

Spatiotemporal Distribution and Habitat Preferences of Ostracods in the Coastal Karagöl Lagoon, Enez, Edirne, Turkey

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Abstract: Karagöl Lagoon is a shallow coastal wetland in the Province of Edirne, Turkey. It is far from settlements as well as not affected by fishing or other human activities and, therefore, its biota can be considered as a source of reference data for a coastal wetland in favourable conditions. Benthic ostracod communities were studied throughout the annual cycle (every second month) at three stations in the wetland. Two euryhaline and eurythermal ostracod species were recorded: *Cyprideis torosa* and *Loxococoncha elliptica*. They were present at all three stations and in all seasonal samples, showing substantial spatial and temporal variations. *Cyprideis torosa* was the dominant species, while *L. elliptica* was a secondary species. The abundance of *C. torosa* and *L. elliptica* was positively correlated with the air temperature, water temperature and salinity but negatively correlated with the oxygen saturation. The abundance of *C. torosa* was also positively correlated with the pH of the water.

Key words: Ostracoda, Karagöl Lagoon, distribution, ecology, Edirne

Introduction

Coastal lagoons are shallow wetlands connected to both sea and rivers (or creeks) and containing one or more inlets between sandy or manmade barriers (BARNES 1980, DAVIDSON-ARNOTT 2010). Many coastal lagoons have been exploited through intense fishing or other anthropogenic activities. Along the 8333 km of the Turkish coastline, there are 14 lagoons at the Black Sea coast, 12 at the Marmara Sea, 128 at the Aegean Sea and 17 at the Mediterranean Sea, comprising a total of 171 lagoons (ALTINSAÇLI et al. 2015a). Many lagoons were formed as a result of accumulation of alluvial sands on the seashore as a result from the flow of large and small rivers into the Aegean Sea such as the Evros (Meriç, Maritsa) River, one of the best-known running waters that flow into the Aegean Sea. These coastal formations contain a differing biota from that in both marine and fresh waters. Lagoons provide diverse habitats for ostracod species. The presence of marine species in connecting canals between the sea and lagoons as

well as the presence of freshwater species in places of water input into lagoons determines the habitat heterogeneity in coastal wetlands.

Ostracods are microcrustaceans that live in aquatic environments. They have ornamented and moving calcareous bivalved shells (carapace) that enclose the whole body and all appendages (XING et al. 2018). The distribution of ostracods is related to several environmental factors, e.g. sediment type, salinity, temperature, pH, dissolved oxygen and depth (MARTINEZ-GARCIA et al. 2013, NACHITE et al. 2010). In estuarine environments, the distribution and abundance of ostracods are affected by the freshwater input and brackish water resources. According to the ecological classification of ostracods in four main groups (ANADON et al. 2002), ostracods inhabiting lagoons and deltas belong to the coastal brackish-marine and continental brackish ecological groups. Species of the genera *Cyprideis*, *Loxococoncha*, *Leptocythere*, *Xestoleberis* and *Heterocypris* are ex-

amples of these euryhaline and eurythermal groups, which can tolerate significant seasonal variations in salinity and temperature (SALEL et al. 2016).

So far, the Karagöl Lagoon has not been exploited for fishing or other anthropogenic activities and there are no human settlements surrounding it. Its biota can be considered as a relatively well-preserved. Therefore, the examination of the diversity and structure of the ostracod communities may provide reference data for evaluating the degree of modification of the coastal wetlands in the region as a result from the human impact.

Materials and Methods

Study area

Karagöl is a choked coastal brackish lagoon. It is an Aegean transitional ecosystem in northern Turkey ($40^{\circ}37'50.35''\text{N}$, $26^{\circ}04'12.17''\text{E}$), with an area of 33.8 ha (with maximum width 474 m and maximum length 854 m) and with an average depth of 0.50 m (maximum depth is 1.5 m; Fig. 1). The Karagöl Lagoon is connected to the Aegean Sea only through a temporary small channel located on its eastern side. Freshwater inflows depend on the rain waters in the region, the temporary Karagöl Creek and other small creeks feeding the lagoon (Fig. 1). In the winter, southerly winds are particularly prevalent, causing high waves and strong winds facilitating the seawater input through the above-mentioned channel.

The creek beds in the Enez District were formed by flows during the Miocene (ÇAĞATAY et al. 1998, YALTIRAK 1996). The Karagöl Creek is such a creek bed that in the past transported alluvium to the Aegean Sea. The mouths of the Karagöl Creek and the Evros (Meriç) River have been closed as a result of sandy barriers formed by alluvium carried by these streams. Waves and currents of the Aegean Sea caused the formation of sandy barriers in the Enez Lagoon and Karagöl Lagoon, both separated from the sea by sandy barriers parallel to the shore. According to the rainfall regime classification, the area is subjected to the Western Marmara Transition Subregion (WMTS) rainfall regime. The annual average precipitation reaches 669.6 mm, 58% of which fall in winter (November – February); the lowest precipitation values are in summer. January is the coldest month, with long-term average temperatures of 5.4°C , while the hottest month is July with an average of 23.9°C (ERGINAL et al. 2007, TÜRKES 1996).

