Türk. entomol. derg., 2017, 41 (4): 357-365
DOI: http://dx.doi.org/10.16970/entoted.316858

ISSN 1010-6960
E-ISSN 2536-491X

Original article (Orijinal araştırma)

Parasitoids of the apple ermine moth, *Yponomeuta malinellus* Zeller, 1838 (Lepidoptera: Yponomeutidae), in the Çoruh Valley, Erzurum Province, Turkey

Çoruh Vadisi'nde (Erzurum, Türkiye) elma ağ kurdu [*Yponomeuta malinellus* Zeller, 1838 (Lepidoptera: Yponomeutidae)]'nun parazitoidleri

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Summary

Parasitoids of *Yponomeuta malinellus* Zeller, 1838 (Lepidoptera: Yponomeutidae), in various host plants (especially apple) were investigated in the Coruh Valley, Erzurum Province, Turkey, during 2015 and 2016. The parasitoids associated with *Y*. *malinellus* were reared in a laboratory, with a total of 255 individual parasitoids emerging from three families, Braconidae, Ichneumonidae (Hymenoptera), and Tachinidae (Diptera). Six parasitoid species, *Habrobracon concolorans* (Marshall, 1900) (Hymenoptera: Braconidae), *Diadegma armillatum* (Gravenhorst, 1829), *Trieces tricarinatus* (Holmgren, 1858), *Itoplectis tunetana* (Schmiedeckneckt, 1914), *Itoplectis maculator* (Fabricius, 1775) (Hymenoptera: Ichneumonidae) and *Bessa parallela* (Meigen, 1824) (Diptera: Tachinidae), were determined. Of these, *H*. *concolorans* was reared from *Y*. *malinellus* for the first time. Apple ermine moth is therefore a new host for this parasitoid. The combined contribution of the parasitoids in parasitizing apple ermine was 25.5%, with *D*. *armillatum* being the most numerous accounting for 5.5% of all parasitoids reared.

Keywords: Coruh Valley, *Habrobracon concolorans*, parasitoid, Turkey, *Yponomeuta malinellus*

Özet

Çoruh Vadisi'nde 2015-2016 yıllarında yürütülen bu çalışma, özellikle elma ağaçlarında konukçu olan, elma ağ kurdu [*Yponomeuta malinellus* Zeller, 1838 (Lepidoptera: Yponomeutidae)]'nun parazitoidlerini belirlemek amacıyla yapılmıştır. Braconidae, Ichneumonidae ve Tachinidae familyalarına bağlı toplam 255 parazitoid örneğinin laboratuvarda çıkışı sağlanmıştır. *Habrobracon concolorans* (Marshall, 1900) (Hymenoptera: Braconidae); *Diadegma armillatum* (Gravenhorst, 1829), *Trieces tricarinatus* (Holmgren, 1858), *Itoplectis tunetana* (Schmiedeckneckt, 1914), *Itoplectis maculator* (Fabricius, 1775) (Hymenoptera: Ichneumonidae) ve *Bessa parallela* (Meigen, 1824) (Diptera: Tachinidae) olmak üzere belirlenen 6 parazitoid tür içerisinde, *H. concolorans* için elma ağ kurdu yeni bir konukçudur. %25.5 oranında parazitlenmenin görüldüğü çalışmada, en fazla çıkış %5.5 ile *D*. *armillatum*'da görülmüştür.

Anahtar sözcükler: Çoruh Vadisi, *Habrobracon concolorans*, parazitoid, Türkiye, *Yponomeuta malinellus*

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Received (Alınış): 29.05.2017 Accepted (Kabul ediliş): 25.01.2018 Published Online (Çevrimiçi Yayın Tarihi): 03.03.2018

Introduction

Yponomeuta malinellus Zeller, 1838 (Lepidoptera: Yponomeutidae), is widespread in the Palearctic region (Kuhlmann et al., 1988) and is known as an important pest of some mahlep cherry, cultivars of apples and twigs of large poplar trees. This pest is a univoltine defoliator of *Malus* spp. in Europe and Asia. It is a member of a complex of host-differentiated defoliators known as the small ermine moths (Menken et al., 1992).

The main hosts of *Y. malinellus* are *Malus* spp. (apple). Some sources state that this pest exclusively feeds on *Malus spp.* (Carter, 1984; Philip and Edwards, 1991; CFIA, 2006), while others include a broader host range (Menken et al., 1992). The most commonly reported hosts are *Malus* spp. and *Pyrus communis* (pear) (Philip & Edwards, 1991; Menken et al., 1992).

