (Fig. 5), 0.4 mm (Fig. 6) (photos by Attila Takács)

RESULTS AND DISCUSSION

Case and larval behaviour

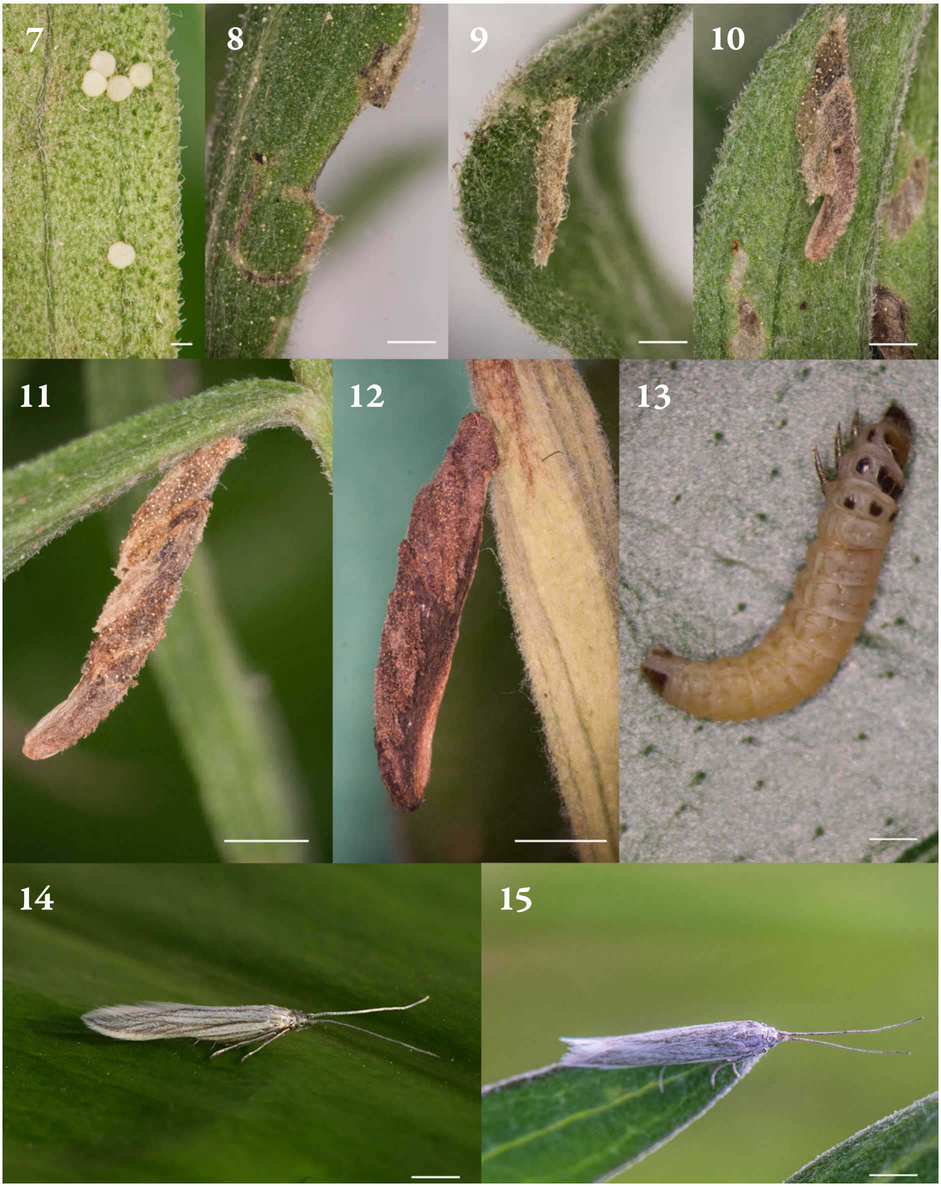
The experiment was started with two males and three females of *Coleophora impalella* collected at Szabadkígyós, Hungary, on 2 May 2022. Oviposition of the captive females began on 4 May 2022. The females laid 22, 27, and 15 eggs, respectively. They deposited all their eggs on the underside of the leaves of their host plant in groups of 2–5 eggs per leaf. The eggs were white, slightly flattened, globular, with longitudinal grooves initiating from the top centre of the egg, and 0.2×1.2 mm in size (Fig. 7).

Ten to twelve days after oviposition 48 larvae hatched from the total of 64 eggs, but only 32 of them reached L5 stage. L5 larvae kept feeding until the beginning of November. Of the 32 observed larvae, 17, 7, and 8 finished feeding by 28 and 31 October, and 2 November, respectively. After the feeding ended, the L5 instars moved from the leaves and attached themselves onto the base of the main stem of the host plant for overwintering.

L1 instars developed as endophagous miners in the mesophyll of leaves. Their mines were 20–30 mm long and wavy in shape (Fig. 8). Before the first moult, the small larvae widened the mine, which was also the first step of making the first case. They moulted in the enlarged mine, and then completed the first case (Fig. 9) as L2 instars. The case was straw-coloured, straight, 3 mm long and 0.8 mm wide.

After every subsequent moult, the new instar enlarged the case lengthwise by cutting and fastening 2–6 mm long and 2–4 mm wide strips of leaves on one another like roof tiles. The shape and colour of the case were also changed. The L3 case (Fig. 10) was 4 mm long and light brown with darker brown streaks; its posterior end conspicuously bent ventrad. The L4 case (Fig. 11) was 7 mm long with about the same colouration and a similarly bent posterior end.

