

Systematic Notes on a Collection of Bats from Malawi. I. Megachiroptera: Epomophorinae and Rousettinae (Mammalia, Chiroptera)

Authors: Bergmans, Wim, and Strien, Nico J. Van

Source: Acta Chiropterologica, 6(2) : 249-268

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: <https://doi.org/10.3161/001.006.0205>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Systematic notes on a collection of bats from Malawi. I. Megachiroptera: Epomophorinae and Rousettinae (Mammalia, Chiroptera)

WIM BERGMANS¹ and NICO J. VAN STRIEN²

¹Zoologisch Museum, Universiteit van Amsterdam, P.O.Box 94766, Amsterdam, the Netherlands
E-mail: wim.bergmans@nciucn.nl

²Julianaweg 2, 3941 DM Doorn, the Netherlands

From July 1986 to August 1991 the junior author collected bats in various localities in Malawi. About 450 of these animals were preserved. In the present study the Megachiroptera are reported. Epomophorinae (Megachiroptera) collected in Malawi by H. Jachmann in 1982 are also reviewed. In addition, a number of specimens in collections in Malawi, Zambia and Zimbabwe have been examined by the junior author, while data on some other samples from Malawi in various other collections, examined earlier by the senior author, have been reconsidered as well. The combined collections contain eight species of Megachiroptera, including *Epomophorus* cf. *labiatus*, *E. gambianus crypturus*, a new species of *Epomophorus* (described herein), *E. wahlbergi*, *Epomops dobsonii*, *Rousettus aegyptiacus leachii*, *R. lanosus*, and *Eidolon helvum*. For the new species, an IUCN Red List category is proposed.

Key words: Megachiroptera, Malawi, systematics, Epomophorinae, Rousettinae

INTRODUCTION

Since the 1980s, Dr. D. C. D. Happold and Mrs. M. Happold have published several reports on the bats of Malawi, the first co-authored by the late J. E. Hill (Happold *et al.*, 1987, 1989, 1997). These studies are mainly faunistic, dealing with species inventories, distribution, ecology, status and conservation. Happold *et al.* (1997) listed the 59 bat species known to occur in Malawi, including seven species of Megachiroptera (they did not deal with subspecies): *Epomophorus gambianus* (Ogilby, 1835), *E. labiatus* (Temminck, 1837), *E. wahlbergi* (Sundevall, 1846), *Epomops dobsonii*

(Bocage, 1889), *Eidolon helvum* (Kerr, 1792), *Rousettus aegyptiacus* (É. Geoffroy-St. Hilaire, 1810), and *R. lanosus* Thomas, 1906. Kock *et al.* (1998) recorded the eighth Megachiroptera, *Plerotes anchietai* (Seabra, 1900).

The objective of the present paper is to contribute to the knowledge of the taxonomy of Megachiroptera from Malawi. The taxonomic status of various forms of *Epomophorus* and *Rousettus* in Malawi is reviewed, and a new species of *Epomophorus* is described. The study builds on earlier ones dealing with or including the same subject (Bergmans *et al.*, 1983; Bergmans, 1988, 1994). Bergmans (1988, 1994) gave

extensive synonymies per species. For these reasons, and because there has been no new opportunity to study extralimital collections, the synonymies in the species accounts have been limited to records from 1983 onward, dealing with or covering Epomophorinae and Rousettinae from Malawi only.

MATERIALS AND METHODS

From July 1986 to August 1991 the junior author collected bats in a number of localities in Malawi. Permits for collecting in National Parks and Reserves were obtained from the Department of National Parks and Wildlife. Many of the bats caught were released, but several hundred were preserved. A number were deposited in the collections of the Biology Department of the University of Malawi in Zomba, the Biology Department of the Chancellor College in Zomba, and the Wildlife Research Unit of the Department of National Parks and Wildlife in Lilongwe; some specimens were left with the National Museum of Malawi in Blantyre; and the remainder was brought to the Zoological Museum of Amsterdam for systematic study. Among these there were 56 Megachiroptera. The junior author also examined 36 specimens in the National Museum of Malawi, the National Museum of Zambia in Livingstone, and the National Museum of Zimbabwe in Bulawayo. The 24 Megachiroptera collected in Malawi by H. Jachmann in 1982 and deposited in the Zoological Museum of Amsterdam have also been examined. Finally, 16 specimens from Malawi present in other collections were examined by the senior author. Together, the present study includes 132 specimens. A preliminary report on the Jachmann collection was published by Bergmans *et al.* (1983), while part of the Rousettinae in the Van Strien collection were included in a general study of African *Rousettus* by Bergmans (1994).

Most of the bats collected by H. Jachmann are preserved in alcohol, some with extracted skulls. Most of those collected by N. van Strien and the ones present in collections in Malawi, Zambia, Zimbabwe and the other collections are dry skins and skulls. In the summaries of material examined, specimens are adult and preserved as skins and skulls unless stated otherwise. Body masses have been copied from field labels, specimens in African collections have been measured by the junior author, and the specimens in Amsterdam by the senior author, in accordance with Bergmans (1988). All measurements in this paper are

in mm. Months in collecting dates are indicated in Roman numbers.

Elevation, latitude and longitude of collecting localities are given in the Gazetteer. The data in this gazetteer have been checked against the gazetteer in Ansell and Dowsett, 1988. The junior author has taken field notes on specimens which were subsequently released. Some of these notes, together with those on collected specimens, allow for some observations on ecology and reproductive biology. The single, immature specimen of *E. helvum* in the Jachmann collection reported by Bergmans and Jachmann (1983) is not reviewed here again, as there are no new data to report.

Collections have been abbreviated as follows: AMNH = American Museum of Natural History, New York, USA; BDUMZ = Biology Department, University of Malawi, Zomba, Malawi; BMNH = British Museum (Natural History), London, United Kingdom; CMNH = Carnegie Museum of Natural History, Pittsburgh, USA; HZM = Harrison Zoological Museum, Sevenoaks, United Kingdom; NMMB = National Museum of Malawi, Blantyre, Malawi; NMZB = National Museum of Zimbabwe, Bulawayo, Zimbabwe; NMZL = National Museum of Zambia, Livingstone, Zambia; NNM = Nationaal Natuurhistorisch Museum, Leiden, the Netherlands; WRU = Wildlife Research Unit, Department of National Parks and Wildlife, Lilongwe, Malawi; ZMA = Zoologisch Museum, Amsterdam, the Netherlands. Other abbreviations are: alc. = alcohol; imm. = immature(s); leg. = collected by; N.P. = National Park; n.r. = not registered (no collection number); SD = standard deviation; # = field number.

RESULTS

Megachiroptera: Epomophorinae

Epomophorus Bennett, 1836

Thomas (1894) reported the first *Epomophorus*, *E. crypturus* Peters, 1852, from Malawi. Andersen (1912) added *Epomophorus wahlbergi* (Sundevall, 1846). In 1953, Lawrence and Loveridge recorded *Epomophorus minor* Dobson, 1880. Harrison (1959), who considered *E. minor* to be a subspecies of *Epomophorus labiatus* (Temminck, 1837), identified material from Malawi as *E. labiatus minor*. Bergmans *et al.* (1983) identified two specimens from

Malawi as *Epomophorus anurus* Heuglin, 1864, and others as *E. minor*.

Epomophorus crypturus was considered by Bergmans (1988) to be a subspecies of *E. gambianus* Ogilby, 1835. Claessen *et al.* (1990) retained it as a full species, but are not followed here for reasons explained by Bergmans (1997: 71). *Epomophorus anurus* was synonymized with *E. labiatus* by Bergmans (1988). *Epomophorus minor*, described as a full species but later considered a subspecies of *E. labiatus* by many authors (see the synonymy in Bergmans, 1988: 118), has been synonymized with *E. labiatus* by Claessen *et al.* (1991). The latter action created a species with exceptional properties: Medium-sized in the north (Central Sudan and Ethiopia), increasing in size towards southern Sudan and northern Kenya, and then decreasing considerably towards Malawi and Zambia; moreover, there is another, clinal size variation, with large specimens in the west and small specimens in the east of its distribution area (Claessen *et al.*, 1991). Thus defined, *E. labiatus* varies to an extent not matched by other fruit bat species with similar continuous distributions (see Bergmans, 1997: 72, for some comments). Pending further study of this phenomenon, and with reservation, the synonymy of *E. minor* with *E. labiatus* as proposed by Claessen *et al.* (1991) is followed here and the specimens concerned are referred to as *E. cf. labiatus*.

The recent survey of the bats of Malawi by Happold *et al.* (1997) included *E. gambianus crypturus* Peters, 1852 (as *E. gambianus*), *E. labiatus*, and *E. wahlbergi*; their definition of *E. labiatus* included *E. minor*, and their *E. gambianus crypturus* included *E. anurus* as recorded from Malawi by Bergmans *et al.* (1983 — see Happold *et al.*, 1987, 1989).

Summarizing, the following four *Epomophorus* species have been identified from Malawi:

A. The *gambianus* group, sensu Andersen, 1912:

1) *Epomophorus cf. labiatus* sensu Claessen and De Vree (1991; specimens from Malawi formerly identified as *E. minor* or *E. labiatus minor*);

2) *Epomophorus gambianus crypturus* (including all specimens identified as *E. crypturus*);

3) *Epomophorus 'anurus'* (see below);

B. The *wahlbergi* group, sensu Andersen, 1912:

4) *Epomophorus wahlbergi*.

The specimens identified as *E. minor* by Bergmans *et al.* (1983) fall within the size ranges published for *labiatus* in the southwest of its East African range by Claessen *et al.* (1991). Therefore, the two specimens identified as *E. anurus* by Bergmans *et al.* (1983), caught side by side with *E. labiatus* sensu Claessen and De Vree (1991) and considerably larger than that, cannot represent *labiatus*. Happold *et al.* (1987, 1989, 1997) had assumed therefore, that they must represent *E. (gambianus) crypturus*. However, the only adult specimen of the two — a male with epaulettes (ZMA 21.693b) — is distinctly smaller in both body and skull measurements than the smallest *E. gambianus crypturus* males as reviewed by both Bergmans (1988) and Claessen *et al.* (1990), and new *E. gambianus crypturus* material from Malawi (this paper). A female collected by the junior author and some specimens studied by him in the NMMB are similarly distinctly intermediate in size between *E. cf. labiatus* and *E. g. crypturus*. To accommodate these specimens, a new species is proposed below.

