

Ichneumon Wasps (Hymenoptera: Ichneumonidae) Reared from Tortrix Moths (Lepidoptera: Tortricidae) in Oak Forests in Sofia Region, Bulgaria

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Abstract: In 2011-2013, studies on ichneumonid parasitoids (Hymenoptera: Ichneumonidae) parasitising tortricids (Lepidoptera: Tortricidae) were carried out in oak forests in Sofia Region. As a result, twenty-four parasitoid species were reared from host insects. Among them, eight parasitoids are new records of the parasitoid complex of the hosts: *Apechthis rufata* (GMELIN), *Theronia atalantae* (PODA), *Lissonota saturator* (THUNBERG), *Lissonota carbonaria* HOLMGREN, *Lissonota culiciformis* GRAVENHORST, *Scambus calobatus* (GRAVENHORST) – on *Archips crataegana* (HÜBNER); *Mesochorus punctipleuris* THOMSON and *Trichomma enecator* (ROSSI) – on *Eudemis profundana* (DENIS & SCHIFFERMÜLLER). Seven parasitoid-hosts associations are new for Bulgaria: *Itoplectis maculator* (FABRICIUS), *Phytodietus polyzonias* (FORSTER), *Apechthis quadridentata* (THOMSON) – *A. crataegana*; *T. enecator*, *Exochus lictor* HALIDAY – *Archips xylosteana* (L.); *A. quadridentata* – *Tortrix viridana* L.; and *A. rufata* – *Pandemis cerasana* (HÜBNER). Two ichneumonid species – *M. punctipleuris* and *Apophua genalis* (MOLLER) have been found only at faunistic studies in Bulgaria and there are no previous data about their hosts of the family Tortricidae.

Key words: parasitoid-host relationships, Ichneumonidae, Tortricidae, oak forests, Bulgaria.

Introduction

The family Tortricidae (leafrollers) is one of the most numerous lepidopteran groups, which can cause economically significant damages in oak forests in Bulgaria. Attacks of leafrollers are caused by two species, *Tortrix viridana* L., 1758 and *Archips xylosteana* (L., 1758), which are the main pests in oak ecosystems (ZAHOV 1983, TSANKOV *et al.* 1997, ZAEMDZHKOVA & BALOV 2011). In natural conditions, the number of insect pests is regulated by pathogens, parasitoids and predators, with parasitic insects being of primary ecological and economic importance for controlling pest insect populations. ZEROVA *et al.* (1989) reported more than 200 parasitoid species from leafrollers. Most authors believe that hymenopterans are the most important leafrollers' parasitoids in various ecosystems, especially the species of family Ichneumonidae (ATHANASSOV *et al.* 1998, GEORGIEV & KOLAROV 1999, LUNGU-CONSTANTINEANU 2009, PLUCIENNIK & OLSZAK 2010,

MAHARRAMOVA 2002A, B, 2010, VELCHEVA *et al.* 2012, AYDOĞDU 2014). However, it should be noted that the trophic relationships of the parasitoids of the family Ichneumonidae and the leafroller pests in oak forests of Bulgaria have not yet been well studied (TSANKOV *et al.* 1998, GANCHEV 1990).

This work presents results of studies on species composition, ecological and biological peculiarities of ichneumonid wasp parasitizing leafroller moths (Lepidoptera: Tortricidae) in oak forests in Sofia region.

Material and Methods

During 2011-2013, studies were carried out in 13 sample plots located in five mountains in Sofia region: Vitosha Mt. (Tihya kat, Byalata voda and Owl museum localities; Dragalevtsi and Knyazhevo Districts; Rudartsi and Bosnek villages), Lyulin Mt.

(Manastirski livadi locality), Lozenska Mt. (village of German), South-West Balkan Range (Seslavtsi village) and Konyavska Mt. (Izvor village). Two sites in Sofia (Forest Research Institute and Borisova Gradina Park) were also examined (Table 1).

