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Research Article

Determination of Aquatic/Semi-aquatic Heteropteran (Nepomorpha and Gerromorpha) Fauna of Çubuk Stream (Ankara) with Some Physicochemical Variables

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ABSTRACT: Water sources not only provide habitat for aquatic insects but also indirectly provide them with prey and other nutrients. Aquatic heteroptera, a significant group of aquatic insects, not only live in water but also play a significant role in the food chain. Also, considering the current state of water, it is known that water resources are quite limited and are dwindling daily. Therefore, it is necessary to determine and protect the quality of existing water resources. In this study, five localities in Çubuk Stream (Ankara) where under pressure of industrial and anthropogenic pollutants were identified and examined for aquatic/semi-aquatic heteroptera fauna and some environmental variables which effective on their distirbution. Samplings was made between April and September (monthly periods) at year 2025, when the seasons have aquatic heteroptera abundance is high. Some physicochemical features (pH, temperature, dissolved oxygen, salinity, and electrical conductivity) were measured at the same time the insect sampling. A total of ten aquatic/semi-aquatic heteropteran species were determined in the sampling locations. Also, it was determined that the dissolved oxygen level in Çubuk Stream was found at a critical level for aquatic organisms. But, it was thought the all observed heteroptera species have higher ecological tolerances.

KEYWORDS: Heteroptera, environmental features, relationship, fauna, Çubuk stream

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J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

INTRODUCTION

Water is one of the most important resources for the sustainability of our planet and requires careful attention in terms of quantity and quality (Abbasi & Abbasi, 2012). Water quality plays a vital role in sustaining ecosystems and human life, and the chemical, physical, and biological properties of water must be known and evaluated in assessing water quality (Walker et al., 2015; Mahapatra et al., 2011).

Many physical and biological factors can alter the abundance and distribution of macroinvertebrates (Sharma et al., 2013). Aquatic macroinvertebrate communities reflect the quality of aquatic ecosystems (Gutiérrez & Ramírez, 2016).

Aquatic invertebrates can be found in almost every imaginable freshwater habitat. Invertebrates living in diverse aquatic habitats account for a large proportion of species diversity and much of the secondary productivity, while also fulfilling numerous ecological roles (Richardson & Jackson, 2002).

Many aquatic insects, combined with their high distribution compared to other macroinvertebrates and their ability to reflect changes in their environment, have contributed to their functional role as tools for monitoring the impact of human activities on water quality (Adu & Oyeniyi, 2019).

Aquatic Hemiptera and Coleoptera species are reported to be sensitive to pollution in water, and their use as water biological indicators can increase the accuracy of water quality assessments (Tchakonté et al., 2015).

Hemiptera is the fifth largest order of the insecta class, and Heteroptera includes more than 45,000 described species, 7 infraorders, and 75-89 families (Rabitsch, 2010; Forero et al., 2024).

About 4450 species of these belong to the infraorder Nepomorpha and Gerromorpha (Henry, 2017). Heteroptera includes 1668 species and subspecies belonging to 51 families in Türkiye and 30 of which belong to Gerromorpha and 55 to Nepomorpha infraorder (Çerçi et al., 2024).

Although there is no specific study on aquatic/semi-aquatic heteroptera in Çubuk Stream, there are some faunistic, ecological and water quality studies in the stream (Yıldız, 2001; Atıcı & Ahıska, 2005).

In this study, the aquatic/semi-aquatic heteroptera fauna and their distribution in Çubuk Stream, an important river in Ankara province, was determined. Also, some physicochemical variables of a section of the stream under intense industrial and human pressure was investigated.

At the end of this sudy, the relationships among the parameters were also evaluated, and the observed heteropteran species living in the area were discussed for their ecological tolerances.

