International Journal of Agriculture and Wildlife Science (IJAWS), 2020, 6(3): 486 - 495
doi: 10.24180/ijaws.799991

International Journal of Agriculture and Wildlife Science

http://dergipark.org.tr/ijaws

Research Article

Seasonal Dynamics of Coccinellid Species in Apple, Cherry, and Hazelnut

Gülay Kaçar*, Abdurrahman Sami Koca

Department of Plant Protection, Faculty of Agriculture, Bolu Abant Izzet Baysal University, Bolu, Turkey

Received: 25.09.2020 Accepted: 16.11.2020

Keywords:
Coccinellidae, aphid, mite, fruits, seasonal dynamic

***Corresponding author**
gulaysahan@yahoo.com

Abstract. Coccinellid species (Coccinellidae: Coleoptera) are important components of biological control in programmes of sustainable plant protection practices, and well-known predators in agroecosystems, In this study, the suppression of predatory coccinellid species on seasonal populations dynamics of aphid and mite species in apple, cherry, and hazelnut orchards were determined in two distinguishing agricultural areas. Coccinellid beetle populations of pest species were observed in apple and cherry orchards of Bolu province, and hazelnut orchards of Düzce province of Turkey throughout the growing seasons of 2015 and 2016. The specimens were sampled by Steiner's funnel, mouth aspirator, and hand-picking. A total of twenty-three coccinellid species belonging to 13 genera were determined. The coccinellids consisted of 13 species in apple orchards, 19 species in cherry orchards, and 5 species in hazelnut orchards. *Stethorus gilvifrons* Mulsant (21.1%) was the most abundant coccinellid, followed by *Adalia bipunctata* L. (14%), *Coccinella septempunctata* L. (8.8%), and *Psyllobora vigintiduopunctata* L. (8.8%) in rank order of abundance in apple orchards. *S. gilvifrons* (21.1%), *Scymnus pallipediformis* Gunther (13%), and *S. apetzi* Mulsant (12.2%) in cherry orchards; *Chilocorus renipustulatus* Scriba (59.1%) and *Propylea quatuordecimpunctata* L. (22.7%) were the most common coccinellid species in hazelnut orchards. Aphid populations were higher during May through August of both years. Mite populations were higher between July and September. These results are discussed considering current thinking on the importance of biological control as part of an integrated pest management program.

Elma, Kiraz ve Fındık Bahçelerindeki Coccinellid Türlerinin Sezonsal Dinamikleri

Anahtar kelimeler:
Coccinellidae, yaprakbiti, akar, meyveler, sezonsal değişim

Özet. Coccinellid türleri (Coccinellidae: Coleoptera) sürdürülebilir bitki koruma programlarında biyolojik mücadelenin önemli bileşenleridir ve tarımsal alanlarda iyi bilinen predatör türleri barındırırlar. Bu çalışmada, elma, kiraz ve fındık alanlarındaki predatör coccinellid türlerin yaprakbiti ve akar türleri üzerindeki sezonsal değişimlerinin etkisi belirlenmiştir. Coccinellid popülasyonlarının zararlılar üzerine etkisi Bolu ilide elma ve kiraz bahçelerinde, Düzce ilinde ise fındık bahçelerinde 2015 ve 2016 yıllarının üretim sezonları arasında takip edilmiştir. Örneklemeler Steiner hunisi, ağız aspiratörü ve elle toplama şeklinde yapılmıştır. Çalışma sonucunda toplam 13 cinse ait 23 coccinellid türü tespit edilmiştir. Elma bahçelerinde 13 tür, kiraz bahçelerinde 19 tür ve fındık bahçelerinde ise beş coccinellid türü belirlenmiştir. Elma bahçelerinde en yaygın tür olarak belirlenen *Stethorus gilvifrons* Mulsant (21.1%), *Adalia bipunctata* L. (14%), *Coccinella septempunctata* L. (8.8%) ve *Psyllobora vigintiduopunctata* L. (8.8%) takip etmiştir. Kiraz bahçelerinde *S. gilvifrons* (21.1%), *Scymnus pallipediformis* Gunther (13%) ve *S. apetzi* Mulsant (12.2%), fındık bahçelerinde ise *Chilocorus renipustulatus* Scriba (59.1%) ve *Propylea quatuordecimpunctata* L. (22.7%) sırasıyla en yaygın türler olarak tespit edilmiştir. Yaprakbiti popülasyonları çalışmanın her iki yılında da Mayıs-Ağustos ayları arasında en yüksek seviyelerine ulaşmıştır. Akar popülasyonları ise en yüksek seviyeye Temmuz ve Eylül aylarında ulaşmıştır. Çalışma sonucunda elde edilen bulgular, entegre zararlı yönetiminin bir parçası olarak biyolojik mücadelenin önemi hakkındaki mevcut düşünceler dikkate alınarak tartışılmıştır.