Larvae and pupae of tortricids were collected by hand in April – May, sampling in different oak stands: *Quercus rubra* L., *Q. robur* L., *Q. petraea* LIEBL., *Q. cerris* L. and *Q. frainetto* TEN. The biological material was transported to the entomological laboratory of the Forest Research Institute where it was reared at room temperatures (18-20 °C). The collected larvae were sorted by species and placed into small plastic boxes, as only in the first year of research the various larvae species were reared by groups in boxes. They were fed with fresh leaves of host plants while specimens pupated. The pupae of moths were placed individually in test tubes and closed with cotton stoppers. The samples (larvae and pupae of leafrollers) were checked daily for emergence of parasitoids. The infested larvae were separated individually in boxes, as changes in the developing stage of parasitoids (pupation, emergence) were recorded daily.

The identification of the pupae and larvae of leafrollers were done using KUSLICKIJ & NAROL'SKIJ (1986), GANCHEV (1979) and PATOČKA (1954).

Results

As a result, 24 species of the family Ichneumonidae from oak forests in Sofia region were recorded. These were identified as follows: 17 to the species level, 5 to the generic level and 2 to the subfamily level. Parasitoids were reared from larvae and pupae of six species of the family Tortricidae: *Archips rosana* (L., 1758), *Archips crataegana* (HÜBNER, 1799), *A. xylosteana*, *T. viridana*, *Eudemis profundana* (DENIS & SCHIFFERMÜLLER, 1775) and *Pandemis cerasana* (HÜBNER, 1786). A part of parasitoids were reared by various tortricid species indicated as Tortricidae spp. (Table 2).

Fifteen parasitoid-host relationships were recorded. Eight parasitoids are new records for the parasitoid complex of the hosts: *Apechthis rufata* (GMELIN, 1790), *Theronia atalantae* (PODA, 1761), *Lissonota saturator* (THUNBERG, 1824), *Lissonota carbonaria* HOLMGREN, 1860, *Lissonota culiciformis* GRAVENHORST, 1829, *Scambus calobatus* (GRAVENHORST, 1829) – on *A. crataegana*; *Mesochorus punctipleuris* THOMSON, 1886 and *Trichomma enecator* (ROSSI, 1790) – on *E. profundana*. Seven parasitoid-hosts associations are new for Bulgaria: *Itopectis maculator* (FABRICIUS, 1775),

Phytodietus polyzonias (FORSTER, 1771), *Apechthis quadridentata* (THOMSON 1877) – *A. crataegana*; *T. enecator*, *Exochus licitor* HALIDAY, 1839 – *A. xylosteana*; *A. quadridentata* – *T. viridana*; and *A. rufata* – *P. cerasana*. Hosts of two parasitoids, *M. punctipleuris* and *Apophua genalis* (MOLLER, 1883) are recorded for the first time in the country. Until now, *M. punctipleuris* has not been reported as trophically connected with any hosts of the Tortricidae. *Mesochorus punctipleuris* was reared from *E. profundana*'s pupa. *A. genalis* was reared from larvae of *A. xylosteana*, *T. viridana* and *Ptycholoma lecheana* (L., 1758) (Table 2).

The most species of of Ichneumonidae (14) were reared from *A. crataegana* (*A. quadridentata*, *A. rufata*, *I. maculator*, *L. carbonaria*, *L. culiciformis*, *L. saturator*, *Lissonota* spp., *P. polyzonias*, *S. calobatus*, *T. atalantae*, *Eriborus* sp., *Hyposoter* sp. Campopleginae spp., Cryptinae sp.); five species were reared from *T. viridana* – *A. quadridentata*, *A. rufata*, *I. maculator*, *Dirophanes invisitor* (THUNBERG, 1824) and *Apophua bipunctoria* (THUNBERG, 1824); three species developed from *A. xylosteana* (*E. licitor*, *T. enecator*, *Hyposoter* sp.), two species from *P. cerasana* (*A. rufata*, *I. maculator*) and *E. profundana* (*Hyposoter* sp., *M. punctipleuris*), and one species (*Triclistus* sp.) from *A. rosana* (Table 2).

