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Diversity, species composition and habitat preferences of Ostracoda (Crustacea) in seven karstic springs of varying salinity in Milas (Muğla, Turkey)

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Abstract
The paper reports a study of Ostracoda diversity in seven cold-water limestone springs in Turkey. The species composition of the Ostracoda assemblages was investigated, and the frequency of taxa was recorded. Many karstic brackish water spring have formed in the coastal carbonate formations of the Turkey. Brackish water springs have due to a distinctive aquatic faunal diversity and complex hydrologic characteristics between marine ecosystems and freshwater ecosystems. The most common species were euryhaline *Cyprideis torosa* and *Loxoconcha elliptica*, represented at six sampling sites (85.7%) and five sampling sites (71.4%), respectively. In total, the most dominant species were *C. torosa* (44.61%) and *L. elliptica* (14.37%). Data are presented based on quantitative sampling from seven springs. The obtained results once again suggested that salinity is directly or indirectly main factor determining of composition of ostracod communities in this system.

Keywords: Ecology, Brackish Spring, Ostracoda, Milas, Turkey

1. Introduction

The district of Milas (whose ancient name was Mylasa, once the capital of the Carians) has been an important historical human settlement since ancient times. Founded by the Carians in the 7th century BC, the port of the ancient city, Passala, was built on the shore of the Muhal Sea in the Sakızlık region. (Today, Hocat Lake is a part of Güllük Lagoon). The study area is located north-east of Güllük (Mandalya, Asin) Bay in the western Aegean region. Alluvia carried by the flowing waters of Sarıçay Creek, by fresh and brackish water springs, and by Hamzabey Creek into Güllük Bay have created wide sand dune on the coast of Güllük Bay. Behind this sand barrier, a lagoon has formed, the Güllük Lagoon, which extends in an east–west direction and covers an area of 200 hectares. Two small lagoons are connected to it. The area surrounding the lagoons is covered by marshes, samphire (*Salicornia*), and tamarisk (*Tamarix*). The alluvial Milas (or Avşar) Plain, found further inland from the lagoons, is today largely covered with cotton fields, corn fields, and olive trees.

Güllük Lagoon and its surrounding marshes form one of the most important wetlands in Turkey in terms of species diversity and habitat diversity. This eutrophic and mesosaline lagoon was formed from fresh and marine habitats [1], making it an attractive subject for both faunistic [1, 2, 3, 4] and floristic studies [5]. One faunistic study conducted on the ecosystem of Güllük Lagoon recorded 68 benthic species and identified nine living fish species [1]. Another study, which focused on identifying species of ostracods in the lagoons located on the Aegean coast [4], identified six species of ostracods (*Cyprideis torosa, Loxoconcha elliptica, Cytherois fischeri, Leptocythere histriana, Heterocypris salina, Potamocypris steuri*) in the Güllük lagoon. A checklist of recent marine and coastal brackish water ostracods of Turkey was given by Perçin-Paçal *et al.* [6]. Members of the class Ostracoda, one of the most diverse groups of crustaceans, are living in all aquatic ecosystems: marine, brackish, and freshwater. The ostracod species found in this region of Turkey inhabit aquatic ecosystems that are quite different from each other [4]. Brackish water springs can be found in contact zones between karstic rocks and alluvial plains. A temporary lake, Lake Karagöl, located near the village of Ovacık, is fed by the flood waters of the Sarıçay Creek in winter and spring, but is completely dry in summer as a result of its drainage channel. This lake is temporary because of dams built on Sarıçay Creek and a lack of rainfall. Seven ostracod species (*Candona neglecta*, *Ilyocypris* *bradyi*, *Cypris pubera*, *Prionocypris zenkeri*, *Hetereocypris incongruens*, *Heterocypris salina*, *Cypridopsis vidua*) were recorded in this lake by Altınsaçlı [4]. Lake Denizcik, by contrast, is a freshwater doline, and is surrounded by soluble karst rocks. Four species of ostracods (*Candona neglecta*, *Ilyocypris bradyi*, *Hetereocypris incongruens*, and *Cypridopsis vidua*) were identified in this lake [4].

Brackish waters differ from marine and inland waters in terms of salinity levels and hydrological and ecological conditions. Cold water springs of different types are also found at the boundaries of the Milas District. The most interesting point in the study area is the Güllük Lagoon, since it is fed by brackish waters from karstic springs (not far from the lagoon). The springs are located further away from the sea and at a higher altitude. The higher water flow rate and high water salinity rates make Güllük Lagoon and brackısh springs an interesting study area for research.

Many brackish water sources exist in the karstic formations of the Mediterranean and Aegean Sea coasts in Turkey. Brackish water ecosystems are ecosystems that have different levels of salinity from freshwater ecosystems and marine ecosystems. Well-known brackish bodies of water include estuaries, lagoons, endorheic lakes, saline inland seas, and coastal or inland brackish water springs. Today, human activities that are concentrated in this part of Güllük Bay, such as intensive coastal tourism, intensive farming activities, and activities of mid-market industrial facilities, pose a risk to underground and surface water sources that feed Güllük Lagoon and the brackish water springs.

The brief informations about of the physicochemical, hydrological and faunistic properties of these six brackish springs have been given by Altınsaçlı [7]. The hydrological mechanisms of these springs were examined by Barut and Gürpınar [8]. Brackish karst springs are located at contact points of an impermeable stratum and permeable limestone [8, 9]. Earlier studies determined the water budget and hydrological properties of karstic aquifers and karstic springs located in the Milas basin, and a hydrogeological circulation model was developed by Barut and Gürpınar [8].

The amounts of sodium, magnesium, potassium, calcium, chloride, bicarbonate, and carbonate ions in water are important factors in determining brackish water types. Therefore, species diversity is determined by the environmental conditions and the osmoregulation abilities of organisms (level of tolerance against the high ion concentrations) in brackish water ecosystems. The rock structures of the surrounding areas and the proximity to the sea are other decisive factors that determine the composition of aquatic animals and plant species that live in brackish habitats.

This paper outlines an ecological-based biomonitoring study conducted in six brackish water springs feeding Güllük Lagoon and one freshwater spring. The aim was to reveal the influence of these springs on the water balance of Güllük Lagoon and Hamzabey Creek. This study researched a number of issues, including: identifying the living ostracod species in karstic springs, the abundance of these species, and the biotic and abiotic factors affecting species distribution. Many invertebrate groups live in these seven karstic sources, but ostracods were selected as a representative taxon of brackish water biodiversity in part because of their potential future use in paleoecological studies.

Shells of ostracods are among the most frequently found animal remains in sedimentary deposits. Ostracods, as other microfossils, possess a great potential for the reconstruction of past environments and have applications in environmental micropaleontology. Ostracod species determined in this study could be used as indicator organisms for the determination of current and past ecological and paleoecological conditions in springs; therefore, the ostracod species in the biocoenosis and thanatocoenosis of these springs were examined.

In addition to determining the biological richness of the study area, a second aim was to identify the hydrological cycles and hydrogeological characteristics of the seven water sources, in light of the ecological problems in the lagoon area. The biological richness and water resources of Turkey have been protected by existing laws and regulations. The ecological, biological, and hydrological scientific studies that have been and will be made on these springs will provide extremely important data concerning the effectiveness of the present protection measures. In Turkey, many water sources have dried up or the amount of water has significantly decreased due to global warming, lack of rain, and the use of primitive agricultural irrigation techniques. These conditions have resulted in the disruption of the fragile and sensitive ecological balance in these water resources.

The objectives of this study are to: (a) describe the diversity and distribution of ostracods found in six karstic brackish water springs and one freshwater spring of the Milas District in Turkey; (b) determine the impact of anthropogenic and agricultural activities on the environmental health of the lagoons; (c) understand the ecological characteristics of ostracods in the seven water sources; (d) examine whether the establishing springs provide any benefits for aquatic biodiversity, and (e) discuss the conservation status of the seven springs.

2. Materials and methods

2.1 Study Sites

All seven springs investigated in this study are located in similar geological strata. Karst springs are located in the west and south-western parts of Milas District (near the Aegean Sea, in Muğla Province). The six brackish water springs near Avşar, Ekinanbarı, Savranköy, Akyol and İçmeköy villages and one freshwater spring near the village of Karacahisar village are all located in Milas District (Fig 1). The brackish water springs are in contact zones between karstic rocks and the alluvial plain formed from silt from Sarıçay Creek, Hamzabey Creek, and small streams in summer. The sampling sites numbers correspond to those in Fig 1.

Characteristics of these springs, based on observations made in the present study and in previous studies [8, 9, 10, 11] are given in Table 1. The data from the MTA [12] indicate that the karstic springs located within the study area are composed of rocks belonging to the Cenozoic (Tertiary, Neogene, Quaternary), Mesozoic (Triassic), and Paleozoic (Permian) epochs.

İçmeköy Spring: Also called Sepetçiler Spring, this brackish water spring is located (37º18'26.6" N 27º44'02.6" E) in İçmeköy county (4 km from the center of Milas District) (Fig. 1). It is a rheocrene spring and is located in a contact zone of Milas limestone, formed from Mt. Sodra (556 m) and the silt layer of Avşar Plain. The bottom is covered by sand and calcareous stones. The water of this slope flows at different speeds. The brackish water of the spring flows into the brackish Acıçay Creek, whose edges are stone walls and whose water flows into Güllük Lagoon. The spring has been converted into a man-made fountain by DSI (State Hydraulic Works) for use by land-based fish farms. The flow of the spring water is higher in the rainy winter and spring periods, and decreases or completely dries up in the summer period. The bottom of the spring is covered equally by fine sand and gravel substrata. The macrophyte species *Phragmites australis* (Cav.) Trin. ex Steud. (Common reed) grows around the spring and its flow channel. The banks of the spring are covered by shrubby plants (*Tamarix* sp.) and trees (*Olea europea*). *Potamon ibericum tauricum* (Czerniavsky 1884) is an abundant aquatic animal species in this spring.

Savranköy Spring: This brackish water spring is located (37º 17'42.9''N 27º 44' 11.6''E) in Savranköy county (3.5 km from the center of Milas District) (Fig 1). The brackish water of this spring flows into Acıçay Creek, similar to İçmeköy Spring. The macrophyte species *Phragmites australis* (Cav.) Trin. ex Steud. (Common reed) grows around the spring and its flow channel. The spring water has been used by land-based fish farms, and is a rheocrene spring. It is located in a contact zone of Milas limestone, formed from Mt. Sodra (556 m) and a silt layer from Avşar Plain, again similar to İçmeköy Spring [8]. The bottom is covered by sand and calcareous stones. The banks of the spring are covered by shrubby plants (*Tamarix* sp.) and trees (*Olea europea*).

Zeytintepe Spring: This brackish water spring is located (37º 15' 50.6" N 27º 43'51.1" E) in Baharlı county (4.5 km from the center of Milas District) (Fig. 1). Zeytinköy spring is located on the same line with İçmeköy spring. Waters of this spring accumulates in a small natural pool. After, water of natural pool flows through to Acıçay by a springbrooks. Macrophytic species growing around the spring include *Phragmites Australis* (Cav.) Trin. ex Steud. (Common reed) and *Nasturtium officinale* (watercress). The banks of the spring are covered by shrubby plants (*Tamarix* sp.) and trees (*Olea Europea).* The spring water has been used by land-based fish farms. It is a rheocrene spring and is located in a contact zone of permeable Milas limestone, formed from Mount Sodra (556 m) and an impermeable silt layer **(**stratum) from Avşar Plain, similar to İçmeköy Spring [8]. The bottom is covered by sand and calcareous stones. *Potamon ibericum tauricum* (Czerniavsky 1884) is an abundant aquatic animal species in this spring.

