A new servaline genet (Carnivora, Viverridae) from Zanzibar Island

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A new subspecies of *Genetta servalina* is described based on the first and only specimen of genet collected in 1995 on the Island of Zanzibar, Tanzania. The skin and skull of *G. servalina archeri* were compared with those of other known *G. servalina* subspecies from continental Africa and differences were noted.

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Zanzibar is a large island (about 88 km long by 24 km wide) lying 40 km off the mid-point of the east coast of Tanzania between 05°43' and 06°28'S and 39°11' and 39°41'E (Swynnerton 1945). It is a recent continental island, formed at the beginning of the Pleistocene, and may have been re-connected with mainland Africa by the last uplift (during either the Mid- or Late Pleistocene) (Moreau & Pakenham 1940). According to Kingdon (1990) it is likely to have had connections with the mainland via a shallow marine channel as recently as 50 000 and again 10 000 years ago. The island receives about 1 600 mm rainfall annually.

The characteristic forest of the island (called Jozani Forest: 06°15'S, 39°24'E) is defined by Greenway (1973) as a freshwater swamp forest containing the oil palm (*Elais guineensis*) and the stilt-rooted screw pine (Pandanus sp.), species considered dominant in the forest by Moreau & Pakenham (1940). A field study by Robins (1976) indicates that the dominant species are *Calophyllum inophyllum* and *Eugenia* sp., with *Pandanus* sp., *Vitex doniana* and *Elaeis guineensis* as subdominants. The forest possesses few large trees and merges at its edges into 'evergreen bush' and, as a consequence, very diverse estimates have been made of its area (Moreau & Pakenham 1940). The survey map (Department of Overseas Survey 1964) suggests an area of 550 ha, whilst administrative documents of the Forestry Department use the figure of 196 ha. Earlier estimates probably included much of the mangrove forest on the north side, coastal evergreen bushland, and even plantations. Nevertheless, Jozani Forest contains several mammals including East African red squirrel (*Parexerus palliatus frerei*), bush pig (*Potochoerus porcus*), elephant shrew (*Rhycocyon pertersiadersi* and *Petrodomus* sp.), as well as several endemics: Zanzibar colobus (*Colobus badius kirkii*), Sykes' monkey (*Cercopithecus (nictitans) a. albogularis*), dwarf red duiker (*Cephalophus adersi*), Zanzibar leopard (*Panthera pardus adersi*) and blue duiker (*Cephalophus monticola sundevalli*).

Zanzibar is host to a limited number of African herpestids and viverrids: *Bdeogale crassicauda, Galerella sanguinea,* and *Civettictis civetta* (Matschie 1892; Lorenz-Libernau 1898; Neumann 1900; Thomas & Wroughton 1908; Ferris 1916; Mansfield-Aders 1920; Bedford 1932; Moreau & Pakenham 1940; Swynnerton 1945; Swynnerton & Hayman 1951; Williams 1951; Pakenham 1984). In addition, two species have been introduced: *Mungos mungo* and *Viverricula indica* (Neumann 1900; Mansfield-Aders 1920 [*Viverricula indica* erroneously named *Viverra megaspila*]; Moreau & Pakenham 1940; Swynnerton & Hayman 1951; Pakenham 1984). No records of any other herpestids or viverrids are known, but Pakenham (1984) mentioned the local names 'Ukwiri' (said to be like *Viverricula* but different) and 'Uhange' (said to be of similar size to *Bdeogale*... and marked like *Viverra* i.e. *Civettictis*). Both are reported from Pete (just south of Jozani Forest) and either of them could relate to *Genetta*.

Mr. Anthony L. Archer, who has been working for nearly five years in Zanzibar, informed us that for the best part of two or three years he had received reports, from several different sources, of what could only have been a genet. On 15 February 1995 he obtained a genet from near Kitogani (06°17'S, 39°26'E), S.E. of Jozani Forest, that had been shot at night by a villager whilst attacking chickens. Kitogani is adjacent (*ca* 4 km) to Jozani Forest and it is highly likely that the genet had been living in this forest reserve. In 1997 Chris and Tilde Stuart (in press) found and photographed tracks that were definitely of genet origin in Jozani Forest edge and bracken thicket.

The skin of the collected specimen clearly belongs to *G. servalina*. Even though the tail is not complete, the numerous, well-defined, small spots on the body which rarely coalesce and the absence of a mid-dorsal line leave no doubt.

As the distribution pattern of the servaline genet is poorly defined in terms of its three presumed East African subspecies (*Genetta servalina bettoni, G. s. intensa* and *G. s. lowei*) and its occurrence on the coastal region has not been recorded, this note aims to describe the insular subspecies of Zanzibar.

Genus *Genetta* G. Cuvier, 1816

Genetta G. Cuvier, 1816. *Règne Anim.*, 1: 156.

Genetta servalina Pucheran, 1855

Genetta servalina Pucheran, 1855. *Rev. Mag. Zool.*, 7: 154. Holotype from 'Gabon'. Includes *Genetta aubryana* Pucheran, 1855 *Rev. Mag. Zool.*, 7: 154. Holotype from 'Gabon'.

Subspecies: Genetta servalina bettoni Thomas, 1902. *Ann. Mag. Nat. Hist.* (7)9: 365. Holotype from Lagari, Kenya.

Genetta servalina intensa Lönnberg, 1917. *Kungl. Svenska Vet.-Akad. Handl.* (2)58(2): 59. Holotype and paratype from Beni and Masisi, Congo (Kinshasa).

Genetta servalina cristata Hayman, 1940. In: I.T. Sanderson. *Trans. Zool. Soc. London* 24(7)1: 686. Holotype from Okoiyong, Cameroon.