Among the recorded ichneumonid species, high percentage values were detected for *I. maculator* (19.0%), *D. invisitor* (16.7%), *A. quadridentata* (14.35%), *A. rufata* (8.33%) and *Lissonota* spp. (13.4%). The percentage of other species was insignificant, among them higher values (up to 5.5%) of *Phytodietus* spp. and Campopleginae spp. were recorded (Table 2).

For many ichneumonids, the percentage of female parasitoids was higher than that of males. The sex ratio (females : males) varied between 1.3 to 2. The males of *A. quadridentata* prevailed the females (Table 2).

Discussion

Itopectis maculator is the most widespread species of the genus. It can parasitize various lepidopteran pupae. The species is known as an endoparasitoid of leafroller pests (AYDOĞDU & GÜNER 2012). In the present study, it was reared from pupae of leafrollers. The parasitoid-host association *I. maculator* – *A. crataegana* is new for the country. In other studies in Bulgaria, *I. maculator* was known as a primary parasitoid on *T. viridana* (TSANKOV & MIRCHEV 1998), *A. xylosteana* (VELCHEVA *et al.* 2012), *Pandemis heparana* (DENIS & SCHIFFERMÜLLER, 1775), *Pandemis dume-*

Table 1. Main characteristic of the sample plots

Locality	Coordinates	Altitude (m)	Oak stand
Knyazhevo District	N 42° 39' 14'' E 23° 14' 33''	753	<i>Quercus petraea</i> , <i>Q. cerris</i>
Rudartsi village	N 42° 34' 54'' E 23° 08' 59''	853	<i>Q. frainetto</i>
Dragalevtsi District	N 42° 37' 20'' E 23° 18' 19''	896	<i>Q. rubra</i>
Bosnek village	N 42° 30' 27'' E 23° 09' 17''	950	<i>Q. petraea</i>
Byalata voda	N 42° 38' 29'' E 23° 13' 49''	985	<i>Q. petraea</i> , <i>Q. cerris</i>
Tihiya kat	N 42° 38' 18'' E 23° 13' 05''	1054	<i>Q. petraea</i>
Owl Museum	N 42° 37' 20'' E 23° 13' 30''	1263	<i>Q. petraea</i>
Manastirski livadi	N 42° 39' 24'' E 23° 12' 18''	892	<i>Q. petraea</i> , <i>Q. cerris</i> , <i>Q. frainetto</i>
Seslavtsi village	N 42° 47' 51'' E 23° 31' 32''	864	<i>Q. petraea</i> , <i>Q. cerris</i>
German village	N 42° 35' 54'' E 23° 26' 07''	671	<i>Q. petraea</i> , <i>Q. cerris</i>
Izvor village	N 42° 24' 51'' E 22° 53' 30''	846	<i>Q. petraea</i> , <i>Q. cerris</i> , <i>Q. frainetto</i>
Borisova Gradina Park	N 42° 40' 35'' E 23° 20' 33''	607	<i>Q. rubra</i>
Forest Research Institute	N 42° 37' 49'' E 23° 21' 13''	643	<i>Q. robur</i>

tana (TREITSCHKE, 1835), *P. cerasana* (Tortricidae) (ANGELOVA 1983). A broad range of tortricid hosts of parasitoids have been reported: *T. viridana*, *A. xylosteanana*, *A. crataegana*, *A. rosana*, *Adoxophyes orana* (FISCHER v. RÖSLERSTAMM, 1834), *Choristoneura murinana* (HÜBNER, 1799) and *Aleimma loeflingiana* (L., 1758) (MAHARRAMOVA 2002b).

