

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. pyrenaicus 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.

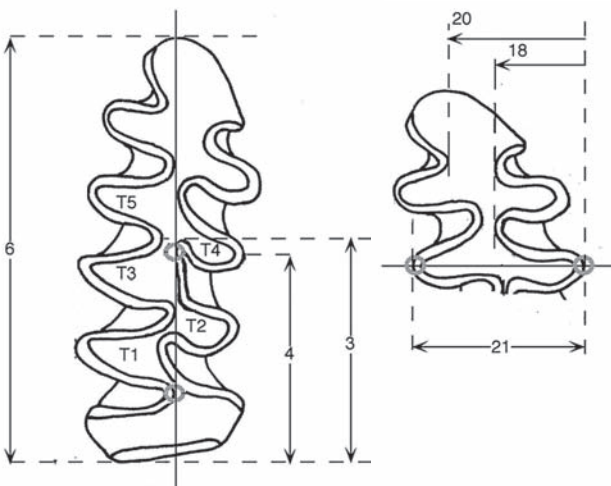


Fig. 2. Morphometry of the first lower molar of *Microtus (Terricola)* species.

(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 = $(V6 - V3)/V6 \times 100$, tilt of the pitomyan rhombus = $V4 - V3$, closure of the anterior loop = $(V20 - V18)/V21 \times 100$, 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 pitomyan 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 pitomyan 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 pitomyan 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
<i>gerbei</i> Loire-Atlantique	15	2.520	0.136	0.035	2.500	2.320	2.770
<i>gerbei</i> Maine et Loire	11	2.595	0.093	0.028	2.590	2.470	2.770
<i>gerbei</i> Western Vendée	12	2.683	0.083	0.024	2.675	2.540	2.800
<i>gerbei</i> South Vendée	16	2.621	0.099	0.025	2.655	2.430	2.750
<i>gerbei</i> Eastern Vendée	8	2.685	0.096	0.034	2.685	2.520	2.800
<i>gerbei</i> total	62	2.612	0.119	0.015	2.640	2.320	2.800
<i>pyrenaicus</i> Navarre	55	2.648	0.106	0.014	2.640	2.440	2.840
<i>pyrenaicus</i> Gironde and Landes	47	2.776	0.153	0.022	2.810	2.440	3.040
<i>pyrenaicus</i> Gers	51	2.634	0.143	0.020	2.650	2.350	2.910
<i>pyrenaicus</i> Hautes-Pyrénées	21	2.614	0.075	0.016	2.610	2.470	2.770
<i>pyrenaicus</i> Tarn	56	2.533	0.139	0.019	2.530	2.260	2.860
<i>pyrenaicus</i> Corrèze	91	2.624	0.118	0.012	2.630	2.340	2.880
<i>pyrenaicus</i> Haute-Vienne	76	2.563	0.104	0.012	2.570	2.360	2.790
<i>pyrenaicus</i> 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
<i>gerbei</i> Loire-Atlantique	15	48.7	1.1	0.3	48.9	46.6	50.4
<i>gerbei</i> Maine et Loire	11	49.6	0.7	0.2	49.5	48.5	50.6
<i>gerbei</i> Western Vendée	12	49.7	0.6	0.2	49.8	48.6	50.4
<i>gerbei</i> South Vendée	16	50.6	0.8	0.2	50.6	49.4	52.5
<i>gerbei</i> Eastern Vendée	8	49.8	0.6	0.2	49.7	49.1	50.7
<i>gerbei</i> total	62	49.7	1.0	0.1	49.8	46.6	52.5
<i>pyrenaicus</i> Navarre	55	50.6	1.3	0.2	50.4	47.5	53.5
<i>pyrenaicus</i> Gironde and Landes	47	51.0	1.1	0.2	51.0	49.2	53.4
<i>pyrenaicus</i> Gers	51	50.7	1.3	0.2	50.6	47.7	54.2
<i>pyrenaicus</i> Hautes-Pyrénées	21	50.5	1.4	0.3	50.8	48.2	53.0
<i>pyrenaicus</i> Tarn	56	50.0	1.5	0.2	50.0	45.7	52.7
<i>pyrenaicus</i> Corrèze	91	49.5	1.2	0.1	49.4	47.1	53.0
<i>pyrenaicus</i> Haute-Vienne	76	49.6	1.2	0.1	49.6	46.1	52.2
<i>pyrenaicus</i> Creuse	70	50.3	1.4	0.2	50.4	47.0	53.1

