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# Comparative diversity of Heteroptera (Hemiptera) in fruit orchards

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**Abstract:** Among phytophagous insects, the Heteroptera (Hemiptera), true bugs, are economically important because of damage crops by sucking plant organs and by transmitting plant pathogens. The diversity and distribution of Heteroptera species associated with fruits were investigated in hazelnut, cherry, and apple orchards in the crop season of Bolu and Düzce provinces from May 2015 to October 2016. The species were collected with a Steiner funnel from three fruit varieties from two provinces and for each area at different vegetation in the western Black Sea Region. The highest number of sucking bug species and the greatest diversity occurred on hazelnut. A total of 48 species belong to 12 families. 16 Miridae, 14 Pentatomidae, 5 Lygaeidae, 3 Ropalidae, 2 Coreidae, 2 Pyrrhocoridae, and 1 Anthocoridae, Cydnidae, Nabidae, Rhyparochromidae, Scutelleridae, and Stenocephalidae species were recorded at the two areas from three fruit varieties. Among them, 27 species were recorded from hazelnut, 22 from cherry, and 19 from apple orchards. Pentatomid family was the most dominant (61%) in both studied areas, with a higher abundance of Miridae (21%) in the number of species. The species *Palomena prasina* (Linnaeus, 1761) (17%) and *Nezara viridula* (Linnaeus, 1758) (16%) (Hemiptera: Pentatomidae) stood out for their abundance relevance during both years. The most economically significant pests were *P. prasina*, *N. viridula,* and *A. amygdali* from the Pentatomidae family, which feed on hazelnut, apple, and cherry, respectively. The values of the Margalef diversity index showed minor differences between fruit varieties: it was highest in cheerier than both other fruit varieties. The Shannon-Weaner diversity index varied between 2.58 and 4.85. The maximum species diversity was recorded in hazelnut, whereas the minimum level was observed in apples.

**Key words:** True bugs, communities, species richness, abundance, fruit varieties

## 1. Introduction

Turkey is one of the major fruit producers all around the world and its geographical position has allowed becoming a supplier of fresh fruits during the four seasons. A wide variety of fruits are grown in all parts of the country. Hazelnut is mainly grown in the Black Sea Region where 70% of the hazelnut production is grown while cherry and apple are distributed, especially in a cool climate zone. The cities of Düzce and Sakarya provide 25% of hazelnut production, whereas Bolu supplies apples (TUIK, 2020)[1].

The fruit orchards provide a habitat for many insect species. The fauna of the suborder Heteroptera “true bugs” (Hemiptera) is diverse in the fruit growing areas and mainly remains to be discovered about their biology and relations with other species (Panizzi and Grazia, 2015). The heteropteran species present the largest and most varied group of hemimetabolous bugs, containing about 50,000 species in over 5800 genera worldwide, with over 1500 species belonging to 470 genera in Turkey (Henry, 2009; Önder et al., 2006; Çerçi and Koçak, 2016; Dursun and Fent, 2017; Meyer, 2016[2]; 2020[3]). Species of this suborder have the sucking mouthparts, evolved into a long, thin beak that feeds on liquids from plants and animals (Weber, 1930; Dolling, 1991; Schuh and Slater, 1995). They adapted to different aquatic and terrestrial habitats such as spider webs (as a part of commensal life), epilimnetic and hypolimnion, and intertidal zones (Weber, 1930; Dolling, 1991; Schuh and Slater, 1995; Naranjo et al., 2010; Meyer, 2020). Some of them such as Pentatomidae and Miridae are important pests and may damage their hosts

[1]TUIK (2020). Türkiye Devlet İstatistik Kurumu. Website page https://www.tuik.gov.tr/ [online] [accessed 08 March 2021].

[2]Meyer JR (2016). General Entomology. Lepidoptera. Website https://www.cals.ncsu.edu/course/ ent425/library /compendium [online] [accessed 08 January 2021].

