

Paleoecologic and biochronologic meaning of the Early Pleistocene molluscan fauna from the Anghiari basin (Tiber River Upper Valley, Central Italy)

Antonella CIANGHEROTTI

Daniela ESU

Dipartimento di Scienze della Terra
Università "La Sapienza", Roma

KEY WORDS – Non-marine molluscs, Paleoecology, Biochronology, Early Pleistocene, Central Italy.

ABSTRACT – The Anghiari Basin, part of the Tiber River Upper Valley, is located on the Umbria-Tuscany boundary (Central Italy). A Lower Pleistocene sedimentary succession cropping out in a clay quarry in the locality Fighille/Citerna (Arezzo, Tuscany) has yielded rich non-marine molluscan assemblages. They indicate that in the Early Pleistocene this area evolved from a mesophilous woody to a more open and damp environment through alternating palustrine phases (due to flooding episodes) and drier periods. The high species diversity and the occurrence of some species having a high climatic significance are indicative of a temperate-warm climate.

The examined assemblages are characterized by the prevalence of still living terrestrial taxa; only three species are extinct: *Gastrocypa* (*Vertigopsis*) *dehmi* Schlickum & Strauch, *Multidentula helenae* Esu and *Parmacella* (*Parmacella*) cf. *P. (P.) sp. 1* sensu Manganelli & Giusti. The structure of the molluscan assemblages is typical of an Early Pleistocene molluscan fauna that can be referred to the Tasso Faunal Unit.

RIASSUNTO – [Significato paleoecologico e biocronologico delle malacofaune del Pleistocene inferiore del Bacino di Anghiari (Alta Valle del Fiume Tevere, Italia Centrale) – Il bacino di Anghiari è localizzato nell'Alta Valle del Fiume Tevere, al confine fra l'Umbria e la Toscana ed è solcato dal Torrente Sovara. Uno dei migliori affioramenti dei depositi pleistocenici del bacino è rappresentato da una cava di argilla in località Fighille/Citerna; nella successione esposta, di età pleistocenica inferiore, sono stati campionati sette distinti livelli, caratterizzati da una malacofauna abbondante e diversificata, che ha fornito interessanti dati paleoecologici e biocronologici. La composizione delle sette associazioni, in cui i taxa terrestri risultano prevalenti, mostra l'evoluzione dell'area da un ambiente boscoso mesofilo (livello 1) ad uno più aperto ed umido (livello 7), attraverso un'alternanza di fasi estremamente umide, legate ad episodi di allagamento e caratterizzate da condizioni di ambiente palustre (livelli 2, 4 e 5), e di fasi più aride, in cui la vegetazione erbosa era dominante (livelli 3 e 6). L'elevato grado di diversità specifica delle associazioni e la presenza di alcune specie particolarmente significative dal punto di vista paleoclimatico suggeriscono il sussistere, durante il periodo di deposizione della successione, di condizioni climatiche temperato-calde.

Delle associazioni esaminate, caratterizzate dalla prevalenza di taxa viventi, fanno parte tre specie terrestri estinte (*Gastrocypa* (*Vertigopsis*) *dehmi* Schlickum & Strauch, *Multidentula helenae* Esu e *Parmacella* (*Parmacella*) cf. *P. (P.) sp. 1* sensu Manganelli & Giusti) che consentono di attribuire la malacofauna di Fighille al Pleistocene inferiore (Unità Faunistica Tasso).

INTRODUCTION

At the Umbria-Tuscany boundary, the Tiber River Upper Valley is divided into two parallel tectonic depressions separated by the Anghiari Rift: the Sansepolcro basin, drained by the Tiber River, and the Anghiari basin, drained by the Sovara Stream (Text-fig. 1).

The morphologic and tectonic evolution of this area and the stratigraphy of the sediments filling the basins have been recently studied (Cattuto *et al.*, 1992; 1995). The substratum of the Anghiari basin consists of turbiditic complex – the "Macigno" and "Marnoso-Arenacea" Formations – which are characteristic units of the Tuscan-Umbrian sequence; they are overlain by a thick fluvial-lacustrine clastic sequence, which was deposited during the Pleistocene (Cattuto *et al.*, 1995). Its sediments consist of gravel, sand and silty-clay; the latter lithology prevails at the base of the sedimentary succession.

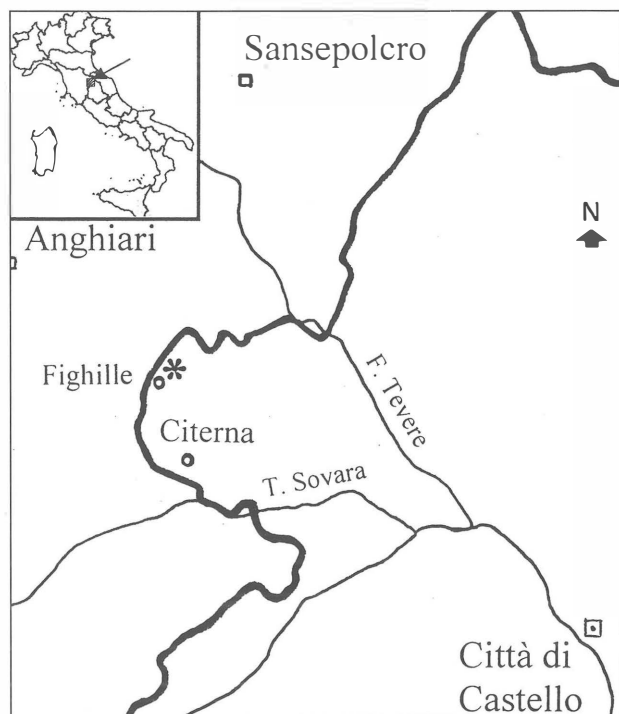
In Lower Pleistocene deposits cropping out in a clay quarry in the locality Fighille/Citerna (Arezzo, Tuscany), rich non-marine molluscan assemblages

and vertebrate remains have been found within the lower strata of the succession.