The cases of the final instars (Fig. 12) were 12–14 mm long and medium brown in colour, with a lighter, oblique stripe on the ventral side close to the posterior end. The colour gradually darkened with age, eventually resembling the colour of the stem of the host plant. The posterior end was only slightly bent ventrad and was somewhat flattened, forming two valves. The longitudinal axes of the cases were directed in an angle of about 40° to the plane of the mouth. The larva (Fig. 13) was 5.5–6 mm long with characteristic black thoracic shields (Takács *et al* 2022).



Figs 7–15. Stages of the development of *Coleophora impalella* Toll, 1961, 7 = eggs on the leaf of *Galatella sedifolia*, 8 = the mine and the placement of the first case are visible on the leaf, 9 = case of the L2 larva, 10 = case of the L3 larva, 11 = case of the L4 larva, 12 = case of the L5 larva, 13 = full-grown caterpillar ready to overwinter, 14 = male imago on the host plant, 15 = female imago on the host plant.
Scale bars = 0.6 mm (Figs 7–8, 12, 14), 0.5 mm (Figs 9–10, 13), 0.8 mm (Fig. 11), 0.4 mm (Fig. 15) (photos by Csaba Szabóky (Fig. 14), Gusztáv Boldog (Fig. 15), Attila Takács (Figs 7–13))

Habitat

The species was found in Hungary only in xero-mesic meadows on moderately alkaline soil where *Galatella sedifolia* grows. The habitat is typically moist early in the season, becoming very dry by late summer. The vegetation (*Peucedano–Asteretum sedifolii* Soó 1947 corr. Borhidi 1996) is characterised by erect forbs, mainly umbellifers, accompanied by a number of tallgrass and bunchgrass species and herbs of mesic meadows and dry steppes. This type of vegetation is characteristic of the Hungarian forest steppe and is broadly distributed in the Eurasian steppe zone from Hungary to the foot of the Altai Mountains and the Dzhungarian Alatau with similar structure and appearance and many related, vicarious species (Borhidi *et al.* 2012).

Coleophora impalella was one of the least known species of the genus that occurs in East Europe. Only the adults and L5 instars were collected or observed so far. The identification of its host plant (Takács *et al.* 2022) provided the opportunity to obtain further information on its development. To our knowledge, this work is the first to provide information on the immature stages (eggs and young cases) of the species.

The data reported here were obtained from a rearing experiment, and therefore may not fully correspond to the natural situation. We still do not know, for instance, if females would deposit all their eggs on the same plant or would use several plants under natural conditions. Similarly, the number of hatched eggs and larvae reaching the L5 stage may be much lower under natural conditions, owing to the presence of predators and parasitoids.

Coleophora impalella is not the only case-bearer species that utilises *Galatella sedifolia* as a host plant. It shares the plant with several other leaf-mining species of the genus, such as *Coleophora conspicuella* Zeller, 1849, *Coleophora frankii* Schmidt, 1886, *Coleophora galatellae* M. Hering, 1942, *Coleophora linosyridella* Fuchs, 1880, *Coleophora pseudoditella* Baldizzone & Patzak, 1983, and *Coleophora ramosella* Zeller, 1849 (Baldizzone 2019). The range of host plants these species utilise varies. *Coleophora impalella* seems to be strictly monophagous, at least in Hungary (Takács *et al.* 2022). Although it has been found also on *Galatella linosyris* (L.) Rchb. fil 1853, only if *Galatella sedifolia* was also present in the habitat. Others are oligophagous and feed also on the closely related *Galatella linosyris* (*Coleophora galatellae*, *Coleophora pseudoditella*, *Coleophora frankii*), or in addition to these, even on *Tripolium pannonicum* (Jacq.) Dobrocz. 1962 (Asteraceae) (*Coleophora linosyridella*) (Baldizzone 2019). *Coleophora conspicuella* and *Coleophora ramosella* are polyphagous on a number of plant species in different genera (*Aster amellus* L. 1753, *Bellis perennis* L. 1753, *Centaurea* sp., *Galatella* sp., *Solidago virgaurea* L. 1753) (Baldizzone 2019). Based on the available information (Baldizzone 2019) and our personal observations, *Galatella sedifolia* is not the primary host plant for most of these species in Hungary.

Our work shed light on developmental features of *Coleophora impalella* that distinguish this species from several of its congeners utilising *Galatella sedifolia*. Whereas the eggs of *Coleophora impalella* begin development after deposition, egg development in *Coleophora conspicuella*, *Coleophora galatellae,* and *Coleophora linosyridella* is delayed for several weeks. As a consequence, the larvae of the latter three species enter the winter only as L1 or L2 instars and continue feeding and development in the spring (A. Takács, unpublished). In contrast, *Coleophora impalella* overwinters as L5 instars and only a few larvae resume feeding next spring. As L5 instars pupate earlier, the adults fly 2–3 weeks before the other species (Takács *et al.* 2022).

We also presented morphological features of *Coleophora impalella* including colour, shape and size of cases of the different instars, which may further facilitate recognition and correct identification of this species. This knowledge may be particularly useful for field workers who wish to find the species in areas where its geographical distribution is poorly known.

*

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