ORCID ID (By author order)
0000-0001-9800-8286 0000-0002-7657-5615

INTRODUCTION

Coccinellids (Coleoptera: Coccinellidae), commonly known as ladybirds, ladybugs, or lady beetles, consisting of more than 6.000 identified species worldwide, consist of 360 different genera and 42 tribes (Nedved and Kovar, 2012; Zazycki *et al*., 2015). In Turkey, the Coccinellidae family is well-known with six subfamilies, 16 tribe, 39 genus, and 105 species (Uygun and Karabüyük, 2013; Oguzoglu *et al*., 2017). Some of them are carnivorous, prey on other insects as predators and some are herbivorous feed on plants. Besides, a very small group of them feed on pollens and fungi (Iperti, 1999; Lundgren, 2009). They are accepted as significant biological control agents in many crops and one of the greatest allies of the farmers (Obrycki and Kring, 1998; Hodek *et al*., 2012; Sarwar, 2016). Entomophagous coccinellids are well-known predators of Sternorrhyncha sub-order (Hemiptera), including aphids, scale insects, mites, psyllids, whiteflies, and allies, which are pests in agricultural fields, orchards, gardens, and similar other places (Hodek, 1973; Gordon, 1985; Hagen, 1987; Majerus, 1994; Kaçar, 2015). They have an important role in biological control-based pest management in agricultural production (Khan *et al*., 2007). In Turkey, there have been many successful classical biological and integrated pest management examples using coccinellids, such as *Cryptolaemus montrouzieri* Mulsant on *Planococcus citri* Risso (Hemiptera: Pseudococcidae), *Rodolia cardinalis* Mulsant on *Icerya purchasi* Maskell (Hemiptera: Margarodidae) which are also effective predators (Ponsonby and Copland, 1997; Erkılıc and Demirbas, 2007). Also, *Exochomus nigromaculatus* Goeze, *Scymnus subvillosus* Goeze, and *S. apetzi* Mulsant have been observed as common coccinellid predators that reduce pest populations in Turkey (Uygun, 1981). Although *E. nigromaculatus, S. subvillosus* and *S.apetzi* feed on aphid and diaspidid species. *E. nigromaculatus* has been reported feeding on spider mites (Düzgüneş *et al*., 1982; Bolu and Uygun, 2003; Aslan and Uygun, 2005; Kaya Başar and Yaşar, 2011).

Aphids (Hemiptera: Aphidoidea) and mites (Acari) are abundant and a remarkable economic group of pests damaging fruit crops in the world. Aphids are a various group of plant-feeding insects belong to Aphididae family of Hemiptera order. These pests predominantly found in temperate climate zones. Approximately 4000 aphid species have been described feeding over 250 agricultural and horticultural crops such as apple, cherry, peach, citrus, and plum. They are found primarily on the fresh parts of the host plants, including tips, flowers, young fruits, developing pods and cover the whole plant at high density (Blackman and Eastop, 2000; Favret, 2014; Blackman and Eastop, 2017). They cause damage directly by sucking cell sap and secreting honeydew resulting in the development of sooty mould on leaves and shoots and indirectly as vectors of certain plant viruses (DiFonzo *et al*., 1997; Raboudi *et al*., 2002; Dedryver *et al*., 2010; Goggin *et al*., 2017). Mites are another serious group of pests that feed on various plants. Mites feeding on plants cause the little yellow specks on leaf surfaces, and when a leaf is turned over, tiny and oval-shaped mites, about pinhead in size, pests are scurrying around. The economic importance of them is mostly based on their destructiveness to agricultural and ornamental plants. They cause direct damage by plant-feeding or by transmitting plant pathogens and viruses (Jeppson *et al*., 1975; Lindquist *et al*., 1996; Van Leeuwen *et al*., 2010; 2015).

Predaceous coccinellids are associated with these arthropod pests as regulating populations naturally. Coccinellids provide good control of these pests by devouring them. Knowledge of the present species, their abundance and seasonal occurrence are considered to understand how to encourage coccinellid activity through conservation and augmentation. Also, knowing the prey/predator relationships is very important for the success of biological control. For this purpose, the current study was conducted to gain insight into the development of population dynamics of coccinellid communities on aphid and mite species in apple, cherry, and hazelnut orchards. This work will support future research on the species characterization and community composition of coccinellids on aphids and mites in fruit orchards.

MATERIAL AND METHOD

Study Sites

The study was carried out in the apple and cherry orchards of the Seben district of Bolu, and hazelnut orchards of Düzce in the Western Black Sea Region of Turkey in 2015-2016 years (Figure 1). Seben district (40° 24′ 40″ N, 31° 34′ 11″ E, 625 m) has a very suitable climate in terms of fruit growing. The climate of the Seben area is the semi-arid Mediterranean climate with cold winters (Aksoy, 2001). The 62% of Bolu fruit production made especially in Seben. Apple is the main crop among Seben fruit production, whereas cherries, peaches, and grapes are also important crops (Zenginbal, 2015; Kacar, 2019). Düzce province (40° 49′ 59″ N, 31° 10′ 0″ E, 150 m) has a moist and non-harsh climate seen in the coastal areas of the Black Sea region. The provincial territory is a pit in the central part, except for the coastal zone, and its environment consists of areas surrounded by

mountains. This area, which is called as Düzce plain, is great importance for agricultural production of this region. Hazelnut is the most cultivated plants in Düzce province (TUIK, 2020). This crop is the main income of many producers. "Tombul", "Çakıldak" and "Foşa" are common hazelnut varieties in this area.

Sampling Method

Each orchard was sampled each forthnight for two growing seasons. Samples were obtained during May and November of two years of this study. Trees were randomly sampled from four cardinal directions. Coccinellid samples were collected from each orchard accordingly different size of the area (Lazarov and Grigov, 1961; Kacar, 2015; Kacar and Koca, 2020) (Table 1).

Table 1. The number of sampled trees according to the number of trees available for sampling area (Lazarov and Grigov, 1961).
Çizelge 1. Örnekleme alanı için mevcut ağaç sayısına göre örneklenen ağaç sayısı.

Number of total trees for each orchard	Number of sampled trees
1-20	All trees
21-70	10-30
71-150	31-40
151-500	41-80
501-100	15% of all trees
More than 1000	5% of all trees

Adult or immature stages of coccinellids were sampled by shaking and knocking on the branch three times, a 1 m^2 section of tree foliage into a Steiner's funnel, mouth aspirator, and hand-picking. Immature stages of coccinellids were fed on their preys until the emergence of the adult stage. The samples were separated, pinned, and labelled in the laboratory for identification.

The presence of aphid and mite colonies was determined by counting on 10 shoots in four directions of the apple, cherry, and hazelnut trees. Samples were taken from winged and wingless forms of aphids during sampling and were placed to Eppendorf tubes containing 70% ethyl alcohol for identification. Also, shoot samples with mite damage were examined under a binocular microscope in the laboratory, and mite samples were taken into vials with 70% alcohol for identification.

