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# Larval parasitoids and larval diseases of *Malacosoma neustria* L. (Lepidoptera: Lasiocampidae) detected in Erzurum Province, Turkey

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**Abstract:** The larval parasitoids and larval diseases of *Malacosoma neustria* (L.) (Lepidoptera: Lasiocampidae) in various host plants were investigated in Erzurum Province, Turkey, during 2004 and 2005. The larval parasitoids were reared in a laboratory, and a total of 29 parasitoid species were established in association with the larvae of *M. neustria* in the families Tachinidae (Diptera), Braconidae, Ichneumonidae, and Chalcidoidea (Hymenoptera). Of the 6 tachinid parasitoids, *Pales pavida* (Meigen) was the most prevalent species and accounted for 25% of the tachinid records. Among the tachinids, there were 2 new records for the Turkish fauna: *Exorista amoena* Mesnil and *Palesisa nudioculata* Villeneuve. *Exorista amoena* was reared from *M. neustria* for the first time. The braconid species *Meteorus lionotus* Thomson and *Cotesia vanessa* (Reinhard) were also reared from *M. neustria* for the first time. Among the 10 chalcidoid species reared, *Monodontomerus aereus* Walker and *Brachymeria secundaria* (Rusc.) were the most prevalent species. Five chalcidoid species, *Asaphes suspensus* (Nees), *A. vulgaris* Walker (Pteromalidae), *Brachymeria secundaria* (Ruschka) (Chalcididae), *Eupelmus urozonus* Dalman (Eupelmidae), and *Eurytoma verticillata* (F.) (Eurytomidae), were reared from *M. neustria* for the first time. Of the 10 species of ichneumonids reared, *Exeristes roborator* F. was the most abundant and accounted for 35% of the total ichneumonid records. The total parasitism rate of all parasitoids was 33.7%. As disease agents of *M. neustria*, the nuclear polyhedrosis virus and 4 pathogenic bacteria, *Brevibacillus agri*, *Alcaligenes xylosoxydans xylosoxydans* (*Achromobacter xylosoxidans*), *Bacillus lentimorbus*, and *Serratia fonticola*, were diagnosed. All of the bacteria from *M. neustria* were recorded for the first time. The percentage of diseased larvae was low, about 3%.

**Key words:** Lepidoptera, Lasiocampidae, *Malacosoma neustria*, parasitoids, disease, bacteria, virus, Erzurum, Turkey

## Erzurum İli'nde (Türkiye) *Malacosoma neustria* L. (Lasiocampidae: Lepidoptera)'nın larva parazitoitleri ve hastalıkları

**Özet:** Değişik konukçularda beslenen *Malacosoma neustria* (L.) (Yüzükkelebeği) (Lepidoptera: Lasiocampidae)'nın larva parazitoitleri ve larva hastalıkları 2004 ve 2005 yıllarında Erzurum İli'nde araştırılmıştır. Laboratuar koşullarında, Tachinidae (Diptera), Braconidae, Ichneumonidae ve Chalcidoidae (Hymenoptera)'ye ait toplam 29 parazitoid türü elde edilmiştir. Saptanan altı tachinid türünden *Pales pavida* (Meigen) ve *Tachina praeceps* Meigen en fazla yoğunluk oluşturmuşlardır. *Exorista amoena* Mesnil ve *Palesisa nudioculata* Villeneuve Türkiye faunası için yeni türlerdir. *Exorista amoena* ilk defa bu çalışma ile *M. neustria*'dan elde edilmiştir. İki braconid türü olan *Meteorus lionotus* Thomson ve

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*Cotesia vanessa* (Reinhard)'nın *M. neustria* larvalarını parazitlediği ilk defa belirlenmiştir. Topam 10 chalcidoid türü arasında, *Monodontomerus aereus* Walker ve *Brachymeria secundaria* (Rusc.) en yaygın olanlardır ve tüm chalcidoidlerin sırasıyla % 35 ve % 32'ini oluşturmaktadırlar. *Asaphes suspensus* (Nees), *A. vulgaris* Walker (Pteromalidae), *Brachymeria secundaria* (Ruschka) (Chalcididae), *Eupelmus urozonus* Dalman (Eupelmidae) ve *Eurytoma verticillata* (F.) (Eurytomidae) türleri ilk kez *M. neustria*'dan elde edilmiştir. Tolam 10 tür olan ichneumonidler içerisinde, *Exeristes roborator* F. en yaygın olanıdır ve ichneumonidlerin % 35'ini oluşturmaktadır. Tüm parazitoitlerin toplam parazitleme oranı % 33,7 olarak belirlenmiştir. *M. neustria* larvalrında hastalık etmeni olarak nükleer polyhedrosis virüsü (NPD) ve *Brevibacillus agri*, *Alcaligenes xylosoxydans xylosoxydans* (*Achromobacter xylosoxidans*), *Bacillus lentimorbus* ve *Serratia fonticola* olmak üzere dört bakteri türü, tespit edilmiştir. Bu türler, *M. neustria*'dan ilk defa elde edilmişlerdir. Hastalıklara bağlı olarak saptanan larvalardaki ölüm oranı yaklaşık % 3 düzeyindedir.

**Anahtar sözcükler:** Lepidoptera, Lasiocampidae, *Malacosoma neustria*, parasitoitler, hastalıklar, bakteri, virüs, Erzurum, Türkiye

## Introduction

The European tent caterpillar or lackey moth, *Malacosoma neustria* (L.) (Lepidoptera: Lasiocampidae), known as "yüzükkelebeği" or "yüksükkelebeği" in Turkish, is one of the most widely distributed species, particularly in the eastern and central Anatolian parts of Turkey (İren, 1977; Çoruh and Özbek, 2002). Its distribution range in the world is wide: Europe, northern Africa, Iran, Syria, Siberia, China, Mongolia, Taiwan, North Korea, and Japan (Dobesberger, 2002). It has been recognized as an important defoliator of a wide variety of deciduous hardwood trees and shrubs throughout its range for many years (Bodenheimer, 1958; İren, 1977; Çanakçıoğlu and Mol, 1998; Özbek et al., 1998; Çoruh and Özbek, 2002; Özbek and Çalmaşur, 2005).

*Malacosoma* species are widespread and are important defoliators of various types of cultivated and wild plants (Costa, 1997). *M. neustria* has a wide host range that includes many fruit trees such as apple (*Malus communis* L.), pear (*Pyrus communis* L.), plum (*Prunus* spp.), and mulberry (*Morus* sp.), and wild and ornamental trees and shrubs including oak (*Quercus* spp.), rose (*Rosa* spp.), oleaster (*Elaeagnus angustifolia* L.), sea buckthorn (*Hippophae rhamnoides* L.), barberry (*Berberis* spp.), and elm (*Ulmus* spp.). Other deciduous trees and shrubs such as willow (*Salix* spp.), poplar and aspen (*Populus* spp.), birch (*Betula* spp.), ash tree (*Fraxinus* spp.), currant (*Ribes* spp.), and bramble bushes (*Rubus* spp.) are also damaged occasionally (Bodenheimer, 1958; İren, 1977; Özbek et al., 1998; Çoruh and Özbek, 2002; Özbek and Çalmaşur, 2005; Özbek and Çoruh, 2010). In eastern Anatolia it is more abundant and destructive, particularly in sea buckthorn, barberry, and some rose species (Çoruh and Özbek, 2002).

*M. neustria* is univoltine and overwinters in the form of egg masses on twigs of the host plants. Newly emerged larvae crawl to the crown, feed gregariously, and gather at major branch forks to construct webbing (tents), which are white in color and easily recognized. Larvae (caterpillars) feed both in the tent as well as outside the crown. As the larvae develop, they become solitary and eventually seek sheltered locations to pupate. The cocoons are yellowish-white, loose, and usually occur in clusters (Çoruh and Özbek, 2002).

