

A preliminary account of the rodents from Pleistocene levels at Grotte des Contrebandiers (Smuggler's Cave), Morocco

Denné N. Reed* and W. Andrew Barr

Department of Anthropology, University of Texas at Austin, 1 University Station C3200, Austin, TX, USA

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New excavations at Grotte des Contrebandiers, Temara, Morocco, have uncovered a micromammal fauna from Pleistocene levels of the cave comprising at least three rodent genera: *Meriones*, *Gerbillus* and *Mus*. This paper presents a preliminary systematic account of the rodents. Taphonomically, the assemblage is unusual for preserving micromammals in relatively low abundance compared with other, nearby cave sites of similar age.

Keywords: Aterian; Muridae; Murinae; Gerbillinae

Introduction

Grotte des Contrebandiers is a Pleistocene cave site on the Atlantic coast of Morocco, situated in the town of Temara Plage, approximately 17 km from Rabat at 33.9217° north and 6.9618° west (datum WGS84). The cave now sits 270 m inland from the beach and 14 m above current sea level (Figure 1).

The site was first discovered by Roche in 1955 and initial excavations were conducted from 1955 to 1957 (Roche 1969, 1976). Excavations continued again from 1967 to 1975 under the partnership of Roche and Texier (1976). In the mid 1990s, Bouzouggar (1997) reopened excavation on a portion of the site as part of his dissertation. The fauna described here was recovered from renewed excavation efforts at Contrebandiers that started in 2006 under the direction of Schurmans et al. (2006, 2007).

La Grotte des Contrebandiers is significant for preserving modern human remains associated with Aterian artefacts. The Aterian is a middle Paleolithic culture and the association of modern humans with this culture is relevant to our understanding of the emergence of modern human behaviour in north Africa and its relation to similar cultural and behavioural transitions in South Africa. The early excavations focused on the Neolithic period of occupation and uncovered several burials from this time. These excavations also recovered Pleistocene hominin remains attributed to anatomically modern *Homo sapiens* (Hublin 1993; Debénath 2000).

The archaeology from Grotte des Contrebandiers points to a late middle or upper Pleistocene age for the lower levels of the site and the work is presently underway to establish a series of absolute dates using Electron Spin Resonance (ESR), Thermal Luminescence (TL) and

Optically Stimulated Luminescence (OSL) techniques. Preliminary dating suggests an age of *ca.* 125 Ka for the opening and initial formation of the cave (Schurmans et al. 2007). Rodent fossils were recovered mostly from Aterian levels and some from Iberomaurusian layers of the excavation. These areas have not yet been tied together into a unified site stratigraphy. Detailed analysis of differences in rodent taxonomic composition across levels will follow a full assessment of the stratigraphy. This paper provides a preliminary account of the rodents recovered from the first 2 years of the excavation (2006–2007). The goal is to provide an initial assessment of the species present and how they are compared to faunas from related Pleistocene and Holocene sites in the region.

Materials and methods

Excavators at Grotte des Contrebandiers record the three-dimensional coordinates of all *in situ* fossils larger than 25 mm using a Topcon (Livermore, CA, USA) GTS-299 Total Station (Dibble 1987; Dibble and McPherron 1988; McPherron et al. 2005). Smaller materials, such as micromammal fossils, were not individually recorded with the Total Station, instead the excavated sediments were collected in buckets, and the centre of the local area that was excavated for a given bucket was recorded by the Total Station. The sediment in each bucket was then wet screened through coarse (5 mm) and fine (2 mm) sieves. All faunal specimens found in the sieves were sorted by element and those that could be identified were given specimen numbers comprising the excavation grid square combined with a unique specimen number. All specimens are stored at the Institut National des Sciences de l'Archéologie et du Patrimoine (INSAP), Rabat, Morocco.