[3]Meyer JR (2020). General Entomology. Heteroptera. Website https://projects.ncsu.edu/cals/course/ent425/ library /compendium/heteroptera [online] [accessed 18 January 2021].

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either directly, by laying eggs and feeding, or indirectly, by the transmission of plant pathogens such as bacteria and viruses, additionally predators are used in biological control (Henry, 2009; Schaefer and Panizzi, 2000). Most species of Miridae, Lygaeidae and Pentatomidae families are fed on plants, but some of them are predaceous (Meyer, 2016; 2020). Except for a few species from Anthocoridae, small privateer insects or flower insects, are predaceous species feeding on a wide range of small arthropods such as insects and their eggs and small-sized life stages (Horton, 2008). The other true bugs, such as predaceous Pentatomidae species, may feed on the last stage larvae or adults. This group is one of the major pests of many crops, since they may transmit plant pathogens or damaged plant tissues, then the plants may weaken by removing sap. Besides, some parasites species from Heteroptera may feed on human blood and transmit some diseases (Meyer, 2016). Many Reduviidae species feed on human blood: A blood-feeding heteropteran, *Triatoma rubida* (Uhler, 1894), feeding on human blood. Kissing bugs (Reduviidae: Triatominae) bite vertebrates (including humans) to feed on their blood; in the process, they spread trypanosomes responsible for Chagas disease—a condition that results in over 7000 deaths per year and substantial diminution in the quality of life for affected individuals (WHO, 2015)[4].

True bugs distributed all around the world, native, introduced, and invasive species of this order occupy both temperate and tropical areas of the world. Distribution and abundance of heteropteran species are affected by climate, topography, elevation, vegetation structure, and other ecological parameters and even by anthropogenic effects (Wallner, 1987; Van Lien and Yuan, 2003; Andrew and Hughes, 2004; Wasowska, 2004; Lassau et al., 2005). Pentatomidae and Reduviidae are the most species rich families of true bugs in Turkey (Önder et al., 2006; Dursun and Fent, 2013; Dursun and Salur, 2013; Yıldırım et al., 2013). Research on the Heteroptera in Turkey found that Rhopalidae family is currently represented by 30 species and 12 genera (Pehlivan, 1981; Dolling, 2006; Önder et al., 2006), Coreidae by 48 species and 20 genera (Dolling, 2006; Dursun and Fent, 2009), Reduviidae by 58 species and 19 genera (Dursun and Salur, 2013; Yıldırım et al., 2013), Nabidae by 24 species and 5 genera (Dursun, 2011), Aradidae by 19 species and 4 genera (Önder et al., 2006) and Pentatomidae by 165 species and 56 genera (Önder et al., 2006; Dursun and Fent, 2013).

The goal of the present work was to investigate the Heteroptera fauna of different fruit orchards of the Bolu and Düzce provinces, in the western Black Sea region of Turkey hoping the result provides information for biodiversity conservation and management of agricultural areas. This contribution hypothesizes that host crops are a great diversity of species of Heteroptera species with phytosanitary importance and that the most abundant species respond to different weather variables and crop habitats. Besides, as a complementary approach, we recorded the geographical distribution, of host plants.

## 2. Materials and methods

### 2.1. Study areas

The present study was carried out in two agroecological zones of the Western Black Sea Region of Turkey where diverse plant structures and grades of altitudes are present. The two zones differ both in topographic and climatic characteristics. The mountainous area of the Bolu region with cold and snowy winters and mild summers is dominated by apple and cherry orchards, while the coastal region of Düzce with warm and humid summers and mild winters is dominated by hazelnut plantations. The work was carried out in two consecutive crop seasons from May 2015 to October 2016. Weather for both years was recorded by a local meteorological station and was characterized by mean temperature and relative humidity (Table 1).

