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Paleoecology of the non-marine molluscs of the Pleistocene Stirone River sequence (Emilia, Northern Italy)

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KEY WORDS - *Paleoecology, Non-marine molluscs, Early Pleistocene, Middle Pleistocene, Northern Italy.*

ABSTRACT - *The Stirone River, a tributary of the Taro River, flows along the boundary between the Parma and Piacenza Districts; along its banks an almost 1000 m thick sedimentary sequence, ranging from the Messinian to the Pleistocene, crops out. Within the Pleistocene succession two main sedimentary cycles can be distinguished: the first (Early Pleistocene) is mostly deposited in a coastal marine environment and intercalated by one continental and two lagoonal episodes; the second (Early Middle Pleistocene) is deposited in a continental environment and separated from the lower beds by an erosional surface.*

The Early and Middle Pleistocene continental deposits have yielded abundant freshwater and land molluscan faunas, which give good indications as to the paleoenvironmental evolution. They suggest that, within the regressive phase of the long Plio-Pleistocene cycle, the area was characterized by a low-energy fluvial environment, followed, with a gradual transition, by two lagoonal episodes with marine intercalations due to sea ingression and regression respectively. The molluscan assemblage from the first Middle Pleistocene continental level indicates the settlement of a fluvial-lacustrine basin surrounded by grasslands and woods. The woodland gradually extended while water energy and depth decreased to form small water bodies.

In accordance with pollen analyses, the aquatic faunas from the two fluvial levels contain some species suggesting warm-temperate climate conditions. A lot of the land species found in the upper continental levels are indicative of a temperate climate.

RIASSUNTO - [Paleoecologia dei molluschi continentali della successione pleistocenica del Torrente Stirone (Emilia, Italia settentrionale)] - *Il Torrente Stirone, affluente del Fiume Taro, scorre lungo il confine fra le province di Parma e Piacenza; lungo le sue sponde affiora una successione sedimentaria dello spessore di un migliaio di metri, che abbraccia un intervallo di tempo dal Messiniano al Pleistocene. All'interno della porzione pleistocenica della successione si distinguono due cicli sedimentari principali: il primo, che si colloca nel Pleistocene inferiore, si è depositato in un ambiente marino costiero ed è intercalato da un episodio continentale e due lagunari; i sedimenti del secondo ciclo, separati da quelli sottostanti da una superficie di erosione, si sono invece depositi nel Pleistocene medio inferiore in ambiente continentale.*

Nei depositi continentali del Pleistocene inferiore e medio sono state rinvenute abbondanti malacofaune dulciacquicole e terrestri, le quali forniscono buone indicazioni riguardo all'evoluzione paleoambientale. Dai caratteri ecologici e dalle frequenze relative degli individui delle specie nelle associazioni si deduce infatti che, all'interno della fase regressiva del lungo ciclo plio-pleistocenico, l'area in esame era caratterizzata da un ambiente fluviale a bassa energia, al quale fecero seguito, attraverso gradualmente cambiamenti ambientali, due episodi lagunari con intercalazioni marine, dovuti rispettivamente a ingressione e regressione marina.

La malacofauna del primo livello continentale medio-pleistocenico indica l'instaurarsi di un bacino fluvio-lacustre circondato da boschi e distese prative, ambiente che gradualmente evolve verso un'espansione del bosco ed una riduzione di motilità e profondità delle acque, con il conseguente sviluppo di paludi.

In accordo con le analisi palinologiche, le malacofaune acquatiche provenienti dai due livelli fluviali danno indicazione di condizioni climatiche temperato-calde. Numerose specie terrestri rinvenute nei livelli continentali superiori risultano indicative di clima temperato.

INTRODUCTION

The Stirone River runs along the boundary between the Parma and Piacenza Districts, joining the Taro River just before it flows into the Po (Text-fig.1).

Along the Stirone River banks a sedimentary sequence nearly 1000 metres thick crops out. Its

lower part consists of 60 m of Messinian "lagomare" marlstones, overlain by about 800 m of Pliocene sediments (Iaccarino & Papani, 1980; Mary *et al.*, 1993). The sequence continues upwards with a Pleistocene regressive phase; in the uppermost part, continental deposits are separated by a discontinuity from the lower beds (Text-fig.2).