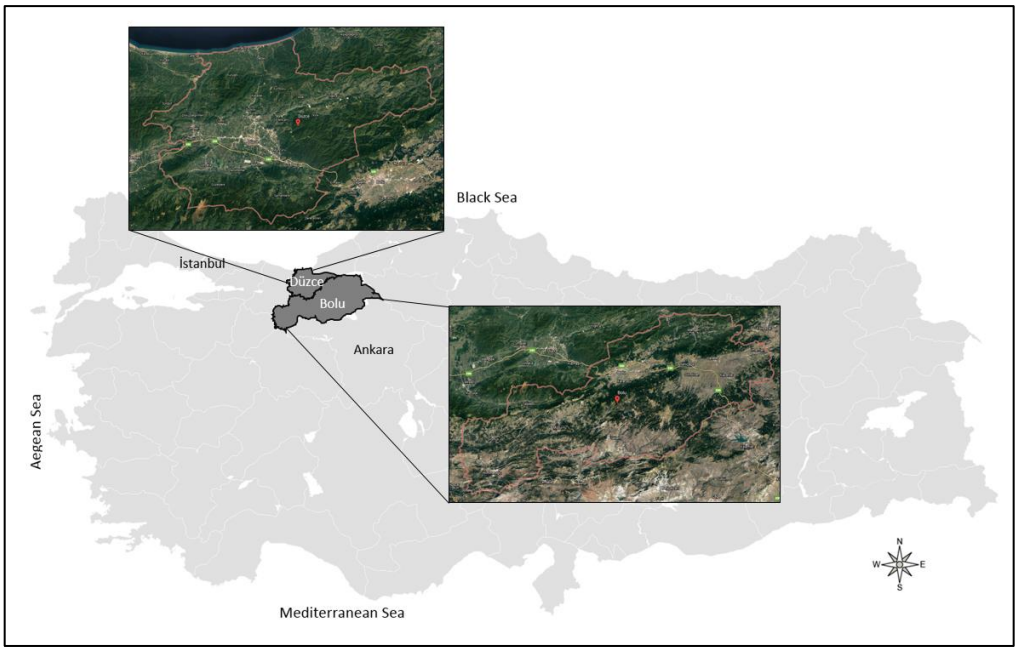

Figure 1. Map of Düzce and Bolu provinces where the study was conducted (Anonymous, 2020).
Şekil 1. Çalışmanın yürütüldüğü Düzce ve Bolu illerinin haritası.

RESULTS

A total of 202 coccinellid specimens were collected from the apple, cherry, and hazelnut orchards. As a result of the study, 23 coccinellid species belonging to 13 genera were determined on the aphid and mite species

given in Table 2. Twenty-one species of coccinellids were predator and two species (*Subcoccinella vigintiquatuorpunctata* L., *P. vigintiduopunctata*) were phytophagous. *Stethorus gilvifrons* Mulsant (18.81%), *Scymnus pallipediformis* Gunther (9.41%), *Scymnus apetzi* Mulsant (8.91%), *Adalia bipunctata* L. (8.42%), and *Coccinella septempunctata* L. (6.94%) were determined as the most abundant species among of coccinellids. The fewest coccinellid species were *Nephus nigricans* Weise (0.50%), *Hippodamia (Semiadalia) undecimnotata* Schnd. (0.50%), and *Stethorus punctillum* Weise (0.99%).

Table 2. Aphid and mite species determined in apple, cherry, and hazelnut orchards in Bolu and Düzce during 2015 and 2016.
Çizelge 2. Bolu ve Düzce illerinde 2015 ve 2016 yıllarında elma, kiraz ve fındık bahçelerinde tespit edilen yaprakbiti ve akar türleri.

Host Plant	Order	Family	Species
Apple	Hemiptera	Aphididae	*Aphis pomi* (Deg.)
			Dysaphis plantaginea (Pass.)
Cherry	Acarina	Tetranychidae	*Tetranychus urticae* (Koch.)
			Panonychus ulmi (Koch.)
		Eriophyidae	*Aculus schlechtendali* (Nal.)
Hazelnut	Acarina	Eriophyidae	*Phytoptus* sp.
			Cecidophyopsis sp.

A total of 57 coccinellid individuals from 13 species were collected in apple orchards of Seben. *S. gilvifrons* (21.1%) was the most abundant coccinellid, followed by *A. bipunctata* (14%), *C. septempunctata* (8.8%), and *P. vigintiduopunctata* (8.8%). The fewest coccinellid species were *Adalia decempunctata* L. and *Coccinula quatuordecimpustulata* L., comprising 3.5% of the collecting species in apple orchards (Table 3).

The aphid population occurred from June to September in 2015, and from May to October in 2016 in apple orchards. The highest population densities of aphids were in May in both years. The mites were only seen in August of the first year, while their population occurred from May to October in the second year. The population of mites peaked in August 2016. The maximum population densities of coccinellids were observed in August 2015, whereas observed in October 2016. While observed that mite and aphid populations decreased, coccinellid populations reached the peak level in both years (Figure 2).

Table 3. Percentage of each species of the total of coccinellids collected (n=57) in apple orchards in Bolu during 2015 and 2016.
Çizelge 3. Bolu ilinde 2015 ve 2016 yıllarında elma bahçelerindeki toplam coccinellid sayısı (n=57) ve her bir türün oranı.