### 2.2. Insect capture and identification

Insects were sampled with a Steiner funnel (measuring 0.50 m × 0.50 cm) by beating plants with a stick (Steiner, 1962). Samples were selected from 25 randomly chosen trees, with 100 branches per orchard. Additionally, aspirator and visual inspection were also used on 30 cm long 100 branches of apple, cherry, and hazelnut trees. A sampling of heteropteran species was made at 15-day intervals during crop seasons in 2015 and 2016. These specimens in killing bottles were dry preserved. The samples were labeled and brought to the lab for identification. Collected materials were kept in 70 V/V% alcohol. These samples were identified at the species level by the second author based on keys of (Tamanini, 1959; Stichel, 1958; 1959; 1960a, b; 1961; Wagner and Weber, 1964; Pehlivan, 1981; Péricart, 1987; Moulet, 1995) using a stereoscope. The samples were placed in the Entomological Collection of Bolu Abant İzzet Baysal University (BAIBU), Plant Protection Department, Turkey.

### 2.3. Data analysis

Species composition, diversity, and similarity of Heteroptera communities of the two study areas (Bolu and Düzce) were analyzed with BioDiversity Pro software (McAleece et al., 1997). To assess variation of the temperature and humidity for both years was calculated by independent t-test using SPSS Statistics.

The Shannon-Wiener (H') (for measuring diversity), Simpson (I), and Berger-Parker *(d)* (considering the dominance), Margalef's richness, and Pielou's evenness index were calculated. The Jaccard and Bray-Curtis *(C*N*)*

[4]WHO (2015). World Health Organization. Investing to Overcome the Global Impact of Neglected Tropical Diseases. World Health Organization; Geneva, Switzerland: 2015. Website page https://apps.who.int/ [online] [accessed 30 December 2021].

indices were used to determine the similarity in species composition between the Heteroptera species for three fruit varieties (Magurran, 2004). Biodiversity indexes were calculated following the standard formulas.

The species diversity (H') for each fruit variety was calculated by using the Wiener–Wiener index (Shannon-Wiener, 1949).

$H' = -\sum pi \, \mathrm{In}(pi)$

where *pi* is the proportion of individuals belonging to the *i*th species.

Simpson's index for dominance was used so that an increase in the value of the index accompanies an increase in diversity and a reduction in dominance.

Simpson's index was defined as (Magurran, 2004):

$I = \sum pi^2$

Species richness (D) was calculated using the formula given by Margalef (1958):

$D = (S-1)/\mathrm{InN}$

where S = total number of species N = total number of individuals in the sample In = natural logarithm

Measurement of evenness (e) or for calculating the evenness of species was used as (Pielou, 1966):

$e = H'/\mathrm{InS}$

The Jaccard *(Cj)* and Bray-Curtis *(C!)* indices were used to determine similarity in species composition between the Heteropteran communities of different sites during the cluster

Jaccard index was defined as:

$Cj = a/a+b+c$

where a is the common species of both areas, b is the number of species in area A, c is the number of species in B area.

Bray-Curtis index was defined as:

CN:2jN/(Na+Nb)

where *N*a is the total number of individuals in area A, Nb is the total number of individuals in area B, and 2*jN* is the sum of the lower of the two abundances for species found in both areas (Bray and Curtis, 1957; Magurran, 2004).

