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Research Article/Araştırma Makalesi

PREDATORY INSECT SPECIES ASSOCIATED WITH SOME ROSACEOUS PLANTS IN EDİRNE (TRAKYA UNIVERSITY ARBORETUM), TURKEY

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Abstract: This study was performed to determine the predatory insects associated with Rosaceae species. Field surveys were carried out in March-June 2013 in Edirne province (Trakya University Arboretum) of European Turkey. Predatory insects were observed and collected in different stages of their life cycles, and larval-pupal samples were reared in laboratory conditions. As a result of this study, predatory insect species which are inhabitants of the Rosaceae species to provide their preys were recorded and 11 predatory insects belonging to 6 families (Chrysopidae, Coccinellidae, Formicidae, Geocoridae, Pentatomidae, Syrphidae) were determined on 5 Rosaceae species. The observations and short information about the recorded species were also presented.

Key words: Trophic interaction, biocontrol, Rosaceae, Turkish Thrace.

Edirne Civarında (Trakya Üniversitesi Arboretumu) Bazı Rosaceae Bitkileri ile Birlikteliğe Sahip Predatör Böcek Türleri

Özet: Rosaceae türleri ile etkileşime sahip predatör böcek türlerini belirlemek amacıyla, 2013 yılı Mart-Haziran periyodunda, Trakya Bölgesi sınırları içinde yer alan Edirne ilinde (Trakya Üniversitesi Arboretumu) arazi çalışması ve toplanan örneklerle ilgili olarak laboratuar çalışması yapılmıştır. Arazi çalışması sırasında predatör böcekler çeşitli yaşam evrelerinde gözlemlenmiş ve toplanmıştır. Toplanan örneklerden larva/pupa aşamasında olanlar laboratuar şartlarında yetiştirilmiştir. Çalışma sonucunda alanda bulunan Rosaceae türleri üzerinde konaklayan ve besinini sağlayan predatör böcekler tanımlanarak belirlenmiş ve 5 bitki türü üzerinde, 6 familyaya ait 11 predatör böcek türü (Chrysopidae, Coccinellidae, Formicidae, Geocoridae, Pentatomidae, Syrphidae) kaydedilmiştir. Tespit edilen türler hakkında yapılan gözlemler ve kısa literatür bilgileri de belirtilmiştir.

Anahtar kelimeler: Trofik etkileşim, biyokontrol, Rosaceae, Türkiye Trakyası.

Introduction

Most of the members of the Rosaceae family are crucial to human beings' way of life since the family includes trees, shrubs and herbaceous plants which are used for landscaping and timber making as well as other related species which are used for production of medicine and food (Flora of China 2004, Hummer and Janick 2009).

Predatory insects are among the natural enemies of several major economically depreciating pest species. Plants affect both insect herbivores and predators by their phenology, chemistry, morphology, and alternative food which they provide to these insects. Plants provide food and shelter for herbivorous insects but on the other hand they can defense themselves directly or indirectly against herbivory by using their traits. One example can be given in terms of plant allelochemicals. A type of allelochemical called “pine tree terpenoids” can behave as allomones, kairomones and synomones against the organisms around it. This substance released by a plant species can deter herbivores by acting as an allomone, attract bark beetles by acting as a kairomone and attract bark beetle predators by acting as a synomone. Hence, pine tree terpenoids produced by the host tree is beneficial to both the plant and the predator. Another typical example is the aphid-plant-predator relationship. Studying the tritrophic associations between an aphid, its plant food and its predator can show the affects each offers to the others. These tritrophic studies reveal a lot about the overall beneficial effects that plants have to offer and the outcomes of these studies contribute to the importance of plant protection (Kılınçer 1983, Barbosa and Letourneau 1988, Schmitz *et al.* 2000, Vanhaelen *et al.* 2002, Schoonhoven *et al.* 2005). In the special case of Rosaceae family, it is also important to reveal the predatory insects and their associations or interactions with herbivorous insects and plant species they feed on. Thus, any kind of knowledge about plant-predatory insects is important both for agriculture and biodiversity. Although there are a number of studies reporting biological observations on predatory insect species found on several Rosaceae species like apple, peach, cherry and other fruit trees in different regions of Turkey (Kılıç and Aykaç 1989, Çam 1993, Çınar *et al.* 2004, Başar and Yaşar 2011, Demirözer and Karaca 2014) no study about the predators on rosaceous plants was performed so far in our present study area. The aim of this study is to contribute to the knowledge of predatory species associated with some rosaceous plants in Turkey.

