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The Rodents of the Brisighella latest Miocene fauna

Claudio DE GIULI ⁽¹⁾

Dipartimento di Scienze della Terra
Università di Firenze

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ABSTRACT — Rodents form the bulk of the Brisighella fauna. Murids are by far the most abundant family, though their diversification is moderate. Only 5 species occur, two were recognized as new species, one belonging to a new subgenus. These are *Stephanomys debruijni* n. sp., the most abundant species, and *Castillomys (Centralomys) benericettii* n. sp.. Rodents other than murids are extremely rare.

The fauna can be easily referred to the MN13 zone. It has no comparisons in Italy other than the Baccinello V3 fauna. The only species in common is the rare *Apodemus*, and no conclusions can be drawn. There is a striking similarity between the Brisighella fauna and the Caravaca, Alcoy and Maritsa faunas. Apomorphies in some species, and the absence of species typical of MN14, suggest a late MN13 age. The geological setting of the Brisighella fauna allows to correlate these faunas with the latest Messinian.

RIASSUNTO — [I roditori della fauna del Miocene terminale di Brisighella] — I roditori rappresentano la parte di gran lunga più consistente della fauna di Brisighella, raccolta, in fessure carsificate nei gessi della Formazione Gessoso-solfifera, nella cava del Monticino presso Brisighella (Faenza, Italia). La serie gessosa, del Messiniano inferiore, e le fessure sono sormontate da argille marine riferite alla Zona a *Sphaeroidinellopsis* del Pliocene inferiore.

I rapporti fisici e cronologici fra le fessure e la Formazione a Colombacci, riferita al Messiniano superiore, non sono ancora completamente chiari. Nelle fessure fossilifere sono presenti come clasti frammenti di calcare e di argille nere che potrebbero provenire dalla Formazione a Colombacci. In ogni modo le faune a vertebrati di Brisighella si collocano in un intervallo di tempo relativamente ristretto, fra la fine del Messiniano inferiore e la base del Pliocene inferiore. I muridi costituiscono la famiglia più abbondante fra i roditori per quanto la loro diversificazione sia ridotta. Sono presenti 5 specie di cui due nuove; una di queste è riferibile ad un sottogenere nuovo. I roditori appartenenti ad altre famiglie sono molto rari. Le condizioni tafonomiche fanno ritenere che la composizione fossile corrisponda ad una effettiva caratterizzazione dell'associazione vivente per quanto riguarda i piccoli mammiferi mentre si ritiene possibile che i grandi mammiferi siano selezionati dalle dimensioni delle fessure. I roditori presenti sono: *Stephanomys debruijni* n. sp., *Paraethomys anomalus*, *Castillomys (Centralomys) benericettii* n. sp., *Occitanomys* sp., *Apodemus* cf. *gudrunae*, *Cricetus* cf. *barrierei*, *Ruscinomys* cf. *lasallei*, *Myomimus* sp., *Atlantoxerus* cf. *rhodius*, *Hylopetes* sp., *Hystrix* sp.

La fauna di Brisighella individua una provincia biogeografica nuova, intermedia fra quella iberico-occitana e quella greca. Differenze paleoecologiche, unite probabilmente a leggere differenze di età, rendono difficile la correlazione con le faune di Baccinello-V3 e di Gravitelli. La fauna endemica del Gargano si conferma posteriore a quella di Brisighella.

La composizione faunistica indica chiaramente l'appartenenza della fauna del Monticino alla zona a mammiferi MN13. Molti roditori presentano livelli evolutivi molto simili a quelli delle località spagnole di Caravaca e Alcoy, e della località di Maritsa a Rodi. Questi livelli evolutivi sono leggermente più avanzati di quelli delle altre località attribuite alla zona MN13 mentre a Brisighella, Caravaca e Alcoy mancano gli elementi caratteristici della più tarda zona MN14. E' forse possibile riconoscere, utilizzando questo gruppo di località, una sottozona indipendente correlabile con la fine del Messiniano.

FOREWORD

A rich vertebrate fauna has been collected in the karst fissure fillings of the Monticino quarry near Brisighella (Faenza, Italy). A preliminary note (Costa *et al.*, 1986) has already reported provisional data. Geological, stratigraphic and paleontological studies are in progress (Marabini & Vai, 1988; De Giuli *et al.*, 1988).

It is worth reviewing the essentials of the local geological section: the base of the exposed sequence is made up of a series of gypsum layers with interbedded clays belonging to the Gessoso-solfifera Formation and is referred to the early Messinian. The gypsum is un-

conformably overlain by a non continuous thin green clay layer (0 to 1 m thick), referred to the Colombacci Formation and considered to be late Messinian in age. A series of marine gray marly clays belonging to the earliest Pliocene *Sphaeroidinellopsis* Zone rest on the Colombacci Fm. and often directly overlies the gypsum sequence. The gypsum was affected by a slight karst erosion, and clays, small conglomerates and bones were deposited in the cavities. There is still no agreement about the relationship between the fissure fillings and the Colombacci Fm. Karst morphologies suggest that the erosion took place over previously tilted gypsum strata, not far from the present day setting. The

⁽¹⁾ The author died suddenly before completing the manuscript, therefore some parts are unfinished.

sediments filling the fossiliferous fissures are mainly composed of green clays which could be derived from either the Gessoso-solfifera Fm or the Colombacci Fm however, the clasts other than the bones, are rolled elements of black clays and fresh-water limestones similar to those occurring in the Colombacci Fm.

Up to now 20 fossiliferous sites have been explored, most of which have since been destroyed by quarrying. Individual fissures may have been encountered several times during the mining of the gypsum. As we did not have sufficient data to confirm this possibility, we chose to consider each fossiliferous point as a distinct site. These are labelled BRS (Brisighella), followed by a number. The fossil content of the sites varies from a few teeth up to very rich and complete faunas. Some sites yielded large and small mammals others only small or large mammals.

Studies in progress have updated the faunal list (De Giuli *et al.*, 1988 and papers of Kotsakis, 1989; Kotsakis & Masini, 1989; Masini, 1989; Masini & Thomas, 1989; Torre, 1989).

INSECTIVORA

Galerix sp. aff. *depereti*
Postpalerinaceus sp.
Episoriculus aff. *gibberodon*
 Soricidae indet.

CHIROPTERA

Megaderma gr. *vireti-mediterraneum*
Rinolophidae sp. A
Rinolophidae sp. B
 Vespertilionidae indet.

PRIMATES

Colobinae cf. *Mesopithecus*

PROBOSCIDATA

cf. Gomphotheridae

CARNIVORA

Plioviverrops faventinus n. sp.
 Hyaenidae indet.
 Canidae indet.

TUBULIDENTATA

Orycteropus sp.

PERISSODACTYLA

Dicerorhinus cf. *megarhinus*
Hipparion sp.

ARTIODACTYLA

Samotragus occidentalis n. sp.

Bovinae cf. *Parabos*
 Bovidae indet.
 Cervidae indet. (small size)
 Suidae indet.

RODENTIA

Hystrix sp.
Stephanomys debruijini n. sp.
Paraethomys anomalus
Castillomys (Centralomys) benericettii n. sgen., n. sp.
Occitanomys sp.
Apodemus cf. *gudrunae*
Cricetus cf. *barrierei*
Ruscinomys cf. *lasallei*
Myomimus sp.
Atlantoxerus cf. *rhodius*
Hyllopetes sp.

LAGOMORPHA

Trischizolagus cf. *maritsae*
Prolagus cf. *sorbinii*

Some reptile, bird, and fish remains are also present. Tab. 1 shows the occurrence of the taxa in the sites. BRS3, BRS5 and BRS6 are particularly rich in micromammals, while large mammals are common in sites BRS1 and BRS5.