## 3. Results and discussion

This study highlights the diversity, abundance, and richness of heteropteran species in apple, cherry, and hazelnut orchards. The number of collected true bugs showed numerical differences in different varieties. Totally 234 true bugs were caught during the study: 144 individuals from hazelnut, 50 from apple, and 40 from cherry. The relative frequency of families also differed: Pentatomidae (61%), Miridae (21%), Lygaeidae and Nabidae (5%), Coreidae (4%), Anthocoridae and Pyrrhocoridae (2%), Cydnidae Ropalidae, Stenocephalidae, and Scutelleridae (0.4%). A total of 48 species from 12 families were identified from three fruit varieties in two crop seasons in Bolu and Düzce regions. Sixteen of them belonged to Miridae, 14 to Pentatomidae, 5 to Lygaeidae, 3 to Ropalidae, 2 to Coreidae, and Pyrrhocoridae, and 1 Rhyparochromidae, Scutelleridae, Anthocoridae, Cydnidae, Stenocephalidae, and Nabidae (Table 2). Pentatomid family (61%) was the most abundant samples in both studied sites, with higher command of Miridae (21%) in the number of true bugs. The Miridae are seen as an originally phytophagous group and their general name "Plant bugs" also refer to this character (Wheeler, 2001). Although this family is usually phytophagous, some species are predacious or with complex feeding (zoophytophages); most phytophagous species choose reproductive parts of plants (buds, flowers, and fruits), some may feed on ripe seeds (Lehr, 1988; Fauval, 1999). All Deraeocorinae and Pilophorini of the family Miridae, as well as some species in another group, are obligate predators (Kerzhner and Josifov, 1999). Reduviidae, Nabidae, and Anthocoridae are zoophagous, while the species of Cydnidae and Scutelleridae are reported as plant feeders. Rhyparochomidae is essentially a polyphagous, and seed feeder. Lygaeidae except

**Table 1.** Climatic and agroecological characteristics of the studied areas in the western part of the Black Sea region in Turkey. Climatic data for both years were measured by the Düzce and Seben (Bolu) meteorological service of Turkey.

| Survey localities | Bolu | Düzce |
|---|---|---|
| Latitude | 40.411156 | 40.8333 |
| Longitude | 31.569862 | 31.1667 |
| Mean altitude (m a. s. l.) | 50 | 160 |
| Mean temperature (°C) | 10.73[a]–10.95[b] | 14.67[a]–14.72[b] (P > 0.05)* |
| Mean relative humidity (%) | 72.47 [a]–68.77[b] | 76.91[a]–76.79[b] (P > 0.05)* |
| Sites of samples | 30 apples and 22 cherries | 81 hazelnuts |

[a]data from 2015; [b]data from 2016, *mean temperature and humidity were not significantly different between for both years.

**Table 2**. Abundance of the Heteroptera species sampled from apple, cherry, and hazelnut orchards for two years in Bolu and Düzce.

