

Contributions to Ostracoda (Crustacea) fauna of Lake Manyas (Kuş)

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Abstract

Natural freshwater resources (e.g., lakes, ponds, rivers, springs) are among the most affected habitats in the world, influenced by pollutants due to increasing industrial and agricultural activities of the human. Understanding the influence of such factors on these ecosystems requires continuous research and monitoring programs on it. Thus, periodic sampling plays a vital role in assessing the biodiversity of these resources and in monitoring the degree of environmental degradation. Lake Manyas, with its rich biodiversity, is one of the most significant aquatic ecosystems and represents a valuable site for faunistic research in this context. Species of the class Ostracoda (Crustacea), which can be found in various aquatic habitats, are recognized with high species diversity and broad environmental tolerance. The species of the class found in lakes are considered reliable bioindicators due to the presence of many species with clearly defined environmental tolerance profiles. To determine the Ostracoda fauna of the Lake Manyas, samples were collected monthly between December 2020 and November 2021. As a result, a total of 38 taxa belonging to 24 genera were identified. Of which, 12 genera and 16 species were reported as new records for the lake.

Keywords: Ostracoda, freshwater, taxonomy, Lake Manyas.

Manyas (Kuş) Gölü Ostracoda (Crustacea) faunasına katkılar

Öz

Doğal tatlı su kaynakları (örneğin göller, göletler, nehirler, kaynaklar) insanoğlunun artan endüstriyel ve tarımsal faaliyetleri nedeniyle kirleticilerden etkilenen dünyada en

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çok etkilenen unsurlar arasındadır. Bu faktörlerin, ekosistemler üzerindeki etkisini anlamak, sürekli araştırma ve izleme programları gerektirir. Bu nedenle, periyodik örnekleme, bu kaynakların biyoçeşitliliğini değerlendirmede ve çevresel bozulmanın derecesini izlemede hayati bir rol oynar. Zengin biyoçeşitliliğe sahip Manyas (Kuş) Gölü, en önemli su ekosistemlerinden biridir ve bu bağlamda faunistik araştırmalar için değerli bir alanı temsil eder. Çeşitli su habitatlarında bulunabilen Ostracoda (Crustacea) sınıfının türleri, yüksek tür çeşitliliği ve geniş çevresel toleransı ile tanınır. Göllerde bulunan ostrakod türleri, açıkça tanımlanmış çevresel tolerans profillerine sahip birçok türün varlığı nedeniyle güvenilir biyoindikatörler olarak kabul edilir. Bu bağlamda Manyas (Kuş) Gölü'nün Ostracoda faunasını belirlemek için Aralık 2020 ile Kasım 2021 arasında aylık olarak örnekler toplandı. Sonuç olarak 24 cinse ait toplam 38 taksa belirlendi. Bunlardan 12 cins ve 16 tür göl için yeni kayıt olarak bildirildi.

Anahtar kelimeler: Ostracoda, tatlı su, taksonomi, Manyas Gölü.

1. Introduction

In an environment that is becoming increasingly polluted, it is crucial to investigate and understand how biodiversity is affected by pollution and anthropogenic factors. Aquatic habitats, which ensure the sustainability of the life cycles of most organisms, are indispensable resources for both humanity and the world. The organisms inhabiting these areas, along with their diversity, can serve as indicators of the ecological condition of the habitat. Ostracoda (Crustacea), which have been the inhabitants of the freshwater ecosystems for millions of years, are widely used as bio-indicators due to both their high diversity and wide range of geographical distribution [1-3].

Although stagnant waters are generally considered more suitable as a habitat for Ostracoda, these organisms can be found in almost all types of aquatic habitats, such as streams, creeks, rivers, lakes, ponds, troughs, waterfalls, caves, lagoons, seas, and oceans [4]. Many species of freshwater ostracods, known for their ability to move both actively and passively from one habitat to another, are considered cosmopolitan due to their high tolerance to tough conditions, including pollution [5,6]. From this perspective, monitoring the diversity of ostracod species within a habitat throughout the year will be crucial for studies aiming to deepen understanding about both the habitat and the organism.

The class Ostracoda is divided into three orders: Myocopida, Platycopida, and Podocopida, with the latter encompassing all freshwater and brackish water forms of ostracods [7,8]. Podocopida, is further subdivided into four superfamilies Darwinuloidea, Cypridoidea, Cytheroidea, and Terrestrialcytheroidea and comprises 20 families. Notably two of these families Cyprididae and Candonidae, constitute 59% of all known freshwater ostracods [9].

