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Notes On Rodents of the Genus *Gerbillus*
(Mammalia: Muridae: Gerbillinae) from Morocco

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The current systematics of rodents of the genus *Gerbillus* from Morocco and adjacent areas of Algeria are based upon the works of Cabrera (1932), Ellerman and Morrison-Scott (1951), and St. Girons and Petter (1965). Much remains to be learned of the distribution, ecology, evolution, and systematics of these rodents in North Africa. Africa.

Species of *Gerbillus* have the plantar surface of the hindfeet either covered with hair or naked and classification reflects this dichotomy at either the generic or subgeneric levels (e.g., Allen, 1939; Ellerman and Morrison-Scott, 1951; Petter, 1959; Wassif et al., 1969; Harrison, 1972; Schlitter and Setzer, 1972). Generally, hairy-footed *Gerbillus* inhabit areas of sand or light sandy soils and naked-footed *Gerbillus* occur on compact substrates containing much rock. This study concerns only hairy-footed species of *Gerbillus*.

During 1971 and 1972, I obtained specimens of *Gerbillus* from several localities in Morocco for cytogenetic study. I visited Morocco in 1973 and collected additional specimens, karyotypes, and data on the environmental and physiographic characteristics of specimen localities. Analysis of this material suggests that at least three medium-sized species of hairy-footed *Gerbillus* occur in Morocco, two of which are described as new.

MATERIALS AND METHODS

Chromosomes were analyzed from cell suspensions of femoral bone marrow (Nadler and Lay, 1967). Karyotypes were arranged in

pairs according to size and centromere position (metacentric, submetacentric, acrocentric). The fundamental number of chromosome arms (FN) is computed by counting biarmed autosomes as two arms and acrocentric autosomes as one arm.

Voucher specimens of karyotyped animals and other specimens were prepared (usually as skins and skeletons) and deposited in the collections of the University of Michigan, Museum of Zoology (UMZ) and Field Museum of Natural History (FMNH). Other specimens and cytogenetic preparations remain in my personal collection (DML), but will ultimately be deposited in the FMNH collection. Specimens in the collections of the British Museum (Natural History) (BM) were used in comparisons.

The following cranial dimensions, useful in distinguishing the taxa treated herein, were taken with dial calipers and rounded to the nearest 0.1 mm.: greatest breadth across the posterior mastoid bullae; greatest breadth across squamous portion of temporal bones; the width of the anterior process of the basioccipital at its articulation with the sphenoid was recorded indirectly as the least width between the medial walls of the tympanic bullae at the level of the above articulation; narrowest point of the interorbital constriction; height from base of tympanic bulla to superiormost point of suprameatal triangle (measured with ventral parts of tympanic bullae and incisors placed on glass slide and then subtracting slide thickness); greatest length of skull; length of nasals from distal tip to frontal articulation; greatest breadth between the lateral tips of the zygomatic process of the temporal bones. The anatomical terminology of middle ear structures follows that of Lay (1972). Color references are based on the color guide of Palmer (1962).

Gerbillus hoogstraali sp. nov.

Holotype. — Adult female, in fluid, skull removed, FMNH, no. 114647, from 7 km. S. Taroudannt, Morocco, elevation about 116 m.; taken on July 16, 1973 by D. M. Lay. This locality lies about 1 km. south of the Sous river.

Description. — A middle-sized species, mean and extremes of standard external measurements of seven specimens are (in mm.): total length, 208.1 (190-221); tail length, 113.8 (103-123); hind foot length, 27.3 (26-28); pinna length, 16.6 (16-17). Dorsal hair color is intermediate to cinnamon and buffy brown and is clearly delimited from the white ventral fur. A whitish postauricular spot exists, but its prominence is reduced due to a buffy suffusion. The posterior borders of the nasal bones at the articulations with frontal bones are either squared off or concave

TABLE 1. Statistical Comparisons of selected cranial variables of *Gerbillus hoogstraali* (H) and *G. occiduus* (O).

