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Recent and Ancient Death-assemblages of Molluscs in Lakes Eğirdir and Beyşehir (SW Anatolia, Turkey)

Riassunto - Tanatocenosi recenti ed antiche di molluschi dai laghi Eğirdir e Beyşehir (Anatolia S-O, Turchia).

Nell'estate del 2000 sono stati raccolti campioni di materiale spiaggiato lungo le sponde del Lago Eğirdir. Successivamente nell'agosto 2002 si sono raccolti campioni da una stratigrafia affiorante vicino al Lago Beyşehir e costituita da sedimenti carbonatici e da gyttja ricchi di molluschi acquatici. La datazione colloca questi ultimi campioni alla fine del Pleistocene Medio. La determinazione delle specie si è rivelata difficoltosa per il fatto che non è stato possibile analizzare la loro anatomia e per il fatto che la sistematica della malacofauna turca risente tuttora di molte vecchie determinazioni che attribuivano alle specie anatoliche i nomi di quelle europee a causa della loro somiglianza. Un problema che è ora in fase di avanzata soluzione.

Il Lago Eğirdir ha avuto durante buona parte del Pleistocene Medio-Finale e l'Olocene delle caratteristiche simili all'ampio bacino del Beyşehir-Suğla: una posizione pedemontana racchiusa tra catene di monti, una notevole estensione con andamento Nord-Sud, fondali bassi intorno ai 15 m di profondità, oscillazioni di livello e di trofia fino a trasformarsi in ampi stagni, probabili incrementi di salinità. Lo studio qualitativo e quantitativo di entrambe le malacofaune nonché le osservazioni tafonomiche sulle conchiglie hanno consentito un approfondimento delle dinamiche di formazione degli accumuli naturali conchigliari in ambito lacustre e alcune considerazioni di interesse archeozoologico per una loro migliore comprensione.

Parole chiave: molluschi d'acqua dolce, tanatocenosi, laghi, Anatolia S-O, Pleistocene medio.

Abstract - In the summer of 2000 samples of beach deposits on the shore of Lake Eğirdir were collected. Subsequently, in August 2002, further samples were taken from a sequence exposed near Lake Beyşehir that was composed of carbonatic and gyttja layers containing abundant aquatic molluscs; these were dated to the end of the Middle Pleistocene. Species identification was made difficult by the fact that anatomical studies could not be made, and also because the taxonomy of Turkish molluscs still suffers from the effects of the once widespread habit of identifying Anatolian species as similar European species. The latter difficulty is well on the way to be resolved.

For much of the Middle-Upper Pleistocene and Holocene, Lake Eğirdir had characteristics similar to those of the large Beyşehir-Suğla Basin: a piedmont location enclosed by mountain ranges, large size and north-south orientation, maximum depth of about 15 m, variable water level and nutrient concentration (occasionally becoming a large pond), and probable increases in salinity. The qualitative and quantitative study of both malacofaunas, together with taphonomic observations on the shells,

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gave deeper insight into the formation processes of natural lacustrine shell accumulations and certain aspects of zooarchaeological interest, improving our understanding of such phenomena.

Keywords: freshwater molluscs, Death-assemblages, lakes, SW Anatolia, Middle Pleistocene.

Aim of the research

In the central-western Anatolian Plateau there are numerous lakes at altitudes between 845 and 1123 m a.s.l. The largest are Beyşehir Gölü (656 km^2), Eğridir Gölü (482 km^2) and Burdur Gölü (200 km^2). Two examples of shell accumulations not of human origin were studied. In this region the faunal content of naturally deposited thanatocoenoses is interesting for the large quantity of shells present, among which new species are sometimes found; they are of both taxonomic and ecological interest. Freshwater mollusc death-assemblages remind us how little we know about the processes that have contributed to their formation. This is a limit that creates problems of interpretation when natural accumulations of shells are encountered during archaeological excavations. It is not always possible to find in a single lake accumulations of both recent and fossil shells; for this reason this study is based on accumulations from two different lakes. Through a comparison between a recent lacustrine death-assemblage and others from the late Middle Pleistocene, an attempt is made to understand the palaeoenvironmental circumstances which created these deposits.

Taxonomic aspects

Uncertainties exist with respect to Turkish freshwater molluscs due to the fact that European and Turkish malacologists have long attributed to Anatolian species the same names used for European fauna on the basis of the morphological similarity of their shells. This has created notable confusion which has only partly been resolved. For pulmonates, Planorbidae and especially prosobranchs, new fieldwork, the revision of old faunal inventories and anatomical investigations (when possible) have led to the improvement of some biogeographical distribution maps, the elimination or confirmation of some species and the creation of new species.

Fig. 1 - The sampling sites at Lake Eğirdir (dot) and Lake Beyşehir (square). (From Glöer & Girod, 2013, modified).

Taxonomic issues related to the faunas of Eğridir Gölü and Beyşehir Gölü were studied in collaboration with Dr. Peter Glöer, Dr. Hartwig Schütt (1923-2009) and Prof. M. Z. Yildirim; comparisons were made with shells in museum and private collections.

