

Hymenopterous parasitoids associated with *Phyllonorycter coryli* (Nic.) and *Phyllonorycter nicellii* (Stt.) on hazel in Poland

Edyta GÓRSKA-DRABIK*, Izabela KOT, Katarzyna GOLAN, Katarzyna KMIEĆ, Bożena ŁAGOWSKA

Department of Entomology, University of Life Sciences in Lublin, Lublin, Poland

Received: 22.12.2015 • Accepted/Published Online: 20.09.2016 • Final Version: 04.04.2017

Abstract: The parasitoid complex associated with *Phyllonorycter coryli* and *P. nicellii* (Lepidoptera: Gracillariidae) leaf miners on hazel in Poland was examined and the contribution in the parasitoid community as well as the parasitization level of two species was defined. The parasitoid community of the nut leaf blister moth, *Phyllonorycter coryli* (Nic.), and the red hazel midget, *Phyllonorycter nicellii* (Stt.), was studied in three localities situated in Lublin. At each locality, leaves with visible mines were collected from the shrubs *Corylus avellana* L. and *C. maxima* Mill. cv. 'Purpurea'. Of the 518 larvae and pupae of *Ph. coryli*, 47 individual of parasitoids were obtained. However, 152 individuals of parasitoids from 898 mines of *Ph. nicellii* successfully emerged. The highest contribution in the parasitoid complex of both leaf miner species was found for the chalcidoid family Eulophidae. The parasitoid community of *Ph. coryli* was made up of 11 species, 7 of which had not been recorded from this host before. Thirteen parasitoid species were reared from larvae and pupae of *Ph. nicellii*, 8 of which were recorded for the first time. The species from the genus *Chrysocharis* had the greatest contribution in the parasitoid community of *Ph. nicellii*, while *Pediobius saulius* Walk. was dominant in the parasitoid fauna of *Ph. coryli*.

Key words: *Phyllonorycter coryli*, *Phyllonorycter nicellii*, Eulophidae, Gracillariidae, parasitoid complex, natural regulation

1. Introduction

Leaf miners are a large, highly specialized trophic group treated as parasites whose larvae feed inside the plant tissue. Often they are classified by the shape of the mine that they create. Many leaf-mining species are an important and conspicuous element of insect fauna, and plenty of them are known as pests of fruit trees and shrubs (Buszko, 1990). Of significant interest of this group are the *Phyllonorycter* species, the dominant genus of the family Gracillariidae (Lepidoptera). Mostly woody plants have been reported as their hosts, with the Fagaceae, Betulaceae, and Salicaceae especially favored (Beiger, 2004).

In Poland, 22 species of leaf miners are known to feed on hazel leaves. Two of them are from the genus *Phyllonorycter*, namely *Ph. coryli* (Nicelli 1851) and *Ph. nicellii* (Stainton 1851) (Beiger, 2004). They feed on the leaves of the common hazel (*Corylus avellana* L.) as well as on the purple-leaved hazel (*Corylus maxima* Mill. cv. 'Purpurea'), which is frequently planted as an ornamental in gardens and urban environments (Dimič, 1971; Gantner et al., 2005; Górska-Drabik and Gantner, 2005, 2006). *Ph. coryli* is an upper-side miner (Askew and Shaw, 1974) and its mine begins as a small silvery spot; then the chamber increases and the skin folds. In turn, *Ph. nicellii* is

an under-side miner and the mine is not too large, heavily bulging with a marbled pattern (Beiger, 2004).

Phyllonorycter leaf-miners are great subjects for examining the interaction between phytophagous and parasitoids (Askew and Shaw, 1974; Shaw and Askew, 1999; Stojanović and Marković, 2005; Yefremova and Mishchenko, 2008; Marković and Stojanović, 2012). In Poland so far, 55 parasitoid species of *Phyllonorycter* have been found. They are strongly represented by Chalcidoidea belonging to Hymenoptera (Vidal and Buszko, 1990; Marczak and Buszko, 1993; Sawoniewicz and Buszko, 1994). This paper identifies the complex of Hymenoptera parasitoids attacking *Ph. coryli* and *Ph. nicellii*, and defines their contribution in the parasitoids community as well as the level of their parasitization.

2. Materials and methods

2.1. Study area

Hazel leaves infested by *Ph. coryli* and *Ph. nicellii* were collected in 2002 and 2003 at the following three localities situated in Lublin (Poland) (22°34'E, 51°14'N):

1 - in a church garden, where the hazel shrubs grew in the vicinity of other ornamentals,

* Correspondence: edyta.drabik@up.lublin.pl

2 - in the area of the Open Air Village Museum, where the shrubs of hazel grew along a path between the houses; around them different species of vegetables and blooming ornamental plants grew,

3 - near a very busy route to Warsaw, where the hazel grew.

No chemical treatments were used in any of the sites.

