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Rhinolophus maendeleo n. sp. from Tanzania, a horseshoe bat noteworthy for its systematics and biogeography [1)]

(Mammalia, Chiroptera, Rhinolophidae)

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Abstract

Described is *Rhinolophus maendeleo* n. sp. from the Coastal Lowland forests, Tanzania. The new species differs from its closest relative *Rh. adami* by the shape of noseleaf and by cranial and bacular characteristics. The systematics of the new species and its Central African forest-dwelling relative is discussed.

Key words: Chiroptera, *Rhinolophus*, new species, systematics, *adami*-group, Tanzania, Coastal Lowland forests, biogeography.

Introduction

In the Afrotropical region the genus *Rhinolophus* LACÉPÈDE 1799 (as the only genus of Rhinolophidae) is relatively poorly represented compared to the horseshoe bat fauna of the Oriental (Indomalayan) region. Altogether 18 species with exclusively Afrotropical distribution are presently known in contrast to 37 Indomalayan endemics (HILL 1992, KOOPMAN 1993). Due to the very high morphological similarity within the family only species groups are used as subdivisions and the proposed sub-family level classifications (e.g. GRAY 1866, PETERS 1871) have not been accepted. Southeast Asia is thought to be the centre of evolution of the family (BOGDANOWICZ & OWEN 1992) where members of all the previously recognised groups occur (HILL 1992) while, based on this classification, only five out of six groups have representatives in the Afrotropical region. On the other hand, according to the recent phenetic analyses of the family (BOGDANOWICZ 1992), the Afrotropical taxa represent independent lineages not associated with Oriental species.

Two specimens of horseshoe bats in the collection of the Senckenberg-Museum, Frankfurt am Main, from the relict forests of NE-Tanzania, cannot be identified with any of the known Afrotropical groups of the genus. These specimens represent a hitherto undescribed species showing close affinities only to *Rh. adami* AELLEN & BROSSET 1968, endemic to Congo (Brazzaville).

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Material and methods

The following taxa were used as comparative material: *Rhinolophus adami*, *Rh. s. simulator* and *Rh. s. alticolus* (see Appendix).

Measurements: Taken from fluid preserved specimens using digital calliper to the nearest 0.1 mm; the cranial and dental dimensions measured under stereomicroscope by digital calliper with 0.01 mm accuracy.

Abbreviations of institutional names: BMNH = The Natural History Museum, formerly British Museum (Natural History), London; FMNH = Field Museum of Natural History, Chicago; HNHM = Hungarian Natural History Museum, Budapest; HZM = Harrison Zoological Museum, Sevenoaks; KMH = Kim M. Howell catalogue; MHNG = Muséum d'Histoire Naturelle, Genève; MNHN = Muséum National d'Histoire Naturelle, Paris; SMF = Senckenberg-Museum, Frankfurt am Main.

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Systematic part

Rhinolophus maendeleo n. sp.
(Figs. 1, 4, 7)

1994 *Rhinolophus* sp. nov., Burgess & Muir, Frontier-Tanzania Coastal Forests Workshop. Coastal forests E. Afr.: Biodiv. & conserv.: 30; Mkulumuzi (Amboni).

1995 *Rhinolophus* n. sp., Clarke & Stubblefield, Frontier-Tanzania Techn. Rep., **16**: 13; Amboni Caves (KMH 7673) and E-Usambara Mts.

1998 *Rhinolophus* sp. 1 (cf. *swinnyi*), Cockle, Kock, Stublefield, Howell & Burgess, Mammalia, **62** (1): 59, tab. 2; Mkulumuzi Forest.

Holotype male ad. (alc., skull, os penis), SMF 79643: Amboni Cave Forest, 05°05′S–39°02′E, 0–80 m, Mkulumuzi River Gorge, 2.5 km W of Tanga, Tanga Distr., NE-Tanzania, 25. II. 1992, L. Stubblefield leg. (KMH 7673); mistnetted 19:10–19:30h in opening in forest on path in front of stream.

Paratype female ad. (alc., skull): Mazumbai Forest Reserve, 04°25′S–38°15′E, east ridge of West Usambara Mts., Lushoto Distr., NE-Tanzania, 29. VIII. 1985, SMF 66960, H. Grossmann leg. (KMH 3216); mistnetted in garden.

