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A contribution to the knowledge of parasitoids of insects associated with Rosaceae species from Edirne Province, European Turkey

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Abstract: Multitrophic associations, including three or higher trophic levels, related with insects on Rosaceae species were investigated. Field studies were conducted in 2013-2014 period in Edirne province, Trakya University Arboretum, of European Turkey. Parasitoid individuals belonging to 6 families and 24 defined species were reared from larval or pupal individuals belonging to 10 families and 13 defined species collected from 7 Rosaceae species in the field. A total of 50 multitrophic associations (plant–host–parasitoid) were recorded in the study area. Among these interactions, 10 host–parasitoid associations were observed for the first time. During the study, some biological and ecological observations were also recorded. In addition, 12 dipteran and hymenopteran species were determined as new records for the fauna of Edirne province and European Turkey.

Keywords: Biocontrol, Interaction, Multitrophic, Tritrophic, Turkish Thrace.

Introduction

Rosaceae is a plant family with a high importance in terms of both the biodiversity and the economic value. It includes about 100 genera and 3000 species, and has a cosmopolitan distribution, mainly in temperate regions of northern hemisphere. Some taxa of the family, i.e. almond, dog rose, pear, plum, rose, and strawberry, constitute livelihood of human being in agricultural, horticultural and other industries like woodworking, and they are also used in traditional and modern medicine (Heywood, 2007; Hummer, 2009). Extensive feeding by insects sometimes damages agricultural crops which decrease efficiency. Synthetic chemical control agents have been used for about 50 years as a fast, effective, and inexpensive solution to overcome this problem. However, overuse of these synthetic agents induces occurrence of risky results such as resistance of pests against the chemicals used, appearance of new pests, environmental pollution, toxicity to humans, and side effects on non-target insects and the natural enemies of the target pests (Aktar et al., 2009; Tunca et al., 2012). Botanical insecticides can be an alternative to synthetic ones for plant protection but studies showed that negative outcomes of botanical insecticides can also be seen on beneficial insects (Simmonds et al., 2002; Tunca et al., 2012).

Insects comprise more than half of all living organisms on earth in terms of species numbers and nearly 50% of insects feed on plants which make the largest part of the total biomass on earth (Schoonhoven et al., 2005). There is a complex web of trophic interactions in parallel with this enormous diversity of insects and plants. Plants affect insect communities by their morphological, chemical, and phenological characteristics. Similarly, insects have an effect on plant traits. In addition, insects interact with each other by several ways. All these interactions affect community dynamics and the community dynamics have an effect on interactions between one or more trophic level of organisms (Schoonhoven et al., 2005; Stam et al., 2014).

From the plant protection point of view, interaction between organisms should be considered during insect pest management practices (Tunca et al., 2011). Biological control is a plant protection method in which the control of pest insect populations on plants is carried out by using natural enemies of the pest organisms. This is a useful method both for environment and human health, and for conservation of biodiversity. Furthermore,

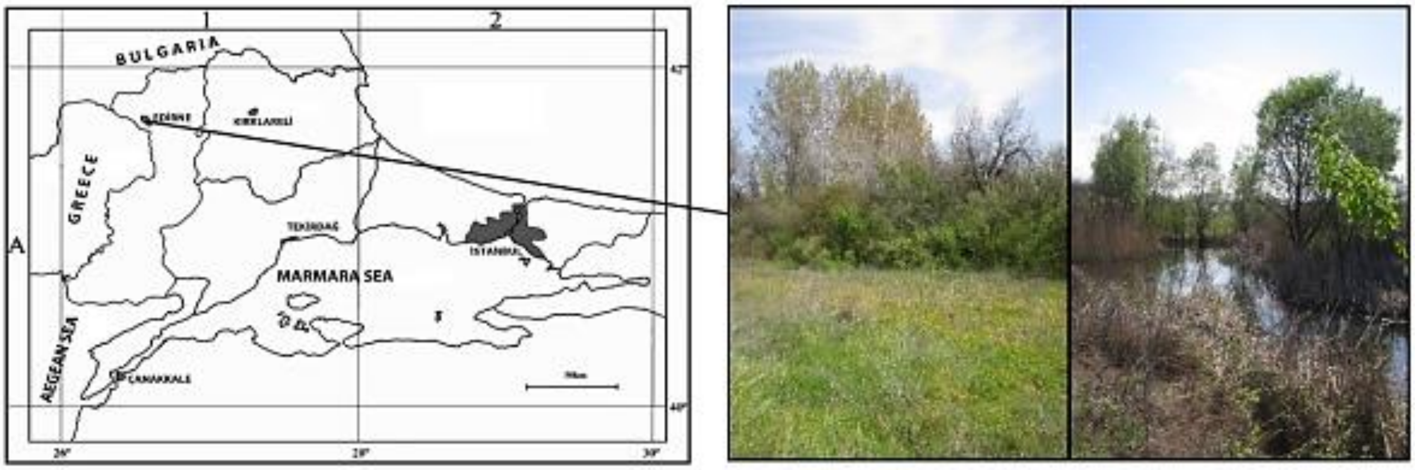

Figure 1. Map of European Turkey and the general view of the study area and the stream in (200 hectares).

insects can be used in biocontrol applications in agricultural areas to treat invasive and noxious plants (Helyer et al., 2014). Inter- and intraspecific interactions should be defined clearly to obtain a progress in biocontrol studies and to conserve plants, insects or the natural field. All types of new biological, behavioral, chemical and ecological findings regarding the associations between plants, target species and their natural enemies will increase the success of biological control and environmental protection.

This study investigates parasitoid species of herbivorous insects (and some predator insects) sampled on members of Rosaceae. Some biological, behavioral, and ecological observations are presented regarding the hosts and the parasitoids.

Materials and Methods

Field studies were carried out 2013-2014 period inside the arboretum area of Trakya University in Edirne Province of European Turkey (Fig. 1). Study area is about 200 hectares and at an elevation of 62 m asl. There is a stream (Güllapoğlu Stream) passing through the arboretum site whose segment located inside the study area has a length of about 1400 m and a width changing from 1 to 4 m (Özyavuz and Korkut, 2008). Since no agricultural activity has been performed in the study area, it was free of any type of chemical treatment before and during the study.

The target herbivorous insects started to appear following the increasing temperature by March. Samples were collected during 2-3 days in a week, on average. In some weeks, the samplings were extended to 4-5 days per week. The larval and pupal stages of the target insects on Rosaceae members were dropped over a cloth by shaking the plant and the specimens found on the cloth were collected by forceps. Additionally, egg, cocoon, larval, pupal, adult, and the nest samples observed on plants were taken carefully from the plant. All samples collected from a single Rosaceae member were placed in 10×15 cm gauze-covered plastic boxes in which leaves of the hosting plant were placed, and transferred to laboratory. Each transfer box was then separated into smaller plastic rearing boxes (10×10 cm size) considering the morphology of larvae. Tent caterpillar nests were placed into larger wooden cages (30×30 cm size) which have stainless steel mesh sides for ventilation. Appropriate plant leaves were provided in all boxes. Each rearing box was numbered and photographed. In total, 750 sampling boxes and about 900 living samples (egg clusters, larvae, pupae, and cocoons) were monitored during the whole laboratory studies. Temperature and humidity conditions of the rearing laboratory were set as 27°C and 52%, relatively. When an adult individual emerged in the rearing boxes, it was properly prepared for identification. All identified specimens are stored in Entomology Museum of Biology Department of Trakya University.