Materials and Methods

Predatory insects were investigated following the emergence of herbivores in parallel with the blooming season of Rosaceae plants (in March) in Trakya University Balkan Arboretum in Edirne province of European Turkey (Fig. 1). The study area (200 hectares) was an uncultivated field without pesticide treatment. Field surveys were carried out from March to June 2013 but the total time period of the study covered 1 year to include the steps in laboratory. Predatory insects were collected individually in the field at their larval, pupal and adult stages. The collections were performed on *Crataegus monogyna* Jacquin, *Prunus* x *domestica* Linnaeus, *P. spinosa* Linnaeus, *Pyrus communis* Linnaeus and *Rubus sanctus* Schreber. The field studies were performed from March to June as 2 days/week due to the seasonal conditions of the region and the biological features of the species. Insect diversity showed a parallel increase with the plant development reaching its peak within this time period. In the field, the flowers, leaves, and stems of the plants were observed carefully and individual insects or their nests seen on each plant were collected gently. Larval and adult stages of insects were captured (after their observation) directly from the plant or from a cloth beneath the plant after shaking it using a forceps or by hand-picking. Pupal stages and nests were collected by removing the plant leaves. Larval and pupal samples were placed in 10×10 cm gauze-covered plastic rearing boxes and were reared in laboratory conditions (temperature 27°C; relative humidity 52%) by feeding the larvae with aphids. Adult samples were directly put into small jars containing 70% ethanol and then brought to laboratory. All rearing boxes and ethanol filled jars were labeled including number of the sample, related plant species, study area, and date of the collection. All adult insects were appropriately prepared and then identified by experts.

Results

A total of 11 predatory insects from 6 families were sampled either as larval, pupal or adult stages on 5 Rosaceae species (Table 1).

Coccinella bipunctata Linnaeus, *C. septempunctata* Linnaeus, *Exochomus quadripustulatus* Linnaeus, *Harmonia axyridis* Pallas (Col.: Coccinellidae) and *Eupeodes corollae* (Fabricius) (Dip.: Syrphidae) were collected from their associated plants (Table 1) only in their larval stages. The larvae were observed around aphid colonies on the sampled plants and were reared into adults in laboratory by feeding them with aphids. *Episyrphus balteatus* (De Geer) was collected both in larval and pupal stages and was reared into adult in laboratory. Cannibalism was observed between the last instar larvae of *C. septempunctata* and those of *H. axyridis*.

Chrysopa viridana Schneider and *C. pallens* Rambur (Neur.: Chrysopidae) were collected in their pupal stages from their associated plants (Table 1) and developed to adults in laboratory rearings. Pupae of *C. pallens* were determined in their nests built on hawthorn and blackthorn. The nests looked like a tent made from old leaves, with only a small pupa in a nest.