TAPHONOMY

Fossils are for the most part concentrated in fissures, though in site BRS4 the few remains were scattered and embedded in sediments filling the bottom of a broad superficial karst cavity in direct contact with the overlying sequence. The karst morphology of the fissures is evident.

Rodents form the bulk of the Brisighella Fauna. Doormice, hamsters, squirrels and porcupines are represented by a single or a few specimens each. Murids are by far the dominant rodent family, although their diversity is moderate. Only 5 species from 5 separate genera occur. Moreover, two of the species are quite rare.

Small mammal remains are mainly concentrated in extremely rich lenses in the BRS3, 5, and 6 sites. The high concentration of fossils can be attributed to the accumulation of pellets produced by birds of prey resting in vicinity of the fissures. This conclusion is supported by the observation that there are neither significant differences in the occurrence of left and right molars nor in the number of first and second molars (Tab. 2).

	BRS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	19	20
<i>Galerix</i> sp.			+	+	+	+						+		+						+
<i>Postpalaerinae</i> sp.						+				+										
<i>Episoriculus</i> aff. <i>gibberodon</i>			+	+	+	+	+		+	+		+	+							+
Soricidae indet. (small size)																				+
<i>Megaderma</i> gr. <i>vireti-mediterraneum</i>					+	+														
Rhinolophidae indet.			+			+	+													+
Vespertilionidae indet.					+	+														
Chiroptera indet.									+											
Colobinae cf. <i>Mesopithecus</i>		+																		
cf. Gomphotheriidae																				+
<i>Plioviverrops faventinus</i> n. sp.			+	+	+	+					+						+		+	
Hyaenidae indet.				+		?														?
Canidae indet.						+														
<i>Orycteropus</i> sp.						?	+													?
<i>Dicerorhinus</i> cf. <i>megarbinus</i>		+																		
<i>Hipparion</i> sp.		+		+		+				+						+				
<i>Samotragus occidentalis</i> n. sp.		+	+		?	+	?		+	+	+					+	+	+	+	?
Bovinae cf. <i>Parabos</i>		+				+											+		+	
Bovidae indet.				+	+															
Cervidae indet. (small size)						+														
Suidae indet.		+																		
<i>Hystrix</i> sp.						+	?						+							
<i>Stephanomys debruijini</i> n. sp.		+	+	+	+	+	+	+	+	+		+	+		+	+	+	+	+	+
<i>Paraethomys anomalus</i>		+	+	+		+	+			+		+	+				+	+	+	+
<i>Castillomys benericettii</i> n. sp.		+	+		+	+	+		+	+		+	+						+	+
<i>Occitanomys</i> sp.										+										+
<i>Apodemus</i> cf. <i>gudrunae</i>				+	+	+	+	+	?										+	+
<i>Cricetus</i> cf. <i>barrierei</i>				+			+													
<i>Ruscinomys</i> cf. <i>lasallei</i>					+	+	+			+										+
<i>Myomimus</i> sp.									?											
<i>Atlantoxerus</i> cf. <i>rhodius</i>				+			+													
<i>Hylopetes</i> sp.							+													
<i>Trischizolagus</i> cf. <i>maritsae</i>			+		+	+	+		+	+						+		+	+	+
<i>Prolagus</i> cf. <i>sorbini</i>		+		+	+	+	+		+	+					+			+	+	+

Tab. 1 - Distribution of taxa in the sites of the Monticino quarry.

Large mammal remains are found either as partially articulated skeletons, or as scattered, transported fragments. Fossils from large or very large macromammals are extremely rare. Among herbivores, proboscideans are poorly represented (only 1 find), as are rhinoceroses, hipparions, and large bovines. Carnivores are almost exclusively represented by the small sized "hyaenid" *Plioviverrops*. De Giuli *et al.*, (1988), think that one of the factors responsible for this selection was the small size of the fissures.

Since this explanation cannot be used to account for the characteristics of the microfauna, the extreme

scarcity of the cricetids and the almost total absence of the glirids seem to be an actual characteristic of the association living in the area.

The occurrence of articulated skeletons, specifically in the BRS5 site, suggests that some of the karst cavities acted as natural traps. This hypothesis is supported by the relative over-representation of carnivore remains.

THE RODENTS

It has already been pointed out that rodents are by

		<i>Stephanomys</i>			<i>Paraethomys</i>		
		BRS3	BRS5	BRS6	BRS3	BRS5	BRS6
M ¹	r	149	37	9	57	10	1
	l	137	30	12	72	4	2
M ²	r	140	42	8	46	10	3
	l	149	22	12	49	12	2
M ₁	r	115	29	7	57	16	1
	l	115	29	8	55	12	4
M ₂	r	149	33	4	57	17	2
	l	148	34	10	60	18	—

Tab. 2 - Occurrence of *Stephanomys* and *Paraethomys* teeth in BRS3, BRS5, and BRS6.

far the most abundant fossils in the Brisighella fauna, which is dominated by the murids though they have many more specimens than any other group, their diversity is moderate, and only five species from five different genera occur. Furthermore, three of the species are quite rare. Other rodent families are represented only by a single or a few specimens.

MURIDS

Taxonomy of murids is not yet fully established, and it is difficult to insert new specimens into phylogenetic lineages that are mainly valid for limited geographic regions. A full revision of the systematics of the Muridae is needed, but is beyond the scope of the present paper.

The fauna we are dealing with has no possible comparison in Italy, except the scant Baccinello-V3 fauna, and therefore difficulties arise in assessing taxonomic rank of the observed differences or similarities.

The nomenclature of the upper molars, namely M1 and M2, is traditionally defined and generally accepted. In the present paper some problems with the use of the same nomenclature in M3 are brought up. There is less agreement over lower tooth nomenclature. I will use the one proposed by Michaux (1971), as emended by Pasquier (1976), measuring length and width of the specimens as suggested by Van de Weerd (1976).

Genus STEPHANOMYS Shaub, 1938

STEPHANOMYS DEBRUIJNI n. sp.

Pl. 1, figs. 1-12; Pl. 2, figs. 1-2

This medium sized *Stephanomys* occurs in all sites of the Monticino quarry where small mammals have been found. The population of BRS3 is extremely rich (see Tab. 2) and has been chosen for the description.

Diagnosis — Size, stoutness and hypsodonty intermediate between *S. ramblensis* and *S. medius*. Stephanodonty is complete in each tooth and in almost all specimens. M¹ with amygdalar shape due to the strongly developed t1-bis in little worn specimens; as wear advances the lingual border of the anterocone is parallel to the lingual and labial borders of the tooth.

Derivatio nominis — This species is named after Dr. Hans de Bruijn, who guided my entrance into the world of micromammals.

