COMPARATIVE ANALYSES OF NON-MARINE OSTRACODS (CRUSTACEA) AMONG WATER BASINS IN TURKEY

Mehmet Yavuzatmaca

*Department of Biology, Faculty of Arts and Science, Bolu Abant İzzet Baysal University, Turkey
E-mail: yavuzatmaca46@gmail.com; https://orcid.org/0000-0002-0398-6763*

Total of 26, 22 and 32 sites in Konya, Antalya and West Mediterranean basins in Turkey, respectively, were sampled twice during 2017 to compare the non-marine ostracod diversity. A total of 1787 individuals belonging to 31 species were recorded from all basins. Of which, nine species are common among basins when *Fabaeformiscandona fragilis* is new for Turkey. High species diversity was found at middle elevational intervals. The highest and lowest Shannon diversity index values were recorded for both Konya (H = 2.19) and Antalya (H = 1.90) basins, respectively. The highest beta diversities values are encountered between closed the Konya and other open basins. Species and environmental variables composition among basins and elevational intervals showed significant differences (p < 0.05, ANOSIM). Of species, cosmopolitans (e.g., *Candona neglecta, Ilyocypris bradyi, Psychrodromus olivaceus*) provide an important contribution to the differences in diversities among basins and elevational intervals. According to Canonical Correspondence Analysis, elevation appeared to be the common influential variables in all basins. Results suggest that alpha diversity is under the control of local and regional factors when beta diversity is primarily affected by regional factor. Although cosmopolitan species are positive indicators, they seem to make a significant contribution to alpha and beta diversities of ostracods.

Keywords: basins, alpha and beta diversity, elevation, cosmopolitan, Ostracoda.

INTRODUCTION

Non-marine ecosystems are altered by natural (e.g., the climatic changes, geologic factors) and anthropogenic activities. Of which, human-mediated deteriorations are irreversible influences on the characteristics of freshwater (or non-marine) habitats by sediment loading, organic pollution, toxic contaminants, habitat fragmentation, flow regulation (especially by dam construction), and introducing of non-indigenous species (Ricciardi & Rasmussen 1999, Søndergaard & Jeppesen 2007, Strayer & Dudgeon 2010). Such influences on water bodies indicate a requirement of water management for long-term ecological sustainability. In order to deal with such problems and provide possible solutions caused by human activities, European Water Framework Directive has introduced water management policy for all of the European countries for the chemical and ecological quality of freshwaters in the year of 2000. Ecological quality is evaluated according to biological, hydro-morphological and physico-chemical composition of water bodies. Biological quality includes the composition and abundance of benthic invertebrates, fish and flora. In this

protection policy, geographical and hydrological units are used instead of administrative or political boundaries targeting to protect water as a single system like a river basin (European Commission 2018). A river or lake basin is an entire geographical area that is drained by a river and its tributaries. Therefore, the species diversity (or richness) in the different aquatic habitats in the river catchment or basin has a crucial role for the conservation of biodiversity (Engen et al. 2008) and for the development of management to conserve status of aquatic systems. Besides to the conservation importance of diversity, such knowledge can improve our understanding on the evolutionary and ecological succession of species in different types of habitats (Whittaker 1972, Hill 1973, Gibb et al. 2013, Külköylüoğlu et al. 2017a).

The number of species per unit area is indicated as the species diversity or richness while biological diversity includes functional group diversity, number of trophic levels and species abundance (Brown et al. 2007). Species diversity is measured as gamma (γ) diversity (regional diversity) that is composed of alpha (α, local diversity) and beta (β, changes in species diversity from one site/region to next) diversities (Whittaker 1972). While regional diversity is represented by various habitats and conditions, local diversity includes one habitat (e.g., lake, creek). Therefore, regional and local species pools can be defined as the subset of γ and α diversities, respectively (Pärtel et al. 1996). Some species in regional species pool may not be encountered in the local species pool as a result of dispersal limitation but this limitation has little effect on the presence of a species in local species pool to being in another site (Brown et al. 2007). Along with dispersal limitation, biotic and abiotic factors can alter the species composition between local sites or regional sites (Zobel et al. 1998). Thereby, β diversity depends on the dispersal ability and ecological tolerances of species.

Ostracods are tiny (0.3–5 mm long) bivalved benthic invertebrates. They show wide distributions in a variety of marine and non-marine habitats (Meisch 2000). Active and/or passive dispersal abilities of species contribute to their wide geographical distribution in the world (McKenzie & Moroni 1986, Rodriguez-Lazaro & Ruiz-Muñoz 2012, Valls et al. 2016). They display quick response to environmental changes because of a short reproductive cycle (Delorme 1991) that allows them to be used as bio-indicator species to evaluate habitat conditions of different aquatic bodies (Külköylüoğlu 2013). Their carapaces with low magnesium calcites are easily fossilized in the sediments that is why they are to be found as fossil forms in rock formations since Early Ordovician (ca. 485 million years old) (Williams et al. 2008). Therefore, ostracods are widely applied in recent marine and non-marine environmental research and also for stratigraphic and palaeoecological purposes (Rodriguez-Lazaro & Ruiz-Muñoz 2012). In this sense, the distributional pattern and eco-

logical information of ostracod species have vital roles to make better and strong inferences about the recent and past status of aquatic bodies.

Until now, 145 non-marine ostracod species have been known from Turkey (Külköylüoğlu *et al.* 2015, Külköylüoğlu *et al.* in review, Yavuzatmaca *et al.* 2017*b*). However, this number is believed to be underestimated and the richness is far above it (Külköylüoğlu pers. comm.). The existing studies on the recent non-marine ostracods in Turkey are so far based on ostracod species diversity, distribution, abundance and ecology in a region (or province, includes many habitats) or in a single habitat (includes monthly and/or seasonal samplings) (e.g., Akdemir 2008, Akdemir *et al.* 2016, Altınsaçlı & Mezquita 2008, Külköylüoğlu 2004, Külköylüoğlu *et al.* 2013, Külköylüoğlu *et al.* 2012*a*, 2012*b*, Özuluğ 2011, Uçak *et al.* 2014, Yavuzatmaca *et al.* 2017*a*). On the other hand, a few studies have included samplings from more than one region or provinces (e.g., Altınsaçlı 2004, Gülen 1985, Külköylüoğlu *et al.* 2017*b*, *c*, Rasouli *et al.* 2014). Although 25 large water basins are present in Turkey (Trmeu 2017–2023), there is no comparative study dealing with the diversity and ecology of ostracods among the basins. Gülen and Altınsaçlı (1999) is the only basin-related ostracod study in Turkey but only the ostracod fauna of Sakarya River basin was given. This present situation is pinpoint the importance of the current study in terms of comparing ostracod diversity among three river basins for the first time in Turkey. The main aim of the study is to compare species diversity and ecological preferences of ostracods in Konya, Antalya, and West-Mediterranean river basins in Turkey. Also, a classification of the lotic and lentic habitats due to the elevation has been used by The Water Management Directorate Department of Turkish Republic Ministry of Agriculture and Forestry. In this classification, three elevational intervals like 0–800, 800–1600 and >1600 m a.s.l. have been used. The effect of elevation on ostracods is an ongoing discussion in the literature (e.g., Guo *et al.* 2013, Külköylüoğlu *et al.* 2012*a*, 2012*b*, Külköylüoğlu *et al.* 2016, Laprida *et al.* 2006, Mezquita *et al.* 1999, Pieri *et al.* 2009, Yavuzatmaca *et al.* 2018). Therefore, comparison of dis/similarity values for species and/or environmental variables among the elevational intervals mentioned above is one of the important point of this study.

MATERIAL AND METHODS

Study sites

Konya basin. According to the natural topography, Konya basin does not drain its waters into the sea. Similar topography is rare and known in a few areas in the world, such as that Great Basin area in Nevada. The importance of such basins is that the water is born and lost in the area within which it can only be used by the organism inhabiting the area.
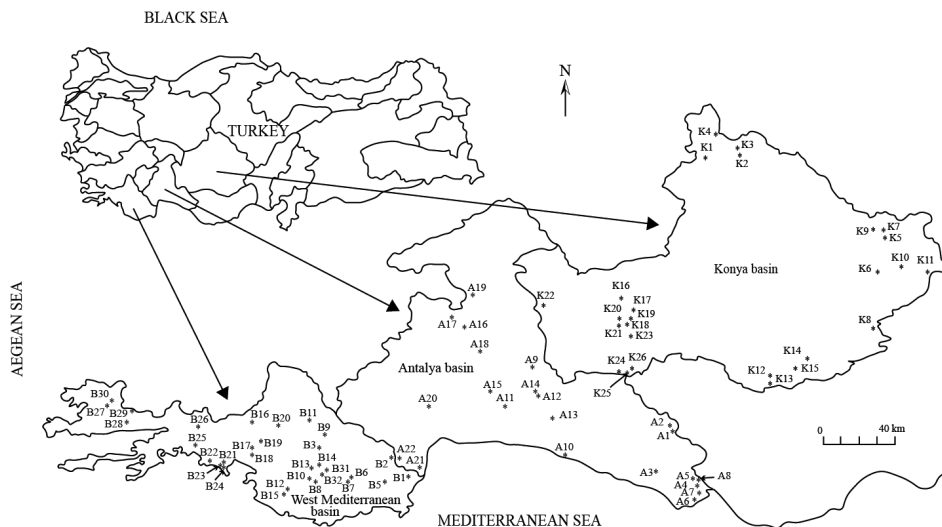
In terms of Konya basin, it is the only known closed basin in the Central Anatolia Region of Turkey. The basin has about 49805 km² of surface area including nine provinces (85% of Aksaray, 73% of Konya, 60% of Karaman, 31% of Niğde, 14% of Isparta, 12% of Nevşehir, 7% of Ankara, 2% of Mersin and 2% of Antalya) covering ca 7% of Turkey (Trmfwm 2016, Trmeu 2017–2023).

Antalya basin. Antalya basin is present in the Mediterranean region of Turkey and its waters are discharged into the Mediterranean Sea. The surface area of the basin is ca. 20331 km² consisting about 3% of the surface area of Turkey. The basin is one of the richest regions of Turkey in terms of water resources (Trmfwm 2016). It harbors 52% of Antalya, 30% of Isparta and 18% of Burdur provinces within its boundaries (Trmeu 2017-2023).

