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COMPARATIVE MORPHOLOGY OF THE FIRST LOWER MOLAR OF PRESENT-DAY AND FOSSIL POPULATIONS OF GROUND VOLES IN ITALY (RODENTIA, ARVICOLIDAE)

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ABSTRACT - *Comparative morphology of the first lower molar of present day and fossil populations of ground voles in Italy (Rodentia, Arvicolidae)* - Il Quaternario, **7**(1), 1994, 35-40 - The fossil records of *Microtus (Terricola)* are abundant in Italy, but their identification has been visual only. In this paper eigth fossil populations from five Late Pleistocene sites are compared, using statistical analyses, to present populations of *Terricola*, and to the fossil type-population of *M. (T.) tarentina* from Villa Castelli (Apulia). The studied populations are ascribed to *M. (T.) savii* and *M. (T.) multiplex*. The intermediate characters of the ground voles from the Broin cave, between the Mid-European group *subterraneus-multiplex* and the recent *M. (T.) savii*, suggest that the simplex type M3/ may be a derived character of *M. (T.) savii*, convergent with that of the Western Mediterranean group *M. (T.) duodecimcostatus*, and not a primitive character.

RIASSUNTO - *Morfologia comparata del primo molare inferiore di Terricola (Rodentia, Arvicolidae) di popolazioni italiane fossili ed attuali* - Il Quaternario, **7**(1), 1994, 35-40 - Attualmente in Italia vi sono quattro specie di terricole, *Microtus (Terricola)*, e i reperti di questo sottogenere sono frequenti nei siti fossili, ma non sono quasi mai determinati a livello specifico. In questo lavoro si è cercato di determinare, con l'aiuto delle analisi statistiche, otto popolazioni fossili del Pleistocene superiore, confrontandole con popolazioni attuali di *Microtus (Terricola) savii, M. (T.) multiplex e* la popolazione fossile tipo di *M. (T.) tarentina*. Ne è risultato che le popolazioni pleistoceniche in esame appartengono a *M. (T.) savii* ad eccezione di quella dell'Arma delle Manie, ascrivibile a *M. (T.) multiplex*. La popolazione di *M. (T.) savii* della Grotta del Broion, presenta caratteri intermedi fra quelle attuali e quelle del ceppo medioeuropeo *subterraneus-multiplex*. Questo potrebbe provare che la forma semplice di M3/ di *M. (T.) savii* è un carattere derivato, convergente con quello del ceppo occidentale mediterraneo *duodecimcostatus*, e non un carattere primitivo.

Key words: *Microtus (Terricola)*, Rodentia, Late Pleistocene and Holocene, Italy.
Parole chiave: *Microtus (Terricola)*, Rodentia, Pleistocene superiore e Olocene, Italia.

1. INTRODUCTION

Four species of ground vole are currently found in Italy: *Microtus (Terricola) savii* (Sélys-Longchamps, 1838), which is common throughout most of the country and in the Southern part of Ticino; *M. (T.) multiplex* (Fatio, 1905) in the Alps and Tuscany; *M. (T.) subterraneus* (Sélys-Longchamps, 1836) in the region of Verona and *M. (T.) liechtensteini* (Wettstein, 1927), a species found in the North-Eastern of the country only, especially on the borders with Austria and Slovenia (Storch & Winking, 1977; Niethammer & Krapp, 1982; Amori *et al.*, 1984). Where-as *M. (T.) subterraneus* and *M. (T.) liechtensteini* are found in the confined and border areas, *M. (T.) savii* and *M. (T.) multiplex* are both widespread species of ground vole in Italy. The fossil species *M. (T.) tarentina* has been described from the Mid-Pleistocene finds of Villa Castelli near Taranto in Apulia (Brunet-Lecomte, 1988b). A great many ground vole teeth have been recorded in Pleistocene finds in Italy (Bartolomei, 1980; Bartolomei *et al.*, 1976; Bartolomei & Broglio, 1977; Bartolomei & Tozzi, 1978; Bon *et al.*, 1991; Sala, 1983c, 1990) but so far their identification has been visual only and is consequently open to debate. This paper seeks to determine to which species eight fossil populations of ground voles from five Late Pleistocene sites belong by comparing them with present-day populations of *M. (T.) savii* and *M. (T.) multiplex* and with the type population of *M. (T.) tarentina* from Villa Castelli.

