

THE TAXONOMIC STATUS OF GIANT SENGIS (GENUS *RHYNCHOCYON*) IN MOZAMBIQUE

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ABSTRACT

The sengis (elephant-shrews) of Mozambique are poorly known, especially the taxonomic status of the giant sengis, genus *Rhynchocyon*. Currently, *Rhynchocyon* from Mozambique are thought to be chequered sengis, *R. cirnei* with specimens from the central coastal areas being placed in the subspecies *R. c. cirnei*, while the subspecific status of those from north-eastern areas has not been determined. To resolve this taxonomic ambiguity, we collected voucher specimens from north-eastern Mozambique. Based on a comparison of pelage patterns and colouration, features that are currently used to distinguish taxa in the genus *Rhynchocyon*, specimens from all of coastal Mozambique show minor variation, but are similar enough to indicate that they all are referable to *R. c. cirnei*.

Keywords: Macroscelidea, *Rhynchocyon*, taxonomy, Mozambique, giant sengis

INTRODUCTION

The 18 species of sengis or elephant-shrews (Macroscelidea) currently recognised (Rathbun, 2009; Dumbacher *et al.*, 2012) are divided into two well-defined subfamilies: the Macroscelidinae (soft-furred sengis with 14 species in four genera) and the Rhynchocyoninae (giant sengis with four species in one genus). Taxonomically they are grouped with the elephants, hyraxes, sea-cows, aardvark, tenrecs, and golden-moles in the supercohort Afrotheria, which was recently defined based largely on molecular data (Springer *et al.*, 2004; Rathbun, 2005).

In 1968, Gordon Corbet and John Hanks published a seminal and largely definitive work on sengi taxonomy that included three species of *Rhynchocyon*, which were based on pelage colour and pattern, and geographical distribution, with virtually no reliance on cranial features. These included *R. cirnei* Peters, 1847; *R. petersi* Bocage, 1880; and

R. chrysopygus Günther, 1881. A fourth, *R. udzungwensis* Rathbun & Rovero, 2008, was subsequently described from Tanzania (Rovero & Rathbun, 2006; Rovero *et al.*, 2008).

The type specimen of the chequered sengi, *R. cirnei*, was collected from the Quelimane area in the Zambezia province of central Mozambique. Corbet & Hanks (1968) defined six subspecies of *R. cirnei* across its distribution, which extends from south of the Congo River to the Zambezi River, which forms the southern-most border of its range. It occurs in forested areas of Zambia, Malawi, Tanzania, and Mozambique, and extends east into Uganda nearly to the Victoria Nile River and to the coast in Tanzania and Mozambique (Rathbun & Nyari, 2012). The six subspecies show variable distinct patterns of dorsal longitudinal lines or stripes and spots (thus the name chequered sengis), as well as allopatric distributions, which together are the basis for their taxonomy (see colour plate and distribution maps for subspecies in Corbet & Hanks, 1968). For example, *R. c. shirensis* Corbet & Hanks, 1968 in the area south of Lake Malawi in extreme west-central Mozambique and southern Malawi (*e.g.* Dzonze Hill; figure 1) is slightly chequered, *R. c. reichardi* Reichenow, 1886 in the highlands surrounding the northern part of Lake Malawi in Malawi (*e.g.* Chinteche) and much of highland Tanzania is very distinctly chequered, and *R. c. cirnei* in the lowland and coastal areas of central Mozambique (*e.g.* Quelimane) is very indistinctly chequered.