| **Family** | **Species** | **A*** | **C*** | **H*** | **Total** | **RH**(%)** |
|---|---|---|---|---|---|---|
| Anthocoridae | *Orius laticollis* (Reuter, 1884) | 0 | 0 | 4 | 4 | 1.7 |
| Coreidae | *Coreus marginatus* (Linnaeus, 1758) | 2 | 0 | 2 | 4 | 1.7 |
| | *Gonocerus acuteangulatus (*Goeze, 1778) | 0 | 2 | 3 | 5 | 2.1 |
| Cydnidae | *Tritomegas bicolor* (Linnaeus, 1758) | 0 | 0 | 1 | 1 | 0.4 |
| Lygaeidae | *Beosus maritimus* (Scopoli, 1763) | 2 | 0 | 0 | 2 | 0,9 |
| | *Lygaeus simulans* (Deckert, 1985) | 0 | 1 | 0 | 1 | 0.4 |
| | *Lygaeus equestris* (Linnaeus, 1758) | 2 | 1 | 0 | 3 | 1.3 |
| | *Geocoris erytrocephalus* (Lepelitier & Serville, 1825) | 0 | 0 | 4 | 4 | 1.7 |
| | *Peritrechus gracilicornis* Puton, 1877 | 2 | 0 | 0 | 2 | 0.9 |
| Miridae | *Campylomma verbasci* (Meyer-Dur, 1843) | 1 | 2 | 0 | 3 | 1.3 |
| | *Charagoehilus gyllenhalii* (Fallen, 1807) | 0 | 1 | 0 | 1 | 0.4 |
| | *Compsidolon* sp. | 0 | 0 | 3 | 3 | 1.3 |
| | *Deraeocoris lutescens* (Schilling, 1837) | 1 | 0 | 5 | 6 | 2.6 |
| | *Deraeocoris putoni* (Montandon, 1885) | 3 | 2 | 1 | 6 | 2.6 |
| | *Deraeocoris ruber* (Linnaeus, 1758) | 0 | 0 | 10 | 10 | 4.3 |
| | *Deraeocoris rutilus* (Herrich-Schaeffer, 1838) | 2 | 0 | 0 | 2 | 0.9 |
| | *Deraeocoris* sp. | 0 | 0 | 1 | 1 | 0.4 |
| | *Lepidargyrus pollinosus* (Horváth, 1906) | 1 | 0 | 0 | 1 | 0,4 |
| | *Lygus gemellatus* (Herrich-Schaeffer, 1835) | 0 | 1 | 0 | 1 | 0.4 |
| | *Lygus pratensis* (Linnaeus, 1758) | 1 | 0 | 2 | 3 | 1.3 |
| | *Lygus rugulipennis* Poppius, 1911 | 5 | 0 | 0 | 5 | 2.1 |
| | *Orthonotus rufifrons* (Fallen, 1807) | 0 | 0 | 1 | 1 | 0.4 |
| | *Pilophorus clavatus* (Linnaeus, 1767) | 0 | 1 | 1 | 2 | 0.9 |
| | *Pytocoris* sp. | 1 | 0 | 1 | 2 | 0.9 |
| | *Phylus coryli* (Linnaeus, 1758) | 0 | 0 | 2 | 2 | 0.9 |
| Nabidae | *Himacerus mirmicoides* (O. Costa, 1834) | 0 | 1 | 4 | 5 | 2.1 |
| Pentatomidae | *Apodiphus amygdali* (Germar, 1817) | 14 | 6 | 0 | 20 | 8.5 |
| | *Arma custos* (Fabricius, 1794) | 0 | 0 | 9 | 9 | 3.8 |
| | *Carpocoris purpureipennis* (DeGeer, 1773) | 0 | 0 | 2 | 2 | 0.9 |
| | *Codophila varia* (Fabricius, 1787) | 0 | 1 | 0 | 1 | 0.4 |
| | *Dolycoris baccarum* (Linnaeus, 1758) | 4 | 2 | 3 | 9 | 3,8 |
| | *Eurydema oleracea* (Linnaeus, 1758) | 1 | 1 | 1 | 3 | 1.3 |
| | *Eurydema ornata* (Linnaeus, 1758) | 2 | 2 | 0 | 4 | 1.7 |
| | *Graphosoma lineatum* (Linnaeus, 1758) | 0 | 3 | 0 | 3 | 1.3 |
| | *Peribalus strictus vernalis* (Wolff, 1804) | 3 | 0 | 2 | 5 | 2.1 |
| | *Mustha spinosula* (Lefebvre, 1831) | 1 | 0 | 0 | 1 | 0.4 |
| | *Nezara viridula* (Linnaeus, 1758) | 0 | 0 | 38 | 38 | 16.2 |
| | *Palomena prasina* (Linnaeus, 1761) | 0 | 1 | 39 | 40 | 17.1 |
| | *Piezodorus lituratus* (Fabricius, 1794) | 0 | 6 | 1 | 7 | 3.0 |
| | *Rhaphigaster nebulosa* (Poda, 1761) | 0 | 1 | 0 | 1 | 0.4 |

**Table 2. (Continued.)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Pyrrhocoridae | *Scantius aegyptius* (Linnaeus, 1758) | 0 | 2 | 0 | 2 | 0.9 |
| | *Pyrrhocoris apterus* (Linnaeus, 1758) | 2 | 0 | 0 | 2 | 0.9 |
| Rhyparochromidae | *Megalonotus praetextatus* (Herrich-Schaeffer & G.H.W., 1850) | 0 | 0 | 1 | 1 | 0.4 |
| Ropalidae | *Brachycarenus tigrinus* (Schilling, 1829) | 0 | 1 | 0 | 1 | 0.4 |
| | *Liorhyssus hyalinus* (Fabricius, 1794) | 0 | 1 | 0 | 1 | 0.4 |
| | *Stictopleurus subtomentosus* (Rey, 1888) | 0 | 1 | 0 | 1 | 0.4 |
| Stenocephalidae | *Dicranocephalus albipes* (Fabricius, 1781) | 0 | 0 | 1 | 1 | 0.4 |
| Scutelleridae | *Eurygaster testudinaria* (Geoffroy, 1785) | 0 | 0 | 2 | 2 | 0.9 |
| Total | | 50 | 40 | 144 | 234 | |