The Lake Manyas whose formation began in the late Holocene and took its current form in the same period [10], is a eutrophic lake with an average depth of 1.5 meters and a surface area of 159 km² located in the Susurluk Basin of Balıkesir province [11, 12]. Since its formation, the lake has provided habitat for humans and all living things around it as a water source [13]. The lake, which is reported to be hypertrophic, receives inflow from the Sığırcı and Kocaçay streams throughout the year, while its only natural discharge

is the Karadere stream [14]. Initially reported by C. Kosswig in 1938 as an important site for bird migration, the lake was granted the status of a National Park in 1959 and was recognized as a “Class A Wetland” by the Council of Europe in 1976 [11,15]. Çiçek et al. [16] reported that the lake water was potable in the 1960s, however, the drought in 1984-1985 and the pollution caused by intensive industrialization and agricultural activities around the lake have been reported to affect the water quality of the lake today [17-18]. The studies have once again revealed that the lake continues to be heavily polluted by multiple factors [19]. In addition, reports of heavy metal pollution raise serious concerns for the health of organisms living in or feeding from this aquatic habitat [18]. In fact, *Alburnoides manyasensis* Turan, Ekmekçi, Kaya & Güçlü, 2013, an endemic fish species that takes its name from this lake, may be among the species affected by pollution because it has been included in the red list by the IUCN [20,21].

The touristic and economic importance of the Lake Manyas [22], its geology [10], reeds [23], water quality [19], chlorophyll and nutritional values in the water [14], plankton [11,12], ostracods [24], lobsters [25], and fish [20] have been studied to date. Thirteen ostracod species were reported previously in the Lake Manyas as part of a study conducted in 1997 [24]: *Darwinula stevensoni*, *Limnocythere inopinata*, *Ilyocypris biplicata*, *Ilyocypris gibba*, *Candona neglecta*, *Physocypris kraepelini*, *Heterocypris incongruens*, *Eucypris virens*, *Tonnacypris lutaria*, *Herpetocypris chevreuxi*, *Cypris pubera*, *Cypridopsis vidua*, and *Potamocypris villosa*. The same study further reported [24] that the identified species closely resembled the ostracod fauna of Western Eurasia and Europe. However, the overall species composition of the Lake Manyas appeared to be in poorer condition than the surrounding lakes. In light of all these data, the current study aimed to observe the changes in the ostracod fauna in the lake.

2. Material and method

Ostracods were collected monthly between December 2020 and November 2021. During the first seven months of the study, samples were taken from 14 stations. After the seventh month, one additional station (1-A) was included, increasing the total to 15 stations. Following the ninth month, three more stations (5-A, 6-A, 14-A) were added, bringing the total number of sampling stations to 18 (Figure 1). The coordinates of the sampling stations were determined by GPS (Magellan eXplorist 610) (Table 1). The sediment samples were collected using a standard hand net with a 200 µm mesh size, preserved in 70% alcohol in 250 mL plastic containers, and subsequently transported to the laboratory.

The collected samples were filtered with three-layer sieves (2 mm, 1 mm and 0.25 mm mesh size) in the laboratory. Ostracods were separated from sediment under a stereomicroscope (Olympus SZX16) and then dissected in lactophenol solution for taxonomic identification. Dissected soft body parts were mounted on slides with lactophenol. Carapaces separated from the soft tissue were stored in small glass bottles in 70% ethanol. Additionally, selected valves for SEM were preserved on micropaleontological slides.

Meisch [7], Meisch et al. [9], Karanovic [26], and Smith et al. [27] were used for identification. Some subfossil specimens, which were represented only by carapaces and/or empty valves, could be identified only to the genus level.

Table 1 Coordinates of the sampling stations.

1	40° 07' 39" N 28° 03' 45" E	7	40° 10' 33" N 27° 51' 16" E
1A	40° 07' 57" N 28° 04' 19" E	8	40° 11' 09" N 27° 52' 16" E
2	40° 08' 18" N 28° 02' 52" E	9	40° 13' 04" N 27° 54' 17" E
3	40° 08' 51" N 28° 00' 23" E	10	40° 13' 32" N 27° 55' 07" E
4	40° 09' 18" N 27° 57' 48" E	11	40° 14' 36" N 27° 57' 17" E
5	40° 08' 53" N 27° 55' 27" E	12	40° 14' 25" N 27° 59' 08" E
5A	40° 08' 23" N 27° 54' 19" E	13	40° 13' 42" N 28° 02' 30" E
6	40° 09' 44" N 27° 50' 28" E	14	40° 13' 27" N 28° 03' 12" E
6A	40° 09' 34" N 27° 51' 03" E	14A	40° 14' 35" N 28° 02' 35" E

