Odontometrical divergence in the Gerbe's vole *Microtus* (*Terricola*) *pyrenaicus gerbei* (Gerbe, 1879) in comparison to the Pyrenean vole *M.* (*Terricola*) *pyrenaicus pyrenaicus* (de Sélys Longchamps, 1847) (Mammalia: Rodentia: Arvicolinae)

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> Abstract

This study confirms the odontometrical divergence of the first lower molar in the Gerbe's vole *Microtus* (*Terricola*) *pyrenaicus gerbei* in comparison with the Pyrenean vole *M. pyreneaicus pyrenaicus* as well as the interest of genetic analyses to resolve its systematic position with regard to *Microtus* (*Terricola*) *pyrenaicus*.

> Key words

Microtus (*Terricola*) *pyrenaicus gerbei*, Arvicolinae, Rodentia, Vendée, Loire Region, France.

Introduction

The Gerbe's vole was described by Gerbe (1879), from specimens of the Loire Basin (France) collected by A. de L'Isle du Dréneuc, under the name of *Arvicola* (*Microtus*) *gerbei*. Since, the Gerbe's vole is classified in the same species as the Pyrenean vole, *Microtus* (*Terricola*) *pyrenaicus* (Ellerman & Morrison-Scott, 1951; Saint Girons, 1973; Niethammer & Krapp, 1982; Wilson & Reeder, 2005), described by Sélys Longchamps (1847) from the region of the Pic du Midi de Bigorre (Hautes-Pyrénées, France). The distribution of *M. pyrenaicus* in Spain spreads from Catalan Pyrenees to Cordillera Cantabrica (Palomo & Gisbert, 2002) and in France includes the Southwest, from Languedoc to Aquitaine, the Central Massif and the South of the Loire Region (Le Louarn & Quéré, 2003).

The comparative odontometrical analysis of the first lower molar (M_1), the most informative tooth in the study of the evolution of voles, in populations of Gerbe's vole (Loire-Atlantique and Maine et Loire) and Pyrenean vole (Brunet-Lecomte & *al*., 1995) had shown a significant divergence between the nominative subspecies *M. pyrenaicus pyrenaicus* and the subspecies *M. pyrenaicus gerbei* distributed at the northwestern margin of the species distribution. The obtaining of a new material from Vendée (South of the Loire Region) of the Gerbe's vole, compared with geographical populations of the Pyrenean vole from Navarre, Southwest and Massif Central justify to make a new study in the aim to confirm the previously obtained results.

Material and method

The studied material was composed of a population of *M. pyrenaicus gerbei* (62 M_1) from Loire-Atlantique (15 M_1), Maine et Loire (11 M_1), Western Vendée (12 M_1), South Vendée (16 M_1) and Eastern Vendée (8 M_1). It was compared to 8 geographical populations of *M.* (*T.*) *pyrenaicus pyrenaicus* from following Region (Spain) or Departments (France): Navarre (Spain, N = 55), Gironde and Landes (France, N = 47), Gers

Fig. 1. Geographical localisation of *Microtus* (*Terricola*) *pyrenaicus* populations. A: Loire-Atlantique, B: Maine et Loire, C: Western Vendée, D: South Vendée, E: Eastern Vendée, G: Navarre (Spain), H: Gironde and Landes, I: Gers, J: Hautes-Pyrénées, K: Tarn, L: Corrèze, M: Haute-Vienne and N: Creuse.