West Mediterranean basin. The basin covering about 3.1 % of the Turkey with about 21223 km² of surface area is located in the West Mediterranean region of Anatolia and its water is released into the Mediterranean and Aegean Seas (Trmfwm 2016). This includes five provinces (80% of Muğla, 33% of Antalya, 21.8% of Denizli, 21.1% of Burdur and 0.3% of Aydın provinces) (Trmeu 2017–2023).

Samplings

A total of 26 (11 lakes and 15 creeks), 22 (5 lakes and 17 creeks) and 32 (13 lakes and 19 creeks) aquatic sites of natural lakes and creeks were sampled twice during August and October of 2017 in Konya, Antalya and West Mediterranean basins in Turkey, respectively (Fig. 1). All ecological variables were measured before sampling to reduce disturbance on the measurements. Among them, dissolved oxygen concentration (DO, mg/L), water temperature (Tw, °C), electrical conductivity (EC, µS/cm), pH and salinity (‰) of water were recorded with a YSI-Professional Plus and a GARMIN etrex Vista H GPS was used to obtain geographical data (elevation, coordinates (for constructing the map, Fig. 1)). The

Fig. 1. Sampling sites in Konya (K), Antalya (A) and West Mediterranean (B) basins

minimum-maximum and mean values of ecological variables for basins and each species are given in Table S1.

A standard sized hand net (200 μm in mesh size) was used to collect ostracod samples from the sediment throughout littoral zones of lakes and the parts of creeks with slow flow regimes with a maximum of 1 m depth. Sediment samples were anchorage with 70% of ethanol in 250 ml plastic bottles *in situ* to preserve ostracod specimens from decay. In the laboratory, sediments including ostracods were filtered through four standardized sieves (0.5, 1.0, 1.5 and 2.0 mm mesh size) under tap water to separate coarse materials and then filtered sediments were collected in 250 ml plastic bottles with added 70% ethanol. Subsequently, ostracods were separated from the sediments under a stereomicroscope (Olympus ACH 1X) by using a pipette and dissecting needles. Dissected soft body parts in lactophenol solution and carapace morphology were accomplished under a light microscope (Olympus BX-51) for the identification of specimens to species and genus level according to Meisch (2000). Ostracod samples are kept at the Limnology Laboratory of Bolu Abant İzzet Baysal University, Turkey.

Statistical analyses

Shannon index values were calculated for each basins and elevational intervals by Species Diversity & Richness 4 software (Seaby & Henderson 2006). This software was also used to estimate Whittaker's beta (β) diversity index values (Wilson & Shmida 1984) for all and dual comparisons of basins and elevational intervals as well. Differences in ostracod communities and environmental variables, and contribution of individual species and environmental variables to any of dissimilarities among the basins and elevational intervals were checked out by Analysis of similarity (ANOSIM) and Similarity percentages (SIMPER), respectively (Community Analysis Package 4 software). In addition, whether there is a significant difference in the mean of ecological variables among the basins and elevational intervals that were tested by One-Way ANOVA (IBM-SPSS Statistics Version 21). The Levene's test and Kolmogorov Smirnov (if $n > 50$) or Shapiro-Wilk ($n < 50$) tests affirmed the homogeneity of variance and data normality assumption, respectively. If assumptions are not met, non-parametric Kruskal-Wallis was applied. Post-hoc analyses were conducted to see possible significance. Elevational intervals like 0–800 (E1), 800–1600 (E2) and >1600 (E3) m a.s.l. was used in the analysis and these intervals are showed hereafter by the abbreviations in brackets. Detrended Correspondence Analysis (DCA) was used to check out the suitability of data for Canonical Correspondence Analysis (CCA). Most effective ecological variables on species composition in each basin were determined by CCA using the CANOCO 4.5 software (Ter Braak 1986). *Cyrideis torosa* is susceptible to salinity (or occur in high saline waters) and so it has been excluded from the CCA analysis to prevent a conditional result (see Discussion). In CCA, species appeared at least two times were used. Monte Carlo permutation test (499 permutations) was performed to see the effectiveness of variables. Meaningful correlations between species encountered at least three times and used environmental variables were tested by a non-parametric Spearmen Rank Correlation analyses (IBM-SPSS Statistics Version 21). The optimum (u_k) and tolerance (t_k) levels of the species occurred three or more times during the study were calculated by C2 software (Juggins 2003). Specimens with damaged soft body parts and carapaces were omitted from the analyses and only undamaged adult individuals are used.

RESULTS

A total of 1787 individuals belonging to 31 ostracod species (gamma (γ) diversity) were recorded from Konya (21 species (spp.), 453 individuals (ind.) from 21 sites), Antalya (15 spp., 401 ind. from 15 sites) and West-Mediterranean basins (21 spp., 933 ind. from 23 sites) (Table 1). Nine species (*Candona neglecta*, *Heterocypris incongruens*, *Ilyocypris bradyi*, *Potamocypris similis*, *P. fallax*, *Physocypria kraepelini*, *Prionocypris zenkeri*, *Pseudocandona albicans* and *Psychrodromus olivaceus*) were found to be common to the three basins (Table 1). Moreover, Konya and Antalya basins showed both the highest (H = 2.19) and the lowest (H = 1.90) Shannon index (alpha, α) values, respectively (Table 2). Among the species, bisexual populations of *Candona sanociensis* (1 ♂ and 1 ♀ from Konya province in a creek at 1374 m a.s.l), *C. neglecta* (4 ♂♂ and 4 ♀♀ from Konya province in a creek at 1622 m a.s.l.), *C. weltneri* (3 ♂♂ and 18 ♀♀ from Konya province in a lake at 1849 m a.s.l.), *Cypria ophtalmica* (1 ♂ from Aksaray province in a lake at 1173 m a.s.l.) and *I. bradyi* (1 ♂ and 2 ♀♀ from Karaman province in a creek at 1352 m a.s.l.) were also found in Konya basin. In the West-Mediterranean basin, bisexual populations of *Candona angulata* (4 ♂♂ and 27 ♀♀ from Burdur province in a lake at 947 m a.s.l.), *C. neglecta* (5 ♂♂ and 22 ♀♀ from Muğla province in a lake at 1736 m a.s.l.), *Fabaeformiscandona fragilis* (1 ♂ from Muğla province in a lake at 223 m a.s.l.), *F. holzkampfi* (1 ♂ from Muğla province in a lake at 1735 m a.s.l.), *Ilyocypris monstrifica* (1 ♂ from Denizli province in a creek at 987 m a.s.l.) and *P. olivaceus* (1 ♂ and 1 ♀ from Muğla province in a creek at 568 m a.s.l.) were found while there were no bisexual populations in Antalya basin.

The highest species number (25 spp.) was observed at E2 (includes 23 sites (6 lakes and 17 creeks) and 38 samplings (6 from Antalya, 13 from West-Mediterranean (West-Med.) and 19 from Konya basins) when the E1 (includes 23 sites (7 lakes and 16 creeks) and 33 samplings (16 from Antalya and 17 from West-Med. basins)) and E3 (includes 14 sites (10 lakes and 4 creeks) and 20 samplings (2 from Antalya, 5 from West-Med. and 13 from Konya basins)) intervals had 19 and 16 spp., respectively (Table 1). Accordingly, the foremost Shannon index value (H = 2.15) was registered in mid interval when the index value tended to decrease in low (H = 1.54) and high (H = 1.93) intervals (Table 2).

Beta (β) diversity values among basins and elevational intervals were given in Table 2. According to dual comparisons, the supreme β diversity values are 0.4444 for Konya – Antalya basins and 0.4146 for E2–E3 intervals (see Table 2).

ANOSIM exhibited significant differences (p < 0.05) in species composition among basins and elevational intervals. According to pairwise comparison, Antalya and Konya basins were significantly different from each other (p < 0.05) while Antalya–West Mediterranean and Konya–West Mediterranean

Table 1. Species and their abundance (or the number of specimens per species, values in the table) in August (Au) and October (Oc) of 2017 from Konya, Antalya and West-Mediterranean (W Med.) basins and in different elevational intervals (E1 (0–800); E2 (800–1600) and E3 (>1600)). Species names in bold refers to cosmopolitan distribution.

| | Basins | | | | | | Elevational Interval (m a.s.l.) | | | | | |
| | Konya | | Antalya | | W Med. | | E1 | | E2 | | E3 | |
Species	Au	Oc	Au	Oc	Au	Oc	Au	Oc	Au	Oc	Au	Oc
Candona angulata				2	15	31		2		31	15	
Candona improvisa	5	12							5	12		
Candona neglecta	18	57	1	2	21	35	1	2	16	17	23	75
Candona sanociensis	2	3							2	3		
Candona weltneri	8	24									8	24
Cypria ophtalmica		2								2		
Cyprideis torosa					115	213	115	213				
Cypris pubera			53								53	
Cypridopsis vidua	2	1			3	1	2			1	3	1
Darwinula stevensoni			10	3	6	3	9	1	5	5	2	
Fabaeformiscandona fabaeformis	1	1								1	1	
Fabaeformiscandona fragilis						1		1				
Fabaeformiscandona holzkampfi					5	1			1		4	1
Herpetocypris chevreuxi			4			11		11			4	
Herpetocypris reptans					2	8			2	8		
Heterocypris incongruens	7	6	152		7	2	7	2	9	6	150	
Heterocypris salina	19	1			2	2	2		19	3		
Ilyocypris bradyi	20	121	9	5	23	101	11	7	41	206		14
Ilyocypris monstrifica	2				1	3			3	3		
Limnocythere inopinata					13	22		4	13	18		
Paracandona euplectella	1	1							1	1		
Physocypria kraepelini	1	3	3		15	33	1		4	30	14	6
Potamocypris fallax		9		1	1	1	1	1		1		9
Potamocypris similis		33	21	66	63	13	21	66	63	46		
Potamocypris unicaudata	7	1							7	1		
Potamocypris variegata			19		9	21	22	18	6	3		
Prionocypris zenkeri		4	6	7	1		6	7	1	4		
Pseudocandona albicans	5		1		1	1	1		4	1	2	
Psychrodromus olivaceus	19	55	14	12	53	74	8	5	76	129	2	7
Psychrodromus fontinalis		1										1
Trajancypris clavata	1		10				10		1			
Total	118	335	303	98	356	577	217	340	279	532	281	138

Table 2. Shannon index (H) and beta (β) diversity values for basins and elevational intervals (E1 (0–800); E2 (800–1600) and E3 (>1600)). vs represents versus.