This species is found throughout most of Europe and parts of Asia. Some countries where this pest is found are Asia (China, Japan, Kazakhstan and Korea), Europe (Czech Republic, Finland, France, Georgia, Germany, Italy, Lithuania, the Netherlands, Sweden, Turkey, Ukraine and the United Kingdom), Middle East (Armenia, Azerbaijan, Iran, Pakistan and Uzbekistan), North America (Canada) (Gershenzon, 1970; Pustovarov, 1980; Mamedov & Makhmudova-Kurbanova, 1982; Arduino et al., 1983; Kuhlmann et al., 1988; Orr, 1991; Unruh et al., 1993; Jonaitis, 2001; Gençer, 2003; Hrudová, 2003; Lee & Pemberton, 2005; CFIA, 2006; Kimber, 2011).

The parasitoids of the small ermine moths of Europe and the former Soviet Union have been extensively studied (Beirne, 1943; Junnikkala, 1960; Friese, 1963; Affolter & Carl, 1986; Dijkerman et al., 1986; Kuhlmann, 1996), while those in Korea, Japan and China are less well known (Friese, 1963). More than 50 species of parasitoids or hyperparasitoids have been associated with the small ermine moths in Europe, but only a few of these are common (Affolter & Carl, 1986). Several authors attribute regulation of ermine moths in Eurasia to parasitoids (Vaclav, 1958; Pyornila & Pyornila, 1979; Affolter & Carl, 1986; Kuhlmann et al., 1988).

In Turkey, *Y. malinellus* has not been studied in detail, although it is an important defoliator of a range of plants particularly in eastern and central Turkey. This species has been reported by Koçak (1989), and several other authors (Iren, 1960; Bulut & Kılınçer, 1989; Erol & Yaşar, 1996; Tozlu et al., 2000; Gençer, 2003, Çoruh, 2005; Çoruh & Özbek, 2008; Çoruh, 2010) have reported finding this pest in Amasya, Ankara, Erzurum, Manisa and Van.

A total of 97% of the fruit produced in Erzurum Province is produced in the Coruh Valley, so a range of pests and diseases are common in this area and cause considerable damage and economic loss (Güçlü et al., 1998). *Yponomeuta malinellus* is a very important pest, especially on *Malus* spp., in this region.

Also, parasitoids of this species have not been a subject of detailed study in Turkey (Iren, 1960; Gençer & Doğanlar, 1996; Gençer, 2003). In this study, our aims were to (1) determine the species parasitoids associated with *Y. malinellus* in Erzurum Province of Turkey, (2) determine natural parasitism rates, (3) consider the potential of parasitoids for classical biological control of this species.

Material and Methods

Study area

This study was conducted during 2015 and 2016. *Yponomeuta malinellus* feeding as caterpillars on the leaves of apple were collected in the Coruh Valley (Erzurum Province) (Figure 1).

The Coruh Valley, with its geological and geomorphological diversity, and unique of vegetation, has extraordinary importance for nature conservation. Its rich biological diversity is the basis for its recognition as one of the most important 25 ecoregions under threat by International Environmental Protection Agency, the World Bank and the Global Environment Fund (Aslantaş et al., 2011).

The climate of the Coruh Valley is particularly suitable for fruit production. Consequently, fruit production is a long-established tradition in many districts within the valley and many localities are known by names of fruit. There are many villages named after the fruit such as almond, walnut, cherry and apple (Karlıdağ & Eşitken, 2006).

Sampling and collection method

A total of 1000 *Y. malinellus* larvae were collected by hand from trees in study area (Figure 1) and each sample was placed in a box with apple leaves and covered with cheesecloth (Figure 2).

Samples were collected from different apple orchards (Figure 3) at about 1200 m altitude. The common apple trees were *Malus pumila* Mill. cultivar Golden Delicious, one of the most important apple cultivars of the 20th century. *Malus pumila* is a highly important commercial crop in the valley.

Figure 1. Map of the study area.

Larvae were reared in a laboratory at ambient temperature to obtain parasitoids and were placed in groups of 10 in boxes (10 by 20 cm) for moth or parasitoid emergence.

Periodically, withered leaves were replaced with fresh ones and checked every 1 or 2 days for 4 to 5 weeks. Emerging adults of parasitoids in the boxes were transferred to a killing jar.

Parasitoids identifications was verified by comparison with the preserved specimens in the Entomology Museum, Erzurum, Turkey (EMET). The unidentified specimens were determined by specialists (Dr. Janko Kolarov, Dr. Miktat Doğanlar, Dr. Kenan Kara and Dr. Saliha Çoruh).

