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Source: Acta Chiropterologica, 5(1) : 125-142

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

URL: https://doi.org/10.3161/001.005.0116

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Acta Chiropterologica, 5(1): 125–141, 2003
PL ISSN 1508-1109 © Museum and Institute of Zoology PAS

A conservation assessment of the bats of the Simandou Range, Guinea, with the first record of *Myotis welwitschii* (Gray, 1866) from West Africa

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We report on the results of a bat survey of the Pic de Fon, Simandou Range, southeastern Guinea. This bat survey was part of a larger Rapid Assessment Program (RAP) study conducted by Conservation International in an area currently explored for iron-ore mining by an international company. We document a speciose bat assemblage characterised by forest species, including bats such as *Epomops buettikoferi*, *Rhinolophus guineensis* and *Hipposideros jonesi* that are endemic to Upper Guinea or West Africa. The sympatric occurence of three species of *Kerivoula* is noteworthy, with *K. phalaena* representing the first record for Guinea. Moreover, three individuals of Welwitsch's mouse-eared bat, *Myotis welwitschii*, were captured during the survey. This is the first record for West Africa and represents a range extension of minimally 3,400 km to the northwest from the nearest known localities. We review the distribution of this species in Africa and conclude that the species shows a paramontane distribution pattern (sensu Koopman, 1983). We also report *M. welwitschii* for the first time from Burundi. Our results of the RAP survey as well as the occurrence of bat species that are endemic to the Upper Guinea Highlands highlight the outstanding regional importance of the montane habitats of West Africa in general, and of the Simandou Range in particular for the conservation of bats in Africa.

Key words: biogeography, Chiroptera, Ethiopian Region, first records, *Myotis welwitschii*, Rapid Assessment Program, Upper Guinea, Vespertilionidae

INTRODUCTION

The distribution of most bat species in Africa is still insufficiently known. This holds especially true for West and Central Africa where few surveys have been carried out to date. In addition, many habitats are vanishing at alarming rates and with them basic but invaluable knowledge of species and their distributions. In West Africa, the forest cover has been reduced to 14.4% of the original forest extent and the remaining forests continue to be degraded or lost. The forests in the Upper Guinea biogeographical region are ranked as biodiversity hotspots of continental and global importance (Myers *et al*., 2000; Brooks *et al*., 2001). Consequently, Conservation International held a Priority-Setting Workshop in 1999 to select key areas for conservation in this region based on the consensus of participating experts (Bakarr *et al*., 2001; see also www.biodiversityscience.org/priority_outcomes/west_africa). The workshop resulted

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in the delimitation of priority areas for biodiversity protection (ranked from high to exceptionally high), including regions that are currently unprotected. Moreover, the workshop highlighted the need for imminent biological surveys to provide baseline scientific information that is lacking for many areas. It was decided that poorly known priority areas should be surveyed as soon as possible through Rapid Assessment Programs (RAP) to gather the necessary scientific basis for their protection and to build capacity in the region.

The first RAP survey resulting from this workshop was conducted in southwestern Côte d'Ivoire (Haute Dodo and Cavally Forest Reserves) in March 2002. The second RAP focused on the Pic de Fon (Simandou Range) in Guinea, an area considered to be of overall very high priority and of extremely high priority for mammals (Bakarr *et al*., 2001). During this second RAP expedition, terrestrial mammals, bats, birds, reptiles, amphibians, insects and plants were surveyed by a multi-disciplinary team of 13 scientists. In the present paper, we report on the results of the bat survey and discuss their conservation relevance for both the regional and continental scale. The results of the other groups will be published elsewhere.

Material and Methods

Study Site

The RAP survey was conducted in southeastern Guinea (Guinée Forestière, Prefecture de Macenta) at two sites on the Simandou mountain range near the summit of the Pic de Fon (1,656 m a.s.l.). The 'Forêt Classée du Pic de Fon', covering a surface of 25,600 ha, was created in 1953 and surrounds the Pic de Fon. The highlands are dominated by montane grasslands. The western slopes show larger tracts of primary forests along ravines, which are connected to the forests found at the base of the mountain range. On the eastern side, only small pockets of gallery forest exist along the streams exiting the Simandou Range. The adjacent plains are dominated by bush-tree savanna with few scattered patches of gallery forest. Annual precipitation varies between 1700 and 2000 mm, with a long dry season lasting five to six months (November to April).

Two localities were sampled: the first close to the summit of the Pic de Fon (highland; 08°32'N, 08°54'W, 1350 m), the second on its western slope near the village of Banko (lowland; 08°31'N, 08°56'W, 600 m). The two sites are about 3.6 km apart.

Sampling and Data Analysis

The fieldwork was accomplished by NE. Mist nets were set for seven nights from 28 November to 6 December 2002 (no nets set on 1–2 December). Two mist net sizes were employed: 12 × 2.8 m and 6 × 2.8 m (16 mm mesh; 2 × 70 d netting) with 5 and 4 shelves, respectively. Total sampling effort was 138.0 net hours for 12 m nets and 23.7 net hours for 6 m nets. Most nets were set on poles near ground level or slightly elevated above the surrounding vegetation (herb layer) in forest, savanna and edge habitat. At the lowland site, nets were set both in fairly undisturbed forest and within stands of banana plants. In addition to ground level mist nets, an elevated net system was set up at the lowland site with a total sampling effort of 28.4 net hours. A pulley and rope system was used to raise three stacked 12 m nets with the top of the nets reaching a height of 12 m. This net system was installed at the edge of undisturbed forest. Additionally, a three-bank harp trap (3.4 m^2 capture area) was set at both sites on 10 nights with a total effort of 114.1 trap hours from 27 November to 6 December. The mist nets were usually open from 18:00 to 0:00 hours, while the harp trap was set from 18:00 to 06:00 hours. A randomised species accumulation curve was calculated with EstimateS 6.0b1 (Colwell, 2000). Although there are several statistical methods for estimating the total species number from samples (e.g., Colwell, 2000), we were unable to use these methods because sampling effort and methods varied greatly between nights and sites. Echolocation calls of hand-held bats were recorded with a Pettersson D 240 bat detector (both in 10× and 20× time expansion mode) and transferred to a Sony Walkman Professional WM-D6C. These calls were later analysed on a standard PC with Avisoft-SASLab Pro 4.2. In the families Rhinolophidae and Hipposideridae, the constant frequency (CF) component of the echolocation calls is highly species-specific. We measured the CF-frequency (maximum amplitude, second harmonic) with spectrograms (Hanning window, FFT length 512) and present the values for species that are taxonomically problematic.

