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A new species of *Chaerephon* (Molossidae) from Madagascar with notes on other members of the family

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We describe a species of *Chaerephon* (Molossidae) new to science from western Madagascar. This bat differs from the other two *Chaerephon* occurring on the island and from comparably sized African and Asian *Chaerephon* based on measurements, pelage and wing coloration, and cranial and dental characters. *Chaerephon* sp. nov. occurs at three sites in the drier western portion of the island. We also provide some natural history and distributional information on other Malagasy members of this family.

Key words: *Chaerephon*, Molossidae, new species, distributional records, western Madagascar

Introduction

The bats of Madagascar are poorly known. As currently understood, seven taxa represent the Molossidae fauna of the island: *Mormopterus jugularis*, *Tadarida fulmilans fulminans*, *Chaerephon leucogaster*, *C. pumilus*, *Mops leucostigma*, *M. midas miarensis*, and *Otomops madagascariensis* (Peterson *et al.,* 1995; taxonomy and spelling in accordance with Simmons, In press). Given the difficulty of capturing members of this family, few data are available about their distribution and natural history, even for the common commensal species.

On Madagascar two species of *Chaerephon* are currently recognized: *C. leucogaster* and *C. pumilus*. The former species often occurs as a commensal, living in man-made shelters, along the drier western coastal and inland areas and it is also reported from the eastern offshore island of Isle Sainte Marie (Peterson *et al.*, 1995). It can be found roosting in monospecific colonies or sharing sites with other molossid bats such as *M. jugularis* and *M. leucostigma*. *Chaerephon pumilus* occurs in areas of the humid east and central highlands and the vast majority of records are associated with human habitations (Peterson *et al.*, 1995). Its range at least partially overlaps with *M. jugularis* (see below).

During the course of biological inventories carried out over the past decade at different sites on the island (Fig. 1), particularly the western portion, we have captured a number of bats, including Molossidae. Amongst these collections is a species of *Chaerephon* that is unknown to science. The purpose of this paper is to describe the

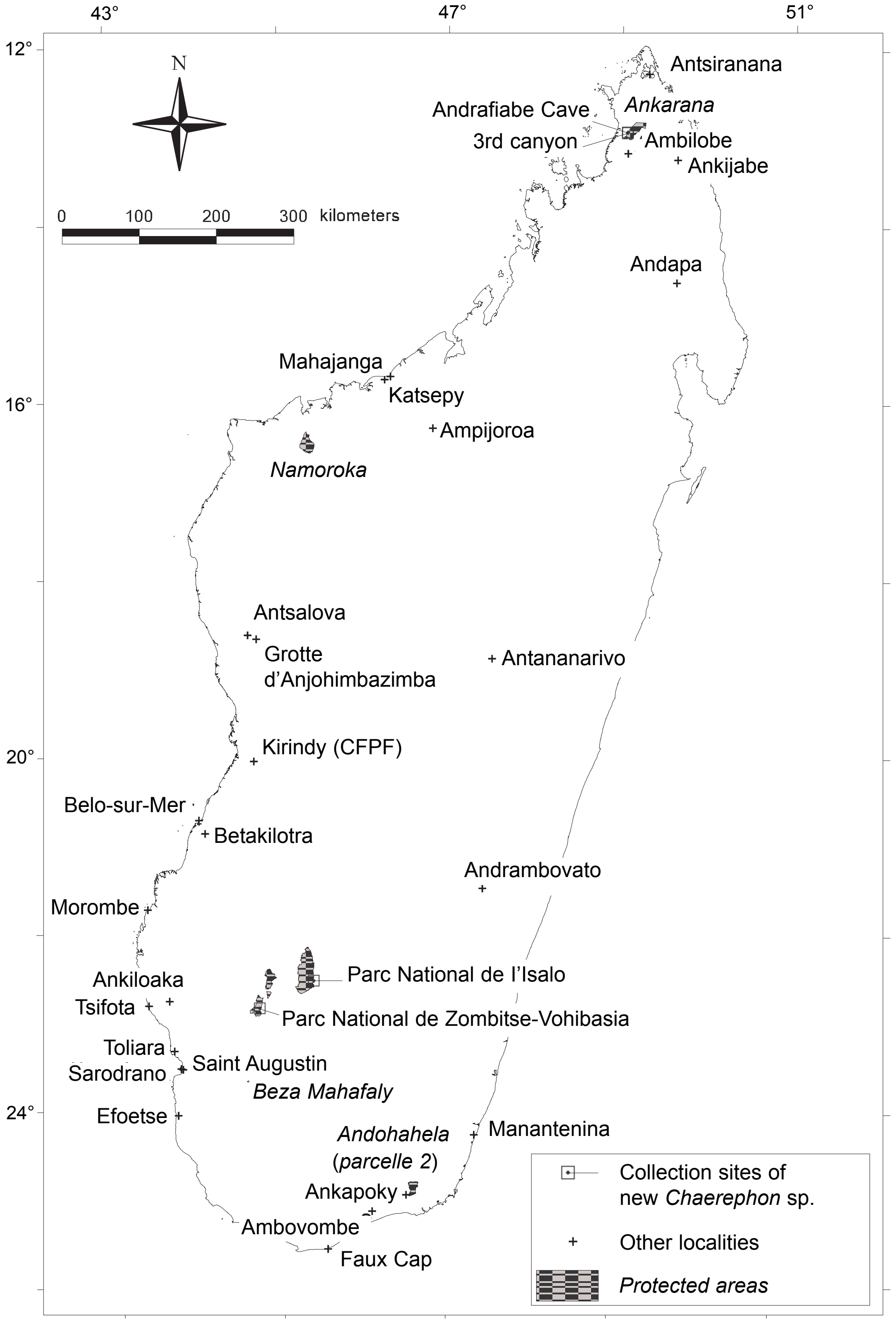

FIG. 1. Map showing sites at which *Chaerephon* sp. nov. has been collected as well as other localities mentioned in text

new taxon and present new distributional records and natural history information for Malagasy molossid bats.

MATERIALS AND METHODS

To investigate the taxonomic identity of the new species of Malagasy Molossidae we have consulted specimens housed in several natural history museums. The acronyms of these institutions are as follows: BMNH — The Natural History Museum, London (formerly British Museum of Natural History); FMNH — Field Museum of Natural History, Chicago; MNHN — Muséum National d'Histoire Naturelle, Paris; UADBA — Université d'Antananarivo, Département de Biologie Animale, Antananarivo; USNM — United States National Museum of Natural History, Washington, D.C.; and UWZM — University of Wisconsin Zoological Museum, Madison, Wisconsin.

We recorded six external measurements in millimeters from collected specimens before preparation. These included: total length, tail length, hind foot length (not including claw), ear length, and forearm length. Further, we measured body mass in grams using a spring balance. For certain taxa, SMG obtained these data directly from specimen labels or field catalogs in museum collections and not from animals we measured. SMG added the additional variable of head and body length from these museum sources. There are notable differences amongst field collectors in the techniques that they use to measure bats; most important for molossids is the difficulty of consistent tail measurements and hind foot length (with or without the claw). When tabulating descriptive statistics of external measurements for certain species (Table 1), we have in some cases only used measurements of a single collector – although this reduces sample size, it also decreases the range and variance of these measurements. SMG also took six wing measurements from liquid preserved specimens: 3rd digit metacarpal, 3rd digit 1st phalanx, 3rd digit 2nd phalanx, 4th digit metacarpal, 4th digit 1st phalanx, and 4th digit 2nd phalanx.

SMG measured seven cranial and five dental characters using digital calipers, accurate to the nearest 0.1 mm. The measurements and their definitions (derived largely from Freeman, 1981) are: greatest skull length: from posterior-most part of occipital to anterior-most point of the premaxillary bone; greatest zygomatic breadth: width taken across zygomatic arches at the widest point; lacrimal width: width across rostrum dorsally at lacrimal protuberances; mastoid breadth: greatest breadth across skull at mastoid processes; maxillary toothrow: length from anterior alveolar border of canine to posterior alveolar border of M^3; palatal length: from posterior border of hard palate to anterior edge of premaxillary bone; postorbital width: dorsal width at most constricted part of skull; post-palatal length: from posterior edge of hard palate, not including post-palatine process, to the midventral lip (basion) of the foramen magnum; upper canine height: greatest length from point immediately dorsal to cingulum to end of unbroken or unworn tooth; upper molariform row: length from PM^4 to M^3 (alveolar); upper toothrow: length from I^1 to M^3; and width M^3: greatest lateral-medial width of tooth. Further, one qualitative character associated with the palatal emargination, as presented in Freeman (1981: 15), was also recorded.

In order to help distinguish the new taxon of *Chaerephon* from other species in this genus of similar size, we conducted a discriminant function analysis followed by a canonical variates analysis in the statistical package SAS (PROC DISCRIM option CANONICAL; SAS, 1990). We used a nonparametric 3 nearest neighbor technique (option METHOD=NPAR K=3; SAS, 1990) for the discriminant function analysis because of the possible nonnormal distribution of our data. We calculated Mahalanobis distances between mean discriminant function centroids and present *F*-statistics for these distances along with canonical axes loadings and eigenvalues. We conducted separate analyses for skull, body, and wing measurements and excluded some skull measurements because missing values would otherwise have greatly reduced sample size for the analyses.