Genetta servalina schwarzi Crawford-Cabral, 1970. *Bol. Inst. Invest. cient. Angola* (7)2: 9. Holotype from Mushie, Congo (Kinshasa). Later considered by the author as perhaps not of subspecific rank (Crawford-Cabral 1980–81).

Genetta servalina lowei Kingdon, 1977. East Afr. Mamm. Vol. III. Part A: 154. Holotype from Dabaga, Tanzania.

Although Lönnberg (1917: 59) was 'not fully convinced that the differences enumerated are important enough for the creating of a separate subspecies' his *Genetta servalina intensa* is recognized by Coetzee (1977). It is made synonymous with *G. servalina* by Wozencraft (1993), and considered as a possible subrace of *G. s. bettoni* by Crawford-Cabral (1980–81).

Genetta servalina schwarzi (Crawford-Cabral 1970, 1981) is not mentioned by Coetzee (1977) nor by Wozencraft (1993).

Genetta cristata is considered as a subspecies of *G. servalina* by Hayman (in Sanderson 1940) and Coetzee (1977), and made synonymous with *G. servalina* by Wozencraft (1993). We follow Rosevear (1974), Crawford-Cabral (1980–81), and IUCN (1996) who consider it a distinct species. Recently its distributional range has been enlarged to include the Niger Delta, Nigeria (Powell 1995, 1997).

The following species and subspecies are recognized in this study:

Genetta servalina servalina Pucheran, 1855

Includes *G. aubryana* which may represent a lighter colour phase (Crawford-Cabral 1970).

Genetta s. bettoni Thomas, 1902

Includes *G. s. intensa* which may represent a darker colour phase and whose distribution corresponds largely with that of *G. s. bettoni* in Congo (K).

G. s. schwarzi Crawford-Cabral, 1970

Provisionaly treated here as a distinct subspecies.

G. s. lowei Kingdon, 1977

Provisionally treated here as a distinct subspecies.

G. s. archeri Van Rompaey and Colyn, 1998

G. cristata Hayman, 1940

Genetta servalina archeri **subsp. nov.**

Holotype

Adult of unknown sex: badly damaged skin with head + body length of 55 cm, tail tip missing, skull with permanent dentition, but missing the back part. The specimen, collected by A. L. Archer on 15 February 1995 has been deposited in the RMCA, Tervuren, Belgium, No. 'Vert. Sect. 97047M1'.

Type locality

Near Kitogani (06°17'S, 39°26'E), S.E. of Jozani Forest, Island of Zanzibar, Tanzania.

Etymology

We dedicate the Zanzibar genet to Mr. A. L. Archer who discovered this forest genet in Zanzibar.

Diagnosis

The skin of the only specimen available shows the principal characteristics of a servaline genet, i.e. darkly, closely spotted, rather short, velvety pelage without a medial dorsal stripe. The numerous, medium-sized, black spots on the back are mostly separate and occasionally coalesce on the spine. The throat and the ventral part of the insides of the fore- and hindlegs are a clear, smoky grey, whereas the lower outside parts are light coloured and carry small spots. The tail is relatively short-haired and soft-furred, and annulated with 10 light-coloured rings, these being narrower than the 9 darker intermediate rings. Dorsally, light-coloured rings have some light-brown hairs mixed medially. The tip of the tail is absent (Figure 1).

In contrast with *G. s. bettoni* and *G. s. lowei* from continen-

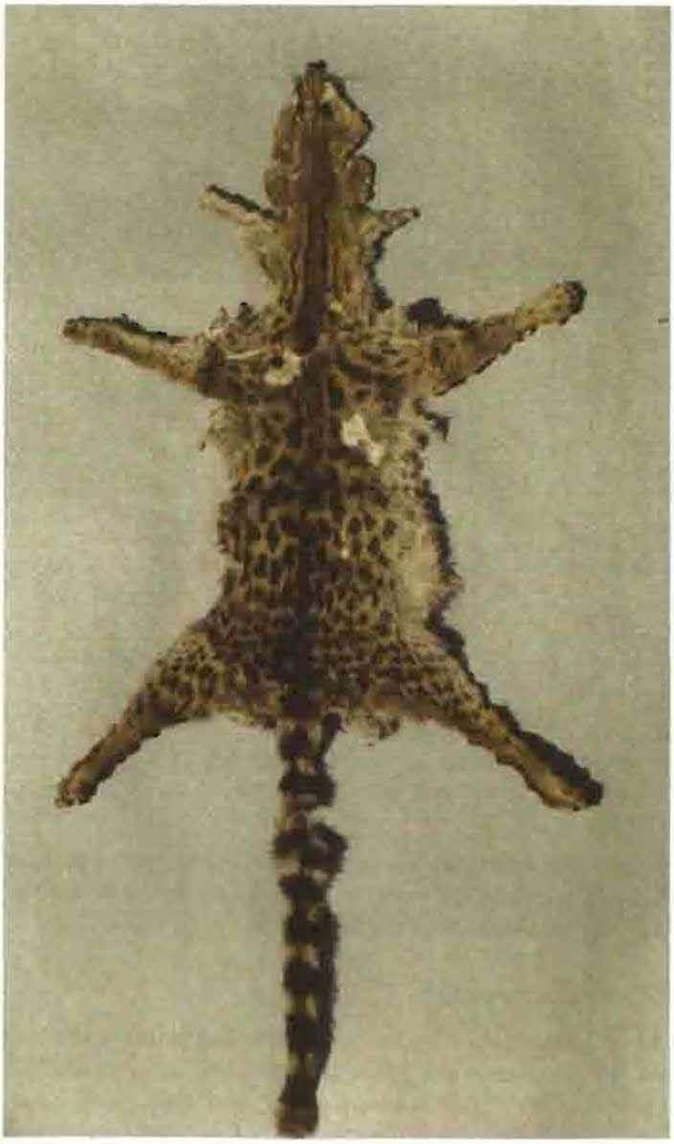

Figure 1 Skin of a servaline genet from Zanzibar Island. Holotype No. 97047M1, RMCA, Tervuren, Belgium.

