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Ostracoda (Crustacea) of Lake Uluabat (Apolyont Gölü) (Bursa Province, Turkey)

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With 3 Figures and 2 Tables

Key words: Ostracoda, Lake Uluabat (Apolyont Gölü), Turkey, wading birds, conservation

Abstract

Lake Uluabat (Apolyont Gölü), an important bird conservation area, was sampled in summer, autumn, winter and spring, and ostracod species' seasonal and spatial distributions were investigated; many of the taxa collected are useful indicator species for monitoring within-basin conditions. The findings suggest that the Lake Uluabat ecosystem is already substantially degraded. Pollution, coupled with extensive water abstraction for irrigation, have the potential to damage the value of the lake, both commercially (as an inland waters fishery), and as an important site for wetland birds. We suggest that ostracod faunal analysis has value in the ecological study of such sites, particularly where more formal physico-chemical monitoring methods are inappropriate or unavailable.

Introduction

Turkey has some of the most important areas for wetland and wading birds in the Palaearctic, as shown by the recent list of the Important Bird Areas (IBAs) of Turkey (MAGNIN & YARAR 1997). Unfortunately, along with those in other circum-Mediterranean xeric habitats, many Turkish wetland sites are under increasing pressure – through anthropogenic impacts (water abstraction, pollution) coupled with the (possibly increasing) effects of climatic aridity (cf. CHERGUI et al. 1999). However, for conservation purposes, the monitoring of many Turkish wetland sites is difficult, both because of the vast extent of the country, and the often limited availability of standard physical and chemical ecological monitoring equipment. We here discuss an approach to the investigation of the "wellbeing" of an important Turkish IBA using data gathered from ostracod faunal assemblages – a technique that is a by-product of those recently developed for palaeoecological and especially palaeolimnological work (see GRIFFITHS & HOLMES 2000).

Freshwater ostracods are benthic animals that live on or amongst the substrate, although a small number of species are bentho-nektonic (bottom swimming) or pelagic. Because individual species can have comparatively narrow habitat preferences, they are increasingly used as indicator species in biomonitoring exercises (e.g. ROSENFELD & ORTAL 1983; ONDERIKOVA 1993; HAVEL & TALBOTT 1995; MARTENS & DE MOOR 1995; GRIFFITHS et al., in press). Ostracods are relatively easy to collect and identify, and the presence and distribution of certain species can provide quantitative and qualitative data on their host environment (GRIFFITHS & HOLMES 2000).

Much of the value of ostracods in environmental monitoring stems from their utilisation in a variety of historico-/palaeoecological studies. Here the ostracod record within sediment sequences (which consists of the remains of their bivalved calcitic shells) provides a proxy record of past environmental change drived either from the ecological preferences of the fauna or from ostracod valve geochemistry (either trace elements or stable isotopes of carbon or oxygen) (GRIFFITHS & HOLMES 2000). Studies such as these (and associated modern calibrative works) have produced large datasets that document faunal responses to ecological and climatic changes, and these provide useful insights into patterns of faunal change in modern water bodies.

Much of Turkey is inhabited by ostracod species that are found throughout the Western Palaearctic (see BRONSHTEIN 1947; HARTMANN 1964) but, aside from early taxonomic works, there has been little study of Turkish freshwater

Ostracoda. However, since 1973 work on the ecology and taxonomy of freshwater ostracods from lakes (e.g. ALTINSAÇLI 1988, 1993; ALTINSAÇLI & KUBANÇ 1990; ALTINSAÇLI & YILMAM 1995; GÜLEN 1977, 1985a, b, 1988; KÜLKÖYLÜĞLU 1998; KÜLKÖYLÜĞLU et al. 1993, 1995) thermal springs (GÜLEN 1984), rivers (GÜLEN & ALTINSAÇLI 1999) and Late Quaternary palaeolakes (e.g. LANDMANN et al. 1996; REED et al. 1999; ROBERTS et al. 1999; GRIFFITHS, unpubl.) has been ongoing. Investigations such as these show that the ostracod species richness of freshwater habitats in Turkey is very high, even though taxonomic problems still remain.

The objectives of the present study were to study the occurrence and distribution of ostracods at Lake Uluabat. Furthermore, an attempt was made to use ostracod faunal data to provide a preliminary assessment of the present status of the lake, an important bird conservation area.

