

Arvicolid finds (Rodentia, Mammalia) from the early Galerian of Colle Curti (Umbro-Marchean Apennines, Central Italy)

Laura ABBAZZI, Federico MASINI, Giovanni FICCARELLI and Danilo TORRE

Received: 12 Feb., 1997

Accepted for publication: 7 Sep., 1998

ABBAZZI L., MASINI F., FICCARELLI G., TORRE D. 1998. Arvicolid finds (Rodentia, Mammalia) from the early Galerian of Colle Curti (Umbro-Marchean Apennines, Central Italy). *Acta zool. cracov.* 41(1): 133-142.

Abstract. In the present work the arvicolid fauna from the early Pleistocene deposits of the Colle Curti site is revised. This study allows us to report the occurrence of *Pliomys lenki*, a new taxon for the early Pleistocene of Italy and to review the systematic position of *Microtus* previously related to *Microtus (Allophaiomys)* gr. *ruffoi*. The teeth of *Microtus* here attributed to *M. (Allophaiomys)* sp. are characterised by a mixture of primitive and derived features. As a matter of fact, the low development of the anteroconid complex as compared to the other late *M. (Allophaiomys)* is associated with a microtine differentiation of the enamel. At present, taking into account the scarcity of this sample, it is not possible to give this vole a precise specific systematic position, though the association of the characters mentioned above and the morphology of the anterior cap, may suggest that this form is a very primitive representative of the lineage of *Microtus (Pallasiinus)* *ratticepoi desoeconomus*. The findings of *Pliomys lenki*, a common species in the sediments of the middle Pleistocene, strengthens the distinctiveness of the Colle Curti assemblage relative to the older late Villafranchian-early Biharian local faunas of Italy. The occurrence of *Microtus (Allophaiomys)* sp. linked to the *M. oeconomus* group allows us to place the fauna close to the early/late Biharian transition.

Key words: Arvicolidae, Systematics, Early Pleistocene, Early Biharian, Central Italy.

Laura ABBAZZI, Giovanni FICCARELLI, Danilo TORRE Dipartimento di Scienze della Terra e Museo di Scienze Naturali (sez. Geo-Paleontologica), Università degli Studi Firenze, Via G. La Pira 4, 50121 Firenze; Federico MASINI Dipartimento di Geologia e Geodesia, Università degli Studi di Palermo, C.so Tukory 131, 90134 Palermo.

I. INTRODUCTION

The mammal assemblage of Colle Curti (Fig. 1), coming from a horizon located within a fluvio-lacustrine succession, has been the object of numerous studies in particular as regards the large mammals (BORSELLI et al. 1988; FICCARELLI & MAZZA 1990; FICCARELLI & SILVESTRI 1991; TORRE et al. 1992; GLIOZZI et al. 1997, MASINI et al., 1995). The co-occurrence of *Megaceroides verticornis* with a rhinoceros referred to *Stephanorhinus* cf. *S. hundsheimensis* (TORRE et al. 1996) which shows a close affinity with the typical form of the middle Pleistocene, and an advanced form of the small sized cervid *Pseudodama* (COLUCCI et al. in progress), allows to refer this local fauna to the beginning of the Galerian mammal age (MASINI et al. 1995). The faunal assemblage

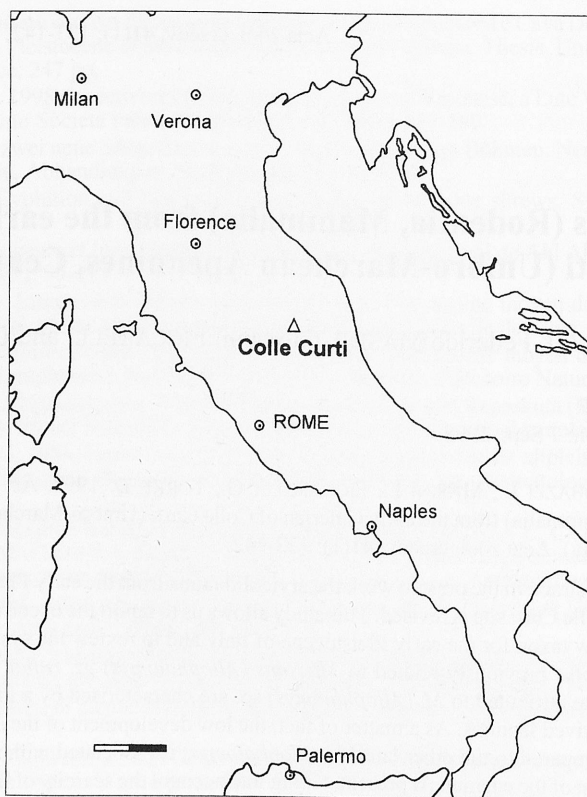


Fig. 1. Location of Colle Curti site. Scale is 100 km.

also includes very abundant remains of *Hippopotamus antiquus*, (MAZZA 1996) and scarce finds indicative of a Villafranchian affinity such as *Leptobos* sp., *Ursus* cf. *U. etruscus*, *Canis* (*Xenocyon*) *falconeri*. Palaeomagnetic investigations (TORRE et al. 1996; COLTORTI et al. in press) have revealed that the fossiliferous sediments lie at the base of a short normal episode falling within a negative interval. Basing on the characters of the fauna, the normal event has been interpreted as the Jaramillo subchron.

