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A new species of *Myosorex* Gray, 1832 (Mammalia: Soricidae) from the Eastern Arc mountains, Tanzania

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Abstract. A new species of *Myosorex* is described from the Udzungwa Mountains in eastern Tanzania. It is a small species of the genus, and particularly smaller than the two extant species known to occur in Tanzania, *Myosorex geata* and *M. zinki*. Like these, the new species is restricted to relictual mountain forest in Tanzania.

Key words. Shrews, Soricidae, *Myosorex*, taxonomy, Eastern Arc Mountains, Tanzania.

Introduction

The Eastern Arc mountains contain some of the biota richest in endemics of montane habitats in Africa (Rodgers & Homewood 1982a; Lovett & Wasser 1993), but very little is known about various faunal groups. This is particularly distressing because of the rapid habitat conversion occurring in many Eastern Arc forests. A team from the University of Dar es Salaam and the Field Museum has conducted surveys to document the small mammal fauna of different Eastern Arc forests (Goodman et al. 1995; Stanley et al. 1996, 1998) and augment our knowledge of the unique mammals found in this montane archipelago (Jenkins 1984; Hutterer 1986; Hutterer, Jenkins & Verheyen 1991).

A new species of *Myosorex* from the Udzungwa Mts was already announced by Hutterer, Jenkins & Verheyen (1991) but left undescribed because only two imperfectly preserved specimens were available then. Based on recent surveys in the Udzungwa and Uluguru Mountains, we now have sufficient material of the new species and the little-known *Myosorex geata* (Allen & Loveridge, 1927) at hand. This note serves to formally describe the new species and to present new information for populations of *Myosorex* from the two Eastern Arc mountain ranges.

Material and methods

As part of an overall investigation of the small mammal fauna of the Eastern Arc mountains, we surveyed one forest reserve in each of the Uluguru and Udzungwa mountain ranges. In the Udzungwa Mountains we collected shrews and rodents along an elevational gradient in the Udzungwa Scarp Forest Reserve. *Myosorex* was found at both 1460 and 2000 m, but not at the two lower sites (910 and 600 m). In the Uluguru Mountains, *Myosorex* was found at two sites in the Uluguru North Forest Reserve, one at 1345 m and another at 1535 m.

A total of 25 specimens were examined including 22 that were collected during the recent expedition conducted by Stanley, two collected by members of the Tanzanian-Belgian Rodent Project in 1986 and 1988, and one collected during a Danish expedition in 1984. The specimens were preserved both as conventional skins, skulls and post-cranial skeletons and in fluid with skulls removed. Specimens are deposited in the Field Museum (FMNH), the

University of Dar es Salaam, the Zoologisk Museum, Kopenhagen (ZMUC) and the Rijksuniversitair Centrum, Antwerpen (RUCA). Other critical specimens examined are deposited in the Natural History Museum, London (BM), the Museum National d'Histoire Naturelle, Paris (MNHN), the Staatliches Museum für Naturkunde, Stuttgart (SMNS), and the Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn (ZFMK).

Dimensions of the skins were recorded in the field and include total length (TL), length of head and body (HB), tail length (TV), length of hind foot (including the claw) (HF), length of ear from notch to tip (EAR), and weight in grams (DeBlase & Martin 1974). All linear measurements were recorded to the nearest whole mm, and weight was recorded to the nearest 0.1 gram.

Cranial and dental measurements were recorded to the nearest 0.01 mm using hand held calipers. These measurements, and their abbreviations include condylo-incisive length (CI), basal length (BL), post-palatal length (PPL), upper toothrow length (UTRL), least interorbital width (LIW), bimaxillary width (BW), nasal width (NW), greatest width of the braincase (GW), height of the braincase (PMH), length of mandible including the incisor (M+1), length of lower toothrow (LTR), length of third upper incisor (I3L), length of canine (CL), width of third upper incisor (I3W), width of canine (CW), length of third upper molar (M3L), width of third upper molar (M3W). These dimensions are defined and illustrated in Dippenaar (1977). Two additional measurements are length of upper cheekteeth (P4–M3), and length of lower molar row (m1–3). Only specimens judged to be adult based on the complete fusion of the suture between the basioccipital and the basisphenoid bones were measured. Standard descriptive statistics were derived for each population. Statistical analyses were carried out using Statistica (StatSoft 1984–1994) and SAS (SAS Institute 1982).