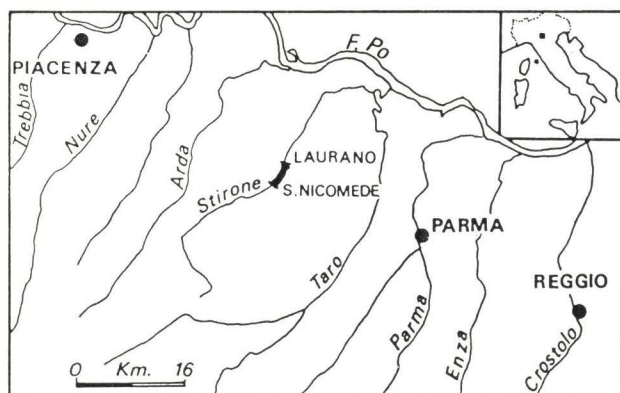
The Plio-Pleistocene succession has been the subject of many biostratigraphic, magnetostratigraphic and paleoclimatic studies (Papani & Pelosio, 1963; Lona & Bertoldi, 1972; Bucha *et al.*, 1975; Pelosio & Raffi, 1977; Bertolani Marchetti *et al.*, 1979; Raffi, 1982; Iaccarino & Pugliese, 1988; Mary *et al.*, 1993; Dominici *et al.*, 1996; Iaccarino, 1996). On the basis of these studies, the Plio-Pleistocene boundary is located within a bioclastic interval between 16 m and 28 m, if we refer to the stratigraphic log by Bertolani Marchetti *et al.* (1979) or Raffi (1982). According to Iaccarino (1996) this boundary falls probably about 3 m below the calcarenites which have the first occurrence of *Arctica islandica* (Linneo) at the top.

The Pleistocene succession is characterized by two main sedimentary cycles, separated by an erosional surface. Within the first cycle (Early Pleistocene), mostly deposited in a coastal marine environment, Pelosio & Raffi (1977) recognize four main oscillations of the sea level schematized as local sedimentary microcycles (see Text-fig. 2). Within the second microcycle, one continental and two lagoonal intercalations can be distinguished.

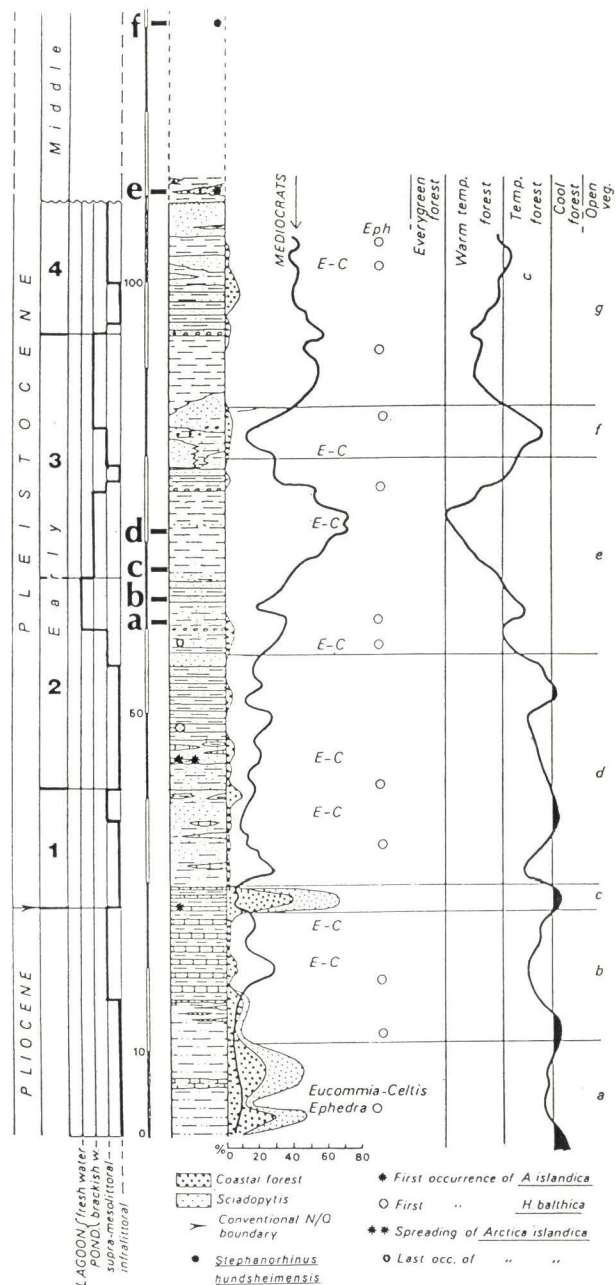
The deposits of the second cycle, whose outcrop is more than 50 m thick, unconformably overlie the marine succession and hold continental molluscan faunas and vertebrate remains. They are overlain by a well recognizable ferrallitic paleosol of regional extent (Paleosuolo di Collecchio) (Cremaschi, 1982). Their attribution to the Early Middle Pleistocene (Galerian Faunistic Unit, personal communication by Prof. B. Sala) is due to the occurrence of *Stephanorhinus hundsheimensis* (Toula) (*Dicerorhinus hemitoechus* (Falconer) in Cigala Fulgosi, 1976).