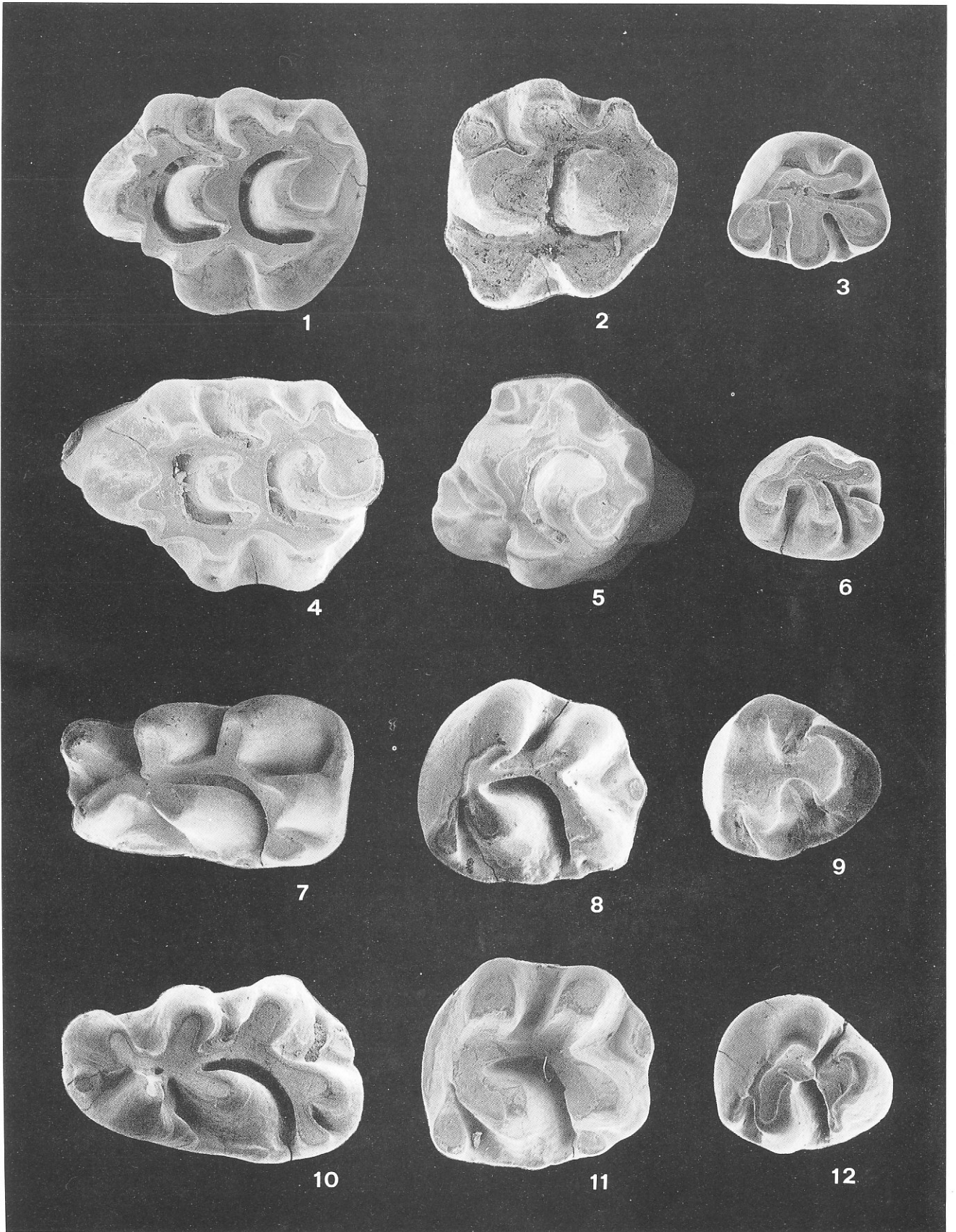
Type — Left M¹, BRS3 (Pl. 1, fig. 1)

Hypodigm — Complete right upper tooth row, BRS2 (Pl. 2, fig. 1); complete right lower tooth row, BRS5 (Pl. 2, fig. 2); all the collection of BRS3.

EXPLANATION OF PLATE 1

Monticino quarry, Brisighella (Faenza, Italy). Magnification approx. ×20

Figs. 1-12 - *Stephanomys debruijni* n. sp.: 1) holotype, M¹ left, BRS3; 2) M² left, BRS3; 3) M³ left, BRS3; 4) M¹ left, BRS3; 5) M² left, BRS3; 6) M³ left, BRS3; 7) M₁ left, BRS3; 8) M₂ left, BRS3; 9) M₃ left, BRS3; 10) M₁ left, BRS3; 11) M₂ left, BRS3; 12) M₃ left, BRS3.



Repository — The micromammal laboratory of the Dipartimento di Scienze della Terra, Università di Firenze.

Type locality — Site 3 of the Monticino quarry, Brisighella (Faenza, Italy). The site is labelled as BRS3.

Age — MN 13 mammal zone; late Messinian.

Stratigraphic range — Restricted to the upper part of the MN 13 zone.

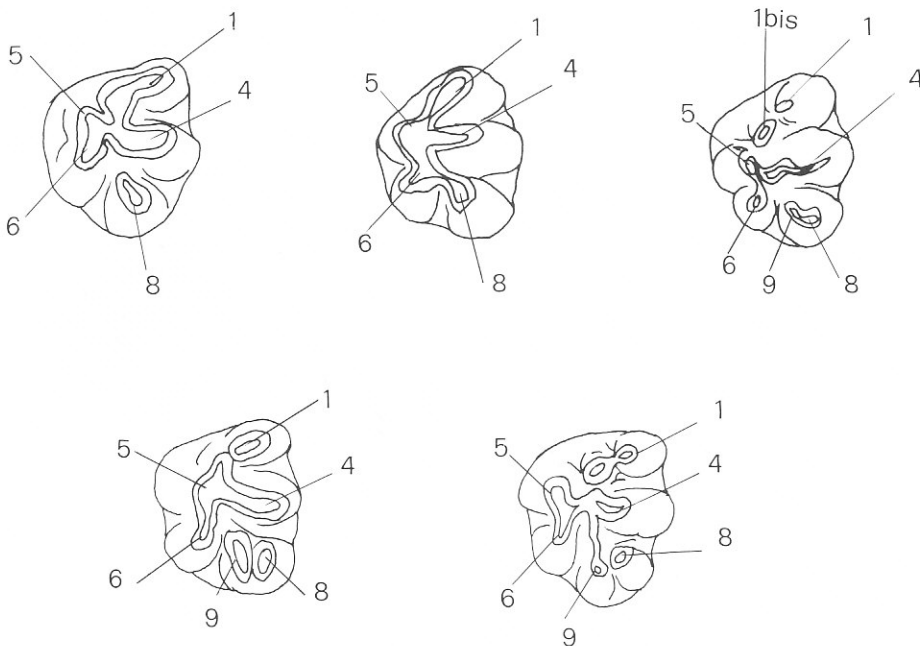
Other localities — Caravaca (Spain); many sites of the Monticino quarry, Brisighella.

Description — A) M^1 . The t1 contacts the t5 in early stage of wear; in a few cases the connection is low and becomes functional only in a more advanced stage of wear; in 5 out of 120 specimens the connection is very low, and in one case it is absent. The t1-bis is large, well developed and always present. The anterior furrow between t1 and t2 is large but shallow, and is completely occupied by the large, protruding t1-bis. This gives the teeth a very stout, rounded shape. Also, t2-bis is always present and, except in a few cases, strongly developed; it completely occupies the anterior furrow between t2 and t3. The t3 is more anteriorly placed than t1. The t3-t5 connection is always present; in only 5 out of 120 specimens it is weak and low. The t4-t5 connection is higher than the t4-t8 connection. The t12 is always present in early stages of wear, it becomes a salient angle in more advanced stages and

disappears in worn specimens. Three roots always occur.

