

Contribution to the Knowledge on the Distribution of Malacostraca (Crustacea) Species of Central and Southern Anatolia, with Some Ecological Notes

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Abstract: In order to contribute to the knowledge on the distribution of Malacostraca (Crustacea) species inhabiting freshwaters of central and southern parts of Anatolia, Turkey, sampling was performed at 69 stations between 29 May and 4 June 2006 and between 19 and 25 June 2006. Malacostraca specimens were found at 26 out of the 69 stations and were represented by 11 taxa (*Gammarus agrarius*, *Gammarus argaeus*, *Gammarus anatoliensis*, *Gammarus balcanicus*, *Gammarus mladeni*, *Gammarus pseudosyriacus*, *Echinogammarus antalyae*, *Asellus aquaticus*, *Palaemonetes antennarius*, *Atyaepyra desmaresti orientalis*, and *Astacus leptodactylus*). The zoogeographical distribution and ecology of the determined taxa are presented herein.

Key Words: Freshwater, Amphipoda, Decapoda, Isopoda, distribution, Turkey

Orta ve Güney Anadolu'nun Malacostraca (Crustacea) Türlerinin Dağılımlarına Bazı Ekolojik Notlar ile Katkılar

Özet: Türkiye içsularında dağılım gösteren Malacostraca (Crustacea) türlerinin dağılımları hakkındaki bilgilere katkı sağlamak amacıyla, 29 Mayıs- 04 Haziran 2006 ile 19-25 Haziran 2006 tarihleri arasında toplam 69 lokaliteden örnekleme yapılmıştır. Örnekleme yapılan istasyonların 26'sında Malacostraca bireylerine rastlanmış olup, toplam 11 takson (*Gammarus agrarius*, *Gammarus argaeus*, *Gammarus anatoliensis*, *Gammarus balcanicus*, *Gammarus mladeni*, *Gammarus pseudosyriacus*, *Echinogammarus antalyae*, *Asellus aquaticus*, *Palaemonetes antennarius*, *Atyaepyra desmaresti orientalis*, *Astacus leptodactylus*) tespit edilmiştir. Örneklenen türlerin zoocoğrafik dağılımları ve ekolojileri hakkında bilgiler verilmiştir.

Anahtar Sözcükler: Tatlısu, Amphipoda, Decapoda, Isopoda, dağılım, Türkiye

Introduction

The subclass Malacostraca, a huge group having many economically important marine and freshwater species, is represented by more than 20,000 species worldwide (Özbek and Ustaoglu, 2006).

The pioneering study (Heller, 1863) about freshwater Malacostraca species in Turkey was on the record of a freshwater crab species, *Potamon fluviatilis* Herbst 1785,

from İstanbul. It was followed by the study by Vavra (1905), which was on the description of a new Amphipod species, *Gammarus argaeus*, from Mount Erciyes. The first study by a native scientist (Geldiay, 1949) mentioned the existence of *Potamobius leptodactylus* Escholtz, 1823 in Çubuk Dam Lake. Later, there was a rapid increase in the number of studies by both foreign and native scientists concerning the distribution of freshwater Malacostraca species in Turkey.

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According to an updated check-list on freshwater Malacostraca species in Turkey, 129 taxa belonging to 37 genera have been reported so far. The latest study on this subject has just been reported by Özbek and Ustaoglu (2007), on the description of a new freshwater Amphipod, *Echinogammarus baliki*.

The aim of the present study was to contribute to the knowledge on the distribution and ecology of freshwater Malacostraca species in Turkey. Thus, a relatively high number of aquatic habitats located in a wide area of central and southern parts of Anatolia were studied.

Materials and Methods

In order to contribute to the knowledge on the distribution of Malacostraca species inhabiting inland waters of central and southern parts of Anatolia, Turkey, sampling was performed on 69 occasions during 2 periods: 29 May to 4 June 2006 and 19 to 25 June 2006 (Figure 1). A hand net having 0.5 mm mesh size was used to sample the benthic material. Benthos samples were fixed in 4% formalin solution in the field and then sorted in the laboratory using a stereo-microscope and deposited

in 70% ethyl alcohol. During the field study, some physical and chemical characteristics (temperature, salinity, pH, dissolved oxygen, and conductivity) of the sampling localities were also measured using a YSI 30 modal SCT-meter, a WTW pH 330 modal pH-meter, and a WTW Oxi 330 modal oxygen-meter. Altitudes and geographical positions of the sampling localities were also noted.