In the present work the arvicolid remains already studied by previous authors and the material resulting from more recent screen-washing of sediment are considered. This analysis allows us to review the systematic position of the remains of *Microtus* (*Allophaiomys*), and to report the occurrence of *Pliomys lenki*.

A c k n o w l e d g m e n t s. The authors are deeply indebted to Dr. Lutz MAUL (Bereich Quartärpaläontologie Weimar, Institut für Geowissenschaften, Friedrich-Schiller-Universität Jena) for his valuable and concrete contribution to the systematic study of the *Microtus* (*Allophaiomys*) remains, and for critically reading the text.

We thank Prof. A. AZZAROLI (Florence) for critically reading the text and for the revision of the English version.

The present research has been supported by M.U.R.S.T. grants.

II. SYSTEMATICS

Rodentia BOWDICH, 1821

Arvicolidae GRAY, 1821

Microtus (Allophaiomys) KORMOS, 1932

Microtus (Allophaiomys) sp.

M a t e r i a l. 2 right M/1, two fragmentary right M/1, 4 right M1\, 5 left M1\ (Fig. 2).

The values of the measurements and of the morphological indices of M/1s according to the scheme of VAN DER MEULEN (1973) are reported in Table I.

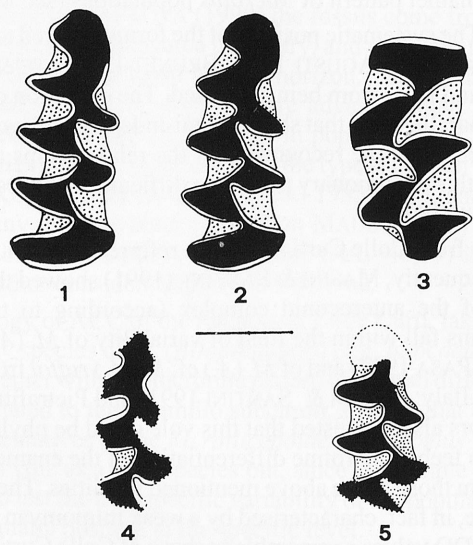


Fig. 2. *Microtus (Allophaiomys)* sp.. 1) right M/1; 2) right M/1; 3) left M1\; 4) Fragmental right M/1; 5) Fragmental right M1. The scale is 1 mm.

Table I

Measurements (mm) and indices of M/1s (see Plate 1, figs. 1,2,5) of *Microtus (Allophaiomys)* sp. from Colle Curti. Legend: L= total length, a=length of ACC, b=pinching between anterior cap (AC2) and pitymyoid rhomb, c= pinching of pitymyoid rhomb; w= width of pitymyoid rhomb, d=width of enamel free area

Taxa	L	a	b	c	w	d	A/L	B/W	C/W
1	2.62	1.08	0.30	0.19	1.02	0.63	41.22	29.41	18.62
2	2.60	1.09	0.25	0.21	0.93	0.59	41.92	26.88	22.58
3	—	0.96*	0.25	0.16	0.88	—	—	28.40	18.18

* estimated measurement

Description. The molars are unrooted with abundant crown cement. All M/1s show a consistent morphology of ACC (which is not very developed, see tab. 1), with confluent triangles T4 and T5 and with a relatively large neck. On the lingual side a shallow LRA4 and an incipient LSA5 occur, while on the buccal side the AC2 has a smooth outline with a shallow BRA3. On medial-labial side a wide enamel free area occurs. Except for the last character these features closely resemble one of the common morphotypes within the species *Microtus (Allophaiomys) pliocaenicus* and *M. (A.) cf. ruffoi* (e.g. morphotype “*pliocaenicus*” of Deutsch Altenburg population in RABEDER 1981 and of Betfia IX population in TERZEA 1988; morphotype “c” of *M. (A.) pliocaenicus* in VANDER MEULEN 1973; morphotype ‘2’ of *M. (A.) cf. ruffoi* in MASINI & SANTINI 1991). The M/1s are characterised by a faint microtine pattern of enamel differentiation, as is also confirmed by the values of the SDQ index (103-84, LIPPI 1997) computed on the two complete M/1s. This index, introduced by HEINRICH (1978) to quantify the evolutionary trend of changes in the enamel thickness within the genus *Arvicola*, provides a mean estimate of the relative thickness of the posterior cutting edges expressed as a percentage of the corresponding anterior edges, and proves to be useful for characterising also the enamel pattern of *Microtus* populations (see REKOVETS 1990).