Results

Summaries of external and cranial measurements are presented in Tables 1 and 2, respectively. An analysis of variance was conducted to examine differences between sexes and no significant sexual dimorphism was found (Table 3). Subsequently, specimens of both sexes were combined to test for significant differences between the two populations (t test; Table 4). Differences between the Uluguru and Udzungwa populations were highly significant. The Uluguru specimens are identified with *Myosorex geata* (Allen & Loveridge, 1927), the specimens from the Udzungwa Mountains represent a species new to science.

Family Soricidae G. Fischer, 1817
Subfamily Soricinae G. Fischer, 1817
Tribe Myosoricini Kretzoi, 1965

Myosorex kihaulei, new species (Figs. 1, 2)

Holotype. – Fully adult male; skin, skull and postcranial skeleton, FMNH 155619; collected 8 September 1995 by Philip M. Kinaule and W. T. Stanley (WTS 2227).

Paratypes. – FMNH 155457-155460, 155611-155618 and 155620-155622; all were collected in the Udzungwa Scarp Forest Reserve at either 1460 m or 2000 m in August and September, 1995. ZMUC M 2134, body in spirit, skull removed; found dead on road on a tea estate at 1850 m in Mufindi, Luisenga Dam, Udzungwa Mountains, by F. P. Jensen on 12 December 1984. RUCA 10984, animal in spirit, skull removed, collected in Mufindi, Udzungwa Mountains, by members of the Tanzanian-Belgian Rodent Project on 21 December 1988.

Type locality. – The type specimen was collected in the Udzungwa Scarp Forest Reserve in central Tanzania, 19.5 km N, 0.5 km W Chita, 8°20'50" S, 35°56'20" E, 2000 m. The locality is shown in Morogoro Region, Kilombero District on Map series Y742, sheet 233/4, edition 1–TSD (Government of Tanzania 1972), but is currently considered to be in Iringa Region according to Iringa District administrative officials in the area. Some of the paratypes were collected at 2000 m and at a lower site at 1460 m (8°28'30" S, 35°54'25" E) within the forest reserve.

Etymology. – The specific epithet was chosen in honor of Mr. Philip M. Kihaule who is responsible for the success of many of the surveys documenting the natural history of the small mammals of the Eastern Arc mountains, and other important areas of Tanzania. He also collected the type specimen.

Diagnosis and description. - A dark and small-sized *Myosorex* similar to *Myosorex geata* but with smaller features of the skull, such as condylo-incisive length and length of upper tooth row. Fourth upper unicuspids minute and shifted in lingual direction (Fig. 2). Tail on average 47% of head and body length. Although limited to a small number of specimens, inspection of the tubercles of the hindfoot revealed that *Myosorex kihaulei* has larger and more rounded tubercles than *M. geata*.