Results

Fifty plant–host–parasitoid associations, either as plant–herbivore–parasitoid or plant–predator–parasitoid associations, were recorded on 7 different Rosaceae species (Tables 1, 2). 10 of these associations were observed as new host–parasitoid associations. These associations were given in Table 3. Some biological and

Table 1. Tri-trophic associations found in the study, which include plant, herbivorous insect, and its parasitoid. (1): cocoon; (2): observed as egg on host; (3): emerged as adult from the host; (4): emerged as larva from the host; (5): larval stage; (6): pupal stage; (7): new herbivore–parasitoid associations observed by this study.

Plant	**Herbivore**	**Parasitoid**
Amygdalus communis Linnaeus (almond)	*Malacosoma neustria* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	*Cotesia* sp. (4) (Hymenoptera: Braconidae: Microgastrinae)
Amygdalus communis Linnaeus	*Malacosoma neustria* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	Tachinidae (4) (Diptera)
Crataegus monogyna Jacquin (hawthorn)	*Aporia crataegi* (5) (Linnaeus, 1758) (Lepidoptera: Pieridae)	*Cotesia glomerata* (4) (Linnaeus, 1758) (Hymenoptera: Braconidae: Microgastrinae)
Crataegus monogyna Jacquin	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria secundaria* (3), (7) (Ruschka, 1922) (Hymenoptera: Chalcididae)
Crataegus monogyna Jacquin	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Crataegus monogyna Jacquin	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Crataegus monogyna Jacquin	*Eriogaster lanestris* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	Tachinidae (2), (4) (Diptera)
Crataegus monogyna Jacquin	*Lymantria dispar* (5) (Linnaeus, 1758) (Lepidoptera: Erebidae)	Tachinidae (2), (4) (Diptera)
Crataegus monogyna Jacquin	Lepidoptera (5)	*Apanteles xanthostigma* (4) (Haliday, 1834) (Hymenoptera: Braconidae: Microgastrinae)
Prunus x *domestica* Linnaeus (plum)	Aphididae (Hemiptera)	*Aphidius rosae* (3) Haliday, 1833 (Hymenoptera: Braconidae: Aphidiinae)
Prunus x *domestica* Linnaeus	*Lymantria dispar* (5) (Linnaeus, 1758) (Lepidoptera: Erebidae)	Microgastrinae (4) (Hymenoptera: Braconidae)
Prunus x *domestica* Linnaeus	*Lymantria dispar* (5) (Linnaeus, 1758) (Lepidoptera: Erebidae)	*Glyptapanteles porthetriae* (4) (Muesebeck, 1928) (Hymenoptera: Braconidae: Microgastrinae)
Prunus x *domestica* Linnaeus	*Lymantria dispar* (5) (Linnaeus, 1758) (Lepidoptera: Erebidae)	Tachinidae (4) (Diptera)
Prunus x *domestica* Linnaeus	*Operophtera brumata* (5) (Linnaeus, 1758) (Lepidoptera: Geometridae)	Tachinidae (4) (Diptera)
Prunus x *domestica* Linnaeus	*Orthosia miniosa* (5) (Denis and Schiffermüller, 1775) (Lepidoptera: Noctuidae)	Tachinidae (4) (Diptera)
Prunus spinosa Linnaeus (blackthorn)	Aphididae (Hemiptera)	*Aphidius matricariae* (3) Haliday, 1834 (Hymenoptera: Braconidae: Aphidiinae)
Prunus spinosa Linnaeus	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Prunus spinosa Linnaeus	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Prunus spinosa Linnaeus	*Eriogaster catax* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	Microgastrinae (4) (Hymenoptera: Braconidae)
Prunus spinosa Linnaeus	*Eriogaster lanestris* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	*Erigorgus* sp. (4), (7) (Hymenoptera: Ichneumonidae)
Prunus spinosa Linnaeus	*Eriogaster lanestris* (5) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	Tachinidae (2), (4) (Diptera)
Prunus spinosa Linnaeus	*Lymantria dispar* (5) (Linnaeus, 1758) (Lepidoptera: Erebidae)	Tachinidae (2), (4) (Diptera)

Table 1. Continuing.

Plant	Herbivore	Parasitoid
Prunus spinosa Linnaeus	*Valeria oleagina* (5) (Denis and Schiffermüller, 1775) (Lepidoptera: Noctuidae)	Tachinidae (4), (7) (Diptera)
Prunus spinosa Linnaeus	-	*Lissonota oculatoria* (Fabricius 1798) (Hymenoptera: Ichneumonidae)
Pyrus communis Linnaeus (pear)	*Aporia crataegi* (5) (Linnaeus, 1758) (Lepidoptera: Pieridae)	*Cotesia glomerata* (4) (Linnaeus, 1758) (Hymenoptera: Braconidae: Microgastrinae)
Pyrus communis Linnaeus	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Pyrus communis Linnaeus	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Pyrus communis Linnaeus	*Atethmia ambusta* (5) (Denis and Schiffermüller, 1775) (Lepidoptera: Noctuidae)	Ichneumonidae (4) (Hymenoptera)
Pyrus communis Linnaeus	*Byctiscus betulae* (5) (Linnaeus, 1758) (Coleoptera: Curculionoidea: Rhynchitidae)	*Bracon jaroslavensis* (4), (7) Telenga, 1936 (Hymenoptera: Braconidae: Braconinae)
Pyrus communis Linnaeus	*Operophtera brumata* (5) (Linnaeus, 1758) (Lepidoptera: Geometridae)	Tachinidae (4) (Diptera)
Pyrus communis Linnaeus	*Paraswammerdamia* sp. (5) (Lepidoptera: Yponomeutidae)	*Apanteles* cf. *corvinus* (4) Reinhard, 1880 (Hymenoptera: Braconidae: Microgastrinae)
Pyrus communis Linnaeus	Tortricidae (5) (Lepidoptera)	*Dolichogenidea* sp. (4) (Hymenoptera: Braconidae: Microgastrinae)
Pyrus communis Linnaeus	Tortricidae (6) (Lepidoptera)	*Itoplectis maculator* (3) (Fabricius, 1775) (Hymenoptera: Ichneumonidae)
Rosa canina Linnaeus (dog rose)	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Itoplectis maculator* (3) (Fabricius, 1775) (Hymenoptera: Ichneumonidae)
Rosa canina Linnaeus	Lepidoptera (5)	*Bracon hebetor* Say, 1836 (Hymenoptera: Braconidae: Braconinae)
Rosa canina Linnaeus	Lepidoptera (5)	*Bracon intercessor* Nees, 1834 (Hymenoptera: Braconidae: Braconinae)
Rubus sanctus Schreber (wild blackberry)	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria secundaria* (7) (Ruschka, 1922) (Hymenoptera: Chalcididae)
Rubus sanctus Schreber	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Rubus sanctus Schreber	*Archips rosana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Nemorilla floralis* (4) (Fallén, 1810) (Diptera: Tachinidae)
Rubus sanctus Schreber	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria secundaria* (7) (Ruschka, 1922) (Hymenoptera: Chalcididae)
Rubus sanctus Schreber	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Brachymeria tibialis* (3) (Walker, 1834) (Hymenoptera: Chalcididae)
Rubus sanctus Schreber	*Archips xylosteana* (6) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	*Itoplectis maculator* (3) (Fabricius, 1775) (Hymenoptera: Ichneumonidae)
Rubus sanctus Schreber	*Orthosia miniosa* (5) (Denis & Schiffermüller, 1775) (Lepidoptera: Noctuidae)	Tachinidae (4) (Diptera)
Rubus sanctus Schreber	Tortricidae (5) (Lepidoptera)	*Compsilura concinnata* (4) (Meigen, 1824) (Diptera: Tachinidae)

ecological observations were also recorded during the study. One species has been identified as a new record for Hymenoptera fauna of Edirne Province and 11 species have been identified as new records for Diptera and Hymenoptera fauna of European Turkey (Table 4).