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Twenty four voucher specimens were sacrificed to check identifications and to document the bat fauna of the area. These specimens are currently deposited in the collection of JF (University of Ulm). Standard body measurements and mass were taken in the field with analogue callipers to the nearest 0.1 mm and Pesola spring balances to the nearest 1 g, respectively. Preserved specimens were measured with digital callipers under a dissecting microscope; body measurements to the nearest 0.1 mm, craniodental measurements to the nearest 0.01 mm (Bm: body mass; Tot: total length, HB + Tail; HB: head and body length from tip of snout to posterior margin of anus; Tail: length of tail from posterior margin of anus to tip of tail; Ear: length of ear from lower margin of conch to tip of ear; Tr: length of tragus along posterior margin from base to tip; FA: length of forearm, including carpals; 3Pha1: first phalanx of third digit; 3Pha2: second phalanx of third digit; Tib: length of tibia; HF: length of hind foot including claws; Crn: greatest length of skull from posteriormost point to front of praemaxillae; Mast: mastoid width; Zyg: zygomatic width; C–C: width across crowns of upper canines; M^n–M^n: width across crowns of posterior upper molars; C–M^n: length of upper (maxillary) tooth row from front of canine to back of posterior molar). We did not compare our measurements with those provided by Konstantinov *et al*. (2000) because the values given by these authors indicate either pooling of adult and juvenile specimens or substantial misidentifications.

The geographical positions of the study sites were determined with a hand-held GPS receiver (Garmin GPS 12). Additional geographic co-ordinates were taken from literature or museum catalogues and verified with maps and the GEOnet Names Server (http://164.214.2.59/gns/html). Co-ordinates of all localities are listed in Appendix II. Distribution records were plotted with ESRI's ArcView GIS 3.2a on a digital elevation model (U.S. Geological Survey; http://edcdaac.usgs.gov/gtopo30). Habitat associations were determined by superimposing point localities onto the latest version of WWF ecoregions (Olson *et al*., 2001; www.worldwildlife.org/ecoregions) with the function 'assign data by location (spatial join)'.

Museum acronyms are as follows: BMNH: British Museum (Natural History), London; DM: Durban Natural Science Museum; FMNH: Field Museum of Natural History, Chicago; HZM: Harrison Zoological Museum, Sevenoaks; IRSNB: Institut royal des Sciences naturelles de Belgique, Bruxelles; MHNG: Muséum d'Histoire naturelle, Genève; MNHN: Muséum National d'Histoire Naturelle, Paris; MRAC: Musée Royal de l'Afrique Centrale, Tervuren; NHMW: Naturhistorisches Museum, Wien; NHMZ: Natural History Museum Zimbabwe, Bulawayo; NMB: National Museum Bloemfontein; NMK: National Museum Kenya, Nairobi; NMZ: National Museum Zambia, Livingstone; ROM: Royal Ontario Museum, Toronto; SMF: Senckenberg Museum, Frankfurt am Main; SMNS: Staatliches Museum für Naturkunde, Stuttgart; TM: Transvaal Museum, Pretoria; ZFMK: Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn; ZMB: Zoologisches Museum der Alexander von Humboldt Universität, Berlin.

Results

The Bat Fauna of the Simandou Range

In total, we captured 276 bats comprising 21 species, 14 genera, and six families. For the nets close to ground level, overall capture success was 0.42 bats per 12 m mist net hour (b/mh), for Megachiroptera 0.33 b/mh and for Microchiroptera 0.09 b/mh. For the elevated nets, overall capture success was 2.57 b/mh, for Megachiroptera 2.50 b/mh and for Microchiroptera 0.07 b/mh. The overall capture success for the harp trap was 1.23 bats per trap hour (b/th), for Megachiroptera 0.03 b/th and for Microchiroptera 1.20 b/th.

The bat assemblage is comprised of both forest and savanna species although species primarily associated with forest habitat dominate the sample (13 species or 62%; Table 1). Species that are either predominantly found in savanna habitats or both in savanna and forest constitute smaller fractions (4 species or 19% for each category; Table 1). The assemblage is also characterized by a high number of species that are (partially) dependent on caves as day roosts (*Rousettus aegyptiacus*, *Rhinolophus* spp., *Hipposideros* spp., *Miniopterus schreibersii*). The species accumulation curve rises steeply and no asymptotic plateau is discernible (Fig. 1), illustrating that the inventory of the bat fauna of the Simandou Range is far from being complete.

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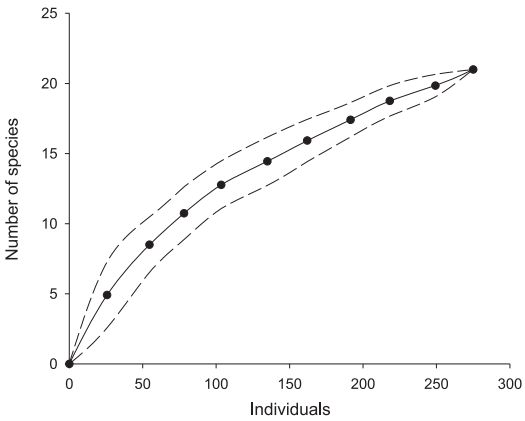

FIG. 1. Randomized species accumulation curve for the bats sampled during the RAP survey (solid line and dots: randomisation, 100 runs; dashed lines: ± 1 SD)

Taxonomic Notes on Selected Species

Epomops buettikoferi: This species is endemic to West Africa and occurs from Senegal in the West to Nigeria in the East (Bergmans, 1989; Dupuy, 1990). In West Africa, *E. franqueti* (Tomes, 1860) is not known further west than Adiopodoumé and Forêt du Banco in SE Côte d'Ivoire (Bergmans, 1989; J. Fahr, unpubl. data). Although Ziegler *et al*. (2002) recently reported the latter species from Guinea (Haute Niger-N.P.: Sidokoro), about 880 km northwest to the nearest known localities in Côte d'Ivoire, their specimen (ZFMK 97.435) was re-examined by one of the present

TABLE 1. Species recorded during the RAP survey of the Simandou Range. The column Lowland and Highland refers to records at the two different sampling localities (see Material and Methods). Habitat: coarse assignment to preferred habitat types (F: forest; S: savannas and woodlands; in parentheses: marginally including the respective habitat type)

Taxon	Lowland	Highland	Habitat	
Pteropodidae				
Epomophorus g. gambianus (Ogilby, 1835)	+			S
Micropteropus pusillus (Peters, 1868)	+	+		S
Epomops buettikoferi (Matschie, 1899)	+		F	(S)
Megaloglossus woermanni Pagenstecher, 1885	+		F	
Myonycteris torquata (Dobson, 1878)	+		F	(S)
Rousettus aegyptiacus unicolor (Gray, 1870)	+	+	F	S
Eidolon h. helvum (Kerr, 1792)		+	F	S
Nycteridae				
Nycteris grandis Peters, 1865	+		F	(S)
Rhinolophidae				
Rhinolophus alcyone Temminck, 1853	+		F	(S)
Rhinolophus guineensis Eisentraut, 1960	+	+	F	
Rhinolophus l. landeri Martin, 1838	+			S
Hipposideridae				
Hipposideros jonesi Hayman, 1947		+	F	S
Hipposideros cf. *caffer* (Sundevall, 1846)	+		F	S
Hipposideros cf. *ruber* (Noack, 1893)	+	+	F	(S)
Hipposideros fuliginosus (Temminck, 1853)	+	+	F	
Vespertilionidae				
Myotis welwitschii (Gray, 1866)		+	(F)	S
Kerivoula lanosa muscilla Thomas, 1906	+		F	(S)
Kerivoula phalaena Thomas, 1912		+	F	
Kerivoula sp.	+		F	
Miniopterus schreibersii villiersi Aellen, 1956	+	+	F	(S)
Molossidae				
Mops spurrelli (Dollman, 1911)	+		F	