Figure 2. Rearing boxes.

Results

All the parasitoids that emerged in the laboratory were members of the orders Diptera and Hymenoptera. From a total of 255 samples, six parasitoid species were reared from *Y. malinellus* during 2015 and 2016 (Table 1). Among these parasitoids, four species, *Diadegma armillatum* (Gravenhorst, 1829), *Trieces tricarinatus* (Holmgren, 1858)*, Itoplectis tunetana* (Schmiedeckneckt, 1914) and *Itoplectis maculator* (Fabricius, 1775), belong to the family Ichneumonidae (Hymenoptera); one species, *Bessa parallela (*Meigen, 1824) belongs to the family Tachinidae (Diptera) and one species, *Habrobracon concolorans* (Marshall, 1900) belongs to the family Braconidae (Hymenoptera). The adults of parasitoids and moths were deposited in the EMET (as detailed in Table 2).

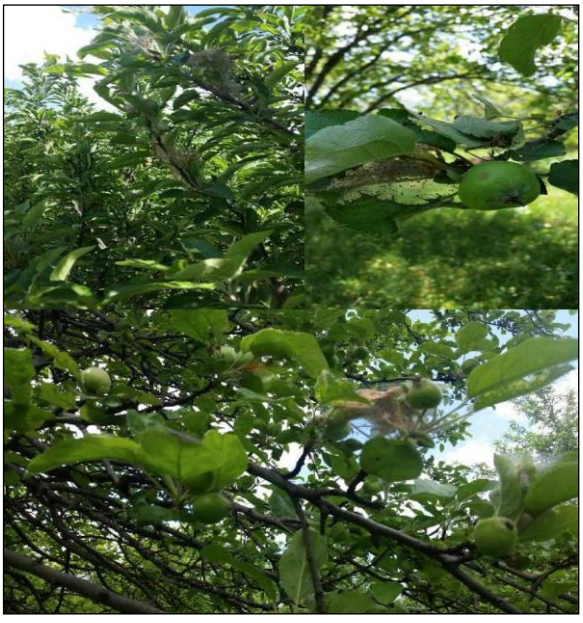

Figure 3. Infestation of *Yponomeuta malinellus* larvae on *Malus pumila*.

Table 1. List of the parasitoids obtained from the *Yponomeuta malinellus* (2015-2016)

Parasitoid species	Order	Family	Number of individual parasitoids	Number of females	Number of males
Diadegma armillatum (%22)	Hymenoptera	Ichneumonidae	55	28	27
Itoplectis maculator (%16)			42	23	19
Trieces tricarinatus (%15)			39	18	21
Itoplectis tunetana (%11)			27	11	16
Habrobracon concolorans (%19)	Hymenoptera	Braconidae	48	27	21
Bessa parallela (%17)	Diptera	Tachinidae	44	23	21
Total	3	6	255	130	125

Table 2. List of records of parasitoids on *Yponomeuta malinellus* (Yu et al., 2012)

Accepted scientific name	Original name	Synonyms	Parasitism	Geographic area*	Associated plant
Diadegma armillatum	*Campoplex armillatus*	*Angitia monospila* *Angitia pseudocombinata* *Campoplex tibialis*	Endoparasitoid	AUS, EP, E, WP	*Alnus glutinosa* *Medicago sativa* *Peucedanum oreoselinum* *Picea* sp.
Itoplectis maculator	*Ichneumon maculator*	*Ichneumon arlequinatus* *Ichneumon graminellae* *Ichneumon lateratoriu* *Ichneumon plaesseus* *Ichneumon scanicus* *Itoplectis rufiventris* *Pimpla castaniventris* *Pimpla cruentata* *Pimpla maculatrix* *Pimpla sexpunctata* *Pimpla tricolor* *Pimpla vincta*	Endoparasitoid	EP, E, WP	*Adonis vernalis* *Alnus glutinosa* *Chaerophyllum bulbosum* *Cnicus paluster* *Daucus carota* *Epilobium angustifolium* *Euphorbia nicaeensis* *Fraxinus excelsior* *Heracleum sphondylium* *Peucedanum oreoselinum* *Picea abies* *Picea excelsa* *Pinus sylvestris* *Quercus ilex* *Quercus sessiliflora* *Rubus* sp. *Taxus baccata*
Trieces tricarinatus	*Chorinaeus tricarinatus*	*Chorinaeus facialis*	Endoparasitoid	E, WP	
Itoplectis tunetana	*Pimpla tunetana*	*Itoplectis alternoides* *Itoplectis europeator* *Itoplectis haemorrhoidalis* *Itoplectis mediorufa*	Endoparasitoid	EP, E, WP	
Habrobracon concolorans	*Bracon concolorans*	*Bracon opacus* *Habrobracon mongolicus* *Habrobracon nigricans*	Endoparasitoid	EP, E, ORR, WP	
Bessa parallela		*Tachina parallela*	Endoparasitoid	PR	

* Geographic area: AUS: Australian region, E: Europe, EP: Eastern Palearctic, NEAR: Nearctic region, NTR: Neotropical, ORR: Oriental, P: Palearctic, WP: Western Palearctic.

