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Abstract: Troughs are artificially transformed natural springs, underground waters, or related habitats. Some effects of such transformation are mentioned in a few studies, but there has been no extensive study on species composition and diversity in troughs. To contribute to the knowledge on the ostracods in troughs, we examined ostracod composition and diversity in 105 troughs from 6 provinces (Bolu, Erzincan, Gaziantep, Kahramanmaraş, Ordu, Van) in Turkey. The troughs were randomly visited between the years 2006 and 2010. A total of 32 ostracod species and a mean number of 2.16 species per trough were found. The most common 4 species (*Heterocypris incongruens*, *Ilyocypris bradyi*, *Psychrodromus olivaceus*, *Candona neglecta*) occurred in 57, 48, 34, and 26 different troughs, respectively. A UPGMA dendrogram displayed these 4 species in the same clustering group. The first 2 axes of canonical correspondence analysis explained about 69.5% of the variations in the species data set between 15 species and 5 environmental variables. The 2 most important explanatory variables, altitude (P = 0.008, F = 2.389) and redox potential (P = 0.034, F = 2.230), were the 2 most effective factors on species occurrence in these troughs. Ecological tolerance and optimum estimates of cosmopolitan species were generally higher than the mean values. The Shannon–Wiener index showed high values for the 4 most common species, supporting the effect of their dominance. Our results suggest that troughs can have relatively high ostracod richness but evenness can be low due to the strong dominance of one or more species.

Key words: Ostracoda, trough, ecology, diversity, distribution

1. Introduction

The numbers of artificial habitats in natural areas have increased since human activities started using these lands and related ecosystem resources. Examples of the most visible effects include artificial structures that have dramatically changed the substrate (Glasby and Connell, 1999; Bacchiocchi and Airoldi, 2003) and altered the physicochemical characteristics and the species composition in many kinds of aquatic bodies (e.g., springs) (Cianficconi et al., 1998; Külköylüoğlu, 1999, 2003). Troughs are examples of artificially transformed natural water bodies (e.g., springs, underground waters) that can be found across Turkey. Troughs are generally located in or near villages and are used primarily to store water for animals, but they are also used to control water flow, transport water for irrigation or drinking, and obtain easy access to underground water. There are approximately 35,000 villages in Turkey (TODAİE, 2011), and each village contains at least 1 trough, though some have several. Thus, troughs are among the most abundant and widely distributed artificial structures in Turkey.

Some natural ecosystems have been intentionally modified with the aim of increasing biodiversity (Carr and Hixon, 1997; Burt et al., 2009). Artificial reefs are constructed of truck tires and concrete blocks to increase fish diversity (Lim et al., 1976), artificial beds composed of plastic are inserted to promote the growth of macroalgae (Goddy and Coutinho, 2002), and artificial substrate (e.g., kelp holdfast and algal turf) is used to encourage the growth of amphipods and polychaetes (Smith and Rule, 2002). However, no study has evaluated how the construction of troughs has affected freshwater aquatic species biodiversity. Thus, in this study, we call them "artificially natural habitats" if they support a diversity of animals and plants at various spatial scales.

Ostracods are microscopic aquatic crustaceans inhabiting a variety of aquatic habitats. They are important in evolutionary (Cohen and Johnston, 1987; Chaplin and Ayre, 1997), ecological (De Deckker, 1981; Külköylüoğlu et al., 2010), and biological (Kesling and Crafts, 1962; Lopez et al., 2002) studies, and as indicators of water quality (Benson, 1990) and habitat preferences (Külköylüoğlu and

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Vinyard, 2000). Despite their abundance and wide range of distribution in different habitats (lakes, ponds, springs, creeks, etc.), there has been no extensive study on the distribution of ostracods in troughs.

The objectives of this study are to: 1) describe the diversity and distribution of ostracods in a number of sites in Turkey; 2) understand the ecological characteristics of ostracods that persist in troughs; 3) examine whether establishing troughs provides any benefits for aquatic biodiversity; and 4) discuss the conservation status of troughs.

2. Materials and methods

A total of 105 troughs from 6 provinces (Bolu, Erzincan, Gaziantep, Kahramanmaraş, Ordu, Van) in Turkey were randomly sampled between 2006 and 2010 (Figure 1) (see for details Akdemir, 2009; Külköylüoğlu and Sarı, 2012; Külköylüoğlu et al., 2012a, 2012b). Six environmental variables (dissolved oxygen [mg L^{-1}], salinity [ppt], water temperature [TCw; °C], electrical conductivity [EC; µS cm^{-1}], redox potential [standard hydrogen electrode, SHE; mV], and pH) were measured in situ with YSI-85 oxygen/temperature and HI-98150 pH/ORP meters. Total dissolved solids (mg L^{-1}) were calculated by multiplying the values of electrical conductivity by 0.65 (Forester and Brouwers, 1985). Geographical data (e.g., altitude, coordinates) come from a geographical positioning system (GARMIN GPS 45). Ostracods were collected with a hand net (0.2 mm mesh size) from the troughs, ranging from 5 cm to 100 cm in depth. The samples were later fixed with 70% alcohol in plastic containers and brought to the laboratory, where they were filtered with standardized sieves (0.25, 0.50, 1.00, and 2.00 mm mesh size). Ostracods were separated from the sediment under a stereomicroscope and stored in 70% alcohol. We primarily followed the systematic key of Meisch (2000); some other literature (Bronshtein, 1988; Karanovic, 2006) was also used.