2. MATERIAL AND METHOD

Material

M. (T.) savii

Code	Nos.	Site
11	13	Cannevié di Volano (Ferrara, Emilia, Italy)
12	11	San Bartolome (Ferrara, Emilia, Italy)
13	60	San Severo (Gargano, Apulia, Italy)
14	6	Coldrerio (Ticino, Switzerland)
15	38	Meride (Ticino, Switzerland)

M. (T.) multiplex

Code	Nos.	Site
21	48	Mazzolla (Pisa, Tuscany, Italy)
22	12	Fivizzano (Massa Carrara,Tuscany, Italy)
23	12	Gudo (Ticino, Switzerland)
24	16	Meride (Ticino, Switzerland)
25	16	Bioggio (Ticino, Switzerland)
26	11	Varenzo (Ticino, Switzerland)

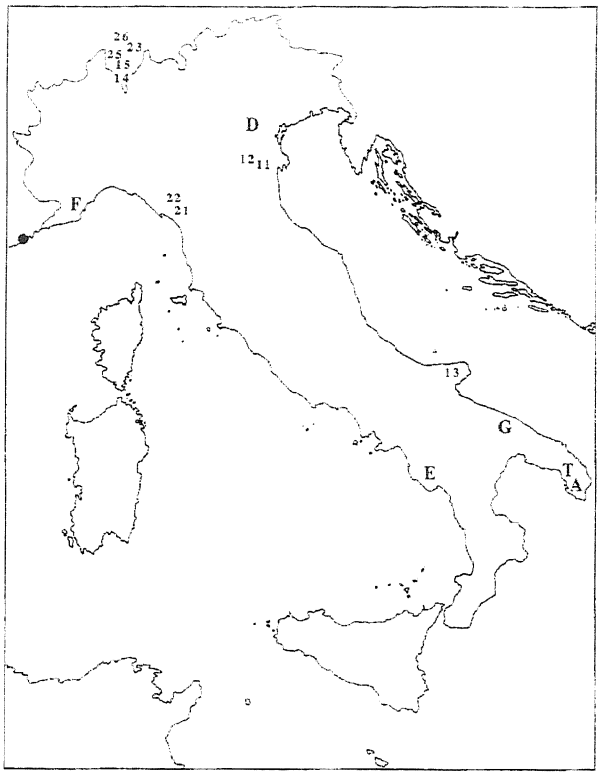

Fig. 1 - Geographic distribution of samples of *Microtus (Terricola)* populations analysed in this study.

Distribuzione dei campioni delle popolazioni di Microtus (Terricola) *analizzate in questo studio.*

Fossil populations

M. (T.) tarentina

Code	No.	Site
T	44	Villa Castelli (Brindisi, Apulia, Italy)

M. (T.) species

Code	No.	Site
A	44	Cipolliane (Gagliano del Capo, Apulia, Italy) Dryas I, 15,000 B.P.
B	20	Cipolliane (Gagliano del Capo, Apulia, Italy) Dryas I, 15,000 B.P.
C	20	Cipolliane (Gagliano del Capo, Apulia, Italy) Dryas I, 15,000 B.P.
D	30	Broion Cave (Berici Hills, Veneto, Italy) Early Pleniglacial
E	30	Cala Cave (Marina di Camerota, Campania, Italy) Tardiglacial
F	10	Armadelle Manie (Finale, Liguria, Italy), Early Pleniglacial
G	13	Mura Cave (Montopoli, Apulia, Italy), Late Tardiglacial, 12,000-10,000 B.P.
H	13	Mura Cave (Montopoli, Apulia, Italy) Late Tardiglacial, 12,000 B.P.

The geographic distribution of the populations is shown in Figura 1. The statistical analyses used are those described by Brunet-Lecomte (1988a).