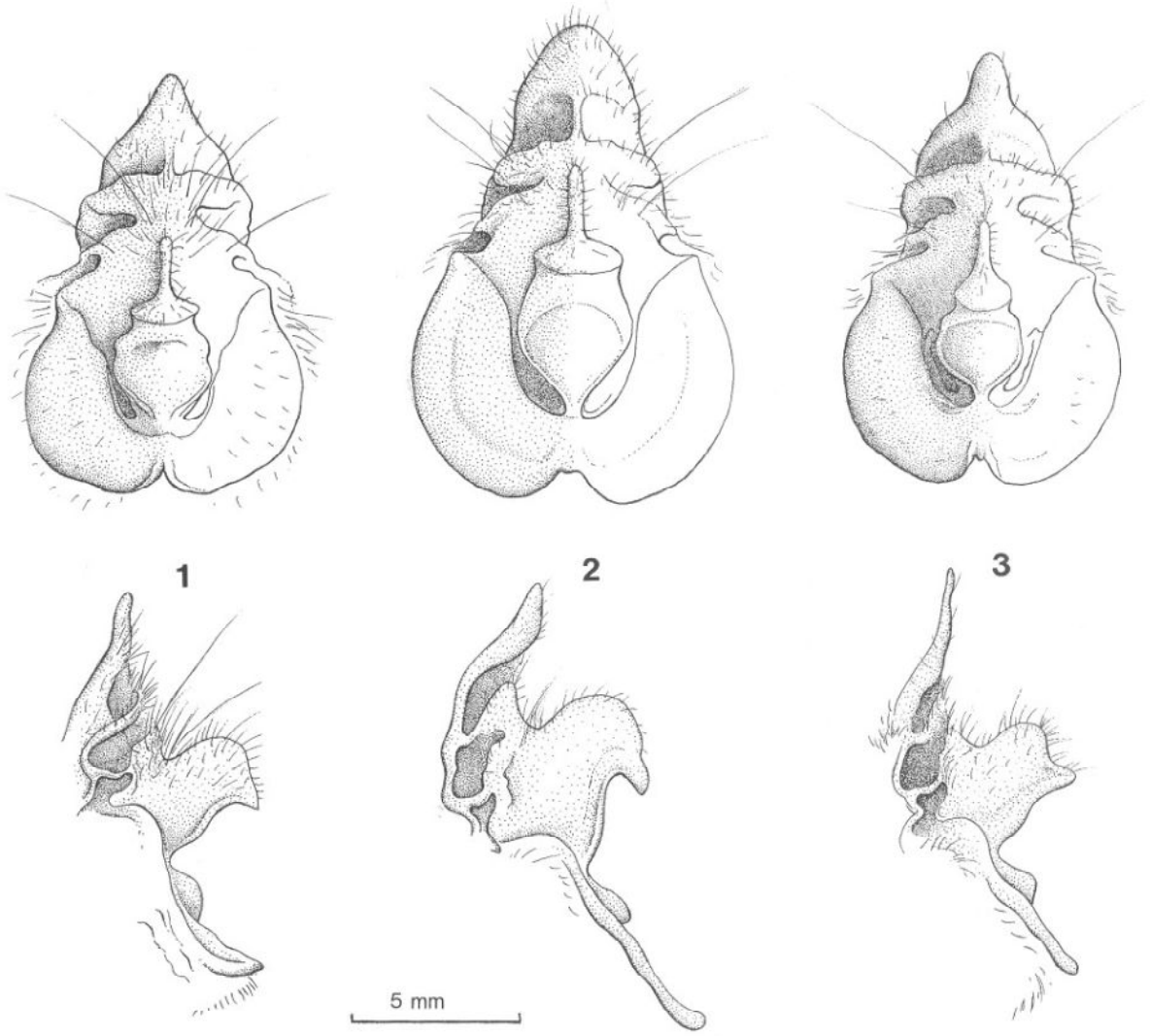
Etymology: From Swahili "maendeleo" for progress; a noun in apposition. Named in allusion to the increasing knowledge of the Tanzanian bat fauna.

Diagnosis: Medium sized bat, forearm length 48–49. Horseshoe and sella of the noseleaf wide, the lancet nearly straight-sided (Fig. 1). Lower lip with three well-defined mental grooves. Skull slender, mastoid width equals or slightly exceeding zygomatic width; rostral inflations of nasal sinus high and wide; palatal bridge more than one-third of upper toothrow length (Fig. 4). These features are combined with the absence of a bony bar over the foramen infraorbitale. Distal part of baculum (os penis) strongly flattened dorsoventrally; dorsal part of the basal cone projecting proximally and deeply incised (Fig. 7).