***Amygdalus communis* (almond)**

Two multitrophic associations, including three trophic levels, were recorded (Table 1).

Table 2. Multirophic associations found in the study, which include three or higher trophic level; plant, herbivore, predator, and their parasitoids. (1): cocoon; (2): emerged as adult from the host; (3): emerged as larva from the host; (4): larval stage; (5): pupal stage; (6): new herbivore–parasitoid associations observed by this study; (7): hyper-parasitoid; (8): multiple-parasitoid.

Plant	Herbivor	Predator	Parasitoid	Hyperparasitoid/ Multiple parasitoid
Crataegus monogyna (hawthor) Jacquin	*Aporia crataegi* (4) (Linnaeus, 1758) (Lepidoptera: Pieridae)	-	*Cotesia glomerata* (3) (Linnaeus, 1758) (Hymenoptera: Pteromalidae)	*Pteromalus chrysos* (2),(7) Walker, 1836 (Hymenoptera: Pteromalidae)
Prunus x *domestica* (plum) Linnaeus	Aphididae (Hemiptera)	Syrphidae (5) (Diptera)	*Pachyneuron formosum* (2) Walker, 1833 (Hymenoptera: Pteromalidae)	*Euneura lachni* (2), (6), (8) (Ashmead, 1887) (Hymenoptera: Pteromalidae)
Prunus x *domestica* Linnaeus	Aphididae (Hemiptera)	Syrphidae (5) (Diptera)	*Pachyneuron muscarum* (2), (6) (Linnaeus, 1758) (Hymenoptera: Pteromalidae)	*Euneura lachni* (2), (6), (8) (Ashmead, 1887) (Hymenoptera: Pteromalidae)
Prunus x *domestica* Linnaeus	-	-	Braconinae (1) (Hymenoptera: Braconidae)	*Eurytoma rosae* (2), (6), (7) Nees, 1834 (Hymenoptera: Eurytomidae)
Prunus x *domestica* Linnaeus	-	-	Microgastrinae (1) (Hymenoptera: Braconidae)	*Eurytoma rosae* (2), (6), (7) Nees, 1834 (Hymenoptera: Eurytomidae)
Pyrus communis (pear) Linnaeus	*Aporia crataegi* (4) (Linnaeus, 1758) (Lepidoptera: Pieridae)	-	*Cotesia glomerata* (3) (Linnaeus, 1758) (Hymenoptera: Braconidae: Microgastrinae)	*Cotesia pieridis* (3), (6), (8) (Bouché, 1834) (Hymenoptera: Braconidae: Microgastrinae)

***Malacosoma neustria–Cotesia* sp.:** Parasitoid larvae emerged from the last instar *M. neustria* larva gregariously and started immediately to spin white silken cocoons close by the host larva. The host was still alive but not feeding during emerging of the parasitoid larvae from *M. neustria* larva. Parasitoid larvae span their cocoons as stacked together and the living host larva exhibited parental care behavior to the clumped parasitoid cocoons – a continuous touch and moving around the cocoons. This behavior continued until the time when adult parasitoids emerge from their cocoons and then host larvae died. 31 adult parasitoids – all male – emerged after a week of pupation.

***Crataegus monogyna* (hawthorn)**

Eight trophic associations, including three or higher trophic levels, were recorded (Tables 1, 2).

***Aporia crataegi–Cotesia glomerata*:** *C. glomerata* appeared to be the most common parasitoid species emerged from *A. crataegi* larvae in laboratory. All *A. crataegi* hosts out of which *C. glomerata* emerged were at their last instars. Before emergence of the parasitoid larvae, some infected host larvae exhibited some behavioral changes for 1-2 days. They were moving or swaying at the top of the rearing box using only their thoracic legs in an abdomen position pointing downwards without touching the box with abdominal prolegs (Fig. 2). In the normal pattern of this behavior, all caterpillars move to the top of the box using all of their legs.

In laboratory, the first emergence of *C. glomerata* larvae from the host *A. crataegi* occurred in the second week of April. Each *C. glomerata* larvae left their hosts gregariously as 30-40 individuals and spun a yellow cocoon in a short time close by the hosts. The larvae and the cocoons were yellow in color and the places of parasitoid emergence from host larvae changed. Adults of *C. glomerata* emerged from their yellow clumped cocoons within 7-10 days. Host larvae were alive until the emergence of the adult parasitoids. During this time, a type of parental care in lepidopteran larvae was observed

Table 3. New host–parasitoid associations observed by this study. (1): cocoon; (2): emerged as adult from the host; (3): emerged as larva from the host; (4): larval stage; (5): pupal stage; (6): hyper-parasitoid; (7): multiple-parasitoid.

Plant	Herbivor	Predator	Parasitoid	Hyperparasitoid/ Multiple parasitoid
Crataegus monogyna (hawthorn) Jacquin	*Archips rosana* (5) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	-	*Brachymeria secundaria* (2) (Ruschka, 1922) (Hymenoptera: Chalcididae)	-
Prunus x *domestica* (plum) Linnaeus	Aphididae (Hemiptera)	Syrphidae (5) (Diptera)	*Pachyneuron formosum* (2) Walker, 1833 (Hymenoptera: Pteromalidae)	*Euneura lachni* (2), (7) (Ashmead, 1887) (Hymenoptera: Pteromalidae)
Prunus x *domestica* Linnaeus	Aphididae (Hemiptera)	Syrphidae (5) (Diptera)	*Pachyneuron muscarum* (2) (Linnaeus, 1758) (Hymenoptera: Pteromalidae)	*Euneura lachni* (2), (7) (Ashmead, 1887) (Hymenoptera: Pteromalidae)
Prunus x *domestica* Linnaeus	-	-	Braconinae (1) (Hymenoptera: Braconidae)	*Eurytoma rosae* (2), (6) Nees, 1834 (Hymenoptera: Eurytomidae)
Prunus x *domestica* Linnaeus	-	-	Microgastrinae (1) (Hymenoptera: Braconidae)	*Eurytoma rosae* (2), (6) Nees, 1834 (Hymenoptera: Eurytomidae)
Prunus spinose (blackthorn) Linnaeus	*Eriogaster lanestris* (4) (Linnaeus, 1758) (Lepidoptera: Lasiocampidae)	-	*Erigorgus* sp. (3) (Hymenoptera: Ichneumonidae)	-
Prunus spinose Linnaeus	*Valeria oleagina* (4) (Denis and Schiffermüller, 1775) (Lepidoptera: Noctuidae)	-	Tachinidae (3) (Diptera)	-
Pyrus communis (pear) Linnaeus	*Aporia crataegi* (4) (Linnaeus, 1758) (Lepidoptera: Pieridae)	-	*Cotesia glomerata* (3) (Linnaeus, 1758) (Hymenoptera: Braconidae: Microgastrinae)	*Cotesia pieridis* (3), (7) (Bouché, 1834) (Hymenoptera: Braconidae: Microgastrinae)
Pyrus communis Linnaeus	*Byctiscus betulae* (4) (Linnaeus, 1758) (Coleoptera: Curculionoidea: Rhynchitidae)	-	*Bracon jaroslavensis* (3) Telenga, 1936 (Hymenoptera: Braconidae: Braconinae)	-
Rubus sanctus (wild blackberry) Schreber	*Archips rosana* (5) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	-	*Brachymeria secundaria* (Ruschka, 1922) (Hymenoptera: Chalcididae)	-
Rubus sanctus Schreber	*Archips xylosteana* (5) (Linnaeus, 1758) (Lepidoptera: Tortricidae)	-	*Brachymeria secundaria* (Ruschka, 1922) (Hymenoptera: Chalcididae)	-

Figure 2. The behavioral change observed in *Aporia crataegi* larvae.

on the parasitoid cocoon cluster. In addition, *A. crataegi* responded aggressively when a physical stimulus was applied artificially during its sitting at the top of the *C. glomerata* cocoons in laboratory.