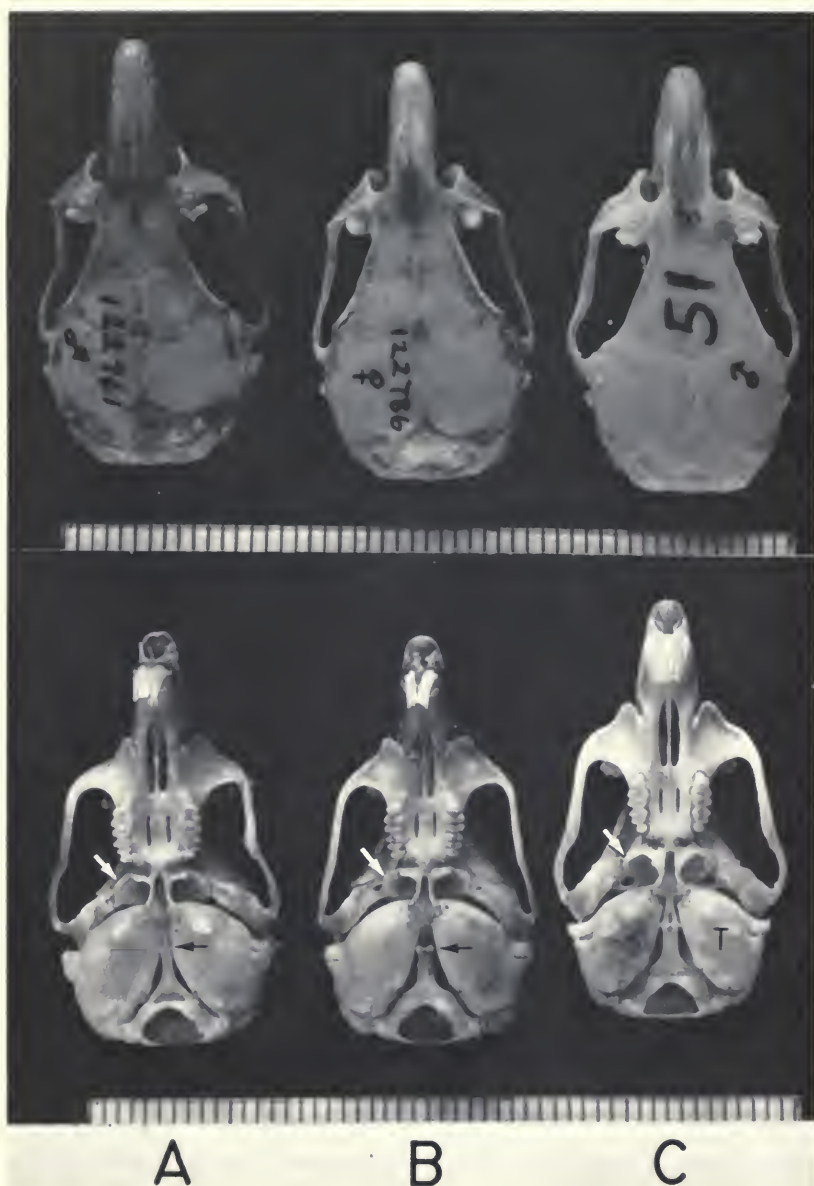| Measurements	Species	Number	Range	Mean	Standard Deviation	T values	2-tail probabilities
Greatest breadth across temporals	H	8	13.5-14.0	13.66	0.15		
	O	10	13.6-14.3	13.91	0.27	-2.29	.036
Breadth between tympanic bullae at basioccipital-sphenoid suture	H	8	0.8-1.0	0.90	0.05	6.42	.001
	O	10	1.0-1.7	1.37	0.20		
Breadth of interorbital constriction	H	8	5.2-5.7	5.49	0.05	6.98	.001
	O	10	5.9-6.4	6.03	0.20		
Height of tympanic bulla and suprameatal triangle	H	8	7.2-7.7	7.41	0.16	-2.10	.052
	O	10	6.3-7.4	7.10	0.39		
Length of nasals	H	7	10.5-11.5	11.07	0.32	2.19	.045
	O	10	10.8-11.8	11.42	0.33		

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Fig. 1. Dorsal and ventral views of skulls of: **A**, *Gerbillus hoogstraali*; **B**, *G. occiduus*; **C**, *G. hesperinus*. White arrows denote lateral pterygoid processes. Black arrows mark the anterior end of the basioccipital at its suture with the basisphenoid. The letter T is on the ventral surface of the tympanic bulla. Scale units in millimeters.