The genus *Apechthis* includes only 16 species worldwide (YU *et al.* 2012). Most its species are endoparasitoids of the Tortricidae larvae or pupae but also parasitize arachnids as well as larvae or pupae of coleopterans and hymenopterans. Oviposition occurs into the larva or pupa of the host (CHOI *et al.* 2015). It was observed that *A. quadridentata* and *A. rufata* were reared from pupae of moths. The parasitoid-hosts associations (*A. quadridentata* – *T. viridana*, *A. crataegana*) and *A. rufata* – *P. cerasana* are new for the country. The brown oak tortrix (*A. crataegana*) is a new host to the science for parasitoids complex of *A. rufata*. In Bulgaria, *A. quadridentata* and *A. rufata* were found as parasitoids of *A. xylosteanana* (TSANKOV *et al.* 1998), as likewise *A. rufata* was also associated with *T. viridana* (KOLAROV 1997). In other studies, parasitoids were reared from pupae of the following lepidopterans: *A. quadridentata* from *A. crataegana* (NOYES 2014), *T. viridana*,

P. lecheana, *A. loeflingiana* (Tortricidae), *Lycaena dispar* (HAWORTH 1802) (Lycaenidae), *Pararge aegeria* (L., 1758) (Nymphalidae), and *A. rufata* was reared from *A. xylosteanana*, *P. cerasana*, *P. lecheana*, *T. viridana* (Tortricidae) (FITTON *et al.* 1998).

Lissonota is a very large cosmopolitan genus with about 400 species, which are best represented in the Holarctic Region. All host records of the species belong to the concealed Lepidoptera larvae living in stems, buds and rolled leaves (KHALAIM 2011). In this study, *L. carbonaria*, *L. culiciformis* and *L. saturator* were reared from larvae of *A. crataegana*. In Bulgaria, *L. carbonaria* was found only as a parasitoid of *Grapholita funebrana* TREITSCHKE, 1835 (Tortricidae) (ATANASOV 1986), *L. culiciformis* – as a parasitoid of *Paranthrene tabaniformis* (RAMBUR, 1866) (Sesiidae) (GEORGIEV & KOLAROV 1999) and *L. saturator* was known as parasitoid of *Anarsia lineatella* ZELLER, 1839 (Gelechiidae) and *Grapholita molesta* (BUSCK, 1916) (Tortricidae) (DIMOVA 1987). In other countries, these parasitoids are connected with many leafroller species but there are no records of trophic associations between *A. crataegana* and any ichneumon wasps (YU *et al.* 2012).

In the present study, *Trichomma enecator* was reared from pupae of two tortricid species. *A. xylo-*

Table 2. Species composition and number of parasites reared from leafroller moths, 2011-2013