MATERIALS AND METHODS

1. Research Area

The Çubuk Stream, a 70 kilometer stream running north to south across the Çubuk Plain, originates in the Aydos Mountains in two branches (Figure 1). After forming the Çubuk I Dam with the Sünlü, Azman, Karapınar, Kızılhisar, and Bellihisar streams, it then joins the Keçiören Stream and the İncesu Stream and Hatip Stream near Akköprü. After these three streams converge at Akköprü, they become the Ankara Stream (Çinkaya & Yüksel, 1996).

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Figure 1. Research Area and the sampling locations (View of localities on Google Maps)

This study was carried out at monthly intervals between April and September 2025 in 5 different locations on Çubuk Stream, Çubuk District, Ankara Province, with a total distance of approximately 15 kilometers. Station 1 is under intense industrial pressure and station 4 is intertwined with agricultural production, while stations 2, 3 and 5 are under general anthropogenic (road, bridge and general human activities) influence (Table 1; Figure 2).

Table 1. Some informations of the sampling localities in the research area (Loc.: Locality)

Loc. No	**Locality**	**Coordinates**	**Elevation**
1	Ülümbüş district	40° 5'16.65"N 32°57'57.44"E	923 m.
2	Yenice district	40° 7'1.21"N 32°58'29.18"E	931 m.
3	Esenboğa district	40° 8'29.26"N 32°59'4.27"E	944 m.
4	Güldarbı district	40° 9'54.49"N 33° 0'25.61"E	955 m.
5	Yazır district	40°10'35.30"N 33° 0'40.25"E	962 m.

2. Sampling for Physicochemical Parameters

In the study area, water samples were taken throughout the study period at monthly intervals.

Water samples were taken under the surface of water and some environmental features (pH, temperature, dissolved oxygen, salinity, and electrical conductivity) were measured in the field with a portable device.

The water quality levels of the measured parameters of each sampling locality was evaluated according to the Quality Criteria (pH, dissolved oxygen, electrical conductivity) for Turkiye 's Intra-Continental Surface Water Resources According to Classes published in the Official Gazette (SWQR, 2021).

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Figure 2. Views of the sampling localities (Photos by A. Özdamar)

3. Obtaining Aquatic Insects

The TS EN ISO 10870 standard, published by the General Directorate of Water Management of the Ministry of Forestry and Water Affairs, was used to collect adult insect samples of aquatic heteroptera. Metal scoops were used in deep, vegetated areas, while collection was carried out by stirring the bottom in muddy, shallower locations. All aquatic heteroptera samples collected from these locations were preserved and labeled according to Kıyak (2000). It was used Poisson (1957), Heiss & Jansson (1985), Jansson (1986), Andersen (1990), (1993), Rabitsch (2005), Soos et. al. (2009), and Fent et. al. (2011)_ literatures to identification of the species.

4. Statistical Analysis Methods

Statistical analyses were performed using SPSS 16.0 using the ANOVA test. The mean values of the physicochemical parameters obtained throughout the study were determined to be significant at $p < 0.05$ and $p < 0.01$ levels (Fisher, 1970). To determine the correlations between the parameters, the Pearson correlation coefficient which is the most widely used measure for determining the degree and

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

direction of linear relationships between continuous variables was used (Keskin & Özsoy 2004).

RESULTS

1. Physicochemical Variables Results

A general look at changes in physicochemical parameter values reveals that, as temperatures increase towards summer, salinity and electrical conductivity follow this parallel pattern.

This inverse relationship, in which dissolved oxygen follows the temperature increase in the opposite direction, is also accompanied by electrical conductivity and salinity.

The physicochemical parameter values (pH, temperature, dissolved oxygen, salinity and electrical conductivity) determined monthly in the localities in the research area were presented in Figure 3.

When the results of the analysis of some physicochemical parameters of water samples taken from the localities in the research area were evaluated according to the Surface Water Pollution Regulation, it was determined that all localities had class I quality level (very good) in terms of average pH while all localities were found at class III quality level (moderate water) for dissolved oxygen.

However, it was determined that all sampling localities except Loc.1 had class II (good) water quality level for conductivity (Table 2).