Measurements (of holotype followed by paratype; in mm, if not stated otherwise). – External: Head and body 46, 49; tail from last vertebra to anus 23, 25.8; hindfoot s. u. 8.0, 8.2; ear from outer base 24.5, 24; horseshoe width 8.4, 8.2; tibia 19.4, 18.9; forearm including carpalia 48.2, 49.1; forearm without carpalia 47.2, 48.3; metacarpal III (between proximal and distal end of bone, excluding wrist) 32.1, 34.6; 1st phalanx digit III 14.6, 14.7; 2nd phalanx digit III 24.3, 24.2; metacarpal IV 36.1, 38.1; 1st phalanx digit IV 8.3, 8.15; 2nd phalanx digit IV 14.4, 14.2; metacarpal V 35.1, 36.2; 1st phalanx digit V 10.3, 10.9; 2nd phalanx digit V 12.15, 12.9; weight 6 g, –.

Skull: Greatest length of skull 20.75, 20.64; occipito-canine (crown) length of skull 20.07, 20.03; occipito-canine (alveolus) length of skull 19.57, 19.60; condylobasal length of skull 17.74, 17.72; condylo-canine (crown) length of skull 17.72, 17.75; condylo-canine (alveolus) length of skull 17.57, 17.59; mastoid width 9.39, 9.42; braincase width 8.5, 8.8; zygomatic width 9.37, 9.35; length of palatal bridge between anterior and posterior emarginations 2.70, 2.78; width across C1/-C1/ crowns 4.74, 4.79; width across M3/-M3/ (crowns) 6.58, 6.55; C-M3/ crown length 7.25, 7.20; C-M3/ alveolar length 6.83, 6.82; C-P4/ crown length 3.30, 3.28; greatest width of anterior rostral inflations 5.01, 4.96; least interorbital width 2.53, 2.49; mandible length from outer point of proc. articularis to I/1 alveolus –, 13.07; mandible length from outer point of proc. condylaris to I/1 alveolus –, 13.14; C-M/3 crown length 7.62, 7.43; C-P/4 crown length 2.83, 2.70.

Description: Pelage dorsally brownish, ventrally beige turning to whitish on lower abdomen and loins; a darker brown collar around lower neck and upper chest. Ears large, reaching beyond the tip of nose when laid forward, tips bluntly rounded. The noseleaf covering almost all of the muzzle; horseshoe wide, no supplementary noseleaf. Sella naked, wide at its base, rising from a rather well-developed cup and constricted in the middle;



Figs. 1–3. Noseleaves of three *Rhinolophus* sp. in front (top row) and lateral (bottom row) view. – 1) *maendeleo* n. sp., holotype SMF 79643; 2) *adami*, holotype MNHN 1968.408; 3) *s. simulator*, holotype BMNH 2.2.7.10.

connecting process hairy, forming a continuous arch and its basal part almost parallel to the sella; the tip of lancet nearly straight-sided (Fig. 1). Three mental grooves in lower lip. Fourth and fifth metacarpals subequal in length, the third metacarpal shorter. First phalanx of digit IV more than one half length of 2nd phalanx. The last caudal vertebra is free from uropatagium.