2.1. Statistical analyses

To examine the relationship between 15 species that occurred in 3 or more troughs and the 5 most important environmental variables, a canonical correspondence analysis (CCA), applied with Monte Carlo tests (499 permutations), was performed using log-transformed environmental data (Birks et al., 1990). Because of its covariance to electrical conductivity, salinity was not used in the analyses. Before conducting the CCA, the suitability of data for CCA was tested with a detrended correspondence analysis (DCA) (ter Braak, 1987). To reduce and/or eliminate the effects of multicollinearity among the variables, the number of environmental variables was kept lower than the numbers of species, and rare species were down-weighted (ter Braak and Barendregt, 1986). The unweighted pair group method with arithmetic mean (UPGMA), used with Jaccard's coefficient, was selected to identify different clustering assemblages of the species. UPGMA was performed with a multivariate statistical package program (MVSP, version 3.1) (Kovach, 1998), while CCA was conducted with the program CALIBRATE, version 1.0 (Juggins, 2001). Binary data (presence and absence) were used in CCA. The program C2 (Juggins, 2003) was used to estimate species' ecological tolerance (t_k) and optimum values (u_k) after using a transfer function based on weighted-averaging (WA) regression. WA provides a quantitative evaluation of species autecology (Bere and Tundisi, 2009). This is a computational process referred to as WA regression. It involves taking the average of the values of environmental variables over those sites where the species is present, weighted by the abundance of the species (ter Braak and van Dam, 1989). During WA, we calculated species optimum value as the average of all sampling sites in which it occurred. Accordingly, one should assume that the response of the species to the environmental variables was unimodal.

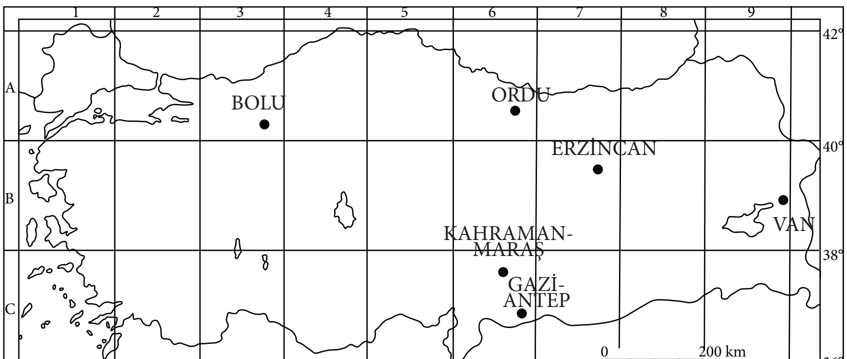

Figure 1. Map showing 6 provinces (Bolu, Ordu, Erzincan, Kahramanmaraş, Gaziantep, Van) with 105 sampling sites.

Spearman's rank correlation analysis, along with Jaccard's test, was used to display levels of correlations among species and environmental variables. Only living adults were accounted for in the analysis; juveniles, subrecent, and damaged individuals were not used. The program Species Diversity and Richness was used to estimate the Shannon–Wiener index (S–W) based on the 9 common species found within the sites (Seaby and Henderson, 2006). A randomization test with 10,000 simulations was run to detect a significant difference in diversity between the samples (Solow, 1993).

3. Results

We found 32 ostracod species in 105 troughs in 6 provinces (Appendix). Species richness of individual troughs varied from 1 to 5 species, averaging 2.16 species across all troughs. Four species (*Heterocypris incongruens*, *Ilyocypris bradyi*, *Psychrodromus olivaceus*, *Candona neglecta*) occurred most frequently in 57, 48, 34, and 26 troughs, respectively (Figure 2).

A randomization test for the S–W analysis showed high and similar diversity for *Ilyocypris bradyi*, *Psychrodromus olivaceus*, and *Candona neglecta*, but such diversity for *H. incongruens* ($P < 0.05$) was low (Table 1).

Although they belong to different genera, these species are located in the same clustering group of the UPGMA dendrogram (Figure 3).

The first 2 axes of CCA exhibited about 69.5% of the variations between 15 species and the 5 most important environmental variables (EC, TCw, SHE, pH, and altitude) (Table 2). Altitude ($P = 0.008$, $F = 2.389$) and redox potential ($P = 0.034$, $F = 2.230$) were the 2 most effective factors on species presence (Figure 4). *Pseudocandona semicognita* was positively and *P. olivaceus* was negatively correlated with altitude ($P < 0.01$); *Potamocypris fulva* was the only species showing a negative correlation to redox potential ($P < 0.05$) (Table 3). Ecological tolerance and the optimum estimates depended on the species and variables, but cosmopolitan species tended to have the highest tolerances (Table 4). Overall, results suggest that troughs can have relatively high ostracod richness (32 species in this study), but evenness can be biased toward the most common species.

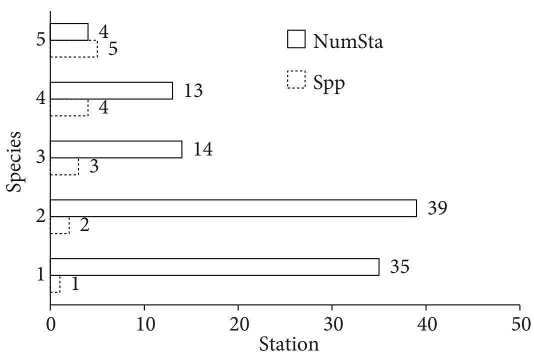

Figure 2. Species frequency distribution among 105 troughs. Thirty-nine troughs were recognized with 2 species. Abbreviations: Spp (numbers of species); and NumSta (numbers of stations).

4. Discussion

Rouch and Danielopol (1997) reported that species diversity of ostracods at the local scale (i.e. between 1 and 100 m in length) was high if 25 species were within an area, medium with 6–24 species, and low with 1–5 species. The 32 ostracod species we found overall indicate high species diversity for the country, although the mean numbers of species (2.16 per trough) were low at individual sites. However, comparisons can be difficult to interpret due to temporal and spatial differences in types of habitat, sampling size, size of the water body, and seasonal differences. For example, Külköylüoğlu (2005) estimated about 13.2 ostracod species per lake in Turkey. In the United States, King et al. (1996) reported species richness from 1 to 13 species per vernal pool in northern California, but Simovich (1998) found 13 species of ostracods in the southern and 24 in the northern and central pools of California's ephemeral wetlands.