Populations of *M. neustria* periodically attain outbreak proportions in eastern Anatolia. During outbreaks, a large number of caterpillars cause widespread and extensive defoliation of host plants and may create an overwhelming nuisance to people encountering them. Severe and repeated defoliation can lead to dieback and/or reduced growth in the affected plants, which in some instances may be serious. Although the outbreak periods reported are irregular, since 1970 the outbreaks have been reported at 3-7 year intervals in the province of Erzurum. Following several consecutive years of defoliation in any locality, leaves of the susceptible host plants, especially *Rosa canina* L., *Berberis vulgaris* L., and *Hippophae rhamnoides* L., were completely defoliated and the damaged twigs were very often dry. At times, the whole plant dries up (Çoruh and Özbek, 2002). Traditionally, fruits of these plants have been consumed by people living in rural areas. However, in recent years, these plants have attracted considerable

international attention from horticulturists, biochemists, and pharmacologists because of the fragrance of the flowers (*Rosa* spp.) and the high content of biologically active substances in their fruits and other organs, such as vitamin C, carotenoids, flavonoids, minerals, and certain enzymes, as well as vitamins $B_1$, $B_2$, E, and K. The above mentioned plant species are increasingly important because of this high antioxidant capacity (Li and Schroeder, 1996; Küpeli et al., 2002; Melnicova et al., 2002; Demir, 2005a , 2005b; Tiitinen et al., 2005; Ercişli et al., 2007; Özbek, 2009). It would also be worthwhile to mention that these plants may be very valuable for promoting wildlife, especially in their native range where many animals use their leaves and fruits for food and shelter.

Climatic conditions, natural enemies, and other factors have been considered in ending outbreaks of insects. Parry (1995) pointed out that elevated levels of parasitism were often associated with the collapse of outbreaks. Mirchev et al. (2001) emphasized that parasitoids play an important role in reducing the population density of many forest insect pests.

Despite its importance as a pest on various trees and shrubs, studies of the natural enemies of *M. neustria* in Turkey are very limited. Bulut (1991) studied egg parasitoids of this species in Ankara and neighboring provinces. More recently, Özbek and Çoruh (2010) recorded egg parasitoids of *M. neustria* in Erzurum Province. Although some researchers have obtained various parasitoid species in the families Tachinidae (Diptera) and Ichneumonidae (Hymenoptera) from larvae of *M. neustria* during their parasitoidal studies on various groups of insects (Doğanlar, 1975; Uğur, 1985; Kansu et al., 1986; Özdemir and Kılınçer, 1990), there has been no in-depth study of the larval parasitoids of *M. neustria* in Turkey.

The objectives of the present study were to determine the identities of the parasitoids and disease agents attacking larvae of *M. neustria* in Erzurum Province, Turkey; to determine natural parasitism rates; and to show the potential of parasitoid(s) and disease agent(s) for classical biological control of *M. neustria* in Turkey or other countries suffering from this pest.

An outbreak of *M. neustria* was observed in 2002, which lasted for about 5 years. The present study was conducted during this outbreak period.

## Materials and methods

### Collection sites

Field studies were conducted during 2004 and 2005 at 3 sites (Figure).

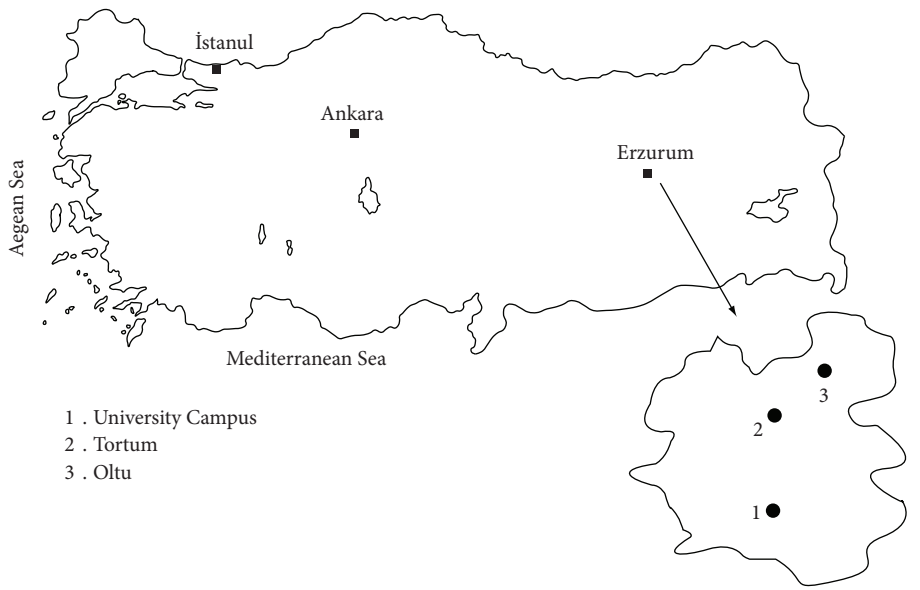


Figure. Sampling sites of larval parasitoids of *Malacosoma neustria* L. in Erzurum Province, Turkey.

The first collection site was the campus of Atatürk University in Erzurum, which has more than 800 ha of wooded area and grass lands at an altitude of 1850 m. Although the trees were predominantly *Pinus* sp., there were various deciduous trees and bushes; the most abundant hosts among them were *Rosa canina* L. (Rosaceae), *Elaeagnus angustifolia* L. (Elaeagnaceae), and *Betula verrucosa* (Youngii) (Betulaceae). *Elaeagnus angustifolia* was rare and occurred sporadically. The second collection site was about 80 km northeast of Erzurum in the village of Aksu (Tortum District), which could be characterized as hilly, uncultivated land ranging from 1950 to 2000 m in altitude. Common barberry, *B. vulgaris*, and *R. canina*, the most abundant host plants, were scattered among various species of shrubs and pines; common barberry was the most predominant host plant. The third collection site was about 110 km northeast of Erzurum, between Çamlıbel and Sarısaz villages (Oltu District), with cultivated land at about 1300-1400 m. Two preferred hosts, sea buckthorn (*H. rhamnoides*) and wild plum (*Prunus* sp.), were abundant and mixed with various species of deciduous trees and shrubs along the borders of fields. Potatoes were cultivated in small areas with rare application of insecticides, and thus the adverse effect of chemicals was negligible. The purpose of choosing 3 locations with different habitats was to increase the chance of diversity among the parasitoids obtained.

At the third collection site (Oltu), as Doğanlar (1982b) indicated, another *Malacosoma* species, *M. franconica* Denis & Schiffermuller, was present in addition to *M. neustria*. Although it was possible to distinguish the 2 species from their larvae, it was easier to identify them from the egg masses. Both of the species showed similar egg-laying habits and placed their eggs as masses around small twigs or branches of the host plants. However, the egg masses of *M. franconica* were covered with a mass of light gray substance that had the appearance of a hardened, stiff, shiny cover. The egg masses of *M. neustria* were naked and uncovered. The eggs could be counted even with the naked eye. Therefore, it was easy to separate the egg masses of these 2 *Malacosoma* species in the field. From the egg masses near tents, the larvae or tents of *M. neustria* could be recognized. It was also noted that *M. franconica* was not as abundant as *M. neustria* in the research area.

**Sampling and rearing**

To obtain parasitoids, the larvae (caterpillars) were collected from the sites. Two samples were collected in each season during 2004 and 2005. The first sampling was done in the first week of June and predominantly comprised second and third instar larvae. The second sampling, which was done during the second week of June, consisted of fourth and fifth instar larvae. The larvae were picked up along with shoots and leaves of randomly chosen host plants. These were placed into labeled cotton bags and brought to the laboratory. The larvae were transferred to fine-mesh nylon rearing cages (30 × 30 × 50 cm). The shoots and leaves of the host plants were dipped into a glass container filled with water and covered with a cotton stopper. The containers were kept in a rearing room at 25 ± 2 °C and 60%-70% relative humidity with natural light. Periodically, withered shoots and leaves were renewed with fresh ones. Soil of about 2 cm in depth was added to the bottom of the cage to facilitate pupation of the parasitoids. The rearing cages were checked daily and the pupae and/or cocoons of the parasitoids were transferred to petri dishes (1.5 × 9 cm). Emerging adults of parasitoids in the cages and petri dishes were removed, killed, and prepared for identification. The percentage of parasitism was calculated by dividing the number of larvae out of which parasitoids emerged by the total number of larvae in a sample.