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authors (JF) and provisionally re-identified. It is a female, preserved as a wet specimen with the skull extracted, the soft palate is lost. Both the incompletely fused skull sutures and epiphyses of the finger joints show that it is a juvenile. Thus, neither measurements (FA: 77.0; Crn: 40.6; Mast: 15.9; Zyg: 21.8; C–C: 8.3; M^1–M^1: 12.7; C–M^1: 13.9) nor skull and external characters allow for a reliable identification as *E. franqueti*. Based on the currently known distribution of *E. buettikoferi* and *E. franqueti*, we consider the occurrence of *E. franqueti* in central Guinea as very unlikely and provisionally re-identify the specimen as *E. buettikoferi* pending further specimens.

Rhinolophus alcyone: A single male (FA: 52.2, Bm: 17.5) had orange-red axillary tufts. The frequency of the CF-component was 67.4 kHz.

Rhinolophus guineensis: Seven individuals were captured. Selected measurements (3♂♂ followed by 4♀♀): FA: 47.0 (46.8–47.2) — 47.0 (46.7–47.4), Bm: 10.5 (10.0–11.5) — 10.0 (9.5–10.5). The males had white axillary tufts. The frequency of the CF-component was 85.3–85.4 kHz ($n = 2$).

Rhinolophus landeri: A single male (FA: 43.5, Bm: 8.0) had orange-brown axillary tufts. The frequency of the CF-component was 103.3 kHz.

Hipposideros jonesi: The single female is rather large in comparison to specimens from western Guinea published by Eisentraut and Knorr (1957; 4♂♂, 3♀♀): Tot: 79.9 — 68.4 ± 1.2 (66.0–69.5), Tail: 25.5 — 22.9 ± 0.2 (22.5–23.0), Ear: 25.5 — 24.0 ± 0.8 (23.0–25.0), FA: 49.5 — 44.6 ± 0.6 (43.5–45.2), Tib: 21.5 — 20.5 ± 0.5 (19.7–21.0), Bm: 8.5 — 6.4 (5.0–7.3); C–C: 3.90 — 3.3 ± 0.2 (3.0–3.7), M^3–M^3: 5.91 — 5.7 ± 0.1 (5.6–5.8), C–M^3: 6.20 — 6.0 ± 0.1 (5.9–6.2). Hayman (1964) documented extensive geographic variation for this species and ascribed this to a morphological cline, with populations from the west (Sierra Leone) being significantly smaller than populations from the east (Ghana). However, specimens from even further east (central Nigeria) are smaller than those from Ghana and populations from Mali, Burkina Faso and Côte d'Ivoire show considerable variation as well (J. Fahr, unpubl. data). It seems that the exceptional geographic variability of *H. jonesi* is not simply clinal as proposed by Hayman (1964), i.e., increasing in size from west to east, but more likely linked to environmental factors such as seasonality and/or precipitation, with bats from more seasonal/mesic regions (e.g., western Guinea, Mali, central Nigeria) averaging smaller than those from less seasonal/more humid areas (e.g., southeastern Guinea, coastal Sierra Leone, Ghana).

Hipposideros cf. *caffer*: The taxonomy of both *H. caffer* and *H. ruber* is currently unresolved and in urgent need of revision. However, it is already apparent that these taxa comprise more than two species. We therefore assign only preliminary identifications to individuals from the survey. Selected measurements for five specimens (3♂♂ followed by 2♀♀): FA: 48.2 (47.5–49.0) — 50.0 (49.2–50.7), Tib: 20.6, 20.9 ($n = 2$), Bm: 8.7 (8.0–9.5) — 8.8 (8.5–9.0), C–C: 4.21, 4.04 ($n = 2$), M^3–M^3: 6.28, 6.30 ($n = 2$), C–M^3: 6.25, 6.21 ($n = 2$). The frequency of the CF-component was 160.2–164.1 kHz ($n = 3$).

Hipposideros cf. *ruber*: The single male (FA: 51.7, Bm: 10.0) that was recorded called with a CF-frequency of 146.7 kHz.

Hipposideros fuliginosus: Selected measurements for four females followed by six males: FA: 53.3 (52.5–53.7) — 54.0 ± 0.7 (53.2–55.3), 3Pha1: 17.2 (16.6–17.6) — 17.8 ± 0.6 (17.1 –18.5), 3Pha2: 19.7 (19.1–19.9) — 19.6 ± 1.1 (18.6–21.5), Bm: 12.9 (11.5 –14.0) — 13.2 ± 0.7 (11.9–14.0), C–C: 5.38 (5.31 –5.46) — 5.36 ± 0.06

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(5.29–5.45), M^3–M^3: 7.64 (7.55–7.76) — 7.75 ± 0.21 (7.51 –8.03), C–M^3: 7.63 (7.53–7.78) — 7.61 ± 0.15 (7.44–7.79). The frequency of the CF-component was 122.5 ± 1.3 (120.0–123.3) kHz ($n = 6$). *Hipposideros lamottei* Brosset, 1985, described from Mt. Nimba, Guinea, differs from *H. fuliginosus* in having considerably shortened phalanges of the 3rd digit and a rather delicate skull and teeth. Selected measurements for the type series of *H. lamottei* are (5♂♂ followed by 1♀; MHNG 1626.36–38, MNHN 1984-487–489): FA: 56.0 ± 0.7 (55.0–56.9) — 55.1, 3Pha1: 13.3 ± 0.7 (12.5–14.3) — 12.5, 3Pha2: 11.4 ± 0.8 (10.5–12.1) — 11.0, C–C: 4.31 ± 0.30 (4.00–4.72) — 4.50, M^3–M^3: 6.61 ± 0.24 (6.20–6.80) — 6.71, C–M^3: 6.60 ± 0.14 (6.40–6.71) — 6.55.

Kerivoula lanosa: A single male has a comb-like fringe of hairs on the uropatagium, which is characteristic for this species. Selected measurements: Ear: 12.5, Tr: 6.2, FA: 31.3, Tb: 13.8, Bm: 4.5, C–C: 3.26, M^3–M^3: 5.32, C–M^3: 5.17.