The Early and Middle Pleistocene continental deposits were sampled in order to study their

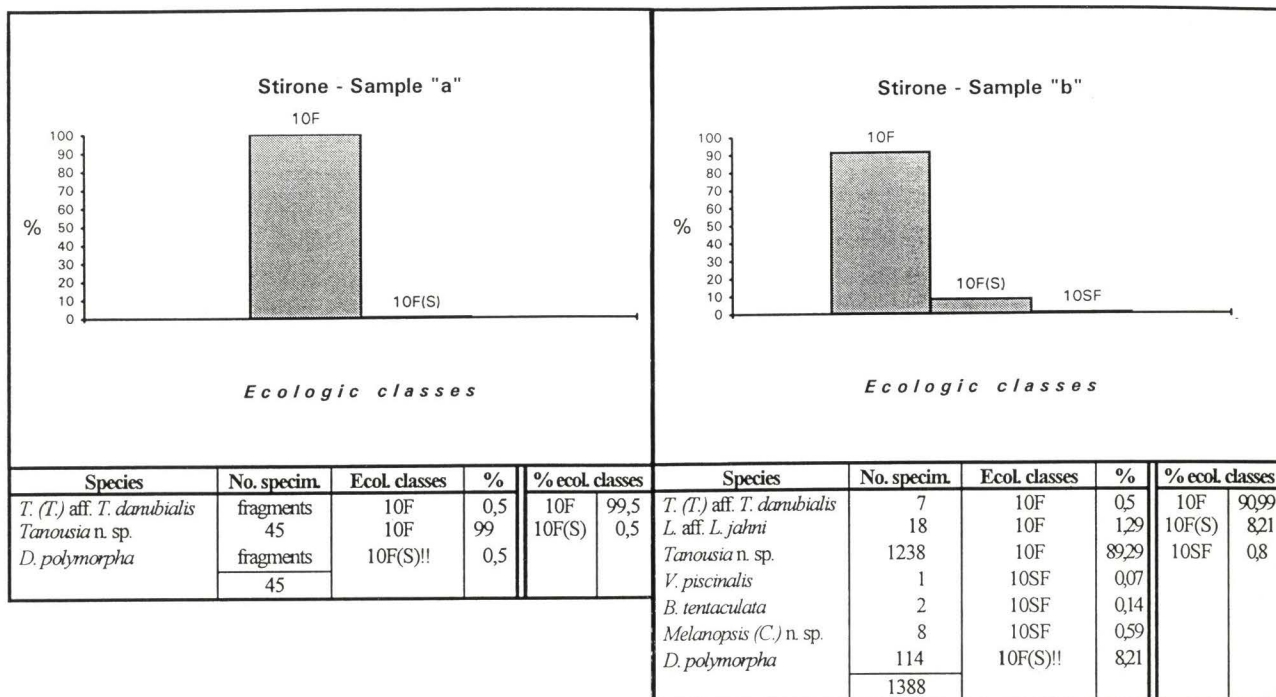
molluscan content. The samples yielded abundant freshwater and terrestrial molluscan faunas; the diversity of the assemblages found at different levels gives good indications as to the paleoenvironmental evolution.



Text-fig. 1 - Location map of the Stirone River sequence (from Bertolani Marchetti *et al.*, 1979).