Herein we follow the generic classification of the Molossidae proposed by Freeman (1981) and subsequently adopted by Simmons (In press), in which *Chaerephon* is given generic status rather than considered a subgenus of *Tadarida*. As currently recognized the genus *Chaerephon* is composed of 18 species (Simmons, In press), distributed across most of the Old World. Several members of this genus are wide ranging. This includes *C. pumilus*, which occurs across much of Africa to the Middle East and on the islands of Boiko, São Tomé, Pemba, Zanzibar, Aldabra, Seychelles, and Madagascar. In contrast, other species, such as *C. gallagheri*, which is only known from the Democratic Republic of Congo, have limited continental ranges. There are several remote island endemics (e.g., *C. leucogaster* from Madagascar, *C. solomonis* from the Solomon Islands, and *C. tomensis* from São Tomé), which indicates that members of this genus are capable of dispersal over water and subsequent colonization and speciation on distant oceanic islands.

SYSTEMATIC DESCRIPTION

Chaerephon jobimena sp. nov.
(Figs. 2, 3, 4; Tables 1, 2)

Holotype — FMNH 169716, an adult ♂, collected on 23 January 2001 by Steven M. Goodman, field number SMG 11932. The specimen was prepared as a round study skin, with associated skull and partial post-cranial skeleton. The skin, skull, and post-cranial skeleton are in good condition. Tissue samples were preserved in EDTA. Measurement – external (in mm): total length 114, tail length 42, hind foot length (without claw) 7, ear length 23, forearm length 46; body mass: 15.5 g; skull: (in mm) greatest skull length 18.8, greatest zygomatic breadth 10.9, postorbital width 3.9, mastoid breadth 10.3, lacrimal width 6.2, post-palatal length 7.3, palatal length 7.8; dental (in mm): maxillary toothrow 6.6, upper molariform row 5.1, upper toothrow 7.8, width M^3 1.8, and upper canine height 2.9 (Table 1).

Etymology — The species epithet is derived from northern dialects of Malagasy, the region of the island the holotype was collected, with *joby* meaning dark or black and *mena* red. When formed as a compound word in Malagasy the 'y' in *joby* becomes an 'i'. The combination of these two words alludes to the two color morphs of this species.

Type locality — Madagascar: Province d'Antsiranana, Réserve Spéciale d'Ankarana, 2.6 km E Andrafiabe, in forest near Andrafiabe Cave, 12°55.9'S, 49°03.4'E, about 50 m a.s.l. (Fig. 1).

Habitat — The type specimen was captured in a harp trap placed on a small knoll about 35 m from the principal west entrance of Andrafiabe Cave. The habitat surrounding the site is dry semi-deciduous forest growing on basaltic soils and alluvial sediments at the base of the western edge of the limestone Ankarana Massif. The limestone in this area is largely eroded into pinnacle karst with solution flutes, stress fractures, and bedding planes. The forest becomes wooded savanna several hundred meters away from the capture site.

Diagnosis — A member of the genus *Chaerephon* (see Freeman, 1981; Peterson *et al*., 1995) given the following characters: tooth behind the canine in line with the canine; posterior upper molar with inverted 'N' shaped cusp; lips wrinkled; ears joined by band of skin. *Chaerephon jobimena* is a relatively robust molossid with an average forearm length of 46.5 mm, five upper cheek teeth, a notably elevated mandibular condyle, and a relatively constricted incisive foramina that is not included in any palatine emargination. It lacks the white wing patches characteristic of several members of this genus. Wing membranes and uropatagium are dark and show no notable change in fur coloration along lower inner edge of wing membrane. The dorsum and throat of *C. jobimena* is a uniform medium chocolate brown. On the mid- to lower-ventrum hairs become more broadly tipped with light brownish-gray, giving an indistinct grizzled gray appearance (Fig. 2). A rufous pelage phase also occurs. Interaural band forms complete connection between the ears.

Paratypes — Madagascar: Province de Toliara, Forêt de Zombitse, 22°51'S, 44°43'E, 870 m a.s.l., collected 18 April 1993 by S. M. Goodman and I. H. Rasolazaka — adult ♀, FMNH 151942 (SMG 5932); adult ♂, FMNH 151985 (SMG 5936). Madagascar: Province de Fianarantsoa, Parc National de l'Isalo, 3.8 km NW Ranohira, along Namaza River, 22°32.4'S, 45°22.8'E, 800 m a.s.l., collected 16–19 April 1999 by S. M. Goodman and D. Rakotondravony — adult ♀, FMNH 166075 (SMG 10990); adult ♂, FMNH 166076 (SMG 10991); adult ♀, FMNH

TABLE 1. External measurements (in mm) and body mass (in g) of *Chaerephon jobimena* and other members of this genus. Descriptive statistics presented as x̄ ± SD (minimum–maximum, *n*). Samples measured by a single field collector are in bold. *t*-test statistical comparisons of measurements of *C. jobimena* and *C. ansorgei* (sexes combined for each species) were conducted: ** — $P < 0.001$, *** — $P < 0.0001$

Species	Total length	Head and body length	Tail length	Hindfoot length	Ear length	Forearm length	Body mass
C. jobimena ♂♂	**112.3 ± 2.88**	–	**39.9 ± 5.86**	**7.9 ± 0.93**	**23.1 ± 0.93**	**46.7 ± 0.87**	14.6 ± 1.08
	(107–117, *9*)	–	**(32–51, *9*)**	**(7–9, *9*)**	**(22–24, *9*)**	**(46–48, *9*)**	(12.5–16.0, *9*)
♀♀	**111.0 ± 3.46**	–	**39.3 ± 4.93**	**8.0 ± 1.00**	**21.7 ± 0.58**	**46.0 ± 1.0**	14.2 ± 1.26
	(109–115, *3*)	–	**(36–45, *3*)**	**(7–9, *3*)**	**(21–27, *3*)**	**(45–47, *3*)**	(13.0–15.5, *3*)
♂♂+♀♀	**112.0 ± 2.92**	–	**39.8 ± 5.43**	**7.9 ± 0.90**	**22.8 ± 1.06**	**46.5 ± 0.90**	14.5 ± 1.09
	(107–117, *12*)	–	**(32–51, *12*)**	**(7–9, *12*)**	**(21–24, *12*)**	**(45–48, *12*)**	(12.5–16.0, *12*)
C. ansorgei	108.6 ± 3.85	–	35.6 ± 4.50	10.7 ± 1.36***	20.0 ± 0.71***	47, 50	–
	(104–112, *5*)	–	(28–40, *5*)	(9–12, *5*)	(19–21, *5*)	–	–
C. bemmeleni	110	–	40	12	17	47	–
C. bivittatus	**113.0 ± 3.87**	–	**38.6 ± 2.16**	**11.3 ± 0.79**	**20.6 ± 1.05**	**48.7 ± 1.74**	19.6 ± 3.54
	(106–119, *20*)	–	**(35–44, *20*)**	**(10–13, *20*)**	**(18–22, *20*)**	**(45–51, *18*)**	(15.0–28.0, *18*)
C. jobensis	112.3 ± 6.12	63.3 ± 2.08	39.3 ± 6.12	11.6 ± 6.12	19.8 ± 1.47	48.9 ± 1.13	21.0 ± 4.46
	(106–122, *11*)	(64–68, *3*)	(20–45, *15*)	(10–12, *13*)	(17–22, *15*)	(47–51, *15*)	(15.0–29.5, *13*)
C. johorensis	–	72, 76	35, 38	17, 18	17, 20	40, 44	23.0, 26.2
C. leucogaster	**88.4 ± 3.70**	–	**29.9 ± 1.88**	**6.9 ± 0.61**	**17.2 ± 0.43**	**36.2 ± 1.26**	9.4 ± 1.53
	(80–95, *21*)	–	**(26–33, *21*)**	**(6–8, *22*)**	**(17–18, *22*)**	**(33–38, *22*)**	(5.6–11.0, *18*)
C. nigeriae	–	69.7 ± 3.30	39.1 ± 4.46	6.3 ± 0.96	18.9 ± 1.18	47.5 ± 2.37	17.0
	–	(61–73, *10*)	(31–45, *10*)	(5–7, *4*)	(18–21, *7*)	(45–52, *6*)	–
C. plicatus	–	68.7 ± 1.42	39.1 ± 3.62	10.6 ± 0.82	20.1 ± 1.51	43.3 ± 0.58	–
	–	(67–71, *11*)	(30–44, *11*)	(9–11, *11*)	(16–21, *11*)	(43–44, *3*)	–
C. pumilus	**95.3 ± 3.16**	–	**35.2 ± 2.66**	8.3 ± 0.58	15.7 ± 3.51	**39.5 ± 0.71**	11.9 ± 1.26
	(90–99, *10*)	–	**(30–40, *10*)**	(8–9, *3*)	(12–19, *3*)	**(39–41, *10*)**	(9.5–14.0, *13*)
C. russatus	**100**[1]	**67.8**[1]	**33.1**[1]	**11.2**[1]	**20.2**[1]	**44.6**[1]	–
	(93–105, *24*)	**(62–73, *24*)**	**(29–36, *24*)**	**(10–13, *24*)**	**(19–22, *24*)**	**(42–46, *24*)**	–

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[1] — Taken from Allen (1917)