Discussion

The valley that takes its name from the Coruh River, which flows for 442 km through Turkey, possesses a landscape as spectacular as it is vast. The Coruh River, which carved out this valley and which, owing to its topographical structure, ranks among the world's fastest flowing rivers, begins on the western slopes of Mt Mescit between the cities of Ispir and Erzurum.

Parasitoids of *Y. malinellus* have been reported in previous studies in Turkey (Gençer, 2003).

Lill et al., (2002) reported that host plant species had a large influence on infestation rates herbivores. There are significantly different infestation rates of apple ermine moth between geographical locations sampled, which is likely due to the habitat type and host plants (Lee & Pemberton, 2005). In this study of the Coruh Valley, the mean parasitism rate was 25.5%. In other studies, in Turkey and internationally, rates between 30 and 90% have been reported (İren, 1960; Junnikkala, 1960; Dijkerman et al., 1986; Kuhlmann, et al., 1988; Gençer & Doğanlar, 1996; Gençer, 2003).

Diadegma armillatum is known to be an important parasitoid in Europe and Eurasia. This species has been obtained from 64 different hosts worldwide. It is a major parasite of ermine moths in Europe (Junnikkala, 1960), causing relatively high percentage of parasitism, ranging from 10 to 40% (Balachowsky, 1966; Zayanchkauskas et al., 1979). In contrast, in Northeast Asia the mean parasitism rate of the moth was 0.3% in Korea and below 0.05% in the other regions. We found that, *D. armillatum* had highest abundance of the parasitoids obtained from *Y. malinellus* in apple in the Coruh Valley. It caused 5.5% mortality which was the highest of the the six parasitoids found in this study. It was obtained from about 22% of the parasitized larvae (55 of 255) in this study. This parasitoid species is considered to provide potentially useful biological control of *Plutella (Plutella) xylostella* (Linnaeus, 1758) (Lepidoptera: Yponomeutidae) and *Y. malinellus* elsewhere in the world (Yu et al., 2012).

Itoplectis maculator has a large range of host species. Yu et al., (2012) listed about 158 host species in lepidopteran families including Lasiocampidae, Noctuidae, Nolidae, Notodontidae, Nymphalidae, Pterophoridae and Pyralidae. This parasitoid has been reared from *Archips* sp. (Lepidoptera: Tortricidae) (İren, 1952, 1960, 1977; Doğanlar, 1982, 1987; Ulu, 1983; Kansu et al., 1986; Özdemir & Kılınçer, 1990), *Archips rosana* (Linnaeus, 1758) (Lepidoptera: Tortricidae) (Ulu, 1983; Doğanlar, 1987, 2003; Öncüer, 1991; Özdemir & Özdemir, 2002; Çoruh & Özbek, 2008), *Tortrix viridana* Linnaeus, 1758 (Lepidoptera: Tortricidae) (Özdemir & Kılınçer, 1990; Öncüer, 1991); *Acleris rhombana* (Denis & Schiffermüller, 1775) (Lepidoptera: Tortricidae) (Çoruh & Özbek, 2008), *Yponomeuta* sp. (Lepidoptera: Yponomeutidae) (İren, 1977; Ulu, 1983; Kansu et al., 1986; Doğanlar, 1987), *Yponomeuta evonymella* (Linnaeus, 1758) (Lepidoptera: Yponomeutidae) (Çoruh & Özbek, 2008), *Y. malinellus* (İren, 1952, 1960; Soydanbay, 1978; Ulu, 1983; Özdemir & Kılınçer, 1990; Öncüer, 1991; Erol & Yaşar, 1996), *Yponomeuta padella* (Linnaeus, 1758) and *Yponomeuta rorrella* (Hübner, 1796) (Lepidoptera: Yponomeutidae) (İren, 1952, 1960; Soydanbay, 1978; Ulu, 1983; Özdemir & Kılınçer, 1990; Öncüer, 1991), *Malacosoma (Clisiocampa) neustria* (Linnaeus, 1758) (Lasiocampidae: Lepidoptera) (Özder, 1999), *Lamprosticta culta* (Denis & Schiffermüller, 1775) (Lepidoptera: Noctuidae) (Okyar & Yurtcan, 2007); *Autographa gamma* (Linnaeus, 1758) (Lepidoptera: Noctuidae) (Okyar & Yurtcan, 2007), *Rhagoletis cerasi* (Linnaeus, 1758) (Diptera: Tephritidae) (Özder, 1999), *Myzus (Myzus) cerasi* (Fabricius, 1775) (Homoptera: Aphididae) (Özder, 1999), and *Hypera variabilis* (Herbst, 1795) (Coleoptera: Curculionidae) (İren, 1952, 1960; Özdemir & Kılınçer, 1990; Öncüer, 1991) in Turkey. It caused 4.2% mortality of the *Y. malinellus* specimens collected in this study, being the second highest of the ichneumonid parasitoids, and was obtained from 16% of the parasitized larvae (42 of 255).