Text-fig. 2 - Stratigraphic log of the Plio-Pleistocene Stirone river sequence with a graph of the paleoenvironment variations on the left and the mediocrats and climate curves on the right (from Bertolani Marchetti *et al.*, 1979, with modifications). The letters indicate the sampled levels and the numbers the four sedimentary microcycles recognized by Pelosio & Raffi (1977) within the Early Pleistocene cycle.



Text-fig. 3 - Paleoeologic features of the molluscan assemblages from samples "a" and "b". Species, number and percentage of specimens, ecologic classes and their relative frequency are reported in the tables. The graphs represent the ecologic spectra.

E C O L O G I C C L A S S E S	
(from Lozek, 1964)	
1W	strictly forestal species
2W(M)	species living mainly in woods, but also in mesophilous places and both damp and dry biotopes
2W(s)	species living in woods and scrubs, sometimes in open places (often in hedges and gardens)
5O	species living in open places without arboreous vegetation
8H	hygrophilous species
10F	aquatic species living in moving waters
10F(S)	aquatic species living in moving waters or (less frequently) in still waters
10P	aquatic species living in marshes and in shallow waters rich in vegetation
10S	aquatic species living in still waters
10SF	aquatic species living in still or moving waters
10SP	aquatic species living either in still waters or in marshes
10SPPp	aquatic species living either in still waters or in marshes and periodic marshes
★ ★	molluscs whose family has been identified, but whose genus and species can't be determined, so that there are not enough informations about their habitat
I	species indicative of warm-damp climate conditions
!!	species characterizing warm-damp climate conditions
+	loess species
(+)	species locally present in loess

Tab. 1 - List of the ecologic classes mentioned in the text and their explanation according to Lozek (1964).

PALEOECOLOGIC ANALYSIS

METHODS

For each sample unit the number of specimens and their percentage were calculated. Taking into consideration the habitat of the species, they were also placed in ecologic classes marked by the abbreviations explained in Tab. 1; then the percentages of the ecologic classes occurring in the sample unit were evaluated. A similar procedure was used by Lozek (1964) and Puisségur (1976) in their paleoeologic studies on Quaternary molluscan faunas of Eastern Central Europe and France.

The ecologic spectra obtained are expressed in histogram form in Text-figs. 3-5.

RESULTS

The first two samples ("a" and "b") were taken at different levels from the alternating thin sands and pelites outcropping on the right river bank between 59.60 m and 65.60 m (= level 10 in Raffi, 1982), as indicated in the log in Text-fig.2. This interval is referable to the lithostratigraphic "unit 5" described by Dominici *et al.* (1996); at the base it presents a discontinuous muddy level with peb-