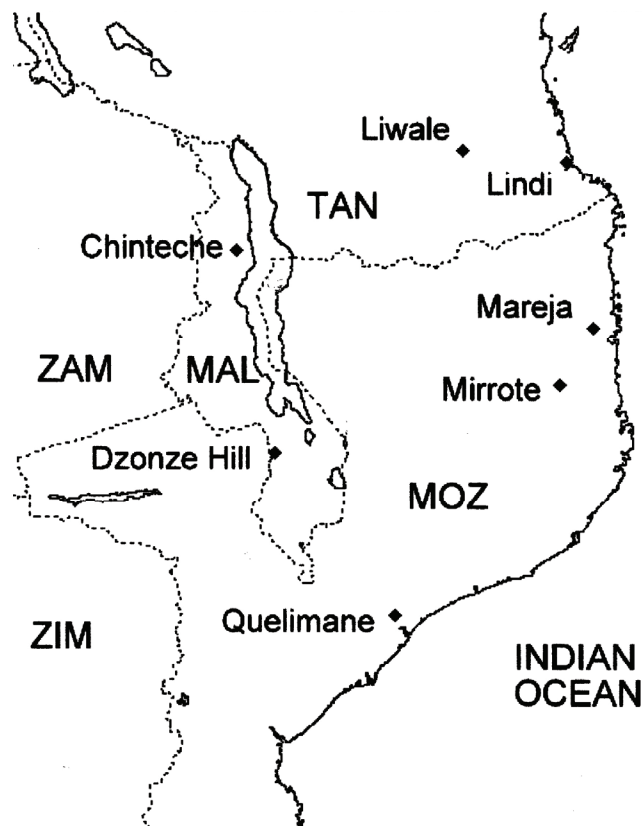


Figure 1. South-eastern Africa illustrating specimen locations (diamonds) and country boundaries (dotted lines). Country name abbreviations: TAN = Tanzania, ZAM = Zambia, MAL = Malawi, MOZ = Mozambique, and ZIM = Zimbabwe.

Corbet & Hanks (1968) map a population of *Rhynchocyon* that was not identified to subspecies from Cabo Delgado Province in north-eastern Mozambique, but state (1968:57) that "...further collecting may well demonstrate clinal variation...or discover yet other [taxa]. The overall pattern of [*R. cirnei*] variation cannot be assessed until more data [specimens] are available from Mozambique". To resolve this taxonomic question, we collected specimens in north-eastern Mozambique for comparison with existing skins in museum collections.

MATERIALS AND METHODS

In north-eastern Mozambique, we live-trapped sengis in the Mareja Community Reserve (figure 1), which is part of Quirimbas National Park, located inland from the coastal city of Pemba. From 14 through 28 June 2011, we used 14 collapsible double-door wire-mesh live traps (Tomahawk Live Traps, Hazelhurst WI, USA; model #203, 15 x 15 x 61 cm) and nylon fishing gill-nets (Memphis Net & Twine Co., Memphis TN, USA; multifilament twine #208, dark brown colour, 7.5 cm stretch mesh, 30 m long and 60 cm deep) to capture *Rhynchocyon*. We trapped in suitable closed-canopy riparian forest habitat with an abundance of leaf litter (Rathbun, 1979), adjacent to the Rio Mareja, where giant sengis had been sighted in July and August 2010 (PGRC, personal observation).

Rhynchocyon does not normally build or use trails (Rathbun, 1979), but where the four-toed sengi (*Petrodromus tetradactylus* Peters, 1846) is syntopic, as at Mareja, *Rhynchocyon* will sometimes use the trails that *Petrodromus* builds and maintains. We set Tomahawk traps on *Petrodromus* trails, and to minimise injury to captured animals, we checked the traps every 2-3 hours during daylight. We did not bait the traps, because Sabuni *et al.* (2011) determined it was of no advantage to do so. We moved the traps to new locations every 2-3 days.

We strung gill-nets vertically along the forest floor on existing game paths, or along straight paths that we cleared of leaf litter and low dense vegetation (Rathbun, 2011). The top of the nets were hung loosely about 30 cm above the ground from vegetation or twig props inserted vertically into the soil. The remaining 30 cm of net fell loosely on the ground, resulting in *Rhynchocyon* becoming entangled when trying to pass through the net. We did not drive animals into the nets, but allowed them to entangle themselves during their normal movements. The nets were set or opened at dawn and checked every 2-3 hours until dark, when they were collapsed onto the ground, which prevented by-catch of nocturnal mammals, such as small antelopes, and destruction of the nets by large mammals, such as elephants. The nets usually were moved to new locations every 2-3 days.