The second specimen identified as *E. anurus* by Bergmans *et al.* (1983) — an immature male (ZMA 21.693a) of which the skull could be examined only now — has been re-identified as immature *E. gambianus crypturus*.

Epomophorus cf. labiatus
(Temminck, 1837) (Figs. 1–3)

Epomophorus minor (Dobson, 1880); Bergmans *et al.*, 1983: 119; Happold *et al.*, 1987: 349; Ansell *et al.*, 1988: 27; Happold *et al.*, 1989: 97; Bergmans, 1988: 119 (in part: the records from Malawi).

Epomophorus crypturus Peters, 1852; Happold *et al.*, 1987: 348 (in part: nine specimens from Karonga represent *Epomophorus cf. labiatus*).

Epomophorus labiatus (Temminck, 1837?); Claessen *et al.*, 1991: 221 (in part: the specimens from Malawi); Happold *et al.*, 1997: 814.

Material Examined

2 ♂♂, 1 imm. ♂, alc., Administration Camp, Kasungu N.P. 24/29-I-1982, leg. H. Jachmann # 12 (ZMA 21.675–21.677); 1 ♀, skull, Blantyre, 15-X-1960, leg. probably P. W. Hanney (NMMB NM118); 1 ♂, alc., skull, house, Lingadzi River valley, 20-II-1982, leg. H. Jachmann (ZMA 21.678); 1 imm. ♂, Mandala, Blantyre, 11-XI-1960, leg. P. W. Hanney (NMMB 74ROM918); 2 imm., ♂ and sex unknown, Museums ground, Blantyre, 29-IV-1983, leg. C. Chimimba (NMMB, n.r.); 1 imm., sex unknown, Bua River Camp, Nkhhotakota Game Reserve, 22-V-1988, leg. N. J. van Strien # 175 (WRU, n.r.); 2 ♂♂, 1 ♀, 2 imm. ♀♀, Cape Maclear, 30/31-V-1975, leg. L. W. Robbins (CMNH 409758–409762); 2 ♂♂, 2 ♀♀, 2 imm. ♀♀, skins, skulls, and 1 ♂, 1 ♀, alc., Karonga, 1956/1957 or no date, leg. R. H. Oram (dry material: HZM 9.1926, 12.2198, 13.2204, 20.2621, 21.2638, 22.2639; spirit specimens: BMNH, numbers not noted); 4 ♂♂, 1 imm. ♂, skins, skulls, Karonga, 24/25-V-1961, leg. P. W. Hanney (NMMB NM500, 74ROM928, -930, -932, -934); 1 ♂, 10 km W of Karonga, 29-XII-1989, leg. N. J. van Strien # 409 (ZMA 26.102); 4 imm. ♂♂,

1 imm. ♀, alc., Lifupa, 8/22-I-1982, leg. H. Jachmann (ZMA 21.671–21.674, 21.687); 2 imm. ♂♂, 2 imm. ♀♀, Lifupa Camp, Kasungu N.P., 18- and 19-V-1988, leg. N. J. van Strien # 156, 158, 160 and 162 (ZMA 26.103–26.104; WRU, n.r.); 1 ♂, alc., skull, house in Lingadzi River valley, Kasungu N.P., 20-II-1982, leg. H. Jachmann # 13 (ZMA 21.678); 5 ♂♂, 2 imm. ♂♂, alc., 3 adult skulls extracted, Lisanthu, Kasungu N.P., 6/13-III-1982, leg. H. Jachmann # 17, 18, 20–24 (ZMA 21.680–21.686); 2 ♂♂, alc., Lusuntha Camp, Vwaza Marsh Game Park, 26-XII-1989, leg. N. J. van Strien # 393/94 (WRU, n.r.); 2 ♀♀, Monkey Bay, 13-VIII-1961, D. J. Eccles (NMMB 74ROM933, -935); 2 specimens, alc., Mpalaganga Farm, 9-XI-1990, leg. N. J. van Strien # 450, 452 (NMMB); 3 ♂♂, 1 imm. ♂, 3 ♀♀, 3 imm. ♀♀, Namazo Bay, 30-X-1987 to 26-XII-1988, leg. N. J. van Strien # 88, 89, 91, 138, 139, 147, 149, 249, 250, 265 (ZMA 26.110–26.119); 4 ♀♀, Nkhhotakota, 11/14-VIII-1946, leg. H. E. Anthony (AMNH 161853, 161856–161858); 1 imm. ♂, alc., Vitanda, 4-III-1982, leg. H. Jachmann (ZMA 21.679); 2 ♂♂, 3 ♀♀, Mulunguzi Road 10, Zomba, 22-I- and 30-XI-1988, 8-XII-1987, 25-XI-1988, and 5-XI-1989, leg. N. J. van Strien #132, 235, 93, 234 and 373 (skull only), respectively (ZMA 26.106–26.109, 26.120).

Measurements (Tables 1 and 2)

Remarks

For a comment on the identity of this species, see the introduction to the genus *Epomophorus* above. Bergmans *et al.* (1983) summarized the known collecting localities of this species (as *E. minor*) in Malawi. Ansell (1985) and Happold *et al.* (1987, 1997) gave additions. The present paper adds four new localities to this list: Blantyre; Lusuntha Camp in Vwaza Marsh Game Park; Namazo Bay; and Nkhhotakota Game Reserve.

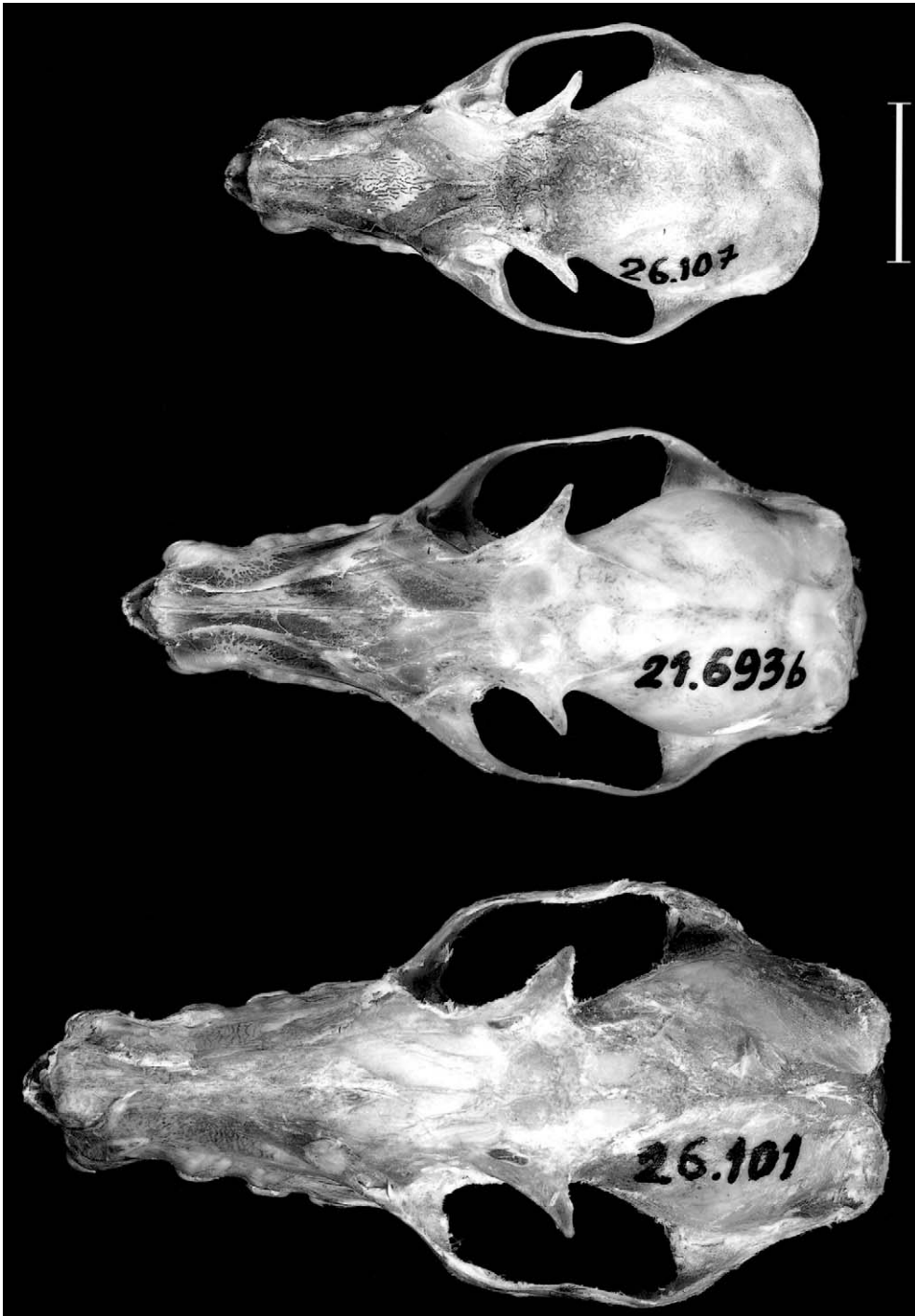


FIG. 1. Dorsal views of the skulls of adult males of the three Malawian species of the *Epomophorus gambianus* group, to show the difference in dimensions. Top: *E. cf. labiatus* (Temminck, 1837) sensu Claessen *et al.* (1991); centre: *E. anelli* n. sp.: holotype, Lisanthu, Kasungu N.P., 19-III-1982, leg. H. Jachmann (ZMA 21.693b); bottom: *E. gambianus crypturus* Peters, 1852, Muona Mission, 1-III-1989, leg. N. J. van Strien (ZMA 26.101).
Photo Mr. Jan van Arkel

The measurement ranges (Tables 1 and 2) in adult specimens seen by us are as follows: Forearm length in 19 ♂♂ 59.8–67.1 (\bar{x} = 63.6, SD = 2.00) and in 15 ♀♀ 58.0–65.1 (60.9, 1.84); greatest skull length in 16 ♂♂ 35.4–40.3 (38.5, 1.10) and in 15 ♀♀ 33.2–37.7 (35.0, 1.09).

