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Preliminary study on distribution, diversity, and ecological characteristics of nonmarine Ostracoda (Crustacea) from the Erzincan region (Turkey)

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Abstract: Ecological characteristics of 32 nonmarine ostracod taxa collected from 89 aquatic habitats of Erzincan (Turkey) during the summer of 2006 were evaluated. All of the species are new reports for the area, while *Cypria sywulae* Meisch, 2000 is a new record for the Turkish ostracod fauna. The first 2 axes of canonical correspondence analysis explain 74.1% of the variance between 15 species and 5 environmental variables. The influence of water temperature on species distribution was significantly higher (P = 0.02) than that of the other ecological factors. The most frequently occurring species were clustered into 3 main groups based on their ecological characteristics using unweighted pair group mean averages. Among the species, cosmopolitans showed a tendency to display wide ranges of tolerance values. *Cypridopsis vidua* (O. F. Müller, 1776) was the only species showing a significant (P = 0.03) negative correlation to habitat type (lentic versus lotic). Our results support the idea that once ecological characteristics of individual species are known, it is possible to use such knowledge in reconstructing past ecological conditions. However, application of this idea may not be limited to local/alpha species diversity. Indeed, our results suggest that studying gamma/regional diversity (Erzincan and environs) allows extending conclusions over a larger geographical scale and wider range of ecosystems.

Key words: Distribution, diversity, ecological tolerance, Erzincan, Ostracoda

1. Introduction

Ostracods are small aquatic crustaceans that can be found in various habitat types with a variety of ecological conditions. They can be used as indicator species to estimate water quality (Delorme, 1969; Benson, 1990) and determine habitat types (Forester, 1991; Külköylüoğlu and Vinyard, 2000), because each species has its own ecological preferences and species-specific tolerance levels. Therefore, once the species' ecology is understood, such knowledge can be helpful in reconstructing the past history of habitats (Forester and Smith, 1992). This can be done because ostracods can be found as fossil forms due to their calcium-carbonated carapaces. Although the idea of indicator species has been applied to different taxonomic groups, there have been few studies conducted over the last 10 years in Turkey; those that are available cover various water bodies such as lakes (Külköylüoğlu and Dügel, 2004), reservoirs (Külköylüoğlu, 2005a), wetlands (Külköylüoğlu, 2005b), and springs (Karakaş-Sarı and Külköylüoğlu, 2008). Given the focus on these particular types of aquatic habitats, previous studies mostly dealt with species diversity in local regions, or so-called alpha diversity. Since alpha diversity implies local species richness only, ecological information will be limited to the conditions prevailing in those particular ecosystems. With such limited ecological knowledge, making general conclusions may also be difficult. Regional species diversity, or so-called gamma diversity, on the other hand, implies measuring overall species diversity on a geographic scale and from different ecosystems (Hunter, 2002). Hence, gamma diversity deals with a larger sampling area covering a wider range of ecological conditions where ostracods can be found. Consequently, sampling efforts in a wider geographical area can provide sufficient data for future estimates of ecological requirements and habitat preferences in ostracod species.

This research was the first extensive study on ostracods in Erzincan. The aims of the present work were to determine the ostracod species composition in the different aquatic habitats of Erzincan, to estimate the relationship between the individual species and measured environmental factors, and to outline ecological requirements and habitat preferences of the most frequently occurring species, along with assessing the tolerance and optimum values of environmental factors for each of them.

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2. Material and methods

2.1. Study area

The province of Erzincan (39°02′N to 40°05′N, 38°16E to 40°45′E) covers ca. 11,900 km^2 of Turkey (Figure 1) and is located in the eastern part of Anatolia, which has a continental climate. A total of 89 sites randomly selected were visited between 23 June and 22 August 2006 in 9 districts located at elevations of between 840 and 1954 m a.s.l. (Appendix).

2.2. Physicochemical and biological measurements

Before sediment sampling, 7 physicochemical environmental variables were measured in situ and water samples were taken. Water temperature (°C), dissolved oxygen (mg L^{-1}), percent oxygen saturation, electrical conductivity (µS cm^{-1}, at 25 °C), salinity (ppt), redox potential (mV), and pH were measured in situ with YSI-85 oxygen-temperature and HI-98150 pH/ORP meters. The values of total dissolved solids (TDS) were calculated from electrical conductivity by multiplying measured values with a 0.65 coefficient (Forester and Brouwers, 1985). Additionally, values of redox potential were later transformed to standard hydrogen electrode (SHE) by SHE = EH + 207 + 0.65 × [25 °C – T(w)]. Air temperature (°C), monthly rainfall, and dry/wet month data were obtained from the Meteorological Station in Ankara. Geographical data [i.e. altitude (m) and coordinates] were recorded with a GARMIN-GPS 45.

Ostracods were collected with a hand net (200-µm mesh size) from different aquatic habitats (lakes, reservoirs, ponds, creeks, springs, ditches, troughs, etc.) in about 100 cm of water depth. One sampling was done from each site, unless otherwise indicated. The stations' names with habitat types, altitudes, latitudes, longitudes, and 9 physicochemical variables are given in the Appendix. Approximately 200 g of sediment sample collected from each site was fixed in 250-mL bottles with 70% ethanol. In the laboratory, these sediment samples were filtered through 4 standard sieves (1.5, 1.0, 0.5, and 0.25 mm) and fixed in 70% ethanol for further studies. Ostracods were separated from the sediment with fine needles and kept in ethanol in glass vials. An Olympus BX-51 microscope was used for species identification after individuals were mounted in lactophenol solution on slides. Species identified with soft body parts and carapace structures were classified based on the systematic descriptions of Broodbakker and Danielopol (1982) and Meisch (2000). Scanning electron microscope (SEM, Jeol/JSM 6335F) photographs of some common ostracod valves were taken at the Scientific and Technological Research Council of Turkey's Marmara Research Center (TÜBİTAK MAM) (Figure 2). All material is kept in the laboratory of the