1) General morphology of M/1: discriminant analysis calculated from the 21 parameters measured on the occlusal surface of M/1 among the various populations.

2) Analysis of the characters total length, relative length of the anterior part, the pitymyan rhombus, the anterior loop: one-way analysis of variance supplemented by the Scheffé contrast method.

3. RESULTS

3.1. General morphology of the first lower molar of the populations

Since a first discriminant analysis including the type-population of *M. (T.) tarentina* indicated on axis 1 a discrimination of this single population of *M. (T.) tarentina* compared with all the other populations, the analysis was repeated excluding *M. (T.) tarentina*.

The first three axes of the discriminant analysis express 32%, 26% and 13% of inter-population variance, respectively. Figure 2 shows the centroids distribution of the populations in plane 1-2 of the discriminant analysis.

Axis 1 clearly separates the present day *M. (T.) multiplex* populations from the present day *M. (T.) savii* populations. Along this same axis, only the fossil population of Arma delle Manie (F) lies on the side of the *M. (T.) multiplex* populations, while all the other fossil populations lie close to the *M. (T.) savii* populations.

The distribution of populations along axis 2 separates the present day *M. (T.) savii* populations and fossil populations other than that of Arma delle Manie as follows:

- the *M. (T.) savii* populations of Emilia (11 & 12) are close to one another, as are the *M. (T.) savii* populations of Ticino (14 & 15), while the population of Gargano has an intermediate position;
- the populations of Cipolliane (A, B and C) are clustered, although separated by present day *M. (T.) savii* populations;

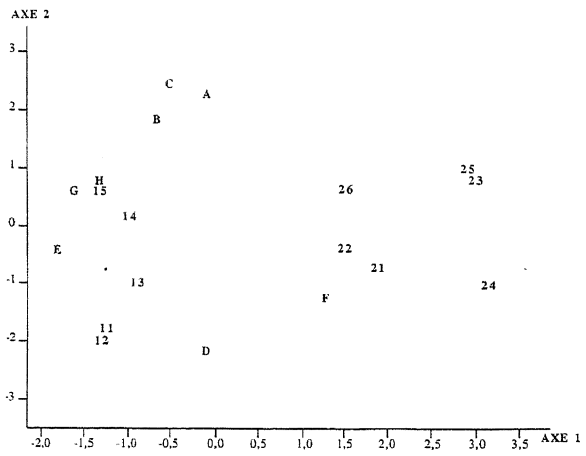

Fig. 2 - Projection of centroids of the samples of *Microtus (Terricola)* populations in the plan 1-2 of canonical discriminant analysis.

Proiezione dei centroidi dei campioni di popolazioni di Microtus (Terricola) *nel piano degli assi 1 e 2 dell'analisi discriminante canonica.*

- the populations of Mura Cave (G & H) are grouped and close to present day *M. (T) savii* populations of Ticino;

- the population of Broion Cave (D) is closer to those of Emilia and Gargano than those of Ticino.

The distribution of populations in plane 1-2 (Fig. 2) reveals the following information:

- the *M. (T.) multiplex* populations of Tuscany (21 & 22) are close to one another, whereas the *M. (T.) multiplex* populations of Ticino have a more widely scattered distribution;

- the population of Cala Cave lies mid-way between the present-day *M. (T.) savii* populations.

3.2 Analysis of M/1 characters

The "total length", "relative length of the anterior part", "pitymyan rhombus" and "anterior loop" characters are described in Tables 1 to 4.

Table 1 shows that:

- the present day *M. (T.) multiplex* populations have a greater total length than the present day *M. (T.) savii* populations;

Table1 - Description, variance analysis and Scheffé's test of the total length (TL) of the first lower molar in *Microtus (Terricola)* populations. Unity for TL is 10-2 mm. SD = Standard deviation.