The material studied is stored in the collection of A. Girod. The paratypes of the three new species *Gyraulus egirdirensis, Gyraulus taseviensis* and *Valvata beysehirensis* recently described and illustrated by Glöer & Girod (2013) are held in the Mollusc collection of the Milan Museo Civico di Storia Naturale; the respective catalogue nos. are MSNM Mo 36589, MSNM Mo 36590, MSNM Mo 36591.

Lake Eğirdir

Lake Eğirdir, 917 m a.s.l. and 482 km^2, is the fourth-largest lake in Turkey after Van Gölü (3755 km^2), Tuz Gölü (1500 km^2) and Beyşehir Gölü. The average depth is 7-8 m, with a maximum of 15 m. In summer stretches of shore emerge, with notable accumulations of mollusc shells. Water-level oscillations may be as much as 5 m (Gülle *et al*., 2008). These are natural death-assemblages made evident by the seasonal drop in the water level, formed by wave action that pushes the mollusc exoskeletons up the beach, building up concentrations. They are deposited on gravels from which the waves have removed the finer sediments. Samples were collected during August 2000 on the NW bank in the Hoyran basin, between the villages of Taşevi and Gençali. In this portion there is an abundant accumulation of spring water behind the shore, where submerged aquatic vegetation is plentiful; it is separated from the lake by a strip of tree-covered land (Fig. 2a). This water flows into Eğirdir Gölü and it may happen that the two environments are united when the lake level is high.

A bulk sample of about 2 kg was collected from the lake bank. After washing and sieving, 100 g was taken for study (Tab. 1).

Together with the shells are also found caddisfly larva cases, beetle exoskeletons and elytra, and crustacean claws. Viviparidae shell fragments occur as well.

The malacofauna of this lake is known from previous work (Stojaspal, 1986; Yildirim, 2004 Yildirim *et al*., 2006; Kebapçi & Yildirim, 2010; Kebapçi *et al*., 2012). At two points near our area (sites 7 and 8 in Yildirim, 2004) the following gastropods were found: *Borysthenia naticina, Bithynia pseudemmericia, Radix*

Fig. 2 - a) Eğirdir Gölü, sampling point; area with springs in foreground. B) Beyşehir Gölü, the Pleistocene strata. (Photos A. Girod).

Tab. 1 - Species and number of individuals from the shore of Lake Eğirdir.

Lake of Eğirdir, shore	**MNI**	**Total**
Freshwater Prosobranchs		
Theodoxus heldreichei (Martens, 1878)	49	
Bithynia pseudemmericia (Schütt, 1964)	105	
Graecoanatolica lacustristurca (Radoman, 1973)	687	
Falsipyrgula pfeifferi (Weber, 1927)	259	
Valvata cristata O.F.Müller, 1774	34	
Valvata piscinalis (O.F.Müller, 1774)	414	
Borysthenia naticina (Menke, 1845)	138	1686
Freshwater Pulmonates		
Lymnaea stagnalis (Linnaeus, 1758)	9	
Lymnaea truncatula (O.F.Müller, 1774)	2	
Physa fontinalis (Linnaeus, 1758)	1	
Haitia acuta (Draparnaud, 1805)	3	
Radix auricularia (Linnaeus, 1758)	37	
Gyraulus convexiusculus (Hutton 1849)	5	
Gyraulus egirdirensis Glöer & Girod 2013	36	
Gyraulus piscinarum (Bourguignat, 1852)	83	
Gyraulus taseviensis Glöer & Girod 2013	73	
Planorbarius corneus (Linnaeus, 1758)	10	259
Freshwater Bivalves		
Dreissena polymorpha (Pallas, 1771)	47	
Pisidium henslowanum (Sheppard, 1825)	19	
Pisidium cf. nitidum Jenyns, 1845	6	
Pisidium sp.	15	87
Land snails		
Oxyloma elegans Risso 1826	1	
Vertigo antivertigo (Draparnaud, 1801)	1	
Vitrea contracta (Westerlund, 1871)	1	
Xerotricha cf. conspurcata (Draparnaud, 1801)	2	5
		2037

peregra, *Stagnicola palustris, Haitia acuta, Physa fontinalis, Planorbis planorbis* and *Gyraulus albus* (Yildirim, 2004). There are several differences between this and the present list, which regards a single sampling site not far from the village of Taşevi. The species *Gyraulus albus* cited in the bibliography needs to be confirmed in the light of recent research. All these species have been described and are well known. Two Planorbidae are new: *Gyraulus egirdirensis* and *Gyraulus taseviensis* (Glöer & Girod, 2013).

Most of the freshwater species are from oligotrophic lentic systems. Habitats vary: *Theodoxus heldreichi* lives on hard substrates and pebbles, *Bithynia pseudemmericia* lives on the bottom and aquatic vegetation, and both species prefer standing water with low hydrodynamism. *Valvata cristata* is a muddy-sediment species, whereas *Valvata piscinalis* moves among aquatic plants. Some land and freshwater pulmonates live in more slowly-moving waters, such as marshes and on lake shores protected by reed beds. They are often restricted to shallow, muddy areas, or in proximity to springs.