*Corresponding author. Email: reedd@mail.utexas.edu

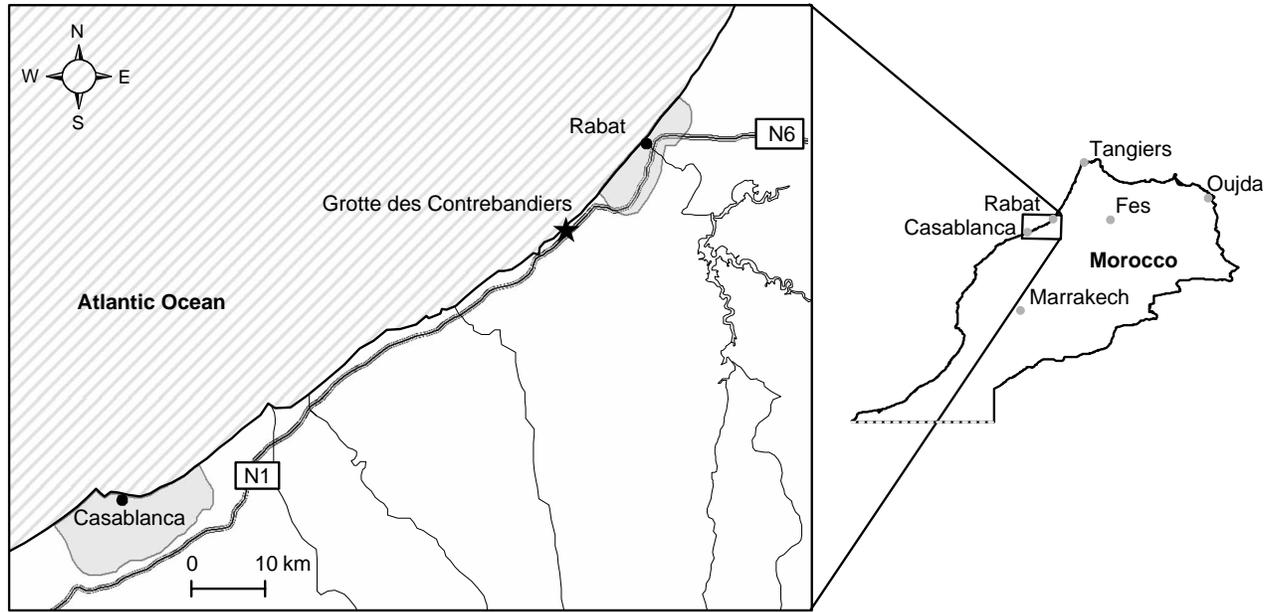


Figure 1. Site location map. Grotte des Contrebandiers is indicated by the star.

Specimens were measured with an ocular measuring reticule mounted on an Olympus (Center Valley, PA, USA) SZX10 stereo zoom microscope with a 0.5× DF PL objective and calibrated against a Peak stage micrometer with 0.1 mm graduations. Length and width measurements record the maximum dimension of the tooth in each

orthogonal direction. The tooth cusp nomenclature for murines is detailed in Figure 2. The nomenclature used for gerbils follows that of Tong (1989).

The *in situ* fossil microfauna recovered at Grotte des Contrebandiers is sparsely distributed in the excavation. As yet, no dense lenses of micromammals have been found

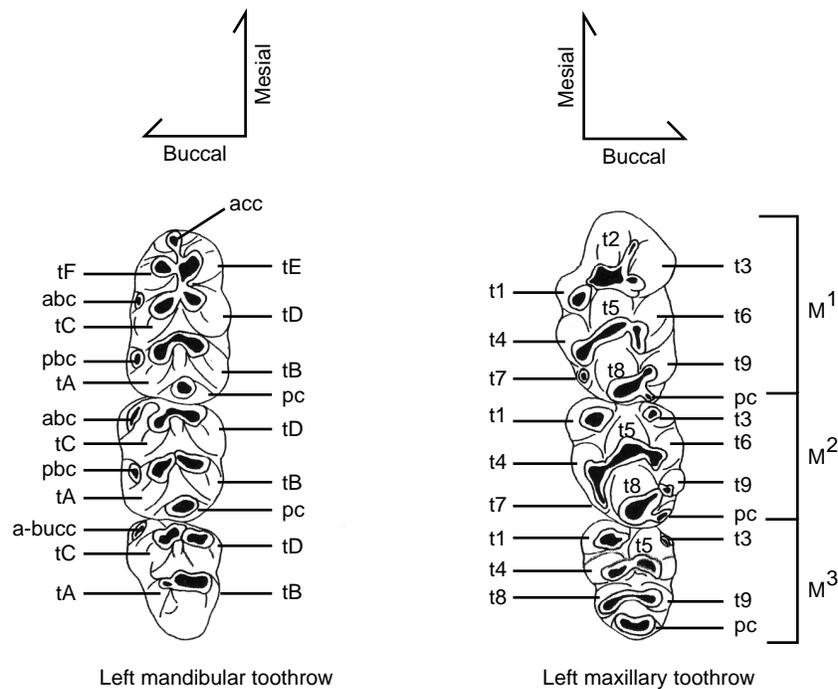


Figure 2. Murine dental nomenclature used in this study. The upper tooth nomenclature follows Miller (1912). The lower tooth nomenclature follows Misonne (1969). Abbreviations: acc, antero-central cusplet; abc, antero-buccal cusplet; pbc, postero-buccal cusplet; pc, posterior cingulum. The figure is modified from Musser (1987, his Figure 1).

in the sediments as are often found in cave sites occupied for long periods by owls (Andrews 1990; Reed 2003, 2005). However, some areas, such as the test pit at the rear of the cave, have higher densities of micromammals suggesting that dense lenses may be uncovered as the excavation expands. Other cave sites in the area, including El Harhoura 2, do have dense micromammal concentrations (Stoetzel 2005; Stoetzel et al. 2006).