2.2. Methods

At each locality, five *C. avellana* and *C. maxima* cv. 'Purpurea' shrubs were selected at random, from which leaves, accessible at arm's length and with visible mines, were collected. The infested leaves were collected every 10–14 days from June to October, resulting in a total of 579 mines of *Ph. coryli* and 1490 mines of *Ph. nicellii*. *Phyllonorycter* species were identified on the basis of the mine using the keys published by Hering (1957) and Beiger (2004). All the colonized mines were placed in petri dishes and then reared using Borkowski's (1969) directions. When there were a few mines on a single leaf, they were cut from the larger piece of the leaf and individually placed in a petri dish. The emerged adult moths and parasitoids were collected, killed with ethyl acetate, prepared, and identified. All the parasitoids reared were identified using the keys published by Tobias (1986) and Trjapitzin (1978). The parasitoid nomenclature was verified after Noyes (2003). The obtained Hymenoptera specimens are kept at the Department of Entomology, University of Life Sciences in Lublin (Poland).

2.3. Data analysis

All obtained parasitoids were counted, and then the relative abundance of species in the parasitoid complex of *Ph. coryli* and *Ph. nicellii* was determined. The parasitization level (C) of the leaf miners by particular parasitoid species was defined.

To compare parasitoid community of *Ph. coryli* and *Ph. nicellii* the Renkonen similarity index was calculated as

$$S_R = \sum_i \min(p_{1i}, p_{2i}),$$

where

p_{1i} is frequency of species i in community 1,

p_{2i} is frequency of species i in community 2 (Balmer, 2002).

This index ranges from 0 to 1 (\pm SE). If species occur in both communities in the same proportions the value of the index is supposed to be close to 1.

3. Results

Of the 518 larvae and pupae of *Ph. coryli*, 47 individuals of parasitoids were obtained and the contribution of parasitization was 9%. However, 152 individuals of parasitoids from 898 mines of *Ph. nicellii* successfully

emerged, and so this number was 16.9% (Table 1). A total of 14 parasitic hymenopteran species of two families were obtained from both leaf-mining species. Most parasitoids belonged to the chalcidoid family Eulophidae, while the family Braconidae included only one species and some specimens classified only to the genus *Apanteles*. Among the obtained parasitoids, 7 species can be both primary and secondary parasitoids, while only *Minotetrastichus frontalis* (Nees) is a gregarious species, as shown in Table 2.

The parasitoid complex of *Ph. coryli* consisted of 11 species, including 10 species from the family Eulophidae [*Pediobius saulius* (Walk.), *Chrysocharis pentheus* Walk., *Chrysocharis nephereus* (Walk.), *Pnigalio pectinicornis* (L.), *Pnigalio soemius* (Walk.), *Sympiesis sericeicornis* (Nees), *Sympiesis gordius* Walk., *Cirrospilus lyncus* Walk., *Cirrospilus diallus* Walk., and *Pnigalio incompletus* Bouček] and 1 species from Braconidae, *Apanteles circumscriptus* (Nees), as presented in Table 1. In this group four species are endoparasitoids, while the others are ectoparasitoids (Table 2). The ratio of ecto- to endoparasitoids was 24:23 (1:1). *Ch. pentheus*, *Ch. nephereus*, *P. pectinicornis*, *P. soemius*, *C. diallus*, *P. incompletus*, and *A. circumscriptus* had not been recorded from *Ph. coryli* before.

As presented in the Figure, *P. saulius* had the highest contribution (38.3%) in the parasitoid complex of *Ph. coryli*, which parasitized 3.4% of the host (18 host individuals were parasitized). The group of predominant species also included *S. sericeicornis* (23.4%) and *C. lyncus* (10.6%); their contribution in parasitisation was respectively, 2.1% (11 parasitised individuals) and 0.9% (5 parasitised individuals), as shown in Table 1.

Table 2 shows the parasitoid complex of *Ph. nicellii* was made up of 13 Hymenoptera species, including 12 chalcidoid species from the family Eulophidae (*P. saulius*, *Ch. pentheus*, *Ch. nephereus*, *P. pectinicornis*, *P. soemius*, *S. sericeicornis*, *S. gordius*, *C. lyncus*, *C. diallus*, *C. elegantissimus* Westwood, *M. frontalis*, and *Neochrysocharis formosus* (Westwood), and 1 species from the family Braconidae (*A. circumscriptus*). Only five parasitoids obtained from larvae and pupae of *Ph. nicellii* are endoparasitoids, while the others are ectoparasitoids, and their ratio was 97:55 (1.8:1) (Tables 1 and 2). *P. saulius*, *Ch. pentheus*, *N. formosus*, *P. pectinicornis*, *P. soemius*, *C. lyncus*, *C. diallus*, and *M. frontalis* were recorded for the first time from *Ph. nicellii* as a host.

The species of the genus *Chrysocharis* had the greatest effect on the abundance of *Ph. nicellii*. The contribution of *Ch. pentheus* in the parasitoid complex was more than twice that of *Ch. nephereus*, as shown in the Figure. Their participation in the total level of parasitism was 2.7 (24 host individuals were parasitized) and 5.9% (53 host individuals were parasitized), respectively (Table 1). The group of predominant species in the parasitoid complex of

Table 1. The contribution of Hymenoptera parasitoids associated with *Phyllonorycter coryli* (Nic.) and *Phyllonorycter nicellii* (Stt.).