To obtain microorganisms, sluggish or exhausted (unhealthy looking) larvae on the foliage and in the tents of *M. neustria* were collected, inserted into sterilized tubes to prevent possible contamination, and brought to the laboratory. All of the isolated bacterial strains were identified based on fatty acid methyl ester (FAME) profiles using Sherlock Microbial Identification System software (Microbial ID, Newark, DE, USA). Nuclear polyhedrosis virus (NPV) was observed by killing larvae in the field. NPV was identified under a normal light microscope by the presence of occlusion bodies.

Identification of the parasitoids was verified by comparison with the preserved specimens in the Entomology Museum, Erzurum, Turkey. The unidentified specimens were determined by specialists. The adults of parasitoids were deposited in the EMET. Among the bacteria, isolation and determination of *Brevibacillus agri* was made by Fikrettin Şahin, and the rest by Arzu Ala Görmez.

## Results and discussion

A total of 29 species of parasitoids were reared from the larvae of *M. neustria* during 2004 and 2005 (Table 1). Among the parasitoids, 6 species in Tachinidae (Diptera), 2 species in Braconidae (Hymenoptera), and 10 species each in Chalcidoidea (Hymenoptera) and Ichneumonidae (Hymenoptera) were reared. The composition of parasitoid species was more diverse at the first collection site than at the second or third.

In Tachinidae, 3 species of *Exorista* were reared from larvae of *M. neustria* from the first collection site (university campus): *E. segregata* (Rondani), *E. amoena* Mesnil, and *E. larvarum* (L.). Among them, *E. segregata* was the most abundant species; it first emerged on 23 July and continued for the next 5 days. *Exorista segregata* was previously reared from the larvae of *M. castrensis kirghisica* Staudinger and *M. franconica* Denis & Schiffermuller in Erzurum Province

Table 1. Larval parasitoids of *Malacosoma neustria* L. in Erzurum Province, Turkey, reared during 2004 and 2005.

| Family and order | Parasitoid species | Locations | | |
|---|---|---|---|---|
| | | First collection site, A.U. campus | Second collection site, Tortum | Third collection site, Oltu |
| Tachinidae (Diptera) | *Exorista amoena* Mesnil | + | | |
| | *E. larvarum* L. | + | | |
| | *E. segregata* Rond. | + | | |
| | *Masicera sphingivora* (R.D.) | + | + | |
| | *Pales pavida* Meig. | + | + | |
| | *Palesisa nudioculata* Vill. | + | | |
| | *Tachina praeceps* Meig. | + | + | |
| Braconidae (Hymenoptera) | *Meteorus lionotus* Thomson | | + | |
| | *Cotesia vanessa* (Reinhard) | | + | |
| Chalcidoidea (Hymenoptera) | *Asaphes suspensus* (Nees) | + | | |
| | *A. vulgaris* Walker | + | | |
| | *Brachymeria secundaria* (Rusc.) | | | + |
| | *Eupelmus urozonus* Dalman | + | | |
| | *Eurytoma verticillata* (F.) | | | + |
| | *Monodontomerus aereus* Walker | | | + |
| | *Pediobius bruchicida* Rondani | | + | |
| | *Pronotalia carlinarum* (Sz. & Er.) | | + | |
| | *Psychophagus omnivorus* (Walker) | | | + |
| | *Torymus triangularis* Thomson | | + | |
| Ichneumonidae (Hymenoptera) | *Endromopoda phragmitidis* P. | + | | |
| | *Exeristes roborator* F. | + | + | + |
| | *Gregopimpla inquisitor* (Scop.) | + | | |
| | *G. malacosomae* (Sey.) | + | | |
| | *Itoplectis viduata* Grav. | + | | |
| | *Lysibia nana* (Grav.) | + | | |
| | *Pimpla turionellae* L. | | + | + |
| | *P. rufipes* Brulle | | + | + |
| | *Scambus nigricans* (Thom.) | + | | |
| | *Tromatobia ornata* (Grav.) | + | | |

(Doğanlar, 1982a). Additionally, parasitoids of various species in the lepidopteran families Lymantriidae, Noctuidae, Notodontidae, Nymphalidae, Pieridae, Sphingidae, Thaumetopoeidae, and Zygaenidae were noted (Kara and Tschorsnig, 2003). *Exorista amoena* was reared from *M. neustria* for the first time in the present study and was added as a new record for the Turkish fauna. The adults first emerged on 26 July and continued for the next 3 days. *Exorista larvarum* first emerged on 26 July and continued for about 1 week. It was known as a parasitoid of *M. neustria*, and it parasitized *M. castrensis kirghisica* and various lepidopteran species belonging to families Arctiidae, Lymantriidae, Noctuidae, Pieridae, and Pyralidae (Kara and Tschorsnig, 2003). The larvae of the 3 *Exorista* species emerging from the host pupated in the soil at the base of the cage. *Masicera sphingivora* (Robineau-Desvoidy) was recorded from the university campus and Tortum. The adults first emerged on 27 July and continued until 11 August. It was known as a parasitoid of *M. neustria*, and it attacked several lepidopteran species belonging to the families Sphingidae, Lymantriidae, and Noctuidae (Kara and Tschorsnig, 2003). *Pales pavida* (Meigen) was found on the university campus and in Tortum. The adults emerged from the host pupae from 22 July to 9 August. It also parasitized *M. castrensis kirghisica* and *M. franconica* (Doğanlar, 1982b). Recently, Özbek and Çalmaşur (2010) obtained *P. pavida* from the pupae of *Abraxas pantaria* (L.) (Lepidoptera: Geometridae) in November in eastern Anatolia, Turkey. Belshaw (1993) listed 39 lepidopteran species as hosts of *P. pavida*. *Palesisa nudioculata* Villeneuve was reared from the larvae of *M. neustria* from the first collection site (university campus). The adults emerged between 27 July and 3 August. Although Kara and Tschorsnig (2003) listed *M. franconica*, *M. neustria* (Lepidoptera: Lasiocampidae), *Euproctis chrysorrhoea*, and *Leucoma salicis* (Lepidoptera: Lymantriidae) as hosts of *P. nudioculata*, this parasitoid species proved to be a new record for the Turkish fauna. *Tachina praeceps* Meigen was reared from the larvae of *M. neustria* from the first and second collection sites. In some samples, 2-3 parasitoid larvae developed in 1 host larva. After the host died, the parasitoid larvae entered the soil and continued their development into pupae. The adults emerged 24-27 July and were identified as parasitoids of *M. neustria* (Herting, 1960). Doğanlar (1982b) reared this species from the larvae of *M. castrensis* in Erzurum Province. It is reasonable to believe that this species was first reared from *M. neustria* in Turkey. Kara and Tschorsnig (2003) listed *Malacosoma alpicola* Staudinger and *Euproctis chrysorrhoea* (L.) (Lepidoptera: Lymantriidae) as other hosts of *T. praeceps*. Among the tachinid parasitoids, *P. pavida*, *T. praeceps*, and *P. nudioculata* were the most prevalent species, accounting for 25%, 21%, and 20% of the records, respectively.

