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A morphological assessment of *Myosorex zinki*, an endemic shrew on Mount Kilimanjaro

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ABSTRACT. The specific status of *Myosorex zinki* is analyzed based on recently collected material from Mt. Kilimanjaro. *M. zinki* historically has been viewed as a subspecies of *M. blarina*, but is distinct from *M. blarina* in several cranial dimensions. The recently collected series exhibits no sexual dimorphism. Contrary to what past records have indicated, *M. zinki* is not restricted in occurrence on the mountain and is found in many habitats on Mt. Kilimanjaro including forest, heathland, and moorland near the edge of the alpine desert. This species remains the only endemic mammalian species to Mt. Kilimanjaro.

KEY WORDS : Insectivora, Soricidae, *Myosorex zinki*, Kilimanjaro, biodiversity, systematics, Africa.

INTRODUCTION

Myosorex zinki was described as a subspecies of *Myosorex blarina* by HEIM DE BALSAC & LAMOTTE (1956) based on a skin with incomplete skull collected at 3700 m on Mt. Kilimanjaro. HEIM DE BALSAC (1967) later suggested that *M. zinki* deserved specific rank, but others retained it as a subspecies of *M. blarina* (HEIM DE BALSAC & MEESTER, 1977; HONACKI et al., 1982; SHORE & GARBETT, 1991). The need for additional specimens was often cited as required to resolve the taxonomic status of the form of *Myosorex* on Mt. Kilimanjaro. In 2002, an elevational survey of the small mammals of Mt. Kilimanjaro produced several specimens on this unique shrew, which allow us to conduct a morphological assessment of this taxon compared to *M. blarina* specimens from the Rwenzori Mountains.

MATERIAL AND METHODS

Specimens of *Myosorex* were collected during a survey of the small mammals of the south-eastern slope of Mt. Kilimanjaro conducted July and August, 2002. Five sites were surveyed at 2043, 2470, 2897, 3477 and 4000 m respectively. Both pitfall lines (for insectivores, primarily) and standard breakback traps (for rodents) were used for the collection of voucher specimens. Details on the methodology (which was identical to other small mammal surveys of montane areas of Tanzania) can be found in STANLEY et al. (1996, 1998). The *Myosorex blarina* examined in this study were all collected in the Rwenzori Mountains and are housed at the Field Museum of Natural History (Chicago, USA). The holotype of *M. blarina zinki* (SMNS 4505) was examined in the Stuttgart Natural History Museum (Germany).

Standard measurements were taken of the specimen in the field including total length, head and body length, tail length, hindfoot length, ear length and weight. All measurements were in mm except weight, which was in grams. Measurements of the cranium and mandible were made with digital calipers to the nearest 0.1 mm. These included condylo-incisive length (CI), basal length (BL), post-palatal length (PPL), length of entire upper tooth row (UTRL), length of complex teeth in upper tooth row (P4-M3), width of third upper incisor (I3W), width of canine (CW), length of third upper molar (M3L), width of third upper molar (M3W), length from first upper incisor to, and including, the upper canine (I-C), least interorbital width (LIW), bimaxillary width (BW), nasal width (NW), greatest width of the braincase (GW), height of the braincase (HBC) (measured by placing skull on microscope slide, measuring from the ventral surface of the slide to the highest point of the cranium and then subtracting the thickness of the slide from that measurement), length of mandible including the incisor (M+I), length of mandibular tooth row including first incisor (LTR), and length of the lower molars 1-3 (m1-3).

Standard descriptive statistics (mean, range, standard deviation and coefficient of variation) were derived for each taxon. We used a one-way analysis of variance to test for significant variation between sexes within *M. zinki* and between *M. zinki* and *M. blarina*. Principal components were extracted from a variance-covariance matrix using the cranial variables converted to natural logarithms. All statistical analyses were done with Excel and SPSS.

RESULTS

Summaries of external and cranial measurements for male and female *M. zinki* are presented in Table 1 and 2, respectively. There were no significant differences between sexes in either external or cranial measurements (Tables 1 and 2). All measurements were subsequently

TABLE 1

External measurements of *Myosorex zinki*. Differences between sexes were not significant (P > 0.05, see text).

