Original article (Orijinal araştırma)

Tachinid (Diptera: Tachinidae) parasitoids reared from lepidopterous and hymenopterous hosts in southern forests of Turkey

Türkiye’nin güneyindeki ormanlarda lepidopter ve hymenopter konukçulardan elde edilen tachinid (Diptera: Tachinidae) parazitoitler

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Abstract

This study was conducted to determine the tachinid (Diptera: Tachinidae) parasitoids of lepidopterous and hymenopterous hosts from forests of southern Turkey (Adana, Hatay, Karaman, Mersin, Niğde and Osmaniye) in 2002-2019. For this purpose, host larvae were collected from forests and herbaceous plant communities and brought to the laboratory with their food-plants. As a result of the study, six tachinid species were reared from nine hosts. Four new hosts for Turkey were recorded. These are Vanessa cardui (L., 1758) and Polygonia c-album (L., 1758) (Lepidoptera: Nymphalidae) for Sturmia bella (Meigen, 1824) (Diptera: Tachinidae), Utetheisa pulchella (L., 1758) (Lepidoptera: Erebidae) for Exorista segregata (Rondani, 1859) (Diptera: Tachinidae) and Thaumetopoea wilkinsoni Tams, 1924 (Lepidoptera: Notodontidae) for Compsilura concinnata (Meigen, 1824) (Diptera: Tachinidae). In addition, two parasitoid-host couples were recorded for the second time in the world. These are U. pulchella for E. segregata and T. wilkinsoni for C. concinnata.

Keywords: Forest, host records, parasitoids, Tachinidae, Turkey

Öz

Bu çalışma Türkiye'nin güneyindeki (Adana, Hatay, Karaman, Mersin, Niğde ve Osmaniye) ormanlarda bulunan lepidopter ve hymenopterlerin, tachinid (Diptera: Tachinidae) parazitoitlerini belirlemek için 2002-2019 yılları arasında yürütülmüştür. Bu amaç için konukçu larvaları orman ağaçları ve yabancı otlar üzerinden toplanarak beslendikleri bitki ile bilirlikkeleri laboratuvara getirilmiştir. Çalışma sonucunda, dokuz farklı konukçudan altı tachinid tür elde edilmiş, 4 konukçu ise Türkiye için yeni konukçu kaydı olarak belirlenmiştir. Bunlar; Sturmia bella (Meigen, 1824) (Diptera: Tachinidae) için Vanessa cardui (L., 1758) ve Polygonia c-album (L., 1758) (Lepidoptera: Nymphalidae), Exorista segregata (Rondani, 1859) (Diptera: Tachinidae) için Utetheisa pulchella (L., 1758) (Lepidoptera: Erebidae) ve Compsilura concinnata (Meigen, 1824) (Diptera: Tachinidae) için Thaumetopoea wilkinsoni Tams, 1924 (Lepidoptera: Notodontidae)'dir. Ayrıca E. segregata için U. pulchella ve C. concinnata için T. wilkinsoni konukçu-parazitoit çiftleri dünyaya için ikinci kez kaydedilmiştir.

Anahtar sözcükler: Orman, konukçu kayıtları, parazitoit, Tachinidae, Türkiye

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Introduction

Forests are terrestrial ecosystems that consist of various trees, shrubs, herbaceous plants, microorganisms, insects and other animals. There are also economically important pests in forests in Turkey. The activities and damage of such pests do not occur suddenly. Forest pests are generally not given sufficient consideration and are even of no interest to the general public with the destruction of the pests only understood after they become an epidemic. It is known that 50 species and more cause damage in Turkish forests. The plant protection operations are conducted against these pests on 205 kHa in 2019. About a million dollars is spent for these activities each year (Anonymous, 2020). In the past, chemical control measures were used intensely. In recent years, mechanical, biological (bird nest construction, ant augmentation, and parasitoid and predator mass production) and biotechnological (pheromone) methods that do not harm nature are applied instead of chemicals. Also, the use of pesticides is very difficult and expensive in huge areas. In addition, pesticides lead to soil, air and water pollution and resistance, and damaging side effects to natural enemies should not be neglected. It is critical to protect natural enemies, so that they can provide effective biological control. Therefore, it is necessary to support the activities of these insects. Declines in beneficial organisms can lead to increased outbreaks of pests. Therefore, it is important to investigate the biology, ecology and host relationships of natural enemies.

Tachinids are an important group of parasitoids and the majority of the hosts are insect pests. Many hosts are lepidopteran pests. Others hosts are species belonging to the orders Coleoptera, Hemiptera, Hymenoptera, Orthoptera, Diptera and Lithobiomorpha (Grenier, 1988; Stireman et al., 2006; Tschorsnig, 2017). Detailed information on Palearctic and Turkish hosts of tachinids can be found in Tschorsnig (2017) and Kara & Tschorsnig (2003), respectively. Kara et al. (2014) have prepared a comprehensive catalog of tachinid-host associations in Turkish forests. It comprises 27 tachinid species reared from 14 hosts belonging to three orders.