Sampling and measurements

Samples were taken from the Karagöl Lagoon using a hand net (mesh size $100\ \mu\text{m}$) in January, March,

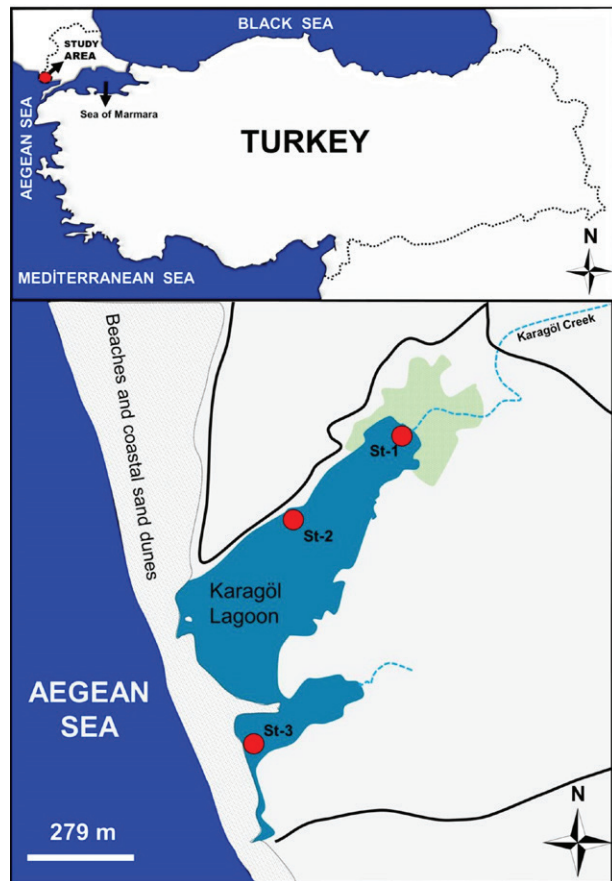


Fig. 1. Locations of sampling sites in the Karagöl Lagoon.

May, July, September and November 2016. At each site, we collected about 200 g of surface sediment, which was fixed in situ in 70% ethanol. The sediment was washed out in the laboratory under pressurised tap water and separated into five grain-size fractions using standardised sieves (2.0, 1.5, 0.5, 0.25 and $0.125\ \text{mm}$ mesh size). Ostracods were sorted under a stereomicroscope and fixed again in 70% alcohol. The soft body parts were dissected in lactophenol solution for taxonomic identification using the keys by BONADUCE et al. (1975), ATHERSUCH et al. (1989), MEISCH (2000) and FUHRMANN (2013), with taxonomy and nomenclature following the latter one. The number of adult individuals belonging to each identified ostracod species was counted. For coordinates and other characteristics of each sampling site, see Table 1.

Seven physicochemical variables, water temperature (T_w [$^{\circ}\text{C}$]), redox potential (ORP [Mv]), pH, percentage of oxygen saturation (Sat [%]), dissolved oxygen (DO [mg l^{-1}]), electrical conductivity (EC [mS/cm]) and salinity (PSU) were measured *in situ* using WTW 340i multimeter at each of the three sampling stations (Table 2). The air pressure (AP [mbar]) was measured with a digital barometer.

Table 1. Locations of the sampling stations at the Karagöl Lagoon with coordinates, depths and substrata types.

Sampling station number	Sampling stations name	Coordinates	Depth (cm)	Substrata
St-1	The north-east part of lagoon	40°38'03.48"N	50	Sandy mud
		26°04'26.28"E		
St-2	The middle part of the lagoon	40°37'56.67"N	50	Sandy mud
		26°04'14.91"E		
St-3	The close section of the lagoon to sea	40°37'36.25"N	50	Sandy mud
		26°04'10.34"E		

Table 2. Mean and standard deviation values of physicochemical parameters and the number of specimens for each ostracod species. Abbreviations: **Ta** (air temperature), **Tw** (water temperature, °C), **ORP** (standard hydrogen electrode, mV), **DO** (dissolved oxygen, mg l⁻¹), **Sat.** (saturation, %), **Sal.** (Salinity, PSU), **EC** (electrical conductivity, mS/cm), **AP** (Air pressure, mbar), **TNI** (Total number of individuals), **CT** (*Cyprideis torosa*) and **LE** (*Loxoconcha elliptica*).