Accordingly, Simovich (1998) concluded that species richness and species composition differ among habitat types, and such differences can be caused by several factors. For example, species richness in northern Italian rice fields decreased over 30 years between the 1960s and 1998 (Rossi et al., 2003). The reason for such a decrease was pesticide usage in these areas. It is apparent that dominance plays a critical role in shaping species diversity in troughs. For example, the 4 most frequently occurring species (*H. incongruens*, *I. bradyi*, *P. olivaceus*, *C. neglecta*) were not only the most dominant, but also the most abundant. These species have a broad geographical distribution in natural systems and a wide ecological tolerance (Meisch, 2000; Külköylüoğlu, 2004). In the present study, we collected them from 57, 48, 34, and 26 different troughs, respectively. This corresponds to more than 75% of occurrences in all species considered here. The number of species per trough did not increase as additional troughs were surveyed (Figure 2). Our findings agree with those of King et al. (1996) that species assemblages can vary within a trough and among troughs within a site (i.e. a city). Indeed, despite their dominance, these 4 species (except on one occasion) were never found together in a single trough. However, they were clustered in a single group of the UPGMA dendrogram (Figure 3). This is probably related to differences in the tolerances of the individual species to the various environmental variables. Indeed, these 4 species occurred where the levels of almost all of

Table 1. Shannon–Wiener (S–W) index results after randomization test for the 9 most frequently occurring ostracods.

Species	H	Variance H	Exp H
Candona neglecta	2.626	0.009557	13.81
Heterocypris incongruens	2.458	0.003995	11.68
Ilyocypris gibba	0.9433	0.031630	2.57
Ilyocypris inermis	2.717	0.007714	15.13
Ilyocypris bradyi	2.647	0.002155	14.11
Pseudocandona semicognita	1.171	0.02881	3.22
Potamocypris similis	1.01	0.02824	2.75
Pseudocandona albicans	1.33	0.05946	3.78
Psychrodromus olivaceus	2.617	0.002251	13.70
All Sample Index	3.765		
Jackknife Std. Error	0.1492		

the variables were greater than the mean values. This may have given these species an advantage by allowing them to exist in the broadest range of conditions, such as troughs located from 29 to 1728 m a.s.l. (this study).

The first 2 axes of CCA showed about 69.5% of the variations between 15 species and 5 environmental variables. Two of these variables, altitude ($P = 0.008$, $F = 2.389$) and redox potential ($P = 0.034$, $F = 2.230$), were the most effective factors on species (Table 2). Among the species, only *P. olivaceus* showed a negative significant correlation to altitude, while *Pseudocandona semicognita* had a positive correlation ($P < 0.01$) (Table 3).

Despite its importance, water temperature was not among the significant factors affecting species occurrence in the CCA diagram (Figure 4). On the other hand, while 2 (*H. incongruens*, *P. semicognita*) species displayed significant positive correlation to temperature, this relationship was negative for *I. inermis* and *P. fallax* ($P < 0.01$) (Table 3). Indeed, while the latter 2 species are mostly known to inhabit springs and spring-related cold waters,

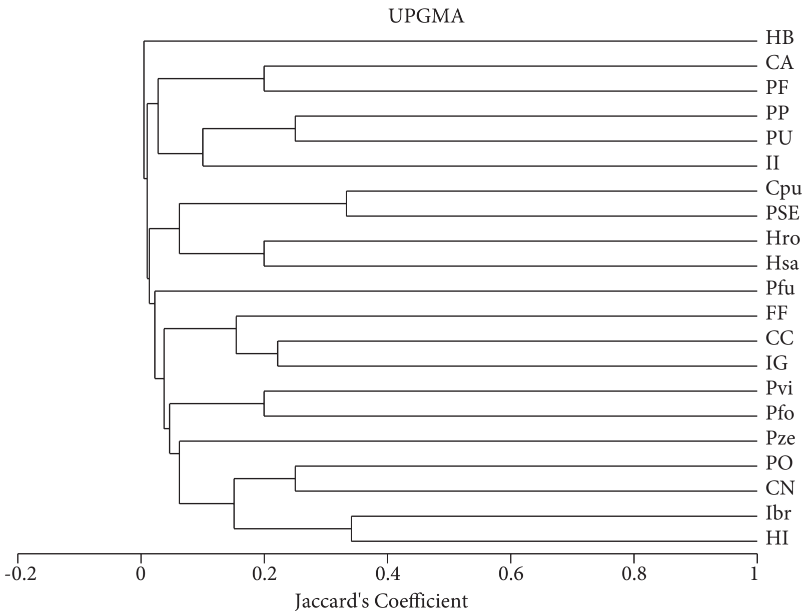

Figure 3. UPGMA clustering groups of 21 species that occurred at least 2 times.

Table 2. Summary of CCA with 15 species and 5 variables. *: DCA result.

Axes	1	2	3	4	Total inertia
Lengths of gradient*	5.065	5.525	6.294	5.084	
Eigenvalues	0.134	0.062	0.042	0.032	4.115
Species–environment correlations	0.511	0.427	0.372	0.318	
Cumulative percentage variance:					
of species data	3.3	4.8	5.8	6.6	
of species–environment relation	47.4	69.5	84.3	95.8	
Sum of all eigenvalues					4.115
Sum of all canonical eigenvalues					0.283

a well-known cosmopolitan species, *H. incongruens*, is known to tolerate wide temperature ranges. Fryer (1997) called it the "horse-trough ostracod" because he observed this species from different types of troughs made of metal, limestone blocks, stone, and ceramics, where *H. incongruens* seldom shared troughs with other ostracods. In contrast, we found this species along with some other ostracods (see Appendix) in about 41 out of 57 troughs. This should not be a surprising result for at least 2 reasons: 1) *H. incongruens* can tolerate wide ranges of environmental factors, as mentioned by Fryer (1997); 2) similar to *H. incongruens*, other species also carry cosmopolitan characteristics in such unique water bodies. Evidently, they are of wide ranges of tolerance to changes in abiotic and biotic factors, as well. Table 3 shows the correlation of 4 species (*C. neglecta*, *P. olivaceus*, *I. bradyi*, *P. fulva*) to the dissolved oxygen of the study sites. Of these, only *I. bradyi* did not express a negatively significant correlation to dissolved oxygen. We do not know much about the ecology of *P. fulva* (Meisch 2000), but the first 2 species are known to prefer well-oxygenated waters.