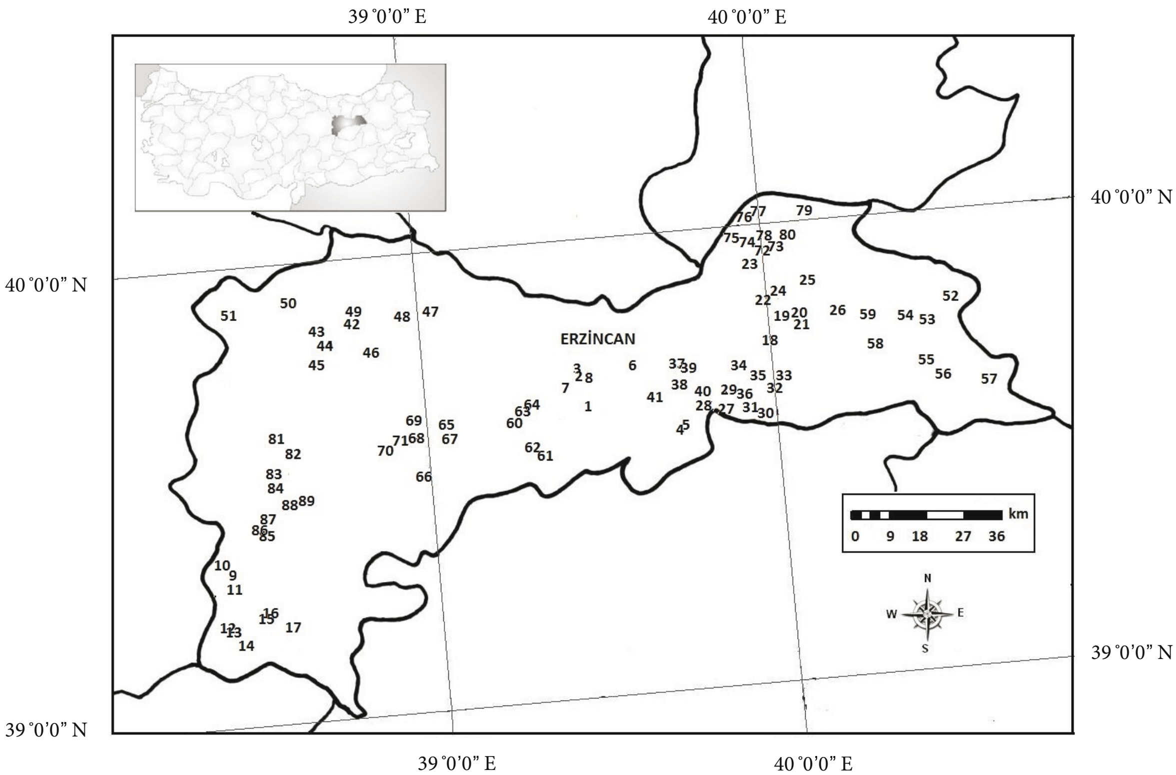

Figure 1. Map illustrating the location of the 89 sampling sites randomly selected in Erzincan.

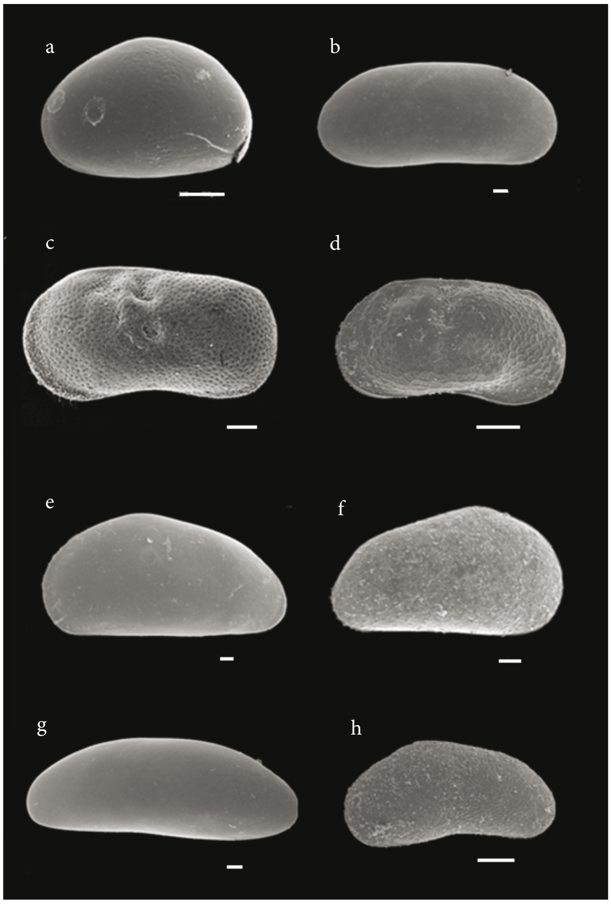

Figure 2. SEM photographs of species: a) *Cypria sywulae* Meisch, 2000; b) *Herpetocypris chevreuxi* (Sars, 1896); c) *Ilyocypris inermis* Kaufmann, 1900; d) *Limnocythere inopinata* (Baird, 1843); e) *Eucypris lilljeborgi* (G. W. Müller, 1900); f) *Prionocypris zenkeri* (Chyzer & Toth, 1858); g) *Dolerocypris fasciata* (O. F. Müller, 1776); h) *Potamocypris similis* G. W. Müller, 1912. Scale bars = 100 µm.

Biology Department of Marmara University, İstanbul, Turkey, and is available upon request.

2.3. Statistical analyses

Different statistical methods were used to analyze the data. Among them, canonical correspondence analysis (CCA) and Monte Carlo tests (499 permutations) were performed after data were log-transformed and tested with detrended correspondence analysis (DCA), which is used to check the length of gradient for CCA (ter Braak, 1986). This method attempts to explain the possible correlation between species and environmental variables, both graphically and numerically identifying the most effective variable(s) for the analyzed species (ter Braak and Barendregt, 1986; Birks et al., 1990). The CCA was performed based on the choice of manual selection amid variables. In order to reduce the arc effect, we only selected variables that were independent from each other (no significant correlation). This selection criterion retained 5 out of the 7 measured variables. We used CCA with 15 species and the 5 most influential environmental variables within 63 sites. Using quantitative data, unweighted pair group mean averages (UPGMA) applied with Jaccard's coefficient tests were selected to display different clustering assemblages of the most common 15 species occurring 2 or more times. UPGMA was performed with a multivariate statistical package program (MVSP, version 3.1) (Kovach, 1998) (Figure 3), while CCA was done with the CALIBRATE program, version 1.0 (Juggins, 2001) (Figure 4). Ecological tolerance (t_k) and optimum estimates (u_k) of individual species were determined with the C2 program (Juggins, 2003) using weighted averaging (WA). During WA, a species' optimum value is taken as the average of all sampling sites where the species occurs, weighted by its present abundance in each. It is assumed that the species shows a unimodal response to the environmental variable(s) used and that it is most abundant in sampling sites with values closer to their optimum values (ter Braak, 1986) (Table).

A nonparametric statistical method of Spearman rank correlation analysis applied with Jaccard's coefficient was used to exhibit levels (weak to strong) of correlations among species and environmental variables. Binary data were used for habitat types as lotic (flowing) waters (1) and lentic (stagnant) waters (0). Only living adults that occurred in at least 2 samples from different localities were included in the analyses, while juveniles, subrecent specimens, and those with broken valves and/or carapaces were excluded.