	Shannon index			β diversity	Dual comparisons	β diversity
Sample	H	Variance H	Exp H		Sample	
Konya	2.19	0.0027	8.90	0.63	Konya vs Antalya	0.4444
Antalya	1.90	0.0028	6.66		Konya vs W Med.	0.4286
W Med.	2.15	0.0013	8.58		Antalya vs W Med.	0.2778
E1	1.54	0.0036	4.69	0.55	E1 vs E2	0.2727
E2	2.15	0.0018	8.59		E2 vs E3	0.4146
E3	1.93	0.0028	6.89		E1 vs E3	0.3714
All Sample Index	2.58					
Jackknife Std Error	0.06					

binary comparisons did not display significant differences (p > 0.05). SIMPER expressed 96.03, 95.68 and 94.59% of average dissimilarity between Antalya-Konya, Antalya–West Mediterranean and Konya-West-Mediterranean basins groups, respectively. For example, *I. bradyi* (15.33%), *P. olivaceus* (13.72%) and *C. neglecta* (10.14%) are the first three species with high percentage contribution to the dissimilarity between the Antalya and Konya basins (see Table 3). Unlike basins, species composition between all couple elevational interval groups showed significant differences (ANOSIM, p < 0.05). SIMPER showed 97.82, 96.33 and 95.41% dissimilarity in the species composition between E1–E3, E2–E3 and E1–E2 intervals, respectively. *Candona neglecta* is the species contributing to the dissimilarities of E1–E3 and E2–E3 intervals with highest percentages as 24.03 and 19.51%, respectively. Similarly, *I. bradyi* provides about 22.63% dissimilarity between E1 and E2 intervals (for more see Table 3).

Like species composition, significant differences were also estimated in the composition of the environmental variables among basins and elevational intervals (ANOSIM, p < 0.05). Composition of the environmental variables in the Konya basin with Antalya and West Mediterranean basins are significantly different (p < 0.05). All of the dual comparisons among elevational intervals showed significant differences based on environmental variables (p < 0.05). According to SIMPER, elevation and electrical conductivity supply 53.23 and 46.30% to 45.71% dissimilarities between Antalya and West Mediterranean basins; 70.22 and 29.43% to 47.69% dissimilarities between Antalya and Konya basins; 56.70 and 42.86% to 42.71% dissimilarities between Konya and West-Mediterranean basins, respectively. Electrical conductivity is the only variable that promotes the dissimilarities between E1–E2 (32.23% dissimilarity), E1–E3

Table 3. Contributions of individual species to dissimilarities among basins and elevational intervals. Abbreviations: W Med., West Mediterranean and %CoDs, % contribution to dissimilarity, E1 = 0–800 m; E2 = 800–1600 m and E3 >1600 m a.s.l.

	Basins			Elevational intervals		
	Antalya–Konya	Antalya–W Med.	Konya–W Med.	E1–E2	E1–E3	E2–E3
Species	%CoDs	%CoDs	%CoDs	%CoDs	%CoDs	%CoDs
C. angulata		3.52	2.31	1.95	2.58	2.69
C. improvisa	3.71		3.25	3.41		2.63
C. neglecta	10.14	7.99	13.96	3.50	24.03	19.51
C. weltneri	6.27		5.54		10.81	8.02
C. torosa		8.13	7.85	7.69	7.74	
C. pubera	3.40	3.17			4.12	3.83
C. vidua			2.47		3.89	2.15
D. stevensoni	4.34	5.14		3.82		1.79
H. incongruens	7.81	6.42	3.60	4.66	6.00	7.29
H. salina	2.60		3.23	3.14		2.00
I. bradyi	15.33	14.06	20.83	22.63	5.35	18.95
L. inopinata		2.99	2.93	2.83		2.13
P. kraepelini	2.38	4.60	3.70	3.08	3.73	4.71
P. fallax			1.51		2.45	1.87
P. similis	7.69	8.14	3.25	7.37	4.47	2.84
P. unicaudata			1.78	1.91		
P. variegata	4.46	7.98	4.03	6.50	6.06	
P. zenkeri	3.94	3.59		2.87	2.37	
P. albicans	2.05					
P. olivaceus	13.72	13.24	10.08	13.65	6.95	11.11
T. clavata	2.57	2.32		1.70		

(52.25% dissimilarity) and E2–E3 (44.33% dissimilarity) with 97.71, 96.30 and 96.38% contributions, respectively.

The mean value of water temperature (Tw, ANOVA, $p > 0.05$), electrical conductivity (EC) and dissolved oxygen (DO, Kruskal-Wallis, $p > 0.05$) did not show significant differences among basins. On the other hand, average value of pH between Antalya and West-Mediterranean basins and elevation between Konya and Antalya, and Konya and West-Mediterranean basins were significantly (Kruskal-Wallis, $p < 0.05$) different from each other. In the sense of elevational intervals, pH and DO did not indicate meaningful unlike-

Table 4. Influence of variables on the ordination of species on CCA diagrams in Konya, West Mediterranean and Antalya basins. Values in bold show the variables with a significant effect.

Basins	Konya			West Mediterranean			Antalya		
Variables	P	λ	F	P	λ	F	P	λ	F
Elevation	**0.002**	0.73	3.43	**0.008**	0.52	2.30	**0.002**	0.96	4.18
Electrical conductivity	**0.022**	0.55	2.74	**0.002**	0.60	2.89	0.218	0.24	1.33
pH	0.184	0.26	1.28	**0.028**	0.41	2.00	**0.006**	0.49	2.62
Water temperature	0.116	0.30	1.56	0.114	0.31	1.57	**0.006**	0.68	3.27
Dissolved oxygen	0.574	0.18	0.89	0.212	0.26	1.30	0.840	0.09	0.44

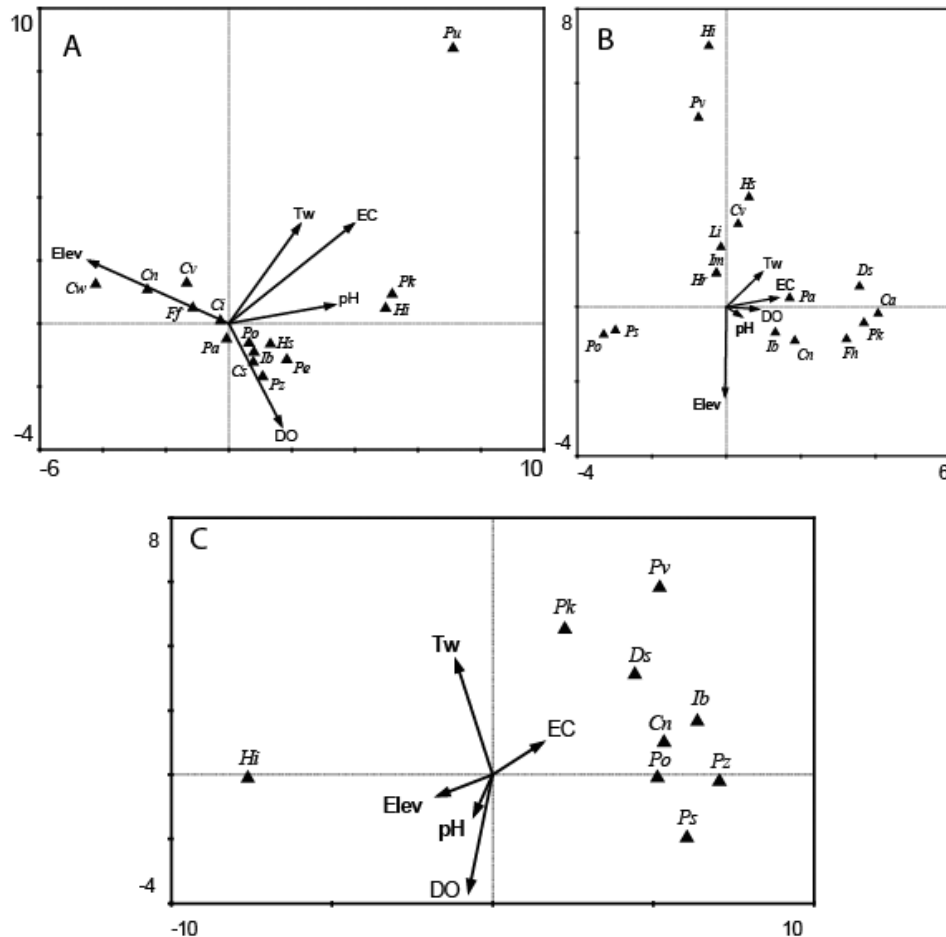ness (Kruskal-Wallis, p > 0.05). However, mean values of Tw and EC depicted significant dissimilarity between E1 and E2, and E2 and E3 intervals, respectively (Kruskal-Wallis, p < 0.05).

Total of 68, 69.9 and 70.9% of relationships between species and used environmental variables in Konya, Antalya and West-Mediterranean Basins were elucidated by the first two axes of CCA (Table S2), respectively. Of the variables, elevation is the common variable that had a significant (p < 0.05) effect on species composition in all basins. In addition to elevation, electrical conductivity (EC) in Konya, EC and pH in West-Mediterranean and pH and water temperature in Antalya basins are the other meaningful variables (p < 0.05) on species composition (Table 4).

Most of the species ordinated on the negative sides of axes 1 and 2 in Konya basin (Fig. 2A) while almost all species except *P. similis* and *P. olivaceus* positioned on the positive sides of axes 1 and 2 in West-Mediterranean basin (Fig. 2B). In Antalya basin, all of species except *H. incongruens* located on the right side of axis 1 where there is only electrical conductivity arrow (Fig. 2C). The well-known cosmopolitan species, *P. olivaceus* and *Pseudocandona albicans* in Konya, and *Herpetocypris reptans* and *I. bradyi* in West-Mediterranean basin aligned relatively closer to the center of CCA diagrams (Figs. 2A and B) that means distribution of these species may not be significantly affected by the variables used. The positioning of all other species in three basins according to the effect of variables on their distributions are as in Figs. 2A, B and C. The significant correlations among environmental variables and species are given in Table 5.

Estimated tolerance (t_k) and optimum (μ_k) levels of 19 species from whole data for five variables are given in Table 6 where *H. incongruens* had highest optimum (1861.55) and tolerance levels (942.23) for elevation, and the lowest optimum (14.84) was recorded for *C. torosa*. *Candona weltneri* exhibited maxi-

mum tolerance level for water temperature (11.13) but minimum tolerance levels for electrical conductivity (17.90) and optimum for water temperature (13.33) among species. One species, *F. holzkampfi* showed high tolerance values for pH (8.96) and dissolved oxygen (10.18) (for more see Table 6).