Table 1 Comparison of 12 skull measurements and 7 dental measurements (in mm) of the Zanzibar genet with *Genetta servalina bettoni*: holotype (BMNH-2.2.6.1), 6 specimens from Mt. Elgon, Uganda: BMNH-34.4.1.46 (M), 34.4.1.51 (M), 34.4. 1.64 (F),34.4. 1.66 (F), 34.4.1.70 (F), and 6 specimens from Elgeyo Forest, Kenya: AMNH-36014 (M), 36015 (M), 36016 (M), 36018 (F), 36019 (F), 36020 (F); 4 specimens of *G. servalina intensa* from Congo (K): Akenge: RMCA-12293 (F), Arebi: RMCA-8513 (F), Lemera: ZSM-1966/123 (F), and Zambo: RMCA-3274 (M); 14 specimens of *G. servalina schwarzi* from Congo (K): Amadjabe: RMCA-89019M46 (U), 89019M47 (U), 89019M50 (U), 89019M53 (U), 89019M54 (U); MC-Z4260 (U), Z4287 (U), Z4338 (U), Z4650 (U), Inkongo: RMCA-7835 (U); Kunungu: RMCA-6952 (U), 8149 (M), 10613 (M), 14861 (U); and 15 specimens of *G. servalina servalina* from Cameroon: Bafia region: AMNH-170378 (U); Bipindi: PCM-Z1X29 (F), MNHU-18951 (M), 18966 (U), 18976 (U), 18978 (U); Dja region: RMCA-7732M80 (U); Efulen: BMNH-3249 (F); Kanyol: PCM-M438 (M); Lelo: PCM-M554 (M); Lomie District: PCM-M734 (M); Lumbinou: PCM-M91 (M); Metet: MCZ-14741 (U); Moloundou: MNHU-18992 (U); Obala: PCM-M626 (F). Dental measurements of only 9 out of the 15 specimens from Cameroon are included. F: female; M: male; U: unknown.

	Holotype of *G. s. archeri*	Holotype of *G. s. bettoni*	12 specimens of *G. bettoni* Mean	4 specimens of *G. s. intensa* Mean	14 specimens of *G. s. schwarzi* Mean	15 specimens of *G. s. servalina* Mean
ROL	29.6	24.8	24.2	26.8	30.0	30.2
PAL	42.3	37.2	36.8	39.7	42.6	42.7
MAX	34.7	30.8	29.9	32.4	35.1	35.7
CAN	13.4	12.1	11.5	12.2	13.2	13.8
ROB	17.9	16.3	16.0	16.9	17.6	18.2
IOB	13.3	11.8	11.7	12.1	12.8	13.5
PAB	22.8	20.3	20.2	21.2	22.1	23.7
ZYG	44.6	39.8	39.6	43.3	43.6	45.1
BRH	25.8	26.1	25.5	26.0	26.0	26.5
MAL	61.6	–	53.1	58.1	62.1	63.4
MAN	38.2	–	32.3	34.5	37.6	38.1
CMH	25.2	–	20.8	22.8	22.1	23.9
P^4L	7.8	7.5	6.8	7.4	8.0	8.1
P^4B	5.6	4.5	4.5	4.6	4.9	5.0
P^4D	9.7	8.3	7.9	8.1	9.0	9.2
M^1L	3.9	4.1	3.6	4.1	4.3	4.7
M^1B	5.6	4.5	4.5	4.7	5.7	5.6
M_1L	7.7	–	6.5	6.7	7.6	7.5
M_1B	3.6	–	3.0	3.2	3.7	3.7

tal East Africa, *G. s. archeri* has no 'yellower base colour' (Kingdon 1977). Because of its larger size *G. s. archeri* can easily be differentiated craniometrically from *G. s. bettoni* (Table 1).

G. s. schwarzi can be distinguished by its dark-coloured feet, the regular disposition of the spots on the back, and the dark stripes extending from the nape to the shoulders.

Skull measurements

As both the greatest and condylobasal length of the skull of the Zanzibar genet are presently unknown, we compared 12 other skull and 7 dental measurements with those of the holotype and 12 other specimens of *G. s. bettoni* from East Africa. As no genet skull from Tanzania was available, we used three males and three females from Mt. Elgon, Uganda, and three males and three females from Elgeyo Forest, Kenya. Measurements of specimens of *G. s. intensa* and *G. servalina schwarzi* from Congo (K) and *G. s. servalina* from Cameroon are also given (Table 1). All 19 measurements of the Zanzibar genet were larger than the mean measurements of the 12 East African *G. s. bettoni*. The greatest differences are seen in the ROL, PAL, MAX, ZYG, MAL, MAN, and P^4B.

Distribution (Figure 2)

It seems that *G. s. bettoni* has a very patchy distribution in East Africa, and no servaline genets have been recorded from the coastal areas of either Kenya or Tanzania. Also, as Zanzibar is not supposed to harbour genets, the question of its origin arises. Two possibilities spring to mind, the first being of a vagrant animal that has 'wandered' out of its normal distributional area. Taylor (1970) found *Genetta servalina* to be rare in East Africa, only occurring in wet forests with a rainfall of over 1 625 mm a year. He records only two localities in Kenya, while Kingdon (1977) gives five (the most easterly being Mt. Kenya). The species is even rarer in Tanzania. Haltenorth & Diller (1980) do not mention the species from Tanzania at all, and Kingdon (1977) mentions only one record: a skin (BMNH-33.8.1.20) collected by G. W. Lowe in 1932 at Dagaba (08°07'S, 35°55'E), and provisionally named *G. servalina lowei*. With the Dagaba Highlands lying approximately 440 km from Zanzibar, and Mt. Kenya being even further away, the possibility of a forest-dwelling genet wandering to the coast and then crossing a marine water body at least 32 km wide seems very remote. A more likely explanation would be that of a recently 'introduced' species, or of escaped pets establishing a population. Arguments against this theory are that *G. servalina* is not known to have been introduced anywhere, and that it is an unlikely pet — most pet genets are either *G. genetta, G. rubiginosa*, or *G. tigrina*. The only plausible explanation would be that a small, very localized, relict population resident on the island has been overlooked. The habitat would be suitable: Jozani Forest, with a rainfall of over 1 500 mm a year (Kingdon 1971) still contains primates and ungulates.