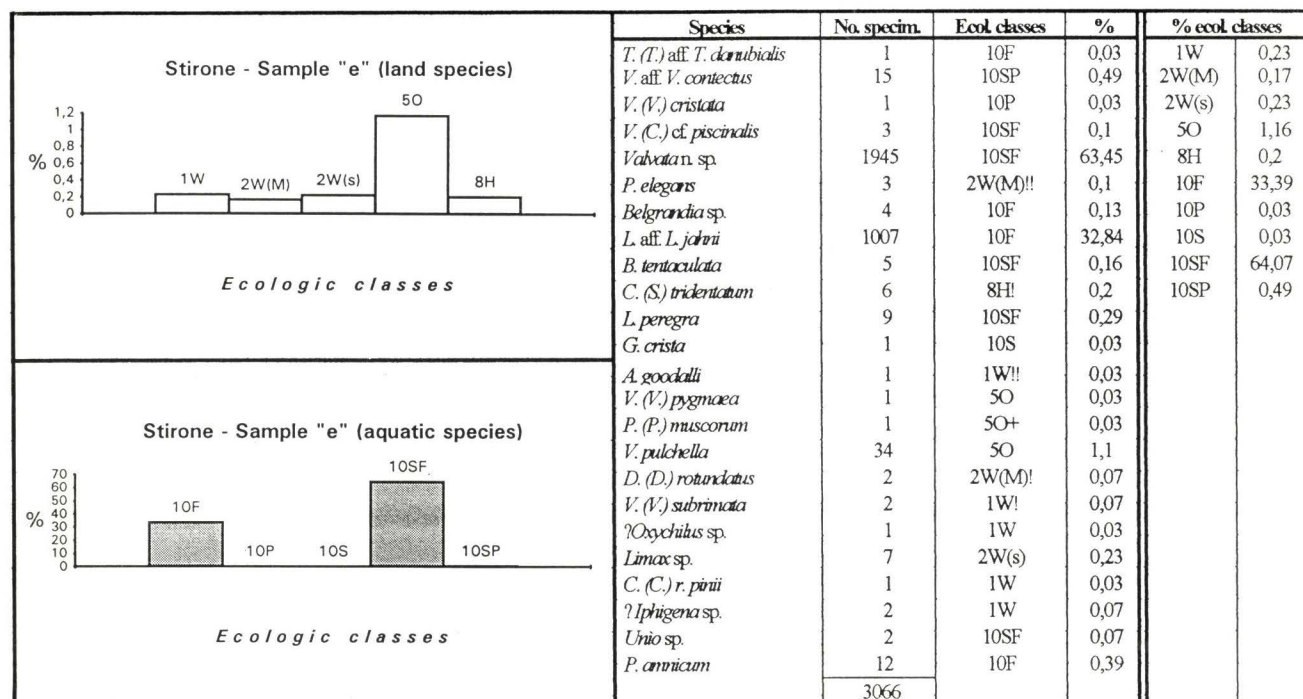
bles overlying shallow water marine deposits with the last occurrence of *Arctica islandica*. The faunal assemblages recorded at levels "a" and "b" are composed of a few freshwater prosobranchs and one bivalve species (Text-fig.3). The molluscs, often concentrated in lenses inside the sediment, are quite well preserved, and frequently the bivalve *Dreissena polymorpha* (Pallas) still has articulated valves with residual colouring characterized by zigzag bands, typical in this species. Both the assemblages are indicative of low-energy fluvial conditions, since *Tanousia* n.sp. is prevalent everywhere (100%; 89.26%): in fact the species belonging to this genus lived in fluvial systems (Schlickum, 1974). In sample "a" *Tanousia* n.sp. is associated only with fragments of *Theodoxus* (*Theodoxus*) aff. *T. danubialis* (Pfeiffer), a fluvial species, and of *Dreissena polymorpha*, also mostly living in moving waters (Glöer et al., 1985). In "b" these species occur, besides another fluvial species (*Lithoglyphus* aff. *L. jahni* (Urbanski)) and others able to colonize still or slowly-moving waters (*Valvata* (*Cincinna*) *piscinalis* (Müller), *Bithynia tentaculata* (Linneo), *Melanopsis* (*Canthidomus*) n.sp.); the presence of latter species seems to indicate that the river current was very slow at some points. The fossil contents of these levels also comprise Characeae gyrogonites, some Helicidae fragments and reworked marine organism

remains: forams, echinoid spines, gastropods (*Turritella*) and much eroded bivalve shells.

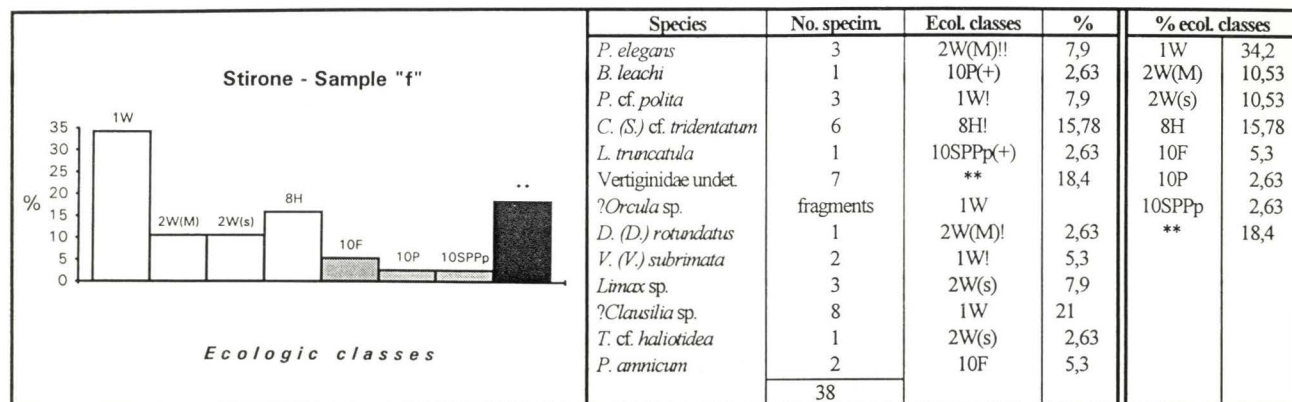
The third sample ("c") was taken not much above 65.60 m, at the bottom of the level corresponding to the first lagoonal episode in the succession, near a horizon containing *Cerastoderma glaucum* (Poiret). The sediment is rich in lignitic fragments. The molluscan fauna of sample "c" contains many specimens of the oligo-mesohaline hydrobiid *Hydrobia ventrosa* (Montagu) mixed with paralic gastropods, bivalves, forams and ostracods and a hundred specimens of the fluvial *Theodoxus* (*Neritaea*) *groyanus* (Férussac); it marks the transition from the freshwater environment just described to a paleolagoon characterized - according to Monegatti & Pelosio, 1994 - by a confinement between 4 and 3 degrees (zone IV) of the Guelorget & Perthuisot scale (1983).