Although these results support the findings of Mezquita et al. (1999), who argued the importance of altitude as a limiting factor on freshwater ostracods in Spanish waters, most recent studies (Külköylüoğlu et al., 2012b) showed that altitude per se has no significant effect on species distribution, though it probably has an indirect effect on other habitat characteristics.

It is important to mention that most of the troughs from the city of Ordu are allocated on the left side of the CCA

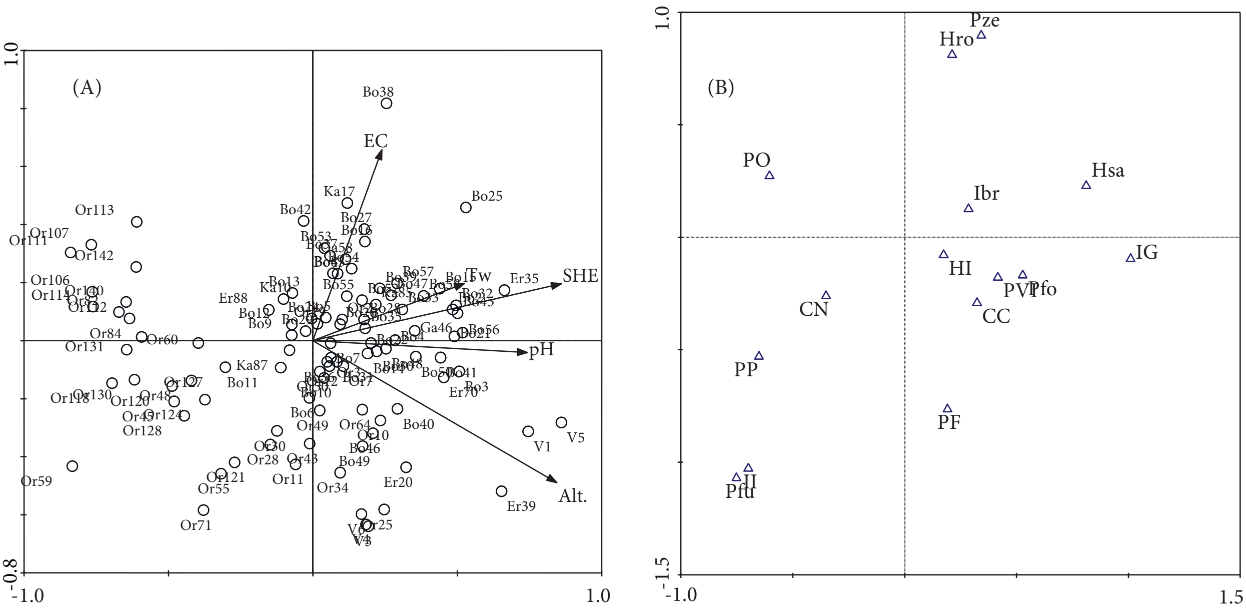

Figure 4. CCA biplot A) between troughs and 5 environmental variables and B) species.

Table 3. Results of Spearman rank correlation analyses (levels of significance: *0.05; **0.01).

Species	pH	Temp.	DO	EC	SHE	Altitude
Candona neglecta			(-) *			
Heterocypris incongruens		(+) *				
Ilyocypris bradyi			(+) *	(+) **		
Ilyocypris inermis		(-) **		(-) **		
Potamocypris fallax		(-) **				
Potamocypris fulva			(-) **		(-) *	
Pseudocandona semicognita		(+) **				(+) **
Psychrodromus olivaceus	(-) *		(-) *	(+) **		(-) **

diagram (Figure 4). We did not find any reasons for such a grouping, although Ordu had the second largest number of troughs (n = 40), with 11 species (see Appendix).

Redox potential characterizing the oxidative state of a water body was the second most important factor affecting species presence. A low SHE value (below 200 mV) is considered to indicate relatively low oxygen concentrations, while high SHE values indicate well-oxygenated waters (Horne and Goldman, 1994). There is not much known about the correlation between ostracod

Table 4. Tolerance and optimum values of 15 species that occurred 3 or more times. Abbreviations: Count (numbers of occurrences); N2 (Hill's coefficient); u_k (optimum estimates); t_k (tolerance); Alti (Altitude, m); Temp. (water temperature); EC (electrical conductivity); SHE (standard hydrogen electrode); Max (maximum); Min (minimum); St. dev. (standard deviation). Species codes (Code) are given in the Appendix.

			Alti		pH		Temp		EC		SHE	
Code	**Count**	**N2**	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k
HI	59	59	974	390	6	3.6	19.7	4.3	475.5	237.5	117.7	79.9
Ibr	48	48	978	322	6.6	3	19.2	4.5	530.1	246.1	128.2	66.6
PO	34	34	724	337.8	4.5	4.1	18.1	3.5	501.7	197.8	80.68	110
CN	26	26	870	320.4	5.2	4.3	18.4	4.3	406.1	240.2	81.48	120
IG	6	6	1115	334.3	7.9	0.4	22.6	4.9	490.8	110.1	146.5	36.3
Pfo	6	6	1106	218.6	7.7	0.6	17.6	4.6	447.3	203.5	168.4	31.3
Pvi	6	6	1031	227.7	7.9	0.3	18.4	3.8	395.4	253.6	155.3	21.2
Pfu	5	5	1003	348.9	5.8	5.3	16.5	4.4	307.2	154.5	9.88	36.9
CC	5	5	978	95.77	7.6	0.4	17.9	5.5	294.4	134.3	177.3	26.5
Pze	5	5	792	32.9	7.8	0.4	19.7	5.2	583.6	251.3	163.6	24.5
PF	4	4	1286	391.2	6	4.2	14.8	2.8	483.2	408.6	125.8	98.9
Hsa	3	3	1098	559.6	8.1	0.4	21	4.6	614.1	146.1	132	48.4
II	3	3	975	218.7	5.4	4.7	13.7	1.2	192.9	223.1	104.2	103
PP	3	3	932	560.7	5.6	4.9	14.5	2.7	347.5	303.7	90.69	83.6
Hro	3	3	851	199.3	7.8	0.1	17.7	3.1	605	132.5	162.2	8.8
		Mean	981	303.9	6.66	2.45	17.99	3.96	445	216.2	122.9	59.7
		Max	1286	560.7	8.1	5.3	22.6	5.5	614.1	408.6	177.3	120
		Min	724	32.9	4.5	0.1	13.7	1.2	192.9	110.1	9.878	8.8
		St. dev.	141	146.2	1.22	2.08	2.408	1.13	121.6	77.21	44.44	36.9

