1. Diversity, distribution and ecology of nonmarine Ostracoda (Crustacea) in Turkey: Application of pseudorichness and cosmoecious species concepts

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Abstract. There are about 130 nonmarine free-living freshwater ostracods in 46 genera reported so far from Turkey. Almost half (47%) of these species in about 24 genera is belonged to one family, the Cyprididae fallowed by the families Candonidae (27%) and Ilyocyprididae (9%). Comparing the total numbers of species worldwide (more than 2100 species), this number is apparently underestimated. This is mainly because of lack of studies in more than half of the country. Nevertheless, result of a large dataset (ca. 3000 samplings) collected from different aquatic bodies of Turkey revealed that some of those species do have wider ranges of ecological tolerances to different environmental variables than what we knew before. Geographical distributions and occurrences of those species from different types of habitats in Turkey are most likely corresponding to their cosmopolitan characteristics. In order to describe a species with wide geographical distribution (cosmopolitan) and wide tolerances to different environmental variables (euryoecious), I would like to use a new term “cosmoecious species”.

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To evaluate the usage of cosmopolitans, details about the concept of “pseudorichness” are also introduced and discussed with example. Descriptive ecology, diversity and geographical data for five cosmoecious species are provided.

Introduction

Ostracods are small aquatic invertebrates (0.25-4.5mm) living in a variety of aquatic habitats such as rivers, streams, creeks, springs, troughs, ditches, ponds, lakes, wells, cave water, thermal waters, deep bottom of seas and oceans (Figure 1). They are one of the oldest crustaceans known from Cambrian to present [1, 2] and have parthenogenetic (asexual) and bisexual populations, but some species are known to have mixed populations [3]. They can change the location either by active or passive modes of dispersion that species with long swimming setae are better using active modes than species with no (or short) swimming setae [4]. Depending on suitability of water conditions [5], ostracods can be found at different altitudes [6] and depths [7] of water bodies. These unique crustaceans are ideal for many types of studies for several reasons: they (i) are found in a variety of aquatic habitats with different ecological conditions, (ii) have wide ranges of geographical distribution in the world, (iii) reproduce more and quickly, and (iv) are useful for reconstructing the past historical environmental conditions due to their

![Figure 1. SEM photographs of some Ostracoda species. Scale bar 100µm.](image)
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calcium-carbonated carapace. Thus, overall, species of Ostracoda are known to be good objects used in evolutionary [8], ecological [9, 10], biological [11, 12] and geological studies as well. Ostracods can be used as indicator species for water quality estimation [13] because they show species-specific ecological requirements, habitat preferences [14] and tolerances to wide variations in most of physical and chemical environmental factors [15, 16, 17, 10]. Besides, most recent studies displayed the fact that ostracods can also be used in conservation purposes at local and/or regional levels [18, 19, 20]. Although such knowledge is necessary for characterizing past and current ecological conditions of aquatic habitats, from which future conditions might be predicted [21, 22], we have little (or no) information about most of the species. However, as underlined by previous studies [23], using ostracods as a tool for these reasons requires detailed knowledge about living ostracods. In Turkey, there are about 130 nonmarine subjective ostracods (this study) but comparing the total numbers of species (ca. 70,000 species) worldwide [24, 25, 26], this number is believed to be underestimated. A large (over 3000 samplings) data set about ecology, distribution and diversity of ostracods collected in Turkey suggested that ostracod species richness is much higher. Although such extensive sampling provides a good dataset on some species, this data still shows an urgent need for evaluation of our knowledge on what we previously know about ostracods. In this chapter, (i) I will focus on the details of the new terms (cosmoecious and pseudorichness) and (ii) diversity, ecology and biogeographical distribution of five cosmoecious ostracod species.

