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ARTICLE *in* ACTA CHIROPTEROLOGICA · DECEMBER 2010

Impact Factor: 0.83 · DOI: 10.3161/150811010X537963

Ara Monadjem
University of Swaziland

Corrie Schoeman
University of KwaZulu-Natal

April E Reside
James Cook University

Fenton Peter David Cotterill
Stellenbosch University

Acta Chiropterologica, 12(2): 371–391, 2010
PL ISSN 1508-1109 © Museum and Institute of Zoology PAS
doi: 10.3161/150811010X537963

A recent inventory of the bats of Mozambique with documentation of seven new species for the country

Ara Monadjem[1, 13], M. Corrie Schoeman[2], April Reside[3], Dorothea V. Pio[4], Samantha Stoffberg[5], Julian Bayliss[6, 7], F. P. D. (Woody) Cotterill[8], Michael Curran[9, 10], Mirjam Kopp[9], and Peter J. Taylor[11, 12]

[1]*All Out Africa Research Unit, Department of Biological Sciences, University of Swaziland, Private Bag 4, Kwaluseni, Swaziland*
[2]*School of Biological and Conservation Sciences, University of KwaZulu-Natal, Durban, Republic of South Africa*
[3]*All Out Africa, P.O. Box 153, Lobamba, Swaziland*
[4]*Département d'Ecologie et Evolution, Université de Lausanne, Biophore 1015, Lausanne, Switzerland*
[5]*Evolutionary Genomics Group, Department of Botany and Zoology, University of Stellenbosch, Private Bag X1, Matieland, Stellenbosch, Republic of South Africa*
[6]*Mulanje Mountain Conservation Trust (MMCT), P.O. Box 139, Mulanje, Malawi*
[7]*Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge, UK*
[8]*AEON – Africa Earth Observatory Network, Departments of Geological Sciences, and Molecular and Cell Biology, University of Cape Town, Rondebosch 7701, Republic of South Africa*
[9]*Institute of Biogeography, University of Basel, St. Johanns-Vorstadt 10, CH-4056, Switzerland*
[10]*Institute of Environmental Engineering, ETH Zurich, HIF C 13, Wolfgang-Pauli-Str. 15, CH-8093 Zurich, Switzerland*
[11]*Durban Natural Science Museum, P. O. Box 4085, Durban, Republic of South Africa*
[12]*Department of Ecology and Resource Management, School of Environmental Sciences, University of Venda, Private Bag X5050, Thohoyandou, 0950, Republic of South Africa*
[13]*Corresponding author: E-mail: ara@uniswacc.uniswa.sz*

The bat fauna of Mozambique is poorly documented. We conducted a series of inventories across the country between 2005 and 2009, resulting in the identification of 50 species from 41 sites. Of these, seven species represent new national records that increase the country total to 67 species. These data include results from the first detailed surveys across northern Mozambique, over an area representing almost 50% of the country. We detail information on new distribution records and measurements of these specimens. Special attention is paid to the Rhinolophidae, because these include several taxa that are currently in a state of taxonomic confusion. Furthermore, we also present some notes on taxonomy, ecology and echolocation calls. Finally, we combine modelled distributions to present predicted species richness across the country. Species richness was lowest across the coastal plain, to the east and far north, and is predicted to increase in association with rising altitude and higher topographic unevenness of the landscape.

Key words: Mozambique, Chiroptera, distribution, check-list, conservation

Introduction

The distribution of Southern African bat species is poorly known compared with other small mammal taxa such as rodents (Skinner and Chimimba, 2005; Monadjem *et al*., 2010), or compared with other regions such as Europe (Mitchell-Jones *et al*., 1999). Our knowledge of the bat fauna of Mozambique is particularly inadequate, given that the most recent synopsis is 35 years old (Smithers and Lobão Tello, 1976). At that time, only a single site (Ilha de Mozambique) had been surveyed in the northern provinces (north of the Zambezi River), an area covering almost 50% of the country. The remaining 'southern' half of the country was only patchily covered, with 19 species known from single localities and a further nine from just two localities. Hence, prior to 2000, a total of 56 bat species were known to occur in Mozambique, and 28 (50%) of these were known from two or fewer sites (Smithers and Lobão Tello, 1976) in a country covering over 801,000 km^2. (At least three of these 56 species are based on misidentifications — see Results below). A further indication of the under-sampled state of bats in Mozambique is that smaller neighbouring countries have higher species richness: for example, Malawi with 62 species and Zimbabwe with 62 species. Since the publication of Smithers and Lobão Tello (1976), six species have been added to the Mozambique list: *Mimetillus thomasi* (Cotterill, 2001*c*), *Scotoecus hindei/albigula* (Cotterill, 2001*b*), *Hipposideros ruber* (Fenton, 1986), *Pipistrellus rueppellii* (Van Cakenberghe and Seamark, 2008), and *Nycteris woodi* and *Hypsugo anchietae* (Monadjem *et al*., 2010); but none of these additions represented new material based on recent surveys. Instead these species were added based on re-identification of previously collected museum specimens.

To address this lack of distributional data, a series of bat surveys were conducted across Mozambique between 2005 and 2009. We pool the data from these various expeditions to provide a broad overview of bat distributions at a country-wide level. Hence, the aim of this paper is to present information from a number of recent bat expeditions to Mozambique, and to synthesise current and historical records of bat species distributions.

The 2003 IUCN assessment of protected areas shows that only 5.7% of Mozambique is designated as protected, and only 2% in 'categories I and II' (nature reserves and national parks), compared to the average of 10.9% for sub-Saharan Africa, 15.8% in the USA and 10.5% in the UK (UNEP-WCMC, 2003). Mozambique has 143 vertebrate species threatened with extinction, 11 of these mammals, a further 174 near threatened animal species (resulting in 12% of the total fauna being threatened or near threatened) and 101 that are data deficient (IUCN, 2009). Seven bat species found in Mozambique are listed as near threatened and three as vulnerable (IUCN, 2009). This paucity of knowledge seriously weakens any attempt to assess the status of the bat fauna of Mozambique. With the post-war resettlement of Mozambique, 70% of the human population is rural and reliant on farming (Hanlon, 2007), so it appears that human threats to bat populations in Mozambique will increase. This paper provides vital baseline information on the bat fauna of Mozambique that is essential for both ecological research and applied conservation work.

Materials and Methods

Study Sites

Mozambique stretches for approximately 2,770 km along the eastern seaboard of Southern Africa, mostly north of the Tropic of Capricorn. Much of the country lies below 200 m above sea level, although a few mountain ranges and peaks are scattered in the central and northern parts (Fig. 1). Mozambique straddles sub-tropical Southern Africa to tropical East Africa, and is characterised by its patchily distributed and erratic precipitation with 95% of the annual precipitation concentrated between October and March (Amaral and Sommerhalder, 2004). The mean annual temperature and rainfall varies across the country, this being mostly affected by latitude and altitude. In the far south, the capital city Maputo (39 m above sea level) has a mean monthly temperature of 23.3°C, and a mean annual rainfall of 769 mm. In the north at Nacala (15 m a.s.l.), the monthly temperature is 26.2°C, and the mean annual rainfall is 945 mm. In contrast, Chimoio in central Mozambique (730 m a.s.l.), has a mean monthly temperature of 21.3°C, and a mean annual rainfall of 1060 mm.

For convenience, we followed the biogeographical divisions denoted by the Bird Atlas (Parker, 1999): 1) southern Mozambique — south of the Save River, 2) central Mozambique — between the Save and Zambezi Rivers, and 3) northern Mozambique — north of the Zambezi River (Fig. 1).

Sampling and Data Analysis

Bat specimens were trapped and collected from 41 sites. Bats were captured using mistnets, canopy nets and/or harp traps, and sampling intensity varied considerably between sites. Where possible, some bats were caught by hand or hand net within roost sites such as caves and hollow tree trunks. Voucher specimens were collected and preserved in 70% ethanol, and deposited in the Durban Natural Science Museum (DM), the Transvaal Museum (TM) or the Geneva Museum of Natural History (MHNG). A few specimens from six sites (see Appendix I) were not collected; for these individuals wing biopsy punches were taken and stored in 99% ethanol before the bat was released.

Forearm length (FA) of live bats was measured in the field using digital callipers to the nearest 0.1 mm. Body mass (Bm), to the nearest 1 g, was obtained using a Pesola spring scale. These measurements on live individuals are presented under 'Field measurements' and were taken by the author that collected the specimens. Only measurements of adult bats are shown under 'Field measurements' unless otherwise stated. All other measurements are based on preserved voucher specimens. For those specimens where skull and dental measurements were necessary for identification (e.g. the Rhinolophidae), the following measurements were taken to the nearest 0.01 mm using digital callipers: greatest length of skull measured dorsally from occiput to anterior point of skull (GSL); condylo-incisive length from occipital condyles to front of incisors (CIL); condylo-canine length from occipital condyles to front of canines (CCL); zygomatic width, the greatest distance across the zygoma (ZW); mastoid width, the greatest distance across the lateral projections of the mastoid processes (MW); width of maxilla between outer edges of M^3 (M^3M^3); braincase width measured at dorsal surface of posterior root of zygomatic arches (BCW); least interorbital width between orbits (IOW); upper toothrow length from anterior surface of C to posterior surface of M^3 (CM^3); greatest width across anterior lateral nasal inflations (NW); length from occipital condyles to front of nasal inflations (NL); and height of nasal inflation directly above the anterior cingulum of M^2 (NH). Measurements are summarised as $\bar{x} \pm$ SD (for external measurements only), range and sample size. Where measurements of males and females differed, these are shown separately for each sex. Where sexes were similar in size or sample sizes were small (e.g. in the case of cranial data), measurements were combined for the sexes.

Species identifications were based on existing keys (e.g., Taylor, 2000; Csorba *et al*., 2003), and by comparisons of specimens with existing collections in the Durban Natural Science Museum. In the case of controversial species we explain the criteria used for determination. In some cases identification was aided by molecular data (see below).

Echolocation calls were recorded from individuals of selected high duty cycle (Hipposideridae and Rhinolophidae) species. Bats were recorded whilst being held by an observer, thus eliminating any possible Doppler shift compensation (Heller and von Helversen, 1989). Echolocation recordings were made using an ANABAT II bat detector (Titley Electronics, Ballina, Australia), or a Pettersson D240x or D980 bat detector (Pettersson Electronik AB, Uppsala, Sweden). ANABAT recordings were analysed with ANALOOK (Chris Corben, version 4.8), and Pettersson recordings with either Raven Pro version 1.3 (R. A. Charif, A. M. Waack, and L. M. Strickman — Cornell Laboratory of Ornithology), or with BatSound Pro v3.20 (Pettersson Electronik AB, Uppsala, Sweden) software. For ANABAT recordings of high duty cycle bats, we defined peak echolocation frequency as the frequency of the constant frequency (CF) component of the call, F(max) (Monadjem *et al*., 2007). For Pettersson recordings of high duty cycle bats, peak echolocation frequency was measured from the peak of the power spectrum (Obrist, 1995).