species and redox potential. However, some earlier studies contributed insight into the importance of redox potential on a few ostracod species. For example, Külköylüoğlu et al. (2012b) emphasized the high tolerance levels of *C. neglecta* and *P. zenkeri* to SHE and pH measured around Lake Van (Turkey). We have obtained similar results for *C. neglecta*, which exhibited the highest tolerance level to SHE (t_k = 120 mV), while *P. zenkeri* displayed low tolerances (Table 4).

However, neither of these 2 species showed a significant correlation to redox potential (Table 3). According to the CCA results, conductivity was not among the influential variables on the species. In contrast, correlation analysis displayed significant correlation between 3 species (*I. bradyi*, *I. inermis*, *P. olivaceus*) and conductivity (P = 0.01). Of these, *I. inermis* showed a negative correlation. We do not know much about the ecological features of *I. inermis*, but we have more knowledge about the other 2 species. As mentioned above, both *I. bradyi* and *P. olivaceus* are of cosmopolitan character and can survive in different salinity ranges (referring to conductivity). Therefore, it is not surprising to find such a positive correlation of these species to conductivity.

Inasmuch as the findings show that some species may have high ranges of tolerance to different variables, those species may not be significantly affected by such variables. This may be due to the cosmopolitan characteristics of the species, which are usually dominant and widely distributed, with relatively high tolerances to environmental variables. Accordingly, in our study, we found that species richness was affected by those of 4 dominant species (Table 1). Indeed, S–W index values (2.5 or higher) correspond to these 4 species. Considering all sampling sites, troughs can have relatively high ostracod richness; however, evenness was biased in favor of those dominant species.

The migration from villages to urban sites in the last 10–20 years is among the major factors affecting the distribution of humans throughout Turkey. The troughs that were built when a village was developed remained in place after the village was left behind. The original springs were not restored after people left. If a village persisted and grew, more springs could have been manipulated. Despite the issues surrounding the conversion of springs to troughs, the establishment of new troughs may provide benefits for some aquatic organisms (e.g., cosmopolitan species). However, species diversity will not be representative of the original (and natural) species composition. This is not to say that troughs are not useful, but that there should be compelling reasons for their conservation. Troughs with high (and unique) species diversity should definitely be conserved and protected. Because this study is specifically on the ostracod biodiversity in troughs, results should not be generalized at the moment. Therefore, future studies on different taxonomic groups (e.g., zooplankton, phytoplankton, and mollusks) in more troughs are needed.

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Appendix. Distribution of 32 ostracod taxa in 105 troughs from 6 provinces (Bolu, Erzincan, Gaziantep, Kahramanmaraş, Ordu, Van) is shown, along with some of the physicochemical and geographical data measured. Abbreviations: Code, station code; SHE, standard hydrogen electrode (mV); DO, dissolved oxygen (mg/L); EC, electrical conductivity (µS/cm); TDS, total dissolved solids (mg/L); Tw, water temperature (°C); Sal, salinity (ppt); Alt, altitude (m); Mean, mean number; Max., maximum number; Min., minimum number; na, not available due to technical problems; St. dev., standard deviation. Species codes (Sp. code): CA, *Candona angulata*; CC, *C. candida*; Cli, *C. lindneri*; CN, *C. neglecta*; CS, *C. sanociensis*; CV, *Cypridopsis vidua**; Cpu, *Cypris pubera*; DS, *Darwinula stevensoni*; Dsi, *Dolerocypris sinensis**; FF, *Fabaeformiscandona fabaeformis*; FL, *F. latens*; HR, *Herpetocypris reptans*; HB, *H. brevicaudata*; HI, *Heterocypris incongruens*; Hro, *H. rotundata*; Hsa, *H. salina*; Ibr, *Ilyocypris bradyi*; IG, *I. gibba*; II, *I. inermis*; PF, *Potamocypris fallax*; Pfu, *P. fulva*; PP, *P. pallida*; Psi, *P. similis*; PU, *P. unicaudata*; PV, *P. variegeta**; Pvi, *P. villosa*; Pot, *Potamocypris* sp.; Pze, *Prionocypris zenkeri*; PAI, *Pseudocandona albicans*; PC, *P. compressa*; Pse, *P. semicognita*; Pfo, *Psychrodromus fontinalis*; PO, *Psychrodromus olivaceus*; SP, *Scottia pseudobrowniana*; TL, *Trajancypris laevis*. Bold letters show subfossil forms of taxa. *: Species were found near the trough where water flows out of the trough and were not included in the analyses.