Ecology

Bergmans *et al.* (1983) gave short descriptions of the vegetation of their collecting localities. Bergmans (1988) analysed the vegetation types where, all through their range, *E. labiatus* and *E. minor* had been collected. Happold *et al.* (1987) analysed what had been published on localities in Malawi and concluded that the species occurs in woodland savanna habitats throughout Malawi, where and when fruiting trees are present, including ornamental

gardens. In 1997, Happold *et al.* gave detailed descriptions of a number of collecting localities. All localities where this species has been collected lie below or at an elevation of about 1,350 m, the most elevated being Chipata Camp (see Happold *et al.*, 1997). Ansell *et al.* (1988) wrote that *E. cf. labiatus* is possibly absent from the extreme south of Malawi — south of Nchalo — as the species appears to reach its southern limit there. This is corroborated by the distribution map (for *E. minor*) in Bergmans (1988). In Malawi, the species is sympatric with several other Megachiroptera: with *E. gambianus crypturus* in Karonga, Administration Camp of Kasungu N.P.; Cape Maclear; Namazo Bay; and Blantyre; with *Epomophorus* n. sp. in Lifupa Camp and Lisanthu and probably in Karonga; with *E. wahlbergi* in Cape Maclear and Zomba;

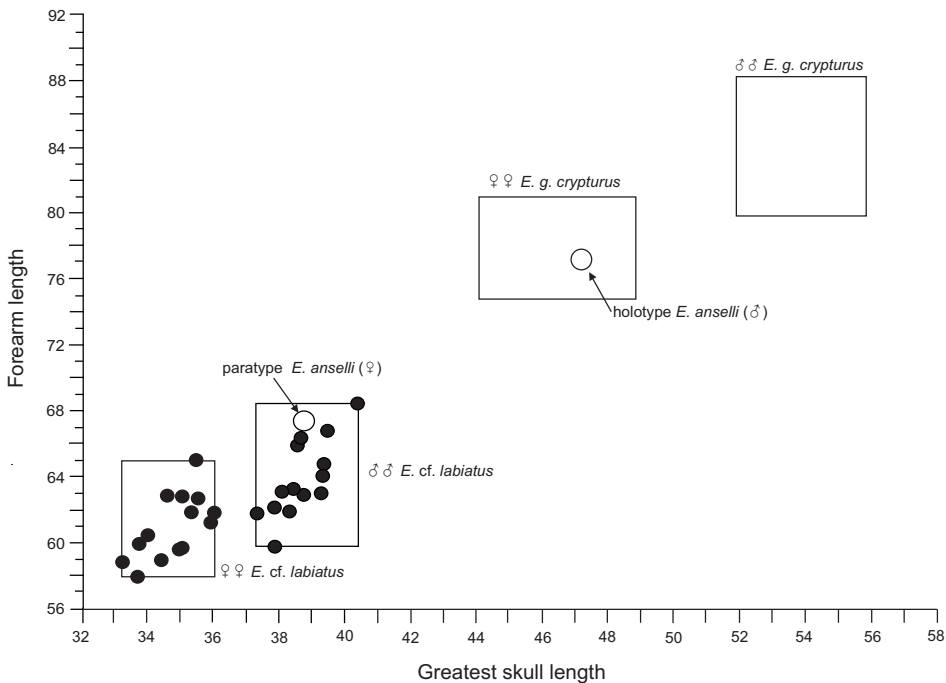


FIG. 2. Forearm lengths (in mm) plotted against greatest skull lengths (in mm) in the three Malawian species of the *E. gambianus* group, to show intermediate position of *E. anselli* n. sp. Black dots: adult ♂♂ and ♀♀ of *E. cf. labiatus* (Temminck, 1837) from Malawi; open circles: adult ♂ holotype and subadult ♀ paratype of *E. anselli* n. sp. from Lisanthu and Lifupa Camp, respectively, in Malawi. Two large rectangles at right: based on minimum and maximum forearm lengths in 51 adult ♂♂ and 40 ♀♀, and on greatest skull lengths in 47 ♂♂ and 34 ♀♀ of *E. gambianus crypturus* Peters, 1852 from all over its range (data from Bergmans, 1988)

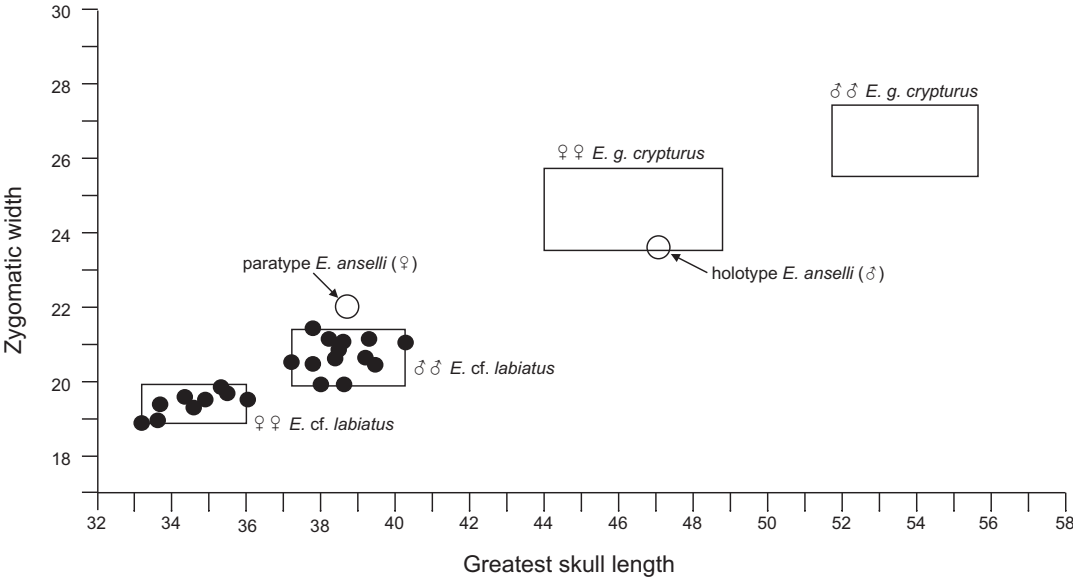


FIG. 3. Zygomatic widths (in mm) plotted against greatest skull lengths (in mm) in the three Malawian species of the *E. gambianus* group, to show intermediate position of *E. anselli* n. sp. Black dots and open circles as in Fig. 2. Two large rectangles at right: based on minimum and maximum zygomatic widths in 25 adult ♂♂ and 31 adult ♀♀ and on greatest skull lengths in 47 ♂♂ and 34 ♀♀ of *E. gambianus crypturus* Peters, 1852 from all over its range (data from Bergmans, 1988)

with *Epomops dobsonii* in Lifupa and Zomba; and with *Eidolon helvum* at Lisanthu.

Reproductive Biology

The specimens reported here have been taken all through the year except in June

TABLE 1. Selected measurements of members of the *Epomophorus gambianus* group in Malawi: adult males of *Epomophorus* cf. *labiatus* (Temminck, 1837), *E. anselli* n. sp. (ZMA 21.693b), and *E. gambianus crypturus* Peters, 1852

Measurement	<i>E. cf. labiatus</i>				<i>E. anselli</i> n. sp. (holotype)	<i>E. gambianus crypturus</i>			
	<i>n</i>	min–max	\bar{x}	SD	\bar{x}	<i>n</i>	min–max	\bar{x}	SD
Forearm length	19	59.8–67.1	63.64	2.00	77.4	6	82.3–86.6	84.65	1.51
Greatest skull length	16	35.4–40.3	38.48	1.10	47.1	7	51.8–54.6	53.70	1.17
Condylobasal length	15	36.3–39.5	37.85	0.83	46.9	7	51.8–54.6	53.88	0.95
Rostrum length	16	14.5–16.3	15.29	0.48	19.8	7	22.9–25.1	24.04	0.65
Palatal length	16	22.4–24.8	23.71	0.62	29.8	7	33.0–35.1	34.67	0.69
Cranium width	14	13.8–14.8	14.32	0.28	15.7	7	17.0–17.6	17.17	0.32
Interorbital width	16	6.3–7.3	6.76	0.29	7.3	7	7.0–9.6	8.37	0.71
Postorbital width	14	7.9–9.4	8.84	0.41	9.7	7	9.0–10.9	10.19	0.61
Zygomatic width	14	19.9–21.4	20.71	0.45	23.6	7	25.3–27.3	26.34	0.66
Mandible length	15	28.5–31.0	29.82	0.76	36.6	7	40.5–43.7	42.08	0.99
Mandible height	12	10.1–12.3	11.35	0.60	13.7	1	16.9	–	–
C ¹ –C ¹	16	6.9–7.9	7.50	0.28	8.7	7	9.6–10.8	10.11	0.39
C ¹ –M ¹	16	12.8–14.1	13.29	0.38	16.4	7	17.5–19.1	18.27	0.51
M ¹ –M ¹	16	10.1–11.4	10.76	0.41	12.2	7	13.5–14.5	14.01	0.38
C ₁ –M ₂	16	14.0–15.2	14.42	0.37	17.5	7	18.9–20.8	19.87	0.60
Body mass	3	37–ca. 57	–	–	–	2	ca. 110–144	–	–