There is evidence for a size bias in the assemblage. The largest taxon, *Meriones*, is also most abundant and is known from numerous isolated teeth, which are large enough to be recovered in the 2 mm sieves. The smaller taxa, on the other hand, are less abundant and very few isolated elements were recovered, presumably because they are passing through the 2 mm sieve. The sampling procedures at Contrebandiers have been modified to incorporate 1 mm screens for future recovery efforts. Thus, the relative abundance of species at the site remains for now insufficiently documented because the smaller species are likely under-represented in the assemblage.

Systematic Description

Family **Muridae** Illiger, 1811
 Sub-Family **Gerbillinae** Gray, 1825
 Genus *Meriones* Illiger, 1811
Meriones sp. indet.

The Genus *Meriones* is represented in the Pleistocene of north Africa by three species, *M. maghrebianus*, *M. maximus* and the still extant *M. shawii*. *Meriones* is the largest and the most abundant rodent in the current sample from Grotte des Contrebandiers. Today, the genus enjoys a broad distribution across what Agusti (1989) termed the 'Afro-asiatic province' which includes littoral north Africa through Algeria, Egypt, the Levant, Anatolia, Pakistan, northern India and into China, and during warmer periods of the Mio-Pliocene, the genus extended north into Spain (Agusti 1989). *Meriones* is believed to have evolved from Pliocene species of *Pseudomeriones* known from Europe and China (Wessels 1999). The genus *Meriones* first appears in north Africa during the Pleistocene (Tong 1989; Wessels 1999).

Material

383 specimens: 2 maxillae with M^{1-3} , 10 maxillae with M^{1-2} , 1 maxilla with M^{2-3} , 31 maxillae with M^1 , 7 maxillae with M^2 , and 153 isolated M^1 , 7 mandibles with I- M_3 , 12 mandibles with I- M_2 , 11 mandibles with I- M_1 , 2 mandibles with I and M_2 , 1 mandible with M_{1-3} , 15 mandibles with M_{1-2} , 30 mandibles with M_1 , 101 isolated M_1 (Table 1).

Description

Meriones is distinguished from other gerbils in having rooted molars with longitudinal crests (anterolophule (-id))