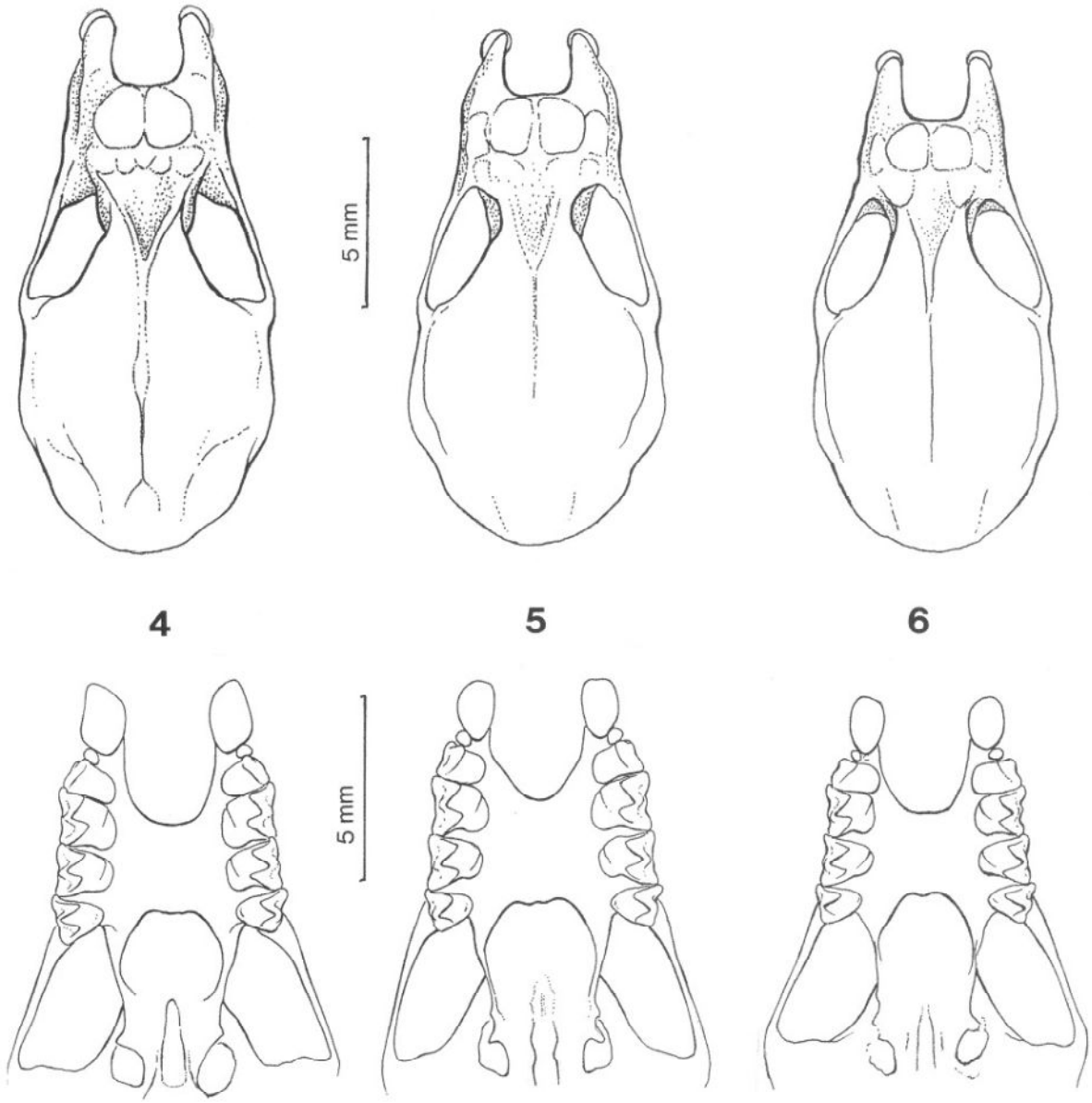
Skull (Fig. 4): Slender, with long rostral part; anterior median rostral inflations enlarged, bulbous, with the posterior rostral inflations of nasal sinus reduced which results in a markedly concave rostral profile with moderately deep rostral depression flanked by strong postorbital ridges. Weak sagittal and lambdoid crest in the male holotype and almost absent in the female paratype. In both specimens the foramen infraorbitale is open by natural absence of a bony bar. Palatal bridge more than one-third of the C-M3/ length. Interpterygoid groove deep, with lateral ridges posteriorly.

Teeth: C1/ with small posterior cingulum cusp in unworn stage, considerably exceeding PM4/ in height; upper PM2/ medium sized, in toothrow, separating C1/ from PM4/; I/1 two-third the bulk of I/2; the small PM/3 partly extruded from toothrow, posteriorly covered by cingulum of PM/4; PM/2 and PM/4 not in contact.

Baculum: 2.66 long, its distal half dorsoventrally compressed; the dorsal part of the basal cone enlarged and deeply emarginated forming two long wings; the ventral incision less deep (Fig. 7).

Comparison

Rh. maendeleo n. sp. externally can be distinguished from the closely related *Rh. adami* by the shape of the lancet (longer in *Rh. adami* with convex sides; Fig. 2). Cranially, *Rh. adami* is larger in the following measure-