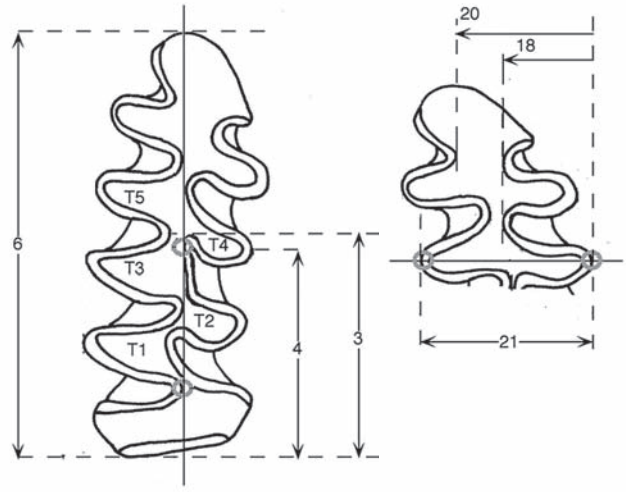


Fig. 2. Morphometry of the first lower molar of *Microtus* (*Terricola*) *species*.

(France, N=51), Hautes-Pyrénées (France, N=21), Tarn (France, N=56), Corrèze (France, N=91), Haute-Vienne (France, N=76), Creuse (France, N=70) (Figure 1).

The comparative analysis was performed on the following parameters (BRUNET-LECOMTE, 1990; BRUNET-LECOMTE *et al*., 2010) (Figure 2): total length = V6, development of the anterior part = (V6–V3)/V6 x 100, tilt of the pitymyan rhombus = V4–V3, closure of the anterior loop = (V20–V18)/V21 × 100, and length/width ratio = V6/V21.

Because of the non-normality or of the non-compliance with the equality of the variances between the populations of the studied criteria, Kruskal-Wallis non-parametric test was used to compare the criteria, followed by a Dunn's test for post-hoc multiple comparisons when necessary (HINTON, 2004) between the population of *M. pyrenaicus gerbei* with each geographical population of *M. pyrenaicus pyrenaicus*.

Results

The description for each parameter is given in Tab. 1 to Tab. 5.

Kruskal-Wallis test showed populations were significant different ($p < 0.0001$) for each studied parameter.

Significant differences (Dunn's test) pointed out between the *M. pyrenaicus gerbei* population and *M. pyrenaicus pyrenaicus* geographical populations are reported in Tab.6. *M. pyrenaicus gerbei* differs very clearly by 3 parameters: the pitymyan rhombus, less tilted (Figure 3), the anterior loop, more open (Figure 4) and the ratio length/width, greater (Figure 5) in *M. pyrenaicus gerbei* than in *M. pyrenaicus pyrenaicus*.

The 5 local sub-populations of *M. pyrenaicus gerbei* showed a strong homogeneity with the exception of that of the Loire-Atlantique characterised by a tilt of the pitymyan rhombus and a ratio length/width close to that observed in populations of *M. pyrenaicus pyrenaicus*.

Conclusion

This study confirms the significant odontometrical divergence of the M_1 criteria between *M. pyrenaicus gerbei* and *M. pyrenaicus pyrenaicus* previously reported (BRUNET-LECOMTE *et al*., 1995).

In 1880 already in their article describing exactly the taxon *gerbei*, GERBE & de L'ISLE considered this one as a different species from *M. pyrenaicus*, in particular on the basis of skull criteria (brain-case convexer, frontal bones less flattened, nasal bones more indented in back and occipital foramen wider). The odontometrical divergences, which cannot allow to resolve this question, highlight nevertheless all the relevance of this one. Only a genetic analysis will allow to know if the taxon *gerbei* is a subspecies of *M. pyrenaicus* either a different species. A pitymyan rhombus less tilted

Tab. 1. Description of the total length of the first lower molar (mm) in *Microtus* (*Terricola*) *pyrenaicus* populations. N = sample size, SD = standard deviation, SEM = standard error of the mean, Min = minimum, Max = maximum.