Subfamily/Tribe/ Species	*n*	Frequency (%)
Subfamily Coccinellinae		
Tribe Coccinellini		
Adalia bipunctata (L.)	8	14.0
Adalia decempunctata (L.)	2	3.5
Adalia fasciatopunctata reveliesei (Mulsant)	3	5.3
Coccinella septempunctata (L.)	5	8.8
Coccinula quatuordecimpustulata (L.)	2	3.5
Harmonia axyridis (Pallas)	3	5.3
Oenopia (Synharmonia) lyncea agnata (Rosenhr.)	3	5.3
Tribe Psylloborini		
Psyllobora vigintiduopunctata (L.)	5	8.8
Subfamily Scymninae		
Tribe Scymnini		
Scymnus apetzi (Mulsant)	3	5.3
Scymnus bivulnerus (Capra)	3	5.3
Scymnus pallipediformis (Gunther)	3	5.3
Tribe Stethorini		
Stethorus gilvifrons (Mulsant)	12	21.1
Subfamily Epilachninae		
Tribe Epilachnini		
Subcoccinella vigintiquatuorpunctata (L.)	5	8.8

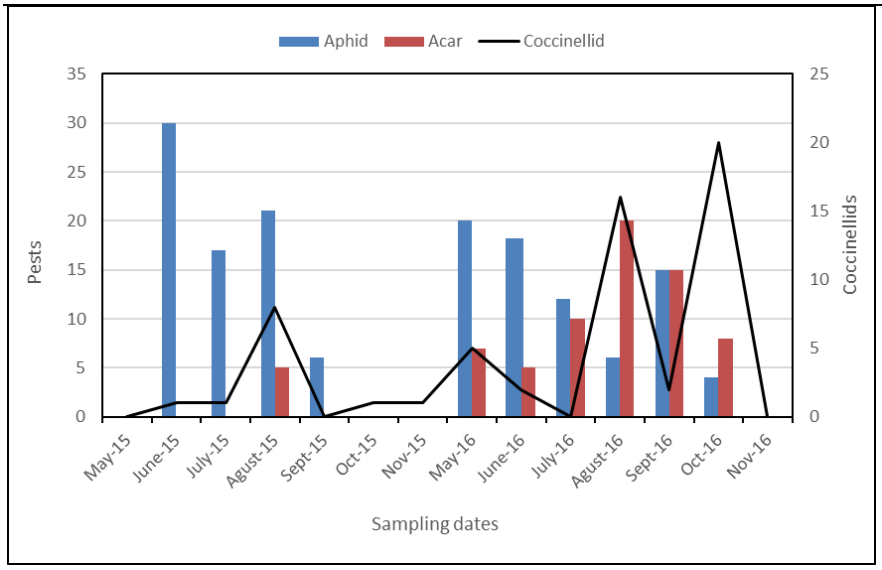

Figure 2. Patterns of population density of aphid, mite and coccinellids in apple orchards for two years.
Şekil 2. Çalışmanın yapıldığı iki yılda elma bahçelerindeki yaprakbiti, akar ve coccinelllidlerin popülasyon yoğunluğu.

Among 19 coccinellid species, *S. gilvifrons* was dominant and accounted of 21.1% of all coccinellids collected in cherry orchards of Seben, and followed by *S. pallipediformis* (13%), and *S. apetzi* (12.2%). The fewest coccinellid species in cherry orchards were found as *Adalia fasciatopunctata revelirei* Mulsant, *Hippodamia* (*Semiadalia*) *undecimnotata* (Schnd.), and *Nephus nigricans* Weise with 0.8% of all species (Table 4).

In cherry orchards, the aphids were observed from June to August 2015, and from June to October in 2016. The maximum population levels of aphids occurred in June 2015 and September 2016. The mites were seen only during June-October 2016, but no mite damage occurred in 2015. The coccinellid population increased from the start of the investigation and peaked in August 2015 and July 2016. The density of aphids and mites declined in the increasing population levels of coccinellids (Figure 3).

Table 4. Percentage of each species of the total of coccinellids collected (n=123) in cherry orchards in Bolu during 2015 and 2016.
Çizelge 4. Bolu ili kiraz bahçelerindeki 2015 ve 2016 yıllarında toplam coccinellid sayısı (n=123) ve her bir türün oranı.

Subfamily/Tribe/ Species	***n***	**Frequency (%)**
Subfamily Coccinellinae		
Tribe Coccinellini		
Adalia bipunctata (L.)	9	7.3
Adalia decempunctata (L.)	2	1.6
Adalia fasciatopunctata revelirei (Mulsant)	1	0.8
Harmonia axyridis (Pallas)	10	8.1
Hippodamia (Semiadalia) undecimnotata (Schnd.)	1	0.8
Coccinella septempunctata (L.)	9	7.3
Coccinula quatuordecimpustulata (L.)	2	1.6
Oenopia (Synharmonia) conglobata (L.)	2	1.6
Tribe Psylloborini		
Psyllobora vigintiduopunctata (L.)	3	2.4
Subfamily Scymninae		
Tribe Scymnini		
Nephus nigricans (Weise)	1	0.8
Scymnus apetzi (Mulsant)	15	12.2
Scymnus bivulnerus (Capra)	4	3.3
Scymnus frontalis (Fabricius)	4	3.3
Scymnus pallipediformis (Gunther)	16	13.0
Scymnus rubromaculatus (Goeze)	5	4.1
Scymnus (Pullus) subvillosus (Goeze)	5	4.1
Scymnus quadriguttatus (Fursch and Kreissi)	6	4.9
Tribe Stethorini		
Stethorus gilvifrons (Mulsant)	26	21.1
Stethorus punctillum (Weise)	2	1.6