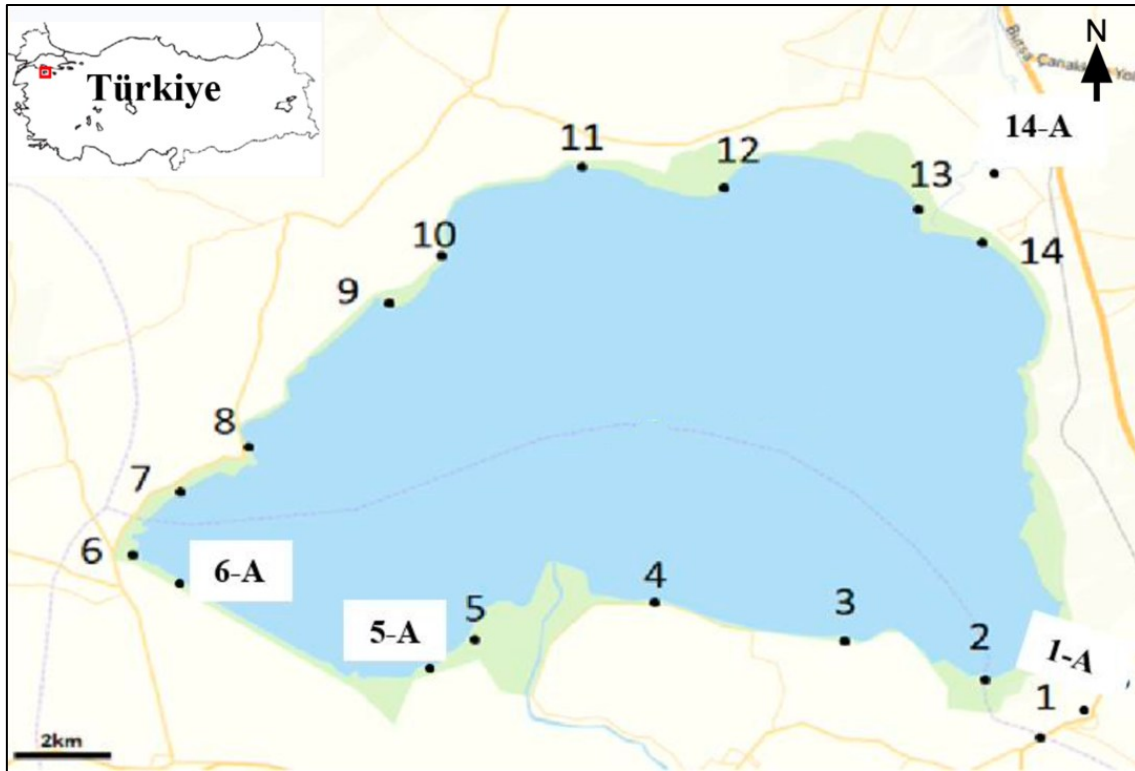


Figure 1 Locations of the sampling stations in the Lake Manyas (Kuş) in the present study. (Modified from Google Maps)

Scanning electron microscopy (SEM) analyses were conducted using a Zeiss EVO 50 SEM at Electron Microscopy Laboratory of the Department of Geological Engineering, Hacettepe University. Ostracod carapaces were carefully mounted onto sample stubs using carbon adhesive tape, and their surfaces were coated with a highly conductive metal to enhance imaging resolution. All examined material has been deposited in the collection of the Department of Biology, Faculty of Science and Letters, Balıkesir University, Balıkesir, Türkiye.

3. Results

A total of 38 taxa were identified in this study. Twenty-five of these were identified to the species level, while the other 13 were identified only to the genus level due to the lack of soft tissue. New record species for the Lake Manyas are marked with "**".

PHYLUM: ARTHROPODA

SUBPHYLUM: CRUSTACEA Pennat, 1777

CLASS: OSTRACODA Latreille, 1802

SUBCLASS: PODOCOPA Sars, 1866

ORDER: PODOCOPIDA Sars, 1866

SUBORDER: Podocopina Sars, 1866

SUPERFAMILY: Darwinuloidea Brady & Norman, 1889

FAMILY: Darwinulidae Brady & Norman, 1889

Genus: *Darwinula* Brady & Robertson, 1885

Darwinula sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 26 Subfossils (Sampling stations: 3, 4, 9, 11, 12, 13, 14); Jan. 2021, 5 Subfossils (Sampling stations: 1, 7, 12, 13); Feb. 2021, 8 Subfossils (Sampling stations: 3, 8, 14); Mar. 2021, 2 Subfossils (Sampling stations: 3, 12), May 2021, 4 Subfossils (Sampling stations: 3, 4); Jun. 2021, 5 Subfossils (Sampling stations: 8, 9); Jul. 2021, 3 Subfossils (Sampling stations: 3, 4, 9); Aug. 2021, 3 Subfossils (Sampling station: 3); Sep. 2021, 11 Subfossils (Sampling stations: 4, 7, 8, 12, 13, 14, 6A); Oct. 2021, 4 Subfossils (Sampling station: 8); Nov. 2021, 2 Subfossils (Sampling stations: 1, 3); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUPERFAMILY: Cypridoidea Braid, 1845

FAMILY: Candonidae Kaufmann, 1900

SUBFAMILY: Candoninae Kaufmann, 1900

Genus: *Candona* Braid, 1845

Candona candida (O.F. Müller, 1776) Baird 1845 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Apr. 2021, 5 individuals (Sampling stations: 1, 2), Oct. 2021, 3 individuals (Sampling station: 6); Nov. 2021, 8 individuals (Sampling stations: 2, 14, 6A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Candonopsis* Vavra, 1891