Parasitoid species	Number	Locality	Host	Percentage, %	
				Number of parasitoids	%
1	2	3	4	5	6
<i>Apophua bipunctoria</i> (THUNBERG, 1824)	1♀	Manastirski livadi	<i>Tortrix viridana</i>	1	0.46
<i>Apophua cicatricosa</i> (RATZEBURG, 1848)	1♂	Tihiya kat	Tortricidae spp.	1	0.46
<i>Apophua genalis</i> (MOLLER, 1883)	1♀	Forest Research Institute	Tortricidae spp. (2)	1	0.46
<i>Apechthis quadridentata</i> (THOMSON, 1877)	7♂, 9♀	Borisova Gradina	<i>Archips crataegana</i> **	31	14.35
	1♂	Byalata voda			
	5♂, 2♀		<i>Tortrix viridana</i> **		
	5♂, 2♀	Manastirski livadi			
<i>Apechthis rufata</i> (GMELIN, 1790)	3♂, 12♀	Borisova Gradina	<i>Archips crataegana</i> *	18	8.33
	1♂	Tihiya kat	<i>Pandemis cerasana</i> **		
	1♂		<i>Tortrix viridana</i>		
	1♂	Manastirski livadi			
Campopleginae spp.	1♂	Knyazhevo District	<i>Tortrix viridana</i>	12	5.56
	2♂, 1♀	Borisova Gradina	<i>Archips crataegana</i>		
	1♂	Forest Research Institute	Tortricidae spp.		
	3♂, 2♀	Rudartsi vill.			
	2♀	Dragalevtsi District			
		village of German			
Cryptinae sp.	1♂	Borisova Gradina	<i>Archips crataegana</i>	1	0.46
<i>Dirophanes invisor</i> (THUNBERG, 1824)	10♂, 17♀	Manastirski livadi	<i>Tortrix viridana</i>	36	16.67
	3♂, 2♀	Byalata voda			
	1♂, 1♀	Tihiya kat			
	1♂, 1♀	Izvor vill.			
<i>Eriborus</i> spp.	1♀	Borisova Gradina	<i>Archips crataegana</i>	4	1.85
	2♂	Dragalevtsi District	Tortricidae spp.		
		Bosnek vill.			
1♀	Tihiya kat				
<i>Exochus lictor</i> HALIDAY, 1839	1♂	Bosnek vill.	<i>Archips xylosteana</i> **	1	0.46
<i>Glypta</i> sp.	1♂	Manastirski livadi	Tortricidae spp.	1	0.46
<i>Hyposoter</i> spp.	1♀	Manastirski livadi	<i>Eudemis profundana</i>	5	2.31
	1♂	Borisova Gradina	<i>Archips crataegana</i>		
	1♂	Owl museum	<i>Archips xylosteana</i>		
	1♀	Dragalevtsi District	Tortricidae spp.		
	1♀	Bosnek vill.			
<i>Itopectis maculator</i> (FABRICIUS, 1775)	1♀	village of German	<i>Pandemis cerasana</i>	41	18.98
	2♂, 5♀	Byalata voda	<i>Tortrix viridana</i>		
	9♂, 5♀	Manastirski livadi			
	6♂, 12♀	Borisova Gradina	<i>Archips crataegana</i> **		
			Tortricidae spp.		
<i>Lissonota carbonaria</i> HOLMGREN, 1860	1♀	Seslavtsi vill.	<i>Archips crataegana</i> *	2	0.93
	1♀				

Table 2. Continued

1	2	3	4	5	6
<i>Lissonota culiciformis</i> GRAVENHORST, 1829	2♀	Borisova Gradina	<i>Archips crataegana</i> *	5	2.31
	1♀	Byalata voda	Tortricidae spp.		
	2♂	Forest Research Institute			
<i>Lissonota saturator</i> (THUNBERG, 1824)	4♀	Borisova Gradina	<i>Archips crataegana</i> *	4	1.85
<i>Lissonota</i> spp.	6♂, 9♀		<i>Archips crataegana</i>	18	8.33
	3♂	Forest Research Institute	Tortricidae spp.		
<i>Mesochorus punctipleuris</i> THOMSON, 1886	1♀	Manastirski livadi	<i>Eudemis profundana</i> *(1)	3	1.39
	2♂		Tortricidae spp.		
<i>Phytodietus polyzonias</i> (FORSTER, 1771)	2♂	Borisova Gradina	<i>Archips crataegana</i> **	11	5.09
	1♂, 1♀	Rudartsi vill.	Tortricidae spp.		
	2♂	Forest Research Institute			
	1♂, 1♀	Tihiya kat			
	1♂	Knyazhevo District			
	1♀	Byalata voda			
	1♂	Manastirski livadi			
<i>Phytodietus geniculatus</i> THOMSON, 1877	1♀	Borisova Gradina	Tortricidae spp.	2	0.93
	1♂	Tihiya kat			
<i>Scambus calobatus</i> (GRAVENHORST, 1829)	2♂, 2♀	Borisova Gradina	<i>Archips crataegana</i> *	4	1.85
<i>Theronia atalantae</i> (PODA, 1761)	5♂		<i>Archips crataegana</i> *	5	2.31
<i>Trichomma enecator</i> (ROSSI, 1790)	1♂, 4♀	Seslavtsi vill.	<i>Archips xylosteana</i> **	8	3.70
	2♂	Manastirski livadi	<i>Eudemis profundana</i> *		
	1♂	village of German			
<i>Triclistus</i> sp.	1♂	Borisova Gradina	<i>Archips rosana</i>	1	0.46