***Aporia crataegi–Cotesia glomerata–Pteromalus chrysos*:** The individuals of *P. chrysos* emerged from *C. glomerata* cocoons which come out of the *A. crataegi* larva on *Crataegus monogyna*. The last *C. glomerata* adults from other lepidopteran samples were seen in the laboratory in the last week of April and *P. chrysos* adults were observed in mid-May.

In the last week of April (April 28th), *C. glomerata* cocoons on which their alive host larva on *C. monogyna* existed were observed in field. In one case, a chalcid wasp was seen on the yellow cocoons. The wasp touched the cocoons with its antenna and exhibited oviposition behavior and searched the proper host for oviposition. However, when the *A. crataegi* larva noticed the wasp, it tried to defense the cocoons against the chalcid wasp

Table 4. New insect records for fauna of Edirne province and European part of Turkey.

Order	Family	Species	New record for
Hymenoptera	Braconidae	*Glyptapanteles porthetriae*	Edirne province
Diptera	Tachinidae	*Compsilura concinnata*	European part of Turkey
		Nemorilla floralis	European part of Turkey
Hymenoptera	Braconidae	*Apanteles xanthostigma*	European part of Turkey
		Bracon jaroslavensis	European part of Turkey
		Cotesia pieridis	European part of Turkey
	Eurytomidae	*Eurytoma rosae*	European part of Turkey
	Ichneumonidae	*Lissonota oculatoria*	European part of Turkey
	Pteromalidae	*Euneura lachni*	European part of Turkey
		Pachyneuron formosum	European part of Turkey
		Pachyneuron muscarum	European part of Turkey
		Pteromalus chrysos	European part of Turkey

showing aggressive behaviors and trying to keep it away from the cocoons.

Five days later from this observation, this cocoon cluster was collected from the field and transferred to laboratory. After 10 days following the transfer (May 12th), 19 *P. chrysos* adults emerged from *C. glomerata* cocoons. *P. chrysos* is a new record for Hymenoptera fauna of European Turkey.

***Archips rosana–Brachymeria secundaria*:** *B. secundaria* emerged as solitary adult from *A. rosana* pupa collected from *C. monogyna*. This host–parasitoid association is recorded for the first time.

***Archips rosana–Brachymeria tibialis*:** *B. tibialis* emerged as solitary adult from *A. rosana* pupa collected from *C. monogyna*.

Lepidoptera–*Apanteles xanthostigma*: The white solitary cocoon of this species observed in a microlepidopteran nest between *C. monogyna* leaves. Host is undetected. *A. xanthostigma* is a new record for Hymenoptera fauna of European Turkey.

***Prunus* x *domestica* (plum)**

10 trophic associations, including three or higher trophic levels, were recorded (Tables 1, 2).

Aphididae–Syrphidae–*Pachyneuron formosum–Euneura lachni* and Aphididae–Syrphidae–*Pachyneuron muscarum–Euneura lachni*: Adults of 3 species of chalcids – *P. formosum*, *P. muscarum*, and *E. lachni* – emerged from the Syrphidae puparia collected around the aphids determined on *Prunus* x *domestica* leaves. It was detected for the first time in this study that *P. formosum* and *E. lachni* used the same Syrphidae pupa and *P. muscarum* and *E. lachni* use the same Syrphidae pupa as a host.

***Pachyneuron formosum*:** 4 individuals of *P. formosum* and 14 individuals of *E. lachni* emerged together from an unidentified Syrphidae puparium. *P. formosum* is a new record for Hymenoptera fauna of European Turkey.

***Pachyneuron muscarum*:** 4 *P. muscarum* and 5 *E. lachni*; 12 *P. muscarum* and 10 *E. lachni* individuals emerged together from one unidentified Syrphidae puparium. *P. muscarum* is a new record for Hymenoptera fauna of European Turkey.

***Euneura lachni*:** 4 *Pachyneuron formosum* and 14 *E. lachni*; 4 *P. muscarum* and 5 *E. lachni*; 12 *P. muscarum* and 10 *E. lachni* individuals emerged together from one unidentified Syrphidae puparium. *E. lachni* is a new record for Hymenoptera fauna of European Turkey.

Braconidae (Braconinae and Microgastrinae)–*Eurytoma rosae*: Adults of *E. rosae* were reared from 2 different cocoon types belonging to Braconinae and Microgastrinae collected from *Prunus* x *domestica* leaves and branch. *E. rosae* was determined for the first time in this study to parasitize Braconidae (Braconinae and Microgastrinae) cocoons. *E. rosae* is a new record for Hymenoptera fauna of European Turkey.

***Lymantria dispar–Glyptapanteles porthetriae*:** *G. porthetriae* larva came out of early instar of *L. dispar* solitary and spun its white cocoon close by the host larva. 6 days later, the adult parasitoid emerged. *L. dispar* larva sat on the cocoon and took care of it until the emergence of the parasitoid. *G. porthetriae* is a new record for Hymenoptera fauna of Edirne province.

***Prunus spinosa* (blackthorn)**

9 trophic associations, including three trophic levels, were recorded (Table 1).

***Archips xylosteana–Brachymeria secundaria*:** *B.*

Figure 3. Tachinidae macrotype eggs (marked by white circles and arrows) on molted skin of *Lymantria dispar*.

secundaria emerged as solitary adult from the *A. xylosteana* pupa collected from Rosaceae. This host–parasitoid association is recorded for the first time.

***Eriogaster lanestris–Erigorgus* sp.:** *Erigorgus* sp. emerged as solitary adult from *E. lanestris* pupa. It is detected for the first time in this study that *Erigorgus* sp. use *E. lanestris* as a host.

***Lymantria dispar*–Tachinidae:** Tachinidae larva emerged from several *L. dispar* larvae, and formed a puparium around itself. Macrotype Tachinidae eggs glued to different segments of several other *L. dispar* larvae were also observed. In one of the samples, 3 white oblong eggs were determined; one was between the head and the 1st segment, and the other egg was on another one glued between the 1st and the 2nd thoracic segments of the lepidopteran larva. However, these eggs were shed when the lepidopteran larva molted (Fig. 3).

***Valeria oleagina*–Tachinidae:** Dipteran larva emerged solitarily from *V. oleagina* larva and formed its puparium, but the emergence of the adult parasitoid did not occur. There is no record about the natural enemies of *V. oleagina* in literature. This finding in this study on *Prunus spinosa* is a new host–parasitoid record.

***Pyrus communis* (pear)**

10 trophic associations, including three or higher trophic levels, were recorded (Tables 1, 2).

***Aporia crataegi–Cotesia glomerata*:** Most of the *A. crataegi* larvae collected from *Pyrus communis* were observed to be parasitized by *C. glomerata*. In laboratory, the first *C. glomerata* larvae emerged from the host larvae collected from *P. communis* in the second week of April.

***Aporia crataegi–Cotesia glomerata–Cotesia pieridis*:** *C. pieridis* emerged from *A. crataegi* larva with *C. glomerata*. In total, 15 adult parasitoids (3 female and 12 male) were observed from the cocoons from *A. crataegi*. Among these, 5 males were *C. pieridis* and other males and females were *C. glomerata*. It is detected for the first time in this study that *C. glomerata* and *C. pieridis* parasitize the same individual of *A. crataegi* together. *C. pieridis* is a new record for Hymenoptera fauna of European Turkey.