We set 14 Tomahawk traps on 14-24 June, none on 25 and 26 June, and ten on 27 and 28 June. We strung no gill-nets on 14 June, three on 15 June, four on 16 and 17 June, five on 19 June, six on 20-24 June, none on 25 and 26 June, and one on 27 and 28 June.

Specimens were euthanized (Gannon *et al.*, 2007) and prepared as classical museum study skins. Standard morphological measurements were taken, along with GPS coordinates of the capture locations. Reproductive condition was determined during preparation of study skins. The skulls and most post-cranial material were either air-dried in preparation for cleaning by dermestid beetles at the California Academy of Sciences, or preserved, along with soft tissues, in formalin. We preserved leg muscle, liver, and kidney tissues for future DNA analysis in 95% ethyl alcohol.

All voucher material was exported by hand to the California Academy of Sciences. Morphological comparison with existing museum specimens from south-eastern Africa was

done by GBR at the Ditsong (Transvaal) National Museum of Natural History in Pretoria, South Africa, The Natural History Museum in London, UK, and the California Academy of Sciences in San Francisco, USA.

RESULTS

We captured eight *Rhynchocyon* (seven adults and one juvenile; table 1), four in the nets and four in the Tomahawk traps. Based on the external body measurements we took (table 1), the mean total length for the seven adults was 533 mm (range 513 mm to 553 mm) and the mean weight was 554 g (range 440 g to 630 g). None of the females had recent embryo scars, embryos, or foetuses.

Table 1. Data associated with Rhynchocyon cirnei sengis trapped in the Mareja Community Reserve, Mozambique. Column abbreviations: Cat no = California Academy of Sciences catalogue number; Cap date (trap type) = capture date, T = Tomahawk trap, G = gill-net; Lat/long = Latitude south and Longitude east in decimal degrees; Elev = elevation in metres; Wt = weight in grams; Meas = the following sequence of external body measurements in millimetres: total length, tail length, right rear foot with nail, right rear foot without nail, notch to crown ear length. Asterisk () by catalogue number indicates immature individual. The skin and skull of CAS 29357 is being transferred to BMNH (accession pending), and tissue samples and post-cranial skeleton remain at CAS.*

Cat no	Sex	Cap date (trap type)	Lat/long	Elev	Wt	Meas
CAS29344	M	16 June 2011 (T)	-12.84363,40.16172	130	600	553-263-86-79-29
CAS29345	F	16 June 2011 (G)	-12.84832,40.16494	152	530	531-250-81-75-30
CAS29351	M	19 June 2011 (G)	-12.84405,40.16090	123	630	544-254-85-77-30
CAS29352	M	20 June 2011 (T)	-12.84204,40.16379	120	540	532-248-80-71-32
CAS29353	F	20 June 2011 (G)	-12.84526,40.16153	130	580	538-254-85-76-32
CAS29355*	M	22 June 2011 (T)	-12.84208,40.16378	120	370	485-218-82-75-29
CAS29357	M	24 June 2011 (G)	-12.84297,40.16235	116	440	513-245-84-75-31
CAS29358	M	24 June 2011 (T)	-12.84504,40.16143	124	560	522-239-81-74-34
Means				127	531	527-246-83-75-31

The *Rhynchocyon* that we collected were captured in a riparian forest area of about 0.5 km², and their pelage showed differences in colour and pattern (figure 2), which indicated non-geographic variation. In general, the dorsal pelage was grizzled light brown, approaching yellowish in lighter specimens, and becoming darker brown/rufous on the rump and thighs. It had a pair of longitudinal central dorsal lines or stripes that were defined by darker chestnut-coloured hair, and these lines were indented with faint pale-yellow or cream-coloured spots along their length. These stripes were variable in how distinct they were from the background colouration of the animals. A second pair of outer stripes was scarcely visible in some specimens, and this pair becomes nearly invisible at some angles and in some light.

The pelage on the head and neck was grizzled light brown, becoming rufous-orange behind the ears and on the nape of the neck. The tail skin was dark brown/black, with about the distal quarter greyish-white with a variable terminal dark tip in some specimens. The ventral pelage was rufous/brown, becoming lighter around the neck.