Avşar Spring: This brackish water spring is located (37º 10' 18, 8" N 27º 47' 52.8" E) in Avşar county (10 km from the center of Milas District). Also known as Gümbüldek spring, it is a rheocrene spring, and is located in a contact zone of Kalınağıl Formation limestone and a silt layer from Avşar Plain [8]. The water flow changes seasonally. The banks of the spring are covered by shrubby plants (*Tamarix* sp.) and trees (*Olea europea*). Macrophytic species in the spring include *Nasturtium officinale* R. Br. (watercress), *Carex riparia* Curtis (greater pond sedge), *Myriophyllum spicatum* L. (Eurasian watermilfoil), *Lemna minor* L. (common duckweed), P*hragmites australis* (Cav.) Trin. ex Steud. (Common reed), *Typha latifolia* L. (common cattail), and *Potamogeton pectinatus* L. (sago pondweed). *Nasturtium officinale* R. Br. (watercress), a leaf vegetable rich in nutritional substances, is collected from this spring t nd sold at local and street markets.
Güllük Lagoon is fed by flowing water from this spring. Water enters the lagoon in the spring and winter months as rain infiltrates the subsurface soil and rock; thus, the seasonal variability in water flow velocity is probably due to the increase of underground water levels. The bottom is covered by sandy-mud and calcareous stones. *Potamon ibericum tauricum* (Czerniavsky 1884) is an abundant species in this spring.

Ekinanbarı Kaynağı: This brackish water spring is located (37º14'42.5" N 27º41'08.8" E) in Ekinanbarı county (10 km from the center of Milas District). The brackish water of this spring is discharged from allochthonous limestone strata into a stream [8]. It is a rheocrene spring, whose water flows from a man-made channel into Acıçay Creek. The spring water has been used by land-based fish farms. Macrophyte species in this spring include *Nasturtium officinale* R. Br. (watercress) and *Phragmites australis* (Cav.) Trin. ex Steud. (Common reed). The banks of the spring are covered with shrubby plants (*Tamarix* sp.) and trees (*Olea europea).* The bottom is covered by sand and calcareous stones. *Potamon ibericum tauricum* (Czerniavsky 1884) is an abundant species in this spring.

Akyol Kaynağı: This brackish water spring is located (37º 13' 24.3" N 27º 41' 11.2" E) in Akyol county (11.5 km from the center of Milas District). It is a rheocrene spring. The brackish water of this spring is discharged from the bottom of allochthonous limestone strata [8]. The spring has a small natural pool, and water of this pool flows into Hamzabey Creek by a little springbrook. Macrophytic species (*Phragmites australis* (Cav.) Trin. ex Steud. (common reed), *Potamogeton pectinatus*, and *Nasturtium officinale*) were observed in the spring. The banks of the spring are covered by shrubby plants (*Tamarix* sp. *Vitex agnus-castus* L., *Nerium oleander* L.) and trees (*Olea Europea).* The bottom is covered by sand and calcareous stones. *Potamon ibericum tauricum* (Czerniavsky 1884) is an abundant species in this spring.

Suçıkan Spring: This freshwater spring is also located (37º 10' 18.8''N 27º 47' 52.8''E) in Karacahisar county (13 km from the center of Milas District). The fresh water of this spring is one of the important water supplies of Hamzabey Creek. Water flow speed varies according to season, but the spring has never yet dried up. Hamzabey Creek water flows through to Avşar Plain via a limestone canyon. It is a rheocrene spring that flows from fractures located in a contact zone of allochthonous calcareous rocks and Neogene sedimentary rocks [8].
Drinking water is provided to the nearby villages by a water pump station at this spring, and the area around the spring is used as a recreational area. The bottom is covered by sand and calcareous stones. The banks of the spring are covered by shrubby plants (*Nerium oleander* L., *Vitex agnus-castus* L.) and trees (*Olea europea, Platanus orientalis* L., *Pinus brutia* Ten., *Salix alba* L.), and the spring itself contains watercress (*Nasturtium officinale* W.T. Aiton.) Except Ostracoda, species belonging to the Amphipoda, Decapoda, Insecta (Chironomidae and Trichoptera), Gastropoda and Oligochaeta were identified in this spring. One fish species, determined as *Oxynoemacheilus* sp. was observed. *Potamon ibericum tauricum* (Czerniavsky 1884) is abundant crab species in this spring.
The maximum and minimum values of the physicochemical parameters measured in the seven karstic springs, other identified features of these springs, and the findings of Barut & Gürpınar [8] are given and compared in Table 1.
The general characteristics of the seven karstic springs of Milas are given in Table 1, including a comparison of hydrological data from previous studies [8] and the present

study.

The maximum and minimum values of the physicochemical parameters measured in the seven karstic springs, other identified features of these springs, and the findings of Barut & Gürpınar [8] are given and compared in Table 1.

Sarıçay Creek and Hamzabey Creek are the two major running water sources forming Güllük Lagoon. Sarıçay Creek is the most important water source used for agricultural irrigation in Avşar Plain since it causes all existing streams in the basin to flow towards Sarıçay. Soil levees (man-made embankments built along the edge of a canal) have been built on the banks of the two creeks to prevent flooding. The DSI has also built many drainage channels in Avşar Plain to prevent the pumping of brackish artesian well water into the fish production pools by fish farms on land; the waste waters of these pools are discharged into creeks and Güllük Lagoon by these channels.

The main canal of flowing brackish water is called Acıçay Creek. A large portion of the reed fields surrounding Güllük Lagoon dried up after excavating the drainage channels.

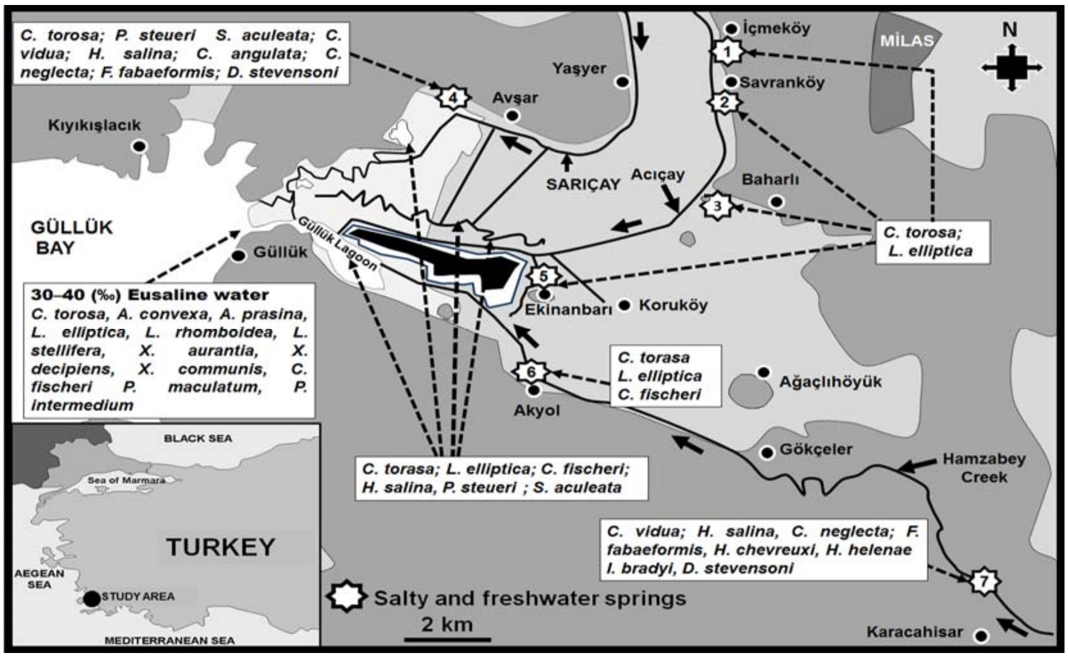

Fig 1: Map showing the location of the study area (sampling sites marked with asterisk) in Milas District and the ostracod species composition in sampling sites

Table 1. Comparison of hydrological data from past studies and the present study. Abbreviations: 1: findings of Barut & Gürpınar [8]; 2: findings of the Barut [9]; 3: findings of the present study; 4: according to the salinity classification of Gasse *et al.* [13]; 5: according to the classification of brackish waters (Venice System) [14], DV (L/s): Drainage Velocity (liter/second), Alt: Altitude, Tw(°C): Water temperature, S: PSU, Salinity(‰), EC: Electrical conductivity.

	İçmeköy	Savranköy	Zeytintepe	Avşar	Ekinanbarı	Akyol	Suçıkan
Coordinates	37º18'26.6''N 27º44'02.6''E	37º17'42.9''N 27º44'11.6''E	37º15'50.6''N 27º43'51.1''E	37º17'30.6''N 27º39'45,9''E	37º14'42.5''N 27º41'08.8''E	37º13'24,3''N 27º41'11.2''E	37º10'18,8''N 27º47'52.8''E
Alt. (a.s.l. m) (1)	20	10	-	10	10-50	20	95
Alt. (a.s.l. m) (2)	14	14	14	7	9	16	110
DV (l/s) (1)	3	4-5	-	0.5-1	6-10	1-5	10-12
DV (l/s) (2)	-	4215	-	1000	5385	-	400
DV (l/s) (3)	800	4020	1300	1100	3992	1100	950
T_w (ºC) (1)	18	19	-	18	17	17.5	15
T_w (ºC) (3)	16.9-24.6	18.5-22.2	15.6- 20.5	18- 21.8	18-20.5	15.5-23.5	15.7-22.5
EC (mS/cm) (1)	18	15	-	7-14	7.5-14	9-10	0.6
EC (mS/cm) (3)	15.2-21.4	15.8-22.9	10.05-15.62	6.69-7.23	13.2-15.88	9.79-12.1	0.23- 0.87
‰S (1)	15	10-19	-	10	7.5	15	0.5
‰S (3)	10-13.5	10-13.4	7.9-9.2	3.1-3.6	7.2-9.3	6-6.9	0-0.2
pH (1)	7.5	7.8	-	7.8	7.5	7.5-	7.2
pH (3)	7.35-7.53	7.35- 7.47	7.1-7.59	7.35-7.47	7.61-7.79	7.1-7.66	6.7-7.48
Water Type (1, 2)	Na, Cl, HCO_3	Na, Cl, HCO_3	-	Na, Cl, HCO_3	Na, Cl, HCO_3	Na, Cl, HCO_3	Mg, HCO_3
Water Type (2, 3)	Na, Cl	Na, Cl	Na, Cl	Na, Cl	Na, Cl	Na, Cl	Ca, Mg, HCO_3)
Sediment Type (1)	-	-	-	-	-	-	-
Sediment Type (3)	Sand, Gravel	Sand, Gravel	Sand, Gravel	Sand, Gravel	Sand, Gravel	Sand, Gravel	Sand, Gravel
Salinity classification (3, 4, 5)	Mesohaline	Mesohaline	Mesohaline	Oligohaline	Mesohaline	Mesohaline	Freshwater
Salinity classification (3, 5)	α- Mesohaline	α- Mesohaline	β- Mesohaline	α- Oligohaline	β- Mesohaline	β- Mesohaline	Limnetic
Salinity classification (3, 5)	α- Mesohaline	α- mesohaline, polymixohaline	-	β- Mesohaline	β- Mesohaline	α- Mesohaline	β- Oligohaline

Sarıçay Creek is the most polluted water flowing into Güllük Lagoon. Wastes and pollutants, caused by agricultural and industrial activities in Milas District, directly or indirectly reach Güllük Bay. Fish aquaculture (sea bream and sea bass) is conducted by 130 land-based fish farms located in or near the brackish water springs. Together, the fish farms have a production capacity of 5541 tons [15, 16].

