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On the Recent and fossil malacofauna of "Vouliagmeni Lake", Perachora (Korinthiakos Gulf, Greece)

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Abstract

This study presents the Recent molluscan benthic fauna of Vouliagmeni "Lake," which is situated in the Perachora Peninsula near Loutraki, Korinthiakos Gulf and the fossil malacofauna from the adjacent Pleistocene marine terraces. Up to now, 207 living species (110 Gastropoda, 90 Bivalvia, 4 Polyplacophora and 3 Scaphopoda) have been documented. In addition, a benthic thanatocoenose includes vast quantities of the bivalve *Mytilaster marioni* (Locard, 1889), *Parvicardium exiguum* (Gmelin in Linnaeus, 1792) and the gastropod *Ventrosia ventrosa* (Montagu, 1803) which are not found living in the "lake" today. These species prove that the molluscan fauna was quite different during the near past. The existence of huge quantities of dead molluscs must be attributed to the ecological changes that occurred in the lake after its permanent connection to the Korinthiakos Gulf through an artificial canal that was opened one century ago. The fossil record includes 262 molluscan species (143 Gastropoda, 111 Bivalvia, 3 Polyplacophora, 5 Scaphopoda) from which 129 species have not been mentioned before for Perachora, while according to the available literature, about 80 of them have not been mentioned before for any other Upper Pleistocene locality in Greece.

Riassunto

Questo studio ha come oggetto la fauna a molluschi bentonici del lago di Vouliagmeni (Penisola di Perachora, nei pressi di Loutraki, Golfo di Korinthiakos) e la malacofauna dei terrazzi marini pleistocenici adiacenti. È stata documentata la presenza di 207 specie viventi (110 Gastropoda, 20 Bivalvia, 4 Polyplacophora e 3 Scaphopoda). Inoltre, è stata rinvenuta una tanatocenosi caratterizzata dall'enorme quantità dei bivalvi *Mytilaster marioni* (Locard, 1889) e *Parvicardium exiguum* (Gmelin in Linnaeus,1972) e del gasteropode *Ventrosia ventrosa* (Montagu, 1803) dei quali non esistono segnalazioni, come specie viventi, nell'area studiata. La presenza di queste specie conferma che la fauna a molluschi, vissuta in un recente passato nel lago di Vouliagmeni, era abbastanza differente rispetto a quella attualmente vivente nella medesima località. Le ragioni della presenza dell'enorme quantità di molluschi morti devono essere attribuite ai cambiamenti ecologici, occorsi al lago in seguito alla connessione con il Golfo di Korinthiakos attraverso un canale artificiale aperto un secolo fa. La malacofauna fossile comprende 262 specie (143 Gastropoda, 111 Bivalvia, 3 Polyplacophora, 5 Scaphopoda) delle quali 129 non erano note per Perachora, mentre 80, da quanto desunto dalla bibliografia, non erano mai state segnalate nel Pleistocene superiore della Grecia.

Key words

Mollusca, Pleistocene Marine terraces, Vouliagmeni Lake, Perachora, Greece.

Introduction

The Perachora Peninsula has been the subject of numerous studies in the past by many authors, because of its active tectonics and seismicity. On the contrary, the palaeontological information concerning its very rich fossiliferous marine Pleistocene terraces, is inadequate. Some of the fossiliferous sections have been studied by Deperet (1913) and Mitzopoulos (1933), while remarks focusing mainly on the destructive terraces have been made in the past by Imperatori (1962), Keraudren (1970), Schröder (1970), Herforth & Richter (1979), Richter *et al.* (1990), Dell'Angelo & Vardala-Theodorou (in press), etc. There was also no study concerning the recent benthic malacofauna and the influence of human activities on the fauna of the Vouliagmeni "lake". The aim of the study is to enrich our knowledge on the spatial and temporal distribution of the molluscan species of the wider Perachora area. In order to achieve this, the marine faunistic assemblages of 30 fossiliferous sections of the Perachora peninsula are presented in the same comparative table with the recent benthic fauna of "lake" Vouliagmeni. In order to understand the evolution of Perachora Peninsula during the Quaternary, the use of absolute dating on shells and the study of palaeoshores has been incorporated.

Matherial and methods

Study area

The Perachora peninsula, is located at the eastern part of Korinthiakos Gulf (38° 1'-38° 3'N and 22° 51'-22° 55'E). (**Fig. 1**). The tectonic activity of the area has strongly influenced the evolution of the lake and the altitude of the marine terraces at an epoch of parallel significant climatic changes and eustatic phenomena (Mariolakos *et al.*, 1982). The study area provides an excellent oppor-