Trieces tricarinatus has been obtained from *Y. malinellus*, *Y. padella*, *Y. rorrella* and *Yponomeuta sedella* (Treitschke, 1832) (Lepidoptera: Yponomeutidae) (Dijkerman et al., 1986), *Yponomeuta cagnagella* (Hübner, 1813) (Lepidoptera: Yponomeutidae) (Aliev, 1983) and *Y. evonymella* (Haeselbarth, 1989). Also, this species is used as a biological control agent of *Y. malinellus* in Canada and the USA (Dijkerman et al., 1986). Nevertheless, studies on this parasitoid are limited in Turkey. Gençer (2003), obtained it from the larvae apple ermine moth in Sivas at a rate of 0.6%. It caused 3.9% mortality of the specimens collected in this study and was obtained from 15% of the parasitized larvae (39 of 255).

Itoplectis tunetana is parasitoid with of some biocontrol importance. In Turkey, this parasitoid has been obtained from *Y. evonymella* (Çoruh & Özbek, 2008), *Y. malinellus* (Özdemir & Kılınçer, 1990; Erol & Yaşar, 1996; Gençer, 2003), *Y. padella* (Özdemir & Kılınçer, 1990) and *Y. rorrella* (Özdemir & Kılınçer, 1990). *Itoplectis tunetana* has 15 different known hosts worldwide (Talebi et al., 2005; Yu et al., 2012). It caused 1.1% mortality of the specimens collected in this study, was obtained from 11% of the parasitized larvae (27 of 255). *Habrobracon concolorans* is a Trans-Eurasian species (Samartsev & Belokobylskij, 2013), being widely distributed in the Palearctic and Oriental regions (Yu et al., 2012). It has seven known hosts worldwide. Beyarslan et al. (2005), listed 62 species of Braconidae from the western Black Sea region in Turkey and reported that *H. concolorans* obtained from *Etiella zinckenella* (Treitschke, 1832) (Lepidoptera: Pyralidae), *Pexicopia malvella* (Hübner, 1805) (Lepidoptera: Gelechiidae), *Cnephasia (Cnephasia) sedana* (Constant, 1884) (Lepidoptera: Tortricidae), all of which are microlepidoptera. It caused 4.8% mortality of the specimens collected in this study and was obtained from 19% of parasitized larvae (48 of 255). Notably, *Y malinellus* is considered to a new host record for *H. concolorans*.

Bessa parallela was the only tachinid parasitoid obtained from the *Y. malinellus*. It is broadly distributed in the Palearctic region and has more than 20 recorded lepidopterous hosts from many families (Herting, 1960). *Bessa parallela* is a gregarious larval parasitoid of some important lepidopteran pests, such as *Pieris rapae* (Linnaeus, 1758) (Lepidoptera: Pieridae) and *Pryeria sinica* Moore, 1877 (Lepidoptera: Zygaenidae) (Shima, 1999). The catalog of Kara & Tschorsnig (2003) lists tachinid parasitoids obtained from different hosts in Turkey. *Bessa parallela* has been obtained from *Yponomeuta* sp., *Y. malinellus*, *Y. padella* and *Nycteola* sp. (Kansu et al., 1986; Kara, 1998; Kara & Özdemir, 2000; Kara & Tschorsnig, 2003). It caused 4.4% mortality of the specimens collected in this study and was obtained from 17% of the parasitized larvae (44 of 255).

The study has provided useful new information on the parasitoids of *Y. malinellus* the Coruh Valley, which will underpin future laboratory and field studies.

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