*A: Apple, *C: Cherry, *H: Hazelnut, **RA: Relative abundance

for Geocorinae, Pentatomidae except for Asopinae, Coreidae, Stenocephalidae, Rhopalidae, and Tingidae are phytophagous (Strawinsky, 1964; Dolling, 1991; Tezcan and Önder, 2003).

We collected 27 true bug species from hazelnut, 22 from cherry, and 19 species from apple orchards. During the study *Palomena prasina* (17%), *Nezara viridula* (16%), and *Apodiphus amygdali* (Germar, 1817) (9%) (Pentatomidae) stood out considering their dominance and phytosanitary significance (Table 1). Tezcan and Önder (2003) determined 31 true bug species from nine families of Heteroptera in organic cherry orchards in Manisa, İzmir of western Turkey. *Stephanitis pyri* (Fabricius, 1775) (Tingidae), *A. amygdali, N. viridula*, and *Dolycoris baccarum* (Linnaeus, 1758) (Pentatomidae) were more abundant than others. Damage of *Acrosternum heegeri* Fieber, 1861 (Pentatomidae), *A. amygdali* and *P. prasina* was formerly recorded on pome and stone fruits (Rings, 1957; Lodos, 1986; McPhersonand and McPherson, 2000; Mehrnejad, 2001; Saruhan and Tuncer, 2010; Kacar and Dursun, 2015). *D. baccarum, Mustha* spinosula (Lefebvre, 1831), *N. virudula, P. prasina* and *Rhaphigaster nebulosa* (Poda, 1761) (Pentatomidae) generally feed on perennial and fruit trees, such as cherry, mulberry, pistachio, and hazelnut (Lodos, 1986; Özgen et al., 2005).

In this study, *Piezodorus lituratus* (Fabricius, 1794) (Pentatomidae) and *A. amygdali* were found as a common species in cherry in Bolu. Heteroptera species from cherry orchards were studied in Turkey by Lodos et al., 1978; Lodos, 1986; Çam, 1993; Ulu et al., 1995; Özbek et al., 1996; Tezcan and Önder, 1999; Ulusoy et al., 1999; Özder, 1999; Özgen et al., 2005; Kaplan, 2019; 2020. In total, 22 species belonging to 7 families of Heteroptera were reported from cherry orchards. Among these species, *Orius laticollis* (Reuter, 1884) (Anthacoridae), *Geocoris erythrocephalus* (Lepelitier & Serville, 1825) (Lygaeidae), *Compsidolon* sp., *Deraeocoris lutescens* (Schilling, 1837), *D. putoni* (Montandon, 1885), *D. ruber (*Linnaeus, 1758), and other *Deraeocoris* species (Miridae), *Himacerus mirmicoides* (O. Costa, 1834) (Nabidae), and *Arma custos* (Fabricius, 1794) (Pentotomidae) are zoophagous, while *Lygus pratensis* (Linnaeus, 1758), and *L. rugulipennis* Poppius, 1911 (Miridae) are polyphagous species. *Atractotomus mali* (Meyer-Dur, 1843), *D. lutescens, D. serenus* (Douglas & Scott, 1868), *Isometopus mirificus* Mulsant & Rey, 1879 (Miridae), *A. nemoralis* (Fabricius, 1794) (Anthocoridae), *D. ater* (Jakovlev, 1889), *O. minutus* (Linnaeus, 1758), *Nabis goedeli* (Klt., 1856) (Nabidae) were reported as predatory species of cherry orchards in İzmir (Tezcan and Önder, 1999). On cherry Lodos et al. (1978) found *Eurydema ornatum* (Linnaeus, 1758) (Pentotomidae) in Burdur and Tekirdağ, *P. viridissima* Mulsant & Rey, 1866 (Pentatomidae) in Manisa, *P. lituratus* in Manisa, and *R. nebulosa* in Aydın and Burdur. Cam (1993) determined 17 Heteroptera species, belong to the families of Anthocoridae, Coreidae, Miridae, Pentatomidae, Reduviidae, and Tingidae (Heteroptera) on mahaleb (*Prunus mahaleb*), sweet- and sour cherries in Tokat. *P. prasina* was less common than *R. nebulosa* (Pentotomidae). Tezcan and Önder (1999; 2003) reported *A. amygdali, Mustha spinosula*, *N. viridula, R. nebulosa, D. baccarum, P. prasina*, and *P. viridissima* in cherry orchards of İzmir. Özgen et al. (2005) collected 12 pentatomid species, six from cherries, five from olives, three from pistachios and apricots in Elazığ, Gaziantep, Malatya, Mardin, and Şanlıurfa. *A. amygdali* and *R. nebulosa* were found in cherry, *P. lituratus* appeared in apricot, while *Acrosternum heegeri* Fieber, 1861 (Pentotomidae) were recorded in pistachio, and olive orchards. Kaplan (2020) determined *A. amygdali*, *N. viridula*, *D. baccarum*, *Eurydema ornata* (L.), and *Mustha spinosula* Lef. in apple trees of Malatya.