TABLE 2. Selected measurements of members of the *E. gambianus* group in Malawi: adult females of *E. cf. labiatus* (Temminck, 1837), *E. anelli* n. sp. (ZMA 26.105; near adult paratype), and *E. gambianus crypturus* Peters, 1852

Measurement	<i>E. cf. labiatus</i>				<i>E. anelli</i> n. sp. (paratype)	<i>E. gambianus crypturus</i>			
	<i>n</i>	min–max	\bar{x}	SD	\bar{x}	<i>n</i>	min–max	\bar{x}	SD
Forearm length	15	58.0–65.1	60.91	1.84	67.5 (68.2)	2	78.6–78.6	–	–
Greatest skull length	15	33.2–37.7	34.95	1.09	38.7	3	46.2–46.6	46.43	0.17
Condylobasal length	11	32.3–36.4	33.90	1.18	38.2	2	45.7–46.2	–	–
Rostrum length	11	12.1–14.7	13.11	0.70	15.4	3	19.1–19.8	19.40	0.29
Palatal length	11	19.8–22.9	20.85	0.86	23.8	3	28.6–29.6	29.00	0.43
Cranium width	11	12.9–14.4	13.71	0.37	15.1	1	16.0	–	–
Interorbital width	11	6.0–7.0	6.33	0.33	7.0	4	7.5–8.6	8.13	0.40
Postorbital width	11	8.1–9.6	8.61	0.42	9.6	1	10.0	–	–
Zygomatic width	10	18.9–20.2	19.48	0.37	22.0	2	24.7–25.3	–	–
Mandible length	11	25.0–28.3	26.65	1.05	31.2	1	33.9	–	–
Mandible height	7	9.1–10.4	9.91	0.41	11.3	–	–	–	–
C ¹ –C ¹	11	6.4–7.4	6.90	0.25	7.8	4	8.8–9.6	9.10	0.30
C ¹ –M ¹	11	11.6–13.1	12.24	0.45	13.9	4	15.3–16.3	15.85	0.36
M ¹ –M ¹	10	9.9–10.7	10.27	0.25	11.9	4	13.0–13.5	13.23	0.19
C ₁ –M ₂	11	12.5–14.1	13.31	0.50	15.2	4	16.5–18.0	17.23	0.60
Body mass	6	37–49	41.83	3.89	ca. 57	2	63–84	74	–

and July; males were also not taken in August and September. Juveniles were taken on 4-I, 13-III, 8-IV, and 18-V, and on 30-X, 11-XI and 24-XI. Nearly adult and young adult specimens were taken on 4- and 29-IV, 18- and 24-V, in IX, and on 31-X and 9-XII. Males with developing or developed testes were taken on 22-I (length testes 5.3), 18-V (2.1), 24-V (6), 24-XII (4.3), 26-XII (4.9), and 29-XII (4.4). Two pregnant females were taken on 13-VIII. A lactating female was taken on 9-IV, but females with large nipples and possibly lactating were taken on 5-II, 4-III, 4-IV, 4-VIII, in IX, on 30-X, 25-XI and 8-XII. The numbers of specimens are too limited to be conclusive but it may be that breeding is continuous with two cycles per year, as Okia (1974) found in what he had identified as *E. labiatus* in Uganda.

Epomophorus gambianus crypturus
Peters, 1852 (Figs. 1–3)

Epomophorus anurus (not of Heuglin, 1864); Bergmans *et al.*, 1983: 118 (in part:

the specimen from Administration Camp, Kasungu N.P., ZMA 21.693a).

Epomophorus crypturus Peters, 1852; Happold *et al.*, 1987: 348 (in part: nine specimens from Karonga represent *E. cf. labiatus* (Temminck, 1837); the specimen from Administration Camp in Kasungu N.P. quoted from Bergmans *et al.*, 1983, represents *Epomophorus* n. sp.); Ansell *et al.*, 1988: 27 (in part: ZMA material includes, and NMMB material may include, *Epomophorus* n. sp.); Happold *et al.*, 1989: 90, 97 (in part: the specimen from Administration Camp in Kasungu N.P. quoted from Bergmans *et al.*, 1983 represents *Epomophorus* n. sp.); Claessen *et al.*, 1990: 182 (possibly in part: see the text). *Epomophorus gambianus crypturus* Peters, 1852; Bergmans, 1988: 93. *Epomophorus gambianus* (Ogilby, 1835); Happold *et al.*, 1997: 813.

Material Examined

1 imm., nearly adult ♂, alc., skull, Administration Camp, Kasungu N.P., 24-I-1982, leg. H. Jachmann # 7 (ZMA 21.693a);

1 ♂, 1 ♀, Mandala, Blantyre, 7-X- and 11-XI-1960, leg. P. W. Hanney, and 1 ♂, 13-X-1961, leg. Ms. Imray (NMMB 74ROM915, -916, -922); 1 ♂, Sunnyside, Blantyre, 9-IX-1961, leg. C. E. Richardson (NMMB 74ROM938); 1 ♂, skin (not seen) and skull, Cape Maclear, 31-V-1975, leg. L. W. Robbins (CMNH); 2 ♂♂, 1 imm., Chikwawa, 31-VII-1961, leg. C. R. Owen (NMMB 74ROM920, -925, -926); 1 ♂, 1 imm. ♂, Karonga, 24-V-1961, leg. D. Mumba and P. W. Hanney, respectively (NMMB 74ROM941, -942); 1 adult ♀, Likabula, 26-VI-1946, leg. H. E. Anthony (AMNH 161852); 1 ♂, Liwonde, 18-X-1961, leg. C. R. Owen (NMMB 74ROM927); 1 ♀, 1 imm. ♀, Mitsidi, Manyowa Hill, 6-IV-1961, leg. Dayes Zalira (NMMB 74ROM921, -924); 1 imm. specimen, sex unknown, alc., 1 adult ♂, Muona Mission, 1-III-1989, leg. N. J. van Strien # 297, 301 (BDUMZ, n.r.; ZMA 26.101); 1 imm. ♀, Namazo Bay, 4-VIII-1988, leg. N. J. van Strien # 137 (ZMA: 25.795); 1 imm. ♀, Salima-Senga Bay, 7-VII-1989, leg. N. J. van Strien # 330 (ZMA: 25.796).

Only adult and nearly adult, i.e. easily identifiable specimens of *E. g. crypturus* have been listed above. Material provisionally assigned to *E. g. crypturus*: 1 imm. ♂, skin only, 1 imm. ♀, Mandala, Blantyre, 13-X-1963, leg. M. Vunja (NMMB 1082–1083); 1 imm. ♀, skin and damaged skull, Cholo, Ruo, elevation 822 m, no date, purchased from R. C. Wood (BMNH 22.12.17.3); 1 imm. ♂, skin and skull fragments, Karonga, II/IV-1956, leg. R. H. Oram (HZM 4.2199); 1 ♀, skull, Kongwe Forest, 30-IX-1960, A. R. Tribe (NMMB 74ROM919; there is a skin with the same number but the forearm, which cannot be measured, appears much too short for *E. gambianus crypturus*); 3 imm. ♀♀, alc., skulls, Zomba, cf. 1890s, leg. A. Whyte, purchased from H. H. Johnston (BMNH 94.1.25.23, 94.6.7.1, 95.12.7.2).

Measurements (Tables 1 and 2)

Remarks

Bergmans *et al.* (1983) recorded *E. gambianus crypturus* (as *E. anurus*) from Administration Camp, Kasungu N.P. They mentioned Likabula and Zomba as two older published records, and listed four localities of specimens in the NMMB collection which data had been provided by the late Mr. W. F. H. Ansell: Blantyre, Chikwawa, Karonga and Liwonde. Happold *et al.* (1987) added Cholo, Ruo River, and Zoa [Tea] Estate as three other published records, and Thondwe as a new one; the identity of the material from Ruo River was uncertain. Ansell *et al.* (1988) mapped a further locality in square 1434-D. Bergmans (1988) listed Lichenya as yet another old record and added Cape Maclear, Livingstonia, and Livingston District to the list of *E. g. crypturus* localities.

From the measurement ranges for *E. gambianus crypturus* in Happold *et al.* (1987), based on the NMMB and their own collection, the smaller specimens which served for the calculations of these ranges appear to be much too small for the species. Dr. and Mrs. D. C. D. Happold kindly provided the underlying data (in litt., 1-VII-2003) and it appears that nine of the ten specimens from Karonga represent *E. cf. labiatus* instead of *E. gambianus crypturus*. These identifications had been copied from the labels in the NMMB and somehow this error went unnoticed, resulting in the erroneous minima in the reported measurement ranges.

Because of the sympatric occurrence of a third species of the *E. gambianus* group in Malawi, described below, which is absolutely larger than Malawian *E. cf. labiatus*, the identity of immature specimens of this group which clearly belong to a larger form than *Epomophorus cf. labiatus* is not easy to assess, as the dimensional variation

in the new species is not yet known. Therefore, localities from where only immature specimens of *E. g. crypturus* have been reported are in need of confirmation. These are Cholo, Livingstonia, and Livingstonia District. New localities reported in the present study are Administration Camp, Kasungu N.P.; Mitsidi, Manyowe Hill; Muona Mission; Namazo Bay; and Salima-Senga Bay.

Bergmans (1988) gave measurement ranges for adult *E. g. crypturus* from all over its distributional range: Forearm length in 51 ♂♂ 80.0–88.4 and in 40 ♀♀ 75.0–83.2, greatest skull length in 47 ♂♂ 51.8–55.7 and in 34 ♀♀ 44.0–48.8. Claessen *et al.* (1990) gave measurement ranges covering all range states except Angola, Malawi and Namibia: Forearm length in ≥ 44 ♂♂ 78.9–90.5 and in ≥ 35 ♀♀ 73.2–84.7, and greatest skull length in ≥ 44 ♂♂ 51.2–56.0 and in ≥ 35 ♀♀ 42.7–51.2. The latter greatest skull length range of 8.5 in females is probably not correct; the minimum may be based on an immature or wrongly identified specimen, and the maximum on a wrongly sexed male. Unfortunately, Claessen *et al.* (1990) failed to list the specimens they examined, and also left out collecting localities, rendering it impossible to either confirm or falsify their results.

