



Water Quality and Aquatic/Semi-Aquatic Heteroptera (Hemiptera) Diversity of Sultan Marshes National Park Soysallı Pond (Develi: Kayseri)

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Abstract: This study was conducted to determine the aquatic/semi-aquatic Heteroptera fauna of Soysallı Pond in Sultan Marshes National Park, Türkiye, and to obtain information about the water quality of the habitats of these aquatic insects. For this purpose, water and aquatic Heteroptera samples were sampled monthly from February to October 2025. Simultaneously with the collection of insect samples, some physicochemical parameters of the water (pH, temperature, dissolved oxygen, salinity, electrical conductivity and total dissolved solids) were measured in the field. Ten aquatic/semi-aquatic Heteroptera species were identified in the research area. The species *Hydrometra stagnorum* (Linnaeus, 1758) was recorded for the first time in Kayseri province. In addition, the current water quality status of the pond was evaluated based on the physicochemical parameters measured in the field.

Keywords: Aquatic/semi-aquatic heteroptera, national park, soysallı pond, water analysis.

Sultan Sazlığı Milli Parkı Soysallı Göleti'nin (Develi: Kayseri) Su Kalitesi ve Sucul/Yarı Sucul Heteroptera (Hemiptera) Çeşitliliği



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Öz: Bu çalışma, Türkiye'deki Sultan Sazlığı Milli Parkı Soysallı Göleti'nin sucul ve yarı sucul Heteroptera faunasını belirlemek ve bu su böceklerinin yaşam alanlarının su kalitesi hakkında bilgi edinmek amacıyla yapılmıştır. Bu amaçla, Şubat ve Ekim 2025 tarihleri arasında aylık olarak su ve sucul Heteroptera örnekleri toplanmıştır. Böcek örneklerinin toplanmasıyla eş zamanlı olarak, arazide suyun bazı fizikokimyasal parametreleri (pH, sıcaklık, çözünmüş oksijen, tuzluluk, elektriksel iletkenlik ve toplam çözünmüş katı madde) ölçülmüştür. Araştırma alanında toplam on sucul/yarı sucul Heteroptera türü tanımlanmıştır. Kayseri ilinde ilk kez *Hydrometra stagnorum* (Linnaeus, 1758) türü kaydedilmiştir. Ayrıca, gölet suyunun mevcut su kalitesi, arazide ölçülen bazı fizikokimyasal parametrelere göre değerlendirilmiştir.

Anahtar kelimeler: Sucul/yarı sucul heteroptera, milli park, soysallı göleti, su analizi.

INTRODUCTION

Water is essential for all life on Earth and is the most valuable and abundant resource, covering more than 70% of the planet (Hossain, 2015). The chemical, physical, and biological properties of water generally define its quality in terms of its suitability for a specific use. Water quality analysis is necessary to check whether the existing system needs improvement or replacement and to monitor whether water quality complies with regulations (Roy, 2019).

Aquatic insects play an important role as sensitive indicators of water quality, and they are also an essential part of aquatic food webs, playing a role in nutrient recycling.

Aquatic insects live in lakes, ponds, streams, rivers, and other wetlands, and are vital components of freshwater ecosystems. Despite their ecological importance, they face threats from climate change, chemical pollution, habitat degradation, and human-induced dangers (Sánchez-Bayo & Wyckhuys, 2019). Aquatic insects make up approximately 60% of the total aquatic fauna living in freshwater habitats and are therefore considered the most diverse group (Balian et al., 2008).

Aquatic heteropterans are essential to benthic macroinvertebrates (Dzavi et al., 2021). Hemiptera may be sensitive to water pollution and can be used as bioindicators, increasing the accuracy of water quality assessments in

urban degraded streams. Thus, the distribution of most aquatic insects is influenced by various biotic and physicochemical factors in both stagnant and flowing ecosystems. The high distribution of most aquatic insects compared to other macroinvertebrates can be used as a tool to monitor the impact of human activities on water quality. Hemiptera species can improve the accuracy of water quality assessments (Tchakonté et al., 2015; Adu et al., 2019).

The aquatic/semi-aquatic Heteroptera includes the infraorders Leptopodomorpha, Gerromorpha, and Nepomorpha, and constitutes a major component of the world's aquatic insects; there are 4,656 species that live in freshwater (Polhemus & Polhemus, 2008). Turkey hosts 99 aquatic/semi-aquatic Heteroptera species (Fent et al., 2011; Küçükbasmacı & Kıyak, 2015; Banbal & Fent, 2016). Aquatic/semi-aquatic heteropterans are water-dependent and their life cycles are dependent on aquatic parameters and water quality (Özdamar & Kıyak, 2025). It is even stated that aquatic Heteroptera can serve as excellent biological indicators; therefore, their conservation should be monitored (De Lima et al., 2026).