B) M^2 . The t1 is large and shaped like a reversed comma. There is no t1-bis, even though some specimens show a narrowing of the grinding surface and (or) a light groove on the wall that could suggest it. The t1-t5 connection is low and in a few cases very low. The t3 is rounded and connected to or leans upon the t5 at the anterior wall of the tooth; in a few cases this anterior connection is low or absent. The t3 is connected posteriorly to the t5 by a low ridge in 35% of the specimens. In all but one case a t5-bis (a strong anterior spur between t5 and t6) occurs. A narrow valley separates t4 and t8, which are always connected by a low ridge. T9 is a well defined tuberculum half way between t6 and t8. The t12 is well defined in 26%, a salient angle in 54% and absent in 20% of the cases. As for the t12 of M^1 there is a correlation between this tuberculum and age. On the other hand in M^2 the absence of t12 is frequent in poorly worn specimens.

C) M^3 . This tooth varies considerably with wear. The general pattern of worn teeth is sufficiently homogeneous, and it could be possible to describe them with a terminology like the one used by Cordy (1976) or Van de Weerd (1976). This terminology suggests an homology with the M^1 and M^2 cusps, according to Thaler (1966). The 80 unworn or slightly worn tooth specimens from the BRS3 *Stephanomys*, need further study. Some examples are shown in Text-fig. 1. The study of this problem digresses from the present study, but the BRS3 is so rich that it would be ideal for addressing the problem.

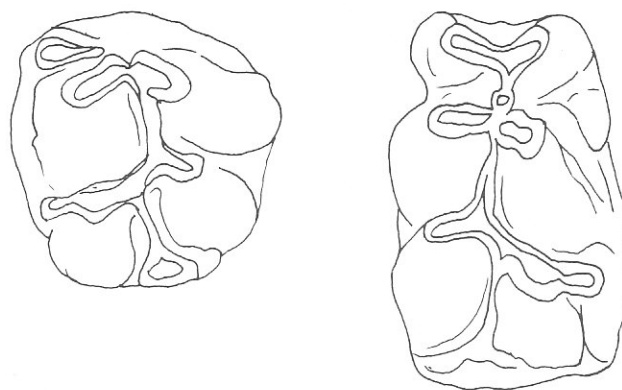


Text-fig. 1 - *Stephanomys debruijnii* n. sp., M^3 from BRS3.

D) M_1 . The tma is a well defined tuberculum in 17%, an enamel spur or crest in 25% and is absent in 58% of the specimens. The tF is slightly larger and more advanced than tE; this gives the anteroconid complex an asymmetric pattern. C1 is slightly smaller than tA, and is connected to the same tuberculum by a strong, short crest. The posterior cingulum (terminal heel in Van de Weerd, 1976) is an enamel crest developed from the postero-labial side of tA to the posterior side of tB at its labial corner: as a consequence a narrow deep closed valley divides the crest from the tB. In a very few cases the connection with tB is not complete and the valley is open. At the attachment with tA the crest is wide and the enamel often divides, forming a distinct tuberculum. The tuberculum, which occurs in 60% of the cases, is extremely variable in shape (rounded, triangular or elliptical). The labial cingulum also displays a variable pattern. A posterior sector between the posterior borders of C1 and tA is always present, and leaves a closed valley between the two cusps. At the labial side of tC, as well as in front of C1 and posterior to tE, a spur can occur. This last spur is often wide and in 23% of the specimens bears a distinct tuberculum. These morphologies are developed to different degrees and combined in different ways, giving rise to various patterns of the labial cingulum, which can be present as a continuous ridge, as a discontinuous series of spurs, or even be absent in part or totally. A strong longitudinal spur always connects tB to the center of the tC-tD connection. In a few cases there is a spur connecting the posterior border of the cp to the tA (Text-fig. 2).

Even though rare, this character seems to be peculiar to the BRS specimens; if the cp is a tuberculum it has a triangular shape.

E) M_2 . The tE is about half the size of the tC, and often it is even smaller. C1 is small and present in 58%



Text-fig. 2 - *Stephanomys debruijini* n. sp., M_2 and M_1 from BRS3.

of the specimens. The cp is a definite tuberculum in 94% of the cases; the enamel crest only seldom reaches tB. The same comments made on the labial cingulum as of the M_1 hold true. The longitudinal spur connecting tB to the tC-tD connection is well marked. As in M_1 , some specimens show a longitudinal spur connecting cp to tA.

F) M_3 . The tE is represented by an enamel crest separated from the tC on the labial side by a valley. In 32% of the specimens the crest bears a small but evident tuberculum. The tA is strongly reduced, with the shape of a small tuberculum or an enamel crest in 63% of the cases, or completely absent (37%). There are no cusps along the labial border. The longitudinal spur is always present, in a few cases it is discontinuous.

Comparisons with other Stephanomys species — The very primitive form *Stephanomys stadii* described by Mein & Michaux (1979) is completely different and

	Length				Width			
	min	mean	max	n	min	mean	max	n
M^1								
Alcoy	2.43	2.63	2.77	16	1.74	1.86	1.97	19
Argoub Kemellal	2.30	2.44	2.57	12	1.67	1.76	1.85	11
BRS-3	2.28	2.48	2.72	80	1.73	1.88	2.05	80
Valdecebro-3	1.98	2.25	2.48	32	1.43	1.64	1.84	39
M_1								
Alcoy	2.12	2.21	2.36	12	1.33	1.40	1.60	14
Argoub Kemellal	2.15	2.21	2.29	9	1.27	1.40	1.54	9
BRS-3	2.17	2.34	2.53	80	1.34	1.50	1.62	80
Valdecebro-3	1.92	2.08	2.25	27	1.21	1.32	1.45	30

Tab. 3 - Comparisons of the measurements in mm of M^1 and M_1 of different *Stephanomys* populations of the late Miocene.

need not be compared. Strict comparisons with the *Stephanomys* of MN14 and later are also not necessary, as their hypsodonty, stoutness and size makes them unmistakable.

Since many publications deal with them they are by far the best known representatives of the genus (Adrover, 1986; Cordy, 1976; Ruiz Bustos, 1986; Gmelig Meyling & Michaux, 1973). On the other hand, little is known about the Late Miocene species. No one other than Van de Weerd (1976) has published analytical data and descriptions and figures are also scant. The known species are *S. ramblensis*, described by Van de Weerd (1976) at Valdecebro-3, *S. medius* from Alcoy defined by Cordy (1976), *S. numidicus* from Argoub Kemellal (see: Coiffait *et al.*, 1985) and *S. debruijni* from Brisighella. Tab. 3 gives the measurements of the specimens of these sites.

The comparison among the measurements of Brisighella-3 and Valdecebro-3 is viable, as the variability and standard deviation of the two populations are similar. The species of Valdecebro is smaller, but its slenderness is about the same.

The populations of Alcoy and Argoub Kemellal are poor, and differences in size are not indicative. The specimens of Alcoy seem to be more slender than those of Brisighella. From a morphological point of view, *S. medius* differs from *S. debruijni* and from *S. ramblensis* in the lesser development and protrusion of t1-bis, which gives the latter two species an oval outline, uninterrupted by the sinus of the anterocone in the upper first molars. In this respect, *S. numidicus* is closer to *S. medius*. The CE on the lower first molars is a character that does not occur in *S. ramblensis*.

The specimens from Caravaca are extremely close to *S. debruijni*. Adrover considers them to be *S. medius*, but the oval shape of the M¹ is like that of the specimens of Brisighella. The only comparable measurements for M₁ are those shown by de Bruijn (1974). If we add in the scatter of de Bruijn (1974, fig. 2) the distribution of BRS3 and of Valdecebro-3 we note that the specimens of the three sites lie on the same regression line. It is unfortunate that a similar comparison can not be accomplished on the M¹.

