ENTOMOLOGY

First record of Microctonus brassicae in Czechia, a potential biological control agent against a primary oilseed rape pest

T. Hovorka

Department of Plant Protection, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Czech Republic

Abstract

After the ban on treating oilseed rape seeds with neonicotinoids in European Union, cabbage stem flea beetles (Psylliodes chrysocephala Linnaeus, 1758) again became one of its main pests. In Czechia, the impact of this pest increases every year, given with the narrowing spectrum of suitable insecticides and growing damage to oilseed rape plants in autumn. Based on this scenario, it is appropriate to look for alternative options to control oilseed rape pests. One option could be supporting beneficial organisms. One of these organisms is the hymenopteran braconid parasitoid Microctonus brassicae (Haeselbarth, 2008), which parasitizes adult cabbage stem flea beetles. Its occurrence has now been confirmed outside Great Britain in Czechia and continental Europe respectively. Five male specimens of M. brassicae emerged from 50 collected adults of cabbage stem flea beetle by sweep netting from two localities in central Bohemia. This parasitoid of adult cabbage stem flea beetles and its larval parasitoids probably play an important role in the life cycle and population dynamics of this pest. Current knowledge about the biology, taxonomic classification and identification of this parasitoid is summarized in this paper.

Introduction

The cabbage stem flea beetle (CSFB), Psylliodes chrysocephala, Linnaeus 1758 (Coleoptera: Chrysomelidae), is currently a major pest of winter oilseed rape (Brassica napus var. oleifera M.) in Europe (Heimbach and Müller, 2013; Stará and Kocourek, 2019). Under central European conditions, this pest has one generation within a year (Williams, 2010). Adults feed on cotyledons and stems or perforate the first true leaves of emerging oilseed rape plants and other cruciferous crops (Kaufmann, 1941).

To keep the CSFB below the harmful threshold, only prepatation with the active substance lambda-cyhalothrin or other pyrethroid insecticides (deltamethrin and cypermethrin) can currently be used in Czechia (Stará and Kocourek, 2019). However, the use of pyrethroids should not be continuous to avoid selection of resistant populations, as is now the case in Great Britain (Willis et al., 2020). Neonicotinoid insecticides such as thiacloprid, which have been traditionally used, have shown to be insufficiently effective under Czech conditions. During 2015-2018, at least two populations of CSFBs (Prague and Potechy) showed tolerance to thiacloprid. Nevertheless, neonicotinoids are no longer directly approved for protection against CSFBs in European union (Stará and Kocourek, 2019). Thus, with the growing importance of this pest and the narrowing range of usable insecticides, farmers’ interest in new CSFB control options is also growing. Given these circumstances, it is necessary to obtain more knowledge about the life cycle of this pest, its natural enemies (parasitoids) and their biology to create a supporting strategy for this important natural regulation system, which in the future could remain the only option for CSFB control. Before proceeding with chemical protection, it is appropriate to use agrotechnical preventive measures, such as sowing in well-prepared soil in the agrotechnical period. With this preventative measure, farmers can achieve evenly grown vegetation. Maintaining the dynamic growth of plants by growth regulators and balancing the nutritional state of soil also have a
positive effect (Gendy and Marquard, 1989). Despite these direct precautions, ecosystem services provided by beneficial organisms at essentially no cost can be used (Polasky, 2008). These organisms include hymenopteran larval and adult pest parasitoids. These organisms can be attracted to fields by creating a suitable environment for them, such as flowering belts at the edge of a field or properly maintained landscape elements (e.g., draws and borders) that provide shelter and food. The reward for farmers can be maintaining pest populations below the harmful level and, consequently, decreasing the amount of chemicals applied to their fields (Hatt et al., 2018).

To date, only five parasitoids of CSFBs larvae have been identified in Europe (Ulber et al., 2010). These larval parasitoids belong to the Ichneumonidae and Braconidae families within the Hymenopteran order, and one species of larval hymenopteran parasitoid belongs to the Chalcidoidea superfamily. Of the parasitoids attacking adult CSFBs, two species, Microctonus melanopus (Ruthe, 1856) and M. brassicae (Haeselbarth, 2008), has been identified to date. The species of M. melanopus was raised from adult CSFBs in Great Britain and France. However, its biology and taxonomic classification is unclear (Ulber et al., 2010). In addition, this species is considered to be a parasitoid of some weevil species (Coleoptera: Curculionidae; Cephalorrhyncha assimilis Paykull, 1792 (Harmon and McCaffrey, 1997); C. obstrictus Marsham, 1802 (Fox et al., 2004); C. pallidactylus Marsham, 1802 (Tobias, 1971); C. leprieuri Brisot, 1881 (Fulmek, 1968); and Hypera meles Fabricius, 1792 (Tobias, 1986)).

To date, the only confirmed parasitoid of adult CSFBs is Microctonus brassicae (Haeselbarth, 2008). This species was described in 2008 by E. Haeselbarth from Great Britain as a Periliius brassicae, and in 2016, Gavin R. Broad transferred it to the genus Microctonus (Wesmael, 1835). The only occurrence of this parasitoid has been documented in Great Britain, where it was raised from collected adult CSFBs from three localities in Norfolk County. The accuracy of its morphological identification was also genetically confirmed by Jordan et al. (2020) by the barcoding method.

The aim of this work was to determine the presence of Microctonus brassicae in Czechia for future research on this potential biological control agent.