In the present study, *A. amygdali, D. baccarum*, and *L. rugulipennis* were common in apple orchards. Formerly *D. baccarum* (in Tekirdağ and Çanakkale), *Eurydema ornata* (Linnaeus, 1758) (in Tekirdağ), *Holcostethus strictus* (Fabricius, 1803), and *M. spinosula* (Pentotomidae) (in

Tekirdağ) were reported in apple orchards in Turkey (Orçan and Kivan, 2017). *A. amygdali* was also found in Kahramanmaraş and *E. ornatum* in Adana in apple orchards (Yiğit and Uygun, 1982).

In this study, *P. prasina, N. viridula, D. ruber*, and *A. custos* were characteristic in hazelnut, where seventeen species (Pentatomidae, Coreidae, and Acanthosomatidae) were found. *P. prasina* causes over 85% damage on fruits (Saruhan, 2004; Tuncer et al., 2005). Tuncer et al. (2005) was determined *Carpocoris purpureipennis, C. pudicus, D. baccarum, Eurydema oleraceum, Eysarcoris inconspicuus, Graphosoma lineatum, Peribalus strictus vernalis, N. viridula, P. prasina, P. viridissima, P. rufipes, Piezodorus lituratus, Rhaphigaster nebulosa* (Pentotomidae), *Gonocerus acuteangulatus, Coreus marginatus* (Coreidae), *Acanthosoma haemorrhoidale,* and *Elasmucha grisea* (Acanthosomatidae) in hazelnut. In another study, some species of Pentatomidae, Coreidae, and Acanthosomatidae families caused over 10% damage "spotted hazelnut kernels". *Campylomma verbasci* (Meyer-Dur, 1843) (Miridae), *D. putoni, D. baccarum* were found hazelnut cultivars in Samsun. The most significant pest causing spotted kernel damage in hazelnut is *P. prasina* (Şen and Saruhan, 2016). In Italy, seven bug species were found, of which *G. acuteangulatus* and *P. prasina* were the most abundant in hazelnut (Tavella et al., 1996). In the present study, *P. prasina*, *N. viridula*, and *A. amygdali* belonging to the family Pentatomidae were common in orchards. They especially feed on vegetative and reproductive tissues, from buds to seeds and stems to shoots, priorly prefer the vascular structure of plants (Panizzi et al., 2021). In the study, it was determined that *P. prasina* in hazelnuts, *N. viridula* in apples, and *A. amygdali* in cherry trees were intensely present and caused damage. These species lead to economical crop loss in hazelnut, apple, and cherry orchards and the spread of pathogens. Therefore, these species are economically and biologically important in the agricultural area.