TABLE 1. Extended

Species	3rd digit metacarpal	3rd digit 1st phalanx	3rd digit 2nd phalanx	4th digit metacarpal	4th digit 1st phalanx	4th digit 2nd phalanx
C. jobimena ♂♂	42.5 ± 1.35	19.6 ± 0.84	16.8 ± 0.63	40.3 ± 1.06	15.4 ± 0.70	9.2 ± 1.35
	(41–45, *10*)	(18–20, *10*)	(16–18, *10*)	(39–42, *10*)	(14–16, *10*)	(7–11, *10*)
♀♀	41	19	16	40	16	9
C. ansorgei	44.0 ± 1.58**	19.6 ± 0.73	18.0 ± 0.79**	42.2 ± 1.48**	15.8 ± 0.67	10.6 ± 0.53**
	(42–46, *9*)	(18–20, *9*)	(16–19, *9*)	(41–45, *9*)	(15–17, *9*)	(10–11, *9*)
C. bemmeleni	42	18	17	40	15	10
C. bivittatus	47.2 ± 1.92	22.4 ± 1.14	20.0 ± 1.00	44.8 ± 0.84	17.2 ± 0.84	12.0 ± 0.71
	(45–50, *5*)	(21–24, *5*)	(19–21, *5*)	(44–46, *5*)	(16–18, *5*)	(11–13, *5*)
C. jobensis	43.8 ± 1.44	19.3 ± 0.83	19.2 ± 0.99	42.1 ± 1.13	15.1 ± 0.83	12.2 ± 1.00
	(41–46, *18*)	(18–21, *18*)	(18–21, *18*)	(41–45, *18*)	(13–16, *18*)	(11–14, *18*)
C. johorensis	42.7 ± 2.66	18.2 ± 1.17	16.5 ± 1.38	40.3 ± 1.86	14.3 ± 1.03	11.2 ± 0.75
	(40–46, *8*)	(17–20, *6*)	(15–18, *6*)	(38–42, *6*)	(13–16, *6*)	(10–12, *6*)
C. leucogaster	32.6 ± 1.33	13.7 ± 0.57	13.6 ± 0.51	31.3 ± 1.57	11.2 ± 0.55	9.4 ± 0.62
	(30–34, *18*)	(13–15, *18*)	(13–14, *18*)	(29–34, *18*)	(10–12, *18*)	(9–11, *18)*
C. nigeriae	45.9 ± 1.77	19.8 ± 1.42	19.1 ± 0.87	43.7 ± 1.35	16.1 ± 0.86	12.4 ± 1.01
	(42–48, *16*)	(17–23, *16*)	(18–21, *14*)	(41–46, *16*)	(15–18, *14*)	(11–14, *14*)
C. plicatus	–	–	–	–	–	–
C. pumilus	37, 38	15, 15	15, 15	34, 36	12, 13	9, 10
C. russatus	–	–	–	–	–	–

166077 (SMG 10998); adult ♂, UADBA 11501 (SMG 10999); adult ♂, UADBA 11502 (SMG 11000); adult ♂, FMNH 166100 (SMG 10968). Madagascar: Province de Fianarantsoa, Parc National de l'Isalo, 3.8 km NW Ranohira, along Namaza River, 22°32.4'S, 45°22.8'E, 800 m a.s.l., collected 1 December 2002 by S. M. Goodman and H. V. Razakarivony — adult ♂, FMNH 175992 (SMG 13344); adult ♂, FMNH 175993 (SMG 13345). Madagascar: Province d'Antsiranana, Réserve Spéciale d'Ankarana, Andrafiabe cave in 3rd canyon next to Andôkotôkana River (access to the Fitsangatsanganan'Ilay Olona Tôkana passage), 3.5 km SE Andrafiabe village, 12°56.5'S, 49°03.3'E, ca. 50 m a.s.l., collected 15 May 2003 by SMG and SGC — adult ♂, FMNH 176329 (SMG 13706). Madagascar: Province d'Antsiranana, Ankarana National Park [sic], west side of park, 'Grotte de Cathedral', collected 5 June 1995 by J. M. Hutcheon — adult ♀, UWZM 27547 (JMH 99). Madagascar: Province d'Antsiranana, Ankarana National Park [sic], west side of park, Grotte d'Andrafiabe, collected 7 June 1995 by J. M. Hutcheon — adult ♂, UWZM 27555 (JMH 107); adult ♂, UWZM 27556 (JMH 108); UWZM 27557 (JMH 109). All of these specimens were preserved in fluid and the skulls removed and cleaned, with the exceptions of FMNH 151985 that the complete cadaver was conserved in fluid and FMNH 151942 that was prepared as a round skin with associated skull and skeleton.

Description — In most adult individuals of *C. jobimena* the dorsal pelage is a dense and velvety rich medium chocolate brown with lightly tipped hairs, particularly on the mid-dorsum to rump, which gives an etched or slightly iridescent appearance. Basally the dorsal hairs are beige-white. In the holotype two small groups of white hair occur symmetrically on the dorsum posterior-laterally to the ear insertions; these patches are not apparent in the other specimens referable to this taxon. Ventrally, the throat is the

FIG. 2. Ventral view of the holotype of *C. jobimena* (FMNH 169716) obtained on 23 January 2001 near Andrafiabe Cave in the Réserve Spéciale d'Ankarana. (Photograph taken by Harald Schütz)

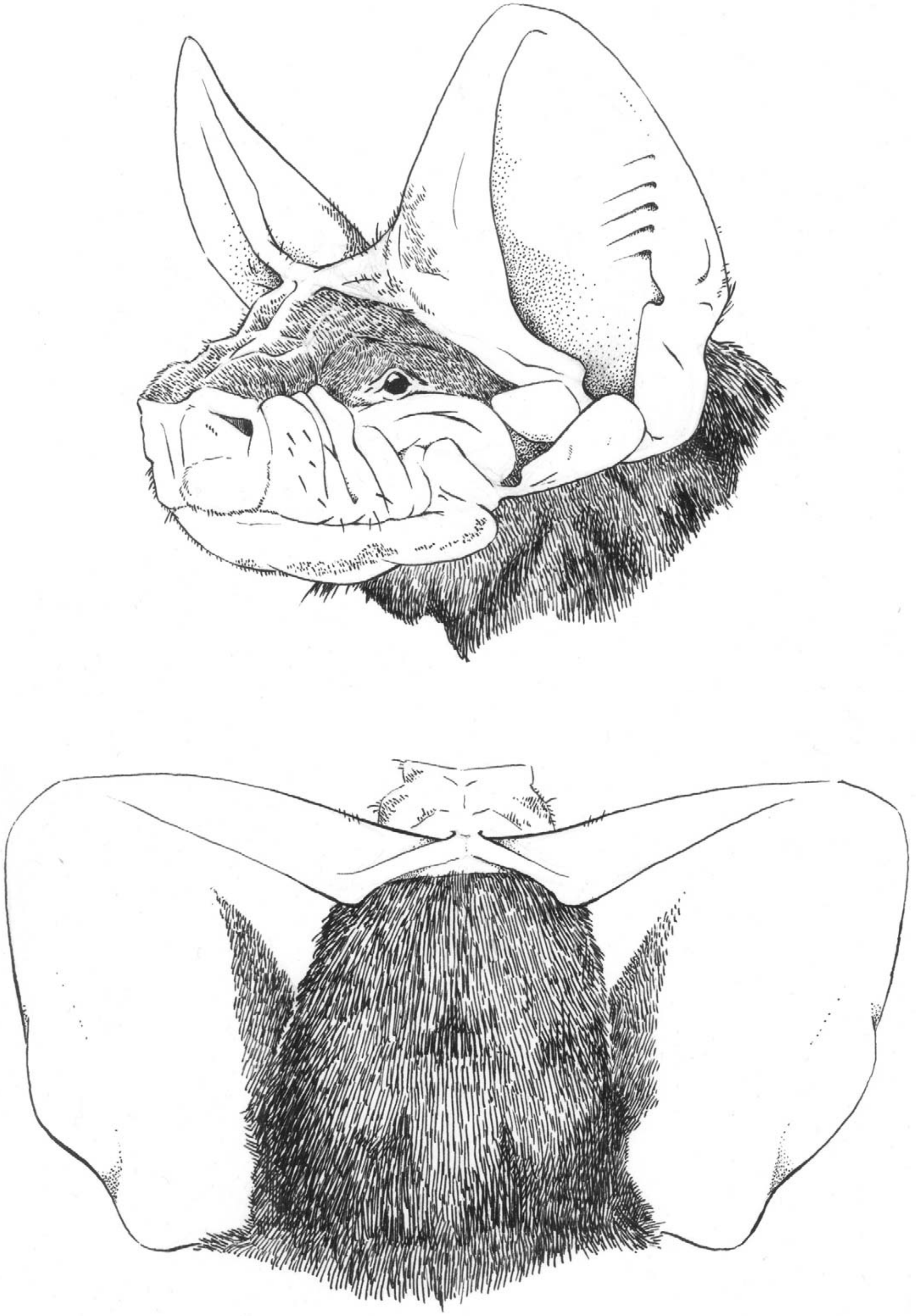

FIG. 3. Drawings of the head of *C. jobimena*. Upper: lateral view and lower: dorsal view. (Drawing made by Rebecca Kramer)