Although some previous studies have been conducted on the aquatic invertebrates of Soysallı Pond, there is no direct study on the aquatic/semi-aquatic Heteroptera diversity and pond water parameters (Kaya et al., 2010; Kaya & Altındağ, 2010; Kaya et al., 2012).

This study aims to determine the water quality of Soysallı Pond, located in Kayseri province and one of Türkiye's important national parks, which is under pressure due to both tourism and industrial activities in the vicinity, according to some physicochemical variables, and to contribute to the regional fauna by identifying the aquatic/semi-aquatic Heteroptera fauna living under the current conditions.

MATERIAL AND METHOD

Soysallı Pond is located in Develi district, Kayseri province, at coordinates 38°23'26.24" N and 35°21'51.58" E and at an altitude of 1077 meters (Figure 1, 2). Sultan Marsh is located in the Develi Plain within the borders of Kayseri province, in the Upper Kızılırmak Section of the Central Anatolia Region. The area covers approximately 1000-1100 km².

Sultan Marshes was included in the category of Wetlands of International Importance under the Ramsar Convention in 1994 and was designated a national park in 2006. Of the 24,523 hectares of the national park, 17,200 hectares are within the Ramsar area (Meriç & Çağırankaya, 2013). Soysallı spring is one of the water sources feeding Sultan Marsh (Özesmi & Per, 2007). To the north of the Sultan Marshes, surface and groundwater from the Soysallı and Çayırözü springs and Mount Erciyes first fill the marshes areas in the north, the Kepir Marshes, before

reaching a different lake (Sönmez & Somuncu, 2016). Soysallı Pond is also formed by the waters originating from the Soysallı spring.



Figure 1. Google Earth view of the research area.



Figure 2. A photo from the research area (Photo by Aybükçe Özdamar).

Collection and Preparation of Aquatic/Semi-Aquatic Heteroptera Specimens: In this study, conducted monthly between February and October 2025, different collection methods and equipment were used to collect various aquatic heteropteran specimens from the pond. Some aquatic heteropteran specimens were collected by mixing the bottom and shore mud layers of the water and sieving them from the mud; others were collected from the water surface or the visible underwater area using 27-29 cm diameter metal sieves. All aquatic insect specimens were collected in accordance with the standard (TS EN ISO 10870) published by the General Directorate of Water Management of the Ministry of Forestry and Water Affairs.

Aquatic Heteroptera specimens collected from the pond were preserved by placing them in 50 mL falcon tubes containing 70% ethyl alcohol using forceps, and then transported to the laboratory for species identification. The collection and preparation procedures were based on Kıyak (2000). Morphological and genital characteristics were used to identify aquatic heteropteran species. Species identification followed Poisson (1957), Heiss & Jansson (1985), Andersen (1990; 1993), Jansson (1986), Nieser et al. (1994), Linnavuori & Hosseini (2000), Rabitsch (2005), Soos et al. (2009), Fent et al. (2011), Ghahari et al. (2013), Küçükbasmacı (2020).

Measurement and Evaluation of Physicochemical

Parameters of Pond Water: Water samples were taken using sample containers to record some physicochemical values (pH, temperature, dissolved oxygen, salinity, electrical conductivity and total dissolved solids) of the pond water. The collected water samples were recorded in the field using a portable, multi-parameter measuring device. Based on the recorded parameters, average values were determined, and the current water quality class of the pond was determined according to the Turkish Inland Surface Water Quality Criteria (SWQR, 2021) published in the Official Gazette of the Republic of Turkey. Heat maps provide a useful graphical representation for determining the interaction of biological functions with environmental change variables, graphically representing complex multivariate data that allows the identification of patterns or correlations between variables such as temperature and salinity (Whiting et al., 2024; Bigham Soostani et al., 2025). Therefore, monthly values of parameters obtained from the field were expressed using a heat map (GraphPad Software programme version 10.4.2).

RESULTS

A total of 10 aquatic/semi-aquatic Heteroptera species were identified in this study. These species and their

families are listed in Table 1. According to the identification results, one species (*H. stagnorum*) was recorded for the first time in Kayseri province.

Table 1. Aquatic/semi-aquatic Heteroptera species identified in the research area (+: Species reported from Kayseri province in previous studies, *: First report from Kayseri province).