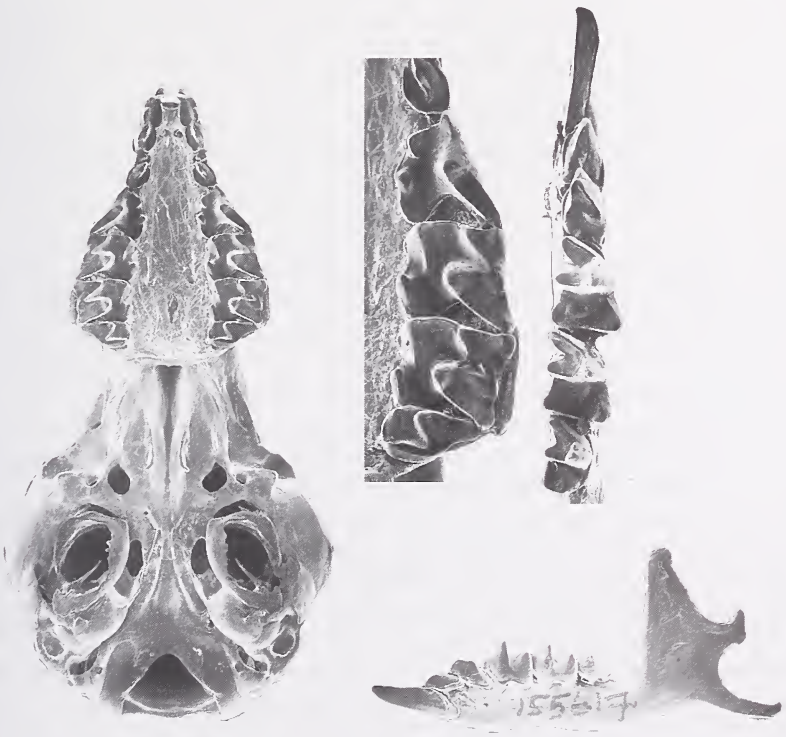
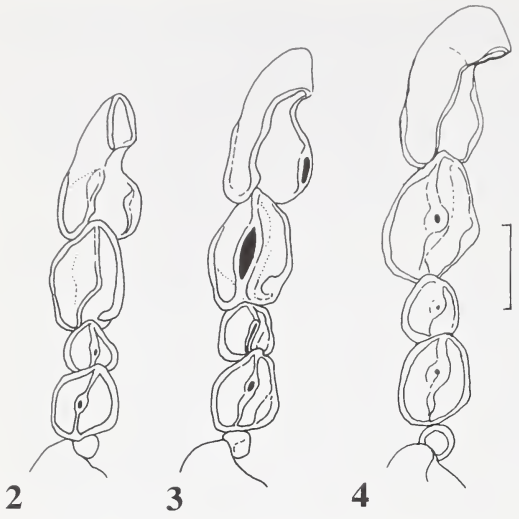


Fig. 1: *Myosorex kihaulei* n. sp., paratype FMNH 155617; cranium in ventral view and left ramus of mandible in labial view, details of the dentition enlarged. SEM-photographs of uncoated skull.



Figs. 2–4: Front dentition of right upper toothrow in occlusal view. 2, *Myosorex kihaulei* n. sp. (RUCA 10984), 3, *M. geata* (RUCA 2305), 4, *M. zinki* (holotype SMNS 4505, reversed). Scale is 1 mm. Note the position of the fourth unicuspid tooth.

External: *Myosorex kihaulei* is a dark animal. Its overall aspect is blackish-brown; the dark body hairs have brownish tips. There is little contrast between dorsal and ventral color. Hindfeet, forefeet and tail similarly dark colored. Fore- and hindfeet bear small claws. The tail is short.

Skull: Small and stout, particularly the snout region (Fig. 1); condylo-incisive length 19.67–20.85 mm, upper toothrow length 7.99–8.99 mm, bimaxillary width 6.25–6.50 mm, greatest width 9.67–10.75 mm, P4–M3 5.17–5.40 mm, m1–m3 4.06–4.34 mm; further values in table 2. Palate with two anterior and one mid-central posterior palatal fissures. Dentition as in *Myosorex* but extra cusplets on upper unicuspids weakly developed; a small cusplet on U1 and almost no trace on U2–4. The fourth upper unicuspid is very small and slightly shifted lingually; posterior boder of third upper unicuspid and the anterior tip of the fourth premolar close or even overlapping (Figs. 1, 2). The lower i2 has two cusps. The condyle of the mandible is wider than high.

External and cranial measurements: Tables 1–4.