In addition to species mentioned above, Doğanlar (1975) obtained 2 tachinid species, *Drino imberbis* Wiedeman and *D. inconspicua* Meigen, from the larvae of *M. neustria* in Erzurum Province. Kansu et al. (1986) recorded *Compsilura concinnata* (Meigen) from the larvae of *M. neustria* in central Anatolia. Additionally, Doğanlar (1982b) obtained *Eucarcelia separate* (Rondani), *Nowickia atripalpis* Rob.-Des., and *Tachina vernalis* Rob.-Des. from the larvae of *M. castrensis* in Erzurum Province. These 3 tachinid species were reported as parasitoids of *M. neustria* (Mesnil, 1965; Kara and Tschorsnig, 2003). Although Doğanlar (1975) obtained *Histochaeta marmorata* Fabricius from *Arctia caja* (L.) (Lepidoptera: Arctiidae) in Erzurum, this species is also known as a parasitoid of *M. neustria* (Emden, 1954). From all these reports, we can conclude that 11 or more tachinid species could parasitize the larvae of *M. neustria* in Erzurum Province as well as other locations in Turkey.

Parasitoid species in the family Braconidae (2 braconid species), *Meteorus lionotus* Thomson and *Cotesia vanessa* (Reinhard), were reared from the larvae of *M. neustria* only from the second collection site (Tortum). Braconid-killed larvae were readily recognized by the presence of a parasitoid cocoon within the dried skin of the larvae, which was firmly attached to the leaves and the twigs. The adult parasitoids emerged about 1 week after the larvae were killed. The adults of *M. lionotus* emerged 26-29 July and those of *C. vanessa* emerged 24-27 July. Both of these parasitoid species were reared from *M. neustria* for the first time. *Operophtera brumata*; *Thera juniperata*, *T. obeliscata*, and *T. variata* (Lepidoptera: Geometridae); and *Neodiprion sertifer* (Hymenoptera: Diprionidae) were reported as the hosts of *M. lionotus* (Yu et al., 2006). *Cotesia vanessa* presented a larger spectrum of host species;

Yu et al. (2006) listed about 30 species in the lepidopteran families including Lasiocampidae, Noctuidae, Nolidae, Notodontidae, Nymphalidae, Pterophoridae, and Pyralidae. However, *M. lionotus* was more prevalent than *C. vanessa*; the first accounted for 67% and the second for 33% of the braconid species. As the literature records, Kansu et al. (1986) added 2 braconid species, *Apanteles* sp. and *Meteorus* sp., from *M. neustria* in central Anatolia.

Parasitoid species in the Chalcidoidea, 2 *Asaphes* (Pteromalidae) species, were reared from the larvae of *M. neustria* collected on the university campus (first site): *A. suspensus* (Nees) and *A. vulgaris* Walker. Adults of the first species emerged on 7 July and those from the second species on 12 July. Both species were new parasitoids of *M. neustria*. Gary et al. (1998) indicated that *Asaphes* was usually considered an exclusive hyperparasitoid of aphids. Various species in the families Agromyzidae, Cecidomyiidae (Diptera), and Aphididae (Hemiptera) were recognized as primary hosts of *A. suspensus* (Natural History Museum, 2010). *Asaphes vulgaris* had more primary hosts than *A. suspensus*. Several curculionid species (Coleoptera); some species in the families Agromyzidae, Cecidomyiidae, Syrphidae (Diptera), Coccidae, Diaspididae, Pseudococcidae, Aphididae, Psyllidae and (Hemiptera); and 1 cynipid species (Hymenoptera: Cynipidae) were indicated as hosts of *A. suspensus* (Natural History Museum, 2010). *Brachymeria secundaria* (Ruschka) (Chalcididae) was obtained only in the larvae collected at the third collection site, Oltu. The adults emerged 1-3 August. It was believed to be a primary parasitoid and the first reared from *M. neustria*. Several species in different families (Geometridae, Lymantriidae, Noctuidae, Notodontidae, Nymphalidae, Pieridae, Tortricidae, and Yponomeutidae) in the order Lepidoptera were known hosts of this species (Natural History Museum, 2010). *Eupelmus urozonus* Dalman (Eupelmidae) was reared from the larvae collected at the first collection site, the university campus. The adults emerged on 18 July. It was obtained from *M. neustria* for the first time. *Eupelmus urozonus* was found to be one of the primary parasitoids of olive fly, *Dacus oleae* Gmelin (Diptera: Tephritidae), and has received considerable attention in the olive-growing countries of the Mediterranean basin (Neuenschwander, 1982; Mustafa and Al-Zaghal, 1987). It is thought to be exceptionally polyphagous, and there are many species in various families in different orders that serve as primary hosts of *E. urozonus*: Apionidae, Attelabidae, Bruchidae, Chrysomelidae, Coccinellidae, Curculionidae, and Scolytidae (Coleoptera); Agromyzidae, Cecidomyiidae, and Tephritidae (Diptera); Aphididae, Coccidae, and Diaspididae (Hemiptera); Cynipidae, Diprionidae, Eurytomidae, Pteromalidae, Tenthredinidae, and Torymidae (Hymenoptera); and Coleophoridae, Gelechiidae, Gracillariidae, Lasiocampidae, Lymantriidae, Pieridae, Tortricidae, and Yponomeutidae (Lepidoptera) (Natural History Museum, 2010). *Eurytoma verticillata* (F.) (Eurotomatidae) was recorded in Oltu, the third collection site. The adults emerged on 16 June. It was first reared from *M. neustria*. It is known worldwide and is a well-known hyperparasitoid of Lepidoptera through Tachinidae, Ichneumonidae, and especially Braconidae (Borlani, 1994). Among its hosts, various primary parasitoids of many species in different families in the orders Hemiptera, Lepidoptera, and Hymenoptera were recorded (Natural History Museum, 2010). *Monodontomerus aereus* Walker (Torymidae) was reared from the larvae of *M. neustria* collected from Oltu. The adults emerged on 11 July. Doğanlar (1984) obtained it from *M. neustria*, *M. franconica*, *Euproctis chrysorrhoea* L., *Leucoma salicis* L., and *Yponomeuta malinella* L. in Erzurum. Kansu et al. (1986) obtained it from *Aporia crataegi* (L.), *Euproctis chrysorrhoea* L., *M. neustria*, and *Archips* sp. in central Anatolia. Sarıkaya and Avcı (2005) recently obtained *M. aereus* from *Choristoneura murinana* (Hbn.) (Lepidoptera: Tortricidae). Boucek (1970) noted that this species has been recorded as a parasite in pupae of many Lepidoptera and in cocoons of some diprionid sawflies. Many primary hosts in Hymenoptera and Lepidoptera were listed (Natural History Museum, 2010). *Pediobius bruchicida* Rondani (Eulophidae) was reared from larvae of *M. neustria* collected from the second collection site, Tortum. The adults emerged on 11 August. This was the first time that *P. bruchicida* was reared from *M. neustria*. It was previously obtained from the larvae of *E. chrysorrhoea* as a primary parasitoid (Öncüer et al., 1977). However, *P. bruchicida* was noted as the hyperparasitoid in *Uraba lugens* Walker (Lepidoptera: Nolidae) by Berry and Mansfield (2006) and in *Sesamia cretica* Led. (Lepidoptera: Noctuidae) by Temerak (2009). Many

species in various orders and families were listed as hosts of this species (Natural History Museum, 2010). *Pronotalia carlinarum* (Szelényi & Erdös) (Eulophidae) was reared from *M. neustria* collected from Tortum. The adults emerged 11-13 July. It was previously known as a parasitoid of *M. neustria* (Natural History Museum, 2010). Other hosts of *P. carlinarum* were recorded from various species of Diptera in different families, such as Agromyzidae, Calliphoridae, and particularly Tephritidae (Natural History Museum, 2010). *Psychophagus omnivorus* (Walker) (Pteromalidae) was reared from *M. neustria* collected from Oltu. The adults emerged on 29 July. It was already known as a parasitoid of *M. neustria.* It attacked *M. disstria* and *M. americanum* (L.) (Natural History Museum, 2010). It was designated as a pupal parasitoid of various pest species, such as *Chrysodeixis chalcites*, *Spodoptera exigua*, *Lacanobia oleracea* (Lepidoptera: Noctuidae) (Mosson et al., 1997), and *Hyphantria cunea* Drury (Lepidoptera: Arctiidae) (Rezaei et al., 2003). Additionally, *Ips typographus* (L.) (Coleoptera: Scolytidae), several sawfly species, and many species in various families of Lepidoptera were listed as hosts of *P. omnivorus* (Natural History Museum, 2010). Only one female of *Torymus triangularis* Thomson (Torymidae) was reared on 18 June 2004 from the larvae collected at the second site, Tortum, and it was a new parasitoid of *M. neustria*. Among the chalcidoid parasitoids, *M. aereus* and *B. secundaria* were the most prevalent species and accounted for 35.29% and 32.35%, respectively. As stated in the literature, *Brachymeria intermedia* (Nees) (Chalcididae) was obtained from the pupa of *M. neustria* in central Anatolia by Kansu et al. (1986). The present study and published literature revealed that a total of 11 chalcidoid species were associated with the larvae of M. *neustria* in Turkey. We have to admit that we could not precisely detect whether all chalcidoids were primary parasitoids of *M. neustria*; among them, gregarious and solitary species may have occurred. Further studies should be conducted on the chalcidoid parasitoids of *M. neustria* in Turkey.