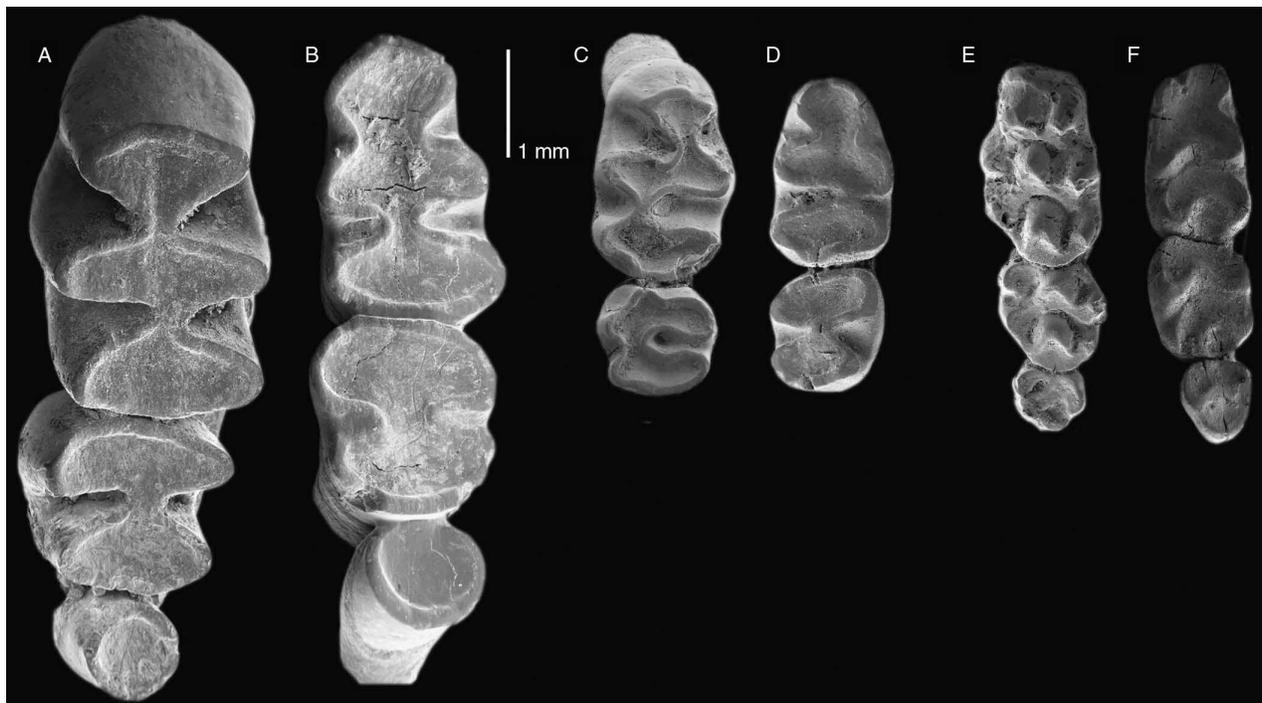


Figure 3. Molar tooth rows: (A) *Meriones* sp. specimen 780, left M^{1-3} ; (B) *Meriones* sp. specimen 119, right M_{1-3} ; (C) *Gerbillus campestris* specimen 193, right M^{1-2} ; (D) *Gerbillus campestris* specimen 124, right M_{1-2} ; (E) *Mus spretus* specimen 762, right M^{1-2} and (F) *Mus spretus* specimen 510, left M_{1-3} .

Table 1. Dental measurements for *Meriones* sp.

Tooth	N	Length		Width	
		Range	Mean \pm SE	Range	Mean \pm SE
M ¹	65	2.71–4.02	3.23 \pm 0.03	1.73–2.35	2.07 \pm 0.02
M ²	18	1.57–2.21	1.80 \pm 0.04	1.45–2.08	1.84 \pm 0.04
M ³	2	0.86–0.90	0.88 \pm 0.02	1.02–1.12	1.07 \pm 0.05
M ₁	65	2.49–3.33	2.86 \pm 0.02	1.65–2.20	1.90 \pm 0.01
M ₂	17	1.77–2.46	2.05 \pm 0.04	1.79–2.33	1.98 \pm 0.03
M ₃	1	na	1.43	na	1.03

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm.

and neoloph (-id)) arranged along the midline in both upper and lower molars (Figure 3(A),(B)). A diagnostic description of the genus is given by Ellerman (1941). The specimens from Contrebandiers match the species descriptions for *M. maghrebianus* (Tong 1989) and *M. maghrebianus hamidae* (Geraads 1994), which are morphologically very similar to extant *M. shawii*.

The molars of *Meriones* are very similar to *Psammomys* but *Meriones* is distinguished from the latter in having a single-grooved upper incisor (Ellerman 1941). None of the maxillary material from Contrebandiers preserves an incisor in place. However, numerous large, isolated upper incisors have a single groove and are assumed to belong to this genus.

Discussion

Few morphological traits distinguish *M. maghrebianus* from *M. shawii*. Tong (1989) discusses three diagnostic differences; first, *M. maghrebianus* has slightly larger molars; second, *M. maghrebianus* possesses an M₃ that is slightly more distally elongate relative to *M. shawii* and third, the ratio of the M¹–M₁ is distinct in the two species.

Morphometric plots of the lower molar dimensions (Figure 4, Table 2) illustrate the degree of similarity in size and shape between samples of *M. maghrebianus* and *M. shawii*. The distribution of the sample from Contrebandiers overlaps the sample means of all other Pleistocene and Holocene samples for both species. The sample mean for Contrebandiers is generally smaller in both length and width and falls closest to the samples of *M. maghrebianus* from Oulad Hamida 1 [formerly Thomas III] (Geraads 1994) and Thomas I quarry (Tong 1989) as well as to the sample of *M. shawii* from the Jebel Irhoud Neanderthal site (Tong 1989).

The sample means of populations attributed to *M. maghrebianus* tend to be longer and proportionately narrower than populations attributed to *M. shawii* suggesting that there may be meaningful differences in tooth shape that distinguish the species. The *Meriones* sp. from Contrebandiers has an M³ that appears similar

to the specimen illustrated in Tong (1989), but only a few specimens preserve this tooth so it is not possible to definitively observe the veracity or variability of this trait. The ratio between upper and lower first molars in Contrebandiers *Meriones* sp. is 1.13, which is within the range for *M. maghrebianus* (1.07–1.15) and below the range for *M. shawii* (1.17–1.24) (Tong 1989) suggesting some similarity to the former. However, given that the range of metric variability in the Contrebandiers samples of *Meriones* encompasses the means of most other fossil and modern samples and that the discrete diagnostic traits separating the fossil and modern forms are few and variable, a more detailed study on a larger sample is needed to resolve the species designation.