The terrestrial species *Vitrea contracta* and *Xerotricha cf. conspurcata* live in the dry calcareous soils that border the lake and their occasional presence is simply due to their passive transport by water.

The prosobranchs are the most important group among the empty shells. The thanatocoenosis is dominated by two species: *Graecoanatolica lacustristurca*, quantitatively the most abundant gastropod (33.73%), and *Valvata piscinalis* (20.32%). Other important components are *Falsipyrgula pfeifferi* (12.71%) and *Borystenia naticina* (6.77%) (Fig. 3).

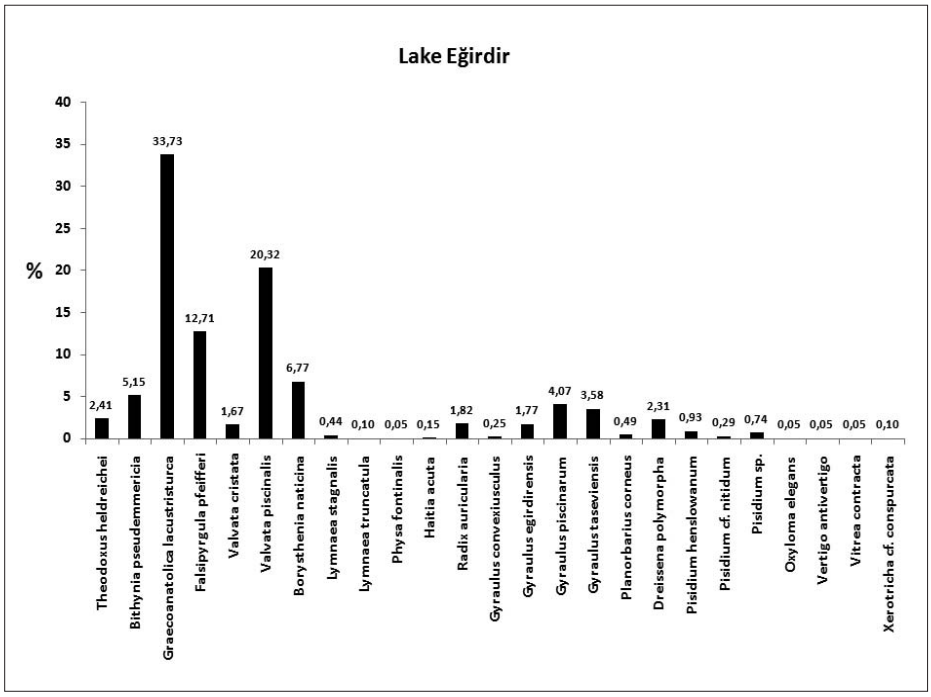

Fig. 3 - Species frequency on the shore of Lake Eğirdir.

Of benthic creatures from Lake Egirdir, *Dreissena polymorpha* is the most common, with a density per m^2 of 13554 individuals (Gülle *et al*., 2008). Many fragments were also collected, mostly the apical portions of young individuals, which implies that the minimum number of individuals is an underestimate. This species attaches itself by a byssus to a hard underwater base, which may be the shell of a large bivalve such as *Unio* that emerges from the lake bottom; young *Dreissena* which colonize zones near the surface die when a fall in water level leaves them exposed. Such massive die-offs have been observed and well documented, for example on the margins of Bafa Gölü (Büyük Menderes Delta, SW Turkey) where *Dreissena polymorpha* and *Mytilaster marioni* (Locard, 1889) have the same destiny, carpeting the banks with dark accumulations of millions of dead individuals (personal observation; Kazanci *et al*., 2008).

Lake Beyşehir

Lake Beyşehir, 1123 m a.s.l., 656 km^2, has a maximum depth of 10 m (Işildar, 2010). The lake occupies the northern basin of the Beyşehir depression, which extends southwards to Lake Suğla. From the strandlines and the Quaternary fossils present it may be deduced that during the Pleistocene pluvial periods, these two lakes rose to the level of the ancient effluents or karstic systems that bordered the shores. Beach ridges at between 10 and 25 m above the present shore-level indicate the probable margins of these outflows (Erol, 1978).

Beyond the existing shore to the southeast of the lake, widespread outcrops of ancient lacustrine deposits may be seen, both north of Beyşehir towards Kireli and along the road which runs eastwards along the valley bottom in the direction of Konya, via Üçpinar. The strata from which the samples discussed here were obtained are situated on a hillock to the west of the national road D695, at the latitude of Çiftlikköy, just south of the turning for this village (37°43'58.38''N-31°42'08.76''E) (Figs. 1, 2b).

The deposit crops out at 1135 m a.s.l. and is cut by a disused quarry where the visible stratigraphy is about 5 metres thick, with alternating layers of carbonates and gyttja (Fig. 4).