Of the 10 ichneumonid species reared, *Exeristes roborator* F. was the most prevalent and accounted for 35%. It was recorded from all 3 collection sites. The adults emerged between 14 June and 12 July. *E. roborator* was known as a parasitoid of *M. neustria* (Yu et al., 2006). *Endromopoda phragmitidis* Perkins was found only on the university campus. The adults emerged 25-27 July. It was reported in Erzurum Province from faunistic studies conducted by Çoruh and Özbek (2008). *Lipara lucens* (Diptera: Chloropidae) was already on record as the host of this parasitoid species (Kolarov, 1997). From the university campus, 2 *Gregopimpla* species, *G. malacosomae* (Seyrig) and *G. inquisitor* (Scopoli), were recorded. The adults of both species emerged almost at the same time (28-30 July). The first was already known as a parasitoid of *M. neustria* (Thompson, 1957; Kolarov, 1997). *Gregopimpla malacosomae* is a monophagous species and, currently, *M. neustria* is the only known host of this parasitoid species. The second species, *G. inquisitor*, was polyphagous and parasitized more than 80 species in different orders and families such as Curculionidae, Scarabeidae, Arctiidae, Gelechiidae, Geometridae, Gracilariidae, Hyponomeutidae, Lycaenidae, Lymantriidae, Momphididae, Noctuidae, Notodontidae, Nymphalidae, Pieridae, Phalaenidae, Phycitidae, Saturnidae, Sphingidae, Thaumetopoeidae, Tortricidae, Zygaenidae, and Tenthredinidae (Thompson, 1957; Sedivy, 1963; Townes et al., 1965; Shaumar, 1966; Kolarov, 1997). *Itoplectis viduata* Gravenhorst was recorded on the university campus and was already known as a parasitoid of *M. neustria*. The adults emerged on 28 July. It attacked various species in lepidopteran families such as Aegeridae, Gelechiidae, Lymantriidae, Noctuidae, Phalaenidae, Pieridae, Pyralidae, Pyraustidae, Tortricidae, and Zyganidae (Thompson, 1957; Sedivy, 1965; Aubert, 1969; Kasparyan, 1973; Kolarov, 1997). *Lysibia nana* (Gravenhorst) was reared from the *M. neustria* larvae collected on the university campus, and it was first reared from *M. neustria* in the present study. The adults emerged 24-26 July. Some species in various families such as Noctuidae, Pieridae, Notodontidae, and Braconidae were known as hosts of this parasitoid species (Yu et al., 2006). From larvae collected in Tortum and Oltu, 2 *Pimpla* species, *P. turionellae* L. and *P. rufipes* Brulle, were reared from *M. neustria*. The adults of the first species emerged 20-23 July, and the adults of the second species emerged between 10 June and 4 July. *Pimpla turionellae* was recorded as a parasitoid of *M. neustria* by Uğur (1985) in Ankara, who reported that it had over 82 hosts among the lepidopteran species. *Scambus nigricans* (Thomson) was reared from the larvae of *M. neustria* collected on the university campus. The adults emerged 20-23

July. This species was already recorded as a parasitoid of *M. neustria* (Yu et al., 2006). It was known to attack various species in different orders and families (Thompson, 1957; Kolarov, 1997). *Tromatobia ornata* (Gravenhorst) was also collected from the university campus. The adults emerged 1-4 August. It was previously known as a parasitoid of *M. neustria* (Thompson, 1957; Kolarov, 1997). *Pimpla turionellae* was reported from *M. neustria* in central Anatolia by Kansu et al. (1986) and *Pimpla illecebrator* (Villers) was reported in Ankara by Özdemir and Kılınçer (1990); both are parasitoids of *M. neustria*. The present study and published literature revealed that a total of 11 ichneumonid species parasitized *M. neustria* larvae in Turkey. Among the ichneumonids, *E. roborator* was found to be the most common species and accounted for 35%. This species was followed by *P. turionellae* and *P. rufipes*, each one accounting for 15% of the ichneumonid records.

On the basis of the data recorded in the present study, it would be reasonable to conclude that parasitoids in general and *E. roborator*, *P. turionellae*, *P. rufipes*, *T. praeceps*, and *P. pavida* in particular could play a major role in controlling *M. neustria* in the field.

**Disease agents associated with the larvae of *M. neustria***

During this study, 2 types of diseases were diagnosed in the larvae of *M. neustria*. The first was NPV, which was observed killing larvae in the field. The larvae killed by NPV were characteristically found hanging in place by their midsection, like an inverted V. The infected larvae appeared sluggish and turned dark in color after death.

The second was bacterial; 4 pathogenic bacteria species, *Brevibacillus agri*, *Alcaligenes xylosoxydans xylosoxydans* (*Achromobacter xylosoxidans*), *Bacillus lentimorbus*, and *Serratia fonticola*, were detected in the diseased larvae (Table 2). Among these, *Brevibacillus agri* was isolated from the larvae of *M. neustria* and an experiment was conducted under field and laboratory conditions (Aslan et al., 2005). Aslan et al. (2005) found that in the laboratory, during the first 8-h period the mortality was 30% in both second and third instar larvae, and in fourth instar larvae it was 10%; under field conditions, the mortalities at the end of 48 h were 33.3% and 37.5% in the third and fourth instar larvae, respectively. No experiment was carried out on the other bacteria. *Alcaligenes xylosoxydans* was isolated for the first time from human ear discharge by Yabuuchi and Yano (1981). Many beneficial functions of this species have been reported in experimental assays, including control of some plant pathogens (Vaidya et al., 2001), stimulation of ionic transport to promote plant growth (Bertrand et al., 2000), and inhibition of aflatoxin production in *Aspergillus* sp. (Yan et al., 2004). Moretti et al. (2008) used *Achromobacter xylosoxidans* (MM1) against *Fusarium* wilt in tomato under glasshouse conditions and reduced wilt incidence by about 50%. *Bacillus lentimorbus* (*Paenibacillus lentimorbus*) was one of the causative agents of milky disease in Japanese beetle, *Popillia*

Table 2. Pathogenic bacteria recorded from the larvae of *Malacosoma neustria* L. in Turkey, including present study.

| Name of bacteria | Reference |
|---|---|
| *Alcaligenes xylosoxydans xylosoxydans* | Present study |
| *Bacillus lentimorbus* | Present study |
| *Serratia fonticola* | Present study |
| *Brevibacillus agri* | Present study |
| *Bacillus thuringiensis* | Yaman et al., 2002 |
| *Proteus mirabilis* | Yaman et al., 2002 |
| *Staphylococcus* sp. | Yaman et al., 2002 |
| *Pseudomonas chlororaphis* | Yaman et al., 2002 |
| *Pseudomonas* sp. | Yaman et al., 2002 |

*japonica* Newman (Coleoptera: Scarabaeidae), and related scarab larvae (Rippere et al., 1998). *Serratia fonticola* was described as a new species of the genus *Serratia* from fresh water and soil by Gavini et al. (1979). It has since been related to contaminants in the respiratory tract and has been isolated in the droppings of European wild birds (Muller et al., 1986). It is a bacterium with an extensive distribution in aquatic environments (Farmer et al., 1985). It was recognized to be a human pathogen in the beginning of the 1990s (Bollet et al., 1991). Recently, Casiano et al. (2008) isolated this bacterium from a fish species, pirarucu (*Arapaima gigas*). Our study is the first report that *S. fonticola* was isolated from insect larva of *M. neustria*. Of course, further studies will be required to confirm this.