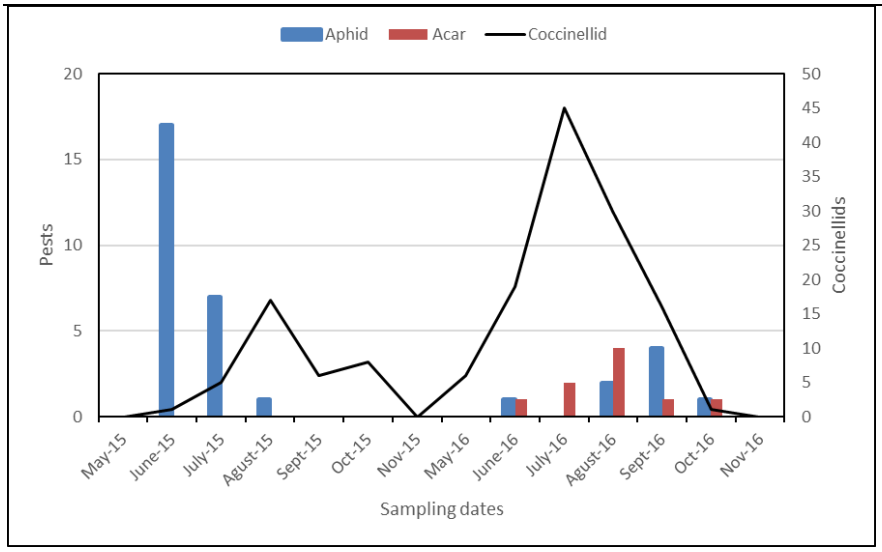

Figure 3. Patterns of population density of aphid, mite and coccinellids in cherry orchards for two years.
Şekil 3. Çalışmanın yapıldığı iki yılda kiraz bahçelerindeki yaprakbiti, akar ve coccinelllidlerin popülasyon yoğunluğu.

A total of 22 coccinellid individuals belonging to five species were collected in hazelnut orchards of Düzce province. *Chilocorus renipustulatus* Scriba (59.1%) and *Propylea quatuordecimpunctata* L. (22.7%) were the most common coccinellids in hazelnut orchards. Among these five species, *Harmonia axyridis* Pallas and *Subcoccinella vigintiquatuorpunctata* L. with 4.5% of density were determined as the least abundant coccinellids (Table 5).

Table 5. Percentage of each species of the total of coccinellids collected (n=22) in hazelnut orchards in Düzce during 2015 and 2016.
Çizelge 5. Düzce ilinde 2015 ve 2016 yıllarında fındık bahçelerindeki toplam coccinellid sayısı (n=22) ve her bir türün oranı.

Subfamily/Tribe/Species	***n***	**Frequency (%)**
Subfamily Chilocorinae		
Tribe Chilocorini		
Chilocorus renipustulatus (Scriba)	13	59.1
Subfamily Coccinellinae		
Tribe Coccinellini		
Harmonia axyridis (Pallas)	1	4.5
Oenopia (Synharmonia) conglabata (L.)	2	9.1
Propylea quatuordecimpunctata (L.)	5	22.7
Subfamily Epilachninae		
Tribe Epilachnini		
Subcoccinella vigintiquatuorpunctata (L.)	1	4.5

DISCUSSION

Our two years study represents the full investigation of the diversity and community composition of coccinellids in Düzce and Bolu provinces of Turkey. The local coccinellid communities was most diverse in cherry, followed by apple and hazelnut orchards. This may reflect the diversity of prey items or abundance. The subfamily Scymninae dominated the community of coccinellids in the apple and cherry orchards, followed by subfamily Coccinellinae. The subfamily Chilocorinae and Coccinellinae dominated In hazelnut orchards. The periods of their activities calculated every month basis for the coccinellid species on cherry and apple are shown in Fig. 2 and Fig. 3. The highest activity was recorded in June, July, August, and September, although more coccinellid species were present throughout the sampling period for each crop.

The coccinellid community in cherry was mainly dominated by the species belonging to the tribes Stethorini and Scymnini such as *S. gilvifrons*, *S. pallipediformis*, and *S. apetzi*. Many studies have been carried out for the survey of coccinellid species in cherry orchards in different provinces of Turkey. Among the coccinellid species *C. septempunctata* and *A. bipunctata* in Nigde and Adana provinces (Ulusoy *et al*., 1999), *C. semptempunctata*, and *S. conglobata* in Elazığ and Mardin provinces (Cınar *et al*., 2004), *S. gilvifrons* in Karaman province (Ozcan, 2007), *C. semptempunctata*, *S. conglobata* and *S. pallipediformis* in Diyarbakir province (Kaplan, 2019), and *S. gilvifrons*, *S. punctillum* and *C. septempunctata* in Bolu province (Kacar ve Koca, 2020) were previously reported.

It seems that the coccinellid species belonging to subfamilies Coccinellinae and Scymninae were the dominant according to these studies.

In apple, the species from the tribes Stethorini and Coccinellini were found the most abundant. *S. gilvifrons, A. bipunctata*, and *C. septempunctata* were dominated species in apple orchards. *S. vigintiquatuorpunctata, Vibidia duodecimguttata* (Poda) in Adana province (Yiğit and Uygun, 1982), *S. gilvifrons* in Antalya province (Ciftci *et al*., 1985), *A. fasciatopunctata revelierei* and *S. conglobate* in Van province (Erol and Yasar, 1996), *C. septempunctata*, Sc*ymnus* sp.*, P. quatuordecimpunctata*, and *S. punctillum* in Elazığ province (Ayaz and Yucel, 2010), and *C. septempunctata* in Bolu province (Kacar, 2019) were determined as common coccinellid species. Studies indicated that coccinellid species belonging to the subfamily Coccinellinae and Scymninae were the most abundant species in apple orchards in Turkey, as in cherry orchards. The tribe Stethorini was reported to the only specialist to mite predators in the Coccinellidae (Biddinger *et al*., 2009). Some attractive characteristics of Stethorini such as prey consumption, longevity, and high reproductive capacity are crucial for biological control of mites.

Each adult of Stethorini may consume 30-60 mites per day (Kundoo and Khan, 2017). The tribe Scymnini contains very small, pubescent coccinellids that are associated with sucking pests such as mealybugs, aphids, diaspidids, and whiteflies (Vidya and Bhaskar, 2017). Members of the Scymnini was reported to feeding on sternorrhynchan Hemiptera; therefore, they are of interest to biological control (Ali *et al*., 2015). Lastly, the tribe Coccinellini has various species in apple and cherry orchards. It has been reported that these species mostly feed on aphid species (Blackman, 1967; Triltsch, 1999; Pervez, 2004; Slipinski, 2007; Farhadi *et al*., 2011; Kundoo and Khan, 2017).