Material and Methods

Study site and sampling stations

The lake and wetlands of Lake Uluabat (also known as Apolyont Gölü) have tectonic origins and are situated at 9 m a.s.l. on the Plain of Karaçabey, Bursa Province, Turkish Anatolia (co-ordinates = 40°12′ N, 29°40′ E) (İNANDIK 1965). Lake Uluabat has a surface area of 156 km^2 and is comparatively shallow (depth$_{(max)}$ = 6 m, mean depth = 2 m). Average seasonal water temperatures throughout the lake basin are 15 °C (March – May), 24 °C (June – August), 14 °C (September – November) and 6 °C (December – February), whilst pH values vary between 7.5 and 9.0 (ALTINSAÇLI, unpubl.).

The lake's area includes a series of marshes, wetlands and islands, and these contribute substantially to the site's importance as a wintering site for waders and waterfowl, and as a breeding site for species such as Pygmy cormorant *(Phalacrocorax pygmeus)*, Squacco heron *(Ardeola ralloides)* and Spoonbill *(Platalea leucorodia)*. The site is one of Turkey's most noted IBAs, with about 430,000 birds having been recorded in 1996 – the highest individual Turkish site count since 1970. This included several species of marked conservation concern, notably Dalmatian pelican *(Pelecanus crispus)*, Little egret *(Bubulcus ibis)* and Glossy ibis *(Plegadis falcinellus)* (MAGNIN & YARAR 1997).

Some parts of the Lake Uluabat shoreline are covered by *Phragmites* and *Typha* marshes, and submerged vegetation is abundant. The River Mustafakemalpaşa (also called River Kirmast) is the lake's major inflow, but there is also input from underground springs. Drainage is via the streams Uluabat and Kocaçay (the latter is also known as the Susurluk or Simav). Furthermore, the entire southern lakeshore is embanked, as are several kilometres of the River Mustafakemalpaşa. At the mouth of the river incoming silt has led to the formation of a large delta and, as elsewhere in the embanked area, natural communities are degraded to sand banks with coarse *Tamarix* scrub. As in much of the circum-Mediterranean zone, lake waters are used to irrigate surrounding fields, increasing seasonally-driven fluctuations in lake levels.

The River Mustafakemalpaşa drains a large part of the regions of Southern Marmara and Northern Aegeis, bringing large quantities of urban and industrial waste into the lake basin each year (MAGNIN & YARAR 1997). Furthermore, drainage water from the surrounding fields seeps back into the lake, so that Lake Uluabat is now eutrophic. Although no formal data are available at present, further eutrophication may pose a serious hazard to the lake ecosystem, threatening its value to both birdlife and to the livelihoods of those local inhabitants who rely on the lake – either for irrigation or for fishing (on which