Parasitoid species	<i>Phyllonorycter coryli</i> (Nic.)						<i>Phyllonorycter nicellii</i> (Stt.)					
	2002		2003		total	C (%)	2002		2003		total	C (%)
	♀	♂	♀	♂			♀	♂	♀	♂		
Chalcidoidea/Eulophidae												
Entedoninae												
<i>Pediobius saulius</i> (Walk.)	7	2	9	-	18	3.4	-	-	1	1	2*	0.2
<i>Chrysocharis pentheus</i> Walk.	-	1	-	-	1*	0.2	19	7	17	10	53*	5.9
<i>Chrysocharis nephereus</i> (Walk.)	2	-	-	-	2*	0.4	9	8	4	3	24	2.7
<i>Neochrysocharis formosus</i> Westwood	-	-	-	-	0	0.0	3	-	-	-	3*	0.3
Eulophinae												
<i>Pnigalio incompletus</i> Bouček	1	-	-	-	1*	0.2	-	-	-	-	0	0.0
<i>Pnigalio pectinicornis</i> (L.)	-	2	-	-	2*	0.4	-	2	-	2	4*	0.4
<i>Pnigalio soemius</i> (Walk.)	-	1	-	1	2*	0.4	-	6	-	3	9*	1.0
<i>Sympiesis sericeicornis</i> (Nees)	3	7	-	1	11	2.1	2	4	1	9	16	1.8
<i>Sympiesis gordius</i> Walk.	-	-	1	-	1	0.2	4	-	-	-	4	0.4
<i>Cirrospilus lyncus</i> Walk.	2	3	-	-	5	0.9	3	1	1	-	5*	0.6
<i>Cirrospilus diallus</i> Walk.	1	-	-	-	1*	0.2	1	-	-	-	1*	0.1
<i>Cirrospilus elegantissimus</i> Westwood	-	-	-	-	0	0.0	1	-	-	-	1	0.1
Tetrastichinae												
<i>Minotetrastichus frontalis</i> (Nees)	-	-	-	-	0	0.0	1	3	10	1	15*(15)	1.7
Ichneumonoidea/Braconidae												
Microgastrinae												
<i>Apanteles</i> spp. (Nees)	-	-	1	-	1	0.2	-	-	4	-	4(4)	0.4
<i>Apanteles circumscriptus</i> (Nees)	1	-	1	-	2*	0.4	1	-	8	2	11	1.2
Total	17	16	12	2	47	9.0	44	31	46	31	152	16.9

C – contribution to parasitization * – new parasitoid species for the host () – number of hosts parasitized

Ph. nicellii also included *S. sericeicornis* and *M. frontalis* as shown in the Figure.

Both in the parasitoid complex of *Ph. coryli* and *Ph. nicellii*, the proportion of females was higher than of males and the sex ratio was 29:18 (1.6:1) and 90:62 (1.5:1), respectively (Table 1).

Renkonen's similarity between the parasitoid community of *Ph. coryli* on the upper surface and *Ph. nicellii* on the under surface was 0.376 (± 0.007). This low value indicates that relative species abundance was not similar among communities. The species belonging to the genus *Chrysocharis* made up a greater part of the parasitoid

complex of under-side mines, while *P. saulius* was dominant in the parasitoid fauna of upper-surface mines.

4. Discussion

In Poland so far about 140 parasitoid species of mining moths have been found. They are represented in particular by Chalcidoidea. Species from the families Braconidae and Ichneumonidae are less numerous (Vidal and Buszko, 1990; Marczak and Buszko, 1993; Sawoniewicz and Buszko, 1994). The parasitoids obtained are typical for leaf miners, but many of them were not reported from the studied *Phyllonorycter* species before.