Sampling site	Sampling Date	Ta	Tw	pH	ORP	DO	SAT.	SAL.	EC	AP	TNI	CT	LE
ST-1	2016 Jan.	8,3	8,53	7,46	3	7,52	95,1	9,41	15,1	1009		45	20
	2016 Mar.	11	10,5	7,52	3	7,78	98,1	9,83	16,1	1009		78	30
	2016 May	22	18,3	7,54	3	6,55	85,1	10,2	18,9	1009		320	49
	2016 July	28	25,3	7,89	3	6,54	84,1	25,3	32,2	1012		780	90
	2016 Sept.	22	22,3	7,42	3	6,51	82,1	30,2	40,5	1009		245	56
	2016 Nov	9	10,3	7,41	3	7,63	97,2	19,2	24,1	1009		67	28
Mean ±SD		15,4±7,59	15,9±6,45	7,54±0,15	3±0	7,09±0,56	90,3±6,43	17,4±8,9	24,48±10,5	1009,5±1,2	TNI	1535	273
ST-2	2016 Jan.	8,4	8,82	7,46	4	7,53	95,3	9,22	14,7	1009		50	19
	2016 Mar.	11,5	9,81	7,45	4	7,61	96,3	9,91	15,7	1009		150	32
	2016 May	22	19,3	7,51	4	6,48	75,5	10,9	18,6	1009		840	54
	2016 July	28	24,7	7,59	4	6,68	76,7	26,3	35,7	1012		1500	130
	2016 Sept.	22	21,3	7,53	4	6,62	76,3	32,2	42,12	1009		1800	102
	2016 Nov	13	11,2	7,43	4	6,53	75,2	31,2	41,3	1009		450	67
Mean ±SD		17,48±6,94	15,85±6,15	7,49±0,05	4±0	6,90±0,47	82,55±9,38	19,95±10,12	28,02±11,3	1009,5±1,2	TNI	4790	404
ST-3	2016 Jan.	9,3	9,21	7,48	-7	6,89	79,1	10,2	17,8	1009		150	62
	2016 Mar.	11,8	10,1	7,45	-7	6,89	82,1	11,2	17,7	1009		742	134
	2016 May	22	18,9	7,59	-7	6,77	76,2	12,1	19,9	1009		1200	200
	2016 July	28	25,3	7,69	-7	6,81	76,2	27,7	37,3	1012		2750	332
	2016 Sept.	22	21,8	7,58	-7	6,82	76,2	36,2	50,3	1009		2200	120
	2016 Nov	11,2	10,2	7,53	-7	6,79	76,2	31,7	47,3	1009		642	88
Mean ±SD		17,38 ±6,95	15,91 ±6,36	0,08±7,55	-7±0	0,04±6,828	2,35±77,66	10,65±21,5	31,7±26,14	1009,5±1,2	TNI	7684	936

Statistical analysis

Faunal similarity (taking into account the number of individuals from each species at each sampling station) between all the sampling stations were compared using the Bray-Curtis coefficient (BRAY & CURTIS 1957). A two-tailed Spearman rank correlation test (with SPSS 21) was used to examine the relationships between nine environmental variables and species. Canonical correspondence analysis (CCA) was used to analyse species–environment relationships in order to identify those environmental factors potentially influencing ostracod assemblages (TER BRAAK 1986). Data were analysed using the MVSP, version 3.22 (KOVACH 2013).

Results

A total of 15,622 ostracod specimens were collected in January, March, May, July, September and November 2016. Two ostracod species, *Cyprideis*

torosa and *Loxoconcha elliptica*, were identified from the three sampling stations: *Cyprideis torosa* (14,009 individuals, 89.67%) and *Loxoconcha elliptica* (1,613 individuals, 10.33%). They occurred in all the seasons and in all parts of the wetland examined (Fig. 2).

The number of individuals of ostracod species at each station was higher in May, July and September and lower in January (Fig. 2). The percentage of *C. torosa* was 85% (1,808) at station 1, 92% (5,194) at station 2 and 89% (5,194) at station 3. The relative abundance of *L. elliptica* was 15% at station 1, 8% at station 2, and 11% at station 3.

The assemblages at stations 1 and 2 were influenced by freshwater surface input, while station 3 was less influenced. The highest individual number (2,750) of *C. torosa* was counted at station 3 in July 2016 (Fig. 2). *Cyprideis torosa* was the dominant species with the highest individual numbers at all stations during all seasons.