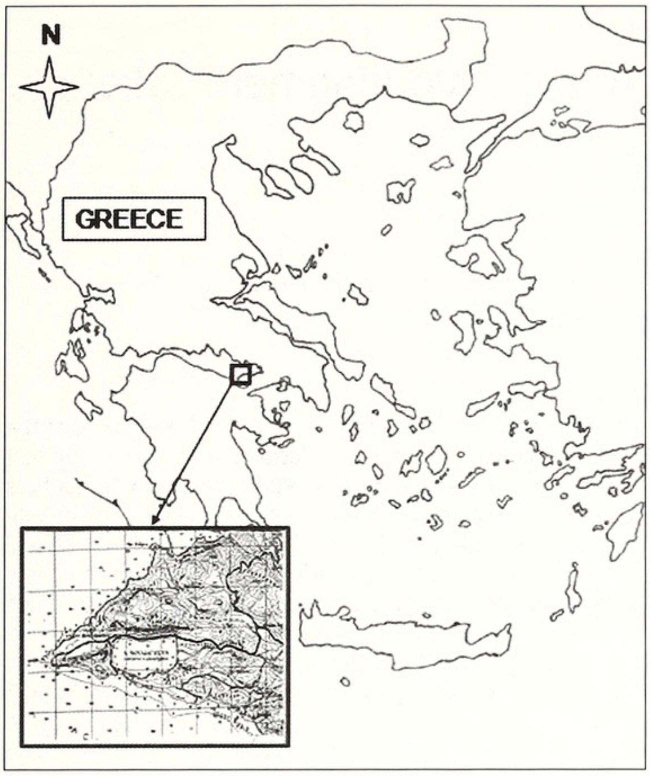

Fig. 1. Map of Greece and Perachora Peninsula.

Fig. 1. Carta della Grecia e della Penisola di Perachora.

tunity to investigate Quaternary marine terraces and compare their fauna to the recent Molluscan fauna.
A little more than 100 years ago, the lake was connected to the open sea by an artificial canal. This human activity had significant influence on the benthic fauna composition. The Vouligmani "lake" occupies a major part of the Perachora peninsula, has a length of 1.8 km, a width of 950 m and a maximum depth of 45 m. Today a strong input and output current is observed at a six-hour period through the artificial canal that connects the "Lake" to Korinthiakos Gulf. In addition, during the inflow period, the water level of the lake rises, about 40-50 cm, as huge quantities of water flow in.

Sampling activities

Sampling was carried out in the "Lake" at 100 stations, covering the total area and using Anchor Dredge, during the period 1992-1995. Sediments were sieved in the field through 1 mm or 0.5 mm mesh sieves, stained with *Rose de Bengal* and fixed in 4% Formalin. Sorting took place in the laboratory. In addition, field measurements of depth, water temperature, salinity, transparency and dissolved oxygen were made (Vardala-Theodorou, 1998). Sediment grain-size analysis was performed for each section (dry sieving) according to Folk (1974). At the fossil sections, sampling was carried out repeatedly until no new species could be found. Selected samples were disintegrated in water and sieved through 0.5 mm or 1 mm mesh screens before sorting. For the marine terraces, trace fossils, marine notches, fissures, (Pirazzoli, 1986) and erosion surfaces were also studied. Lithostratigraphic, palaeoecologic – including palaeotaphonomical – studies were conducted for each section. Sampling for absolute dating by the ESR and TL methods (Michail *et al.*, 1998) was carried out in collaboration with NCSR-Demokritos in Athens (Institute of Archaeometry, Dr. E. Bassiakos and Dr. N. Zacharias). Species ecological preferences were given (Vardala-Theodorou 1998) for all species according to Cadee (1984), Geronimo (1985), Ferrero & Merlino (1992), Zenetos (1986), Koutsoumbas (1992) while the different types of biocoenoses and bathymetric zones were given according to Peres & Picard (1964). Determination was based on classical taxonomical papers and check lists, while more recent papers and data bases were also used (Sabelli *et al.* 1990, Zenetos, 1996, Koutsoumbas 1992, Giannuzzi-Savelli *et al.*, 1994, 1996, 1999, 2001, 2003, 2005, Ponder, 1985, Bouchet & Rocroi 2005, Pedriali & Robba 2005, Zenetos *et al.* 2003, 2005; Clemam, 2004, http://www.mnhn.fr/base. malaco.html, CIESM, http://www.ciesm.org/online/atlas/index.htm, ITIS http://www.itis.usda.gov.)

Results

Recent fauna

The recent molluscan fauna of the Vouliagmeni "Lake" given in **Table 1** includes 207 living benthic taxa (110 Gastropoda, 90 Bivalvia, 4 Polyplacophora, 3 Scaphopoda), sampled from 100 stations. Water temperature varied from 6°C in February to 27°C in July. The salinity varied from 33% to 38 %. Dissolved oxygen varied from 6,5-8,5 mgr /lt at depths up to 15 m. Anoxic conditions prevailed at depths below 35 m. Transparency was studied with the use of SECCHI disk which was always visible up to the depth of 7 m but never more than 16 m. Grain-size analysis showed the existence of coarse grains, gravel and sand-gravel at the periphery of the lake at depths up to 15 meters, while clays and silts prevail at depths from 15-45 meters at the deeper central parts of the lake. As it has been documented for other localities (Vardala-Theodorou 1998), marine species usually living in biocoenoses and representing considerable depths, can been found living at depths less than 3 m, mainly in environments protected by the waves (Simboura *et al.*, 1995b). Dendrogramms (ibid 1998) based on the presence/absence of the recent benthic fauna did not allow a satisfying grouping of the stations. This is due to the very strong micro differences of the substrate of the peripheral zone and the restrictions of the sampling methods.