Birstein (1951), Holthius (1961), Karaman and Pinkster (1977a, 1977b, 1987), Mateus and Mateus (1990), and Kocataş et al. (1991) were followed for the taxonomic identification.

Results

As a result of the field sampling, Malacostraca specimens were found at 26 out of the 69 localities, which included lakes, rivers, streams, and creeks in central and southern Anatolia, Turkey. In some of the localities water temperatures are above 30 °C, while in others they are below 10 °C. Similarly, dissolved oxygen, pH, and salinity values vary greatly among the localities (Table 1).

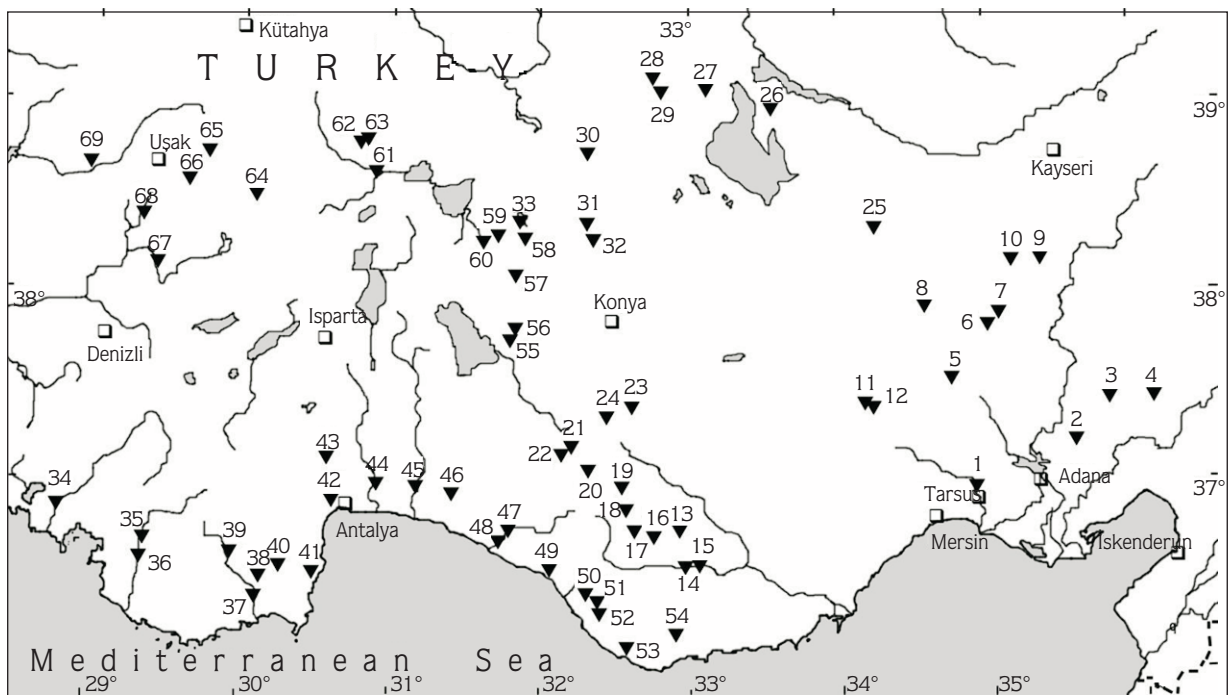


Figure 1. Geographic positions of sampling localities (for the names of the localities see Table 1).

Table 1. Numbers, names, geographic positions and some measured physico-chemical features of sampling localities (Temp.: water temperature, D.O.: dissolved oxygen, O.S.: oxygen saturation, Cond.: conductivity, S.: salinity).