Comparisons and remarks. – From Tanzania, only two extant and one extinct species of *Myosorex* are known. The first is *Myosorex geata,* described by Allen & Loveridge (1927) under the name *Crocidura maurisca geata* and based on two specimens collected in October 1926 at Nyingwa and Vituri, both in the Uluguru Mountains. They compared their specimens with *C. maurisca* and concluded: "From the typical *C. maurisca* of Entebbe, Uganda, this mountain race seems to differ in its darker color and shorter tail". Heim de Balsac (1967) was the first to recognize that this taxon instead belongs to the genus *Myosorex*, and since then it was regarded as species *Myosorex geata*. Our observations and data of the crania support this view (Tab. 2). *M. geata* was known from the type and paratype only; our new specimens considerably broaden the basis for comparison. Like *M. kihaulei*, *M. geata* is a dark shrew. Externally, both are very similar (Tab. 1). Cranially they differ significantly in size (Tabs 2 and 4) and in details of the upper dentition (Fig. 3). First incisor and

Table 1: External measurements for samples of two populations of *Myosorex*, given as mean, min-max, and (standard deviation). Measurements for the holotype and paratype of *Myosorex geata* as described by Allen and Loveridge are also given.

External measurement	N	Total length	Head & body	Tail length	Hindfoot	Ear	Weight
Udzungwa							
male	8	115.1 111–121 (3.4)	76.7 70–81 (3.5)	40.2 36–44 (2.4)	13.2 12–14 (0.7)	8.2 7–9 (0.7)	10.5 8.6–12 (1.2)
female	2	117.5 109–126 (12.0)	76 72–80 (5.6)	41.3 40–43 (1.5)	12.5 12–13 (0.7)	9 9–9 (0)	8.5 8–9 (0.7)
Uluguru							
male	3	113.3 108–118 (5.0)	72.3 68–75 (3.8)	40.7 40–41 (0.6)	13.7 13–14 (0.6)	7 6–8 (1)	10.1 9.8–10.5 (0.5)
female	3	113 109–117 (4)	72 70–74 (2)	41.3 40–43 (1.5)	12.7 12–14 (1.1)	7.3 5–9 (2.1)	8.6 7.6–10 (1.2)
Type material							
M. GEATA Holotype (male)	1	–	75	40	10	8	–
M. GEATA Paratype (female)	1	–	65	45	10	5	–

unicuspids are heavier, additional cusplets are present on all three upper unicuspids, and the fourth upper unicuspid is in line with the other three; there is no contact or overlap between the posterior edge of the third unicuspid and the anterior tip of the fourth premolar.

Myosorex zinki Heim de Balsac & Lamotte, 1956, the only other extant species of *Myosorex* known from Tanzania (Grimshaw, Cordeiro & Foley 1995), is a much larger animal (Table 5). Heim de Balsac (1957) and Heim de Balsac & Lamotte (1956) compared it to the large *M. blarina* Thomas, 1906 from the Rwenzori Mountains. Meester & Dippenaar (1978) treated *zinki* as a subspecies of *blarina,* while Hutterer regarded it as a separate species (Grimshaw, Cordeiro & Foley, 1995). The skull of the holotype (SMNS 4505) is broken, but the condylo-incisive length has been estimated as 23.20 mm (versus 21.02 in *M. kihaulei*), upper toothrow length is 9.62 mm (versus 8.59), and the length of m1–3 is 4.53 (versus 4.22). The anterior upper dentition is much longer (Fig. 4).

Myosorex robinsoni Meester, 1955, an extinct taxon described from Pleistocene beds of Swartkrans, South Africa (Meester 1955), is smaller than *M. kihaulei* in dental measurements (Tab. 5). The species is also known from Pleistocene and Pliocene deposits in Tanzania and Ethiopia (Butler & Greenwood 1979, Wesselman 1984). Therefore the hypothesis had to be tested whether the extant *Myosorex* from

Table 2: Selected cranial measurements of *Myosorex* from the Uluguru and Udzungwa Mountains. See text for descriptions of measurements. Cranial measurements for the holotype of *Myosorex geata* as described by Allen and Loveridge are also given.