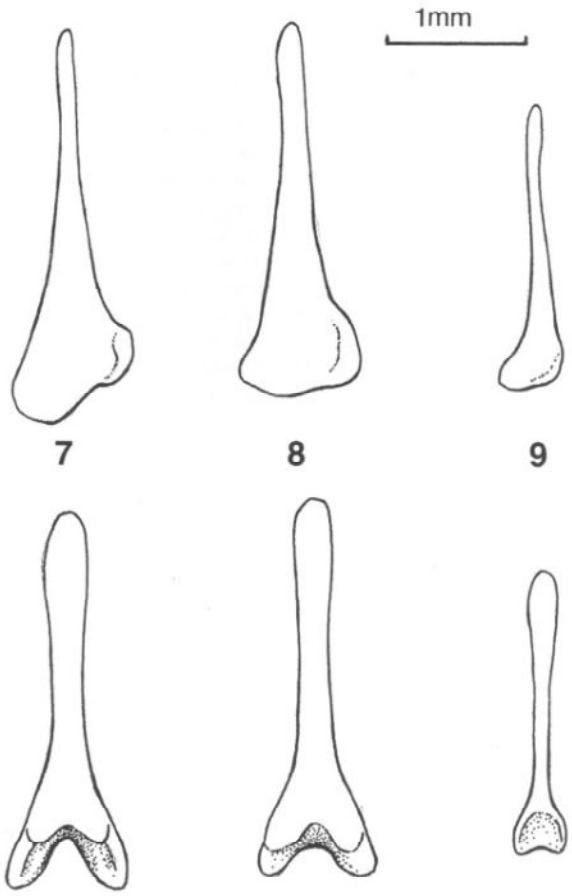


Figs. 4–6. Skulls in dorsal view (top row) and basal region of skulls (bottom row) of three *Rhinolophus* sp. – 4) *maendeleo* n. sp., holotype SMF 79643; 5) *adami*, holotype MNHN 1968.408; 6) s. simulator, HNHM 76.156.1.

ments (n = 6): palatal bridge length 2.99–3.23; greatest width of anterior rostral inflation 5.08–5.46; interorbital width 2.64–2.81; mastoid width 9.47–9.88; width across M–M3/ 6.64–6.87. The bony bar across the foramen infraorbitale is present. The interpterygoid groove is deep in both species but its walls run nearly parallel in *maendeleo* n. sp. while they are constricted close to the proximal end in the case of *Rh. adami* (Fig. 5). The baculum of *Rh. adami* (Fig. 8–9) has a much shorter basal cone with shallow dorsal and ventral incisions.

In the area where *Rh. maendeleo* n. sp. has been found, the only other taxon with similar external appearance is *Rh. s. simulator* Andersen 1904. This latter, however, is smaller in forearm length (42.0–47.2) and has a more pronounced, wider based connecting process and hastate lancet (Fig. 3). Cranially the two taxa are distinguishable by the less inflated narial swellings (Fig. 6), presence of bony bar across the foramen infraorbitale, and smaller measurements of *Rh. s. simulator* (n = 42: occipito-canine length of skull 17.27–19.25; C-M3/ crown length 6.31–7.08; mastoid width 8.62–9.33; articular length of mandible 11.60–12.54; C-M/3 crown length 6.66–7.35).

Besides in both specimens of *Rh. maendeleo* n. sp., the bony bar across the foramen infraorbitale is not developed on one side of one specimen of *Rh. cognatus* Andersen 1906 (Bay of Bengal, S. Andaman, Port Blair, BMNH 6.12.1.12) and absent from both sides of one



Figs. 7–9. Bacula of two *Rhinolophus* sp. in lateral (top row) and ventral (bottom row) view. – 7) *maendeleo* n. sp., holotype SMF 79643; 8) *adami*, ad. paratype MHNG 1129.84; 9) *adami*, subad., HNHM 97.5.1.

specimen of *Rh. fumigatus* Rüppell 1842 (Murka, Tavo West N.P., Kenya, SMF 41816).

Another similar horsehoe bat is *Rh. simulator alticolus* Sanborn 1936, a West African forest endemic. The proper taxonomic status of this taxon (originally assigned as subspecies to *Rh. alcyone*) is controversial (Hill & Morris 1971, Koopman 1975, 1993), sometimes being regarded as separate species (Eisentraut 1956, Rosevear 1965, Hayman & Hill 1971) although only on the base of a comparison with *Rh. alcyone* and *Rh. landeri*. *Rh. s. alticolus* is showing some affinities to *Rh. maendeleo* n. sp. and *Rh. adami* by its wide horseshoe, larger sella and the sides of the lancet more or less straight, but cranially and by measurements it is very similar to *Rh. s. simulator*.

Systematics

Among the Afrotropical *Rhinolophus* sp., the following set of characters apply to *Rh. maclaudi* Pousargues 1897 (currently including *ruwenzorii* Hill 1942 and *hilli* Aellen 1973), *Rh. adami* Aellen & Brosset 1968 and *Rh. maendeleo* n. sp. only: very large ears and sella, tip of lancet straight-sided or rounded (not hastate), three mental grooves, narrow skull (mastoid width subequal to or wider than zygomatic width), bulbous narial inflations, PM2/ in toothrow and long palate. Many of these characters are regarded as basal features (Andersen 1905) and in the Indomalayan region are typical for the species of the *philippinensis*-group of Bogdanowicz (1992). Of this group, *Rh. maclaudi* is characterized by a very elaborate noseleaf and specially formed nasal inflations, and, according to Bogdanowicz (1992), clusters far from the *philippinensis*-group; its phylogenetic position is uncertain. *Rh. adami* (not investigated by Bogdanowicz) was placed originally near the African members of the *ferrum-equinum*-group (Aellen & Brosset 1968), but based on the above mentioned features, along with *Rh. maendeleo* n. sp. represents a different clade within African rhinolophids which is here formally established as the *adami*-group.