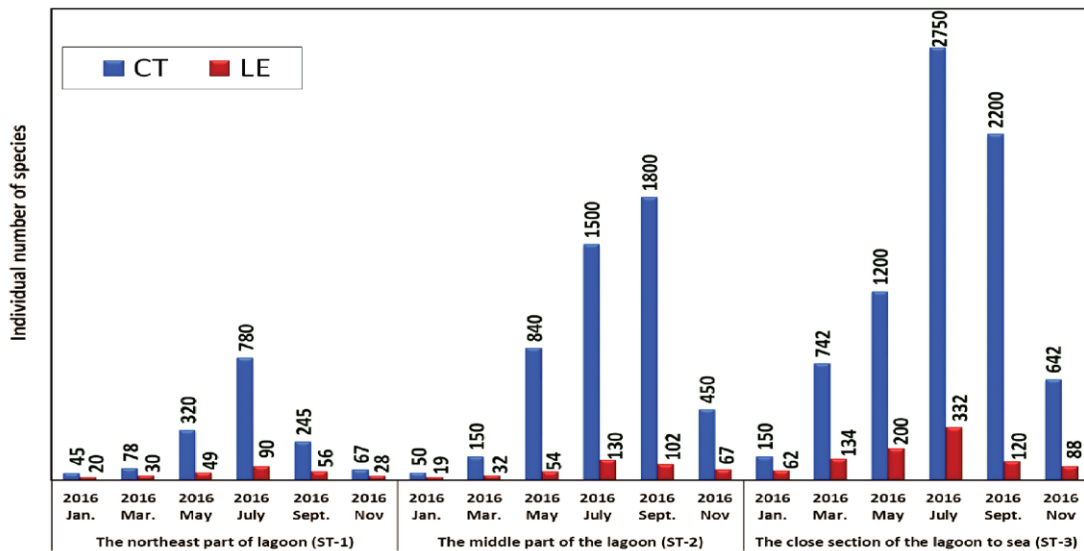


Fig. 2. Seasonal changes in the abundance of ostracod species. CT (*Cyprideis torosa*) and LE (*Loxococoncha elliptica*).

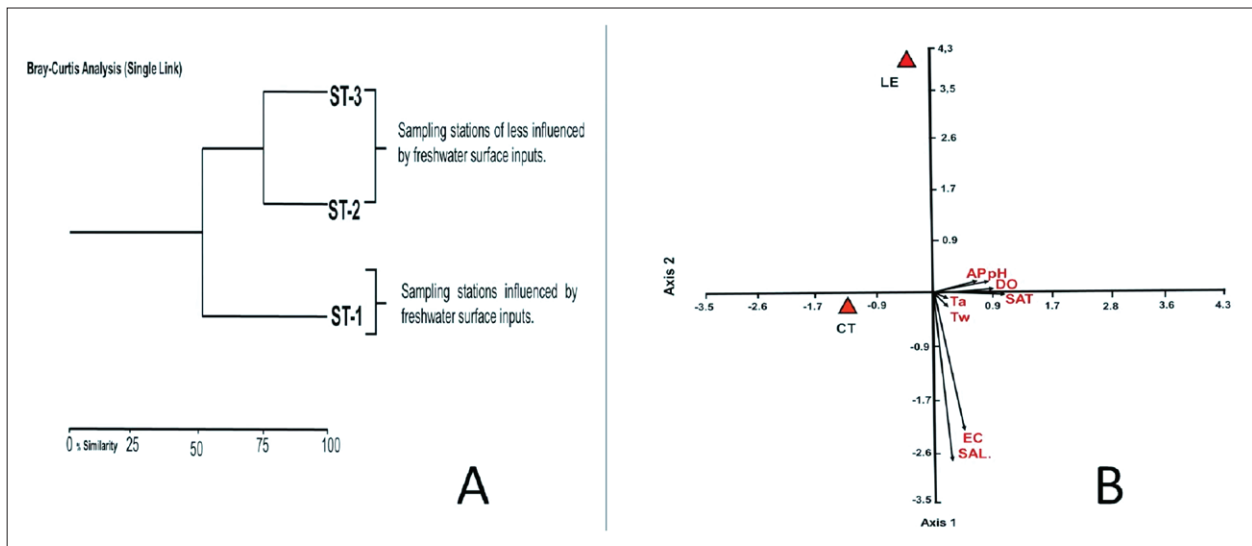


Fig. 3. A: The Bray-Curtis similarity dendrogram of the three sampling stations; B: Canonical correspondence analysis (CCA) showing the relationship between the two species (red triangle) and eight environmental variables (black arrows). For an explanation of the abbreviations and variables see Table 2.

The Bray-Curtis coefficient test revealed the greatest similarity (75.2%) between stations 2 and 3; 51.6% similarity was found between sampling station 1 and each of stations 2 and 3. The Bray-Curtis dendrogram showed (Fig. 3A) a cluster comprising sampling stations 2 and 3 and another branch containing only the sampling station 1.

As a result of the CCA analyses, salinity and EC were found to be important parameters in the study area, as seen by the length of the arrows (Fig. 3B). Both *C. torosa* and *L. elliptica* are euryhaline and eurythermal species that can tolerate wide environmental factors. The CCA results confirm that they are not significantly affected by environmental parameters in the wetland.

According to the Spearman rank correlation analysis, *C. torosa* was positively correlated with Ta, Tw, pH, SAL and EC, but negatively correlated with oxygen saturation (Table 3). A positive correlation was observed between *L. elliptica* and air temperature, water temperature and salinity; it was negatively correlated with oxygen saturation (Table 3).

Discussion

Cyprideis torosa and *L. elliptica* are found in marine, brackish and freshwaters in Turkey (ALTINSAÇLI & GRIFFITHS 2002, PERÇIN-PAÇAL et al. 2015). They were found during the entire sampling period, with *C. torosa* being more abundant. These two species

Table 3. Spearman correlation results of the species with environmental parameters (for abbreviations see Table 2) **Correlation is significant at the *p < 0.05, **p < 0.01 level (2-tailed).