Descrizione, analisi della varianza e test di Scheffé della lunghezza totale (TL) del primo molare inferiore nelle popolazioni di Microtus (Terricola). *L'unità per TL è 10 alla meno 2 mm. SD = Deviazione standard.*

	Total length (TL)			
Population	N	Mean	S.D.	Scheffé's test*
T	40	287,3	13,3	A
A	44	284,8	12,5	AB
B	20	280,6	12,6	ABC
C	20	284,9	9,6	AB
D	30	254,7	10,4	D
E	30	251,9	14,0	D
F	10	263,5	13,6	ABCD
G	13	263,2	14,1	ABCD
H	13	262,1	14,5	BCD
11	13	261,9	14,3	CD
12	11	261,5	10,4	CD
13	60	249,6	11,2	D
14	6	257,2	13,3	CD
15	38	258,6	13,0	CD
21	48	271,5	13,6	ABCD
22	12	274,0	19,8	ABCD
23	12	284,2	9,5	AB
24	16	272,7	16,8	ABCD
25	16	286,0	10,1	AB
26	11	266,2	13,1	ABCD

*Means with the same letter are not significantly different (p≥ 0,05).

- within *M. (T.) multiplex*, the total length of the populations of Tuscany is comparable with that of the populations of Ticino;

- within *M. (T.) savii*, the total length of the population of Gargano is less than the total length of the populations of Emilia and Ticino;

- among the fossil populations, *M. (T.) tarentina* and the populations of Cipolliane are characterized by a great total length, whereas the other populations have an average to small total length.

Table 2 - Description, variance analysis and Scheffé's test of the relative length of the anterior part (AP) of the first lower molar in *Microtus (Terricola)* populations. AP is without unity. SD = Standard deviation.

Descrizione, analisi della varianza e test di Scheffé della lunghezza relativa della parte anteriore (AP) del primo molare inferiore nelle popolazioni di Microtus (Terricola). *AP è senza unità. SD = Deviazione standard.*

	Relative length of the anterior part (AP)			
Population	N	Mean	S.D.	Scheffé's test*
T	40	0,484	0,0206	F
A	44	0,510	0,0149	ABCDEF
B	20	0,506	0,0106	BCDEF
C	20	0,511	0,0124	ABCDEF
D	30	0,534	0,0180	F
E	30	0,503	0,0155	BCDEF
F	10	0,518	0,0173	ABCDE
G	13	0,497	0,0178	CDEF
H	13	0,495	0,0127	DEF
11	13	0,517	0,0100	ABCDE
12	11	0,520	0,0186	ABCD
13	60	0,513	0,0129	ABCDE
14	6	0,494	0,0052	DEF
15	38	0,492	0,0101	EF
21	48	0,523	0,0142	ABCD
22	12	0,520	0,0129	ABCDE
23	12	0,524	0,0105	ABC
24	16	0,526	0,0139	AB
25	16	0,520	0,0109	ABCD
26	11	0,525	0,0117	ABC

*Means with the same letter are not significantly different (p≥ 0.05)

Table 2 shows that:

- the present day *M. (T.) multiplex* populations have a more developed relative length of the anterior part than the present day *M. (T.) savii* populations;

- within *M. (T.) multiplex*, the relative length of the anterior part of the populations of Tuscany is comparable with that of the populations of Ticino;

- within *M. (T.) savii*, the relative length of the anterior part of the populations of Ticino is less than that of the populations of Emilia and Gargano;

- *M. (T.) tarentina* is the population with the least developed relative length of the anterior part;

- the fossil populations of Cipolliane and Cala Cave have a relative length of the anterior part mid-way between that of *M. (T.) multiplex* and *M. (T.) savii*. The same applies to the populations of Arma delle Manie and Mura Cave, although the population of Arma delle Manie

Table 3 - Description, variance analysis and Scheffé's test of the pitymyan rhombus (PR) of the first lower molar in *Microtus (Terricola)* populations. Unity for PR is 10-2 mm. SD = Standard deviation.