Cosmoecious species

Külüçüoğlu [27] introduced and proposed a new term “cosmoecious” derived from the combination of two terms “cosmopolitan” (species wide geographical distribution) and “euryoeccious” (species with wide tolerances to different ecological variables). Accordingly, a cosmoecious species is the species with wide ranges of tolerances to various environmental variables within a large geographical distribution or occurrence (Figure 2). The term is different than generalist species (a species with broad food or habitat preferences) and specialist species (an organism with restricted use of habitats or resources) [28]. When specialists utilize their resources more efficiently than generalists, they are not able to adapt (or tolerate) changes in food and habitat conditions. In contrast, generalist species have wider food usage than specialists. The work of McNaughton and Wolf [29] and others (e.g., [30]) suggested that species with wide distribution tend to be more abundant
locally. Therefore, cosmoecious species can be locally abundant species with wide geographical distribution and wide tolerances to different ecological conditions. The new term is used when species geographical distribution and ecological tolerances are known. Besides, knowledge about the minimum and maximum levels of at least 4 main environmental variables measured in situ such as temperature, dissolved oxygen, pH, electrical conductivity is required. Using the term “cosmoecius” provides better description of species with these characters.

**Pseudorichness**

As mentioned above, ostracods can be used as indicator species of water quality estimation. The idea of indicator species concept [31, 32, 33] includes using both positive (i.e., cosmopolitan species with wide ranges of tolerance to pollution) and negative indicator species (i.e., non-cosmopolitan or sensitive species with limited ranges of tolerance) for determining the water quality in variety of aquatic systems [34]. Implication of this concept is to look at the relationship between increasing human disturbance and pollution which is better determined when the numbers of positive indicators increased.
[35-38] and [14] stated that the proportion of tolerant and/or opportunistic cosmopolitan species may be positively correlated with habitat disturbance or reduction in water quality. If cosmopolitans can tolerate high levels of changes in water quality, this can help them to extend their geographical distribution into a variety of aquatic environments. Thus, successful increase in the abundance of cosmopolitan may in turn reduce the total number of native or negative species. This can eventually cause a decrease in species diversity and change community structure.

The term “cosmoeocious” described above is related to the concept of “pseudorichness” which describes the ratio between noncosmopolitan (e.g., negative indicators) and cosmopolitan (e.g., positive indicators) species found in a particular habitat [39]. This ratio (noncosmopolitan/cosmopolitan) named as “pseudorichness ratio” (PR) can be used along with ecological tolerances and optimum estimates of cosmoeocious species. The proposition of pseudorichness hypothesis brings out several questions about the relationships between geographical distribution of ostracods (and other taxonomic groups) and their ecological requirements. Such questions include: Are cosmopolitan ostracod species (if not all) euryoeocious or vice versa? Do cosmopolitan species have high tolerances to environmental changes? If yes, what is the level of tolerances? Which factor(s) is/are more important on their abundance? How is species diversity affected by cosmopolitan species? What are the optimum estimates of these species? Inquiring such questions from present ecological conditions specify the importance of ostracods (and other taxa when the concept is applied to use) in multi-and inter-disciplinary studies in which reconstruction of past environmental conditions can be estimated from ostracods. Accordingly, increasing numbers of cosmopolitan species may correspond to either a low water quality or the first levels of species succession in a newly developing habitat, or both.

**Why do numbers of cosmopolitan species increase?**

i) Changes in physical and/or chemical conditions of environment: since cosmopolitans have high tolerances to changes in habitat conditions (e.g., pollution), increasing levels of such changes can provide advantages to cosmopolitans but can be disadvantage to noncosmopolitan species.

ii) Newly structuring habitats: cosmopolitans can play important role on the structuring the first steps of succession in a newly developing habitats due to their ability to tolerate wide ranges of changes in environmental variables [40]. Consequently, the ratio of pseudorichness can provide early knowledge about the
characteristics of water quality. Indeed, comparing the ratio in several different aquatic habitats seems to support the assumptions of the concept.

