

New data on the taxonomy and distribution of anostracan fauna from Turkey

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Until recently, current knowledge on the distribution of anostracan fauna in Turkey has been rather limited and mostly relied upon old records dating back to the 1970s. Field investigations initiated during the last few years have revealed the presence of at least five species new to science and have contributed new data on the distribution and status of anostracans in Turkey. Ten *Chirocephalus* species are currently listed for Turkey, belonging to the “diaphanus” and “bairdi” groups, respectively. Representatives of other genera include *Branchinecta ferox* Milne-Edwards, 1840 and *Branchinecta orientalis* Sars, 1901 (Branchinectidae), *Branchinella spinosa* Milne-Edwards, 1840 (Thamnocephalidae) and *Branchipus laevicornis* Daday, 1912 (Branchipodidae). Interestingly, the latter has been found to coexist with *Branchinecta orientalis*, a case never recorded previously. Some old references also list *Branchinectella media* Schmankeiwitsch, 1873, *Chirocephalus reiseri* Marcus, 1913, and *Streptocephalus auritus* Koch, 1841, but these data need to be verified.

Key words: Anostraca, taxonomy, distribution, Turkey.

INTRODUCTION

Although the very first anostracan species ever mentioned for Turkey was *Chirocephalus tauricus*, described by Pesta in 1921 from an unknown locality in Taurus Mountains, subsequent documentation on Anostraca in this country has been fragmentary in the past and mostly relied upon old records dating back to the 1970s (Cottarelli, 1971; Cottarelli & Mura, 1974). Between 1963 and 1970, the temporary waters of Asiatic Turkey were surveyed within the frame of a project of faunistic campaigns in the Near East promoted by the former Zoological Institute of La Sapienza University (Rome). Since then, no systematic investigations have been performed and consid-

erable gaps still exist, mainly due to lack of experts on Anostraca and possibly of adequate funding.

During the 1990s field investigations were promoted again in order to gather information about the presence of this crustacean order in Turkey (Balik & Ustaoglu, 1993; Uçal & Ergen, 1994; Başbuğ & Demirkalp, 1997; Beladjal & Mertens, 1997; Kazancı *et al.*, 1998; Başbuğ, 1999a, b).

Recently, the presence of at least five species new to science (Brtek & Cottarelli, 2006; Cottarelli *et al.*, 2007, 2010) has been documented for the Anatolian altiplano, thus enhancing knowledge on the distribution and species richness of Anostraca in Turkey (Mura *et al.*, 2005a; Ustaoglu *et al.*, 2005). The present contribution is part of a joint effort to fill the existing gaps while stressing the need for further investigating the biodiversity of Turkish temporary waters, often

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overlooked, and thus, particularly endangered, both as a result of human negligence and due to their inherent ephemeral nature.

MATERIALS AND METHODS

Distribution records were obtained both from literature and a number of surveys carried out between 1996 and 2005 along the Aegean Sea coastal region, in the Anatolian altiplano, and in the Munzur and Taurus Mountains. Samples were obtained by means of a plankton net (mesh size 150 µm) and subsequently preserved in 4% formic aldehyde (or 80% ethanol for SEM studies) pending identification in the laboratory. Sampling localities were determined with a global positioning system (Garmin GPS 12). Species identification was performed according to Daday (1910, 1913) and Brtek (1968, 1995, 2002).

RESULTS AND DISCUSSION

The updated distribution of anostracan fauna in Turkey is presented in Figure 1 and Table 1. Five anostracan genera are currently represented in Turkey: *Artemia* Leach, 1819, *Branchinecta* Verrill, 1869, *Branchinella* Sayce, 1903, *Branchipus* Schaeffer, 1766, and *Chirocephalus* Prévost, 1803. Four of these are typical representatives of fresh or brackish waterbodies while one (*Artemia*) is confined to hypersaline waters.

