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Parasitoids of the Cypress Bark Beetle *Phloeosinus bicolor* (Brullé, 1832) (Coleoptera: Curculionidae) in Hungary

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Abstract: *Ecphylus caudatus* Ruschka, 1916, *Spathius phymatodis* Fisher, 1966 (both Hymenoptera: Braconidae) and *Eurytoma blastophagi* Hedqvist, 1963 (Hymenoptera: Eurytomidae) were found as new parasitoids of the invasive cypress bark beetle (CBB) *Phloeosinus bicolor* (Brullé, 1832), synonym *P. aubei* (Perris, 1855) (Coleoptera: Curculionidae: Scolytinae). *Ecphylus caudatus* and *Eurytoma blastophagi* as well as *Leluthia transcaucasica* (Tobias, 1976) (Braconidae), also reared from *P. bicolor,* are new to the Hungarian fauna. The latter parasitoid species was found to be predominant in samples of *P. bicolor* collected from galleries of CBB in Budapest in the common juniper trees *Juniperus communis* L. (Pinales: Cupressaceae) in 2015-2016. A list of parasitoid species is presented and their possible importance for controlling the pest populations is discussed.

Key words: beneficial parasitoids, horticulture, ornamental scale-leaved conifers, urban green area.

Introduction

Parasitoids of bark beetles (Coleoptera: Curculionidae: Scolytinae) have been intensely studied (for a review, see Kenis et al. 2007). However, when it comes to coniferous host trees, most studies have been focused on those parasitoids hosted by bark beetles associated with trees of the genus *Pinus*, while those hosted by species living in scale-leaved conifers (Cupressaceae) are much less studied (Lieutier et al. 2016). Natural enemies of pests of the family Cupressaceae become of interest when a new insect-host plant interaction arises, threatening these evergreen trees. Such a threat is posed to *Thuja, Juniperus, Chamaecyparis* and *Cupressus* spp. (cultivars in urban green areas) by the cypress bark beetle (CBB) *Phloeosinus bicolor* (Brullé, 1832) [synonym *P. aubei* (Perris, 1855)] (Coleoptera: Curculionidae: Scolytinae) after reaching Central Europe in the course of the expansion of its geographical range from the Mediterranean Basin northwards.

The parasitoids of CBB populations occurring in the native range have been intensely studied revealing a number of hymenopteran parasitoid species, as follows:

Bethylidae: *Cephalonomia hypobori* Kieffer, 1919 from Israel (IL) (Mendel 1986);

Braconidae: *Dendrosoter protuberans* (Nees, 1834) from IL, Romania (RO) and Turkey (TR) (Mendel & Halperin 1981, Mendel 1986, Olenici et al. 2015, Beyarslan 2015, Beyarslan et al. 2017), *Hecabolus sulcatus* Curtis, 1834 from Azerbaijan (AZ) (Abdinbekova et al. 2010, Kenis et al. 2007), *Leluthia ruguloscolyti* (Fischer, 1962) from TR and Iran (IR) (Beyarslan 2015, Beyarslan et al. 2017, Farahani et al. 2016), *L. transcaucasica* (Tobias, 1976) from Russia (RU) and TR (Lelej

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2012, Beyarslan et al. 2017), *Spathius rubidus* (Rossi, 1794) from AZ, TR and IR (Abdinbekova et al. 2010, Beyarslan 2015, Beyarslan et al. 2017, Gadallah & Ghahari 2017);

Eupelmidae: *Calosota aestivalis* Curtis, 1836 from IL (Mendel 1986, Noyes 2019), *Eupelmus carinifrons* Yang, 1996 from China (CN) (Gibson 2011), *E. pini* Taylor, 1927 from unspecified location (N/A) (Noyes 2019), *E. urozonus* Dalman, 1820 (N/A) (Noyes 2019), *Eupelmus* sp. from IL (Mendel 1986);

Eurytomidae: *Eurytoma morio* Boheman, 1836 from IT, IL and RO (Zocchi 1956, Mendel & Halperin 1981, Mendel 1986, Olenici et al. 2015, Noyes 2019), *Phleudecatoma platycladi* (Yang, 1996) (N/A) (Noyes 2019);

Pteromalidae: *Callocleonymus chuxiongensis* (Yang, 1996) (N/A) (Noyes 2019), *Cerocephala eccoptogasteri* Masi, 1921 from IL (Mendel & Halperin 1981, Mendel 1986, Noyes 2019), *C. cornigera* Westwood, 1832 from RO (Tudor 1969, Noyes 2019), *Cheiropachus quadrum* (Fabricius, 1787) from RO (Tudor 1969, Noyes 2019), *Dinotiscus colon* (L., 1758) from RO and IR (Tudor 1969, Lotfalizadeh & Khalgani 2008, Noyes 2019), *Heydenia pretiosa* Forster, 1856 from IL (Mendel 1986, Noyes 2019), *H. scolyti* Yang, 1996 (N/A) (Noyes 2019), *Macromesus brevicornis* Yang, 1996 (N/A) (Noyes 2019), *Metacolus sinicus* Yang, 1996 (N/A) (Noyes 2019), *M. unifasciatus* Forster, 1856 from IT, IL and RO (Zocchi 1956, Mendel 1986, Olenici et al. 2015, Noyes 2019), *Notanisus gracilis* (Yang, 1996) (N/A) (Noyes 2019), *Raphitelus maculatus* Walker, 1834 from IL (Mendel & Halperin 1981, Mendel 1986, Noyes 2019), *Theocolax phloeosini* Yang, 1989 from CN (Yang 1989, Noyes 2019);

Eulophidae: *Entedon ergias* Walker, 1839 (N/A) (Kenis et al. 2007) and *Tetrastichus cupressi* Yang, 1996 (N/A) (Noyes 2019).