3. Results

A total of 32 ostracod taxa were recorded in 63 out of 89 samples (Appendix); the 26 other samples did not contain any ostracods. Of these, *Cypria sywulae* was a new report for Turkey. The 15 most common species were grouped into 3 main clusters on the UPGMA dendrogram (Figure 3); 2 species [*Herpetocypris chevreuxi* (Sars, 1896) and *Eucypris lilljeborgi* (G. W. Müller, 1900)] were located separately. The 3 groups consist of the 5 ostracod species *Psychrodromus fontinalis* (Wolf, 1920), *Eucypris virens* (Jurine, 1820), *Potamocypris similis* G. W. Müller, 1912, *Psychrodromus* sp., and *Pseudocandona albicans* (Schäfer, 1934); the 3 species *Cypridopsis vidua*, *Psychrodromus olivaceus* (Brady & Norman, 1889), and *Ilyocypris inermis* Kaufmann, 1900; and, finally, the 5 species *Potamocypris fulva* (Brady, 1868), *Heterocypris incongruens* (Ramdohr, 1808), *I. bradyi* (Sars, 1890), *P. fallax* G. W. Müller, 1900, and *Candona neglecta* Sars, 1887. Another 17 ostracod species were not used in the statistical analyses: *Darwinula stevensoni* (Brady & Robertson, 1870); *Candona candida* (O. F. Müller, 1776); *C. angulata* Müller, 1900; *Fabaeformiscandona* sp.; *Cypria sywulae*; *Cyclocypris ovum* Jurine, 1820; *Ilyocypris decipiens*

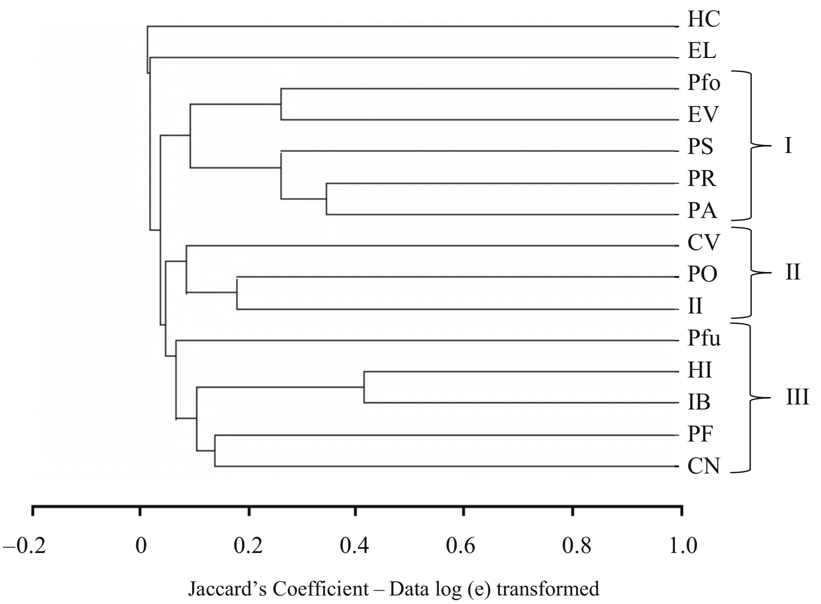

Figure 3. Three clustering groups of UPGMA analysis for the 15 most common species based on binary data (presence and absence). Two species (HC and EL) were located separately. Abbreviations are listed in the Appendix.

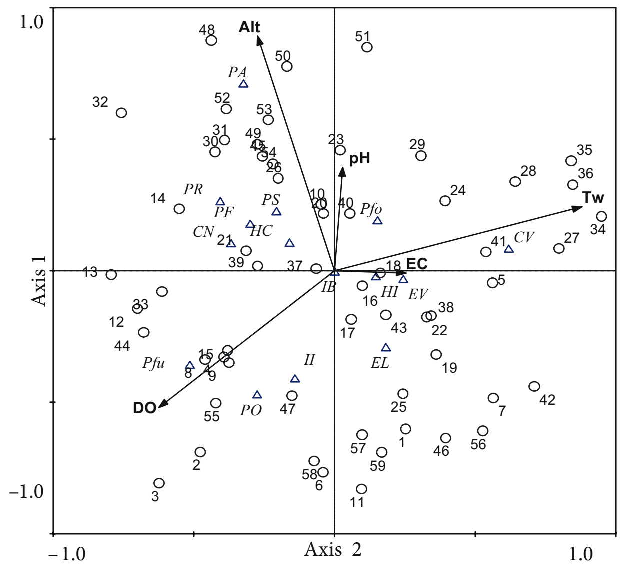

Figure 4. CCA site–species–environmental triplet based on the 15 most common species recorded in 63 (out of 89) sites and 5 environmental variables [water temperature (Tw), dissolved oxygen (DO), altitude (Alt), electrical conductivity (EC), and pH]. The only variable that significantly contributed to the CCA model was water temperature; the other variables did not contribute. Axes I and II had relatively small variances of 4.8 and 6.9, respectively. Species are indicated with triangles, whereas sample sites are indicated with circles. For species codes and sample site numbers, see the Appendix.

Masi, 1905; *Cypris pubera* O.F. Müller, 1776; *Prionocypris zenkeri* (Chyzer & Toth, 1858); *Herpetocypris brevicaudata* Kaufmann, 1900; *Stenocypria fischeri* (Lilljeborg, 1883); *Heterocypris salina* (Brady, 1868); *Dolerocypris fasciata* (O. F. Müller, 1776); *D. sinensis* (Sars, 1903); *Isocypris beauchampi* (Paris, 1920); *Potamocypris villosa* (Jurine, 1820); and *Limnocythere inopinata* (Baird, 1843). Reporting these species from different types of habitats, however, contributes to the species richness of the area and extends existing knowledge about their geographical distribution. Seven of them (*I. decipiens*, *C. sywulae*, *H. brevicaudata*, *S. fischeri*, *D. fasciata*, *D. sinensis*, and *I. beauchampi*) have rarely been recorded from Turkey, and ecological knowledge of these species remains unresolved. In contrast, 9 species (*D. stevensoni*, *C. candida*, *C. angulata*, *C. ovum*, *C. pubera*, *P. zenkeri*, *H. salina*, *P. villosa*, and *L. inopinata*) have previously been reported from a variety of habitats in Turkey (see Section 4).

The first 2 axes of CCA were able to explain 74.1% of the variance between 15 species and 5 environmental variables with about 6.9% cumulative percentage variance of species data (Figure 4). Distribution of species within each group in UPGMA corresponded to the distribution of species in the CCA diagram. Water temperature was the most significantly influential factor on species (P = 0.024, f = 2.236), while the other variables showed weak or no influence: dissolved oxygen (P = 0.154, f = 1.406), altitude (P = 0.450, f = 1.015), electrical conductivity (P = 0.720, f = 0.601), and pH (P = 0.696, f = 0.486).