Fossil fauna

From the Upper Pleistocene terraces of Perachora peninsula - now at altitudes varying from 1 m up to 100 m, 262 Molluscan fossils from 30 sections have been identified (143 Gastropoda, 111 Bivalvia, 3 Polyplacophora, 5 Scaphopoda). From these, 129 species are mentioned for the first time for Perachora, while for about 80 of them this study is also the first record for the marine Pleistocene of Greece (Vardala Theodorou, 1998

MOLLUSCA		
POLYPLACOPHORA		
Lepidopleurus sp.	R	
Ischnochiton rissoi (Payraudeau, 1826)	R	
Chiton olivaceus Spengler, 1797	R	F
Callochiton septemvalvis (O.G. Costa, 1829)		F
Acanthochitona fascicularis Gray, 1821	R	F
GASTROPODA		
Patella caerulea Linnaeus, 1758	R	F
Patella rustica Linnaeus, 1758	R	F
Acmaea virginea (Müller, 1776)		F
Smaragdia viridis (Linnaeus, 1758)	R	F
Diodora gibberula (Lamarck, 1822)	R	F
Diodora graeca (Linnaeus, 1758)	R	F
Diodora italica (Defrance, 1820)	R	F
Emarginula octaviana Coen, 1939	R	F
Emarginella huzardii (Payraudeau, 1826)	R	F
Puncturella noachina (Linnaeus, 1771)?	R	
Scissurella costata D'Orbigny, 1824		F
Haliotis tuberculata Linnaeus, 1758	R	
Clanculus corallinus (Gmelin in Linnaeus, 1791)	R	F
Clanculus cruciatus (Linnaeus, 1758)	R	F
Calliostoma conulus (Linnaeus, 1758)		F
Calliostoma Calliostoma) granulatum (Von Born, 1778)		F
Calliostoma (Calliostoma) gualterianum (Philippi, 1848)	R	
Calliostoma (Calliostoma) laugieri (Payraudeau, 1826)		F
Calliostoma (Calliostoma) zizyphinum (Linnaeus, 1758)		F
Jujubinus exasperatus (Pennant, 1777)	R	F
Jujubinus striatus striatus (Linnaeus, 1758)	R	F
Osilinus articulatus (Lamarck, 1822)	R	F
Osilinus mutabilis (Philippi, 1846)	R	F
Osilinus turbinata (Von Born, 1778)	R	F
Gibbula (Colliculus) adansonii (Payraudeau, 1826)	R	F
Gibbula (Gibbula) albida (Gmelin in Linnaeus, 1791)	R	F
Gibbula (Gibbula) ardens (Von Salis, 1793)	R	F
Gibbula (Strerомphala)divaricata (Linnaeus, 1758)		F
Gibbula (Forskalena) fanulum (Gmelin in Linnaeus, 1791)	R	F
Gibbula guttadauri (Philippi, 1836)	R	F
Gibbula (Gibbula) magus (Linnaeus, 1758)	R	F
Gibbula (Phorcus) philberti (Recluz, 1843)	R	
Gibbula (Phorcus) richardi (Payraudeau, 1826)	R	
Gibbula (Colliculus) turbinoides (Deshayes, 1835)	R	
Gibbula (Tumulus) umbilicaris (Linnaeus,1758)	R	
Tricolia pullus pullus (Linnaeus, 1758)	R	F
Tricolia speciosa (Von Muhlfeldt, 1824)		F
Tricolia tenuis (Michaud, 1829)	R	
Bolma rugosa (Linnaeus, 1767)		F
Cerithium rupestre Risso, 1826	R	F
Cerithium vulgatum (Bruguière, 1792)	R	F
Bittium reticulatum (Da Costa, 1778)	R	F
Bittium latreillii (Payraudeau, 1826)	R	F
Pirenella conica (Blainville, 1826)	D	F
Turritella communis Risso, 1826	R	F
Turritella turbona Monterosato, 1877	R	F
Melaramphe neritoides (Linnaeus, 1758)	R	F
Rissoa labiosa (Montagu, 1803)	R	F
Rissoa monodonta Philippi, 1836		F
Rissoa similis Scacchi, 1836		F
Rissoa splendida Eichwald, 1830	R	F
Rissoa ventricosa Desmarest, 1814	R	
Alvania (Alvania) cancellata (Da Costa, 1778)	R	F
Alvania (Alvania) carinata (Da Costa, 1778)	F	
Alvania (Alvania) cimex (Linnaeus, 1758)	R	F
Alvania (Alvania) discors (Allan, 1818)		F
Alvania (Alvania) geryonia (Chiereghin in Nardo, 1847)	R	
Alvania (Alvania) testae Aradas & Maggiore, 1844	R	
Setia sp.		F
Manzonia crassa (Kanmacher, 1798)	R	F
Manzonia zetlandica (Montagu, 1811)		F
Pusillina marginata (Michaud, 1832) F		
Pusillina incospicua (Alder, 1844)	R	
Pusillina lineolata (Michaud, 1832)	D	F
Pusillina philippi (Aradas & Maggiore, 1844)	R F	
Rissoina (Rissoina) bruguieri (Payraudeau, 1826)	R	F
Caecum auriculatum De Folin, 1868	R	
Caecum clarkii Carpenter, 1858	R	
Caecum subannulatum De Folin, 1870	R	
Caecum trachea (Montagu, 1803)	R	F
Circulus tricarinatus (Wood, 1848)	F	
Ventrosia ventrosa (Montagu, 1803)	D	F
Truncatella subcylindrica (Linnaeus, 1767)	R	
Aporrhais pespelecani (Linnaeus, 1758)	R	F
Calyptraea chinensis (Linnaeus, 1758)		F
Capulus hungaricus (Linnaeus, 1758)	R	F
Vermetus (Thylacodus) semisurrectus Ant. Bivona, 1832	R	
Vermetus (Vermetus) triquetrus Ant. Bivona, 1832	R	
Petaloconchus (Macrophragma) glomeratus (Linnaeus, 1758)		F
Zonaria pyrum (Gmelin, 1791)		F