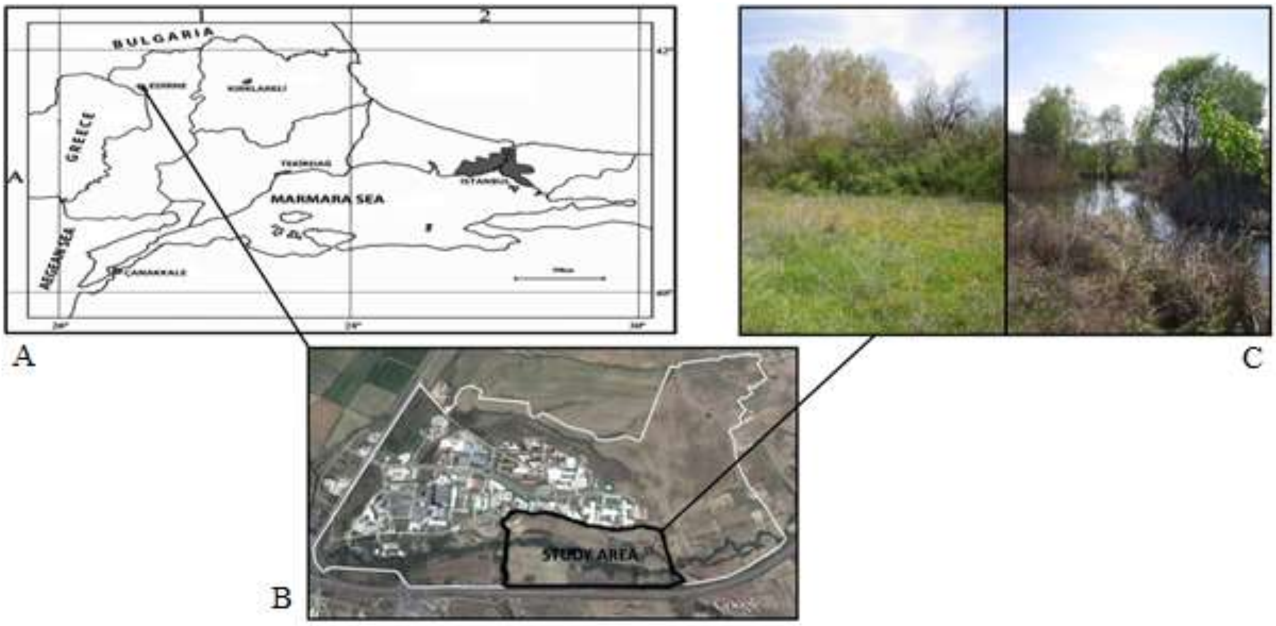

Fig. 1. (A) Map of European Turkey. (B) The study area, Trakya University Balkan Campus (white-lined area) and the arboretum (black-lined area) (Google Earth 2015). (C) The general view of the study area.

Table 1. Predatory insects and their associated Rosaceae plants recorded during the study. [(1)]: individuals collected from the field in larval stage; [(2)]: collected in pupal stage; [(3)]: collected in adult stage; [(4)]: non-herbivorous at all life stages.

Rosaceae Plant	Predatory Insect
Crataegus monogyna Jacquin (hawthorn)	*Chrysopa pallens* Rambur [(2)] (Neuroptera: Chrysopidae)
Prunus x *domestica* Linnaeus (plum)	*Coccinella bipunctata* Linnaeus [(1)] (Coleoptera: Coccinellidae) *Coccinella septempunctata* Linnaeus [(1)] (Coleoptera: Coccinellidae) *Harmonia axyridis* Pallas [(1)] (Coleoptera: Coccinellidae) *Episyrphus balteatus* (De Geer) [(1), (2)] (Diptera: Syrphidae) *Eupeodes corollae* (Fabricius) [(1)] (Diptera: Syrphidae) *Chrysopa viridana* Schneider [(2)] (Neuroptera: Chrysopidae)
Prunus spinosa Linnaeus (blackthorn)	*Coccinella septempunctata* Linnaeus [(1)] (Coleoptera: Coccinellidae) *Geocoris erythrocephalus* (Lepeletier & Serville) [(3)] (Hemiptera: Geocoridae) *Perillus bioculatus* (Fabricius) [(3)] (Hemiptera: Pentatomidae) *Chrysopa pallens* Rambur [(2)] (Neuroptera: Chrysopidae)
Pyrus communis Linnaeus (pear)	*Exochomus quadripustulatus* Linnaeus [(1)] (Coleoptera: Coccinellidae)
Rubus sanctus Schreber (wild blackberry)	*Coccinella septempunctata* Linnaeus [(1)] (Coleoptera: Coccinellidae) *Perillus bioculatus* (Fabricius) [(3)] (Hemiptera: Pentatomidae) *Crematogaster ionia* Forel [(3), (4)] (Hymenoptera: Formicidae)

Geocoris erythrocephalus (Lepeletier & Serville) (Hem.: Geocoridae) was collected as adults from blackthorn by shaking the plant or observed between the leaves.

Perillus bioculatus (Fabricius) (Hem.: Pentatomidae) were observed gregariously in their first or second nymphal stages on blackthorn and wild blackberry stems.

Crematogaster ionia Forel (Hym.: Formicidae) adults (workers) were observed between wild blackberry bush leaves. 5-6 individual ants were continuously moving in and out of a nest looked like a leafrollers' nest, as if they were feeding and storing; it probably was a Tortricidae pupa.

Discussion

Chrysopa viridana and *C. pallens* (Chrysopidae) are generalist predators but they also feed on pollen rich in proteins, carbohydrates, fats, and vitamins (Bozsik 1992, Lundgren 2009). Chrysophid species are important biological control agents of aphids, mites and coccids. *C. pallens,* one of most well-studied chrysophid, is used in biocontrol of aphids, lepidoptera larvae, mites, and thrips which are major economically depreciating arthropods (Lundgren 2009, Pappas *et al.* 2011). The adult or larval individuals of *C. viridana* and *C. pallens* were documented on rosaceous plants in previous studies. Aldini (2012) recorded adults of these chrysopid species on plum trees and Paulan *et al.* (2001) and Bozsik (2006) documented them on *Crataegus monogyna* and *Prunus spinosa*. Tritrophic view includes that plant volatiles have an impact on herbivores and on predators and parasitoids as their natural enemies. Herbivore-induced plant chemicals affect natural enemies and attract them to the plants to find the herbivores (McEwen *et al.* 2001). For instance, it was reported that the silver vine *Actinidia polygama* Siebold & Zuccarini attracted *Chrysopa pallens* by releasing two dihydronepetalactols (Hyeon *et al.* 1968, van Emden and Harrington 2007). Boo *et al.* (1998) proved that *C. pallens* adults responded to aphid-induced sex pheromones as kairomones. In the present study, *C. pallens* and *C. viridana* were found on blackthorn, hawthorn, and plum in their pupal stages. Therefore, the possible effects of rosaceous plant allelochemicals on these chrysophid species could be considered for a possible bio-control of aphids on the plants.