	UDZUNGWA		ULUGURU		
	Male (n = 8)	Female (n = 2)	Male (n = 3)	Female (n = 3)	Holotype
CI	20.18 19.67–20.85 (0.44)	20.34 19.87–20.81 (0.66)	20.94 20.66–21.12 (0.24)	20.85 20.70–20.99 0.14	21
BL	17.98 17.14–18.50 (0.48)	18.05 17.73–18.36 (0.44)	18.73 18.42–18.96 (0.28)	18.62 18.46–18.86 0.21	
PPL	9.16 8.77–9.45 (0.23)	9.03 8.98–9.08 (0.07)	9.30 9.12–9.42 (0.16)	9.24 9.18–9.30 0.06	9
UTR	8.54 7.99–8.88 (0.26)	8.76 8.53–8.99 (0.32)	9.11 8.99–9.18 (0.10)	9.01 8.92–9.12 0.10	8.5
LIW	4.33 4.06–4.50 (0.13)	4.16 4.08–4.23 (0.10)	4.39 4.23–4.53 (0.15)	4.45 4.34–4.58 0.12	
BW	6.39 6.25–6.50 (0.09)	6.37 6.26–6.47 (0.10)	6.41 6.35–6.47 (0.06)	6.48 6.40–6.56 0.08	
NW	2.91 2.82–3.00 (0.07)	2.90 2.85–2.95 (0.07)	2.96 2.91–3.05 (0.07)	3.04 3.03–3.05 0.01	
GW	10.42 9.67–10.75 (0.33)	10.38 10.38–10.38 (0.00)	10.53 10.48–10.64 (0.09)	10.55 10.32–10.69 0.20	10.3
HBC	6.43 6.26–6.58 (0.12)	6.46 6.45–6.47 (0.01)	6.66 6.61–6.75 (0.07)	6.54 6.34–6.73 0.19	
MI	12.55 12.19–12.82 (0.20)	12.68 12.51–12.85 (0.01)	13.07 13.01–13.13 (0.06)	13.06 12.97–13.20 0.12	
LT	7.75 7.27–8.06 (0.29)	8.07 7.83–8.32 (0.35)	8.26 8.16–8.32 (0.09)	8.19 8.10–8.30 0.10	8
I3L	0.49 0.44–0.58 (0.05)	0.56 0.54–0.58 (0.03)	0.44 0.40–0.51 (0.06)	0.43 0.42–0.44 0.01	
CL	0.77 0.67–0.89 (0.08)	0.84 0.79–0.89 (0.07)	0.82 0.78–0.85 (0.03)	0.77 0.71–0.82 0.05	
I3W	0.49 0.44–0.58 (0.05)	0.53 0.51–0.55 (0.02)	0.57 0.53–0.60 (0.04)	0.53 0.50–0.56 0.03	
CW	0.69 0.64–0.73 (0.03)	0.72 0.72–0.73 (0.01)	0.73 0.72–0.74 (0.01)	0.70 0.68–0.73 0.02	
M3L	1.54 1.46–1.60 (0.05)	1.57 1.54–1.61 (0.05)	1.62 1.58–1.65 (0.04)	1.60 1.54–1.63 0.05	
M3W	0.89 0.87–0.91 (0.01)	0.87 0.83–0.92 (0.06)	0.95 0.90–1.00 (0.05)	0.92 0.87–0.95 0.04	

Table 3: F values from one-way anovas (effect = sex) of populations of *Myosorex* from the Uluguru and Udzungwa Mountains. None were significant at the 0.05 level.