Ecology

Bergmans *et al.* (1983) gave a short description of the collecting locality in Kasungu N.P. In 1988, Bergmans gave a short summary of the vegetation types where *E. g. crypturus* had been collected all through its range: Various types of woodlands of tropical and subtropical East Africa south of about 8°S. The known Malawian localities all lie within Miombo and undifferentiated woodland. Ansell *et al.* (1988) assumed that the species would probably occur all through Malawi. Collecting elevations run from 100 to possibly over 1,500 m. In the

adjoining Zambian part of the Nyika Plateau the species has been collected at 2,150 m. Finally, Happold *et al.* (1997) described several localities in detail. *Epomophorus g. crypturus* has been found to be sympatric with *E. cf. labiatus* at Administration Camp in Kasungu N.P., in Blantyre, Cape Maclear, Karonga and Namazo Bay, with *E. wahlbergi* at Cape Maclear, and with *Epomops dobsonii* at Administration Camp, Kasungu N.P.

Reproductive Biology

A juvenile (forearm length 51, greatest skull length 31.5) was taken on 6 April, nearly adult specimens were caught on 7 and 31 July and on 13 October, a male with enlarged testes (length 7.4) was taken on 1 March and a possibly lactating female on 11 November.

Epomophorus anelli n. sp. (Figs. 1–3)

Epomophorus anurus (not of Heuglin, 1864), Bergmans *et al.*, 1983: 118 (in part: the specimen from Lisanthu, ZMA 21.693b).

Epomophorus crypturus (not of Peters, 1852), Happold *et al.*, 1987: 349 (in part: “the Kasungu specimen referred to as *anurus* by Bergmans *et al.*, 1983”); Happold *et al.*, 1989: 97 (in part: “*anurus* from Kasungu National Park in Malawi”).

Epomophorus labiatus (not of Temminck, 1837), Bergmans, 1988: 101 (in part: the specimen from Lisanthu, ZMA 21.693b); Claessen *et al.*, 1991: 220–221 (in part: the *labiatus* [*anurus*] material from Malawi cited from Bergmans *et al.*, 1983 and Bergmans, 1988).

Holotype Specimen

1 adult ♂, alc., skull extracted, Lisanthu (13°00'S, 33°10'E), 1,000 m a.s.l., Kasungu N.P., Malawi, 19-III-1982, leg. H. Jachmann # 25 (ZMA 21.693b).

Paratype specimen: 1 nearly adult ♀, skin, skull, Lifupa Camp (13°05'S, 30°08'E), elevation 1,050 m, Kasungu N.P, Malawi, 19-V-1988, leg. N. J. van Strien # 162 (ZMA 26.105).

Measurements (Tables 1 and 2)

Diagnosis

A medium-sized species of the *E. gambianus* group with in the single known adult male a forearm length of 77.4, a greatest skull length of 47.1, a long, low and narrow rostrum, an anteriorly domed braincase, indistinct separated temporal ridges, a small mandibular height, six palatal ridges of which the 5th and 6th clearly postdental, relatively broad wings with the length of the 5th finger about 136% of the forearm length, a narrow uropatagium, and without a whitish belly fur patch.

The nearly adult female paratype from Lifupa Camp has a forearm length of 67.5 (field measurement 68.2), a greatest skull length of 38.7, and a zygomatic width of 22.0. In this specimen the rostrum is tapering, the braincase is anteriorly strongly domed, the temporal ridges are indistinct, the mandible is low, the anterior side of its fifth palatal ridge is between the first upper molars, and the length of its 5th finger (in the dried wing) is 134.6% of its forearm length.

Differential Diagnosis

Compared to the Malawian males of the two sympatric species of the *E. gambianus* group, the male holotype specimen is — and most probably all adult males of *E. anselli* are — absolutely larger than males of *E. cf. labiatus* in all body, skull and tooth measurements (Figs. 1–3) except interorbital width which matches the maximum in that species, and absolutely smaller than males of *E. gambianus crypturus* except in interorbital width which is as in the lower

range of that measurement in that species. Its rostrum is relatively more delicate than that in *E. gambianus crypturus*, its mandibular coronoid process relatively narrower, its wing relatively slightly broader with the 5th finger about 135% of its forearm length instead of about 130% in *E. gambianus crypturus*, and its uropatagium narrower.

Its teeth are only slightly smaller than in the two Malawian specimens of *E. gambianus crypturus* which are available to the authors, for example: P³ 2.5 × 1.75 against 2.6 × 1.8 and 2.9 × 1.9 in *E. g. crypturus*; P⁴ 3.15 × 1.9 against 3.3 × 1.9 and 3.15 × 2.0; and M¹ 3.5 × 2.1 against 3.6 × 2.0 and 3.65 × 2.15. In six Malawian *E. cf. labiatus* these measurements are smaller and more distinctly different: P³ length 2.0–2.3, width 1.35–1.6; P⁴ length 2.3–2.75, width 1.5–1.8; and M¹ length 2.5–3.15, width 1.55–1.65.

The nearly adult female paratype specimen from Lifupa Camp is absolutely larger than Malawian females of *E. cf. labiatus* in all body, skull and tooth measurements except interorbital and postorbital widths which both equal the maximum in that species, and in body mass, and absolutely smaller than known adult females of *E. gambianus crypturus* in all measurements except in some teeth dimensions, and in body mass. If compared to similarly aged, nearly adult females of *E. gambianus crypturus*, the female paratype of *E. anselli* has a smaller skull, a more delicate rostrum, a relatively narrower mandibular coronoid process, and lower canines; the fifth palatal ridge clearly partly between the first upper molars instead of clearly behind them; and relatively broader wings, with the 5th finger about 135% of the forearm length instead of about 130%. Its cheek teeth dimensions either overlap or are smaller than those in the two available Malawian *E. gambianus crypturus* females: P³ 2.6 × 1.75

against 2.65×1.8 and 2.8×1.8 ; P^4 3.15×1.75 against 3.1×1.75 and 3.15×1.9 ; and M^1 3.4×1.8 against 3.1×2.1 and 3.4×2.1 . In the ten available female specimens of *Epomophorus* cf. *labiatus* the teeth are smaller, with P^3 lengths 1.9–2.3, widths 1.35–1.6; P^4 lengths 2.4–2.8, widths 1.4–1.6; and M^4 lengths 2.5–3.0 and widths 1.4–1.65.

Compared to other, allopatric members of the *E. gambianus* group, *E. anseli* is absolutely larger than *E. minimus* but seems to approach typical, i.e. northern specimens of *E. labiatus* (Temminck, 1837). As far as can be ascertained at present, it can be distinguished from that species by the characters mentioned in the diagnosis. It may also be expected to be found to differ in measurement ratios, averages and ranges.

Description

A member of the *E. gambianus* group, not unlike typical, i.e. northern *E. labiatus* in overall dimensions, with in the single known adult male a forearm length of 77.4 and a greatest skull length of 47.1, and in the nearly adult female paratype a forearm length of 67.5 (dry measurement) and a greatest skull length of 38.7.

The rostrum in the male is long, low and narrow; its length amounts to 42% of its greatest skull length, its anterior height (measured from the ventral side of the maxillary bone bordering the anterior side of C^1 to the upper side of the anterior frontale above it) to 11.3%, its C^1 – C^1 width to 18.5% and its M^1 – M^1 width to 25.9%. The teeth are typical for the group, with length \times width of P^3 2.5×1.75 , of P^4 3.15×1.9 , and of M^1 3.5×2.1 . The braincase is domed anteriorly. The poorly developed temporal ridges do not fuse but remain at some distance from one another and run parallel towards the occiput. The mandibular height is relatively small and amounts to 29.3% of the greatest skull length and to 37.7% of the

mandibular length. The palatal ridge pattern in the male is typical, with six ridges altogether, two of which are postdental. The wing is relatively broad, with the total length of the fifth finger at 135.9% of the forearm length. The colours of the fur on head and dorsum are not different from those in the average male *Epomophorus* specimen. Ventrally, there is the transverse band of dark brown hair high on the breast between the epaulets typical for males of the genus (and of some other epomophorine genera). However, caudal to it the fur is very light brown in the centre of breast and belly, gradually passing into only very slightly darker fur on the flanks, and there is no white belly patch. The uropatagium is only about 5 wide at the ankle and 13 at the level of the knee. The wing is inserted at the basis of the second toe.

In the nearly adult female paratype the rostrum is relatively long, low and narrow; its length 39.8% of its greatest skull length, its anterior height 11.6%, its C^1 – C^1 width 20.2%, and its M^1 – M^1 width 30.7%. Length \times width in P^3 are 2.6×1.75 , in P^4 3.15×1.75 , and in M^1 3.4×1.8 . The braincase is anteriorly strongly domed. The temporal ridges are indistinct and do not fuse. The mandibular height is 29.2% of the greatest skull length and 36.2% of the mandibular length. The anterior side of the fifth palatal ridge is between the first upper molars. As the specimen is nearly adult, this is likely to represent the adult configuration, which within the *gambianus* group is found occasionally in the smaller species. The length of the fifth finger is 134.6% of the forearm length. The fur colours are a bit dull, suggesting that the juvenile colouration partly persist in this specimen.