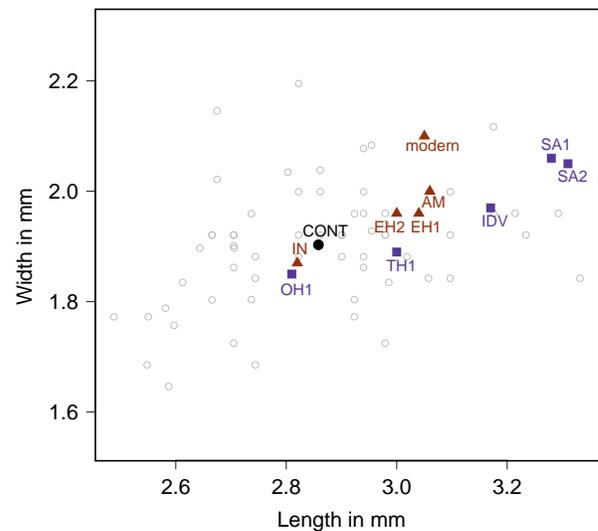


Figure 4. Bivariate plot of M₁ dimensions for *Meriones* sp. Open grey circles show the distribution of specimens from Grotte des Contrebandiers. The solid circle indicates the sample mean. The triangles show the means for Pleistocene and Holocene samples attributed to *M. shawii*. The squares indicate means for Pleistocene samples of *M. maghrebianus*. AM, Ain Mefta; CONT, Contrebandiers; EH1 and EH2, El Harhoura 1 and 2; IDV, Irhoud Derbala Virage; IN, Irhoud Neanderthal; OH1, Oulad Hamida 1; SA1 and SA2, Sidi Abderrahman 1 and 2; TH1, Thomas I.

Table 2. Dimensions of the M₁ of *Meriones* sp. from Grotte de Contrebandiers compared with samples of *Meriones* from other north African sites.

Tooth	N	Length		Width	
		Range	Mean ± SE	Range	Mean ± SE
Contrebandiers	65	2.49–3.33	2.86 ± 0.02	1.65–2.20	1.90 ± 0.01
Modern <i>M. shawii</i>	30	ca. 2.6–3.2	ca. 3.05	ca. 1.75–2.25	ca. 2.1
Irhoud Neanderthal (<i>M. s.</i>)	17	2.60–3.06	2.82 ± 0.07	1.67–2.17	1.87 ± 0.08
Ain Mefta (<i>M. s.</i>)	15	2.90–3.20	3.06 ± 0.05	2.0 ± 0.06	1.80 – 2.25
El Harhoura 2 (<i>M. s.</i>)	12	2.75–3.18	3.00 ± 0.04	1.76–2.24	1.96 ± 0.04
El Harhoura 1 (<i>M. s.</i>)	3	2.96–3.14	3.04	1.87–2.09	1.96
Sidi Abderrahman 1 (<i>M. m.</i>)	11	3.09–3.44	3.28 ± 0.08	1.87–2.22	2.06 ± 0.09
Sidi Abderrahman 2 (<i>M. m.</i>)	34	2.91–3.74	3.31 ± 0.08	1.86–2.18	2.05 ± 0.03
Irhoud Derbala Virage (<i>M. m.</i>)	103	2.75–3.54	3.17 ± 3.03	1.72–2.34	1.97 ± 0.02
Oulad Hamida 1 (<i>M. m. hamidae</i>)	57	2.61–3.03	2.81 ± 0.01	1.64–2.03	1.85 ± 0.01
Thomas 1 (<i>M. m.</i>)	6	2.72–3.24	3.00 ± 0.08	1.77–2.04	1.89 ± 0.04

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm. Tong (1989), Abbasi and Aouraghe (2002), Geraads (2002) and Stoetzel (2005). Dimensions for modern *M. shawii* estimated from graphs in Tong (1989).

Genus *Gerbillus* Lataste, 1881

Gerbillus campestris (Loche, 1867)

In order to be consistent with earlier publications, we refer these specimens to *Gerbillus campestris*, recognising that some authors (Musser and Carleton 2005) prefer to elevate the subgenus to which this species belongs (*Dipodillus*) to generic rank. There are approximately 13 species of *Gerbillus* mostly restricted to north Africa, extending down into Mali, Ethiopia and northern Kenya. Only one species in the genus, *G. dasyurus*, is found outside Africa in the Levant (Musser and Carleton 2005). *G. campestris* is widely distributed in Morocco and is particularly abundant in the central plains along the Atlantic coast (Aulagnier and Thevenot 1986).

Material

16 specimens: 1 maxilla with M¹⁻², 2 maxillae with M¹, and 1 isolated M¹, 2 mandibles with M₁₋₂, 8 mandibles with M₁, 1 isolated M₁, 1 isolated M₂ (Table 3).