Affinities

A. L. Archer compared the skin with *Genetta s. bettoni* specimens in the Kenyan National Museum. He found the pelage to differ considerably in the irregularity of the spotting, in the thinner streaking on the back of the neck, and in the spot below the eyes being more buff than white. The zygomatic arch of the skull appeared broader and the teeth more robust (a possible adaptation for feeding on snails and land crabs).

Examination of the *G. s. bettoni* specimens from the RMCA (Tervuren) and IRSNB (Brussels) also shows that there is considerable variation between populations from the mountainous regions of eastern Congo (K) and those of Mt. Elgon in western Kenya. This is the case for the pattern of spots (form, colouration and distribution), and also for the colouration of the legs (that range from clear, smoky grey to deep black). The craniometric data, however, allow better discrimination of *G. s. archeri*, whose skull dimensions are considerably different from those of *G. s. bettoni*, and correspond more with those of central African *G. s. schwarzi* and *G. s. servalina* (Table 1).

Kingdon (1977) mentions the record of a servaline genet

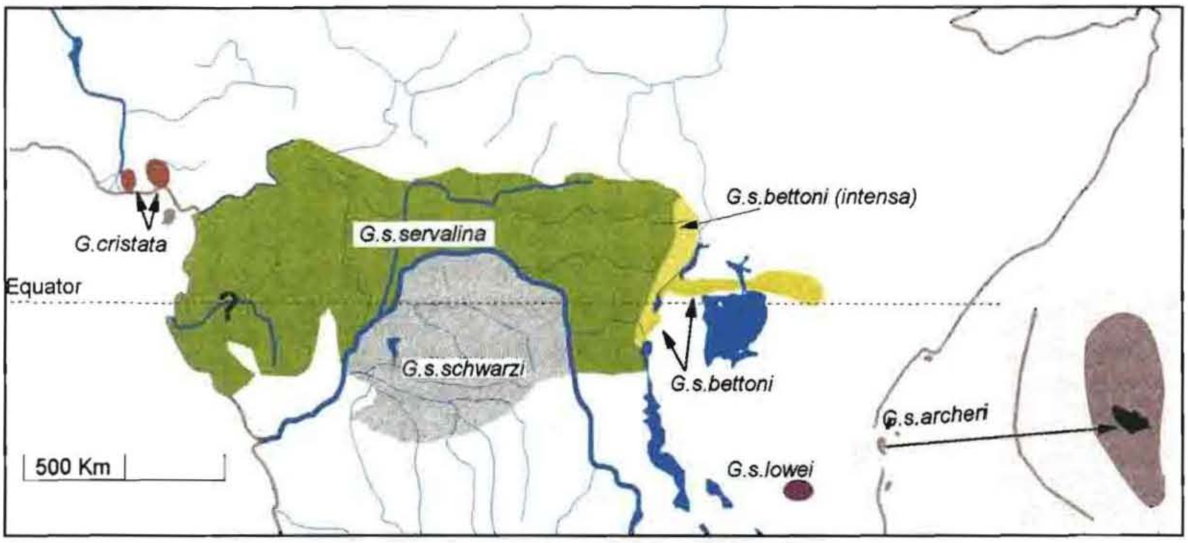

Figure 2 Distribution of *Genetta servalina* Pucheran, 1855 and *G. cristata* Hayman, 1940 in Africa. *G. servalina* comprises *G. s. servalina* (= *aubryana*, (?) exact type locality unknown), *G. s. schwarzi, G. s. bettoni, G. s. lowei* and *G. s. archeri*.

from Dabaga in Tanzania, at a distance of more than 350 km from the coast. However, in the absence of a formal description of this subspecies, provisionally named '*G. s. lowei*' by Kingdon, and owing to the unavailability of the specimen, we refer to the figure following page 138 in Kingdon (1977), which clearly shows that *G. s. lowei*, as *G. s. bettoni*, has a yellow base colour, including the throat and ventral parts, and in contrast to *G. s. archeri*, does not have spots on the lower parts of the legs.

Conservation

Access to the Jozani Forest has been facilitated in recent years by its division into a number of 600 × 200 m rectangular blocks, separated by paths 4 m wide. Although the forest is stated to be 'statutorily protected' as a 'forestry reserve', it is frequently disturbed by pig-hunters with firearms and dogs (Pakenham 1984). Considering the small size of Jozani Forest it is highly likely that the population of the Zanzibar genet will be small and endangered. Stricter protection of Jozani Forest, and listing of this subspecies on CITES Appendix I, seem necessary to prevent *G. s. archeri* becoming extinct shortly after its discovery.

Abbreviations

AMNH: American Museum of Natural History, New York, NY, USA.

BMNH: The Natural History Museum, London, UK.

Congo (B): People's Republic of Congo, capital Brazzaville.

Congo (K): Democratic Republic of Congo, capital Kinshasha.

IRSNB: Royal Institute of Natural Sciences, Brussels, Belgium.

MC: SBPUR1: Station Biologique de Paimpont, Université Rennes 1, France.

MCZ: Museum of Comparative Zoology, Cambridge, MA, USA.