Habitat, status and faunal assignment

The Amboni Cave Forest is a coastal lowland forest of 350 ha at an altitude from sea level to 80 m, consisting of degraded forest and evergreen thicket in a limestone gorge, under the Protection of Monuments (Amboni Caves) Order, 1937, originally protected during the German administration (Clarke & Stubblefield 1995). – The Mazumbai Forest is a primeval lower montane rain forest of 450 ha, at an altitude of 1400–1900 m (Redhead 1981, Lovett & Norton 1989), protected by its status as University Natural Forest Reserve of the Sokoine University of Agriculture, Morogoro.

The known range of the new species is wholly within protected areas. The habitat characterises *Rh. maendeleo* n. sp. as a faunal element of the Zanzibar-Inhambane phytogeographic zone (see Sheil 1992), respectively the Swahili regional centre of endemism of Burgess et al. (1998), whose forests extend inland to the foothills of some of the Eastern Arc mountains. Although Mazumbai Forest is even further inland and at a higher altitude of the West Usambara Mts., this recently defined Swahili regional centre is still not definitely delimitated.

Local congeners of *Rhinolophus* sp.: Until present, no *Rhinolophus* sp. is reported for Mazumbai Forest (Redhead 1981), and *Rh. maendeleo* n. sp. represents the first record of the genus.

The bat fauna of the Amboni Caves (= Mkulumuzi Caves, = Siga Caves) is comparatively well known having been investigated under several biological aspects (Sjöstedt 1910, Alluaud & Jeannel 1914, Ajello et al. 1960, Cockle et al. 1998). However, there are rather few species of *Rhinolophus*. The cave and surrounding forest are inhabited by *Rh. hildebrandtii* Peters 1878 (Kulzer 1959, Cockle et al. 1998, SMF 79633), *Rh. eloquens* (SMF 81201: Amboni Caves), while *Rh.* cf. *swinnyi* Gough 1908 listed by Cockle et al. (1998) is the present new species.

Biogeography

The East African forests of the coastal belt from Somalia to Mozambique have a unique diversity of flora

(SHEIL 1992) and mammal fauna (KINGDON & HOWELL 1993) with a high number of endemics. These forests are relics of a once continuous forest belt from West to East Africa, broken up several times during drier climatic periods (HAMILTON 1982). Among bats, the members of the newly established *adami*-group provide an interesting addition to this list. Endemic Chiroptera of the Zanzibar-Inhambane phytogeographic zone are: *Pteropus voeltzkowi* MATSCHIE 1909, *Myonycteris relicta* BERGMANS 1980, *Taphozous hildegardeae* THOMAS 1909, *Rh. deckenii* PETERS 1867, *Glauconycteris kenyacola* PETERSON 1982, *Kerivoula africana* DOBSON 1878, and *Tadarida (Mops) brachyptera* (PETERS 1852). *Rh. maendeleo* n. sp. emphasises the biogeographic identity of a separate SE-African faunal region (BURGESSS et al. 1993).

The relationship of the bats of this Zanzibar-Inhambane zone with species of the Guinea-Congolian lowland forest on the supraspecific level is documented by *Rh. adami* of the Congo (B) lowlands as the closest relative of *Rh. maendeleo* n. sp., by *Rh. silvestris* AELLEN 1959 as nearest relative of *Rh. deckenii*, and by *Tadarida (Mops) leonis* (THOMAS 1908), the closest relative of *T. (M.) brachyptera*. At species level, W-African lowland forest taxa in common with the E-African coastal lowland forests are: *Hipposideros gigas* (WAGNER 1845), *H. cyclops* (TEMMINCK 1853), and possibly *H. camerunensis* EISENTRAUT 1956, which reaches east to W-Kenya only. At subspecies level *Miniopterus m. minor* PETERS 1866 in the East and M. *minor newtonii* BOCAGE 1889, and *M. m. occidentalis* JUSTE & IBAÑEZ 1992, in the West are mutual representatives.