Applied biological control studies with tachinid flies against certain forest pests were successfully performed in Canada and the USA in the 1900s (Grenier, 1988). Augmentative releases were conducted with Blepharipa pratensis (Meigen, 1824) in 1933 and Compsilura concinnata (Meigen, 1824) (Diptera: Tachinidae) in 1976 against the gypsy moth, Lymantria dispar (L., 1758) (Lepidoptera: Erebidae). These two parasitoids have been successfully established and are important parasitoids of the gypsy moth in many states of the USA (Blumenthal et al., 1979). Against the winter moth, Operophtera brumata (L., 1758) (Lepidoptera: Geometridae), two tachinids, Lypha dubia (Fallén, 1810) and Cyzenis albicans (Fallén, 1810) (Diptera: Tachinidae), were used in Canada in 1955-1980. Only the latter species was successfully established (Pschorn-Walcher et al., 1969). In Turkey, Phryxe caudata (Rondani, 1859) (Diptera: Tachinidae) is produced by means of an islet, a wire cage and a water chambered wire cage technique and released against Thaumetopoea pityocampa (Denis & Schiffermüller, 1775) (Lepidoptera: Notodontidae) which causes significant damage to pine trees (Kanat & Türk, 2002; Özdal, 2002).

This paper focuses on the tachinid parasitoids of some forest pests in southern Turkey.

Materials and Methods

This research was conducted to determine the tachinid parasitoids of lepidopterous and hymenopterous hosts from forests of southern Turkey (Adana, Hatay, Karaman, Mersin, Niğde and Osmaniye) in 2002-2019. Host larvae were collected from forests and herbaceous plant communities.

The collected host larvae were brought to the laboratory together with the plants they consume for rearing, transferred to distinct cages, and kept at 25 ± 2°C and 60-70% RH. Daily checks were made, and food was refreshed as needed. Also, parasitoid emergence was observed daily. After adult parasitoids were obtained, flies were prepared for identification. Reared parasitoids were described according to Mesnil (1944-1965), Tschorsnig & Herting (1994) and Tschorsnig & Richter (1998). Herting & Dely-Draskovits
was also followed for species nomenclature. Lepidopterous samples were identified using the keys of Doğanlar & Avcı (2001), Doğanlar et al. (2005), and Mazzei et al. (2020). Hymenopterous host was identified using the paper of Smith (1974). Plants were identified by Dr. Mehtap Öztekin (Systematic Botany, Department of Collections, National Botanical Gardens Directorate, Ministry of Agriculture and Forestry, Republic of Turkey, Ankara).

The date of emergence, the number of male and female individuals, the host species, the place where the hosts were collected and the plant where the host insect fed are given for each parasitoid separately. In addition, general information is given on distribution, hosts, and biology of reared parasitoids.

Results and Discussion

Six tachinid species were reared as parasitoids of eight lepidopteran and one hymenopteran host.

Subfamily: Exoristinae

**Tribe: Exoristini**

*Exorista segregata* (Rondani, 1859)

Reared specimens. 07.10.2017, ♀, reared from *Utetheisa pulchella* (L., 1758) (Lepidoptera: Erebidae), collected in Yenişehir, Mersin from *Heliotropium* sp. (Boraginaceae); 06.07.2009, ♂, reared from *L. dispar* collected in Tarsus, Mersin from *Quercus cocifera* L., 1753 (Fagaceae); and 03.08.2017, 7♂♂♀♀, reared from *Thaumetopoea ispartaensis* Doğanlar & Avcı, 2001 (Lepidoptera: Notodontidae) collected in Toroslar District, Mersin from *Cedrus libani* A. Rich. (Pinaceae).

Distribution in Turkey. İstanbul (Schimitschek, 1944), Trakya (Gürses, 1975), Erzurum (Doğanlar, 1975; Doğanlar, 1982; Kılıç & Alaoğlu, 1996; Özbek & Çoruh, 2012), Ankara, Kırşehir, Niğde (Kansu et al., 1986), Tokat (Kara, 1998; Kara & Alaoğlu, 2001; Atay & Kara, 2014), Isparta (Avcı & Kara, 2002), Belen (Mückstein et al., 2004), Lakes District (Avcı, 2009), Nevşehir (Bartsch & Tschorsnig, 2010), Mersin (Akdağci, 2010) and Muğla (Lutovinovas et al., 2018).

Hosts in Turkey. *Thaumetopoea pityocampa* (Schimitschek, 1944), *Euproctis chrysorrhoea* (L., 1758) (Lepidoptera: Erebidae) (Gürses, 1975), *Leucoma salicis* (L., 1758), *Malacosoma castrensis* (L., 1758), *Malacosoma francoen* (Denis & Schiffermüller, 1775) (Lepidoptera: Lasiocampidae), *Simyra* sp. (Lepidoptera: Noctuidae) (Herting, 1960; Doğanlar, 1975), *Euproctis* sp., *Phaleria bucephala* (L., 1758) (Lepidoptera: Notodontidae), *Simyra dentinosa* Freyer, 1838 (Lepidoptera: Noctuidae) (Doğanlar, 1982; Atay & Kara, 2014), *Hyles centralis* (Stauding, 1887) (Lepidoptera: Sphingidae) (Bartsch & Tschorsnig, 2010), *L. dispar* (Kara & Tschorsnig, 2003; Avcı, 2009), *L. salicis* (Kansu et al., 1986; Kılıç & Alaoğlu, 1996; Kara & Alaoğlu, 2001), *Malacosoma neustria* (L., 1758) (Lepidoptera: Lasiocampidae) (Kara & Alaoğlu, 2001; Özbek & Çoruh, 2012), *Parocneria terebinthi* (Freyer, 1838) (Lepidoptera: Erebidae) (Kara & Alaoğlu, 2001), *Aporia crataegi* (L., 1758) (Lepidoptera: Pieridae) (Kansu et al., 1986; Kara & Tschorsnig, 2003), *T. ispartaensis* (Avcı & Kara, 2002), *Pieris* sp., *Aglais io* (L., 1758) (Lepidoptera: Nymphalidae), *Zygaeena carniolica* (Scopoli, 1763) (Lepidoptera: Zygaenidae) (Kara & Tschorsnig, 2003), *Cucullia lanceolata* (Villers, 1789) (Lepidoptera: Noctuidae) (Mückstein et al., 2004), *Pieris brassicae* (L., 1758) (Lepidoptera: Pieridae) (Akdağci, 2010) and *Hyles siehei* Püngeler, 1903 (Lepidoptera: Sphingidae) (Bartsch & Tschorsnig, 2010).