Figure 2. Comparison of representative *Rhynchocyon cirnei* study skins. Left pair: California Academy of Sciences specimen numbers CAS29358 and CAS29352 from Mareja Community Reserve, Mozambique, which represent the extreme variation we observed. Right pair: Ditsong Museum topotype specimen numbers TM662 and TM661 from Quelimane, Mozambique. See figure 1 and table 1 for details.

We examined an image of the mounted (taxidermy) type specimen of *R. cirnei* from the Leiden Museum, with the intent of comparing its pelage with our specimens from Mareja and those in other museums, but the specimen appeared faded (perhaps due to being on display in bright light), and thus it was not useful. However, at the Ditsong Museum we were able to examine two topotype study skins of *R. cirnei* collected at “Quelimane” (figures 1 and 2), about 80 km north of the Zambezi River. We found the pelage pattern and colour of the topotypes very similar to our Mareja specimens, with the main variable being the density of the dorsal background colouration. We also examined a specimen (TM9149) from Dzonze Hill, Malawi (figure 1), and it was quite similar to the specimens from Mareja and Quelimane. However, three specimens (TM9140, TM9151, and TM8943) from Chinteche, Malawi (figure 1), were remarkably different, most notably they had three pairs of very

distinct chequers (as opposed to the one distinct and one indistinct pair of stripes from Mareja, Quelimane, and Dzonze Hill).

The giant sengi in The Natural History Museum in London (BM34.1.116), from Mirrote in north-central Mozambique (figure 1), is the basis for the un-identified subspecies or cline suggested by Corbet & Hanks (1968). Mirrote is on the south side of the Lurio River, about 130 km south of our Mareja study site, and 535 km north of Quelimane. The pelage pattern and colour of the Mirrote specimen showed a slightly more defined second pair of longitudinal stripes on a slightly darker dorsal background colour, compared to the specimens from Mareja, but it was similar to the darker of the two topotypes from Quelimane (figure 3). The darker background pelage resulted in the chestnut colouration of the stripes being slightly less pronounced than most of the other specimens from Mozambique that we examined. Also, the very sparse and short hair on the dorsum of the rear feet was slightly more chestnut coloured than that of the Mareja and Quelimane specimens. Overall, however, the pelage in the Mirrote specimen was not remarkably different from the variation we found in the Mareja and Quelimane specimens we examined (figures 2 and 3). While at The Natural History Museum in London, we examined specimens from southern Malawi and northern Malawi and south-western Tanzania (figure 4), which supported our general observations from the Ditsong Museum in Pretoria.



Figure 3. Comparison of representative Rhynchocyon cirnei study skins. Left and right specimens (California Academy of Sciences numbers CAS29352 and CAS29358) from Mareja Community Reserve, Mozambique. Centre specimen (The Natural History Museum, London, number BM34.1.116) from Mirrote, Mozambique. See figure 1 and table 1 for details.



Figure 4. Comparison of *R. cirnei* study skins (BM=The Natural History Museum in London, CAS=California Academy of Sciences in San Francisco) from south-eastern Africa, clockwise from lower left: Corbet & Hanks's (1968) Mirrote specimen (BM34.1.11.6); *R. c. cirnei* (CAS 29358 and CAS29352) from Mareja, Mozambique; *R. c. macrurus* (BM62.405, BM62.404, BM1938.10.13.5) from inland south-eastern Tanzania; *R. c. macrurus* (BM63.1852 and BM62.400) from coastal south-eastern Tanzania; *R. c. shirensis* (BM22.12.17.116, BM14.4.29.2, and BM22.12.17.115) from southern Malawi; *R. c. reichardi* (BM30.2.7.1) from south-western Tanzania.