Appendix

Specimens used for comparisons:

Rhinolophus adami: Congo (B): Kimanika Cave, Kouilou, MNHN 1968.408 (holotype), 1985.1185, 1985.1188a–c, 1985.1189a–c, 1985.1190a–b, HNHM 97.5.1. – Meya-Nzouari Cave, Kouilou, MNHN 1968.409–410 (paratypes), MHNG 1129.84 (paratype).

Rhinolophus s. simulator: South Africa: Pietermaritzburg, KwaZulu-Natal, SMF 55043–44. – Farm Dornhoek, Pietermaritzburg, SMF 55038–39. – Uvongo, KwaZulu-Natal, FMNH 152607. – Sandspruit, Rooiberg, Northern Prov., SMF 19560–61. – Sandspruit Cave, Warmbad, Northern Prov., FMNH 152608. – Zebediela, Northern Prov., SMF 19559. – Botswana: Livingstone Cave, Molepolole, HNHM 95.48.1. – Zimbabwe: Mazoe, BMNH 2.2.7.10 (holotype). – Orchid Cave, Sinoia [= Chinhoyi] Area, HZM 9.3896, 12.3908. – Lake McIlwain, SW of Harare, HZM 13.4246. – Asbestos Mine, Umtali, HZM 14.5386. – Zambia: "N. Rhodesia", BMNH 56.184. – Ngwerere Cave, Lusaka Distr., SMF 47485, HNHM 76.156.1–2. – Lusaka Distr., 15°18'S 28°20'E, HZM 28.11479. – Kafue, HZM 6.3254. – Tanzania: no locality, HZM 5.2144. – Mwanihana Forest, 600m, Udzungwa Mts., Morogoro Region, SMF 62866, 82528. – Uluguru North Forest Reserve, Uluguru Mts., Morogoro Region, FMNH 158337 – 8 km NWN Amani, East Usambara Mts., Tanga Region, FMNH 150073 – Chome Forest Reserve, South Pare Mts., Kilimanjaro Region, FMNH 153928 – Arusha National Park, HZM 18.6262, 21.7160, 22.7161, 24.7777 – Kenya: Mt. Elgon, Western Prov., FMNH 67903–67909. – 25 mi NW of Kitale, HZM 20.6653.

Rhinolophus s. alticolus SANBORN 1936: Cameroon: Mt. Cameroon, 5800 ft., FMNH 42596 (holotype), 42597–9 (paratypes) – Buea, BMNH 56.188. – Cave near Buea, 3500 ft., 04°09'N, 09°14'E, BMNH 68.896-898. – Wildi Cave, above Buea, Mt. Cameroon, SMF 42322–7 (see EISENTRAUT 1963). – Guinea: Mt. Nimba, 1450 m, MNHN 1985.1522–1528.

References

AELLEN, V., & BROSSET, A. (1968): Chiroptères du sud du Congo (Brazzaville). – Revue suisse Zool., **75** (2): 435–445; Genève.

AJELLO, L., MANSON-BAHR, P. E. C., & MOORE, J. C. (1960): Amboni Caves, Tanganyika, a new endemic area for *Histoplasma capsulatum*. – Amer. J. trop. Med. Hyg., **9** (6): 633–638; Baltimore.

ALLUAUD, C., & JEANNEL, R. (1914): Observations sur la faune des grottes du Kulumuzi. – Pp. 373–378 *in*: JEANNEL, R., & RACOVITZA, E. G. (eds.), Biospéologica. XXXIII. Enumération des grottes visitées 1911–1913 (cinquième série). – Arch. Zool. expériment. générale, **53** (7): 325–558; Paris.

ANDERSEN, K. (1905): On the bats of the *Rhinolophus philippinensis* group, with descriptions of five new species. – Ann. Mag. nat. Hist., (7) **16**: 243–257; London.

BOGDANOWICZ, W. (1992): Phenetic relationships among bats of the family Rhinolophidae. – Acta theriol., **37** (3): 231–240; Bialowieza.

BOGDANOWICZ, W., & OWEN, R. D. (1992): Phylogenetic analyses of the bat family Rhinolophidae. – Z. zool. Syst. Evolut.-Forsch., 30: 142–160; Hamburg, Berlin.

BURGESS, N. D., CLARKE, G. P., & RODGERS, W. A. (1998): Coastal forests of eastern Africa: status, endemism patterns and their potential causes. – Biolog. J. Linnean Society, **64**: 337–367; London.

BURGESS, N. D., DICKINSON, A., & PAYNE, N. H. (1993): Tanzanian coastal forests – new information on status and biological importance. – Oryx, **27** (3): 169–173; London.