These two approaches can be used to have valuable contribution (1) in pinpointing importance of cosmopolitan species, (2) getting benefit from these species on protecting environment, (3) in biomonitoring studies, (4) determining pollution levels of habitats, and (5) using them as bioindicator species. Hypotheses of these approaches inquiring into answers of 5 different questions are presented with examples. Increasing numbers of cosmopolitan species may be the indication of pollution in the natural systems from outside to inside along with increasing differing negative factors. Therefore, proportional relationship (ratio of pseudorichness) can be expected between the numbers of invader cosmopolitans and increasing levels of pollution. As Küلكöylüoğlu et al. [41] underlined that this is not to ignore the presence of cosmopolitans, nor to say that all invaders are cosmopolitans. It is rather value cosmopolitans as species for indicating aquatic conditions that they can be considered as a useful tool by conservationists. Thus, the pseudorichness concept interprets low water quality with species quality not the quantity, but quantity is used to calculate the ratio. The hypotheses of the pseudorichness concept provided below are not limited and should also be tested widely in different organism in a variety of habitats.

**Hypotheses of pseudorichness**

Ho 1: The numbers of cosmopolitan species are lower in natural habitats than artificial habitats.
Ho 2: Decreasing the ratio of numbers of noncosmopolitan to cosmopolitan species implies changes in the habitat conditions (e.g., increasing pollution)
Ho 3: Monitoring the pseudorichness ratio can provide estimates about habitat quality changes in future.

**Application rules**

1) Numbers of cosmopolitan and noncosmopolitan species in taxonomic groups studied should be determined at first.

   Rationality: It is suggested to look at characteristics of species (i.e. cosmopolitan or not) in different taxonomic groups to support general status of habitat. This is important, otherwise, the ratio cannot be
determined. However, such requirement includes a good estimation and knowledge about geographical distribution of taxonomic level.

2) Ecological tolerance and optimum estimates of species should be calculated.
   Rationality: This should back up whether species are euryecious or not. Thus, such application includes data of more than one environmental variable.

3) Seasonal distribution/occurrence of species (or taxonomic level) should be known (if possible).
   Rationality: Considering differences at the global latitudinal scale, sampling of particular area can cover at least two or more seasons (monthly if possible).

**Interpretation:** Figure 3 shows three possible cases from the ratio estimation. First one is expected when numbers of noncosmopolitans (nc) are higher than cosmopolitans (co) in habitats with high quality. The second possibility can be found when the numbers of species are equal. This is actually one of the cases that requires to consider collecting additional data about species and the habitat. In the third possibility, numbers of cosmopolitans are higher than noncosmopolitans in habitats with low quality.

![Figure 3](image)

**Figure 3.** Comparing the numbers of cosmopolitans (co) and noncosmopolitan (nc) species with the actual values of dissolved oxygen from 15 aquatic bodies (see Table 1 below).
Case 1) \( \text{nc} / \text{co} > 1 \), numbers of cosmopolitan < numbers of noncosmopolitan
Case 2) \( \text{nc} / \text{co} = 1 \), equilibrium point
Case 3) \( \text{nc} / \text{co} < 1 \), numbers of cosmopolitan > numbers of noncosmopolitan

Accordingly, using data from Table 1 makes it possible to compare natural and artificial habitats by means of comparing the numbers of cosmopolitan and noncosmopolitans along with the pseudorichness ratio (PR). As we see from Table 1, increasing numbers of cosmopolitans tend to cause a decline in the ratio. Indeed, such habitats with \( \text{PR} < 1 \) are known to have disturbed areas by anthropogenic activities.

Materials and methods

Taxonomic data about species reported from Turkey was gained from previous studies done in Turkey. These samples have been randomly collected from variety of sites along with measuring five major environmental variables (pH, temperature, dissolved oxygen, electrical conductivity, altitude) at different aquatic bodies of Turkey. Data given in Table 1 includes sites sampled monthly in one year or at least four seasons, in which except Lake Banyoles (Spain) [47], all others are found in Turkey. Detailed standard sampling

Table 1. Total numbers of species (totspp) reported from 15 different water bodies along with the numbers, pseudorichness ratio (PR = \( \text{nc} / \text{co} \)) and percent species of cosmopolitan (co) and noncosmopolitans (nc). Note that Lake Sünnet 2 includes 9 living and 4 fossil forms. This is used to show how increasing numbers of species will change the ratio.
procedure for different types of habitats (see [10, 43, 48]) can be found elsewhere in the literature. Taxonomic identification of species was done with the keys of Bronshtein [49]) and Meisch [50] but the list of Martens and Savatenalinton [51] was also used to compare the current names of species.