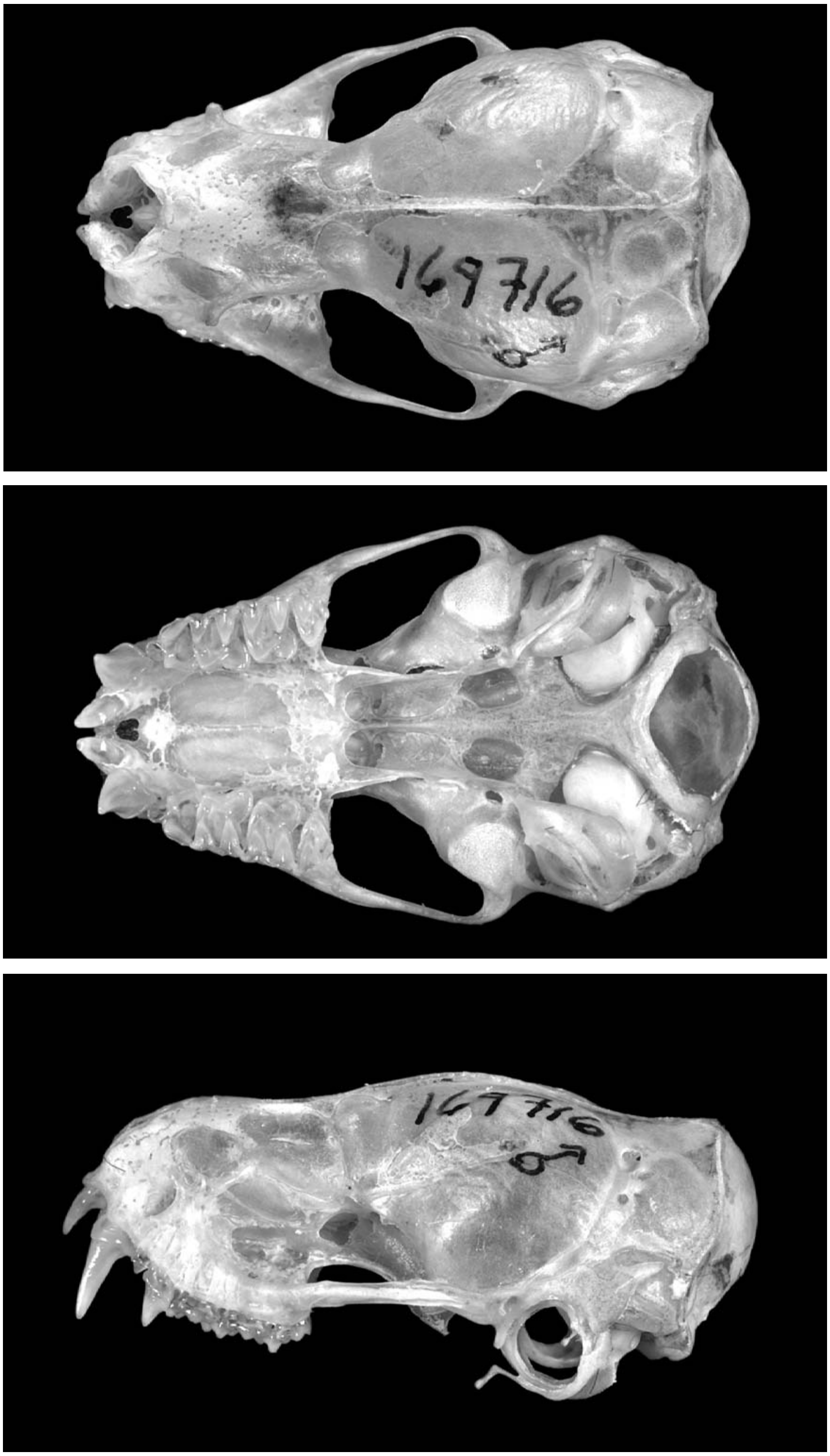

FIG. 4. Different views of cranium of *C. jobimena* (holotype FMNH 169716). Top — dorsal, middle — ventral, and bottom — lateral. (Photograph taken by John Weinstein, image number Z94380_04d)

same color as the dorsum, but at the level of the upper thoracic region there is a relatively abrupt change in pigmentation and the hairs become more broadly tipped light brownish-gray (Fig. 2). This transition is slightly diffused and does not form a distinctive throat collar. There is no notable change in fur coloration along the lower inner edge of the wing membrane. In three of the 12 adult specimens of *C. jobimena* the pelage coloration is distinctly rufous and this species shows two chromatic phases. Of 89 individuals captured for which color morph was recorded at Ankarana, 17 were rufous and 72 were dark; rufous males ($\bar{x}$ = 45.6 mm) had a shorter mean forearm than gray-colored males ($\bar{x}$ = 46.0). This species lacks the conspicuous postaural crest, interaural pocket, or glands at the base of the tail found in some other members of this genus (e.g., Allen, 1917; Hill, 1974; Kingdon, 1974; Harrison, 1975). The wing membrane and uropatagium are dark brownish-black. The muzzle is relatively blunt. The upper lips have approximately 5–6 wrinkles per side and a regular, but not dense, covering of hairs (Fig. 3).

The ears are notably longer in *C. jobimena* than in the two other species of *Chaerephon* occurring on Madagascar, but falling within the general range of several African and Asiatic species with comparable forearm lengths (Table 1). The pinnae of *C. jobimena* are relatively erect and partially supported by a well-developed anterior border (Fig. 3). There is a broad membrane connecting the ears, the center of which forms a shallow 'V'-shape. The antitragus is lobe-shaped and slightly asymmetric — measuring 5 mm (width) by 3 mm (height) — and the tragus is a minute spike-like structure hidden behind the antitragus.

The skull of *C. jobimena* is relatively robust, with a short broad rostrum, expanded braincase, and tapered postorbital constriction (Fig. 4). The lambdoidal crests are relatively well developed and the supraoccipital and frontal areas slightly inflated, giving the braincase a bulbous but not overly rounded appearance. No sagittal crest is present and the interorbital region has a slight depression. Lacrimal protuberances and infraorbital foramina are relatively well developed, and nasals are not inflated. Paired basisphenoid pits are present and moderately deep. Incisive foramina are in the form of two small holes directly behind the canines and with a narrow septum separating them and there is not a pronounced emargination of the palate (condition 1 of Taylor, 1999).

Distribution — This species is currently known from the northern end of Madagascar in the Réserve Spéciale d'Ankarana and in the southern central area from the Parc National d'Isalo and the Parc National de Zombitse-Vohibasia (Fig. 1).

COMPARISONS

Of the 18 species of *Chaerephon* recognized by Simmons (In press) the following species (generalized distribution in parentheses) fall within the approximate size range of *C. jobimena* (based on forearm length) and were measured and examined for comparison with this taxon: *C. ansorgei* (broad range in Africa), *C. bemmeleni* (broad range in Africa), *C. bivittatus* (eastern and southern Africa), *C. jobensis* (Moluccas, Indonesia, New Guinea, and Australia), *C. johorensis* (Malaya and Sumatra), *C. nigeriae* (broad range in Africa), *C. plicatus* (broad range in Asia and the Philippines, and has been recorded on Keeling Island), *C. pumilus* (broad range in Africa, and islands of Comoros, Madagascar, and Seychelles), and *C. russatus* (broad range in Africa). Other species were not included in these analyses because they are smaller than *C. jobimena* (*C. chapini*, *C. gallagheri*, *C. major*, *C. shortridgei*) or larger (*C. aloysiisabaudiae*) (Hayman and Hill, 1971; Kingdon, 1974; Koopman, 1994; Taylor, 1999, 2000; Fenton and Eger, 2002). A few taxa were not included in these comparisons because of their insular ranges that are distant from Madagascar (*C. bregullae*, *C. solomonis*, *C. tomensis*). Even though smaller than *C. jobimena*, the Malagasy endemic *C. leucogaster* is included herein for comparative purposes.

Other Malagasy members of the genus *Chaerephon* can be distinguished easily from *C. jobimena*. This latter species is notably larger in external and cranial characters than *C. leucogaster* (Tables 1 and 2), has a relatively uniform dark pelage, and dark wings. *Chaerephon pumilus* is smaller than *C. jobimena* in numerous external and cranial measurements (Tables 1 and 2) and has several pelage characters, such as the band of white hairs on undersides of wings, that readily differentiate these species. In contrast to east African populations, *C. pumilus* on Madagascar do not have distinctive white wing membranes. In addition, nonparametric discriminant function analysis followed by canonical variates analysis indicate that *C. pumilus* differs from *C. jobimena* based on skull, body, and wing measurement (Tables 3 and 4, Fig. 5).

Chaerephon jobimena can be distinguished from most extralimital African and Asiatic members of this genus with approximately the same forearm length (Table 1) by pelage characters (Hill, 1974; Kingdon, 1974; Bates and Harrison, 1997; Bonaccorso, 1998; Bouchard, 1998; Taylor, 1999, 2000; Willis *et al.*, 2002). *Chaerephon nigeriae* and *C. russatus* have well-developed postaural crests, which are not present in *C. jobimena*. Further, *C. nigeriae* has long white hairs on the back and flanks, at least in males, and whitish wing and interfemoral membranes. *Chaerephon bivittatus* has distinct white spots or short stripes on the head and shoulders. The pelage coloration in *C. russatus* is a uniform russet-brown to cinnamon-brown. In *C. jobensis* the dorsal fur is notably short and mottled brown with a white grizzled appearance. *Chaerephon bemmeleni* has nearly transparent wing tips, bands of white fur at the base of the lower wings, and well-developed glands at the base of the tail. The three species that show pelage characteristics that approach those of *C. jobimena* are *C. ansorgei* from Africa, and *C. johorensis* and *C. plicatus* from Asia. The latter two taxa are apparently closely related and are members of the same species group (Simmons, In press). All four species show dichromatism in pelage coloration with rufous and dark brown morphs. The throat hairs of *C. ansorgei* are generally elongated and dark, forming a sort of 'beard', although in some cases this pelage character appears to be rather variable (Rautenbach *et al.*, 1984), and the wing membranes are light in coloration and translucent. In dark individuals of *C. plicatus* the dorsum is generally a blackish-brown and the ventrum notably paler — the lower portion is edged with a gray wash. The dorsum in dark morphs of *C. jobimena* is a medium chocolate brown and notably lighter than in dark individuals of *C. plicatus*. On the basis of specimens that we have examined, individuals of each morph type tend to be lighter in *C. jobimena* than in the comparable morph of *C. johorensis* and *C. plicatus*.

Hill (1974) described the well-developed interaural band and pocket in *C. johorensis*, which is similarly developed in *C. plicatus*. In this species complex the pocket can be closed by an extension of the band that joins inner-anterior margins of the ears. The base of the pocket is largely without fur with the exception of a few long hairs on the anterior portion. *Chaerephon jobimena* does not possess this structure (Fig. 3).