***Byctiscus betulae–Bracon jaroslavensis*:** Rolled leaves made by the *B. betulae* were observed in most of the *Prunus* x *domestica* plants studied. From the rolled leaves transferred to the laboratory, 2 *B. jaroslavensis* emerged from 2 different samples. When the leaf rolls were opened after the emergence of the parasitoid, whitish silky solitary cocoons were seen. This is the first record of *B. jaroslavensis* as a parasitoid of *B. betulae* and also the first host record of *B. jaroslavensis*. In addition, *B. jaroslavensis* is a new record for Hymenoptera fauna of European Turkey.

***Paraswammerdamia sp.* (?)–*Apanteles* cf. *corvinus*:** *Apanteles* cf. *corvinus* emerged from the host larva as a male solitary endoparasitoid.

Tortricidae–*Dolichogenidea* sp.: This parasitoid emerged from a microlepidopteran larva as a solitary white cocoon. The host is an unidentified Tortricidae species.

Tortricidae–*Itoplectis maculator*: *I. maculator* emerged as an adult solitary parasitoid from the pupa of an unidentified Tortricidae species collected from *Pyrus communis*.

***Rosa canina* (dog rose)**

3 trophic associations, including three trophic levels, were recorded (Tables 1, 2).

***Archips xylosteana–Itoplectis maculator*:** *I. maculator* emerged as an adult solitary parasitoid from *A. xylosteana* pupa collected from Rosa canina.

***Bracon hebetor*:** 2 yellowish cocoons surrounded partly with whitish silk were found around caterpillar droppings between the leaves (Fig. 4). The host Lepidoptera could not be seen. In laboratory conditions (at 11th of May), 2 adult *B. hebetor* individuals emerged from these cocoons.

***Bracon intercessor*:** 6 yellowish-whitish transparent

Figure 4. *Bracon hebetor* cocoons with droppings of host caterpillar (marked by white circle).

cocoons were found between *Rosa canina* leaves (Fig. 5A). The remains of the undetermined lepidopteran host and its droppings close by the parasitoid cocoons were also seen. In laboratory conditions, 5 adult *B. intercessor* emerged from the cocoons (Fig. 5B, C).

***Rubus sanctus* (wild blackberry)**

7 trophic associations, including three trophic levels, were recorded (Table 1).

***Archips rosana–Brachymeria secundaria*:** *B. secundaria* emerged as solitary adult from *A. rosana* pupa collected from *Rubus sanctus* leaves. This is a new host–parasitoid finding.

***Archips rosana–Nemorilla floralis*:** *N. floralis* larva emerged solitarily from *A. rosana* pupa collected from *Rubus sanctus* leaves. The larva then made its own puparium and emerged as an adult from its pupa. *N. floralis* is a new record for Diptera fauna of European Turkey.

Tortricidae–*Compsilura concinnata*: It was observed that the larvae of *C. concinnata* came out of lepidopteran larva and formed a puparium. The host larva belongs to a member of Tortricidae. *C. concinnata* is a new record for Diptera fauna of European Turkey.

***Lissonota oculatoria*:** *L. oculatoria*, whose host could not be defined in this study, is a new record for Hymenoptera fauna of European Turkey.

Discussion

***Amygdalus communis* (almond)**

***Malacosoma neustria–Cotesia* sp.:** The taxonomy of Microgastrinae is based almost entirely on the female sex, mainly because the characters in males are poorly developed and somewhat variable, and it is not possible to identify these specimens further (M.R. Shaw, pers. comm., 2015). There are many records reporting that *M. neustria* is parasitized by *Cotesia* sp. (Yu et al., 2012).

***Crataegus monogyna* (hawthorn)**

***Aporia crataegi–Cotesia glomerata*:** Parasitism influences the host body in variety of ways. Behavioral, morphological and physiological changes may occur at the parasitized animal. For example, the reaction of a parasitized host to a physical stimulus like light or heat may change, and foraging, social role or interactions may be altered. These types of changes in parasitized hosts may occur due to the traumatic side effects of parasitism

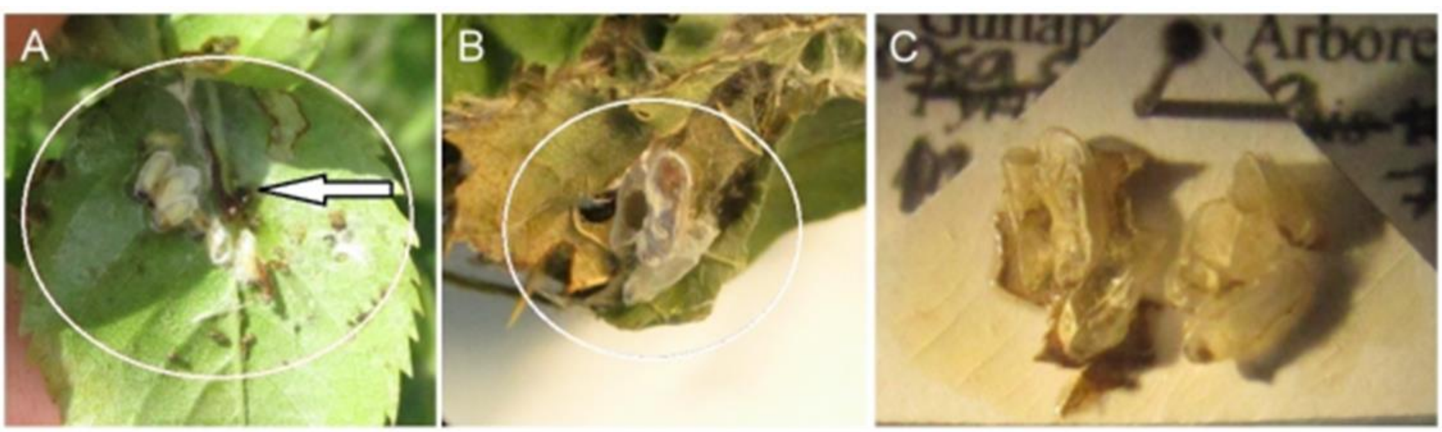

Figure 4. *Bracon intercessor* cocoons: (A) Cocoons and lepidopteran host remains (marked by arrow) found between *Rosa canina* leaves. (B) Cocoons from which the parasitoids emerged, one parasitoid still waits for emergence. (C) Empty cocoons after all *B. intercessor* adults emerged.

on the host pathology or maybe caused by the biochemicals that are injected by female parasitoids into the host body during oviposition (Godfray, 1994; Moore, 1995; Lewis et al., 2002; Tanaka and Oshaki, 2009). Accordingly, in this study, the behavioral (motional) change in *A. crataegi* larvae may be a result of the parasitoid biochemicals or the traumatic side effects of parasitisation.

Some parasitoid species turn their hosts into a bodyguard of the cocoons for a hyperparasitoid threat (called as the usurpation hypothesis). The parasitized larvae may sit at the top of the parasitoid cocoons egress from itself; or it may behave aggressively to the physical existence of a hyperparasitoid to remove it around the cocoons. The reason of this behavior may be a result of the indirect effect of the parasitism or may be due to the neurophysiological changes caused by the chemicals released by the parasitoid at oviposition (Moore, 1995; Harvey et al., 2008).

The plants associated with *C. glomerata* belong to the families of Amaryllidaceae, Apiaceae, Brassicaceae, Fabaceae, Fagaceae, Lamiaceae, Poaceae, and Rosaceae (*Cotoneaster horizontalis*, *Malus domestica*, *Prunus domestica*) (Yu, 2012). In this study the host of this parasitoid feeds on both *Crataegus monogyna* and *Pyrus communis*.