Sta. no.	Locality	Geographic Position	Temp. (°C)	D.O. (mg/l)	O.S. (%)	pH	Cond. ($\mu\text{S}_{25\text{ }^\circ\text{C}}$)	S. (‰)
1	Berdan Creek	36°56'59"N 34°53'38"E	16.8	6.8	71	7.8	250	0.1
2	Handere Stream	37°11'07"N 35°33'44"E	---	---	---	---	---	---
3	Deliçay Creek	37°24'46"N 35°47'02"E	31.3	5.9	84	8.2	431	0.2
4	Savrun Creek	37°23'18"N 36°04'49"E	29.4	6.2	79	8.2	366	0.2
5	Göksu River	37°46'57"N 35°54'31"E	22.5	6.1	71	8.4	395	0.2
6	Asmaca Stream	37°49'21"N 35°53'51"E	21.0	5.8	70	8.5	429	0.2
7	Bağdere Stream	37°50'47"N 35°46'00"E	17.6	5.8	70	8.2	292	0.1
8	Sultan Sazlığı	38°14'04"N 35°13'48"E	19.0	2.5	27	7.6	816	0.4
9	Ağcaşar Stream	38°07'18"N 35°21'54"E	12.7	7.4	77	8.1	295	0.1
10	Deliçay Creek	38°08'00"N 35°09'43"E	13.0	7.0	78	8.3	307	0.1
11	Halkapınar Stream	37°25'46"N 34°11'37"E	19.7	5.5	72	8.5	320	0.2
12	İvriz Creek	37°25'08"N 34°10'29"E	10.0	7.1	67	8.2	217	0.1
13	Balkusan Stream	36°43'08"N 32°55'54"E	12.0	7.1	78	8.1	301	0.1
14	Yaylapazarı Creek	36°33'15"N 32°56'50"E	16.0	7.4	74	8.2	423	0.2
15	Ermenek Creek	36°33'07"N 32°57'25"E	---	---	---	---	---	---
16	Küçükçay Creek	36°41'51"N 32°45'49"E	18.0	6.7	79	8.0	409	0.2
17	Kervansaray Stream	36°43'48"N 32°37'58"E	---	---	---	---	---	---
18	Kızılkırtık Stream	36°50'20"N 32°34'51"E	26.0	5.3	79	8.2	316	0.2
19	Balcılar Creek	36°57'03"N 32°32'10"E	20.7	5.7	71	8.3	330	0.2
20	Gökdere Stream	37°02'04"N 32°19'56"E	13.2	6.3	70	8.3	248	0.1
21	Çarşamba Stream	37°10'28"N 32°12'48"E	11.0	6.3	67	8.3	267	0.2
22	Çarşamba Stream	37°08'01"N 32°08'30"E	---	---	---	---	---	---
23	Çarşamba Stream	37°23'08"N 32°36'12"E	---	---	---	---	---	---

Table 1. Continued.

Sta. no.	Locality	Geographic Position	Temp. (°C)	D.O. (mg/l)	O.S. (%)	pH	Cond. ($\mu\text{S}_{25\text{ }^\circ\text{C}}$)	S. (‰)
24	Çarşamba Stream	37°19'55"N 32°26'34"E	22.0	6.9	90	8.6	380	0.2
25	Melendiz Creek	38°19'36"N 34°14'26"E	27.0	6.1	88	8.4	710	0.3
26	Ağaçören Stream	38°57'11"N 33°33'10"E	22.5	4.0	56	8.1	1259	0.6
27	Kulu Lake (=Düden L.)	39°03'41"N 33°07'53"E	22.0	5.8	70	9.8	26200	16.1
28	Samsam Stream	39°07'08"N 32°45'33"E	18.0	4.8	54	8.3	507	0.2
29	Kozanlı Stream	39°02'14"N 32°48'37"E	18.2	5.1	60	8.4	562	0.3
30	Çayözü Stream	---	26.0	5.1	70	8.1	404	0.2
31	Kökez Stream	38°21'32"N 32°18'54"E	22.0	6.2	80	8.1	401	0.2
32	Beşgöz Fountain	38°16'42"N 32°21'03"E	27.0	5.1	71	8.8	377	0.2
33	Çavuşçu Lake	38°21'21"N 31°51'19"E	23.3	9.0	107	8.0	540	0.3
34	Dalaman Creek	36°49'58"N 28°47'53"E	26.2	9.6	121	7.9	448	0.2
35	Eşen Creek	36°39'00"N 29°21'44"E	25.0	9.0	102	7.7	480	0.2
36	Eşen Creek	36°33'32"N 29°21'02"E	15.3	6.3	63	7.5	466	0.2
37	Karaçay Creek	36°20'52"N 30°07'44"E	15.6	8.5	86	8.1	294	0.1
38	Akçay Creek	36°28'42"N 30°06'08"E	25.4	5.9	84	8.2	301	0.1
39	Avlan Lake	36°34'15"N 29°57'02"E	25.6	7.3	89	8.4	288	0.1
40	Alakır Creek	36°31'17"N 30°16'05"E	19.2	8.5	90	8.1	322	0.2
41	Bağirsak Creek	36°30'51"N 30°29'59"E	23.0	7.4	88	8.0	628	0.3
42	Göksu Creek	36°51'51"N 30°37'05"E	15.8	6.6	66	7.2	764	0.4
43	Kırkgöz Springs	37°06'34"N 30°34'49"E	24.2	7.5	90	8.0	418	0.2
44	Aksu Creek	36°57'52"N 30°54'11"E	18.1	9.5	101	8.4	412	0.2
45	Köprü Creek	36°57'13"N 31°10'29"E	29.8	6.5	88	8.4	422	0.2
46	Kargı Creek	36°55'11"N 31°24'23"E	22.0	6.9	90	8.6	380	0.2