Very frequent specimens of *H. ventrosa* were also found at the level of the second lagoonal episode ("d"), associated with strictly brackish and marine molluscs. *H. ventrosa* inhabits brackish water but prefers lower salinities, up to 2 ‰, and dislikes open coasts. It is usually confined to shallow drainage ditches, creeks or lagoons with a soft substratum and quiet water with little or no direct contact with the sea (Fretter & Graham, 1978).

Sample "e" was taken above 110 m (Text-fig. 2) in continental deposits which rest unconformably



Text-fig. 4 - Paleoeologic features of the molluscan assemblage from sample "e". Species, number and percentage of specimens, ecologic classes and their relative frequency are reported in the table. The graph represents the ecologic spectrum.



Text-fig. 5 - Paleocologic features of the molluscan assemblage from sample "f". Species, number and percentage of specimens, ecologic classes and their relative frequency are reported in the table. The graph represents the ecologic spectrum.

on the lower beds; it yielded a complete skull of *Stephanorhinus hundsheimensis* (Toula). Numerous land and freshwater species with many specimens were found in this layer (Text-fig. 4). 98% of the molluscan assemblage consists of aquatic molluscs, for the most part (64%) prosobranchs living in moving or still waters [*V. (C.) piscinalis*, *Valvata* n. sp., *B. tentaculata*], although species which colonize exclusively rivers and streams, such as *L. aff. L. jahni*, are also quite abundant (33.4%). The rest of the assemblage is composed of a very low percentage of land molluscs (about 2.4%) with differing ecologic features: forestal species [*Pomatias elegans* (Müller), *Azeca goodalli* (Férussac), *Discus (Discus) rotundatus* (Müller), *Vitrea (Vitrea) subrimata* (Reinhardt), ?*Oxychilus* sp., *Limax* sp., *Clausilia (Clausilia) rugosa pinii* Westerlund, ?*Iphigena* sp.] occur, besides hygrophilous species [*Carychium (Sara) tridentatum* (Risso)] and others which prefer more open places [*Vertigo (Vertigo) pygmaea* (Draparnaud), *Pupilla (Pupilla) muscorum* (Linneo), *Vallonia pulchella* (Müller)]. This kind of assemblage fits in with a fluvial-lacustrine environment with slowly moving waters rich in vegetation, surrounded by woodland with clearings.

The last sample ("f"), taken 20 metres above sample "e" from sediments bearing other remains of *S. hundsheimensis*, yielded a molluscan fauna poor in specimens comprising abundant land species (89%) (Text-fig. 5); most of them - such as *P. elegans*, *Platyla cf. polita* (Hartmann), *D. (D.) rotundatus*, *V. (V.) subrimata* - are characteristic of forestal biotopes, others, such as *C. (S.) tridentatum*, colonize very damp places. Few aquatic species (11%) occur in this assemblage, some of which [the prosobranch *Bithynia leachi* (Shepard) and the pulmonate *Lymnaea truncatula*

(Müller)] live in stagnant and others in moving waters [the bivalve *Pisidium amnicum* (Müller)]. The high percentage (nearly 55%) of forestal species indicates a prevalently woody environment, which probably included zones characterized by different degrees of humidity and swampy areas.