*Utetheisa pulchella* is a new host for *E. segregata* in Turkey. There is only a single record of *E. segregata* reared from *U. pulchella* in the world (Kugler, 1980).

Remarks. In southern Europe has been seen from March to December, in several generations, visits flowers, hosts are species belonging to Erebidae, Zygaenidae, Noctuidae, Lasiocampidae, Notodontidae, Nymphalidae, Pieridae and Saturniidae (Tschorsnig & Herting, 1994).
**Diplostichus janitrix** (Hartig, 1837)

Reared specimens. 07.10.2019, ♀, reared from *Diprion pini* (L., 1758) (Hymenoptera: Diprionidae), collected in Aladağlar, Adana from *Pinus nigra* Arnold subsp. *pallasiana* (Lamb.) Holmboe var. *pallasiana* (Pinaceae).

Distribution in Turkey. Ankara (Tunca et al., 2009).

Hosts in Turkey. *Diprion pini* (Tunca et al., 2009) and *Neodiprion sertifer* Geoffroy (Aksu, 2010).

Remarks. This parasitoid is seen till mid-September from end of June in pine forests, it does not visit flowers and probably has only one generation in Europe. It has been only rarely collected in the field, but is usually reared from its hosts. *Diplostichus janitrix* has a narrow host range. Diprionidae (Hymenoptera) is the usual host family and it was mostly reared from *Diprion* spp. (Tschorschig & Herting, 1994; Tschorschig, 2017).

**Tribe: Blondellini**

**Compsilura concinna** (Meigen, 1824)

Reared specimens. 28.04.2017, ♂♂, 10♀♀, reared from *Thaumetopoea wilkinsoni* Tams, 1824 (Lepidoptera: Notodontidae), collected in Central District, Mersin from *Pinus brutia* Ten. (Pinaceae).

Distribution in Turkey. Ankara (Tuatay et al., 1972), Uşak, Denizli (Öncüer et al., 1977), Erzurum (Doğanlar, 1982; Kılıç & Alaoğlu, 1996), Ankara, Kirşehir, Niğde (Kansu et al., 1986), Artvin, Erzurum, Gümüşhane, Trabzon (Eroğlu, 1995), Samsun (Tuncer & Ecevit, 1996; Sullivan et al., 2012), Tokat (Kara, 1998; Atay & Kara, 2014), Bursa (Kovancı et al., 1999), Eskişehir (Kara & Özdemir, 2000; Aksu, 2005), Isparta (Avci & Kara, 2002), Hatay (Kaya & Kornoşor, 2008), Lakes District (Avci, 2009), Hatay (Kaya et al., 2016), Sakarya (Balkan et al., 2015), Muğla (Lutovinovas et al., 2018) and Edirne (Tek & Okyar, 2018).

Hosts in Turkey. *Euproctis* sp. (Lepidoptera: Erebidae) (Tuatay et al., 1972), *E. chrysorrhoea* (Öncüer et al., 1977; Soydanbay, 1978; Eroğlu, 1995; Kara, 1998), *L. salcis* (Doğanlar, 1982; Kansu et al., 1986; Kılıç & Alaoğlu, 1996), *M. neustria, L. dispar* (Kansu et al., 1986; Avci, 2009), *Hyphantria cunea* (Drury, 1773) (Lepidoptera: Erebidae) (Tuncer & Ecevit, 1996; Sullivan et al., 2012), *Parnassius apollo* (L., 1758) (Lepidoptera: Papilionide) (Kovancı et al., 1999), *P. brassicae* (Kara, 1998; Kaya & Kornoşor, 2008; Akdağçık, 2010), *Yponomeuta padella* (L., 1758) (Lepidoptera: Yponomeutide) (Kara & Özdemir, 2000), *T. pityocampa* (Oğurlu, 2000), *Autographa gamma* (L., 1758) (Lepidoptera: Noctuidae) (Kara & Tschorschig, 2003), *P. terebinthi* (Kara & Alaoğlu, 2001), *T. ispartaensis* (Avci & Kara, 2002), *Pontia daplidice* (L., 1758) (Lepidoptera: Pieridae), *Helicoverpa armigera* (Hübner, 1808) (Lepidoptera: Noctuidae) (Kaya & Kornoşor, 2008), *Helicystogramma triannulella* (Herrich-Schäffer, 1854) (Lepidoptera: Gelechiidae) (Kaya et al., 2014) and *Thaumetopoea solitaria* (Freyer, 1838) (Lepidoptera: Notodontidae) (Atay & Kara, 2014).