Table. Tolerance (t_k) and optimum estimates (u_k) of the 15 most common species. Abbreviations: Sp, species code; Count, number of species occurrences found among the sampling sites; Max, maximum numbers of individuals; N2, Hill's effective numbers of occurrences (see Appendix for other abbreviations).

Sp	Count	Max	N2	Altitude (m)		T_w		pH		DO		EC		SHE		Sal	
				u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k	u_k	t_k
CN	8	44	2	1571.38	158.07	16.22	4.2	7.1	0.31	4.03	1.19	760.45	1235	206.91	17.43	0.37	0.62
PA	2	3	2	1797.00	014.14	17.7	3.53	7.29	0.15	2.70	0.01	569.12	121.76	200.50	0.07	0.26	0.07
IB	34	106	13	1429.58	239.25	21.3	5.92	7.06	1.91	4.14	1.03	627.78	349.03	183.68	21.78	0.3	0.19
II	5	47	3	1288.25	329.42	18.07	2.72	5.39	4.16	5.26	0.77	509.72	229.17	197.67	12.21	0.26	0.22
EV	5	15	2	1468.25	379.67	24.92	4.22	7.61	0.46	3.37	1.52	807.56	239.92	167.45	21.13	0.59	0.49
EL	2	16	2	1315.83	248.19	24.01	1.20	7.54	0.59	4.80	0.24	339.62	054.30	176.15	34.43	0.16	0.07
HC	2	11	2	1755.79	545.17	21.44	1.13	7.92	0.21	4.83	0.04	425.98	363.59	157.28	11.70	0.24	0.14
Pfo	5	105	2	1560.65	46.15	24.67	5.59	7.57	0.21	3.79	1.37	702.73	292.16	174.01	16.29	0.32	0.14
PO	2	3	2	1323.75	337.29	01.17	0.63	6.96	0.19	5.46	0.80	892.75	325.97	208.26	08.70	0.37	0.35
PR	2	2	2	1686.67	217.08	01.70	4.24	7.38	0.01	4.11	1.78	346.26	194.59	201.57	08.76	0.26	0.07
HI	25	178	11	1415.82	310.98	22.92	3.71	6.19	2.86	3.66	1.36	752.84	651.82	190.75	22.56	0.36	0.33
CV	6	24	4	1348.88	294.6	28.75	4.16	7.67	0.33	2.56	1.05	759.14	191.93	165.5	22.7	0.35	0.09
Pfu	4	64	2	1397.07	488.62	13.56	2.29	7.33	0.29	5.67	1.24	450.55	195.66	195.81	15.94	0.22	0.13
PF	10	262	2	1593.92	260.35	18.94	3.49	7.25	1.11	4.71	0.81	354.88	125.79	197.11	67.93	0.32	0.39
PS	3	104	1	1760.18	263.38	19.8	2.44	7.41	0.27	3.46	1.93	597.28	266.12	196.72	11.35	0.28	0.14

According to Spearman correlation analyses, *C. vidua* was the only species that showed a significant negative correlation to habitat type (lotic or lentic habitats) ($P = 0.03$); no other species had a significant correlation to environmental variables ($P > 0.05$). Ecological tolerance and optimum estimates of species revealed that species with cosmopolitan characteristics usually had broad tolerance levels for different variables, but exceptions were also observed (see Table). Our results may imply moderate to high gamma diversity for the area.

4. Discussion

As described above, the first clustering group of the UPGMA dendrogram consisted of 5 ostracod species (see Figure 3), of which 4 are bottom-dependent species without (or with reduced) swimming setae on the second antenna, while a single species, *Eucypris virens*, is known to have setae. This indicates that species of this group might mainly inhabit substrates where they can crawl or walk, while their limited ability for active movement excludes these species from a broader range of habitats. Among the species of this cluster, *E. virens* is known to occur over a wide range of salinities (Yılmaz and Külköylüoğlu, 2006), and it can cope with warm (up to 24 °C; see Külköylüoğlu et al., 2007) as well as cold (10 °C; see Mezquita et al., 1999) waters. In the present study, this species was found closer to the center of the CCA diagram (Figure 4), which may imply its broad tolerance ranges for the selected environmental variables since the species did not show statistically significant relationships with other variables used. *Eucypris virens* also showed the highest optimum estimates for electrical conductivity (807.56 µS cm^{-1}) (Table).

Apart from *E. virens*, another 4 species were encountered at the same sampling site (station 78) located at ca. 1789 m a.s.l. These include *Psychrodromus fontinalis*, rarely reported from Turkey. During the present study, this species was found in 5 sampling stations varying from lake to spring habitats. The water temperature, pH, and dissolved oxygen levels in these stations ranged from 22.2 to 28.8 °C, 7.38 to 7.88, and 2.55 to 6.14 mg/L, respectively (Appendix). According to Meisch (2000), *P. fontinalis* has a strong preference for permanently cold waters, mostly spring and spring-associated habitats. Indeed, most recently, the species was reported from springs, streams, and/or waters related to spring habitats of Italy (Rossetti et al., 2006; Bottazzi et al., 2008; Pieri et al., 2009) and Turkey (Dügel et al., 2008). Despite its preferences for cold waters, in the current study, a couple individuals of *P. fontinalis* were found in a stream (station 29) with relatively warm water (ca. 24 °C), which was poorly oxygenated (ca. 5.0 mg L^{-1}). This implies that its tolerance range may be wider than previously estimated. Indeed, in our case, its relatively broad tolerance range (ca. 5.6 °C) and fairly high optimum estimate (24.6 °C) for water temperature (Table) seem to support this idea. However, due to limited data, interpretation of this species' ecological characteristics may not be correct, and further studies are required.

Two other species (*Potamocypris similis* and *Pseudocandona albicans*) of the first group exhibit some similarities in their ecology and habitat preferences. Meisch (2000) already underlined the poor knowledge on the ecology of *P. similis*. Meisch (2000) also stated that *P. similis* prefers ponds with sandy or muddy bottoms and the littoral zones of lakes. This species has been reported from Northeast Italy (Pieri et al., 2009) and Anatolia (Sarı and Külköylüoğlu, 2010), but again without details about its ecology. Külköylüoğlu and Sarı (2011) presented a significant positive correlation of *P. similis* with dissolved oxygen in cool waters (ca. 15 °C). We collected this species from 3 slow-flowing creeks (Appendix; stations 18, 27, and 78), where it tolerated low to high salinities and temperatures of 17.7 to 24 °C. Additionally, *P. similis* showed the highest optimum for altitude (ca. 1760 m) and a tolerance of 263.38 m. Its tolerance value to dissolved oxygen ($t_k = 1.93$ mg L^{-1}) was the highest among those ever reported. Unlike *P. similis*, considerable ecological data are available for *P. albicans* from Europe (Hiller, 1972; Gülen, 1985; Meisch, 2000; Rossi et al., 2003), North America (Külköylüoğlu, 1999; Karanovic, 2006), western Asia and Micronesia (Beyer and Meisch, 1996), and China (Yu et al., 2009). This species appears to be tolerant to oligo- to mesohaline conditions (Külköylüoğlu, 1999). We found the species at 2 sites (stations 73 and 78) with low dissolved oxygen (1.84 and 3.27 mg L^{-1}), low to medium water temperature (14.7 to 19.7 °C), and brackish waters of up to 638 µS cm^{-1}, at relatively high elevations (1789 and 1809 m a.s.l.). The possible relation between elevation and species distribution is reflected by the position of this species (occurrence of the species was correlated with altitude) in the upper left part of the CCA diagram. Our results support earlier findings stating that *P. albicans* has a wide tolerance to salinity (Külköylüoğlu, 1999). The species has a preference for high altitudes and low temperatures; it is considered an indicator for cold water by Mezquita et al. (1999).