Candonopsis kingsleii Brady & Robertson, 1870 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Apr. 2021, 6 individuals (Sampling station: 3); May 2021; 26 individuals (Sampling stations: 3, 4, 5); Jun. 2021, 25 individuals (Sampling stations: 3, 4, 5); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Fabaeformiscandona* Krstic, 1972

Fabaeformiscandona fabaeformis Fisher, 1821 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Apr. 2021, 2 individuals (Sampling station: 2); May 2021, 9 individuals (Sampling stations: 2, 5); Jun. 2021, 20 individuals (Sampling stations: 2, 5); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Nannocandona* Ekman, 1914

Nannocandona stygia Sywula, 1976 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Oct. 2021; 7 individuals (Sampling station: 2); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Neglecandona* Kristic, 2006

Neglecandona neglecta Sars, 1887

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 19 individuals (Sampling stations: 5, 6, 12, 13, 14); Jan. 2021, 3 individuals (Sampling stations: 4, 12, 13); Feb. 2021; 11 individuals (Sampling stations: 6, 13, 14); Mar. 2021, 4 individuals (Sampling stations: 3, 8, 11, 12); Apr. 2021, 1 individual (Sampling station: 7); May 2021, 25 individuals (Sampling stations: 1, 2, 3, 4, 5, 6, 11, 12, 13); Jun. 2021, 23 individuals (Sampling stations: 2, 3, 4, 5, 11, 13); Jul. 2021, 9 individuals (Sampling stations: 4, 5, 11, 13, 6A, 14A); Aug. 2021, 23 individuals (Sampling stations: 2, 4, 6, 6A); Sep. 2021, 32 individuals (Sampling stations: 2, 4, 6, 14, 14A); Oct. 2021, 10 individuals (Sampling stations: 1, 4, 11, 14, 6A); Nov. 2021, 10 individuals (Sampling stations: 2, 14, 6A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Pseudocandona* Kaufmann, 1900

Pseudocandona sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: May 2021, 3 subfossils (Sampling stations: 2, 3, 6); Jul. 2021, 2 subfossils (Sampling stations: 6, 9); Sep. 2021, 1 subfossil (Sampling station: 6A); Oct. 2021, 7 subfossils (Sampling stations: 4, 6); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Pseudocandona compressa Koch, 1838 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Apr. 2021, 3 individuals (Sampling station: 5); Jun. 2021, 3 individuals (Sampling stations: 6); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Pseudocandona hartwigi (G.W. Müller, 1900) Martens & Dumont 1984 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jul. 2021, 1 individual (Sampling station: 2); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

FAMILY: Ilyocyprididae Kaufmann, 1900

SUBFAMILY: Ilyocypridinae Kaufmann, 1900

Genus: *Ilyocypris* Brady & Norman 1899

Ilyocypris bradyi Sars, 1890 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 4 individuals (Sampling station: 1); Apr. 2021, 14 individuals (Sampling stations: 11, 13); Oct. 2021, 1 individual (Sampling station: 14A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Ilyocypris gibba Ramdohr, 1808

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 3 individuals (Sampling station: 6); Feb. 2021, 4 individuals (Sampling station: 14); Apr. 2021, 10 individuals (Sampling stations: 2, 6); May 2021, 111 individuals (Sampling stations: 2, 3, 6, 7, 9, 10, 11, 14); Jun. 2021, 263 individuals (Sampling stations: 2, 3, 6, 7, 9, 10, 11, 12, 13, 14); Jul. 2021, 102 individuals (Sampling stations: 2, 3, 4, 5, 6, 7, 11, 12, 13, 14,); Aug. 2021, 19 individuals (Sampling stations: 6, 11); Sep. 2021, 32 individuals (Sampling stations: 1, 6, 12, 13); Oct. 2021, 48 individuals (Sampling stations: 2, 6, 8, 12, 14); Nov. 2021, 96 individuals (Sampling stations: 2, 6, 11, 12, 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Ilyocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 86 subfossils (Sampling stations: 1, 4, 7, 8, 10, 11, 12, 13, 14); Jan. 2021, 24 subfossils (Sampling stations: 1, 7, 8, 11, 13, 14); Feb. 2021, 29 subfossils (Sampling stations: 3, 6, 8, 13); Mar. 2021, 7 subfossils (Sampling stations: 1, 3, 4, 10, 11); Apr. 2021, 1 subfossil (Sampling station: 3); May 2021, 14 subfossils (Sampling stations: 1, 4, 13); Jun. 2021, 4 subfossils (Sampling stations: 1, 4); Jul. 2021, 5 subfossils (Sampling stations: 1, 9, 10, 6A); Aug. 2021, 28 subfossils (Sampling stations: 2, 3, 4, 5, 7, 14, 6A); Sep. 2021, 62 subfossils (Sampling stations: 3, 4, 5, 7, 8, 11, 6A, 14A); Oct. 2021, 25 subfossils (Sampling stations: 1, 11, 13); Nov. 2021, 14 subfossils (Sampling stations: 1, 3, 4, 7, 8, 13); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