Discussion. The systematic position of the forms referred to the subgenus *Allophaiomys* has been widely discussed (see AGUSTI 1991; BRUNET-LECOMTE & CHALINE 1991; REPENNING 1992; MARTIN 1995) and is far from being clarified. The evolution of *Allophaiomys* involved the differentiation of many parallel lines that show a semi-independent evolution of characters starting from the early Pleistocene, and the recognition of the relationships among the species which have been identified during this evolutionary phase is a difficult task, because of prevailing synpleiomorphies (cf. also MARTIN 1995).

The remains of *Microtus* from Colle Curti have been referred to *M. (A.) gr. pliocaenicus* by FICARELLI et al. (1990). Subsequently, MASINI & SANTINI (1991) showed that, for what concerns the morphometric characters of the anteroconid complex (according to the scheme of VAN DER MEULEN 1973), these remains fall within the field of variability of *M. (A.) ruffoi* (type population from Cava Sud, North Italy; PASA 1947) and of *M. (A.) cf. M. (A.) ruffoi* from the late Villafranchian localities Pirro Nord (South Italy; MASINI & SANTINI 1991) and Pietrafitta (Central Italy; GENTILI et al. 1996). The same authors also suggested that this vole could be phylogenetically linked to *M. (A.) burgondiae*. Indeed, the feeble microtine differentiation of the enamel of the M/1s from Colle Curti distinguishes them from those of the above mentioned localities. The samples from Cava Sud, Pirro Nord and Pietrafitta are, in fact, characterised by a weak mimomyan pattern ($SDQ > 100$, LIPPI 1997; MASINI et al. 1997). SDQ values comparable to those of Colle Curti are found for instance in *M. (A.) burgondiae* and *M. (A.) nutiensis* ($SDQ = 90.08$ and 85.58 , LIPPI 1997) from Monte Peglia (Central Italy; VANDER MEULEN 1973) where this feature is associated to a more complex and elongated ACC. In fact, one of the striking characters of the teeth from Colle Curti is the very short ACC, which is significantly less elongated than that of *Microtus* from localities of approximately the same age or even older (Table II): *Microtus (A.) nutiensis* and *M. (A.) burgondiae* from Mas Rambault, Les Valerots (CHALINE 1972), *Microtus (A.) superpliocaenicus* from Deutsch Altenburg 4A (RABEDER 1981), *Microtus thenii* from Untermassfeld (MAUL 1990a). The *M. ratticepoides-oeconomus* lineage, which NADACHOWSKI (1982) lumped in the single species *M. oeconomus*, is characterised by the shortest ACC (MAUL 1990a; MAUL et al. in press) among the various lineages and species occurring during the middle to late Pleistocene of the European regions, with the exception of the endemic Iberian species *M. (A.) chalinei* (Atapuerca site, CUENCA-BESCÓS et al. 1995). Furthermore, the simple ACC morphology characteristic of *M. (Pallasiinus) gr. ratticepoides-oeconomus* can be easily reconnected to the Colle Curti M/1s, and the peculiar association of primitive (ACC morphology and low A/L) and derived (microtine differentiation, wide enamel free area of AC2) features in these specimens, is to be expected in a primitive representative of the *oeconomus* group of that age.

The occurrence of a primitive new species related to *M. ratticepoides*, named *M. eoratticeps*, has recently been reported by PAUNOVIC & RABEDER (1996) from the middle early Pleistocene lo-

cality *Tatjina draga*, in Croatia. Judging from the picture of the holotype, this species is characterised by a developed LRA4, an incipient BRA5, and by primitively confluent triangles T4 and T5. These features are associated to a microtine enamel pattern. The A/L index shows a very large variability, ranging from 39.3 to 52.3 with a mean value of 45.53. The cited characters of the holotype, in agreement with its chronological position, would suggest to take in consideration also the possibility that these remains belong to, or are closely related with *M. (A.) burgondiae*. However, the extremely wide range of A/L index, could also indicate that this sample is actually composed by specimens belonging to two different species.

The possibility that the vole of Colle Curti is related to the *burgondiae* species can be denied because of its lower A/L value, smaller size and the less developed LRA4.

Among the older populations referred to *M. gr. ratticepoides-oeconomus*, that of Karaj-Dubina (Ukraine, MARKOVA 1982, 1990) shows some intermediate morphology between the sample of Colle Curti and those of the typical *ratticepoides* from the late Biharian (e.g. Voigtstedt, West Runton), in having a derived condition with not confluent triangle T4-T5 associated to a primitive not developed LRA4. According to MARKOVA (1990) the fossils come from sediments with a reverse magnetisation below the Brunhes-Matuyama boundary, and therefore they can be confidently considered younger than the Colle Curti fossil bearing horizon. Though the A/L index of this population has not been reported, it appears slightly more advanced than that of Colle Curti. Closed triangles T4-T5 and a well developed LRA4 occur in populations of *M. ratticepoides* from early middle Pleistocene localities as well, as indicated by the type specimen from West Runton (HINTON 1926), the sample from Kozi Grzbiet (NADACHOWSKI 1985) in Poland, and that from Voigtstedt, (MAUL 1990a) in Germany. For the latter population MAUL (1990a) gives a mean A/L value of 45.90, which is comparable to that of Somssich-hegy (A/L=46.77) in Hungary (JÁNOSSY 1986, 1990), which the same author considers slightly less derived.