The skulls of *C. jobensis*, *C. bivittatus*, *C. johorensis*, and *C. ansorgei* are notably

TABLE 2. Cranial and dental measurements (in mm) of *C. jobimena* and other members of this genus. Descriptive statistics presented as x̄ ± SD (minimum–maximum, *n*). Standard deviation is not presented for palate emargination, which is a qualitative character. *t*-test statistical comparisons of measurements of *C. jobimena* and *C. ansorgei* (sexes combined for each species) were conducted: * — $P < 0.05$, ** — $P < 0.001$, *** — $P < 0.0001$

Species	Greatest skull length	Greatest zygomatic breadth	Postorbital width	Mastoid width	Lacrimal width	Post-palatal length	Palatal length
C. jobimena ♂♂	18.8 ± 0.33 (18.4–19.4, *7*)	11.1 ± 0.28 (10.8–11.6, *7*)	3.9 ± 0.10 (3.8–4.1, *7*)	10.5 ± 0.17 (10.2–10.7, *7*)	6.2 ± 0.08 (6.1–6.3, *7*)	7.4 ± 0.33 (7.0–8.0, *7*)	7.7 ± 0.23 (7.3–8.0, *7*)
♀♀	18.2 ± 0.26 (18.0–18.2, *3*)	10.9 ± 0.15 (10.7–11.0, *3*)	3.9 ± 0.06 (3.8–3.9, *3*)	10.3 ± 0.06 (10.3–10.4, *3*)	6.2 ± 0.14 (6.1–6.3, *3*)	7.2 ± 0.15 (7.0–7.3, *3*)	7.3 ± 0.40 (6.9–7.7, *3*)
♂♂+♀♀	18.6 ± 0.41 (18.0–19.4, *10*)	11.0 ± 0.26 (10.7–11.6, *10*)	3.9 ± 0.09 (3.8–4.1, *10*)	10.4 ± 0.15 (10.2–10.7, *10*)	6.2 ± 0.08 (6.1–6.3, *10*)	7.3 ± 0.29 (7.0–8.0, *10*)	7.6 ± 0.32 (6.9–8.0, *10*)
C. ansorgei	19.3 ± 0.34** (18.8–19.7, *6*)	11.4 ± 0.27** (11.2–11.8, *7*)	4.0 ± 0.10* (3.9–4.2, *8*)	10.8 ± 0.20*** (10.5–11.1, *6*)	6.6 ± 0.35** (6.0–7.1, *7*)	7.5 ± 0.35 (6.8–7.9, *7*)	7.8 ± 0.29 (7.3–8.1, *7*)
C. bemmeleni	18.3, 18.8	11.1, 11.3	4.0, 4.1	10.4, 11.0	6.9, 6.9	6.5, 7.0	7.6, 8.0
C. bivittatus	19.9 ± 0.57 (18.8–20.6, *18*)	12.1 ± 0.53 (11.0–12.7, *18*)	4.1 ± 0.20 (3.8–4.4, *18*)	11.3 ± 0.47 (10.5–11.8, *8*)	7.0 ± 0.51 (6.3–7.7, *16*)	7.6 ± 0.23 (7.1–8.1, *18*)	8.4 ± 0.33 (7.7–9.0, *18*)
C. jobensis	20.8 ± 0.68 (19.3–22.0, *15*)	12.1 ± 0.56 (11.3–13.4, *16*)	4.1 ± 0.14 (3.8–4.3, *15*)	11.3 ± 0.61 (10.6–12.5, *15*)	7.4 ± 0.38 (6.9–8.2, *11*)	8.0 ± 0.40 (7.2–8.0, *15*)	8.3 ± 0.32 (7.9–9.0, *16*)
C. johorensis	20.0 ± 1.17 (18.8–21.4, *5*)	11.7 ± 1.36 (10.4–13.3, *5*)	4.5 ± 0.17 (4.3–4.7, *7*)	11.1 ± 1.06 (10.1–12.3, *5*)	6.7 ± 0.82 (6.0–7.8, *6*)	6.7 –	7.5 ± 0.29 (7.1–7.9, *5*)
C. leucogaster	15.7 ± 0.39 (14.9–16.3, *23*)	9.6 ± 0.28 (9.0–10.2, *25*)	3.4 ± 0.10 (3.2–3.6, 27)	9.1 ± 0.23 (8.7–9.6, *24*)	5.5 ± 0.23 (5.1–5.9, *26*)	6.2 ± 0.21 (5.8–6.6, *24*)	6.2 ± 0.30 (5.3–6.8, *27*)
C. nigeriae	19.3 ± 0.43 (18.7–20.0, *8*)	12.0 ± 0.30 (11.4–12.4, *11*)	3.9 ± 0.18 (3.6–4.2, *12*)	10.9 ± 0.18 (10.7–11.2, *9*)	6.8 ± 0.27 (6.3–7.3, *11*)	7.3 ± 0.34 (6.8–7.1, *7*)	8.5 ± 0.32 (8.2–9.2, *11*)
C. plicatus	19.1 ± 0.50 (18.1–19.6, *11*)	10.9 ± 0.36 (10.1–11.4, *12*)	3.7 ± 0.19 (3.4–4.1, *14*)	10.1 ± 0.26 (9.7–10.4, *11*)	6.8 ± 0.38 (6.4–7.5, *13*)	7.0 ± 0.32 (6.4–7.5, *11*)	7.9 ± 0.31 (7.4–8.5, *13*)
C. pumilus	17.4 ± 0.32 (16.9–17.9, *14*)	10.6 ± 0.21 (10.3–10.9, *14*)	3.7 ± 0.13 (3.5–3.9, *14*)	10.0 ± 0.20 (9.6–10.3, *14*)	6.1 ± 0.22 (5.7–6.4, *11*)	6.6 ± 0.18 (6.3–6.9, *13*)	7.0 ± 0.38 (6.5–7.8, *14*)
C. russatus	18.5 (17.8–19.4, *23*)	11.0[1] (10.5–11,4, *23*)	– 3.9, 4.2	– 10.3, 10.6	– 6.1, 6.1	– 7.1, 7.7	– 7.2, 7.3

[1] — Taken from Allen (1917)

TABLE 2. Extended

Species	Maxillary toothrow	Upper molariform row	Upper toothrow	Width M^3	Height upper canine	Palate emargination
C. jobimena ♂♂	6.8 ± 0.20	5.0 ± 0.16	7.9 ± 0.16	1.9 ± 0.08	2.7 ± 0.17	–
	(6.6–7.2, *7*)	(4.8–5.3, *7*)	(7.8–8.3, *7*)	(1.8–2.0, *7*)	(2.5–2.9, *3*)	–
♀♀	6.5 ± 0.06	4.9 ± 0.21	7.5 ± 0.15	1.9 ± 0.10	2.4 ± 0.16	–
	(6.4–6.5, *3*)	(4.7–5.1, *3*)	(7.4–7.7, *3*)	(1.8–2.0, *3*)	(2.3–2.5, *3*)	–
♂♂+♀♀	6.7 ± 0.23	5.0 ± 0.18	7.8 ± 0.25	1.9 ± 0.08	2.6 ± 0.21	–
	(6.4–7.2, *10*)	(4.7–5.3, *10*)	(7.4–8.3, *10*)	(1.8–2.0, *10*)	(2.3–2.9, *10*)	–
C. ansorgei	7.1 ± 0.21***	5.5 ± 0.25***	8.2 ± 0.23**	2.2 ± 0.07***	2.9 ± 0.22*	1.7
	(6.8–7.5, *9*)	(5.2–5.9, *9*)	(8.0–8.6, *7*)	(2.0–2.2, *8*)	(2.7–3.3, *6*)	(1–2, *7*)
C. bemmeleni	5.0, 5.0	6.7, 6.7	7.8, 8.1	2.0, 2.1	2.3, 2.5	2, 2
C. bivittatus	7.4 ± 0.23	5.4 ± 0.21	8.7 ± 0.31	2.2 ± 0.10	3.0 ± 0.29	2.0
	(7.0–7.7, *18*)	(5.0–5.7, *18*)	(8.2–9.2, *18*)	(2.0–2.3, *18*)	(2.7–3.7, *18*)	(2–2, *18*)
C. jobensis	7.6 ± 0.28	5.9 ± 0.45	8.8 ± 0.33	2.3 ± 0.20	3.2 ± 0.37	1.3
	(6.9–8.0, *16*)	(5.1–6.4, *16*)	(8.1–9.4, *15*)	(1.9–2.8, *16*)	(2.7–4.1, *15*)	(1–2, *13*)
C. johorensis	6.9 ± 0.40	5.4 ± 0.34	7.6 ± 0.22	2.1 ± 0.11	2.6 ± 0.22	1.2
	(6.5–7.6, *7*)	(5.1–6.0, *7*)	(7.3–7.6, *5*)	(1.9–2.2, *7*)	(2.4–3.0, *7*)	(1–2, *5*)
C. leucogaster	5.6 ± 0.19	4.6 ± 0.23	–	1.7 ± 0.11	2.3 ± 0.20	0.9
	(5.3–6.0, *27*)	(4.1–4.9, *27*)	–	(1.3–1.9, *27*)	(1.9–2.8, *27*)	(0–1, *27*)
C. nigeriae	7.3 ± 0.66	5.4 ± 0.18	8.6 ± 0.22	2.2 ± 0.10	3.2 ± 0.23	1.9
	(5.2–7.8, *13*)	(5.2–5.7, *12*)	(8.3–9.0, *12*)	(2.0–2.3, *13*)	(2.9–3.6, *11*)	(1–2, *9*)
C. plicatus	6.7 ± 0.19	5.0 ± 0.13	8.0 ± 0.28	2.0 ± 0.15	2.9 ± 0.41	1.1
	(6.4–7.1, *14*)	(4.7–5.3, *14*)	(7.5–8.6, *14*)	(1.7–2.2, *14*)	(2.3–3.7, *14*)	(0–2, *9*)
C. pumilus	6.3 ± 0.19	5.0 ± 0.21	7.4 ± 0.22	1.8 ± 0.17	2.7 ± 0.22	0.9
	(5.9–6.5, *14*)	(4.6–5.4, *14*)	(7.1–7.7, *14*)	(1.5–2.2, *14*)	(2.4–3.0, *14*)	(0–2, *10*)
C. russatus	6.6, 6.7	4.8, 5.4	7.7, 7.8	1.9, 2.0	2.4, 2.7	1, 1