FAMILY: Cyprididae Baird, 1845

SUBFAMILY: Cypridinae Baird, 1845

Genus: *Cypris*, Müller, 1776

Cypris pubera Müller, 1776

Material: Balıkesir-Susurluk Basin-Lake Manyas: Mar. 2021, 6 individuals (Sampling station: 6); Apr. 2021, 15 individuals (Sampling stations: 7, 9); Jun. 2021; 11 subfossils (Sampling station: 1); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Eucypridinae Bronshtein, 1947

Genus: *Eucypris* Vavra, 1891

Eucypris virens Jurine 1820

Material: Balıkesir-Susurluk Basin-Lake Manyas: Feb. 2021, 19 individuals (Sampling stations: 2, 6, 11, 12); Mar. 2021, 9 individuals (Sampling stations: 13, 14); Apr. 2021, 30 individuals (Sampling stations: 1, 2, 7, 9, 10, 11, 13); May. 2021, 17 individuals (Sampling stations: 7, 10, 11); Jun. 2021, 2 individuals (Sampling stations: 2, 9); Jul. 2021, 1 individual (Sampling station: 1); Sep. 2021, 132 individuals (Sampling stations: 1, 1A); Oct. 2021, 1 individual (Sampling station: 11); Nov. 2021, 4 individuals (Sampling station: 1A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Eucypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jan. 2021, 6 subfossils (Sampling stations: 11, 13, 14); Feb. 2021, 11 subfossils (Sampling stations: 10, 13, 14); Mar. 2021, 1 subfossil (Sampling station: 11); Apr. 2021, 5 subfossils (Sampling station: 6); May 2021, 35 subfossils (Sampling stations: 1, 6, 13); Jun. 2021, 9 subfossils (Sampling stations: 1, 13); Sep. 2021, 12 subfossils (Sampling stations: 6, 11, 14); Oct. 2021, 33 subfossils (Sampling stations: 1, 4, 9, 12, 13, 14, 1A, 6A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Prionocypris* Brady & Norman, 1896

Prionocypris zenkeri (Chyzer & Toth, 1858) *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Feb. 2021, 2 individuals (Sampling station: 6); May 2021, 2 individuals (Sampling station: 10); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Prionocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 3 subfossils (Sampling station: 6); Mar. 2021, 1 subfossil (Sampling station: 10); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Trajancypris* Martens, 1989

Trajancypris clavata Baird, 1838 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Mar. 2021, 5 individuals (Sampling stations: 1, 2, 6); Apr. 2021, 27 individuals (Sampling stations: 1); Jun. 2021, 1 individual (Sampling station: 14); Jul. 2021, 3 individuals (Sampling station: 1); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Trajancypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jun. 2021, 2 subfossils (Sampling station: 1); Sep. 2021, 2 subfossils (Sampling station: 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Herpetocypridinae Kaufmann, 1900

Genus: *Herpetocypris* Brady & Norman, 1899

Herpetocypris chevreuxi Sars, 1896

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jul. 2021, 3 individuals (Sampling station: 14); Sep. 2021, 11 individuals (Sampling station: 1A); Oct. 2021, 5 individuals (Sampling stations: 1A); Nov. 2021, 6 individuals (Sampling stations: 1A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Herpetocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Sep. 2021, 11 subfossils (Sampling stations: 1, 6, 13, 14A); Oct. 2021, 2 subfossils (Sampling station: 1); Nov. 2021, 1 subfossil (Sampling station: 4); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Stenocypris* Sars, 1889

Stenocypris major Baird, 1859 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Aug. 2021, 3 individuals (Sampling station: 1); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Psychrodromus* Danielopol & McKenzie, 1977

Psychrodromus olivaceus Brady & Norman, 1889 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2021, 78 individuals (Sampling station: 1); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Candonocypris* Sars, 1895

Candonocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Nov. 2021, 1 subfossil (Sampling station: 6); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Cyprinotinae Bronstein, 1947

Genus: *Heterocypris* Claus, 1892

Heterocypris barbara Gauthier & Brehm, 1928 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jul. 2021, 18 individuals (Sampling station: 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Heterocypris incongruens Ramdohr, 1808

Material: Balıkesir-Susurluk Basin-Lake Manyas: Mar. 2021, 32 individuals (Sampling stations: 11, 14); Apr. 2021, 9 individuals (Sampling stations: 11, 13); May 2021, 60 individuals (Sampling stations: 9, 10, 11, 14); Jun. 2021, 10 individuals (Sampling stations: 1, 6, 12, 14); Aug. 2021, 3 individuals (Sampling stations: 6A); Sep. 2021, 6 individuals (Sampling stations: 6A); Oct. 2021, 2 individuals (Sampling stations: 2, 14A);