Olive oil production is the most important income-generating economic activity in Milas District. Of 18 olive oil factories, 12 are located in the drainage basin of Sarıçay Creek and seven in the drainage basin of the Hamzabey Creek. Wastewater discharged from the 18 olive oil factories and the Yeniköy Thermal Power Plant negatively affects existing life in the two creeks and in Güllük Lagoon.

An ornithological study was carried out in Güllük Lagoon by Ertan *et al.* [17]. The lagoon has gained Important Bird Area (IBA) status due to the large number of small cormorant (*Phalocrocorax pygmaeus*) that rest in the lagoon during migration [18].

A hydraulic model of the brackish water springs in the Milas District is shown in Fig. 2.

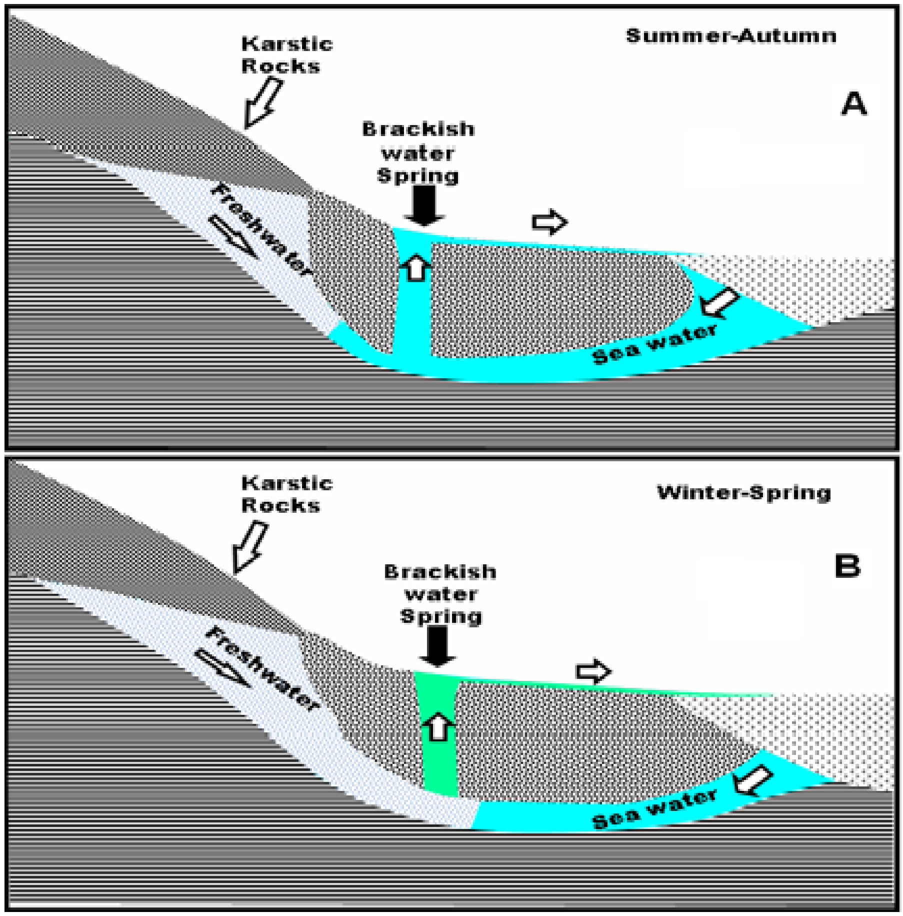

Fig 2: Schematic representation of the hydraulic model of the brackish water springs in Milas. Freshwater and seawater enters brackish water springs in two ways: **A)** the seawater inlet is greater than the freshwater inlet in the springs (as in İçmeköy, Savranköy, Zeytintepe, Avşar, Ekinanbarı, and Akyol springs); **B)** the freshwater inlet is greater than the seawater inlet in the spring (as in the Avşar spring).

2.2. Sampling and Laboratory Techniques

Ostracods and surface sediments were collected from the shallow littoral zone (<1 m) at each site using a hand net (250 µm mesh size). Two hundred milliliters of sediment (with submerged aquatic plants) were collected from a depth of 10 to 60 cm (ca. 1 m 2 of area) using a standard hand net (250 µm mesh size). The collected samples were kept in polyethylene jars (250 ml bottles) containing 4% formaldehyde solution and fixed *in situ*. In the laboratory, samples were washed with pressurized tap water, and separated from sediment using four standardized sieves (2.0, 1.5, 0.5, and 0.25 mm mesh size). Subsequently, specimens were preserved in 70% ethanol and glycerine (1:1 ratio) and the retained material transferred to a Petri dish. Ostracod dissections were prepared following the procedure of Namiotko *et al.* [19]. The number of adult and juvenile individuals belonging to each identified ostracod species was counted under a stereomicroscope. Specimens were determined using the taxonomic publications by Bronshtein [20], Mordukhai-Boltovskoi [21], Barbeito-Gonzales [22], Hartmann & Puri [23], Bonaduce *et al.* [24], Breman [25], Stambolidis [26], Athersuch *et al.* [27], Yassini [28], Meisch [29], and Karanovic [30]. Various invertebrate and vertebrate animal species and macrophyte species other than ostracod species were identified to the lowest possible taxon (Table 2). These data were not used for statistical analysis. This data were not used for statistical analysis.

The total numbers of individuals of ostracod species (including adult and juvenile) were counted in each surface sediment sample collected by hand net. Subfossil ostracod shells simultaneously observed in the same surface sediments were investigated like the adult and juvenile ostracod samples.

Table 2: Species list of other fauna and flora collected with ostracod species from Güllük Lagoon, Acıçay Creek, and seven karstic springs.

Other floral and faunal components of Güllük Lagoon, Acıçay, Seven Karstic springs	
FAUNA	**REPTILIA**
POLYCHAETA	*Emys orbicularis* (Linnaeus, 1758)
Hediste diversicolor (O.F. Müller, 1776)	*Natrix natrix* (Linnaeus, 1758)
Heteromastus filiformis (Claparède, 1864)	**AVES**
Perinereis cultrifera (Grube, 1840)	*Pelecanus onocrotalus* L. 1758
CRUSTACEA	*Pelecanus crispus* Bruch, 1832
Amphipoda	*Anas strepera* L. 1758
Gammarus aequicauda (Martynov, 1931)	*Anas platyrhynchos* L. 1758
Gammarus crinicornis Stock, 1966	*Netta rufina* (Pallas, 1773)
Gammarus subtypicus Stock, 1966	*Fulica atra* L. 1758
Isopoda	*Egretta alba* L. 1758
Idotea baltica (Palas, 1772)	*Egretta garzetta* (L. 1776)
Sphaeroma serratum (Fabricius, 1787)	*Anser anser* L. 1758
Tanaidecea	*Phoenicopterus ruber* L. 1758
Leptochelia savignyi (Krøyer, 1842)	*Glareola pratincola* L. 1766
Tanais cavolini Milne-Edwards, 1829	*Phalacrocorax pygmeus* Pallas, 1773
Tanais filiformis Lilljeborg, 1864	*Phalacrocorax carbo* (L. 1758)
Decapoda	**FLORA**
Upogebia pusilla Petanga, 1792	*Juncus littoralis* C.A.Mey.
Carcinus aestuarii Nardo, 1847	*Juncus maritimus* Lam.
Potamon ibericum tauricum (Czerniavsky, 1884)	*Phragmites australis* (Cav.) Trin. ex Steudel
MOLLUSCA	*Ruppia maritima* L.
Bivalvia	*Polygonum amphibium* L
Cerastoderma glaucum (Poiret, 1789)	*Tamarix* sp.
Abra ovata (Philippi, 1846)	*Salicornia* sp.
Gastropoda	*Nasturtium officinale* R. Br. ,
Bittium reticulatum (da Costa, 1778)	*Carex riparia* Curtis
Theodoxus fluviatilis (Linnaeus, 1758)	*Myriophyllum spicatum* L.
Hydrobia acuta (Draparnaud, 1805)	*Lemna minor* L.
Hydrobia ventrosa (Montagu, 1803)	*Typha latifolia* L.
PISCES	*Potamogeton pectinatus* L.
Chelon labrosus (Risso, 1826)	*Nasturtium officinale* R. Br.
Liza ramada (Risso, 1826)	
Liza saliens (Risso, 1810)	
Mugil cephalus (Linneaus, 1758)	
Solea solea Linneaus, 1758	
Sarpa salpa (L. 1758)	
Anguilla anguilla (L. 1758)	

The total numbers of individuals of ostracod species (including adult and juvenile) were counted in each surface sediment sample collected by hand net. Subfossil ostracod shells simultaneously observed in the same surface sediments were investigated like the adult and juvenile ostracod samples.

Physicochemical variables were measured seasonally for all seven springs in the Milas District. At each spring, several physicochemical parameters, including water temperature (ºC), salinity (‰), pH, dissolved oxygen (mg/L), oxygen saturation (%) and electrical conductivity (mS/cm) were measured *in situ* with handheld model WTW 340i multimeter equipment before sampling. The data on physico-chemical environmental variables, ostracod species, and number of ostracod specimens for each spring are shown in Table 3. Each spring was monitored at seasonal intervals.

2.3 Data analysis

Correlation between species, environmental variables, and species and environmental variables were analysed with a two-tailed nonparametric Spearman Correlation analysis using the SPSS 10.0 software program [31]. Significant results were determined at 0.01 and/or 0.05 critical levels.

The ostracod species at the sampling sites were classified using the Bray-Curtis similarity coefficient to construct dendrograms. Species richness and diversity of the sampling sites were calculated using the Shannon Weaver diversity index.

Binary (presence–absence) data was used to show relationships among species by means of the Bray-Curtis Jaccard's Coefficient of non-weighted pair group mean averages (UPGMA), as analysed with the Multivariate Statistical Package (MVSP) Version 3.1 [32].

Table 3: Data on physico-chemical environmental variables, ostracod species, and number of ostracod specimens in each spring (Abbreviations: pH; DO (mg/L): dissolved oxygen; T (w) (°C): water temperature; EC (mS/cm): electrical conductivity; %S: oxygen saturation; Sal. (PSU=‰): salinity; CT: *Cyprideis torosa*; LE: *Loxoconcha elliptica*; CF: *Cytherois fischeri*; PS: *Potamocypris steueri*; SA: *Sarscypridopsis aculeata;* CV*: Cyridopsis vidua;* HS*: Hetereocypris salina;* CA*: Candona angulata;* CN*: Candona neglecta;* FF*: Fabaeformiscandona fabaeformis;* HC*: Herpetocypris chevreuxi;* HH*: Herpetocypris helenae;* IB*: IIyocypris bradyi;* DS*: Darwinula stevensoni*.