Geographical and chronological range of Stephanomys — The genus was believed by Cordy (1978) to

occur only in the Mediterranean regions of Spain and Western France. Originating in Spain in the Late Turolian, it did not spread to France earlier than the Late Ruscinian. In France, Mein & Michaux (1979) reported the earlier occurrence of *S. stadii* in the Middle Turolian site of Cucuron, but the genus apparently disappeared in the Late Turolian. In North Africa *S. numidicus* occurs in the Argoub Kemellal site referred by Coiffait *et al.* (1985) to the MN 13 zone. The occurrence of *S. debruijni* in Italy, and its close resemblance, if not equivalence, to the Spanish form of Caravaca, raises a definite problem with either its occurrence in France or about its migration routes.

Genus *PARAETHOMYS* Petter, 1968

PARAETHOMYS ANOMALUS (de Bruijn *et al.*, 1976).

Pl. 2, figs. 3-14

Genus *CASTILLOMYS* Michaux, 1969.

In many sites of the Monticino quarry a few specimens of a small sized murid, with characteristics that hardly fit in any known form, occur. As this form is apparently present only in Brisighella, and the material is poor, I prefer not to split the family with a new genus for the moment. Nevertheless, a specific differentiation alone hardly accounts for the peculiarity of this form. Therefore, I propose a new subgeneric name, using as genus the one that seems to me closest in morphology and time.

Subgenus *CENTRALOMYS* n. sgen.

Type species — *Castillomys (Centralomys) benecettii* n. sp.

Diagnosis — Degree of stephanodonty somewhat intermediate between *Castillomys* and *Occitanomys*. Tubercula bent backwards as in *Orientalomys*. M² with 4 roots. Both M¹ and M₂ with t1-t5 and t4-t8 connections, but without any t3-t5 connection; isolated t3 and well developed t1-bis.

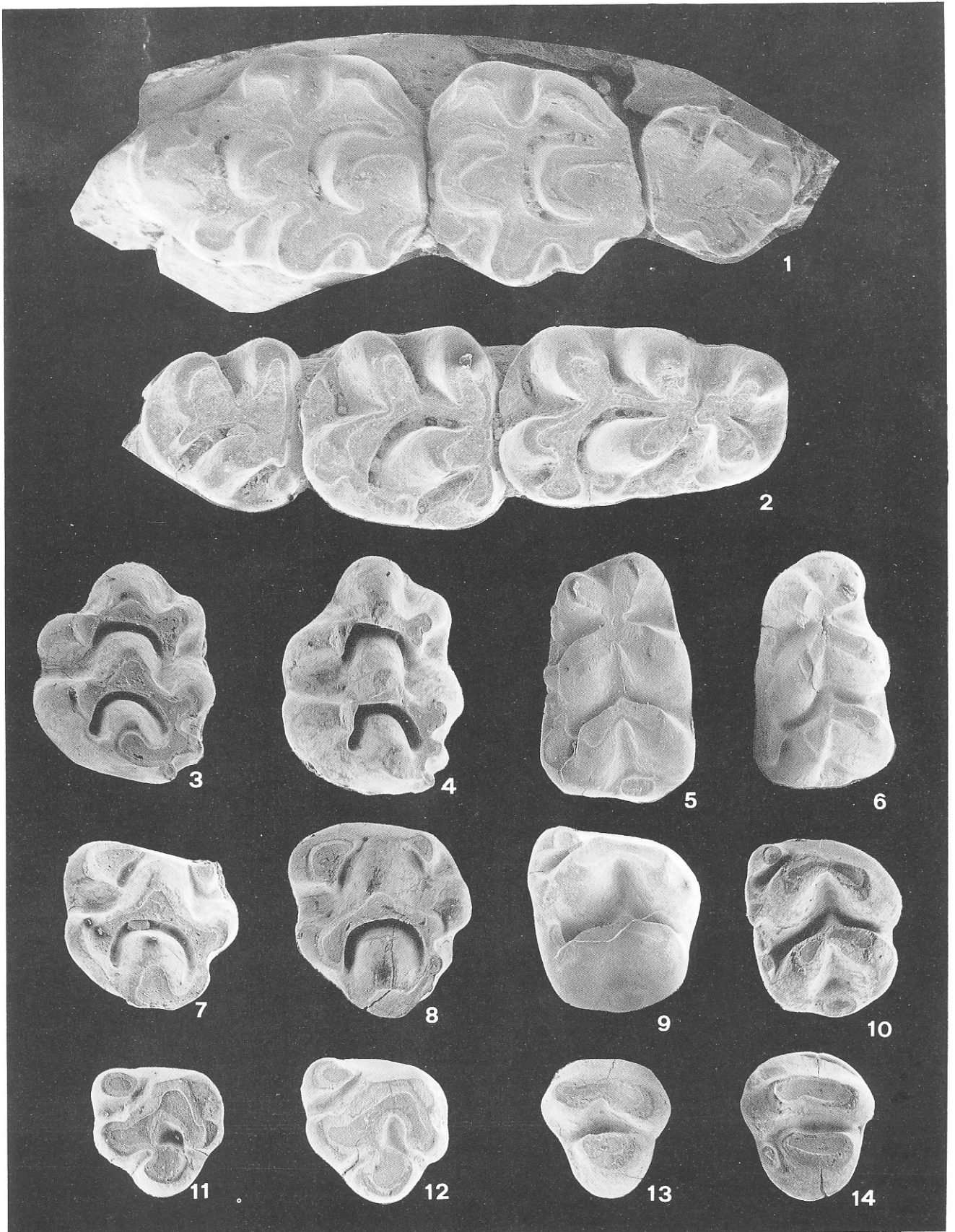
Derivatio nominis — The subgenus is named according to the intermediate geographical and morpho-

EXPLANATION OF PLATE 2

Monticino quarry, Brisighella (Faenza, Italy). Magnification approx. ×20

Figs. 1-2 - *Stephanomys debruijni* n. sp.: 1) upper right molars, BRS2) lower right molars, BRS5.

Figs. 3-14 - *Paraethomys anomalus*: 3-4) M¹ left, BRS3; 5-6) M₁ left, BRS3; 7-8) M² left BRS3; 9-10) M₂ left, BRS3; 11-12) M¹ left, BRS3; 13-14) M₃ left, BRS3.



ological position among the small and medium sized murids of the Mediterranean area.

Comparisons — If we compare the Brisighella *Castillomys* to the specimens of *Castillomys* from Maritsa and Moreda, and to the specimens of *Orientalomys* from Tourkobounia and Çalta, one can recognize many characteristics that link these forms to each other, and the central link looks to be the Brisighella specimens. On the M^1 the occurrence of t1-bis and a narrow crest connecting t1 and t2 is shared by Brisighella and Maritsa, while Moreda and Tourkobounia show a large and low crest and no t1-bis. On the other hand, the occurrence of an accessory cusp in the groove between t2 and t3 occurs in Brisighella and Tourkobounia. The M^2 has 4 roots in the BRS1 specimens; in TOU and CA this is a constant characteristic, while MA and MO specimens always have 3 roots. The occurrence of t1-bis and a narrow valley between t6 and t9 once again connects BRS and MA: TOU and MO do not display t1-bis, t1 is connected to t5 by a large, low crest, and the valley between t6 and t9 is broad. The t9 is more advanced in BRS, MA and MO than in TOU.

CASTILLOMYS (CENTRALOMYS) BENERICETTII n. sp.
Pl. 3, figs. 1-10

Diagnosis — Small sized murid, occurring with few specimens in many of the Brisighella sites (its absence in BRS 3, by far the richest site is surprising). The comparative description of the new subgenus accounts for the new species.

Derivatio nominis — The species is named after Mr. Tonino Benericetti of Zattaglia (Faenza), who first discovered fossils in the Brisighella locality, and skillfully recovered the major part of the micromammal fauna.