Though the morphology of ACC of the remains of Colle Curti, taken singly, is common for its primitive features to many species of *M. (Allophaiomys)* (e.g. *plioaenicus*, *ruffoi*, *burgondiae*) its consistent occurrence together with the microtine pattern of enamel differentiation in a sample coming from sediments correlated to the Jaramillo subchron, suggest that this vole could be related to the most primitive representatives of the *M. ratticepoides-oeconomus* lineage. Therefore, it would be worth considering this vole as a new species but, since the sample is too scarce in order to exhaustively illustrate and to test the intraspecific variability of the population, we prefer not to assign to it a more precise systematic position at the specific level.

However, the occurrence of *Microtus (Allophaiomys)* sp. at Colle Curti is a further confirmation that during the late part of the early Pleistocene, *Microtus* was represented in Europe by several lineages characterised by different evolutionary stages.

The forms belonging to the phyletic lineage of *M. ratticepoides-oeconomus*, are well documented in the Central Europe sites where their occurrence is connected to tundra and forest-tundra like environments (NADACHOWSKI 1982; GROMOV & POLYAKOV 1992). In Italy the presence of this group has been reported only for the late Pleistocene at Northern Italy localities (BARTOLOMEI et al. 1977; SALA 1990). However, the occurrence of arvicolids with palaeoarctic affinity during the early middle Pleistocene is not a novelty for the Italian regions, as indicated by the finds of *Prolagus pannonicus* and (?) *Predicrostonyx* (KOTSAKIS 1988; KOTSAKIS et al. 1992) at the middle Galian site of Fontignano (Ponte Galeria, Rome).

Pliomys MÉHELY, 1914

Pliomys lenki (HELLER, 1930)

Nomenclatorial remarks. TERZEA (1983) has recognised that *Pliomys lenki* HELLER, 1930 and *P. coronensis* MEHELY, 1914 are conspecific; the distinction between the two species, based mainly on the occurrence of a bifid root in the M1/ of *coronensis* has not been con-

sidered sufficient for a separation at the specific level. However, this conclusion does not seem to be accepted by TERZEA (1996) herself nor by other authors (cf. FEJFAR & HEINRICH 1990) since in recent works the name *lenki* continues to be used. In this paper we maintain the denomination *lenki* waiting for a further clarification on this topic.

M a t e r i a l. Left M/1 (juv.), left M/1 (missing of the anterior part of the anteroconid complex); left M/3 (juv.), right M/3, right M2/, left M3/ and right M3/ (Fig. 3). Measurements are reported in Table II.

D e s c r i p t i o n. The molars are rooted, without cement and with a microtine differentiation of the enamel; the triangles are slightly confluent. The complete M/1 shows a low degree of wear, open roots and well visible 4th buccal and 5th lingual re-entrant angles, which extend till about middle height of the crown. The height of the hyposinuid (the posterior labial sinuid, Hsd according to RABEDER 1981), which provides a measure of the hypsodonty in arvicolids with rooted molars, agrees with the values of early and middle Pleistocene populations of Europe (e.g. Betfia-V,

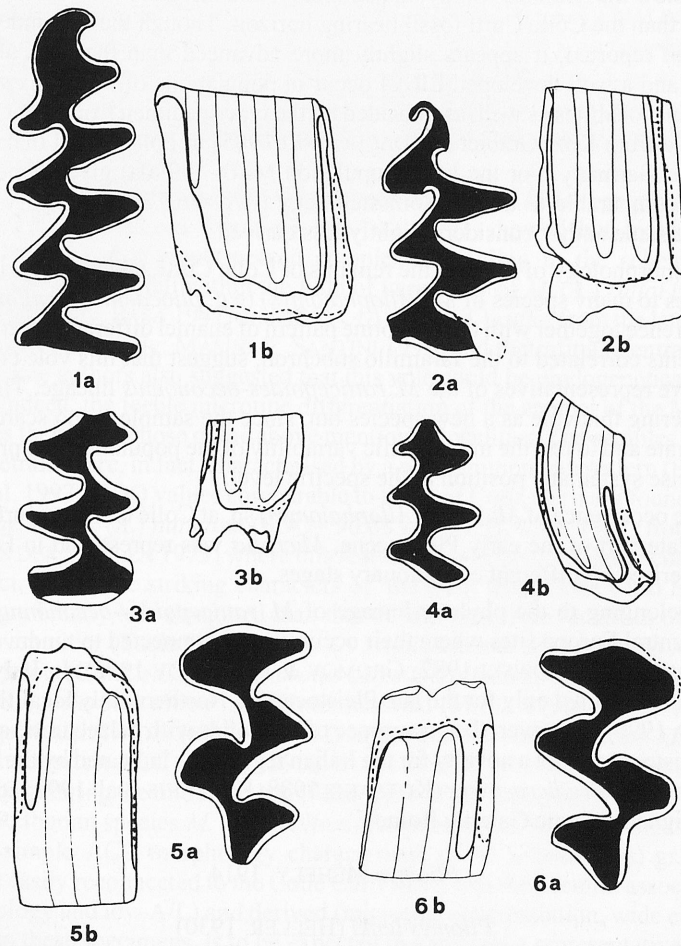


Fig. 3. *Pliomys lenki* 1) left M/1; 2) fragmental left M/1; 3) right M/2; 4) left M/3; 5) left M2; 6) right M2. With a and b are indicated the occlusal and labial side, respectively. Vertical scale for labial side, horizontal scale for occlusal side. Scales are 1 mm.