Nov. 2021, 7 individuals (Sampling stations: 1A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Heterocypris salina Brady, 1868 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Sep. 2021, 7 individuals (Sampling stations: 1A, 14A); Oct. 2021, 10 individuals (Sampling stations: 6, 1A); Nov. 2021, 3 individuals (Sampling stations: 2, 3, 14, 1A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Heterocypris reptans Kaufmann, 1900 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Mar. 2021, 10 individuals (Sampling station: 11); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Heterocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: May 2021, 3 subfossils (Sampling station: 13); Jun. 2021, 19 subfossils (Sampling stations: 2, 10, 11) Jul. 2021, 25 subfossils (Sampling stations: 3, 4, 7, 11, 13, 14A); Aug. 2021, 11 subfossils (Sampling stations: 2, 5A); Sep. 2021, 10 subfossils (Sampling stations: 6, 14A); Oct. 2021, 6 subfossils (Sampling stations: 11, 14); Nov. 2021, 9 subfossils (Sampling stations: 1, 11, 6A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Cyclocypridinae Kaufmann, 1900

Genus: *Physocypria* Vavra, 1897

Physocypria kraepelini Müller, 1903

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 187 individuals (Sampling stations: 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14); Jan. 2021, 98 individuals (Sampling stations: 1, 6, 7, 8, 9, 11, 12, 14); Feb. 2021, 24 individuals (Sampling stations: 3, 13); Mar. 2021, 4 individuals (Sampling station: 11); Apr. 2021, 48 individuals (Sampling stations: 1, 4, 5, 6, 11); May 2021, 40 individuals (Sampling stations: 1, 4, 5, 6, 11, 14); Jun. 2021, 62 individuals (Sampling stations: 2, 3, 4, 6, 10, 12, 13); Jul. 2021, 102 individuals (Sampling stations: 1, 4, 5, 7, 11, 14); Aug. 2021, 26 individuals (Sampling stations: 2, 3, 6, 7, 14); Sep. 2021, 45 individuals (Sampling stations: 2, 3, 4, 6, 7, 8, 11, 13, 14, 5A); Oct. 2021, 48 individuals (Sampling stations: 3, 4, 6, 7, 8, 11, 12, 13, 14); Nov. 2021, 43 individuals (Sampling stations: 2, 3, 6, 7, 8, 11, 12, 13, 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Cypria* Zenker, 1854

Cypria ophtalmica Jurine, 1820 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 32 individuals (Sampling stations: 5, 14); Jan. 2021, 32 individuals (Sampling stations: 1, 4, 5, 13); Feb. 2021, 182 individuals (Sampling stations: 1, 2, 6, 7, 8, 11, 13, 14); Mar. 2021, 74 individuals (Sampling stations: 1, 2, 3, 7, 10, 12, 13); Apr. 2021, 40 individuals (Sampling stations: 2, 4, 9, 10, 11, 13); May 2021, 120 individuals (Sampling stations: 2, 3, 5, 10, 11, 13); Jun. 2021, 149 individuals (Sampling stations: 1, 5, 7, 11, 14); Jul. 2021, 22 individuals (Sampling stations: 13, 5A, 6A); Aug. 2021, 27 individuals (Sampling stations: 1, 10, 11, 6A, 14A); Sep. 2021, 5 individuals (Sampling stations: 1, 5, 11); Oct. 2021, 24 individuals (Sampling station: 2); Nov. 2021, 33 individuals (Sampling stations: 1, 2, 14, 6A); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Cypridopsinae Kaufmann, 1900

Genus: *Cypridopsis* Brady, 1867

Cypridopsis vidua Müller, 1776

Material: Balıkesir-Susurluk Basin-Lake Manyas: May 2021, 13 individuals (Sampling stations: 2, 3, 5, 9, 10); Jun. 2021, 44 individuals (Sampling stations: 5, 6, 14); Jul. 2021, 28 individuals (Sampling stations: 1, 2, 5, 6, 14, 5A); Aug. 2021, 17 individuals (Sampling stations: 1, 6, 14); Sep. 2021, 27 individuals (Sampling stations: 1, 5A); Oct. 2021, 33 individuals (Sampling station: 1); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Cypridopsis sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 3 subfossils (Sampling stations: 12, 14); Jul. 2021, 1 subfossil (Sampling station: 8); Aug. 2021, 2 subfossils (Sampling station: 5); Sep. 2021, 2 subfossils (Sampling stations: 3, 13); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Genus: *Potamocypris* Brady, 1870