In the Fighille quarry, one of the best outcrops of the Pleistocene sequence was exposed. Its lower unit is formed by 15 metres of tilted grey clay bearing rich non-marine molluscs and some vertebrate remains with alternating reddish silty levels and conglomerate lenses; above this unit, a sub-horizontal gravel-sand complex is present. An angular unconformity has been recognized between the two units (Cattuto *et al.*, 1995).

The scanty vertebrate remains were identified by F. Masini (personal communication, October, 1998) as *Leptobos* ex gr. *L. etruscus* (Falconer) – *L. vallisarni* Merla. They indicate that the deposition of the Quaternary fluvial-lacustrine sequence started in the Early Pleistocene, because the biochronologic range of these bison-like forms is comprised between the Olivola and Farneta Faunal Units (F.U.) (Late Villafranchian); dubious presence of *L. vallisarni* is recorded up to the Colle Curti F.U. (Early Galerian) (Gliozzi *et al.*, 1997).

The upper levels of the same locality, bearing vertebrate remains referred to *Elephas antiquus* Falconer



Text-fig. 1 - The area in which the studied site is located.

& Kautley by Bartolomei (1969), belong to the upper sedimentary complex and are attributed to the Middle Pleistocene (Cattuto *et al.*, 1995).

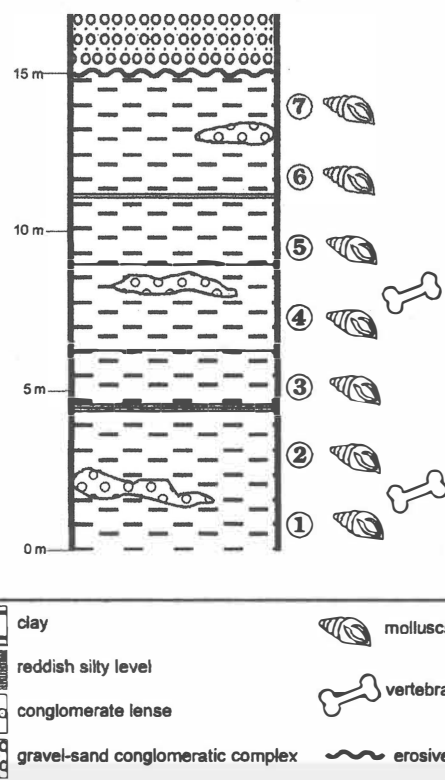
The purpose of this paper is improving the knowledge about the paleoenvironmental evolution of the Anghiari basin through the analysis of the ecologic characters of the non-marine molluscs recorded and framing the fauna in the biochronologic scheme of the Italian Plio-Pleistocene molluscan assemblages as reported in Gliozzi *et al.* (1997).

METHODS

The grey clay strata of the lower unit outcropping in the Fighille quarry have been sampled at seven distinct levels (1÷7) along the fossiliferous sequence (Text-fig. 2) beginning from the base of the exposed succession, figured by Cattuto *et al.* (1995). The reddish silty levels and the conglomerate lenses interbedded are barren.

Each sample of about 2 kg of sediment was washed and sieved by a 0.088 mm net.

The non-marine molluscs recorded in each sample have been counted and every species or genus identified has been attributed to an ecologic class on the basis of its ecologic character, according to the method introduced by Ložek (1964) and used by several authors after him (including the writers of this paper). The ecologic classes to which the molluscs from Fighille belong are reported in Tab. 1.



Text-fig. 2 - Stratigraphic column of the sampled Lower Pleistocene succession exposed in the Fighille quarry.

Then, the percentage of specimens of the ecologic classes represented in each sample has been calculated and these data have been turned into graphs (ecologic spectra) and analysed in order to understand the paleoecologic and paleoclimatic significance of the Fighille molluscan assemblages.

PALEOECOLOGIC ANALYSIS

All the samples taken in the Fighille quarry deposit yielded a rich array of well preserved terrestrial and aquatic molluscs among which the land taxa prevail.

The numerous species recorded belong to prosobranch gastropods (among which only two aquatic species are present): *Cochlostoma* sp., *Platyla similis* (Reinhardt), *Pomatias elegans* (Müller), *Bithynia leachi* (Sheppard), *Valvata cristata* Müller; pulmonate gastropods (among which only two species are strictly linked to an aquatic environment): *Carychium* (*Carychium*) *minimum* Müller, *Carychium* (*Saraphia*) *tridentatum* (Risso), *Lymnaea truncatula* (Müller), *Succinea* (*Succinella*) *oblonga* Draparnaud, *Cochlicopa lubrica* (Müller), *Vertigo* (*Vertigo*) *antivertigo* (Draparnaud), *Vertigo* (*Vertigo*) *mouliniana* (Dupuy), *Vertigo* (*Vertigo*) *pygmaea* (Draparnaud), *Vertigo* (*Vertigo*) *substriata* (Jeffreys), *Vertigo* (*Vertilla*) *angustior* Jeffreys, *Truncatellina cylindrica* (Férussac),