Artemia is a cosmopolitan anostracan occurring both in saltworks and saline lakes. Although in some instances the female specimens sampled have been ascribed to *A. salina* (Linnaeus, 1758), no males were ever found in any of the localities; therefore, all of the populations supposedly belong to parthenogenetic *Artemia*, with the exception of those in Burdur Acıgol and Tuz Lake (Gökçeada) which need further confirmation due to the presence of few females and many juvenile individuals. It is worth noting that in Gökçeada island, *Artemia* was found to coexist with *Branchinella spinosa* (see also Mura, 1993; Abatzopoulos et al., 1999), also occurring in Tuz Lake (Niğde) (Cottarelli & Mura, 1974) and later disappeared due to severe drought in the past few years (Başbuğ, personal communication).

Representatives of *Branchinecta* include *B. ferox* (Milne-Edwards, 1840) and *B. orientalis* (Sars, 1901). The former is a south Palearctic and circum-Mediterranean taxon inhabiting temporary waters, rich in mineral salts in steppes and steppe-like regions. In the European part of its range, where it has an extre-

mely restricted distribution, it is often found to coexist with *Chirocephalus diaphanus* (Prévost, 1803) and *C. carnuntanus* Brauer, 1877 (Petkowski, 1991; Petrov & Cvetović, 1997). The record for Turkey, dating back to the 1970s, is the first from an elevation of more than 1000 m a.s.l.

Branchinecta orientalis, a Palearctic species, appears as a Mongolian steppic element widely distributed in highly mineralized or saline waters of Asia Minor and Central Asia, where it usually occurs at high elevations (Brtek & Thiéry, 1995). Its re-description by Petkowski (1991) confirmed the distinctive features shared with its congener *B. ferox*, first reported by Brtek (1959, 1962). In the European part of its range, it occurs, though it is quite rare, in former Yugoslavia (Petrov & Cvetović, 1997). There are no records of coexistence with other anostracan species, with the exception of Iran, where it has been found to coexist with *Branchinella spinosa* (Mura & Azari Takami, 2000). The present record, associated with *Branchipus laevicornis*, from the Anatolian altiplano requires further study due to a separation in time of the two species.

Branchinella spinosa (Milne-Edwards, 1840), a typical circum-Mediterranean halophilic species, is the second record for Turkey and probably the only one, due to the extinction of the former population from Tuz Lake (Niğde) (Başbuğ, personal communication). This genus has been recently revised by Rogers (2003) and defined using modern standards. Accordingly, this species formerly considered as *Branchinella*, should now be ascribed to *Phallocryptus* Biraben, 1951.

Branchipus laevicornis Daday, 1913 seems to be endemic to the Anatolian plateau. Due to the distance of the three sampling points from each other, this species may have a much wider distribution in Turkey than that currently known. This species was never recorded together with *Branchinecta orientalis* in Alpu pools. Four years later, this coexistence was verified in the laboratory by hatching of cysts which had been isolated from mud collected from these pools. This interesting case of coexistence should be further investigated.

Ten species are currently listed for the genus *Chirocephalus*: *C. algidus* and *C. brteki* (Cottarelli et al., 2010), *C. anatolicus* and *C. cupreus* (Cottarelli, et al., 2007), *C. diaphanus carinatus* Daday, 1910, *C. murae* (Brtek & Cottarelli, 2006), *C. paphlagonicus* Cottarelli, 1971, *C. ponticus* (Beladjal & Mertens, 1997), *C. tauricus* Pesta, 1921, *C. vornatscheri* Brtek, 1968. All