Description

Specimens from Grotte des Contrebandiers attributed to *G. campestris* match the size and morphology given for this species by Tong (1989). They possess an M¹ with a protocone that is mesially displaced relative to the paracone, a well-developed anterolophule and strongly

alternating longitudinal crests with the anterolophule positioned lingually and the neolophe buccally (Figure 3(C),(D)). There is a slight postero-buccal sinus on the distal end of M¹.

The M² hosts a small anterior cingulum associated with the paracone. The buccal neolophe joins the paracone with the metacone and there is a very slight postero-buccal sinus on the distal end of this tooth. On the lower molars, the anterolophid and neolophid are both well developed and importantly, the anteroconid is related to the protoconid (buccally) rather than the paraconid (lingually) as seen in other taxa. Specimens from Contrebandiers are well within the size range of *G. campestris* reported from other Pleistocene and Holocene sites in Morocco (Figure 5, Table 4).

Discussion

Morphologically and metrically, the sample from Grotte des Contrebandiers is indistinguishable from the sites of Thomas I and Irhoud Neanderthal as reported by Tong (1989) (Figure 5). The Contrebandiers sample is slightly larger than El Harhoura 2 (Stoetzel 2005) and Oulad Hamida I (Geraads 1994).

Sub-Family **Murinae** Gray, 1825

Genus **Mus** Linnaeus, 1758

Mus spretus (Lataste, 1883)

Table 3. Dental measurements for *Gerbillus campestris*.

Tooth	N	Length		Width	
		Range	Mean ± SE	Range	Mean ± SE
M ¹	1	na	2.05	na	1.31
M ₁	12	1.84–2.27	2.05 ± 0.03	1.12–1.55	1.308 ± 0.03

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm.

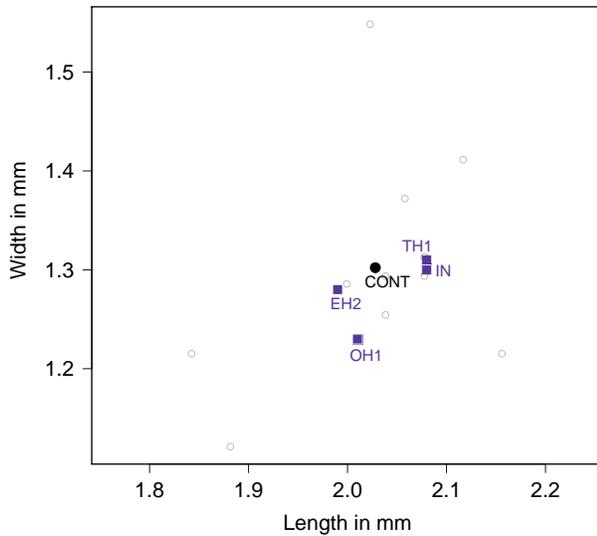


Figure 5. Bivariate plot of M_1 dimensions for *Gerbillus campestris*. Open circles show the distribution of specimens from Grotte des Contrebandiers. The solid circle indicates the sample mean. The squares indicate means for other fossil samples of *Gerbillus campestris*. Site codes as in Figure 4.

Material

133 specimens: 1 maxilla with M^{1-3} , 9 maxillae with M^{1-2} , 18 maxillae with M^1 , 2 maxillae with M^2 , and 1 isolated M^1 , 2 mandibles with I- M_3 , 2 mandibles with I- M_2 , 1 mandible with I- M_1 , 6 mandibles with M_{1-3} , 55 mandibles with M_{1-2} , 1 mandible with M_{2-3} , 13 mandibles with M_1 , 9 mandibles with M_2 , 11 isolated M_1 , 2 isolated M_2 (Table 5).

Description

The t1 on M^1 is distally offset from t2 and t3 and is situated at the level of t5. The t3 cusp is well separated from and slightly distal to t2. Some specimens have a well-developed cingulum around the mesial edge of t2. There is no sign of a t7 cusp. The t9 cusp is well separated from t8. The anterior incisive foramen reaches well past the anterior margin of M^1 , to the level of t1–t5. The first molar

is long but lacks the elongation of the mesial portion of the t2 on M^1 often seen in *Mus*. On the M^2 , the t1 is large and well developed, but the t3 is reduced to just a crest or very small crest depending on the specimen and degree of wear. The M^3 is reduced, but remains large relative to other *Mus*.

Wide valleys separate the t3, t6 and t9 cusps along the buccal edge of the tooth. This effect is caused by the overall length of M^1 and mesio distally narrow cusps, especially in unworn specimens. All specimens display a masseteric knob at the ventral base of the zygomatic plate, anterior to M^1 at about the distance of the length of M^1 .