FIG. 2. Lateral view of skulls and mandibles. Black dots mark the extent of the posterior mastoid chambers of the bulla. **1**, Anterior mastoid chamber, **2**, posterior superior mastoid chamber, **3**, posterior inferior mastoid chamber. White arrows denote posterior inferior end of the external line of the septum separating the superior and inferior posterior mastoid chambers. Other symbols as in Figure 1.

anteriorly. The anterior end of the basioccipital bone and the interorbital constriction are relatively narrow (table 1). Diploid number of chromosomes is 72 (fig. 3).

Measurements. — Selected measurements of the holotype are: total length 211; tail length, 121; hind foot length, 28; ear length, 17; greatest length of skull, 29.3; length of nasals, 10.9; breadth across temporals, 13.7; breadth between tympanic bullae at basioccipital-sphenoid suture, 0.9; interorbital constriction, 5.5; height of tympanic bulla and suprameatal triangle, 7.4.

Distribution. — Presently known only from type locality, but likely occurs in suitable sandy habitat within the lower Sous valley.

Habitat-Natural History Miscellanea. — The type locality extends approximately 7 km. in both east-west and north-south directions and is characterized by areas of low sand dunes (3.5-4.5 m. above level ground) and intervening level ground of hard-packed sandy clay. Fine reddish sand forms a light cover on the hard alluvial surface. During the days of July 16 and 17, 1973 a strong westerly wind shifted loose sand over the entire area.

The principal vegetation consisted of thorny *Zizyphus* shrubs which varied in density but seldom exceeded 1.5 m. in height. Six specimens were trapped at burrow entrances located at the bases of *Zizyphus* stands. No animals were caught elsewhere, but fresh

tracks and diggings indicated activity throughout the area. One large rodent, possibly *Meriones grandis*, was observed in the area at dawn one morning. Shed snakeskins were very numerous in the area but no snakes were observed during night (6 hours) or day (8 hours) observations. One female trapped July 16 showed six placental scars and two subadults (total length 190, 191) were trapped at the same time, indicating a breeding period in the late spring or early summer.

Specimens examined. — Total of 10: 114567 FMNH (type); 117632, 122760-2 UM; 4572-3, 4575-7 DML. Karyotypes are available for three of these specimens.

Remarks. — I take great pleasure in naming this species for Dr. Harry Hoogstraal in recognition of his significant contributions to knowledge of the fauna and medical zoology of North African mammals.

Comparisons. — Pertinent comparisons are provided in the following species account.

Gerbillus occiduus sp. nov.

Holotype. — Adult female, skin and skeleton, FMNH no. 114648 from Aoreora (80 km. WSW Goulimine), Morocco, elevation about 43 m.; taken on January 16-17, 1971 by L. Robbins and J. Gruwell.

Description. — A middle-sized species, mean and extremes of standard external measurements of eight specimens are total length 207.1 (202-213); tail length, 111.0 (103-119); length hind foot, 29.1 (28-30); length pinna, 13.9 (12-16). Dorsal hair color is intermediate to cinnamon and buffy brown and is clearly delimited from the white ventral fur. A prominent white postauricular spot exists. The posterior border of the nasal bones is wedge-shaped or truncated (fig. 1). The anterior end of the basioccipital bone and the interorbital constriction are relatively wide (fig. 1, table 1). Diploid number of chromosomes is 40 (fig. 4).

Measurements. — Selected measurements of the holotype are: total length, 209; tail length, 111; hindfoot length, 29; pinna length, 15; greatest length of skull, 30.7; length of nasals, 12.7; breadth across temporals, 14.2; breadth between tympanic bullae at basioccipital-sphenoid suture, 1.5; interorbital constriction, 6.0; height of tympanic bulla and suprameatal triangle, 7.6.

Distribution. — Presently known from only the type locality.

Habitat-Natural History Miscellanea. — The type locality is an area of sparsely vegetated sand dunes but no other information is available (E.T. Hopper, *in litt.*).

Two pairs of animals trapped wild on January 16-17, 1971 bred beginning in June 1971. One female gave birth to ten litters of the following sizes (dates in parentheses): 3 (June 14), 4 (July 14), 3

(Aug. 22), 5 (Sept. 22), 5 (Nov. 2), 3 (Dec. 10), 5 (Feb. 5, 1973), 1 (Aug. 6, 1972). Another female produced a single litter of four on June 15, 1971. Mean litter size is 3.45. At least four of the litters of the first female totalling 16 progeny, contained six partial albinos: the fur was entirely white but the eyes were black. The ratio of 16 wild: 6 partial albinos suggests that both parents were heterozygous for a simple mendelian recessive locus for partial albinism. All other progeny had wild type coat color. Causes for the failure of these albinos to breed were not determined.