*Thaumetopoea wilkinsoni* is a new host for *C. concinna* in Turkey. There is only one record of *C. concinna* being reared from *T. wilkinsoni* (Tschorschig, 2017).

Remarks. In Europe, this common parasitoid has two generations and is seen from May-September on flowers or foliage. It is reared from numerous Lepidoptera, whereas Microlepidoptera and Tenthredinidae are only rarely parasitized (Tschorschig & Herting, 1994; Tschorschig, 2017).

**Tribe: Eryciini**

**Phryxe caudata** (Rondani, 1859)

Reared specimens. 20.10.2005, ♂, 3♀♀, reared from *T. wilkinsoni* collected in Mezitli, Mersin from *P. brutia*; 10.11.2005, ♂, reared from *T. wilkinsoni* collected in Beylice Village, Tarsus, Mersin from *P. brutia*; 11.11.2005, ♀, reared from *T. wilkinsoni* collected in Karaman on *Pinus nigra* Arnold (Pinaceae); 15.11.2005, ♂, reared from *T. wilkinsoni* collected in Çamalan Village, Tarsus, Mersin from *P. brutia*; 15.11.2005, ♂,
reared from *T. wilkinsoni* collected in Tekir, Adana from *P. nigra*; 21.04.2006, ♀; reared from *T. wilkinsoni* collected in Mut, Mersin from *P. brutia*; 21.04.2006, ♀, reared from *T. wilkinsoni* collected in Silifke, Mersin from *P. brutia*; 28.10.2007, ♀, reared from *T. wilkinsoni* collected in Pozanti, Adana from *P. nigra*; 25.04.2009, ♀♂, reared from *T. wilkinsoni* collected in Sarıçam, Adana from *P. brutia*; 25.04.2009, ♀, ♂, reared from *T. wilkinsoni* collected in Osmaniye from *P. brutia* and *Pinus halepensis* Miller (Pinaceae); 25.04.2009, ♀, reared from *T. wilkinsoni* collected in Ceyhan, Adana from *P. halepensis*; and 26.04.2009, ♀, reared from *T. wilkinsoni* collected in Serinyol, Hatay from *P. brutia*.

**Distribution in Turkey.** Antalya (Tosun, 1976), İzmir (Soydanbay, 1978), Isparta (Avcı & Kara, 2002), Lakes Districts (Avcı & Öğurulu, 2002), Muğla (Özçankaya & Can, 2004) and Tokat (Atay & Kara, 2014).

**Hosts in Turkey.** *Thaumetopoea ispartaensis*, *T. pityocampa* (Denis & Schiffermüller, 1775) (Soydanbay, 1978; Avcı & Öğurulu, 2002, Kanat & Türk, 2002; Özdal, 2002; Kara & Tschorsnig, 2003; Özçankaya & Can, 2004; Atay & Kara, 2014), and *T. wilkinsoni* (Battisti et al., 2015).

**Remarks.** *Thaumetopoeidae* (currently placed in Notodontidae) is the usual host family for *P. caudata* and which is commonly reared from *Thaumetopoea* spp., especially *T. pityocampa* (Tschorsnig, 2017). In Turkey, *P. caudata* is produced and released in nature against *T. pityocampa* (Kanat & Türk, 2002; Özdal, 2002).

**Drino inconspicua** (Meigen, 1830)

Reared specimens. 01.04.2005, ♀, reared from *D. pini*, collected in Mut, Mersin from *P. brutia*; 21.04.2006, ♀, reared from *D. pini*, collected in Mut, Mersin from *P. brutia*; 07.06.2007, ♀♂, reared from *D. pini*, collected in Karaman from *P. nigra*; and 20.10.2012, ♀, reared from *D. pini*, collected in Alihoca Village, Niğde from *P. nigra*.

**Distribution in Turkey.** Erzurum (Doğanlar, 1975; Doğanlar, 1982), Kirkırelari (Haeselbarth, 1983), Konya (Tschorsnig, 2005), Bolu (Korkmaz, 2007), Lakes District (Avcı, 2009) and Burdur, Muğla (Lutovinovas et al., 2018).

**Hosts in Turkey.** *Malacosoma neustria* (Doğanlar, 1975), *L. dispar* (Herting, 1983; Avcı, 2009) *D. pini* (Tschorsnig, 2005), *Neodirion sertifer* (Geoffroy, 1785) (Hymenoptera: Diprionidae), (Akınç & Avcı, 2016) and *P. bucephala* (Schimitschek, 1944; Doğanlar, 1982).

**Remarks.** In Europe, this parasitoid is commonly found in pine forests. It is collected from early June to Mid-September and mostly has two generations per year. In the field it is rather rare, but is more commonly reared from its hosts. *Driron* spp. Schrank, 1802 (Hymenoptera: Diprionidae) are common hosts, but it is also reared from a few Lepidoptera, especially *L. dispar* and *Dendrolimus pini* L. (Lepidoptera: Lasiocampidae) (Tschorsnig & Herting, 1994; Tschorsnig, 2017).