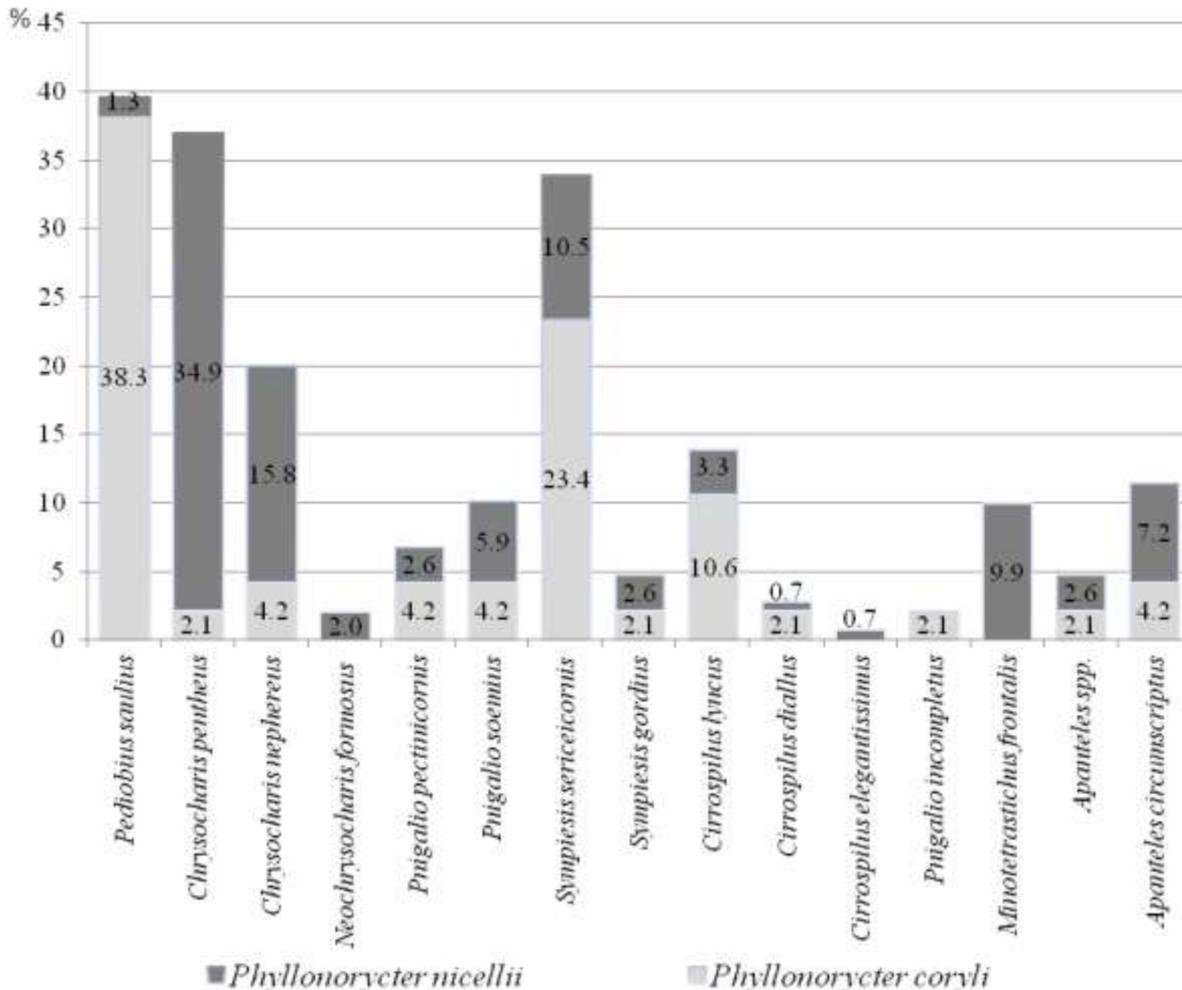


Figure. Relative abundance of species in the *Phyllonorycter* parasitoid complex.

In the present study, the Hymenoptera community was most numerously represented by the family Eulophidae (13 species), while from Braconidae only one species was stated. Many previous reports confirmed the great contribution of parasitic Hymenoptera from the family Eulophidae in reducing the number of leaf-mining moths. According to Gates et al. (2002), as much as 80% of leaf miners parasitoids are representatives of Eulophidae. They appear in especially great numbers in apple orchards, where mining pests occur, mainly *Stigmella malella* (Stainton 1854) and *Phyllonorycter blancardella* (Fabr.) (Olszak, 1992). So far, 8 species of parasitic Hymenoptera have been recorded from *Ph. coryli*, namely *Chrysocharis laomedon* (Walk.), *C. lynceus*, *Elachertus inunctus* Nees, *Pediobius alcaeus* (Walk.), *P. saulius*, *S. gordius*, *S. sericeicornis* (Noyes, 2003), and *Chrysocharis phryne* (Walk.) in Poland (Vidal and Buszko, 1990). On the other hand, a complex of 12 parasitoid species of *Ph. nicellii* was reported: *Achrysocharoides splendens* (Delucchi), *Ch.*

laomedon, *Ch. nephereus*, *E. inunctus*, *S. gordius* (Noyes, 2003), *Achrysocharoides atys* (Walk.), *S. sericeicornis*, *Minotetrastichus frontalis* (syn. *Tetrastichus ecus*), *Cirrospilus elegantissimus*, *Prugalis longulus* (Zetterstedt), *S. gordius*, and *P. alcaeus* in Poland (Vidal and Buszko, 1990). The present study identified seven new parasitoid species associated with *Ph. coryli* and eight new species associated with *Ph. nicellii* as a host.