Two samples of Valvatidae shells from gyttja layers gave the following ^{14}C AMS dates (Accelerator Mass Spectrometry Radiocarbon dating):

Sample Bey 3: (GrA-53007) 46000+850-600 yr BP $\delta^{13}C$-7.38‰

Sample Bey 5: (GrA-53009) 44450+650-550 yr BP $\delta^{13}C$-6.66‰

Since these gyttja layers are overlain by thick carbonate sediments, contamination by young carbon from percolating meteoric water after the retreat of the lake must be taken into account (Roberts *et al.*, 1999). The error in age determination could be between 4 and 6 ka. The two dates obtained are quite similar and correspond to the late Middle Pleistocene. The raised beaches of the Beyşehir-Suğla Basin at 1130 and 1135 m a.s.l. represent the contact between the Upper and Middle Pleistocene (Erol, 1978); the dates from the new samples collected from between 1130 and 1133 m thus fit comfortably into this period, notwithstanding the error margin.

In 2002 samples each weighing about 2 kg were taken at various depths below the present surface (top of section):

Sample 1: 130-140 cm in compact carbonatic deposits

Sample 2: 245-255 cm in loose carbonatic deposits (soft)

Sample 3: 280-290 cm in gyttja rich in freshwater shells

Sample 4: 325-335 cm in loose carbonatic deposits (soft)

Sample 5: 425-435 cm in gyttja rich in freshwater shells

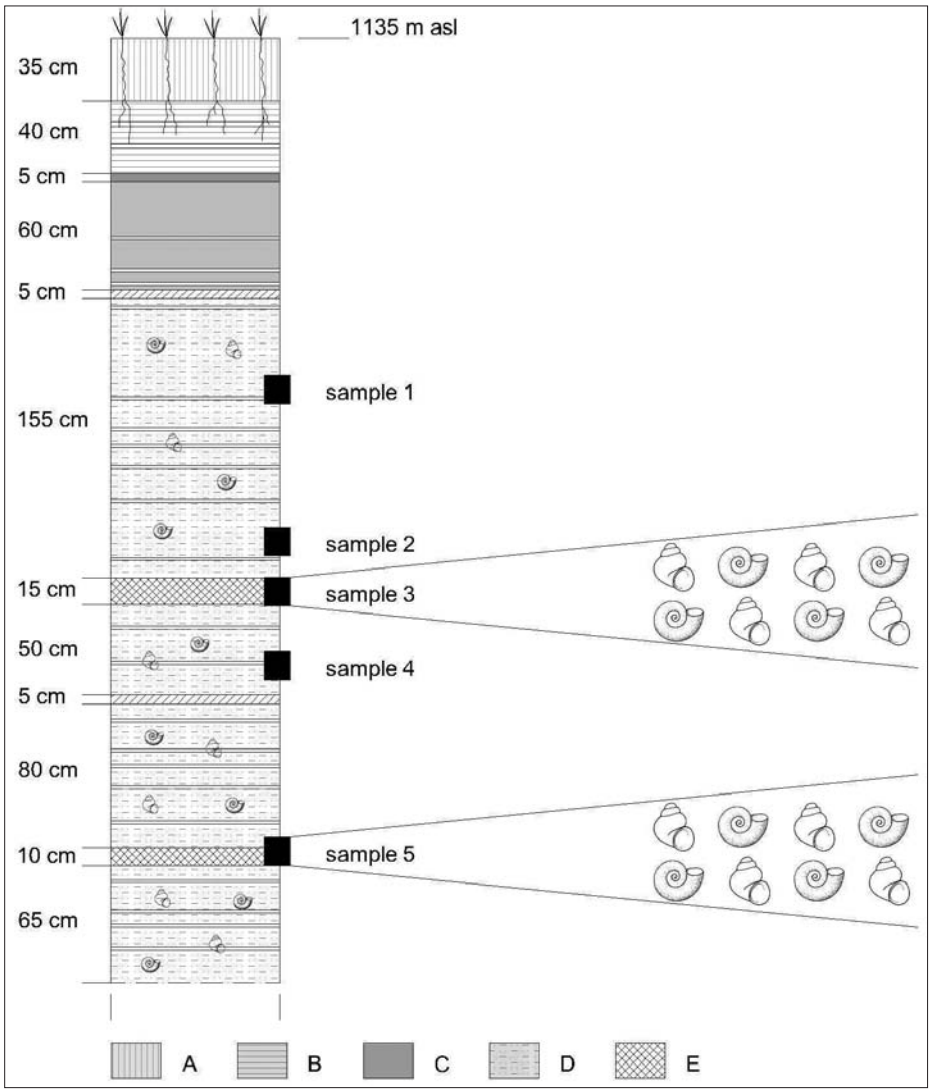

Fig. 4 - Lake Beyşehir, Pleistocene stratigraphy. A) uppermost red terrigenous layer; B) disaggregated lake sediments with roots; C) grey carbonatic clay; D) carbonatic deposits; E) gyttja. (Drawing G. Maggioni, CORA).

In the ancient Beyşehir-Suğla Basin various peat layers have been reported (Roberts, 1982; Roberts & Wright, 1993); Samples 3 and 5 are from gyttja layers.

The samples were immersed in water to which a little H_2O_2 (130 vol., 35%) had been added for 24 hours and then wet-sieved with light jets of water, using a sieve column with 20, 10 and 1 mm meshes. The species found, their frequency and the weight (in grammes) of residual material left after sieving are shown in Tab. 2.