(*) New host record of the parasitoid species

(**) New host record for Bulgaria of the parasitoid species

1) First record of a tortricid host for a parasitoid species

2) First host record of the parasitoid species for Bulgaria

steana is a new host of this parasitoid for Bulgaria, and *E. profundana* is a new to science. In Bulgaria, *T. enecator* was known as a parasitoid of *Cydia pomonella* (L., 1758) and *T. viridana* (Tortricidae) (GANCHEV 1990). In other studies, *T. enecator* was associated with many species of the Tortricidae: *A. crataegana* (see LUNGU-CONSTANTINEANU 2009), *Archips betulana* (HÜBNER, 1787), *A. xylosteana* and *Epinotia tetraquetra* (HAWORTH, 1811) (YU *et al.* 2012).

Theronia atalantae is a single primary or secondary endoparasitoid with broad range of hosts (ZEROVA *et al.* 1989). In this study, the parasitoids were recorded from *A. crataegana*'s pupae. Until now, this ichneumonid species was associated with only two species of the family Tortricidae, i.e. the green oak moth (*T. viridana*) and *Ptycholomoides aeriferana* (HERRICH-SCHÄFFER, 1851) (see LUNGU-

CONSTANTINEANU 2009, YU *et al.* 2012). *T. atalantae* is also known as a secondary parasitoid of *Apechthis capulifera* (KRIECHBAUMER, 1887), *Therion circumflexum* (L., 1758), *Hyposoter validus* (PFANKUCH, 1921) (Ichneumonidae) (KOLAROV 1997) and *Agria mamillata* (PANDELLE, 1896) (Sarcophagidae) (GEORGIEV 1996).

In this study, *Exochus lictor* was reared from *A. xylosteana*'s pupa. That parasitoid-host association is new for the country. In Bulgaria, *E. lictor* is known as a parasitoid of *E. profundana* (Tortricidae) and *Gelechia turpella* (DENIS & SCHIFFERMÜLLER, 1775) (Gelechiidae) (GEORGIEV & KOLAROV 1999). In literature, the ichneumon wasp is connected with a few hosts of the Tortricidae, and it was also found on *A. xylosteana* (YU *et al.* 2012).

In present research, *Phytodietus polyzonias* and *Scambus calobatus* were reared from *A. crataegana*

na's larvae. The trophic relationship of *P. polyzonias* with *A. crataegana* is new for Bulgaria, and this of *S. calobatus* with the tortricid moth is new to the science. In Bulgaria, ichneumonids were known as parasitoids of many species of the Tortricidae (KOLAROV 1997, TSANKOV *et al.* 1998) but until now they were not trophically connected with *A. crataegana*. *S. calobatus* and *P. polyzonias* were reported as solitary ectoparasitoids of leafrollers (AYDOĞDU 2014), and *A. crataegana* was not found as a host of *S. calobatus* (see YU *et al.* 2012).

Mesochorus punctipleuris and *Apophua genalis* were found only in faunistic studies in Bulgaria (KOLAROV 1981a,b). In the present study, *M. punctipleuris* was reared from *E. profundana*'s pupa, and *A. genalis* was reared from caterpillars of leafrollers. In literature, the list of hosts of *M. punctipleuris* does not include species of the Tortricidae. It

has been reported as connected with only three species: *Aporia crataegi* (L., 1758) (Pieridae), *Hypera arator* (L., 1758) (Curculionidae) and *Bathyplectes curculionis* (THOMSON, 1887) (Ichneumonidae) (YU *et al.* 2012). The other ichneumonid, *A. genalis*, is known as a parasitoid of *A. betulana*, *T. viridana*, *C. Murinana* and *Lozotaenia forsterana* (FABRICIUS, 1781) (Tortricidae) (YU *et al.* 2012).

In conclusion, it could be noted that new parasitoid-host associations between ichneumonids and tortricids were recorded in this study, thus expanding the knowledge on ecology of both taxonomic groups.

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