Type — Left M^1 , BRS1 (Pl. 3, fig. 1).

Hypodigm — Left M^1 , BRS1 (Pl. 3, fig. 2); left M^2 , BRS1 (Pl. 3, fig. 3); left M^2 , BRS1 (Pl. 3, fig. 4).

Repository — The micromammal laboratory of the Dipartimento di Scienze della Terra, Università di Firenze.

Type locality — BRS1, Monticino quarry, Brisighella (Faenza, Italy).

Age — MN 13 mammal zone; late Messinian.

Stratigraphic range — Seems to be limited to the MN 13 zone.

Description — A) M^1 . These teeth are wide and stout. A crest connects t1 to t5 and t4 to t8. A large t1-bis always occurs between t1 and t5, while in some specimens one or two accessory cups are well developed in the valley in front of the t2-t3 connection. T1-bis, t2 and t3 are about on the same line, slightly oblique with respect to the longitudinal axis; on the contrary t1 is strongly deflected backward. T3 has no spurs and is isolated from t5 and t6 (it is feebly connected to t6 in only one case); the valley separating t3 from t6 is usually large. T4, t5, t6 and t9 are about the same size; t8 is large and protrudes towards t9. In some cases a feeble t12 occurs.

B) M^2 . Second upper molars are quite homogeneous in morphology. As in M^1 , a crest connects t1 to t5 and t4 to t8. T1-bis always occurs; t1 and t1-bis are of the same size and their axes form an almost 90 degree angle. Also, t3 is of the same size as t1, and is isolated from t5 and t6. T4, t5, t6 and t9 are about the same size, t8 is larger. Sometimes the t8-t9 connection is formed by an enamel crest, sometimes the crest is wide and forms an additional cusp between t8 and t9. The most noticeable characteristic of the teeth is the occurrence, already noted, of 4 roots on both specimens.

Other localities — BRS2, 4, 5, 6, 8, 9, 11, 12, 20.

Description of the specimens from other localities — In the BRS1 site no further molars have been found that can be referred to this species. As in all sites *Castillomys benericettii* is very rare, and it is difficult to

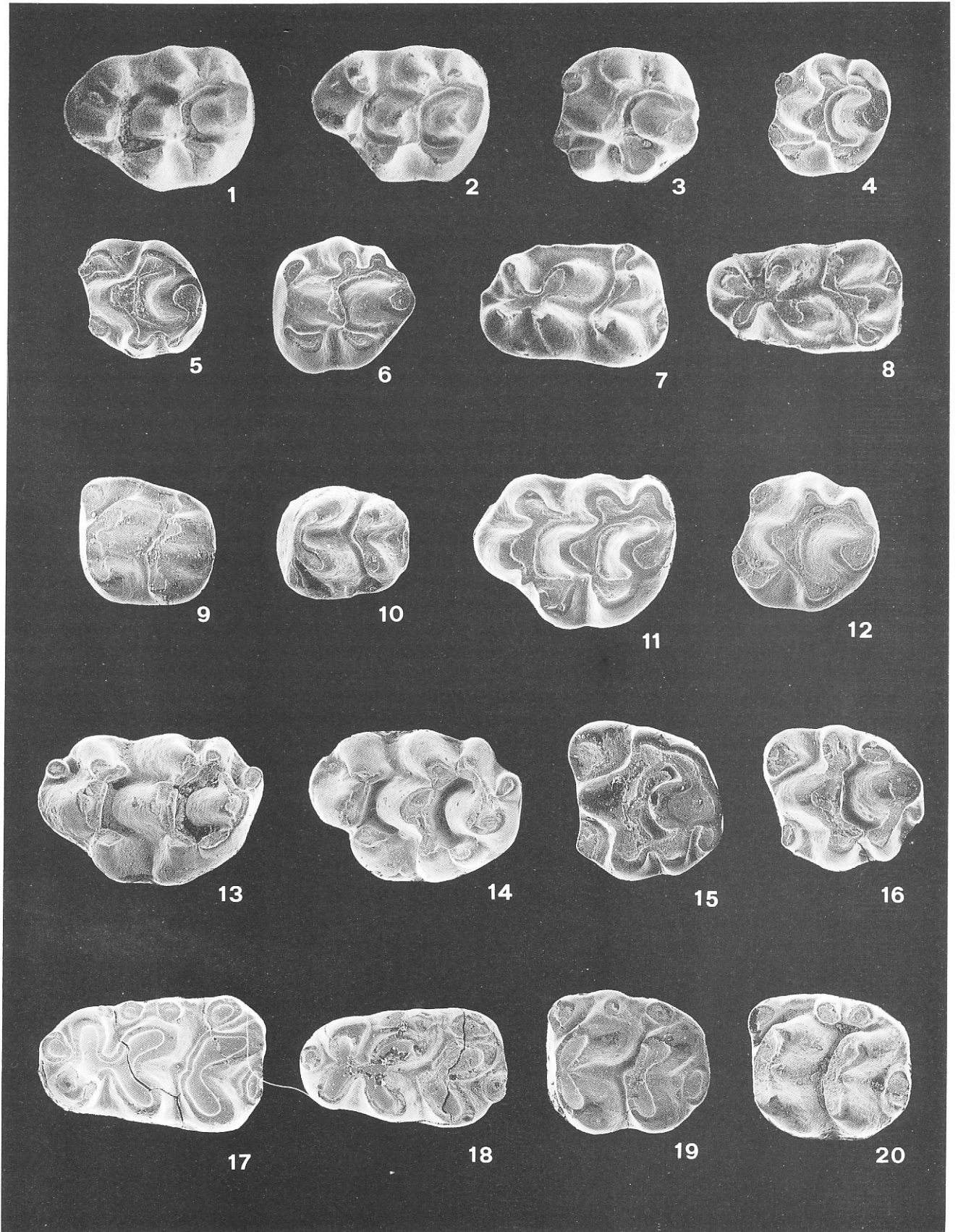
EXPLANATION OF PLATE 3

Monticino quarry, Brisighella (Faenza, Italy). Magnification approx. $\times 20$

Figs. 1-10 - *Castillomys (Centralomys) benericettii* n. sgen. (n. sp.): 1) holotype, M^1 left, BRS1; 2) M^1 left, BRS1; 3-4) M^2 left, BRS1; 5) M^2 right, BRS8; 6) M^2 left, BRS8; 7) M_1 right, BRS8; 8) M_1 left, BRS8; 9) M_2 right, BRS8; 10) M_2 left, BRS12.

Figs. 11-12 - *Occitanomys* sp.: 11) M^1 left, BRS18; 12) M^2 left, BRS18.

Figs. 13-20 - *Apodemus* cf. *gudrunae*: 13-14) M^1 left, BRS?; 15-16) M^2 right, BRS6; 17-18) M_1 right, BRS3; 19- 20) M_2 right, BRS26.



decide whether any small sized murid tooth other than M^1 and M^2 , can be referred to this species⁽²⁾. The M^1 are very homogeneous and easy to recognise. All the specimens conform those of BRS1. On the M^2 , four roots are present in 10 out of 11 specimens.

The BRS8 site yielded upper molars of both *Castillomys benericettii* and *Occitanomys*. Their size are very similar but two different groups can be distinguished. One group has no labial cingulum and faint signs of tma, the other has a labial cingulum and no tma at all. As a consequence, the first group rectangular in shape, and the second more triangular in outline. I think that the first group can be referred to *Castillomys benericettii* (Pl. 3, figs. 5-9). A few specimens bear a distinct but small tma, this tuberculum is generally absent or is a feeble spur fading into an enamel lamina. The cp is always present, but never strong and in a few cases is reduced to an enamel crest. A central ridge joins the tA-tB connection to the tC-tD connection in a few cases.