External measurement	N	Total length (mm)	Head & body (mm)	Tail length (mm)	Hindfoot (mm)	Ear (mm)	Weight (g)
Male	6	129.7 ± 6.3	93.7 ± 5.4	35.8 ± 1.6	16.3 ± 1.2	7.5 ± 0.8	16.5 ± 2.3
		118-137	84-100	33-37	15-18	6-8	14.5-19.5
Female	6	130.3 ± 4.7	93.0 ± 2.4	36.2 ± 2.5	15.8 ± 0.4	7.2 ± 1.0	15.7 ± 1.2
		125-137	89-95	33-40	15-16	6-9	14-17

TABLE 2

Cranial measurements (mm) of male and female *Myosorex zinki* (mean value ± standard deviation, range) with results of a one-way ANOVA to test for sexual dimorphism.

Measurement	Males (n = 5*)	Females (n = 6)	F value	p
CI	22.9 ± 0.64 (22.1-23.7)	22.8 ± 0.61 (22.0-23.6)	0.20	0.66
BL	20.3 ± 0.63 (19.5-21.0)	20.1 ± 0.59 (19.2-20.8)	0.22	0.65
PPL	10.5 ± 0.36 (10.0-10.9)	10.4 ± 0.35 (9.7-10.7)	0.17	0.69
UTR	9.5 ± 0.20 (9.2-9.7)	9.4 ± 0.22 (9.1-9.7)	0.43	0.53
P4-M3	5.4 ± 0.18 (5.1-5.6)	5.3 ± 0.14 (5.1-5.4)	0.16	0.70
I3W	0.6 ± 0.03 (0.5-0.6)	0.5 ± 0.03 (0.5-0.6)	5.05	0.05
CW	0.7 ± 0.05 (0.6-0.7)	0.6 ± 0.02 (0.6-0.6)	2.58	0.14
M3L	1.5 ± 0.05 (1.4-1.5)	1.5 ± 0.07 (1.4-1.6)	0.05	0.83
M3W	0.9 ± 0.03 (0.8-0.9)	0.8 ± 0.05 (0.8-0.9)	0.77	0.40
I-C	4.3 ± 0.12 (4.1-4.4)	4.2 ± 0.14 (4.1-4.4)	1.48	0.25
LIW	4.9 ± 0.17 (4.6-5.0)	4.7 ± 0.10 (4.6-4.9)	2.04	0.19
BW	6.5 ± 0.17 (6.3-6.8)	6.5 ± 0.10 (6.3-6.6)	1.02	0.34
NW	2.3 ± 0.07 (2.2-2.4)	2.2 ± 0.05 (2.2-2.3)	2.93	0.12
GW	11.6 ± 0.18 (11.3-11.8)	11.5 ± 0.33 (11.1-12.0)	0.50	0.50
HBC	7.1 ± 0.11 (6.9-7.2)	7.0 ± 0.23 (6.7-7.4)	0.08	0.79
MI	14.1 ± 0.31 (13.8-14.5)	14.0 ± 0.44 (13.4-14.6)	0.33	0.58
LT	8.6 ± 0.19 (8.4-8.9)	8.5 ± 0.22 (8.3-8.8)	0.51	0.49
m1-3	4.26 ± 0.08 (4.2-4.4)	4.2 ± 0.11 (4.0-4.3)	0.34	0.57

* Sample size for HBC was 4 for males.

TABLE 3

Cranial measurements (mm) of *Myosorex blarina* and *Myosorex zinki* (mean value ± standard deviation, range) with results of a one-way ANOVA to test for significant differences between species. Measurements in bold represent those that exhibit significant differences.