For certain taxa (in particular, *Miniopterus natalensis* and *Rhinolophus* species), molecular analyses were used to confirm species identification. Total genomic DNA was extracted using either the Qiagen DNeasy Blood & Tissue Kit (Qiagen) or the Wizard® SV Genomic DNA Purification System (Promega,

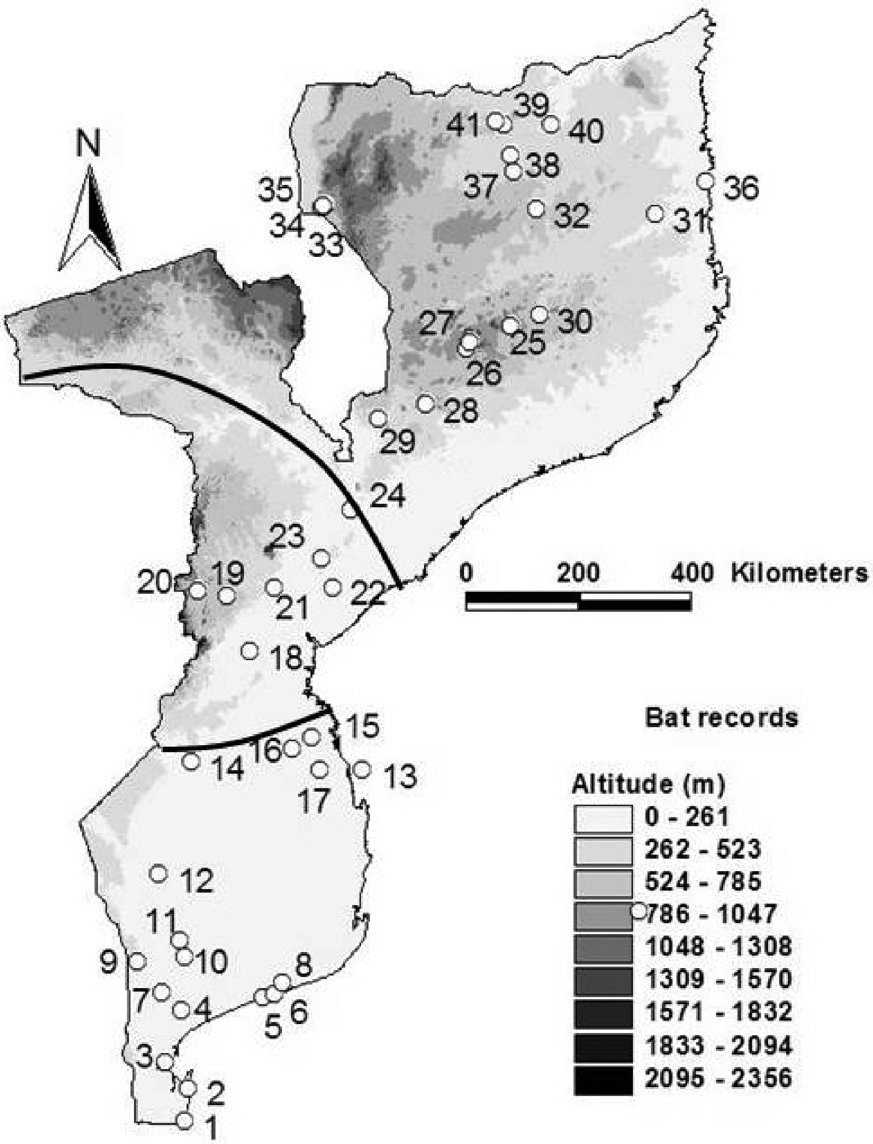

FIG. 1. Map of Mozambique showing the sites at which bats were captured during this study (2005–2009). The sampling sites are overlaid on a digital elevation model (altitude in metres). The boundaries of the three biogeographic zones (following Parker, 1999) are represented by the two black lines. The southern line follows the Save River, whereas the northern line follows the Zambezi River. The numbers refer to sites and correspond to the site numbers presented in Appendix I

Madison, Wisconsin, USA) and according to the manufacturer's instructions. We amplified and sequenced ca. 750 bp of the mitochondrial DNA (mtDNA) cytochrome *b* gene and ca. 550 bp of the mtDNA control region, following the protocols in Matthee *et al.* (2004) and Stoffberg *et al.* (2010). Phylogenetic hypotheses were estimated using both parsimony (PAUP* 4.0b10 — Swofford, 2002) and Bayesian MCMC analyses (implemented in the BEAST V1.4.8 package; available at http://beast.bio.ed.ac.uk).

The distributions of 46 (of the 67) species of bats occurring in Mozambique were modelled across their Southern African range by Monadjem *et al.* (2010) using the MaxEnt algorithm (version 2.3 — Phillips *et al.*, 2006). Nine continuous environmental variables were used as predictors in the final model: altitude, mean annual temperature, maximum temperature of the hottest month, minimum temperature of the coldest month, temperature seasonality, annual precipitation, precipitation of the wettest month, precipitation of the driest month and precipitation seasonality. The MaxEnt model was run with all distribution records (100% training), the regularization multiplier was set to 1 and the maximum number of iterations was set to 500; all other MaxEnt settings remained as default. Only species with ten or more distribution localities in Southern Africa were modelled. For further details see Monadjem *et al.* (2010). The predicted distributions of the 46 bat species within Mozambique were analyzed in ArcView 3.2. Individual distributions were then combined using the Map Calculator function in Spatial Analyst to produce a single map of bat species richness for the country. The IUCN Red List status follows the Global Mammal Assessment (GMA) of African small mammals in January 2004 (IUCN, 2009) and taxonomy follows Monadjem *et al.* (2010) unless otherwise stated.

Results

Over 500 individuals from 50 species and seven families were captured (Table 1) at 41 sites across Mozambique (Fig. 1). Differences in numbers of species collected per site may, at least partially, be attributed to differences in sampling intensity, including the number of nights spent trapping. At five of the eight sites where a single species was captured (Appendix I), this was due to ad hoc collecting rather than intensive netting and trapping. At 15 sites, five or more bat species were captured, whilst three sites (foothills of Mount Namuli, plateau of Mount Namuli and Mount Mabu) yielded more than 10 species of bats (Appendix I). During this study, three expeditions were organised to the plateau of Mount Namuli, two to Mount Mabu and a single expedition to the foothills of Mount Namuli. However, the Namuli plateau was visited prior to this for an ornithological survey (Ryan *et al.*, 1999), during which a single bat (*Myotis tricolor*) was collected and deposited in the Durban Natural Science Museum. Hence, it is not clear whether these sites are genuinely species rich or whether they have larger richness merely as a result of extra sampling effort.

TABLE 1. Summary of 50 bat species captured during this study (2005–2009)

Species	Region*		
	Southern	Central	Northern
Pteropodidae			
Epomophorus crypturus			●
E. labiatus			●
E. wahlbergi	●	●	●
Lissonycteris goliath			●
Myonycteris relicta		●	
Rousettus aegyptiacus		●	●
Rhinolophidae			
Rhinolophus blasii			●
R. clivosus			●
R. deckenii		●	
R. fumigatus			●
R. hildebrandtii	●	●	●
R. landeri		●	●
R. cf. *maendeleo*			●
R. simulator			●
R. cf. *swinnyi*	●		
Hipposideridae			
Hipposideros caffer	●	●	●
H. ruber			●
H. vitattus		●	
Triaenops afer	●	●	●
Nycteridae			
Nycteris grandis			●
N. hispida			●
N. macrotis	●	●	●
N. thebaica	●	●	
Molossidae			
Chaerephon ansorgei			●
C. pumilus		●	●
Mops condylurus	●	●	
Sauromys petrophilus			●
Tadarida aegyptiaca			●
T. fulminans			●
Vespertilionidae			
Eptesicus hottentotus			●
Glauconycteris variegata	●		●
Kerivoula argentata	●		
K. lanosa	●		
K. cf. *phalaena*			●
Laephotis botswanae			●
Myotis bocagii			●
M. tricolor			●
Neoromicia capensis		●	
N. nana	●	●	●
N. rendalli	●		
N. zuluensis		●	●
Nycticeinops schlieffeni	●	●	●
Pipistrellus hesperidus	●	●	●
Scotoecus hindei/albigula	●	●	●
Scotophilus dinganii	●		●
S. leucogaster	●		
S. cf. *viridis*	●	●	●
Miniopteridae			
Miniopterus cf. *fraterculus*			●
M. inflatus		●	●
M. natalensis	●		
Species total	20	21	38

* — Southern = south of Save River, Central = between Save and Zambezi Rivers, Northern = north of Zambezi River (see Fig. 1)

However, the bat species alpha-richness recorded across the country in this study may well be an underestimate. This is supported by the modelled distribution richness of bats across Mozambique which suggests that mean species richness across most of the country is 9–16 species (Fig. 2).

Based on the modelled species richness, the number of species of bats varied from six to 30 across the country (Fig. 2). Richness was generally lowest in the coastal plain but increased with increasing altitude and in broken terrain. The mountainous regions along the Zimbabwe border, the Tete Province in north-west of the central section, and isolated mountains in northern Mozambique (e.g., Mount Namuli) had the highest richness. However, the alluvial plains along the Save River also exhibited very high species richness.