Fig. 2. Ordination of species on CCA diagrams based on the effectiveness of the variables on their distribution in Konya (A), West-Mediterranean (B) and Antalya (C) basins. Abbreviations: Elev, elevation (m a.s.l.); Tw, water temperature (°C); EC, electrical conductivity (μS/cm); DO, dissolved oxygen (mg/l); Ca, *Candona angulata*; Ci, *C. improvisa*; Cn, *C. neglecta*; Cs, *C. sanociensis*; Cw, *C. weltneri*; Cv, *Cypridopsis vidua*; Ds, *Darwinula stevensoni*; Ff, *Fabaeformiscandona fabaeformis*; Fh, *F. holzkampfi*; Hr, *Herpetocypris reptans*; Hi, *Heterocypris incongruens*; Hs, *H. salina*; Ib, *Ilyocypris bradyi*; Im, *I. monstrifica*; Li, *Limnocythere inopinata*; Pe, *Paracandona euplectella*; Pk, *Physocypria kraepelini*; Ps, *Potamocypris similis*; Pu, *P. unicaudata*; Pv, *P. variegata*; Pz, *Prionocypris zenkeri*; Pa, *Pseudocandona albicans* and Po, *Psychrodromus olivaceus*

Table 5. Spearman Rank Correlation Analysis results among environmental variables and species.

		Water temperature	Conductivity	Salinity	Dissolved oxygen	*Candona neglecta*	*Heterocypris salina*
Elevation	Corr. coeff.	–0.251*	–0.551**	–0.638**		0.552*	0.926**
	Sig. (2-tailed)	0.016	0.000	0.000		0.012	0.008
	N	92	92	92		20	6
pH	Corr. coeff.				0.286**		
	Sig. (2-tailed)				0.006		
	N				92		
Conductivity	Corr. coeff.				–0.217*		
	Sig. (2-tailed)				0.038		
	N				92		
Cyprideis torosa	Corr. coeff.		0.900*		–0.900*		
	Sig. (2-tailed)		0.037		0.037		
	N		5		5		
Ilyocypris bradyi	Corr. coeff.	–0.479*					
	Sig. (2-tailed)	0.018					
	N	24					

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

The species *F. fragilis* herein (Tables 1 and S1) were new for the Turkish non-marine ostracod fauna and thus, the number of non-marine ostracods in Turkey has increased to 146 species. The gamma (31) diversity of the three river basins (Konya, Antalya and West-Mediterranean) is about 21.23% of Turkey (146) when their surface area is ca 13% of Turkey's surface area. The number of species in these basins is not very low considering their surface area. Nevertheless, the absence of basin-related studies dealing with ostracods in Turkey did not allow for any crosscheck comment about this ratio.

Binary comparisons of basins with the Shannon diversity index values for Konya and Antalya and for Antalya and West-Mediterranean basins were explained by the suggestion of "sampling effect" hypothesis (Hill *et al.* 1994) as the number of encountered species is expected to be high when the sampled sites increase, since the number of sampled sites in each of the Konya and West-Mediterranean basins are higher than Antalya basin. On the other hand, similar to previous studies (e.g., Akdemir & Külköylüoğlu 2011, Pieri *et al.* 2009, Yavuzatmaca *et al.* 2018), comparison between the Konya and West-

Table 6. Optimum (μ_k) and tolerance (t_k) levels of 19 species from whole Konya, West Mediterranean and Antalya basins for elevation (Elev, m a.s.l.), water temperature (Tw, °C), pH, electrical conductivity (EC, μS/cm) and dissolved oxygen concentration (DO, mg/l). N$_2$ is the Hill's coefficient value that indicates the measure of effective number of occurrences.

Species	Count	Max	N2	Elev u_k	Elev t_k	Tw u_k	Tw t_k	pH u_k	pH t_k	EC u_k	EC t_k	DO u_k	DO t_k
I. bradyi	24	49	9.26	1266.74	279.43	16.38	3.29	8.12	0.23	437.77	61.31	8.58	0.80
C. neglecta	19	39	7.59	1563.32	348.63	18.29	5.43	8.19	1.18	240.90	105.27	8.15	2.65
D. stevensoni	9	6	6.72	662.18	537.92	23.95	5.83	8.45	0.35	492.06	107.82	8.06	1.46
P. albicans	7	2	6.40	1272.63	521.99	20.76	5.71	7.95	0.60	281.21	64.89	8.64	1.09
P. variegata	9	15	5.47	335.41	344.83	21.89	6.62	8.11	0.40	418.18	62.37	8.72	1.31
C. vidua	6	2	5.44	1270.29	755.12	23.83	7.82	8.47	0.98	235.87	61.99	9.10	1.37
P. olivaceus	21	70	5.08	1267.30	277.38	15.01	3.53	8.21	0.45	257.68	65.75	8.34	0.71
P. similis	6	66	3.93	955.93	515.44	15.97	1.85	8.41	0.32	290.81	79.38	8.69	0.53
P. zenkeri	5	7	3.38	612.78	547.37	18.81	3.50	8.16	0.21	374.44	8.80	8.97	0.62
P. kraepelini	10	27	3.21	1222.67	475.68	19.66	5.95	8.82	0.67	598.94	163.95	9.70	1.59
I. monstrifica	3	3	2.57	988.33	3.52	23.62	8.83	8.71	0.99	433.67	17.88	9.81	2.83
L. inopinata	3	18	2.41	906.20	302.69	19.88	2.74	8.18	0.04	447.51	22.59	8.21	0.72
C. weltneri	4	21	2.12	1849.97	2.67	13.33	11.13	7.19	0.52	91.26	17.90	6.47	2.89
F. holzkampfi	3	4	2.00	1691.83	126.40	23.88	2.91	8.96	0.46	257.27	52.82	10.18	0.92
C. angulata	3	31	1.94	1165.38	577.77	18.54	6.52	8.54	0.50	639.51	149.51	9.69	0.80
H. salina	6	17	1.92	1220.79	486.94	16.02	9.07	7.71	0.82	460.13	197.21	8.30	0.74
C. torosa	5	211	1.89	14.84	11.13	24.85	2.48	6.75	0.37	19590.20	876.15	4.96	0.67
P. fallax	3	9	1.46	1537.18	818.67	15.00	6.17	8.08	0.27	403.09	22.98	9.46	0.56
H. incongruens	8	150	1.34	1861.55	942.23	25.34	3.75	8.23	0.81	170.87	118.34	9.68	1.71

Mediterranean basins did not reinforce "sampling effect" hypothesis because their alpha index values are very close to each other. It seems that the abiotic (e.g., physico-chemical variables, habitat destruction) quality of sampled sites may affect the diversity of ostracods along with this ecological hypothesis.

The beta diversity value among three basins is larger than the dual comparisons. Of the dual comparisons, the highest beta diversity values were reported between the Konya, open Antalya, and West-Mediterranean basins, respectively (Table 2). The results of ANOSIM supports significant differences in species composition among basins and between Konya and Antalya basins (p < 0.05). The drivers of beta diversity are arranged as i) dispersal limitation, ii) productivity and iii) environmental heterogeneity (Astorga *et al.* 2014). Among them, productivity is beyond the scope of the present study. The dispersal limitation may be used as an explanation, by way of the beta diversity values for ostracods since longer distance dispersion of non-marine ostracods are achieved passively by human, wind, birds, fishes and insects (McKenzie & Moroni 1986, Green 2016; Valls *et al.* 2016). Antalya and West –Mediterranean basins have a border to Mediterranean and Aegean Sea (Fig. 1). In the summer season, touristic activities are far more intense in both basins. The presence of 13 common species in both close basins (Table 1) showed the human effect on distribution of ostracod species as previously suggested by Valls *et al.* (2016). As a result, the lowest beta diversity value was noted between Antalya and West Mediterranean basins (Table 2). Indeed, the ratio of non-cosmopolitan to cosmopolitan species called as "Pseudorichness" (Külköylüoğlu 2013) in Antalya (0.37) and West-Mediterranean (0.40) basins indicate such anthropogenic influence when this ratio is 0.91 in Konya basin (Table 1). This is because the "Pseudorichness" ratio is smaller than one means there are possible anthropogenic effects related to disturbance (Külköylüoğlu 2013). Therefore, the Antalya and West-Mediterranean basins seem to be more affected than the Konya basin anthropogenically since these are under the pressure of tourist activities more than the latter one. Electrical conductivity and elevation gave rise to environmental variables heterogeneities among basins (see results) and these kinds of heterogeneities affect the beta diversity values. Of the variables, the regional factor, elevation, seems to be a deterministic factor for the highest beta diversities. Since the highest beta diversity values (Table 2) and significant average value difference of elevation (Kruskal-Wallis, p < 0.05) were reported between Konya and both open basins. Additionally, decreases in air and water temperatures with ascending elevation and consequently physico-chemical variables fluctuations are well documented in Yavuzatmaca *et al.* (2018). The significant negative correlations of elevation with water temperature (p < 0.05) and electrical conductivity (p < 0.01) here (Table 5) support this previous statement. This shows that

elevation indirectly influences the occurrences of ostracod species. Therefore, species with wider tolerance ranges (cosmopolitans) have advantages over non-cosmopolitans in aquatic bodies. This is the case in the present study. Since cosmopolitan species (e.g., *I. bradyi*, *P. olivaceus*, *C. neglecta*), appear to play important roles with high percentages in the dissimilarities and alpha diversities among basins (see Table 3).

Most recently, Külköylüoğlu *et al.* (2017*c*) implied the importance of geographical differences (or regional factor) for beta diversity in the Düzce and Karabük provinces, Turkey. On the other hand, Higuti *et al.* (2009) proposed that beta diversity is equally affected by both local and regional factors, indicating the presence of low beta diversity between homogeneous systems. The significant differences of elevation and high beta diversity between closed and open basins herein reinforce the final statement of Higuti *et al.* (2009). In Belarus, the significant correlation of alpha diversity of ostracods with temperature was recorded by Nagorskaya & Keyser (2005) when Higuti *et al.* (2009) suggested that local factors had more influence than regional factor on alpha diversity in Brazil. Other studies in Turkey have suggested that the suitability of habitats (ecological conditions) would be better than altitude, pH, and salinity as explanatory factors for ostracod diversity (Külköylüoğlu *et al.* 2012*c*). Overall, the results of the studies mentioned above and the present study suggest that beta diversity is affected most by regional factors (e.g., elevation, system (open and/or closed basins)) and then by local factors (e.g., electrical conductivity, water temperature, pH) while alpha diversity is mainly under the control of local factors (see below).