Tentatively I refer one M_2 from BRS12 to this species (Pl. 3, fig. 10).

Genus OCCITANOMYS Michaux, 1969

OCCITANOMYS sp.
Pl. 3, figs. 11-12

Description — T1-bis is present in M^1 and M^2 as in *O. brailloni*. M^1 : its shape is relatively stout due to the development of the labial cingulum, which does not bear extra cups other than of c1. This makes these specimens closer to *Occitanomys* than to *Castillomys* and gives a rather triangular shape to some specimens.

⁽²⁾ During August 1988, some new localities have been found in the Monticino quarry at Brisighella. One of these, BRS25, is particularly rich in small sized murids, namely *Castillomys benericettii*. It will allow in a next future to solve the problem of describing the complete dentition of this species.

Genus APODEMUS Kaup, 1829

APODEMUS cf. GUDRUNAE Van de Weerd, 1976.
Pl. 3, figs. 13-20

The *Apodemus* of Brisighella cannot be distinguished by direct comparisons from *Apodemus gudrunae* of Valdecebro-3, their size and morphology are extremely similar. The specimens from Brisighella have a higher percentage of tma and t7 (not just because of the loss of some specimens among the *Paraethomys*), a stouter structure, and a more marked individualisation of the tubercula. This last characteristic suggests in some way *Rbagapodemus*, but hypsodonty is not as developed as in *Rbagapodemus*.

MINOR RODENT GROUPS

Rodents other than murids are very rare in the Brisighella fauna. Only a few sites yielded isolated or scant specimens. Only partial conclusions can be drawn about taxonomy, but their bearing on paleogeographic and paleoecologic assessments is important.

Genus CRICETUS Leske, 1779

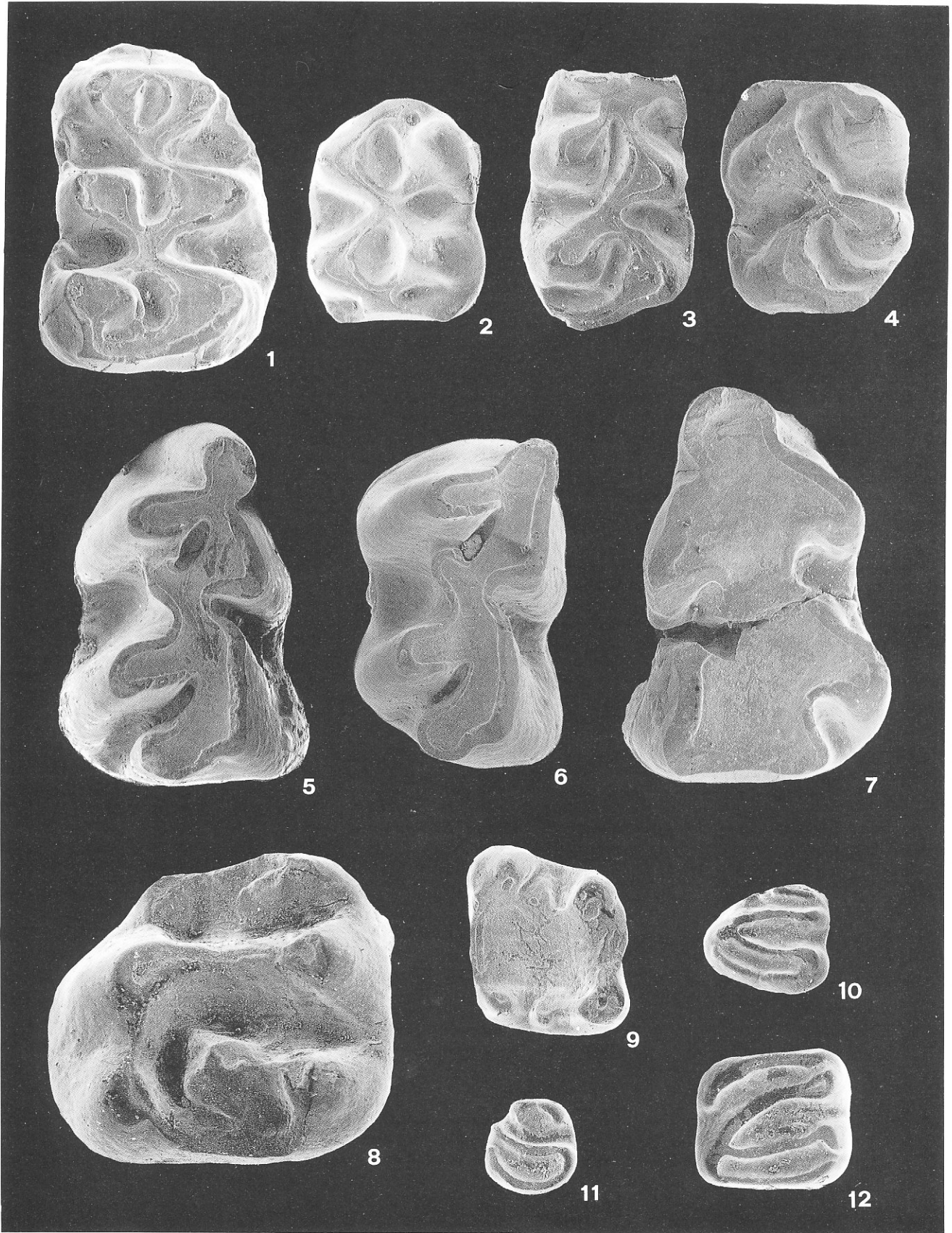
CRICETUS cf. BARRIEREI Mein & Michaux, 1970
Pl. 4, figs. 1-4

Cricetus occurs in BRS3 (one broken specimen) and in BRS6 (five specimens). The only complete M^1 present is definitely smaller than *Cricetus angustidens* of Nimes and Sète, but larger than *Cricetus kormosi* of Crevillente-6. It strongly resembles the specimens from Vilafont and Caravaca preserved in the collections of the Utrecht University. With respect to the Caravaca specimens that from Brisighella is slightly smaller and its tubercula are not bent as far backwards. In many respects it conforms to the specimens of *Cricetus barrieriei* described by Mein & Michaux (1970) in the site of Chabrier. On the basis of its size and morphology it

EXPLANATION OF PLATE 4

Monticino quarry, Brisighella (Faenza, Italy). Magnification approx. $\times 20$

- Figs. 1-4 - *Cricetus* cf. *barrieriei*: 1) M^1 right, BRS6; 2) M^2 right, BRS3; 3) M_1 right, BRS3; 4) M_2 right, BRS6.
Fig. 5-7 - *Ruscinomys* cf. *lasallei*: 5) M^1 right, BRS6; 6) M_1 right, BRS6; 7) M^1 left, BRS6.
Fig. 8 - *Atlantoxerus* cf. *rhodius*: 8) M^{1-2} left, BRS8.
Fig. 9 - *Hylopetes* sp.: 9) M_1 right, BRS6.
Figs. 10-12 - *Myomimus* sp.: 10) P_1 left, BRS6; 11) P^1 left, BRS6; 12) M^{1-2} left, BRS6.



can be referred to *Cricetus* cf. *barrierei*.

The Chabrier site is held to belong to the subzone of Hautimagne. A *Cricetus* cf. *barrierei* has been described by Brandy & Jaeger (1980) from the Messinian site of Ain Guettara in Western Morocco.