As recorded in the literature, Yaman et al. (2002) isolated *Bacillus thuringiensis*, *Proteus mirabilis*, *Staphylococcus* sp., *Pseudomonas chlororaphis*, and *Pseudomonas* sp. from *M. neustria* and found that *B. thuringiensis*, *Proteus mirabilis*, and *P. chlororaphis* showed infection of the first and second instar larvae of *M. neustria* (Table 3).

Table 3. Parasitoids of *Malacosoma neustria* L. recorded in Turkey, including present study.

| Name of parasitoid | Order and family | Stage of the host | Reference(s) |
|---|---|---|---|
| *Baryscapus nigroviolaceus* | Hym.: Eulophidae | Egg | Özbek and Çoruh, 2010 |
| *Baryscapus oophagus* | Hym.: Eulophidae | Egg | Özbek and Çoruh, 2010 |
| *Baryscapus evonymella* | Hym.: Eulophidae | Egg | Özbek and Çoruh, 2010 |
| *Pronotalia carlinarum* | Hym.: Eulophidae | Egg | Özbek and Çoruh, 2010 |
| *Trichogramma buluti* | Hym.: Trichogrammatidae | Egg | Bulut, 1991; Özbek and Çoruh, 2010 |
| *Anastatus bifasciatus* | Hym.: Trichogrammatidae | Egg | Bulut, 1991; Özbek and Çoruh, 2010 |
| *Telenomus laevisculus* | Hym.: Scelionidae | Egg | Bulut, 1991; Özbek and Çoruh, 2010 |
| *Ooencyrtus neustriae* | Hym.: Encyrtidae | Egg | Bulut, 1991; Özbek and Çoruh, 2010 |
| *Ooencyrtus tardus* | Hym.: Encyrtidae | Egg | Bulut, 1991 |
| *Ooencyrtus masii* | Hym.: Encyrtidae | Egg | Bulut, 1991 |
| *Ooencyrtus* sp. | Hym.: Encyrtidae | Egg | Bulut, 1991 |
| *Drino inconspicua* | Dip.: Tachinidae | Larva | Doğanlar, 1975 |
| *Drino imberbis* | Dip.: Tachinidae | Larva | Doğanlar, 1975 |
| *Exorista amoena* | Dip.: Tachinidae | Larva | Present study |
| *E. larvarum* | Dip.: Tachinidae | Larva | Kara and Tschorsnig, 2003; present study |
| *E. segregate* | Dip.: Tachinidae | Larva | Kara and Tschorsnig, 2003; present study |
| *Compsilura concinnata* | Dip.: Tachinidae | Larva | Kansu et al., 1986 |
| *Masicera sphingivora* | Dip.: Tachinidae | Larva | Kara and Tschorsnig, 2003; present study |
| *Pales pavida* | Dip.: Tachinidae | Larva | Present study |
| *Palesisa nudioculata* | Dip.: Tachinidae | Larva | Present study |
| *Tachina praeceps* | Dip.: Tachinidae | Larva | Present study |
| *Apanteles* sp. | Hym.: Braconidae | Larva | Kansu et al., 1986 |
| *Meteorus* sp. | Hym.: Braconidae | Larva | Kansu et al., 1986 |
| *Meteorus lionotus* | Hym.: Braconidae | Larva | Present study |
| *Cotesia Vanessa* | Hym.: Braconidae | Larva | Present study |
| *Asaphes suspensus* | Hym.: Pteromalidae | Larva | Present study |
| *A. vulgaris* | Hym.: Pteromalidae | Larva | Present study |
| *Psychophagus omnivorus* | Hym.: Pteromalidae | Larva | Present study |
| *Brachymeria secundaria* | Hym.: Chalcididae | Larva | Present study |
| *Eupelmus urozonus* | Hym.: Eupelmidae | Larva | Present study |
| *Eurytoma verticillata* | Hym.: Eurotomatidae | Larva | Present study |
| *Pediobius bruchicida* | Hym.: Eulophidae | Larva | Present study |
| *Pronotalia carlinarum* | Hym.: Eulophidae | Larva | Present study |
| *Monodontomerus aereus* | Hym.: Torymidae | Pupa | Doğanlar, 1984; Kansu et al., 1986; present study |
| *Torymus triangularis* | Hym.: Torymidae | Larva | Present study |
| *Endromopoda phragmitidis* | Hym.: Ichneumonidae | Larva | Çoruh and Özbek, 2008; present study |
| *Exeristes roborator* | Hym.: Ichneumonidae | Larva | Present study |
| *Gregopimpla inquisitor* | Hym.: Ichneumonidae | Larva | Present study |
| *G. malacosomae* | Hym.: Ichneumonidae | Larva | Present study |
| *Itoplectis viduata* | Hym.: Ichneumonidae | Larva | Present study |
| *Lysibia nana* | Hym.: Ichneumonidae | Larva | Present study |
| *Pimpla illecebrator* | Hym.: Ichneumonidae | Pupa | Özdemir and Kılınçer, 1990 |
| *Pimpla turionellae* | Hym.: Ichneumonidae | Pupa | Uğur, 1985; Kansu et al., 1986; present study |
| *P. rufipes* | Hym.: Ichneumonidae | Larva | Present study |
| *Scambus nigricans* | Hym.: Ichneumonidae | Larva | Present study |
| *Tromatobia ornata* | Hym.: Ichneumonidae | Larva | Present study |

## Conclusion

The data presented here revealed that larval parasitoids could play an important role in controlling *M. neustria* in Erzurum Province as the parasitism rate was high (33.7%). Additionally, Özbek and Çoruh (2010) determined egg parasitoids of *M. neustria* in Erzurum, and the parasitism rate was 21.81%. As disease agents, NPV and pathogenic bacteria were other biological agents involved in the regulation of the outbreaks of *M. neustria* in Erzurum Province. Furthermore, all of the natural enemies of *M. neustria* recorded so far in Turkey are listed in Table 3. As a whole, these organisms, in addition to atmospheric conditions, must have regulated the population of *M. neustria* under natural conditions in Turkey. Witter et al. (1972) noted that weather conditions, starvation, parasitoids, diseases, and genetic factors, either separately or together, were responsible in the collapse of *M. disstria* Hubner outbreaks. It should be noted that all of the parasitoids recorded as larval parasitoids of *M. neustria* in the present study were polyphagous, except *Gregopimpla malacosomae*. Their potential, especially that of the latter species, as candidates for biological control agents of this pest is high as they are also suggested to be very important natural control agents in the field. Thus, by taking into consideration all of the natural enemies of *M. neustria*, it can be emphasized that pest control strategies should address the preservation of these and other natural enemies via judicious use of pesticides that have a minimal impact on the natural enemy's complex. In addition, where possible, suitable habitats should be provided in and around fields to encourage the development and survival of natural enemies.

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## References

Aslan, I., Çoruh, S., Özbek, H., Yaman, M. and Şahin, F. 2005. *Brevibacillus agri*, a pathogenic bacterium of *Malacosoma neustria* (Lepidoptera, Lasiocampidae). Fresen. Environ. Bull. 14(2): 98-100.

Aubert, J.F. 1969. Les ichneumonides Ouest-Palearctiques et leurs hotes. Tome I. Pimplinae, Xoridinae et Acaenitinae. Quatre Feuilles Editeur France 74: 49-63.

Belshaw, R. 1993. Tachinid Flies. Diptera: Tachinidae. Handbooks for the Identification of British Insects, Vol. 10. Royal Entomological Society of London, London.