Kerivoula phalaena: A single female (FA: 29.0, Bm: 3.0, C–C: 3.0, M^3–M^3: 4.6) represents the first record of this species for Guinea.

Kerivoula sp.: Five individuals (1♂, 4♀♀) without a comb-like fringe of hairs on the uropatagium were captured. These are larger than *K. phalaena*. A definite identification requires the detailed comparison with other members of the genus.

Miniopterus schreibersii: Four individuals (2♂♂, 2♀♀) were caught. These are smaller than *M. inflatus*, which has been documented for the highlands in Liberia. Selected measurements for one male and one female, respectively: Tot: 105.1, 102.6, Tail: 49.2, 49.3, FA: 43.6, 45.1, Tib: 16.9, 18.0, Bm: 10.0, 8.5, C–C: 4.53, 4.52, M^3–M^3: 6.52, 6.40, C–M^3: 5.96, 6.05.

Myotis welwitschii

Surprisingly, we captured three individuals of *M. welwitschii*, a bat previously known only from East and Southern Africa. This bat (Fig. 2) is distinguished from all

FIG. 2. *Myotis welwitschii* from Pic de Fon, Simandou Range (photo by P. Naskrecki)

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other *Myotis* species occurring in Africa by the distinct coloration of its membranes and pelage. The measurements of these specimens generally agree with those from East and Southern Africa. However, the length of the maxillary tooth row (C–M^3) seems to be rather large in the specimens from Guinea compared to published measurements (Table 2; see also Ratcliffe, 2002).

All three individuals (2♂♂, 1♀) were captured in the upper shelves of 12 m nets (2–3 m above ground level) in edge habitat during the night of 29/30 November at 19:09, 21:27, and 00:10 hours, respectively. The netting sites were located in a patch of montane grassland situated between two stretches of forest running down the western slope. Both forest patches converge below into a single large forest. The males were caught at the edge of a line of trees in the grassland, running parallel to the wider forest. The female was caught just 150 m downhill from where the males were caught, directly at the edge of the wider forest about 200 m above the point of forest convergence. Both males had scrotal testes (9.8 × 6.7 and 12.6 × 7.0 mm, respectively), the female was nulliparous.

This exciting record prompted us to review the documented distribution of *M. welwitschii* based on literature, museum specimens, and personal communications (Appendix I). In total, we gathered 61 records that could be geographically distinguished. Two additional localities were indistinguishable based on their co-ordinates or proved to be synonymous with other localities: Kapalasa Farm (indistinguishable from Kapino Dam) and 'near Skukuza' (Appendix I).

Myotis welwitschii is now documented for the following 15 countries: Angola, Burundi, Congo (K.), Ethiopia, Guinea, Kenya, Malawi, Mozambique, Rwanda, South Africa, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe (Appendix I). The specimen from Rwegura (MHNG 1607.095, Appendix I) is the first record for Burundi. Most of the localities are situated in highlands or mountains (Fig. 3). The altitudinal range spans from 55 to 2311 m elevation a.s.l., with a median of 1209 m (n = 61, Appendix II). The analysis of occupied ecoregions revealed a pronounced preference for woodlands and forest-savanna mosaic (Table 3). To date, no record is known from the closed forest zone of the Central Congo Basin.

TABLE 2. Body and tooth measurements of *M. welwitschii* from Guinea versus East and Southern Africa

Character	Guinea			East and Southern Africa		
	F-N° 97	F-N° 105	F-N° 113	$\bar{x}$ ± 1 SD	min–max	n
Sex	♂	♂	♀	§		
Bm	16.0	18.0	18.5	16.3 ± 1.6	15.0–19.0	6
Tot	123.0	127.6	123.0	121.0 ± 2.9	115.0–127.0	11
HB	64.1	69.0	62.9	62.1 ± 2.0	60.0–65.0	12
Tail	58.9	58.6	60.1	58.8 ± 3.0	55.0–65.0	13
Ear	22.6	21.6	20.8	21.7 ± 2.0	19.0–25.1	13
Tr	9.9	11.2	10.1	10.6 ± 0.7	10.0–11.5	6
FA	57.8	56.7	58.8	56.0 ± 1.5	53.0–58.3	17
Tibia	23.9	22.5	24.0	25.1 ± 2.5	22.0–28.8	5
HF	12.7	12.7	12.7	11.3 ± 1.0	10.0–13.0	10
C–C	–	5.98	5.55	5.5	5.2–5.7	4
M^3–M^3	8.73	9.03	8.65	8.5 ± 0.3	8.2–8.9	5
C–M^3	8.23	7.69	8.26	7.6 ± 0.3	7.2–7.9	8

§: 18 specimens: 7♂♂, 2♀♀, 9 unsexed (BMNH 66.4.12.2 [holotype], 0.11.6.1, 22.12.17.75, –.76; DM 954; F 2602 [Malawi, Liwonde]; FMNH 144313; HZM 1.2633; MRAC 12661, 80.055-M-0169; ROM 36337, 50533, 65964, 91210; SMF 12145; SMNS 29988; TM 3977).

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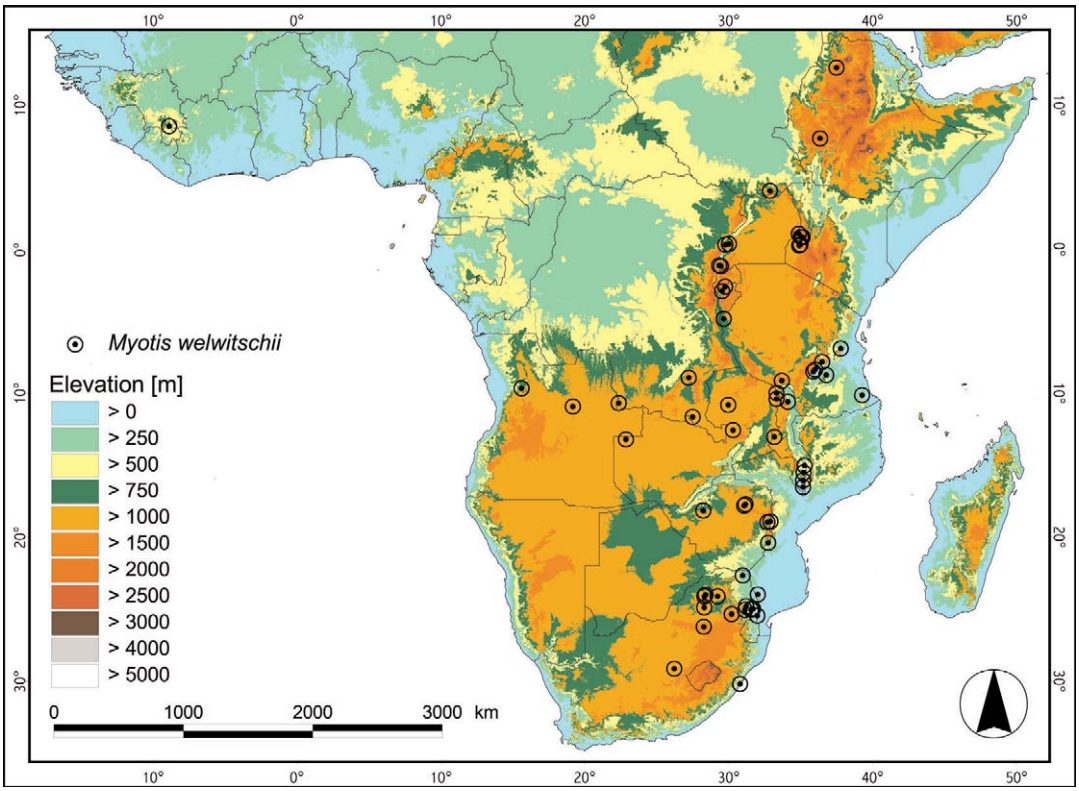