Tab. 3. Description of the tilt of the pitomyan 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
<i>gerbei</i> Loire-Atlantique	15	-0.027	0.032	0.008	-0.020	-0.080	0.030
<i>gerbei</i> Maine et Loire	11	0.005	0.045	0.014	-0.010	-0.040	0.080
<i>gerbei</i> Western Vendée	12	0.035	0.024	0.007	0.035	-0.010	0.070
<i>gerbei</i> South Vendée	16	0.018	0.020	0.005	0.020	-0.010	0.050
<i>gerbei</i> Eastern Vendée	8	0.045	0.030	0.010	0.045	-0.020	0.080
<i>gerbei</i> total	62	0.011	0.039	0.005	0.010	-0.080	0.080
<i>pyrenaicus</i> Navarre	55	-0.023	0.038	0.005	-0.020	-0.150	0.050
<i>pyrenaicus</i> Gironde and Landes	47	-0.019	0.033	0.005	-0.020	-0.100	0.060
<i>pyrenaicus</i> Gers	51	-0.010	0.033	0.005	-0.010	-0.070	0.070
<i>pyrenaicus</i> Hautes-Pyrénées	21	-0.037	0.038	0.008	-0.030	-0.130	0.020
<i>pyrenaicus</i> Tarn	56	-0.023	0.043	0.006	-0.020	-0.150	0.070
<i>pyrenaicus</i> Corrèze	91	-0.035	0.031	0.003	-0.030	-0.120	0.020
<i>pyrenaicus</i> Haute-Vienne	76	-0.018	0.034	0.004	-0.020	-0.080	0.060
<i>pyrenaicus</i> 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.

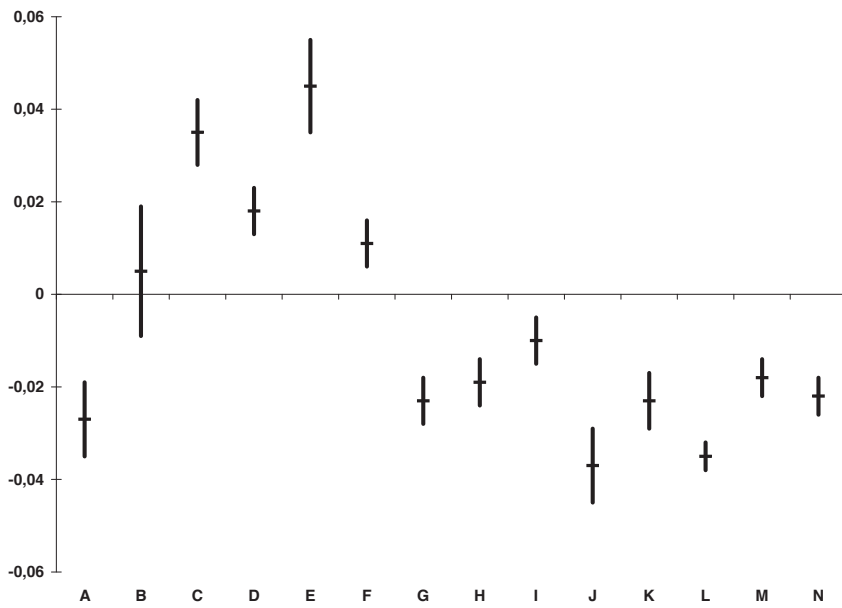
Population	N	Mean	SD	SEM	Median	Min	Max
<i>gerbei</i> Loire-Atlantique	15	37.9	6.8	1.8	38.1	28.6	48.0
<i>gerbei</i> Maine et Loire	11	37.4	5.1	1.6	35.9	30.5	47.2
<i>gerbei</i> Western Vendée	12	39.4	2.9	0.8	40.3	33.3	42.4
<i>gerbei</i> South Vendée	16	34.6	4.1	1.0	35.9	26.3	40.8
<i>gerbei</i> Eastern Vendée	8	37.9	4.2	1.5	39.2	28.3	41.7
<i>gerbei</i> total	62	37.2	5.1	0.6	37.7	26.3	48.0
<i>pyrenaicus</i> Navarre	55	22.9	8.3	1.1	23.1	1.0	40.0
<i>pyrenaicus</i> Gironde and Landes	47	24.1	6.3	0.9	24.3	12.7	38.4
<i>pyrenaicus</i> Gers	51	23.7	6.0	0.8	22.8	13.6	40.2
<i>pyrenaicus</i> Hautes-Pyrénées	21	31.5	6.2	1.4	32.4	21.2	41.6
<i>pyrenaicus</i> Tarn	56	32.5	7.4	1.0	31.9	19.1	55.8
<i>pyrenaicus</i> Corrèze	91	30.0	5.7	0.6	30.4	13.7	45.5
<i>pyrenaicus</i> Haute-Vienne	76	28.2	4.8	0.6	28.6	15.2	41.2
<i>pyrenaicus</i> 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
<i>gerbei</i> Loire-Atlantique	15	2.58	0.08	0.02	2.56	2.43	2.71
<i>gerbei</i> Maine et Loire	11	2.74	0.12	0.04	2.73	2.57	2.92
<i>gerbei</i> Western Vendée	12	2.78	0.10	0.03	2.73	2.70	3.01
<i>gerbei</i> South Vendée	16	2.74	0.10	0.03	2.74	2.59	2.93
<i>gerbei</i> Eastern Vendée	8	2.87	0.12	0.04	2.84	2.74	3.07
<i>gerbei</i> total	62	2.73	0.14	0.02	2.72	2.43	3.07
<i>pyrenaicus</i> Navarre	55	2.55	0.09	0.01	2.54	2.38	2.72
<i>pyrenaicus</i> Gironde and Landes	47	2.58	0.13	0.02	2.54	2.34	2.88
<i>pyrenaicus</i> Gers	51	2.58	0.12	0.02	2.56	2.33	2.87
<i>pyrenaicus</i> Hautes-Pyrénées	21	2.58	0.10	0.02	2.59	2.42	2.78
<i>pyrenaicus</i> Tarn	56	2.55	0.10	0.01	2.55	2.37	2.75
<i>pyrenaicus</i> Corrèze	91	2.52	0.10	0.01	2.52	2.31	2.73
<i>pyrenaicus</i> Haute-Vienne	76	2.52	0.09	0.01	2.52	2.34	2.75
<i>pyrenaicus</i> 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 ($P \geq 0.05$).