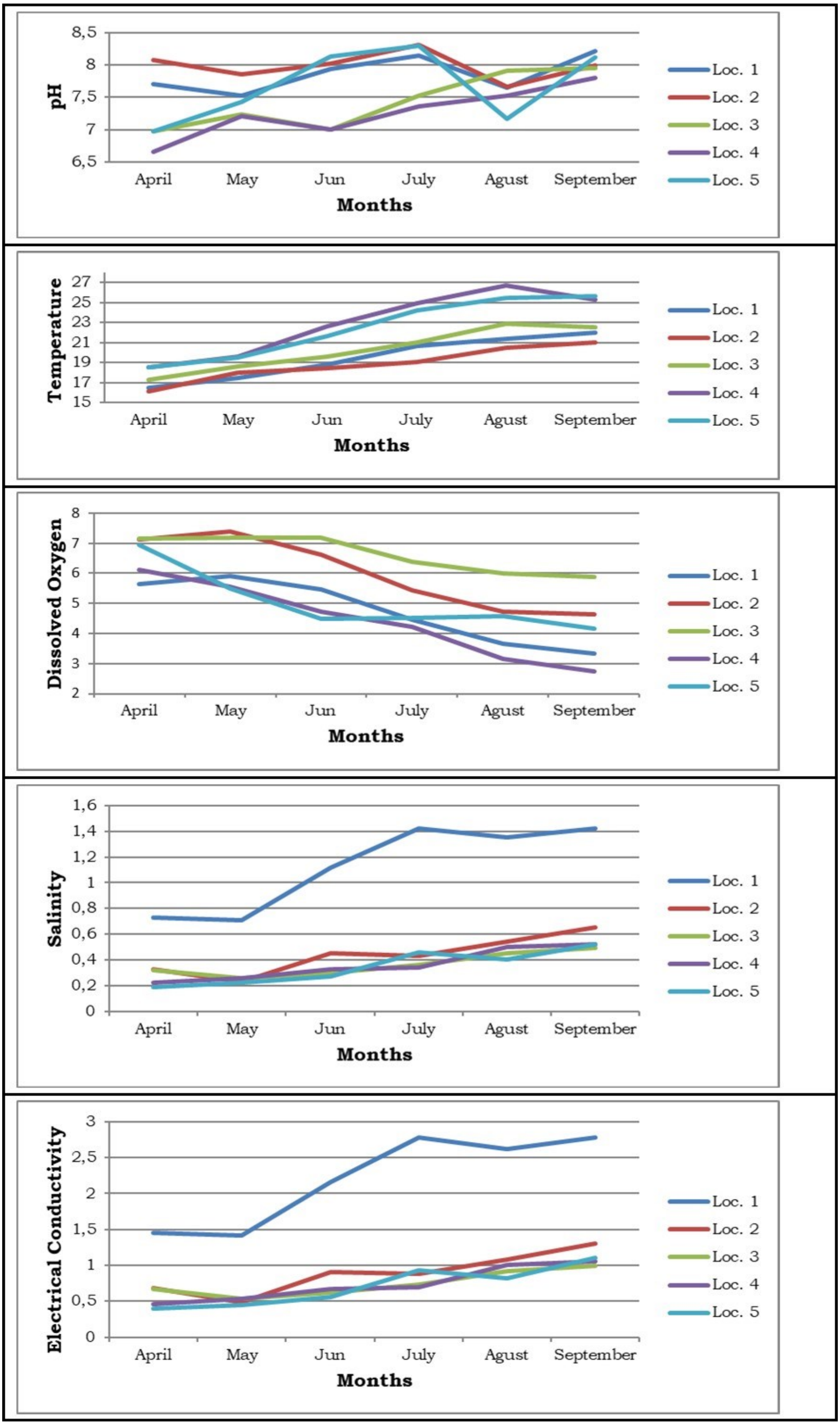
Also, the highest salinity values in average was determined at Loc.1 during the study period.