Table II

Comparison of the anteroconid elongation (A/L) among various *Microtus* populations from early and middle Pleistocene European sites. Legend: 1 – Colle Curti, present work, 2 – Betfia-IX (TERZEA 1988); 3 – Cava Sud (MASINI & SANTINI 1991); 4 – Monte Peglia (MASINI & SANTINI 1991); 5 – Deutsch Altenburg 4 (RABEDER 1981); 6 – Atapuerca, level TD3 (CUENCA-BESCÓS *et al.* 1995); 7 – Untermassfeld (MAUL 1990a); 8 – Voigtstedt (MAUL 1990a).

Taxa	n	range	mean
<i>Microtus (Allophaiomys)</i> sp. ⁽¹⁾	2	41.22-41.92	41.57
<i>M. (A.) pliocaenicus</i> ⁽²⁾	242	38.10-48.00	43.32
<i>M. (A.) ruffoi</i> ⁽³⁾	66	40.20-47.41	43.93
<i>M. (A.) burgondiae</i> ⁽⁴⁾	187	42.62-50.52	46.46
<i>M. (A.) nutiensis</i> ⁽⁴⁾	59	41.91-50.00	46.42
<i>M. (A.) superpliocaenicus</i> ⁽⁵⁾	10	44.30-47.30	44.80
<i>M. (A.) chalinei</i> ⁽⁶⁾	1	42.00	42.00
<i>M. gregaloides</i> ⁽⁶⁾	12	49.00-54.00	51.00
<i>M. thenii</i> ⁽⁷⁾	27	44.07-52.38	48.82

Chiscau, TERZEA 1983, 1989; Sackdilling, Erpfingen 3, Holstejn, Kozi Grzbiet, BARTOLOMEI *et al.* 1975; NADACHOWSKI 1985). These data suggest that this feature has not, or has been very slightly, involved in the evolution of this taxon.

The second M/1 shows an intermediate wear; the sinuous line reaches the occlusal surface, producing the enamel free area on the labial side of the posterior lobe. In the complete M/1 the typical “agrestoid” morphology is evident, in opposition to the “nivaloid” morphotype which characterises the lineage of *Pliomys episcopalus*.

D i s c u s s i o n. The sample of *Pliomys lenki* from Colle Curti represents the oldest record of this species in Italy, and corresponds to an early phase of the dispersal of this taxon in the European regions. The occurrence of this species at Colle Curti represents a new datum, since it was previously known from faunas referred to the early Toringian (e.g. Isernia, SALA 1983).

The first occurrence of *Pliomys lenki* in Europe dates from the early Pleistocene; the oldest remains are in fact associated with *Mimomys* and *Microtus (Allophaiomys) pliocaenicus*. In Romania it occurs at Betfia-V together with *Mimomys savini*, *M. pusillus* and *M. (A.) pliocaenicus* (TERZEA 1983; FEJFAR & HEINRICH, 1990). It is associated with *Mimomys savini*, *Microtus (Allophaiomys) nutiensis* and *M. (A.) burgondiae* (CHALINE 1972) in France at Les Valerots, and occurs in other European localities characterised by similar arvicolid assemblages (BARTOLOMEI *et al.* 1975; cf. MAUL 1990b; NADACHOWSKI 1985, 1990).

During the following phases of the middle Pleistocene this specie reaches a very wide geographical range, extending from the republics of the Russian federation (e.g. Moldova, Ukraine, cf. BARTOLOMEI *et al.* 1975) to Spain (BARTOLOMEI *et al.* 1975).

In Central-Eastern Europe *P. lenki* disappears during the late part of the middle Pleistocene (BARTOLOMEI *et al.* 1975, RADULESCU & SAMSON 1985; TERZEA 1993, 1994), while in su southern regions as Spain (Lezetxiki; CHALINE 1970; BARTOLOMEI *et al.* 1975; Cueva de la Corihuela, Cueva Hora, Cueva Millan, cf. ALVAREZ *et al.* 1992) and Italy, it persist as a relict form (*P. lenki relictus*, BARTOLOMEI *et al.* 1975) till the early Würmian Pleniglacial. In Italy the more recent find-

ings come from the Mousterian levels of Grotta S. Leonardo (BON et al. 1991), and Ponte A di Veja (BARTOLOMEI & BROGLIO 1976; SALA 1990; BON et al. 1991; cf. FERRARIS et al. 1990).