Trough Name	Code	pH	SHE	DO	EC	TDS	Tw	Sal	Alt.	Sp.code	DATE	Latitude (N)	Longitude (E)
Güneyce trough	Or2	8.05	161	5.6	427.5	278	18.8	0.2	872	HI	11/6/2010	40°26.351′	37°46.748′
Ahmet Koç hayratı	Or3	7.98	160	na	370.7	241	16.1	0.2	1026	Ibr, **Pot1.**, HI	11/6/2010	40°25.869′	37°47.032′
Yeşilce trough	Or7	7.91	165	na	582	378	11.6	0.3	1337	PP	11/6/2010	40°32.407′	37°47.278′
Yeşilce tepesi	Or10	8.48	131	na	391.7	255	16	0.2	1415	HI, Ibr	11/6/2010	40°33.393′	37°50.043′
Mes-Kavaklıdere yolu	Or11	8.97	107	na	4.5	2.93	14.9	0.2	1167	CN, PO, II, **Pot2.**	11/6/2010	40°28.594′	37°47.480′
Kavaklıdere hayratı	Or12	8.69	120	na	542	352	13.6	0.3	1242	HI, PO, Pfo, Ibr, **Pse1.**	11/6/2010	40°29.116′	37°48.677′
Güzle köyü trough	Or19	8.63	123	na	583	379	15.1	0.3	1035	HI, PO	12/6/2010	40°30.823′	37°41.337′
Harçbeli çeşme	Or25	10.3	17.9	na	112.4	73.1	21	na	1500	Pfu	12/6/2010	40°36.146′	37°38.255′
Hacı D.Altun hayratı	Or28	9.37	89.3	na	161.9	105	11.9	0.1	1213	CN	12/6/2010	40°37.976′	37°37.253′
Fatma taş hayratı	Or30	9.64	66.3	na	222.5	145	13.6	0.1	1179	PO, Pfu, **Pot3., TL1**	12/6/2010	40°38.134′	37°37.122′
Yapılış 1995 trough	Or34	10.6	1.28	na	101.8	66.2	21.5	0.1	1236	HI	12/6/2010	40°39.860′	37°33.467′
Yapılış 25.06.1995	Or43	9.73	93.8	na	195	127	13.9	0.1	1275	PF, **CA sp1.**	12/6/2010	40°39.228′	37°33.110′
Aybastı yol-2 trough	Or45	9.3	34.8	na	355	231	11.8	0.2	971	CN, Pfu	12/6/2010	40°40.573′	37°33.021′
Tokgözler hayratı	Or48	9.81	–32	na	290.8	189	15.7	0.1	792	HI, Ibr	12/6/2010	40°40.494′	37°31.682′
Gölköy Gürgentepe yol	Or49	na	213	na	305.5	199	15.9	0.1	1119	CN, HI	13/6/2010	40°42.903′	37°37.229′
Gürgentepe yol-1	Or50	na	213	na	471.9	307	15.5	0.2	1085	HI	13/6/2010	40°43.442′	37°37.416′
Gürgentepe Çamaş yolu	Or55	12.4	–115	na	138.9	90.3	17	0.1	1127	HI	13/6/2010	40°47.952′	37°34.427′
Çamaş hacımahmut ma.	Or59	11.4	–315	na	165.5	108	19.2	0.1	746	CN, PO, **Il1**	13/6/2010	40°53.299′	37°31.651′
Çamaş köy trough	Or60	11.8	–17	na	184.1	120	18.9	0.1	517	CN	13/6/2010	40°53.946′	37°31.402′
Buzdolabı trough	Or64	na	209	na	210.6	137	21.8	0.1	1008	CN, HI	13/6/2010	40°48.795′	37°37.120′
Alabalık havuzu	Or71	na	na	na	61.9	40.2	17.7	na	1077	CN	13/6/2010	40°51.531′	37°40.218′
Kabadüz Esenyurt	Or82	na	na	na	381.7	248	20.2	0.2	244	CN, PO, Ibr	14/6/2010	40°52.764′	37°53.951′
Orçim trough	Or84	na	na	na	318.1	207	21.4	0.2	324	HI	14/6/2010	40°52.295′	37°53.852′
Perşembe yolu-3	Or92	na	na	na	484.4	315	19.3	0.2	29	PU	14/6/2010	41°07.313′	37°41.667′
Artılar acısu trough	Or106	na	na	na	403.8	262	19.2	2.1	140	HI, PO	15/6/2010	40°56.465′	37°24.380′
Korgan yolu-2 trough	Or107	na	na	na	645	419	17.8	0.3	146	HI, PO	15/6/2010	40°56.363′	37°24.253′
Sahibül Hayrat	Or111	na	na	na	670	436	14.9	0.3	216	PO	15/6/2010	40°55.134′	37°22.180′
Korgan yolu-5 trough	Or112	na	na	na	324.1	211	21.8	0.2	216	HI, PO, **Pot4**	15/6/2010	40°55.134′	37°22.180′
Kasımoğlu mermer	Or113	na	na	na	818	532	19.7	0.4	230	CN, PO	15/6/2010	40°55.118′	37°21.944′
Alağan mah. Trough	Or114	na	na	na	456.1	296	16.9	0.2	292	PO, PU, PP, **Pse2**	15/6/2010	40°54.357′	37°19.842′

Appendix. (continued)