Sampling Sites	T(w)	pH	Sal.	EC	DO	%S		CT	LE	CF	HS	CA	CN	FF	SA	PS	CV	HC	HH	IB	DS
Sta.1 05.01.08	17.1	7.4	10	15.2	4.61	47.9		13	6	0	0	0	0	0	0	0	0	0	0	0	0
St.1 24.02.08	17.5	7.5	10	16.4	4.59	47.4		21	10	0	0	0	0	0	0	0	0	0	0	0	0
St.1 30.03.08	17.2	7.4	11	17.6	4.68	48.5		25	14	0	0	0	0	0	0	0	0	0	0	0	0
St.1 20.04.08	17.8	7.5	12	19.7	4.55	49.2		70	37	0	0	0	0	0	0	0	0	0	0	0	0
St.1 18.05.08	18.5	7.5	13	22	4.75	51.4		120	70	0	0	0	0	0	0	0	0	0	0	0	0
St.1 20.06.08	20.6	7.5	14	22.3	4.65	49.5		200	110	0	0	0	0	0	0	0	0	0	0	0	0
St.1 19.07.08	24.6	7.5	13	21.4	4.74	49.8		198	95	0	0	0	0	0	0	0	0	0	0	0	0
St.1 24.08.08	22.5	7.4	13	21.1	4.98	53.3		170	65	0	0	0	0	0	0	0	0	0	0	0	0
St.1 27.09.08	23	7.4	13	21.1	4.81	51.6		65	34	0	0	0	0	0	0	0	0	0	0	0	0
St.1 25.10.08	22.6	7.4	13	22.2	4.84	52.5		40	19	0	0	0	0	0	0	0	0	0	0	0	0
St.1 23.11.08	17	7.5	12	19.6	4.65	47.2		30	13	0	0	0	0	0	0	0	0	0	0	0	0
St.1 20.12.08	16.9	7.4	10	15.7	4.71	48.5		14	8	0	0	0	0	0	0	0	0	0	0	0	0
Average	19.6±2.9	7.4±0.1	12±1	19.5±2.4	4.71±0.1	49.7±2.0	Tot.	966	481	0	0	0	0	0	0	0	0	0	0	0	0
St.2 05.01.08	18.5	7.4	10	15.8	6.3	74.2		8	3	0	0	0	0	0	0	0	0	0	0	0	0
St.2 24.02.08	19.6	7.4	10	16.2	6.51	76.1		15	4	0	0	0	0	0	0	0	0	0	0	0	0
St.2 30.03.08	19.8	7.4	11	16.6	6.66	79.1		19	6	0	0	0	0	0	0	0	0	0	0	0	0
St.2 20.04.08	19.8	7.4	11	18.6	5.9	70		35	24	0	0	0	0	0	0	0	0	0	0	0	0
St.2 18.05.08	20.3	7.4	13	21.4	5.81	64.6		50	31	0	0	0	0	0	0	0	0	0	0	0	0
St.2 20.06.08	21.8	7.4	13	21.5	5.82	64.6		100	43	0	0	0	0	0	0	0	0	0	0	0	0
St.2 19.07.08	22	7.5	13	21.7	5.83	65		135	36	0	0	0	0	0	0	0	0	0	0	0	0
St.2 24.08.08	22.2	7.5	13	21.9	5.85	69.1		96	23	0	0	0	0	0	0	0	0	0	0	0	0
St.2 27.09.08	21.7	7.4	13	21.4	5.8	64.2		56	14	0	0	0	0	0	0	0	0	0	0	0	0
St.2 25.10.08	21.3	7.4	13	22.9	5.8	64		34	12	0	0	0	0	0	0	0	0	0	0	0	0
St.2 23.11.08	20.5	7.4	12	21	5.85	69.3		22	6	0	0	0	0	0	0	0	0	0	0	0	0
St.2 20.12.08	19.5	7.4	11	18.5	5.9	70.1		10	3	0	0	0	0	0	0	0	0	0	0	0	0
Average	20.6±1.2	7.4±0.0	12±1	19.8±2.5	6.00±0.5	69.2±5.1	Tot.	580	205	0	0	0	0	0	0	0	0	0	0	0	0

Table 3: (Continued)

Sampling Sites	T(w)	pH	Sal.	EC	DO	%S		CT	LE	CF	HS	CA	CN	FF	SA	PS	CV	HC	HH	IB	DS
St. 3 05.01.08	16.0	7.10	7.9	10.05	3.30	57.3		11	2	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 24.02.08	16.3	7.21	7.9	14.12	3.20	60.2		13	5	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 30.03.08	17.0	7.35	8.0	14.75	3.70	69.7		21	7	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 20.04.08	17.7	7.41	8.0	14.82	4.21	73.3		26	21	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 18.05.08	17.5	7.43	8.1	14.85	4.30	75.3		32	24	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 20.06.08	18.0	7.45	8.4	15.10	4.45	77.3		90	27	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 19.07.08	19.5	7.56	8.7	15.15	4.52	77.6		77	30	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 24.08.08	20.5	7.60	9.1	15.41	4.56	80.0		71	22	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 27.09.08	21.0	7.59	9.1	15.43	4.61	82.5		65	8	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 25.10.08	18.5	7.56	9.2	15.62	4.70	85.1		31	5	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 23.11.08	16.4	7.35	8.6	14.56	3.41	63.4		19	2	0	0	0	0	0	0	0	0	0	0	0	0
St. 3 20.12.08	15.6	7.30	8.0	14.38	3.32	58.5		15	2	0	0	0	0	0	0	0	0	0	0	0	0
Average	17.8±1.8	7.41±0.16	8.4±0.5	14.52±1.5	4.02±0.59	71.7±9.7	Tot.	471	155	0	0	0	0	0	0	0	0	0	0	0	0
St.4 05.01.08	18.0	7.37	3.1	6.69	4.30	45.5		4	0	0	6	5	4	2	6	3	6	0	0	0	2
St.4 24.02.08	18.2	7.38	3.2	7.00	4.45	46.0		7	0	0	7	12	4	4	5	2	7	0	0	0	4
St.4 30.03.08	18.3	7.36	3.2	7.10	4.50	47.2		13	0	0	5	16	6	6	7	4	8	0	0	0	6
St.4 20.04.08	18.3	7.35	3.3	7.40	4.65	49.1		16	0	0	4	21	5	6	6	5	15	0	0	0	7
St.4 18.05.08	18.5	7.35	3.4	7.50	4.76	51.5		25	0	0	15	45	12	10	10	10	50	0	0	0	11
St.4 20.06.08	18.5	7.36	3.4	7.72	4.80	50.9		35	0	0	35	34	28	16	17	25	100	0	0	0	13
St.4 19.07.08	19.5	7.41	3.6	7.10	4.73	51.0		42	0	0	22	25	21	15	24	36	60	0	0	0	9
St.4 24.08.08	21.5	7.45	3.6	7.11	4.71	50.6		36	0	0	13	14	15	12	18	21	54	0	0	0	6
St.4 27.09.08	21.8	7.47	3.6	7.11	4.70	52.4		28	0	0	10	8	12	9	16	10	45	0	0	0	5
St.4 25.10.08	20.3	7.39	3.5	7.23	4.80	52.3		22	0	0	8	6	7	8	10	8	20	0	0	0	3
St.4 23.11.08	20.0	7.39	3.5	7.20	4.85	52.3		12	0	0	6	2	3	7	12	6	10	0	0	0	3
St.4 20.12.08	18.1	7.35	3.5	7.11	4.83	52.3		7	0	0	3	3	3	6	9	3	7	0	0	0	3
Average	19.2±1.4	7.39±0.04	3.4±0.2	7.19±0.26	4.67±0.17	50.1±2.5	Tot.	247	0	0	134	191	120	101	140	133	382	0	0	0	72

Table 3: (Continued)

Sampling Sites	T(w)	pH	Sal.	EC	DO.	%S		CT	LE	CF	HS	CA	CN	FF	SA	PS	CV	HC	HH	IB	DS
St.5 05.01.08	18.1	7.6	7.2	13.3	5.7	83.3		12	4	0	0	0	0	0	0	0	0	0	0	0	0
St.5 24.02.08	18.3	7.7	7.5	13.3	6	89.1		17	6	0	0	0	0	0	0	0	0	0	0	0	0
St.5 30.03.08	18.5	7.7	7.9	13.3	6.3	90		25	6	0	0	0	0	0	0	0	0	0	0	0	0
St.5 20.04.08	18.7	7.6	7.9	13.2	6.4	90.4		31	7	0	0	0	0	0	0	0	0	0	0	0	0
St.5 18.05.08	19.2	7.6	8.1	13.5	6.65	92.5		43	13	0	0	0	0	0	0	0	0	0	0	0	0
St.5 20.06.08	19.3	7.6	8.9	14.9	6.6	92.7		56	8	0	0	0	0	0	0	0	0	0	0	0	0
St.5 19.07.08	19.5	7.7	9	15.4	6.55	91.6		50	5	0	0	0	0	0	0	0	0	0	0	0	0
St.5 24.08.08	20.2	7.8	9.3	15.9	6.4	90.6		45	4	0	0	0	0	0	0	0	0	0	0	0	0
St.5 27.09.08	20.5	7.7	8.9	14.9	6.42	90.2		34	4	0	0	0	0	0	0	0	0	0	0	0	0
St.5 25.10.08	19.1	7.7	8.6	13.6	4.75	60.6		28	3	0	0	0	0	0	0	0	0	0	0	0	0
St.5 23.11.08	18.2	7.7	7.9	13.3	4.56	57.5		11	3	0	0	0	0	0	0	0	0	0	0	0	0
St.5 20.12.08	18	7.7	7.8	13.3	4.5	55		15	3	0	0	0	0	0	0	0	0	0	0	0	0
Average	19.0±0.8	7.7±0.1	8.2±0.7	14.0±1.0	5.9±0.8	82.0±15	Tot.	367	66	0	0	0	0	0	0	0	0	0	0	0	0
St.6 05.01.08	16.2	7.1	6	9.79	4.5	59		12	2	0	0	0	0	0	0	0	0	0	0	0	0
St.6 24.02.08	16.5	7.2	6.1	10.1	5.2	85.2		14	5	0	0	0	0	0	0	0	0	0	0	0	0
St.6 30.03.08	17.2	7.4	6.2	10.7	4.7	69.7		21	4	0	0	0	0	0	0	0	0	0	0	0	0
St.6 20.04.08	17.8	7.4	6.2	10.8	4.21	56.3		32	7	0	0	0	0	0	0	0	0	0	0	0	0
St.6 18.05.08	21	7.5	6.3	11.7	3.53	30.1		45	11	6	0	0	0	0	0	0	0	0	0	0	0
St.6 20.06.08	21.6	7.5	6.3	11.8	3.2	29.9		60	7	4	0	0	0	0	0	0	0	0	0	0	0
St.6 19.07.08	23.5	7.5	6.4	11.3	3.5	28.8		45	6	3	0	0	0	0	0	0	0	0	0	0	0
St.6 24.08.08	23.1	7.5	6.4	11.3	3.48	28.6		40	4	2	0	0	0	0	0	0	0	0	0	0	0
St.6 27.09.08	23	7.6	6.5	11.8	3.49	28.7		31	4	2	0	0	0	0	0	0	0	0	0	0	0
St.6 25.10.08	17.3	7.7	6.9	12.1	3.63	44.6		25	2	0	0	0	0	0	0	0	0	0	0	0	0
St.6 23.11.08	16	7.3	6.6	11.7	4.1	50.1		17	2	0	0	0	0	0	0	0	0	0	0	0	0
St.6 20.12.08	15.5	7.3	6.3	11	4.12	50.4		16	2	0	0	0	0	0	0	0	0	0	0	0	0
Average	19.1±3.1	7.4±0.2	6.4±0.2	11.2±0.7	3.97±0.6	46.8±19	Tot.	358	56	17	0	0	0	0	0	0	0	0	0	0	0

Table 3: (continued)