Neosimnia spelta (Linnaeus, 1758)		F	*Nassarius (Hinia) pygmaeus* (Lamarck, 1822)	R	F
Lamellaria latens (Mueller, 1776)		F	*Nassarius (Hinia) reticulatus* (Linnaeus, 1758)		F
Erato laevis (Donovan, 1803)		F	*Cyclope neritea* (Linnaeus, 1758)		F
Trivia arctica (Pulteney, 1789)		F	*Columbella rustica* (Linnaeus, 1758)	R	F
Natica (Natica) dillwynii P Payraudeau, 1826		F	*Mitrella minor* (Scacchi, 1836)		F
Natica lactea Guilding, 1831		F	*Mitrella gervillii* (Payraudeau, 1826)		F
Natica (Naticarius) stercusmuscarum (Gmelin, 1791)	R	F	*Granulina clandestina* (Brocchi, 1814)		F
Euspira guillemini (Payraudeau, 1826)	R	F	*Gibberula philippii* (Monterosato, 1878)	R	F
Galeodea echinophora (Linnaeus, 1758)		F	*Mitra zonata* Marryatt, 1818		F
Cymatium sp.		F	*Vexillum (Pusia) ebenus* (Lamarck, 1811)		F
Phalium granulatum (Von Born, 1778)		F	*Vexillum (Pusia) littorale* (Forbes, 1843)	R	F
Phalium saburon (Bruguière, 1792)		F	*Vexillum tricolor* (Gmelin in Linnaeus, 1791)	R	F
Marshallora adversa (Montagu, 1803)	R	F	*Cancellaria cancellata* (Linnaeus, 1767)		F
Monophorus perversus (Linnaeus, 1758)	R	F	*Conus mediterraneus* Hwass in B Bruguière, 1792	R	F
Cerithiopsis tubercularis (Montagu, 1803)		F	*Comarmondia gracilis* (Montagu, 1803)		F
Dizoniopsis bilineata (Hoernes, 1848)		F	*Raphitoma concinna* (Scacchi, 1836)	R	F
Epitonium commune (Lamarck, 1822)	R	F	*Raphitoma echinata* (Brocchi, 1814)		F
Gyroscala lamellosum (Lamarck, 1822)	R	F	*Raphitoma laviae* (Philippi, 1844)	R	
Epitonium turtoni (Turton, 1819)	R	F	*Raphitoma leufroyi* (Michaud, 1828)	R	F
Punctiscala cerigottana (Sturany, 1896)		F	*Raphitoma linearis* (Montagu, 1803)	R	
Melanella frielei (Jordan, 1895)		F	*Raphitoma purpurea* (Montagu, 1803)	R	
Eulima glabra (Da Costa, 1778)		F	*Philbertia horrida* Monterosato, 1884	R	F
Vitreolina sp.		F	*Crassopleura incrassata* (Dujardin, 1837)		F
Vitreolina incurva (B.D.D., 1883)		F	*Bela brachystoma* (Philippi, 1844)	R	
Bolinus brandaris (Linnaeus, 1758)	R	F	*Bela nebula* (Montagu, 1803)	R	F
Hexaplex trunculus (Linnaeus, 1758)	R	F	*Mangelia attenuata* (Montagu, 1803)	R	
Trophonopsis muricatus (Montagu,1803)	R		*Mangelia smithii* (Forbes, 1840)	R	F
Muricopsis cristata (Brocchi, 1814)	R	F	*Mangelia stossiciana* Brusina, 1869		F
Typhinellus sowerbyi (Broderip, 1833)	R		*Mangelia vauquelini* (Payraudeau, 1826)	R	
Hadriania oretea (De Gregorio,1885)	R	F	*Mangelia unifasciata* Deshayes, 1835	R	
Ocinebrina aciculata (Lamarck, 1822)		F	*Heliacus subvariegatus* (D'Orbigny, 1852)	R	F
Ocinebrina edwardsii (Payraudeau, 1826)	R		*Pseudotorinia architae* (O.G. Costa, 1841)		F
Buccinulum corneum (Linnaeus, 1758)		F	*Odostomia conoidea* (Brocchi, 1814)	R	
Pisania striata (Gmelin in Linnaeus, 1791)	R	F	*Odina* sp.		F
Fusinus pulchellus (Philippi, 1844)		F	*Turbonilla delicata* (Monterosato, 1874)	R	F
Fusinus rostratus (Olivi, 1792)		F	*Turbonilla jeffreysii* (Jeffreys,1848)		F
Fusinus syracusanus (Linnaeus, 1758)	R		*Turbonilla lactea* (Linnaeus, 1758)	R	F
Fasciolaria lignaria Linnaeus, 1758		F	*Turbonilla rufa* (Philippi, 1836)	R	F
Nassarius (Telasco) costulatus cuvierii (Payraudeau, 1826)	R	F	*Acteon tornatilis* (Linnaeus, 1758)	R	F
Nassarius (Sphaeronassa) mutabilis (Linnaeus, 1758)		F	*Retusa semisulcata* (Philippi, 1836)		F
Nassarius (Niothia) denticulatus (A. Adams, 1851)	R	F	*Retusa. truncatula* (Bruguière, 1792)	R	F
Nassarius incrassatus (Strom, 1768)	R	F	*Retusa obtusa* (Montagu, 1803)		F
Nassarius (Uzita) lima (Dillwin, 1817)	R		*Pyrunculus* sp.		F