Remarks

Bergmans *et al.* (1983) identified the holotype specimen of *Epomophorus anseli* as *E. anurus*, which is now considered

a synonym of *E. labiatus*. (They gave as forearm length 77.1 which was erroneous.) Their identification was based on its similarity in size with *anurus (labiatus)* specimens from South and Southwest Sudan and Northeast Congo-Kinshasa. Later analyses of the geographical variation of that species, either excluding *E. minor* (Bergmans, 1988) or including *E. minor* as a synonym (Claessen *et al.*, 1991), showed that there was no connection, in the sense of populations of about equally sized specimens, between those northern and northwestern *E. labiatus* populations and the one in Malawi. That would still not call for taxonomic distinction, as many species have representatives north and south of a large Central African divide (see e.g. Bergmans, 1997: 71). However, according to Claessen *et al.* (1991), Malawi is inhabited by a much smaller representative of *E. labiatus* (identified as *E. minor* by Lawrence *et al.*, 1953; as *E. labiatus minor* by Harrison, 1959; as *E. minor* again by Bergmans *et al.*, 1983 and Bergmans, 1988; as *E. labiatus* by Claessen *et al.*, 1991; and as *E. cf. labiatus* in the present paper). *Epomophorus anelli* is very clearly intermediate between the much smaller *E. cf. labiatus* and the relatively large *E. gambianus crypturus*. Both these species are sympatric (or nearly so) with *E. anelli*. The possibility of *E. anelli* representing cases of interbreeding between *E. labiatus* and *E. gambianus crypturus* seems unlikely because at Karonga small series of all three appear to have been collected side by side by P. W. Hanney and D. Mumba on 24- and 25-V-1961: 5 specimens of *E. labiatus*, possibly 4 to 5 of *E. anelli* (see below), and 2 of *E. crypturus gambianus*.

Referred Material

The following specimens in the NMMB collection could not be re-examined after their initial study by the junior author when in Malawi, but they almost certainly

represent *E. anelli*: 1 nearly adult ♀ and 1 adult ♀, Karonga, Malawi, 24-V-1961, leg. P. W. Hanney (NMMB 74ROM923 and -929); The adult female specimen (NMMB 74ROM929) has an alleged forearm length of 64 (field measurement on label, forearm bones not preserved), a greatest skull length of 37.7, and a zygomatic width of 20.2. The nearly adult female (NMMB 74ROM923) has an alleged forearm length of 68 (field measurement; forearm bones not preserved), a greatest skull length of 38.1, and a zygomatic width of 19.9. Other measurements of these specimens are not available but these few known measurements indicate that these females too are larger than females of *E. cf. labiatus*.

Doubtful Specimens

In the material studied by the junior author in the NMMB collection there are three more specimens which are possibly referable, or partly referable, to the new species. However, as there has been no opportunity to examine them again for this description, their identity is not certain. The specimens are: 1 ♂, Karonga, 24-V-1961, P. W. Hanney (NMMB 74ROM937); 1 imm. skull, without data (NMMB 74ROM939); 1 nearly adult 'female', Karonga, 24-V-1961, leg. P. W. Hanney (NMMB 74ROM940).

In the male (NMMB 74ROM937) the forearm length is 64 (field measurement; forearm bones not preserved), and its greatest skull length is 46.4. If the forearm length is correct (which can be ascertained by comparing other wing bone measurements with those in other males of *Epomophorus*) the skin represents *E. cf. labiatus* and the skull is evidently mismatched. Its greatest length of 46.4 matches that in male *E. anelli*, but its morphology should also be compared to that in female *E. gambianus crypturus*. The skull with number NMMB 74ROM939 is 38.0 in greatest length and represents either a male of *E. cf. labiatus* or

a female of *E. anelli*. The reason to list it here is its NMMB collection number, which suggests that it may belong to the series collected at Karonga by P. W. Hanney on 24-V-1961. Specimen NMMB 74ROM940 has a forearm length of 61.5 and a greatest skull length of 37.4. As the sex could not be checked from the skin (very young adult *Epomophorus* males have no epaulets), re-examination of the specimen must learn if it is a female *E. anelli* or a male *E. cf. labiatus*.

Ecology

The type specimen was mistnetted in Miombo woodland at an elevation of 1,000 m, over a stream between two water berry trees, *Syzygium cordatum* Hochst., in fruit (Bergmans *et al.*, 1983). Other species collected at the same site include *Epomophorus cf. labiatus*, *Epomops dobsonii*, and *Eidolon helvum*, while *E. gambianus crypturus* was collected less than 2 km to the east, at the Administration Camp of Kasungu N.P. The vegetation of Lifupa Camp, the locality where the female paratype was collected (exact elevation unknown, but between 1,000 and 1,100 m) is Miombo woodland with *Brachystegia* and *Julbernardia* (Bergmans *et al.*, 1983).

Reproductive Biology

The male type specimen, collected on 19 March, had scrotal testes of 8.2 in length (measured through the skin). The nearly adult paratype was collected on 19 May.

Etymology

The new species has been named in honour of the late Mr. W. F. H. Ansell for his important contributions to the mammalogy of Malawi and other African countries. Mr. Ansell died on the 6th of December, 1996. He had just completed editing the book "Mammals of Ghana, Sierra Leone and The Gambia" (Grubb *et al.*, 1998).

Conservation Status

Following a useful suggestion by the Global Mammal Assessment (GMA) African Small Mammals Workshop, together in London in January 2004 to assess Red List status of African small mammals, an IUCN Red List conservation status for *E. anelli* is proposed. The species is known from two general areas only, the Kasungu National Park (collected in 1982 and 1988) and (most probably) the Karonga area (collected in 1961), both within the rectangle between 09°56'S and 13°05'S, and 33°08'E and 33°56'E. The authors have no reason to believe that the species is in any danger but at the same time the available data are few and between 43 and 16 years old, and for the moment the IUCN category Data Deficient seems most appropriate.

Epomophorus wahlbergi
(Sundevall, 1846)

Material Examined

1 ♀, alc., skull, halfway between Blantyre and Zomba (hit by a car), 10-V-1989, leg. N. J. van Strien # 364 (ZMA 26.136); 1 imm. ♀, Golden Sands Camp, Cape Maclear, 21-VI-1989, leg. N. J. van Strien # 319 (ZMA 26.135); 1 imm. ♀, 1 ♂, Chipeni Farm, near Zomba, 24-IV-1988, leg. N. J. van Strien # 152, 153 (ZMA 26.129–26.130); 1 ♀, alc., Misuku Mission, Misuku Hills, 21-VI-1990, leg. N. J. van Strien # 436 (ZMA 26.137); 1 ♀, Mughese/Misuku, 19-XI-1970, leg. W. J. Wilson (NMZB V2197/63683); 2 imm. ♀ ♀, 1 ♀, Ntchisi Forestry Resthouse, 23-XII-1987 (1 imm.), 20-V-1988, leg. N. J. van Strien # 112, 165, 173 (ZMA 26.132–26.134); 1 ♂, 1 imm. ♂, 2 ♀ ♀, Wilindi Forest, 23/29-X-1972, leg. R. J. Dowsett (NMZL 3224–3227); 3 ♀ ♀, Zoa Tea Estate, 3-VIII-1960/19-XI-1960/2-IV-1961, leg. B. Morris (NMMB 74ROM914, -917, -936); 2 ♂ ♂, 1 imm. ♂, 3 ♀ ♀, 2 imm. ♀ ♀ (in one case:

mandible only), Mulunguzi Road 10, Zomba, 11-XII-1987/13-XII-1988, leg. N. J. van Strien #99, 101, 140–141, 228, 231, 238, 243 (ZMA 26.121–26.128); 1 ♂, foot of Zomba plateau, 4 km N of Zomba, 29-XII-1988, leg. N. J. van Strien # 266 (ZMA 26.131).

Measurements (Table 3)

Remarks

In *E. wahlbergi* the sutures between pterygoid and basisphenoid and between basisphenoid and basioccipital may remain visible into the adult stage, and other ways to determine adult age should be applied as well. Forearm length and greatest skull length ranges in the Malawian population of *E. wahlbergi* largely agree with those recorded for specimens from Mozambique (see Bergmans, 1988), which are relatively large for the species.

Ecology

Epomophorus wahlbergi has been found from Misuku in the north to Zoa Estate in the south of the country, in Miombo and undifferentiated woodland (Cape Maclear, Zomba and Zoa Estate) and in Afromontane vegetation (Misuku Mission, Mughese/Misuku, Ntchisi Forest and Wilindi Forest), and at elevations ranging from about 500 m (Cape Maclear) to 1,900 m (Wilindi Forest). In two instances it was found to occur together with other Epomophorinae: with *E. gambianus crypturus* and *E. cf. labiatus* at Cape Maclear, and with the latter species in Zomba.

Reproductive Biology

Nearly adult specimens have been collected on 21 March near Zomba, on 21 June at Cape Maclear and Misuku, on 23 October in Wilindi Forest, and on 11 November in Zomba. A young adult male was collected on 18 March in Zomba. Sexually active males were caught on 6 November (testes 6.5×5.1) and 29 December (testes 5.3×4.7), and a young adult male with undeveloped epaulettes but with developing testes (3.8×3.3) on 11 November, all in Zomba. An immature female with small nipples was caught on 30 May in Ntchisi Forest; two females each with an embryo on 23 and 25 October in Wilindi Forest (crown-rump lengths of the embryos 30 and 31); a female with a newly born young (forearm 35) on 13 November; females with large nipples on 12 and 21 March near and in Zomba, on 20 May in Ntchisi Forest, and on 10 September, 25 November and 11 and 15 December in Zomba; a female with a large young (forearm 61.8) was taken on 19 November in Zomba. These data are too few to be conclusive but suggest year-round reproduction, possibly with peak periods.