Tab. 2 - Species and number of individuals from the Pleistocene strata of Lake Beyşehir.

Species \ Samples	1 g 78	2 g 104	3 g 68	4 g 288	5 g 62	Tot MNI
Freshwater Prosobranchs						
Viviparus sp.			1			1
Bithynia pseudemmericia (Schütt, 1964)	235	2837	2023	1694	23470	30259
Islamia cf. *anatolica* Radoman, 1973	281	3348		2089	7063	12781
Valvata beysehirensis Glöer & Girod, 2013	341	2122	4571	2372	13836	23242
Borysthenia naticina (Menke, 1845)	1363	6361	11582	5536	32261	57103
Freshwater Pulmonates						
Lymnaea stagnalis (Linnaeus, 1758)	45	43	89	136	711	1024
Anisus sp.		7	54			61
Gyraulus convexiusculus (Hutton 1849)	6	67	329	39	149	590
Gyraulus crista (Linnaeus, 1758)			3			3
Planorbarius corneus (Linnaeus, 1758)	2	1	3	1	66	73
Acroloxus lacustris (Linnaeus, 1758)	2					2
Freshwater Bivalves						
Unio sp.		1	1	2	3	7
Pisidium sp.	7			20		27
Pisidium amnicum (O.F.Müller, 1774)	6			2	4	12
Pisidium personatum Malm, 1855	10			18		28
Land snails						
Oxyloma elegans Risso 1826	5	6		3		14
Tandonia sp.		1				1
Total	2303	14794	18656	11912	77563	125228
Ostracoda	59	201		383	347	
Characeae oogonium	7	51		111	256	

For *Bithynia pseudommericia* the minimum number of individuals (MNI) is based on the number of opercula. Several items were present sporadically but their poor state of preservation did not permit reliable species identification.

In the case of Lake Beyşehir too, the majority of the species found are known from the central-western Anatolian Plateau. There is some doubt with renard to *Islamia* cf. *anatolica* because the genus *Islamia* usually occurs near springs, e.g. those at Kirkgöz (Radoman, 1973; Yildirim, 1999; Kebapçi & Yildirim, 2010). Specimens of this species have been sent to M.Z. Yildirim for comparison with individuals of any present-day population that may live in the same area. *Valvata beysehirensis* is a new, recently described species (Glöer & Girod, 2013).

Observations concerning taphonomy

In Sample 1 the shells were well-preserved, although whitened; those of *B. pseudemmericia* proved more fragile during handling than *Islamia* sp.

In Sample 2 the shells were often very corroded, fragile and powdered easily.

In Sample 3 the shells were light brownish-yellow coloured and in excellent condition.

In Sample 4 the shells were bleached, weak although little corroded; many disintegrated.

In Sample 5 the shells were quite shiny, light brownish-yellow coloured, not corroded although rather fragile. They were very fragmentary and resembled the thanatocoenosis from the shore of Lake Eğirdir. The *B. pseudemmericia* shells were more broken than those of *Valvata* sp. and *Borystenia* sp.

The greater fragility of *B. pseudemmericia* may be due to the greater globosity and size of its shell compared to the lenticular and less large *Valvata* sp. and the much smaller and hemispherical *Islamia* sp. The opercula of *B. pseudemmericia* were well preserved and the NMI is based on them.

Samples 3 and 5 were collected from gyttja layers and contained abundant malacofauna and plant detritus; they formed during periods when lake levels were low and material accumulated on the shore.

Samples 1, 2 and 4 were collected from carbonate-rich deposits formed during high water levels in periods of high evaporation and their mollusc content was lower. In order to gain a better understanding of the mollusc concentrations in the various layers in the sequence, the number of individuals was calculated per 50 g of residual sediment (Fig. 5).

Overall population composition

An overall analysis of the Pleistocene malacofauna shows the predominance of prosobranchs *Borysthenia naticina, Bithynia pseudemmericia, Valvata beysehirensis* and *Islamia* cf. *anatolica* (98.5%), with differences between samples ranging from 99.2% (Sample 2) to 96.6% (Sample 1).

The preponderance of just a few species is only partly due to the vagaries of sampling and differences in the shells' mechanical resistances. It is the result of the repeated deposition of empty shells and reflects the relative abundance of individuals of these species in the environment. Pulmonate and bivalve gastropods occur in negligible quantities, perhaps sporadically; the presence of *Oxyloma elegans* and a dorsal shell of *Tandonia* sp.(Fig. 6; Tab. 2) may be considered chance events.