Sampling Sites	T(w)	pH	Sal.	EC	DO	%S		CT	LE	CF	HS	CA	CN	FF	SA	PS	CV	HC	HH	IB	DS
St.7 05.01.08	16.4	6.7	0	0.34	4.56	65.2		0	0	0	3	0	11	10	0	0	10	7	3	4	5
St.7 24.02.08	15.7	7.1	0	0.29	4.79	72.2		0	0	0	3	0	13	16	0	0	13	6	3	3	5
St.7 30.03.08	16.8	7.2	0	0.31	5.3	85.2		0	0	0	4	0	20	20	0	0	12	6	4	2	6
St.7 20.04.08	16.5	7.5	0	0.23	4.78	71.3		0	0	0	5	0	26	30	0	0	22	8	5	8	7
St.7 18.05.08	16.6	7.5	0	0.43	4.07	52.4		0	0	0	9	0	48	60	0	0	70	16	13	15	11
St.7 20.06.08	17.3	7.5	0	0.47	4.2	55.4		0	0	0	22	0	42	78	0	0	140	12	10	22	13
St.7 19.07.08	18.6	7.6	0.1	0.6	4.71	59.2		0	0	0	12	0	28	34	0	0	87	9	12	12	14
St.7 24.08.08	21.5	7.6	0.2	0.87	4.52	58.2		0	0	0	10	0	14	22	0	0	64	8	6	8	10
St.7 27.09.08	22.5	7.6	0.1	0.75	4.56	65.2		0	0	0	9	0	9	7	0	0	34	7	5	4	9
St.7 25.10.08	21.3	7.5	0.1	0.73	4.04	50.4		0	0	0	6	0	8	6	0	0	22	6	4	4	6
St.7 23.11.08	17.5	7.4	0	0.45	4.35	59.5		0	0	0	3	0	9	4	0	0	14	4	3	2	8
St.7 20.12.08	17	6.9	0	0.35	4.62	70.1		0	0	0	2	0	6	3	0	0	7	2	2	2	8
Average	18.1±2.3	7.3±0.3	0.0±0.1	0.48±0.2	4.54±0.3	63.7±9.9	Tot.	0	0	0	88	0	234	290	0	0	497	91	70	86	102
							F. Tot.	2989	963	17	222	191	354	391	140	133	879	91	70	86	174

The relationship between ostracod site assemblages was examined using UPGMA (Unweight Pair Group method with Arithmetic Mean) hierarchical clustering based on Bray Curtis similarity coefficient (Multivariate Statistical Package (MVSP) Version 3.1 [32]. Bray-Curtis cluster analysis was used to obtain the species-sampling sites and sampling sites-species similarity in sampling sites (log (x+1) transformation was done before the analysis) [33]**.**

The Shannon-Weaver index, which combines information on species richness (number of species) and how individuals are distributed among species, was calculated. A living ostracod species database of seasonal samples from the seven sampling sites of Milas county was calculated by means of the (log2) Shannon-Weaver index H') [34].

Canonical Correspondence Analysis (CCA), a gradient analysis technique, was used to examine the relationship between environmental variables and species. Faunistic and environmental data were analysed by canonical correspondence analysis (CCA) [35, 36]. In the ordination procedure, four physicochemical variables were used. Variables affecting species distribution were, in order of importance according to CCA: redox potential, pH, percent oxygen saturation, dissolved oxygen, electrical conductivity, salinity, and water temperature.

3. Results

A total of 6700 specimens belonging to 14 ostracod species (*Cyprideis torosa* (Jones 1850), *Loxoconcha elliptica* (Brady 1868), *Cytherois fischeri* (Sars 1866), *Darwinula stevensoni* (Brady & Robertson 1870), *Potamocypris steueri* (Klie 1935), *Sarscypridopsis aculeata* (Costa 1847), *Cypridopsis vidua* (O. F. Müller 1776), *Heterocypris salina* (Brady 1868), *Candona angulata* (G.W. Müller 1900), *Candona neglecta* (Sars 1887), *Fabaeformiscandona fabaeformis* (Fischer 1851), *Herpetocypris chevreuxi* (Sars 1896), *Herpetocypris helenae* (G. W. Müller 1908), *Ilyocypris bradyi* (Sars 1890)) were identified from karstic springs (six brackish and one freshwater springs).

These comprised 12 genera and seven families (Cytherideidae, Loxonconchidae, Paradoxostomatidae, Darwinulidae, Cyprididae, Candonidae and Ilyocyprididae). The most common species in the seven karstic springs was *C. torosa* (six sites, 85.7%), followed by *Loxoconcha elliptica* (five sites, 71.4%), then *H. salina*, *D. stevensoni*, *C. neglecta*, *F. fabaeformis* (two sites, 28.5%), *C. fischeri, C. angulata, S. aculeata, P. steueri, C. vidua, H. chevreuxi, H. helenae,* and *I. bradyi* (one site, 14.2%). The predominant species in the seven karstic springs was *C. torosa* (2889 individuals, 44.61%) followed by *L. elliptica* (963 individuals, 14.37%), then *C. vidua* (879 individuals, 13.12), *F. fabaeformis* (391 individuals, 5.84%), *C. neglecta* (354 individuals, 5.28%), *H. salina* (222 individuals, 3.32%), *C. angulata* (191 individuals, 2.85%), *D. stevensoni* (174 individuals, 2.6%), *S. aculeata* (140 individuals, 2.09%), *P. steueri* (133 individuals, 1.98%), *H. chevreuxi* (91 individuals, 1.36%), *I. bradyi* (86 individuals, 1.28%), *H. helenae* (70 individuals, 1.05%), and *C. fischeri* (17 individuals, 0.25%). The highest number of ostracod individuals was obtained from Avşar Spring (1520 specimens, 22.62%) followed by Suçıkan Spring (1458 specimens, 21.77%), İçmeköy Spring (1447 specimens, 21.61%), Savranköy spring (758 individual, 11.73%), Zeytintepe Spring (626 specimens, 9.35%), Ekinanbarı Spring (433 specimens, 6.47%), and Akyol Spring (431 specimens, 6.45%). A total of 14 ostracod samples were collected from the seven karstic springs (Fig. 1), with a salinity ranging from 0.0 psu to 13 psu. The list of species and their coded abundance at each sampling point and season are presented in Fig. 1 and Table 2. The most impoverished sites as far as the number of species and individuals are concerned were sampling sites 3, 6, 7, 9 and 12. At all these sites, a maximum number of three species was recorded, which almost always (with the exception of sampling site 3) included *C. torosa*, accompanied usually by *H. salina*. Water temperature, pH, DO, salinity, and electrical conductivity values did not show strong seasonal changes (Table 2). The highest pH value (6.7) was recorded at sampling site 7 and the lowest (7.8) at sampling site 5. The highest temperature value (24.6 °C) was recorded at sampling site 1 and the lowest (15.5 °C) at sampling site 6. The highest salinity value (14‰) was recorded at sampling site 1 and the lowest (0%) at sampling site 7. The highest dissolved oxygen value (6.66 mg/L) was recorded at sampling site 1 and the lowest (3.20 mg/L) at sampling site 3 and 6. The highest dissolved oxygen saturation value (92.7 mg/L %) was recorded at sampling site 5 and the lowest (28.6 mg/L %) at sampling site 6. The highest electrical conductivity value (22.9 mS/cm) was recorded at sampling site 2 and the lowest (0.23 mS/cm) at sampling site 7. Correlations observed between physicochemical variables and identified ostracod species from the seven springs are shown in Table 4.

Table 4: Spearman correlations among the environmental variables and ostracod species. Codes are the same as in Table 1. High correlations ($P < 0.05$) are indicated in bold face. **Correlation is significant at the (*p < 0.05, **p < 0.01) level (2-tailed).

	$T_{(w)}$	pH	SAL.	EC	DO	%S
$T_{(w)}$	1	0.470(**)	0.356(**)	0.360(**)	0.318(**)	-0.065
pH	0.470(**)	1	0.240(*)	0.250(*)	0.160	0.161
SAL.	0.356(**)	0.240(*)	1	0.991(**)	0.383(**)	0.133
EC	0.360(**)	0.250(*)	0.991(**)	1	0.372(**)	0.135
DO	0.318(**)	0.160	0.383(**)	0.372(**)	1	0.564(**)
%S	-0.065	0.161	0.133	0.135	0.564(**)	1
CT	0.564(**)	0.403(**)	0.682(**)	0.694(**)	0.197	-0.004
LE	0.319(**)	0.307(**)	0.850(**)	0.866(**)	0.206	0.137
CF	0.350(**)	0.162	-0.112	-0.092	-0.375(**)	-0.409(**)
HS	-0.039	-0.225(*)	-0.756(**)	-0.755(**)	-0.097	-0.225(*)
CA	0.079	-0.263(*)	-0.403(**)	-0.401(**)	0.019	-0.361(**)
CN	-0.103	-0.238(*)	-0.777(**)	-0.778(**)	-0.095	-0.168
FF	-0.101	-0.246(*)	-0.775(**)	-0.776(**)	-0.083	-0.166
SA	0.095	-0.252(*)	-0.399(**)	-0.401(**)	0.031	-0.351(**)
PS	0.093	-0.254(*)	-0.400(**)	-0.400(**)	0.030	-0.353(**)
CV	-0.059	-0.218(*)	-0.767(**)	-0.765(**)	-0.098	-0.194
HC	-0.195	-0.073	-0.604(**)	-0.603(**)	-0.151	0.094
HH	-0.187	-0.066	-0.603(**)	-0.602(**)	-0.152	0.093
IB	-0.191	-0.070	-0.603(**)	-0.602(**)	-0.154	0.091
DS	-0.039	-0.203	-0.773(**)	-0.769(**)	-0.150	-0.229(*)

(*p<0.05, **p<0.01)

The correlation between identified ostracods species in seven karstic springs is shown in Table 5.

Table 5: Correlation between identified ostracods species in seven karstic springs. Correlations with absolute values *p < 0.05 and **p < 0.01 are enhanced in bold.