Very little is known about parasitoids of CBB populations in the parts of its range where it has recently expanded, though the colonisation of new areas is a slow process, often continuing over decades. A pioneering study was published by Olenici et al. (2015), reporting on three parasitoid species of CBB located in Solca, NE Romania, east from the Carpathian Mountain range (see data on the above list).

In a recent study aiming at revealing the life-cycle and biology of CBB in Hungary, the overall level of parasitation of mature larvae was found to be as high as 70%, with most of the parasitoids developing to adults and leaving the galleries later in the same season, while only 7% of the parasitised larvae overwintered inside the galleries (Bozsik & Szőcs 2017). However, taxonomic identification of parasitoid species was not reported in that study. Here we report on the first results of a survey of revealing parasitoids of CBB in Hungary, where colonisation of CBB has been intensified in the past decades.

Materials and Methods

Branches or trunks of *Juniperus communis* with reproductive galleries of CBB were collected in 2015 at the Experimental Station of the Plant Protection Institute (PPI), near Budapest, Hungary (GPS 47.5478835 N, 18.9353656E), at the end of the breeding season of CBB. The galleries were isolated together with the pieces of branches or trunks of declining (wind broken) host trees. Isolates were kept in cages under natural conditions till the end of December, then were gradually warmed up, first at +6 to +10°C, then finally to 26°C, 18/6 photoperiod and humidified laboratory conditions. Emergence of parasitoids was monitored daily in the laboratory, adult parasitoids were then collected and preserved in 70 % ethanol for taxonomical identifications.

Identification of parasitoids was based on the external morphology of reared adult wasps, using a Leica MZ6 stereomicroscope for observations. The following identification keys were used: families (Goulet & Huber 1993), Braconidae (Tobias 1986), Pteromalidae (Graham 1969), Eurytomidae (Chalcidoidea) (Zerova 1995).

Results

Seven parasitoid species emerged from CBB larvae situated in galleries of trunks of *Juniperus communis* trees collected in Hungary (Table 1). Five of them were identified to the species level while other two were identified to the family level and deposited for future species determination. Three of the identified species belonged to the family Braconidae while each of the families Eurytomidae and Pteromalidae were represented by one species. The two unidentified species represented Pteromalidae and Proctotrupidae. Three species, *Ecphylus caudidatus* Ruschka, 1916, *Spathius phymatodis* Fischer, 1966 (both Braconidae) and *Eurytoma blastophagi* Hedqvist, 1963 (Eurytomidae) were found as new parasitoids of CBB. Three species, *E. caudatus, E. blastophagi* and *L. transcaucasica* were new to the Hungarian fauna.

As for the numbers of specimens emerged from the collected samples, the dominant species was *L.*

Table 1. Hymenopteran parasitoid species of cypress bark beetle *Phloeosinus bicolor* found in this study in Hungary. Bold: new parasitoid-cypress bark beetle relations. *New to the Hungarian fauna.

Superfamily	Family	Parasitoid species	Number of adults
Ichneumonoidea	Braconidae	***Ecphylus caudatus* Ruschka, 1916 ***	1
		Leluthia transcaucasica (Tobias, 1976)*	54
		***Spathius phymatodis* Fisher, 1966**	7
Chalcidoidea	Eurytomidae	***Eurytoma blastophagi* Hedqvist, 1963 ***	2
	Pteromalidae	*Metacolus unifasciatus* Förster, 1856	3
		unidentified	5
Proctotrupoidea	Proctotrupidae	unidentified	1

transcaucasica, which substantially outnumbered the remaining species. The second most abundant species was *S. phymatodis*.

Discussion

Out of the five identified parasitoid species, three species were found to be hosted by CBB for the first time. This might be an indication that these species switched to CBB fairly recently, in the area colonised by CBB in the course of its spread and populations formed in Central Europe. Although quantitative analysis was not an objective of the present study, the low numbers recorded for these species shows that none of these parasitoids can be regarded at present as effective biocontrol agents of CBB.

Three parasitoid species of CBB found in this study are new to the fauna of Hungary. Of these, *L. transcaucasica* seems to be the most interesting species from practical point of view because it has been found more frequently in our samples. This parasitoid species has a Palaearctic distribution (Farahani et al. 2016). It has been reported also from Slovakia (van Achterberg 2019) and also as a parasitoid of several bark beetle species, including CBB (mentioned as *P. bicolor* by Gadallah & Ghahari 2017).

Another species that we have recorded, *Metacolus unifasciatus* Forster, 1856, has been recognised as a parasitoid of CBB for long time in a number of countries (Zocchi 1956, Mendel 1986, Olenici et al. 2015, Noyes 2019). Follow-up studies could verify whether the abundant population formed in Hungary may contribute to controlling the populations of CBB.

The results of this preliminary survey reveal that several parasitoid species are associated with CBB in Hungary and indicate that probably many other parasitoids could be found in more comprehensive future studies. Quantitative analysis is beyond the scope of the present study; nevertheless, *L. transcaucasica* seems to be by far the most promising parasitoid of CBB for natural control. As some of these species have been found for the first time in Hungary, their life cycles and ecology in the climatic conditions of Central Europe are unknown. Revealing details of the biology of *L. transcaucasica* and mapping its distribution in Central Europe would be important for assessing its potential for controlling CBB in the region.

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