

New Entomophagous Enemies of *Ips typographus* (Linnaeus, 1758) (Coleoptera: Curculionidae) from Bulgaria

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Abstract: Five entomophages of *Ips typographus* (Linnaeus) (Coleoptera: Curculionidae, Scolytinae) were recorded between 2008–2014 in spruce forests in three Bulgarian mountains (Vitosha, Lyulin and Western Rhodopes). They belong to two hymenopteran and two dipteran families: *Coeloides bostrichorum* GIRAUD, *Dendrosoter middendorffii* (RATZEBURG) (Hymenoptera: Braconidae), *Roptrocercus xylophagorum* (RATZEBURG) (Hymenoptera: Pteromalidae), *Medetera pinicola* KOWARZ (Diptera: Dolichopodidae) and *Lonchaea fugax* BECKER (Diptera: Lonchaeidae). The entomophages were reared from cocoons and puparia collected in larval galleries of the pest. Among them, *M. pinicola* and *L. fugax* are predators of *I. typographus*, and the remaining species are parasitoids of the host. *Medetera pinicola* and *L. fugax* are new species for the fauna of Bulgaria and the Balkan Peninsula, while *C. bostrichorum* and *D. middendorffii* were established as new parasitoids of *I. typographus* from Bulgaria, and *R. xylophagorum* was found in a new locality in the country. The most numerous was *C. bostrichorum*, with 90.7% of all emerged adults. The parasitism of *I. typographus* caused by *C. bostrichorum* in Vitosha Mt. varied between 12.0 and 55.2%, with an average of 38.1%.

Key words: *Ips typographus*, predators, parasitoids, new records, impact, Bulgaria

Introduction

The spruce bark beetle, *Ips typographus* (Linnaeus, 1758) (Coleoptera: Curculionidae, Scolytinae) is the most dangerous xylophagous insect pest in spruce forests in the Palaearctic region. For this reason, numerous studies on its natural enemies have been conducted in order to clarify their impact as biological control agents.

In Europe, more than 70 entomophagous species, both parasitoids and predators, are known to be associated with *I. typographus* (KENIS *et al.* 2004). However, in Bulgaria there is insufficient knowledge about natural enemies of this pest. Until now, only five species have been reported as parasitoids of *I. typographus* in the country: *Ropalophorus*

clavicornis (WESMAEL) (Hymenoptera: Braconidae), *Tomicobia seitneri* (RUSCHKA), *Dinotiscus eupterus* (WALKER), *Rhopalicus tutela* (WALKER) and *Roptrocercus xylophagorum* (RATZEBURG) (Hymenoptera: Pteromalidae) (GEORGIEV, TAKOV 2005; GEORGIEV, STOJANOVA 2006).

This paper reports four new entomophages of *I. typographus* and a new locality of *R. xylophagorum* in Bulgaria.

Materials and Methods

The studies were conducted during the period 2008–2014. The biological material (cocoons of hymenop-

teran parasitoids and puparia of dipteran predators) was collected in *I. typographus* galleries on dead trees of *Picea abies* (L.) H. KARST. in four localities in three Bulgarian mountains (Table 1).

Both localities in Vitosha Mt. are situated in the Bistrishko Branishte Biosphere Reserve in old Norway spruce stands killed by *I. typographus*: at an altitude of 1550 m (200 m north of Pogledets hut), and at 1816 m (650 m north-east of Golyam kupen peak). The locality in Lyulin Mt. is situated at 250 m west of St. St. Cyril and Methodius Monastery, and the one in Western Rhodopes – 6 km south of Trigrad village (Smolyan Region).

Two different types of sampling were used: random for faunistical studies and systematic for evaluation of the parasitism.

After collection, the cocoons and puparia of entomophages were put in polystyrene tubes and containers. They were transported to the University of Forestry in Sofia for rearing in laboratory conditions at room temperature (20-25°C). The samples were observed daily for emergence of adult parasitoids and predators.

In May 2013, parasitism on *I. typographus* caused by *Coeloides bostrichorum* GIRAUD was determined at 1816 m by taking four bark samples (15 x 25 cm) from four different spruce trees in Vitosha Mt. (Fig. 1). A total of 105 larval galleries of *I. typographus* with 40 cocoons of parasitoids were observed.