Families	No	Species	Current status of species
Semi-Aquatic Heteroptera Species			
Hydrometridae	1	<i>Hydrometra stagnorum</i> (Linnaeus, 1758)	*
Gerridae	2	<i>Gerris argentatus</i> Schummel, 1832	+
	3	<i>Gerris lacustris</i> (Linnaeus, 1758)	+
	4	<i>Gerris thoracicus</i> Schummel, 1832	+
Aquatic Heteroptera Species			
Nepidae	5	<i>Nepa cinerea</i> Linnaeus, 1758	+
Corixidae	6	<i>Corixa punctata</i> (Illiger, 1807)	+
	7	<i>Sigara nigrolineata</i> (Fieber, 1848)	+
	8	<i>Sigara striata</i> (Linnaeus, 1758)	+
Naucoridae	9	<i>Ilyocoris cimicoides cimicoides</i> (Linnaeus, 1758)	+
Pleidae	10	<i>Plea minutissima minutissima</i> Leach, 1817	+

When the average values determined as a result of the analysis of some physicochemical parameters of monthly water samples from Soysallı Pond are evaluated according to Surface Water Quality Regulation (SWQR), it has been determined that the water has a class I (very good) level in terms of average pH, class I (very good) level in terms of dissolved oxygen and class I (very good) level in terms of electrical conductivity. The average values of some physicochemical properties determined by field measurement from Soysallı Pond and the water quality classes according to SWQR (2021) are presented in Table 2.

Table 2. Values of the measured physicochemical parameters (DO: Dissolved Oxygen, EC: Electrical conductivity, Temp: Temperature, Salin: Salinity, TDS: Total Dissolved Solids, WQC: Water Quality Class, $\pm$: Standard deviation).

pH	DO (mg/L)		EC (μ S/cm)		Temp.(°C)		Salin. (‰)		TDS (ppm)	
	Value	WQC	Value	WQC	Value	WQC	Value	WQC	Value	WQC
	8,03 $\pm$ 0,815	I	12,36 $\pm$ 1,655	I	131 $\pm$ 61	I	20,08 $\pm$ 5,789	I	0,07 $\pm$ 0,03	I

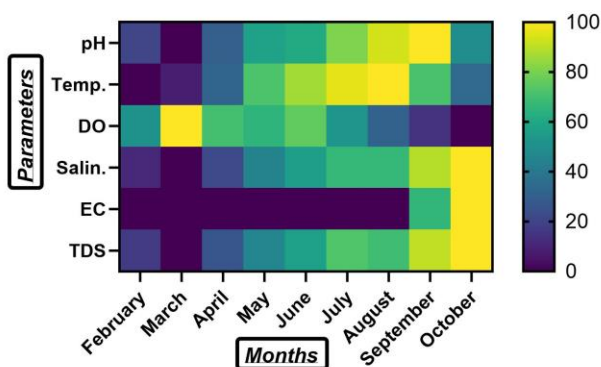


Figure 3. Graph of physicochemical parameters measured in the research area (heat map technique).

DISCUSSION AND CONCLUSION

According to the available literature, twenty-one aquatic/semi-aquatic heteropteran species have been recorded in Kayseri (Fent et al., 2011; Dursun & Fent, 2018; Yazıcı, 2020; Özdamar, 2025). Ten aquatic/semi-aquatic Heteroptera species were identified in the research area (Table 1). In this study conducted at the Sultan Marshes National Park Soysallı Pond, the species *H.*

stagnorum (Hydrometridae) was recorded for the first time in Kayseri province. Furthermore, this is also the first time this family has been recorded in Kayseri (Table 1). Thus, the number of previously known aquatic/semi-aquatic Heteroptera species from Kayseri province has been increased to twenty-two, contributing to the faunistic literature. In addition, this study presents the first faunistic insect inventory of the Soysallı National Park pond and adds the new information to the literature regarding the condition and quality of the pond water.

Monthly variations in physicochemical parameters obtained from the research area were expressed as a heat map and line graphs (Figures 3, 4) pH levels significantly affect water quality (Dewangan et al., 2023). When the pH range is between 3.5 and 4.5, aquatic life can be significantly inhibited (Avvannavar & Shrihari, 2008). In light of the literature, these results suggest that Soysallı Pond is suitable for aquatic life in terms of pH, possessing values suitable for the growth and reproduction of aquatic organisms. According to the Surface Water Quality Regulation (2021), when the average pH value of the water

in Soysallı Pond is evaluated, it is seen that the water is of very good quality (Table 2).