longer and more robust that *C. jobimena* (Table 2). Further, the first four species have prominent anterior and posterior sagittal crests, and in *C. jobimena* only the anterior crest is slightly developed. The interorbital depression is absent in *C. jobensis* and *C. bivittatus*, is slightly developed in *C. ansorgei* and *C. johorensis*, and more prominent in *C. jobimena*. A lambdoidal crest, slightly inflated frontals, prominent lacrimal protuberances, and moderately developed basisphenoid pits, the latter of which are deeper in *C. russatus*, are found in all members of this genus. The supraoccipital region of *C. jobimena* is more inflated that in any other species of this genus, with the exception of *C. russatus* and *C. bemmeleni*.

On the basis of general size and pelage coloration, *C. jobimena* is similar in measurements and pelage coloration (see above) to the species *C. ansorgei*, which occurs in the southern portion of Africa south of 12°N latitude (Eger and Peterson, 1979). A number of morphological characters clearly distinguish these two species, including external, cranial, and dental measurements (Tables 1 and 2). In addition, results of nonparametric discriminant function analysis followed by canonical variates analysis indicate that *C. ansorgei* differs from *C. jobimena* based on body and wing measurements and possibly on skull measurements (Tables 3 and 4, Fig. 5). Further, adult male and female *C. jobimena* are lighter in body mass than *C. ansorgei* — in the former species (Table 1) males weigh on average 14.6 g (range 12.5–16.0, $n = 9$) and females 14.2 (range 13.0–15.5, $n = 3$), and in the latter species (Eger and Peterson, 1979) males weigh on average 16.5 g (range 12.5–22.0, $n = 24$) and females 15.8 (range 9.0–22.0, $n = 46$). Thus, based on these characters, *C. jobimena* and *C. ansorgei* are demonstratively different from one another.

NATURAL HISTORY

Chaerephon jobimena is currently known from three sites on Madagascar, all of which are in zones with various types of dry deciduous forest. Further, two of the three sites are in areas with large rock outcrops, filled with crevices and caves potentially suitable as bat roosts.

The northernmost site, near the extreme north of the country, is the Réserve Spéciale d'Ankarana, which encompasses a massif of middle Jurassic limestone. This karstic zone measuring about 25 km long and 8 km wide is a myriad of caves, pinnacle karst, and canyons (Cardiff and Befourouack, 2003). We have inventoried numerous caves across the central portion of the massif and *C. jobimena* has only been found at three

TABLE 3. Morphological differences between *C. jobimena*, *C. ansorgei*, and *C. pumilus* based on nonparametric discriminant function analysis. Mahalanobis distances between discriminant function centroids differ according to the given *F*-statistics and probabilities (*P*). Differences in data availability for given specimens required the use of only select skull measurements and of separate discriminant analyses for skull, body, and wing measures. Skull characters used in the discriminant function analysis are listed in Table 4. Probabilities are approximate given small sample sizes

Analysis category		*F*-statistics by species matrices	
		C. ansorgei	*C. jobimena*
Skull (*d.f.* = 29)	*C. jobimena*	2.12 ($P < 0.09$)	–
	C. pumilus	4.73 ($P < 0.01$)	3.62 ($P < 0.01$)
Body (*d.f.* = 16)	*C. jobimena*	3.61 ($P < 0.04$)	–
	C. pumilus	16.51 ($P < 0.001$)	37.25 ($P < 0.001$)
Wing (*d.f.* = 21)	*C. jobimena*	4.98 ($P < 0.01$)	–
	C. pumilus	15.16 ($P < 0.001$)	16.26 ($P < 0.001$)

sites (main Andrafiabe Cave entrance in western cliff, the Andrafiabe cave in 3rd canyon next to Andôkotôkana River, and the Andrafiabe cave in the 2nd canyon). These three localities are within a radius of 2 km of one another, are connected by the Andrafiabe cave complex, are all close to the western face of the massif, and are within several hundred meters of the ecotone between dry semi-deciduous forest and anthropogenic savanna. All individuals of this species captured at Ankarana were exiting caves after sunset and in the early hours of night. The known bat fauna of the Réserve Spéciale d'Ankarana is composed of 14 documented species (Goodman *et al*., In press).

The most central site at which we have recorded *C. jobimena* is in the Parc National de l'Isalo, a sandstone massif that has been heavily eroded and down-cut by water action. Specimens from this area were captured during two different field trips, both at the same exact locality in the Namaza River valley. The Namaza River starts as a dead-end canyon deep within the massif, with towering cliff faces about 150 m tall. The site from which the bats were obtained, is situated just after the termination of the cliff face; all individuals were netted soon after dark, over the river, and in a direction exiting the canyon. Near the capture site there is gallery forest growing along the river's banks and about 250 m downstream the

TABLE 4. Loadings of canonical axes 1 and 2 (C1 and C2) from canonical variates analysis for skull, body, and wing characters of *C. jobimena*, *C. ansorgei*, and *C. pumilus*. Eigenvalues represent the variation among species centroids explained by each axis. The data used are the same used in the discriminant function analysis (Table 3). Missing data for some specimens required the use of only select skull measurements and of seperate analyses for skull, body, and wing measures. Loadings suggest that upper toothrow, maxillary toothrow, total length, forearm length, hindfoot length, third digit first phalanx, and fourth digit second phalanx are important in distinguishing the species

Character category	Measure	C1	C2
Skull	Greatest zygomatic breadth	0.840	-0.006
	Postorbital width	0.858	-0.153
	Lacrimal width	0.762	0.123
	Maxillary toothrow	0.947	0.016
	Upper molariform row	0.700	0.400
	Upper toothrow	0.961	0.046
	Width M^3	0.769	0.460
	Eigenvalues	1.797	0.626
	% variation explained	74.2	25.8
Body	Total length	0.821	-0.311
	Tail length	0.274	-0.525
	Hindfoot length	-0.083	0.844
	Ear length	0.877	-0.255
	Forearm length	0.911	0.398
	Eigenvalues	18.708	1.636
	% variation explained	92.0	8.0
Wing	Third digit metacarpal	0.749	0.471
	Third digit first phalange	0.938	0.064
	Third digit second phalange	0.574	0.667
	Fourth digit metacarpal	0.792	0.537
	Fourth digit first phalange	0.853	0.223
	Fourth digit second phalange	0.051	0.763
	Eigenvalues	7.188	2.12
	% variation explained	77.2	22.8

natural vegetation shifts to a narrow band of dry deciduous forest and then anthropogenic savanna. A total of 12 bat species have been recorded within this park (Goodman *et al.*, In press).

The third site from which we have obtained material of *C. jobimena* is the transitional dry deciduous-spiny bush forest of the Parc National de Zombitse-Vohibasia. Here the forest rests on alluvium soils with little topographic variation, and we are unaware of any rock outcrops in the vicinity of the capture site. The specimen of *C. jobimena* reported on from this site was previously identified as *C. pumilus* (Rasolozaka, 1994). The bat fauna of the Zombitse-Vohibasia forest is composed of 10 species (Goodman *et al.*, In press).

We suspect that with further exploration of western Madagascar, particularly in

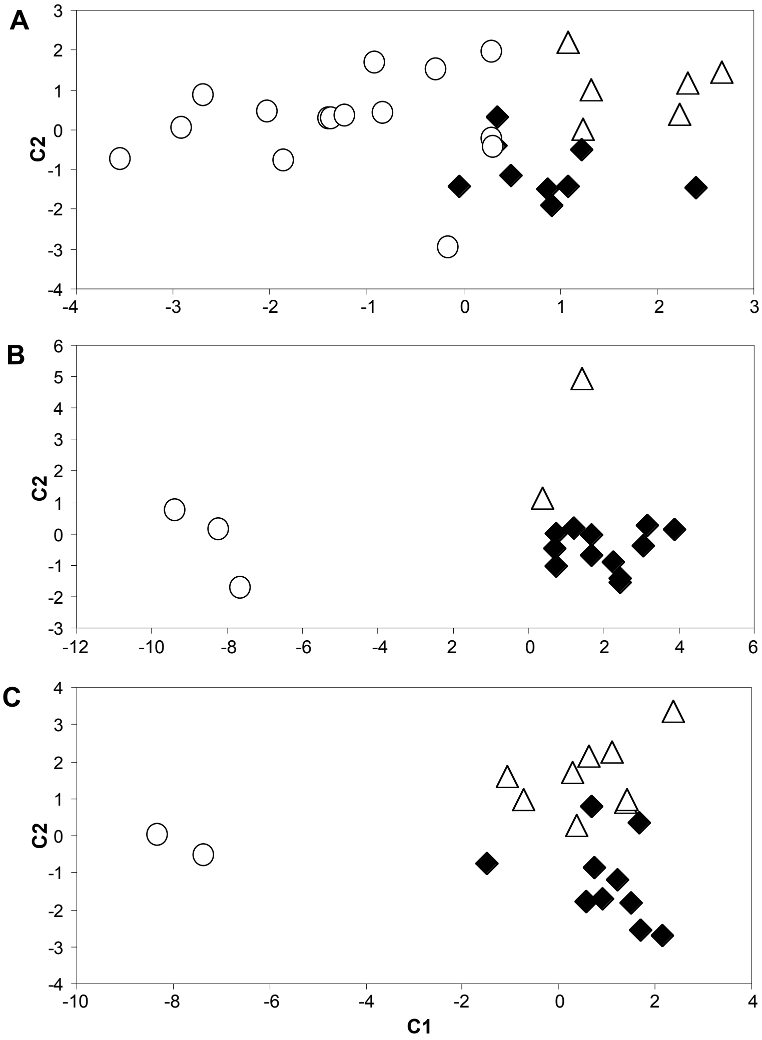

FIG. 5. Canonical variates analysis axes scores for skull (A), body (B), and wing (C) measurements for specimens of *Chaerephon ansorgei* (△), *C. jobimena* sp. nov. (◆), and *C. pumilus* (○). Missing values for some specimens required the separate analysis of skull, body, and wing measurements and the use of only select skull measures. Axes are scaled relative to their eigenvalues. Loading contribution of variables to each axis are shown in Table 4

zones with water-cut rock outcrops, researchers will find *C. jobimena* at other sites. All three of the currently known localities for this species are within protected areas.