	Ta	Tw	pH	ORP	DO	SAT	SAL	EC	AP	CT	LE
Ta	1,000										
Tw	,934**	1,000									
pH	,664**	,594**	1,000								
ORP	0,000	-,007	-,269	1,000							
DO	-,689**	-,627**	-,254	-,197	1,000						
SAT	-,501*	-,428	-,323	,152	,659**	1,000					
SAL	,554*	,640**	,241	-,177	-,503*	-,651**	1,000				
EC	,454	,585*	,213	-,170	-,419	-,654**	,963**	1,000			
AP	,660**	,647**	,633**	0,000	-,216	-,116	,216	,215	1,000		
CT	,846**	,773**	,676**	-,197	-,519*	-,728**	,702**	,636**	,474*	1,000	
LE	,718**	,612**	,582*	-,446	-,378	-,661**	,644**	,583*	,474*	,887**	1,000

are widespread in Turkish brackish water regions (ALTINSAÇLI 2004; ALTINSAÇLI et al 2015a; PERÇİN-PAÇAL et al. 2015). They were also found as the two most abundant ostracods in Mediterranean coastal lagoons (MARCO-BARBA et al. 2013). According to the Spearman rank correlation analyses, it seems that the most important ecological factors for the abundance of the two ostracod species are Ta, Tw and Sal. The other parameters measured by us do not play a major role in affecting the ostracod abundance.

The observations of *C. torosa* in environments with higher oxygen values (6.48–7.78 mg L⁻¹) are similar to those by MARCHEGIANO et al. (2017). This does not mean that *C. torosa* cannot live in low DO levels; this species is also known for its ability to survive in depleted oxygen environments or even hypoxia (JAHN et al. 1996, MESQUITA-JOANES et al. 2012). It is distributed globally, especially in the coastal zones of Europe, south-west Asia and Africa as well as in polar, temperate, subtropical and tropical aquatic regions (WOUTERS 2016). *Cyprideis torosa* is a euryhaline species with a high salinity tolerance (MEISCH 2000, WOUTERS 2016). It can also tolerate a wide range of temperature, oxygen and substratum types (AIELLO et al. 2006, DE DECKKER & LORD 2017). The distribution of *C. torosa* in Turkey has been well documented: it is widespread from the southern to western Mediterranean coasts, the Aegean Sea, coastal zones of the Black Sea and in the Sea of Marmara as well as in inland waters (ALTINSAÇLI et al. 2015a,b, ALTINSAÇLI & MEZQUITA 2008, PERÇİN-PAÇAL et al. 2015). *Cyprideis torosa* is the dominant species in eu-saline and hypersaline waters (sensu VENICE SYSTEM 1959) by ALTINSAÇLI et al. (2015c). In other studies conducted on the Akdeniz and Akbük Lagoons, *C. torosa* was also dominant (ALTINSAÇLI et al. 2015a).

This species was determined in β -mesosaline waters in the Akbük Lagoon and in α -mesosaline-polysaline ranges in the Akdeniz Lagoon (ALTINSAÇLI et al. 2015a). Both species were observed in the present study in β -mesosaline-eusaline ranges in the Karagöl Lagoon, according to the Venice system of classification (1959). *Cyprideis torosa* prefers habitats that are nutrient-rich, with muddy or sandy-muddy substrata (ALTINSAÇLI et al. 2015b, c). However, this species has also been determined on entirely sandy substrata and on algae (ALTINSAÇLI et al. 2015b). The habitat type of the Karagöl Lagoon is sandy and muddy.

Cyprideis torosa is a polymorphic and highly variable species, according to its carapace forms. The nodes at certain places on the shell of *C. torosa* appear in low saline (< 5 PSU) brackish waters (KEYSER & ALADIN 2004, SANDBERG 1964, VESPER 1972). Because of this, nodes as used as an environmental indicator of low salinity and/or low calcium content (KEYSER 2005). In this study, nodes were observed on the subfossil valves of the *C. torosa* at sampling station 1, where freshwater input was present.

Loxoconcha elliptica is a very common species in Turkish brackish waters (ALTINSAÇLI 2004, ALTINSAÇLI et al. 2015a, PERÇİN-PAÇAL et al. 2015). It is also very common in Europe, especially in estuaries and has been recorded in channels and channel margins with fine sediment (RUIZ et al. 1996) as a periphytic species (CARBONEL 1980). *Loxoconcha elliptica* is found in habitats with extreme salinity, associated with algae and mud. It is a very euryhaline (MARTINEZ-GARCIA et al. 2013), eurythermic and opportunistic ostracod species of coastal environments, similar to *C. torosa* (NACHITE et al. 2010). The number of individuals of *L. elliptica* was high in muddy and detritus-rich substrata but lower

in sandy and detritus-poor substrata (ALTINSAÇLI 2004, ALTINSAÇLI & MEZQUITA 2008, ALTINSAÇLI et al. 2015b).