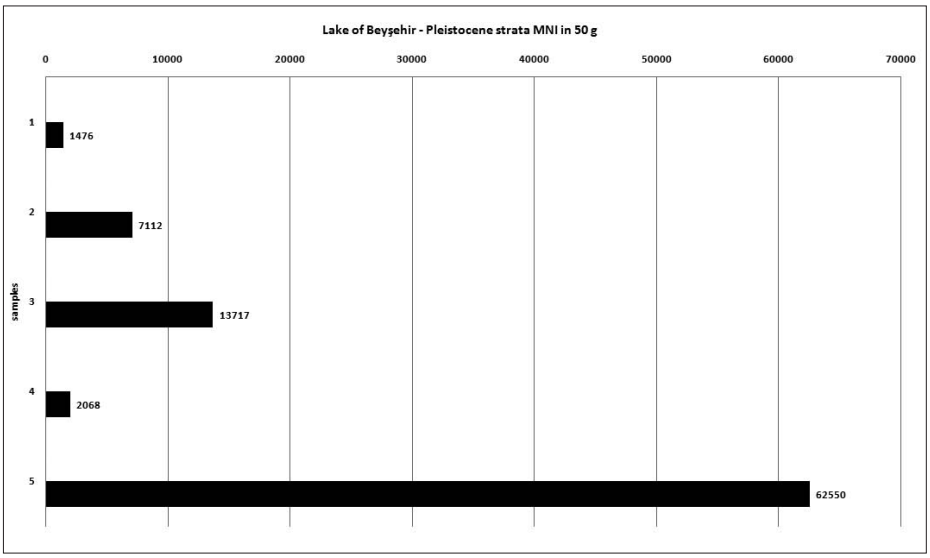

Fig. 5 - Lake Beyşehir, Minimum number of individuals (MNI) present in 50 g of residual sediment.

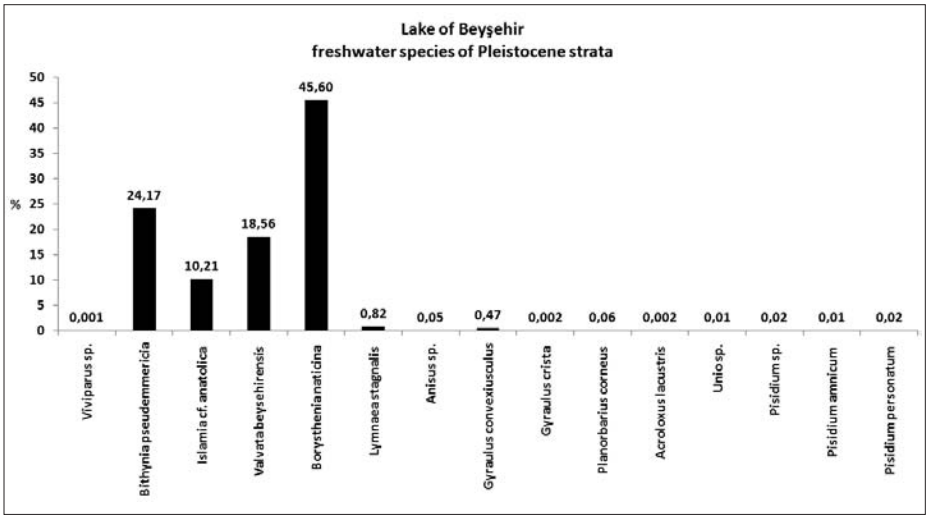

Fig. 6 - Frequency of the species from the Pleistocene strata of Lake Beyşehir.

With regard to the ecology of the species, these molluscs also belong to an oligotrophic lentic system (Yildirim, 2004). More specifically, species such as *Bithynia pseudemmericia*, *Lymnaea stagnalis, Anisus* sp.*, Gyraulus convexiusculus, Planorbarius corneus* and *Acroloxus lacustris* live in shallow muddy areas, where the water is slow moving and contains more nutrients.

Lake Beyşehir has never been deep and over time water levels have periodically dropped until it was little more than a pond (Roberts, 1982). The isotopic composition of this lake fell on an evaporation line and it was possibly related to a surface or underground outlet, lake turnover time, and the inflow volumes from the drainage basin (Gunyakti *et al*. 1993: 200, Fig. 3). It shares with ancient Anatolian *ovas* (dry lake beds) several species that are widespread in Anatolia: *Borysthenia naticina, Bithynia pseudemmericia* and *Pisidium amnicum* (Schütt, 1991).

This history helps to explain the composition of the fossil malacofauna, which indicates the presence of a coastal area with shores protected by heliophytic vegetation (*Phragmites*).

It makes difficult, though, a detailed analysis of changes in the molluscan fauna over time. Modest variations in frequency may be noted, perhaps due to differences in lake levels and presumable concomitant variations in salinity (Fig. 7).

An anomalous feature may be seen in Sample 3 (from a gyttja layer), in which *Islamia cf. anatolica* is completely absent, but *Valvata beysehirensis* (24.5%) and *Borysthenia naticina* (62.1%) unusually abundant. We know nothing of the ecology of fossil *Valvata beysehirensis*, except that the genus *Valvata* lives in lotic water conditions; the habitat of *Borysthenia naticina* in Turkey includes lakes, whereas in Europe it seems to consist of the sandy bottoms, covered with a thin detritus layer, of large and medium lowland rivers (Piechocki, 2004).

Sample 3 (from a gyttja layer) is lacking in Ostracods and the oogonia of the Characeae. Perhaps this stratum corresponded to a very low lake level and lacked an input of dead mollusc shells from springs near the lake.