Berry, J.A. and Mansfield, S. 2006. Hyperparasitoids of the gum leaf skeletoniser, *Uraba lugens* Walker (Lepidoptera: Nolidae), with implications for the selection of a biological control agent for *Uraba lugens* in New Zealand. Aust. J. Entomol. 45(3): 215-218.

Bertrand, H., Plassard, C., Pinochet, X., Touraine, B., Normand, P. and Cleyet-Marel, J.C. 2000. Stimulation of ionic transport system in *Brassica napus* by a plant growth-promoting rhizobacteria (*Achromobacter* sp.). Can. J. Microbiol. 46: 229-236.

Bodenheimer, F.S. 1958. Türkiye'de Ziraate ve Ağaçlara Zararlı Olan Böcekler ve Bunlarla Savaş Hakkında Bir Etüt (translated into Turkish by N. Kenter). Bayur Matbaası, Ankara.

Bollet, C., Gainnier, M., Sainty, J.M., Orhesser, P. and De Micco, P. 1991. *Serratia fonticola* isolated from a leg abscess. J. Clin. Microbiol. 29: 834-835.

Borlani, M. 1994. New records of parasitoids from *Hyphantria cunea* (Drury, 1773) in Italy (Lepidoptera, Arctiidae). Entomofauna Z. Entomol. 15(37): 425-432.

Boucek, S. 1970. Contribution to the knowledge of Italian Chalcidoidea, based mainly on a study at the Institute of Entomology in Turin, with descriptions of some new European species (Hymenoptera). Memor. Soc. Entomol. Ital. 59: 35-102.

Bulut, H. 1991. Yüzük kelebeği (*Malacosoma neustria* L.)'nin yumurta parazitoitleri, bulundukları yerler ve doğal etkinlikleri üzerinde araştırmalar. Bitki Kor. Bült. 31(1-4): 75-97.

Casiano, H., Choresca, C.H. Jr., Kim, J.H., Gomez, D.K., Jang, H., Joh, S.J. and Park, S.C. 2008. Isolation of *Serratia fonticola* from pirarucu *Arapaima gigas*. Korean J. Vet. Res. 48(1): 89-92.

Costa, J.T. 1997. Caterpillars as social insects. Amer. Sci. 85(2): 150-159.

Çanakçıoğlu, H. and Mol, T. 1998. Orman Entomolojisi. İstanbul Üniversitesi, Orman Fakültesi, İstanbul.

Çoruh, S. and Özbek, H. 2002. Erzurum yöresinde *Malacosoma neustria* L. (Lepidoptera, Lasiocampidae)'nın biyolojisi, konukçuları ve zararı üzerinde bir araştırma. Atatürk Üniv. Zir. Fak. Derg. 33(3): 280-284.

Çoruh, S. and Özbek, H. 2008. A faunistic and systematic study on Pimplinae (Hymenoptera: Ichneumonidae) in Eastern and Northeastern parts of Turkey. Linzer Biol. Beitr. 40(1): 419-462.

Demir, H. 2005a. Some physical and chemical properties of the fruits of *Rosa* spp. in Erzurum Province. Food Sci. Techn. 26(6): 28-38.

Demir, H. 2005b. Physical and chemical features of some wild fruits growing in Oltu, Erzurum Province. Food Sci. Techn. 27(6): 28-36.

Dobesberger, E.J. 2002. *Malacosoma neustria*. Lackey Moth, Pest Facts Sheet, Plant Health Risk Assessment Unit. Science Division, Canadian Food Inspection Agency, Guelph, Ontario. Available at www.siaq.org/_textes/acia_guide_insectes.pdf.

Doğanlar, M. 1975. Erzurum Bölgesinde Önemli Lepidopter Tırtıllarında Bulunan Tachinidae Sinekleri ve Bunların Kısa Biyolojileri. Atatürk Üniv. Yay., Erzurum.

Doğanlar, M. 1982a. Doğu Anadolu'da saptanan bazı parazit sinekler 1. Exoristinae (Diptera: Tachinidae). Türk. Bitki Kor. Derg. 6: 161-173.

Doğanlar, M. 1982b. Doğu Anadolu'da saptanan bazı parazit sinekler II. Echinomyiinasae, Dexiinae, Phasiinae (Diptera: Tachinidae). Türk. Bitki Kor. Derg. 6: 209-220.

Doğanlar, M. 1984. Notes on Chalcidoidea of Turkey. I. Chalcididae, Eurytomidae, Torymidae, Ormyridae, Perilampidae, Eucharitidae. Türk. Bitki Kor. Derg. 8: 151-155.

Emden, F.I. van 1954. Diptera Cyclorrhapha: Calyprata I. Tachinidae and Calliphoridae. Handbooks for the Identification of British Insects, Vol. 10. Royal Entomological Society of London, London.

Ercişli, S., Orhan, E., Özdemir, Ö. and Şengül, M. 2007. The genotypic effect on the chemical composition and antioxidant activity of sea buckthorn (*Hippophae rhamnoides* L.) barriers grown in Turkey. Horticulturae 115: 27-33.

Farmer, J.J., Davies, B.R. and Hickman-Brenner, F.W. 1985. Biochemical identification of new species and biogroups of Enterobacteriaceae isolated from clinical specimens. J. Clin. Microbiol. 21: 46-76.

Gary, A., Gibson P. and Vikberg V. 1998. The species of *Asaphas* Walker from America North of Mexico, which remarks on extralimital distributions and taxa (Hymenoptera: Chalcidoidea, Pteromalidae). J. Hymenoptera Res. 7(2): 209-256.

Gavini, F., Ferragut, C., Izard, D., Trinel, P.A., Leclerc, H., Lefebvre, B. and Mossel, D.A. 1979. *Serratia fonticola*, a new species from water. Int. J. Syst. Bacteriol. 29: 92-101.

Herting, B. 1960. Biologie der Westpalaarktischen Raupenfliegen Diptera, Tachinidae. Monographien Angew. Entomol. 16: 1-188.

İren, Z. 1977. Önemli Meyve Zararlıları, ve Mücadele Metotları. Ankara Bölge Zirai Mücadele Araştırma Enstitüsü, Mesleki Eserler Serisi, Ankara.

Kansu, A., Kılınçer, N., Uğur, A. and Gürkan, O. 1986. Larval and pupal parasitoids of the lepidopterous pests of cultivated plants growing in Ankara, Nevşehir, and Niğde provinces. In: Proceedings of the Second Turkish National Congress of Biological Control, Adana, pp. 146-161.

Kara, K. and Tschorsnig, H.P. 2003. Host catalogue for the Turkish Tachinidae (Diptera). J. Appl. Entomol. 127: 465-476.

Kasparyan, D.R. 1973. A review of the Palearctic ichneumonids of the tribe Pimplini (Hym. Ichneumonidae), the genera *Itoplectis* Forst. Entomol. Rev. 52(3): 444-455.

Kolarov, J. 1997. Fauna Bulgarica. 25. Hymenoptera, Ichneumonidae Part I. Pimplinae, Xoridinae, Acaenitinae, and Collyriinae. Edito. Academica, Sofia.

Küpeli, E., Koşar, M., Yeşilada, E., Hüsnü, K. and Başer, C. 2002. A comparative study on the anti-inflammatory, antinociceptive and antipyretic effects of isoquinoline alkaloids from the roots of Turkish *Berberis* species. Life Sciences 72: 645-657.

Li, T.S.C. and Schroeder, W.R. 1996. Sea buckthorn (*Hippophae rhamnoides* L.): a multipurpose plant. Hort. Techn. 6: 370-380.

Melnicova, I.V., Kulesh, N.I., Koltsova, E.A. and Gorovoy, P.G. 2002. Antioxidant and antiradical activity of *Rosa* L. species of flora Primorski lands. Plant Resources 38: 24-33.