Specimens examined. — Total of 18; FMNH(type) 114648; UMZ 122765-6, 122773-86; DML 4392. Karyotypes are available for nine of these.

Remarks. — The name *occiduus* is Latin for western.

Comparisons. — *G. hoogstraali, G. occiduus,* and *G. hesperinus* Cabrera, 1906 are distinguished by the following cytogenetic, cranial, and pelage characteristics.

Karyotypes of the species differ significantly. *G. hoogstraali* has a diploid complement (2N) of 72, and FN = 80. The karyotype contains six submetacentric and 64 acrocentric autosomes. The sex chromosomes are a large submetacentric and a medium-sized metacentric (fig. 3). *G. occiduus* shows a 2N = 40 and FN = 76. The karyotype shows eight metacentric and 30 submetacentric autosomes. The sex chromosomes are medium-sized metacentrics (fig. 4). *G. hesperinus* Cabrera possesses 2N = 58 and FN = 76. The karyotype reveals 20 submetacentric and 36 acrocentric autosomes. The sex chromosomes are large and medium-sized metacentrics (fig. 5).

The diagnostic cranial features of *G. hesperinus* that distinguish it from both *G. hoogstraali* and *G. occiduus* are: less voluminous auditory bullae with smaller tympanic and posterior mastoid chambers; short and constricted posterior palatine foraminae; narrow lateral pterygoid processes, which produce smaller fossae for the medial pterygoid muscles; small posterior inferior mastoid chamber (about one-half as voluminous as in either of the other two species) (figs. 1, 2).

The crania of *G. hoogstraali* and *G. occiduus* can always be identified by the anterior process of the basioccipital that is broad in the latter and narrow in the former and the least interorbital breadth which varies in the same manner (fig. 1, table 1). This difference in basioccipital width is also constant between subadult

FIG. 3. Karyotype of *G. hoogstraali* with 2N = 72. It is not possible to distinguish between the X and Y chromosomes until female specimens are studied.

FIG. 4. Karyotype of *G. occiduus* with 2N = 40.

FIG. 5. Karyotype of *G. hesperinus* with 2N = 58. It is not possible to distinguish between the X and Y chromosomes until female specimens are studied.

specimens of both species. The nasal bones (at the articulation with the frontal bones) are truncated into a posteriorly directed wedge in *G. occiduus* but are broader and squared off or are concave anteriorly in *G. hoogstraali* (fig. 1). Beading of the supraoribital ridge is usually more prominent in *G. occiduus* particularly along the posterior third of the ridge (figs. 1, 2). The external orifices of both hypoglossal canals are readily visible when the inferior surface of the skull is viewed from the anterior in *G. occiduus*, but the laterally broadened occipital condyles obscure these canals in *G. hoogstraali*. The portion of the tympanic bullae anterior to the external auditory meatus is more inflated in all dimensions in *G. occiduus* than in *G. hoogstraali* (figs. 1, 2). Further, these two species differ significantly in at least five cranial dimensions (table 1).

These species differ in a number of pelage features. A narrow but distinct dark eye ring characterizes *G. occiduus* but is less prominent than that in *G. hoogstraali*, in which a distinct ring of

dark hairs surrounds the eye. The eye ring of *G. hesperinus* is very similar to that of *G. occiduus*, but lacks the clear white band of hair between the eye and base of pinna that characterizes the latter. The pinnae of *G. occiduus* show a slight, dark pigmentation around the distal free edge while the distal one-half to two-thirds are darkly pigmented in *G. hoogstraali* and *G. hesperinus*. Pinna length of *G. occiduus* averages shorter than in the other two species. Mean pinna length, range, and sample sizes are: *G. hoogstraali* (16.3, 14-17, n = 9); *G. hesperinus* (16.1, 14-19, n = 12); *G. occiduus* (13.8, 12-16, n = 8).

Prominent black terminal rings on the fresh dorsal pelage of *G. hoogstraali* and *hesperinus* give this region a much darker appearance than in *G. occiduus*. Further, the subterminal rings are more cinnamon colored in the former two species; the latter tends toward buffy brown.