FIG. 3. Distribution of *M. welwitschii* plotted on the 30 arc second digital elevation model (USGS)

DISCUSSION

Myotis welwitschii

The record from Guinea corresponds to a range extension of 3400 km in a straight line across the Gulf of Guinea to the inferred type locality in Angola (Pungo Andongo/Cuanza; see Crawford-Cabral, 1989). If we more realistically assume a distribution pattern in which the closed rain forest zone of the Congo Basin is excluded (Table 3, Fig. 3), the record from Guinea is 4400 km distant from the nearest known localities along the Albertine Rift (Mutsora; Lake Ondo). This exceptional range extension emphasises our very fragmentary knowledge of bat distributions in Africa.

The distribution pattern of *M. welwitschii* is conspicuously tied to highlands or mountains (Fig. 3; ≤ 500 m alt., n = 9; ≤ 1,000 m alt., n = 12; ≤ 1,500 m alt., n = 22; ≤ 2,000 m alt.: n = 11; > 2,000 m alt., n = 7). This is in accordance with Koopman's (1986) view who was the first to point out this particular distribution pattern for *M. welwitschii*, which he had earlier termed 'paramontane' (Koopman, 1983), i.e., species that are restricted to mountainous regions although their altitudinal range covers both lower and higher elevations. When viewed in detail, many of the records are situated in areas of topographical complexity, i.e., on the slopes of mountains or highland plateaus. At lower altitudes, this species has mainly been found towards the coastal plains along the Indian Ocean (Tanzania, Mozambique, South Africa). The reason for the paramontane distribution of *M. welwitschii* is difficult to explain. In other bat species, this pattern is probably linked

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TABLE 3. Number and percentage of records of *M. welwitschii* from different biomes and Afrotropical ecoregions as determined by the GIS-overlay

Biome	Ecoregion	Records	
		n	%
Tropical and subtropical moist broadleaf forests		11	18.0
	Guinean montane forests	1	1.6
	East African montane forests	1	1.6
	Albertine Rift montane forests	4	6.6
	Eastern Arc forests	2	3.3
	Northern Zanzibar-Inhambane coastal forest mosaic	1	1.6
	Southern Zanzibar-Inhambane coastal forest mosaic	1	1.6
	KwaZulu-Cape coastal forest mosaic	1	1.6
Tropical and subtropical dry broadleaf forests		1	1.6
	Zambezian Cryptosepalum dry forests	1	1.6
Tropical and subtropical grasslands, savannas, and shrublands		37	60.7
	Victoria Basin forest-savanna mosaic	6	9.8
	Angolan Miombo woodlands	2	3.3
	Central Zambezian Miombo woodlands	9	14.8
	Eastern Miombo woodlands	2	3.3
	Southern Miombo woodlands	6	9.8
	Zambezian and Mopane woodlands	8	13.1
	Southern Africa bushveld	4	6.6
Flooded grasslands and savannas		1	1.6
	Zambezian flooded grasslands	1	1.6
Montane grasslands and shrublands		11	18.0
	Ethiopian montane grasslands and woodlands	2	3.3
	Ruwenzori-Virunga montane moorlands	1	1.6
	South Malawi montane forest-grassland mosaic	3	4.9
	Eastern Zimbabwe montane forest-grassland mosaic	1	1.6
	Drakensberg montane grasslands, woodlands and forests	2	3.3
	Highveld grasslands	2	3.3

to a high dependency on rock caves as day roosts (Fahr *et al*., 2002). The density of caves is usually much higher in mountainous regions, possibly leading in some species to the observed paramontane pattern. However, *M. welwitschii* has been reported to roost unconcealed in vegetation, e.g., on bushes and trees, and has sometimes been found in furled banana leaves (Smithers and Lobão Tello, 1976; Smithers and Wilson, 1979; Rautenbach, 1982; Ansell and Dowsett, 1988; Taylor, 1991). To our knowledge, only a single specimen was taken in a cave, where it was found roosting on the side wall (TM 41034).

Based on our record from West Africa, we suggest that this bat could occur in other mountainous regions between Upper Guinea and East Africa, e.g., the Jos Plateau in Nigeria, the northern part of the Cameroon Mountain Range between Nigeria and Cameroon (Mambilla Plateau, Shebshi Mts., Adamawa Highlands), and the Bongos and Tondou Massifs in northeastern Central African Republic. The southwestern margin of the known range (records south of northern Angola and western Zambia) coincides roughly with the isohyete of 1000 mm annual precipitation, probably excepting southern Angola, Namibia, western Botswana and the Cape Province of South Africa from the distribution range.

Although this species is widely distributed in Africa, it is rarely recorded in bat inventories. The number of known localities almost equals the number of specimens

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recorded at these localities. Either the abundance of *M. welwitschii* is generally very low or this bat is difficult to capture with current sampling methods. Our record from Guinea is remarkable in this respect as we caught three individuals during the same night. Many of the captures of *M. welwitschii* were in mist nets placed over water or in riverine vegetation. However, the current data do not allow us to distinguish between the possibilities that this species has been caught when coming down to drink or while foraging over water. Several other *Myotis* species are known to hunt over or near water, and the same might be true for *M. welwitschii*.

The bat fauna of the Simandou Range

Including the results of our study, 63 species are documented for Guinea (J. Fahr, unpubl. data). We recorded 21 species for the Simandou Range, i.e., one third of the known bat fauna of the country, during the very short study period of the RAP survey. However, the real species number for both the country and the Simandou Range is certainly much higher than currently known (Fig. 1). On the other hand, our combination of sampling methods (mist nets both near ground and canopy level, harp traps) shows that a substantial portion of the local assemblage can be surveyed within a rather short study period.

The bat fauna of the Simandou Range is largely dominated by forest species. Several species preferring open habitats have likewise been recorded, reflecting the mosaic structure of the habitat, which comprises lowland forests, gallery forests, bush-tree savannas and montane grasslands. The mixture of habitat types and the elevational gradient of the area might therefore support an exceptionally rich bat assemblage that urgently needs to be documented more thoroughly by means of additional surveys.