A number of species recorded from Mozambique in the past are based on doubtful material and further evidence is required to corroborate their existence in the country. A single specimen of *Pteropus subniger* (ZMB 67215) exists from Inhambane in southern Mozambique. This extinct species was endemic to Reunion and Mauritius (Bergmans, 1990), and it is highly doubtful whether a breeding population existed in Mozambique in historical times. A single specimen of *Rhinolophus capensis* was recorded by Smithers and Lobão Tello (1976) from Gorongoza National Park. However, *R. capensis* is endemic to the southern parts of South Africa, and specimens previously labelled as *R. capensis* from south-central Africa were based on misidentifications (Ansell, 1986; Monadjem *et al*., 2010). A single record of *Mops thersites* from Ilha de

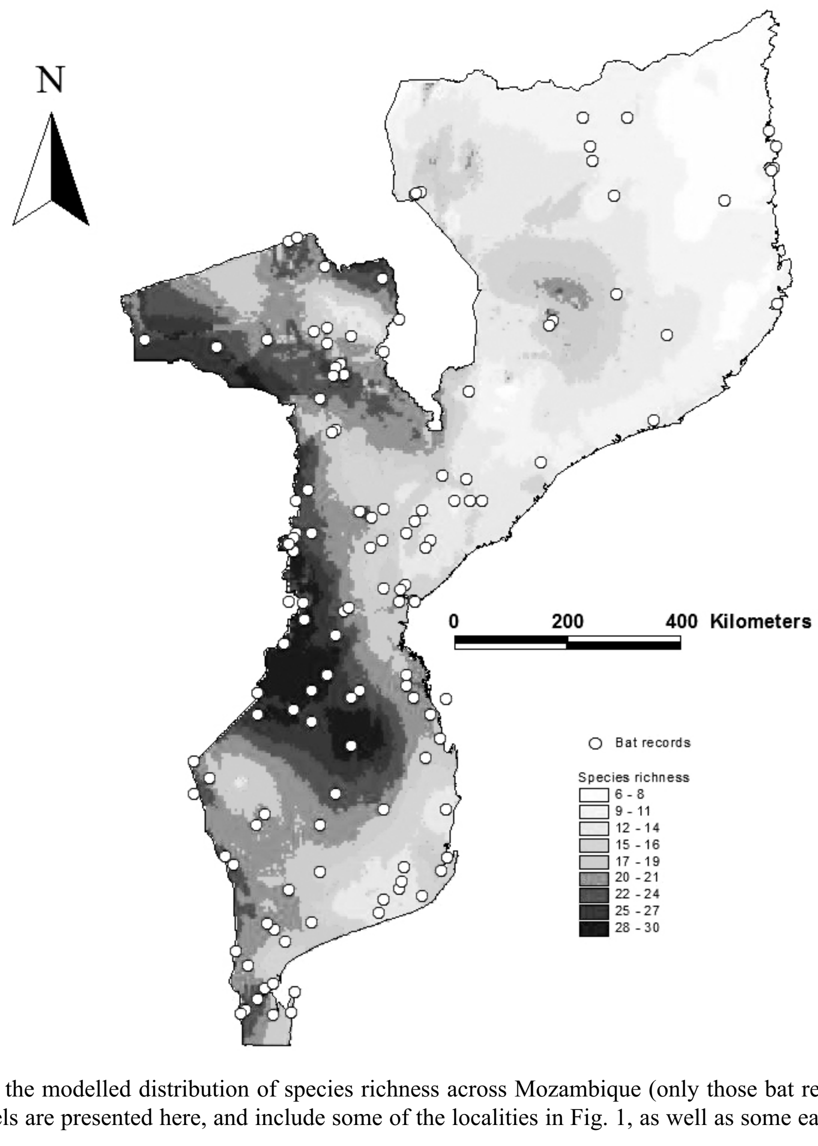

FIG. 2. Map showing the modelled distribution of species richness across Mozambique (only those bat records used in developing the distribution models are presented here, and include some of the localities in Fig. 1, as well as some earlier museum specimens)

Mozambique (Smithers and Lobão Tello, 1976) is likely to represent *M. brachypterus*; this requires further research (Monadjem *et al.*, 2010). *Neoromicia melckorum* (= *Eptesicus melckorum*) was recorded by Smithers and Lobão Tello (1976) from central Mozambique. Whilst *N. melckorum* has been shown to be conspecific with *N. capensis* (Kearney, 2005), the south-central African records of *N. melckorum* may represent a new species (*N.* cf. *melckorum* — Monadjem *et al.*, 2010). Further survey work is required to establish whether this species occurs in Mozambique. The single record of the northern hemisphere *Nyctalus noctula* (Smithers and Lobão Tello, 1976) is almost certainly a misidentification (Simmons, 2005) and is not included in either Van Cakenberghe and Seamark (2008) or Monadjem *et al.* (2010). We do not consider any of these five species as part of the Mozambican bat fauna.

Seven species collected during this study represent new country records: *Epomophorus labiatus*, *Myonycteris relicta*, *Rhinolophus deckenii*, *Rhinolophus* cf. *maendeleo*, *Kerivoula* cf. *phalaena*, *Laephotis botswanae*, and *Scotophilus leucogaster*, bringing the country total to 67 species of bats (Appendix II) which is comparable to other subtropical Southern African countries. For example, 65 bat species have been recorded from Zambia, 63 species from Angola, 62 species from Zimbabwe, and 62 species from Malawi (Ansell, 1978; Smithers and Wilson, 1979; Happold *et al.*, 1987; Crawford-Cabral, 1989; Cotterill, 1996; Happold and Happold, 1997; Bergmans and van Strien, 2004; Skliba *et al.*, 2007). Equatorial African countries typically have higher species richness, e.g., 85 bat species recorded in Kenya, 98 in Uganda and 116 in the DRC (Happold *et al.*, 1987; Thorn *et al.*, 2009).

Species Accounts

Pteropodidae

Epomophorus crypturus Peters 1852

This species was recorded at seven localities north of the Zambezi River (Appendix I), where it was captured in relatively large numbers (e.g., nine individuals at a single site).

Field measurements: FA (adult male) 83.7 ± 1.11 (82.7–84.9, 3); Bm (adult male) 107.7 ± 2.52 (105–110, 3); FA (adult female) 78.7 ± 3.13 (75.7–81.6, 4); Bm (adult female) 79.0 ± 8.29 (70–89, 4).

Epomophorus labiatus (Temminck 1837)

Five specimens of *E. labiatus* were captured at Meponda on the banks of Lake Niassa (Appendix I). This constitutes a new record for this species in Mozambique.

Field measurements: FA (adult female) 59.6 ± 2.23 (57.8–62.1, 3); Bm (adult female) 39.0 ± 8.19 (32–48, 3).

Epomophorus wahlbergi (Sundevall 1846)

This species was recorded at 11 sites throughout the country, but was scarce or absent in the far north, where *E. crypturus* was abundant. The two species were captured sympatrically at two sites, Namapa and Mount Namuli (Appendix I).

Field measurements: FA (adult male) 87.2 ± 2.26 (84.7–89.1, 3); Bm (adult male) 110.0 ± 9.17 (102–120, 3); FA (adult female) 82.6 ± 2.93 (78.5–85.8, 6); Bm (adult female) 92.5 ± 8.04 (81–102, 6).

Lissonycteris goliath Bergmans 1997

This taxon was originally described as a subspecies of *L. angolensis* (Bergmans, 1997), but was elevated to species rank by Cotterill (2001*a*). This species was recorded from two sites in northern Mozambique, where it was relatively abundant in the foothills of Mount Namuli (nine specimens were captured at this site). It was previously known from the Zimbabwe border (Smithers and Lobão Tello, 1976, where they referred to this species as *L. angolensis*) and from Marromeu, central Mozambique (Cotterill, 2001*a*).

Field measurements: FA (adult female) 83.9 ± 2.11 (81.4–87.4, 6); Bm (adult female) 94.7 ± 5.32 (88–101, 6). Four juveniles had FA ranging 77.2–83.5 and Bm 68–87; far larger than that for *Myonycteris relicta* (below).

Myonycteris relicta Bergmans 1980

A single specimen of this rarely collected species was captured in Chinizuia Forest and constitutes a new species record for Mozambique. The only other record for Southern Africa is from south-east Zimbabwe on the Mozambique border at the Haroni-Rusiti confluence; elsewhere the species occurs in coastal forests of East Africa (Bergmans, 1997).

Field measurements: FA (juvenile female) 71.1 (1); Bm (juvenile female) 52 (1).

Rousettus aegyptiacus
(E. Geoffroy Saint-Hilaire 1810)

This species was recorded at four sites in central and northern Mozambique. A large colony was located in a cave system on the Cheringoma plateau (Appendix I).

Field measurements: FA (adult male) 94.6 ± 1.67 (92.3–98.5, 11); Bm (adult male) 135.8 ± 7.08 (122–149, 11); FA (adult female) 96.8 (96.2–97.3, 2); Bm (adult female) 119 (102–136, 2).

Rhinolophidae

We encountered several difficulties with identifying specimens of *Rhinolophus* from Mozambique, either because of imperfect matches of morphological criteria in keys (e.g., Csorba *et al.*, 2003) or known echolocation frequency or because individuals which matched a particular species morphologically (e.g., *R.* cf. *swinnyi*) were found to differ considerably based on mtDNA (cytochrome *b*) sequences. The new molecular data form part of a separate paper in preparation (S. Stoffberg, unpublished data).

Rhinolophus blasii Peters 1867

Eight rhinolophid individuals captured in the foothills and montane plateau of Mount Namuli and two from Mount Mabu were ascribed to *R. blasii* on the basis of the pointed connecting process, minute 1st upper premolar inside the toothrow, cranial measurements (Table 2) and on molecular grounds. However, peak echolocation frequencies ranged between 93.2–95.4 kHz (ANABAT, Pettersson D240x, *n* = 10), 8–9 kHz higher than previously recorded for *R. blasii* in Swaziland and South Africa (Monadjem, 2005; Schoeman and Jacobs, 2008; Monadjem *et al.*, 2007). This difference may be due to geographic variation or may indicate cryptic species.

Field measurements: FA (adult male) 44.6 ± 1.10 (43.5–46.4, 5); Bm (adult male) 8.6 ± 0.65 (8.0–9.5, 5); FA (adult female) 45.1 (44.7–45.4, 2); Bm (adult female) 8.3 (8.0–8.5, 2). Mean nose-leaf width was 8.48 ± 0.33 for males (*n* = 5) and 8.45 for females (*n* = 2).

Rhinolophus clivosus Cretzschmar 1828

Several rhinolophid individuals captured in the foothills and montane plateau of Mount Namuli and Mount Mabu were ascribed to *R. clivosus* on the

TABLE 2. Cranial measurements (mean, range and number of specimens) of *Rhinolophus* specimens collected recently in Mozambique (preserved in the Mammal Collection of the Durban Natural Science Museum). For measurement codes see Sampling and data analysis.