	CT	LE	CF	HS	CA	CN	FF	SA	PS	CV	HC	HH	IB	DS
CT	1	0.774(**)	0.210	-0.50.(**)	-0.095	-0.538(**)	-0.544(**)	-0.089	-0.086	-0.520(**)	-0.605(**)	-0.605(**)	-0.605(**)	-0.511(**)
LE	0.774(**)	1	0.080	-0.778(**)	-0.510(**)	-0.778(**)	-0.778(**)	-0.510(**)	-0.510(**)	-0.778(**)	-0.510(**)	-0.510(**)	-0.510(**)	-0.766(**)
CF	0.210	0.080	1	-0.156	-0.102	-0.156	-0.156	-0.102	-0.102	-0.156	-0.102	-0.102	-0.102	-0.040
HS	-0.500(**)	-0.778(**)	-0.156	1	0.677(**)	0.983(**)	0.982(**)	0.679(**)	0.680(**)	0.993(**)	0.601(**)	0.603(**)	0.602(**)	0.946(**)
CA	-0.095	-0.510(**)	-0.102	0.677(**)	1	0.576(**)	0.581(**)	0.994(**)	0.996(**)	0.612(**)	-0.165	-0.165	-0.165	0.560(**)
CN	-0.538(**)	-0.778(**)	-0.156	0.983(**)	0.576(**)	1	0.996(**)	0.577(**)	0.579(**)	0.994(**)	0.702(**)	0.702(**)	0.701(**)	0.953(**)
FF	-0.544(**)	-0.778(**)	-0.156	0.982(**)	0.581(**)	0.996(**)	1	0.584(**)	0.584(**)	0.991(**)	0.697(**)	0.696(**)	0.696(**)	0.947(**)
SA	-0.089	-0.510(**)	-0.102	0.679(**)	0.994(**)	0.577(**)	0.584(**)	1	0.999(**)	0.614(**)	-0.165	-0.165	-0.165	0.554(**)
PS	-0.086	-0.510(**)	-0.102	0.680(**)	0.996(**)	0.579(**)	0.584(**)	0.999(**)	1	0.616(**)	-0.165	-0.165	-0.165	0.557(**)
CV	-0.520(**)	-0.778(**)	-0.156	0.993(**)	0.612(**)	0.994(**)	0.991(**)	0.614(**)	0.616(**)	1	0.668(**)	0.669(**)	0.668(**)	0.955(**)
HC	-0.605(**)	-0.510(**)	-0.102	0.601(**)	-0.165	0.702(**)	0.697(**)	-0.165	-0.165	0.668(**)	1	0.999(**)	1.000(**)	0.671(**)
HH	-0.605(**)	-0.510(**)	-0.102	0.603(**)	-0.165	0.702(**)	0.696(**)	-0.165	-0.165	0.669(**)	0.999(**)	1	0.999(**)	0.672(**)
IB	-0.605(**)	-0.510(**)	-0.102	0.602(**)	-0.165	0.701(**)	0.696(**)	-0.165	-0.165	0.668(**)	1.000(**)	0.999(**)	1	0.671(**)
DS	-0.511(**)	-0.766(**)	-0.040	0.946(**)	0.560(**)	0.953(**)	0.947(**)	0.554(**)	0.557(**)	0.955(**)	0.671(**)	0.672(**)	0.671(**)	1

Water temperature, electrical conductivity, salinity, pH, oxygen saturation and dissolved oxygen were found at expected levels in in the course of this study in the seven springs.
A high positive correlation was determined between *C. torosa* and *L. elliptica* and salinity. A high negative correlation was determined between all other ostracod species and salinity. Weakly negative correlation was noted between the *C. fisheri* and salinity, which may reflect the low number of individuals of this species. High negative correlation was observed between *C. torosa* and *L. elliptica* and all other ostracod species, except *C. fisheri*.

The results from the Shannon-Weaver diversity index indicated that the highest level of diversity in the seven karstic springs was found at sampling site 4 (3.067) in January and the lowest at sampling site 6 (0.381) in October (Table 6). The highest biodiversity values were measured in İçmeköy and Akyol springs in May, in Savranköy and Zeytintepe springs in April, in Avşar and Suçıkan springs in January, and in Ekinanbarı spring in February (See Table 6). The lowest biodiversity values were measured in İçmeköy, Savranköy, Ekinanbarı, and Suçıkan springs in August, in Zeytintepe spring in December, in Avşar spring in July, and in Akyol spring in October (see Table 6).

Table 6: Shannon Weaver Diversity index values in spring, summer, fall and winter (Abbreviations: H'log2= Shannon-Weaver diversity index)

Sites/ Dates	Shannon H' log 2	Sites/ Dates	Shannon H' log 2	Sites/ Dates	Shannon H' log 2	Sites/ Dates	Shannon H' log 2
Sta.1.	0.917	Sta.2. Jan.	0.845	Sta.4. Jan.	3.067	Sta.6. Jan.	0.592
Sta.2.	0.828	Sta.2. Feb.	0.742	Sta.4. Feb.	3.016	Sta.6. Feb.	0.831
Sta.3.	0.807	Sta.2. Mar.	0.795	Sta.4. Mar.	3.024	Sta.6. Mar.	0.634
Sta.4.	2.994	Sta.2. Apr.	0.975	Sta.4. Apr.	2.918	Sta.6. Apr.	0.679
Sta.5.	0.616	Sta.2. May	0.960	Sta.4. May	2.848	Sta.6. May	1.104
Sta.6.	0,789	Sta.2. Jun.	0.882	Sta.4. Jun.	2.868	Sta.6. Jun.	0.769
Sta.7.	2.630	Sta.2. Jul.	0.742	Sta.4. Jul.	0.439	Sta.6. Jul.	0.803
		Sta.2. Aug.	0.708	Sta.4. Aug.	2.892	Sta.6. Aug.	0.678
		Sta.2. Sept.	0.722	Sta.4. Sept.	2.829	Sta.6. Sept.	0.788
		Sta.2. Oct.	0.828	Sta.4. Oct.	2.940	Sta.6. Oct.	0.381
		Sta.2. Nov.	0.750	Sta.4. Nov.	2.956	Sta.6. Nov.	0.485
		Sta.2. Dec.	0.779	Sta.4. Dec.	3.025	Sta.6. Dec.	0.503
Sta.1. Jan.	0.900	Sta.3. Jan.	0.619	Sta.5. Jan.	0.811	Sta.7. Jan.	2.836
Sta.1. Feb.	0.907	Sta.3. Feb.	0.852	Sta.5. Feb.	0.831	Sta.7. Feb.	2.703
Sta.1. Mar.	0.942	Sta.3. Mar.	0.811	Sta.5. Mar.	0.709	Sta.7. Mar.	2.630
Sta.1. Apr.	0.930	Sta.3. Apr.	0.992	Sta.5. Apr.	0.689	Sta.7. Apr.	2.665
Sta.1. May	0.949	Sta.3. May	0.985	Sta.5. May	0.782	Sta.7. May	2.593
Sta.1. Jun.	0.938	Sta.3. Jun.	0.779	Sta.5. Jun.	0.544	Sta.7. Jun.	2.401
Sta.1. Jul.	0.909	Sta.3. Jul.	0.856	Sta.5. Jul.	0.439	Sta.7. Jul.	2.513
Sta.1. Aug.	0.851	Sta.3. Aug.	0.789	Sta.5. Aug.	0.408	Sta.7. Aug.	2.401
Sta.1. Sept.	0.928	Sta.3. Sept.	0.499	Sta.5. Sept.	0.485	Sta.7. Sept.	2.464
Sta.1. Oct.	0.907	Sta.3. Oct.	0.581	Sta.5.Oct.	0.459	Sta.7. Oct.	2.613
Sta.1. Nov.	0.884	Sta.3. Nov.	0.454	Sta.5. Nov.	0.750	Sta.7. Nov.	2.726
Sta.1. Dec.	0.946	Sta.3. Dec.	0.523	Sta.5. Dec.	0.650	Sta.7. Dec.	2.753

The UPGMA dendrogram (Fig. 3), constructed from the species occurrence data, revealed four major clustering groups.

When constructed based on the presence/absence of ostracod species, the UPGMA dendrograms showed that ostracod species from the springs formed two clustering groups (Fig. 3). Based on species occurrence, UPGMA was able to cluster 13 species into two groups (Fig. 3) with three brackish species (*C. torosa, L. elliptica, C. fischeri*) in the first group and eleven continental brackish (*P. steueri, S. aculeata, C. vidua, H. salina, C angulata, C. neglecta, F. fabaeformis, H. chevreuxi, H. helenae, I. bradyi, D. stevensoni*) in the second group. Some species in the second group (e.g., *H. salina, P. steueri* and *C. angulata*) have clear tolerance to salinity.

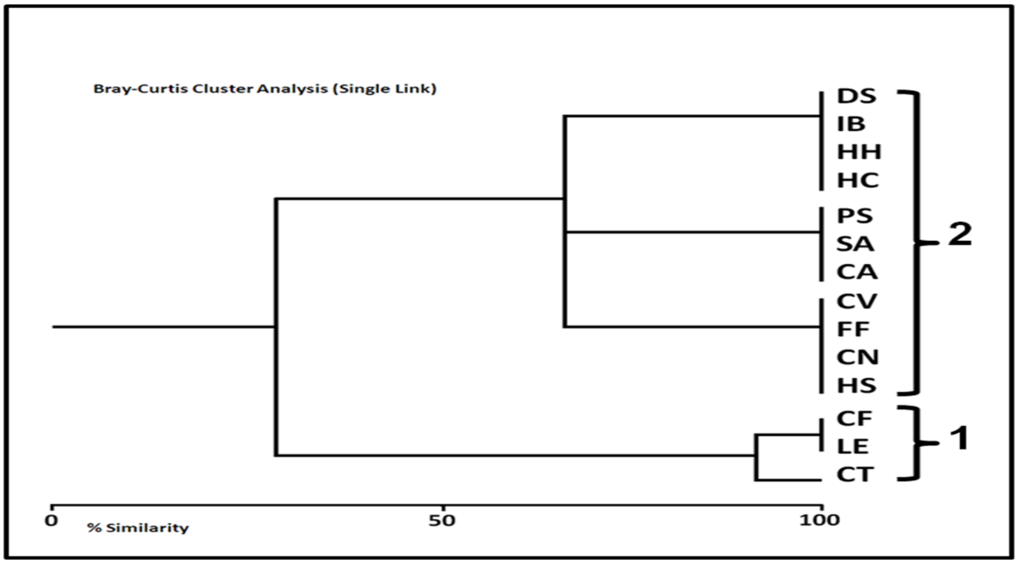

Fig 3: Dendrogram showing similarity of ostracod species on the basis of their presence– absence in seven springs during the study period.

The UPGMA dendrogram created according to species similarity of the seven springs shows that springs are formed two clustering group (Fig. 4).

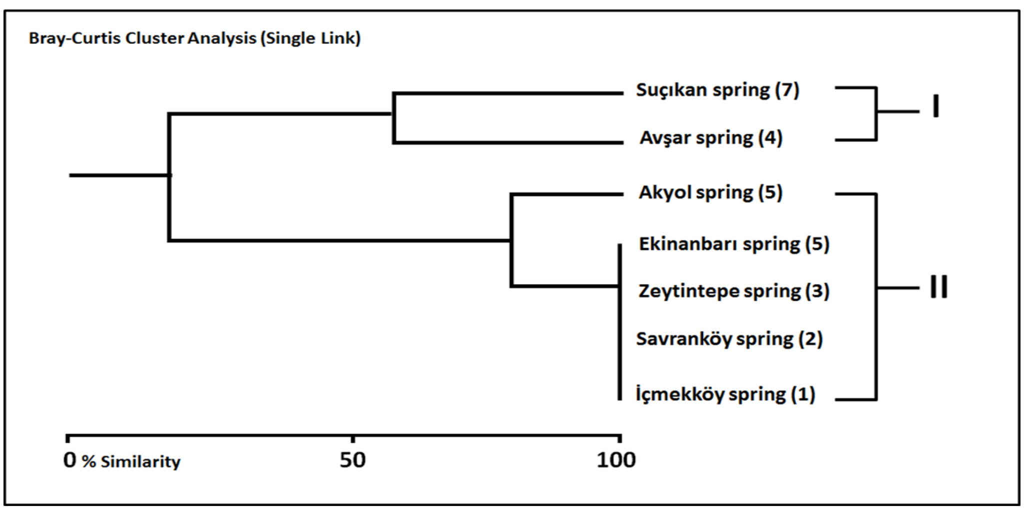

Fig 4: Dendrogram is showing similarities of ostracod species determined in the seven springs

Based on species occurrence, UPGMA was able to cluster 7 springs into two groups (Fig. 4) with two slightly brackish (oligohaline)-fresh water (limnetic) sampling sites (Avşar, Suçıkan) in first group and five brackish water sampling sites (İçmeköy, Savranköy, Zeytintepe, Ekinanbarı, Akyol) in the second in two groups. Canonical Correspondence Analysis (CCA), a gradient analysis technique, was used to examine the relationship between environmental variables and species. Main results of CCA are shown in Table 7 and triplot graph of CCA is shown in Fig. 5.