CCA explored elevation as a common factor on the alpha diversity in all basins (Table 4). According to the results of 30 studies done in and out of Turkey, elevation was found to be an important variable on alpha diversity only in five studies (Table S3). Whereas the other effective local variables herein (electrical conductivity, pH and water temperature) (Table 4) were commonly indicated as influential variables on ostracod species composition, e.g., electrical conductivity in 16, water temperature in 14 and pH in 10 studies (Table S3). Consequently, this literature survey and the results of the present study may pinpoint that local factors have a greater impact than regional factors on alpha diversity of ostracods. The relationships of local and regional factors with individual species show difference among the regions (Figs. 2A, B and C). For example, *C. neglecta* had a significant correlation with elevation but oriented on the opposing side of this variable in West-Mediterranean (Fig. 2C) and did not locate close the arrow of variable in Antalya (Fig. 2B) while it showed a close relationship with elevation in Konya (Fig. 2A). Also, *C. neglecta* had high optimum and tolerance levels (1563.32±348.63) (Table 6) and a wide range (0-3194 m a.s.l.) (Yavuzatmaca *et al.* 2017*a*) of elevation. This is the case

for other common species *I. bradyi* which had a strong correlation with water temperature but did not show any close relationship in all basins (Figure 2A, B and C) when there is a wide range of water temperature (1.68–35.5 °C) (Yavuzatmaca *et al.* 2017*a*, the present study) for species (see Table 6 and Figs. 2A, B and C). This shows that even if a species has a low or high optimum and tolerance levels for a variable, the relationship of species with the same variable may vary in different regions. Also, species are affected in different ways by each variable because ecological variables (e.g., pH, dissolved oxygen, water temperature) show correlations among themselves (Table 5). Since we cannot determine which variable is primarily important for the distribution and occurrence of an individual species, it is inevitable to encounter the distinct relationships of a species with the same variable in different regions. Although this is the case, optimum and tolerance levels of species and their relationship with ecological variables provide important information for paleontologists to make retrospective environment estimates and to determine the changes that have occurred.

As previously stated (e.g., Külköylüoğlu *et al.* 2012*c*, Yavuzatmaca *et al.* 2017*a*, *b*), the high species diversity was reported in the mid-elevational interval in the present study (Table 2). Whereas the finding of high diversity at low (e.g., Pèrez *et al.* 2015, Yavuzatmaca *et al.* 2018) and high (e.g., Külköylüoğlu *et al.* 2012*a*, 2016) elevational intervals are also available in the literature. The difference between the present study and previous ones is the difference in the elevation ranges used. We investigated 800 m, while most other studies used ranges about 100, 150, 200 or 250 m. Thereby, this wide range allows us to see the effect of elevation on the species in a wide perspective. It is known that some of the species are of narrow tolerance ranges while others have very wide ranges (Table 5). When we look at the differences in species composition among the elevational intervals subjected herein (Table 3), especially the species with cosmopolitan distribution (e.g., *I. bradyi*, *C. neglecta*, *P. olivaceus*) tend to contribute with high percentages. The average value differences of water temperature and electrical conductivity among elevational intervals herein (see results) strengthened the changing of ecological variables with elevation as proposed previously (Külköylüoğlu *et al.* 2012*c*, McCain & Grytnes 2010; Schindler *et al.* 1990). This kind of change explains the conditions in mid and high elevations. Since if the species have wide ecological tolerance ranges – especially cosmopolitans – they may occur in all (e.g., *C. neglecta*, *C. angulata*, *H. incongruens*, *I. bradyi*) when others occur in limited elevational ranges (e.g., *T. clavata*, *C. improvisa*, *C. pubera*). Of course, this does not mean all cosmopolitans are found everywhere because their tolerance levels vary among themselves. On the other hand, conditions in low ranges may be assumed to be suitable for many species but biotic factors (e.g., competition, prey/predation relationship, anthropogenic environmental deterioration) can become critical.

"Pseudorichness (PR)" ratio of E1 (PR = 0.27) may demonstrate the effect of human on aquatic bodies when compared with mid (E2, PR = 0.67) and high (E3, PR = 0.78) elevational intervals that is also supported by the numbers of cosmopolitan species (15 spp.) found in low elevation. All of them indicate that at low elevations biotic factors are more effective than abiotic factors when compared with high elevations. Therefore, further studies including biotic factors are needed to make better inferences about the effect of elevation on ostracods.

Cyprideis torosa is an opportunistic species that occur mostly in brackish to saline water bodies (e.g., ponds, lakes, lagoons, estuaries) (Meisch 2000). Sandberg (1964) suggested nodes (lateral projections on valves) are observed on the valves of species in conditions with < 5% salinity. The occurrence of these nodes helps the animal to increase osmotic pressure during molting in low saline environments (Keyser 2005). Indeed, a total of 327 individual species without nodes were collected from four samplings in three lakes while one individual with nodes was encountered from a creek. The average values of electrical conductivity (14837.5 μS/cm) and salinity (7.28‰) of the lakes are higher than the values of electrical conductivity (573 μS/cm) and salinity (0.28‰) of the creek (see Table S1). Also, the species with the highest optimum and tolerance values (Table 6) displayed a strong correlation with electrical conductivity (Table 5). Thus, the findings of the present study support previous statements that presence of *C. torosa* with or without nodes is indeed dependent on changes in water salinity.

Finally, the present study provides important contributions to the freshwater ostracod fauna of Turkey and ecological information about ostracod species. Although cosmopolitans are positive indicators, they play an important role in the diversities (alpha, beta and gamma) of basins and elevational intervals. Local and regional factors are best suited to elucidate the alpha and beta diversities of ostracods, respectively among basins. Human-induced deterioration is less in the Konya basin than in open basins (Antalya and West-Mediterranean) but this does not mean to ignore touristic activities (referring to anthropogenic activities) that have economic and ecological significance, (e.g., habitat deterioration in the present study). The occurrence of species at low elevations may be under the control of biotic and human-mediated abiotic factors while abiotic factors may be effective at high elevations. This study has also shown the lack of basin-related studies in Turkey. Therefore, increasing in the number of basin-related studies in the future will be of great importance to the evaluation of aquatic environments and in determining the regional species pool.

*

REFERENCES

Akdemir, D. (2008): Differences of Ostracoda (Crustacea) Assemblages among two maar lakes and one sinkhole lake in the Konya region (Turkey). – *Turkish Journal of Zoology* **32**(2): 107–113.

Akdemir, D. & Külköylüoğlu, O. (2011): Freshwater Ostracoda (Crustacea) of Diyarbakır Province, including a new report for Turkey. – *Turkish Journal of Zoology* **35**: 671–675. https://doi.org/10.3906/zoo-0912-32

Akdemir, D. & Külköylüoğlu, O. (2014): Preliminary study on distribution, diversity and ecological characteristics of nonmarine Ostracoda (Crustacea) from Erzincan region (Turkey). – *Turkish Journal of Zoology* **38**: 421–431. https://doi.org/10.3906/zoo-1301-16

Akdemir, D., Külköylüoğlu, O., Yavuzatmaca, M. & Sarı, N. (2016): Freshwater ostracods (Crustacea) of Gaziantep (Turkey) and their habitat preferences according to movement ability. – *Fundamental and Applied Limnology* **187**(4): 307–314. https://doi.org/10.1127/fal/2016/0665.

Altinsaçlı, S. (2004): Investigation on Ostracoda (Crustacea) fauna of some important wetlands of Turkey. – *Pakistan Journal of Biological Sciences* **7**(12): 2130–2134. https://doi.org/10.3923/pjbs.2004.2130.2134

Altinsaçlı, S. & Mezquita, F. (2008): Ostracod fauna of salt Lake Acıgöl (Acı Tuz) (Turkey). – *Journal of Natural History* **42**: 1013–1025. https://doi.org/10.1080/00222930701851735

Astorga, A., Death, R., Death, F., Paavola, R., Chakraborty, M. & Muotka, T. (2014): Habitat heterogeneity drives the geographical distribution of beta diversity: the case of New Zealand stream invertebrates. – *Ecology and Evolution* **4**(13): 2693–2702. https://doi.org/10.1002/ece3.1124

Brown, R., Jacobs, L. A. & Peet, R. K. (2007): Species richness: small scale. – Encyclopedia of Life Sciences, John Wiley & Sons, Ltd., pp. 1–8. https://doi.org/10.1002/9780470015902.a0020488

Delorme, L. D. (1991): Ostracoda. Pp. 811–848. – *In:* Thorp, J. H. & Covich, A. P. (eds): *Ecology and Classification of North American Freshwater Invertebrates,* 2nd ed. Academic Press. https://doi.org/10.1016/B978-012690647-9/50021-1

Dügel, M., Külköylüoğlu, O. & Kılıç, M. (2008): Species assemblages and habitat preferences of Ostracoda (Crustacea) in Lake Abant (Bolu, Turkey). – *The Belgian Journal of Zoology* **138**(1): 50–59.

Engen, S., Saether, B., Sverdrup-Thygeson, A., Grotan, V. & Odegaard, F. (2008): Assessment of species diversity from species abundance distributions at different localities. – *Oikos* **117**(5): 738–748. https://doi.org/10.1111/j.0030-1299.2008.16466.x

European Commission, (2018): Available at http://ec.europa.eu/environment/index_en.htm [Accessed 2 August 2018]

Escrivà, A., Poquet, J. M. & Mesquita-Joanes, F. (2015): Effects of environmental and spatial variables on lotic ostracod metacommunity structure in the Iberian Peninsula. – *Inland Waters* **5**: 283–294. https://doi.org/10.5268/IW-5.3.771

Escrivà, A., Rueda, J., Armengol, X. & Mesquita-Joanes, F. (2014): Artificial dam lakes as suitable habitats for exotic invertebrates: Ostracoda ecology and distribution in reservoirs of the Eastern Iberian Peninsula. – *Knowledge and Management of Aquatic Ecosystems* **412**: 09. https://doi.org/10.1051/kmae/2013091

Gibb, H., Johansson, T., Stenbacka, F. & Hjältén, J. (2013): Functional Roles Affect Diversity-Succession Relationships for Boreal Beetles. – *PLoS ONE* **8**(8): 1–14. https://doi.org/10.1371/journal.pone.0072764

Green, A. J. (2016): The importance of waterbirds as an ovelooked pathway of invasion for alien species. – *Diversity & Distributions* **22**: 239–247. https://doi.org/10.1111/ddi.12392

Guo, Y., Frenzel, P., Börner, N., Akita, L. G. & Zhu, L. (2013): Recent Ostracoda of Taro Co (Western Tibetan Plateau). IL Naturalista Siciliano **37**(1): 161–162. – *In*: Abstract of 17th International Symposium on Ostracoda, Roma, Italy, 23–26 July 2013.