Genus RUSCINOMYS Depéret, 1890

RUSCINOMYS cf. LASALLEI Adrover, 1969

Pl. 4, figs. 5-7

Ruscinomys occurs in BRS6 (eight specimens) and as single worn specimens in BRS4 and BRS9. It is much more hypsodont than *Ruscinomys schaubi* of Los Mansuetos, while its morphology is quite different from that of the *Ruscinomys* sp. "A" from Valdecerbo-3 described by Van de Weerd (1976). The BRS specimens conform with the species *Ruscinomys lasallei* from Alcoy described by Adrover, 1969. Thus, considering its hypsodonty and size, the cricetid of Brisighella will be referred to *Ruscinomys* cf. *lasallei*. This species, according to Van de Weerd (1976), possibly occurs also in Caravaca.

Genus ATLANTOXERUS Major, 1893

ATLANTOXERUS cf. RHODIUS de Bruijn *et al.*, 1970

Pl. 4, fig. 8

This sciurid genus is present as a single specimen from BRS 3. Because of the scantiness of the material, only general features can be noted. The pattern of the teeth, as well as their size, better conform to the species described by de Bruijn *et al.* (1970), from Maritsa, than to *A. adroveri*, described by de Bruijn & Mein (1968), from Los Mansuetos. Therefore it is referred to *Atlantoxerus* cf. *rhodius*.

Atlantoxerus was a widespread but rare animal during Late Miocene and Early Pliocene times, with a circum-mediterranean distribution.

Genus HYLOPETES Thomas, 1908

HYLOPETES sp.

Pl. 4, fig. 9

A single specimen occurs in BRS 6. It is a right M_1 of a flying squirrel that surely belongs to one of those species that Bouwens & de Bruijn (1986) grouped under the generic name of *Hylomyscus*. Broadly speaking it is from the "troisième groupe: émail chagriné, pas ou peu de lophules" according to Mein (1970). The specimen from Brisighella is slightly smaller than the cor-

responding teeth of *Hylomyscus macedoniensis* from Maramena (see: Bouwens & de Bruijn, 1986).

Genus MYOMIMUS Ognev, 1924

MYOMIMUS sp.

Pl. 4, figs. 10-12

It only occurs in BRS6, as a few specimens (1 left M^{1-2} , 1 left P_4 , 1 right P_4), and cannot be referred to any particular species. The dental pattern of the M^{1-2} is less complicated than the one shown for *Myomimus maritsensis* (see: de Bruijn *et al.*, 1970; pl. 7, fig. 2) from Maritsa. Nevertheless, according to Daams (1981), a goodly percentage of the Maritsa population shows a simpler morphotype of the M^1 and M^2 than the figured one. On the other hand, all the P_4 from Maritsa are similar to the two specimens of Brisighella.

Myomimus is still living in Eastern Europe and Asia, occurs in the Pleistocene of Palestine, in the Mio-Pliocene of Greece (Maramena and Maritsa), and has never been recorded in the Ibero-occitane province later than the Vallesian.

Genus HYSTRIX Linnaeus, 1758

HYSTRIX sp.

Hystrix occurs in BRS5 and BRS12. The presence of this genus, which cannot be better determined, is revealed by a few teeth, a femur, and a humerus fragment.

CONCLUSIONS

On the whole the rodents indicate that the BRS fauna can be referred to the MN13 zone. The fauna has many species in common with typical localities referred to this zone, for instance Valdecerbo-3, Crevillente-6, and Alcoy. The greatest resemblance seems to be with the fauna from Caravaca, unfortunately still not published in detail. Nevertheless, some species connect it with localities considered to be MN14, namely Maritsa and Hautimagne.

The evolutionary level reached by some species may better define the biochronological setting. All the genera shared with Valdecerbo-3 and Crevillente-6 seem to be represented in Brisighella by apomorphic species. This is true for *Stephanomys*, *Apodemus*, *Cricetus* and *Ruscinomys*. On the other hand, these forms appear to be plesiomorphic with respect to the species of Hautimagne, Orrios and of the other localities referred to the MN14 Zone. The evolutionary level of many forms connects the Brisighella fauna with those

of Caravaca and Alcoy. It is possible to distinguish, within the MN13 Zone a definite biochronologic unit represented by the faunas of Brisighella, Caravaca and Alcoy. Possibly Maritsa can also be referred to this biochronological unit, as de Bruijn (1974) has already suggested.

The geological setting of the Brisighella fauna allows to correlate well these faunas, with a time interval ranging from the end of the first evaporitic event and the earliest Pliocene, thus confirming the ideas of de Bruijn (1973) and de Bruijn *et al.* (1975), which, at the time, were not supported by any direct evidence.

The two new species, *Stephanomys debriujini* and especially *Castillomys benericettii*, show that we are dealing with a biogeographical province that differs from the Ibero-occitane province and possibly from the Greek province. This is also supported by the occurrence of new large mammals (Masini & Thomas, 1989; Torre, 1989) and lagomorphs (Masini, 1989). This Italian region was not isolated. Some species suggest there were close connections with oriental faunas. For example, *Plioviverrops faventinus*, is phylogenetically linked to *P. orbigny*, from Greece, and *Samotragus occidentalis*, is the western-most representative of this genus in the Mediterranean Area. The occurrence of *Myomimus* in a MN 13 fauna also suggests an oriental pattern. On the other hand, the eastern-most representative of *Stephanomys* is found in Brisighella.

Data on Italian faunas of similar ages are not abundant. The best known is the Baccinello-V3 (Grosseto) fauna (Hürzeler & Engesser, 1976; Hürzeler, 1987; Engesser, 1989), which differs considerably from the Brisighella fauna, as suids, cervids, and hipparions are widely represented and the carnivores are more diversified. The rodent fauna of Baccinello is poor but different in composition. As a matter of fact, there are too few common faunal elements to permit detailed correlations based on associated characteristics. *Stephanomys*, which does not occur among the rodents from Baccinello, is apparently replaced by *Rhagapodemus*. The rodents of the two localities only share *Apodemus* but the few specimens collected from the two sites are insufficient, in my opinion, for any conclusions based on phylogenesis. Notwithstanding, Engesser (1989), suggests that the Baccinello *Apodemus* is more primitive than the one of Brisighella. In this case Baccinello-V3 would be older than the latest Messinian. It would be an important conclusion, as geological and paleontological inferences lead De Giuli *et al.* (1983) to feel that the Baccinello V3 fauna could be earliest Pliocene or latest Miocene in age. Hürzeler (1987) referred the V3 level to MN14.

Gravitelli, near Messina in Sicily, is the second Italian locality which yielded a mammal fauna that could be compared with Brisighella. The geological

setting beneath the second gypsiferous sequence indicates that this fauna could be slightly older than Brisighella fauna. The Gravitelli fauna was destroyed by the earthquake that struck Messina in 1908, and is therefore known only from descriptions and figures in the literature (Seguenza, 1902; 1907). Few of its elements appear to be comparable to either those from Brisighella or from Baccinello V3.

Differences in the taphonomic conditions are evident in the three localities, and thus the variations in the faunas could be reasonably referred to the existence of three fairly different biotopes. Also, the age of the three sites does not seem to be exactly the same.

The Gargano fauna must also be close in age to the Brisighella fauna. The early Pliocene age of the Gargano fissure fillings given by De Giuli & Torre (1984) is confirmed by the plesiomorphic pattern of *Apodemus* cf. *gudrunae* from the Monticino sites, but further studies are needed to confirm the eastern provenance of the "second wave" immigrants proposed by De Giuli *et al.* (1987).

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