Measurement	*M. blarina* (n = 4)	*M. zinki* (n = 11*)	F value	p
CI	22.0 ± 0.35 (21.5-22.3)	22.8 ± 0.59 (22.0-23.7)	6.44	0.02
BL	19.6 ± 0.36 (19.1-19.9)	20.2 ± 0.58 (19.2-21.0)	3.57	0.08
PPL	9.6 ± 0.18 (9.4-9.8)	10.4 ± 0.33 (9.7-10.9)	20.49	0.001
UTR	9.6 ± 0.24 (9.3-9.9)	9.4 ± 0.19 (9.1-9.7)	3.09	0.10
P4-M3	5.7 ± 0.19 (5.4-5.9)	5.3 ± 0.14 (5.1-5.6)	14.00	0.002
I3W	0.7 ± 0.06 (0.6-0.8)	0.6 ± 0.03 (0.5-0.6)	50.5	0.000
CW	0.9 ± 0.04 (0.9-0.9)	0.6 ± 0.04 (0.6-0.7)	165.7	0.000
M3L	1.8 ± 0.07 (1.7-1.9)	1.5 ± 0.06 (1.4-1.6)	88.9	0.000
M3W	1.1 ± 0.02 (1.0-1.1)	0.8 ± 0.04 (0.8-0.9)	118.0	0.000
I-C	4.2 ± 0.08 (4.1-4.3)	4.2 ± 0.13 (4.1-4.4)	0.001	0.97
LIW	5.4 ± 0.08 (5.2-5.4)	4.8 ± 0.14 (4.6-5.0)	53.6	0.000
BW	7.2 ± 0.13 (7.1-7.4)	6.5 ± 0.13 (6.3-6.8)	76.3	0.000
NW	2.5 ± 0.07 (2.4-2.6)	2.3 ± 0.06 (2.2-2.4)	32.0	0.000
GW	11.7 ± 0.19 (11.5-12.0)	11.5 ± 0.27 (11.1-12.0)	3.35	0.08
HBC*	7.0 ± 0.18 (6.8-7.2)	7.0 ± 0.18 (6.7-7.4)	0.07	0.79
MI	14.1 ± 0.21 (13.8-14.4)	14.1 ± 0.36 (13.4-14.6)	0.07	0.79
LT	8.8 ± 0.14 (8.6-8.9)	8.6 ± 0.19 (8.3-8.9)	4.85	0.04
m1-3	4.6 ± 0.12 (4.4-4.7)	4.2 ± 0.09 (4.0-4.4)	37.3	0.000

* Sample size for HBC for *M. zinki* was 10.

combined for a comparison of crania from *M. zinki* to samples of *M. blarina*. Coefficients of variation for cranial characters were all less than 9%. Summaries of cranial measurements for the two taxa are presented in Table 3. Out of the 18 measurements taken, 12 were significantly different (P < 0.05) between groups (one-way ANOVA;

Table 3). The initial principal components analysis indicated that four variables : I-C, GW, HBC, and MI did not contribute meaningfully to the extraction of components in multivariate space (communalities < 0.7), so these were not included in the principal components analysis. The first two components derived explained 87.5 and 5.9% of the variation, respectively. The dimensions that had the highest loadings (greater than 0.90) on the first principal component were those of breadth (LIW and BW) and width and length of teeth (I3W, CW, M3W, M3L). The second component was most heavily influenced by length variables (CI and BL), but these loadings were less than 0.90 and specimens are not clearly separated along the second component. A plot of individual specimen scores is presented in Fig. 1. The differences between the two taxa in both breadth of the skull and the dimensions of the third upper molar are exhibited in Figs 2 and 3.

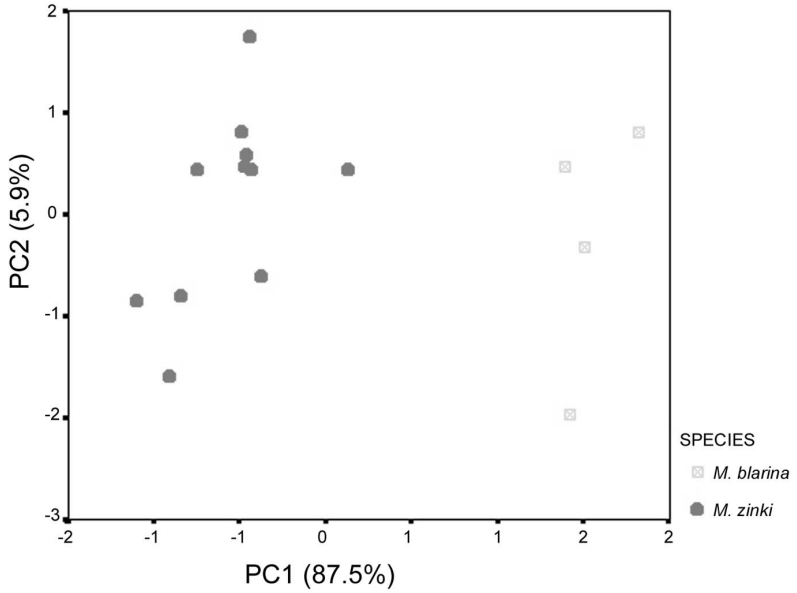

Fig. 1. – Projection of individual specimen scores on the first two principal components.