Coccinella septempunctata and *C. bipunctata* (Coccinellidae) are among the most common aphidophagous species in Turkey (Demirsoy 1990, Iperti 1999, Yurtsever 2001). *Harmonia axyridis* is a polyphagous coccinellid species that feeds mostly on aphids but it also preys on other pests (lepidopter eggs, coccoids, psyllids, tetranychids, and thrips) of agricultural and ornamental plants. From this point of view, the polyphagous habit of *H. axyridis* might contribute to the survival of rosaceous plants like *Crataegus* sp. and *Prunus* sp. in presence of pest insect species (Adriaens *et al.* 2008, Helyer *et al.* 2014). However, there are reported cases that *H. axyridis* might sometimes attack non-pest insect species (Helyer *et al.* 2014). *C. bipunctata* and *H. axyridis* are used as biological control agents against Aphididae throughout the world. *Exochomus quadripustulatus*, another coccinellid species we observed in the present study, is also an important predator feeding both on aphids and coccoids (Farooq-Ahmad 2012). Rosaceous plants reported to be associated with *C. septempunctata* are *Amygdalus communis*, *Prunus armeniaca* Linnaeus, *P. avium* Linnaeus, *P. cerasifera* Ehrh., *Rubus caesius* Linnaeus; with *C. bipunctata* are *Malus communis* Linnaeus, *Persica vulgaris* Mill., *Prunus armeniaca*, *P. avium*, *Rosa* sp.; and with *E. quadripustulatus* are *Malus communis*, *Prunus amygdalus* Batsch, *P. avium*, *P. domestica*, *P. persica* Linnaeus, and *Pyrus communis* (Soydanbay (Tunçyürek) 1978, Iperti 1999, Erler 2004, Aslan and Uygun 2005, Başar and Yaşar 2011). *C. septempunctata* and *H.*

axyridis are known to feed sometimes with pollen (Lundgren 2009) but this habit of these two species was not observed in the present study. Intraspecies cannibalism was determined to occur among *C. septempunctata* and *H. axyridis* larvae reared in laboratory conditions (Iperti 1999). Cannibalism is common among larvae and adults during laboratory rearing (Iperti 1999) and is biologically advantageous for the cannibal coccinellid (Hawkes 1920). In this study, we observed that the last instars of *C. septempunctata* larvae preyed on their conspecifics despite the presence of aphids. *C. septempunctata* was reported to show cannibalism towards its eggs also in the presence of aphids (Khan *et al.* 2003). According to Toft and Wise (1999) and Khan *et al.* (2003), a mixed diet based on aphids and cannibalism on conspecifics has a positive contribution to their larval survival and their developmental period. On the other hand, when the available food (e.g. aphids) in their environment is limited, the individuals show usually cannibalistic behavior to survive. The food deficiency-caused cannibalism was observed in laboratory conditions among last instars of *H. axyridis* larvae. According to the studies on *H. axyridis* and *C. bipunctata*, cannibalism may have both positive and negative effects on the cannibal individual (Table 2).

Table 2. Positive and negative effects of cannibalism on the cannibal individual (Wagner *et al.* 1999, Dixon 2000, Snyder *et al.* 2000, Koch 2003, Ware *et al.* 2009).

Negative aspects of cannibalism	Positive aspects of cannibalism
If prey-predator sizes are nearly the same, the cannibal can be in a prey position during its predation attempt or it can take damage.	Cannibalism provides the energy requirement of dominant predator immediately and decreases competition for food.
The dominant predator may be negatively affected from any parasite or viruse of its prey.	If cannibals feed on a predator which has resistance to parasites, cannibalism gives an advantage for possible diseases to it.
If the predator feeds on its genetically close relatives its inclusive fitness may be lost.	A mixed diet, composed of aphid and cannibalism, leads a faster growth and development and higher survival of cannibals due to high quality of its food.