ECOLOGIC CLASSES (after Ložek, 1964)	
1W	strictly forestal species
1W(f)	forestal species living among rocks and ground litter
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)
4S	species living in dry and sunny places without arboreous vegetation
5O	species living in open places without arboreous vegetation
5OW	species living in open places or in dry open woods
7M	mesophilous species which sometimes can live in damp or dry places
8H	hygrophilous species
9P	strongly hygrophilous species living in marshes or in similar very damp to wet places, generally very close to the water
T	terrestrial molluscs whose genus and species can't be determined, so that there are not enough informations about their habitat
10	aquatic species which can live in different biotopes or whose habitat can't be determined
10FPpQ	aquatic species living in moving waters, periodic marshes or springs
10P	aquatic species living in marshes and in shallow waters rich in vegetation
10SPpP	aquatic species living either in still waters or in marshes and periodic marshes
!	species indicative of warm-damp climate conditions
!!	species exclusive of warm-damp climate conditions
+	loess species
(+)	species locally present in loess

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

Gastrocopta (Vertigopsis) dehmi Schlickum & Strauch, *Granaria illyrica* (Rossmässler), *Pupilla muscorum* (Linné), *Vallonia costata* (Müller), *Vallonia pulchella* (Müller), *Multidentula helenae* Esu, *Punctum (Punctum) pygmaeum* Draparnaud, *Discus (Discus) rotundatus* (Müller), *Vitrinobrachium* sp., *Vitrea* sp., *Oxychilus* sp., *Parmaella (Parmaella)* cf. *P. (P.)* sp.1 sensu Manganelli & Giusti, *Milax* sp., *Limax* sp., *Testacella haliotideae* Draparnaud, *Clausilia* sp., *Pseudotrichia* cf. *P. rubiginosa* (Schmidt), *Cepaea* cf. *C. nemoralis* (Linné), Hygromiidae indet., Helicidae indet. and Heterodonts bivalves: *Pisidium personatum* Malm, *Pisidium* cf. *P. personatum* Malm, *Pisidium* sp.

In total thirty-six species were recorded in the Figihle quarry (Text-fig. 3).

The analysis of the ecologic character of these molluscs enables a detailed paleoenvironmental reconstruction of the succession. The ecologic spectra obtained from the assemblages give indications of different kinds of environment in the seven levels examined (Text-fig. 4).

The molluscan assemblage found in the 1st level is mostly composed of land prosobranch and pulmonate gastropods; it is dominated by species living in more or less dense woods (60%), such as *Platyla*

similis, *Pomatias elegans*, *Limax* sp., *Milax* sp. and *Cepaea* cf. *C. nemoralis*. Species characteristic of dry calcareous biotopes with grassy vegetation (5O) are represented by few specimens of *Cochlostoma* sp. and *Truncatellina cylindrica* (9.2% in all). Some mesophilous and hygrophilous elements – *Vitrea* sp. (3.0%) and *Carychium (Saraphia) tridentatum* (4.6%), respectively – are also part of the assemblage. Aquatic molluscs occur with only one specimen of a bivalve (*Pisidium* sp.).

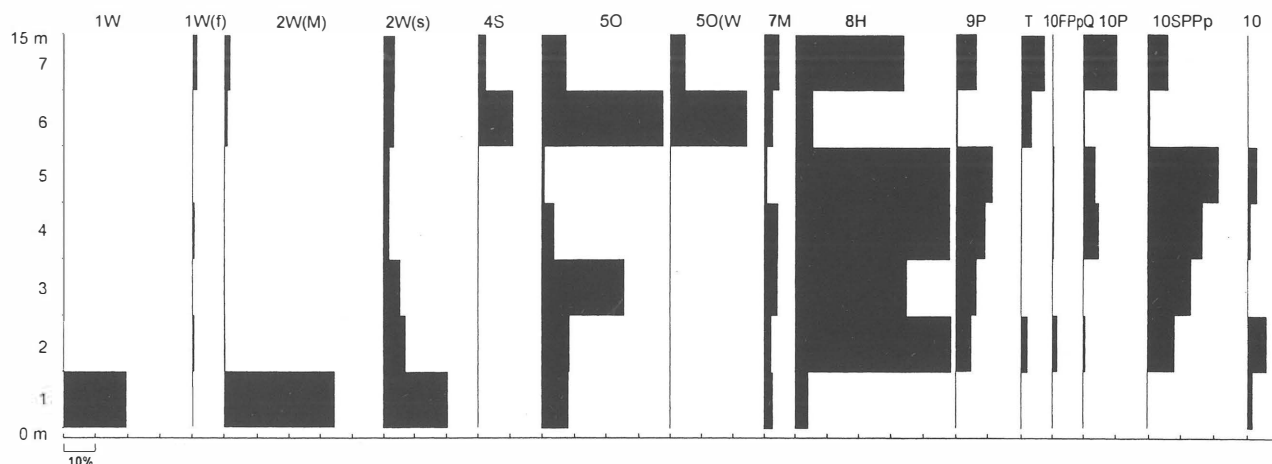
A sharp decrease in forest molluscs (1W, 2W) can be observed in the following level, where they represent only 8.67% of the assemblage; on the other side, a considerable increase in hygrophilous species of the groups 8H and 9P takes place: their specimens comprise over 60% of the assemblage. The dominant species is *Vertigo (Vertigo) angustior*, which lives in very wet, permanently marshy grassland or amongst moss in damp hollows (Kerney & Cameron, 1979; Pokryszko, 1990; Killeen, 1992), followed by a quite similar percentage of *C. (S.) tridentatum*, which can live in woods, damp grassland and well-vegetated places. A fair number of specimens of *Succinea (Succinella) oblonga* which inhabits similar places is also present. These data, together with 5.4% of land palustrine pulmonates [*Vertigo (Vertigo) antivertigo*, *Carychium (Carychium) minimum*, *Pseudotrichia* cf. *P. rubiginosa*] and 16.8% of strictly aquatic molluscs (*Lymnaea truncatula*, *Bithynia leachi*, *Pisidium personatum* and *Pisidium* sp.), clearly indicate a very damp environment such as a marsh or fen or damp sparsely-vegetated places as flood plains of rivers, which is the favoured habitat for *S. (S.) oblonga* and *P. rubiginosa* (Kerney & Cameron, 1979).