Similar to our findings, two species were observed in an environmental study conducted on the north-western Mediterranean coast by SALEL et al. (2016). In southern Iberia, RUIZ et al. (1997) determined *L. elliptica* and *C. torosa* in an estuary. *Cyprideis torosa* was determined an dominant in other Mediterranean lagoons in many of recent studies. SALEL et al. (2016) pointed out that *C. torosa* dominates in confined regions, as well as in marine channels linked to inlets, while *L. elliptica* dominates where there is freshwater input leading to lower salinity levels, as is the case with the Karagöl Lagoon.

According to the results of the Spearman rank correlation analysis, statistically significant correlations existed between physicochemical variables and *C. torosa* and *L. elliptica*. The positive correlation determined between salinity and these species was an expected result from the Karagöl Lagoon because these two species are the most typically occurring in coastal brackish water. Similar relationships were observed in a study performed in five brackish karstic springs located in the Muğla Province (ALTINSAÇLI et al. 2015b).

Ecological factors such as pH, dissolved oxygen, conductivity, temperature, bottom substratum, water flow speed and depth also play important roles in determining the biological diversity and abundance of bottom-dwelling (benthic) organisms like ostracods. Our results indicate that a close relationship exists between ostracod assemblages, salinity, water flow and bottom substratum type. Many studies performed on ostracods have shown that salinity is one of the main controlling factors determining their distribution (ALADIN 1993, HORNE & BOOMER 2000, MEISCH 2000; RUIZ et al. 2000a; b, ALTINSAÇLI 2014, ALTINSAÇLI et al. 2014, 2015b).

Alluviums carried to the Karagöl Creek formed a sandy barrier between the Karagöl Lagoon and the Aegean Sea. More freshwater input and less detritus transport by the Karagöl Creek can explain the dominance of *C. torosa* during all the seasons at each station. This species is resilient (POQUET et al. 2008), not easily affected by contamination and able to tolerate a wide range of ecological parameters (BARUT et al. 2015, RUIZ et al. 2000a). On the other hand, *L. elliptica* requires brackish or seawater input with muddy and rich detritus to be dominant.

This study provides a starting point to evaluate both past and present conditions. Monitoring the intact natural habitat of the Karagöl Lagoon provides important ecological-change data for future studies.

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References

- AIELLO G., BARRA D., COPPA M. G., VALENTE A. & ZENI F. 2006. Recent infralittoral Foraminiferida and Ostracoda from the Porto Cesareo Lagoon (Ionian Sea, Mediterranean). *Bollettino della Societa Paleontologica Italiana* 45: 1-14
- ALADIN N. V. 1993. Salinity tolerance, morphology and physiology of the osmoregulation organs in Ostracoda with special reference to Ostracoda from the Aral Sea. In: JONES P. & MCKENZIE K. (Eds.): *Ostracoda in the Earth and Life Sciences*. A.A. Balkema, Rotterdam, 387- 403.
- ALTINSAÇLI S. 2004. Investigation on Ostracoda (Crustacea) Fauna of Some Important Wetlands of Turkey, Pakistan *Journal of Biological Sciences* 7(12): 2130-2134.
- ALTINSAÇLI S. 2014. Species diversity and distribution of Ostracoda (Crustacea) in mesosaline Lake Bafa (Aegean Region, Turkey). *Journal of Entomology and Zoology Studies* 2 (2): 16-32.
- ALTINSAÇLI S. & GRIFFITHS H.I. 2002. A review of the occurrence and distribution of the recent nonmarine Ostracoda (Crustacea) of Turkey. *Zoology in the Middle East* 27: 61-67
- ALTINSAÇLI S. & MEZQUITA F. 2008. Ostracod fauna of salt Lake Acıgöl (Acı Tuz) (Turkey). *Journal of Natural History* 42: 13-14. DOI: 10.1080/00222930701851735
- ALTINSAÇLI S., ALTINSAÇLI S. & PERÇİN-PAÇAL F. 2014. Species composition and distribution of ostracods (Crustacea, Ostracoda) in some lakes and lagoons (Kocaeli and Sakarya, Turkey). *Journal of Entomology and Zoology Studies* 2(5): 182-192.
- ALTINSAÇLI S., PERÇİN-PAÇAL F. & ALTINSAÇLI S. 2015a. Diversity, spatiotemporal distribution, abundance, species composition and habitat preferences of Ostracoda in Akbük and Akdeniz coastal mesosaline lagoons (Muğla, the South Aegean Region, Turkey). *Oceanological and Hydrobiological Studies* 44 (2): 206-222. DOI: 10.1515/ohs-2015-0020-5129
- ALTINSAÇLI S., ALTINSAÇLI S. & PERÇİN-PAÇAL F. 2015b. Diversity, species composition and habitat preferences of Ostracoda (Crustacea) in seven karstic springs of varying salinity in Milas (Muğla, Turkey). *International Journal of Fisheries and Aquatic Studies* 3 (2): 374-390.
- ALTINSAÇLI S., PERÇİN-PAÇAL F. & ALTINSAÇLI S. 2015c. Assessments on diversity, spatiotemporal distribution and ecology of the living ostracod species (Crustacea) in oligo-hypersaline coastal wetland of Bargilya (Milas, Muğla, Turkey). *International Journal of Fisheries and Aquatic Studies* 3 (2): 357-373.
- ANADON P., GLIOZZI E. & MAZZINI I. 2002. Palaeoenvironmental reconstruction of marginal marine environments from combined paleoecological and geo-chemical analyses on ostracods. In: HOLMES J.A. & CHIVAS A. (Eds.), *The Ostracoda: Applications in Quaternary Research*. Geophysical Monograph. American Geophysical Union, Washington DC, pp. 227-247.