At The Natural History Museum in London, we also examined a series of specimens from south-eastern Tanzania (north side of the lower Rovuma River). These are referable to *R. c. macrurus* Günther, 1881 (Corbet & Hanks, 1968), and showed remarkable geographic variation, with animals inland having distinct chequers (*i.e.* BM62.405 from Liwale; figures 1 and 4) that graded into the coastal animals that were so dark that the chequers were mostly masked (BM63.1852 from Lindi; figures 1 and 4). In the inland specimens, the inner two pairs of chequers were distinct, with an indistinct outer third pair, which were not present in specimens from Mareja, Quelimane, and Dzonze Hill.

DISCUSSION

With a better understanding of the pelage patterns and colouration of *R. cirnei* from Mozambique and adjacent countries (figure 4), we can interpret the taxonomy and distribution of *Rhynchocyon* in this region with a little more clarity than in the past. Based on our observations of available specimens, we believe that in general *R. c. cirnei* (Corbet & Hanks, 1968) occurs in coastal and lowland forests of Mozambique from the south side of the Rovuma River south to the north side of the Zambezi River (both of these rivers are possible historical and current geographical barriers for sengis). The variation in pelage colour and pattern across this large area indicates that there is no seventh subspecies or cline.

To further assess the possible distribution of *R. c. cirnei*, we examined specimens from adjacent areas. The specimens from Chinteche, Malawi, are indeed distinctive, and it seems reasonable that they are referable to *R. c. reichardi* (Corbet & Hanks, 1968). The specimens that we examined from Dzozne Hill, Malawi, presumably would be *R. c. shirensis* (Corbet & Hanks, 1968), but their pelage seemed to be near, if not within, the variation that we found in specimens from Mareja and Quelimane. Thus we believe that this taxon will require closer examination. We suspect that when molecular analyses are eventually done (see below), *R. c. cirnei* and *R. c. shirensis* will be found to be in the same taxon, most likely distinct from subspecies from highland areas of Malawi, Zambia, and Tanzania, as well as from specimens in the Congo Basin. These inland subspecies may be elevated to one or more different full species status with further analyses.

As pointed out by Corbet & Hanks (1968), we also found overall pelage similarities between the inland form of *R. c. macrurus* (with three pairs of chequered stripes) and specimens of *R. c. cirnei* from Mareja and Quelimane (with only two pairs of stripes). However, the very dark coastal form of *R. c. macrurus* has very different pelage when compared with forms from lowland and coastal Mozambique. Because of the poorly understood geographic variation in *R. c. macrurus*, which may be clinal (Corbet and Hanks, 1968; Kingdon, 1974), additional research definitely is needed to resolve the perplexing status and distribution of this taxon.

It is difficult to compare the size of the Mareja *Rhynchocyon* with other forms because of the lack of a common metric across all taxa, and small sample sizes. The average adult total length of the Mareja specimens was 527 mm (table 1). Based on the data assembled in Rovero et al. (2008) for the same metric, *R. udzungwensis* = 564 mm, *R. chrysopygus* = 518 mm, *R. c. stuhlmanni* Matschie, 1893 from the Congo Basin = 515 mm, *R. petersi* = 509 mm, *R. c. macrurus* dark coastal form = 485 mm, and *R. c. reichardi* = 456 mm. It appears that *R. c. cirnei* may be among the larger forms of *Rhynchocyon*.

Molecular analyses have been used in studies of soft-furred sengi taxonomy and phylogeography (Douadey *et al.*, 2003; Smit *et al.*, 2007), and a morphologically cryptic species was discovered and described from South Africa using molecular analysis (*Elephantulus pilicaudus* Smit, 2008; Smit *et al.*, 2008), and similar methods were used to better understand the relatively cryptic species in the genus *Macroscelides* (Dumbacher *et al.*, 2012) from south-western Africa. These results illustrate the importance and strength of DNA sequence analyses in clarifying sengi taxonomy, but unfortunately these methods are only slowly being applied to giant sengis. For now, we are restricted to the legacy of using external morphology of *Rhynchocyon* (Corbet & Hanks, 1968), which indicates there is no seventh subspecies or cline of *R. cirnei* in eastern Mozambique. However, a more thorough and better understanding of the complicated phylogeography of *Rhynchocyon* awaits the benefit of DNA sequencing.