***Aporia crataegi–Cotesia glomerata–Pteromalus chrysos*:** In this sample, *P. chrysos* is the primer parasitoid of *C. glomerata* and the hyperparasitoid (secondary parasitoid) of *A. crataegi*. The aggressive response of *A. crataegi* larva to the wasp that moved around the *C. glomerata* cocoons can be considered as a typical example of the usurpation hypothesis, in which the parasitized *A. crataegi* larva guards the *C. glomerata* cocoons towards to a possible hyperparasitoid attack.

According to Noyes (2015) records, *P. chrysos* is associated with the plant families of Fabaceae, Fagaceae, Poaceae, Rosaceae (*Malus communis*, *M. domestica*, *Prunus* sp., *P. padus*), and Ulmaceae. In this study, the observed plant associate of this chalcid parasitoid is *Crataegus monogyna*. It is known that *C. glomerata* from *A. crataegi* is parasitized by *P. chrysos* in fruit trees (Wilbert, 1960).

***Archips rosana–Brachymeria secundaria*:** *B. secundaria* was recorded mostly as pupal hyperparasitoid on Hymenoptera (Braconidae, Ichneumonidae) and Lepidoptera [Geometridae, Lymantriidae, Noctuidae, Notodontidae, Nymphalidae, Pieridae, Tortricidae (*Laspeyresia pomonella*, *Pandemis cerasana*, and *Polychrosis botrana*), and Yponomeutidae] members (Noyes, 2015). In this study, emergence of *B. secundaria* from *A. rosana* is a new parasitoid–host association finding. Recorded plant associates of *B. secundaria* are in the families of Rosaceae (*Malus communis*), Salicaceae, and Tamaricaceae (Doğanlar, 1987; Öncüer, 1991; Noyes 2015).

Lepidoptera–*Apanteles xanthostigma*: *A. xanthostigma* is a regular solitary parasitoid of both *Swammerdamia* and *Paraswammerdamia* species (Yponomeutidae) that feed on various Rosaceae members. However, the parasitoid is not very specialized but also has several other regular hosts most of which are microlepidopterans (M.R. Shaw, pers. comm., 2015). The recorded lepidopteran hosts are from the families Gelechiidae, Geometridae, Chimabachidae, Gracillariidae, Lymantriidae, Nepticulidae, Noctuidae, Pyralidae, and Tortricidae. *A. xanthostigma* also oviposits in galls of Cecidomyiidae (Diptera) species. In addition, the recorded plant associates of *A. xanthostigma* are from the families Betulaceae, Fagaceae, Oleaceae, Pinaceae, Rosaceae (*Crataegus* sp., *Cydonia oblonga*, *Malus domestica*, *M. pumila*, *M. sylvestris*, *Mespilus germanica*, *Prunus domestica*, *Pyrus communis*, *P. sativa*), and Salicaceae (Yu et al., 2012).

***Prunus* x *domestica* (plum)**

Aphididae–Syrphidae–*Pachyneuron formosum–Euneura lachni* and Aphididae–Syrphidae–*P. muscarum–E. lachni*: Within the Syrphidae, Sternorrhyncha (Hemiptera) predators are subject to parasitoid attacks mostly, in comparison to saprophag taxons, mainly because Sternorrhyncha predators are present in relatively reachable positions for parasitoids (Shaw and Askew, 1978; Rotheray 1993). In this study, all of the 3 parasitoid species (*Pachyneuron formosum*, *P. muscarum* and *Euneura lachni*) that emerged from Syrphidae pupae are grouped in Pteromalinae (Chalcidoidea: Pteromalidae). According to Shaw and Askew (1978), Pteromalidae (with Eulophidae) is the most important family that attacks Diptera species. There is no information in literature about a species which is a hyperparasitoid of Syrphidae in Pteromalinae. However, there are findings about the species that is primary parasitoid for Syrphidae (Noyes, 2015). In addition, there is a common behaviour of *Pachyneuron* species; they obligatory parasitize the

Diptera or Hymenoptera pupae that are in a capsul (Kamijo and Takada, 1973).

***Pachyneuron formosum*:** *P. formosum* is a parasitoid of aphidophagous Syrphidae (*Betasyrphus serarius*, *Episyrphus balteatus*, *Eupeodes corollae*, *E. luniger*, *Neocnemodon fulvimanus*, *Sphaerophoria scripta*, *Syrphus ribesii*, and *Xanthandrus comtus*) (Bouček, 1970; Doğanlar, 1986; Noyes, 2015). It is also a parasitoid on several Lepidoptera (Lasiocampidae, Pieridae) and Hymenoptera (Ichneumonidae) species. Additionally, it has been observed in several studies that *P. formosum* acts as a hyperparasitoid on Aphididae and Pseudococcidae species through Aphidiinae (Şahbaz and Uysal, 2006; Kos et al., 2012; Noyes, 2015). Avcı and Özbek (1991) reported that 15 adults of *P. formosum* emerged from a single Syrphidae (*Episyrphus balteatus*) pupa taken from *B. brassicae*. Moreover, 3 adult females of *P. formosum* were reared from a Syrphidae pupa found on *Rumex* sp. leave (S.E. Tek, unpub. data). In this study, 4 individuals of *P. formosum* and 14 individuals of *E. lachni* emerged together from an unidentified Syrphidae puparium. Here, *P. formosum* may be a primary parasitoid, as well.

The recorded plant associates of *P. formosum* in literature are in the families of Apiaceae, Asteraceae, Brassicaceae, Chenopodiaceae, Cupressaceae, Fabaceae, Fagaceae, Gnetaceae, Pinaceae, Poaceae, Polygonaceae, Resedaceae, Rhamnaceae, Rosaceae (*Prunus avium*, *P. cerasus*, *P. persica*, *Pyrus communis*, Rutaceae, and Tamaricaceae (Noyes, 2015).

***Pachyneuron muscarum*:** *Pachyneuron* species are recorded as primary and hyper- parasitoids. *P. muscarum* is recorded mostly as a polyphagous secondary parasitoid (there is little data about being primary parasitoid on Lepidopteran eggs). It parasitizes some species of Coleoptera, Diptera (Agromyzidae, Cecidomyiidae, and Chloropidae), Hemiptera, Hymenoptera and Lepidoptera. Also, it becomes secondary parasite by attacking primary parasitoids of Encyrtidae (Hymenoptera: Chalcidoidea) in Coccidae, Pseudococcidae (Hemiptera) and Coccinellidae (Coleoptera) larvae; hyperparasite on Psyllidae (Hemiptera) nymphs and aphidophagous Coccinellidae pupae; or becomes tertiary parasite through a secondary chalcid parasite of the same species (*P. muscarum*) or through another Encyrtid species of Chalcidoidea (Bouček, 1970; Rosen and Kfir, 1983; Doğanlar, 1986; Dzhanokmen, 2009; Noyes, 2015). *Pachyneuron* species develop as primary parasitoid on aphidophagous Diptera. There are some parasitoid species records on Chloropidae, Chamaemyiidae, and Syrphidae puparia in America and Europe (Graham, 1969; Burks, 1979). However, according to Rosen and Kfir (1983), some of these primary/hyper-parasitoid records are suspicious. The researchers, thus, made a laboratory study about to see if a hyperparasitoid *Pachyneuron* could become a primary parasitoid on a dipteran pupa and found that *P. muscarum* developed as a primary parasitoid in Diptera pupae. Although it parasitizes Syrphidae puparia, it could not succeed to develop into adult. According to Rosen and Kfir (1983), *P. muscarum* cannot be a primary parasitoid on a non-parasitized homopteran host but it can be on a dipteran host. Additionally, host decision mechanism in *P. muscarum* works according to being a soft bodied host placed in a hard-dry shell. In this study, there are 2 different parasitoid species (*P. muscarum* and *Euneura lachni*) emerged from single puparium in two puparia samples. *P. muscarum* reared gregariously as adults from the wild-collected parasitized host pupae of Syrphidae for the first time in this study.