A striking feature of the bat fauna in the Upper Guinea Highlands (including Mt. Nimba, the Wonegizi-Ziama Range, the Simandou Range and the Fouta Djallon) is the disproportionally high number of species that are either endemic to Upper Guinea or represented in this region by isolated populations, e.g., *Rhinolophus simulator alticolus* Sanborn, 1936, *R. denti knorri* Eisentraut, 1960, *R. hillorum* Koopman, 1989, *R. guineensis*, *R. maclaudi* Pousargues, 1897, *R. ziama* Fahr, Vierhaus, Hutterer and Kock, 2002, *Hipposideros jonesi*, *H. marisae* Aellen, 1954, *H. lamottei*, *Myotis tricolor* (Temminck, 1832), *Hypsugo crassulus bellieri* (De Vree, 1972), *Miniopterus schreibersii villiersi*, *M. i. inflatus* Thomas, 1903, and *Chaerephon b. bemmeleni* (Jentink, 1879). Many of these species are also strictly or partially dependent on caves as day roosts (*Rhinolophus* spp., *Hipposideros* spp., *Myotis tricolor*, *Miniopterus* spp.), which are offered by the high topodiversity of this region. As a subset of this regional fauna, the bat assemblage of the Simandou Range is likewise characterized by many cave-dwelling species. We strongly suspect that several of the species listed above but not yet recorded from the Simandou Range will be found in this region as many of these species are known from localities between 40 and 120 km distant from Pic de Fon.

Several species are not only endemic to Upper Guinea but also appear to have astonishingly small distribution ranges, i.e., *R. maclaudi*, *R. ziama*, *R. guineensis*, *H. marisae* and *H. lamottei*. Of these, *H. marisae* is classified as 'Vulnerable', *R. guineensis* as 'Lower Risk: Near Threatened' and *H. lamottei* as 'Data Deficient' according to the latest IUCN Red List (Hutson *et al*., 2001). Fahr *et al*. (2002) proposed to classify *R. maclaudi* as 'Endangered' and the recently described *R. ziama* as 'Data Deficient'. Both *R. ziama* and *H. lamottei*

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are known from two localities each, and almost nothing is known about their biology. It is also remarkable that, out of nine species described from continental Africa within the last 20 years, three (denoted with asterisks) were discovered in the Upper Guinea Highlands: *Epomophorus minimus* Claessen and De Vree, 1991, *Rhinolophus hillorum**, *R. ziama**, *R. maendeleo* Kock, Csorba and Howell, 2000, *R. sakejiensis* Cotterill, 2002, *Hipposideros lamottei**, *Plecotus balensis* Kruskop and Lavrenchenko, 2000, *Glauconycteris curryae* Eger and Schlitter, 2001, *Scotophilus nucella* Robbins, 1984.

Conclusion

To summarize these data, we have found that 1) the Simandou Range harbours a speciose bat assemblage characterized by forest and cave-dwelling species, 2) the Upper Guinea Highlands support many species that are endemic to West Africa, in some cases even endemic to these Highlands (restricted range size species), 3) some of these species are globally threatened or near threatened, and 4) several new species have been recently discovered in this region, indicating that much remains to be found in this area.

Currently, the Simandou Range is being explored for iron-ore deposits by an international mining company. Preliminary results from the drilling program indicate an exceptionally high-grade iron-ore deposit (66–69%), similar to that found on Mt. Nimba in Liberia. The latter deposit has been exploited through open cast mining with the result that the Liberian portion of Mt. Nimba is now almost completely devoid of natural vegetation (Colston and Curry-Lindahl, 1986; Gatter, 1997). Today, on Mt. Nimba, larger tracts of fairly undisturbed montane habitats can only be found on the Guinean and Ivorian sides. Open cast mining in the Simandou Range would be equally devastating for the remaining habitats. The Simandou Range together with the other larger forest reserves in Guinea (i.e., Ziama, Diécké, Mt. Bero, Mt. Nimba) form the last stronghold of fairly undisturbed and protected highland habitats in the forest zone of Guinea. We expect disastrous consequences for the bat fauna of the region if these areas should be destroyed through mining, deforestation and encroaching settlements. The unexpected record of *M. welwitschii*, together with species endemic to the Upper Guinea Highlands or West Africa, essentially highlight the conservation relevance of the region in general and of the Simandou Range in particular. Our findings support the conclusion of the Priority Setting Workshop that ranks the montane habitats of Guinea as being of extremely high priority for mammals (Bakarr *et al*., 2001) and endorse the Upper Guinea region as a biodiversity hotspot of global importance.

Acknowledgements

We thank Jennifer McCullough and Leeanne Alonso (Conservation International) for their invitation to and organization of the RAP. The successful teamwork and assistance of the RAP members as well as Mamadou Saliou Diallo (Guinée-Ecologie) is much appreciated. Rio Tinto Mining & Exploration Ltd. provided essential support for the RAP during fieldwork. The Guinean authorities permitted fieldwork to be conducted in the Forêt Classée du Pic de Fon. Specimens were exported under a permit from the Ministère Nationale des Eaux et Forêts (No. 100-739, 11 December 2002). We are very grateful to the following curators for providing data on specimens in the collections under their care: Peter Taylor (DM), William Stanley (FMNH), David Harrison (HZM), Georges Lenglet (IRSNB), Manuel Ruedi (MHNG), Wim van Neer (MRAC), Nico Avenant (NMB), Susan Woodward (ROM), Dieter Kock (SMF), Fritz Dieterlen (SMNS), and Teresa Kearney (TM). Meredith Happold (Canberra), Ernest Seamark (Pretoria), Paul van Daele (Livingstone, Zambia) and P. Taylor kindly made available unpublished distribution records. Our special thanks go to D. Kock who

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provided many additional references. We thank Piotr Naskrecki (Cambridge, USA) for allowing us to use one of his pictures for this publication. M. Happold, D. Kock, J. McCullough and an anonymous referee made useful comments on earlier versions of the manuscript. The present work was partially funded through the German Research Ministry (BIOTA project).