The main pests were determined as big bud mites (*Cecidophyopsis* sp. and *Phytoptus* sp.) in hazelnuts of Düzce. The coccinellid community in hazelnut was mainly dominated by the species belonging to the tribes Chilocorini and Coccinellini such as *C. renipustulatus* and *P. quatuordecimpunctata*. Further, these species were only occurred in hazelnuts. But these are not included among the most favourite prey items for coccinellids. *Chilocorus* contains 79 species distributed all over the world and mainly preying on Coccoidea as the largest genus of the tribe Chilocorini (Giorgi *et al*., 2009; Escalona *et al*., 2017). Aphids also are preferred preying of most Coccinellini (Slipinski, 2007). Other phytophagous species, however, such as diaspidids and psyllids, are usually found in hazelnut orchards (field observation) and potentially attract several coccinellid species.

The population dynamics of coccinellids are usually intimately associated with the density of aphid population (Honek, 1982; Shulka, 1990). The biological control of mites also encompasses two groups of bio-control agents: the predatory mites in the family Phytoseiidae and various species of coccinellids, particularly the tribe Stethorini (McMurtry *et al*., 1970; Helle and Sabelis, 1985; McMurtry and Croft, 1997; Biddinger *et al*., 2009). Studies of the association between prey and natural enemies have shown that predator species of Coccinellidae prominence with two characterises: searching ability and aggregation on host patches (Begon *et al*., 1996). The findings of the current research show the presence of various coccinellid communities on different crops, which may be associated with the kind of prey items existed in the orchards. The information about the population structure of coccinellid community and the relationships between species and the host tree plays a critical role determining which species should be selected when a biological control scheme should be implemented as well as for improving subsequent management of ecosystems and the effectiveness of conservation policies (Santos *et al*., 2012). The enrichment of coccinellids in any crop helps reduce pesticide use and regulates pest levels under more environmentally conscious farming practices. The increasing diversity of coccinellids supports a more complete biological control of pests in both space and time, as different species precede the type and stage of prey.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

DECLARATION OF AUTHOR CONTRIBUTION

G.K. conceived the original idea, and G.K. and A.S.K. performed research, analyzed the data and interpreted the results. All authors wrote, reviewed and approved the manuscript.

ACKNOWLEDGMENT

The authors wish to thank senior Prof. Dr. Nedim UYGUN (Cukurova University, Department of Plant Protection, Adana, Turkey) and Asst. Prof. Derya ŞENAL (Bilecik Şeyh Edebali University, Department of Plant Protection, Bilecik, Turkey) for identification of coccinellid species. This work was funded by Bolu Abant Izzet Baysal University, Scientific Research Projects Coordination (Project No: BAP-2015.10.06.874 and BAP-2015.10.06.889).

REFERENCES

Aksoy, N. (2001). *Karakiriş dağı (Seben-Nallıhan) florasi*. Yüksek Lisans Tezi, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü, Orman Mühendisliği Anabilim Dalı, İstanbul.

Ali, M., Perveen, R., Naqvi, A. U. N., Ahmed, K., Raza, G., & Hussain, I. (2015). The tribe Scymnini (Coccinellidae: Coleoptera) from Sindh province, Pakistan. *Journal of Insect Science*, *15*(1).

Anonymous, 2020. Map of Düzce and Bolu provinces of Turkey. earth.google.com/web/search/turkey/. Access date: July 08, 2020.

Aslan, M. M., & Uygun, N. (2005). The aphidophagus coccinellid (Col.: Coccinellidae) species in Kahramanmaraş, Turkey. *Turkish Journal of Zoology, 29*, 1-8.

Ayaz, T., & Yücel, A. (2010). Elazığ ili elma alanlarında bulunan zararlı ve yararlı Arthropod türlerinin belirlenmesi üzerine araştırmalar. *Harran Üniversitesi Ziraat Fakültesi Dergisi, 14*(1), 9-16.

Begon M., Harper J. L., & Townsend, C. R. (1996). *Ecology: Individuals, Populations and Communities*. 3rd Ed., Blackwells, Oxford.

Biddinger, D. J., Weber, D. C., & Hull, L. A. (2009). Coccinellidae as predators of mites: Stethorini in biological control. *Biological Control*, *51*(2), 268-283.

Blackman, R. L. (1967). The effects of different aphid foods on *Adalia bipunctata* L. and *Coccinella 7-punctata* L. *Annals of Applied Biology*, *59*(2), 207-219.

Blackman, R. L., & Eastop, V. S. (2000). *Aphids on the World's Crops: An Identification and Information Guide*. John Wiley and Sons, 2nd Ed., UK.

Blackman, R. L., & Eastop, V. S. (2017). Taxonomic issues. In H. F. Van Emden, & R. Harrington (Eds.), *Aphids as Crop Pests* (pp. 1-27), Wallingford, UK: CAB International.

Bolu, H. & Uygun, N. (2003). Güneydoğu Anadolu Bölgesi antepfıstıklarında Coccoidea türleri, yayılış alanları, bulaşma oranları ve doğal düşmanlarının belirlenmesi. *Bitki Koruma Bülteni, 43*(1-4), 111-123.

Cınar, M., Cimen, İ., & Bolu, H. (2004). Elazığ ve Mardin illeri kiraz ağaclarında zararlı olan türler, doğal düşmanları ve önemlileri üzerinde gözlemler. *Türkiye Entomoloji Dergisi, 28*(3), 213-220.

Ciftci, K., Türkyılmaz, N., Kumaş, F., & Özkan, A. (1985). Antalya ili elma bahçelerindeki önemli zararlılar ile doğal düşmanlarının tespiti üzerinde ön çalışmalar. *Bitki Koruma Bülteni, 25*(1-2), 49-61.