Descrizione, analisi della varianza e test di Scheffé del rombo pitymyoide (PR) del primo molare inferiore nelle popolazioni di Microtus (Terricola). *L'unità per PR è 10 alla meno 2. SD = Deviazione standard.*

	Pitymyan rhombus (PR)			
Population	N	Mean	S.D	Scheffé'test*
T	40	-2,1	4,7	CD
A	44	1,5	4,4	ABCD
B	20	-0,6	3,3	BCD
C	20	1,0	2,9	ABCD
D	30	3,4	4,3	ABC
E	30	0,3	2,8	BCD
F	10	5,7	6,5	AB
G	13	-0,1	2,8	BCD
H	13	0,5	4,1	ABCD
11	13	-4,1	3,0	D
12	11	1,2	3,7	ABCD
13	60	0,6	3,3	ABCD
14	6	-1,3	2,0	BCD
15	38	0,2	3,0	BCD
21	48	5,3	3,5	AB
22	12	1,7	3,1	ABCD
23	12	3,2	2,5	ABC
24	16	2,1	3,0	ABCD
25	16	4,5	3,6	ABC
26	11	6,1	2,5	A

*Means with the same letter are not significantly different (p≥ 0,05)

is closer in this respect to *M. (T.) multiplex* and the Italian *M. (T.) savii* populations, while the populations of Mura Cave are closer to the *M. (T.) savii* populations of Ticino. The population of Broion Cave has a relatively long anterior part.

Table 3 shows that:

- the present day *M. (T.) multiplex* populations have a less steeply inclined pitymyan rhombus than the present day *M. (T.) savii* populations;
- within *M. (T.) multiplex*, the pitymyan rhombus of the populations of Tuscany is comparable with that of the populations of Ticino;
- within *M. (T.) savii*, the pitymyan rhombus shows no clear geographical variation among populations;
- *M. (T.) tarentina* has a clearly sloping pitymyan rhombus;
- in the fossil populations, the pitymyan rhombus is less steeply inclined in the populations of Broion cave and Arma delle Manie, while the other populations have a more steeply sloping pitymyan rhombus.

Table 4 shows that:

- the present day *M. (T.) savii* populations generally have a more open anterior loop than do the present day *M. (T.) multiplex* populations;
- within *M. (T.) multiplex*, the anterior loop of the populations of Ticino is more closed than in the populations of Tuscany;
- within *M. (T.) savii*, the anterior loop is more open in the populations of Ticino and Gargano than in the populations of Emilia;
- *M. (T.) tarentina* has a very open anterior loop;
- in the fossil populations, the anterior loop is closed in the populations of Broion cave and Arma delle Manie, while the other populations have a more open anterior loop.

4. DISCUSSION AND CONCLUSION

Synthesis of the general analysis and the analysis of M/1 characters shows that *M. (T.) tarentina* is clearly different from *M. (T.) savii* and *M. (T.) multiplex*, and that the fossil populations of Cipolliane (A, B & C), Broion Cave (D), Cala cave (E) and Mura Cave (G & H) belong to the morphological group *M. (T.) savii*, whereas the fossil population of Arma delle Manie fits in with the morphological group of *M. (T.) multiplex.*

M.(T.) tarentina, which in its M/3 morphology belongs to the same group as *M. (T.) savii*, clearly stands apart in its M/1 morphology, characterized by a little developed anterior part and a very open anterior loop. None of the other fossil populations studied bears resemblance

Table 4 - Description, variance analysis and Scheffé test of the close of the anterior loop (AL) of the first lower molar in *Microtus (Terricola)* populations. Unity for AL is 10-2 mm. SD = Standard deviation.

Descrizione, analisi della varianza e test di Scheffé della chiusura del laccio anteriore (AL) del primo molare inferiore nelle popolazioni di Microtus (Terricola). *L'unità per AL è 10 alla meno 2 mm. SD = Deviazione standard.*