Table 1. Continued.

Sta. no.	Locality	Geographic Position	Temp. (°C)	D.O. (mg/l)	O.S. (%)	pH	Cond. ($\mu\text{S}_{25\text{ }^\circ\text{C}}$)	S. (‰)
47	Kapuz Creek	36°46'41"N 31°44'50"E	---	---	---	---	---	---
48	Alaraçay Creek	36°41'29"N 31°43'02"E	18.7	8.4	91	8.6	273	0.1
49	Dimçayı Creek	36°31'34"N 32°03'32"E	20.6	7.9	84	8.2	586	0.3
50	Delice Stream	36°23'02"N 32°18'32"E	19.6	6.0	67	8.4	532	0.3
51	Bıçkıcı Stream	36°21'32"N 32°22'36"E	19.8	7.6	83	8.6	362	0.2
52	Çörüş Stream	36°17'15"N 32°22'26"E	2.4	7.5	90	8.5	385	0.2
53	Kaladron Stream	36°06'37"N 32°34'21"E	23.7	8.8	104	8.6	546	0.3
54	Anamur Creek	36°10'19"N 32°53'48"E	17.4	8.4	93	8.1	234	0.1
55	Sarıöz Stream	37°45'01"N 31°46'32"E	17.9	5.9	78	7.8	858	0.4
56	Sarıöz Stream	37°47'46"N 31°48'02"E	17.5	6.3	75	7.6	867	0.4
57	Demirlik Stream	38°04'11"N 31°49'51"E	15.1	10.2	118	8.0	572	0.3
58	Battal Stream	38°16'08"N 31°53'50"E	21.5	10.0	130	8.0	529	0.3
59	Cebişli Creek	38°17'03"N 31°42'07"E	20.9	14.6	188	8.2	627	0.3
60	Adıyan Creek	38°15'23"N 31°36'44"E	17.8	6.4	74	7.6	608	0.3
61	Kalıçay Creek	38°36'04"N 30°53'37"E	22.5	5.0	66	7.6	689	0.3
62	Avşar Stream	38°50'02"N 30°46'27"E	24.2	7.2	94	7.9	696	0.3
63	Akarçay Creek	38°46'40"N 30°46'50"E	20.7	4.9	61	7.7	407	0.2
64	Saltık Stream	38°29'05"N 30°04'26"E	20.4	4.4	54	7.8	408	0.2
65	Banaz Creek	38°42'33"N 29°45'01"E	17.9	10.5	122	8.1	1010	0.5
66	Banaz Creek	38°32'56"N 29°37'15"E	20.3	7.0	86	8.1	986	0.5
67	Büyük Menderes River	38°06'03"N 29°25'21"E	19.1	6.7	79	7.8	618	0.3
68	Banaz Creek	38°22'03"N 29°19'36"E	21.0	7.4	88	7.1	779	0.4
69	Gediz River	38°37'58"N 28°57'05"E	27.6	10.9	138	8.5	1112	0.5

---: could not be measured.