Potamocypris sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 5 subfossils (Sampling stations: 12, 14); Feb. 2021, 1 subfossil (Sampling station: 14); May 2021, 1 subfossil (Sampling station: 7); Jun. 2021, 1 subfossil (Sampling station: 13); Nov. 2021, 1 subfossil (Sampling station: 12); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUBFAMILY: Isocypridinae Rome, 1965

Genus: *Isocypris* Müller, 1908

Isocypris cf. *beauchampi* Paris, 1920 *

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 4 individuals (Sampling station: 13); Feb. 2021, 1 individual (Sampling station: 13); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

SUPERFAMILY: Cytheroidea Baird, 1850

FAMILY: Limnocytheridae Sars, 1925

SUBFAMILY: Limnocytherinae Sars, 1925

Genus: *Limnocythere* Brady 1867

Limnocythere inopinata (Baird, 1843) Brady, 1867

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 35 individuals (Sampling stations: 7, 9, 10); Jan. 2021, 124 individuals (Sampling stations: 7, 8, 14); Feb. 2021, 11 individuals (Sampling stations: 8, 14); Mar. 2021, 1 individual (Sampling station: 10); Apr. 2021, 17 individuals (Sampling station: 9); May 2021, 213 individuals (Sampling stations: 3, 9, 10); Jun. 2021, 63 individuals (Sampling stations: 7, 8, 9); Jul. 2021, 4 individuals (Sampling station: 7); Aug. 2021, 4 individuals (Sampling stations: 11, 14); Sep. 2021, 19 individuals (Sampling stations: 2, 7, 8, 13, 14); Oct. 2021, 43 individuals (Sampling stations: 7, 8, 9, 14); Nov. 2021, 20 individuals (Sampling stations: 7, 8, 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

Limnocythere sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Dec. 2020, 3 subfossils (Sampling station: 3); Jan. 2021, 2 subfossils (Sampling station: 1); Feb. 2021, 3 subfossils (Sampling stations: 2, 3, 12); Mar. 2021, 1 subfossil (Sampling station: 10); May 2021, 2 subfossils (Sampling stations: 7, 14); Jul. 2021, 6 subfossils (Sampling stations: 4, 9, 13); Aug. 2021, 20 subfossils (Sampling station: 7); Sep. 2021, 1 subfossil (Sampling station: 4); Oct. 2021, 2 subfossils (Sampling station: 13); Nov. 2021, 3 subfossils (Sampling stations: 3, 4, 13); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

FAMILY: Hemicytheridae Puri, 1953

Genus: *Tyrrhenocythere* Ruggieri, 1955

Tyrrhenocythere sp.

Material: Balıkesir-Susurluk Basin-Lake Manyas: Jan. 2021, 1 subfossil (Sampling station: 8); Oct. 2021, 2 subfossils (Sampling stations: 8, 14); leg: Ç. ÇAPRAZ, det: O. KÜLKÖYLÜOĞLU & Ç. ÇAPRAZ