- ATHERSUCH J., HORNE D. J. & WHITTAKER J. E. 1989. Marine and brackish water ostracods. In: KERMACK D. M. & BARNES R. S. K. (Eds.): Synopses of the British Fauna (New Series), No. 43, E.J. Brill, Leiden (for the Linnean Society of London and the Estuarine and Brackish Water Sciences Association), 361 p.
- BARNES R. S. K. 1980. Coastal lagoons: the natural history of a neglected habitat. Cambridge: Cambridge University Press.
- BARUT I. F., NAZIK A., BALKIS N., AKSU A. & ERSAN M. S. 2015. Ostracoda as bioindicators of anthropogenic impact in salt lakes, salt pans, and a lagoon: A case study from the Gulf of Saros coast (NE Aegean Sea), Turkey. *Revue de Micropaléontologie* 58: 351–367.
- BONADUCE G., CIAMPO G. & MASOLI M. 1975. Distribution of Ostracoda in the Adriatic Sea. *Publicazioni Della Stazione Zoologica di Napoli* 40:1-154.
- BRAY J. R. & CURTIS J. T. 1957. An ordination of upland forest communities of southern Wisconsin. *Ecological Monographs* 27:325-349.
- CARBONEL P. 1980. Les ostracodes et leur intérêt dans la définition des écosystèmes estuariens et de plateforme continentale: essais d'application à des domaines anciens. *Mémoires de l'Institut de Géologie du Bassin d'Aquitaine* 11. Université de Bordeaux, Talence, 350 p.
- ÇAĞATAY M. N., GÖRÜR N., ALPAR B., SAATÇILAR R., AKKÖK R., SAKINÇ M., YÜCE H., YALTIKAK C. & KUŞÇU İ. 1998. Geological evolution of the Gulf of Saros, NE Aegean Sea, *Geo-Marine Letters*, 18 (1): 1–9.
- DAVIDSON-ARNOTT R. 2010. Introduction to Coastal Processes and Geomorphology. Cambridge: Cambridge University Press.
- DE DECKER P. & LORD A. 2017. *Cyprideis torosa*: a model organism for the Ostracoda? *Journal of Micropalaeontology* 36: 3-6.
- ERGINAL A. E., ÖZCAN H. & ÖZTÜRK M. Z. 2007. Monitoring shoreline changes of the Kavak Delta (Saros Gulf-NW Turkey) using. KAPPAS M. (Ed.): *Global Change Issues in Developing and Emerging Countries: Proceedings of the 2nd Göttingen GIS and Remote Sensing Days 2006*, 4th to 6th October, Göttingen, Germany, 2007, 4: 383-392.
- FUHRMANN R. 2013. Atlas quartärer und rezenter Ostrakoden Mitteldeutschlands. *Altenburger Naturwissenschaftliche Forschungen* 15: 1-320.
- HORNE D. J. & BOOMER I. 2000. The role of Ostracoda in saltmarsh meiofaunal communities. In: SHERWOOD B. R., GARDINER B. G. & HARRIS T. (Eds.): *British Saltmarshes*. London: Linnean Society, 181-202.
- JAHN A., GAMENICK I. & THEEDE H. 1996. Physiological adaptations of *Cyprideis torosa* (Crustacea, Ostracoda) to hydrogen sulphide. *Marine Ecology Progress Series* 142: 215-223.
- KEYSER D. 2005. Histological peculiarities of the nodding process in *Cyprideis torosa* (Jones) (Crustacea, Ostracoda). In: IKEYA N., TSUKAGOSHI A. & HORNE D.J.: *Evolution and Diversity of Ostracoda*. *Hydrobiologia* 538: 95-106.
- KEYSER D. & ALADIN N. 2004. Nodding in *Cyprideis torosa* and its causes. *Studia Quaternaria* 21: 19–24.
- KOVACH W. L. 2013. MVSP: a multivariate statistical package for Windows, version 3.22. Kovach Computing Services, Pentraeth.
- MARCHEGIANO M., GLIOZZI E., CESCHIN S., MAZZINI I., ADATTE T., MAZZA R., GLIOZZI S., ARIZTEGUI D. 2017. Ecology and distribution of living ostracod assemblages in a shallow endorheic lake: The example of Lake Trasimeno (Umbria, central Italy). *Journal of Limnology* 76(3): 469-487.
- MARCO-BARBA J., HOLMES, J. A., MESQUITA-JOANES F. & MIRACLE M. R. 2013. The influence of climate and sea-level change on the Holocene evolution of a Mediterranean coastal lagoon: Evidence from ostracod palaeoecology and geochemistry. *Geobios* 46: 409-421.
- MARTÍNEZ-GARCÍA B., PASCUAL A., RODRÍGUEZ-LÁZARO J., MARTÍN-RUBIO M. & ROFES J. 2013 The Ostracoda (Crustacea) of the Tina Menor estuary (Cantabria, southern Bay of Biscay): Distribution and ecology. *Journal of Sea Research* 83: 111–122.
- MEISCH C. 2000. Freshwater Ostracoda of Western and Central Europe. In: SCHWOERBEL J. & ZWICK P. (Eds.) *Süßwasserfauna von Mitteleuropa* 8/3. Spektrum Akademischer Verlag GmbH, Heidelberg, Berlin, pp. 1-522.
- MESQUITA-JOANES F., SMITH A. J. & VIEHBERG F. A. 2012. The ecology of Ostracoda across levels of biological organisation from individual to ecosystem: a review of recent developments and future potential. In: HORNE D.J., HOLMES J.A., RODRIGUEZ LAZARO J. & VIEHBERG F. (Eds.): *Ostracoda as proxies for Quaternary climate change*. *Developments in Quaternary Science* 17. Amsterdam: Elsevier pp. 15-35.
- NACHITE D., RODRÍGUEZ-LÁZARO J., MARTÍN-RUBIO M., PASCUAL A. & BEKKALI R. 2010. Distribution and ecology of recent ostracods from the Tahadart estuary (NW Morocco). *Revue de Micropaléontologie* 53: 3-15.
- PERÇIN-PAÇAL F., ALTINSAÇLI S. & BALKIS H. 2015. An updated checklist of recent marine and coastal brackish water ostracods (Crustacea Ostracoda) in Turkey, *Journal of Entomology and Zoology Studies* 3 (3): 20-33.
- POQUET J. M., MEZQUITA F., RUEDA J. & MIRACLE M. R. 2008. Loss of Ostracoda biodiversity in Western Mediterranean wetlands. *Aquatic conservation: Marine and Freshwater Ecosystems* 18: 280–296.
- RUIZ MUÑOZ F., GONZÁLEZ-REGALADO MONTERO M. L. & MORALES GONZÁLEZ J.A. 1996. *Distribución y ecología de los foraminíferos y ostrácodos actuales del estuario mesomareal del río Guadiana* (SO España). *Geobios* 29: 513–528.
- RUIZ F., GONZÁLEZ-REGALADO M. L. & MORALES J. A. 1997. Ecología de Ostrácodos en medios estuarinos: El Subsistema Carreras (Río Guadiana, SO de España). *Estudios Geológicos* 53: 345–357.
- RUIZ F., GONZALEZ-REGALADO M. L., MENEGAZZO L., RAMPAZZO G., PISTOLATA M. & MOLINAROLI E. 2000a. Los ostracodos de la Cuenca del Lido (laguna de Venecia, NE Italia). *Geogaceta* 27: 151–153.
- RUIZ F., GONZALEZ-REGALADO M. L., BACETA J. I. & MUÑOZ J. M. 2000b. Comparative ecological analysis of the ostracod faunas from low- and high-polluted southwestern Spanish estuaries: a multivariate approach. *Marine Micropaleontology* 40: 345-376.
- SALEL T., BRUNETON H. & LEFEVRE D. 2016. Ostracods and environmental variability in lagoons and deltas along the north-western Mediterranean coast (Gulf of Lions, France and Ebro delta, Spain). *Revue de micropaléontologie* 59: 425-444.
- SANDBERG P. A. 1964. The ostracod genus *Cyprideis* in the Americas. *Stockholm Contributions in Geology* 12: 1–178.