Materials and Methods

Adult cabbage stem flea beetles were collected by sweep netting from two Czech field sites within the central Bohemia region at the end of September 2020 (Slapanice GPS: 50.3216647N, 14.1097611E and Unhoští GPS: 50.0833436N, 14.1017786E localities; date of collection: 25.9.2020). Adult CSFBs were collected from winter oilseed rape and adjacent white mustard. Fifty individuals from each collection: 25.9.2020). Adult CSFBs were collected from winter oilseed rape and adjacent white mustard. Fifty individuals from each collection maintained under controlled conditions approximately 2 months after collection (10.12.2020). Another four individuals hatched from the CSFBs during the following 20 days. All five individuals were identified as males.

Identification of Microctonus brassicae

All emerged wasp specimens were identified as Microctonus brassicae (Haeselbarth, 2008). This is the first report on this parasitic wasp species from Czechia and continental Europe. The species belongs to the hymenopteran parasitic family Braconidae. Together with Ichneumonidae, these families form one of the most species-rich families within Hymenoptera. In nature and in man-made ecosystems (agroecosystems), they are important natural regulators of pests. M. brassicae is further classified in the subfamily Euphorinae and the genus Microctonus. This subfamily is one of the many subfamilies (236 species known in Europe; de Jong Yde et al., 2021) within the Braconidae family and contains several small species parasitizing not only Coleoptera but also Hemiptera, Neuroptera, Psocoptera, Orthoptera and Hymenoptera (Quicke, 2015; Yu et al., 2016).

Male and female of M. brassicae are different in colour. According to Jordan et al. (2020), females are orange to brown, and males are predominantly black with yellow-brown legs (Figures 1 and 2). Females have 21 flagellomeres, while males have 25 to 26 flagellomeres. The mean size of the body from the head to the last metasomal segment is usually 2.5 mm in diameter, with the males being slightly larger (mean body length in males: 2.6 mm, females: 2.3 mm; Jordan et al., 2020). The genus Microctonus is characterized by two fused cells (submarginal and discal) in the front wing and an elongated first metasomal tergite (Figures 1 and 2) (Haeselbarth, 2008; Jordan et al., 2020).

Life-cycle

Microctonus brassicae is a solitary koinobiont endoparasitoid. Females lay their eggs on the pronotum or elytra, which is the most preferred site, but mouthparts and the tip of adult CSFB abdomens can also be chosen. The larva hatches from the egg and, after entering the body of the host, feeds on the haemolymph for most of its larval development (Jordan et al., 2020). Once the larva reaches its last (fifth) stage of development, it leaves the host’s body through its anus and seeks shelter (mostly underground), where it pupates in a silk cocoon (Figure 3). The adult then hatches from the cocoon (Quicke, 2015). The time to complete the whole lifecycle from oviposition in the CSFB to emergence of the adult took on average 43.5 days (Jordan et al., 2020). It is currently unknown whether adult CSFBs survive when parasitoid larvae leave their bodies. However, it is known that the larva of the parasitoid feeding on the body of the CSFB significantly affects its behaviour and, in the later stages of its development, the level of CSFB host plant (cru-ciferous plant) consumption. Cabbage stem flea beetles adults are sterile due to the presence of parasitoid larvae (Jordan et al., 2020), which also occurs in other species of the Microctonus genus (Loan and Holdaway, 1961). This fact can highly affect the future population density of pests if strongly parasitized. Thus, we will focus on this problem in the future in more detail.

Results
Figure 1. *Microctonus brassicae* male emerged from the CSFB adult (Šlapanice locality 2020): A) Overall view B) detail of fore wing venation.

Figure 2. Male of *Microctonus brassicae*: A) Whole specimen B) Detail of Mesopleuron.
Discussion and Conclusions

Braconid wasps of the genus Microctonus have been successfully used for the biological control of pests (Aeschlimann, 1983; Barratt et al., 2007). Two species can serve as an example: M. aethiopoides (Loan, 1975) and M. hyperodae (Loan, 1974). These two species were successfully introduced into New Zealand as a biological control agent of two weevil pests (Sitona discoideus Gyllenhal, 1834, and Liptronotus bonariensis Kuschel, 1955) in alfalfa pastures and graminaceous crops. For both species of parasitoids, the average parasitisation rate was over 50% (Prestidge et al., 1991; Kean and Barlow, 2000). Similar results were obtained by Jordan et al. (2020) from Great Britain in the case of M. brassicae parasitoids of CSFBs in oilseed rape. This study by Jordan et al. (2020) served as a template for this and future research. The laboratory experiments with CSFBs exceeded the average parasitisation rate by over 44%. The study also described in more detail the life cycle of this parasitoid and the possibilities of breeding and reproducing in captivity. The protocol for breeding this parasitoid in captivity, which has been successfully described, indicates the possibility of its use for biological control of cruciferous crops against CSFBs in the future. However, it is necessary to optimize laboratory breeding for the conditions in Czechia and then to test the functionality of this bioagent in practice. Another possibility of using this parasitoid in the protection of cruciferous plants outside the laboratory is the release of parasitized adult CSFBs back into nature. However, it is necessary to accurately identify parasitized adults and determine the degree of parasitism of CSFB populations (Jordan et al., 2020) across Czechia.

In this article, the first report of the occurrence of the parasitoid M. brassicae from Czechia and continental Europe is presented. The report on its occurrence shows that due to the great distance between Great Britain and Czechia and the likely widespread distribution of this species, there is potential for its use in the biological control of oilseed rape against CSFBs.

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