CONCLUSIONS

The molluscan data suggest that, at the end of the second local sedimentary microcycle (at about 60-66 m in Text-fig. 2), recognized by Pelosio & Raffi (1977) within the regressive phase of the long Plio-Pleistocene cycle, the area was characterized by a low-energy fluvial environment ("a" and "b"), followed with a gradual transition by two lagoonal episodes with marine intercalations caused by marine ingression and regression respectively ("unit 6" in Dominici *et al.*, 1996). The paleocologic reconstruction inferred by the paleontologic data of this portion of the sedimentary succession is not in good agreement with the preliminary paleoenvironmental interpretation based on sedimentologic data by Mutti (1996). The Author describes a general trend of facies as a depositional system of recessive fan delta and not, as appears from paleontologic data (Pelosio & Raffi, 1977; Raffi, 1982), as a trend towards a relative deepening. Mutti (1996) explains this fact as an effect of the local tectonic evolution.

The molluscan assemblage from the first Middle Pleistocene continental level (sample "e") indicates the settlement of a fluvial-lacustrine basin surrounded by grasslands and woods. This interpretation is in accordance with the sedimentologic data by Cremaschi (1982), who reveals in this portion of the sequence the presence of cyclothemes of meandrous and sinuous river

deposits. These units contain wood remains in the meander gravelly bars, besides mollusc and vertebrate remains in the silty deposits.

Through a gradual environmental evolution, the woodland extended, while water energy and depth decreased to form small water bodies; these conditions were favourable for the molluscan assemblage recorded in sample "f".

All the assemblages examined comprise some elements which give good paleoclimatic indications. As regards the aquatic faunas from the two fluvial levels, *Lithoglyphus* (sample "b"), *Melanopsis* (s. "b") and *D. polymorpha* (ss. "a" and "b") suggest warm-temperate conditions, in accordance with pollen analysis by Bertolani Marchetti *et al.* (1979). In fact, the genus *Lithoglyphus* and *D. polymorpha* are widespread in the Quaternary interglacial phases of Europe (Lozek, 1964) and the representatives of the genus *Melanopsis*, which became extinct in Italy at the end of the Early Pleistocene, live at present in warmer southern areas. The last two assemblages (samples "e" and "f") are rich in land species with climatic significance: *P. elegans*, *C. (S.) cf. tridentatum*, *A. goodalli*, *D. (D.) rotundatus*, *V. (V.) subrimata*. These species occur in the Quaternary warm-damp spans (Lozek, 1964) and therefore point to temperate climate conditions.