Gülen, D. (1985): The species and distribution of the group of Podocopa (Ostracoda-Crustacea) in freshwaters of Western Anatolia. – *İstanbul Üniversitesi Fen Fakültesi Mecmuası Seri B* **50**: 65–80.

Gülen, D. & Altinsaçli, S. (1999): The Ostracoda (Crustacea) fauna of Sakarya river basin. – *Geosound* **35**: 69–84.

Higuti, J., Lansac-Tôha, F. A., Velho, L. F. M. & Martens, K. (2009): Biodiversity of non-marine ostracods (Crustacea, Ostracoda) in the alluvial valley of the upper Paraná river. – *Brazilian Journal of Biology* **69**: 661–668. https://doi.org/10.1590/S1519-69842009000300020

Hill, J., Curran, P. J. & Foody, G. M. (1994): The Effect of Sampling on the Species-Area Curve. – *Global Ecology and Biogeography Letters* **4**(4): 97–106. https://doi.org/10.2307/2997435

Hill, M. O. (1973): Diversity and evenness: A unifying notation and its consequences. – *Ecology* **54**(2): 472–432. https://dx.doi.org /10.2307/1934352.

Iglikowska, A. & Namiotko, T. (2012): The impact of environmental factors on diversity of Ostracoda in freshwater habitats of subarctic and temperate Europe. – *Annales Zoologici Fennici* **49**: 193–218. https://doi.org/10.5735/086.049.0401

Juggins, S. (2003): Software for Ecological and Palaeoecological Data Analysis and Visualization, – C2 User Guide. University of Newcastle, Newcastle-upon-Tyne, UK.

Keyser, D. (2005): Histological peculiarities of the noding process in *Cyprideis torosa* (Jones) (Crustacea, Ostracoda). – *Hydrobiologia* **538**: 95–106. https://doi.org/10.1007/s10750-004-4940-x

Külköylüoğlu, O. (2003): Ecology of freshwater Ostracoda (Crustacea) from lakes and reservoirs in Bolu, Turkey. – *Journal of Freshwater Ecology* **18**(3): 343–347. https://doi.org/10.1080/02705060.2003.9663968

Külköylüoğlu, O. (2004): On the usage of ostracods (Crustacea) as bioindicator species in different aquatic habitats in the Bolu region, Turkey. – *Ecological Indicators* **4**: 139–147. https://doi.org/10.1016/j.ecolind.2004.01.004

Külköylüoğlu, O. (2005a): Ecology and phenology of freshwater ostracods in Lake Gölköy (Bolu, Turkey). – *Aquatic Ecology* **39**: 295–304. https://doi.org/10.1007/s10452-005-0782-5

Külköylüoğlu, O. (2005b): Ecological requirements of freshwater Ostracoda (Crustacea) in two limnocrene springs (Bolu, Turkey). – *Annales de Limnologie – International Jurnal of Limnology* **41**(4): 237–246. https://doi.org/10.1051/limn/2005016

Külköylüoğlu, O. (2013): Diversity, distribution and ecology of non-marine Ostracoda (Crustacea) in Turkey: application of pseudorichness and cosmoecious species concepts. – *Recent Research Development in Ecology* **4**: 1–18.

Külköylüoğlu, O., Akdemir, D., Sari, N., Yavuzatmaca, M., Oral, C. & Başak, E. (2013): Distribution and ecology of Ostracoda (Crustacea) from troughs in Turkey. – *Turkish Journal of Zoology* **37**: 277–287. https://doi.org/10.3906/zoo-1205-17

Külköylüoğlu, O., Akdemir, D., Yavuzatmaca, M. & Yilmaz, O. (2015): A checklist of recent non- marine Ostracoda (Crustacea) of Turkey with three new records. – *Review of Hydrobiology* **8**(2): 77–90.

Külköylüoğlu, O., Dügel, M. & Kiliç M. (2007): Ecological requirements of Ostracoda (Crustacea) in a heavily polluted shallow lake, Lake Yeniçağa (Bolu, Turkey). – *Hydrobiologia* **585**: 119–133. https://doi.org/10.1007/s10750-007-0633-6

Külköylüoğlu, O., Sari, N. & Akdemir, D. **(**2012*a*): Distribution and ecological requirements of ostracods (Crustacea) at high altitudinal ranges in Northeastern Van (Turkey). – *Annales de Limnologie-International Journal of Limnology* **48**: 39–51. https://doi.org/10.1051/limn/2011060

Külköylüoğlu, O., Sari, N., Akdemir, D., Yavuzatmaca, M. & Altinbağ, C. (2012*b*): Distribution of sexual and asexual Ostracoda (Crustacea) from different altitudinal ranges in the Ordu region of Turkey: Testing the Rapoport Rule. – *High Altitude Medicine & Biology* **13**(2):126–136. https://doi.org/10.1089/ham.2011.1111.

Külköylüoğlu, O., Tanyeri, M. & Yilmaz, O. (2017*a*): Alpha and beta species diversity of freshwater Ostracoda (Crustacea) and their seasonal distribution in Seben-Taşliyayla reservoir (Bolu, Turkey). – *Turkish Journal of Fisheries and Aquatic Sciences* **17**: 1357–1365. https://doi.org/10.4194/1303-2712-v17_6_28

Külköylüoğlu, O., Yavuzatmaca, M., Akdemir, D. & Sari, N. (2012*c*): Distribution and Local Species Diversity of Freshwater Ostracoda in Relation to Habitat in the Kahramanmaraş Province of Turkey. – *International Review of Hydrobiology* **97**(4): 247–261. https://doi.org/10.1002/iroh.201111490

Külköylüoğlu, O., Yavuzatmaca, M., Çelen, E., Akdemir, D. & Dalkiran, N. (2018): Ecological classification of the freshwater Ostracoda (Crustacea) based on physicochemical properties of waters and habitat preferences. – *Annales de Limnologie – International Journal of Limnology* **54**: 26. https://doi.org/10.1051/limn/2018017

Külköylüoğlu, O., Yavuzatmaca, M., Sari, N. & Akdemir, D. (2016): Elevational distribution and species diversity of freshwater Ostracoda (Crustacea) in Çankırı region (Turkey). – *Journal of Freshwater Ecology* **31**(2): 219–230. https://doi.org/10.1080/02705060.2015.1050467

Külköylüoğlu, O., Yavuzatmaca, M., Tanyeri, M. & Yilmaz, O. (2017*b*): Ostracoda (Crustacea) species composition and environmental correlates in diffeerent aquatic habitats of the Zonguldak and Bartın regions (Turkey). – *Turkish Journal of Zoology* **41**: 686–695. https://doi.org/10.3906/zoo-1512-36

Külköylüoğlu, O., Yilmaz, S. & Yavuzatmaca, M. (2017c): Comparison of Ostracoda (Crustacea) species diversity, distribution and ecological characteristics among habitat types. – *Fundamental and Applied Limnology* **190**(1): 63–86. https://doi.org/ 10.1127/fal/2017/0872

Laprida, C., Diaz, A. & Ratto, N. (2006): Ostracods (Crustacea) from thermal waters, southern Altiplano, Argentina. – *Micropaleontology* **52**: 177–188. https://doi.org/10.2113/gsmicropal.52.2.177

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. https://doi.org/10.1016/j.seares.2013.03.014

MARTINEZ-GARCIA, B., SUAREZ-HERNANDO, O., MENDICOA, J. & MURELAGA, X. (2015): Living ostracod species from permanent and semi-permanent ponds of Bardenas Reales de Navarra (Northern Spain) with remarks on their ecological requirements. – *Ameghiniana* **52**: 598–612. https://doi.org/10.5710/AMGH.17.07.2015.2895

McCAIN, C. M. & GRYTNES, J. A. (2010): Elevational gradients in species richness. – *In*: Encyclopedia of Life Sciences. John Wiley & Sons Ltd., Chichester. https://doi.org/10.1002/9780470015902.a0022548

McKENZIE, K. G. & MORONI, A. (1986): Man as an agent of crustacean passive dispersal via useful plants: exemplified by Ostracoda ospiti esteri of the Italian Ricefields ecosystem: and implications arising therefrom. – *Journal of Crustacean Biology* **6**(2): 181–198. https://doi.org/10.1163/193724086X00019

MEISCH, C. (2000): Freshwater Ostracoda of Western and Central Europe. Süßwasserfauna von Mitteleuropa, 8. – Spektrum Akademischer Verlag, Heidelberg I–xii.

MEZQUITA, F., GRIFFITHS, H. I., SANZ, S. J., SORIA, M. & PINON, A. (1999): Ecology and Distribution of Ostracods Associated with Flowing Waters in the Eastern Iberian Peninsula. – *Journal of Crustacean Biology* **19**: 344–354. https://doi.org/10.1163/193724099X00150

MISCHKE, S., ALMOGI-LABIN, A., ORTAL, R., ROSENFELD, A., SCHWAB, M. J. & BOOMER, I. (2010): Quantitative reconstruction of lake conductivity in the Quaternary of the Near East (Israel) using ostracods. – *Journal of Paleolimnology* **43**: 667–688. https://doi.org/10.1007/s10933-009-9359-y

NAGORSKAYA, L. & KEYSER, D. (2005): Habitat diversity and ostracod distribution patterns in Belarus. – *Hydrobiologia* **538**: 167–178. https://doi.org/10.1007/s10750-004-4959-z

ÖZULUĞ, O. (2011): A preliminary study on Ostracoda (Crustacea) fauna of the Istranca Streams-Turkey. – *Journal of Fisheries Sciences* **5**(2): 93–98. https://doi.org/10.3153/jfscom.2011011

PÄRTEL, M., ZOBEL, M., ZOBEL, K. & VAN DER MAAREL, E. (1996): The species pool and its relation to species richness: evidence from Estonian plant communities. – *Oikos* **75**: 111–117. https://doi.org/10.2307/3546327

PÈREZ, L., LOZANO-GARCIA, S. & CABALLERO, M. (2015): Non-marine ostracodes from highland lakes in East-central Mexico. – *Revista de Biologica Tropical (International Journal of Tropical Biology and Conservation)* **63**(2): 401–425. https://doi.org/10.15517/rbt.v63i2.15240

PIERI, V., MARTENS, K., STOCH, F. & ROSSETTI, G. (2009): Distribution and ecology of non-marine ostracods (Crustacea, Ostracoda) from Friuli Venezia Giulia (NE Italy). – *Journal of Limnology* **68**(1): 1–15. https://doi.org/10.4081/jlimnol.2009.1

RASOULI, H., AYGEN, C. & KÜLKÖYLÜOĞLU, O. (2014): Contribution to the freshwater Ostracoda (Crustacea) fauna of Turkey: Distribution and ecological notes. – *Turkish Journal of Fisheries and Aquatic Sciences* **20**: 11–20. https://doi.org/10.4194/1303-2712-v14_1_02

RICCIARDI, A. & RASMUSSEN, J. B. (1999): Extinction rates of North American freshwater fauna. – *Conservation Biology* **13**(5): 1220–1222. https://doi.org/10.1046/j.1523-1739.1999.98380.x

RODRIGUEZ-LAZARO, J. & RUIZ-MUÑOZ, F. (2012): A general introduction to ostracods: morphology, distribution, fossil record and applications. – *In*: HORNE, D. J., HOLMES, J. A., RODRIGUEZ-LAZARO, J. & VIEHBERG, F. A. (eds): Development in Quaternary Science, Ostracoda as proxies for Quaternary climate change. Elsevier, Amsterdam, 1–14.