Results

Diversity: There are about 130 subjective species of nonmarine free-living freshwater ostracods belonging to 46 genera in about 12 families reported so far from Turkey (Table 1). About 84% of all species in 24 genera are belonged to three families Cyprididae (47%), Candonidae (27%) and Ilyocyprididae (9%) (Figure 4). This number is apparently underestimated when comparing the total numbers of freshwater species worldwide (ca. 2100 species) [51], but not very different from most of the European countries (e.g. see [50]).

![% numbers of species per family](image)

**Figure 4.** Percent numbers of species per family. Note that some families carrying mostly marine ostracods do also have species which can be found in the brackish waters or lagoons.

Ecology: Ecological data for some cosmopolitan species that are also characterized as “cosmoecious species” are given below. Most of these species are also the most frequently occurring species in Turkey and elsewhere (except the poles). Table 2 shows upper and lower values of five different environmental variables for 15 cosmopolitan species. Besides, the data compiled from a broad literature work support the idea that tolerance and optimum levels of these cosmopolitan species (*Heterocypris incongruens*,
Ilyocypris bradyi, Candona neglecta, Psychrodromus olivaceus, Physocypria kraepelini, Cypria ophthalmica, Candona candida, Cypridopsis vidua, Eucypris virens, Potamocypris villosa, Prionocypris zenkeri, Darwinula stevensoni, Herpetocypris reptans) are relatively higher for some environmental variables than those of noncosmopolitan species.

Table 2. Upper and lower values of 15 cosmopolitan species for five different variables (pH, water temperature (t°C), dissolved oxygen (DO, mg/l), electrical conductivity (EC, µS/cm), altitude (Alt, m). (modified from [35]). Sources: a) [52], b) [39], c) [53], d) [16], e) [54], f) [55], g) [17], h) [56], i) [57], j) [58], k) [59], l) [49], m) [60], n) [9], o) [5], p) [61], q) [6], r) [62], s) [38], t) [37], u) [63], v) [43], w) [46], x) [64], y) [21], z) [40], A) [65], B) [42], C) [66], D) [67], E) [68], F) [69], G) [70], H) [71], J) [72], K) [47], L) [73]. (*) approximate value.

<table>
<thead>
<tr>
<th>Species</th>
<th>pH</th>
<th>t°C</th>
<th>DO</th>
<th>EC</th>
<th>Alt</th>
</tr>
</thead>
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<tr>
<td>Ilyocypris gibba</td>
<td>6.2±1.90⁰</td>
<td>7.50±4.20⁰</td>
<td>3.00±1.40⁰</td>
<td>260±2800³</td>
<td>1.0±3.194³</td>
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<tr>
<td>Heterocypris incongruens</td>
<td>6.00±12.8⁰</td>
<td>6.60±13.7⁰</td>
<td>1.00±1.40⁰</td>
<td>56.0±3320⁰</td>
<td>1.0±3.194³</td>
</tr>
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<td>Candona neglecta</td>
<td>6.84±9.4⁰</td>
<td>2.2±27.9¹</td>
<td>0.32±15.4⁰</td>
<td>56.9±92⁰</td>
<td>172±3.194³</td>
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<tr>
<td>Ilyocypris bradyi</td>
<td>5.43±9.8¹</td>
<td>5.8±25.7⁰</td>
<td>0.28±14.1⁰</td>
<td>15.6±2320⁰</td>
<td>0.5±3.194³</td>
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<td>Psychrodromus olivaceus</td>
<td>6.46±9.5⁰</td>
<td>1.68±24.4⁰</td>
<td>1.74±20⁰</td>
<td>61.1±69⁰</td>
<td>0.5±138⁰</td>
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<td>Candona candida</td>
<td>5.9±9.6⁰</td>
<td>9.6±23.8⁰</td>
<td>1.44±9.71⁰</td>
<td>26.9±64⁰</td>
<td>71±3.194³</td>
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<td>Sarscypridopsis aculeata</td>
<td>9.21±7.5⁰</td>
<td>14.00±25.0⁰</td>
<td>4.9±12.1⁰</td>
<td>260±1800⁰</td>
<td>5.0±1208³</td>
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<tr>
<td>Cypridopsis vidua</td>
<td>5.20±12.0⁰</td>
<td>5.00±36.0⁰</td>
<td>1.44±19.0⁰</td>
<td>37⁰±7410⁰</td>
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<td>Potamocypris villosa</td>
<td>6.6±9.8⁰</td>
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<td>238±253⁰</td>
<td>0.5±3.194³</td>
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<tr>
<td>Cypria ophthalmica</td>
<td>5.0±13.0⁰</td>
<td>3.50±33.0⁰</td>
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<td>40.8±526⁰</td>
<td>35±134⁰</td>
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<td>6.00±9.2⁰</td>
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<td>1.00±14.0⁰</td>
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<td>Eucypris virens</td>
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<td>Physocypria kraepelini</td>
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<td>0.5±166³</td>
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<td>2.01±20.7⁰</td>
<td>221±74⁰</td>
<td>32³±191⁰</td>
</tr>
</tbody>
</table>