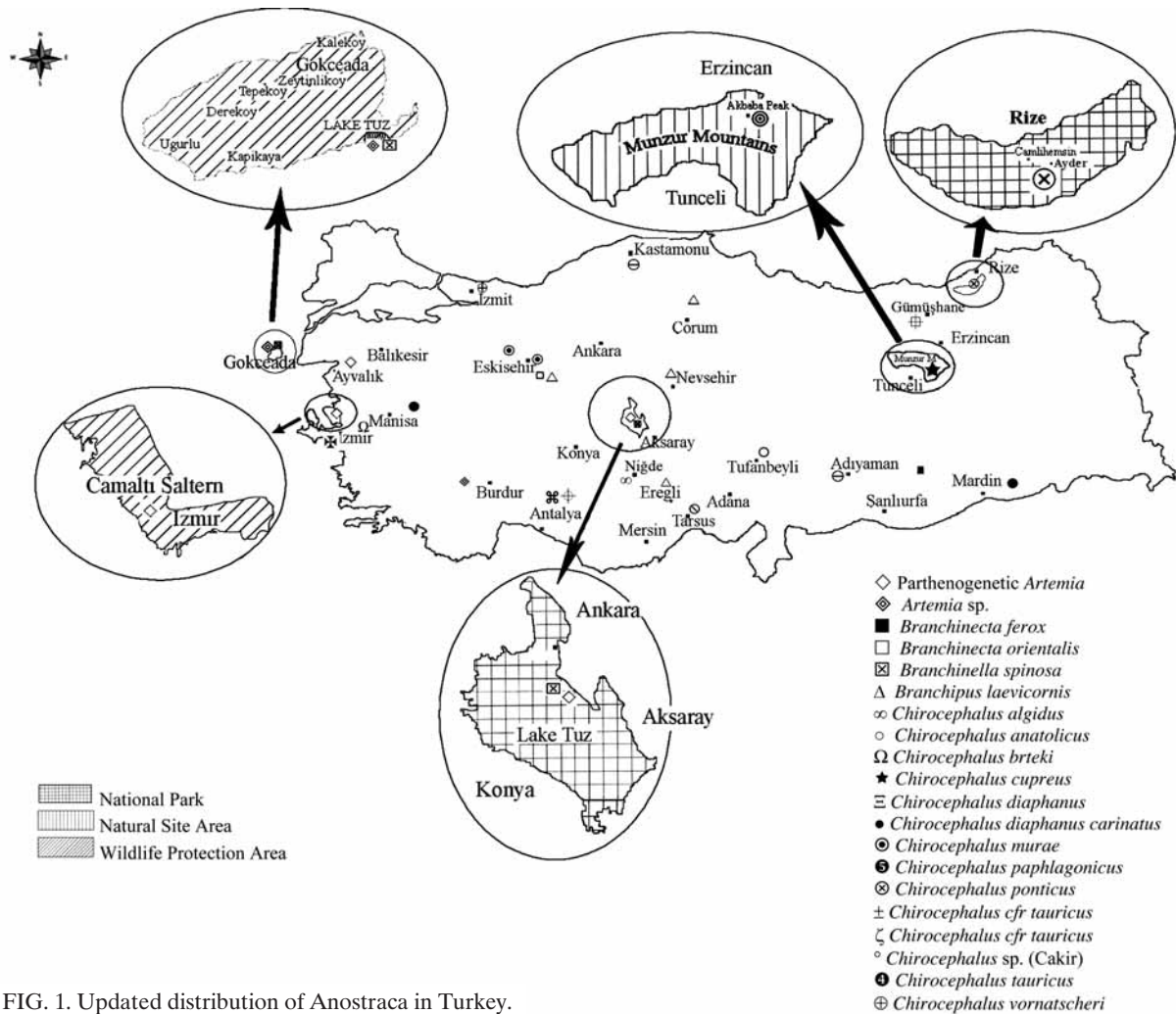


FIG. 1. Updated distribution of Anostraca in Turkey.

but *C. diaphanus carinatus*, typical of the Balkan Peninsula, are endemic to Turkey, mostly known, thus far, only from the type locality.

Based on the morphology of the male antenna and of other previously described characters, four of the above species (*C. anatolicus*, *C. brteki*, *C. murae*, and *C. vornatscheri*) have been included in the “bairdi” species group (comprising eight species and one subspecies) established by Brtek (1995) using conventional comparative morphological analysis. The remaining ones belong to the “diaphanus” group of species, including the largest number (19 + 2 subspecies) of taxa known in the genus. As to the *Chirocephalus* sp. listed in Table 1, the species is still undetermined due to the need of additional material.