Cranial measurements	Uluguru 3 males, 3 females	Udzungwa 8 males, 2 females
CI	0.32	0.17
BL	0.31	0.03
PPL	0.33	0.59
UTR	1.35	0.96
LIW	0.29	2.94
BW	1.75	0.10
NW	2.75	0.02
GW	0.01	0.02
HBC	1.10	0.14
MI	0.03	0.66
LT	0.75	1.90
I3L	0.08	4.60
CL	1.76	1.20
I3W	2.52	0.99
CW	2.91	2.19
M3L	0.30	0.84
M3W	0.61	0.78

the Udzungwa Mountains could represent a living population of *M. robinsoni*. This hypothesis, however, must be rejected. Apart from the small size of *M. robinsoni*, structural differences exist between the two taxa. In *M. robinsoni* the four upper unicuspids are subequal in size and all in one line (Butler & Greenwood 1979, fig. 9). The lower second incisor has only one cusp, a primitive condition not found in any

Table 4: Results of test for significant differences in cranial measurements from two populations of *Myosorex* from the Uluguru and Udzungwa Mountains. Results are presented as means for each of the two samples for each measurement, t-value and p. P values below 0.05 are in bold.

Cranial measurements	Uluguru (n = 6)	Udzungwa (n = 10)	t-value	p
CI	**20.89**	**20.22**	**–3.47**	**0.00**
BL	**18.68**	**17.99**	**–3.46**	**0.00**
PPL	9.27	9.13	–1.45	0.17
UTR	**9.06**	**8.59**	**–3.98**	**0.00**
LIW	4.42	4.30	–1.76	0.10
BW	6.44	6.39	–1.31	0.21
NW	**3.00**	**2.91**	**–2.77**	**0.01**
GW	10.54	10.41	–1.00	0.33
HBC	**6.60**	**6.43**	**–2.61**	**0.02**
MI	**13.06**	**12.57**	**–5.57**	**0.00**
LT	**8.23**	**7.82**	**–3.11**	**0.008**
I3L	0.44	0.46	0.52	0.61
CL	0.79	0.78	–0.22	0.83
I3W	0.55	0.50	–2.12	0.05
CW	0.72	0.70	–1.43	0.17
M3L	**1.61**	**1.55**	**–2.77**	**0.01**
M3W	**0.93**	**0.89**	**–2.63**	**0.02**

other *Myosorex* species. Butler & Greenwood (1979) in their classical study of the Olduvai shrews also provide some measurement of postcranial elements which show that *M. robinsoni* also had shorter limbs than *M. kihaulei*. The humerus of the Tanzanian population of *M. robinsoni* measures 8.33 mm (n=8) in length, while that of *M. kihaulei* measures 8.78 mm (n=7). Femur length is 9.27 mm (n=2) in *M. robinsoni* and 9.56 mm (n=7) in *M. kihaulei*. The relationships of the fossil *M. robinsoni* are not yet clear. Butler & Greenwood (1979) state that it "is a close relative of the living *M. geatus* and *M. cafer tenuis*", while Butler (1998) concludes that "*Myosorex robinsoni* is related, but not directly ancestral, to the extant South African species *Myosorex cafer* and *Myosorex varius*".

Comparisons of *M. kihaulei* to other species in the genus (but are not known from Tanzania) are as follows. *Myosorex varius* (Smuts, 1832) can be distinguished from *M. kihaulei* in color, being paler above and below, with a much stronger contrast between the both regions. Cranially the species is somewhat larger on average (Tab. 5). *M. varius* also occurs in grassland, while all other species occur in forest. It is known from South Africa, and perhaps from a population in eastern Zimbabwe (Meester & Dippenaar 1978).

Myosorex schalleri Heim de Balsac, 1967 is smaller than *M. kihaulei* in cranial dimensions (Table 5); it differs clearly by its very long tail (about 80% of HB) and details of the skull and dentition. The species is known only by the holotype which is a juvenile.

Other named extant species of *Myosorex* are considerably larger than *M. kihaulei* (Table 5) and require no further comparison.

Distribution. – So far, *Myosorex kihaulei* has been recorded in the Udzungwa Mountains, Tanzania. Future surveys may record this species from other montane habitats in eastern Africa.