BURGESS, N. D., & MUIR, C. (1994): Frontier-Tanzania Coastal Forests Workshop. Coastal forests of Eastern Africa: Biodiversity and conservation. – iii + 55 [+56] pp.; London, Dar es Salaam (Society for Environmental Exploration; Royal Society of the Protection of Birds, UK; Univ. of Dar es Salaam).

CLARKE, G. P., & STUBBLEFIELD, L. K. (1995): Status report for 7 coastal forests in Tanga Region, Tanzania. – Frontier-Tanzania Technical Report, **16**: i–vi + 1–67; London, Dar es Salaam (Soc. Environm. Exploration; Univ. Dar es Salaam).

COCKLE, A., KOCK, D., STUBBLEFIELD, L., HOWELL, K. M., & BURGESS, N. D. (1998): Bat assemblages in Tanzanian coastal forests. – Mammalia, **62** (1): 53–68; Paris.

EISENTRAUT, M. (1956): Beitrag zur Chiropteren-Fauna von Kamerun (Westafrika). – Zool. Jahrb. Syst., **84** (8): 505–540; Jena.

– – – (1963): Die Wirbeltiere des Kamerungebirges. – 353 pp.; Hamburg, Berlin (P. Parey).

GRAY, J. E. (1866): A revision of the genera of Rhinolophidae, or horseshoe bats. – Proc. zool. Soc., **6**: 81–83; London.

HAMILTON, A. C. (1982): Environmental history of East Africa. A study of the Quaternary. – 328 pp.; London, New York (Academic Press).

HAYMAN, R. W., & HILL, J. E. (1971): Order Chiroptera. – Pp. 1–73 *in*: MEESTER, J. & SETZER, H. W. (eds.), The mammals of Africa: an identification manual. Part 2. – Washington D.C. (Smithsonian Inst.).

HILL, J. E. (1992): Order Chiroptera. – Pp. 54–161 *in:* CORBET, G. B., & HILL, J. E. (eds.), The mammals of the Indomalayan region: A systematic review. – 488 pp.; Oxford, New York etc. (Oxford Univ. Press).

HILL, J. E., & MORRIS, P. (1971): Bats from Ethiopia collected by the Great Abbai Expedition 1968. – Bull. Brit. Mus. nat. Hist. (Zool.), **21** (2): 25–49; London.

KINGDON, J., & HOWELL, K. M. (1993): Mammals in the forest of eastern Africa. – Pp. 229–241 *in:* LOVETT, J. C., & WASSER, S. K. (eds.), Biogeography and ecology of the rain forest of eastern Africa. – 341 pp., Cambridge, U.K. (University Press).

KOOPMAN, K. F. (1975): Bats of the Sudan. – Bull. Amer. Mus. nat. Hist., **154**: 353–444; New York.

– – – (1993): Order Chiroptera. – Pp. 137–142 *in*: WILSON, D. E., & REEDER, D. M. (eds.), Mammal species of the world. – 2nd ed., xviii + 1206 pp.; Washington, London (Smithsonian Inst.).

KULZER, E. (1959): Fledermäuse aus Ostafrika. Über eine Sammlung von Chiropteren aus Kenia und Tanganyika mit ethologischen und ökologischen Beobachtungen. – Zool. Jahrb. Syst. Ökol. Geogr. Tiere, **87** (1/2): 13–42; Jena.

LOVETT, J. C., & NORTON, G. W. (1989): Afromontane rainforest on Malundwe Hill in Mikumi National Park, Tanzania. – Biological Conservation, **48** (1): 13–19; Barking, UK.

PETERS, W. (1871): Über die Gattungen und Arten der Hufeisennasen, Rhinolophi. – Monatsber. kgl. preuss. Akad. Wiss. Berlin, **1871**: 301–331; Berlin.

REDHEAD, J. F. (1981): The Mazumbai Forest: an island of lower montane rain forest in the West Usambaras. – Afric. J. Ecol., **19**: 195–199; Oxford, UK.

ROSEVEAR, D. R. (1965): The bats of West Africa. – xvii + 418 pp.; London (Trust. Brit. Mus. Nat. Hist.).

SHEIL, D. (1992): Tanzanian coastal forests – unique, threatened, and overlooked. – Oryx, **26** (2): 107–114; London.

SJÖSTEDT, Y. (1910): Die Tierwelt der Steppen und Berge. Die Mkulumusi-Höhlen bei Tanga. – Wissenschaftliche Ergebnisse der schwedischen zoologischen Expedition nach dem Kilimandjaro, dem Meru und den umgebenden Massaisteppen Deutsch-Ostafrikas 1905–1906. – Bd. **1**, Abt. 1: 67–70; Stockholm (Palmquist).

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