Population	N	Mean	SD	SEM	Median	Min	Max
gerbei Loire-Atlantique	15	2.520	0.136	0.035	2.500	2.320	2.770
gerbei Maine et Loire	11	2.595	0.093	0.028	2.590	2.470	2.770
gerbei Western Vendée	12	2.683	0.083	0.024	2.675	2.540	2.800
gerbei South Vendée	16	2.621	0.099	0.025	2.655	2.430	2.750
gerbei Eastern Vendée	8	2.685	0.096	0.034	2.685	2.520	2.800
gerbei total	62	2.612	0.119	0.015	2.640	2.320	2.800
pyrenaicus Navarre	55	2.648	0.106	0.014	2.640	2.440	2.840
pyrenaicus Gironde and Landes	47	2.776	0.153	0.022	2.810	2.440	3.040
pyrenaicus Gers	51	2.634	0.143	0.020	2.650	2.350	2.910
pyrenaicus Hautes-Pyrénées	21	2.614	0.075	0.016	2.610	2.470	2.770
pyrenaicus Tarn	56	2.533	0.139	0.019	2.530	2.260	2.860
pyrenaicus Corrèze	91	2.624	0.118	0.012	2.630	2.340	2.880
pyrenaicus Haute-Vienne	76	2.563	0.104	0.012	2.570	2.360	2.790
pyrenaicus Creuse	70	2.652	0.124	0.015	2.640	2.450	2.960

Tab. 2. Description of the development of the anterior part of the first lower molar (%) in *Microtus (Terricola) pyrenaicus* populations. N = sample size, SD = standard deviation, SEM = standard error of the mean, Min = minimum, Max = maximum.

Population	N	Mean	SD	SEM	Median	Min	Max
gerbei Loire-Atlantique	15	48.7	1.1	0.3	48.9	46.6	50.4
gerbei Maine et Loire	11	49.6	0.7	0.2	49.5	48.5	50.6
gerbei Western Vendée	12	49.7	0.6	0.2	49.8	48.6	50.4
gerbei South Vendée	16	50.6	0.8	0.2	50.6	49.4	52.5
gerbei Eastern Vendée	8	49.8	0.6	0.2	49.7	49.1	50.7
gerbei total	62	49.7	1.0	0.1	49.8	46.6	52.5
pyrenaicus Navarre	55	50.6	1.3	0.2	50.4	47.5	53.5
pyrenaicus Gironde and Landes	47	51.0	1.1	0.2	51.0	49.2	53.4
pyrenaicus Gers	51	50.7	1.3	0.2	50.6	47.7	54.2
pyrenaicus Hautes-Pyrénées	21	50.5	1.4	0.3	50.8	48.2	53.0
pyrenaicus Tarn	56	50.0	1.5	0.2	50.0	45.7	52.7
pyrenaicus Corrèze	91	49.5	1.2	0.1	49.4	47.1	53.0
pyrenaicus Haute-Vienne	76	49.6	1.2	0.1	49.6	46.1	52.2
pyrenaicus Creuse	70	50.3	1.4	0.2	50.4	47.0	53.1

Tab. 3. Description of the tilt of the pitymyan rhombus (mm) in *Microtus (Terricola) pyrenaicus* populations. N = sample size, SD = standard deviation, SEM = standard error of the mean, Min = minimum, Max = maximum.

Population	N	Mean	SD	SEM	Median	Min	Max
gerbei Loire-Atlantique	15	– 0.027	0.032	0.008	– 0.020	– 0.080	0.030
gerbei Maine et Loire	11	0.005	0.045	0.014	– 0.010	– 0.040	0.080
gerbei Western Vendée	12	0.035	0.024	0.007	0.035	– 0.010	0.070
gerbei South Vendée	16	0.018	0.020	0.005	0.020	– 0.010	0.050
gerbei Eastern Vendée	8	0.045	0.030	0.010	0.045	– 0.020	0.080
gerbei total	62	0.011	0.039	0.005	0.010	– 0.080	0.080
pyrenaicus Navarre	55	– 0.023	0.038	0.005	– 0.020	– 0.150	0.050
pyrenaicus Gironde and Landes	47	– 0.019	0.033	0.005	– 0.020	– 0.100	0.060
pyrenaicus Gers	51	– 0.010	0.033	0.005	– 0.010	– 0.070	0.070
pyrenaicus Hautes-Pyrénées	21	– 0.037	0.038	0.008	– 0.030	– 0.130	0.020
pyrenaicus Tarn	56	– 0.023	0.043	0.006	– 0.020	– 0.150	0.070
pyrenaicus Corrèze	91	– 0.035	0.031	0.003	– 0.030	– 0.120	0.020
pyrenaicus Haute-Vienne	76	– 0.018	0.034	0.004	– 0.020	– 0.080	0.060
pyrenaicus Creuse	70	– 0.022	0.031	0.004	– 0.030	– 0.090	0.040