Volvulella acuminata (Bruguière, 1789)	R	F	*Pteria hirundo* (Linnaeus, 1758)		F
Cylichnina umbilicata (Montagu,1803)		F	*Chlamys flexuosa* (Poli, 1795)	R	F
Ringicula auriculata (Menard D.L. Groye, 1811)		F	*Chlamys glabra* (Linnaeus, 1758)	R	F
Bulla striata Bruguière, 1792	R		*Chlamys multistriata* (Poli, 1795)	R	F
Atys brocchii (Michelotti, 1847)	R	F	*Chlamys (Manupecten) pesfelis* (Linnaeus, 1758)		F
Haminoea hydatis (Linnaeus, 1758)	R	F	*Chlamys varia* (Linnaeus, 1758)	R	F
Haminoea navicula (Da Costa, 1778)	R	F	*Pecten (Pecten) jacobaeus* (Linnaeus, 1758)	R	F
Weinkauffia turgidula (Forbes, 1844).	R	F	*Aequipecten opercularis* (Linnaeus, 1758)	R	F
Cylichna cylindracea (Pennant, 1777)		F	*Lissopecten hyalinus* (Poli, 1795)	R	F
Philine catena (Montagu, 1803)		F	*Palliolum incomparabile* (Risso, 1826)	R	
Philine aperta (Linnaeus, 1758)	R		*Lima (Mantellum) hians* (Gmelin in Linnaeus, 1791)	R	F
Cavolinia cf. inflexa (Lesueur, 1813)		F	*Lima (Mantellum) inflata* (Link, 1807)		F
Lobiger serradifalci (Calcara, 1840)	R		*Lima (Lima) lima* (Linnaeus, 1758)		F
SCAPHOPODA			*Limea (Limatulella) loscombi* Mac Gillivray, 1843	R	
Dentalium dentalis Linnaeus, 1758		F	*Spondylus gaederopus* Linnaeus, 1758		F
Dentalium inaequicostatum Dautzenberg, 1891	R	F	*Anomia ephippium* Linnaeus, 1758	R	F
Dentalium vulgare Da Costa, 1778	R	F	*Pododesmus (Heteranomia) squamula* (Linnaeus, 1758)	R	F
Fustiaria rubescens (Deshayes, 1825)	R	F	*Pododesmus (Monia) patelliformis* (Linnaeus, 1761)	R	F
Cadulus politus (S. Wood, 1842)		F	*Ostrea edulis* Linnaeus, 1758	R	F
BIVALVIA			*Ostreola stentina* (Payraudeau, 1826)		F
Nucula nitidosa Winckworth, 1930	R	F	*Anodontia (Loripinus) fragilis* (Philippi, 1836)	R	F
Nucula nucleus (Linnaeus, 1758)		F	*Loripes lacteus* (Linnaeus, 1758)	R	F
Nucula (Leionucula) tenuis (Montagu, 1808)		F	*Ctena (Ctena) decussata* (O.G. Costa, 1829)	R	F
Nuculana (Jupiteria) commutata (Philippi, 1844)		F	*Myrtea spinifera* (Montagu, 1803)	R	F
Nuculana (Lembulus) pella (Linnaeus, 1767)		F	*Lucinoma boreale* (Linnaeus, 1767)		F
Arca noae (Linnaeus, 1758)	R	F	*Lucinella divaricata* (Linnaeus, 1758)		F
Arca tetragona (Poli, 1795)		F	*Thyasira flexuosa* (Montagu, 1803)	R	
Barbatia (Barbatia) barbata (Linnaeus, 1758)	R	F	*Diplodonta rotundata* (Montagu, 1803)		F
Barbatia (Acar) clathrata (Defrance, 1816)		F	*Chama circinata* Monterosato, 1878		F
Striarca lactea (Linnaeus, 1758)	R	F	*Chama (Psilophus) gryphoides* Linnaeus, 1758	R	F
Glycymeris (Glycymeris) bimaculata (Poli, 1795)		F	*Pseudochama (Pseudochama) gryphina* (Lamarck,1819)	R	F
Glycymeris (Glycymeris) glycymeris (Linnaeus, 1758)		F	*Lepton (Lepton) squamosum* (Montagu, 1803)	R	
Glycymeris (Glycymeris) pilosa (Linnaeus, 1767)		F	*Kellia suborbicularis* (Montagu, 1803)	R	
Mytilaster marioni (Locard, 1889)	R, D	F	*Tellimya ferruginosa* (Montagu, 1808)		F
Mytilaster sp.		F	*Venericardia antiquata* (Linnaeus, 1758)	R	F
Mytilus (Mytilus) galloprovincialis Lamarck, 1819	R	F	*Glans trapezia* (Linnaeus, 1767)	R	
Modiolarca subpicta (Cantraine, 1835)	R		*Cardita calyculata* (Linnaeus, 1758)		F
Gregariella petagnae (Scacchi, 1832)		F	*Astarte sulcata* (Da Costa, 1778)	R	F
Musculus discors (Linnaeus, 1767)	R	F	*Didacna fuchsi* Philippson		F
Modiolus adriaticus (Lamarck, 1819)	R		*Acanthocardia (Acanthocardia) aculeata* (Linnaeus, 1758)		F
Modiolus barbatus (Linnaeus, 1758)	R		*Acanthocardia (Acanthocardia) deshayesii* (Payraudeau, 1826)		F
Lithophaga lithophaga (Linnaeus, 1758)	R	F	*Acanthocardia (Acanthocardia) echinata* (Linnaeus, 1758)	D	F
Pinna (Pinna) nobilis Linnaeus, 1758	R	F	*Acanthocardia (Acanthocardia) paucicostata* (G.B. Sowerby II, 1841)	D	F