The composition of the assemblage from the 3rd level is quite similar to the previous one, since the dominance of the same hygrophilous taxa persists: the main difference consists in the presence of a higher number of land pulmonates (28.7%) living in open habitats [*Vertigo (Vertigo) pygmaea*, *Vallonia pulchella*, *Pupilla muscorum*] (Ložek, 1964; Pokryszko, 1990) and in a general decrease of the taxa strictly linked to the aquatic environment as *Bithynia* and *Pisidium*. Terrestrial mesophilous elements [*Cochlicopa lubrica*, *Parmaella (P.)* cf. *P. (P.)* sp.1, *Punctum (Punctum) pygmaeum*] reach 4.72%. This assemblage, in comparison with the one from the underlying level, indicates an expansion of the open environment.

In the following two levels, 4 and 5, very damp conditions seem to be restored. In particular, the percentage of hygrophilous (8H) and palustrine (9P) land species, here represented by the genera *Carychium*, *Succinea* and *Vertigo*, is about 65% in both levels, while strictly aquatic species (*Valvata cristata*, *B. leachi*, *L. truncatula*, *P. personatum*) reach 24% (level 4) / 30% (level 5). The species linked to open or woody habitat are almost lacking. The environment seems dominated by flooding conditions.

Ecologic classes	Species	Lev. 1	Lev. 2	Lev. 3	Lev. 4	Lev. 5	Lev. 6	Lev. 7
1	<i>Platyla similis</i> (REINHARDT)	10 15.38%						
	<i>Vitrinobrachium</i> sp.	1 1.54%						
	<i>Clausilia</i> sp.	2 3.08%						
2	<i>Gastrocopta (Vertigopsis) dehmi</i> SCHLICKUM & STRAUCH		2 0.50%		2 0.57%			2 1.29%
	<i>Discus (Discus) rotundatus</i> (MÜLLER)						1 0.32%	1 0.65%
	<i>Pomatias elegans</i> (MÜLLER)	13 20.00%						
3	<i>Cepaea cf. nemoralis</i> (LINNÉ)	12 18.46%	1 0.25%	1 0.13%			2 0.65%	2 1.29%
	<i>Oxychilus</i> sp.				2 0.57%			
	<i>Milax</i> sp.	4 6.15%						
4	<i>Limax</i> sp.	8 12.31%	32 7.92%	46 6.04%	5 1.42%	7 2.09%	11 3.57%	6 3.87%
	<i>Testacella haliotidea</i> DRAPARNAUD	3 4.62%						
	<i>Granaria illyrica</i> (ROSSMÄSSLER)						3 0.97%	1 0.65%
5	<i>Multidentula helenae</i> ESU						34 11.04%	3 1.94%
	<i>Cochlostoma</i> sp.	5 7.69%						
	<i>Vertigo (Vertigo) pygmaea</i> (DRAPARNAUD)		1 0.25%	81 10.63%	11 3.12%			3 1.94%
6	<i>Truncatellina cylindrica</i> (FÉRUSSAC)	1 1.54%						
	<i>Vallonia pulchella</i> (MÜLLER)		37 9.18%	92 12.07%	3 0.85%	3 0.90%		
	<i>Pupilla muscorum</i> (LINNÉ)		1 0.25%	46 6.04%	1 0.28%		127 41.23%	10 6.45%
7	<i>Vallonia costata</i> (MÜLLER)						84 27.27%	8 5.16%
	<i>Vitrea</i> sp.	2 3.08%						
	<i>Parmacella (Parmacella) cf. sp. 1</i> MANGANELLI & GIUSTI			1 0.13%				
8	<i>Cochlicopa lubrica</i> (MÜLLER)		9 2.23%	33 4.33%	17 4.82%	3 0.90%	9 2.92%	8 5.16%
	<i>Punctum (Punctum) pygmaeum</i> DRAPARNAUD		1 0.25%	2 0.26%				
	<i>Vertigo (Vertigo) substriata</i> (JEFFREYS)							4 2.58%
9	<i>Vertigo (Vertilla) angustior</i> JEFFREYS		95 23.51%	181 23.75%	4 1.13%	1 0.30%	6 1.95%	21 13.55%
	<i>Carychium (Sarraphia) tridentatum</i> (RISSE)	3 4.62%	81 20.05%	25 3.28%		4 1.19%		
	<i>Succinea (Succinea) oblonga</i> DRAPARNAUD		45 11.14%	93 12.20%	187 52.97%	176 52.54%	13 4.22%	34 21.94%
10	<i>Carychium (Carychium) minimum</i> MÜLLER		7 1.73%	11 1.44%	11 3.12%	7 2.09%		11 7.10%
	<i>Vertigo (Vertigo) antivertigo</i> (DRAPARNAUD)		13 3.22%		24 6.80%	34 10.15%	1 0.32%	
	<i>Vertigo (Vertigo) moulinsiana</i> (DUPUY)			1 0.13%	1 0.28%	1 0.30%		
11	<i>Pseudotrachia cf. rubiginosa</i> (SCHMIDT)		2 0.50%	43 5.64%				
	<i>Hygromiidae</i> indet.		9 2.23%					5 3.23%
	<i>Helicidae</i> indet.						11 3.57%	8 5.16%
12	<i>Pisidium personatum</i> MALM		7 1.73%			1 0.30%		
	<i>Pisidium cf. personatum</i> MALM				1 0.28%			
	<i>Valvata cristata</i> MÜLLER				2 0.57%			
13	<i>Bitithynia leachi</i> (SHEPPARD)		3 0.74%		17+19op. 4.82%	14+14op. 4.18%	10p. 0.32%	18op. 11.61%
	<i>Lymnaea truncatula</i> (MÜLLER)		35 8.66%	106 13.91%	62 17.56%	75 22.39%	2 0.65%	10 6.45%
	<i>Pisidium</i> sp.	1 1.54%	23 5.69%		3 0.85%	9 2.69%		
		65	404	762	353	335	308	155