Heterocypris incongruens (Ramdohr, 1808)

Fryer [74] called the species “horse-trough ostracod” because he had observed the species mostly from troughs. Beyer et al. [75] also reported this species (along with four others “Sarscypridopsis lanzarotensis, S. aculeate, Potamocypris arcuata, Plesiocypridopsis newtoni”) from cattle-troughs in the
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Canary islands. Indeed, one of the most current study done in more than 100 troughs of Turkey showed that *H. incongruens* was the most frequently occurring species [76]. However, distribution of *H. incongruens* is not limited to troughs that the species can also be found in many different water bodies such as ditches, pits, ponds, ephemeral pools, littoral zones of lakes and wetlands. *Heterocypris incongruens* is a well known cosmopolitan species with wide ranges (Table 2) and relatively high tolerance levels to different environmental variables. It has been reported from sea level to 2000m a.s.l. The species has been reported with a wide temperature range from 6°C [56] to 31.7°C [71]. According to Margalef [77] *H. incongruens* can tolerate low oxygen, high chloride and organic materials; therefore, the species can be a good indicator of alpha-mesosaprobic waters. Additionally, Shornikov and Trebukhova [78] stated that the species prefers heavily polluted water bodies. It is true that this species is one of the last to disappear from polluted waters. However, this is not their preference to live in such water bodies. Rather, it is because of their broader tolerance and optimum ranges that ability makes its succession possible in polluted and newly developed habitats [40]. Indeed, optimum estimates of this species for water temperature (uk = 21°C), redox potential (uk = 185mV) and electrical conductivity (uk = 443µS/cm) was above the mean of the water bodies in Kahramanmaraş province, Turkey [5]. *Heterocypris incongruens* is herein called as cosmoecious species due to its wide geographical distribution and wide ranges of tolerances to different variables in variety of aquatic habitats.

*Candona neglecta* (Sars, 1887)