Table 2. Average physicochemical parameter values and water quality classes of the sampling localities (sd: standard deviation; WQC: Water Quality Class)

Loc. No	**pH**		**Dissolved Oxygen** (mg/L)		**EC** (mS/cm)		**Temperature** (°C)	**Salinitiy** (‰)
	Mean/sd	**WQC**	**Mean/sd**	**WQC**	**Mean/sd**	**WQC**	**Mean/sd**	**Mean/sd**
Loc. 1	7,86± 0,282	I	4,74± 1,09	III	2,2± 0,637	III	18,48± 2,226	1,12± 0,332
Loc. 2	7,98± 0,217	I	5,98± 1,204	III	0,89± 0,288	II	18,85± 1,782	0,43± 0,148
Loc. 3	7,43± 0,435	I	5,56± 2,791	III	0,74± 0,177	II	20,31± 2,212	0,36± 0,089
Loc. 4	7,26± 0,401	I	4,42± 1,319	III	0,73± 0,244	II	22,93± 3,302	0,36± 0,123
Loc. 5	7,68± 0,568	I	5,03± 1,043	III	0,71± 0,283	II	22,6± 2,95	0,34± 0,135

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Figure 3. Monthly changes of physicochemical parameter values according to localities



J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Statistical analyses revealed positive correlations between some parameters (EC - salin., temp. - salin., temp. - EC, and pH - EC), while others showed negative correlations (temp. - Salin., DO - Salin., DO - EC). The correlation levels of the physicochemical parameter values obtained as a result of the research are given in Table 3.

Table 3. Correlation values between the measured parameters (DO: dissolved oxygen, EC: electrical conductivity, Temp: temperature, Salin: salinity).

Parameters	**Minimum**	**Maximum**
EC–Salin.	0,999 ($p<0.01$) Loc. 5	1,000 ($p<0.01$) (Loc. 1-4)
Temp.–Salin.	0,823 ($p<0.05$) Loc. 2	0,955 ($p<0.01$) Loc. 1
DO–Salin	-0,873 ($p<0.05$) Loc. 1	-0,985 ($p<0.01$) Loc. 4
DO–Temp	-0,861 ($p<0.05$) Loc. 5	-0,944 ($p<0.01$) Loc. 1
DO–EC	-0,877 ($p<0.05$) Loc. 1	-0,987 ($p<0.01$) Loc. 4
EC– Temp.	0,822 ($p<0.05$) Loc. 2	0,956 ($p<0.01$) Loc. 1
pH-EC	0,791 ($p<0.05$) Loc. 3	0,892 ($p<0.05$) Loc. 4

2. Heteroptera Fauna Results

In this study, it wasdetermined a total of 10 aquatic/semiaquatic heteropteran species belonging to 6 families in the sampling localities in Çubuk Stream. The distribution status of these species in Türkiye was presented in Table 4.

DISCUSSION

Özdamar & Kıyak (2025) reported a correlation between some physicochemical parameters of water in their ecofaunistic study. The results of this study similarly indicate a negative or positive correlation between the physicochemical parameters of water. The negative correlations were reported to be between dissolved oxygen and pH, temperature and salinity, while the positive correlations were generally reported to be between electrical conductivity and pH, temperature, and salinity. Akınwole and Adeola (2012) conducted a study that included some of the parameters used in this study (pH, temperature and dissolved oxygen) and as a result, they stated that there was a strong relationship between some physicochemical parameters measured in water and that some parameter values could be used to estimate some other parameter values. Omboga (2011) reported a strong correlation between electrical conductivity and salinity. In this study, electrical conductivity and salinity fluctuated monthly in parallel (Figure 3). When electrical conductivity values were analyzed with salinity using the Pearson correlation method, a correlation between r=0.999 (loc. 5 [$p<0.01$]) and r=0.1000 (other locs. [$p<0.01$]) was found (Table 3).