There are three main roots under the M^1 , a prominent mesial root, a large lingual root where a cleft down the middle shows it to be made from two fused roots and one disto-buccal root. Similarly on the M^2 , the lingual root is large and appears to be made from the fusion of two roots and there are two lingual roots for a total of three. The M^3 also has three closely positioned roots, two mesial roots and a third distal root midway between the anterior roots.

In the lower molar toothrow, M_1 has a typical murine pattern with the four mesial cusps arranged in a clover-leaf shape (Figure 3(E),(F)). The tE cusp is smaller than tF but is not reduced to the same extent as in *M. musculus* (Darviche and Orsini 1982; Palomo et al. 2009) or *M. hamidae* (Geraads 1994). The four cusps meet centrally and are not buccally offset as in *M. musculus*. The buccal cusps on M_1 are displaced slightly distally relative to the lingual cusps. The chevrons on M_1 form acute angles and there is no buccal cingulum. The buccal edge of the tooth is devoid of accessory cusps. There is, however, a prominent posterior cingulum centrally positioned on M_1 .

The chevrons of M_2 are more open and nearly form right angles. The tE cusp on M_2 is small and often reduced to only a crest. There is a large posterior cingulum as in the M_2 .

The M_3 is reduced in size and complexity though two laminae are preserved on this tooth, a broad mesial lamina and a much smaller distal lamina. The M_3 is roughly (ca. 90%) the size of the distal portion of the M_2 (i.e. the distal lamina + posterior cingulum). This tooth has two roots.

Table 4. Dental dimensions of M_1 for *Gerbillus campestris* from Grotte des Contrebandiers compared with samples from other Moroccan Pleistocene and Holocene sites.

Tooth	N	Length		Width	
		Range	Mean ± SE	Range	Mean ± SE
Contrebandiers	12	1.84–2.27	2.05 ± 0.03	1.12–1.55	1.31 ± 0.03
El Harhoura 2	13	1.86–2.09	1.99 ± 0.02	1.22–1.35	1.28 ± 0.01
Thomas I	30	1.89–2.36	2.08 ± 0.04	1.16–1.43	1.31 ± 0.03
Irhoud Neanderthal	6	1.94–2.27	2.08 ± 0.15	1.23–1.37	1.30 ± 0.07
Oualad Hamida 1	326	1.76–2.23	2.01 ± 0.004	1.04–1.40	1.23 ± 0.003

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm. Tong (1989), Geraads (2002) and Stoetzel (2005).

Table 5. Dental measurements for *Mus spretus*.

Tooth	N	Length		Width	
		Range	Mean \pm SE	Range	Mean \pm SE
M ¹	28	1.77–2.08	1.93 \pm 0.02	1.03–1.52	1.18 \pm 0.02
M ²	12	1.06–1.21	1.15 \pm 0.02	1.03–1.14	1.06 \pm 0.01
M ³	1	na	0.68	na	0.72
M ₁	49	1.52–1.74	1.64 \pm 0.01	0.90–1.07	0.99 \pm 0.01
M ₂	20	0.96–1.18	1.08 \pm 0.01	0.84–1.06	0.99 \pm 0.01
M ₃	5	0.64–0.78	0.71 \pm 0.02	0.53–0.75	0.69 \pm 0.04

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm.

Discussion

Mus is characterised by a mesio distally elongated M¹ that exceeds the length of M² and M³ combined (Ellerman 1941) and with a strongly offset t1 and an asymmetrical occlusal outline. The M³ is usually much reduced and in most *Mus* species measures ca. 60% of M² while the elongated M¹ is ca. 180% of M². The *Mus* specimens from Contrebandiers are morphologically very homogeneous. These specimens show a strong offset of t1 on M¹ as in *Mus* but the occlusal outline is not strongly asymmetrical (Figure 3(E)). The M³ length for the single tooth preserved at Contrebandiers is $(100 \times 0.68 \text{ mm}/1.15 \text{ mm} =)$ 59% of the mean M² length and the M¹ is $(100 \times 1.93 \text{ mm}/1.15 \text{ mm} =)$ 168% of M². The M³ is thus as reduced as in modern *Mus* but the M¹ is not quite as elongate.

M. musculus and *M. spretus* overlap considerably in size, although the latter is slightly larger on average (Darviche et al. 2006). In *M. musculus*, the long axis of the t1 is oblique to the long axis of the tooth; while in *M. spretus*, this cusp is parallel to the long axis of the tooth (Stoetzel 2005). The specimens from Contrebandiers show the latter, parallel condition. The mean of the Contrebandiers sample is larger than the samples of *M. musculus* and *M. spretus* from other north African sites (Table 6, Figure 6).