The few females available from Duruca and Susam lakes (Taurus Mountains) resemble the females of *C. tauricus*, as recently re-described (Cottarelli et al., 2010); due to the unavailability of males, we could

not ascribe unambiguously these individuals to *C. tauricus*. Future samplings should confirm the above assumption, thus providing more information about the distribution of this taxon, since no data exist about *locus typicus* (see Pesta, 1921). A number of old references also list *Branchinectella media* Schmanke-witsch, 1873, *Chirocephalus reiseri* Marcus, 1913, and *Streptocephalus auritus* Koch, 1841, (Fiers, 1978), but these data need confirmation.

CONCLUSIONS

As it can be noted from the distribution map (see Fig. 1), a large part of Turkey still remains unexplored. While extending the scarce data existing for the anostracan fauna, the present study stresses the need for extensive and systematic exploration of the territory in order to update the information available for this branchiopod order and, more importantly, to confirm

TABLE 1. Updated information on *Anostraca* from Turkey

Species name	Locality	Geographical coordinates	Altitude (m a.s.l.)	Pool characteristics	Pool size	References
Parthenogenetic <i>Artemia</i>	Izmir Çamaltı	38° 39' N-26° 53' E	sea level	salterns	—	Uçal & Ergen (1994), Koru & Diraman (2003), Başbuğ (2004), Koru (2004)
	Balıkesir Ayvalık	39° 15' N-26° 42' E	sea level	salterns	—	Uçal & Ergen (1994)
	Tuz Golu (Lake Tuz)	38° 45' N-33° 22' E	899	salt lake	1600 km ²	Cottarelli & Mura (1974), Başbuğ & Demirkalp (1997), Başbuğ (1999a, b)
<i>Artemia</i> sp.	Burdur Acigöl	37° 49' N-29° 53' E	837	brackish lake (sodium sulphate)	100 km ²	Kazancı et al. (1998)
	Gökçeada (İmbroz) Island Lake Tuz	40° 07' N-25° 57' E	sea level	lagoon	1.5 km ²	Balik & Ustaoglu (1993)
<i>Branchinecta ferox</i>	Karabahçe (Urfa)	37° 47' N-39° 47' E	1200	temporary pool	150 m ²	Cottarelli & Mura (1974)
<i>Branchinecta orientalis</i>	Alpu (Eskisehir)	39° 46' N-30° 57' E	790	temporary pools	150 m ²	Present study
<i>Branchinella spinosa</i>	Gökçeada (İmbroz) Island Lake Tuz	40° 07' N-25° 57' E	sea level	lagoon	1.5 km ²	Present study
	Tuz Golu (Lake Tuz)	38° 45' N-33° 22' E	899	salt lake	1600 km ²	Cottarelli & Mura (1974)
<i>Branchipus laevis</i>	Mecitözü (Çorum)	40° 32' N-35° 08' E	680	prairie pool	—	Cottarelli & Mura (1974)
	Acigöl (Nevsehir)	38° 36' N-34° 31' E	1240	pool	1.6 km ²	Cottarelli & Mura (1974)
	Alpu (Eskisehir)	39° 46' N-30° 57' E	790	temporary pools	150 m ²	Present study
	Eregli (Konya)	37° 31' N-34° 03' E	1054	—	—	Daday (1913)
<i>Chirocephalus algidus</i>	Lake Alagöl (Ulukışla, Niğde)	37° 23' N-34° 30' E	2903	temporary pool	200 m ²	Cottarelli et al. (2010)
<i>Chirocephalus anatolicus</i>	Tufanbeyli (Adana)	28° 15' N-36° 14' E	—	—	—	Cottarelli et al. (2007)
<i>Chirocephalus brteki</i>	Lake Alan (Menemen, İzmir)	38° 41' N-27° 10' E	600	shallow lake (max. depth 1.5 m)	5 km ²	Cottarelli et al. (2010)
<i>Chirocephalus cupreus</i>	Munzur Mountains Akbaba peak (Erzincan)	39° 33' N-39° 28' E	2650	temporary pools	3 m ²	Cottarelli et al. (2007)
<i>Chirocephalus diaphanus</i>	Bornova (İzmir)	38° 28' N-27° 15' E	90	temporary pools	—	Present study