Episyrphus balteatus and *Eupeodes corollae* are generalist predators with their larvae feeding mostly on aphids and adults on nectar and pollen (Cowgill *et al.* 1993, Lindsey 2015). Because of the effective predatory feature of their larvae, these species are important in biocontrol of aphids (Zeki and Kılınçer 1990, Cowgill *et al.* 1993, Putra and Yasuda 2006). Rosaceous plants on which *E. balteatus* larvae find their prey are *Malus domestica* and *Prunus domestica* (Pehlivan and Atakan 2014). Bolu and Hayat (2008) quoted Rosaceae plant associates of *E. corollae* as *Amygdalus communis*, *Malus communis*, *M. floribunda* Siebould ex Van Houtte, *Prunus armeniaca*, *P. avium*, *P. domestica*, *P. mahaleb* Linnaeus, *P. persica*, *Pyrus communis*, *Rosa* sp., and *Rubus fruticosus* Linnaeus. Plants have important indirect effects on predators like *E. balteatus* as they can affect the development of larvae and pupae of the predators through their aphid preys (Dyer 1995, Amiri-Jami *et al.* 2015). According to a study carried out by Vanhaelen *et al.* (2002), specialist aphids feed on their preferred plant if it is rich in its specific metabolites. In addition, when syrphids feed on these specialist aphids, their development, survival rate, fecundity, and reproduction may be negatively affected because high content of plant allelochemicals can be toxic and transferred to the predator through the aphid prey.

The geocorid bug, *Geocoris erythrocephalus*, feeds on small insects in several different habitats all with rosaceous plants. The associated plant species belonging to this family are *Crateagus* sp., *Prunus armeniaca*, *Pyrus angustifolia* Aiton, *P. malus*, *Rosa* sp., and *Rubus* sp. (Lodos *et al.* 1999, Torma 2009, Matocq *et al.* 2014). The members of Geocorinae subfamily are mostly predators feeding on soft-bodied insects. They generally prey upon mites and insects which are pests of many ornamental and crop plants (Çakır and Önder 1990, Ulubilir and Yabaş 1995, Öztemiz 2012, Mead 2001). In this study, *G. erythrocephalus* individuals were recorded from *Prunus spinosa* and visited the plant probably in search of prey items.

The two-spotted stink bug *Perillus bioculatus* nymphs show a high gregariousness during their first instars. Other stink bugs change their behavior from gregarious to solitary in late instars but *P. bioculatus* nymphs may still show gregarious behaviors to some extent until their last instars (Schaefer and Panizzi 2000). *P. bioculatus* were observed in their first or second instars and they showed a high gregarious behavior. These instars do not feed during these developmental stages and just provide their humidity needs from the plant sap. They start to feed on insect preys after the second instar. There are many reported cases that predatory insects like *P. bioculatus* can detect the plant originating volatiles as a result of herbivorous feeding (Dickens 1999, Weissbecker *et al.* 1999, Schaefer and Panizzi 2000).

Crematogaster ionia foragers were observed in a lepidopteran nest of rolled leaves. When they were first noticed, foragers had already fed on some part of the lepidopteran pupa. Considering the fact that the lepidopteran pupa remains were already dried up when the ants attacked, it is most likely to conclude that foragers were feeding on an already dead lepidopteran body. Although not certain, the remains of the partly consumed pupa looked like to be a pupa of a tortricid. *Crematogaster* foragers were reported to feed mainly on honeydew during their visits on plants, but eggs and larval and pupal stages of several aphid species are also preyed on. The predatory behavior of the genus has formerly been well documented (Du Merle and Mazet 1983, Richard *et al.* 2001). Radeghieri (2004) recorded *C. scutellaris* preying upon larvae and pupae of a lepidopteran species (Gracillariidae). *C. ionia* feeds on honeydew of members of Coccoidea (Coccidae and Marchalinidae) (Ülgentürk 2001, Ülgentürk *et al.* 2012). *C. ionia* has also a facultative mutualistic association with Lepidoptera (Lycaenidae) larvae in which foragers feed on larval secretions (Fiedler, 2010). However, the ant species for this record of Fiedler (2010)'s study is not precise, stated as "*Crematogaster* cf. *ionia*". Although Karaman (2010) reported that there is not much data about *C. ionia* ecology, workers of this species are generalized omnivores.

In conclusion, predatory insects associated with some Rosaceae species were investigated in this study. A total of 11 predatory insects belonging to 6 families were determined on 5 Rosaceae species. Some relevant information about behavioral patterns of these insects was given under the tritrophic concept. To understand the complete mechanism underneath, it is important to study several topics, i.e. associations, interactions, allelochemicals, and genetic relationships, regarding the predators and the plants on which the predators find their preys.

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