In its morphology, the *Mus* sample from Contrebandiers is similar to *M. haouzi* Jaeger (1975) from Jebel Irhoud Ochre, though the former is considerably larger.

M. spretus from Contrebandiers shares with *M. haouzi* the broad spacing between the buccal cusps of M¹ and the clear separation between t2 and t3.

The Contrebandiers specimens are considerably larger than *M. hamidae* from Oulad Hamida 1 (Geraads 1994). The Contrebandiers specimens are further distinguished from this species in having a tE on M₁ that is larger and nearly equal in size to tF. Furthermore, in *M. hamidae*, the four mesial cusps are connected by crests that join together more buccally whereas in the Contrebandiers specimens these cusps meet in the midline of the tooth. In both *M. musculus* and *M. hamidae*, the shape of the mesial four cusps is significantly more asymmetrical, whereas the more symmetrical arrangement seen in the Contrebandiers specimens is characteristic of *M. spretus*. The Contrebandiers specimens show the closest affinity to *M. spretus* from El Harhoura 2, but differ in being significantly larger and in having better individuated t2 and t3 cusps on the M¹.

Conclusions

The rodent fauna recovered from Grotte des Contrebandiers most closely resembles that of El Harhoura 2 (Stoetzel 2005; Stoetzel et al. 2006). *Gerbillus campestris* and *Mus spretus* are found at both localities. At El Harhoura 2, the *Meriones* is attributed to *M. shawii* whereas we have assigned the taxon at Contrebandiers to *Meriones* sp. Given the difficulty in distinguishing these

Table 6. Dimensions of the M₁ of *Mus spretus* from Grotte des Contrebandiers compared with samples of *Mus* from other north African sites.

Tooth	N	Length		Width	
		Range	Mean \pm SE	Range	Mean \pm SE
Contrebandiers	49	1.52–1.74	1.64 \pm 0.01	0.95–1.07	0.99 \pm 0.01
Modern (<i>M. spretus</i>)	40	Not given	1.51 \pm 0.009	Not given	0.89 \pm 0.006
El Harhoura 2 (<i>M. spretus</i>)	16	1.45–1.71	1.61 \pm 0.018	0.92–1.05	0.99 \pm 0.011
Modern (<i>M. musculus</i>)	14	Not given	1.41 \pm 0.013	Not given	0.84 \pm 0.009
El Harhoura 2 (<i>M. musculus</i>)	16	1.48–1.65	1.57 \pm 0.014	0.86–1.060	0.97 \pm 0.011
Sidi Abdallah (<i>M. haouzi</i>)	19	1.44–1.76	1.57 \pm 0.018	0.86–1.03	0.93 \pm 0.00
OH1 (<i>M. hamidae</i>)	15	1.40–1.49	1.45	0.85–0.93	0.89

Notes: N is the number of individual specimens. SE is the standard error of the mean. All measurements are in mm. Geraads (1994), Stoetzel (2005) and Darviche et al. (2006, Table 2 Moroccan sample).

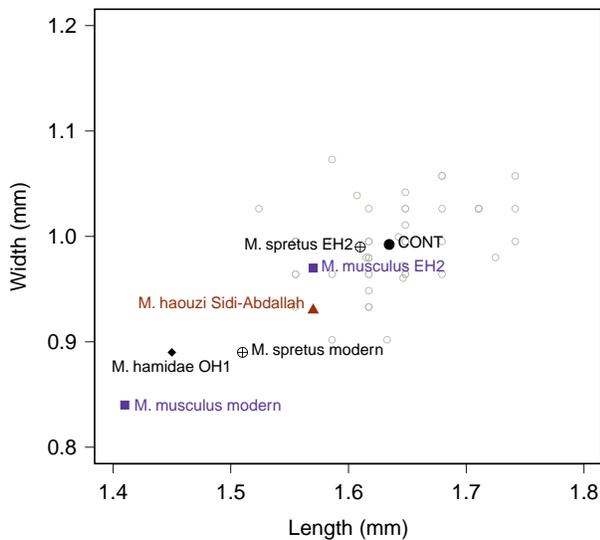


Figure 6. Bivariate plot of M_1 dimensions for *Mus spretus*. Open circles show the distribution of specimens from Grotte des Contrebandiers. The solid black circle shows the sample mean. The crossed circles are *Mus spretus*, the triangle is *M. haouzi*, squares are *M. musculus* and the diamond is *M. hamidae*. Site codes as in Figure 4.

two taxa, it is possible that the same species is represented in both places. A more complete sample (including more M^3 s) may help resolve the issue. The initial sampling regime produced rodent samples that were biased against smaller taxa. Improved sampling should increase the diversity and give a more accurate estimate of relative abundances of the various species.

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