The species were identified using the following keys: Braconidae (TOBIAS 1976); Pteromalidae (GRAHAM 1969; BOUČEK, RASPLUS 1991); Dolichopodidae (D'ASSIS FONSECA 1978; GRICHANOV 2007); Lonchaeidae (STACKELBERG 1970).

Results

Adults of five entomophagous species belonging to two hymenopteran and two dipteran families were reared from larval galleries of *I. typographus*: *Coeloides bostrichorum* GIRAUD, 1872, *Dendrosoter middendorffii* (RATZEBURG, 1848) (Hymenoptera: Bra-



Fig. 1. Cocoons of *Coeloides bostrichorum* Giraud, 1872 (Braconidae) in larval galleries of *Ips typographus*

Table 1. Main characteristics of the studied areas

Locality	Mountain	Altitude, m a.s.l.	Exposition	Stand age, years	Geographical coordinates	
					Latitude	Longitude
1	Vitosha	1550	NE	120	42°34'44.9"	23°19'01.3"
2	Vitosha	1816	W	120	42°33'21.7"	23°19'18.7"
3	Lyulin	1050	N	80	42°39'00.8"	23°10'57.6"
4	Western Rhodopes	1505	NE	90	41°32'52.0"	24°24'03.2"

Table 2. Collection of biological materials and emergence of adults

Species	Locality*	Date of cocoons/pupariums collection	Number of studied material	Emerged adults	Emergence period
<i>Coeloides bostrichorum</i>	1	01.06.2008	6	3 ♂♂, 2 ♀♀	04-10.06.2008
	3	21.04.2009	1	1 ♀	21.04.-30.09.2009
		21.10.2012	66	13 ♂♂, 46 ♀♀	10.01.-15.02.2013
	2	01.05.2013	29	9 ♂♂, 14 ♀♀	20.05.-15.06.2013
<i>Dendrosoter middendorffii</i>	4	18.05.2014	2	1 ♀	03.06.2014
<i>Roptrocercus xylophagorum</i>	4	18.05.2014	2	2 ♀	11.6.-07.11.2014
<i>Medetera pinicola</i>	1	01.06.2008	5	5 ♂♂	02-04.06.2008
<i>Lonchaea fugax</i>	1	01.06.2008		1 ♀	08.06.2008

* See Table 1

conidae), *Roptrocerus xylophagorum* (RATZEBURG, 1844) (Hymenoptera: Pteromalidae), *Medetera pinicola* KOWARZ, 1877 (Diptera: Dolichopodidae) and *Lonchaea fugax* BECKER, 1895 (Diptera: Lonchaeidae) (Table 2). Among them, the most abundant was the braconid *C. bostrichorum* with 88 specimens (90.7% of all emerged adults).

Two species, *M. pinicola* and *L. fugax* are predators of *I. typographus*, and the remaining *C. bostrichorum*, *D. middendorffii* and *R. xylophagorum* are parasitoids of the host.

Medetera pinicola and *L. fugax* are new species for the fauna of Bulgaria and the Balkan Peninsula. *Coeloides bostrichorum* and *D. middendorffii* were identified as new parasitoids of *I. typographus* in Bulgaria. A second locality of *R. xylophagorum* was found in the country.

Parasitism of *I. typographus* caused by *C. bostrichorum* in the studied locality in Vitosha Mt. varied between 12.0 and 55.2%, with an average of 38.1%.

Discussion

The brachicerous flies *M. pinicola* and *L. fugax* are new to the Bulgarian fauna. Nevertheless the two species are well known as predators of preimaginal stages of *I. typographus* (KENIS *et al.* 2004). The dolichopodid *M. pinicola* is a Holarctic species and it has not been recorded previously from the countries on the Balkan Peninsula (NEGROBOV 1991; GRICHANOV 2007; POLLET 2013). In Europe *M. pinicola* is associated not only with *I. typographus* but also with *Hylurgops palliatus* (GYLLENHAL) and *Tomicus* spp., although the *Medetera* species are not necessarily restricted to scolytine diet (KENIS *et al.* 2004). In North America it is associated with *Dendroctonus frontalis* ZIMMERMAN, *D. pseudotsugae* ERICHSON, *D. ponderosae* HOPKINS, *D. rufipennis* KIRBY, *Orthotomicus caelatus* (EICHHOFF), *Dryocoetes autographus* (RATZEBURG), *Ips utahensis* WOOD (BICKEL 1985) and *Tomicus piniperda* (LINNAEUS) (BRIGHT 1996). The impact of dolichopodid flies on bark beetle populations is discussed controversially in the literature but some *Medetera* species can reach high densities and cause mortality rates of 70-90% (KENIS *et al.* 2004).