Duman köy	Or118	na	na	na	439.3	286	12.5	0.2	737	HI, PO, II, PF	15/6/2010	40°51.318′	37°16.116′
Fizme trough	Or120	na	na	na	472.3	307	16.5	0.2	813	Poi, **Pot5**	15/6/2010	40°51.136′	37°16.686′
No name	Or121	na	na	na	137.4	89.3	22.6	0.1	890	HI	15/6/2010	40°50.940′	37°16.631′
No name	Or124	na	na	na	320	208	21.4	0.2	722	CN, HI, PO, Pfu	15/6/2010	40°50.098′	37°16.626′
Kumru Korgan yolu	Or127	na	na	na	498	324	21.9	0.2	748	CN, PO, Ibr, HI	15/6/2010	40°49.874′	37°16.978′
No name	Or128	na	na	na	308.1	200	18.6	0.1	799	HI, Ibr	15/6/2010	40°49.697′	37°17.515′
No name	Or130	na	na	na	487.7	317	13.6	0.2	781	Ibr, **Pse3**	15/6/2010	40°49.588′	37°18.311′
No name	Or131	na	na	na	526	342	14.6	0.3	644	CN, Ibr, PO, Pfu, DS	15/6/2010	40°49.310′	37°18.978′
Mehmet Kasırga hayrat	Or140	na	na	na	587	382	17.2	0.3	430	CN, HI, PO	16/6/2010	41°02.402′	37°12.713′
TCK 1984 trough	Or142	na	na	na	755	491	17.3	0.4	424	CN, PO, Ibr, **Pot6**	16/6/2010	41°01.158′	37°11.916′
Çayırlı trough	Er20	7.09	209	na	224.5	146	13.9	0.1	1579	CN, CA, PF	1/8/2006	40°04′487″	39°47′142″
Üzümlü trough 1	Er35	7.18	201	na	1074	698	18.8	0.5	1554	PF, Ibr, HI	6/8/2006	39°56′200″	39°36′488″
Üzümlü trough 2	Er39	7.38	191	4.1	207.4	135	21.1	0.1	1716	HI	18/8/2006	39°45′296″	39°41′393″
Kemah trough	Er70	7.62	176	4.8	293.3	191	24.7	0.1	1100	Ibr, HI	16/8/2006	38°54′184″	39°34′418″
İliç trough	Er88	na	na	4.4	907	590	21.4	0.4	906	Ibr, HI	22/8/2006	38°34′635″	39°28′732″
Bolatın trough	Ka10	6.94	210	na	284.1	185	16.5	0.1	599	HI, PO, **HR1**	7/6/2010	37°30′0987″	41°30′323″
Ceceli trough 2	Ka17	6.47	182	na	708	460	22.9	0.4	495	HI	7/6/2010	37°30′6927″	41°36′322″
Göynük trough	Ka85	7.35	214	na	482	313	18.7	0.2	916	PO, **Il2**	28/7/2010	37°40′528″	37°26′150″
Yonca trough	Ka87	na	177	na	463.6	301	17.4	0.2	884	PO, Psi, Ibr, HI	28/7/2010	37°30′407″	37°27′580″
Şahinbey trough	Ga46	8.05	134	5.2	244	159	29.7	0.1	703	HI	26/7/2010	36°51′386″	37°18′22.0″
Islahiye trough	Ga58	8.01	141	6.3	497	323	24	0.2	563	HI, PO	28/7/2010	37°04′24.7″	36°36′56.1″
Sarıbey trough	Bo2	7.47	178	5	593	385	24.6	0.3	1052	IG, PC	3/6/2006	40°46′05″	31°31′02″
Manda trough	Bo3	8.01	145	4.3	326.7	212	27.5	0.2	1075	CN, CC, Ibr, IG, CS	3/6/2006	40°46′14″	31°30′05″
Kuruyalak	Bo4	7.95	154	4.3	467.7	304	21.2	0.2	1046	Ibr, HI	3/6/2006	40°45′41″	31°31′12″
Pınarya trough	Bo5	7.24	200	5.6	544	354	13.2	0.3	1028	HR	3/6/2006	40°45′15″	31°31′31″
Pelitköy trough	Bo6	7.12	205	na	135	87.8	13.8	0.1	1021	CN, CC, II	4/6/2006	40°37′23″	31°27′47″
Pelit trough	Bo7	7.9	162	5.1	435.9	283	15.8	0.2	1018	CN, CC, Ibr, IG, FF	4/6/2006	40°37′26″	31°27′40″
Piroğlu trough	Bo8	8.09	150	na	696	452	16.8	0.3	897	CN, Pvi, CA	4/6/2006	40°39′44″	31°28′02″
Güneytepe trough	Bo9	8.07	149	na	301	196	16.9	0.2	781	Pze, CN, Ibr	27/6/2006	40°28′31″	31°00′18″
Arıkçayırı trough	Bo10	7.13	204	na	174.2	113	15.9	0.1	951	CC, Ibr	27/6/2006	40°27′51″	30°54′49″
Örencik trough	Bo11	8.17	144	17	241.4	157	14.8	0.1	897	Ibr, Pvi, Pfo, FL	27/6/2006	40°27′05″	30°50′20″
Bulanık trough	Bo12	8.04	150	13	310.8	202	17.5	0.2	730	Ibr, HI	27/6/2006	40°25′34″	30°45′20″
Seki trough	Bo13	8.04	150	8.1	448	291	17.2	0.2	705	Ibr, IG, HI	27/6/2006	40°24′53″	30°45′21″
Bayındır yolu	Bo14	7.65	169	7.8	244.8	159	21.9	0.1	865	PO, Ibr, HB	27/6/2006	40°22′42″	30°46′57″
Bayındır trough	Bo15	7.66	166	12	592	385	25.9	0.3	910	Ibr, HI	27/6/2006	40°20′04″	30°44′18″
Kuyubaşı trough	Bo16	8.64	107	12	650	423	25.5	0.3	612	Ibr, HI	27/6/2006	40°15′04″	30°44′42″
Adaköy trough	Bo20	7.74	169	5.1	556	361	15.2	0.3	1056	Ibr, Hro	28/6/2006	40°48′28″	32°03′22″
Gölbaşı trough	Bo21	7.65	167	5.3	517	336	24.7	0.3	1113	IG, HI	28/6/2006	40°48′37″	32°01′06″
Kındıra trough	Bo22	7.92	156	7.1	501	326	18.1	0.3	1099	CN, Ibr	28/6/2006	40°49′20″	32°59′36″
Sarıyer trough	Bo24	7.7	170	6.5	400.1	260	16.7	0.2	826	Pze, CC, Ibr, HI	30/6/2006	40°32′31″	31°16′10″

Appendix. (continued)