III. CONCLUSIONS

Despite the low number of species recovered and the fragmentary state of the remains, the local fauna of Colle Curti represents an important point of reference which characterises the succession of the Italian mammal assemblages during the late early Pleistocene. As a matter of fact it documents the faunal renewal at the beginning of the Galerian Mammal Age, as testified by the occurrence of the deer *Megaceroides verticornis*. The occurrence of *Pliomys lenki*, previously known in Italy from faunas referred to the early Toringian, strengthens the value of this locality for defining the beginning of the Galerian unit. The more advanced character of this assemblage relative to those of the latest Villafranchian (e.g. Farneta and Pirro faunal units) is moreover testified by the occurrence of *Microtus (Allophaiomys)* sp., which may be considered a form connected to the evolutionary lineage of *Microtus (Pallasiinus) ratticepoides-oeconomus*, and therefore indicative of the late early Biharian (according to FEJFAR & HEINRICH 1990).

Table III

Measurements (mm) of M/1s (see Fig. 3, Figs. 1 and 2) of *Pliomys lenki* from Colle Curti. Legend: L= occlusal length, W= maximum width, Hsd= height of hyposinuid

Taxa	L	W	Hsd
1	(2.33)	0.94	2.39
2	—	0.94	—

REFERENCES

AGUSTI J. 1991. The *Allophaiomys* complex in Southern Europe. *Geobios*, **25**(1): 133-144.

ALVAREZ M. T., MORALES A., SESÉ C. 1992. Mamíferos del yacimiento del Pleistoceno superior de Cueva Millan (Burgos, España). *Estudios geológicos*, **48**: 193-204.

BARTOLOMEI G., BROGLIO A. 1976. Risultati preliminari delle nuove ricerche nei depositi quaternari della grotta A di Veja. *Bollettino del Museo Civico di Storia Naturale di Verona*, **2**: 217-238.

BARTOLOMEI G., CHALINE J., FEJFAR O., JÁNOSSY D., JEANNET M., V. KOENIGSWALD W., KOWALSKI K. 1975. *Pliomys lenki* (HELLER 1930) (Rodentia, Mammalia) en Europe. *Acta zool. cracov.*, **20**(10): 394-467.

BARTOLOMEI G., BROGLIO A., PALMA DI CESNOLA A. 1977. Chronostratigraphie et écologie de l'Epigravettien en Italie. *Coll. Intern. C.N.R.S., La fin des temps glacier en Europe*, **271**: 297-324.

BON M., PICCOLI G., SALA B. 1991. I Giacimenti Quaternari di vertebrati fossili nell'Italia Nord-orientale. *Memorie di Scienze Geologiche*, **43**:185-231.

BORSELLI V., FICCARELLI G., LANDUCCI F., MAGNATTI M., NAPOLEONE G., PAMBIANCHI G. 1988. Segnalazione di mammiferi pleistocenici nell'area di Colfiorito (Appennino umbro-marchigiano) e valutazione della potenzialità del giacimento con metodi geofisici. *Bollettino della Società Paleontologica Italiana*, **27**(2): 253-257.

BRUNET-LECOMTE P. , CHALINE J. 1991. Morphological evolution and phylogenetic relationships of the European ground voles (Arvicolidae, Rodentia). *Lethaia*, **24**: 45-53.

CHALINE J. 1970. *Pliomys lenki*, forme relique dans la microfaune de Würm ancien de la Grotte de Lezetxiki (Guipúzcoa-Espagne). *Munibe*, **22** (1-2): 43-49.

CHALINE J. 1972. Les Rongeurs du Pléistocène moyen et supérieur de France. *Cahiers de Paléontologie*, Paris.