MNHU: Museum für Naturkunde der Humboldt-Universität Berlin, Berlin, Germany.

PCM: The Powell-Cotton Museum, Birchington, UK.

RMCA: Royal Museum for Central Africa, Tervuren, Belgium.

ZSM: Zoologische Staatssammlung, München, Germany.

ROL: length of rostrum, from lateral base of hamular process of lacrimal to anterior-most edge of premaxillae; PAL: length of palate, from posterior edge of alveolus of I^1 to posterior edge of palatine; MAX: greatest crown length of maxillary tooth-row; CAN: breadth of canines, distance between labial crown edges of C^1-C^1; ROB: breadth of rostrum, distance between lateral base of hamular process of lacrimals; IOB: least interorbital breadth; PAB: breadth of palate, distance between labial crown edges of M^1-M^1 ; ZYG: greatest zygomatic breadth; BRH: height of braincase, distance from occipital bone between bullae to parietal, excluding parietal crest; MAL: mandible length, from anterior edge of I_1 alveolus to posterior surface of mandibular condyle; MAN: greatest crown length of mandibular tooth-row; CMH: mandible height, perpendicular distance from dorsal edge of coronoid process to line from angular process to ramus; P^4L: length of fourth upper premolar; P^4B: breadth of fourth upper premolar; P^4D: diagonal length of fourth upper molar; M^1L: length of first upper molar; M^1B: breadth of first upper molar; M_1L: length of first lower molar; M_1B: breadth of first lower molar.

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Short Communications

Relative brain size of some southern African myomorph rodents

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Relative brain sizes, based on actual measurement of the brains of nine species of myomorph rodents, two insectivores and a macroscelidid are reported. Relative brain sizes of the macroscelidid and *Tatera leucogaster* were far larger than those of the other rodents. With the exception of *T. leucogaster*, relative brain sizes were largest in semi-arboreal, omnivorous and nocturnal rodent species.

Numerous papers have been published on the relative brain size of mammals both globally (Eisenberg & Wilson 1978; Clutton-Brock & Harvey 1980; Mace, Harvey & Clutton-Brock 1981; Hofman 1983) and within southern Africa (Sheppey & Bernard 1984; Bernard, Paton & Sheppey 1988; Bernard & Nurton 1993). Relative brain size refers to the size of the brain after the effect of body size has been removed, and has been shown to be associated with behavioural and life-history attributes of small mammals (Eisenberg & Wilson 1978; Mace *et al.* 1981; Harvey & Krebs 1990). Bernard & Nurton (1993) demonstrated that the relative brain size of southern African rodents is correlated with both their modes of locomotion and diet. In their study, however, actual brain size was not measured and cranial volume was used as a substitute for brain size. Furthermore, for most of the species, body weights were taken from the literature and not from the measured specimens (Bernard & Nurton 1993).

The objective of the present study was to investigate the relative brain sizes of some southern African myomorph rodents based on actual brain measurements of individuals of known body weight, and thus to test the validity of the results of Bernard & Nurton (1993).

The specimens used in this study were obtained as part of a mammal survey of Swaziland (Monadjem 1997a). Live-trapped small mammals were killed in the field using chloroform, and standard museum measurements taken. The brains were then prepared following Bernard *et al.* (1988). Skin and excess flesh were removed from the skulls, which were fixed in 10% formalin for three days and then transferred to a formal nitric solution (1% formalin in 0.5% nitric acid). This solution was changed every second day for four weeks. The brains were then removed from the skulls and stored in 70% alcohol. For each specimen brain weight was measured to the nearest 0.001 g. The length of the brain, and length, breadth and height of the cerebral hemispheres (see Bernard *et al.* (1988) for definition of these terms) were measured using a stereo microscope with an eyepiece micrometer.

Relative brain size was calculated as the difference between the observed brain weight and the expected brain weight. The expected brain weight was generated by the regression of brain weight on body weight for the myomorph rodents only; brain and body weight were log-transformed for the regression. The calculated regression for brain weight (Y) on body weight (X) was:

$$Y = -0.773 + 0.326X$$

This regression was statistically significant ($F = 11.466$; $df = 1,7$; $p = 0.012$). Since two insectivores and a single macroscelidid were the only non-rodents examined, it was not possible to generate independent regressions for these two orders. Hence, the relative brain sizes of the insectivores and the macroscelidid were calculated using the myomorph rodent regression line solely for the sake of comparison of the brain sizes of the insectivores and the macroscelidid with those of myomorph rodents.

The body weights, brain measurements and relative brain sizes of twelve species of small mammals caught in Swaziland are shown in Table 1. Two species, *Tatera leucogaster* and *Elephantulus brachyrhynchus*, stand out with very large relative brain sizes, while *Aethomys chrysophilus*, *A. namaquensis* and *Dendromus mystacalis* have positive relative brain sizes. All other species have negative relative brain sizes (except the insectivore *Myosorex varius* which has a relative brain size close to zero). *Tatera leucogaster* has enlarged auditory bullae (de Graaff 1981), and its large relative brain size may thus be due to enlarged auditory lobes. The large relative brain size of *E. brachyrhynchus* may be a phylogenetic feature of the Macroscelidea. Interestingly the three rodent species (excluding *T. leucogaster*) with positive relative brain sizes are all at least semi-arboreal (de Graaff 1981; Skinner & Smithers 1990) supporting the observation that arboreal rodents have larger brain sizes than terrestrial ones (Mace *et al.* 1981; Bernard & Nurton 1993).