Species	GSL			CCL			ZW			MW			M^3M^3			CM^3		
	n	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max
R. landeri	2	19.55	19.4–19.7	2	17.20	17.0–17.4	2	10.30	10.1–10.5	2	9.57	9.5–9.6	2	7.16	7.0–7.3	2	7.36	7.1–7.6
R. cf. *swinnyi*	5	17.73	17.1–18.2	6	15.46	15.1–15.7	6	8.68	8.2–9.0	6	8.58	7.9–8.8	6	6.04	5.8–6.3	6	6.30	6.2–6.4
R. fumigatus	2	22.70	22.4–23.0	3	19.67	19.3–20.3	3	11.37	11.1–11.6	3	10.53	10.4–10.7	3	8.22	8.0–8.3	3	8.17	8.0–8.4
R. clivosus	6	22.60	22.1–23.0	7	19.74	19.2–20.0	7	11.68	11.1–12.0	7	10.26	10.0–10.6	7	8.18	7.9–8.4	7	8.27	8.2–8.4
R. deckenii		22.55			19.50			12.02			10.70			8.37			8.51	
R. cf. *maendeleo*		19.88		2	17.28	17.2–17.3	2	9.44	9.4–9.5	2	9.48	9.4–9.5	2	6.7	6.6–6.8	2	7.02	7.01–7.04
R. blasii	4	18.68	18.2–19.4	4	16.0	15.7–16.1	5	8.87	8.8–9.0	4	8.83	8.7–8.9	5	6.07	5.8–6.2	5	6.32	6.2–6.5
R. simulator		18.80			15.90			9.08			8.58			6.41			6.31	
R. hildebrandtii																		
Clade1 (large, montane)	2	29.99	29.7–30.3	2	25.58	25.2–25.9	2	14.21	14.1–14.3	2	13.16	13.1–13.2	2	9.82	9.6–10.1	2	10.48	10.3–10.7
Clade2 (small, savanna)	3	27.71	26.7–28.5	3	24.17	23.7–25.0	3	13.64	13.2–14.2	3	12.35	12.1–12.7	3	9.47	9.3–9.7	3	9.86	9.7–10.0

TABLE 2. Continued

Species	IOW			NW			NL			NH			BCW			CIL		
	n	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max	*n*	$\bar{x}$	min–max
R. landeri	2	2.56	2.5–2.6	2	5.40	5.4–5.4	2	16.45	16.3–16.6	2	6.16	6.0–6.3	2	9.09	9.0–9.2	2	17.25	17.2–17.3
R. cf. *swinnyi*	6	2.26	2.0–2.6	6	4.20	4.0–4.4	6	14.95	14.6–15.3	6	5.31	5.1–5.5		8.11	7.5–8.4	3	15.78	15.5–16.1
R. fumigatus	3	2.96	2.8–3.2	2	6.15	6.0–6.2	3	19.33	19.0–19.6	3	7.49	7.4–7.9	3	9.95	9.8–10.2	2	20.30	19.8–20.8
R. clivosus	7	2.79	2.6–3.0	7	6.10	5.8–6.7	7	18.76	18.5–19.0	7	7.05	6.8–7.3	7	10.06	9.8–10.4	6	20.22	19.3–20.9
R. deckenii		2.88			5.48			18.64			7.01			10.40			19.60	
R. cf. *maendeleo*	2	2.61	2.5–2.7	2	4.94	4.9–5.0	2	16.59	16.5–16.6	2	5.82	5.80–5.84	2	8.89	8.8–8.9		17.65	
R. blasii	5	2.51	2.4–2.7	5	4.84	4.7–4.9	4	15.84	15.6–16.1	5	5.21	5.0–5.3	5	8.48	8.3–8.6		16.76	
R. simulator		1.99			4.81			15.90			5.42			8.07			16.60	
R. hildebrandtii																		
Clade1 (large, montane)	2	3.54	3.5–3.6	2	7.82	7.6–8.0	2	24.58	24.4–24.6	2	10.08	9.6–10.6	2	12.39	12.3–12.5	2	26.83	26.5–27.2
Clade2 (small, savanna)	3	3.44	3.4–3.5	3	7.58	7.2–8.2	3	23.46	22.8–24.3	3	9.40	8.9–9.9		11.85	11.6–12.1	3	24.73	23.8–25.6

basis of the rounded connecting process, minute 1st upper premolar outside of the toothrow, cranial measurements (Table 2) and molecular grounds. However, peak echolocation frequencies ranged between 79.8–81.0 kHz (ANABAT, Pettersson D240x, *n* = 12), 10–11 kHz lower than in South Africa (Monadjem *et al.*, 2007, 2010; Schoeman and Jacobs, 2008). Despite these differences in echolocation frequency, the Mozambican individuals showed no genetic differentiation (mtDNA control region) from South African *R. clivosus*.

Field measurements: FA (adult male) 52.7 ± 0.67 (51.8–53.5, 7); Bm (adult male) 14.5 ± 0.91 (13.0–15.5, 7); FA (adult female) 54.5 (1); Bm (adult female) 16.0 (1). Mean nose-leaf width was 8.13 ± 0.63 for males (*n* = 7) and 8.0 for the single female.

Rhinolophus deckenii Peters 1868

A single male specimen assigned to this species was collected from Chinizuia forest. It had a rounded connecting process, similar to *R. clivosus*, but the 1st upper premolar was large and partly within the toothrow. Although the location of the premolar was atypical for *R. deckenii* (in which it is typically outside the toothrow), this character is variable in *R. deckenii* and occasionally the premolar is located partly within the toothrow (Csorba *et al.*, 2003). The skull had well developed zygomatic arches, sagittal and occipital crests and moderately inflated anterior medial narial inflations. Cranial measurements (Table 2) fell within the range of values given for *R. deckenii* in Csorba *et al.* (2003), although greatest skull length was identical to the minimum value of that recorded for *R. deckenii*. The baculum is characteristic of *R. deckenii* (as figured in Cotterill, 2002) in both length (3.8 mm cf. 3.9 mm in Cotterill, 2002) and shape (Fig. 3). Peak echolocation frequency of a single male was recorded at 72 kHz (ANABAT, *n* = 1).

Field measurements: FA (adult male) 49.9 (1); Bm (adult male) 15.5 (1). Nose-leaf width was 8.9 for the single male.

Rhinolophus fumigatus Rüppell 1842

Identified on the basis of wide noseleaf (> 9 mm) and hairy sella, three specimens were collected at two sites in northern Mozambique. Peak echolocation call of a single male was 54 kHz (ANABAT), which is almost identical to the peak frequencies

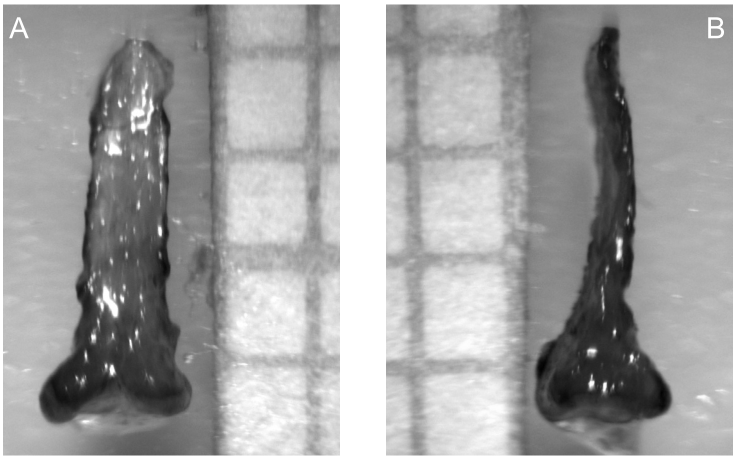

FIG. 3. Ventral (A) and lateral (B) views of the baculum of *R.* cf. *deckenii* (DM 8560), from Chinizuia, central Mozambique. One small square on the graph paper represents 1 mm

recorded in South Africa (53.7 kHz — Schoeman and Jacobs, 2008; Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 51.6 ± 1.97 (50.1–53.8, 3); Bm (adult male) 12.0 ± 1.00 (11.0–13.0, 3). Mean nose-leaf width was 11.03 ± 0.60 for the three males.

Rhinolophus hildebrandtii Peters 1878

This species was recorded at eight sites in southern, central and northern Mozambique. A large colony was discovered in a cave system in the Cheringoma plateau (Appendix I). Peak echolocation frequencies ranged between 35–40 kHz (ANABAT, Pettersson D240x, *n* = 15). Variable peak echolocation frequencies for *R. hildebrandtii* populations have previously been recorded in Southern Africa (Monadjem *et al.*, 2010). For example, calls recorded in South Africa have intermediate peak frequencies of ≈ 33 kHz at Sudwala caves and ≈ 44 kHz at Pafuri, in the Kruger National Park (Schoeman and Jacobs, 2008; M. C. Schoeman, unpublished data). At Lutope Gorge, just south of Sengwa in Zimbabwe, 17 individuals with peak frequencies of ≈ 37 kHz and one with 46 kHz were captured and recorded (Taylor *et al.*, 2005). Based on the analysis of two mtDNA genes (cytochrome *b* and control region), two divergent lineages of *R. hildebrandtii* are present in Mozambique (referred to as Clade1 and Clade2 in Table 2), one comprising smaller-sized individuals occurring in savanna habitats at lower elevations (Namapa, Niassa Game Reserve, Gerhard's Cave — Clade 2) and another comprising large-sized individuals from montane habitats (Mounts Mabu and Inago — Clade 1) (P. J. Taylor, S. Stoffberg, A. Monadjem, F. P. D. Cotterill, and M. C. Schoeman, unpublished data). These two forms are morphologically distinct as shown by the non-overlap between them in most cranial measurements (Table 2).

Field measurements: For the low elevation taxon, FA (adult male) 63.3 ± 1.40 (60.1–65.2, 12); Bm (adult male) 30.9 ± 2.57 (28.0–34.5, 12); FA (adult female) 62.2 ± 2.16 (59.6–64.6, 4); Bm (adult female) 27.88 ± 5.04 (23.5–34.0, 4). Mean nose-leaf width was 14.36 ± 0.49 for males (*n* = 12) and 14.35 ± 0.72 for the females (*n* = 4). For two females from Mounts Mabu and Inago (montane form), mean FA was 67.5 (66–69) mm. Nose-leaf width for these two females was 15.0 and 15.1 mm.

Rhinolophus landeri Martin 1838

This species was recorded at three sites in central and northern Mozambique. The male had bright orange axillary tufts in the armpits. Peak echolocation frequencies were 102.2 kHz (female; ANABAT, *n* = 1) and 104 kHz (male; Pettersson D240x, *n* = 1) 3–5 kHz lower than in South Africa (Schoeman and Jacobs, 2008; Monadjem *et al.*, 2010)

Field measurements: FA (adult male) 46.3 (1); Bm (adult male) 9.5 (1); FA (adult female) 46.3 (1); Bm (adult female) 10.0 (1). Nose-leaf width was 7.9 for the single female.