- COLTORTI M., ALBIANELLI A., BERTINI A., FICCARELLI G., LAURENZI M.A., NAPOLEONE G., TORRE D. in press. The Colle Curti mammal site in the Colfiorito area (Umbria-Marchean Apennine, Italy): geomorphology, stratigraphy, paleomagnetism and palynology. *Quaternary International*.
- COLUCCI A. P., ABBAZZI L., MASINI F., TORRE D. in progress. Genus *Pseudodama* in the Pleistocene of the Italian peninsula: an example of mosaic evolution.
- CUENCA-BESCÓS G., CANUDO J. I., LAPLANA C. 1995. Los arvicolídeos (Rodentia, Mammalia) de los niveles inferiores de Gran Dolina (Pleistoceno inferior, Atapuerca, Burgos, España). *Revista Española de Paleontología*, **10**(2): 202-218.
- FERRARIS M., SALA B., SCOLA V. 1990. The late Pleistocene fauna with *Pliomys lenki* from the Ghiacciaia cave loess. *Quaternary International*, **5**: 71-79.
- FEJFAR O., HEINRICH W. D. 1990. Muroid Rodent Biochronology of the Neogene and Quaternary in Europa. [In:] LINDSAY *et al* (Eds.)-European Neogene Mammal Chronology NATO ASI series. **180**: 91-118.
- FICCARELLI G., MAZZA P. 1990. New fossil findings from the Colfiorito basin (Umbria-Marchean Apennine). *Bollettino della Società Paleontologica Italiana*, **29**(2): 245-248.
- FICCARELLI G., MAGNATTI M., MAZZA P. 1990. Occurrence of *Microtus (Allophaiomys)* gr. *plioaenicus* in the Pleistocene lacustrine Basin of Colfiorito (Umbria-Marchean Apennine, Central Italy). *Bollettino della Società Paleontologica Italiana*, **29**(1): 89-90.
- FICCARELLI G., SILVESTRINI M. 1991. Biochronologic remarks on the local fauna of Colle Curti (Colfiorito basin, Umbria-Marchean Apennine, Central Italy). *Bollettino della Società Paleontologica Italiana*, **30**(2): 197-200.
- GENTILI S., ABBAZZI L., MASINI F., AMBROSETTI P., ARGENTI P., TORRE D. 1996. Voles from the Early Pleistocene from Pietrafitta (Central Italy, Perugia). *Acta zool. cracov.*, **39**(1): 185-199.
- GLIOZZI E., ABBAZZI L., AMBROSETTI P. L., ARGENTI P., AZZAROLI A., CALOI L., CAPASSO BARBATO L., DI STEFANO G., FICCARELLI G., 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. *Rivista italiana di Paleontologia e Stratigrafia*, **103**(3): 369-388.
- GROMOV I. M., POLIAKOV I. Ya. 1992. Fauna of the USSR. Mammals. Voles (Microtinae). **3**(8).
- HEINRICH W. D. 1978. Zur biometrischen Erfassung eines Evolutionstrends bei *Arvicola* (Rodentia, Mammalia) aus dem Pleistozän Thüringens. *Säugetierk. Inform.*, **2**: 3-21.
- HINTON M. A. C. 1926. Monograph of the voles and lemming (Microtinae) living and extinct. British Museum (Natural History), London.
- JÁNOSSY D. 1986. Pleistocene vertebrate faunas of Hungary. Developments in Palaeontology and stratigraphy. Elsevier, Akad. Kiadó, Budapest.
- JÁNOSSY D. 1990. Arvicolids from the Lower Pleistocene sites at Beremend 15 and Somssich-hegy 2, Hungary. Int. Symposium on "Evolution, Phylogeny and Biostratigraphy of Arvicolids (Rodentia, Mammalia)": 223-230.
- KOTSAKIS T. 1988. Biostratigraphy of Plio-Pleistocene arvicolids (rodents) of Italy. *Modern Geology*, **13**: 163-175.
- KOTSAKIS T., ESU D., GIROTTI O. 1992. A post-Villafranchian cold event in central Italy testified by continental Molluscs and Rodents: *Bollettino della Società Geologica Italiana*, **111**(2): 335-340.
- LIPPI P. 1997. I micromammiferi del Pleistocene inferiore di Cava Pirro. Dissertation, University of Florence. 2 voll..
- MARKOVA A. K. 1982. Pleistocene rodents of the Russian Plain (their paleogeographic and stratigraphic implications). Nauka.
- MARKOVA A. K. 1990. Pleistocene microtheriofauna of the European part of the USSR. Int. Symposium on "Evolution, Phylogeny and Biostratigraphy of Arvicolids (Rodentia, Mammalia)": 313-338.
- MARTIN R. A. 1995. A new Middle Pleistocene species of *Microtus (Pedomys)* from the Southern United States, with comments on the taxonomy and early evolution of *Pedomys* and *Pitymys* in North America. *Journal of Vertebrate Paleontology*, **15**(1): 171-186.
- MASINI F., SANTINI G., 1991. *Microtus (Allophaiomys)* (Arvicolidae, Rodentia, Mammalia) from Cava Pirro (Apricena, Gargano) and other Italian localities. *Bollettino della Società Paleontologica Italiana*, **30**(3): 355-380.
- MASINI F., FICCARELLI G., TORRE D. 1995. Late Villafranchian and the earliest Galerian mammal faunas from some intermontane basins of North-Central Italy. *Memorie della Società Geologica Italiana*, **48**(1994): 381-389.
- MASINI F., MAUL L., LIPPI P., ABBAZZI L. 1997. Evolutionary changes of enamel differentiation in Mediterranean and Central European populations. INQUA-SEQS-EUROMAM. International Workshop: "Origin, evolution, systematics, stratigraphic and geographic range of *Allophaiomys* (Rodentia, Arvicolinae)". Moscow, 22-26 September, 1997. Pp: 19-20.