The relative brain sizes presented here compare well with those reported by Bernard & Nurton (1993) based on cranial volume. Three (*Mastomys natalensis*, *A. namaquensis* and *Rhabdomys pumilio*) species appear in both data sets, and have similar relative brain sizes. For example, *M. natalensis* had a relative brain size of –0.16 and –0.15 in Bernard & Nurton (1993) and in this study respectively. A further comparison could be made between the closely related *Otomys angoniensis*, with a relative brain size of –0.06 in this study, and *O. irroratus*, with a relative brain size of –0.05 (Bernard & Nurton 1993). Owing to the close match between these two studies, I combined the data from these two sources for the investigation of possible associations between relative brain size and ecological or behavioural features of these myomorph rodents. The fourteen species of myomorph rodents were assigned (using de Graaff 1981; Skinner & Smithers 1990; Monadjem 1997b) to the following three categories. (1) Locomotion: terrestrial or semi-arboreal. (2) Diet: folivorous, granivorous or omnivorous. (3) Activity: diurnal or nocturnal (Table 2).

Semi-arboreal species had significantly higher relative brain sizes than terrestrial species ($t = 2.77$; $df = 12$; $p = 0.05$). There was a near-significant difference between the relative brain sizes of species with different diets ($F = 3.458$; $df = 2,11$; $p = 0.07$), with folivores exhibiting the smallest and omnivores the largest relative brain sizes (Table 3). There were also significant differences in relative brain size

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Table 1 Mean body weight (± *SD*), mean brain weight (± *SD*), relative brain size, mean brain length, mean brain height (= height of cerebral hemispheres), mean brain width (= width of hemispheres) and mean length of hemispheres of 12 species of small mammals from Swaziland

Species (and Order)	*n*	Mean body weight (g)	Mean brain weight (g)	Relative brain size	Brain length (mm)	Brain height (mm)	Brain width (mm)	Hem. length (mm)
Rodentia (Myomorpha)								
Tatera leucogaster	5	51.4 ± 27.1	0.877 ± 0.061	+0.27	19.2	7.2	11.2	10.0
Aethomys chrysophilus	5	66.4 ± 9.2	0.822 ± 0.029	+0.16	19.1	6.7	10.4	10.4
Aethomys namaquensis	1	50.1	0.693	+0.09	16.8	5.6	10.6	8.4
Dendromus mystacalis	1	8.0	0.393	+0.06	14.7	5.5	7.4	6.6
Lemniscomys rosalia	5	59.0 ± 7.7	0.626 ± 0.043	–0.01	16.9	6.5	9.4	8.5
Mus minutoides	4	5.8 ± 0.5	0.265 ± 0.082	–0.03	10.0	2.9	3.5	6.1
Otomys angoniensis	1	76.0	0.633	–0.06	17.4	6.2	10.3	9.5
Mastomys natalensis	3	50.7 ± 7.6	0.457 ± 0.018	–0.15	15.5	7.2	11.4	10.2
Rhabdomys pumilio	5	47.6 ± 8.9	0.410 ± 0.022	–0.18	15.2	5.5	8.6	8.1
Insectivora								
Myosorex varius	1	12.0	0.405	+0.03	17.4	6.3	7.0	9.5
Crocidura cyanea	1	7.2	0.256	–0.07	10.7	3.0	–	6.5
Macroscelidea								
Elephantulus brachyrhynchus	1	48.0	0.833	+0.24	18.5	7.5	11.5	11.0

Table 2 Ecological and behavioural attributes, and relative brain sizes of fourteen southern African myomorph rodent species. (Locomotion: A = semi-arboreal, T = terrestrial. Diet: F = folivorous, G = granivorous, O = omnivorous. Activity: D = diurnal, N = nocturnal)

Species	Relative brain size	Locomotion	Diet	Activity
Tatera leucogaster	+0.27	T	O	N
*Graphiurus murinus**	+0.18	A	O	N
Aethomys chrysophilus	+0.16	A	G	N
Aethomys namaquensis	+0.09	A	G	N
Dendromus mystacalis	+0.06	A	O	N
*Rattus rattus**	+0.04	A	O	N
Lemniscomys rosalia	–0.01	T	F	D
*Parotomys brantsii**	–0.01	T	F	D
Mus minutoides	–0.03	T	O	N
*Otomys irroratus**	–0.05	T	F	D
Otomys angoniensis	–0.06	T	F	D
*Otomys unisulcatus**	–0.10	T	F	D
Mastomys natalensis	–0.15	T	G	N
Rhabdomys pumilio	–0.18	T	F	D

* from Bernard & Nurton (1993)

Table 3 Mean relative brain sizes of myomorph rodents in each of the ecological/behavioural categories

Ecological/ behavioural category	n	Mean relative brain size
Locomotion		
Semi-arboreal	9	0.106
Terrestrial	5	–0.036
Diet		
Omnivorous	6	0.104
Granivorous	3	0.033
Folivorous	5	–0.068
Activity		
Nocturnal	6	0.078
Diurnal	8	–0.068

between nocturnal and diurnal species ($t = 2.74$; $df = 12$; $p = 0.05$) with diurnal species having lower relative brain sizes.

There are three potential shortcomings associated with this study viz. (1) the small sample sizes, (2) the fact that the sexes were not examined separately, and (3) the use of the rodent regression line to calculate relative brain sizes of the insectivores and the macroscelidid. This study is of interest, however, because firstly it supports the findings of Bernard & Nurton (1993) and thus confirms that cranial volume does reflect actual brain size, and secondly it extends their data set. An analysis of the relative brain size of all southern African rodents may provide further insight, but should be attempted taking cognizance of phylogeny.

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Communication in marsh mongooses (*Atilax paludinosus*): anal gland secretion and scat discrimination in adults, and individual variation in vocalisations of juveniles

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Atilax paludinosus is a solitary, nocturnal mongoose that communicates with conspecifics through sound, scent and behavioural displays. Individual variation in vocalisations appears to be restricted to juvenile sounds. Differential responsiveness to scats and anal gland secretions provides preliminary evidence for individual discrimination amongst adults. In particular, there is a significant difference in responsiveness to scent products from mongooses of the opposite sex. The significance of individual variation in communication patterns of a solitary animal is discussed.