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REFERENCES

- Corbet, G.B. & J. Hanks (1968). A revision of the elephant-shrews, Family Macroscelididae. *Bulletin of the British Museum of Natural History (Zoology)* **16**: 1-111.
- Douady, C.J., F. Catzeflis, J. Raman, M.S. Springer & M.J. Stanhope (2003). The Sahara as a vicariant agent, and the role of Miocene climatic events, in the diversification of the mammalian order Macroscelidea (elephant shrews). *Proceedings of the National Academy of Sciences of the U.S.A.* **100**: 8325-8330.
- Dumbacher, J.P., G.B. Rathbun, H.A. Smit & S.J. Eiseb (2012). Phylogeny and taxonomy of the round-eared sengis or elephant-shrews, genus *Macroscelides* (Mammalia, Afrotheria, Macroscelidea). *Public Library of Science (PLoS) ONE* **7**(3): e32410 (12 pp + 4 pp supplement).
- Gannon, W.L., R.S. Sikes & The Animal Care and Use Committee (2007). Guidelines of the American Society of Mammalogists for the use of wild mammals in research. *Journal of Mammalogy* **88**: 809-823.
- Kingdon, J. (1974). *East African Mammals; an Atlas of Evolution in Africa*. Vol. IIA. Academic Press, New York.
- Rathbun, G.B. (1979). The social structure and ecology of elephant-shrews. *Zeitschrift fur Tierpsychologie Suppl.* **20**: 1-77.
- Rathbun, G.B. (subeditor) (2005). Order Macroscelidea. In J.D. Skinner and C.T. Chimimba (eds), *The Mammals of the Southern African Subregion*, third edition. Cambridge University Press, Cape Town. Pp. 22-34.
- Rathbun, G.B. (2009). Why is there discordant diversity in sengi (Mammalia; Afrotheria; Macroscelidea) taxonomy and ecology? *African Journal of Ecology* **47**: 1-13.
- Rathbun, G.B. (2011). Protocols for surveying *Rhynchocyon* Website. California Academy of Sciences, San Francisco, California. http://researcharchive.calacademy.org/research/bmammals/eshrews/protocols_for_surveying_rhynchocyon.html. [Accessed December 2011].
- Rathbun, G.B. & A.S. Nyari (2012). Sengi Distribution Maps web site. California Academy of Sciences, San Francisco, California. <http://researcharchive.calacademy.org/research/bmammals/eshrews/distribution.html> [Accessed January 2012].
- Rovero, F. & G.B. Rathbun (2006). A potentially new giant sengi (elephant-shrew) from the Udzungwa Mountains, Tanzania. *Journal of East African Natural History* **95**: 111-115.
- Rovero, F., G.B. Rathbun, A. Perkin, T. Jones, D. Ribble, C. Leonard, R.R. Mwakisoma & N. Doggart (2008). A new species of giant sengi or elephant-shrew (genus

- Rhynchocyon*) highlights the exceptional biodiversity of the Udzungwa Mountains of Tanzania. *Journal of Zoology, London*, **274**: 126-133.
- Sabuni, C., A. Beddetti & H. Leirs (2011). Can giant sengis (genus *Rhynchocyon*) be captured with baited traps? *Afrotherian Conservation - Newsletter of the IUCN-SCC Afrotheria Specialist Group* **8**: 9-12.
- Smit, H.A., T.J. Robinson & B.J. Van Vuuren (2007). Coalescence methods reveal the impact of vicariance on the spatial genetic structure of *Elephantulus edwardii* (Afrotheria, Macroscelidea). *Molecular Ecology* **16**: 2680-2692.
- Smit, H.A., T.J. Robinson, J. Watson & B.J. Van Vuuren (2008). A new species of elephant-shrew (Afrotheria: Macroscelidea: *Elephantulus*) from South Africa. *Journal of Mammalogy* **89**: 1257-1269.
- Springer, M.S., M.J. Stanhope, O. Madsen & W.W. De Jong (2004). Molecules consolidate the placental mammal tree. *Trends in Ecology & Evolution* **19**: 430-438.