The second clustering group of the UPGMA (Figure 3) included 3 ostracod species. *Cypridopsis vidua*, a cosmopolitan species, has been known to display broad tolerances to different environmental conditions. In the present study, we found *C. vidua* among the 5 most frequently occurring species in waters with electrical conductivity of 1008 µs cm^{-1}. It was actually the only species with a significant negative correlation to habitat type ($P = 0.03$). Such a finding may be interpreted such that *C. vidua* may not have a certain kind of habitat preference. The Table reveals that optimum estimates of *C. vidua* for water temperature (28.75 °C) and pH (7.67) were the highest in the current study. This species was located near the temperature arrow in the CCA diagram (Figure 4). This corresponds to the temperature range between 17.4 and 33.1 °C (Appendix). These results are concordant with a possible high flexibility to tolerate changes in the different environmental variables. *Psychrodromus olivaceus* was collected from slightly brackish (547–1008 µS cm^{-1}) aquatic bodies along with *C. vidua*, *Heterocypris incongruens*, and *Ilyocypris bradyi*. The CCA diagram (Figure 4) placed *P. olivaceus* in the left lower corner, closer to the dissolved oxygen arrow. This may imply a positive relationship of its distribution to dissolved oxygen. Indeed, *P. olivaceus* has been reported from ponds, pools, ditches, and slow- (or non-) flowing waters (Rossetti et al., 2006) that are well oxygenated.

The last species of this group, *Ilyocypris inermis*, was found to be close to *P. olivaceus* in the CCA diagram. *I. inermis* is mostly found in spring and spring-associated waters, where it tends to prefer cold waters (Meisch, 2000; Rossetti et al., 2005), but in recent studies, it has also been found in lakes and peat bogs (Pieri et al., 2009), rice fields (Rossi et al., 2003), ponds, slow-flowing creeks, and irrigation canals (this study). Mezquita et al. (1996) collected this species from springs and rivers in Spain with conductivity of 485–750 µS cm^{-1}, pH of 7.38–8.55, dissolved oxygen of between 6.6–8.0 mg L^{-1}, and water temperature of 12.8 to 18.0 °C. Külköylüoğlu and Yılmaz (2006) reported *I. inermis* frequently in a shallow limnocrene spring almost all year round, during which water temperature fluctuated between 5.7 and 17.6 °C. Külköylüoğlu et al. (2010) found this species in a landslide lake in Bolu, Turkey, with water temperatures ranging between 11.44 and 15.71 °C. In the present study, this species was collected from relatively high elevations of between 889 and 1553 m, where pH levels lie between acidic (6.76) and basic (8.33) conditions. In contrast to our results, a peculiar geographic distribution was previously described for this species from low elevations (below 240 m) in the southern part of NE Italy (Pieri et al., 2009). Our results support the earlier views that *I. inermis* may prefer low temperature values, but apparently it can also tolerate low levels of DO and high levels of electrical conductivity. Hence, tolerance to these environmental variables might be broader than previously thought.

The third clustering group in the UPGMA results (Figure 3) consisted of 5 species. Three of these (*C. neglecta*, *H. incongruens*, and *I. bradyi*) are well-known cosmopolitans with a widespread geographical distribution in a variety of aquatic habitats (Meisch, 2000; Külköylüoğlu et al., 2007). In the ordination diagram (Figure 4), they are plotted near the center, implying broad tolerances to the environmental variables investigated in the current study. This is especially true for *I. bradyi* and *H. incongruens*, which were the most frequently occurring species, reported from different habitats during this study. When comparing species' tolerance and optimum estimates (Table), it is clear that species with cosmopolitan characteristics also display higher tolerance values. For example, *I. bradyi* had the broadest tolerance for water temperature (5.92 °C), whereas *C. neglecta* displayed high tolerance for electrical conductivity (up to 1235 µS cm^{-1}). *Heterocypris incongruens* did not show any clear relationship to the investigated variables. It is a cosmopolitan species with broad tolerances to a range of environmental variables and could be called a "cosmoecious" species (Külköylüoğlu, 2007), along with the other 2 species, *I. bradyi* and *C. neglecta*. Ecological information for the other 2 species from this UPGMA cluster, *P. fulva* and *P. fallax*, is still relatively scarce. According to Meisch (2000), *P. fulva* can be found from ditches, slow-flowing waters, springs, and lakes. Külköylüoğlu et al. (2007) reported *P. fulva* as a new record for Turkey, where it was found in a cold (1.56 °C), heavily polluted eutrophic lake (Lake Yeniçağa) with relatively high electrical conductivity (465 µS cm^{-1}) and medium dissolved oxygen values (11.37 mg L^{-1}). This is the lowest temperature record for this species. In the present study, this species was found in slow-flowing, spring-fed creeks at high altitudes (925 to 1925 m a.s.l.) with water temperature ranging from 12.0 to 18.4 °C, dissolved oxygen values being relatively low (ranging from 4.5 to 6.5 mg L^{-1}), and waters being alkaline. Additionally, *P. fulva* showed the highest tolerance and optimum estimates for altitude and dissolved oxygen values. Our results suggest that this species tends to occur in well-oxygenated waters at high elevations in Turkey.