Epomops dobsonii (Bocage, 1889)

Material Examined

1 ♂, alc., skull, Administration Camp, Kasungu N.P., 24-I-1982, leg. H. Jachmann (ZMA 21.689); 1 ♀, Chilinda Camp, Nyika N.P., 29-XII-1990, leg. N. J. van Strien # 459 (ZMA 26.142); 1 imm. ♀, alc., Lifupa,

TABLE 3. Forearm length, greatest skull length and body mass of adult *E. wahlbergi* (Sundevall, 1846) in Malawi

Measurement	Sex	<i>n</i>	min–max	\bar{x}	SD
Forearm length	♂ ♂	5	85.1–90.5	87.36	1.75
	♀ ♀	12	78.1–85.1	82.02	2.08
Greatest skull length	♂ ♂	4	51.2–52.5	51.71	0.56
	♀ ♀	8	44.0–48.7	46.55	1.49
Body mass	♂ ♂	4	ca. 125–ca. 150	–	–
	♀ ♀	4	ca. 85–ca. 115	–	–

Kasungu N.P., 9-I-1982, leg. H. Jachmann (ZMA 21.688); 1 imm. ♀, alc., Lisanthu, Kasungu N.P., 7-III-1982, leg. H. Jachmann (ZMA 21.692); 1 imm. ♀, skin, Misuku-Mugheze Mission, 23-VI-1990, leg. N. J. van Strien # 445 (ZMA 26.143); 1 specimen, alc., 1 imm. ♂, Nkhata Bay (doctor's house), 24-XII-1989, leg. N. J. van Strien # 386, 387 (BDUMZ; ZMA 26.141); 1 ♀, 1 imm. ♀, 21- and 22-II-1982, rocky outcrop, Kasungu N.P., leg. H. Jachmann (ZMA 21.690–21.691); 1 imm. ♀, 2 ♀♀, Mulunguzi Road 10, Zomba, 9-II-, 22-II-, and 25-III-1989, respectively, leg. N. J. van Strien # 274, 278, and 312 (ZMA 26.138–26.140).

Remarks

Bergmans *et al.* (1983) recorded the first *E. dobsonii* for Malawi, based on specimens from several localities in Kasungu N.P. In 1989 Bergmans added Livingstonia, based on material in the BMNH, and Zomba, based on a personal communication by the junior author (29-VII-1989). In 2001, Chitaukali *et al.* recorded the species from Chitpome Valley on the Nyika Plateau. The new collection contains specimens from three further new localities: Chilinda Camp in Nyika N.P., Misuku-Mugheze Mission, and Nkhata Bay.

In size, the new specimens fall within the known ranges (see Bergmans, 1989). The adult male from Zomba, still without epaulettes, has a forearm length of 84.4, a greatest skull length of 51.0, and a body mass of ca. 110. In the adult females from Chilinda Camp and Zomba, these measurements are 80.5 and 84.6; 45.7 and 46.35; and 80–90 and 87, respectively. Maturity is not always easy to assess in *E. dobsonii*, as skull base sutures may remain partly open and visible into adult age.

Ecology

All known localities are in Miombo and undifferentiated woodland. Those at

Chilinda Camp, Misuku-Mugheze and possibly Zomba are very near, or in, Afro-montane vegetation. Locality elevations vary from 500 m (Nkhata Bay) to 2,300 m (Chilinda Camp).

Reproductive Biology

A full-grown male still without epaulettes was captured on 25 March. An adult female with large nipples was taken on 29 December, one with small nipples on 22 February.

Megachiroptera: Rousettinae

Rousettus aegyptiacus leachii (Smith, 1829)

Material Examined

1 imm. ♀, 10-VI-1988, 1 ♀, 2-VII-1988, 1 ♂, 3-VII-1988, 1 ♀, 1988, 2 ♀♀, alc., Lengwe N.P., near pool along link road, at 3 km W of tourist camp, leg. N. J. van Strien # 198, 199, 203, 204, 210, 211 (ZMA 26.144–26.147; NMMB, n.r.)

Measurements

See Bergmans, 1994: 92.

Remarks

In size, the Malawian specimens of *Rousettus aegyptiacus leachii* agree with those of other eastern and southern African populations. In dental characters they agree with the typical form of *R. ae. leachii*, and not with the relatively small-toothed form from the western Rift Valley (Rwanda, Kenyan highlands; see Bergmans, 1994: 95).

Ecology

All known localities of *R. ae. leachii* are in a relatively small region in the south of the country. Lengwe N.P. is close to the known localities of Mlolo, at less than 100 m, Nchalo (elevation unknown) and Ngabu, at 100 m. The dominant vegetation

is Miombo woodland, with small incursions of Mopane woodland, and lowland grassland and swamp along rivers.

Reproductive Biology

The immature female taken on 10 June had a forearm length of 84.9, against 91.4 and 95.1 in the two adult females. The male, collected on 3 July, had large testes (15.0×10.8). The adult female taken on 2 July had large nipples.

Rousettus lanosus Thomas, 1906

Material Examined

1 ♂, 2 imm. ♂♂, 4 ♀♀, 2 imm. ♀♀, 5 of which in alc., 2 specimens of unknown sex, alc., Misuku-Mughese Mission Malawi, 21-VI-1990, leg. N. J. van Strien # 421/27, 430, 435 (ZMA 24.573–24.574,

26.074–26.076, 26.149–26.152); 1 ♀, skin, skull, Doctor's house beach, Nkhata Bay, Malawi, 25-XII-1989, leg. N. J. van Strien # 392 (ZMA 26.148).

Measurements (Table 4)

Remarks

In 1994, Bergmans discussed the geographical variation of *R. lanosus* Thomas, 1906 and identified the specimens from Malawi and some from eastern Tanzania as representing a third morphologically different group next to the typical form from the Western Rift and the larger-toothed form described as *Rousettus kempfi* Thomas, 1909 — now generally considered a subspecies of *R. lanosus* — from the Kenyan highlands and probably Sudan and possibly Ethiopia. No other taxonomic study of this species appears to have been undertaken since.

TABLE 4. Measurements of adult males and females of *R. lanosus* Thomas, 1906 from Malawi

Measurement	Misuku / Mughese Mission					Nkhata Bay
	ZMA 26.149 (♂)	ZMA 24.574 (♀)	ZMA 26.076 (♀)	ZMA 26.150 (♀)	ZMA 26.151 (♀)	ZMA 26.148 (♀)
Forearm length	91.4	91.5	91.8	91.3	92.0	92.9
3rd metacarpal length	63.5	—	—	64.5	63.4	63.1
Tail length (field)	15	—	—	20	16	—
Ear length (field)	20.4	—	—	20.6	22.5	21.9
Hindfoot length (field)	20.0	—	—	21.0	19.6	22.2
Greatest skull length	44.0	—	—	43.5	43.5	43.4
Condylbasal length	41.3	—	—	41.4	41.1	41.0
Rostrum length	17.5	—	—	17.3	17.4	17.5
Palatal length	22.3	—	—	22.5	22.4	22.4
Cranium width	18.3	—	—	17.9	17.7	17.7
Interorbital width	8.2	—	—	8.0	8.1	7.9
Postorbital width	9.7	—	—	11.1	10.0	10.0
Zygomatic width	25.7	—	—	25.2	25.1	24.7
Mandible length	33.6	—	—	33.6	33.6	33.4
Mandible height	12.1	—	—	12.8	11.6	12.1
C ¹ –C ¹	10.0	—	—	9.6	9.4	9.5
C ¹ –M ²	14.8	—	—	14.7	15.2	14.8
M ² –M ²	12.8	—	—	12.7	12.7	13.0
C ₁ –M ₃	17.1	—	—	16.5	17.2	17.5
Length × width of P ⁴	2.70 × 1.35	—	—	2.60 × 1.35	2.80 × 1.45	2.95 × 1.5
Length × width of M ¹	2.45 × 1.45	—	—	2.50 × 1.35	2.50 × 1.35	2.50 × 1.5
Length × width of M ²	1.45 × 1.05	—	—	1.50 × 0.95	1.45 × 1.05	1.50 × 1.1

The Malawian/Tanzanian form of *R. lanosus* combines a relatively large skull with large relative widths over C¹–C¹ and M²–M² and large cheek teeth. The distribution of these characters over the various (groups of) populations has been listed in Table 5.

The palatal ridge pattern of 4 + 4 + 1 found by Bergmans (1994) in one or two specimens (the others being without soft palate) and thought to represent a possible further distinctive character, is not the normal state, as shown by the three new specimens preserved in alcohol, which have the pattern of 4 + 3 + 1 normally noted in this species.

Specimens # 431–434, collected with the others at Misuku-Mughese, have been left in Malawi (2 in BDUMZ, n.r., and 2 probably in WRU) and have not been examined.

Ecology

The Misuku-Mughese (or Mugesse) Mission, also called Misuku Mission, is in the extreme North of the country, with several mountainous elevations up to 1,900 m and covered with Afromontane vegetation, amidst the dominant Miombo and undifferentiated woodland. Nkhata Bay is in the latter vegetation, at an elevation of ca. 500 m, which is the lowest known for the species. Two specimens each yielded one specimen of the nycteribid fly *Dipseliopoda setosa* Theodor, 1956. *Roussettus lanosus* has been

collected together with *E. wahlbergi* and *E. dobsonii*.

Reproductive Biology

The adult male, collected on 21 June, had rather large testes (9.6 × 7.2 mm). A subadult male taken on the same day had testes of 4.3 × 3.6. The four adult females from the type locality had rather large to large nipples. The adult female collected on 25 December at Nkhata Bay was lactating. One female (ZMA 26.076) shows very strong tooth wear in canines and anterior premolars; she has lost P⁴, M¹ and M² on both sides, M₂ on the left side and M₃ on both sides.