Among the parasitoids obtained, *Ch. pentheus*, *P. pectinicornis*, *P. soemius*, and *C. diallus* were not earlier reported from either *Phyllonorycter* species. *Ch. pentheus* is a solitary endoparasitoid of different leaf miners from Diptera and Coleoptera, mainly however, of Lepidoptera from the Nepticulidae and Gracillaridae (Trjapitzin, 1978; Hansson, 1985). It was reported from *Stigmella floslactella* (Haw.) (Szczepański, 1983), *Fomoria (Ectoedemia) septembrella* (Stt.), *Leucoptera laburnella* (Stt.), *L. listratella* (H-S), *Ectoedemia agrimoniae* Frey (Vidal and Buszko, 1990), *Lyonetia clerkella* (L.) (Adachi, 1998), and *Phyllocnistis*

Table 2. Parasitoids recorded from *Phyllonorycter coryli* (Nic.) and *Phyllonorycter nicellii* (Stt.) and their status (according to the literature data).

Species	Status ^a					
	Primary	Secondary	Endoparasite	Ectoparasite	Solitary	Gregarious
Chalcidoidea/Eulophidae						
Entedoninae						
<i>Pediobius saulius</i> (Walk.)	+	+	+		+	
<i>Chrysocharis pentheus</i> Walk.	+	+	+		+	
<i>Chrysocharis nephereus</i> (Walk.)	+		+		+	
<i>Neochrysocharis formosus</i> Westwood	+		+		+	
Eulophinae						
<i>Pnigalio incompletus</i> Bouček	+			+	+	
<i>Pnigalio pectinicornis</i> (L.)	+	+		+	+	
<i>Pnigalio soemius</i> (Walk.)	+			+	+	
<i>Sympiesis sericeicornis</i> (Nees)	+	+		+	+	
<i>Sympiesis gordius</i> Walk.	+	+		+	+	
<i>Cirrospilus lyncus</i> Walk.	+	+		+	+	
<i>Cirrospilus diallus</i> Walk.	+			+	+	
<i>Cirrospilus elegantissimus</i> Westwood	+			+	+	
Tetrastichinae						
<i>Minotetrastichus frontalis</i> (Nees)	+	+		+		+
Ichneumonoidea/Braconidae						
Microgastrinae						
<i>Apanteles</i> spp.(Ness)	+		+		+	+
<i>Apanteles circumscriptus</i> (Nees)	+		+		+	

^a - The status of the parasitoid species is given according to Bouček and Askew (1968), Trjapitzin (1978), Zajančkauskas et al. (1979), Noyes (2003); Mafi and Ohbayashi (2010), Stojanović and Marković (2005), Górný (1979), Elekçioğlu and Uygun (2006), Doğanlar and Yiğit (2011), Van den Berg et al. (1988); ^r - rare

citrella Stt. (Mafi and Ohbayashi, 2010). The second is *P. pectinicornis*, a solitary ectoparasitoid, which may act as either primary or secondary parasitoid. It was reared from numerous species of leaf-mining moths (Gracillariidae, Nepticulidae, Elachistidae, Gelechiidae, Lyonetidae, Tischeriidae) (Noyes, 2003). In Poland, it has been reported from *Ph. blancardella*, *S. malella*, *L. malifoliella* (Costa), *Lyonetia clerkella*, and *Callisto denticulella* (Thnbg.) (Goos, 1965; Górný, 1979; Piotrowski, 1980; Kadłubowski, 1981; Olszak, 1992; Górska-Drabik, 2007; Górska-Drabik and Napiórkowska-Kowalik, 2009). Likewise, *P. soemius* has not been reported from leaf miners colonizing hazel,

although Bouček and Askew (1968) reared it from larvae of many *Phyllonorycter* species. *P. soemius* is a polyphagous ectoparasitoid of about 90 leaf miner species and gall maker larvae of Coleoptera, Diptera, Hymenoptera, and Lepidoptera (Noyes, 2003). On the other hand, *C. diallus* develops on the larvae of numerous leaf-mining moths, mostly of Gracillariidae and Nepticulidae (Noyes, 2003). Recently it was reported from *Ph. citrella* (Lo Pinto et al., 2005), *Cameraria ohridella* Desch. & Dem. (Volter and Kenis, 2006), and *Phyllonorycter issikii* (Kumata) (Yefremova and Mishchenko, 2008). The same information corresponded to *C. lyncus*, which was reported from *Ph.*

nicellii for the first time. So far, *Ph. nicellii* has not been also reported as a host of *P. saulius*, *Neochrysocharis formosus* (syn. *Achrysocharella formosa*), or *Minotetrastichus frontalis*. The first one is a larval endoparasitoid of small moths from Gracillariidae, Bucculatricidae, Tortricidae, Yponomeutidae, and Gelechiidae, and sometimes may act as a hyperparasitoid (Trjapitzin, 1978). It can develop on larvae of many *Phyllonorycter* species, like *Ph. blancardella* (Kadłubowski, 1981; Balázs, 1997), *Ph. platani* (Staud.) (Vidal and Buszko, 1990; Marković and Stojanović, 2012), and *Ph. robiniella* (Clem.) (Stojanović and Marković, 2005). It was also obtained from *C. denticulella* (Górska-Drabik and Napiórkowska-Kowalik, 2009), *Tischeria* sp. (Nikitenko et al., 2005), and *C. ohridella* (Horváth, 2006). In turn, *N. formosus* is distributed worldwide and colonized more than 100 leaf-mining species from Coleoptera, Hemiptera, Diptera, Lepidoptera, and Hymenoptera (Noyes, 2003). *M. frontalis* is also the most common polyphagous parasitoid of various groups of leaf miners (Noyes, 2003). It was reared from *Phyllonorycter corylifoliella* (Hübner), *P. blancardella* (Tomov, 2002), *C. ohridella* (Grabenweger, 2003; Volter and Kenis, 2006; Bystrowski et al., 2008), *Ph. robiniella* (Stojanović and Marković, 2005), and *Ph. platani* (Marković and Stojanović, 2012).