Previously, the Palearctic lonchaeid *L. fugax* was not found from the Balkan Peninsula (CARLES-TOLRA 2013). The larvae of *Lonchaea* are known to develop as saprophages, coprophages or predators. In conifers some species are known to be obligatory

predators, occurring in high number and killing larvae of bark beetles (KENIS *et al.* 2004).

The braconid *C. bostrichorum* is widely distributed in the Palearctic and is found in many European and Asiatic countries: Austria, Germany, Czech Republic, Finland, France, Hungary, Italy, Poland, Russia, Slovakia, Sweden, Switzerland (VAN ACHTERBERG 2013), Belgium (HOUGARDY, GREGOIRE 2004), Mongolia (JANOVSKY 1977), Romania (FORA *et al.* 2014), Turkey (ÜNAL 2010), Iran (GHAHARI, FISCHER 2011), China (WANG *et al.* 2006) and Japan (WATANABE 1958). In Bulgaria it was reported only once by TSCHORBADJIEFF (1927) as a parasitoid of *Orthotomicus erosus* (WOLLASTON). *Coeloides bostrichorum* is known as an idiobiont larval ectoparasitoid of several bark beetles associated with coniferous trees (KENIS *et al.* 2004; JANOVSKY 1977). The most common host of *C. bostrichorum* is *I. typographus*, on which the parasitism can reach up to 92% (FEICHT 2006).

The other braconid, *D. middendorffii*, is also a Palearctic species but more widely distributed (VAN ACHTERBERG 2013; YU 1997-2012; FORA *et al.* 2014; BASIRI *et al.* 2013). In Bulgaria it was reported as a parasitoid of bark beetles *Scolytus scolytus* (FABRICIUS) (TSCHORBADJIEFF 1927), *Tomicus minor* (HARTIG) (BALEVSKI, GEORGIEV 2003) and *Pityogenes bistridentatus* (EICHHOFF) (DOYCHEV, BALEVSKI 2006). The list of *D. middendorffii* hosts includes many other scolytids, predominantly developing on coniferous but also on broadleaf trees (KENIS *et al.* 2004; HALPERIN, HOLZSCHUH 1984; YU 1997-2012; TOBIAS 1976; BELOKOBYSKII 1988; HERTING 1973; BASIRI *et al.* 2013; WEGENSTEINER *et al.* 2015). BELOKOBYSKII (1988) and ALAUZET (1990) reported also the braconid wasp as a parasitoid of the weevils *Magdalis memnonia* (GYLLENHAL) and *Pissodes castaneus* (DE GEER). According to FACCOLI (2002), *D. middendorffii* is one of the most common larval ectoparasitoids of *I. typographus*, but LOZAN, ZELENÝ (2002) found low level of parasitisation – only up to 4.7%.

The pteromalid *R. xylophagorum* is a cosmopolitan species with wide range of scolytid hosts (MITROIU 2013; NOYES 2014). In Bulgaria it was reported as a parasitoid of *I. typographus* from Bistrishko Branishte Biosphere Reserve in Vitosha Mt. (GEORGIEV, STOJANOVA 2006). According to the authors, host mortality was very low (1.6%).

In conclusion, the new records increase our knowledge on the Bulgarian fauna and on the impact of the predators and parasitoids on *I. typographus*.

References

- ALAUZET, C. 1990. Dynamique des populations d'un ravageur des pins: *Pissodes notatus* F. (Col.: Curculionidae) II. – Rôle du parasitisme. – *Entomophaga*, **35** (1): 119-126.
- BALEVSKI, N., G. GEORGIEV 2003. New parasitoids from the family Braconidae (Hymenoptera) on xylophagous forest insects in Bulgaria. – *Forest Science*, **2**: 85-88.