**Tribe: Gonini**

**Sturmiella bella** (Meigen, 1824)

Reared specimens. 12.09.2002, ♂; 17.09.2002, ♀; 21.09.2002, 2♂♂; 30.09.2002, 2♂♂, reared from *Aglais urticae* (L., 1758) (Lepidoptera: Nymphalidae), collected in Aladağlar, Adana from *Urtica* sp. (Urticaceae); 16.07.2003, 2♀♀; 24.07.2003, 2♂♂, reared from *A. urticae*, collected in Alihoca Village, Niğde from *Urtica* sp.; 17.09.2002, ♀, reared from *Vanessa cardui* (L., 1758) (Lepidoptera: Nymphalidae) collected in Aladağlar, Adana from *Malva* sp. (Malvaceae); 29.03.2003, ♀, reared from *V. cardui* collected in Karabucak, Tarsus, Mersin from *Malva* sp.; 22.02.2003, ♂; 21.03.2003, ♀; 29.03.2003, ♂, ♀; 29.03.2003, ♀; 07.04.2003, ♀♂; 13.03.2004, ♀♂; 14.03.2004, ♀♂; 08.04.2007, ♀♂; 16.04.2007, ♀, reared from *Vanessa atalanta* (L., 1758) (Lepidoptera: Nymphalidae) collected in Karabucak, Tarsus, Mersin from *Urtica* sp.; 2.07.2007, ♀, reared from *V. atalanta* collected in Alihoca Village, Niğde from *Urtica* sp.; 22.08.2002, 3♀♀;
23.08.2002, ♂, ♀, reared from Polygonia c-album (L., 1758) (Lepidoptera: Nymphalidae) collected in Aladağlar, Adana from Urtica sp.; 3.08.2005, ♂♀; 3.08.2005, 2♂♂, ♀♀, reared from P. c-album collected in Alihoca Village, Niğde from Urtica sp.; and 12.09.2007, ♀, reared from P. c-album collected in Tekir, Adana from Urtica sp.

Distribution in Turkey. Erzurum (Doğanlar, 1975), Marmara Region (Atak & Atak, 1984), Tokat (Kara, 1998), Sakarya (Balkan et al., 2015) and Kayseri (Atay et al., 2018).

Hosts in Turkey. Aglais urticae (Doğanlar, 1975; Kara, 1998; Atay et al., 2018), P. brassicae (Atak & Atak, 1984) and V. atalanta (Atay et al., 2018).

Vanessa cardui and P. c-album are new hosts for S. bella in Turkey.

Remarks. This parasitoid is commonly found in warmer areas and is generally seen from mid-July to mid-September in meadows, bushes and forest edges in Europe. In warmer central Europe in open areas it is not rare and much more often reared from its hosts. This tachinid is usually reared from Nymphalidae, rarely from other Macrolepidoptera (Tschorsnig & Herting, 1994; Tschorsnig, 2017).

In this study, tachinid parasitoids of some species belonging to the order Lepidoptera and Hymenoptera were studied in the southern forests of Turkey. Six tachinid species were reared from nine hosts. These were C. concinna, D. inconspicua, D. janitrix, E. segregata, P. caudata and S. bella from the subfamily Exoristinae. These species were previously reared from different hosts in Turkey. In addition, four new hosts for Turkey were recorded. These were U. pulchella for E. segregata, P. c-album and V. cardui for S. bella, and T. wilkinsoni for C. concinna. In addition, two parasitoid-host couples were recorded for only the second time worldwide. These were T. wilkinsoni for C. concinna and U. pulchella for E. segregata.

Turkey has a wide range of ecosystems under different climatic conditions. Forest areas are mostly natural ecosystems free from human activities. In these areas, natural balance usually occurs, but from time to time this balance deteriorates in favor of pests and irreversible ecosystem losses occur with this damage. For this reason, it is necessary to know the species diversity, habitat associations and the host complexes of harmful and beneficial organisms. Concurrently, it is important to support their populations. Although Tachinidae species, an important parasitoid group, are important for suppressing populations of many forest pests, studies on this family have been relatively limited in the Turkish forests. The areas studied have diverse habitats which have many insect species. Therefore, it is expected that more host-parasitoid interactions will be found in these forests with further research.

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References

Akdağçık, Z., 2010. Çukurova Bölgesi Cruciferae Üretim Alanlarında Zararlı olan Lepidopter Türlerin Populasyon Gelişmeleri, Predator ve Parazitotllerin Belirlenmesi ve Pieris brassicae (L.)'nin Bazı Biyolojik Özellikleri ile Mükadelesi Üzerine Araştırmalar. Çukurova University, Institute of Natural and Applied Sciences, (Unpublished) PhD Thesis, Adana, Turkey, 83 pp (in Turkish).

Akınçi, A. E. & A. Avcı, 2016. Neodiprion sertifer’i’n Göller Bölgesi ormanlarında biyolojisi ve doğal düşmanları. Turkish Journal of Forestry, 17 (1): 30-36 (in Turkish with abstract in English).

Aksu, S., 2005. Eskişehir ve Çevresinde Saptanan Exoristinae ve Phasiinae (Diptera: Tachinidae) Türleri. Osmangazi University, Graduate School of Natural and Applied Sciences, (Unpublished) MSc Thesis, Eskişehir, Turkey, 129 pp (in Turkish).
Aksu, Y., 2010. Studies on Neodiprion sertifer (Geoff) (Hymenoptera; Diprionidae), an important pest of Pinus sylvestris plantations. Orman Mühendisliği, 47 (1-2-3): 26-34 (in Turkish).

Anonymous, 2020. Orman Genel Müdürlüğü 2019 Yılı Faaliyet Raporu. (Web page: https://www.ogm.gov.tr/ekutuphane/FaaliyetRaporu/Forms/AllItems.aspx) (Date accessed: 27 July 2020) (in Turkish).