RECORDS OF OTHER MOLOSSIDAE ON MADAGASCAR

Over the course of the past decade SMG and others have visited a number of sites to inventory bats and have captured numerous molossids. We present here, by species, records that add information to the distribution and natural history of this group, as summarized by Peterson *et al*. (1995) and Eger and Mitchell (2003). We also present information on Malagasy specimens held in natural history museums not associated with our recent inventories on the island. We present coordinates, elevation, and habitat types of these different sites (Fig. 1, Appendix). Unless otherwise stated, all records are represented by voucher specimens held in the Field Museum of Natural History and/or The Université d'Antananarivo, Département de Biologie Animale.

Mormopterus jugularis. Peterson *et al*. (1995) reported this endemic and largely commensal species from a range of sites from eastern, central, southwestern, and southern Madagascar, but not from western Madagascar. We have captured it at several sites in areas of dry habitat, most in the western portion of the island (listed north to south): Andrafiabe/Cathedral Cave (Ankarana), Ankijabe (Daraina), Ambilobe (with *Mops leucostigma*), several sites in Isalo (Namaza River, Canyon des Singes, along Menamaty River), Efoetse (Tsimanampetsotsa), and Andohahela (parcel II). The vast majority of these individuals were found at roost sites in caves or buildings. There are also specimens (USNM) from the southern portion of the island captured at Faux Cap, Ankapoky, Tsihombe, and Ambovombe. In portions of the east specimens of *M. jugularis* came from the village of Andapa, within 100 m of another colony of *C. pumilus* (FMNH and UADBA); in the train station of Andrambovato, along the eastern escarpment and in a zone largely surrounded by forest (FMNH and UADBA); and in a building at Manantenina (USNM). In November 2003 in the Parc National de Midongy du Sud a small colony of less than 10 individuals of *M. jugularis* was found inhabiting a rock fissure along a boulder-strewn river wash. This locality is within eastern humid forest, at least 4 km from the forest edge, and bears evidence of the type of roosting site that this species naturally occupies in this habitat type.

During a late January 2001 visit to Cathedral Cave (an extension of the Andrafiabe Cave system) in Ankarana, we found *M. jugularis* at the end of its breeding season. Near the entrance of the cave was a nursery colony with an estimated 1,000 young nearly capable of flying but still with subadult dentitions, as milk teeth were present. Close to 100 dead and dying young were found on the cave floor in a zone with sticky mud. Several of these individuals had large and partially hardened mud balls attached to their feet. These balls presumably formed after the bats dropped to the cave floor, crawled along the ground, and were unable to reach a vertical surface before they became too laden with mud.

Tadarida f. fulminans. The holotype (BMNH 82.3.1.34) of the nominate form, which is considered endemic to Madagascar, was collected in the vicinity of Fianarantsoa by Rev. W. D. Cowan (Thomas, 1903) and there had been no subsequent record of it on Madagascar (Peterson *et al*., 1995) until 1999. In mid-April of that year, SMG captured two individuals referable to this species along the Namaza River, Parc National de l'Isalo. One of these individuals, which was saved as a voucher specimen

(FMNH 166074), was compared to the holotype of *T. f. fulminans* in the BMNH, and found to be similar to one another in general shape and cranial and dental measurements (Table 5).

The Madagascar specimens were compared to a small series of *T. fulminans* collected in Kenya and Tanzania and Mozambique, the former being notably larger in external measurements than the eastern African specimens (Table 5). Given the general similarity in cranial measurements among these specimens, we assume the variation in external characters can be attributed to different techniques the field collectors used to measure the specimens. For the most part the cranial variables for the two Malagasy specimens tend to be towards the upper limit or slightly larger than the Kenya-Tanzania material. In contrast the specimens from Mozambique tend to be larger than the Madagascar material. The white ventral pelage coloration of the Kenyan material is often restricted to a relatively narrow portion of the mid-venter area and is similar to that in the Isalo specimen. In contrast, specimens referable to *T. f. mastersoni* from Mozambique have much more extensive white on the venter, almost reaching the lower flanks in a few specimens.

The site at which we captured the Isalo specimens of *T. fulminans* was over a river at the entrance of a deep sandstone canyon. The habitat type fits that of African populations of this species, which authors have noted to occur in granite regions with high and steep-sided inselbergs, and to be distinctly rupicolous (Cotterill, 2001).

Chaerephon leucogaster. Peterson *et al.* (1995) listed a few records of this species from the western coastal area of the island, to which we can add the following sites (listed north to south): Ambilobe (with *M. jugularis*), Katsepy (with *M. leucostigma*), Antsalova (with *M. leucostigma*), Kirindy

TABLE 5. Measurements of adult *Tadarida fulminans* from Madagascar (including holotype for which cranial measurements are only available), eastern Africa (Tanzania and Kenya), and Mozambique. Statistics presented as $\bar{x}$ ± SD (minimum–maximum, *n*)

Sample	Total length	Tail length	Hindfoot length	Ear length	Forearm length	Body mass	Greatest skull length	Greatest zygomatic breadth
Holotype								
T. f. fulminans (BMNH 82.3.1.34)	–	–	–	–	–	–	23.0	13.7
T. f. fulminans ♀ from Isalo (FMNH 166074)	152	61	11	21	61	27.5	23.4	13.4
Kenya and Tanzania (3 ♂♂ and 4 ♀♀)	138.8 ± 5.98 (131–149, *6*)	52.3 ± 4.31 (46–58, *7*)	12.0 ± 1.73 (10–14, *7*)	22.2 ± 1.63 (19.5–24, *7*)	57.3 ± 3.06 (54–60, *3*)	27.2 ± 2.95 (23–31, *5*)	22.5 ± 0.47 (21.9–23.2, *5*)	13.1 ± 0.27 (12.7–13.5, *6*)
Mozambique (5 ♂♂ and 2 ♀♀)	136.7 ± 4.68 (131–144, *7*)	51.9 ± 3.34 (47–58, *7*)	12.0 ± 0.82 (11–13, *7*)	22.6 ± 0.98 (21–24, *7*)	– –	– –	23.2 ± 0.36 (22.6–23.6, *6*)	13.8 ± 0.25 (13.4–14.1, *6*)

TABLE 5. Extended

Sample	Postorbital width	Mastoid breadth	Lacrimal width	Post-palatal length	Palatal length	Maxillary toothrow	Molariform row	Upper toothrow
Holotype								
T. f. fulminans (BMNH 82.3.1.34)	4.9	13.0	8.5	9.6	9.3	8.7	6.4	10.0
T. f. fulminans from Isalo (FMNH 166074)	4.6	12.9	8.4	10.1	9.8	8.8	6.4	10.1
Kenya and Tanzania	5.2 ± 0.23 (5.0–5.7, *7*)	13.0 ± 0.33 (12.6–13.5, *6*)	7.9 ± 0.23 (7.7–8.3, *6*)	9.7 ± 0.53 (9.0–10.5, *6*)	8.6 ± 0.23 (8.3–8.8, *6*)	8.2 ± 0.23 (7.8–8.5, *7*)	6.0 ± 0.11 (5.9–6.2, *7*)	9.4 ± 0.28 (9.1–9.8, *6*)
Mozambique	5.1 ± 0.06 (5.0–5.2, *6*)	13.4 ± 0.26 (13.1–13.7, *6*)	8.7 ± 0.35 (8.1–9.0, *6*)	10.1 ± 0.22 (9.8–10.4, *6*)	9.3 ± 0.20 (8.9–9.4, *6*)	8.9 ± 0.26 (8.4–9.1, *6*)	6.5 ± 0.01 (6.4–6.6, *6*)	10.1 ± 0.22 (9.7–10.3, *6*)

(CFPF), Belo-sur-Mer, Betakilotra (Kirindy-Mitea), Morombe, Ankiloaka (with *M. leucostigma*), and Ranobe (with *M. leucostigma*). The vast majority of these records are individuals captured at roost sites in buildings. There are few records of this species in the wild.

On 16 November 2002 a pregnant female *C. leucogaster* was obtained near the village of Betakilotra. The animal was found roosting under the exfoliating bark of a standing dead tree, about 5 m off the ground, and in a sandy valley with agricultural fields and stands of massive baobab trees. Three other members of this species flew off from the site.