Text-fig. 3 - Percentages of specimens of the species collected in the seven levels sampled in the Lower Pleistocene sediments outcropping in the Fighille quarry. For explanation of symbols see Tab. 1.



Text-fig. 4 - Percentage diagram of paleoecologic features of the non-marine molluscan assemblages recorded in the Fighille quarry. For symbols see Tab. 1.

The high number of specimens of *S. (S.) oblonga*, typical of such environmental conditions, in both levels (about 53%) supports this hypothesis.

In the 6th level the composition of the assemblage is quite different from the previous one (Text-fig. 4). An open and drier environment is testified by the prevalence of molluscs living in open habitats (81.49%, 4S, 5O) some of which in very dry places (*Truncatellina cylindrica*, *Granaria illyrica*, *Multidentula helenae*, *Pupilla muscorum*). *Multidentula helenae* and *G. illyrica* occur for the first time in the succession and *T. cylindrica*, only present at the base, reappears in this level. *Multidentula helenae* is an extinct species, the ecologic meaning of which is inferred by closest living species (Esu, 2000). Hygrophilous and palustrine species still occur but in a lower percentage (about 7%), whereas the percentage of forestal species is doubled (4.44%). In this level many broken specimens of terrestrial species, of which only the apertures were found (i.e., *M. helenae*, *G. illyrica*), and fragments of Helicidae testify a some transport of the material.

Correspondingly to the last level the environment is represented by a damper area with less expanded open places. The share of forestal species increases reaching 7.10% of the assemblage, while species indicative of open environment (4S, 5O) are present with a really lower number of specimens: their percentage (81.49% in the previous level) now falls to 16.13%. A new increase in hygrophilous and aquatic stagnant elements also takes place: the hygrophilous ones [*C. (C.) minimum*, *S. (S.) oblonga*, *Vertigo (Vertigo) substriata*, *Vertigo (Vertilla) angustior*] represent more than 45% of the assemblage; the stagnant ones (*Bithynia* sp., *L. truncatula*) represent 18.06%.

BIOCHRONOLOGY

The faunal assemblages recorded in the Fighille sedimentary succession are characterized by the

prevalence of terrestrial taxa. Most of the species are still living; only three taxa are extinct: *G. (V.) dehmi*, *M. helenae* and *Parmacella (P.)* cf. *P. (P.)* sp.1. The living species are widespread, except for *V. substriata*, *Vitrinobrachium* sp. and *T. haliotidea* which are scattered at present in Italy (Bodon *et al.*, 1995); the latter species were present in the Italian peninsula since the Early Pleistocene and certainly during the Pleistocene were more spread than now (Esu & Girotti, 1991; Benvenuti *et al.*, 1998). Such a type of assemblages recorded in the Fighille quarry permit to frame the whole malacofauna into the Italian malacological terrestrial assemblages of the Early Pleistocene, characterized by a high number of still living terrestrial species and by a few extinct taxa. Older, Pliocene assemblages, are characterized by a great stock of archaic land taxa which did not survive this period (Gliozzi *et al.*, 1997; Ciangherotti *et al.*, 1998; Esu, 1999).

The extinct species *G. (V.) dehmi* gives good chronostratigraphic information being one of the few Pliocene terrestrial survivors in the Early Pleistocene. It is known from Middle Pliocene to lowermost Pleistocene deposits of continental basins in Central and Western Europe (Ciangherotti *et al.*, 1996; Ciangherotti & Esu, 1997; Esu, 1999). In Italy its stratigraphic range is comprised between the Middle Pliocene (Piedmont basin, Triversa F.U.) and the Early Pleistocene (Steggio basin, Venetian Prealps and Angiari basin; both probably referable to Tasso F.U. on the base of mammal remains): within this time span the last occurrence of *G. (V.) dehmi* seems to fall in correspondence with the Tasso F.U. as it is unknown in the assemblages referred to Farneta F.U. (see biochronologic molluscan scheme by D. Esu and O. Girotti in Gliozzi *et al.*, 1997, fig. 3 and Ciangherotti *et al.*, 1998, fig. 1); then, it does not seem to extend through the whole Early Pleistocene time span.

The species *M. helenae* has been found at first in the Fighille quarry (Early Pleistocene) and later on in another deposit of northern Umbria (Montone, Perugia) referred to the Early-Middle Pleistocene (Esu, 2000). It is unknown in Pliocene deposits so far.