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Received 21 February 2003, accepted 19 March 2003

APPENDIX I

Distribution records (countries in alphabetical order) of *Myotis welwitschii* (museum specimens; literature; pers. comm.):

ANGOLA: Alto Chicapa (Hayman, 1963; Kock, 1967), no spec. loc. (BMNH 66.4.12.2, holotype *Scotophilus welwitschii* Gray, 1866; Kershaw, 1922; Hill and Carter, 1941; Roberts, 1951; Ellerman *et al*., 1953; Harrison and Fleetwood, 1958; Kock, 1967; Findley, 1972; Crawford-Cabral, 1989: loc. typ. 'probably N of Cuanza River – perhaps Pungo Andongo or its surroundings, near Cuanza');

BURUNDI: Rwegura (Kayanza) (MHNG 1607.095);

CONGO (K.): Dilolo (MRAC 12661; Poll, 1939; Frechkop, 1939, 1943; Hill and Carter, 1941; Schouteden, 1944, 1948; Anciaux de Faveaux, 1958; Harrison and Fleetwood, 1958; Hayman *et al*., 1966; Kock, 1967), Elisabethville [Lubumbashi] (IRSNB 15428, 18513; MRAC 23462; Anciaux de Faveaux, 1958; Hayman *et al*., 1966; Kock, 1967; Ansell, 1978), Lake Ondo (Hayman *et al*., 1966; Kock, 1967), Lusinga (Upemba-N.P.) (IRSNB 10848; Frechkop, 1954; Anciaux de Faveaux, 1958; Hayman *et al*., 1966; Kock, 1967; Findley, 1972), Mutsora (Hayman *et al*., 1966; Kock, 1967), Rutshuru (Virunga-N.P.) (IRSNB 4789; Frechkop, 1939, 1943, 1954; Schouteden, 1944, 1948; Harrison and Fleetwood, 1958; Hayman *et al*., 1966; Kock, 1967; Findley, 1972);

ETHIOPIA: Afallo (région de Ghera, Kaffa) (MHNG 1717.018), Gondar (Rode, 1933; Kock, 1967; Largen *et al*., 1974);

GUINEA: Pic de Fon (Simandou Range) (this study);

KENYA: Endebess (Mt. Elgon) (HZM 1.2633; Harrison and Fleetwood, 1958; Harrison, 1961; Kock, 1967; Aggundey and Schlitter, 1984), Hoey's Bridge (Cherangani) (ROM 36337; Aggundey and Schlitter, 1984), Kakamega Forest (ROM 50533, 65964; Aggundey and Schlitter, 1984; Ratcliffe, 2002), North Nandi Forest (NHMW), Trans Nzoia Distr. (NMK; Harrison, 1961; Kock, 1967; Aggundey and Schlitter, 1984);

MALAWI: Chiromo (BMNH 22.12.17.76; Kershaw, 1922; Frechkop, 1939; Roberts, 1951; Harrison and Fleetwood, 1958; Kock, 1967; Findley, 1972; Happold *et al*., 1988), Cholo [Thyolo] (Ruo River) (BMNH 22.12.17.75; Kershaw, 1922;

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Frechkop, 1939; Roberts, 1951; Harrison and Fleetwood, 1958; Kock, 1967; Findley, 1972; Happold *et al*., 1988), Kapalasa Farm (Namadzi) (Happold and Happold, 1997), Kapino Dam (Namadzi) (Happold and Happold, 1997), Kasungu-N.P. (administration area) (Happold *et al*., 1988), Livingstonia (NHMZ; Ansell and Dowsett, 1988; Happold *et al*., 1988), Liwonde-N.P. (Happold *et al*., 1988);

MOZAMBIQUE: three mapped but unnamed localities: 1 at W-border of Gaza District, 2 in Vila de Manica area (Smithers and Lobão Tello, 1976);

RWANDA: Butare (MRAC 80.055-M-0169; Baeten *et al*., 1984);

SUDAN: Gilo (Imatong Mts.) (SMNS 29988; Dieterlen and Rupp, 1979; Koopman, 1986);

TANZANIA: near Kigoma (Lake Tanganyika) (ROM 91210), Kinole (N-slope Uluguru Mts.) (ZMB, holotype *Vespertilio venustus* Matschie, 1899; Frechkop, 1939; Swynnerton and Hayman, 1951; Roberts, 1951; Harrison and Fleetwood, 1958; Kock, 1967), btw. Kipara and Ikulia Rivers (HZM 5.5426), 15 km SSE Masisiwe (Kihanga, Udzungwa Scarp-F.R., Udzungwa Mts.) (FMNH 164084), Mwatesi Stream (Rungwe Mts.) (NMZ 2698; Ansell and Ansell, 1973), Ndundulu Forest (West Kilombero Scarp-F.R., Udzungwa Mts.) (FMNH 169543), Rondo-F.R. (50–60 km W Lindi, Lindi Distr.) (SMF 82545; Burgess *et al*., 2000); Uhafiwa Luhega Forest (near Uhafiwa, Mufindi Distr., Udzungwa Mts.) (SMF 79571);

UGANDA: right bank Mubuku River (above confl. with Kyoha River, E-slope Rwenzori Mts.) (FMNH 144313; Stanley *et al*., 1996; Kityo and Kerbis, 1996; Ruedi and Mayer, 2001);

ZAMBIA: Makutu Mountains (NMZ 2572; Ansell and Ansell, 1973), Mbulo Forest (Lukolwe-Luzu road, west bank of Zambezi River) (P. van Daele, pers. comm.), Mafinga Mountains (NMZ 2573; Ansell and Ansell, 1973), Nsombo (Lake Bangweolo) (SMF 12145; Kock, 1967; Findley, 1972), Wasa Camp (Kasanka-N.P.) (A. M. Hutson and P. A. Racey, 22 November 2002);

SOUTH AFRICA: Bloemfontein City (NMB 1263; Lynch, 1983), Boksburg (TM 17035; Rautenbach, 1982), Craigieburn (near Umkomaas, KwaZulu-Natal) (DM 954; Taylor, 1991), Doornsloot (NHMZ; Rautenbach, 1982), Kanaan (near Hazyview, Mpumalanga) (TM 46638; C. Schoeman, S. Stoffberg and E. C. J. Seamark, pers. comm. 15.I.2003), Klipfontein farm 53 (30 km NE Ellisras) (TM 39421; Rautenbach *et al*., 1993; Ruedi and Mayer, 2001), Lebombos (near Shingedzene, Kruger-N.P.) (Pienaar, 1964; Rautenbach, 1982), Lydenburg (80 km ENE, Transvaal) (BMNH 0.11.6.1; Kershaw, 1922; Hill and Carter, 1941; Ellerman *et al*., 1953; Harrison and Fleetwood, 1958; Kock, 1967; Findley, 1972), Makapansgat (historic cave, Potgietersrus) (TM 41034), Matukwala (dam 5 km NW Punda Maria, Kruger-N.P.) (Pienaar *et al*., 1980; Rautenbach, 1982; Rautenbach *et al*., 1993), Nwaswitshake River (Kruger-N.P.) (Rautenbach, 1982), PK Santa (Belfast, Elandsklip) (TM 963 [variously reported as from Belfast or Elandsklip]; Roberts, 1951; Ellerman *et al*., 1953; Harrison and Fleetwood, 1958; Kock, 1967; Rautenbach, 1982), near Skukuza (Kruger-N.P.) (Ratcliffe, 2002), Skukuza (staff picnic site, Sabie River, Kruger-N.P.) (TM 42489), Skukuza (7 km E, Sabie River, Kruger-N.P.) (TM 42488), Warmbaths (TM 42688).