Rhinolophus cf. *maendeleo* Kock, Csorba and Howell 2000

Two specimens assigned to this recently described species were recorded from Mount Namuli in northern Mozambique. They all had a rounded connecting process, similar to *R. clivosus*, but the

1st upper premolar was small and situated in the toothrow (unlike *R. clivosus*). The skull was slender and narrow in shape with gracile zygomatic arches (and MW greater or equal to ZYW — see Table 2), undeveloped sagittal and lambdoid crests, a long rostrum with bulbous anterior narial inflation in relation to posterior inflations (giving concave rostral profile) as described by Kock *et al*. (2000); cranial measurements match closely the values for the holotype and paratype of this species recorded by these authors. However, slight differences between the Mount Namuli male (DM 10833) and the *R. maendeleo* holotype are present in baculum shape (not shown) and the presence of a bony bar closing the infraorbital foramen (open in holotype and paratype of *R. maendeleo* but only on the right hand side of one Mount Namuli specimen (DM10833) and on neither side in DM10839). These differences warrant further analyses to determine whether these individuals represent an undescribed species, preferably including molecular comparisons of the Mount Namuli specimens with the holotype and/or paratype. Specimens from Mount Gorongosa and Nyika Plateau of Malawi may also be referable to this species and should be examined (F. P. D. Cotterill, personal communication).

Field measurements: FA (adult male) 47.5 (1); FA (adult female) 48.9 (1). Nose-leaf width was 8.7 for the male and 8.3 for the female.

Rhinolophus simulator K. Andersen 1904

A single specimen assigned to this species was collected just south of the Niassa Game Reserve, northern Mozambique. Although it matched *R. simulator* in most characters (including cranial measurements — Table 2), the anterior upper premolar was tiny and mostly outside the toothrow (inside toothrow in *R. simulator*) and the ear length was 17 mm which is extremely short for this species. Due to technical difficulties its echolocation call could not be recorded.

Field measurements: FA (adult male) 42.4 (1); Bm (adult male) 6 (1). Nose-leaf width was 7.8 for the single male.

Rhinolophus cf. *swinnyi* Gough 1908

A series of small rhinolophids was collected from a cave ('Gerhard's cave') south of the Save River, and from Mount Inago and Mount Namuli in northern Mozambique. Using existing keys based on morphological and cranial measurements (Taylor, 2000; Csorba *et al*., 2003), these specimens were identifiable as *R. swinnyi*. However, molecular analyses of the mtDNA cytochrome *b* gene (which included other Southern African species such as *R. blasii*, *R. capensis*, *R. denti*, *R. landeri*, *R. simulator* and *R. swinnyi*) show that these individuals group with typical *R. simulator* (S. Stoffberg, unpublished) from which they differ both in morphology (smaller skull lengths) and echolocation (peak echolocation frequencies ranging between 99–103 kHz; Pettersson D980, $n = 10$). Specimens were observed to have dark-brown coloured spots on the cheeks. We thus chose to provisionally designate these genetically distinctive, small, brown-cheeked specimens (which are most likely an undescribed cryptic species morphologically similar to *swinnyi*) as 'cf. *swinnyi*'. Peak echolocation frequencies of *R. swinnyi* in South Africa are similar at 106.6 kHz, but those for *R. simulator* in South Africa are 20 kHz lower (Schoeman and Jacobs, 2008). This suggests that these individuals may represent an undescribed species.

Field measurements: FA (adult male) 42.5 ± 0.56 (42.0–43.3, 5); Bm (adult male) 6.0 ± 0.82 (5.0–7.0, 4); FA (adult female) 42.5 ± 0.60 (41.6–43.1, 5); Bm (adult female) 6.7 ± 0.97 (5.5–8.0, 5). Mean nose-leaf width was 7.24 ± 0.44 for males ($n = 5$) and 7.38 ± 0.31 for the females ($n = 5$). (See Table 2 for cranial measurements).

Hipposideridae

There is some confusion as to how many species exist within the *Hipposideros caffer-ruber* complex; recently, Vallo *et al*. (2008) demonstrated seven lineages based on cytochrome *b* sequences. Of these, the A1 and B2 lineages could be geographically associated with the names of *caffer* (A1 lineage extending from South Africa to central Mozambique including the type locality Durban, South Africa) and *ruber* (B2 extending from Malawi to Kenya and Tanzania including the type locality Dar es Salaam), respectively. It is thus highly likely that the names *caffer* and *ruber* as used here are correctly applied, with the former occurring widely in Mozambique and the latter restricted to northern Mozambique (no records from northern Mozambique were included in Vallo *et al*., 2008).

Hipposideros caffer (Sundevall 1846)

This species was recorded at nine sites throughout Mozambique. *Hipposideros caffer* and *H. ruber* (below) were not recorded sympatrically although there are no obvious ecological differences in the habitats selected by these two species within Mozambique. Further survey work is needed to determine whether their distributions overlap in northern Mozambique. Peak echolocation frequencies of two individuals were recorded at 145 kHz (ANABAT), which is similar to the peak echolocation frequencies recorded in South Africa (142.6 kHz — Schoeman and Jacobs, 2008; Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 45.9 ± 1.55 (44.1–48.7, 13); Bm (adult male) 7.4 ± 1.21 (6.0–9.5, 12); FA (adult female) 46.6 ± 1.50 (44.1–47.8, 6); Bm (adult female) 6.5 ± 0.50 (6.0–7.0, 3).

Hipposideros ruber (Noack 1893)

This species is represented by just five individuals recorded at three sites in northern Mozambique, which constitute the second record of this species for Mozambique (Fenton, 1986). This species is considerably larger than *H. caffer* from which it can reliably be distinguished by forearm length (>50 mm in *H. ruber* and <49 mm in *H. caffer*), and also the enlarged nasal compartments (Fenton, 1986). Little is known about the ecology of this species in Southern Africa and only a few specimens have been collected in the region. Peak echolocation frequencies ranged between 130.5 (Pettersson D240x, *n* = 1) and 132–136 kHz (ANABAT, *n* = 4).

Field measurements: FA (adult male) 51.7 ± 0.71 (51.2–52.7, 4); Bm (adult male) 10.3 ± 0.50 (10.0–11.0, 4); FA (adult female) 50.0 (1); Bm (adult female) 9.0 (1).

Hipposideros vittatus (Peters 1852)

Five specimens of this species were collected at two sites in central Mozambique. A large colony was discovered in a cave system in the Cheringoma plateau (Appendix I). Peak echolocation frequencies ranged between 64–66 kHz (ANABAT, *n* = 2) which are similar to the peak frequencies recorded in Southern Africa (61–65 kHz — Schoeman and Jacobs, 2008; Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 97.0 (1); Bm (adult male) 143 (1); FA (adult female) 96.2 (1); Bm (adult female) 100 (1).

Triaenops afer Peters 1877

Benda and Vallo (2009) restrict *T. persicus* Dobson 1871 within the Middle East, so we classify this African species as *T. afer* Peters 1877. This species was recorded at eight sites in southern, central and northern Mozambique. Fifteen individuals were captured at the entrance to a cave system in the Cheringoma plateau suggesting that a large roosting colony occurs there. Another large colony occurs just south of the Save River. However, the core of its Southern African distribution is central and northern Mozambique, with marginal intrusion into Zambia and Zimbabwe and south of the Save River. Echolocation calls are sexually dimorphic: peak echolocation frequencies of males ranged between 71–75 kHz (*n* = 7) and those of females between 82–85 kHz (ANABAT, *n* = 11). In Malawi, males called at 72–75 kHz and females at 80–85 kHz (D. C. D. Happold and M. Happold, unpublished, cited in Taylor *et al.*, 2005).

Field measurements: FA (adult male) 54.1 ± 1.18 (51.7–55.8, 16); Bm (adult male) 12.1 ± 1.00 (10.0–13.0, 11); FA (adult female) 52.4 ± 1.34 (49.8–55.2, 16); Bm (adult female) 10.8 ± 1.42 (8.0–12.5, 9).

Nycteridae

Nycteris grandis Peters 1865

A single female was collected from within a hollow baobab tree (*Adansonia digitata*) at Pemba, northern Mozambique. This is only the third record of this species from Mozambique (Monadjem *et al.*, 2010).

Field measurements: FA (adult female) 61.5 (1); Bm (adult female) 30 (1).

Nycteris hispida (Schreber 1774)

Five specimens were recorded from four localities in southern and northern Mozambique. *Nycteris hispida* is considerably smaller than *N. thebaica* with shorter ears and trifid (not bifid) upper incisors (Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 39.6 (38.9–40.2, 2); Bm (adult male) 7.5 (7.0–8.0, 2); FA (adult female) 37.7 (35.3–41.7, 3); Bm (adult female) 6.7 (6.0–7.0, 3). Ear length of a single male was 18.5.

Nycteris macrotis Dobson 1876

Four specimens were collected from three sites in southern, central and northern Mozambique. Live individuals can be confused with *N. thebaica*, but *N. macrotis* is slightly larger with longer forearm, and is easily distinguished by the semi-lunate tragus.

The skull morphology of the two species differs significantly with *N. macrotis* having a more robust skull with a longer condylo-incisive length (> 18.8 mm) (Monadjem *et al*., 2010).

Field measurements: FA (adult male) 52.0 ± 1.40 (50.4–53.0, 3); Bm (adult male) 16.7 (15.0–17.5, 3); FA (adult female) 52.2 (1); Bm (adult female) 16.0 (1).

Nycteris thebaica E. Geoffroy 1813

Six specimens were recorded from four sites in central Mozambique. This species can easily be confused with *N. macrotis* but is slightly smaller and more gracile (see above), and has a pyriform tragus (Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 45.9 ± 1.77 (43.9–47.8, 4); Bm (adult male) 9.3 ± 1.50 (8.0–11.0, 4); FA (adult female) 47.1 ± 0.76 (46.6–48.0, 3); Bm (adult female) 10.3 ± 1.04 (9.5–11.5, 3). Ear length of a single male was 29.3.

Molossidae

Chaerephon ansorgei (Thomas 1913)

Nine individuals were netted across a small stream in northern Mozambique. Prior to our expeditions there was only a single record of this species from Chiutu, central Mozambique (Monadjem *et al*., 2010).

Field measurements: FA (adult male) 45.7 (1); Bm (adult male) 22 (1); FA (adult female) 46.2 ± 0.78 (44.8–47.3, 8); Bm (adult female) 19.1 ± 1.10 (18.0–20.0, 8).