The species *Parmacella* (*P.*) sp.1 is recorded from lacustrine limestones of Colle Val d'Elsa (Siena, Tuscany) (Manganelli & Giusti, 1993) the age of which is referred to be Late Pleistocene in Sheet 113 "Castelfiorentino" of the Geological Map of Italy (Merla & Bortolotti, 1967). The age of this formation is much discussed, since at the base of the same lacustrine limestone formation, at Monte Oliveto locality (San Gimignano, Sheet 113 Geol. Map It.), a vertebrate fauna, with *Elephas antiquus* and other mammal remains, referred to the early Middle Pleistocene was recovered (Berzi, 1972). Therefore, the lacustrine limestone formation can also be referred to the Middle Pleistocene. Hence, it is more difficult to substatin the hypothesis of Manganelli & Giusti (1993), who suggest a Middle-Late Pliocene age for a part of the lacustrine limestone formation and indicate for *Parmacella* (*P.*) sp.1 a stratigraphic range from the Middle-Late Pliocene to the Middle Pleistocene. Then, *Parmacella* (*P.*) sp.1 seems to be exclusively a Pleistocene element. A specimen very similar to *Parmacella* (*P.*) sp.1 was found by us in the Lower Pleistocene deposits belonging to S. Maria di Ciciliano Unit (Tasso F.U., Ambrosetti *et al.*, 1995a) at Ponticelli, Tiberino basin, Umbria (unpublished data).

In conclusion, the three extinct species permit to refer the deposit of Fighille to the Early Pleistocene and give also a detailed biochronologic indication, since *G. (V.) dehmi* doesn't seem to be present in assemblages younger than those referred to Tasso F.U. and *Parmacella* (*P.*) sp.1 in assemblages older than Tasso F.U.

CONCLUSIONS

The paleoecologic informations obtained for the distinct molluscan assemblages found in the seven levels of the Fighille quarry succession allow to reconstruct the environmental development. The area, originally wooded and characterized by mesophilous conditions (level 1), seems to pass to a more open and damp environment (level 7) through clearly palustrine phases characterized by wet meadows and shallow ponds (levels 2, 4, 5) alternated with drier periods dominated by grassy vegetation (levels 3, 6), as shown in Text-fig. 4. This kind of paleoenvironment evolution, in which phases of damp and drier conditions alternate, and the presence of mixed malacofauna suggest an area affected repeatedly by flooding conditions, as the presence of gravel lenses and reddish oxidized silty levels in the sedimentary succession also testify.

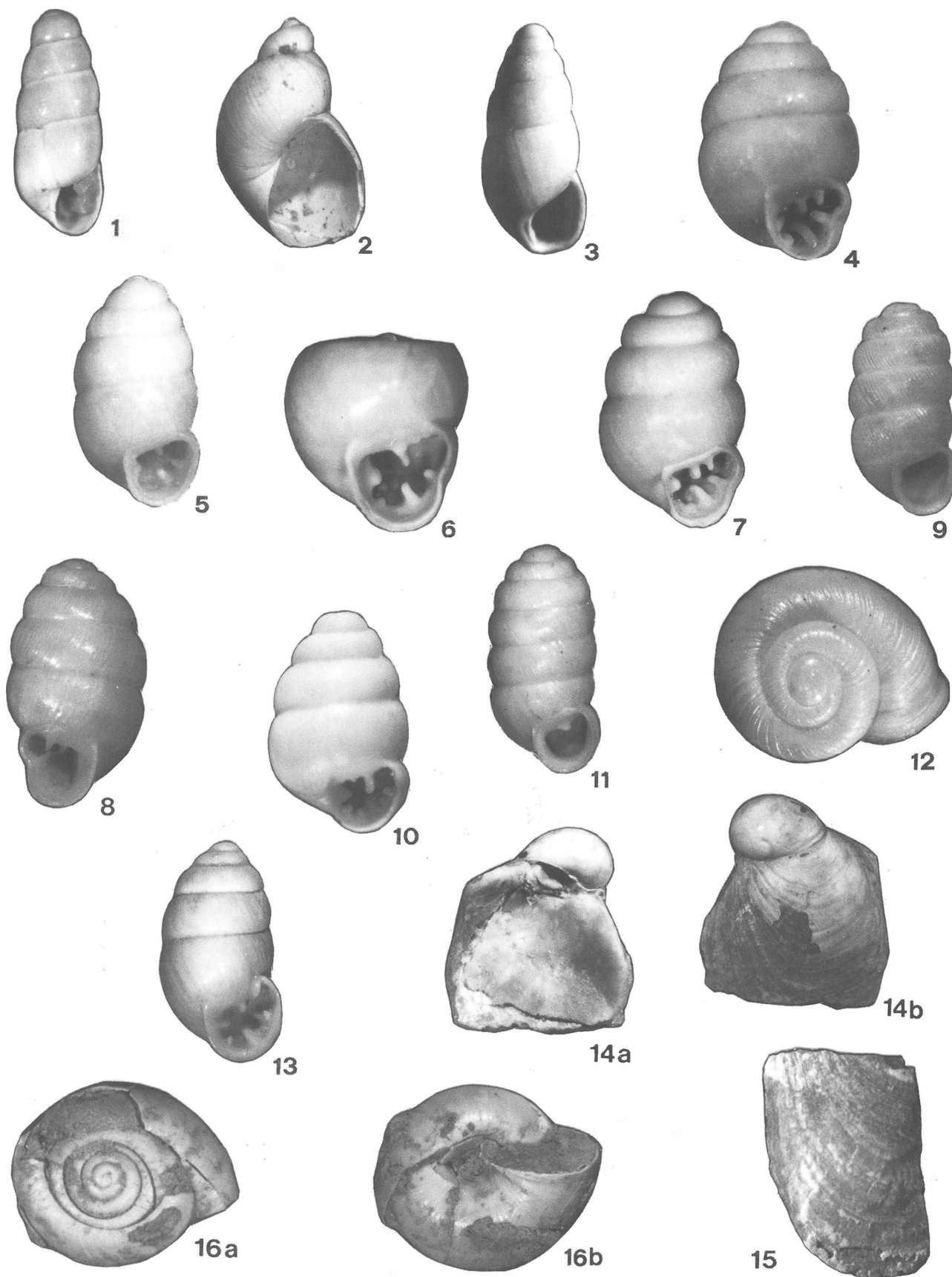
Furthermore, the molluscan faunas examined give some indications about the nature of the climate during the deposition of the succession as they comprise some still living species having a high climatic significance. Among the forestal species *C. cf. C. nemoralis* occurs in almost all the sampled levels, with the only exception of levels 4 and 5; it is associated with *Platyla similis*, *Pomatias elegans* and *C. (S.) tridentatum* in the lower levels (1+3) and to *Discus (Discus) rotundatus* in the upper two levels (6 and 7). *Carychium (S.) tridentatum* is also present in level 5. The occurrence of these land species which live today in temperate-warm climatic conditions and characterize the warmest Quaternary phases in Europe (Ložek, 1964; Kerney & Cameron, 1979; Boeters *et al.*, 1989) suggest similar requirements for the studied Early Pleistocene molluscan fauna.