Ormanpınar trough	Bo25	8.02	143	6.6	946	615	28.4	0.5	829	PO, Pze, CN, Ibr	30/6/2006	40°27′22″	31°09′01″
Akbaşlar trough	Bo27	7.83	160	7.1	890	579	18.4	0.2	881	Ibr, HI	30/6/2006	40°26′40″	31°10′22″
Dolayüz trough	Bo28	7.91	155	9.3	463.4	301	20.4	0.2	909	HI, Hsa	30/6/2006	40°26′42″	31°11′40″
Parmaksızlar trough	Bo29	7.95	156	8.4	430.9	280	15.2	0.2	924	PO	30/6/2006	40°26′21″	31°11′22″
Uğurlualan trough	Bo30	7.45	182	11	482	313	17	0.2	1152	PO, CN, SP	30/6/2006	40°25′06″	31°16′50″
Güllüören trough	Bo31	7.59	178	7.5	442.6	288	13.8	0.2	1155	PO, Ibr, HB	30/6/2006	40°25′0″	31°20′24″
Yaylabeli trough	Bo32	7.12	200	4.5	654	425	22.7	0.3	1125	PO, CN, Ibr, Pfo	30/6/2006	40°30′02″	31°20′59″
Dedeler trough	Bo33	7.69	169	7.1	674	438	19.1	0.3	1126	Ibr	30/6/2006	40°31′11″	31°19′25″
Keçikıran trough	Bo35	7.56	179	7.8	613	398	15.2	0.3	1166	Ibr	30/6/2006	40°34′20″	31°22′43″
Güneyfelakettin	Bo36	7.38	192	12	431.4	280	12.5	0.2	1153	Ibr, HI	30/6/2006	40°35′29″	31°23′26″
Bozbey trough	Bo37	7.88	159	6	695	452	17.6	0.4	797	Ibr, HI	1/7/2006	40°25′38″	31°35′14″
Tepeköy trough	Bo38	7.59	176	7.3	1431	930	18.1	0.8	797	Ibr, HI	1/7/2006	40°23′52″	31°34′08″
Susuz trough	Bo39	7.63	173	6	699	454	18.2	0.4	1027	HI	1/7/2006	40°20′31″	31°34′17″
Kuzca trough	Bo40	8.34	126	10	122.4	79.6	24.7	0.1	1017	Pvi	1/7/2006	40°20′38″	31°45′22″
Borucak trough	Bo41	8.06	141	9.4	361.4	235	26.6	0.2	1022	HI	1/7/2006	40°21′17″	31°46′56″
Şahbazlar trough	Bo42	7.79	165	6.4	755	491	16.7	0.4	658	PO, Ibr, Hro, Hsa	2/7/2006	40°53′23″	31°54′54″
Sazlar trough	Bo43	7.41	186	7.8	518	337	19.2	0.3	721	Ibr, HI	2/7/2006	40°56′06″	32°07′01″
Afşartarakçı trough	Bo45	7.72	165	8.4	775	504	21.4	0.4	1282	Ibr, HI	2/7/2006	40°49′19″	32°19′42″
Koçumlar trough	Bo46	8.22	139	6.6	237.1	154	17.4	0.1	1308	HI	2/7/2006	40°48′47″	32°15′39″
Çağış trough	Bo47	7.26	197	7.3	787	512	15.4	0.4	1202	PO	11/8/2006	40°49′03″	32°23′55″
Demirsopran trough	Bo48	7.3	195	6.8	576.8	375	15.2	0.2	1267	Ibr, Pfo	11/8/2006	40°46′08″	32°23′07″
Ortaca trough	Bo49	7.49	185	7.4	146.4	95.2	15	0.1	1321	Pvi, Pfo	11/8/2006	40°46′51″	32°25′09″
Kayısopran trough	Bo50	7.62	174	na	565	367	18.4	0.3	1289	Pvi, HI	11/8/2006	40°48′06″	32°28′60″
Çanakçılar trough	Bo52	7.94	152	6.8	504	328	21.1	0.3	838	PO, Ibr, HI, Hro	11/8/2006	40°45′24″	31°47′08″
Muratlar trough	Bo53	7.1	203	5.9	670	436	16	0.3	764	PO, Pze	11/8/2006	40°46′07″	31°48′42″
Yayladin trough	Bo54	7.94	153	6.5	601	391	20.7	0.3	762	PO, Pze, Ibr, Pvi	11/8/2006	40°47′24″	31°50′06″
Taşçılar trough	Bo55	7.24	193	11	526	342	17.6	0.3	875	HI	13/8/2006	40°49′06″	31°44′06″
Çobankaya trough	Bo56	7.37	182	8.7	446.3	290	26.5	0.2	1022	HI	13/8/2006	40°49′23″	31°43′45″
Hamzabey trough	Bo57	7.71	165	7.6	523	340	24.3	0.3	783	CN, Ibr, HI, Pfo, FF	13/8/2006	40°46′05″	31°39′09″
Saraycık trough	Bo58	8.89	87	20	513	333	29.9	0.3	772	HI	13/8/2006	40°44′49″	31°44′39″
Kadak water*	V1	8.59	76.4	5.4	624	406	25.9	0.1	1728	Cli, HI, Hsa, Ibr, IG, Pse	6/7/2009	39°00′71″	43°45′06″
İdris Bey trough	V2	8.02	181	8.1	341	222	15.7	na	1674	TL	6/7/2009	38°57′38″	43°40′90″
Geyikler Çeşmesi	V3	7.86	93.6	7.4	140	91	14.8	0.1	1673	HI, Ibr	7/7/2009	38°58′27″	43°36′43″
Kırklar Mezarlığı	V4	7.13	110	9.3	150	97.5	14.1	na	1677	HI, Ibr	7/7/2009	38°58′26″	43°36′44″
Durukanal trough	V5	8.4	87.3	4.5	607	395	29.2	0.1	1674	Cpu, HI, Ibr, PAI	8/7/2009	38°57′46″	43°41′00″
Kümbet trough	V6	7.85	112	6.7	218	142	12.3	na	1718	HI	8/7/2009	38°59′80″	43°46′20″
Ute water*	V8	8.18	82.73	2.45	643.00	418	28.50	0.10	1684	CV, CPu, DSi, HI, PV, PSe	13/7/2009	38°56′57″	43°45′09″
Mean		8.1	142	7.6	452.7	294	18.6	0.25	949				
Max.		12.4	214	20	1431	930	29.9	2.1	1728				
Min.		6.47	–315	4.1	4.5	2.93	11.6	0.1	29				
St. dev.		1.05	77.1	3	233.4	152	4.29	0.22	369				