This is also a well known species with cosmopolitan distribution at least in Holarctic region, and is one of the most frequently occurring species in Europe [18, 50] and Turkey [10, 14, 36, 37, 79]. Most recently the species was reported from 1252m of altitude [80] but its altitudinal range goes upto 2290m. Like *H. incongruens*, it is believed that *C. neglecta* can also have relatively high tolerance levels to changes in water conditions. Indeed, working in the pre-alpine deep lake Mondsee, Danielopol et al. [81] showed that the last species disappeared from the lake due to eutrophication was *C. neglecta*. This suggests species high tolerance levels to different variables. According to Meisch [50], *C. neglecta* tolerated low oxygen levels below 3 mg/l in warm waters during summer. Actually, Külköylüoğlu [40] reported the species in almost anoxic (0.32 mg/l) spring water. Because of wide temperature ranges, the occurrence of *C. neglecta* was not affected by water temperature (2.2 - 27.91°C) fluctuations in a highly disturbed spring water and a mesotrophic reservoir enriched with continuous nutrient input in Bolu
The species revealed a strong negative correlation to water temperature with highest tolerance (tk = 3.8°C) and optimum estimates to dissolved oxygen (uk = 9.08mg/l) and pH (uk = 7.79) in helocrene spring [57]. Similar results were found in Spain [82] as water temperature (uk = 10.7°C, tk = 1.6°C), dissolved oxygen (uk = 8.8mg/l, tk = 2.3mg/l), and pH (uk = 7.42, tk = 0.36). Working in freshwater habitats of West-Pomerania in Germany, Viehberg [83] found *C. neglecta* with highest tolerance to water temperature (tk = 4.6°C) than the other 63 ostracod species. Most recently, Yavuzatmaca et al. [84] found this species in a cave of Turkey with the highest pH level (ca. 8.10) so far. Accordingly, its broad geographical distribution and wide levels of tolerances appears to be advantage for its progressive succession in a variety of habitats. Indeed, finding the species from continuous core samples of the Lateglacial lacustrine environment in the southern Baltic Sea (Germany) supported this idea [83]. Overall, like *H. incongruens*, results suggest that *C. neglecta* can be called cosmoecious species.

*Ilyocypris bradyi* (Sars, 1890)

The species is known from interstitial habitats [85], mesotrophic lake [41], eutrophic lakes [43, 86], springs [17, 71], peat bogs [87], ponds, swamps and slow flowing waters [50, 88]. However, it is believed that its distribution is not limited amid these types of habitats that the species can also occur in extreme habitats including troughs, ditches and cave water. For example, living individuals of *I. bradyi* were most recently found from Sarıkaya Cave (Turkey) in a cool (14.7°C), brackish (electrical conductivity 535μS/cm) and alkaline (pH 8.09) water [84]. *Ilyocypris bradyi* having with stygophilic characteristics can be encountered in habitats with a wide range of environmental variability [56, 64, 67]. As pointed by earlier studies [43, 50] that *I. bradyi* was most likely euryhaline and polythermophilic species with wide tolerance to salinity and temperature, but it was also reported from slightly saline alkaline inland waters [14]. In contrast, Mezquita et al. [82] -except pH and alkalinity- did not find wide tolerance ranges to measured environmental variables in Spanish waters. In Northwestern China, Li et al. [73] revealed that the species displayed wide tolerance ranges to salinity (0.32 – 13.98‰) and several other variables in Lake Qinghai. Most recently, studies showed that *I. bradyi* is of much wider tolerances to different environmental variables such as redox potential (147.41 – 296.24 mV) dissolved oxygen (0.48 – 13.46 mg/l), pH (6.1 – 8.5), electrical conductivity (272.9 – 864 μS/cm), water temperature (9-24.4°C) and air temperature (13.2–23.1°C) [23, 37, 46, 73, 89] from sea level up to
1415 m of elevation [71]. Hence, due to its wide tolerances to different environmental variables and broad geographical distribution [41], *I. bradyi* can be classified as cosmoecius species.