Tab. 4. Description of the closure of the anterior loop (%) in *Microtus (Terricola) pyrenaicus* populations. N = sample size, SD = standard deviation, SEM = standard error of the mean, Min = minimum, Max = maximum.

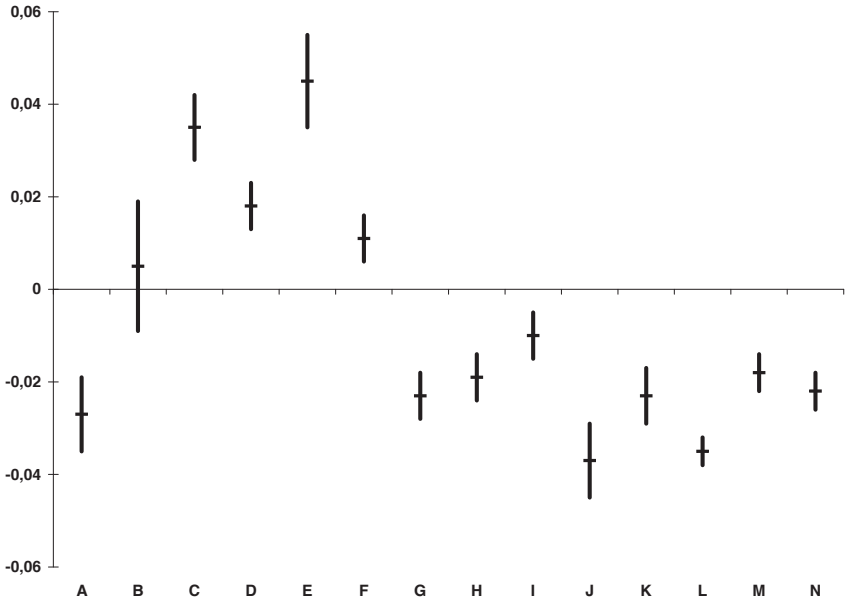
Population	N	Mean	SD	SEM	Median	Min	Max
gerbei Loire-Atlantique	15	37.9	6.8	1.8	38.1	28.6	48.0
gerbei Maine et Loire	11	37.4	5.1	1.6	35.9	30.5	47.2
gerbei Western Vendée	12	39.4	2.9	0.8	40.3	33.3	42.4
gerbei South Vendée	16	34.6	4.1	1.0	35.9	26.3	40.8
gerbei Eastern Vendée	8	37.9	4.2	1.5	39.2	28.3	41.7
gerbei total	62	37.2	5.1	0.6	37.7	26.3	48.0
pyrenaicus Navarre	55	22.9	8.3	1.1	23.1	1.0	40.0
pyrenaicus Gironde and Landes	47	24.1	6.3	0.9	24.3	12.7	38.4
pyrenaicus Gers	51	23.7	6.0	0.8	22.8	13.6	40.2
pyrenaicus Hautes-Pyrénées	21	31.5	6.2	1.4	32.4	21.2	41.6
pyrenaicus Tarn	56	32.5	7.4	1.0	31.9	19.1	55.8
pyrenaicus Corrèze	91	30.0	5.7	0.6	30.4	13.7	45.5
pyrenaicus Haute-Vienne	76	28.2	4.8	0.6	28.6	15.2	41.2
pyrenaicus Creuse	70	29.4	6.8	0.8	29.5	0.0	44.8

Tab. 5. Description of the ratio of length/width of the first lower molar in *Microtus (Terricola) pyrenaicus* populations. N = sample size, SD = standard deviation, SEM = standard error of the mean, Min = minimum, Max = maximum.