Mesnil, L.P. 1965. Larvaevorinae (Tachininae). In: Die Fliegen der Palaarktischen Region g. I. II. III (Ed. E. Lindner), Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1112 pp.

Mirchev, P., Georgiev, G.T. and Tsankov, G. 2001. Studies on the parasitoids of *Gelechia senticetella* (Stgr.) (Lep.: Gelechiidae) in Bulgaria. Anzeiger für Schadlingskunde 74(4): 94-96.

Moretti, M., Glardi, G., Gullino, M.L., and Garibaldi, A. 2008. Biological control potential of *Achromobacter xylosoxydans* for suppressing *Fusarium* wilt of tomato. Int. J. Bot. 4: 369-375.

Mosson, H.J., Marris, G.C. and Edwards J.P. 1997. The comparative biology of the pupal endoparasitoid *Psychophagus omnivorus* (Hym.: *Pteromalidae*) on three candidate lepidopteran hosts. BioControl 42(3): 367-376.

Muller, H.E., Steigerwalt, A.G. and Brenner, D.J. 1986. Isolation of *Serratia fonticola* from birds. Zentralblatt für Bakteriol., Mikrobiol. und Hygiene 261: 212-218.

Mustafa, T.M. and Al-Zaghal, K. 1987. Frequency of *Dacus oleae* (Gmelin) immature stages and their parasites in seven olive varieties in Jordan. Insect Science and Application 8: 165-169.

Natural History Museum, 2010. Universal Chalcidoidea Database. Natural History Museum, London. Available at http://www.nhm.ac.uk/research-curation/research/projects/chalcidoids/database/ (date accessed 14th January 2011).

Neuenschwander, P. 1982. Searching parasitoids of *Dacus oleae* (Gmel.) (Dipt.: Tephritidae) in South Africa. Z. Angew. Entomol. 94: 509-522.

Öncüer, C., Yalçın, E. and Erkin, E. 1977. Ege Bölgesi'nde meyve ağaçlarında zarar yapan *Euproctis chrysorrhoea* L. (Lepidoptera: Lymantriidae) larvalarının doğal düşmanları ve bunların etkililikleri. Türk. Bitki Kor. Derg. 1(1): 39-47.

Özbek, H. 2009. *Cnaemidophorus rhododactyla*, a new *Rosa* spp. pest for Turkey, and its new parasitoids. Phytoparasitica 36(5): 502-504.

Özbek, H. and Çalmaşur, Ö. 2005. A review of insects and mites associated with roses in Turkey. Acta Hort. 690: 167-174.

Özbek, H. and Çalmaşur, Ö. 2010. Spotted ash looper, *Abraxas pantaria* (L.) (Lepidoptera: Geometridae), a new ash pest in Turkey. Turk. J. Zool. 34(3): 351-358.

Özbek, H. and Çoruh, S. 2010. Egg parasitoids of *Malacosoma neustria* (L.) (Lepidoptera: Lasiocampidae) in Erzurum Province of Turkey. Türk. Entomol. Derg. 34(4): 551-560.

Özbek, H., Güçlü, Ş. and Tozlu, G. 1998. Arthropoda pests of *Rosa* spp. in Erzurum, Erzincan, Bayburt, and Artvin provinces. In: Proceedings of Turkish National Symposium of *Rosa*, Gümüşhane, pp. 219-230.

Özdemir, Y. and Kılınçer, N. 1990. Pimplinae and Ophioninae (Hymenoptera: Ichneumonidae) species in Central Anatolia. In: Proceedings of the Second Turkish National Congress of Biological Control, Ankara, pp. 309-318.

Parry, D. 1995. Larval and pupal parasitism of the forest tent caterpillar, *Malacosoma distria* Hübner (Lepidoptera: Lasiocampidae), in Alberta, Canada. The Canad. Entomol. 27: 877-893.

Rezaei, V., Moharramipour, S. and Talebi, A.A. 2003. The first report of *Psychophagus omnivorus* (Walker) and *Chouioia cunea* (Yang) parasitoid wasps of American white webworm *Hyphantria cunea* Drury (Lep.: Arctiidae) from Iran. Appl. Entomol. Phytopathol. 70: 137-138.

Rippere, K.E., Tran, M.T., Yousten, A.A., Hilu, K.H. and Klein, M.G. 1998. *Bacillus popilliae* and *Bacillus lentimorbus*, bacteria causing milky disease in Japanese beetles and related scarab larvae. Int. J. Syst. Bacteriol. 48: 395-402.

Sarıkaya, O. and Avcı, M. 2005. Studies on the parasitoid complex of *Choristoneura murinana* (Hbn.) (Lep.: Tortricidae) in Turkey. J. Pest Sci. 78(2): 63-66.

Sedivy, J. 1963. Faunistische und taxonomische Bemerkungen zu den Ichneumoniden der Tschechoslowakei. Pimplinae, II. (Hymenoptera: Ichneumonidae, Pimplinae). Acta Faun. Ent. Mus. Nat. Pragae 9 (80): 155-177.

Sedivy, J. 1965. Contribution to the knowledge of the host of Ichneumon flies I. Zaprvy. Ceskoslovensk spolecnosti entomol. C SAV 1(4): 6-13.

Shaumar, N. 1966. Les Ichneumonides di Egypte. Entomophaga 11: 441-469.

Temerak, S.A. 2009. Studies on *Pediobius bruchicida* (Rond.) (Hym., Eulophidae) a hyperparasitoid of *Sesamia cretica* Led. (Lep.: Noctuidae). Z. Angew. Entomol. 95: 267-272.

Tiitinen, K.M., Hakal, M.A. and Kallio, H.P. 2005. Quality components of sea buckthorn (*Hippophae rhamnoides* L.) varieties. J. Agr. Food Chem. 53: 1692-1699.

Thompson, W.R. 1957. A Catalogue of the Parasites and Predators of Insect Pests. Sec. 2. Host Parasite Catalogue, Part 4. Host of the Hymenoptera (Ichneumonidae). Commonwealth Institute of Biological Control, Ottawa, pp. 333-561.

Townes, H., Momoi, S. and Townes, M. 1965. A Catalogue and reclassification of the Eastern Palaearctic Ichneumonidae. Mem. Amer. Ent. Inst. 5: 1-661.

Uğur, A. 1985. Pupa Asalağı Bazı Arıların Konukçu Seçimi ve Parazitleme Gücü. Ankara Üniv. Zir. Fak. Yay., Ankara.

Vaidya, R.J., Shah, I.M., Vyas, P.R. and Chhatpar, H.S. 2001. Production of chitinase and its optimization from a novel isolate *Alcaligenes xylosoxydans*: potential in antifungal biocontrol. World J. Microbiol. Biotech. 17: 691-696.

Witter, J.A, Kulman, H.M. and Hodson, C. 1972. Life tables for the forest tent caterpillar. Ann. Ent. Soc. America 65: 25-31.

Yabuuchi, E. and Yano, I. 1981. *Achromobacter* gen. nov. and *Achromobacter xylosoxidans* (ex Yabuuchi and Ohyama 1971) nom. rev. Int. J. Syst. Bacteriol. 31: 477-478.

Yaman, M., Ertürk, Ö. and Demirbağ, Z. 2002. Studies of bacteria as microbial control agents of the lackey moth, *Malacosoma neustria* L (Lepidoptera: Lasiocampidae) in Turkey. Pol. Acad. Sci. Biol. Sci. 50: 207-211.

Yan, P.S., Song, Y., Sakuno, E., Nakajima, H., Nakagawa, H. and Yabe, K. 2004. Cyclo(L-leucyl-L-prolyl) produced by *Achromobacter xylosoxidans* inhibits aflatoxin production by *Aspergillus parasiticus*. Appl. Environ. Microbiol. 70: 7466-7473.

Yu, D.S., Achterberg, C. van. and Horstmann, K. 2006. Interactive Catalogue of World Ichneumonidae. Taxonomy, Biology, Morphology, and Distribution. Compact Disc (master version). Taxopad, Vancouver, Canada.