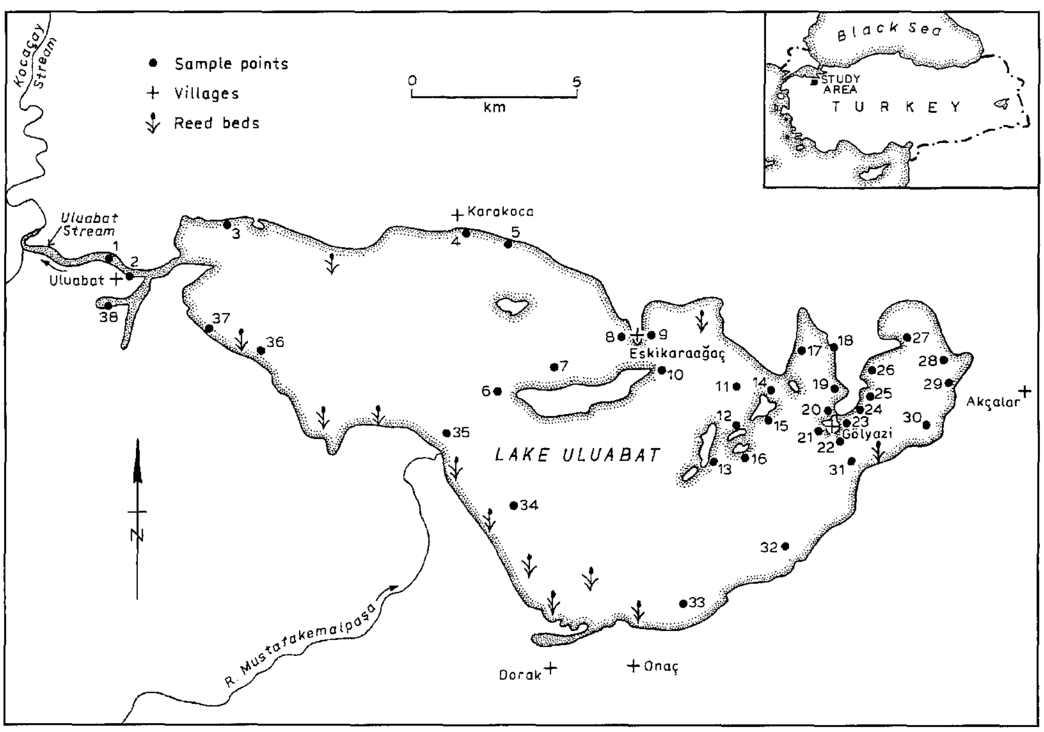

Fig 1. Location of Lake Uluabat and sampling stations.

Table 1. Lake Uluabat sampling stations.

Station	Details
1	Shore, Uluabat Stream. 1–3 m from bank, depth = 0.20–0.30 m, shoreline with *Phragmites* sp., *Typha* sp.
2	Below the bridge at the entrance road to Uluabat Village, sampling site 1–2 m from bank, sampling depth: 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp., *Salix alba*, *Fraxinus exelsior*.
3	Shore, Issız Han. 1–3 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
4	Eastern shore, Karakoca Village. 1–3 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
5	Lakeshore, Batakciduzu region. 1–3 m from bank, depth = 0.20–0.30 m, shoreline with *Phragmites* sp., *Typha* sp.
6	Western shore, Halil Bey Island. 200 m from bank, depth = 2 m.
7	Northern shore, Halil Bey Island. 200 m from bank, depth = 2.10 m.
8	Western shore, Eskikaraa ğaç Village. 1–3 m from bank, depth = 0.30–0.40 m.
9	Eastern shore, Eskikaraa ğaç Village. 1–3 m from bank, depth = 0.30–0.40 m.
10	Eastern shore, Halil Bey Island. 200 m from bank, depth = 2 m.
11	Western shore, Terzioglu Island. 200 m from bank, depth = 1.50 m.
12	Northern shore, Kerevitada Island. 1–2 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
13	Eastern shore, Mana stır (Mutlu) Island. 10 m from bank, depth = 1.20 m, shoreline with *Phragmites* sp., *Typha* sp.
14	Northern shore, Terzioglu Island. 1–2 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
15	Southern shore, Terzioglu Island. 10 m from bank, depth = 1 m, shoreline with *Phragmites* sp., *Typha* sp.
16	Southern shore, Heybeli Island. 10 m from bank, depth = 0.90 m, shoreline with *Phragmites* sp., *Typha* sp.
17	Lakeshore, Gölyazı Village (Alidede region). 300 m from bank, depth = 1 m, shoreline with *Phragmites* sp., *Typha* sp.
18	Pool along lake shore. Depth = 0.30–0.40 m but fluctuating, shoreline with grass.
19	Western shore, Gölyazi Village, Taskapı region. 1–3 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
20	Northern shore, Gölyazı Village (Emin Liman region). 1–3 m from bank, depth = 0.30–0.40 m.
21	Southern shore, Gölyazı Village. 100 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
22	Southern shore, Gölyazı Village. 100 m from bank, depth = 1.25 m, shoreline with *Phragmites* sp., *Typha* sp.
23	Eastern shore, Gölyazı (Apolyont) Village (Hamamalti region). 1–3 m from bank, depth = 0.30–0.40 m.
24	Lakeshore, Gölyazi village, Hamamalti region. 200 m from bank, depth = 1.70 m, shoreline with *Phragmites* sp., *Typha* sp.
25	Lakeshore, Bektas Hill region. 300 m from bank, depth = 1.20 m, shoreline with *Phragmites* sp., *Typha* sp.
26	Eastern shore, Gölyazi Village, Taskapı region. 1–3 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
27	Lakeshore, Gavurmezari Hill region. 200 m from bank, depth = 1.30 m, shoreline with *Phragmites* sp., *Typha* sp.
28	Lakeshore, Hisartepe Hill region. 300 m from bank, depth = 1.20 m, shoreline with *Phragmites* sp., *Typha* sp.
29	Lakeshore, Kiremit Ocaklari region. 200 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
30	Lakeshore, Eskikiremitlik region. 300 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
31	Lakeshore, Balabanlar region. 300 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
32	Lakeshore, Yenibaglar region. 300 m from bank, depth = 1.25 m, shoreline with *Phragmites* sp., *Typha* sp.
33	Lakeshore, Hanyolu region. 300 m from bank, depth = 1.20 m, shoreline with *Phragmites* sp., *Typha* sp.
34	Shore, Ilicalar region. 500 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
35	Mouth of R. Mustafakemalpa şa. 300 m from bank, depth = 1.50 m, shoreline with *Phragmites* sp., *Typha* sp.
36	Lakeshore, Kumburnu region. 1–3 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.
37	Lakeshore, Huseyin's Farm. 1–3 m from bank, depth = 0.20–0.30 m, shoreline with *Phragmites* sp., *Typha* sp.
38	Canal entering Uluabat Stream. 1 m from bank, depth = 0.30–0.40 m, shoreline with *Phragmites* sp., *Typha* sp.