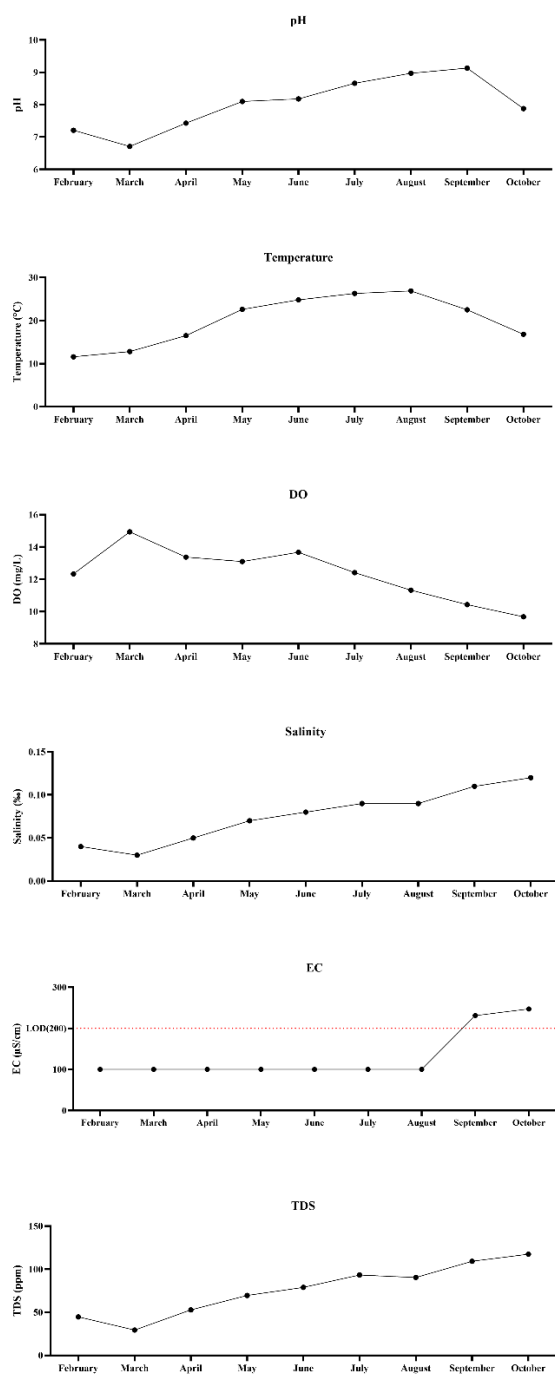


Figure 4. Line graphs of physicochemical parameters measured in the research area. In the EC graph, the dashed line indicates the measurement limit of the instrument (LOD = 200 µS/cm). Data from months below the measurement limit are included in the graph as LOD/2 (100 µS/cm).

Aquatic organisms generally have narrow temperature tolerances. Therefore, although water bodies act as buffers against atmospheric temperature changes, even moderate changes in water temperature can have serious effects on aquatic life, including bacteria, algae, invertebrates, and fish (Carr & Neary, 2008). Water

temperature is one of the major factors affecting macroinvertebrates. Recording how benthic invertebrates respond to changes in water temperature is crucial for understanding the impacts of climate change on freshwater ecosystems (Jourdan et al., 2018).

Smith & Collier (2002), in their study on aquatic insects, stated that stress caused by high air temperatures can affect the ability of female aquatic insects to develop mature eggs, potentially reducing their population numbers. They noted that mortality increased when the water temperature exceeded 30 °C, and that all insects died rapidly when the water temperature reached 35 °C. Although there are monthly fluctuations depending on the seasons, the average temperature of Soysallı Pond has been determined to be approximately 20 °C, which meets the criteria for aquatic insects (Table 2).

When the DO (dissolved oxygen) concentration in freshwater falls below 5-6 mg/L, it falls below the level necessary for aquatic organisms, leading to a hypoxic state (Dong et al., 2011). Both monthly and average values clearly show that the dissolved oxygen levels in Soysallı Pond water are well above the critical levels for aquatic life. According to the Surface Water Quality Regulation (2021), when the average DO value of the water in Soysallı Pond is evaluated, it is seen that the water is of very good quality (Table 2).

Salinity is a critical environmental factor for aquatic organisms (Montagna et al., 2018). Salinity stress is a significant environmental factor that alters biodiversity, shapes aquatic ecosystems, and affects species distribution (Dildar et al., 2025). Increased salinity has been shown to limit biodiversity, cause shifts in biotic communities, exclude less tolerant species, and have acute or chronic effects at specific stages of their life cycles (Weber-Scannell & Duffy, 2007). Sağlam & Adiloğlu (1997) stated that, according to the US Salinity Laboratory System, waters are divided into four categories based on their electrical conductivity. These are: low salinity (0-250 µS/cm), medium salinity (250-750 µS/cm), high salinity (750-2250 µS/cm), and very high salinity (greater than 2250 µS/cm). These results suggest that the water of Soysallı Pond, which was found to have low salinity, hosts aquatic Heteroptera species that thrive in low-salinity waters. Based on the literature, it is clear that the salinity of Soysallı Pond water is quite low and suitable for aquatic life. According to the Surface Water Quality Regulation (2021), when the average EC value of the water in Soysallı Pond is evaluated, it is seen that the water is of very good quality (Table 2, Figure 3, 4).