Chaerephon pumilus (Cretzschmar 1826)

This species was recorded from four sites across the country. It has previously been collected widely in southern and central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (subadult male) 38.0 (1); Bm (subadult male) 8.0 (1); FA (adult female) 38.0 ± 0.76 (36.9–39.0, 7); Bm (adult female) 11.2 ± 1.04 (9.5–12.0, 5).

Mops condylurus (A. Smith 1833)

This species was recorded at six sites in southern and central Mozambique. It has not been recorded from northern Mozambique, where the rarely collected *Mops niveiventer* may occur (although the latter species has yet to be recorded from Mozambique).

Field measurements: FA (adult male) 47.4 ± 1.54 (45.4–49.7, 15); Bm (adult male) 26.0 ± 3.25 (21.0–31.0, 15); FA (adult female) 46.2 ± 1.28 (43.3–49.8, 29); Bm (adult female) 27.1 ± 2.99 (21.0–33.0, 24).

Sauromys petrophilus (Roberts 1917)

Three individuals were recorded at a single site in northern Mozambique. Previously, this species was only known from Chiutu, central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 35.9 (1); Bm (adult male) 7.0 (1); FA (adult female) 36.2 (35.5–37.6, 2); Bm (adult female) 7.0 (6.0–8.0, 2).

Tadarida aegyptiaca (E. Geoffroy 1818)

Two specimens were netted across a small stream at a single site in northern Mozambique. In Mozambique, *T. aegyptiaca* appears to be associated with broken, hilly and mountainous terrain and has not yet been recorded from the flat coastal plain.

Field measurements: FA (adult male) 49.6 (1); Bm (adult male) 21.0 (1); FA (adult female) 49.8 (1); Bm (adult female) 21.0 (1).

Tadarida fulminans (Thomas 1903)

A single specimen was netted across a small stream in northern Mozambique, which constitutes only the third record of this poorly collected species in the country. The species was not reported by Smithers and Lobão Tello (1976), but two specimens collected from the Tete Province in central Mozambique are housed in the Smithsonian Institution (Monadjem *et al*., 2010).

Field measurements: FA (juvenile female) 59.3 (1); Bm (juvenile female) 36.0 (1).

Vespertilionidae

Eptesicus hottentotus (A. Smith 1833)

A single specimen was collected in the Manho forest (1800 m) on the plateau of Mount Namuli. Previously, a single specimen was collected from Chiutu in the Zambezi Valley (Smithers and Lobão Tello, 1976). The species has been extensively recorded across Southern Africa, as far west as Angola, and as far north as Kenya (Simmons, 2005; Monadjem *et al*., 2010). The species is often associated with mountainous terrain, including records from nearby Mount Mulanje (Kearney *et al*., 2008).

Its occurrence in Afromontane forest on Mount Namuli is therefore somewhat unsurprising.

Field measurements: FA (adult male) 47.6 (1).

Glauconycteris variegata (Tomes 1861)

Two individuals of this species were netted over a small water body in mature woodland along the Save River in southern Mozambique. Five previous specimens were collected from southern and central Mozambique (Smithers and Lobão Tello, 1976; Monadjem *et al*., 2010).

Field measurements: FA (adult male) 43.1 (1); FA (adult female) 42.6 (1); Bm (adult female) 15.5 (1).

Kerivoula argentata Tomes 1861

Two specimens were collected in southern Mozambique. One specimen was captured in mature woodland along the Save River, the other in coastal forest in the Maputo Special Reserve. Previously, five specimens were collected from scattered localities across the country (Smithers and Lobao Tello, 1976).

Field measurements: FA (adult male) 36.7 (36.6–36.7, 2); Bm (adult male) 8.0 (7.0–9.0, 2).

Kerivoula lanosa (A. Smith 1847)

One specimen was collected in mature woodland along the Save River in southern Mozambique. This constitutes only the second record of this species in the country.

Field measurements: FA (adult male) 29.7 (1); Bm (adult male) 4.0 (1).

Kerivoula cf. *phalaena* Thomas 1912

A single adult male of this species was recorded in mid-altitude forest on Mount Mabu. It is smaller than the two Southern African species, *K. lanosa* and *K. argentata.* The species may be undescribed, or may represent a new record of an existing species (not previously recorded in Southern Africa). The two candidate species in Africa that match the overall size and coloration of this enigmatic specimen are *Kerivoula africana* Dobson 1878 and *K. phalaena* Thomas 1912. However, the distinction between these two species is unclear based on the original species descriptions. Hayman and Hill (1971) discern the two species based on pelage coloration and the number of cusps on the inner, upper incisors (bicuspid in *K. africana* and unicuspid in *K. phalaena*). However, these characters are inconclusive in the Mount Mabu specimen. The specimen exhibits a dark brown coloration both dorsally and ventrally, lacking characteristic grizzling, and has a conspicuous secondary cusp on the inner, upper incisor. However, cranial and external measurements are larger than reported for *K. africana*, and other dental and cranial characters differ (and are more similar to *K. phalaena*). Therefore the specimen may represent an undescribed species, but this requires confirmation with an appropriate sample size of comparative specimens. In any case, this Mount Mabu specimen represents a most interesting discovery for Mozambique, and the first record of a *Kerivoula* species in the *africana*/*phalaena* group for Southern Africa as defined by Monadjem *et al*. (2010).

Field measurements: FA (adult male) 27.5 (1), BM (adult male) 3.5 (1)

Laephotis botswanae Setzer 1971

A single adult male specimen of *L. botswanae* was recorded from the lower slopes (ca. 550 m) of Mount Mabu (MNHG 1971.009). Identification was based on a principal component analysis of cranial measurements with the dataset from Kearney and Seamark (2005). The Mount Mabu specimen fell clearly within specimens attributed by Kearney and Seamark (2005) to *L. botswanae* (data not shown). Therefore this specimen vouches for a new distribution record for Mozambique, not having previously been recorded from the country (Van Cakenberghe and Seamark, 2008; Monadjem *et al*., 2010). The paucity of museum records for *L. botswanae* suggests that this species is rare throughout its range across Southern Africa (Taylor, 2000; Kearney and Seamark, 2005). However, the species has been commonly recorded throughout southern Malawi (Happold *et al*., 1987; Happold and Happold, 1989, 1997), including numerous records from lowland forest fragments around the base of Mount Mulanje, only ca. 60 km away from Mount Mabu (M. Curran and M. Kopp, unpublished data). Hence, the discovery of *L. botswanae* in Mozambique close to the Malawi border was not surprising.

Field measurements: FA (adult male) 35.2 (1), BM (adult male) 6 (1).

Myotis bocagii (Peters 1870)

Six specimens were captured at two sites (foothills of Mount Namuli and the shores of Lake

Niassa) in northern Mozambique. Previously, one specimen was recorded from central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 38.9 (1); Bm (adult male) 9.0 (1); FA (adult female) 40.8 ± 1.48 (39.3–42.8, 4); Bm (adult female) 9.8 ± 0.65 (9.0–10.5, 4).

Myotis tricolor (Temminck 1832)

This species was collected from the foothills and plateau of Mount Namuli, Mount Mabu and Mount Chiperone in northern Mozambique. Two prior records exist for central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 49.9 (48.0–51.7, 2); Bm (adult male) 13.5 (13.0–14.0, 2).

Neoromicia capensis (A. Smith 1829)

Four specimens were captured at two sites in central Mozambique. It was previously widely recorded from southern and central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 34.5 (32.7–36.3, 2); Bm (adult male) 7.5 (7.0–8.0, 2); FA (adult female) 36.4 (35.8–37.0, 2); Bm (adult female) 7.8 (7.5–8.0, 2).

Neoromicia nana (Peters 1852)

This common species was netted at 12 sites throughout Mozambique, making it the most widespread species encountered during this study. It was found characteristically roosting within a rolled-up banana leaf at the base of Mount Mabu. Riccucci and Lanza (2008) showed that the genus name *Neoromicia* is feminine, and therefore the species name should be *N. nana* (this species was previously known by the masculine form of *N. nanus*).

Field measurements: FA (adult male) 30.1 ± 1.90 (26.7–32.5, 22); Bm (adult male) 3.4 ± 0.44 (3.0– 4.0, 21); FA (adult female) 30.7 ± 1.50 (27.7–32.0, 22); Bm (adult female) 4.1 ± 1.08 (3.0–6.5, 21).

Neoromicia rendalli (Thomas 1889)

A single specimen was captured in southern Mozambique, which constitutes the third record of this species for the country (Monadjem *et al*., 2010).

FA (adult female) 37.6 (1); Bm (adult female) 9.5 (1).

Neoromicia zuluensis (Roberts 1924)

This species was recorded at four sites in central and northern Mozambique.

Field measurements: FA (adult male) 30.6 ± 1.15 (29.7–31.9, 3); Bm (adult male) 4.0 ± 0 (4.0, 3); FA (adult female) 30.0 ± 1.18 (28.8–31.2, 4); Bm (adult female) 4.1 ± 0.25 (4.0–4.5, 4).

Nycticeinops schlieffeni (Peters 1859)

This species was collected from nine sites across the country. It was previously collected from southern and central Mozambique (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 30.9 ± 0.42 (30.6–31.4, 3); Bm (adult male) 6.0 ± 0.50 (5.5–6.5, 3); FA (adult female) 31.4 ± 1.16 (29.6–33.2, 13); Bm (adult female) 5.7 ± 0.82 (5.0–7.0, 11).

Pipistrellus hesperidus (Temminck 1840)

Thirteen specimens were collected in the foothills and montane plateau of Mount Namuli, northern Mozambique and a further two individuals from southern Mozambique (Appendix I). Two prior specimens were recorded from central and southern Mozambique (Smithers and Lobão Tello, 1976). Hence, the species occurs throughout the country.

Field measurements: FA (adult male) 30.9 ± 1.03 (29.8–31.8, 3); Bm (adult male) 5.0 ± 0.50 (4.5–5.5, 3); FA (adult female) 31.5 (31.3–31.6, 2); Bm (adult female) 6.8 (6.5–7.0, 2).

Scotoecus hindei/albigula Thomas 1901, 1909

Six individuals referable to either *S. hindei* or *S. albigula* were collected from four sites across the country. There is confusion regarding the specific status of *hindei/albigula* (Monadjem *et al*., 2010), and therefore we have chosen to lump these two species until the genus has been revised. This species was first reported from Zinave National Park, southern Mozambique by Cotterill (2001*a*).

Field measurements: FA (adult male) 34.2 ± 1.08 (33.4–35.4, 3); Bm (adult male) 11.7 ± 0.76 (11.0–12.5, 3); FA (adult female) 33.5 ± 0.71 (32.9–34.0, 3); Bm (adult female) 8.0 (1).