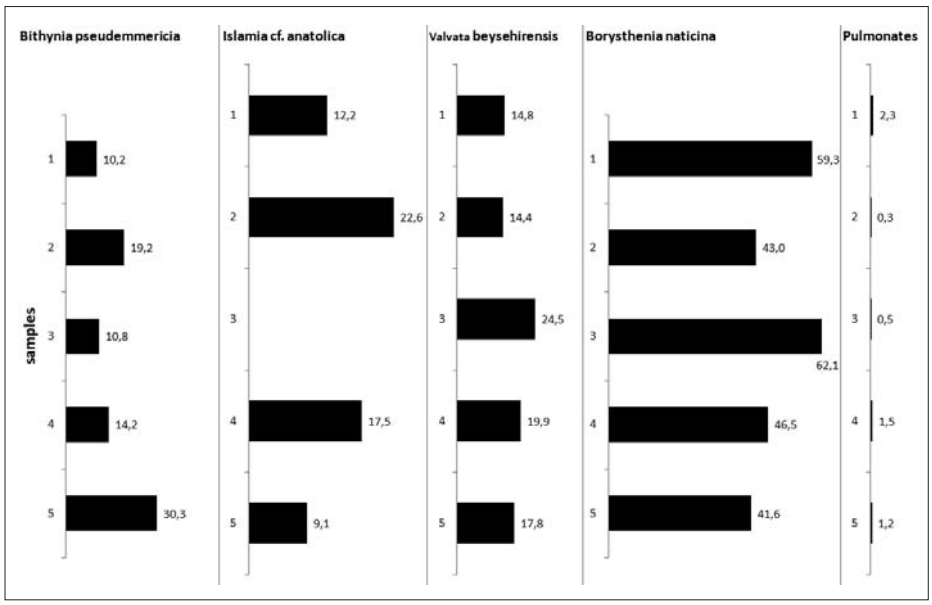

Fig. 7 - Frequencies of freshwater prosobranchs and pulmonates in the samples of the Pleistocene strata of Lake Beyşehir.

Faunistic changes in Lake Beyşehir and the Beyşehir-Suğla-Konya system, with the disappearance of some species and the arrival of others, occurred throughout the Quaternary in association with changes in their hydrological regimes (Tab. 3).

The absence of *Theodoxus heldreichi* in the Pleistocene layers studied is connected with the nature of the lakebed and the lack of a hard substrate. The following species are also not present in the sediments studied: *Graecoanatolica lacustristurca* Radoman 1973, *Graecoanatolica pamphylica* (Schütt, 1964), *Kirelia carinata* Radoman 1973, *Falsipyrgula beysehirana* (Schütt, 1965), *Falsipyrgula carinata* (Radoman, 1983), *Falsipyrgula schuetti* Yildirim 1999, *Valvata cristata* (Müller, 1774), *Valvata piscinalis* (Müller, 1774), *Dreissena polymorpha anatolica* (Locard, 1893), as well as several Planorbidae and bivalves (Schütt, 1965; Schütt, 1993; Schütt & Yildirim, 1999; Kebapçi & Yildirim, 2010; PDF 274, Yildirim & Kebapçi, 2009). *Dreissena polymorpha iconica* Schütt 1991 is listed in several ancient layers in the Beyşehir-Suğla basin (de Ridder, 1965; Erol, 1978; Schütt, 1993) and in the Konya basin it is found in alternate phases (Roberts, 1982; Roberts *et al*., 1999), but is not present in the Lake Beyşehir strata studied here.

It is possible that the absence of several small-sized species may be due to sampling methods.

Tab. 3 - Comparison of present-day and fossil lacustrine and land molluscs from the Beyşehir and Konya basins. (?) The presence of these species needs further confirmation.

Species	**Beyşehir Middle Pleistocene**	**Beyşehir living species**	**Konya Basin LGM Holocene**
Theodoxus heldreichi (Martens, 1879)		x	x
Viviparus sp.	x		
Viviparus contectus (Millet, 1813)		x	x
Bithynia pseudemmericia Schütt, 1964	x	x	x
Islamia cf. *anatolica* Radoman, 1973	x		
Graecoanatolica lacustristurca Radoman 1973		x	
Graecoanatolica pamphylica (Schütt, 1964)		x	
Kirelia carinata Radoman 1973		x	x
Falsipyrgula beysehirana (Schütt, 1965)		x	x
Falsipyrgula carinata (Radoman, 1983)		x	
Falsipyrgula schuetti Yildirim 1999		x	x
Valvata beysehirensis	x		
Valvata cristata (Müller, 1774)		x	x
Valvata piscinalis (Müller, 1774)		x	x
Borysthenia naticina (Menke, 1845)	x	x	
Oxyloma elegans (Risso, 1826)	x	x	
Tandonia sp.	x		
Lymnaea stagnalis (Linnaeus,1758)	x		