In the present study, the Shannon-Wiener diversity and Simpson's dominant index were higher in hazelnut than in apple and cherry. The values of the Shannon-Wiener index of diversity range from 2.58 to 4.85 in two areas. The maximum species diversity was recorded in hazelnut, and the minimum level was observed in apples. Simpson's dominant index was changed from 0.05 (cherry) to 0.15 (hazelnut). The diversity index values of Margalef's richness index presented a slight difference; it was highest in cherry than both fruits. The Margalef's richness index varied between 4.60 and 5.69. The lover species richness (4.61) was detected in apple orchards, and the maximum (5.69) was noted in the cherry. The species' evenness index varied from 0.86 to 1.47. The lower species evenness was detected in apple orchards, and the maximum index was recorded in hazelnut orchards. *C. verbasci*, *D. putoni*, and *D. baccarum* were found as common species of these fruit (Figure). All the meteorological factors, ambient temperature, and humidity were identified as not being the strongest factors affecting species diversity for both years. Mean temperature and humidity were not significantly different between both areas ($P > 0.05$) (Table 1).

Patterns of species diversity and structure of the heteropteran assemblages of fruit cultivars were investigated in both agroecological zones in the western part of the Black Sea Region of Turkey in a two-year study. Our results pointed out the diversity, abundance, and richness, of the heteropteran fauna in apple, cherry, and hazelnut orchards. The number of sampled true bug species showed numerical differences among different

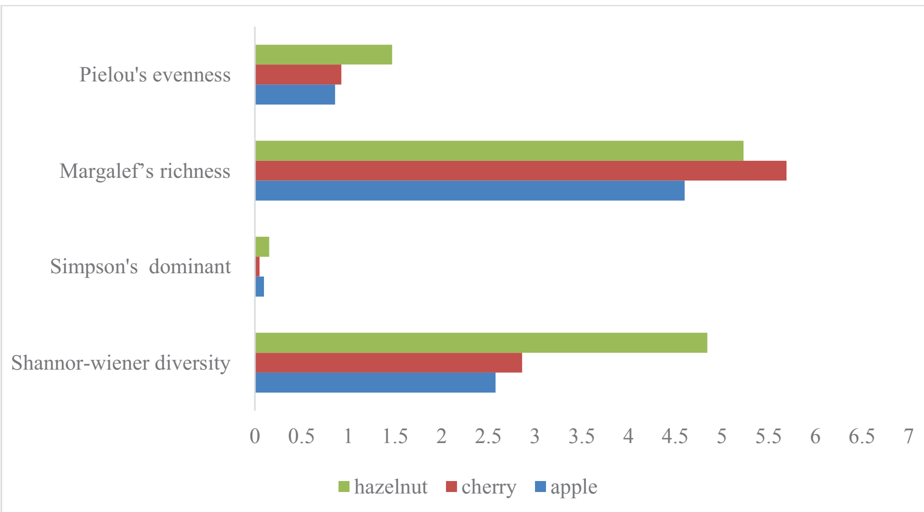


**Figure.** The diversity index of Heteroptera sampled from apple, cherry, and hazelnut orchards in Bolu and Düzce.

fruit varieties. There are fewer studies on the diversity of true bugs that live in hazelnut orchards, than in those that live in other fruits. Host plant preference, the geographical range of these insects are frequently defined by the dispersion of their host plants. Host-specific bug species can occur only in that habitat where their hosts are also can be found unless other factors prevent their existence. The knowledge of host plant preference is necessary, and it can be used in the forecast, and prediction based on the knowledge of host plant distribution. Insects with a wide host range may feed on different hosts in each site or alter hosts in varied parts of their area. Now we do not have enough data on species distribution and host plant preference, thus we must rely rather on extrapolation than existing data. The easiest way to increase our knowledge is by choosing key species for further investigation.

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