Scotophilus dinganii (A. Smith 1833)

Twenty-five individuals were recorded from eight sites in southern and northern Mozambique.

It is possible that the species has been overlooked in central Mozambique since it was recorded there in the past (Smithers and Lobão Tello, 1976).

Field measurements: FA (adult male) 52.7 ± 2.21 (50.2–56.6, 7); Bm (adult male) 23.9 ± 2.94 (21.5–29.5, 7); FA (adult female) 53.4 ± 1.99 (50.3–57.2, 18); Bm (adult female) 26.4 ± 5.17 (18.0–37.0, 18).

Scotophilus leucogaster (Cretzschmar 1826)

A single individual was collected from mopane woodland near the Kruger National Park boundary in southern Mozambique. This constitutes the first recent record of this species for the country. Four specimens assigned to this species are mentioned in Van Cakenberghe and Seamark (2008), but these are based on old specimens that may refer to *S.* cf. *viridis* which is applied here as the available name for the smallest, yellow-bellied *Scotophilus* species in Southern Africa (see *Scotophilus* cf. *viridis* below). These four specimens require re-examination to establish exactly which species they refer to.

Field measurements: FA (adult male) 48.3 (1); Bm (adult male) 23.0 (1).

Scotophilus cf. *viridis* (Peters 1852)

Twenty-five individuals were recorded from 10 sites in southern and northern Mozambique, making it the second most widespread species encountered during this study. The species has probably been overlooked in central Mozambique since it has been recorded there in the past (Smithers and Lobão Tello, 1976). Toward absolving the confusion associated with the status of this taxon, the smallest yellow-bellied species of *Scotophilus* in Southern Africa were assigned to *S. viridis* by Monadjem *et al.* (2010), distinct from the similar sized, but cream-bellied *S. leucogaster*. The recent paper by Jacobs and Barclay (2009), assigned the name *S.* '*mhlanganii*' for their studied population of this small, yellow-bellied *Scotophilus*, but this most unfortunate introduction of a nomen nudum into an already confusing taxonomy has created more problems than it solves (Monadjem *et al.*, 2010).

Field measurements: FA (adult male) 46.4 ± 1.22 (44.1–48.2, 17); Bm (adult male) 19.2 ± 2.90 (16.0– 24.5, 16); FA (adult female) 47.7 ± 2.06 (45.4–51.7, 8); Bm (adult female) 26.1 ± 7.06 (17.0–33.0, 6).

Miniopteridae

Miniopterus cf. *fraterculus* Thomas and Schwann 1906

Five adult male bats referable to this species were captured on the lower slopes of Mount Namuli, with further specimens from Mount Mabu in northern Mozambique. The two specimens that were collected had greatest skull lengths of 14.3 and 14.8 mm, with head lengths of 16.0 and 16.2 mm, respectively. The three released individuals had head lengths of 15.8, 16.1 and 16.8 mm. These head and skull measurements are significantly shorter than *Miniopterus natalensis* but within the range of *M. fraterculus*. The closest population of *M. fraterculus* to that on Mount Namuli (and the nearby Mount Zomba in neighbouring Malawi) is > 1000 km away in South Africa (Monadjem *et al.*, 2010) suggesting that this isolated population may be specifically distinct.

Field measurements: FA (adult male) 43.7 ± 0.95 (42.1–44.5, 5); Bm (adult male) 8.0 ± 0.35 (7.5–8.5, 5).

Miniopterus inflatus Thomas 1903

Eight individuals were captured at the entrance of a cave system in the Cheringoma plateau (Appendix I), suggesting that a large colony was roosting within the caves. Additional records are from Mount Chiperone and Mount Namuli in northern Mozambique. These constitute the second record of this species from Mozambique. The greatest skull length of two individuals was 16.4 and 16.6 mm, with head lengths of 18.4 and 18.6 mm, respectively. The other six individuals had head lengths of 17.6–18.3 mm, larger than that of *M. natalensis* but within the range of *M. inflatus*.

Field measurements: FA (adult male) 47.3 ± 0.47 (46.7–48.1, 7); Bm (adult male) 15.0 ± (14.0–16.0, 7); FA (adult female) 47.0 (1); Bm (adult female) 13.0 (1).

Miniopterus natalensis (A. Smith 1833)

Three individuals were captured at Gerhard's Cave and Inhambane in southern Mozambique and a single individual from Mount Mabu in northern Mozambique. Molecular analyses based on cytochrome *b* show that the individuals from Gerhard's Cave are similar to *M. natalensis* (AJ841977.1 — Stadelmann *et al.*, 2004) from Springbok, South Africa.

Field measurements: FA (adult male) 47.1 (46.7–47.5, 2); Bm (adult male) 10.5 ± (9.0–12.0, 2); FA (adult female) 46.3 (1); Bm (adult female) 10.5 (1).

Conclusions

Though still in its infancy, our knowledge of the bat fauna of Mozambique has been much improved by this series of surveys. The number of known bat species has been elevated to 67, a comparable number to other similarly sized countries in Southern Africa. This paper has shed light on important taxonomic issues that should be addressed with further survey work and molecular analyses. Moreover, in a scientific world increasingly dominated by whole genome biology and dependence on the availability of expensive technology, surveys are often undervalued. However, large-scale surveys provide precious occurrence data which allow us to investigate species' ecological requirements, vulnerability to extinction, and future distribution patterns using for example predictive modelling techniques.

Acknowledgements

This is the 16th communication of the All Out Africa Research Unit (www.alloutAfrica.org). AM is grateful to Kim Roques from All Out Africa for financial and logistic support and to Julien Cornut for assistance in the field. Specimens collected by JB, MC and MK were collected under the British funded Darwin Initiative Award (15/036) 'Monitoring and Managing Biodiversity Loss in South-East Africa's Montane Ecosystems'. This is a project coordinated by the Royal Botanic Gardens Kew and BirdLife International (UK) in collaboration with the Mozambique Agricultural Research Institute (IIAM) and the Mulanje Mountain Conservation Trust (MMCT) in Malawi. MC and MK were further funded by a National Geographic Society/Waitt Grants Program Award (W37-08). DVP is grateful to Alexander Arnold for assistance in the field and was supported by a EU Marie-Curie Early Stage Research Training grant: HOTSPOTS MEST-CT-2005-020561. MCS and SS are very grateful to the Toyota Enviro Outreach for logistical support. Two anonymous reviewers greatly improved the original version of this paper.

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Received 15 February 2010, accepted 13 September 2010

APPENDIX I

Sites at which specimens were collected during this study, bat species recorded at each site and museum(s) in which specimens have been deposited (TM — Transvaal Museum, DM — Durban Natural Science Museum, MHNG — Natural History Museum of Geneva, MM — Maputo Natural History Museum). The sites are arranged roughly from south to north. The site numbers correspond with the numbers in Fig. 1. For each site, species are listed in alphabetical order

Site	Site number	Latitude	Longitude	Species
				Southern Mozambique
Ponto D'Ouro	1	-26.84049	32.87484	*Chaerephon pumilus*, *Hipposideros caffer*, *Mops condylurus*
Maputo Special Reserve	2	-26.34534	32.92919	*Epomophorus wahlbergi* (TM), *Kerivoula argentata* (TM), *Scotophilus dinganii* (TM)
Maputo	3	-25.9653	32.589	*Epomophorus wahlbergi*, *Neoromicia nana*, *Scotophilus dinganii*, *Scotophilus* cf. *viridis*
Palmiera	4	-25.21716	32.8321	*Neoromicia rendalli* (DM)
Paradise Magoo	5	-25.0146	34.011	*Epomophorus wahlbergi*, *Neoromicia nana*, *Pipistrellus hesperidus*
Chidenguele	6	-24.95743	34.18951	*Scotophilus* cf. *viridis* (TM)
Magude, north of	7	-24.94134	32.54862	*Neoromicia nana* (DM), *Nycticeinops schlieffeni* (DM), *Scotoecus hindei/albigula* (DM), *Scotophilus* cf. *viridis* (DM)
Inhambane	8	-24.7886	34.31278	*Miniopterus natalensis*, *Mops condylurus*, *Neoromicia nana*, *Nycteris hispida*, *Scotophilus dinganii*
Rio Wanetsi	9	-24.49252	32.17136	*Pipistrellus hesperidus* (DM)
Chokwe	10	-24.40597	32.88168	*Mops condylurus* (DM)
Mepuze, south of	11	-24.16792	32.80604	*Nycteris macrotis* (DM)
Mepuze	12	-23.20518	32.49864	*Hipposideros caffer* (DM), *Scotophilus leucogaster* (DM)
Bazaruto	13	-21.661	35.488	*Mops condylurus*, *Nycteris hispida*
Massangena	14	-21.55513	32.96057	*Epomophorus wahlbergi* (DM), *Hipposideros caffer* (DM), *Neoromicia nana* (DM), *Nycticeinops schlieffeni* (DM), *Scotoecus hindei/albigula* (DM), *Scotophilus dinganii* (DM), *Scotophilus* cf. *viridis* (DM)
Save River, south of bridge on EN1	15	-21.17578	34.7465	*Glauconycteris variegata* (DM), *Kerivoula argentata* (DM), *Kerivoula lanosa* (DM), *Nycticeinops schlieffeni* (DM), *Scotophilus dinganii* (DM), *Scotophilus* cf. *viridis* (DM)
Save River	16	-21.34427	34.458217	*Nycteris hispida* (TM)
Gerhard's Cave	17	-21.66954	34.864403	*Hipposideros caffer* (TM), *Miniopterus natalensis* (TM), *Nycteris thebaica* (TM), *Rhinolophus hildebrandtii* (DM, TM), *Rhinolophus* cf. *swinnyi* (DM), *Triaenops afer* (DM, TM)
				Central Mozambique
Buzi River	18	-19.92783	33.82821	*Epomophorus wahlbergi* (DM), *Mops condylurus* (DM), *Nycticeinops schlieffeni* (DM), *Triaenops afer* (DM)
Chimoio	19	-19.1164	33.4833	*Neoromicia capensis*, *Nycteris thebaica*
Casa Msika	20	-19.04024	33.06507	*Chaerephon pumilus* (DM), *Mops condylurus* (DM)
Gorongosa National Park	21	-18.97847	34.17577	*Hipposideros vittatus* (DM), *Neoromicia nana* (DM), *Nycticeinops schlieffeni* (DM), *Scotoecus hindei/albigula* (DM), *Scotophilus* cf. *viridis* (DM)
Chinizuia forest	22	-18.97724	35.05221	*Epomophorus wahlbergi* (DM), *Myonycteris relicta* (DM), *Neoromicia capensis* (DM), *Neoromicia zuluensis* (DM), *Rhinolophus deckenii* (DM), *Rhinolophus hildebrandtii* (DM), *Rhinolophus landeri* (DM), *Scotophilus* cf. *viridis* (DM)
Cheringoma Caves	23	-18.56478	34.87204	*Hipposideros caffer* (DM), *Hipposideros vittatus* (DM), *Miniopterus inflatus* (DM), *Nycteris macrotis* (DM), *Nycteris thebaica* (DM), *Rhinolophus hildebrandtii* (DM), *Rousettus aegyptiacus* (DM), *Triaenops afer* (DM)
Caia Lodge	24	-17.8471	35.32311	*Nycteris thebaica* (DM), *Nycticeinops schlieffeni* (DM)
				Northern Mozambique
Mount Inago	25	-15.0800	37.3900	*Epomophorus wahlbergi*, *Rhinolophus hildebrandtii* (DM), *Rhinolophus* cf. *swinnyi* (DM)
Mount Namuli, foothills	26	-15.46221	37.01918	*Epomophorus crypturus* (MHNG), *Epomophorus wahlbergi* (DM), *Hipposideros ruber* (DM), *Lissonycteris goliath* (DM), *Miniopterus* cf. *fraterculus* (DM), *Myotis bocagii* (DM),