Since the dissolution of solid substances is directly proportional to temperature, it should be noted that the degree of salinity is also related to temperature (Kadak and Aras, 2017). Salinity increases in the summer months, when evaporation is very common (Tepe, 2009). Therefore, higher salinity values are expected in the

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

hotter summer months (Figure 3). When temperature values were analyzed with salinity values according to the Pearson correlation method, a correlation of r = 0.823 (loc. 2 [p<0.05]) and r = 0.955 (loc. 1 [p<0.01]) was found (Table 3).

The amount of oxygen that water can hold varies depending on water temperature, salinity, and water pressure. As salinity decreases, gas solubility increases (Kale, 2016). When dissolved oxygen values were analyzed with salinity according to the Pearson correlation method, a negative correlation was found between r=-0.873 (loc. 1 [p<0.05]) and r=-0.985 (loc. 4 [p<0.01]) (Table 3).

As temperature increases, metabolic rate increases and oxygen levels decrease (Ünlü et al., 2008). When dissolved oxygen values were examined with temperature according to the Pearson correlation method, a negative correlation was found between r=-0.861 (loc. 5 [p<0.05]) and r=-0.944 (loc.1 [p<0.01]) (Table 3).

There is a strong correlation between electrical conductivity and salinity, and as salinity decreases, gas solubility increases (Omboga, 2011; Kale, 2016). Therefore, a decrease in dissolved oxygen levels at higher electrical conductivity values can be considered normal (Figure 3). When dissolved oxygen values were examined with electrical conductivity values according to the Pearson correlation method, a negative correlation was found between r=-0.877 (loc. 1 [p<0.05]) and r=-0.987 (loc. 4 [p<0.01]) (Table 3).

Electrical conductivity increases in parallel with the increase in salinity and temperature (Barlas et al. 1995). In this case, it is expected that electrical conductivity and salinity values increase and decrease together (Figure 3). When electrical conductivity values were analyzed with temperature values according to the Pearson correlation method, a positive correlation was found between r=-0.822 (loc. 2 [p<0.05]) and r=-0.956 (loc. 1 [p<0.01]) (Table 3).

In this study, when the water quality of Çubuk Stream was evaluated according to the Water Quality Control Regulation (SWQR,2021), it was determined to have very good water quality in terms of pH, but it was observed to have moderate water quality, especially in terms of dissolved oxygen. According to Rouf et al. (2022) dissolved oxygen levels in water falling below 5.0 mg/L put aquatic life under physiological stress. Generally, dissolved oxygen values in Çubuk Stream are seen to be at a critical level for aquatic organisms (Table 2). In terms of electrical conductivity, except for Locality 1 (moderate), the other localities are good (Table 2). The known positive correlation between salinity and electrical conductivity is influential in this situation. Furthermore, the intensive industrialization around Locality 1 is also thought to have a role in this situation.

The water quality of all surface water bodies, such as large rivers, lakes, and streams, is crucial. In assessing water quality, all chemical, physical, and biological parameters are equally important and should be evaluated together. When the biological results of this study are examined for aquatic hemipteran species, the species that were previously reported to have more sensitive ecological tolerance in the study conducted by Özdamar & Kıyak (2025) were not found. When the biological results of this study were examined for aquatic hemipteran species, no species previously reported to have more sensitive ecological tolerances were found in the study conducted by Özdamar and Kıyak (2025).

As seen in Table 4, the species identified in this study, as in the previous study, exhibited broader tolerances to the physicochemical parameters measured in this study. This suggests that different species have different ecological tolerances to these parameters.

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Although Tchakonté et al. (2015) noted that hemipterans are sensitive to pollution, they also show that the ecological tolerances of different hemipteran species differ, as previously mentioned.

CONCLUSION

In this study, a section of Çubuk Stream, intertwined with agricultural, industrial, and anthropogenic influences, was sampled from different locations. Also, some physicochemical features of these different locations was determined, demonstrating the stream's quality status. Generally, it was determined that the stream water is poorly balanced in terms of dissolved oxygen, potentially restricting the life of aquatic organisms. Furthermore, by examining the relationships between some physicochemical parameters used in water quality studies, we determined that these parameters can provide positive or negative information about each other. The composition of aquatic heteroptera species, a key insect group in aquatic ecosystems, was also determined in this study. Furthermore, water and water resources are dwindling/destroying daily. Therefore, wetland research is crucial for both ensuring water sustainability and establishing aquatic organism inventories.