Atilax paludinosus is a solitary and nocturnal herpestid, generally living in close proximity to water. Studies on captive animals have shown that the mongooses tolerate conspecifics within the rearing group until sexual maturity, after which an extensive range of agonistic behaviour patterns dominates their relationships if the animals are maintained for extended periods in groups (Baker 1988a, 1988b, 1992).

Communication in mongooses involves the use of behavioural displays, sound and scent. In *Atilax*, close communication occurs through the medium of vocalisations and behavioural displays, while distance communication is facilitated through the deposition of anal and cheek gland secretions.

It has been shown that some home range overlap occurs in this nocturnal mongoose (Maddock 1988). Consequently distance communication would have the capacity to facilitate successful contacts between neighbouring conspecifics during the breeding season, particularly if the information content of the message included details regarding the sex and reproductive status of the individuals. At close quarters, brief encounters between mongooses would also be facilitated if the message content of the sounds were sex- or individual-specific.

While work on several herpestids (Rasa 1973; Gorman 1976; Hefetz, Ben-Yaacov & Yom-Tov 1984) has demonstrated that these animals are able to identify specific individuals through their anal gland secretions, no information is available for nocturnal, solitary mongooses. Characteristic of herpestines is the deposition of scats in middens, which are used by a number of different animals of the same species, and sometimes by different species.

Individual variation in vocalisations occurs in the sociable *Helogale* (Rasa 1986), while existing work on *Atilax* vocalisations shows that three broad categories of sounds are made (bray types made by adults only; and grizzle types and humphs made by both adults and juveniles; Baker 1988a). Details regarding individual variation are lacking.

This study examines the extent of individual variation in the vocal repertoire of juvenile *Atilax*, as well as the capacity of adult mongooses to discriminate between the scent products of conspecifics.

The data presented here were obtained from seven captive water mongooses (three males, four females) which were housed singly as adults or in pairs as juveniles in outdoor enclosures measuring 1.5 × 3 × 1.2 m or 3 × 3 × 3 m. Details regarding their maintenance are given in Baker (1987).

Sounds were recorded from three juvenile mongooses (one female and two males) between one week and four months of age. Sound recording details and methods of sonagraphic analysis are given in Baker (1988a). Of the three main types of vocalisations produced by *Atilax* (Baker 1988a), only type two (grizzles) and type three (humphs) are produced by juveniles. Comparisons of the following call parameters for these vocalisations were carried out: duration; range in frequency; number of pulses; number of formants (tonal bands); formant width (tonal band width); fundamental frequency; and number of harmonics. Definitions of each of these parameters follows Rossing (1982). An analysis of variance was used to examine whether or not individual variation in sounds occurred.

Scat discrimination tests were carried out once a week over 10 weeks using four different, separately caged, mongooses. Three mongooses were female (D, E and K aged 14 years) and one was a male (G aged 15 years). Mongooses were housed in four adjacent cages in the following sequence E, G, D and K. At the start of the trial a single fresh scat was collected from each animal and used for the duration of the study, or until it no longer attracted the attention of the subject. Test scats were allowed to weather naturally. Each test involved presenting a mongoose with a scat of a non-neighbour conspecific and also its own scat (control) for a period of

10 min. Frequency of response (sniffing, anal marking, cheek rubbing) as well as duration of response was recorded.

Response to anal gland secretions was tested using the three adult female mongooses only (detailed above). Fresh scent marks from anal drags that had been deposited on clean polyvinyl carbonate (PVC) tubes were presented to conspecifics for 10 min, and frequency, duration and type of response were recorded. Responses to neighbouring versus non-neighbouring conspecific secretions were compared, and analysed with the aid of the Mann-Whitney non-parametric test.

Vocalisations were situation specific and characterised by particular features in their structure (Baker 1988a). The type two (grizzle) vocalisations were separated into two categories based on their maximum frequency. The lower frequency zitts ($n = 28$) were produced when young animals were calling for parental attention if disoriented on leaving the nest. It was only the harmonic number which showed individual variation (Table 1).

Higher frequency grizzles ($n = 25$) were produced as a result of frustration of goal-directed behaviour, as a location call to attract the attention of the mother, and also during play fighting with siblings. Individual variation in duration, range in frequency, number of formants and fundamental frequency was recorded (Table 1).

The type three vocalisation (Baker 1988a), the humph ($n = 26$), was produced by young animals when calling for attention and also in anticipation of food. Significant differences in duration, range in frequency, number of formants and fundamental frequency were recorded (Table 1).

Mongooses responded to scats for up to 39 days ($\bar{x} = 12.8$ (± 10.4) days. In three of the mongooses, significantly longer attention (in days) was paid to scats from opposite-sex conspecifics ($p < 0.05$; Figure 1). However, no significant difference in the average time (in seconds) spent sniffing scats from the opposite- or same-sex mongooses was established. Mean sniff duration of scats from same-sex individuals was 1.6 s while that of opposite-sex individuals was 1.9 s. Low levels of interest were shown in control scats (own scats). In only 43.8% of trials did the mongooses pay attention to their own scats.