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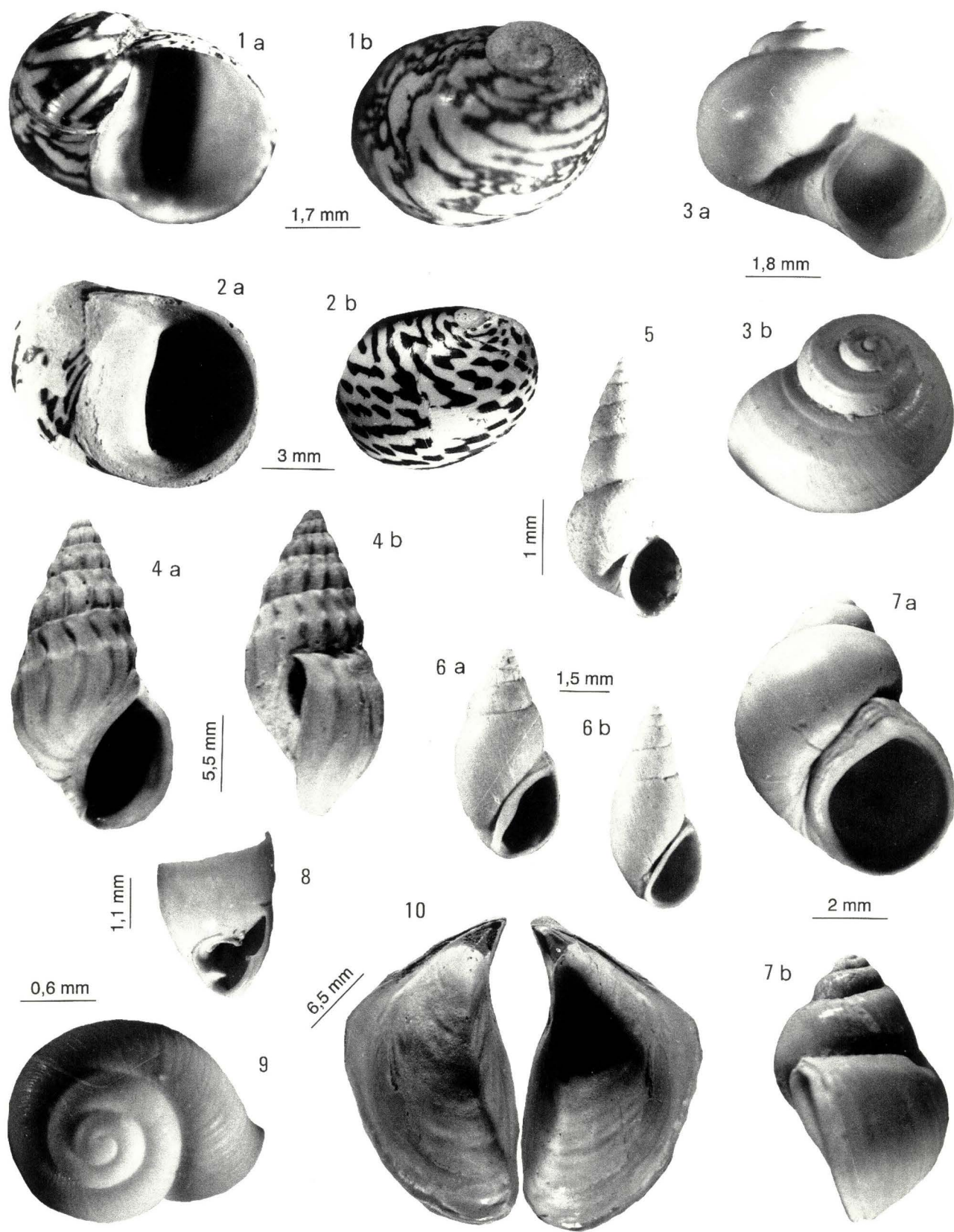
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EXPLANATION OF PLATE 1

- Fig. 1 - *Theodoxus (Neritaea) groyanus* (Férussac).
a,b) Stirone River (sample c); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0954; b) Esu-Girotti coll.; M.P.U.R. - 7 - 1342.
- Fig. 2 - *Theodoxus (Theodoxus) aff. T. danubialis* (Pfeiffer).
a,b) Stirone River (sample b); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0945; b) Esu-Girotti coll.; M.P.U.R. - 7 - 1341.
- Fig. 3 - *Valvata* sp.n.
a,b) Stirone River (sample e); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0937; b) Esu-Girotti coll.; M.P.U.R. - 7 - 1343.
- Fig. 4 - *Melanopsis (Canthidomus) sp.n.*
a,b) Stirone River (sample b); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0946; b) Esu-Girotti coll.; M.P.U.R. - 7 - 0947.
- Fig. 5 - *Hydrobia ventrosa* (Montagu).
Stirone River (sample d); Esu-Girotti coll.; M.P.U.R. - 7 - 0964.
- Fig. 6 - *Tanousia* sp.n.
a,b) Stirone River (sample b); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0949; b) Esu-Girotti coll.; M.P.U.R. - 7 - 1344.
- Fig. 7 - *Lithoglyphus* aff. *L. jahni* (Urbanski).
a,b) Stirone River (sample b); a) Esu-Girotti coll.; M.P.U.R. - 7 - 0948; b) Esu-Girotti coll.; M.P.U.R. - 7 - 1345.
- Fig. 8 - *Azeca goodalli* (Férussac).
Stirone River (sample e); Esu-Girotti coll.; M.P.U.R. - 7 - 0914.
- Fig. 9 - *Vallonia pulchella* (Müller).
Stirone River (sample e); Esu-Girotti coll.; M.P.U.R. - 7 - 0941.
- Fig. 10 - *Dreissena polymorpha* (Pallas).
Stirone River (sample b); Esu-Girotti coll.; M.P.U.R. - 7 - 0966.



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