- MAUL L. 1990a. Biharische Kleinsäugerfunde von Untermaßfeld, Voigtstedt und Sußenborn und ihre chronologische Stellung im Rahmen der biharischen Micromammalia-Faunen Europas. Thesis PhD.
- MAUL L. 1990b. Überblick über die unterpleistozänen Kleinsäugerfaunen Europas. *Quartärpaläontologie*, **8**: 153-191.
- MAUL L., MASINI F., ABBAZZI L., TURNER A. 1998. Geochronometric application of evolutionary trends in the dentition of fossil arvicolids. *Mededelingen Rijks Geologische Dienst.*, **60**: 565-
- MAZZA P. 1996. New evidence on the Pleistocene Hippopotamuses of Western Europe. *Geologica Romana*, **31**: 61-241.
- MEULEN VAN DER A. J. 1973. Middle Pleistocene Smaller Mammals from the Monte Peglia (Orvieto, Italy) with Special Reference to the Phylogeny of *Microtus* (Arvicolidae, Rodentia). *Quaternaria*, **17**: 1-144.
- NADACHOWSKI A. 1982. Late Quaternary Rodents of Poland with Special Reference to Morphotype Dentition Analysis of Voles. *Polsk. Akad. Nauk. Zakk. Zool. Syst. Dows.*: 1-109.
- NADACHOWSKI A. 1985. Biharian voles (Arvicolidae, Rodentia, Mammalia) from Kozi Grzbiet (Central Poland). *Acta zool. cracov.*, **29**: 13-28.
- NADACHOWSKI A. 1990. Lower Pleistocene Rodents of Poland: Faunal Succession and Biostratigraphy. *Quartärpaläontologie*, **8**: 215-223.
- PASA A. 1947. I mammiferi di alcune antiche brecce veronesi. *Memorie Museo Civico di Storia Naturale, Verona*, **1**: 1-111.
- PAUNOVIC M., RABEDER G. 1996. Die altpleistozänen Kleinsäugerfaunen Razvodje und Tatinja draga in Süd-Kroatien. *Beiträge zur Paläontologie von Österreich*, **21**: 69-84.
- RABEDER G. 1981. Die Arvicoliden (Rodentia, Mammalia) aus dem Pliozän und dem älteren Pleistozän von Niederösterreich. *Beiträge zur Paläontologie von Österreich*, **8**: 1-373.
- RADULESCU C., SAMSON P. 1985. Pliocene and Pleistocene mammal biostratigraphy in southern Transylvania (Romania). *Travaux de l'Institut de Spéologie "Emile Racovitza"*, **24**: 85-96.
- REKOVETZ L. I. 1990. Principal developmental stages of the water vole genus *Arvicola* (Rodentia, Mammalia) from the East European Pleistocene. *International Symposium on "Evolution, Phylogeny and Biostratigraphy of Arvicolids (Rodentia, Mammalia)"*: 369-384.
- REPENNING C. 1992. *Allophaiomys* and the Age of Olyor suite, Krestovka Sections, Yakutia. *U.S. Geological Survey Bulletin*, **2037**.
- SALA B. 1983. La fauna del giacimento di Isernia La Pineta (nota preliminare). [In:] CALDERINI (Ed.) – Isernia La Pineta: un accampamento più antico di 700.000 anni. *Catalogo della omonima mostra, Museo Nazionale di Isernia, Bologna*. Pp: 71-79.
- SALA B. 1990. Loess fauna in deposits of shelters and caves in the Veneto region and examples in other region of Italy. [In:] M. Cremaschi (ed.) – *The loess in Northern and Central Italy*. Pp: 139-149.
- TERZEA E. 1983. *Pliomys "lenki"* (HELLER, 1930) (Rodentia, Mammalia), dans le Pleistocene de Roumanie. *Travaux de l'Institut de Spéologie "Emile Racovitza"*, **22**: 65-80.
- TERZEA E. 1988. La faune de vertébrés du Pléistocène inférieur de Betfia-IX (Départ. De Bihor, Roumanie). Note préliminaire. *Travaux de l'Institut de Spéologie "Emile Racovitza"*, **27**: 79-85.
- TERZEA E. 1989. Les arvicolides (Rodentia, Mammalia) du Pleistocene moyen de Chiscau-I (Départ. De Bihor, Roumanie). *Travaux de l'Institut de Spéologie "Emile Racovitza"*, **28**: 57-72.
- TERZEA E. 1993. Evénements évolutifs et de dispersion chez les rongeurs au Quaternaire de Roumanie. *Travaux de l'Institut de Spéologie "Emile Racovitza"*, **32**: 107-118.
- TERZEA E. 1994. Mammalian events in the Quaternary of Romania and correlations with the climatic chronology of Western Europe. *Acta zool. cracov.*, **38(1)**: 109-120
- TERZEA E. 1996. Biochronology of the Pleistocene deposits at Betfia (Bihor, Romania). *Acta zool. cracov.*, **39(1)**: 531-540.
- TORRE D., FICCARELLI G., MASINI F., ROOK L., SALA B. 1992. Mammal dispersal events in the early Pleistocene of Western Europe. *Courier Forschungsinstitut Senckenberg*, **153**: 51-58.
- TORRE D., ALBIANELLI A., BERTINI A., FICCARELLI G., MASINI F., NAPOLEONE G. 1996. Paleomagnetic calibration of Plio-Pleistocene Mammal localities in Central Italy. *Acta zool. cracov.*, **39(1)**: 559-570.