Atak, U. & E. D. Atak, 1984. Lahana kelebeğinin (Piers brassicae L.)'nin biyo-ekolojisi ve mikrobiyal ilaçlarla savaşımı üzerinde araştırmalar. Bitki Koruma Bülteni, 24 (4): 173-199 (in Turkish).

Atay, T. & K. Kara, 2014. Tachinids (Diptera: Tachinidae) reared from lepidopterous and heteropterous hosts from some localities in the Kelkit Valley (Amasya, Tokat, Sivas) of Turkey. Turkish Journal of Zoology, 38 (4): 500-507.

Atay, T., M. Özdemir & K. Kara, 2018. Tachinids (Diptera: Tachinidae) reared from lepidopterous hosts in Kayseri provinces with new host records. Journal of Entomological Research Society, 20 (2): 103-108.

Avci, M., 2009. Parasitoids complex and new host plants of the Gypsy Moth, Lymantria dispar L. in the Lakes District, Turkey. Journal of Animal and Veterinary Advances, 8 (7): 1402-1405.

Avci, M. & K. Kara, 2002. Tachinidae parasitoids of Traumatocampa ispartaensis from Turkey. Phytoparasitica, 30 (4): 361-364.

Avci, M. & İ. Oğurlu, 2002. “The importance, biology and natural enemies of the pine processions moth [Thaumetopoea pityocampa (Den. & Schiff.)] in the lakes district, 28-36”. Proceedings of Pine Processionary Moth Symposium (24-25 April 2002, Kahramanmaraş, Turkey), 226 pp.

Balkan, T., K. Kara & T. Atay, 2015. Tachinidae (Diptera) species of the Sakarya (Turkey) province with two new records. Turkish Journal of Zoology, 39 (6): 1050-1055.

Bartsch, D. & H.-P. Tschorsnig, 2010. Raupenfliegen (Diptera:Tachinidae) aus Wirtten der West- und Zentralpaläarktis. Mitteilungen des entomologischen Vereins Stuttgart, 45 (2): 137-140.

Battisti, A., M. Avci, D. N. Avtzis, M. L. B. Jamaa, L. Berardi, W. A. Berretta, M. Branco, G. Chakali, M. A. A. Fels, B. Frérot, J. A. Hódar, I. Ionescu-Mălăncuș, K. Ípekdağ, S. Larsson, T. Manole, Z. Mendel, N. Meririsse, P. Mirchev, N. Nemer, M.-R. Paiva, J. Pino, A. Protasov, N. Rahim, J. Rousselet, H. Santos, D. Sauvard, A. Schof, M. Simonato, A. Yart & M. Zamoum, 2015. “Natural History of the Processionary Moths (Thaumetopoea spp.): New Insights in Relation to Climate Change, 15-79”. In: Processionary Moths and Climate Change: An Update (Ed. A. Roques). Springer, Dordrecht, Netherlands, 427 pp.

Blumenthal, E. M., R. A. Fusco & R. C. Reardon, 1979. Augmentative release of two established parasite species to suppress populations of the gypsy moth. Journal of Economic Entomology, 72 (2): 281-288.

Doğanlar, M., 1975. Erzurum Bölgesinde Önemi Lepidopter Tirtillannda Bulunan Tachinidae Sinekleri ve Bunun筰 Karsa Biyolojileri. Atatürk Üniversitesi Yayınları, Erzurum, No: 375: 136s (in Turkish).

Doğanlar, M., 1982. Doğu Anadolu da saptanan bazı parazit sinekler 1. Exoristinae (Diptera: Tachinidae). Türkiye Bitki Koruma Dergisi, 6 (3): 161-173 (in Turkish with abstract in English).

Doğanlar, M. & M. Avci, 2001. A new species of Traumatocampa Wallengren (Lepidoptera: Thaumetopoeidae) feeding on cedar from İsparta (Türkiye). Turkish Journal of Entomology, 25 (1): 19-22.

Doğanlar, M., O. Doğanlar & F. Doğanlar, 2005. Morphology and systematics of European species of Traumatocampa Wallengren, 1871 with descriptions of two new species from the Mediterranean region of Turkey (Lepidoptera, Thaumetopoeidae). Entomofauna, 26 (13): 229-240.

Eroğlu, M., 1995. Investigations on the development and efficacy of Compsilura concinnata (Meigen) (Diptera, Tachinidae) on Euproctis chrysorrhoea (L.) (Lepidoptera, Lymantriidae). Turkish Journal of Entomology, 19 (3): 169-176.

Grenier, S., 1988. Applied biological control with tachinid flies (Diptera, Tachinidae). Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz, 61 (3): 49-56.

Gürses, A., 1975. Trakya bölgesinde Alın Kelebek (Euproctis chrysorrhoea L.)’in Biyo-ökolojisi ve Savaşı Üzerinde Araştırmalar. Zirai Mucadele ve Zirai Karantina Genel Müdürlüğü, Ankara, 79 s (in Turkish).

Haesselbarth, E., 1983. Determination list of entomophagous insects 9. International Union for Biological Sciences, International Organization for Biological Control (IUBC) of Noxious Animals and Plants. West Palaearctic Regional Section, 6 (1): 1-49.