TABLE 1. continued

Species name	Locality	Geographical coordinates	Altitude (m a.s.l.)	Pool characteristics	Pool size	References
<i>Chirocephalus diaphanus carinatus</i>	Kula (Manisa) Eskisehir-Bursa road	38°34'N-28°44'E 39°49'N-30°24'E	780 825	temporary pool temporary pool	75 m ² 100 m ²	Cottarelli & Mura (1974) Brtek & Cottarelli (2006)
<i>Chirocephalus murae</i>	Eskisehir-Sakarilica road	39°56'N-30°35'E	1100	temporary pool	200 m ²	Brtek & Cottarelli (2006)
<i>Chirocephalus paphlagonicus</i>	Kastamonu Kızilin (Adiyaman)	41°19'N-33°34'E 37°33'N-38°04'E	1000 —	temporary pool —	195 m ² —	Cottarelli (1971) Beladjal & Mertens (1997)
<i>Chirocephalus ponticus</i>	Bilici Gölü Ayder (Rize)	40°51'N-41°09'E	3100	glacier lake	12 km ²	Beladjal & Mertens (1997)
<i>Chirocephalus</i> cfr. <i>tauricus</i>	Duruca lake (Gundogmus, Antalya)	36°57'N-32°07'E	1950	lake	1 km ²	Ustaoglu et al. (2005)
<i>Chirocephalus</i> sp.	Cakir Lake (Karahava, Gumushane)	40°34'N-39°41'E	2570	lake (max. depth 10 m)	—	Present study
<i>Chirocephalus</i> cfr. <i>tauricus</i>	Susam Lake (Gundogmus, Antalya)	36°56'N-32°08'E	1990	lake (max. depth 1.9 m)	—	Present study
<i>Chirocephalus tauricus</i>	Toros Daglari (Taurus Mountains)	—	—	—	—	Pesta (1921)
<i>Chirocephalus vornatscheri</i>	Izmit	40°46'N-29°56'E	25	—	—	Brtek (1968)

the persistence of previously recorded species. Many of those, in fact, may have been eliminated by human activities, as has been reported for many other parts of the world (see review in Mura, 1999).

The high biodiversity thus far recorded for Turkey and the fact that only a few of the biotopes hosting fairy shrimps are located in protected areas (Fig. 1), underline the need for a better understanding of the value of temporary habitats, often overlooked and particularly endangered, both as a result of human negligence and due to their inherent ephemeral nature. They also stress the importance of a proper conservation policy in order to avoid elimination of rare and/or insufficiently known species, not only by human action but also by invasive allochthonous species. As an example, it must be mentioned the danger represented by the New World brine shrimp species, *Artemia franciscana* presently occupying several biotopes in the Western Mediterranean area where it successfully eliminated many of the local *A. salina* populations (Amat et al., 2005). It is worth noting that scientists often misuse the binomina *A. salina*, *A. urmiana*, *A. sinica*, and *A. tibetiana*, as well as parthenogenetic forms, thus far grouped “controversially and not very logically” under the binomen *A. parthenogenetica* (Abatzopoulos et al., 2002). As to Turkey, in particular, few of the past studies have considered the taxonomical status of the species and the mode of reproduction. The recorded taxa have often been generically ascribed to *A. salina*, without any further investigation (see for example Başbuğ & Demirkalp, 1997; Başbuğ, 1999a, b), or in some instances considered as parthenogens due to unbalanced sex ratio recorded in the field.

The above considerations stress the need for filling the distribution gap and they also support the importance of careful multidisciplinary studies (morphological, morphometric, and molecular) to solve taxonomical problems (see for example Mura & Brecciaroli, 2004; Mura et al., 2005b).

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