SANDBERG, P. (1964): The ostracod genus Cyprideis in the Americas. – *Stockholm Contributions in Geology* **12**: 1–178.

Schindler, D. W., Beaty, K. G., Fee, E. J., Cruikshank, D. R., Debruyn, E. R., Findlay, D. L., Linsey, G. L. & Shearer, J. A. (1990): Effects of climatic warming on lakes of the central boreal forest. – *Science* **250**: 967–970. https://doi.org/10.1126/science.250.4983.967

Seaby, R. M. & Henderson, P. A. (2006): *Species diversity and richness version 4*. – Pisces Conservation Ltd., Lymington, England.

Søndergaard, M. & Jeppesen, E. (2007): Anthropogenic impacts on lake and stream ecosystems, and approaches to restoration. – *Journal of Applied Ecology* **44**: 1089–1094. https://doi.org/10.1111/j.1365-2664.2007.01426.x

Strayer, D. L. & Dudgeon, D. (2010): Freshwater biodiversity conservation: recent progress and future challenges. – *Journal of the North American Benthological Society* **29**(1): 344–358. https://doi.org/10.1899/08-171.1

Ter Braak, C. J. F. (1986): Canonical correspondence analysis: A new eigenvector technique for multivariate direct gradient analysis. – *Ecology* **67**: 1167–1179. https://doi.org/10.2307/1938672

Trmeu (2017): Wastewater treatment action plan, 2017–2023. – Turkey Republic Ministry of Environment and Urban, Ankara, 302 pp.

Trmfwm (2016): Action plans for lakes and wetlands (2016–2018). Turkey Republic Ministry of Forest and Water Management, Ankara, 191 pp. [in Turkish]

Torres Saldarriaga, A. & Martínez, J. I. (2010): Ecology of non–marine ostracoda from La Fe reservoir (El Retiro, Antioquia) and their potential application in paleoenvironmental studies. – *Revista de la Academia Colombiana de Ciencias Exactas, Fisicas y Naturales* **34**(132): 397–409.

Uçak, S., Külköylüoğlu, O., Akdemir, D. & Başak, E. (2014): Distribution, diversity and ecological characteristics of freshwater Ostracoda (Crustacea) in shallow aquatic bodies of the Ankara region, Turkey. – *Wetlands* **34**: 309–324. https://doi.org/10.1007/s13157-013-0499-5

Valls, L., Castillo-Escrivá, A., Mesquita-Joanes, F. & Armengol, X. (2016): Human-mediated dispersal of aquatic invertebrates with waterproof footwear. – *Ambio* **45**: 99–109. https://doi.org/10.1007/s13280-015-0689-x

Valls, L., Rueda, J. & Mesquita-Joanes, F. (2014): Rice fields as facilitators of freshwater invasions in protected wetlands: the case of Ostracoda (Crustacea) in the Albufera Natural Park (E Spain). – *Zoological Studies* **53**: 68. https://doi.org/10.1186/s40555-014-0068-5

Van der Meeren, T., Almendinger, J. E., Ito, E. & Martens, K. (2010): The ecology of ostracodes (Ostracoda, Crustacea) in western Mongolia. – *Hydrobiologia* **641**: 253–273. https://doi.org/10.1007/s10750-010-0089-y

Viehberg, F. (2006): Freshwater ostracod assemblages and their relationship to environmental variables in waters from northeast Germany. – *Hydrobiologia* **571**: 213–224. https://doi.org/10.1007/s10750-006-0241-x

Whittaker, R. H. (1972): Evolution and measurement of species diversity. – *Taxon* **21**: 213–251. https://doi.org/10.2307/1218190

Williams, M., Siveter, D. J., Salas, M. J., Vannier, J., Popov, L. E. & Pour, M. G. (2008): The earliest ostracods: The geological evidence. – *Senckenbergiana Lethaea* **88**(1): 11–21. https://doi.org/10.1007/BF03043974

Wilson, M. V. & Shmida, A. (1984): Measuring beta diversity with presence/absence data. – *Journal of Ecology* **72**: 1055–1064. https://doi.org/10.2307/2259551

Yavuzatmaca, M., Külköylüoğlu, O., Akdemir, D. & Çelen, E. (2018): On the relationship between the occurrence of ostracod species and elevation in Sakarya province,

Turkey. – *Acta Zoologica Academiae Scientiarum Hungaricae* **64**(4): 329–354. https://doi.org/10.17109/AZH.64.4.329.2018

Yavuzatmaca, M., Külköylüoğlu, O. & Yilmaz, O. (2015): Distributional patterns of non-marine Ostracoda (Crustacea) in Adıyaman province (Turkey). – *Annales de Limnologie–International Journal of Limnology* **51**(2): 101–113. https://doi.org/10.1051/limn/2015005

Yavuzatmaca, M., Külköylüoğlu, O. & Yilmaz, O. (2017*a*): Estimating distributional patterns of non-marine Ostracoda (Crustacea) and habitat suitability in the Burdur province (Turkey). – *Limnologica* **62**: 19–33. https://doi.org/10.1016/j.limno.2016.09.006

Yavuzatmaca, M., Külköylüoğlu, O., Yilmaz, O. & Akdemir, D. (2017*b*): On the relationship of ostracod species (Crustacea) to shallow water ion and sediment phosphate concentration across different elevational range (Sinop, Turkey). – *Turkish Journal of Fisheries and Aquatic Sciences* **17**: 1333–1346. https://doi.org/10.4194/1303-2712-v17_6_40

Zobel, M., Van Der Maarel, E. & Dupre, C. (1998): Species pool: the concept, its determination and significance for community restoration. – *Applied Vegetation Science* **1**: 55–66. https://doi.org/10.2307/1479085

Supplementary Table 1. Minimum-maximum (min-max) and mean values of ecological variables for basins (Konya, Antalya and West Mediterranean) and for individual species and provinces where species collected.

Basins	Elevation (m a.s.l.)		Water temperature (°C)		pH		Conductivity (µS/cm)		Dissolved oxygen (mg/L)		Salinity (‰)		Province
	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	
Konya	967-1855	1442	8.60-39.5	20.03	6.70-9.80	8.21	35.70-84900	3110.73	1.28-13.03	8.06	0.01-61.3	2.04	Please see material and methods section for the provinces in the border of basins
Antalya	4.0-2043	553	9.3-35	22	7.02-9.81	8.01	101.8-38100	1955	3.64-9.9	8.2	0.03-24.2	1.3	
W Med.	0-1829	783	8.6-33	21	6.68-10.9	8.44	2.87-20610	1961	2.6-14.1	8.56	0.06-11.4	1	
Species	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	Province
1 C. angulata	308-1731	995.33	15.2-24.9	20.9	7.02-8.82	8.12	206.9-854	631.97	7.8-10.35	9.22	0.1-0.43	0.32	Antalya. Burdur. Muğla
2 C. improvisa	1373-1373	1373	20.1-21.9	21	7.79-7.83	7.81	140-453	296.5	6.33-7.6	6.97	0.007-0.12	0.06	Niğde
3 C. neglecta	79-1761	1266	12.1-29	18.46	6.87-10.9	8.43	43.2-785	299.72	5.57-13	8.66	0.04-0.38	0.15	Muğla. Antalya. Isparta. Burdur. Denizli. Karaman. Konya. Niğde
6 C. sanociensis	1371-1374	1373	15.2-19.4	17.3	8.29-8.32	8.31	160.8-480	320.4	8.6-9.06	8.83	0.08-0.23	0.16	Konya
8 C. weltneri	1849-1855	1851	8.6-28	18.1	6.7-8.15	7.26	35.7-984	422.53	5-10.4	7.63	0.02-0.08	0.04	Konya
4 C. ophtalmica	1173		17		7		598		8.6		0.34		Aksaray