The sampling localities were at quite a wide variety of altitudes. Some of them were at higher than 1000 m (a.s.l.), while some others were almost at sea level.

At the end of the study, 11 taxa were determined. Of these, 3 belong to Decapoda, 7 to Amphipoda, and 1 to Isopoda (Table 2). The localities where Malacostraca species were found are listed for each species in Table 2 separately. *G. anatoliensis* was the most frequently observed species, found at 11 localities. *A. desmarestii orientalis*, *G. mladeni*, and *G. pseudosyriacus* were found only at a single station. *A. leptodactylus salinus* was found also at a single station because sampling method was not suitable for it. We mainly sampled the Malacostraca specimens from shallow parts of the aquatic habitats. In fact, crayfish specimens have been introduced into lakes, ponds, and reservoirs because of their economic importance.

Discussion and Conclusion

Determination of the ecological requirements of Malacostraca species inhabiting inland waters in Turkey is of great importance because there is almost no information about them, especially on the endemic ones and species having limited distributional area. The sampling stations were quite varied in terms of their geographical positions and ecological aspects. A similarity dendrogram (UPGMA) was constituted mainly based on

the measurements of some physico-chemical characteristics of the localities studied in field work (Figure 2). As a result, station 27 constitutes an outer group different from 2 more similar groups. Stations 5 and 6 were the most similar ones, located at different points of the same river (Göksu River).

The literature contains very few studies on the distribution and ecology of *E. antalyae*, an Amphipod species endemic in Turkey. The species was firstly described from Kirkgöz Springs, Antalya, by Karaman (1971), as a subspecies of *Echinogammarus thoni* (Schäferna, 1922). Only 2 records have mentioned the distribution of this species; the first one is a descriptive paper (Karaman, 1971) and the other (Özbek et al., 2003) is a record mentioning the existence of *E. antalyae* in Yuvarlakçay Stream, Muğla. In the present study, *E. antalyae* was found at 3 localities in the study area. Among the localities where *E. antalyae* was found, one is its type locality (Kirkgöz Springs), while the others are given as new records for the distributional area of this species (Table 2).

A comparison made between the physico-chemical values measured in the present study and those of Yuvarlakçay Stream reported by Özbek et al. (2003) shows some similarities. It appears that *E. antalyae* prefers such habitats where salinity values are relatively high (0.1-0.3 ppt) and located not far from the sea and at low altitudes (Tables 3 and 4).

Table 2. Taxonomic positions and distributions of determined taxa.

Order	Family	Taxa	Stations
Decapoda	Palaemonidae	<i>Palaemonetes antennarius</i> (Milne Edwards, 1837)	42, 43, 44
	Atyidae	<i>Atyaepyra desmarestii orientalis</i> Bouvier, 1913	43
	Astacidae	<i>Astacus leptodactylus salinus</i> Nordmann, 1842	32
Isopoda	Asellidae	<i>Asellus aquaticus</i> (L., 1758)	8, 23, 43, 61
Amphipoda	Gammaridae	<i>Echinogammarus antalyae</i> G. S. Karaman, 1971	37, 43, 49
		<i>Gammarus agrarius</i> G. S. Karaman, 1973	43, 45
		<i>G. argaeus</i> Vavra, 1905	8
		<i>G. anatoliensis</i> Schellenberg, 1937	18, 21, 22, 33, 55, 56, 57, 58, 59, 61, 62
		<i>G. balcanicus</i> Schäferna, 1923	12, 13, 17, 36, 42, 54
		<i>G. mladeni</i> G.S. Karaman & Pinkster, 1977	25
		<i>G. pseudosyriacus</i> G.S. Karaman & Pinkster, 1977	18