- BASIRI, N., H. LOTFALIZADEH, M.-H. KAZEMI 2013. *Dendrosoter middendorffii* (RATZEBURG, 1848) (Hymenoptera: Braconidae) a parasitoid of the fruit bark beetles in Iran. – *Biharean Biologist*, **7** (2): 104-105.
- BELOKOBLYSKIL, S. 1988. Family Braconidae, subfam. Doryctinae. – In: Tobias, V. (Ed.) Keys to the insects of the European part of the USSR. 3. Hymenoptera. Part 4. Nauka, Leningrad, 502 pp. (In Russian).
- BICKEL, D.J. 1985. A revision of the Nearctic *Medetera* (Diptera: Dolichopodidae). – *United States Department of Agriculture, Technical Bulletin*, **1692**: 1-109.
- BOUČEK, Z., J.-Y. RASPLUS 1991. Illustrated key to West-Palaeartic genera of Pteromalidae (Hymenoptera: Chalcidoidea). Institut National de la Recherche Agronomique, Paris, 140 p.
- BRIGHT, D. E. 1996. Notes on native parasitoids and predators of the larger pine shoot beetle, *Tomicus piniperda* (LINNAEUS) in the Niagara region of Canada (Coleoptera: Scolytidae). – *Proceedings of the Entomological Society of Ontario*, **127**: 57-62.
- CARLES-TOLRA, M. 2013. Fauna Europaea: Lonchaeidae. – In: Pape, T., P. Beuk. Fauna Europaea: Diptera: Brachycera, version 2.6.2. (Last update 29 August 2013). URL: <http://www.faunaeur.org>.
- D'ASSIS FONSECA, E.C.M. 1978. Diptera, Orthorrhapha, Brachycera, Dolichopodidae. Handbooks for the Identification of British Insects, Royal Entomological Society of London, London. 90 pp.
- DOYCHEV, D., N. BALEVSKI 2006. New Braconid Parasitoid Species from Bulgarian Fauna (Hymenoptera: Braconidae). – *Acta Entomologica Bulgarica*, **12**, (3, 4): 5-10 (In Bulgarian, English abstract).
- FACCOLI, M. 2002. Winter mortality in sub-corticolous populations of *Ips typographus* (Coleoptera, Scolytidae) and its parasitoids in the South-eastern Alps. – *Journal of Pest Science*, **75**: 62-68.
- FEICHT, E. 2006. Frequency, species composition and efficiency of *Ips typographus* (Col., Scolytidae) parasitoids in infested spruce forests in the National Park 'Bavarian Forest' over three consecutive years. – *Journal of Pest Science*, **79**: 35-39.
- FORA, C., C. BANU, I. CHISĂLIȚĂ, M. MOATĂR, I. OLTEAN 2014. Parasitoids and predators of *Ips typographus* (L.) in unmanaged and managed Spruce forests in Natural Park Apuseni, Romania. – *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **42** (1): 270-274.
- GEORGIEV, G., A. STOJANOVA 2006. New Pteromalid parasitoids (Hymenoptera: Pteromalidae) of *Ips typographus* (L.) (Coleoptera: Scolytidae) in Bulgaria. – *Silva Balcanica*, **7** (1): 89-93.
- GEORGIEV, G., D. TAKOV 2005. Impact of *Tomicobia seitneri* (RUSCHKA) (Hymenoptera: Pteromalidae) and *Ropalophorus clavicornis* (WESMAEL) (Hymenoptera: Braconidae) on *Ips typographus* (LINNAEUS) (Coleoptera: Scolytidae) populations in Bulgaria. – *Forest Science*, **4**: 61-68.
- GHAHARI, H., M. FISCHER 2011. A study on the Braconidae (Hymenoptera: Ichneumonoidea) from some regions of northern Iran. – *Zeitschrift für Entomologie*, **32** (8): 181-196.
- GRAHAM, M.W.R. DE V. 1969. The Pteromalidae of northwestern Europe (Hymenoptera: Chalcidoidea). – *Bulletin of the British Museum (Natural History) (Entomology)*, Supplement **16**: 1-908.
- GRICHANOV, I.Y. 2007. A checklist and keys to Dolichopodidae (Diptera) of the Caucasus and East Mediterranean. – *Plant Protection News, Supplement*: 1-160.
- HALPERIN, J., C. HOLZSCHUH 1984. Contribution to the knowledge of bark beetles (Coleoptera: Scolytoidea) and associated organisms in Israel. – *Israel Journal of Entomology*, **18**: 21-37.