Legal information

This study was carried out with the research permit numbered E-21264211-288.04-17752416 from the General Directorate of Nature Conservation and National Parks of the Ministry of Agriculture and Forestry of the Republic of Turkey.

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J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

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Table 4. Aquatic/Semiaquatic (Nepomorpha and Gerromorpha) heteropteran species identified in the research area

Family	Species/Subspecies	Distribution in Turkiye	Literatures	WQC
Gerridae (Semiaquatic)	*Gerris argentatus* Schummel, 1832	Adana, Ankara, Bartın, Burdur, Çankırı, Çorum Düzce, Karabük, Kastamonu Kayseri, Aydın, Antalya, Muğla, Denizli, Isparta, , Samsun	Hoberlandt, 1948; Özesmi & Önder, 1988; Kıyak, Salur & Canbulat, 2008; Salur & Mesci, 2009; Özdamar & Kıyak, 2025	I.-II.-III.
	Gerris thoracicus Schummel, 1832	Adana, Afyon, Ağrı, Ankara, Antalya, Ardahan, Aydın, Balıkesir, Bolu, Bursa, Burdur, Çankırı, Denizli, Edirne, Erzincan, Gaziantep, Hatay, Iğdır, Isparta, İzmir, Kastamonu, Kayseri, Konya, Mersin, Muğla, Niğde, Sivas, Tekirdağ, Trabzon, Van, Zonguldak	Lindberg, 1922; Hoberlandt, 1948; Kıyak et al., 2004, 2008; Önder et al., 2006; Salur & Mesci, 2009; Fent et al., 2011; Dursun, 2012; Topkara & Ustaoğlu, 2014; Yazıcı, 2020; Özdamar & Kıyak, 2025	I.-II.-III.
Nepidae (Aquatic)	*Nepa cinerea* Linnaeus, 1758	Adıyaman, Afyonkarahisar, Ağrı, Amasya, Ankara, Aydın, Bartın, Bitlis, Bolu, Burdur, Çorum, Denizli, Düzce, Edirne, Isparta, Istanbul, Kahramanmaraş, Karabük, Kars, Kayseri, Kırklareli, Kırşehir, Kocaeli, Konya, Nevşehir, Sakarya, Samsun, Sinop, Sivas, Van	Kritshenko, 1918; Horváth, 1919; Fahringer, 1922; Hoberlandt, 1952; Bat et al., 2000; Kıyak et al., 2004; 2007; Önder et al., 2006; Salur and Mesci, 2009; Topkara et al., 2009; Dursun, 2011; Fent et al., 2011; Çerçi and Koçak, 2016; Dursun and Fent, 2018, Özdamar & Kıyak, 2025	I.-III.
Corixidae (Aquatic)	*Corixa punctata* (Illiger, 1807)	Adana, Afyonkarahisar, Ağrı, Amasya, Ankara, Antalya, Ardahan, Aydın, Bolu, Burdur, Bursa Çanakkale, Çankırı, Denizli, Düzce, Edirne, Isparta, İstanbul, İzmir, Kars, Kastamonu, Kayseri, Kırklareli, Kırşehir, Kocaeli, Konya, Muğla, Samsun, Zonguldak	Horváth, 1883; Kiritshenko, 1918; Hoberlandt, 1948, 1952; Linnavuori, 1965; Jansson, 1986; Yıldırım et al., 1999; Önder et al., 2006; Kıyak et al., 2007; Dursun, 2011; Fent et al., 2011; Topkara, 2013; Dursun and Fent, 2018; Özdamar & Kıyak, 2025	I.-II.-III.
	Sigara nigrolineata (Fieber, 1848)	Adana, Ağrı, Ankara, Antalya, Ardahan, Artvin, Aydın, Bolu, Burdur, Bursa, Çanakkale, Çorum, Denizli, Diyarbakır, Düzce, Edirne, Erzincan, Erzurum, Eskişehir, Gaziantep, Hatay, Isparta, İzmir, İstanbul, Kastamonu, Kırşehir, Kilis, Kocaeli, Konya, Mersin, Muğla, Rize, Sakarya, Samsun, Sivas, Şanlıurfa, Trabzon, Tokat, Tunceli, Van	Hoberlandt, 1948, 1952; Seidenstücker, 1963; Linnavuori, 1965; Önder et al., 1984, 2006; Kıyak et al., 2004, 2007; Dursun, 2011; Fent et al., 2011; Topkara, 2013; Dursun and Fent, 2018;	I.-II.-III.
	Sigara striata (Linnaeus, 1758)	Ağrı, Afyonkarahisar, Ankara, Antalya, Ardahan, Aydın, Bolu, Burdur, Çanakkale, Çankırı, Çorum, Denizli, Edirne, Erzurum, Isparta, İzmir, Kayseri, Konya, Manisa, Mersin, Muğla, Sakarya, Samsun, Van	Kiritshenko, 1918; Hoberlandt, 1952; Jansson, 1986; Önder et al., 2006; Kıyak et al., 2007; Dursun, 2011; Fent et al., 2011; Topkara, 2013; Dursun and Fent, 2018	I.-II.-III.