Other Specimens Examined. — *G. hesperinus*, total of 14 from Morocco: 5 km. NE-5 km S Essouira (= Mogador), UM 122755-57, 22.5.30.24-31, (BM) 7.6.17.3, DML 4582; Cape Tefelney, (BM) 66.6067.

Discussion. — The ranges of *G. hesperinus*, *G. hoogstraali*, and *G. occiduus* are allopatric, each is apparently limited to a relatively small area of sand, and all lie near or along the Atlantic coast west of the High Atlas and Antiatlas mountains.

The High Atlas extend to the ocean north of Agadir and separate the sandy lowlands inhabited by *G. hesperinus* and *G. hoogstraali*. Similarly, an extension of the Antiatlas reaches the sea south of Tiznit forming a barrier between the ranges of *G. hoogstraali* and *G. occiduus*.

To my knowledge, hairy-footed *Gerbillus* are known to occur only in and around places of abundant, loose sand. Thus, the availability of loose sand seemingly constitutes an ecological constraint on the distribution of these gerbils and particularly the three above-mentioned species. The intervening mountain ranges are formidable barriers. Not only are they almost exclusively rock, but the higher regions support(ed) extensive forests, which could also form a significant barrier to dispersal.

If the distributions of these three species are to be interpreted on the basis of the present geomorphology and ecology of southwestern Morocco, one could conclude that *G. hesperinus* and *G. hoogstraali* dispersed across two and one mountain range,

respectively, to reach their present ranges. Another explanation seems more likely.

The crustal orogeny that produced the present elevations of the High Atlas and Antiatlas mountains began in the late Miocene and continued into the middle Pliocene (Choubert, 1945). The Sous valley, a broad syncline, was formed during the initial uplift of the High and Antiatlas ranges.

Pliocene and Early Pleistocene eustatic sea levels were high (200-300 m. above present MSL), but fluctuated, and most or all of the areas now inhabited by *G. hesperinus, G. hoogstraali,* and *G. occiduus* were inundated (Choubert, 1950). Sea levels for the period between 1,000,000 and 400,000 BP are insufficiently known, but were considerably higher than at present during most of this time (Lecointre, 1952); but, levels during the period from the latter date to the present are known with considerable accuracy (Fairbridge, 1961; Kassler, 1973). Mean sea level varied between 20 and 100 m. above the present level from 400,000 until about 120,000 BP, the beginning of the Riss-Illinoian glacial. The Riss and Wurm glacial, interstadial and interglacial sea level changes are well documented and averaged much lower than present levels (Fairbridge, 1961; Kassler, 1973). The Riss marine regression exposed a corridor along the present continental shelf that at maximum was 9 - 23 km. wide between Aoreora and Essouira. The corridor was open for about 20,000 years and closed during the Monastrian (Sangamon) interglacial. Bottom profiles and contour maps reveal that the continental shelf off Morocco slopes gently seaward from the coast to the 100 m. contour (Heezen et al., 1959). The Wurm regression reopened this corridor for a period of more than 40,000 years, and maximum exposure and width (12-30 km.) occurred about 20-17,000 BP. By 6000 BP, the Flandrian transgression reached present sea levels (Fairbridge, 1961; Kassler, 1973).

On the basis of the known geological record it is unlikely that *G. hesperinus* or *G. hoogstraali* could have spread into southwestern Morocco during the Pliocene or early Pleisotcene, assuming that either/both existed then. There is a distinct possibility that hairy-footed *Gerbillus* dispersed northward from the Spanish Sahara region during either or both the Riss and Wurm low stands or possibly at some as yet unknown earlier Pleistocene low stand(s).

The discovery by Tchernov (1968) of fossils of the extant *G. dasyrus* in deposits dated as ± 125,000 BP suggests that other

modern species such as *G. hesperinus* and *G. hoogstraali* could have existed then. In any event, the Flandrian transgression onto the continental shelf seems likely to have isolated the latter two species or their ancestors about 6000 BP.

Additional study of these rodents is necessary to clarify the details of their origin and evolution. Fortunately, what is known of their distribution and affinities offers encouraging prospects for estimating rates of differentiation and speciation within *Gerbillus*.

ACKNOWLEDGEMENTS

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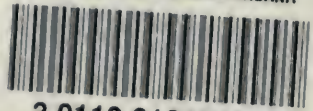
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