Herting, B., 1960. Biologie der Westpalaarktischen Raupenfliegen (Dipt., Tachinidae). Monographien zur angewandten Entomologie, Hamburg und Berlin, 188 pp.
Tachinid (Diptera: Tachinidae) parasitoids reared from lepidopterous and hymenopterous hosts in southern forests of Turkey

Herting, B., 1983. Determination list of entomophagous insects Nr. 9. International Organization for Biological and Integrated Control of Noxious Animals and Plants/West Palaearctic Regional Section Bulletin, 6 (1): 1-49.

Herting, B. & Á. Dely-Draskovits, 1993. “Family Tachinidae, 118-458”. In: Catalogue of Palaearctic Diptera. Anthomyiidae-Tachinidae, (Eds. A. Soós & L. Papp), Budapest, Hungary, 624 pp.

Kanat, M. & M. Türk, 2002. “New cage method for struggling against Thaumetopoea pityocampa (Schiff), 109-114”. Proceedings of Pine Processionary Moth Symposium (24-25 April 2002, Kahramanmaraş, Turkey), 226 pp.

Kansu, A., N. Kılıncer, N. Uğur & O. Gürkan, 1986. “Ankara, Kırşehir, Nevşehir ve Niğde illerinde kültür bitkilerinde zararlı lepidopterlerin larva ve pupa asalakları, 146-161”. Türkiye I. Biyolojik Mücadele Kongresi (12-14 Şubat 1986, Adana, Turkey), 476 pp (in Turkish).

Kara, K., 1998. Tokat ve Çevresinde Saptanan Exoristinae ve Phasiinae (Diptera: Tachinidae) Alın famílialarına Ait Sinemler Üzerinde Sistematik Çalışmalar. Gaziosmanpaşa University, Institute of Natural and Applied Sciences, (Unpublished) PhD Thesis, Tokat, Turkey, 248 pp (in Turkish).

Kara, K. & Ö. Alaoğlu, 2001. Some new host records of Tachinidae (Diptera) from Turkey. Studia Dipterologica, 8 (1): 349-351.

Kara, K. & Y. Özdemir, 2000. Tachinid flies (Diptera, Tachinidae) reared from lepidopterous larvae in Central Anatolia (Turkey). Zoology in the Middle East, 20 (1): 117-120.

Kara, K. & H.-P. Tschorsnig, 2003. Host catalogue for the Turkish Tachinidae (Diptera). Journal of Applied Entomology, 127 (8): 465-476.

Kara, K., T. Atay & T. Balkan, 2014. “Tachinids (Diptera, Tachinidae) living on forest pests as parasitoid in Turkey, pp 735-738”. 2nd Symposium of Turkey Forest Entomology and Pathology Symposium (7-9 April 2014, Antalya, Turkey), 766 pp.

Kaya, K. & S. Kornosor, 2008. The lepidopterous pest species, their parasitoids and population dynamics of the important ones in winter vegetables areas in Hatay province. Turkish Journal of Entomology, 32 (3): 195-209.

Kaya, K., F. C. Cengiz, M. E. Çalışkan & S. Çalışkan, 2016. The lepidopteran pests of sweet potato: first record of Helcystogramma triannulella (Herrich-Schäffer) (Lepidoptera: Gelechiidae) with population development and natural enemies in Turkey. Turkish Journal of Entomology, 40 (2): 149-156.

Kılıç, N. & Ö. Alaoğlu, 1996. Biology and parasitoids of satin moth Leucoma salicis (L.) (Lepidoptera, Lymantriidae) a pest of poplar trees in Erzurum Province (Turkey). Turkish Journal of Entomology, 20 (4): 269-279 (in Turkish with abstract in English).

Korkmaz, Y., 2007. Batı Karadeniz Bölgesi Tachinidae (Hexapoda: Diptera) Türleri Üzerinde Faunistik Çalışmalar. Gaziosmanpaşa University, Institute of Natural and Applied Sciences, (Unpublished MSc Thesis, Tokat, Turkey, 54 pp (in Turkish).

Kovanci, B., N. S. Gencer & M. Kaya, 1999. Uludağ (Bursa)’da Bulunan Apollon kelebeği, Parnassius apollo (L.) (Lepidoptera: Papilionidae) üzerinde biyolojik ve ekolojik araştırmalar. Turkish Journal of Agriculture and Forestry, 23 (4): 875-884 (in Turkish with abstract in English).

Kugler, J., 1980. New taxa of Tachinidae (Diptera) with a list of the species from Israel and adjacent territories. Israel Journal of Entomology, 13: 27-60.

Lutovinovas, E., H.-P. Tschorsnig, M. Barták, Š. Kubík, O. Dursun, H. S. Civelek & K. Kara, 2018. Contribution to the tachinid fauna of southwestern Turkey (Diptera: Tachinidae). Annales de la Société entomologique de France (N.S.), 54 (4): 335-366.

Mazzei, P., D. Morel & P. Panfili. 2020. Moths and Butterflies of Europe and North Africa. (Web page: https://www.leps.it) (Date accessed: 22 July 2020).

Mesnil, L. P., 1944-1965. “Larvaevorinae (Tachininae), 370-751”. In: Die Fliegen der Palaarktischen Region (Ed. E. Lindner). Schweizerbart’sche Verlagshandbuchhandlung, Stuttgart, Germany, 1168 pp.

Mückstein, P., H.-P. Tschorsnig & J. Vaňhara, 2004. Some new host records of West Palaearctic Tachininae (Diptera). Dipterologica Bohemoslova, 12 (1): 111-113.