GAZETTEER

Gazetteer of collecting localities mentioned in this paper. Coordinates and elevations have been checked against Ansell and Dowsett (1988):

- Administration Camp, Kasungu N.P.: 13°00'S, 33°09'E; 1,000 m a.s.l.;
- Blantyre: 15°47'S, 35°00'E; 1,000 m;
- Bua River Camp, Nkhotakota Game Reserve: ca. 12°49'S, 34°10'E; 600 m;
- Cape Maclear: 13°58'S, 34°49'E; 480 m;
- Chelinda Camp, Nyika N.P.: 10°35'S, 33°48'E; 2,300 m;
- Chikwawa: 16°03'S, 34°47'E; 120 m;
- Chilinda Camp (see Chelinda Camp);
- Chipata Camp: 13°04'S, 33°56'E; ca. 1,350 m;
- Chipeni Farm, near Zomba: 15°24'S, 35°25'E; 750 m;
- Chipome Valley: 10°20'S, 33°50'E; 1,530 m;
- Cholo (= Thyolo): 16°04'S, 35°09'E; 900 m;

TABLE 5. The distribution of varying characters in different geographical groupings of *R. lanosus* Thomas, 1906

Character	Congo Kinshasa, Rwanda, W Uganda [spp. <i>lanosus</i>]	Sudan [cf. spp. <i>kempi</i>]	Ethiopia [spp. <i>kempi</i> ?]	Kenya, E Uganda [spp. <i>kempi</i>]	Tanzania (Bagilo, Isongo, Mahenge) [<i>kempi</i> and other subspecies?]	Malawi [other subspecies?]
Skull	small	small	?	small	large	large
C ¹ –C ¹	small	small	?	small	large	large
M ² –M ²	small	large	?	large	large	large
P ⁴ , M ¹ , P ₄ , M ₁	small	large	large*	large	large	large

* — Largen *et al.* (1974) identified Ethiopian specimens as *R. l. kempi*, probably on the basis of teeth measurements only

Karonga: 09°56'S, 33°56'E; 480 m;
 Kongwe (= Kongowe) Forest: 13°35'S, 33°55'E; 1400 m;
 House, Lingadzi River valley: 13°00'S, 33°09'E; 1,050 m;
 Lengwe N.P.: 16°14'S, 39°35'E;
 Lichenya Plateau: 15°58'S, 35°32'E; up to 2,358 m;
 Lichinji: Probably the same as Lichenya;
 Lifupa: 13°03'S, 33°09'E; 1,050 m;
 Lifupa Camp: 13°05'S, 33°08'E; 1,050 m;
 Likabula Forestry Depot: 15°56'S, 35°30'E; 760 m;
 Lingadzi River (house): 13°00'S, 33°09'E; 1,050 m;
 Lisanthu, Kasungu N.P.: 13°00'S, 33°10'E; 1,050 m;
 Livingstonia Mission: 10°36'S, 34°06'E; ca. 1,300 m;
 Liwonde: 15°04'S, 35°13'E; 500 m;
 Lusuntha Camp, Vwaza Marsh Game Park: ca. 11°09'S, 33°37'E; 1,250 m;
 Manyowa Hill: Not traced;
 Misuku Hills: 09°40'S, 33°32'E; over 1,500 m;
 Misuku Mission, Misuku Hills: 09°40'S, 33°32'E; 1500 m;
 Misuku-Mughese (or Mugesse) Mission: see Misuku Mission;
 Mitsidi (= Mzedi): 15°47'S, 35°06'E; over 1,500 m;
 Mlolo: 16°26'S, 35°10'E; less than 100 m;
 Monkey Bay: 14°04'S, 34°55'E; 480 m;
 Mugesse Forest, Mugesse Hill: 09°39'S, 33°32'E; up to 1888 m;
 Mughese/Misuku: See Misuku Mission;
 Muona Mission: 16°25'S, 35°10'E; 100 m;
 Mzedi Hill: 15°47'S, 35°06'E; over 1,500 m;
 Namadzi: 15°31'S, 35°11'E; 1,000 m;
 Namazo Bay: 14°10'S, 34°49'E; 475 m;
 Nchalo: 16°15'S, 34°51'E; 100 m;
 Ngabu: 16°27'S, 34°53'E; 100 m;
 Nkhata Bay: 11°36'S, 34°18'E; 500 m;
 Nkhotakota: 12°56'S, 34°18'E; 500 m;
 Ntchisi (Forestry) Rest House, Ntchisi Forestry Station: 13°23'S, 34°00'E; 1,500 m;
 Rocky outcrop, Kasungu N.P.: 12°53'S, 33°03'E; ca. 1,100 m;
 Ruo River: 16°08'S, 35°34'E; 800–1,000 m;
 Salima Senga Bay: 13°43'S, 34°38'E; 475 m;
 Thondwe: 15°29'S, 35°14'E; 1,100 m;
 Vitanda: 12°57'S, 33°10'E; 1,000 m;
 Wilindi Forest: 09°42'S, 33°29'E; 1,900 m;
 Zoa (Tea) Estate: 16°14'S, 35°12'E; 800 m;
 Zomba: 15°23'S, 35°19'E; 800–900 m.

ACKNOWLEDGEMENTS

The junior author is grateful to the Department of National Parks and Wildlife of Malawi for allowing him to collect bats in National Parks and Reserves during the years 1987 to 1991. Both authors

acknowledge the help of Dr. and Mrs. David and Meridith Happold in solving a problem with published data on *Epomophorus*. They also wish to thank two anonymous reviewers. The Zoological Museum of the University of Amsterdam thanks Dr. Nico van Strien for the donation of the Megachiroptera collected by him in Malawi.

LITERATURE CITED

- ANDERSEN, K. 1912. Catalogue of the Chiroptera in the collection of the British Museum. I. Megachiroptera. Trustees British Museum, London, ci + 854 pp.
- ANSELL, W. F. H. 1985. Mammals from Malawi, Part I. Nyala, 11: 18–24.
- ANSELL, W. F. H., and R. J. DOWSETT. 1988. Mammals of Malawi. An annotated check list and atlas. Trendrine Press, St. Ives, 4 + 170 pp., maps A–H, 1–180.
- BERGMANS, W. 1988. Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 1. General introduction; Material and methods; Results: The genus *Epomophorus* Bennett, 1836. Beaufortia, 38: 75–146.
- BERGMANS, W. 1989. Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 2. The genera *Micropteropus* Matschie, 1899, *Epomops* Gray, 1870, *Hypsiphatius* H. Allen, 1861, *Nanonycteris* Matschie, 1899, and *Plerotes* Andersen, 1910. Beaufortia, 39: 89–153.
- BERGMANS, W. 1994. Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 4. The genus *Rousettus* Gray, 1821. Beaufortia, 44: 79–126.
- BERGMANS, W. 1997. Taxonomy and biogeography of African fruit bats (Mammalia, Megachiroptera). 5. The genera *Lissonycteris* Andersen, 1912, *Myonycteris* Matschie, 1899 and *Megaloglossus* Pagenstecher, 1885; General remarks and conclusions; Annex: Key to all species. Beaufortia 47: 11–90.
- BERGMANS, W., and H. JACHMANN. 1983. Bat records from Malawi (Mammalia, Chiroptera). Bulletin Zoologisch Museum Universiteit van Amsterdam, 9: 117–122.
- CHITAU KALI, W. N., H. BURDA, and D. KOCK. 2001. On small mammals of the Nyika Plateau, Malawi. Pp. 415–426, in African small mammals (C. DENYS, L. GRANJON, and A. POULET, eds.). IRD Éditions, Paris, 570 pp.
- CLAESSENS, C. J., and F. DE VREE. 1990. Systematic and distributional notes on the larger species of the genus *Epomophorus* Bennett, 1836 (Chiroptera: Pteropodidae). Pp. 177–186, in Vertebrates

- in the tropics (G. PETERS and R. HUTTERER, eds.). Museum Alexander Koenig, Bonn, 424 pp.
- CLAESSEN, C. J., and F. DE VREE. 1991. Systematic and taxonomic notes on the *Epomophorus anurus-labiatus-minor* complex with the description of a new species (Mammalia: Chiroptera: Pteropodidae). *Senckenbergiana biologica*, 71: 209–238.
- GRUBB, P., T. S. JONES, A. G. DAVIES, E. EDBERG, E. D. STARIN, and J. E. HILL. 1998. Mammals of Ghana, Sierra Leone and The Gambia. Trendrine Press, St. Ives, vi + 265 pp., species distribution maps.
- HAPPOLD, D. C. D., and M. HAPPOLD, 1989. The bats (Chiroptera) of Malawi, Central Africa: Check-list and keys for identification. *Nyala*, 14: 89–112.
- HAPPOLD, M., and D. C. D. HAPPOLD, 1997. New records of bats (Chiroptera: Mammalia) from Malawi, east-central Africa, with an assessment of their status and conservation. *Journal of Natural History*, 31: 805–836.
- HAPPOLD, D. C. D., M. HAPPOLD, and J. E. HILL. 1987. The bats of Malawi. *Mammalia*, 51: 337–414.
- HARRISON, D. L. 1959. Report on the bats (Chiroptera) in the collection of the National Museum of Southern Rhodesia, Bulawayo. Occasional Papers of the National Museum of South Rhodesia, 23B: 217–231.
- KOCK, D., H. BURDA, W. N. CHITAUKALI, and M. J. OVERTON. 1998. *Plerotes anchietae* (Seabra, 1900) in Malawi, Central Africa (Mammalia: Chiroptera). *Zeitschrift für Säugetierkunde*, 63: 114–116.
- LARGEN, J. J., D. KOCK, and D. W. YALDEN. 1974. Catalogue of the mammals of Ethiopia. 1. Chiroptera. *Monitore Zoologico Italiano (N.S.)*, Supplement 5: 221–298.
- LAWRENCE, B., and A. LOVERIDGE. 1953. Zoological records of a fifth expedition to east Africa. 1. Mammals from Nyasaland and Tete; with notes on the genus *Otomys*. *Bulletin of the Museum of Comparative Zoology, Harvard*, 110: 1–80, 3 pls.
- MORRIS, B. 1964. Mammals of Zoa Estate, Cholo. *Nyasaland Journal*, 17: 71–78.
- OKIA, N. O. 1974. The breeding pattern of the eastern epauletted bat, *Epomophorus anurus* Heuglin, in Uganda. *Journal of Reproduction and Fertility*, 37: 27–31.
- SWEENEY, R. C. H. 1959. A preliminary annotated check list of the mammals of Nyasaland. The Nyasaland Society, Blantyre, 71 pp., 1 map.
- THOMAS, O. 1894. On the mammals of Nyasaland: Third contribution. *Proceedings of the Zoological Society of London*, 1894: 136–146.

Received 14 July 2004, accepted 16 October 2004