Dedryver, C. A., Le Ralec, A., & Fabre, F. (2010). The conflicting relationships between aphids and men: a review of aphid damage and control strategies. *Comptes Rendus Biologies*, *333*(6-7), 539-553.

DiFonzo, C. D., Ragsdale, D. W., Radcliffe, E. B., Gudmestad, N. C., & Secor, G. A. (1997). Seasonal abundance of aphid vectors of potato virus Y in the RedRiver Valley of Minnesota and North Dakota. *Journal of Economic Entomolology, 90*: 824-831.

Düzgüneş, Z., Toros, S., Kılınçer, N., & Kovancı, B. (1982). *Ankara İlinde Bulunan Aphidoidea Türlerinin Parazitoit ve Predatürlerinin Tespiti*. Tarım ve Orman Bakanlığı Zirai Mücadele ve Zirai Kararantina Genel Müdürlüğü, Ankara, 251 s.

Erkılıc, L., & Demirbas, H. 2007. *Biological Control of Citrus Insect Pests in Turkey*. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, No. 056, Wallingford, UK.

Erol, T., & Yaşar, B. (1996). Van ili elma bahçelerinde bulunan zararlı türler ile doğal düşmanları. *Türkiye Entomoloji Dergisi, 20*(4), 281-293.

Escalona, H. E., Zwick, A., Li, H. S., Li, J., Wang, X., Pang, H., Hartley, D., Jermiin, L.S., Nedvěd, O., Misof, B., Niehuis, O., Ślipiński, A., & Tomaszewska, W. (2017). Molecular phylogeny reveals food plasticity in the evolution of true ladybird beetles (Coleoptera: Coccinellidae: Coccinellini). *BMC Evolutionary Biology*, *17*(1), 1-11.

Farhadi, R., Allahyari, H., & Chi, H. (2011). Life table and predation capacity of *Hippodamia variegata* (Coleoptera: Coccinellidae) feeding on *Aphis fabae* (Hemiptera: Aphididae). *Biological Control*, *59*(2), 83-89.

Favret, C. (2014). Cybertaxonomy to accomplish big things in aphid systematics. *Insect Science*, *21*(3), 392-399.

Giorgi J. A., Vandenberg N. J., Mchugh J. V., Forrester J. A., Ślipiński S. A., Miller K. B., Shapiro L. R. & Whiting, M. F. (2009). The evolution of food preferences in Coccinellidae. *Biological Control, 51,* 215–231.

Goggin, F. L., Quisenberry, S. S., & Ni, X. (2017). Feeding injury. In H. F. Van Emden, & R. Harrington (Eds.), *Aphids as Crop Pests* (pp. 1-27), Wallingford, UK: CAB International.

Gordon, R. D. 1985. The Coccinellidae (Coleoptera) of America north of Mexico. *Journal of the New York Entomological Society, 93,* 1-912.

Hagen, K. S. (1987). Nutritional ecology of terrestrial insect predators. In: F. Slansky, & J. G. Rodriquez (Eds.), *Nutritional Ecology of Insects, Mites, Spiders and Related Invertebrates* (pp. 533-577), John Wiley & Sons, New York.

Helle, W., & Sabelis, M. W. (1985). Spider Mites; Their Biology, Natural Enemies, and Control, Vols. A and B. Elsevier, Amsterdam.

Hodek, I. (1973). *Biology of Coccinellidae*. Czechoslovak Academy of Science, Prague.

Hodek, I., Van Emden, H. F., Honek, A. (2012). *Ecology and Behaviour of the Ladybird Beetles (Coccinellidae)*. Blackwell Publishing Ltd., UK.

Honék, A. (1982). Factors which determine the composition of field communities of adult aphidophagous Coccinellidae (Coleóptera). *Zeitschrift für Angewandte Entomologie, 94,* 157-168.

Iperti, G. (1999). Biodiversity of predaceous coccinellidae in relation to bioindication and economic importance. *Agriculture, Ecosystems & Environment, 74*(1-3), 323-342.

Jeppson, L. R., Keifer, H. H., & Baker, E. W. (1975). *Mites Injurious to Economic Plants*. University of California Press. London, UK.

Kacar, G. (2015). Survey of coccinellid species and their preys in olive groves in Turkey. *Egyptian Journal of Biological Pest Control*, *25*(1), 157.

Kacar, G. (2019). Seben (Bolu) elma bahçelerinde belirlenen zararli, yararli türler ve biyoekolojileri. *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi, 5*(2), 286-291.

Kacar, G., & Koca, A. S. (2020). Bolu ili kiraz ve vişne bahçelerinde belirlenen zararlı ve faydalı türler**.** *Uluslararası Tarım ve Yaban Hayatı Bilimleri Dergisi*, *6*(3), (in press).

Kaplan, M. (2019). Diyarbakır ili bazı kiraz bahçelerinde bulunan zararlı ve faydalı böcek türleri ile bazı önemli zararlı türlerin doğada görülme zamanı. *Avrupa Bilim ve Teknoloji Dergisi, 17*, 283-289.

Kaya Başar, M., & Yaşar, B. (2011). Isparta ili meyve bahçelerinde saptanan Coccinellidae (Coleoptera) türleri. *Türkiye Entomoloji Dergisi*, *35*(3), 519-534.

Khan, I., Din, S., Khalil, S. K., & Rafi, M. A. (2007). Survey of predatory Coccinellids (Coleoptera: Coccinellidae) in the Chitral district, Pakistan. *Journal of Insect Science, 7*(7), 1-6.

Kundoo, A. A., & Khan, A. A. (2017). Coccinellids as biological control agents of soft bodied insects: a review. *Journal of Entomology and Zoology Studies*, *5*(5), 1362-1373.

Lazarov, A., & Grigorov, P. (1961). *Karantina Na Rastenijata Zemizdat*, Sofia, Bulgaria.

Lindquist, E. E., Bruin, J., & Sabelis, M. W. (1996). *Eriophyoid Mites: Their Biology, Natural Enemies and Control*. Elsevier, Amsterdam.