	Basins	Elevation (m a.s.l.)		Water temperature (°C)		pH		Conductivity (µS/cm)		Dissolved oxygen (mg/L)		Salinity (‰)		Province
		min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	
7	*C. torosa*	0-146	36.2	21.8-32.7	25.78	6.68-9.01	7.8	573-20610	11984.6	4.81-9.91	6.8	0.28-11.37	5.88	Muğla
5	*C. pubera*	2009		26		7.85		584		7.99		0.03		Antalya
9	*C. vidua*	220-1855	1445	12.1-31.5	22.55	7.07-9.69	8.36	125-500	288.02	6.73-10.9	9.18	0.02-0.19	0.1	Muğla. Aksaray. Konya. Antalya
10	*D. stevensoni*	94-1731	686	15.2-31	23.33	8.01-8.91	8.54	206.9-835	490.68	5.57-10.35	8.26	0.1-6.1	0.89	Antalya. Muğla. Isparta. Burdur
11	*F. fabaeformis*	1217-1737	1477	20.6-26.8	23.7	7.84-8.42	8.13	147.5-148.9	148.2	7.27-7.49	7.38	0.06-0.07	0.07	Konya
12	*F. fragilis*	223		22.4		9.36		372		14.1		0.18		Muğla
13	*F. holzkampfi*	1492-1735	1653	19.3-24.9	22.87	8.78-9.69	9.1	206.9-487	307.63	8.8-10.9	10.02	0.1-0.23	0.15	Burdur. Muğla
14	*H. chevreuxi*	262-2009	1136	23.2-26	24.6	7.85-8.2	8.03	332-584	458	7.99-9.1	8.55	0.03-0.15	0.09	Antalya
16	*H. reptans*	987-991	989	17.9-21.6	19.75	8.15-8.21	8.18	449-481	465	7.53-8.5	8.02	0.22-0.23	0.23	Denizli
15	*H. incongruens*	262-2043	991	13.3-35.5	25.18	7.46-9.8	8.63	101.8-1688	587.35	6.8-12.9	8.77	0.05-0.86	0.29	Antalya. Isparta. Konya. Karaman
17	*H. salina*	96-1354	867	13.3-35.5	20.1	7-9.35	8.04	296-1688	674	6.87-9.34	8.41	0.14-0.86	0.34	Muğla. Aksaray. Konya. Karaman
18	*I. bradyi*	79-1622	1047	13.1-35.5	19.3	7.41-9.35	8.17	148.9-1688	435.95	6.87-9.8	8.35	0.07-0.86	0.2	Isparta. Muğla. Konya. Antalya. Karaman. Aksaray.
19	*I. monstrifica*	985-991	988	17.9-33.2	24.23	8.15-9.8	8.72	387-481	439	7.53-12.9	9.64	0.19-0.23	0.21	Konya. Denizli

	Basins	Elevation (m a.s.l.)		Water temperature (°C)		pH		EConductivity (µS/cm)		Dissolved oxygen (mg/L)		Salinity (‰)		Province
		min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	min-max	mean	
20	*L. inopinata*	262-991	747	17.9-23.2	20.9	8.15-8.21	8.19	332-481	420.67	7.53-9.1	8.38	0.15-0.23	0.2	Antalya. Denizli
22	*P. euplectella*	1173-1354	1264	13.3-17	15.15	7-7.46	7.23	296-598	447	8.3-8.6	8.45	0.14-0.34	0.24	Aksaray. Karaman
23	*P. kraepelini*	310-1737	1251	15.2-33.2	23.71	7.14-10.9	9.09	129.6-1144	488.51	5.57-13	9.82	0.06-0.57	0.24	Antalya. Isparta. Burdur. Konya. Muğla
26	*P. fallax*	79-1742	763	13.1-25.9	17.67	7.62-8.21	7.98	303-513	406	8.62-9.6	9.07	0.14-0.25	0.2	Muğla. Antalya. Isparta. Konya
27	*P. similis*	458-1371	1046	12.1-21.8	16.63	8.19-8.82	8.33	79.9-504	338.17	7.19-9.2	8.48	0.08-0.26	0.17	Antalya. Konya
28	*P. unicaudata*	1192-1193	1193	15.2-35.5	25.35	9.35-9.63	9.49	1688-3480	2584	1.28-6.87	4.08	0.86-1.83	1.345	Konya
29	*P. variegata*	94-991	374	14.2-31	23.89	7.12-8.43	8.12	303-742	420.22	7.53-10.4	8.47	0.14-0.36	0.2	Antalya. Denizli
24	*P. zenkeri*	322-1378	932	14.2-23.9	18.52	7.93-8.35	8.13	352-392	374	7.8-9.56	8.72	0.17-0.19	0.18	Isparta. Karaman. Muğla
21	*P. albicans*	185-1855	1262	13.2-26.9	21.83	7.07-8.82	8.02	160.8-500	343.39	7.06-10.35	8.69	0.02-0.22	0.14	Antalya. Denizli. Aksaray. Karaman. Konya. Muğla
25	*P. olivaceus*	189-1742	962	12.1-27.4	18.3	7.41-8.82	8.07	79.9-580	352.42	7.11-9.6	8.5	0.08-0.26	0.17	Antalya. Muğla. Isparta. Karaman. Konya
30	*P. fontinalis*	1622		13.2		7.65		261		7.9		0.12		Konya
31	*T. clavata*	4-1354	679	13.3-34.8	24.05	7.46-8.06	7.76	296-38100	19198	6.81-8.3	7.56	0.14-24.2	12.17	Antalya. Karaman

Supplementary Table 2. Summary tables of CCA for Konya, Antalya and West Mediterranean basins.

	Konya Basin				
Axes	1	2	3	4	Total inertia
Eigenvalues	0.81	0.57	0.34	0.24	7.12
*Lengths of gradient	0.00	5.82	7.52	3.99	
Species-environment correlations	0.96	0.90	0.68	0.56	
Cumulative percentage variance					
of species data	11.3	19.3	24.0	27.3	
of species-environment relation:	40.0	68.0	84.7	96.6	
Sum of all eigenvalues					7.12
Sum of all canonical eigenvalues					2.02
	Antalya Basin				
Axes	1	2	3	4	Total inertia
Eigenvalues	0.98	0.74	0.53	0.17	5.34
*Lengths of gradient	0.00	5.25	3.13	1.63	
Species-environment correlations	0.98	0.91	0.80	0.47	
Cumulative percentage variance					
of species data	18.3	32.2	42.2	45.4	
of species-environment relation:	39.7	69.9	91.5	98.5	
Sum of all eigenvalues					5.34
Sum of all canonical eigenvalues					2.46
	West Mediterranean Basin				
Axes	1	2	3	4	Total inertia
Eigenvalues	0.86	0.63	0.43	0.10	6.81
*Lengths of gradient	6.34	5.07	13.6	3.22	
Species–environment correlations	0.97	0.88	0.78	0.50	
Cumulative percentage variance					
of species data	12.6	21.9	28.2	29.7	
of species-environment relation:	40.8	70.9	91.5	96.2	
Sum of all eigenvalues					6.81
Sum of all canonical eigenvalues					2.10

Supplementary Table 3. The effective ecological variables on the species composition (or alpha diversity) based on Canonical Correspondence Analysis from the known literature. Abbreviations: EC, electrical conductivity; Elev, elevation; DO, dissolved oxygen; Tw, water temperature; Sal, salinity; Ta, air temperature; ORP, oxidation and reduction potential; Ca^{+2}, calcium; Mg^{+2}, magnesium; La, lake area; Htp, habitat type; sT, sediment type; sOp, sediment organic phosphate. Many under the habitat column means that study includes more than one habitat (e.g., lake, creek, spring, trough).

EC	Elev	DO	pH	Tw	Sal	Other	Habitat	Country	Citation
+					+	Ta, ORP	Lakes, Reservoirs	Turkey	Külköylüoğlu 2003
	+			+		ORP	Lake	Turkey	Külköylüoğlu 2005a
+		+	+				Spring	Turkey	Külköylüoğlu 2005b
			+			Ca^{+2}, Mg^{+2}, La	Many	Germany	Viehberg 2006
+				+		ORP	Lake	Turkey	Külköylüoğlu et al. 2007
+		+		+			Lake	Turkey	Dügel et al. 2008
+				+			Many	Italy	Pieri et al. 2009
+	+						Lake	Israel	Mischke et al. 2010
+		+	+	+			Reservoir	Colombia	Torres Saldarriaga & Martínez 2010
	+			+	+	Ca^{+2}, alkalinity, nutrient	Many	Mongolia	Van der Meeren et al. 2010
+		+	+	+		Ca^{+2}, organic matter or sediment	Many	Lapland-Poland	Iglikowska & Namiotko 2012
+		+				ORP, HtP	Many	Turkey	Külköylüoğlu et al. 2012a
				+		HtP	Many	Turkey	Külköylüoğlu et al. 2012b
				+			Many	Turkey	Külköylüoğlu et al. 2012c
	+					ORP	Trough	Turkey	Külköylüoğlu et al. 2013
					+	Vegetation, sT	Estuary	Spain	Martínez-García et al. 2013
			+				Many	Turkey	Akdemir & Külköylüoğlu 2014

EC	Elev	DO	pH	Tw	Sal	Other	Habitat	Country	Citation
		+					Dam	Spain	Escrivá *et al.* 2014
		+		+	+	Moisture	Many	Turkey	Uçak *et al.* 2014
		+					Rice fields	Spain	Valls *et al.* 2014
+						Ta	River	Spain	Escrivá *et al.* 2015
+			+				Ponds	Spain	Martínez-García *et al.* 2015
+	+		+	+			Many	Turkey	Yavuzatmaca *et al.* 2015
				+	+	Ta	Many	Turkey	Akdemir *et al.* 2016
+	+						Many	Turkey	Külköylüoğlu *et al.* 2016
+				+	+		Many	Turkey	Külköylüoğlu *et al.* 2017b
			+				Many	Turkey	Külköylüoğlu *et al.* 2017c
			+	+			Many	Turkey	Yavuzatmaca *et al.* 2017a
+					+	Mg^{+2}, sOp	Many	Turkey	Yavuzatmaca et al., 2017b
+			+	+	+	ORP	Many	Turkey	Külköylüoğlu *et al.* 2018

(Variable name spans the columns EC, Elev, DO, pH, Tw, Sal, Other)

Contributions to a Manual of Palaearctic Diptera

Edited by L. Papp and B. Darvas

Volumes 1–3, Appendix

The excellently illustrated volumes of the "Contributions to a Manual of Palaearctic Diptera" morphological, physiological, genetical, ecological and economic up-to-date knowledge of dipterous species (midges and flies), which have significant importance in genetics as model organisms, in plant cultivation as pests or beneficial parasitoids, in animal husbandry and human health as vectors of serious illnesses and which are important for ecosystem function, are treated. Morphological keys to generic level for adults and larvae are provided, which help readers with identification of dipterous pests and parasitoids, while readers in the field of applied dipterology will find suitable environmentally friendly methods against pests or biological control methods.

Volume 1 (published in 2000): 24 chapters of general and applied dipterology, by 31 specialists, on 978 pages with 956 figures on 176 plates. Volume 2 (published in 1997): 38 dipterous family chapters, by 23 specialists, on 592 pages with 1895 figures on 258 plates. Volume 3 (published in 1998): 56 dipterous family chapters, by 32 specialists, on 880 pages with 1773 figures on 294 plates. Appendix (published in 2000): 16 dipterous family chapters, by 19 specialists, on 604 pages with 2134 figures on 207 plates.

Order should be sent to
NEST Foundation, Collegium Budapest
Ms Szilvia Zimber, E-mail: szimber@colbud.hu