Acanthocardia spinosa (Solander, 1786)		F	*Abra (Abra) alba* (W. Wood, 1802)	D	F
Acanthocardia (Rudicardium) tuberculata (Linnaeus, 1758)	R	F	*Abra (Abra) ovata* (Philippi, 1836) = *A. (Abra) segmentum* (Recluz, 1843)		F
Parvicardium exiguum (Gmelin in Linnaeus, 1791)	D	F			
Parvicardium ovale (G.B. Sowerby II, 1841)	R	F	*Coralliophaga lithophagella* (Lamarck, 1819)	R	F
Plagiocardium (Papillicardium) papillosum (Poli, 1795)	R	F	*Venus (Venus) verrucosa* Linnaeus, 1758	R	F
Laevicardium crassum (Gmelin in Linnaeus, 1791)	R	F	*Globivenus effossa* (Ant. Bivona in Philippi, 1836)		F
Laevicardium oblongum (Gmelin in Linnaeus, 1791)	R	F	*Chamelea gallina gallina* (Linnaeus, 1758)	R	F
Cerastoderma glaucum (Poiret, 1789)	D	F	*Clausinella brongniartii* (Payraudeau, 1826)	R	F
Cerastoderma edule Linnaeus, 1758?	D	F	*Timoclea (Timoclea) ovata* (Pennant, 1777)	R	F
Spisula subtruncata (Da Costa, 1778)	D	F	*Dosinia (Pectunculus) exoleta* (Linnaeus, 1758)	R	F
Donacilla cornea (Poli, 1795)	R		*Dosinia (Dosinia) lupinus* (Linnaeus, 1758)	R	F
Solen sp.	R	F	*Gouldia minima* (Montagu, 1803)	R	F
Ensis ensis (Linnaeus, 1758)	R	F	*Callista (Callista) chione* (Linnaeus, 1758)	R	F
Ensis siliqua minor (Chenu, 1843)	R	F	*Pitar (Pitar) rudis rudis* (Poli, 1795)	R	F
Tellina (Arcopella) balaustina Linnaeus, 1758		F	*Tapes (Ruditapes) decussatus* (Linnaeus, 1758)	R	F
Tellina (Tellinella) distorta Poli, 1791	R	F	*Paphia aurea* (Gmelin in Linnaeus, 1791)	R	F
Tellina (Moerella) donacina Linnaeus, 1758	R	F	*Paphia lucens* (Locard, 1886)	R	F
Tellina (Fabulina) fabula Gmelin, 1791		F	*Paphia rhomboides* (Pennant, 1777)		F
Tellina (Laciolina) incarnata Linnaeus, 1758	D	F	*Venerupis senegalensis* (Gmelin,1791)		F
Tellina (Peronidia) nitida Poli,1791		F	*Petricola (Lajonkairia) lajonkairii* (Payraudeau, 1826)	R	
Tellina pulchella Lamarck, 1818	R		*Petricola (Petricola) lithophaga* (Retzius, 1786)	R	F
Tellina (Serratina) serrata Renier in Brocchi, 1814		F	*Mysia undata* (Pennant, 1777)	R	F
Gastrana fragilis (Linnaeus, 1758)	D	F	*Corbula (Varicorbula) gibba* (Olivi, 1792)	R	F
Donax (Capsella) variegatus Gmelin in Linnaeus, 1791	R		*Gastrochaena dubia* (Pennant, 1777)	R	F
Psammobia (Gobraeus) depressa (Pennant, 1777)	R		*Hiatella arctica* (Linnaeus, 1767)	R	F
Psammobia (Psammobia) fervensis (Gmelin in Linnaeus, 1791)	R	F	*Saxicavella jeffreysi* Winckworth, 1930	R	
Psammobia (Psammobella) costulata Turton, 1822		F	*Pholas dactylus* Linnaeus, 1758		F
Azorinus (Azorinus) chamasolen (Da Costa, 1778)	R	F	*Thracia (Thracia) papyracea* (Poli, 1791)	R	
Solecurtus scopula (Turton, 1822)		F	*Thracia pubescens* (Pulteney, 1799)	R	F
Solecurtus strigillatus (Linnaeus, 1758)		F	*Clavagella melitensis* Broderip, 1835		F
Pharus legumen (Linnaeus, 1758)	R		*Pandora inaequivalvis* (Linnaeus, 1758)	R	
Scrobicularia cottardi (Payraudeau, 1826)		F	*Pandora pinna* (Montagu, 1803)	R	