Population	N	Mean	SD	SEM	Median	Min	Max
gerbei Loire-Atlantique	15	2.58	0.08	0.02	2.56	2.43	2.71
gerbei Maine et Loire	11	2.74	0.12	0.04	2.73	2.57	2.92
gerbei Western Vendée	12	2.78	0.10	0.03	2.73	2.70	3.01
gerbei South Vendée	16	2.74	0.10	0.03	2.74	2.59	2.93
gerbei Eastern Vendée	8	2.87	0.12	0.04	2.84	2.74	3.07
gerbei total	62	2.73	0.14	0.02	2.72	2.43	3.07
pyrenaicus Navarre	55	2.55	0.09	0.01	2.54	2.38	2.72
pyrenaicus Gironde and Landes	47	2.58	0.13	0.02	2.54	2.34	2.88
pyrenaicus Gers	51	2.58	0.12	0.02	2.56	2.33	2.87
pyrenaicus Hautes-Pyrénées	21	2.58	0.10	0.02	2.59	2.42	2.78
pyrenaicus Tarn	56	2.55	0.10	0.01	2.55	2.37	2.75
pyrenaicus Corrèze	91	2.52	0.10	0.01	2.52	2.31	2.73
pyrenaicus Haute-Vienne	76	2.52	0.09	0.01	2.52	2.34	2.75
pyrenaicus Creuse	70	2.54	0.12	0.02	2.55	2.10	2.95

Tab. 6. Result of Dunn's test for post hoc multiple comparisons between *Microtus (Terricola) pyrenaicus gerbei* population and each *Microtus (Terricola) pyrenaicus pyrenaicus* geographical population. S = Significant ($p < 0.05$), NS = Not Significant ($P \geq 0.05$).

Population	Total length of the first lower molar	Development of the anterior part	Tilt of the Pitymyan rhombus	Closure of the anterior loop	Ratio of length/width
gerbei vs:					
pyrenaicus Navarre	NS	S	S	S	S
pyrenaicus Gironde & Landes	S	S	S	S	S
pyrenaicus Gers	NS	S	NS	S	S
pyrenaicus Hautes-Pyrénées	NS	NS	S	NS	S
pyrenaicus Tarn	NS	NS	S	S	S
pyrenaicus Corrèze	NS	NS	S	S	S
pyrenaicus Haute-Vienne	NS	NS	S	S	S
pyrenaicus Creuse	NS	NS	S	S	S