Species	Beyşehir Middle Pleistocene	Beyşehir living species	Konya Basin LGM Holocene
Stagnicola palustris (Müller, 1774)		x	
Galba truncatula (Müller, 1774)		x	
Radix auricularia (Linnaeus, 1758)		x	
Radix cf. ovata (Draparnaud, 1805)		**?**	
Planorbis planorbis (Müller, 1774)		x	
Anisus sp.	x		
Gyraulus albus (Müller, 1774)			?
Gyraulus convexiusculus (Hutton 1849)	x		
Gyraulus crista (Linnaeus, 1758)	x		
Gyraulus euphraticus (Mousson, 1874)		**?**	
Gyraulus piscinarum (Bourguignat, 1852)		x	
Segmentina nitida (Müller, 1774)		x	
Planorbarius corneus (Linnaeus, 1758)	x	x	
Acroloxus lacustris (Linnaeus, 1758)	x		
Unio sp.	x		
Unio pictorum (Linnaeus, 1758)		x	
Unio elongatulus eucirrus Bourguignat, 1860		x	
Pisidium sp.	x		
Pisidium amnicum (Müller, 1774)	x	x	
P. annandalei (Prashad, 1926)		x	
P. casertanum		x	
P. milium Held, 1856		x	
P. nitidum Jenyns, 1832		x	
Pisidium personatum Malm, 1855	x	x	
P. subtruncatum Malm, 1855		x	
Pisidium tenuilineatum		x	
Dreissena iconica Schütt, 1991			x
*Dreissena polymorpha anatolica (*Locard, 1893)		x	
Dreissena polymorpha iconica Schütt, 1991			

Observations and conclusions on the death-assemblages of the two lakes

The composition of recent freshwater mollusc faunas of the Anatolian Lakes is the result of ancient and modern events in the individual basins: climatic changes, geological features, modification of the water-level, periods of complete disappearance or transformation into marshland, variations of salinity, the impact of human activity (Driessen, 1970; Gunyakti *et al*., 1993; Kashima *et al*., 1997; Naruse *et al*., 1997; Kuzucuoğlu *et al*., 1999; Yavuz Özdemir & Özkan, 2007; Kazanci *et al*., 2008; Işildar, 2010). During the Pleistocene and Holocene right up to the present,

both abiotic and biological factors have influenced these lakes many times, causing both the disappearance and the reintroduction of various species.

Morphologically, the two lakes are similar: 45 and 48 km long, oriented north-south, not more than 10 m deep with average depths that vary between 5 and 9 m according to season. Over the last 50 years the level of Lake Eğirdir has varied by up to 5 m, and that of Lake Beyşehir by up to circa 3 m (Gülle *et al*., 2008; Işildar, 2010).

The mollusc population of Eğirdir Gölü is composed of species that dwell in micro-niches of various kinds and are distributed throughout the environment on three levels: on soft lakebed deposits with accumulated decaying plant debris, on harder deposits with gravel and stones covered with *epiphyton,* or on hydrophytic or heliophytic aquatic plants. This three-dimensionality ends with the death of the individual animals, the shells of which accumulate on the bottom. These are mixed by wave action and washed up on the shores. These natural phenomena may make reliable palaeoenvironmental interpretation difficult during the study of archaeological material. When a shell accumulation is the result of repeated water movements that mix the lake-bottom deposits, the material is usually damaged, the shells abraded and weakened-before being subjected to further fragmentation when they are disturbed by extraction and study. When, on the other hand, an accumulation is the result of primary deposition, the shells tend to be well preserved; this applies to all species, regardless of the shape and robustness of the shell.

All the shells from the death-assemblage on the shore of Eğirdir Gölü were well preserved, including those of the Lymnaeidae and Physidae, which are less resistant than *Graecoanatolica, Valvata, Falsipyrgula, Bithynia, Theodoxu* and the pulmonate gastropods with flattened spirals in general (such as the Planorbidae). During the formation of the Eğirdir Gölü thanatocoenosis the malacological material was not subjected to powerful mechanical stresses. The large piles of empty shells on the shore of Lake Egirdir were created by wave action.

In the fossil malacofauna of Lake Beyşehir the death assemblages formed at greater depths (Samples 1, 2 and 4, from carbonatic layers) always contain species that would normally live near the shore. These are the pulmonate gastropods *Lymnaea stagnalis*, various *Gyraulus* sp., *Planorbarius corneus*, *Acroloxus lacustris* and *Oxyloma elegans*. This occurrence may only be explained in part by the greater depth during periods of high water levels of the lake. The phenomenon of sediment mixing always gives rise to uncertain palaeoenvironmental interpretations (Dominici & Zuschin, 2005). Such sediment mixing has been invoked in the case of Lake Konya, of large surface area but modest depth, where the high-energy environment and the resulting wave-action on the lake-bed and shoreline caused the erosion, transportation and redeposition of previously-accumulated sediments (Roberts *et al*., 1999: 629). A similar interpretation is adopted here with regard to Samples 1, 2 and 4 from Lake Beyşehir, in which the weakening and abrasion of the shells of *Bithynia pseudemmericia, Borysthenia naticina, Valvata beysehirensis* and *Islamica* cf. *anatolica* may be observed. This would likewise account for the presence of certain other components by there having been moved from the shore into deeper water.

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