- TER BRAAK C. J. 1986. Canonical correspondence analysis: a new eigenvector technique for multivariate direct gradient analysis. *Ecology* 67 (5): 1167-1179.
- TÜRKEŞ M. 1996. Spatial and temporal analysis of annual rainfall variations in Turkey. *International Journal of Climatology* 16 (9): 1057-1076.
- VENICE SYSTEM. 1959. Final resolution of the symposium on the classification of brackish waters. *Archive for Oceanography and Limnology* 11: 243-248.
- VESPER B. 1972. Zum Problem der Buckelbildung bei *Cyprideis torosa* (Jones, 1850) (Crustacea, Ostracoda, Cytheridae). *Mitteilungen aus dem Hamburgischen Zoologischen Museum und Institut* 68: 79-94.
- WOUTERS K. 2016. On the modern distribution of the euryhaline species *Cyprideis torosa* (Jones, 1850) (Crustacea, Ostracoda). *Journal of Micropalaeontology* 36: 21-30.
- XING L., SAMES B. C., MCKELLAR R., XI D., BAI M. & WAN X. 2018. A gigantic marine ostracod (Crustacea: Myodocopa) trapped in mid-Cretaceous Burmese amber. *Scientific Reports* 8.1: 1365. DOI:10.1038/s41598-018-19877-y
- YALTIRAK C. 1996. Tectonic history of the Ganos Fault System. *TAPG Bulletin* 8: 137-156.

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