The temperate-warm character of the molluscan fauna is also evidenced by the general high species

EXPLANATION OF PLATE 1

- Fig. 1 - *Platyla similis* (Reinhardt). Level 1. M.P.U.R. -7-1413, (× 23.5).
- Fig. 2 - *Succinea (Succinella) oblonga* Draparnaud. Level 7. M.P.U.R. -7-1414, (× 7).
- Fig. 3 - *Cochlicopa lubrica* (Müller). Level 7. M.P.U.R. -7-1415, (× 6).
- Fig. 4 - *Vertigo (Vertigo) antivertigo* (Draparnaud). Level 2. M.P.U.R. -7-1416, (× 19).
- Fig. 5 - *Vertigo (Vertigo) pygmaea* (Draparnaud). Level 3. M.P.U.R. -7-1417, (× 18).
- Fig. 6 - *Vertigo (Vertigo) moulinsiana* (Dupuy). Level 3. M.P.U.R. -7-1418, (× 24).
- Fig. 7 - *Vertigo (Vertigo) substriata* (Jeffreys). Level 7. M.P.U.R. -7-1419, (× 23).
- Fig. 8 - *Vertigo (Vertilla) angustior* (Jeffreys). Level 3. M.P.U.R. -7-1420, (× 22).
- Fig. 9 - *Truncatellina cylindrica* (Férussac). Level 6. M.P.U.R. -7-1421, (× 19).
- Fig. 10 - *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch. Level 7. M.P.U.R. -7-1422, (× 20).
- Fig. 11 - *Pupilla muscorum* (Linné). Level 6. M.P.U.R. -7-1423, (× 10).
- Fig. 12 - *Vallonia costata* (Müller). Level 6. M.P.U.R. -7-1424, (× 17).
- Fig. 13 - *Multidentula helenae* Esu. Level 6. M.P.U.R. -7-1372, (× 7).
- Fig. 14 - *Parmacella (Parmacella) cf. P. (P.) sp.1 sensu* Manganelli & Giusti. 14a) ventral view, 14b) dorsal view showing the protoconch and a part of the spathula. Level 3. M.P.U.R. -7-1425/2, (× 6).
- Fig. 15 - *Parmacella (Parmacella) cf. P. (P.) sp.1 sensu* Manganelli & Giusti. Fragment of the spathula probably belonging to the specimen of Fig. 14. The total lenght of the specimen was about 14 mm. Level 3. M.P.U.R. -7-1425/2, (× 6).
- Fig. 16 - *Pseudotrichia cf. P. rubiginosa* (Schmidt). 16a) dorsal view, 16b) ventral view. Level 3. M.P.U.R. -7-1426, (× 5.7).

[All specimens are kept in the collection Esu-Girotti in Rome, M.P.U.R. -7]



diversity (36 species have been recorded in the whole succession with a presence of almost 13 up to 19 species in each level) and by the presence of two warm climate taxa not living in Italy anymore: *Gastrocopta (Vertigopsis) dehmi* (levels 2, 4, 7), an extinct species, which was spread in Pliocene warm climate forestal assemblages of Western and Central Europe, Italy included (Ambrosetti *et al.*, 1995b; Esu, 1999), and the subgenus *Parmacella (Parmacella)* (level 3), living today in warm areas of the Mediterranean basin (Manganelli & Giusti, 1993) preferring a medium degree of aridity and warm conditions.

The biochronologic indications yielded by the structure of the assemblages permit to place the whole malacofauna in the Early Pleistocene and to refer it to the stock of the non-marine malacofaunal assemblages corresponding to the Tasso F.U.

ACKNOWLEDGMENTS

This paper was supported by MURST grant (60%, responsibile D. Esu) and by CNR, Centro di Studio per il Quaternario e l'Evoluzione Ambientale, Roma. Many thanks are due to Prof. C. Cattuto of the University of Perugia for the notice of the fossiliferous outcrop of Fighille and to Prof. O. Girotti of the University of Rome for his help in photographs and in the field work.