the economy of the village of Gölyazi entirely depends). Furthermore, because of the polluted state of the lake, plans to develop it as a source of drinking water for Bursa Province have been cancelled recently.

Ostracod samples were taken at 38 stations in and around Lake Uluabat (see Fig. 1). With the exception of station 18 (a lakeside pool) the bottom substratum was muddy with detritus throughout (see Table 1).

Sampling methodology

Studies at Lake Uluabat involved taking qualitative ostracod samples throughout the year (i.e. in summer, autumn, winter and spring). In shallow waters (<1 m) ostracods were collected using Müller's plankton net (mesh size = 250 μm) (Bronshtein 1947). In deeper waters mud samples were collected with a custom-built 20 × 20 × 40 cm Ekman-Birge grab sampler. All samples were fixed in the field in 4% formaldehyde. In the laboratory, samples were washed with pressurised tap water and sieved to a mesh size of 0.25 mm. Samples were stored in 1:1 70% ethanol:glycerine, and species identifications were made using both soft parts and carapace-based characters using standard keys (e.g. Klie 1939; Bronshtein 1947) but with systematic nomenclature following Hartmann & Puri (1974) and Griffiths & Evans (1995a). Permanent and temporary soft part preparations were made with Canada balsam and lactophenol, respectively, with the valves of the carapaces being stored on micropalaeontological slides. The study material is now housed in the Zoology Museum, Biology Department, University of Istanbul.

Data analyses

Sampling site data are expressed as ostracod species richness (N_s), or as mean species richness ($N_{s[x]}$) plus or minus one standard deviation.

Relationships between site assemblages were examined further using UPGMA (Unweighted Pair Group Mean Average) clustering based on species presence/absence (binary) data and Jaccard's Coefficient (species data only shown). Additional analysis was done by DCA (Detrended Correspondence Analysis), an ordination technique that summarises multivariate data into scatter diagrams and which also allows investigation of species' response to environmental variables (JONGMAN et al. 1995). A further DCA was undertaken using all site seasonal occurrence data (not shown). All procedures were run on MVSP Ver. 3.0 software (KOVACH 1998). During DCA, species downweighting was applied to all taxa occurring in less than one in five of all cases.

Results

Studies at Lake Uluabat revealed the presence of 12 ostracod species. The seasonal occurrence of each taxon at each sampling station and site taxocene species richness (N_s) are shown in Table 2.

The most common species at Lake Uluabat was the nektonic *Physocypria kraepelini* (26 sites, 68.42%), followed by *Ilyocypris biplicata* (20 sites, 52.63%), *Darwinula stevensoni* (18 sites, 47.37%), *Candona neglecta* (16 sites, 42.10%), *Cypridopsis vidua* (14 sites, 36.84%), *Candona angulata* (13 sites, 34.21%) and *Fabaeformiscandona caudata* (12 sites, 31.58%). All other species occurred at <4 sites (*i.e.* < 10.5%), the least common being *Heterocypris incongruens* (1 site, 2.6%). Sampling site species richnesses (N_s) ranged from zero to seven (one site only each – 36 and 27, respectively), $N_{s(x)} = 3.26 \pm 1.75$ (n = 38). (A full, site-based list of species numbers and collection dates is available from SELÇUK ALTINSAÇLI on request.)

Faunistics

• *Darwinula stevensoni* (BRADY & ROBERTSON, 1870)
Darwinula stevensoni was found throughout the basin of Lake Uluabat, occurring at all sampling stations (and throughout much of the year) except at stations 1–5, 14, 17–19, 22, 23, 26, 28–32 and 36–38. This species is well known for its preference for shallow, limnic waters (GRIFFITHS & BUTLIN 1994). Many of the other sites lacking this species were in the NE of the lake.