The occurrence of *P. fallax* at high altitudes was reported from NE Italy along with low conductivity values (Pieri et al., 2009). We also found this species at high altitudes (1138 to 1954 m a.s.l.) but at low (217 µS cm^{-1}) to relatively high (1074 µS cm^{-1}) conductivities. In our study, the temperature tolerance of *P. fallax* was within the range of 13.7 to 26.9 °C, higher than that of *P. fulva*. It has the highest tolerance to different oxygen contents (Table), as it was collected from water bodies with low (1.86 mg L^{-1}) to medium (6.17 mg L^{-1}) oxygen content. Although *P. fulva* and *P. fallax* belong to the same genus, they were never recorded at the same site. This may indicate different ecological requirements for the 2 species. However, general conclusions cannot be drawn because of the limited data. *Potamocypris fallax* probably prefers cold waters at high altitudes and can also tolerate high salinities with low-oxygenated waters. Meisch (2000) reported the cooccurrence of *P. fallax* and *P. zschokkei* from the same area, indicating that they might prefer similar ecological conditions, both being cold stenothermal. Finding species belonging to different genera in the same clustering groups suggests that those species (and genera) may have some common ecological requirements. However, this view cannot be generalized because of the limitations of the data from the current study and the fact that ecological knowledge of many ostracod species is still limited.

As mentioned before, in the current study, statistical analyses were limited to the 15 most common species. The remaining 17 species were too rare to deduce sound ecological knowledge; however, they still contribute to the species richness of the area. For example, *C. sywulae* is a new report for Turkey, and 31 species (including rare species) are new for the area studied.

Regional species diversity (or so-called gamma diversity) implies measuring overall species diversity on a geographic scale (e.g., the city of Erzincan and its environs) and from different ecosystems (Hunter, 2002). Hence, compared to alpha diversity, gamma diversity deals with a larger sampling area with a wider range of ecological conditions of habitats where ostracods can be found. Sampling efforts in a wider geographical area can thus provide sufficient data for future estimates of ecological requirements and habitat preferences of ostracod species. The gamma diversity of Erzincan adds up to 32 species from 63 out of 89 sites.

We did not find ostracods in 26 samples. It is probable that species either have not reached the sites or that the sites are not suitable for them. Of course, some biotic factors (e.g., competition, predation) can also have effects on species diversity, but this was beyond the scope of this work and therefore not covered in this study. Nevertheless, such issues could be critical for further studies.

The diversity found in Erzincan in this study is indeed higher than the diversity of Diyarbakır (Akdemir and Külköylüoğlu, 2011) and Van (Külköylüoğlu et al., 2012), where 23 and 29 species were found in 50 of 90 and 57 of 78 sampling sites, respectively. However, such a difference in diversity is likely related to the number of sampling sites, as numbers of species tend to increase with increasing sampling area [Island Biogeography Theory of MacArthur and Wilson (1967)].

Since our sampling sites (N = 89) still cover only a small portion of ostracod habitats in the Erzincan region, more extensive fieldwork is required for a more accurate estimate of ostracod diversity in this area. Our sampling was also limited to one season only (i.e. the summer period), whereas it is clearly known from literature that certain ostracod species are only found during other seasons (Meisch, 2000). These issues should be considered for future studies.

In conclusion, the results of our study seem to support our hypothesis that the gamma diversity of the Erzincan region, with 32 species, is higher than the gamma diversity of other nearby regions. The 5 most influential environmental variables explained 74.1% of the variation in the 15 most common species, with water temperature being the most important variable for ostracod species distribution. Among the analyzed species, cosmopolitans typically showed relatively higher tolerances to different factors than rare or specialist species. Our study has contributed to the ecological characterization of the most abundant ostracods in the study area. Once ecological requirements of individual ostracod species are well known, this knowledge can be used for the reconstruction of past ecological conditions.

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Appendix. Geographical information (station names, altitudes, latitudes-N, longitudes-E) and 9 physicochemical variables from 89 different water bodies in Erzincan (Turkey). Abbreviations: Alt = altitude (m); Ta = air temperature (°C); Tw = water temperature (°C); SHE = standard hydrogen electrode (redox potential, mV); %S = oxygen saturation (%); DO = dissolved oxygen (mg/L); EC = electrical conductivity (µS/cm); TDS = total dissolved solids (mg/L); Sal = salinity (ppt); NA = not available. Species codes: Dst, *Darwinula stevensoni*; CC, *Candona candida*; CN, *Candona neglecta*; CA, *Candona angulata*; FA, *Fabaeformiscandona* sp.; PA, *Pseudocandona albicans*; Csy, *Cypria sywulae*; CS, *Cyclocypris ovum*; ID, *Ilyocypris decipiens*; IB, *Ilyocypris bradyi*; II, *Ilyocypris inermis*; CP, *Cypris pubera*; EV, *Eucypris virens*; EL, *Eucypris lilljeborgi*; PZ, *Prionocypris zenkeri*; HB, *Herpetocypris brevicaudata*; HC, *Herpetocypris chevreuxi*; PO, *Psychrodromus olivaceus*; Pfo, *P. fontinalis*; PR, *Psychrodromus* sp.; SF, *Stenocypria fischeri*; HI, *Heterocypris incongruens*; HS, *Heterocypris salina*; DF, *Dolerocypris fasciata*; DS, *Dolerocypris sinensis*; Ibea, *Isocypris beauchampi*; CV, *Cypridopsis vidua*; Pfu, *Potamocypris fulva*; PF, *Potamocypris fallax*; PS, *Potamocypris similis*; Pvi, *Potamocypris villosa*; LI, *Limnocythere inopinata*.