Among the reared eulophid species, *Ch. nephereus* and *P. incompletus* have not been reared from *Ph. coryli* before. However, *Ch. nephereus* was reported from many leaf-mining moths, including *Ph. nicellii* (Noyes, 2003). *P. incompletus* infests leaf-mining Lepidoptera (Schauff et al., 1998). It was reported from *Ph. citrella* (Elekçioğlu and Uygun, 2006), *Ph. corylifoliella* (Mineo and Sinacori, 1998), and *Tuta absoluta* (Meyrick 1917) (Doğanlar and Yiğit, 2011).

Based on our data, *A. circumscriptus* from Braconidae is mentioned for the first time as a parasitoid of *Ph. coryli*. *A. circumscriptus* is a common solitary parasitoid of *Phyllonorycter* species and some related families of mining Lepidoptera (Nixon, 1973). It was reported as a parasitoid of numerous moth species from the families Gracillariidae and Elachistidae (Marczak and Buszko, 1993).

In the present study, the most abundant species in the parasitoid complex of *Ph. coryli* were *P. saulius* and *S.*

sericeicornis, which totally parasitized 5.5% of the host. The other 9 species obtained comprised 3.5% of the total parasitization. Likewise, the greatest share in parasitization of *Ph. nicellii* was also by two species – *Ch. pentheus* and *Ch. nephereus*, which totally parasitized 8.6%, while the other 11 species parasitized 8.2% of the host. The obtained results seem to confirm the view and the results of previous reports. They submit that the entomophagous complex usually includes one or a few species of special importance for the number regulation of the phytophagous insects. The other, often quite numerous species destroy only a small percentage of the pest population (Szmids, 1971; Szujewski, 1980; Adachi, 1998; Del Bene and Gargani, 2003; Bystrowski et al., 2008; Yefremova and Mishchenko, 2008; Marković and Stojanović, 2012).

According to Askew and Shaw (1974), the parasitoid complexes of the upper-surface and under-surface *Phyllonorycter* mines generally are qualitatively and quantitatively similar. In the present study, the relative abundance of parasitoid species was not similar among communities. The reason for this is probably the great number of parasitoid species associated with the genus *Phyllonorycter*.

In modern crop protection, where the number of used insecticides is still reduced, special attention to the role of Hymenoptera parasitoids should be paid. Their participation in natural regulation of phytophagous is indisputable. In this manuscript, we report the results of research that provides an important contribution to the knowledge extension of the Hymenoptera parasitoid complex associated with *Phyllonorycter* leaf miners on hazel. The results from our study revealed that the parasitoid community of *Ph. coryli* was made up of 11 species, 7 of which had not been recorded from this host before. Thirteen parasitoid species were reared from larvae and pupae of *Ph. nicellii*, 8 of which were recorded for the first time.

Acknowledgment

We would like to express our deep gratitude to Professor Bartłomiej Miczulski for help in identification of the parasitoid species belonging to the order Hymenoptera.

References

- Adachi I (1998). Hymenopterous parasitoids of the peach leafminer, *Lyonetia clerkella* (Linnaeus) (Lepidoptera: Lyonetiidae). *App Entomol Zool* 33: 299-304.
- Askew RR, Shaw MR (1974). An account of the Chalcidoidea (Hymenoptera) parasitising leaf-mining insects of deciduous trees in Britain. *Biol J Linn Soc* 6: 289-335.
- Balázs K (1997). The importance of parasitoids in apple orchards. *Biol Agric Hortic* 15: 123-129.
- Balmer O (2002). Species lists in ecology and conservation: abundance matter. *Conserv Biol* 16: 1160-1161.
- Beiger M (2004). Owady minujące Polski. Klucz do oznaczania na podstawie min. Bogucki Wyd. Nauk. Poznań, pp 894 (in Polish).
- Borkowski A (1969). O hodowli larw owadów minujących. *Pol J Entomol* 39: 185-190 (in Polish).