- HERTING, B. 1973. Coleoptera to Strepsiptera. A catalogue of parasites and predators of terrestrial arthropods. Section A. Host or Prey/Enemy. 3. Commonwealth Agricultural Bureaux, Institute of Biological Control, 185 pp.
- HOUGARDY, E., J.-C. GREGOIRE 2004. Biological differences reflect host preference in two parasitoids attacking the bark beetle *Ips typographus* (Coleoptera: Scolytidae) in Belgium. – *Bulletin of Entomological Research*, **94** (4): 341-347.
- JANOVSKY, V. 1977. Entomophagous insects attacking forest pests in Mongolia. – In: Lavrenko, E. (Ed.). Insects of Mongolia. 5. The joint Soviet-Mongolian complex biological expedition. Nauka, Leningrad, 60-77. (In Russian).
- KENIS, M., B. WERMELINGER, J.C. GRÉGOIRE 2004. Research on parasitoids and predators of Scolytidae – a review. – In: Lieutier, F., K.R. Day, A. Battisti, J.C. Grégoire, H.F. Evans (Eds.). Bark and wood boring insects in living trees in Europe, a synthesis. Kluwer Academic Publishers, pp. 237-290.
- LOZAN, A., J. ZELENÝ 2002. Braconid (Hymenoptera, Braconidae) parasitoids of bark beetles in upland spruce stands of the Czech Republic. Proceedings: Ecology, Survey and Management of Forest Insects Kraków, Poland – September 1-5, 152-153.
- MITROIU, M.-D. 2013. Fauna Europaea: Pteromalidae. – In: Fauna Europaea, version 2.6.2. (Last update 29 August 2013). URL: <http://www.faunaeur.org>.
- NEGROBOV, O.P. 1991. Family Dolichopodidae. – In: Sóos, Á., L. Papp, (Eds.). Catalogue of Palaeartic Diptera. Vol. 7. Dolichopodidae–Platypezidae. Akadémiai Kiadó, Budapest, 11-139.
- NOYES, J.S. 2014. Universal Chalcidoidea database. The Natural History Museum, Cromwell Road, London, SW7 5BD, UK (Last update August 2014). URL: <http://www.nhm.ac.uk/entomology/chalcidoids/>.
- POLLET, M. 2013. Fauna Europaea: Dolichopodidae. – In: Pape, T., P. Beuk. Fauna Europaea: Diptera: Brachycera, version 2.6.2. (Last update 29 August 2013). URL: <http://www.faunaeur.org>.
- STACKELBERG, A.A. 1970. Family Lonchaeidae. – In: Bei-Bienko G.J. (Ed.). Key to the insects of the European part of the USSR. Diptera. Vol. 5. Part 2. Leningrad, 358-373. (In Russian).
- TOBIAS, V. 1976. Braconids of Caucasus (Hymenoptera, Braconidae). Leningrad, 286 pp. (In Russian).
- TSCHORBADJIEFF, P. 1927. Referate und Berichte im Jahre 1926-1927. – *Mitteilungen der Bulgarischen Entomologischen Gesellschaft in Sofia*, **4**: 12-30. (In Bulgarian).
- ÜNAL, S. 2010. Bark beetles and their predators with parasites of Oriental Spruce (*Picea orientalis* (L.) LINK) forests in Turkey. – *e-Journal of New World Sciences Academy*, **5**: 21-34.
- VAN ACHTERBERG, K. 2013. Fauna Europaea: Braconidae. – Fauna Europaea, version 2.6.2. (Last update 29 August 2013). URL: <http://www.faunaeur.org>.
- WANG, Y.-P., X.-X. CHEN, H. WU, J.-H. HE 2006. The genus *Coeloides* WESMAEL of subfamily Braconinae (Hymenoptera: Braconidae) in China. – *Zootaxa*, **1239**: 1-17.
- WATANABE, C. 1958. A revision of the species of the genus *Coeloides* WESMAEL occurring in Japan, with description of a new species. – *Insecta Matsumurana*, **22**: 1-6.
- WEGENSTEINER, R., B. WERMELINGER, M. HERRMANN 2015. Natural enemies of bark beetles: Predators, parasitoids, pathogens and nematodes. – In: Vega, F.E., R.W. Hofstetter (Eds.). Bark beetles: Biology and ecology of native and invasive species. Academic Press, London, pp. 247-304.
- Yu D. 1997-2012. Home of Ichneumonoidea. URL: <http://www.taxapad.com/>.

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