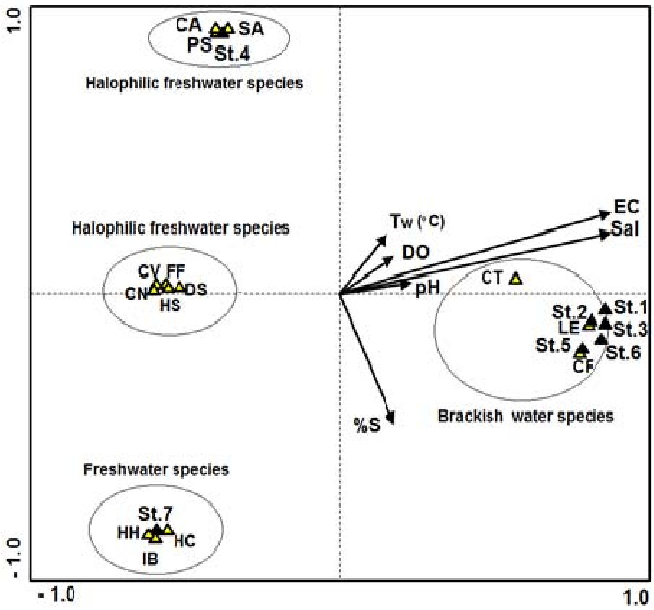

Fig 5: Canonical Correspondence Analysis (CCA) biplot of ostracod species and forward- selected environmental variables from samples taken in seven karstic sources (Species codes are as in Table 3. Yellow triangles: Ostracod species. Black triangles: Sampling site)

Table 7: Summary of results from CCA performed on the entire dataset

CCA	1	2	3	4	Total inertia
Eigenvalues	0.871	0.355	0.222	0.000	1.528
Species-environment correlations	0.999	1.000	0.873	0.160	
Cumulative percentage variance					
of species data	57.0	80.2	94.8	94.8	
of species-environment relation	60.1	84.6	100.0	100.0	
Sum of all eigenvalues					1.528
Sum of all canonical eigenvalues					1.448

Many brackish water sources, wetlands and salt marshes are located within the borders of Muğla province. However, during this study and previously field surveys some ostracod species have been determined from the brackish water sources, brackish wetlands and salt marshes located in Muğla province (Table 8).

Table 8: Ostracod species have been determined from the brackish water sources, brackish wetlands and salt marshes located in Muğla province in during this study and previously field surveys. (HB: *Heterocypris barbara* (Gauthier & Brehm, 1928), LI: *Limnocythere inopinata* (Baird, 1843), PP: *Paralimnocythere psammophila* (Flossner, 1965); IB: *Ilyocypris biplicata* (Koch, 1838), Abbreviations of other species are as in the Table 3).

Sampling sites	Coordinates	CT	LE	CF	DS	PS	SA	CV	HS	CA	CN	FF	HC	HH	IB	LP	HB	LI
Kadın Creek	37° 03' 15.98" N 28°20' 25.40"E	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+
Sülüngür Gölü	36° 47' 17.90" N 28°38' 30.74"E	+	+	+		+	+		+									
Ala Lake	36° 49' 03.80" N 28°36' 27.10"E	+	+	+			+	+	+			+						
Sülüklü Lake	36° 49' 26.75" N 28°37' 08.99"E	+	+		+	+	+	+	+	+	+	+	+		+			+
Akçapınar Creek	37° 01' 53.94" N 28° 20' 17.92"E	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
Kocagöl Lake	36° 40' 52.35" N 28°49' 31.55"E	+	+	+			+	+	+									
Küçük Dalyan Lake	36° 41' 34.78" N 28°48' 04.74"E	+	+	+			+	+	+	+								
Orhaniye Creek	36° 45' 21.77" N 28° 08' 01.35"E	+	+	+														
Akgöl Lake	36° 42' 01.57" N 29° 02' 10.85"E	+	+	+			+	+	+	+								
Sarıgerme Kükürtlü Lake	36° 43' 22.69" N 28° 45' 14.01"E								+									
Katlıç Lake	36° 41' 11.12" N 29° 03' 55.56"E	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Thermaris Kükürtlü Lake	36° 41' 38.29" N 28° 47' 26.28"E								+									
Aksaz Creek Mouth	36° 52' 38.87" N 28° 27' 39.27"E	+	+		+			+	+			+						
Çamlıköy wetland	36° 49' 03.80" N 28° 36' 27.10"E	+	+	+	+		+	+	+	+	+	+	+	+	+	+		
Karacasöğüt coastal wetland	36° 54' 27.07" N 28° 10' 10.73"E	+	+	+	+		+	+	+									
Karacasöğüt coastal wetland	36° 55' 06.74" N 28° 08' 40.01"E	+	+	+	+		+	+	+									
Datça Ilıca Spring	36° 03' 09.74" N 27° 41' 10.58"E	+																
İztuzu Lake	36° 46' 43.97" N 28° 37' 59.92" E	+	+															
Hisarönü Azmak Creek	36° 48' 21.60" N 28° 07' 28.96" E	+	+		+	+	+	+	+	+	+	+	+	+	+	+		+

Ostracod species have been previously reported from two lakes (Sülüngür and Kocagöl=Kapıkargın) among all wetlands shown in Table 8 by Altınsaçlı [4].

4. Discussions

C. torosa and *L elliptica* were the most abundant species, with up to 2889 specimens and 963 individuals per sample (518 and 337 specimens collected, respectively, for the whole study). The salinity rate can vary from the hypersaline to oligosaline in the habitats found of *Cyprideis torosa* [37]. *C. torosa* shows tolerance to conditions of saline, brackish, and freshwater habitats such as hypersaline lagoons, brackish lagoon, salt marshes, estuaries, and pure freshwater ponds. This species is used as an indicator organism for identification of brackish water. It is probably the species that best tolerates the highest salinities in European continental waters, which can be as much as 180 g/L [38]. Likewise, the presence of this species has been reported in many shallow coastal wetlands in the European coast [29]. In areas where salinity levels fall below < 5‰, the phenotypic tubercles are present on shells of this species [37, 39, 40, 41, 42]. This species-specific feature for this species therefore gives information about salinity changes in the past. *C. torosa* was described in a saltpan (with together *L. elliptica*) where salinity exceeded 65‰ [43, 44] and in the shallow, hypersaline, athalassic Acıgöl Lake [45]. It was also recovered from the pure freshwater (0.0 psu) conditions of the Gemiç spring that feeds Lake Acıgöl [45]. In addition, this species was found in salinities ranging to from hypersaline to oligosaline in fourteen coastal wetlands of Turkey [4].

In the present study, the smooth form (*C. torosa* forma *littoralis*) of *Cyprideis torosa* was found in both the biocoenosis and thanatocoenosis of mesosaline İçmeköy, Savranköy, Zeytintepe and Ekinanbarı springs. The noded shell form (*C. torosa* forma *torosa*) of *Cyprideis torosa* was found in the biocoenosis of the mesosaline (3.1-3.6‰) Avşar spring. The smooth and noded shell forms of this species were found in the thanatocoenosis of this same spring. This case clear shows that water salinity of Avşar spring exceeds 5‰ in low rainfall years. Avşar Spring has the highest freshwater input among the other five brackish water springs (See Fig. 2b). Apart from Avşar spring, the rate of sea water entering groundwater aquifers is greater than the proportion of freshwater in the other five brackish water springs (See Fig. 2a).

Evaluation of benthic material allowed useful knowledge about the ostracod community and population ecology to us. The benthic sediment plays an important role in releasing nutrients to the overlying water column. Nutrient-rich muddy or sandy-muddy substrates are preferred as a habitat by *Cyprideis torosa*. However, this species has been determined on entirely sandy substrates and on algae [29]. In the present study, individuals of *C. torosa* were sampled from nutrient-poor, sand y, and gravelly substrates of İçmeköy, Savranköy, Zeytintepe, Avşar, Ekinanbarı, and Akyol springs. Ostracod species were collected from nutrient-poor, sandy, and gravel substrates of sampling sites 1, 2, 3, 4, 5, and 6. The numbers of *C. torosa* individuals varied between 20,000 and 40,000 individuals/m2 [46]. The maximum abundance of this species was 1.8 million individuals (including adult and adolescent forms)/m2 [46]. The highest number of individuals (966 individuals) of this species was found on the sandy-gravel substrate of İçmeköy spring and the lowest number (247 individual) in the freshwater input of Avşar spring. Its densities increased in summer and decreased in autumn and winter. This species also has a wide distribution in the coastal water of Aegean Seas [4, 22, 47, 48]. *C. torosa* were recorded in the Baltic Sea [49], lagoons and estuaries on the shore of Mediterranean Sea [29, 50, 51, 52], and coastal waters of the Black Sea [53, 54, 55].

The results of earlier studies [4, 55] and this present study shows that in the same living space, number of individuals of *Cyprideis torosa* are greater than individual number of *L. elliptica*. Some earlier studies [4, 55] performed in Turkey determined that the highest numbers of individuals of *C. torosa* and *L. elliptica* were found in the local populations inhabiting detritus-rich muddy substrates. However, lower numbers of individuals of these two species were determined in sandy-gravel substrates of all brackish springs when compared to rich muddy substrates.

A powerful stream occurs, depending on the water flow of the spring. Ostracods are not generally good swimmers, so the low population density of these species is an expected result for this study. According to these results, the presence of gravel-sandy and nutrient- poor substrates can have negative influences on the numbers of individuals in the population of the two species. In other words, both species lack the ability to create very large populations in sandy-gravel habitats. *Cyprideis torosa* preserves its eggs and larvae from hypersaline environments with egg brood chambers. This is one of the most important morphological characteristics for the continuation of the lineage of this species. Table 1 shows the abundance of the two species common to the seven karstic springs studied here. Two euryhaline and halophilic species (*C. torosa* and *L. elliptica*) were common in coastal brackish habitats around of Aegean Sea and Mediterranean Sea. In the present study, *L. elliptica* was only found in mesohaline water. These results once again show that these species are very euryhaline, with significant correlations between their presence and the salinity range.

Loxoncha elliptica was frequently found in the salinity ranging between 18 and 30‰, typical of shallow coastal brackish water habitats such as lagoons, river mouths, and salt marshes, and in conjunction with *C. torosa,* which also tolerates a salinity range between 18 and 30‰ [4, 24, 27, 48, 56, 57, 58]. It was recorded previously in lagoons in Turkey [4, 48]. *Loxoconcha elliptica* tolerates high salinity (up to 65‰ salinity) as does *C. torosa* [43, 44].

Three ostracod species, *L. elliptica*, *C. torosa* and *C. fischeri*, are defined as euryhaline species [50, 51, 59, 60, 61, 62]. *L. elliptica* is the second predominant species in İçmeköy, Savranköy, Zeytintepe, Ekinanbarı and Akyol springs, after *C. torosa*; however, this species was not been found in either the oligosaline (3.1-3.6‰) Avşar spring or the freshwater Suçıkan spring. The number of individuals of *L. elliptica* is high in muddy and rich detritus substrates and lower in sandy and low detritus substrates, as determined by previous studies [4, 45, 55]. This case has been confirmed once again in the present study. The population density of this species increases in summer, whereas it decreases in autumn and winter.

Cytherois fischeri (Sars 1866) is a common and widespread brackish ostracod species that tolerates salinities from 4 to 35‰ [4, 27, 55]**.** This species was reported in Güllük Lagoon [4]. The finding of this species in the Akyol spring very close to Güllük Lagoon is expected based on the geographical proximity. A low population density for this species was determined, in agreement with previous studies [4, 55].