TDS (Total Dissolved Solids) indicates the amount of mineral salts, metals, anions, or cations dissolved in water (Dwicaño et al., 2021). It represents the concentration of dissolved minerals and ions in water,

which can affect the water's conductivity, taste, and suitability for various applications (Syafiqoh et al., 2018). According to the WHO (2003), the TDS values of raw water are classified into five categories for drinking and other uses. For drinking and other uses, Category-I is classified as values below 300 ppm (excellent), Category-II as 300 to 600 ppm (good), Category-III as 600 to 900 ppm (moderate), Category-IV as 900 to 1200 ppm (poor), and Category-V as values above 1200 ppm (very poor). According to this information, it is clear that the water of Soysallı Pond is in excellent condition (Table 2, Figure 3, 4).

The total dissolved solids (TDS) concentration in inland waters is primarily controlled by climatic and geological factors. TDS concentrations in natural freshwater typically range from approximately 20 to 1000 mg/L. The main effect of TDS concentration on animals and plants is generally related to increased osmotic pressure with higher TDS concentrations. Aquatic species are adapted to specific TDS ranges, and osmoregulation difficulties occur outside this range (Boyd, 2019). In this respect, these results suggest that the determined TDS values are consistent with expected values in freshwater.

According to Irfan & Alatawi (2019), there is a close relationship between water resources and aquatic biodiversity, and both ecological units are interdependent. In this study, while investigating the water quality of Soysallı Pond, the aquatic heteropteran insect fauna was also described, thus revealing both the condition of the water and the faunistic composition of aquatic Heteroptera.

The most important parameter for the continuation and density of biodiversity in Sultansazlığı National Park is the availability of water (Sönmez & Somuncu, 2016). This situation highlights the importance of determining the existence and quality of Soysallı Pond, an important wetland area within the Sultan Marshes.

In another recent study, *H. stagnorum* was detected for the first time in a different area, and instantaneous water quality data from that area was also recorded. According to the results of this study, the species was found to live in waters with Class I-II water quality (Ozdamar & Kiyak, 2025).

It has been suggested that area-targeted studies will reveal more new records for nearby provinces, considering the species previously reported from these provinces (Chitadze et al., 2024). In this study, although previously reported from nearby provinces, *H. stagnorum* is reported for the first time from Kayseri province.

When recent studies reporting this species are examined (Küçükbasmacı, 2020; Ozdamar & Kiyak, 2024; Özdamar & Kiyak, 2025), these results suggest that the altitude and coordinate selection is quite wide, indicating that there is no particular preference, and it can be

reiterated that area-targeted studies are needed for the detection of the species from different areas.

A study conducted on a different group of aquatic insects also indicated that the group of aquatic insects examined was sensitive to water parameters and that these insects were related to water quality (Özdamar & Kiyak, 2017; Özdamar & Kiyak, 2018; Erdoğan et al., 2025). Özbek & Mutlu (2026) calculated the water quality of the pond they studied as 'excellent' using the Weighted Arithmetic Water Quality Index (WAWQI); however, they emphasized that although the water quality was generally suitable, the negative aspects observed at the individual parameter level should be taken into consideration in terms of ecological monitoring. In light of all this information, when defining aquatic insect faunas, which are inextricably linked to their aquatic habitats, it is essential to also present the parameters of their habitats. This way, the health status of these habitats can be determined, ensuring their protection and sustainability.

Several factories serving various sectors are located near Soysallı Pond. To protect water quality, the treatment and discharge systems of these factories should be inspected and, if necessary, redesigned. Furthermore, the pond formed by the accumulation of water from the source serves the local population; therefore, facility personnel must act meticulously to prevent it from being exposed to anthropogenic effects. The area surrounding the water source is also quite rich in vegetation, and livestock graze extensively in this area. In this regard, the local population must be informed about the proper use of the water.

Ethical Standards

This research was conducted with the permission of the General Directorate of Nature Conservation and National Parks of the Ministry of Agriculture and Forestry of the Republic of Türkiye (Permit number: 21264211-288.04-17752416).

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