• *Ilyocypris biplicata* (KOCH, 1838)
This geographical parthenogen was found throughout Lake Uluabat, at all depths to 2 m and < 300 m from the shore. Found sporadically at many sampling stations, female *I. biplicata* were found throughout the year, however, males were only found on a small number of occasions – always in late summer or autumn.

• *Ilyocypris gibba* (RAMDOHR, 1808)
Found throughout the year to a maximum depth of 1.5 m (station 31) but more usually at <0.5 m and at a limited range of sites. No males were recorded.

• *Candona angulata* G.W. MÜLLER, 1900
Candona angulata was found in comparatively high numbers throughout the year, mainly at sites >100 m from the NE bank of the lake at depths from 0.5–1.5 m; the sole exception was the canal entering Uluabat Stream (station 38) with depths from 0.3–0.4 m.

• *Candona neglecta* SARS, 1887
A widespread and common benthic species, sporadically abundant in much of Lake Uluabat stations (3, 4, 6, 7, 11, 17, 21, 22, 24, 27–31, 35, 38) although restricted to sites 4, 17, 27 and 31 in winter. The species was most frequently encountered in the NE part of the lake basin.

• *Fabaeformiscandona caudata* (KAUFMANN, 1900)
The ecology of this limnic species is poorly understood. *Fabaeformiscandona caudata* was found mainly in the NE of the lake basin (sites 6, 12, 15–17, 22, 25, 27–30 and 38). Only females were collected at most sampling stations, but males occurred throughout the year at sites 27–29. As males are usually considered to be rare, it is possible that the Lake Uluabat material belongs within the similar *F. lozeki* (ABSOLON, 1973) for which the soft parts have not been described.

• *Physocypria kraepelini* G.W. MÜLLER, 1903
A common nektonic species that was collected at stations 3, 4, 6–9, 11, 12, 14–17, 19, 22, 24–30, 32, 35 and 38 where (for the most part) it was collected throughout the year. There is no clear pattern in species distribution.

• *Cypris pubera* O.F. MÜLLER, 1776
Cypris pubera was collected (as small numbers of females) in shallow, warm waters at stations 37 (spring and summer) and 38 (spring only). *Cypris pubera* is a common component of semi-arid zone temporary water faunas, usually inhabiting lake margins or (often slightly saline) waters that dry out.

• *Eucypris virens* (JURINE, 1820)
This geographically parthenogenetic taxon was collected (as females only) at shallow, lake edge stations (1, 5, 37) in spring.

• *Heterocypris incongruens* (RAMDOHR, 1808)
One of the commonest Turkish ostracod species, only females of this geographically parthenogenetic species were collected, and only in summer at station 18 – a shallow lakeshore pool.

• *Herpetocypris chevreuxi* SARS, 1896
Herpetocypris chevreuxi was collected only sporadically: in spring, summer and autumn at station 20, and in spring at station 5. All specimens found were female.

Table 2. Lake Uluabat seasonal species occurrence.

Species	Sampling stations																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
D. stevensoni	–	–	–	–	–	y–w	y–w	u	w	y–p	y–w	y	y	–	y	y–a	–	–	–
I. biplicata	–	y–w	–	u	–	p+u	y–w	–	–	y–w	–	y–p	y–w	–	–	y	y	–	–
I. gibba	p	–	u	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. angulata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	y	–	–
C. neglecta	–	–	u	y–s	–	y–w	y–w	–	–	–	p+u	–	–	–	–	–	y	–	–
F. caudata	–	–	–	–	–	u	–	–	–	–	–	y	–	–	y	y–w	y	–	–
P. kraepelini	–	–	y	y	–	y–w	y–w	y	y	–	y	y	–	u+a	y	y	y	–	y–w
C. pubera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. virens	p	–	–	–	p	–	–	–	–	–	–	–	–	–	–	–	–	–	–
H. incongruens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	u	–
H. chevreuxi	–	–	–	–	p	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. vidua	–	–	y	–	–	–	–	y	y	–	y	–	–	–	y–w	–	y–w	–	–
No. species	2	1	4	3	2	5	4	3	3	2	4	4	2	1	4	4	6	1	1