- Bouček Z, Askew RR (1968). Index of Palearctic Eulophidae (excl. Tetrastichinae). Index of Entomophagous Insects 3, Le Francois, Paris.
- Buszko J (1990). Studies on the mining Lepidoptera of Poland. X. Mining Lepidoptera of Toruń and surrounding area. Acta Zool Cracov 33: 369-452.
- Bystrowski C, Celmer-Warda K, Tarwacki G (2008). Effects of horse chestnut (*Aesculus hippocastanum* L.) site on horse chestnut leafminer (*Cameraria ohridella* Deschka & Dimič) parasytoids appearance and number in Central Poland. Forest Res Pap 69: 49-55.
- Del Bene G, Gargani E (2003). *Cameraria ohridella* Deschka & Dimic (Lep. Gracillariidae) and its natural enemies in Tuscany. Redia 86: 115-127.
- Dimič N (1971). Miner lista – štetočine lijeske. Zaštita Bibja 22: 105-113.
- Doğanlar M, Yiğit A (2011). Parasitoid complex of the tomato leaf miner, *Tuta absoluta* (Meyrick 1917), (Lepidoptera: Gelechiidae) in Hatay, Turkey. J Nat Sci 14: 28-37.
- Elekçioglu NZ, Uygun N (2006). The parasitoid complex of the citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in the East Mediterranean region of Turkey and their role in biological control. Turk J Zool 30: 155-160.
- Gantner M, Jaśkiewicz B, Górská-Drabik E (2005). Microlepidopteran hazelnut pests in Poland. Microlepidopteran hazelnut pests in central-east Poland. Acta Hort 686: 385-392.
- Gates MW, Heraty JM, Schauff ME, Wagner DL, Whitefield JB, Wahl DB (2002). Survey of the parasitic Hymenoptera on leafminers in California. J Hymenopt Res 11: 213-270.
- Goos M (1965). Owady minujące liście jabłoni na terenie woj. wrocławskiego. Część I: Niektóre zagadnienie z biologii i ekologii owadów minujących. Pol J Entomol B 39/40: 229-244 (in Polish).
- Górny S (1979). Pasożytnicze błonkówki na olszy czarnej – *Alnus glutinosa* (L.) Gaertn. w okolicach Ostródy. Pol J Entomol 49: 305-369 (in Polish).
- Górská-Drabik E (2007). Hymenopteran parasitoids of leaf-mining moths (Lepidoptera) affecting apple trees in Lublin (SE Poland). Pol J Entomol 76: 353-360.
- Górská-Drabik E, Napiórkowska-Kowalik J (2009). Parasitic Hymenoptera reared from *Callisto denticulella* (Thnbg.) (Lepidoptera, Gracillariidae). Pol J Entomol 78: 121-126.
- Górská-Drabik E, Gantner M (2005). Charakterystyka zgrupowania motyli minujących liście *Corylus maxima* Mill. cv. *purpurea*. Prog Plant Prot 45: 683-685 (in Polish).
- Górská-Drabik E, Gantner M (2006). Motyle minujące zasiedlające *Corylus avellana* L. i *Corylus maxima* Mill. cv. *purpurea*. Prog Plant Prot 46: 446-448 (in Polish).
- Grabenweger G (2003). Parasitism of different larval stages of *Cameraria ohridella*. Biocontrol 48: 671-684.
- Hansson C (1985). Taxonomy and biology of the Palearctic species of *Chrysocharis* Foerster 1856 (Hymenoptera: Eulophidae). Entomol Scand 26: 1-130.
- Hering E (1957). Bestimmungstabellen der Blattminen von Europa einschliesslich des Mittelmeerbeckens und der Kanarischen Inseln, 's-Gravenhage, 1185+221 pp.
- Horváth B (2006). Biology and parasitoid community of horse-chestnut leafminer (*Cameraria ohridella*) in Szigetköz. PhD thesis. University of West Hungary, Mosonmagyaróvár, Hungary.
- Kadłubowski W (1981). Kompleks pasożytniczy szrotówka *Lithocolletis blancardella* (F.) (Lepidoptera, Gracillariidae) w zachodniej Polsce. Pol J Entomol 51: 493-499 (in Polish).
- Lo Pinto M, Salerno G, Wajnberg E (2005). Biology and behaviour of *Cirrospilus diallus* and *Cirrospilus pictus*, parasitoids of *Phyllocnistis citrella*. Biocontrol 50: 921-935.
- Mafi SA, Ohbayashi N (2010). Biology of *Chrysocharis pentheus*, an endoparasitoid wasp of the citrus leafminer *Phyllocnistis citrella* Stainton. J Agric Sci Technol 12: 145-154.
- Marczak P, Buszko J (1993). Braconid wasps (Hymenoptera, Braconidae) reared from mining Lepidoptera. Wiad Entomol 12: 259-272.
- Marković Ć, Stojanović A (2012). Parasitoids of *Phyllonorycter platani* (Staudinger) (Lepidoptera, Gracillariidae) in Serbia. J Plant Stud 1: 79-84.
- Mineo G, Sinacori A (1998). Interrelazioni tra l'artropodofauna dell'agrumeto e quella della flora associate, B Zool Agr Bach II, 1998, 30: 313-319 (in Italian).
- Nikitenko GN, Fursov VN, Sviridov SV, Gumovsky AV, Kotenko AG, Narolsky NB, Tolkanits VI (2005). Dubova shirokominuyucha mil'ta inshchi minuyuchi luskokrili na dubi. Povidomlennya 3. Prirodni vorogi minuyuchikh shchikidnikiv duba v Ukraini ta sumizhnikh teritoriyakh, Vestn Zool 39: 35-47 (in Russian).
- Nixon GEJ (1973). A revision of the north-western European species of the vitripennis, triangulator, fratemus, formosus, parasitellae, metacarpalis and circumscriptus-groups of *Apanteles* Foerster (Hymenoptera: Braconidae). B Entomol Res 63: 169-228.
- Noyes JS (2003). Universal Chalcidoidea. [Internet]. [cited 23 July 2014]. Available from: <http://nhm.ac.uk/entomology/chalcidoids/index.html>.
- Olszak RW (1992). Parazytoidy błonkoskrzydłe (Hymenoptera - Parasitica) sadów jabłoniowych -występowanie i rola w ograniczaniu liczebności szkodników. ISK, Skierniewice, Poland (in Polish).
- Piotrowski S (1980). Występowanie i rola pasożytów szrotówka białaczka (*Lithocolletis blancardella* F.) w sadzie jabłoniowym ISiK w Prusach. Co nowego w sadownictwie 1: 33-35 (in Polish).
- Sawoniewicz J, Buszko J (1994). Gąsienicznikowate (Hymenoptera, Ichneumonidae) wyhodowane z motyli minujących (Lepidoptera) w Polsce. Wiad Entomol 13: 55-61 (in Polish).