The recorded plant associates of *P. muscarum* are in the families of Asteraceae, Boraginaceae, Brassicaceae, Chenopodiaceae, Cyperaceae, Fabaceae, Grossulariaceae, Oleaceae, Pinaceae, Poaceae, Rosaceae (*Crataegus* sp., *Malus domestica*, *Prunus* sp., *P. armeniaca*, *P. cerasifera*, *P. domestica*, *P. institia*, *P. padus*, *P. spinosa*, *Pyrus communis*), Rutaceae, Tiliaceae, Ulmaceae, and Vitaceae (Noyes, 2015).

***Euneura lachni*:** This species is hyperparasitoid on several aphid (Aphididae) species through Aphidiinae and Braconidae species. Also, there are records that some species of Syrphidae (Diptera), Aleyrodidae (Hemiptera), and Lasiocampidae (Lepidoptera) are the primary hosts of *E. lachni* (Brown and Clark, 1960; Kamijo, 1983; Noyes, 2015). About the Syrphidae host, Brown and Clark (1960) reared one adult female of *E. lachni* from a *Neocnemodon coxalis* puparium. In this study, 4 *Pachyneuron formosum* and 14 *E. lachni*; 4 *P. muscarum* and 5 *E. lachni*; and 12 *P. muscarum* and 10 *E. lachni* individuals emerged together in pairs from unidentified Syrphidae puparia. The recorded plant associates of *E. lachni* in the literature are in the families of Fagaceae, Pinaceae, Rosaceae (*Malus pumila*, *Prunus* sp., *P. amygdalus*, *P. domestica*, *P. persica*, *Rosa* sp.), and Salicaceae (Noyes, 2015).

Ni et al. (1994) studied multiparasitism on the eggs of pine lasiocampids (*Dendrolimus* sp.). According to them, *E. lachni* do not parasitize the fresh eggs but parasitize only the eggs which are firstly parasitized by *Trichogramma* sp. and whose embryonic development is at 1–7 days. The authors also reported in the same study that if non-congeneric embryo was at its 3–5 days of development, *E. lachni* reached its highest parasitization rate on the Lepidoptera egg and highest adult emergence.

Kleptoparasitoidism is a term defining this type of strategy/behavior of parasitoid hymenopterans. The definition of Frank and Kaufman (2006) about kleptoparasitoidism (or cleptoparasitoidism) is "a form of multiple parasitoidism in which a parasitoid preferentially attacks a host that is already parasitoidized by another species." According to Silveira and Japyassú (2012), kleptoparasitism is a term that refers to a reciprocal interaction in which one individual takes advantage from the foraging investments of another.

In our present study, 2 of the observed parasitoid complexes, *Euneura lachni*–*Pachyneuron formosum* and *E. lachni*–*P. muscarum* can be considered as kleptoparasitoidism examples. Indeed, *E. lachni* might act as a kleptoparasitoid or, perhaps might be parasitizing *Pachyneuron* pupae. In order to enlighten these aspects, adult sizes (of both males and females) of *E. lachni*, which emerged from the Syrphidae pupae, were compared with their typical size range reported by Kamijo and Takada (1973). Size comparisons of three puparium samples suggest three outcomes. First puparium sample, out of which *E. lachni* and *P. muscarum* emerged, suggests that *E. lachni* may be a kleptoparasitoid of *P. muscarum*. Second puparium sample, out of which *E. lachni* and *P. muscarum* emerged like the first one, suggests that *E. lachni* may be a hyperparasitoid of *P. muscarum*. Third puparium sample, out of which *E. lachni* and *P. formosum* emerged, suggests that *E. lachni* may be a kleptoparasitoid of *P. formosum*. Therefore, size comparisons suggest that *E. lachni* may act both as a primary and a secondary parasitoid on Syrphidae pupae. Also under these conditions, *P. formosum* and *P. muscarum* may be primary parasitoids of the Syrphidae pupae. In addition, *P. muscarum* may be a host of *E. lachni*. However, further studies need to be performed about these three parasitoid species.

The only Syrphidae host record of *E. lachni* is *Neocnemodon coxalis* which is a Nearctic dipteran species. Thus, in this study *E. lachni* becomes a new parasitoid record of Syrphidae (undetermined species) for the Palearctic region. In addition, it is a new finding that *E. lachni* constructs a parasitoid complex with *P. formosum* or *P. muscarum* in a Syrphidae pupa.

Braconidae (Braconinae and Microgastrinae)–*Eurytoma rosae*: *E. rosae* is a parasitoid in some species of Coleoptera (Buprestidae, Scolytidae), Diptera (Cecidomyiidae, Tephritidae), Hymenoptera (Cynipidae), and Lepidoptera (Arctiidae, Glyphipterygidae, Tortricidae) (Noyes, 2015). It was reared from 2 different cocoon types belonging to Braconinae and Microgastrinae, collected from *Prunus* x *domestica* leaf and branch.

At the first case, 5 whitish gregarious cocoons were found on the plant leaves from which 4 *E. rosae* adults emerged (Fig. 6A). In this case, the cocoons of Braconidae looked similar with the cocoons found on *Rosa canina* (Figs. 5A, B, C, and 6C). Thus, it can be said that these whitish transparent cocoons belong to Braconinae, and most probably belong to a *Bracon* species (maybe *Bracon intercessor*, Figure 5A, B, C).

At the second case, white gregarious clumped cocoons were collected from a branch of the host *Prunus* x *domestica* (Fig. 6B) and 1 *E. rosae* adult was reared from one of the cocoons. The cocoons looked like those of Microgastrinae. After the adult emergence, the cocoons were investigated under the microscope and it was observed that nearly all had only one emerging hole while there were 2 parasitoid emerging holes at 1 cocoon from which *E. rosae* emerged (Fig. 6B), marked by white circles).

According to the parasitoid catalogue of Herting (1977), *Bracon intercessor* is parasitized by 2 *Eurytoma* species (*E. curculionum* and *E. tristis*). In addition, the parasitoid hosts of *E. rosae* are within Cynipidae taxon (Noyes, 2015), and only 2 host species from Encyrtidae and Eulophidae families are the records of "*Eurytoma* nr. *rosae*" as a hyperparasitoid (Herting, 1977). Thus, there is no clear information about whether *E. rosae* parasitize a Braconidae species or no certainty about hyperparasitoid behavior of *E. rosae*.

It can be said from the observations in this study that *E. rosae* is a parasitoid of Braconidae (Braconinae and Microgastrinae) cocoons. This is the first host record of *E. rosae* and therefore, it shows firstly a hyperparasitic behavior on the host of these 2 different Braconidae species.

The plant associates of *E. rosae* belong to the families of Aceraceae, Asteraceae, Fagaceae, Oleaceae, Rosaceae (*Rosa* sp., *R. canina*, *R. damascena*, *R. pimpinellifolia*, *Rubus idaeus*), and Rubiaceae (Yu et al., 2012; Noyes, 2015). In this study, the cocoons were collected from *Prunus* x *domestica* as a new associate plant for *E. rosae*.

***Lymantria dispar–Glyptapanteles porthetriae*:** According to Yu et al. (2012), the recorded plant associates of *G. porthetriae* belong to Fagaceae (*Querqus* sp.). In this study, *G. porthetriae* is associated with *Prunus* x *domestica*.