Species	Sampling stations																		
	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
D. stevensoni	y–w	y–w	–	–	y	y	–	y	–	–	–	–	–	y–w	y	y–w	–	–	–
I. biplicata	–	y–w	y	–	y	y	–	u+a	y	y–w	y–w	–	y–w	y–w	y	–	–	–	–
I. gibba	–	–	–	–	–	–	p+u	–	–	–	–	y	–	–	–	–	–	–	–
C. angulata	–	–	y–a	–	–	w+p	–	y	–	–	y–a	–	–	–	–	–	–	–	y
C. neglecta	–	y–w	y	–	y	–	–	y	y	y–w	y–w	y	–	–	–	p	–	–	y–w
F. caudata	–	–	y	–	–	y	–	y	y	u+p	y–w	–	–	–	–	–	–	–	p
P. kraepelini	y–a	y–w	y	–	y	y	p+u	u+a	y–w	u	y–w	–	u+a	–	–	u+a	–	–	p+u
C. pubera	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	p+up	p
E. virens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	p	–
H. incongruens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
H. chevreuxi	y–w	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. vidua	y–w	–	y–w	y–w	y	y	–	y	–	y–w	y–w	–	–	–	–	–	–	–	–
No. species	4	4	6	1	5	6	2	7	4	5	6	2	2	2	2	3	0	2	5

p = spring; u = summer; a = autumn; w = winter; y = all year; – = absent.

• *Cypridopsis vidua* (O.F. MÜLLER, 1776)
This common species was found throughout the year, and at stations 3, 8, 9, 11, 15, 16, 20, 23–25, 27, 29 and 30. The species is said to be intolerant of low aquatic oxygen tensions so this may have in part affect within-basin distribution (DANIELOPOL 1991).

UPGMA clustering and DCA

UPGMA clustering of species occurrences within L. Uluabat shows a clear separation of species groups (Fig. 2). Firstly this is between the rarer species (above) and the more abundant species (below). The second major cluster resolves between benthic forms occurring primarily in the NE of the lake basin *(C. angulata, C. neglecta, F. caudata)* and species with broader distributions *(I. biplicata, C. vidua, P. kraepelini, D. stevensoni)* with the two last (nektonic) taxa clustering together.

The first two axes of the DCA (Fig. 3) accounted for a cumulative variance of 41% of the variation within the dataset, and broadly agreed with the results obtained by clustering. Here the open, deep water fauna that dominates in the NE of the lake basin was characterised by species with relatively high loadings on both axes (i.e. *C. neglecta, C. angulata, F. caudata*). Meanwhile the more generally distributed deep, open water fauna was characterised by the benthic *I. biplica-*

ta and *D. stevensoni* (relatively low loadings on Axis 1, but high loadings on Axis 2) and nektonic species with relatively high loadings on Axis 1, but low loadings on Axis 2 *(P. kraepelini, C. vidua)* (Fig. 3). The DCA of site seasonal occurrence data (not shown) additionally underlines the existence of several distinct suites of species, one (along the southern shore) dominated by *D. stevensoni* and *I. biplicata*, another dominated by candonids on the northern shore, and an intermediate fauna (mainly of *I. biplicata*, *D. stevensoni* and *P. kraepelini*). Finally, the shallow water nektonic fauna of *C. vidua* and *P. kraepelini* is again emphasised from sites between 0.3–0.5 m deep and < 3 m from the shoreline.