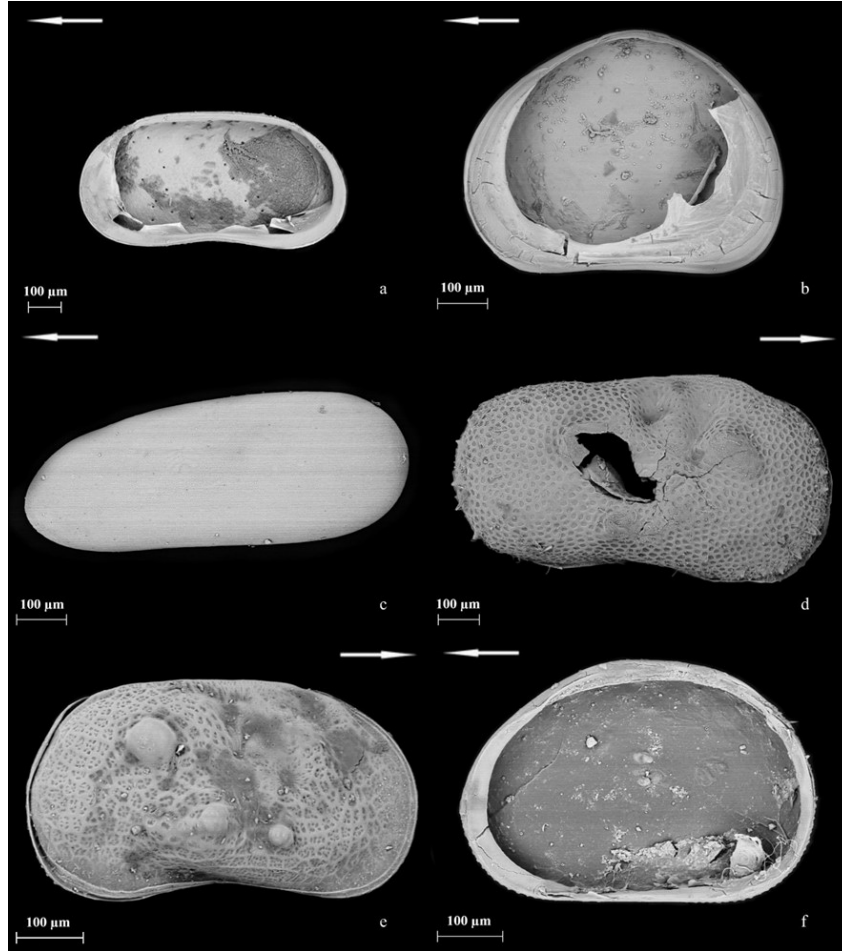


Figure 2 Scanning Electron Microscope images of ostracod taxa that appeared every month during the present study (a: *Neglecandona neglecta* juv.; b: *Cypria ophtalmica*; c: *Darwinula* sp.; d: *Ilyocypris gibba*; e: *Limnocythere inopinata*; f: *Physocypris kraepelini*)

4. Discussion

Thirteen ostracod species had previously been reported from the Lake Manyas [23], nine of them (*C. pubera*, *C. vidua*, *E. virens*, *H. chevreuxi*, *H. incongruens*, *I. gibba*, *L. inopinata*, *N. neglecta*, and *P. kraepelini*) were also identified in the present study. Ostracod carapaces belonging to thirteen taxa: *Candonacypris* sp., *Cypridopsis* sp., *Eucypris* sp., *Herpetocypris* sp., *Heterocypris* sp., *Ilyocypris* sp., *Limnocythere* sp., *Potamocypris* sp., *Prionocypris* sp., *Pseudocandona* sp., *Trajancypris* sp., *Tyrrhenocythere* sp., and *Darwinula* sp. had no soft tissues, they were identified only to the genus level in the present study. Of them, *Darwinula* sp. were collected throughout the year at each sampling stations with hundreds of subfossil carapaces. Notably, the year-round presence of *Darwinula stevensoni* in the Lake Manyas has been reported in a

previous study [23]. Furthermore, considering that this species has also been recorded in other studies from nearby regions [28–31], it is likely that the *Darwinula* subfossil carapaces identified in the present study belong to *D. stvensoni*. Three species—*Ilyocypris biplicata*, *Potamocypris villosa*, and *Tonnacypris lutaria*—reported previously from the lake were not found in the current study. Although *T. lutaria* is known to co-occur with *E. virens* [7] frequently, it was not observed in this study. *P. villosa*, known to be a cosmopolitan species [32–35], was also absent in this study. Although *I. biplicata* and *I. gibba* were reported as two separate species in the previous study [23], *I. biplicata* was classified as a synonym of *I. gibba* [7, 15, 25 36–39].

In the present study, six of the 38 taxa (*N. neglecta*, *C. ophtalmica*, *Darwinula* sp., *I. gibba*, *L. inopinata*, *P. kraepelini*) (Figure 2) were constantly present in the lake. 12 genera (*Candona*, *Candonacypris*, *Candonopsis*, *Cypria*, *Fabaeformiscandona*, *Isocypris*, *Nanocandona*, *Prionocypris*, *Stenocypris*, *Pseudocandona*, *Trajancypris*, *Tyrrhenothere*) and 16 species (*C. candida*, *C. kingslei*, *C. ophtalmica*, *F. fabaeformis*, *H. barbara*, *H. salina*, *H. reptans*, *I. beauchampi*, *I. bradyi*, *N. stygia*, *P. zenkeri*, *P. compressa*, *P. hartwigi*, *P. olivaceus*, *S. major*, *T. clavata*) were determined as new records for the Lake Manyas. All 16 species newly recorded in the Lake Manyas are cosmopolitan species with widespread distribution in Palaearctic region [7].

The Lake Manyas with 25 species exhibits a higher species diversity than three nearby lakes—19 taxa in the Lake Sapanca, 18 taxa in the Lake İznik [40], and 12 taxa in the Lake Uluabat [41]. However, it is notable that nearly all ostracod species found in the Lake Manyas are cosmopolitans. This data supports the 'pseudorichness' concept previously proposed in several ostracod studies [4,6,42–44].

It is known that anthropogenic pollution and habitat degradation negatively affect many species communities [45]. When these pollution elements change ecological conditions even slightly, fragile species that cannot tolerate this change may disappear, while leading to the invasion of cosmopolitan species. Likewise, according to data reported from recent studies, it has been determined that Lake Manyas is exposed to intense pollution by many factors [46]. Heavy metal pollution is also reported, which concerns the health of organisms that live or feed on this aquatic habitat [47]. The predominance of cosmopolitan species in the present study is also an indication of the pollution of the Lake Manyas.

As a result, the Lake Manyas (Kuş) provides a habitat that is quite rich in terms of ostracod diversity. However, its ecological integrity is under threat and necessitates conservation measures. Furthermore, the impacts of anthropogenic pollutants on this ecosystem should be closely monitored.

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