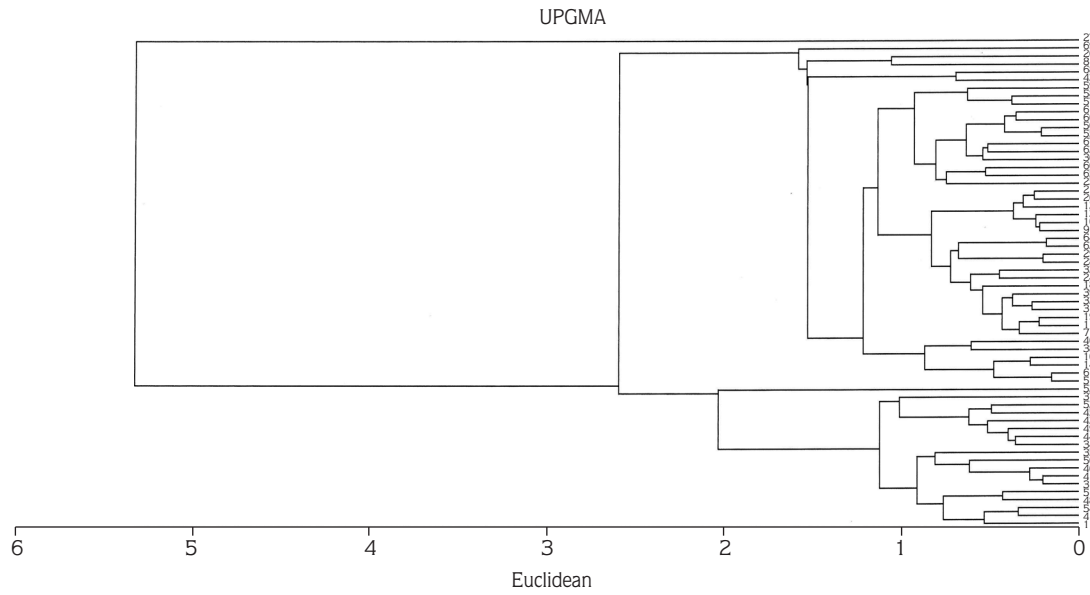


Figure 2. A dendrogram showing the similarity of the localities based on the measured physico-chemical features during the field studies (logarithmic transformation was applied to all of the measured parameters, except pH values).

Table 3. Min. and max. values of some measured physical and chemical parameters of the localities where malacostraca species were found (for abbreviations see Table 1).

TAXA	Temp. (°C)	D.O. (mg/l)	O. Sat. (%)	pH ($\mu\text{S}_{25\text{ }^\circ\text{C}}$)	Cond. (‰)	S
<i>P. antennarius</i>	15.8-24.2	6.6-9.5	66-101	7.2-8.4	412-764	0.2-0.4
<i>A. desmaresti orientalis</i>	24.2	7.5	90	8.0	418	0.2
<i>A. leptodactylus</i>	27.0	5.1	71	8.8	377	0.2
<i>A. aquaticus</i>	19.0-24.2	2.5-7.5	27-90	7.6-8.0	418-816	0.2-0.4
<i>E. antalyae</i>	15.6-24.2	7.5-8.5	84-90	8.0-8.2	294-586	0.1-0.3
<i>G. agrarius</i>	24.2-29.8	6.5-7.5	88-90	8.0-8.4	418-422	0.2
<i>G. argaeus</i>	19.0	2.5	27	7.6	816	0.4
<i>G. anatoliensis</i>	11.0-26.0	5.0-10.2	66-130	7.6-8.3	316-867	0.2-0.4
<i>G. balcanicus</i>	10.0-17.4	6.3-8.4	63-93	7.2-8.2	217-764	0.1-0.4
<i>G. mladeni</i>	27.0	6.1	88	8.4	710	0.3
<i>G. pseudosyriacus</i>	26.0	5.3	79	8.2	316	0.2

Another Amphipod species endemic for Turkey is *G. anatoliensis* and it was found in fountains and creeks located at high altitudes, above 900 m, in this study (Table 4). Some records have also mentioned the existence of this species at altitudes higher than 1500 m (Karaman and Pinkster, 1987). A characteristic feature of *G. anatoliensis* is the variations in dorsal elevations of

metasomal segments between populations. Similarly, the specimens sampled from Sarıöz Stream (station 56) have well developed dorsal elevations very similar to those of the species belonging to the *Gammarus roeseli*-group. The number of distribution localities of *G. anatoliensis*, which can be regarded as a typical species for the Lake District area of Turkey, is increased in this study.