APPENDIX I. Continued

Site	Site number	Latitude	Longitude	Species
				Myotis tricolor (DM), *Neoromicia nana* (DM), *Pipistrellus hesperidus* (DM), *Rhinolophus blasii* (DM), *Rhinolophus clivosus* (DM), *Rousettus aegyptiacus* (DM), *Scotophilus dinganii* (DM)
Mount Namuli	27	-15.36925	37.061361	*Eptesicus hottentotus* (DM), *Miniopterus* cf. *fraterculus* (DM), *Miniopterus inflatus* (DM), *Myotis tricolor* (DM), *Pipistrellus hesperidus* (DM), *Rhinolophus blasii*, *Rhinolophus clivosus* (DM), *Rhinolophus hildebrandtii* (DM), *Rhinolophus* cf. *maendeleo* (DM), *Rhinolophus* cf. *swinnyi* (DM)
Mount Mabu	28	-16.286477	36.403013	*Epomophorus wahlbergi*, *Hipposideros ruber* (DM), *Laephotis botswanae* (MHNG), *Miniopterus* cf. *fraterculus* (MHNG), *Miniopterus natalensis* (DM), *Myotis tricolor* (DM), *Kerivoula* cf. *phalaena* (MHNG), *Rhinolophus blasii* (DM), *Rhinolophus clivosus* (DM), *Rhinolophus hildebrandtii* (DM), *Rhinolophus landeri* (MHNG), *Rousettus aegyptiacus* (MM)
Mount Chiperone	29	-16.50694	35.72583	*Miniopterus inflatus* (DM), *Myotis tricolor* (DM)
Ribaue, 40 km west of	30	-14.97082	38.07951	*Chaerephon ansorgei* (DM), *Epomophorus crypturus* (DM), *Lissonycteris goliath* (DM), *Rousettus aegyptiacus* (DM), *Scotoecus hindei/albigula* (DM), *Scotophilus dinganii* (DM), *Tadarida aegyptiaca* (DM), *Tadarida fulminans* (DM)
Namapa	31	-13.49489	39.78403	*Epomophorus crypturus* (DM), *Epomophorus wahlbergi* (DM), *Rhinolophus hildebrandtii* (DM), *Triaenops afer* (DM)
Balama Coutada	32	-13.41615	38.03745	*Epomophorus wahlbergi* (DM), *Triaenops afer* (DM)
Meponda	33	-13.40146	34.87048	*Chaerephon pumilus* (DM), *Epomophorus crypturus* (DM), *Epomophorus labiatus* (DM), *Hipposideros ruber* (DM), *Myotis bocagii* (DM), *Neoromicia nana* (DM), *Nycteris hispida* (DM),
Meponda, 10 km east of	34	-13.37021	34.93798	*Rhinolophus fumigatus* (DM)
Meponda, 6 km east of	35	-13.36474	34.89817	*Neoromicia zuluensis* (DM)
Pemba	36	-13.00637	40.52368	*Chaerephon pumilus* (DM), *Epomophorus crypturus* (DM), *Nycteris grandis* (DM), *Rhinolophus landeri* (DM),
Niassa Game Reserve, south of	37	-12.86879	37.69196	*Hipposideros caffer* (DM), *Neoromicia nana* (DM), *Nycteris macrotis* (DM), *Nycticeinops schlieffeni* (DM), *Rhinolophus simulator* (DM), *Sauromys petrophilus* (DM), *Scotophilus* cf. *viridis* (DM), *Triaenops afer* (DM)
Niassa Game Reserve, Kiboko, 23 km south of	38	-12.62413	37.65644	*Neoromicia nana* (DM), *Neoromicia zuluensis* (DM), *Scotophilus* cf. *viridis* (DM), *Triaenops afer* (DM)
Niassa Game Reserve, Maputo Camp	39	-12.18234	37.55024	*Epomophorus crypturus* (DM), *Hipposideros caffer* (DM), *Neoromicia nana* (DM), *Neoromicia zuluensis* (DM), *Nycticeinops schlieffeni* (DM), *Rhinolophus fumigatus* (DM), *Rhinolophus hildebrandtii* (DM)
Niassa Game Reserve, Nkuli Camp	40	-12.16906	38.24283	*Hipposideros caffer* (DM), *Neoromicia nana* (DM), *Nycticeinops schlieffeni* (DM), *Scotophilus dinganii* (DM), *Scotophilus* cf. *viridis* (DM), *Triaenops afer* (DM)
Niassa Game Reserve, on Matondovela Road	41	-12.1319	37.43574	*Epomophorus crypturus* (DM), *Hipposideros caffer* (DM)

Appendix II

Updated checklist and conservation status of 67 species of bats recorded from Mozambique

Species	Confirmed[1]	Not confirmed[2]	Red List	Reference
		Pteropodidae		
Eidolon helvum	●		Least concern	Monadjem *et al*. (2010)
Epomophorus crypturus	●		Least concern	This study
E. labiatus	●		Least concern	This study
E. wahlbergi	●		Least concern	This study
Lissonycteris goliath	●		Vulnerable	This study
Myonycteris relicta	●		Vulnerable	This study
Rousettus aegyptiacus	●		Least concern	This study
		Rhinolophidae		
Rhinolophus blasii	●		Near threatened	This study
R. clivosus	●		Least concern	This study
R. darlingi	●		Least concern	Monadjem *et al*. (2010)
R. deckenii	●		Data deficient	This study
R. fumigatus	●		Least concern	This study
R. hildebrandtii	●		Least concern	This study
R. landeri	●		Least concern	This study
R. cf. *maendeleo*	●		Data deficient	This study
R. simulator	●		Least concern	This study
R. cf. *swinnyi*	●		Near threatened	This study
		Hipposideridae		
Cloeotis percivali		●	Vulnerable	Smithers and Lobão Tello (1976)
Hipposideros caffer	●		Least concern	This study
H. ruber	●		Least concern	This study
H. vitattus	●		Least concern	This study
Triaenops afer	●		Least concern	This study
		Emballonuridae		
Coleura afra	●		Least concern	Van Cakenberghe and Seamark (2008)
Taphozous mauritianus	●		Least concern	Monadjem *et al*. (2010)
T. perforatus		●	Least concern	Smithers and Lobão Tello (1976)
		Nycteridae		
Nycteris grandis	●		Least concern	This study
N. hispida	●		Least concern	This study
N. macrotis	●		Least concern	This study
N. thebaica	●		Least concern	This study
N. woodi	●		Near threatened	Monadjem *et al*. (2010)
		Molossidae		
Chaerephon ansorgei	●		Least concern	This study
C. bivittatus		●	Least concern	Smithers and Lobão Tello (1976)
C. pumilus	●		Least concern	This study
Mops brachypterus		●	Least concern	Smithers and Lobão Tello (1976)
M. condylurus	●		Least concern	This study
M. niveiventer		●	Least concern	Smithers and Lobão Tello (1976)
Sauromys petrophilus	●		Least concern	This study
Tadarida aegyptiaca	●		Least concern	This study
T. fulminans	●		Least concern	This study
T. ventralis		●	Near threatened	Smithers and Lobão Tello (1976)
		Vespertilionidae		
Eptesicus hottentotus	●		Least concern	This study
Glauconycteris variegata	●		Least concern	This study
Hypsugo anchietae	●		Least concern	Monadjem *et al*. (2010)
Kerivoula argentata	●		Least concern	This study
K. lanosa	●		Least concern	This study
K. cf. *phalaena*	●		Least concern	This study
Laephotis botswanae	●		Least concern	This study
Mimetillus thomasi	●		Least concern	Monadjem *et al*. (2010)
Myotis bocagii	●		Least concern	This study

APPENDIX II. Continued

Species	Confirmed[1]	Not confirmed[2]	Red List	Reference
Myotis tricolor	●		Least concern	This study
M. welwitschii		●	Least concern	Smithers and Lobão Tello (1976)
Neoromicia nana	●		Least concern	This study
N. capensis	●		Least concern	This study
N. rendalli	●		Least concern	This study
N. zuluensis	●		Least concern	This study
Nycticeinops schlieffeni	●		Least concern	This study
Pipistrellus hesperidus	●		Least concern	This study
P. rueppellii		●	Least concern	Van Cakenberghe & Seamark (2008)
Scotoecus albofuscus	●		Data deficient	Monadjem *et al*, (2010)
S. hindei/albigula	●		Data deficient	This study
Scotophilus dinganii	●		Least concern	This study
S. leucogaster	●		Least concern	This study
S. nigrita	●		Near threatened	Van Cakenberghe & Seamark (2008)
S. cf. *viridis*	●		Least concern	This study
		Miniopteridae		
Miniopterus inflatus	●		Least concern	This study
M. cf. *fraterculus*	●		Least concern	This study
M. natalensis	●		Near threatened	This study
Species total	59	8		

[1] — Specimens of species were either examined by the authors or by Monadjem *et al.* (2010)

[2] — These are typically old specimens possibly housed in European institutions and not located or examined by Monadjem *et al.* (2010), but mentioned in Smithers and Lobão Tello (1976) or Van Cakenberghe and Seamark (2008)