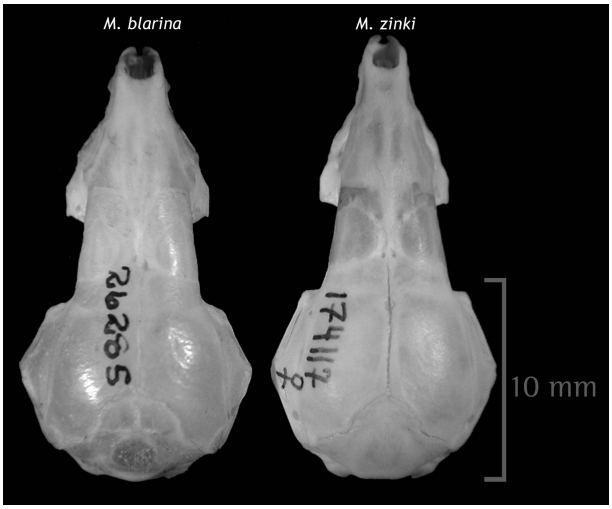

Fig. 2. – Crania of *M. zinki* and *M. blarina.*

DISCUSSION

Several authors have pointed out the distinctiveness of *M. zinki* (Heim de Balsac & Lamotte, 1956; Grimshaw et al., 1995), but the small number of specimens available until now caused some to retain the taxon as a subspecies of *M. blarina* (Heim de Balsac & Meester, 1977; Honacki et al., 1982). With the specimens now available, the recognition of *Myosorex zinki* as a species is now warranted, supporting statements by Heim de Balsac & Lamotte (1956), Heim de Balsac (1970), Hutterer (in Grimshaw et al., 1995) and others (Stanley & Hutterer, 2000).

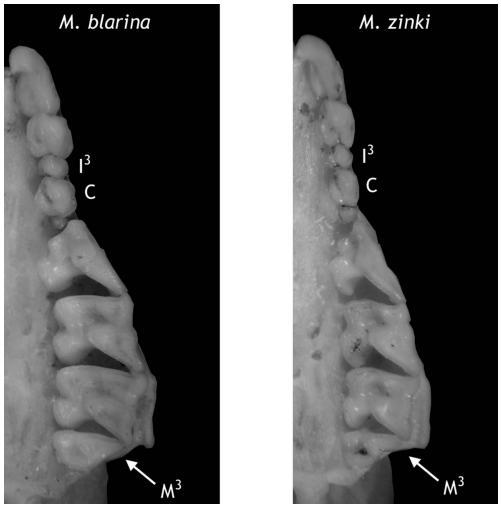

Fig. 3. – Upper tooth row of *M. zinki* and *M. blarina.*

Because of the small number of specimens previously collected and the localities of those collections, *M. zinki*

was thought to be rare and restricted in distribution on Mt. Kilimanjaro (Heim de Balsac, 1967; Grimshaw et al., 1995). A recent survey of the small mammals along the south-eastern slope of Mt. Kilimanjaro (W.T. Stanley, unpubl. data) documented the presence of this shrew in many different habitats on the mountain including forest, heathland, moorland, and the edge of the alpine desert. While it was not as abundant as other shrews at each site surveyed, *M. zinki* was the most widely distributed insectivore along the elevational gradient, ranging from 2470 to 4000 m (Fig. 4). While *M. zinki* was not documented at the lowest site (2043 m), it is too early to say it does not occur in the lower forests of Kilimanjaro.

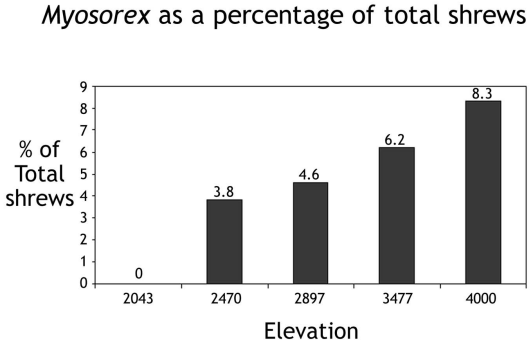

Fig. 4. – Graph of distribution of *Myosorex* along an elevational gradient on the south-eastern slope of Mt. Kilimanjaro. The numbers above each bar represent the percentage of total shrews captured at each elevation.

Myosorex zinki remains the only endemic mammal on Mt. Kilimanjaro so far, but detailed systematic study of the small mammals in eastern Africa may reveal other taxa endemic to this mountain. Burgess et al. (2000) hold that *Crocidura monax* is restricted to Mt. Kilimanjaro while other authors (Stanley et al., 2000) list this species from various Eastern Arc mountains. The problem requires careful examination. Further studies are also needed to both expand our knowledge of the ecology and distribution of *M. zinki* on Kilimanjaro and determine if it or closely related forms occur on nearby mountains, such as Mt. Meru.

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