REFERENCES

- AMBROSETTI, P., BASILICI, G., CAPASSO BARBATO, L., CARBONI, M.G., DI STEFANO, G., ESU, D., GLIOZZI, E., PETRONIO, C., SARDELLA, R., & SQUAZZINI, E., 1995a, Il Pleistocene inferiore nel ramo sud-occidentale del bacino Tiberino (Umbria): aspetti litostratigrafici e biostratigrafici: *Il Quaternario*, 8: 19-36.
- , —, CIANGHEROTTI, A.D., CODIPIETRO, G., CORONA, E., ESU, D., GIROTTI, O., LO MONACO, A., MENEGHINI, M., PAGANELLI, A. & ROMAGNOLI, M., 1995b, La Foresta Fossile di Dunarobba (Terni, Umbria, Italia centrale): contesto litostratigrafico, sedimentologico, palinologico, dendrocronologico e paleomalacologico: *Il Quaternario*, 8: 465-508.
- BARTOLOMEI, G., 1969, Rinvenimento di resti di Elefante presso Citerna (Perugia): *Ann. Univ. Ferrara*, n.s., sez. 9, 4 (17): 267-274.
- BENVENUTI, M., ESU, D., GERACI, V. & GHETTI, P., 1998, The molluscan assemblages in the fluvio-lacustrine succession of the Plio-Pleistocene Mugello basin (Tuscany, Italy): *Riv. Ital. Paleont. Strat.*, 104: 263-278.
- BERZI, A., 1972, An early middle Pleistocene fauna at Monte Oliveto (S. Gimignano, Siena, Italy): *Palaeontographia Ital.*, 68: 29-33.
- BODON, M., FAVILLI, L., GIUSTI, F. & MANGANELLI, G., 1995, Gastropoda Pulmonata. In Minelli, A. *et al.* (eds.), Checklist delle specie della fauna italiana, 16: 1-60, Calderini, Bologna.
- BOETERS, H.D., GITTENBERGER, E. & SUBAI, P., 1989, Die Aciculidae (Mollusca: Gastropoda Prosobranchia): *Zool. Verh. Rijksmus. Natuur. Hist. Leiden*, 252: 1-234.
- CATTUTO, C., CENCETTI, C., FISAULI, M. & GREGORI, L., 1995, I bacini pleistocenici di Anghiari e Sansepolcro nell'alta valle del F. Tevere: *Il Quaternario*, 8: 119-128.
- , —, & GREGORI, L., 1992, Il Plio-Pleistocene nell'area medio-alta del bacino del F. Tevere: possibile modello morfotettonico: *Studi Geol. Camerti, Spec. vol.* (1992/1): 103-108.
- CIANGHEROTTI, A.D. & ESU, D., 1997, New findings of *Gastrocopta (Vertigopsis) dehmi* Schlickum & Strauch (Gastropoda, Vertiginidae, Gastrocoptinae) in the Early Pleistocene of Italy: *Abstr. Int. Congr. Palaearctic Mollusca, Heldia*, 4: 161.
- , —, & GIROTTI, O., 1996, La malacofauna continentale. In Carraro, F. (ed.), *Revisione del Villafranchiano nell'area-tipo di Villafranca d'Asti: Il Quaternario*, 9: 93-95.
- , —, & —, 1998, Review of the history of the Late Neogene and Early Quaternary non-marine molluscs of Italy: *Meded. Ned. Inst. Toegepaste Geowetensch. TNO*, 60: 491-498.
- ESU, D., 1999, Contribution to the knowledge of Neogene climatic changes in western and central Europe by means of non-marine molluscs. In Agustí, J. *et al.* (eds.), *Hominoid evolution and climatic change in Europe*, 1: 328-354, Cambridge Univ. Press.
- , 2000, A new species of *Multidentula* Lindholm in the Early Pleistocene of Italy (Gastropoda: Pulmonata: Enidae): *Arch. Molluskenkunde*, 128: 213-216.
- , & GIROTTI, O., 1991, Late Pliocene and Pleistocene assemblages of continental molluscs in Italy. A survey: *Il Quaternario*, 4: 137-150.
- GLIOZZI, E., ABBAZZI, L., ARGENTI, P., AZZAROLI, A., CALOI, L., CAPASSO BARBATO, L., DI STEFANO, G., ESU, D., FICCARELLI, G., GIROTTI, O., KOTSAKIS, T., MASINI, F., MAZZA, P., MEZZABOTTA, C., PALOMBO, M.R., PETRONIO, C., ROOK, L., SALA, B., SARDELLA, R., ZANALDA, E. & TORRE, D., 1997, Biochronology of selected mammals, molluscs and ostracods from the Middle Pliocene to the Late Pleistocene in Italy. The state of the art: *Riv. Ital. Paleont. Strat.*, 103: 369-388.
- KERNEY, M.P. & CAMERON, R.A.D., 1979, A field guide to land Snails of Britain and North-west Europe: 288 pp., Collins, London.
- KILLEEN, I.J., 1992, The land and freshwater molluscs of Suffolk: *Suffolk Nat. Soc.*: 171 pp., C.H. Healey, Ipswich.
- LOŽEK, V., 1964, Quartärmollusken der Tschechoslowakei: *Rozpr. Ustr. Ust. Geol.*, 31: 1-368.
- MANGANELLI, G. & GIUSTI, F., 1993, Notulae malacologicae, XLV. Fossil Parmacellidae from Italy: *Arch. Molluskenkunde*, 121: 143-156.
- MERLA, G. & BORTOLOTTI, V., 1967, Note illustrative della Carta Geologica d'Italia. Foglio 113 "Castelfiorentino": *Serv. Geol. It.*: 62 pp., Roma.
- POKRYSZKO, B.M., 1990, The Vertiginidae of Poland (Gastropoda: Pulmonata: Pupilloidea) - a systematic monograph: *Ann. Zool. Polska Akad. Nauk*, 43: 135-257.

(manuscript received February 12, 1999
accepted December 23, 1999)

Antonella CIANGHEROTTI

Daniela ESU

Dipartimento di Scienze della Terra
Università "La Sapienza"
Piazzale A. Moro 5, 00185 Roma, Italy