Oğurlu, İ., 2000. Biyolojik Mücadele. Isparta, Süleyman Demirel Üniversitesi, Isparta, 145 s (in Turkish).
Öncüler, C., E. Yalçın & E. Erkin, 1977. Ege Bölgesinde meyve ağaçlarında zarar apam Euproctis chrysorrhoea L. (Lep: Lymantridiadae) larvalarının doğal düşmanları ve bunların etkiliilik durumları. Türkiye Bitki Koruma Dergisi, 1 (1): 39-47 (in Turkish with abstract in English).

Özbek, H. & S. Çoruh, 2012. Larval parasitoids and larval diseases of Malacosoma neustria L. (Lepidoptera: Lasiocampidae) detected in Erzurum Province, Turkey. Turkish Journal of Zoology, 36 (4): 447-459.

Özçankaya, İ. M. & P. Can, 2004. Research on the improvement of mechanical and biological pest control possibilities of Thaumetopoea pityocampa (Den. & Schiff.) (Lep.: Thaumetopoeidae) in the Kızılırmak forestation area in the Muğla province. T.C. Çevre ve Orman Bakanlığı Ege Ormançılık Araştırma Müdürlüğü Teknik Bülteni, 26: 84 s (in Turkish).

Özdal, M. H., 2002. “Struggling method with islets against Thaumetopoea pityocampa, 101-108”. Proceedings of Pine Processionary Moth Symposium (24-25 April 2002, Kahramanmaras, Turkey), 226 pp.

Pschorn-Walcher, H., D. Schroeder & O. Eichhorn, 1969. Recent attempts at biological control of some Canadian forest insect pests. Technical Bulletin of the Commonwealth Institute of Biological, 11: 1-18.

Schimitschek, E., 1944. Forstsinwesen der Türkîe und ihre Umwelt, Prague: Volk und Reich Verlag, 371 pp.

Smith, D. R., 1974. Conifer Sawflies, Diprionidae: Key to North American genera, Checklist of world species, and new species from Mexico (Hymenoptera). Proceedings of The Entomological Society of Washington, 76 (4): 409-418.

Soydanbay, M., 1978. Türkçe’de bitki zararlısı bazı böceklerin doğal düşman listesi. Kısm II.Türkiye Bitki Koruma Dergisi, 2 (2): 61-92 (in Turkish with abstract in English).

Stireman, J. O., J. E. O’ Hara & D. M. Wood, 2006. Tachinidae: Evolution, behavior and ecology. Annual Review of Entomology, 51: 525-555.

Sullivan, G. T., I. Karaca, S. K. Osman-Sullivan & K. Kara, 2012. Tachinid (Diptera: Tachinidae) parasitoids of overwintered Hypanthia cunea (Drury) (Lepidoptera: Arctiidae) pupae in hazelnut plantations in Samsun province, Turkey. Journal of the Entomological Research Society, 14 (1): 21-30.

Tek, S. E. & Z. Okyar, 2018. A contribution to the knowledge of parasitoids of insects associated with Rosaceae species from Edme province, European Turkey. Acta Biologica Turcica, 31 (3): 86-101.

Tosun, İ., 1976. Akdeniz Bölgesi, iğne yapraklı ormanlarda zarar yapan böcekler ve önemli türelerin parazit ve yırtıcıları üzerine araştırmalar, İstanbul Üniversitesi Orman Fakültesi Dergisi, 26 (2): 218-253 (in Turkish).

Tschorsnig, H.-P., 2005. Determination list of entomophagous insects Nr. 14. International Organization for Biological and Integrated Control of Noxious Animals and Plants/West Palaearctic Regional Section Bulletin, 28 (11): 1-71.

Tschorsnig, H.-P., 2017. Preliminary host catalogue of Palaearctic Tachinidae (Diptera). 480 pp. (Web page: http://www.nadstaptera.org/Tach/WorldTachs/CatPalHosts/Cat_Pal_tach_hosts_Ver1.pdf) (Date accessed: 15 July 2020).

Tschorsnig, H.-P. & B. Herting, 1994. Die Raupenfliegen (Diptera: Tachinidae) Mitteleuropas: Bestimmungstabellen und Angaben zur Verbreitung und Ökologie der einzelnen Arten. Stuttgart Beiträge zur Naturkunde (A), 506: 170 pp.

Tschorsnig, H.-P. & V. A. Richter, 1998. “Family Tachinidae. 691-827”. In: Contributions to a Manual of Palaearctic Diptera (Eds. L. Papp & B. Darvas), Science Herald Budapest, Hungary, 880 pp.

Tuatay, N., A. Kalkandelen & N. Aysev Çağatay, 1972. Nebat Koruma Müzesi Böcek Kataloğu (1961-1971). Zirai Mücadele ve Zirai Karantina Genel Müdürlüğü, Ankara, 119 s (in Turkish).

Tunc, H., K. Kara & C. Özkın, 2009. Two tachinids (Tachinidae: Tachinidae) parasitoids of Diprion pini (L.) (Hymenoptera: Diprionidae), along with a new record for the Turkish Tachinidae Fauna. Turkish Journal of Zoology, 33 (2): 241-244.

Tuncer, C. & O. Ecevit, 1996. “Studies on the short biology of fall webworm (H. cunea Drury, Lep.: Arctiidae) in hazelnut growing area of Samsun Province and its natural enemies, 134-145”. Findik ve Diğer Sert Kabuklu Meyveler Sempozyumu (10-11 January 1996, Samsun, Turkey), 419 pp.