- Schauff ME, Lasalle J, Wijesekara GA (1998). The genera of Chalcidoid parasitoids (Hymenoptera: Chalcidoidea) of citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae). *J Nat Hist* 32: 1001-1056.
- Shaw MR, Askew RR (1999). Reproductive variability in *Pediobius alcaeus* (Walker) (Hymenoptera: Eulophidae), a parasitoid of *Phyllonorycter* (Lepidoptera: Gracillariidae). *J Hym Res* 8: 127-131.
- Stojanović A, Marković Ć (2005). Parasitoid complex of *Phyllonorycter robiniella* (Clemens 1859) (Lepidoptera, Gracillariidae) in Serbia. *J Pest Sci* 78: 109-114.
- Szczepański H (1983). Bleskotki (Hymenoptera, Chalcidoidea) grądów Białowieskiego Parku Narodowego. *Pol Pismo Entomol* 53: 147-178 (in Polish).
- Szmidt A (1971). Rola owadów pasożytniczych z rzędu Hymenoptera w ograniczaniu liczebności szkodników w lesie, *Zesz Probl Post Nauk Roln* 144: 111-115 (in Polish).
- Szujecki A (1980). *Ekologia owadów leśnych* PWN, Warszawa, Poland (in Polish).
- Tobias VI (1986). Hymenoptera III, Braconidae, Microgasterinae. In: Medvedev GS, editor. *Opredeliteli Nasekomykh Evropeyskoy Chasti SSR*. Nauka, Leningrad. pp. 344-459 (in Russian).
- Tomov RI (2002). Parasitoid community attacking invading leafminer *Cameraria ohridella* Deschka et Dimič (Lepidoptera: Gracillariidae) in region of Sofia. In: Congress abstracts from VIIth European Congress of Entomology, Greece, Thessaloniki, Hellenic Entomol Soc, pp. 336.
- Trjapitzin VA (1978). Eulophidae. In: Medvedev GS, editor. *Opredeliteli Nasekomykh Evropeyskoy Chasti SSR*. Nauka, Leningrad. pp 381-467 (in Russian).
- Van den Berg H, Waage JK, Cock MJW (1988). Natural enemies of *Helicoverpa armigera* in Africa: a review. Wallingford, UK: CAB International.
- Vidal S, Buszko J (1990). Studies on the mining Lepidoptera of Poland. VIII. Chalcidoid wasps reared from mining Lepidoptera (Hymenoptera, Chalcidoidea). *Pol J Entomol* 60: 73-103.
- Volter L, Kenis M (2006). Parasitoid complex and parasitism rates of the horse chestnut leafminer, *Cameraria ohridella* (Lepidoptera: Gracillariidae) in the Czech Republic, Slovakia and Slovenia. *Eur J Entomol* 103: 365-370.
- Yefremova ZA, Mishchenko AV (2008). The parasitoid complex (Hymenoptera, Eulophidae) of the leafminer *Phyllonorycter issikii* (Kumata) (Lepidoptera, Gracillariidae) from the Middle Volga Basin. *Zool Zh* 87: 189-196.
- Zajančauskas P, Jonaitis V, Jakimavičius A, Stanionyte S (1979). Entomoparazity nasekomych vrediteliej sada Litwy. "Mokslas", Vilnius (in Russian).