***Prunus spinosa* (blackthorn)**

***Eriogaster lanestris–Erigorgus* sp.:** The recorded hosts of *Erigorgus* sp. are mainly from Arctiidae, Geometridae, Lasiocampidae (*Eriogaster philippsi*, *Malacosoma castrense*; *Selenephera lobulina pinivora*), Lemoniidae, Lymantriidae, Noctuidae (has the most host record), Notodontidae, Nymphalidae, Papilionidae, Pieridae, Sphingidae, Thaumetopoeidae, Tortricidae, and Zygaenidae, all within Lepidoptera. The *Erigorgus* parasitoids are reported to be a solitary endoparasitoid and can oviposit in larva and emerge from the host pupa (Yu et al., 2012).

Erigorgus lanator is recorded as the parasitoid of another *Eriogaster* species (*Eriogaster philippsi*) (Yu et al., 2012). In this study, emergence of *Erigorgus* sp. from *Eriogaster lanestris* is a new parasitoid–host association finding.

***Pyrus communis* (pear)**

***Aporia crataegi–Cotesia glomerata–Cotesia pieridis*:** It is reported that *C. pieridis* is a parasitoid of *A. crataegi* (Shaw et al., 2009). Both parasitoid species can occur in the same host, though when this occurs *C. pieridis* is usually retarded or entirely suppressed (Wilbert, 1960). The few (only 5) individuals of *C. pieridis* (all were males) is an indication of this. Wilbert (1960) observed that *C. glomerata* and *C. pieridis* were found together in the same larval host of *Pieris brassicae*. In this study, the two parasitoid species were found together in the same *A. crataegi* host as a new finding.

The recorded plant associate of *C. pieridis* is *Rosa* sp. (Rosaceae) (Yu, 2012). In this study, the host of *C. pieridis* is *Pyrus communis*.

***Byctiscus betulae–Bracon jaroslavensis*:** This weevil species uses a wide range of plant hosts, but it is associated mainly with *Coryllus*, *Populus*, *Vitis* sp. and *Prunus spinosa* (Tozlu, 2001; Alford 2007).

There are some *Bracon* records (*Bracon admotus*, *B. discoideus*, and *B. flavipes*) as parasitoid of *Byctiscus betulae* (Yu et al., 2012; Yu, 2012). However, there is no record or study about *Bracon jaroslavensis* hosts. Thus, the present *Byctiscus betulae–Bracon jaroslavensis* association is a new finding.

***Paraswammerdamia sp.* (?)*–Apanteles* cf. *corvinus*:** Larval host of *Apanteles* cf. *corvinus* might be a *Paraswammerdamia* species. There is no published record about the presence of *Apanteles corvinus* in Turkey but it is present in Bulgaria and Greece (to note, Edirne province has borders with these countries) (Fauna Europaea 2014). In addition, both taxa are associated with various Rosaceae including *Pyrus communis* (Robinson et al., 2010; Yu et al., 2012).

Tortricidae–*Dolichogenidea* sp.: It is known that *Dolichogenidea* species are solitary or gregarious endoparasitoids of lepidopteran larvae including Tortricidae (Shaw, 2012; van Noort, 2016). The recorded plant associates of *Dolichogenidea* sp. belong to Asteraceae, Convolvulaceae, and Solanaceae (Yu et al., 2012). In this study, an association between *Dolichogenidea* sp. and *Pyrus communis* (Rosaceae) were recorded.

Tortricidae–*Itoplectis maculator*: The recorded plant associates of *I. maculator* belong to Apiaceae, Asteraceae, Betulaceae, Euphorbiaceae, Fabaceae, Fagaceae, Grossulariaceae, Oleaceae, Onagraceae, Pinaceae, Ranunculaceae, Rosaceae (*Fragaria ananassa*, *Malus domestica*, *Prunus padus*, and *Rubus* sp.), Salicaceae, Sapindaceae, Taxaceae, Triticeae, and Vitaceae (Yu, 2012). In this study, this ichneumonoid species was observed to be associated with *Pyrus communis*, *Rosa canina*, and *Rubus sanctus*.

***Rosa canina* (dog rose)**

***Bracon hebetor*:** This braconid species is a gregarious ectoparasitoid and has an importance in biological control (Brower et al., 1996; Ghimire, 2008). It parasitizes mainly Lepidoptera members (Arctiidae, Blastobasidae, Gelechiidae, Lymantriidae, Nolidae, Oecophoridae, Papilionidae, Pieridae, Plutellidae, Sesiidae, Tineidae, Tortricidae, and Yponomeutidae) and the host records show that it parasitizes mostly Pyralidae, Noctuidae, and Tortricidae. In addition to the lepidopteran hosts, there are also some records about Coleoptera (Chrysomelidae, Curculionidae) and Hymenoptera (Braconidae, Cynipidae) members (Yu et al., 2012).

The plant associates of *B. hebetor* belong to Apiaceae, Arecaceae, Asteraceae, Burseraceae, Fabaceae, Juglandaceae, Lythraceae, Malvaceae, Poaceae, Salicaceae, Solanaceae, Theaceae, and Vitaceae families. In this study, its cocoons were found between *Rosa canina* (Rosaceae) leaves.

***Bracon intercessor*:** *B. intercessor* is a gregarious external parasitoid (Georgiev, 2000; Georgiev, 2005; Yu et al., 2012). However, Muller (2006) recorded this parasitoid as solitary larval ectoparasitoid of curculinoid *Hadroplontus litura*. *B. intercessor* individuals sometimes lay their eggs into sawfly galls (Hym.: Tenthredinidae) or weevil (Col.: Curculionidae) root galls (Volovnik, 1994; Kopelke, 2003; Muller, 2006). The primary host records for *B. intercessor* belong to Coleoptera (Cerambycidae, Curculionidae, Mordellidae, Rhynchitidae), Hymenoptera (Eurytomidae, Tenthredinidae), and Lepidoptera (Gelechiidae, Sesiidae, Tortricidae) (Tobias, 1986; van Achterberg et al., 1990; Freese, 1997; Muller, 2006). The recorded plant associates of *B. intercessor* belong to the families of Amaranthaceae, Apiaceae, Asteraceae, Boraginaceae, Euphorbiaceae, Fabaceae, Poaceae, and Salicaceae (Yu et al., 2012; Yu, 2012). It is a new finding that *B. intercessor* is associated with a Rosaceae species.

***Rubus sanctus* (wild blackberry)**

Tortricidae–*Compsilura concinnata*: It is known that this Tachinidae species is parasitoid of several taxa in Coleoptera, Hymenoptera and Lepidoptera including Tortricidae (Arnaud, 1978).

***Lissonota oculatoria*:** Its defined hosts mostly belong to Arachnida. There are also host records in Coleoptera (Curculionidae) and Lepidoptera (Tortricidae, Yponomeutidae) (Yu et al., 2012).

The recorded plants associated with *L. oculatoria* belong to Apiaceae, Fagaceae, and Taxaceae (Yu, 2012). In this study, this ichneumonoid species is associated with Rosaceae.

Conclusion

In conclusion, multitrophic associations related with insects on Rosaceae species were investigated in this study. A total of 50 multitrophic associations (plant–host–parasitoid) were recorded in the study area. Among these, 10 host–parasitoid associations were observed for the first time. In addition, for the fauna of Edirne province and European Turkey, 12 dipteran and hymenopteran species were determined as new records. It is essential to conduct further studies like allelochemicals or genetic relationships regarding the parasitoids and the plants on which the parasitoids find their preys, in order to understand the complete mechanism underneath.

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