No.	Station name	Alt.	Latitude	Longitude	Ta	Tw	pH	SHE	%S	DO	EC	TDS	Sal	Species code
1	Reed bed 1	1684	39°28′423″	39°38′277″	28.0	29	6.92	209.200	40.8	3.70	547.0	355.55	3.02	Dst, DF
2	Horhor	1096	39°37′006″	39°44′010″	20.6	19.9	6.51	238.115	20.2	1.80	734.0	477.10	0.40	--
3	Reed bed 2	1150	39°26′239″	39°42′920″	20.6	22.7	7.68	170.29	50.7	4.78	830.0	539.50	0.40	HC
4	Creek 1	1157	39°43′553″	39°35′056″	22.2	13.2	7.36	195.27	57.9	5.74	574.0	373.10	0.30	Pfu, IB
5	Small water ditch 1	1157	39°43′822″	39°35′216″	22.2	12.2	7.18	204.52	60.4	6.50	570.0	370.50	0.30	Pfu, IB, HI
6	Ekşisu pond	1443	39°36′935″	39°43′910″	29.2	17.4	7.03	211.34	61.1	5.74	1008	655.20	0.50	CC, CN, Csy, PO,CV
7	Beytahtı lake	1166	39°24′036″	39°41′628″	26.0	24.2	NA	NA	28.1	2.24	1119	727.35	0.60	--
8	Lakelet 1	1152	39°27′934″	39°42′125″	26.0	27.6	NA	NA	33.0	2.60	474.1	308.16	0.20	PZ, IB
9	Spring water 1	966	38°23′522″	39°19′321″	27.3	16.5	6.76	199.02	48.0	4.62	547.0	355.55	0.00	II, PO, IB
10	Çaltı stream	840	38°22′521″	39°21′426″	27.3	20.0	6.86	202.05	21.1	1.75	607.0	394.55	1.39	EV
11	Irrigation canal 1	1425	38°23′656″	39°17′890″	27.3	16.5	7.32	195.92	60.1	5.83	498.5	324.02	0.20	CN, II, HI
12	Dilli creek	1409	38°22′902″	39°13′630″	27.3	17.9	7.01	211.31	63.1	5.84	352.8	229.32	0.20	IB
13	Creek 2	1530	38°23′157″	39°13′030″	27.3	19.2	7.14	203.57	18.2	1.92	467.3	303.74	0.20	--
14	Subatan pond	1880	38°24′376″	39°11′314″	27.3	28.4	7.01	204.59	76.3	6.02	135.1	87.815	0.10	HI
15	Keban dam lake	839	38°30′245″	39°14′882″	27.3	26.9	7.72	164.86	89.4	6.99	474.0	308.10	0.20	--
16	Small water ditch 2	1096	38°30′420″	39°14′270″	27.3	27.4	7.12	196.14	73.2	5.41	392.2	254.93	0.20	--
17	Yeşilyurt creek	925	38°33′500″	39°12′090″	27.3	18.4	7.01	211.09	52.5	4.70	242.3	157.49	0.10	Pfu
18	Büyükyayla stream	1706	39°59′765″	39°45′436″	25.1	17.7	7.61	175.84	74.4	7.06	247.3	160.74	0.10	CN, PS
19	Spring water 2	1564	40°03′457″	39°47′602″	25.1	12.2	7.03	213.32	53.7	5.30	264.4	171.86	0.10	IB
20	Trough 1	1579	40°04′487″	39°47′142″	25.1	13.9	7.09	208.91	40.0	3.89	224.5	145.92	0.10	CN, CA, PF
21	Center irrigation pond	1657	40°04′501″	39°47′155″	25.1	22.7	7.74	165.49	55.2	4.79	340.4	221.26	0.20	--
22	Çamurdere stream	1509	39°59′663″	39°50′296″	25.1	18.8	7.88	164.83	69.4	6.14	642.0	417.30	0.20	CN, EV, Pfo, IB
23	Cennetpınar pond	1710	39°57′494″	39°55′410″	25.1	23.3	7.51	179.30	81.2	6.79	435.1	282.81	0.20	--
24	Irrigation canal 2	1560	40°01′311″	39°50′811″	25.1	25.2	8.13	142.27	61.9	5.05	286.2	186.03	0.10	EL, Ibea
25	Borumun creek	1460	40°06′724″	39°51′673″	25.1	23.0	7.74	169.60	58.4	4.84	879.0	571.35	0.40	IB, HI
26	Acı lake	1449	40°11′116″	39°47′388″	26.0	21.2	6.79	221.60	37.0	3.17	2602	1691.3	1.30	CN, HI
27	Creek 3	1215	39°51′218″	39°36′237″	28.4	24.0	7.88	202.61	47.3	3.86	100.3	65.195	0.10	PS, IB, HI
28	Karacalar lakelet	1681	38°54′769″	39°37′382″	28.4	25.9	7.25	190.01	40.7	3.13	376.2	244.53	0.20	--
29	Otluk lake	1708	39°54′694″	39°37′502″	28.4	24.2	7.47	168.32	57.8	4.68	464.7	302.05	0.20	EV, Pfo
30	Spring water 3	1616	39°58′303″	39°35′171″	28.4	19.3	7.61	175.50	54.7	4.90	353.1	229.51	0.20	PF
31	Pelitli-Çamlıca creek	1420	39°57′189″	39°35′363″	28.4	29.2	7.69	163.57	60.4	4.49	693.0	450.45	0.30	--
32	Han creek	1397	39°59′727″	39°37′386″	28.4	26.0	7.82	159.45	53.8	4.36	423.6	275.34	0.20	IB, HI
33	Gran lake	2668	39°56′022″	39°40′320″	30.4	20.2	7.5	181.82	47.4	4.32	173.4	112.71	0.10	--
34	Geyik lake	2846	39°56′444″	39°39′744″	30.4	24.9	8.5	120.66	53.7	4.73	120.4	078.26	0.10	CS, Pvi
35	Trough 2	1554	39°56′200″	39°36′488″	29.9	18.8	7.18	200.53	20.7	1.86	1074	698.10	0.50	PF, IB, HI
36	Small water ditch 3	1600	39°56′200″	39°36′490″	29.9	27.0	7.79	158.30	41.0	3.18	944.0	613.60	0.50	EV, IB, HI
37	Pahnik stream	1220	39°44′376″	39°41′782″	22.2	14.8	7.21	202.43	53.2	5.32	183.6	119.34	0.10	--
38	Small water ditch 4	1209	39°43′627″	39°39′696″	22.2	23.5	7.29	190.97	56.5	4.70	363.0	235.95	0.20	EL, HI
39	Trough 3	1716	39°45′296″	39°41′393″	22.2	21.1	7.38	191.23	46.5	4.13	207.4	134.81	0.10	HI
40	Small water ditch 5	1311	39°48′102″	39°39′196″	22.2	28.0	7.73	162.65	62.6	4.84	305.4	198.51	0.10	--