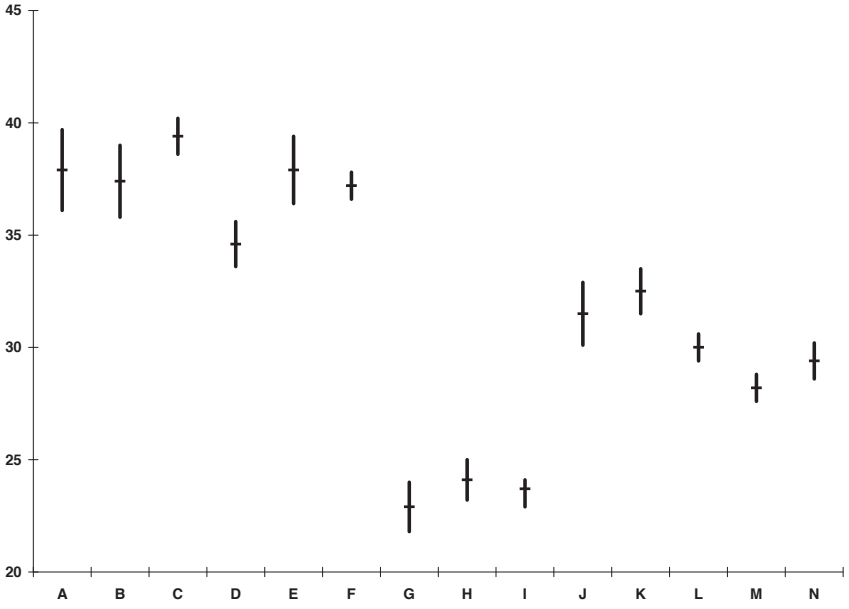
gerbei

A = Loire – Atlantique
B = Maine et Loire
C = W. Vendée
D = S. Vendée
E = E. Vendée
F = Total

pyrenaicus

G = Navarre
H = Landes/Gironde
I = Gers
J = Hautes – Pyrénées
K = Tarn
L = Corrèze
M = Haue-Vienne
N = Creuse

Fig. 3. Tilt of the pitymyan rhombus (mm) of the first lower molar: Mean ± Standard Error of the Mean (SEM) in *Microtus* (*Terricola*) *pyrenaicus* populations.



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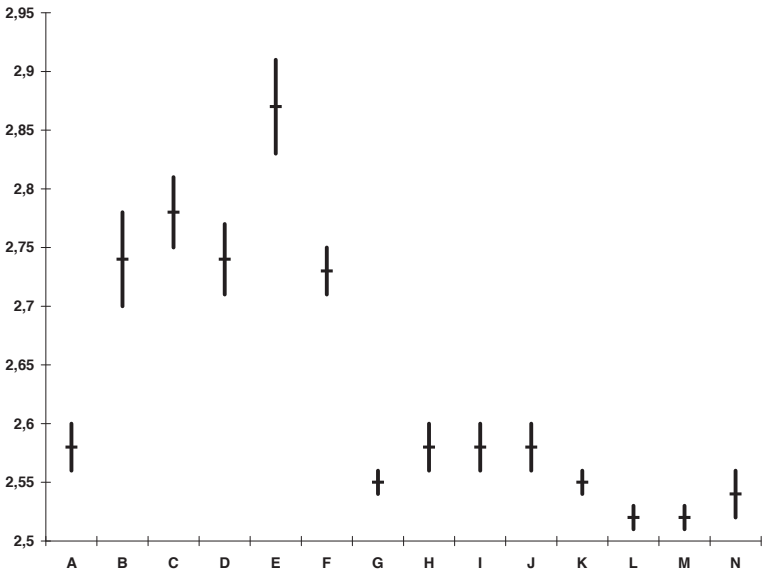
pyrenaicus

G = Navarre
H = Landes/Gironde
I = Gers
J = Hautes – Pyrénées
K = Tarn
L = Corrèze
M = Haue-Vienne
N = Creuse

Fig. 4. Closure of the anterior loop (%) of the first lower molar: Mean ± Standard Error of the Mean (SEM) in *Microtus* (*Terricola*) *pyrenaicus* populations.



gerbei

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pyrenaicus

G = Navarre
H = Landes/Gironde
I = Gers
J = Hautes – Pyrénées
K = Tarn
L = Corrèze
M = Haue-Vienne
N = Creuse

Fig. 5. Ratio length/width of the first lower molar: Mean±Standard Error of the Mean (SEM) in *Microtus* (*Terricola*) *pyrenaicus* populations.

and a large ratio length/width are more often observed in Pleistocene species than in present-day species of *Terricola* (BRUNET-LECOMTE & PAUNESCO, 2004 & 2008). The Loire Basin was able to be a refugium area during Middle or Upper Pleistocene cold periods for some micromammals like *Microtus* and activate a genetic isolation of *gerbei* taxon from *M. pyrenaicus pyrenaicus* or another Pleistocene *Terricola* species.

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