**Psychrodromus olivaceus** (Brady & Norman 1889)

Although its occurrence has been reported from springs and/or spring related ponds and pools with cool to moderate temperature [18, 90, 91], the species is known from variety of aquatic bodies [92, 85, 50] such as troughs [76]. Roca and Baltanás [53] found this species in cold (6.5-16.4°C) Pyrenean springs from low to high alkaline (0.3-4.9 meq/l) waters located at high altitudes (1380m). In Northern Apenninic springs (N. Italy), Bottazi et al. [93] found this species from a limited range of elevation between 919 and 1124m. Due to its preference for cold waters with low salinity and dissolved oxygen, it was called oligothermophilic species [40]. However, recent studies [20, 43, 57] suggested that *P. olivaceus* has much higher tolerance ranges to different variables (Table 2) including redox potential in rheocrene spring waters (146.6-232 mV) in Bolu, Turkey [46]. Indeed, optimum and tolerance levels of the species to water temperature showed similar ranges between Spanish (10.9 and 1.8°C) [82] and Turkish (10.97 and 3.8°C) [57] waters. Similarly, it exhibited wide ranges of tolerance and optimum levels to dissolved oxygen measured from variety of aquatic habitats of Turkey and Spain [82] as 0.36 and 9.1mg/l, respectively. This species was one of the most frequently occurring species in Turkish troughs where pH was about 11.4 [76]. Accordingly, results support that *P. olivaceus* can tolerate low levels of oxygen contents, pH, conductivity and temperature (Table 2); however, it tends to prefer cool freshwaters. Although geographical distribution of this species is not as wide as the other species mentioned here, the species can be called as “cosmoecius” due to its wide tolerance ranges and occurrences in a variety of habitats.

**Cypridopsis vidua** (O.F. Müller, 1776)

This is another cosmopolitan species [94] well known with its wide range of distribution and tolerances to variety of environmental factors (Table 2). *Cypridopsis vidua* has been reported from fresh to saline water aquatic environments [23, 53, 95]. In a man-made lake (Lake Aladağ, Bolu, Turkey), optimum values for pH (7.93) and temperature (18.30) of the species were the second highest among the other species [45]. In an extensive sampling from variety of waters in Bolu, Turkey, the species showed the highest optimum and tolerance values to pH (uk=9.29, tk=1.21), water temperature
(uk=28.33, tk=5.96) and altitude (uk=1378.23, tk=478.17) [48]. Meisch [50] categorized *C. vidua* as mesohalophilic, implying its medium levels of salinity tolerance, but recent studies [96] clearly showed that this species is widely distributed with high range of tolerances to salinity. For example, Ganning [97, 98] reported this species from waters with low (1ppt) to high (20ppt) salinity ranges. Meisch and his colleagues [65] reported this species from Canary islands (Futuna, Wallis, Hawaii) with relatively low electrical conductivity (37ms/cm) but Meisch and Broodbakker [60] were also able to find the species from the waters of other Canary and Cape Verde islands (Gomera, Hierro, La Palma, Fuerteventura) with very high values of conductivity (7.41 mS/cm). Working in the waters of Portugal, Martins et al. [99] underlined that *C. vidua* was able to tolerate low oxygenated waters (see Table 2). Overall, findings indicate that *C. vidua* carries all characteristics of a cosmoecious species.

**Discussion and conclusion**

We have about 130 nonmarine free-living freshwater ostracods in Turkey. Almost half (47%) of these species is belonged to one family, the Cyprididae followed by the families Candonidae (27%) and Ilyocyprididae (9%). Due to lack of studies, this number is believed to be underestimated. Among the species, some shows both extensive geographical distribution (cosmopolitan) and wide ranges of ecological tolerances (euryoecious) and higher optimum levels to different environmental variables than previously known. Thus, it is herein proposed to call such species as “cosmoecious species”. Application of using cosmoecious species are shown in ostracods but not limited to them. To support such idea, I looked at the lower and upper values of 15 different nonmarine ostracod species for the five major environmental variables (pH, DO, EC, temp., Alt.). Results showed that these 15 species have been reported alive from different aquatic bodies of the world where the ranges between lower and upper levels of ecological variables are much wider than previously known. In relation to cosmoecious species, detailes of another new term “pseudorichness” is also discussed for ostracods from 15 aquatic bodies. The concept of “pseudorichness” can be used for several different purposes by means of using the ratio between the numbers of noncosmopolitan to cosmopolitans, which is called pseudorichness ratio (PR). Accordingly, it is expected that when the ratio is smaller than one, such aquatic body is mostly dominated by cosmopolitans. This ratio is more than one in waters with the dominancy of noncosmopolitans. Therefore, water quality estimation can be done by using PR where waters with the lower ratio will have poor water quality. Although a good data is presented here, these
results are only dealt with ostracods and cannot be generalized at the moment. However, these preliminary results are promising. Future studies, I believe, will support these ideas.

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