J.Het.Turk., 7(2), Nov, 2025 (eISSN 2687-3249)

Table 4. Continued

Naucoridae (Aquatic)	*Ilyocoris cimicoides* (Linnaeus, 1758)	Adana, Afyonkarahisar, Ankara, Ardahan, Aydın, Bartın, Burdur, Çorum, Denizli, Düzce, Isparta, İstanbul, İzmir, Karabük, Kars, Kastamonu, Kayseri, Kırklareli, Konya, Muğla, Niğde, Samsun, Sivas, Zonguldak	Balık et al., 2006; Önder et al., 2006; Kıyak et al., 2007; Salur and Mesci, 2009; Topkara et al., 2009; Dursun, 2011; Fent et al., 2011; Çerçi and Koçak, 2016; Dursun and Fent, 2018; Özdamar & Kıyak, 2025	I.-III.
Notonectidae (Aquatic)	*Notonecta maculata* Fabricius, 1794	Adana, Amasya, Ankara, Antalya, Aydın, Burdur, Çankırı, Denizli, Düzce, Isparta, İstanbul, Karabük, Kastamonu, Kırklareli, Kırşehir Muğla, Osmaniye, Samsun, Sinop,	Hoberlandt, 1952; Önder et al., 2006; Kıyak et al., 2007; Dursun, 2011; Fent et al., 2011; Özdamar & Kıyak, 2025	I.-II.-III.
	Notonecta viridis Delcourt, 1909	Adana, Afyonkarahisar, Antalya, Burdur, Çankırı, Denizli, Düzce, Edirne, Erzincan, Hatay, Isparta, İzmir, Karabük, Kırşehir, Konya, Muğla, Osmaniye, Samsun, Sivas, Tokat, Van, Zonguldak	Kıyak et al., 2004, 2007; Önder et al., 2006; Dursun, 2011; Fent et al., 2011; Topkara and Ustaoğlu, 2015; Dursun and Fent, 2018; Özdamar & Kıyak, 2025	I.-II.-III.
Pleidae (Aquatic)	*Plea minutissima minutissima* Leach, 1817	Adana, Ankara, Antalya, Çorum, Denizli, Edirne, Isparta, Muğla Burdur, Kayseri Konya, Nevşehir, Samsun, Sivas	Hoberlandt, 1952; Özesmi and Önder, 1988; Kıyak et al., 2004, 2007; Önder et al., 2006; Dursun, 2011; Fent et al., 2011; Dursun and Fent, 2018; Özdamar & Kıyak, 2025	I.-II.-III.

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