Darwinula stevensoni was recorded in the shallow athalassic saline Lake Acıgöl [45], and in many fresh water habitats [4, 63]. *D. stevensoni* is highly tolerant to variations in environmental conditions in North African lakes [64, 65]. It prefers high levels of oxygen to aerate the eggs and juveniles in its brood chamber**.** Freshwater habitats are preferred, but it tolerates higher salinities to some extent [66]. Recently, Van Doninck *et al.* [67] showed that *D. stevensoni* had a higher tolerance for salinity and temperature when compared to other asexual ostracods, while Rossi *et al.* [68] reported a high hypoxia tolerance for *D. stevensoni*.

Potamocypris steueri is an inhabitant of marine waters (salinity up to 10‰) in moderately warm climate regions such as the circum-Mediterranean region [69]. This species was recorded in estuaries, brackish ponds near the sea shore, and lagoons [4, 20, 69, 70, 71, 72, 73]. *P. steueri* was recorded in Güllük Lagoon, Tuzla Saltpan, and Lake Köyceğiz [4]. Avşar Spring is a typical karstic brackish water resource fed from a zone of mixed seawater and fresh groundwater in the coastal aquifer. Therefore, this species was only found in the oligosaline Avşar Spring. The large numbers of individuals of *P. steuri* were collected from a halophilic species of macrophytes, *Potamogeton pectinatus* L. (sago pondweed) [4]. In this study, individuals of this species were collected on same macrophyte species in Avşar Springs.

Cosmopolitan species such as *Sarscypridopsis aculeata* prefer slightly saline (brackish) water bodies of both inland and coastal types [29, 74, 75, 76]. *Sarscypridopsis aculeata* (Costa 1847) was recorded from brackish water of Dalyan (Poyraz) Lagoon, Arapçiftliği Lagoon and Kocagöl Lake by Altınsaçlı [4], and Lake (Lagoon) Küçükboğaz by Altınsaçlı *et al.* [55]. *S. aculeata* was found in the oligosaline water of Avşar spring, in accordance with previous findings for the characteristics of *S. aculeata*.

Heterocypris salina is known to inhabit pure freshwater and slightly saline coastal and inland waters [4, 48, 54, 55, 63, 77]. *H. salina* can tolerate salinities up to 20‰ [29]. At the same time, according to Mischke *et al.* [78], *H. salina* can tolerate the hypersaline conditions (salinity > 40‰) of the present-day salt lakes. As a cosmopolitan species tolerant to brackish water conditions and eutrophication [29], *H. salina* was found living in both freshwater (Suçıkan spring) and oligohaline conditions (Avşar spring) in the present study. This species was found living in two slowly flowing spring pools fed by mesosaline (Avşar spring) and fresh (Suçıkan spring) slowly flowing spring waters.

Candona angulata is a typical species found in freshwater and slightly brackish waters. It prefers permanent freshwater water bodies but can tolerate some salinity variations [29]. The presence of *C. angulata* is a clear indicator of the input of freshwater to underground pool of Avşar Spring, as is the presence of other ostracod species (*Potamocypris steueri, Sarscypridopsis aculeata, Cyridopsis vidua, Hetereocypris salina, Candona neglecta, Fabaeformiscandona fabaeformis* and *Darwinula stevensoni*).

Candona neglecta occurs in a wide range of habitats, including springs, lakes, slightly saline lagoons, ponds, marshes, and brooks. It can be quite tolerant of eutrophic and hypoxic conditions [29, 79, 80]. It is found in oligosaline and mesosaline habitats [81]. It inhabits swampy puddles, marshes, littoral zone of lakes, small freshwater ponds, springs, slowly flowing streams or creeks, swampy puddles, slightly saline lagoons in Turkey [4, 55, 63, 82, 83]. The faunistic records of the Altınsaçlı [4] indicate that *C. neglecta* was found in 42 important wetlands in Turkey. These faunistic records confirm that this species is clearly a common species in Turkey. It is distributed throughout the whole Holarctic region [29].

Herpetocypris chevreuxi occurs in pure freshwater as well as in slightly salty coastal and inland waters [29]. The findings of the species on Gran Canaria concur with that observation [84]. The species is distributed throughout the Holarctic [29] and Neotropical regions [85]. *H. chevreuxi* inhabits swampy puddles, marshes, the littoral zone of lakes, small freshwater ponds, springs, and slowly flowing streams or creeks [4, 55, 63, 82, 83]**.**

The phytophyllic species *Cypridopsis vidua* is a cosmopolitan species. It clearly shows a preference for ponds and the littoral zone of lakes with dense vegetation [4, 48, 55, 63, 86].This species was determined in oligosaline conditions in Turkey [48, 55]. The species can tolerate an increase in salt content [29]. The numbers of this ostracod was also significantly higher at sampling sites with low organic contents in sediments than at sampling sites with high organic content. *Heterocypris incongruens* is known to tolerate, at least temporarily, an increase in salinity up to around 16‰ [29], but it certainly cannot survive in pure marine water and only poorly in hypersaline conditions. *Heterocypris incongruens* has a cosmopolitan distribution. Males are presently only known from the circum-Mediterranean regions [29]. Altınsaçlı and Griffiths [63] and Altınsaçlı [4] states that the species is widely distributed

Despite its preference for freshwater habitats, *Darwinula stevensoni* tolerates higher salinities to some extent [66]. Recently, Van Doninck *et al.* [67] showed that *D. stevensoni* had a higher tolerance for salinity and temperature than other asexual ostracods, while Rossi *et al.* [68] reported a high hypoxia tolerance in *D. stevensoni*. It was recorded in oligosaline conditions (0.7-4.6 psu) of Sarısu Lagoon ın Turkey by Altınsaçlı *et al.* [55]. In the present study, this species was detected in freshwater (Suçıkan Spring) and oligosaline (Avşar Spring) conditions in two springs. This case once again showed that this species may tolerate varied levels of salinity.

As a poor swimmer, *llyocypris bradyi* prefers slowly flowing, cooler waters of springs and streams but is also found in ponds and swamps [29, 87]. It is widely distributed in the Holarctic region [29] and has been reported from 36 very ecologically important wetlands in Turkey [4].

The freshwater Suçıkan spring and oligosaline Avşar spring showed a higher number of species when compared to the other brackish springs. Some of the most common species (5 sampling sites), excluding cytheroids, showed a great range of tolerance to salinity, (e.g., *C. torosa* and *L elliptica).*

Avşar spring contained both the salinity tolerant freshwater ostracod species (*H. salina, C. angulata, C. neglecta, Fabaeformiscandona fabaeformis, S. aculeata, P. steuri, C. vidua, D. stevensoni*) and brackish water ostracod (*Cyprideis torosa*) assemblage due to the input of freshwater from the underground pool of the Avşar spring. By contrast, the pure freshwater Suçıkan spring contained both by cosmopolitan freshwater (*C. vidua, H. salina, D. stevensoni*) ostracod species, freshwater ostracod species (*H. salina, C. neglecta, F. fabaeformis, C. vidua, H. chevreuxi, D. stevensoni*) and a salinity tolerant (slightly saline conditions) and freshwater species (*H. helenae*).

The present study showed that the diversity of the ostracod community at sampling sites 1, 2, 3, 5 and 6 was low (2 species). Despite this situation, ostracod species diversity at sampling sites 4 (9 species) and 7 (8 species) was higher than at other sampling sites. The low numbers of species recorded at sampling sites 1, 2, 3, 5, and 6 can be attributed to the continuous input of brackish underground waters, which leads to increasing salinity concentrations and hence the dominance of just a few euryhaline species, such as *C. torosa* and *L. elliptica.*

The cause of rich species diversity in the Avşar spring compared with the other springs is the following: The typical brackish spring species, *C. torosa,* was determined together with other seven continental fresh-brackish ostracod species in the low salinity conditions of Avşar spring.

Samples collected from sea in front of Güllük lagoon revealed 12 species of ostracods (*Cyprideis torosa, Aurila convexa, Aurila prasina, Loxoconcha elliptica, Loxoconcha rhomboidea, Loxoconcha stellifera, Xestoleberis aurantia, Xestoleberis decipiens, Xestoleberis communis, Cytherois fischeri, Paradoxostoma maculatum, Paradoxostoma intermedium*) (Altınsaçlı, unpublished) (see Fig. 1).

This result shows that ostracod species diversity is rich in the marine environments while it is low in brackish water springs. By contrast, ostracod species diversity increases in oligosaline and freshwater environments. The results of Bray-Curtis Similarity analysis support this case (see Fig. 4).

According to the results of the Spearman correlation analysis, statistically significant correlations existed between the species and physico chemical parameters. The positive correlation determined between salinity and *C. torosa* and *L. elliptica* was an expected result for seawater intrusion into natural springs, because these two species are the most typical species for coastal brackish water.

Abiotic factors such as pH, dissolved oxygen, conductivity, salinity temperature, bottom substrate, water flow speed, and depth also play important roles in determining the biological diversity and abundance of bottom-dwelling (benthic) organisms like ostracods. The results of this study indicate that a meaningful and close relationship exists between ostracod assemblages, salinity, water flow, and bottom substrate type. Many studies performed on ostracods showed that salinity is one of the main controlling factors determining the distribution of ostracod species [29, 48, 50, 51, 55, 88, 89, 90].

CCA analysis results indicate that salinity and electrical conductivity are the most important environmental variables in the seven springs (see Fig.5). Also, CCA analysis showed that salinity and electrical conductivity content were significant in explaining the ostracod community composition with the set of environmental variables used. All these results once more suggest that ostracod species may be used as indicator species to understand ecological conditions.

The data for the seven karstic springs (one of freshwater and the other six brackish) indicate a significant relationship between species composition and environmental conditions. In particular, electrical conductivity and salinity appeared to have significant impacts on ostracod species composition in the seven karstic springs. These ostracods were represented by freshwater, freshwater-oligohaline, polyhaline, and mesohaline species. It is notable that results of this study are almost similar with the results of performed study on the mesosaline lagoons Akdeniz and Akbük by Altınsaçlı *et al.* [91].

The results from this study confirmed that a portion of the land-based fish farms use flowing brackish waters from the brackish springs, but many of them use brackish water obtained from artesian wells at a 20–30 meter depth. Water samples taken from artesian wells at a 5 meter depth (less than 0.5 psu) are freshwater, while artesian wells at a 10-15 meter depth deliver slightly salty water (0-5-3 psu). The water from the artesian wells at a depth of 15–50 meters is so salty (5-15 psu) it is not used in agriculture.

A decline each year is visible in the harvest of cotton (a salinity-tolerant plant) which can be grown in sodic soils. This has created a negative impact on economic activity in the region. Salt-affected soils occur near the Savranköy springs, and agricultural crops do not grow in those soils. Electrical conductivity (3.7 mScm-1) and pH (8.7) values were determined for those saline soils in the present study.

The input of seawater to ground water in Avşar plain is increasing due to decreased freshwater inputs to underground water. The reason for this is the use of surface and underground freshwaters for agricultural and municipal (domestic use) activities in this region. The expanding human population, intensive use of fresh or brackish groundwater, soil salinization, intensive mining activities, extensive agricultural practices, non-sustainable touristic activities, and discharge of massive amounts of waste water into the water bodies results in deterioration of water quality around the seven karstic springs. The results presented here would support the use of ostracod species as indicator species to understand ecological conditions and the quality of water.

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6. References

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