Tab. 1. Checklist of Recent (R) molluscs from the "Perachora lake" and Pleistocene (F) molluscs from the fossiliferous terraces of the Perachora peninsula. D denotes species collected not alive, only shells.

Tab. 1. Checklist dei molluschi attuali (R) del "lago di Perachora" e di quelli pleistocenici (F) provenienti dai terrazzi fossiliferi della penisola di Perachora. D indica le specie raccolte solamente come conchiglie.

cum. lit). Thirty nine (39) species, including *Strombus bubonius* Lamarck, 1822 and *Tritonidea viverrata* Kiener – mentioned by Mitzopoulos (1933) for Perachora – have not been relocated. In addition, some species, *Mytilaster marioni* (Locard, 1989), *Parvicardium exiguum* Gmelin in Linnaeus 1791 and *Ventrosia ventrosa* (Montagu, 1803) were found only dead in extreme quantities during dredging. The usual ecosystem changes due to anthropogenic impact include (UNEP/MAP, 2004, 154 p. 4) Microbial contamination, Industrial pollution, Oil pollution, Fishing and Mariculture, Biological invasions, and Habitat loss. The last case is due mainly to trawling. The Perachora situation is quite different and does not fit in any of the proposed categories. It represents a habitat transformation. The opening of an artificial canal changed rapidly the situation. The entire "lake" was transformed into a completely open marine environment, allowing the increase of the species diversity (207 species). As shown in **Table 1**, the number of the recent living species is quite large (about 15 times more) in respect to the number of the species only found dead. Contrary to the species found alive, the dead species are found in extreme quantities. This never occurs for the recent species. The dead species represent the LEE biocoenose and were deposited before the artificial connection of the Lake to the open sea. Also, the species *Cerastoderma glaucum* (Poiret, 1789) has been found in loose sediments above and below the MSL and possibly represents a Holocene (Flandrian?) transgression. A similar (opposite) situation is given by Ozturk *et al.* (2002). At Lake Bafa inTurkey, the changes in the ecological situation and the isolation of the lake by an alluvium set had as a result the drastic increase of *Mytilaster marioni* and the disappearance of *Dressenia polymorpha* due to changes of salinity. In the case of Turkey, the transformation is due to natural causes and in Perachora, Greece to human activity. Both recent and fossil materials are stored in the Shell collection at Goulandris Natural History Museum in Kifissia, Greece. The total checklist of the Recent (R), Fossil (F) and Dead (D) Mollusca documented for Perachora study area is given bellow. Trace fossils of *Lithodomus* were found in numerous sites all over the study area. Their altitude varied from less than 1 meter up to 100 m. Usually they could be correlated with depositional terraces. Absolute dating has been realized on 4 Mollusca species and one Coral, collected from five sections ranging in altitude from 4 m to 100 m. (**Table 3**).

Fossil site (F)	Altitude in m	Grouping
F. 20	0,5-1	a
F. 25	45	c
F. 32	2	a
F. 32	10-12	c
F. 32	30-35	d
F. 45	10-14	c
F. 60	1-2	a
F. 71-91	1-1,5	a
F. 75	1-3	a
F. 90	1-2	a
F. 90	4-6	b
F. 98	32-37	d
F. 105	100	e
F. 170-180	1-2	a
F. 590	10	c
F. 650	2-3	a

a group – *Lithodomus* traces at altitudes 0-3 m
b group – *Lithodomus* traces at altitudes 4-6 m
c group – *Lithodomus* traces at altitudes 10-15 m
d group – *Lithodomus* traces at altitudes 30-45 m
e group – *Lithodomus* traces at altitudes 95-100 m

Tab. 2. Checklist of Recent (R) molluscs from the "Perachora lake" and Pleistocene (F) molluscs from the fossiliferous terraces of the Perachora peninsula. D denotes species collected not alive, only shells.