Table 5: Comparison of some cranial and dental measurement (mm) of species of *Myosorex*, based mainly on the holotypes.

Taxon	CI	UTRL	P4–M3	m1–3	Source
M. robinsoni	–	8.53	4.55	4.01	Meester 1955; Butler & Greenwood 1979
M. schalleri	18.90	8.40	–	–	holotype MNHN 1981–1107
M. kihaulei	21.02	8.59	5.13	4.22	holotype FMNH 155621
M. geata	21.15	9.05	5.36	4.28	RUCA 2305
M. varius	21.5	9.0		4.29	ZFMK
M. tenuis	21.7	9.5			holotype BM 4.9.1.22
M. okuensis	21.89	9.30	5.62	4.27	holotype ZFMK 69.376
M. blarina	22.1	10.8	–	–	holotype BM
M. babaulti	22.42	9.48	5.64	4.60	ZFMK 68.545
M. eisentrauti	22.60	9.27	5.18	4.10	holotype ZFMK 69.372
M. rumpii	22.70	9.69	5.66	4.56	holotype ZFMK 69.375
M. longicaudatus	22.75	9.93	5.43	4.27	ZFMK 82.135
M. zinki	23.20	9.62	5.52	4.35	holotype SMNS 4505
M. cafer	23.2	9.8	–	–	Meester & Dippenaar 1978
M. sclateri	25.2	10.5	–	–	holotype BM 4.12.3.12

Conservation. – *Myosorex kihaulei* was discovered in submontane and montane habitats in an area already nominated for increased conservation status. Rogers & Homewood (1982b) called for more protection for the Udzungwa Scarp Forest Reserve and suggested that it was second only to Mwanihana in biodiversity value for the Udzungwa Mountains. The discovery of a new species of shrew within this forest heralds the probability that there are many other organisms that live in this forest and which have not yet been described. The habitat that supports this unique fauna must be conserved.

Discussion

We place *Myosorex* here in the tribe Myosoricini Kretzoi, 1965, of which it is the type genus (Kretzoi 1965). It has long been known that this genus shows some ancestral characters (Heim de Balsac 1966). A biochemical study by Maddalena & Bronner (1992) has shown that *Myosorex* is not closely related to either Soricini/ae or Crocidurini/ae, the latter being the taxon in which *Myosorex* was most often placed. Although Kretzoi's name is available, as pointed out for example by Jammot (1983) and Hutterer (1993, 1995), extant *Myosorex* were recently regarded by some authors (Bedford, Bernard & Baxter 1998) as members of the Crocidosoricinae, a taxon named by Reumer (1987) to cover some extinct Miocene shrews of Europe. The phylogenetic relationships between Crocidosoricinae and extant *Myosorex* have never been investigated, but even if investigation demonstrate a closer relationship between the two groups the name Myosoricini would have formal priority.

Myosorex kihaulei may not be the last addition to this genus from Africa. We have another series from the Rungwe Mountains under study which has not been allocated to any taxon yet. A further problem is the status of an isolated *Myosorex* population occurring in eastern Zimbabwe and adjacent Mozambique (Smithers 1983), which Heim de Balsac (1967) referred to as *Myosorex* near *geata,* while Meester et al. (1986) referred to the same population as *Myosorex cafer* (Sundevall, 1846). These animals are small and may approach *M. geata* or *M. kihaulei.* This population and other populations from further south require careful study in order to analyze the real diversity of the genus.

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Zusammenfassung

Es wird eine neue Spitzmaus der Gattung *Myosorex* (Soricidae) aus den Udzungwa Bergen in Ost-Tansania beschrieben. *Myosorex kihaulei* ist eine der kleinsten Arten der Gattung und deutlich kleiner als die beiden bisher aus Tansania bekannten Arten *Myosorex geata* und *M. zinki.* Alle drei Arten sind auf isolierte Bergwälder Tansanias beschränkt.

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