41	DSİ irrigation pond	1189	39°39′600″	39°39′344″	22.2	26.0	7.2	194.95	13.1	1.03	683.0	443.95	0.30	HI
42	Small water ditch 6	1561	38°48′122″	39°51′445″	29.4	29.8	7.77	159.38	33.5	2.55	440.1	286.06	0.20	Pfo
43	Small water ditch 7	1696	38°44′200″	39°52′060″	29.4	26.9	7.67	166.46	39.5	3.13	552.0	358.80	0.30	PF, IB, HI
44	Spring water 4	1880	38°44′542″	39°50′025″	29.4	20.2	7.33	197.42	55.6	4.80	545.0	354.25	0.30	IB
45	Büyük stream	1878	38°42′537″	39°47′036″	29.4	19.9	7.44	184.61	64.0	5.59	507.0	329.55	0.20	--
46	Small water ditch 8	1683	38°51′487″	39°48′665″	29.4	28.9	7.59	170.56	41.2	3.09	1391.0	904.15	0.60	--
47	Yurtbaşı HİS pond	1921	39°01′730″	39°52′353″	28.8	21.1	7.99	153.73	54.0	4.85	315.8	205.27	0.20	HC
48	Güver creek	1925	38°57′097″	39°52′654″	28.8	15.0	7.64	178.90	45.9	4.47	266.6	173.29	0.10	CN, Pfu, IB
49	Kalkancı pond	1653	38°48′365″	39°52′533″	28.8	26.3	7.70	165.85	57.6	4.66	292.8	190.32	0.10	ID
50	Akarsu pond	1648	38°38′392″	39°55′463″	28.8	17.0	7.58	181.61	66.6	6.17	335.5	218.08	0.20	PF
51	Small water ditch 9	1498	38°26′719″	39°55′076″	28.8	32.5	7.69	161.92	30.1	2.19	1860.0	1209.0	0.90	HI
52	Tuzlasuyu creek	1618	40°31′863″	39°48′079″	28.8	20.5	7.54	176.52	45.8	4.21	243.7	158.40	0.10	--
53	Tercan dam lake	1465	40°25′724″	39°45′959″	28.8	26.7	7.90	154.89	58.7	4.64	309.8	201.37	0.10	--
54	Reed Bed	1409	40°22′254″	39°46′613″	28.8	28.8	7.38	182.73	10.2	0.87	461.1	299.72	0.20	CP, CV
55	Göktaş pond	1593	40°25′586″	39°39′890″	28.8	29.6	8.16	134.61	81.5	6.16	788.0	512.20	0.40	ID
56	Esenevler creek	1599	40°28′235″	39°38′751″	28.8	33.1	8.06	139.33	37.1	2.63	920.0	598.00	0.40	SF, CV, IB, HI
57	Irrigation canal 3	1553	40°35′809″	39°37′255″	28.8	21.7	7.46	182.54	51.9	4.54	870.0	565.50	0.40	II, Pfo, IB
58	Bağpınar creek	1444	40°16′965″	39°43′408″	28.8	27.2	7.63	169.67	58.7	4.66	580.0	377.00	0.30	EV, IB, HI
59	Gökçe creek	1413	40°15′031″	39°46′785″	28.8	14.8	7.24	200.63	33.3	3.30	1353.0	879.45	0.70	IB, HI
60	Topalhasan creek	1444	40°21′353″	39°16′896″	28.8	23.4	7.63	172.94	61.5	5.14	736.0	478.41	0.40	--
61	Karasu river	1043	39°02′008″	39°36′543″	31.0	19.7	7.61	176.44	52.2	4.79	595.0	386.75	0.30	--
62	Small creek	1459	39°17′749″	39°33′618″	31.0	19.6	7.71	170.60	29.1	2.62	571.0	371.15	0.30	IB, HI
63	Small Ardos lake	1458	39°17′750″	39°39′617″	31.0	28.1	7.61	169.78	42.0	3.25	709.0	460.85	0.30	HB, CV, IB
64	Big Ardos lake	1493	39°18′108″	39°39′858″	31.0	24.3	7.82	161.45	48.9	4.00	592.0	384.81	0.30	--
65	Kömür stream	1047	39°02′273″	39°36′798″	31.0	25.9	7.53	176.31	37.1	2.91	769.0	499.85	0.40	CV, LI
66	Dedek pond	1819	38°59′227″	39°31′797″	31.0	26.5	7.77	161.22	60.7	4.90	182.8	118.82	0.10	--
67	Tanasur creek	1187	39°02′539″	39°35′248″	31.0	19.3	7.32	193.11	31.8	2.80	389.2	252.98	0.20	IB, HI
68	Spring water 5	1482	38°57′913″	39°36′321″	29.5	13.7	7.40	209.84	61.1	5.80	362.8	235.82	0.20	PR, PF, IB
69	Small water ditch 10	1730	38°56′695″	39°37′858″	29.5	19.6	7.20	198.91	39.0	3.70	487.0	316.55	0.20	IB, HI
70	Trough 4	1100	38°54′184″	39°34′418″	29.5	24.7	7.62	176.39	57.4	4.75	293.3	190.64	0.10	IB, HI
71	Reed bed	1262	38°56′010″	39°35′647″	29.5	18.6	7.48	187.06	56.4	5.23	464.1	301.66	0.20	IB, HI
72	Spring water 6	1795	39°58′950″	39°57′933″	24.2	11.5	7.26	202.27	35.8	3.84	393.1	255.51	0.20	--
73	Small lakelet	1809	39°58′034″	39°58′104″	24.2	14.7	7.16	205.09	18.1	1.84	465.8	302.77	0.20	PA, IB
74	Unnamed creek	1846	39°56′325″	39°57′881″	24.2	21.7	7.25	195.44	45.6	4.39	354.0	230.11	0.20	PF, IB
75	Çerkez spring water	1954	39°52′988″	39°58′735″	24.2	22.8	7.58	175.53	40.8	3.43	392.0	254.81	0.20	CN, PF, IB
76	Eleddin creek	1952	39°55′892″	40°00′651″	24.2	26.2	7.55	174.82	35.8	2.84	538.0	349.71	0.30	IB
77	Otlukbeli lake	1931	39°58′768″	40°00′989″	24.2	20.6	7.27	194.66	48.0	4.27	474.9	308.68	0.20	CV
78	Yeniova creek	1789	39°59′222″	39°58′738″	24.2	19.7	7.38	197.44	35.8	3.27	638.0	414.70	0.30	FA, PA, Pfo, PR, PS, IB
79	Umurlu creek	1802	40°06′956″	40°00′864″	24.2	17.4	7.48	185.14	61.1	5.72	341.9	222.23	0.20	--
80	Ağamçağam creek	1688	40°03′857″	39°58′763″	24.2	19.2	7.31	192.57	37.8	3.45	637.0	414.05	0.30	PF, IB
81	Acısu spring water	1138	38°33′740″	39°35′212″	26.0	13.8	5.04	331.78	48.0	4.93	217.3	141.24	1.10	PF, HI
82	Boyalık stream	1041	38°35′380″	39°32′547″	26.0	24.7	8.33	187.99	48.5	4.01	246.5	160.22	1.30	II, IB
83	İliç lakelet	1024	38°35′593″	38°33′053″	26.0	16.5	6.40	183.32	36.0	3.52	2476	1609.40	1.30	IB, HI
84	Spring water 5	918	38°33′997″	39°31′180″	26.0	15.7	6.76	247.84	35.3	3.54	2487	1616.55	1.30	--
85	Karasu river	890	38°31′472″	39°26′830″	26.0	18.2	NA	NA	45.9	3.28	438.7	285.15	0.20	--
86	Bahçebağlar stream	889	38°30′772″	39°26′896″	26.0	18.4	NA	NA	46.9	4.74	326.9	212.48	0.20	II
87	Kerar stream	895	38°31′537″	39°27′361″	26.0	19.0	NA	NA	39.0	3.01	1069.0	694.85	0.50	--
88	Trough 5	906	38°34′635″	39°28′732″	26.0	21.4	NA	NA	54.0	4.38	907.0	589.55	0.40	IB, HI
89	Yeşilyurt stream	904	38°35′585″	39°28′741″	26.0	16.5	NA	NA	31.9	2.57	622.0	404.30	0.30	--