Table 4. Vertical distribution (a.s.l.) patterns of determined taxa (*A. leptodactylus* is omitted).

TAXA	0 m	50 m	100 m	200 m	300 m	400 m	500 m	600 m	700 m	800 m	900 m	1000 m	1100 m	1200 m	1300 m	1400 m	1500 m	1600 m	1700 m	1800 m	1900 m	2000 m	
<i>P. antennarius</i>																							
<i>A. desmaresti orientalis</i>																							
<i>A. aquaticus</i>																							
<i>E. antalyae</i>																							
<i>G. agrarius</i>																							
<i>G. argaeus</i>																							
<i>G. anatoliensis</i>																							
<i>G. balcanicus</i>																							
<i>G. mladeni</i>																							
<i>G. pseudosyriacus</i>																							

Ecologically, *G. balcanicus* is one of the best known Amphipod species, but, because of the high variability observed between populations, the species is frequently confused with other species or reported as a new species. As a result, there are many synonyms given in the literature (Karaman and Pinkster, 1987). The male specimens collected at station 6 have fewer setae in their fourth pereopods than in the original description and this feature was regarded as population variability. *G. balcanicus* has a relatively wide distribution area covering some parts of Asia and Europe and this can be explained by its eurobiont character (Karaman and Pinkster, 1987). This species was found at 6 localities in this study and distances between the localities were very great (Figure 1).

G. argaeus, *G. mladeni*, and *G. pseudosyriacus* were found only at a single locality each (Table 2). *G. argaeus* and *G. mladeni* were sampled at altitudes around 1000 m, while *G. pseudosyriacus* was sampled near 1500 m a.s.l. (Table 4). *G. argaeus* was found at locality 8, where electrolyte concentrations were relatively high (Tables 2 and 3). Karaman and Pinkster (1977b) concluded that this species mostly prefers waters having rich calcium ions. Another strange point that must be taken into consideration was the dissolved oxygen value of the locality where *G. argaeus* was found in this study. The measured value of the dissolved oxygen was very low (2.5 mg/l), which can be fatal for most other freshwater Gammarid species. We know that freshwater Amphipod

species generally prefer well saturated waters, especially those belonging to the *G. balcanicus*-group.

G. pseudosyriacus, a member of the *G. pulex*-group, was usually found in more or less desert-like areas where the water temperatures can reach 34 °C (Karaman and Pinkster, 1977a). The altitude of the locality where this species was found in the present study was relatively high. On the other hand, the station is located on the edge of a Konya village, which has a semi-desert character. To date, *G. pseudosyriacus* has been reported from İzmir, Muş, Artvin, Elazığ, and Van provinces, Hazar Lake and Karamık Marsh in addition to Syria, Israel, and Afghanistan (Karaman and Pinkster, 1977a; Özbek and Ustaoglu, 2005). There are no records on the existence of *G. pseudosyriacus* in Kızılkırtık Stream.

The type locality of *G. mladeni*, another endemic Amphipod species for Turkey, is Konya. The species was also reported from Niğde, Kırşehir, Aksaray, Cihanbeyli, and Hatay, but there are no data about the ecology of this species in the records (Karaman and Pinkster, 1977b; Özbek and Ustaoglu, 2005). This species was found at station 25, with an almost 1000 m altitude, and relatively high water temperature and pH values (Tables 2 and 4). There are no records mentioning the existence of this species at this locality.

The Palaemonid and Atyiid decapods found in this study are those species that are frequently distributed in estuarine habitats where high salinity variations and low altitude values are observed (Holthius, 1961). Similarly,

in this study, 2 species (*P. antennarius* and *A. desmaresti orientalis*) were found at the localities where high salinity values exist.

The only Isopod species found in this study was *A. aquaticus*, which has a holarctic distribution area (Birstein, 1951). Çamur and Kirgız (2000) mentioned the

existence of this species in many freshwaters of the Thrace region of Turkey. Similarly, Özbek and Ustaoglu (2001, 2005) reported this species from 11 localities in İzmir and 19 localities in the Lake District area, Turkey. In our study, *A. aquaticus* was found at 4 localities at altitudes between 300 and 1000 m.

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