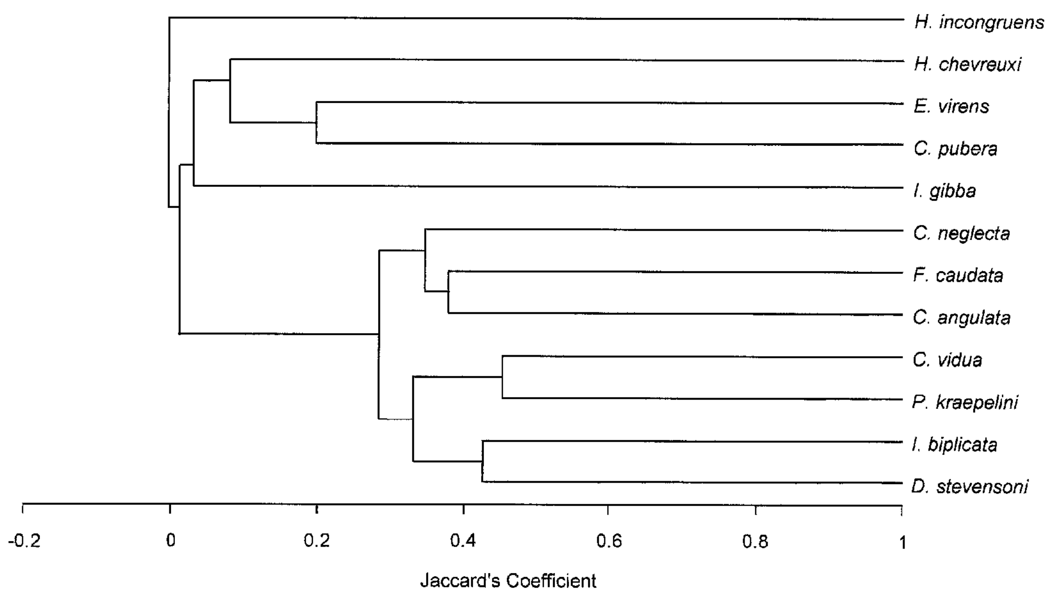

Fig. 2. UPGMA cluster of Lake Uluabat species assemblages.

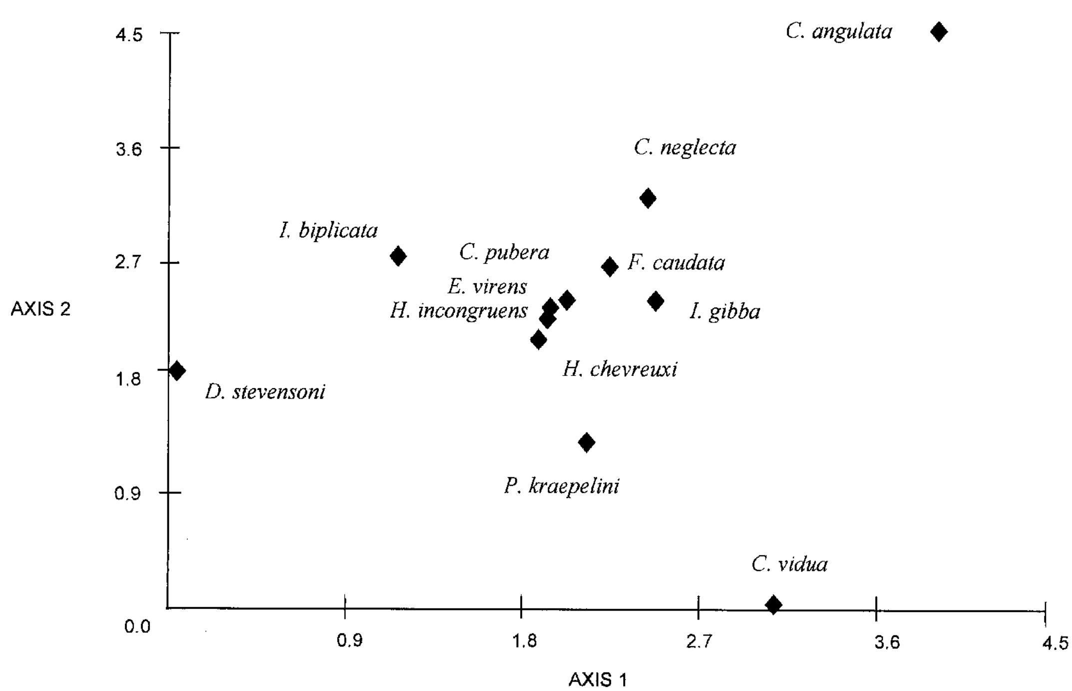

Fig. 3. DCA of Lake Uluabat species assemblages.

Discussion

The ostracod fauna of Lake Uluabat is typically European in terms of species composition, and most of the species present occur throughout western Eurasia. Sampling stations of below average species richness (where $N_{s(x)} \leq 3.26$) were almost all located in three main areas: (1) Uluabat Stream (sites 1, 2), (2) along the southern (embanked) lakeshore, or (3) near to towns or villages, notably Karakoca (sites 4, 5) and Eskikaraağaç (9, 10, 15); the other low diversity sites were in the NE of the lake and within 5 km of Gölyazi village. Overall, species richness within the lake basin is not unusual, although perhaps somewhat low for a lake of this size, trophic status and alkalinity (DE DECKKER & FORESTER 1988; FRYER 1985). However, to some extent this may reflect the shallowness of this basin, the lack of overt niches available and possibly, in places, the negative effect of embanking the southern shore. It also seems likely, however, that other anthropogenic affects have acted to reduce N_s within Lake Uluabat.