Tab. 2. Checklist dei molluschi attuali (R) del "lago di Perachora" e di quelli pleistocenici (F) provenienti dai terrazzi fossiliferi della penisola di Perachora. D indica le specie raccolte solamente come conchiglie.

Discussion and conclusions

From the species that have been identified, 52 were found only as recent, 108 only as fossils and the rest living or Dead and Fossils. The living benthic marine malacofauna indicates a zone at the periphery of the lake that was strongly influenced by the substrate which is very rich in terrigenous elements, present mostly at depths less than 12-15 m. A zone including *Turritella communis* and *Corbula gibba* can be observed at depths from 15-30 m. At stations directly preceding this anoxic central area, the bivalve *Corbula gibba* has been collected at quantities up to 12. The index *Turritella/Corbula* varied from 25 to 0,08 at stations with increased occurrence of *Corbula* in comparison to stations with anoxic conditions in the center of the lake. Gadel & Mongin (1973) and Papathanasiou & Zenetos (1993), consider that the changes in relative quantities represent changes in chemical pollution. Up to now, there are no available data from Perachora to correlate the variation of the Index of *Turritella/Corbula* with pollution, sedimentation or turbidity. Changes in the relative quantities of *Turritella/Corbula* have been also observed at Pliocene fossiliferous localities (Vardala – Theodorou unpublished). This fact shows that the changes of the index must not be correlated only with human pollution. This opinion is not contradicting the fact that *Corbula gibba* is tolerant to excess of organic matter enrichment (Borja *et al.* 2000). At depths more than 30 m, the occurrence of Mollusca decreases rapidly, towards the clearly anoxic central and deeper part of the lake where no Mollusca are found. Biometrical studies, carried out on recent and

Code	Site	Altitude in m	Genus	species	Method	Absolute date
HR1	F. 20	4	*Glycymeris*	*glycymeris*	ESR	78 +/– 13 Ka
HR3	F. 500	5-6	*Spondylus*	*gaederopous*	ESR	59 +/– 9 Ka
HR4	F. 110	25-30	*Callista*	*chione*	ESR	69 +/– 11 Ka
TH2	F. 21	8-10	*Ostrea*	*edulis*	TL	86 +/– 15 Ka
TH8	F. 110	25-30	*Ostrea*	*edulis*	TL	91 +/– 20 Ka
TH6	F. 105	100	*Cladocora*	*caespitosa*	TL	132 +/– 35 Ka

Tab. 3. Absolute dates from Quaternary terraces of Perachora Peninsula (according to Vardala-Theodorou 1998 and Michail *et al.*, 1998).

Tab. 3. Datazioni assolute dei terrazzi quaternari della Penisola di Perachora (secondo Vardala-Theodorou 1998 e Michail *et al.*, 1998).

fossil material, showed no uniform trends for size differences between fossil and recent species in the Perachora area. (Vardala-Theodorou, 1998). The influence of human activities is strongly shown by the changes of the benthic malacofauna after the opening of the artificial canal. Before the opening of the canal, the salinity of the lake was lower, as it is clearly shown by the dead species (*Mytilaster marioni, Parvicardium exiguum, Ventrosia ventrosa*) found in extreme quantities, making up more than 50% of the weight of the dredged sample.

Natica lactea was collected only at the younger main terraces ("Neotyrrhenian"), where *Spondylus gaederopus* of large dimensions was also found. Quite often, the last two main depositional terraces are found at the same altitude. The oldest is quite eroded and the youngest fills the lower parts of the relief. The highest depositional fossiliferous terrace is found today at an altitude of about 100 m and has an absolute age of about 132.000 +/- 35.000 Ka. The main marine terraces were deposited during the last 3 main warm phases of the Quaternary. Destructive terraces are also well represented at altitudes varying from 0, 5 m to100 m. Trace fossils of *Lithodomus* have been documented at altitudes from less than 1 m up to lightly less than 100 m. (See **Table 2**).

The combined study on the Mollusca from the marine terraces and the recent benthic fauna increased our knowledge on the malacofauna of the Quaternary of Greece. It has not been possible to compare the recent malacofauna with that of the open sea of Korinthiakos gulf. The only detailed malacological study is limited to the Bivalves of the western part of Korinthiakos basin at Patraikos (Zenetos, 1986). The role of restriction of water circulation at the deeper parts of the lake is shown by the anoxic conditions that prevail at depths more than 35 meters, where obviously the water circulation is not at all affected by the very strong surface water circulation (Nicolaidou & Anagnostaki, 1983). But most of all, our study shows the role and the magnitude of human activities. The opening of the small artificial canal was the cause of the almost immediate death of huge quantities of species and triggered their replacement by the 207 recent species from Korinthiakos in a period of about 100 years.

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