Lundgren, J. G. (2009). Nutritional aspects of non-prey foods in the life histories of predaceous Coccinellidae. *Biological Control, 51*(2), 294-305.

Majerus, M. E. N. (1994). *Ladybirds.* Harper Collins, London.

McMurtry, J. A., Huffaker, C. B., & Van de Vrie, M. (1970). Ecology of tetranychid mitesand their natural enemies: a review. I. Tetranychid enemies: their biologicalcharacters and the impact of spray practices. *Hilgardia, 40*, 331–390.

McMurtry, J.A., Croft, B. A. (1997). Life-styles of phytoseiid mites and their roles inbiological control. *Annual Review of Entomology, 42,* 291–321.

Nedved, O., & Kovar, I. 2012. Phylogeny and classification. In H. F. Hodek, H. F. Vanemden, & A. Honek (Eds*.), Ecology and Behaviour of the Ladybird Beetles (Coccinellidae)* (pp. 1-12). United Kingdom: Wiley-Blackweel.

Obrycki, J. J., & Kring, T. J. (1998). Predaceous Coccinellidae in biological control. *Annual Review of Entomolology, 43,* 295-322.

Oğuzoğlu, Ş., Avcı, M., Şenal, D., & Karaca, İ. (2017). First record of *Anatis ocellata* (Linnaeus, 1758) (Coleoptera: Coccinellidae) in Turkey. *Türkiye Entomoloji Bülteni*, *7*(2), 197-202.

Ozcan, R. (2007). *Başyayla (Karaman) ilçesinde kiraz ağaçlarında bulunan zararlı böcekler, akarlar ve doğal düşmanlarının tespiti üzerine araştırmalar*. Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, Konya.

Pervez, A. (2004). Predaceous coccinellids in India: predator-prey catalogue (Coleoptera: Coccinellidae). *Oriental Insects*, *38*(1), 27-61.

Ponsonby D. J. & Copland, J. W. (1997). Predators. Coccinellidae and Other Coleoptera. In Y. Ben-Dov, & C. J. Hodgson (Eds). *Soft Scale Insects, their Biology, Natural Enemies and Control* (pp. 29-60). Elsevier, Amsterdam.

Raboudi, F., Ben Moussa, A., Makni, H., Marrakchi, M., & Makni, M. (2002). Serological detection of plant viruses in their aphid vectors and host plants in Tunisia. *EPPO Bulletin, 32,* 495-498.

Santos, S. A., Raimundo, A., Bento, A., & Pereira, J. A. (2012). Species abundance patterns of coccinellid communities associated with olive, chestnut and almond crops in north-eastern Portugal. *Agricultural and Forest Entomology*, *14*(4), 376-382.

Sarwar, M. (2016). Biological control to maintain natural densities of insects and mites by field releases of lady beetles (Coleoptera: Coccinellidae*). International Journal of Entomology and Nematology, 2*(1), 021-026.

Shulka, R. P. (1990). Spatial distribution of key pests of mustard and their natural enemies in India. *Tropical Pest Management, 36,* 85-88.

Slipinski, A. (2007). *Australian Ladybird Beetles (Coleoptera: Coccinellidae): Their Biology and Classification*. Australian Biological Resources Study, Canberra.

Triltsch, H. (1999). Food remains in the guts of *Coccinella septempunctata* (Coleoptera: Coccinellidae) adults and larvae. *European Journal of Entomology*, *96*(4), 355-364.

TUİK. 2020. Crop production statistics. www.tuik.gov.tr/. Access date: July 08, 2020.

Ulusoy, M. R., Vatansever, G., & Uygun, N. (1999). Ulukışla (Niğde) ve Pozantı (Adana) yöresinde kirazlarda zararlı olan türler, doğal düşmanları ve önemlileri üzerindeki gözlemler. *Türkiye Entomoloji Dergisi, 23*(2), 111-120.

Uygun, N. (1981). Türkiye Coccinellidae (Coleoptera) faunası üzerinde taksonomik araştırmalar. *ÇÜ Ziraat Fakültesi Yayınları, 157,* 43-45.

Uygun, N. & Karabüyük, F. (2013). Coccinellidae (Gelin Böcekleri), Türkiye Biyolojik Mücadele Derneği. http://www.biyolojikmucadele.org.tr/uploads/Coccinellidae.pdf. Access date: May 10, 2020.

Van Leeuwen, T., Witters, J., Nauen, R., Duso, C., & Tirry, L. (2010). The control of eriophyoid mites: state of the art and future challenges. *Experimental and Applied Acarology*, *51*(1-3), 205-224.

Van Leeuwen, T., Tirry, L., Yamamoto, A., Nauen, R., & Dermauw, W. (2015). The economic importance of acaricides in the control of phytophagous mites and an update on recent acaricide mode of action research. *Pesticide Biochemistry and Physiology*, *121*, 12-21.

Vidya, C. V., & Bhaskar, H. (2017). Scymnini (Coleoptera: Coccinellidae) associated with major sucking pests of Kerala. *Journal of Biological Control*, *31*(4), 212-216.

Yiğit, A., & Uygun, N. (1982). Adana, İçel ve Kahramanmaraş illeri elma bahçelerinde zararlı ve yararlı faunanın saptanması üzerinde çalışmalar. *Bitki Koruma Bülteni, 22*(4), 163-178.

Zazycki, L. C. F., Semedo, R. E. S., Silva, A., Bisognin, A. Z., Bernardi, O., Garcia, M. S., & Nava, D. E. (2015). Biology and fertility life table of *Eriopis connexa*, *Harmonia axyridis* and *Olla v-nigrum* (Coleoptera: Coccinellidae). *Brazilian Journal of Biology, 75*(4), 969-973.

Zenginbal, H. (2015). Bolu ili meyvecilik potansiyeli ve ceviz yetiştiriciliği. *Ziraat Mühendisliği*, *362*, 10-16.