Table 1 Parameters of each call. For each parameter the mean, standard error and level of significance is given. (*Type two and type three calls are described in Baker 1988a)

	Vocalization type two*		Vocalization type three*
Parameter	Zitt	Grizzle	Humph
Duration (s)	1.13 ± 0.14 ns	1.28 ± 0.07 $p < 0.05$	0.28 ± 0.01 $p < 0.05$
Range in frequency (kHz)	3.02 ± 0.16 ns	4.37 ± 0.24 $p < 0.05$	4.1 ± 0.29 $p < 0.05$
Number of pulses	2.6 ± 0.73 ns	–	–
Number of formants	1.57 ± 0.21 ns	1.8 ± 0.1 $p < 0.05$	0.5 ± 0.12 $p < 0.05$
Formant width (kHz)	0.35 ± 0.06 ns	0.67 ± 0.08 ns	–
Fundamental frequency (kHz)	–	0.67 ± 0.13 $p < 0.05$	0.39 ± 0.04 $p < 0.05$
Number of harmonics	1 ± 0.46 $p < 0.05$	–	3.15 ± 0.64 ns

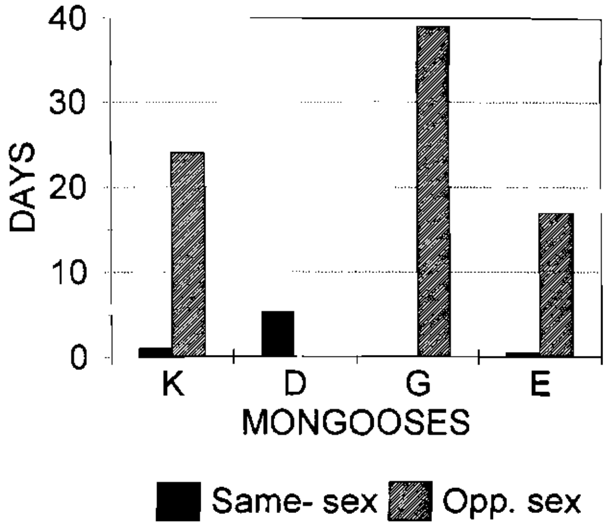

Figure 1 Length of time (in days) that mongooses showed an interest in scats of same-sex and opposite sex conspecifics (K, D and E are females; G is a male).

Table 2 shows individual variation in response to anal gland secretions for all mongooses. Mongooses responded to the secretions by sniffing them and anal marking the object with the test secretion. Duration of response was indicated by the duration of sniffs while intensity of response was measured by the number of sniffs. Significant differences in the number of sniffs, duration of sniffing response and also anal mark number were recorded. When comparing the response of mongooses to their neighbour's anal secretions versus their non-neighbour's secretions, results show a significant difference in anal mark number ($p < 0.01$) and also in sniff number ($p < 0.01$), with non-neighbour mongooses showing a far greater interest in conspecific secretions than the neighbouring mongooses. Sniff durations were not significantly different between the two groups, however.

In marsh mongooses most social interactions occur during the rearing of young, and it is therefore at this time that the greatest emphasis on individual recognition would be placed. Sounds produced in these circumstances, where tolerance between two or more individuals is required, are somewhat complex in their structure as predicted by Kiley-Worthington (1984), and show marked individual variation in a range of parameters. By way of contrast, sounds produced in agonistic circumstances, such as the growl and bray (Baker 1988a) are more simple in structure, and preliminary results from analysis show that these adult sounds show no individual variation. This accords with the view of Kiley-Worthington (1984), who indicates that individual variation in communication patterns develops to reduce frustration in conflict, and thus serves to promote group cohesion in sociable groups especially.

Suggestions that social species of carnivores have richer and more complex vocal repertoires than their solitary counterparts (Peters & Wozencraft 1989) seem to hold true for the herpestids. Sounds produced by solitary *Atilax* show less vari-

Table 2 Individual variation in response to anal gland secretions among adult female mongooses. Level of significance for each behavioural response is included

	Non-neighbour mongooses				Neighbouring mongooses		
	E response to D	E response to K	D response to E	K response to E	D response to K	K response to D	ANOVA
Mean sniff duration (s)	5.6 ± 0.62	6.7 ± 0.93	6.1 ± 0.6	5.8 ±0.81	3.9 ±0.56	9 ± 1.96	$p < 0.05$
Mean number of sniffs	8.2 ± 0.03	5.4 ± 0.56	5.4 ± 0.63	4.6 ± 0.02	3.2 ± 0.58	1.8 ± 0.37	$p < 0.05$
Mean number of anal marks	5 ± 1.73	2 ± 0.44	3.4 ± 0.74	0.4 ± 0.24	0	0	$p < 0.05$

ety and complexity than those produced by sociable *Helogale*, as would be expected in a non-social, forest-dwelling mammal (Kiley 1972). Because *Atilax* specialises on crab prey, they are quite likely to meet conspecifics at feeding grounds, and this may obviate the need for a complex vocal repertoire aimed at promoting encounters in a forest habitat. It is particularly the juvenile vocal repertoire of *Atilax* that shows individual variation, indicating that only at that stage is there strong emphasis on distinguishing amongst individuals. Communication between adults appears to rely quite heavily on their ability to produce scent.

Middens are habitually used by solitary marsh mongooses, and as it has been demonstrated that scats retain a viable odour for lengthy periods, and also give information regarding sexual status, it is believed that faecal deposits serve as important reservoirs of information in this species. For a solitary animal, the ability to identify the sex and condition of conspecifics at a distance is particularly adaptive. While results presented here show that three of the four mongooses paid longer attention to scats from the opposite sex, the sample size is too small to be conclusive in this regard.

Atilax deposits anal gland secretions regularly in its territory (Baker 1987). The capacity to determine the identity and sexual status of the owner of such marks would aid mongooses in their appraisal of neighbouring conspecifics. The differential response to anal scent gland products demonstrated in this study provides preliminary evidence that marsh mongooses are able to discriminate amongst secretions from different conspecifics. This is further supported by the differential responsiveness of mongooses to secretions from neighbouring and non-neighbouring conspecifics. Further work to ascertain the mongooses' response to conspecifics at different times of the breeding season is necessary, however. In addition, anal gland scent discrimination in both male and female mongooses should be ascertained.

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