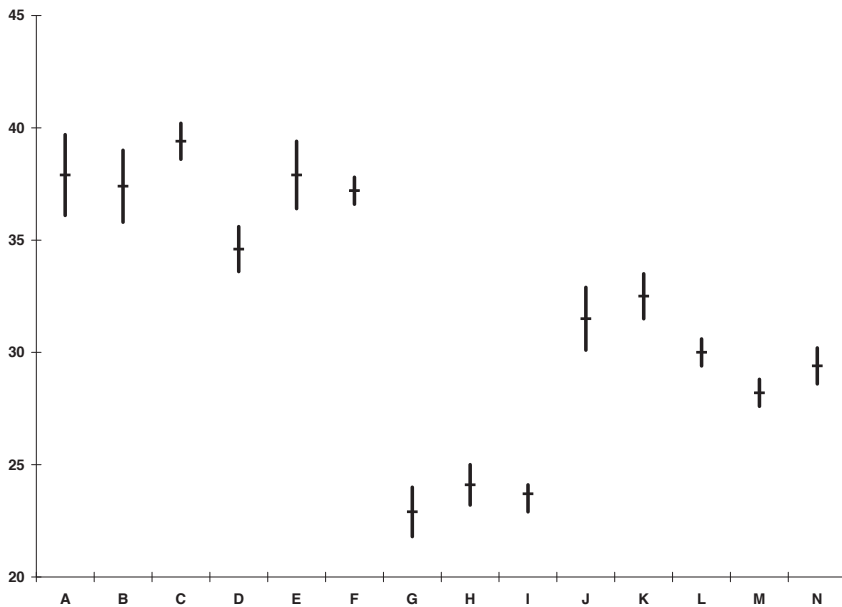
Population	Total length of the first lower molar	Development of the anterior part	Tilt of the Pitymyan rhombus	Closure of the anterior loop	Ratio of length/width
<i>gerbei</i> vs:					
<i>pyrenaicus</i> Navarre	NS	S	S	S	S
<i>pyrenaicus</i> Gironde & Landes	S	S	S	S	S
<i>pyrenaicus</i> Gers	NS	S	NS	S	S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

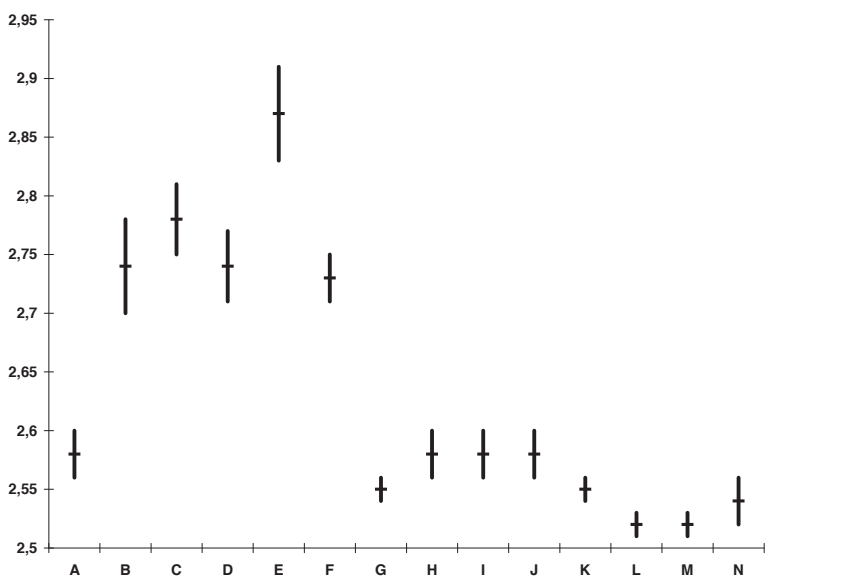
Fig. 3. Tilt of the pitmyan rhombus (mm) of the first lower molar: Mean \pm Standard Error of the Mean (SEM) in *Microtus (Terricola) pyrenaicus* populations.



gerbei
 A = Loire – Atlantique
 B = Maine et Loire
 C = W. Vendée
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pyrenaicus
 G = Navarre
 H = Landes/Gironde
 I = Gers
 J = Hautes – Pyrénées
 K = Tarn
 L = Corrèze
 M = Haute-Vienne
 N = Creuse

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



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 = Haute-Vienne
 N = Creuse

Fig. 5. Ratio length/width of the first lower molar: Mean \pm 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* or another Pleistocene *Terricola* species.

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