The fauna inhabiting the lake is not remarkable for lakes in Balkano-Anatolia. However, many of those studied previously in western Turkey (e.g. ALTINSAÇLI 1988, 1993; ALTINSAÇLI & KUBANÇ 1990, ALTINSAÇLI & YILMAM 1995; KÜLKÖYLÜĞLU 1998; KÜLKÖYLÜĞLU et al. 1993, 1995) typically feature both candonids and cytheroids (many of which characterise old or tectonic lakes; FROGLEY et al., in press). At Lake Uluabat, few of the species collected were candonids, and cytheroids are absent – despite the apparent tectonic origin of the lake. Although several candonids were present, the fauna consists mainly of taxa with wide ecological tolerances and extensive geographical ranges. All of these are known to live in a range of water bodies, including eutrophic waters, and the fauna resembles that found in other eutrophic lakes in southern Europe and the Near East.

UPGMA and DCA show that the lake's candonids are largely concentrated into the NE of the basin, whereas elsewhere a more generalist fauna is present – presumably reflecting either the influence of polluted riverine inflow, and/or the effects of embanking. Although we have no historical/ecological data on the ostracod fauna of Lake Uluabat, its present fauna (in terms of N_s and composition) does not yet characterise a system under severe stress. Despite this, several of the species present often are found in mixohaline waters *(D. stevensoni, C. angulata, C. pubera, H. chevreuxi* and the marginal *H. incongruens)* which here (in the absence of chemical data) seem indicative of increased nutrient status, with conductivity acting as an analogue of salinity (cf. FRYER 1978). However, if shallowing and eutrophication continue, faunal changes may be expected. For example, *D. stevensoni* (a long-lived pouch brooding species; GRIFFITHS & BUTLIN 1994) will die out under conditions of oxygen depletion. Also, if the system moves further into eutrophy, there will progressive loss of the longer-lived benthic species until only hardy generalists remain (i.e. *P. kraepelini, C. vidua*). Under such conditions, *H. incongruens* may colonise the basin from marginal pools – this clonal species being known to do well under conditions of low metazoan competition (GRIFFITHS, unpubl.).

Conclusions

Between 1937–1993, 14,800 ha of Lake Uluabat's floodplain were drained or embanked; moreover, the lake is used to irrigate 6,350 ha of agricultural land to the north and east, and its inflow is substantially reduced by the pumping of water from River Mustafakemalpaşa for the irrigation of a further 20,258 ha: the status of the lake is therefore believed to have deteriorated. At present, there are plans to divert a major tributary of the River Mustafakemalpaşa for the reservoir for a hydro-electric power scheme at Çinarcik (which will lead to loss of a further third of the lake's inflow) and, in addition, there are continuing problems with pollution from local settlements, from the River Mustafakemalpaşa catchment, and from run-off from surrounding agricultural land. The lake also receives substantial nutrient input from its bird populations (MAGNIN & YARAR 1997). In this context, a minor sediment short coring program would offer great potential for recording changes that have occurred within the lake basin within the historical period. Ideally, work such as this should be coupled to biomonitoring effort to assess the continuing status of the lake. Certainly Lake Uluabat is a candidate for close ecological monitoring over the next decades – particularly as much of the local economy depends on fishing, and the rest is agricultural and relies upon the lake for irrigation. At present Lake Uluabat is in a similar condition to many other circum-Mediterranean lakes – numbers of which are being over-exploited and used for removal of domestic and industrial waste waters, e.g. the Balkan lakes Dojran (GRIFFITHS et al., in press) and Pamvotis (FROGLEY & GRIFFITHS, in press). Although these systems are poorly understood, palaeoecological works suggest that alkaline lakes are stable over long periods of time, and then reach some threshold, at which they "flip" from eutrophy into hypertrophy, often over relatively short time-scales (GRIFFITHS & EVANS 1995b). Considerably more studies are needed for the understanding of these processes, from both the theoretical and applied points of view.

At present, although Lake Uluabat is listed as a RAMSAR site, national legislations have few obligations towards active site protection (LYSTER 1993). Given the demands on freshwater resources in Turkey, clear conflicts of interest exist between conservation concerns and the needs of local human populations. Notable amongst these is the ever-increasing demand for water for agriculture, the lack of an integrated agricultural policy and low (often non-existent) water costs to farmers. These have led to limited development of water economisation strategies, and often have had marked effects upon Turkish IBAs (MAGNIN & YARAR 1997). Given the local and regional significance of Lake Uluabat, the lake is a suitable and worthwhile candidate for a long-term monitoring program that integrates both synecological and palaeoecological studies.

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