	Anterior loop (AL)			
Population	N	Mean	S.D	Scheffé'test
T	40	0,445	0,071	A
A	44	0,299	0,061	BC
B	20	0,287	0,055	BC
C	20	0,296	0,058	BC
D	30	0,183	0,0174	CD
E	30	0,330	0,074	AB
F	10	0,237	0,089	BCD
G	13	0,298	0,085	BC
H	13	0,299	0,070	BC
11	13	0,242	0,069	BCD
12	11	0,245	0,070	BCD
13	60	0,291	0,081	BC
14	6	0,337	0,064	AB
15	38	0,302	0,053	BC
21	48	0,219	0,081	BCD
22	12	0,217	0,100	BCD
23	12	0,184	0,056	CD
24	16	0,133	0,031	D
25	16	0,204	0,058	BCD
26	11	0,249	0,046	BCD

*Means with the same letter are not significantly different (p≥ 0,05).

to *M. (T.) tarentina* of Villa Castelli. In particular, the populations of Apulia, Cipolliane (A, B & C) and Mura cave (G & H), show no close morphological tie with *M. (T.) tarentina* described for this region. This observation allows us to conjecture that *M. (T.) tarentina* may well have been extinct or rare by the Late Glacial.

The population of Arma delle Manie, which is close to the present day *M. (T.) multiplex* populations of Tuscany both in general morphology and M/1 characters may be ranked with the *M. (T.) multiplex* species, confirming the presence of the species in Liguria by the early Pleniglacial.

The populations of Cipolliane belong to the same morphological group as *M. (T.) savii* while occupying a marginal position in the plane 1-2 of the discriminant analysis, and being closer to the present day populations of Ticino than the present day populations of Tuscany and Gargano (axis 2 of the discriminant analysis). The analysis of M/1 characters shows that these populations have a large M/1 with a fairly open anterior loop, while the development of the anterior part and the slope of the pitymyan rhombus lie mid-way between the various present day populations of *M. (T.) savii.*

The population of Broion Cave shows a general morphology, which is quite close to that of the present day *M. (T.) savii* populations of Emilia and Gargano: the relative length of the anterior part is more developed, the pitymyan rhombus steeper (more archaic) and the anterior loop more closed. The morphology of this population seems intermediate between that of *M. (T.) savii* and that of the Mid-European group (phyletic group *subterraneus-multiplex*) (Brunet-Lecomte, 1990; Brunet-Lecomte & Chaline, 1991), which is characterized by a closed anterior loop, a well developed anterior part and a complex type M/3.

M.(T.) savii has a simplex type M/3, with 3 lingual salient angles, like thewestern Mediterranean group *M. (T.) duodecimcostatus.* The morphology of this tooth, however, is closer to that of the Mid-European group (separated triangles, *M. (Microtus)* -like). The population of Broion Cave seems, therefore, to show the phyletic connection with *M. (T.) subterraneus-multiplex* group. If this hypothesis is correct, either *M. (T.) savii* is a primitive species arrived to Italy later than the evolved species of the Mid-European group; or *M. (T.) savii* is derived by an evolved species of this group. In this latter case the simplex type M/3 is a derived character converging to that of the Western Mediterranean group and showing a counter-tendency to the normal evolution. This latter usually tends to increase the number of triangles in order to augment the occlusal surface.

The population of Cala Cave, both in general morphology and dental characters, lies mid-way between the present day *M. (T.) savii* populations of Tuscany, Gargano and Ticino. The populations of Mura cave are close to the present day *M. (T.) savii* populations of Ticino, both in their general morphology and their dental characters.

Major climatic variations in Italy during the Late Pleistocene (Bartolomei *et al.*, 1977; Sala, 1980, 1983a, 1983b) may be a primary factor in explaining the morphological variations among present day and fossil *M. (T.) savii* populations. Accordingly, on the basis of current knowledge no systematic conclusion can be drawn for the fossil populations of *M. (T.) savii* within the framework of this study. For the morphological development of tooth characters, only the slope of the pitymyan rhombus shows a significant difference between the present day and the fossil populations of *M. (T.) savii* ($p = 0.009$): the rhombus has sloped by 0.01 mm since the Late Pleistocene. Although this slope is not spectacular, it is characteristic of the evolution of the group of ground voles of Europe since Mid-Pleistocene (Brunet-Lecomte & Chaline, 1991, forthcoming).

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