ZIMBABWE: Helensvale (Salisbury, Mashonaland) (HZM 3.4131; Smithers and Wilson, 1979), Kingsway (Salisbury, Mashonaland) (HZM 4.4133; Smithers and Wilson, 1979), Mount Selinda (Melsetter Distr.) (TM 3977 [probably reported as from two distinct localities in the literature: 'Mt. Selinda' and 'Melsetter']; Roberts, 1951; Ellerman *et al*., 1953; Harrison and Fleetwood, 1958; Kock, 1967), Old Umtali (HZM 2.4100), Sengwa Wildlife Research Area (Fenton, 1975).

Appendix II

Gazetteer of localities reported in this paper, including geographic co-ordinates and elevation (in m; values obtained from the digital elevation model (USGS) are shown in brackets):

Locality	Co-ordinates	Elevation
15 km SSE Masisiwe (Kihanga, Udzungwa Scarp-F.R., Udzungwa Mts.)	08°22'S, 35°59'E	1800
Afallo (région de Ghera, Kaffa)	07°41'N, 36°20'E	[2085]
Alto Chicapa	10°56'S, 19°09'E	[1273]

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Appendix II. Continued

Locality	Co-ordinates	Elevation
Bloemfontein City	29°08’S, 26°12’E	[1411]
Boksburg	26°13’S, 28°15’E	[1632]
btw. Kipara and Ikulia Rivers	08°45’S, 36°45’E	[858]
Butare	02°36’S, 29°44’E	1800
Chiromo	16°32’S, 35°09’E	[55]
Cholo [Thyolo] (Ruo River)	16°04’S, 35°09’E	900
Craigieburn (near Umkomaas, KwaZulu-Natal)	30°12’S, 30°46’E	[148]
Dilolo	10°42’S, 22°20’E	[977]
Doornsloot	24°01’S, 28°22’E	[1301]
Elisabethville [Lubumbashi]	11°40’S, 27°28’E	[1209]
Endebess (Mt. Elgon)	01°04’N, 34°51’E	[1923]
Gaza District (W-border)	[ca. 24°00’S, 32°00’E]	[197]
Gilo (Imatong Mts.)	04°02’N, 32°51’E	[1736]
Gondar	12°36’N, 37°28’E	[2133]
Helensvale (Salisbury)	17°44’S, 31°09’E	[1503]
Hoey’s Bridge [Moi’s Bridge] (Cherangani)	00°53’N, 35°07’E	[1828]
Kakamega Forest	00°16’N, 34°53’E	1524
Kanaan (near Hazyview, Mpumalanga)	25°04’S, 31°06’E	[557]
Kapalasa Farm (Namadzi)	15°31’S, 35°11’E	1000
Kapino Dam (Namadzi)	15°31’S, 35°11’E	1000
Kasungu-N.P. (administration area)	13°03’S, 33°09’E	1000
Kigoma (near, Lake Tanganyika)	04°53’S, 29°38’E	1067
Kingsway (Salisbury)	17°49’S, 31°03’E [Salisbury]	[1481]
Kinole	06°54’S, 37°46’E	[740]
Klipfontein farm 53 (30 km NE Ellisras [Vaalwater])	24°08’S, 28°18’E	[1357]
Lake Ondo	01°08’S, 29°19’E	[1081]
Lebombos (near Shingedzene, Kruger-N.P.)	25°27’S, 31°58’E [Lebombo Mts.: 26°15’S, 32°00’E]	[97]
Livingstonia	10°36’S, 34°06’E	1200
Liwonde-N.P.	15°02’S, 35°15’E [administration camp]	500
Lusinga (Upemba-N.P.)	08°56’S, 27°12’E	1760
Lydenburg (50 mi ENE, Transvaal)	ca. 24°49’S, 30°11’E [Lydenburg: 25°06’S, 30°27’E]	[539]
Mafinga Mountains	09°59’S, 33°18’E	1950
Makapansgat (historic cave, Potgietersrus)	24°08’S, 29°12’E	[1433]
Makutu Mountains	10°25’S, 33°18’E	2070
Matukwala (dam 5 km NW Punda Maria, Kruger-N.P)	22°41’S, 30°57’E [Matukwane, Matukwata]	[597]
Mbulo Forest (Lukolwe-Luzu road, west bank of Zambezi River)	13°13’S, 22°51’E	[1046]
Mount Selinda	20°24’S, 32°43’E	[1005]
Mutsora	00°19’N, 29°45’E	1200
Mwatesi Stream (Rungwe Mts.)	09°08’S, 33°40’E	2015
Ndundulu Forest (West Kilombero Scarp-F.R., Udzungwa Mts.)	07°50’S, 36°28’E	1450
North Nandi Forest	00°20’N, 34°58’E	[2018]
Nsombo (Lake Bangweolo) [= Lake Bangweulu]	10°49’S, 29°57’E	[1172]
Nwaswitshake River (Kruger-N.P.)	25°02’S, 31°32’E	[275]
Old Umtali	18°58’S, 32°40’E	[1095]
Pic de Fon (Simandou Range)	08°32’N, 08°54’W [highland]	1350

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Appendix II. Continued

Locality	Co-ordinates	Elevation
Pic de Fon (Simandou Range)	08°31'N, 08°56'W [lowland, near Banko village]	600
PK Santa (Belfast, Elandsklip)	25°20'S, 30°11'E [railroad station]	[1916]
Pungo Andongo	09°40'S, 15°35'E	[924]
right bank Mubuku River (above confl. with Kyoha River, E-slope Rwenzori Mts.)	00°22'N, 30°00'E	2100
Rondo-F.R. (50-60 km W Lindi, Lindi Distr.)	10°09'S, 39°15'E	[473]
Rutshuru (Virunga-N.P.)	01°11'S, 29°27'E [formerly Albert-N.P.]	1285
Rwegura (near, Kayanza)	02°55'S, 29°31'E	[2311]
Sengwa Wildlife Research Area	18°10'S, 28°13'E	[853]
Sidokoro (Haute Niger-N.P.)	ca. 10°14'N, 10°28'W	
Skukuza (7 km E, Sabie River, Kruger-N.P.)	24°59'S, 31°40'E	[268]
Skukuza (staff picnic site, Sabie River, Kruger-N.P.)	24°59'S, 31°35'E	[285]
Trans Nzoia Distr.	00°50'N, 35°00'E	[1828]
Uhafiwa Luhega Forest (near Uhafiwa, Mufindi Distr., Udzungwa Mts.)	08°30'S, 35°51'E	1400
Vila de Manica area	[ca. 18°56'S, 32°53'E]	[666]
Warmbaths	24°53'S, 28°17'E	[1151]
Wasa Camp (Kasanka-N.P.)	12°34'S, 30°17'E	[1272]

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