Chaerephon pumilus. Peterson *et al.* (1995) noted records from central portion of the eastern escarpment. We captured a single individual of this species in the village of Andapa in the northern portion of the eastern humid forest. In the same village was a roost of *M. jugularis*. This record is the westernmost we are aware of for *C. pumilus* on the island.

Mops leucostigma. The only record of this species from the drier portions of Madagascar, presented by Peterson *et al.* (1995), was from Ampijoroa, inland from Mahajanga. We have collected it at the following sites (listed north to south): Ambilobe (near colonies of *M. jugularis* and *C. leucogaster*), Katsepy (with *C. leucogaster*), Antsalova (with *C. leucogaster*), Kirindy (CFPF), Ankiloaka (with *C. leucogaster*), Tsifota, Ranobe, and Saint Augustin. All of these records are associated with human-built structures, except at Kirindy (CFPF). At this locality, *M. leucostigma* was obtained flying over a small waterhole along the Kirindy River in a large area of dry deciduous forest.

Mops midas miarensis. Previously there were few records of this Malagasy endemic subspecies (Peterson *et al.*, 1995). In recent years it has been netted in the Parc National de Zombitse-Vohibasia (Rasolozaka, 1994), identified from Barn Owl (*Tyto alba*) pellets collected near the Réserve Spéciale de Beza Mahafaly (Goodman *et al*., 1993), found roosting in the attic of a house in Ambovombe (USNM), and netted near Ranobe (FMNH) just outside of a building housing a colony of *C. leucogaster* and *M. leucostigma* (H. Thomas, pers. comm.). The locality reported for a specimen of this species in southwestern Madagascar at the site of 'Tamabuc' (Peterson *et al*., 1995) is almost certainly a cacography for 'Tamatave' [=Toamasina] of eastern Madagascar [specimen in question is BMNH 99.11.3.6].

Otomops madagascariensis. This endemic species was previously known from two sites on Madagascar: Namoroka, where the holotype was collected, and the Sarodrano area south of Toliara. We have captured this species in the Réserve Spéciale d'Ankarana (several different caves), Parc National de Bemaraha (Grotte d'Anjohimbazimba), Parc National de l'Isalo (Namaza River), and near Sarodrano (Grotte d'Ambanilia and Grotte de Bisihiko).

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LITERATURE CITED

ALLEN, J. A. 1917. The American Museum Congo expedition collection of bats. Part I. Systematic list. Bulletin of the American Museum of Natural History, 37: 405–496.

BATES, P. J. J., and D. L. HARRISON. 1997. Bats of the Indian subcontinent. Harrison Zoological Museum, Kent, England, xvi + 258 pp.

BONACCORSO, F. J. 1998. Bats of Papua New Guinea. Conservation International, Washington, D.C., 489 pp.

BOUCHARD, S. 1998. Chaerephon pumilus. Mammalian Species, 574: 1–6.

CARDIFF, S. G., and J. BEFOUROUACK. 2003. The Ankarana Special Reserve. Pp. 1501–1507, *in* The natural history of Madagascar (S. M. GOODMAN and J. P. BENSTEAD, eds.) The University of Chicago Press, Chicago, xxi + 1709 pp.

COTTERILL, F. P. D. 2001. Further notes on large Afrotropical free-tailed bats of the genus *Tadarida* (Molossidae: Mammalia). Arnoldia Zimbabwe, 10 (18): 199–210.

EGER, J. L., and L. MITCHELL. 2003. Chiroptera, bats. Pp. 1287–1298, *in* The natural history of Madagascar (S. M. GOODMAN and J. P. BENSTEAD, eds.) The University of Chicago Press, Chicago, xxi + 1709 pp.

EGER, J. L., and R. L. PETERSON. 1979. Distribution and systematic relationships of *Tadarida bivittata* and *Tadarida ansorgei* (Chiroptera: Molossidae). Canadian Journal of Zoology, 57: 1887–1895.

FENTON, M. B., and J. L. EGER. 2002. Chaerephon chapini. Mammalian Species, 696: 1–2.

FREEMAN, P. W. 1981. A multivariate study of the family Molossidae (Mammalia: Chiroptera): Morphology, ecology, evolution. Fieldiana: Zoology (N.S.), 7: 1–173.

GOODMAN, S. M., O. LANGRAND, and C. J. RAXWORTHY. 1993. The food habits of the Barn Owl *Tyto alba* at three sites on Madagascar. Ostrich, 64: 160–71.

GOODMAN, S. M., D. ANDRIAFIDISON, R. ANDRIANAIVOARIVELO, S. G. CARDIFF, E. IFTICENE, R. K. B. JENKINS, A. KOFOKY, T. MBONOAHY, D. RAKOTONDRAVONY, J. RANIVO, F. RATRIMOMANARIVO, J. RAZAFIMANAHAKA, and P. A. RACEY. In press.

The distribution and conservation of bats in the dry regions of Madagascar. Animal Conservation.

HARRISON, D. L. 1975. A new species of African free-tailed bat (Chiroptera: Molossidae) obtained by the Zaire River Expedition. Mammalia, 39: 313–318.

HAYMAN, R. W., and J. E. HILL. 1971. The mammals of Africa. An identification manual. Part 2. Order Chiroptera. Smithsonian Institution Press, Washington, D.C., 1–73 pp.

HILL, J. E. 1974. New records of bats from southeastern Asia, with taxonomic notes. Bulletin of the British Museum of Natural History (Zoology), 27: 127–138.

KINGDON, J. 1974. East African mammals. An atlas of evolution in Africa. Vol. II, Part A (insectivores and bats). Academic Press, London, xi + 341 pp.

KOOPMAN, K. F. 1994. Chiroptera: systematics. Pp. 1–217, *in* Handbuch der Zoologie, Vol. VIII, Mammalia, Part 60 (J. NIETHAMMER, H. SCHLIEMANN, and D. STARCK, eds.). Walter de Gruyter, Berlin, vii + 217 pp.

PETERSON, R. L., J. L. EGER, and L. MITCHELL. 1995. Chiroptères. Vol. 84. Faune de Madagascar. Muséum National d'Histoire Naturelle, Paris, 204 pp.

RASOLOZAKA, I. H. 1994. Les micro-chiroptères. Pp. 64–67, *in* Inventaire biologique, Forêt de Zombitse (S. M. GOODMAN and O. LANGRAND, eds.). Recherches pour le Développement, Série Sciences Biologiques, Spécial, Centre d'Information et de Documentation Scientifique et Technique, Antananarivo, 106 pp.

RAUTENBACH, I. L., D. A. SCHLITTER, and L. E. O. BRAACK. 1984. New distributional records of bats for the Republic of South Africa, with special reference to the Kruger National Park. Koedoe, 27: 131–135.

SAS. 1990. SAS User's Guide, version 8. SAS Institute, Cary, North Carolina.

SIMMONS, N. B. In press. Order Chiroptera. *In* Mammal species of the World: a taxonomic and geographic reference, 3rd edition (D. E. WILSON and D. M. REEDER, eds.). Smithsonian Institution Press, Washington, D.C.

TAYLOR, P. J. 1999. Problems with the identification of southern African *Chaerephon* (Molossidae), and the possibility of a cryptic species from South Africa and Swaziland. Acta Chiropterologica, 1: 191–200.

TAYLOR, P. J. 2000. Bats of southern Africa. University of Natal Press, Pietermaritzburg, vii + 206 pp.

THOMAS, O. 1903. Three new species of *Nyctinomus*. The Annals and Magazine of Natural History, 12 (7): 501–505.

WILLIS, C. K. R., J. M. PSYLLAKIS, and D. J. H. SLEEP. 2002. Chaerephon nigeriae. Mammalian Species, 710: 1–3.

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APPENDIX

Latitudinal and longitudinal coordinates and elevation of collection sites mentioned in text

Site	South latitude	East longitude	Elevation (m)
Ambilobe	13°11.5’	49°03.5’	25
Ambovombe	25°10’	46°05’	135
Ampijoroa	16°18.868’	46°48.620’	100
Andohahela, Parcel II	24°49.0’	46°36.6’	120
Andrambovato	21°31’	47°25’	800
Andapa	14°39’	49°38.5’	500
Ankapoky	24°59’	46°30’	100
Ankijabe	13°15.6’	49°38.1’	125
Ankiloaka	22°46.548’	43°36.889’	90
Antsalova	18°39’	44°37’	150
Belo-sur-Mer	20°44.139’	44°00.266’	10
Betakilotra	20°53.2’	44°04.8’	35
Beza Mahafaly	23°40’	44°37’	150
Canyon des Singes (Isalo)	22°29.2’	45°22.7’	700
Cathedral Cave (Ankarana)	12°56.0’	49°03.5’	± 60
Efoetse	24°04’	43°42’	0
Faux Cap	25°35.5’	45°32’	0
Grotte d’Ambanila (Sarodrano)	23°32.397’	43°44.763’	0
Grotte d’Anjohimbazimba (Bemaraha)	18°41.7’	44°43.0’	110
Grotte de Bisihiko	23°32.933’	43°46.044’	10
Katsepy	15°45.808’	46°14.695’	5
Kirindy (CFPF)	20°04.578’	44°40.492’	30
Manantenina	24°18’	47°20’	30
Morombe	21°44.417’	43°22.333’	15
Menamaty River (near Isalo)	22°29.133’	45°23.502’	700
Namaza River (Isalo)	22°32.4’	45°22.8	800
Namoroka	16°28’	45°21’	200
Ranobe	23°02.4’	43°36.6’E	10
Saint Augustin	23°32.933’	43°46.044’	10
Tsifota	22°49.445’	43°21.913	5
Zombitse-Vohibasia	22°50’	44°42’	800