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Western Woermann's Fruit Bat *Megaloglossus azagnyi* Nesi, Kadjo & Hassanin, 2013, ♀ from Shiare schoolyard (SMF 92119). Photo: M. Weinbrenner 2001.

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A survey of small mammals in the Volta Region of Ghana with comments on zoogeography and conservation

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ABSTRACT
We examined small mammal (insectivores, bats and rodents) diversity in community and legally protected forest remnants in the Ghana-Togo Highlands of the Volta Region of Ghana, West Africa, a zoologically understudied area compared to neighboring Togo to the East, or Ghana west of the Volta River. We recorded 34 small mammal species: three species of shrews (Soricidae Fischer, 1815), 12 species of rodents, one primate (Galagidae Gray, 1825) and 17 species of bats (Chiroptera Blumenbach, 1779). The rodent *Stochomys longicaudatus* (Tullberg, 1893) appears to be a first record for Ghana. Two shrew, three rodent and one bat species were first records for the Volta Region. By comparing our small mammal captures and limited microhabitat data from 1999 and 2001 to forest cover change maps for the period 2000-2015 we discuss trends in species community changes due to forest cover loss and other disturbance regimes. Aside from contributing to our understanding of the distribution of several small mammal species, the study demonstrates the progressive loss of forest habitat in the Volta Region.

KEY WORDS
Inventory, conservation, Dahomey Gap, Togo Highlands, new records.

RÉSUMÉ
Zoogéographie et conservation des petits mammifères dans la région de la Volta au Ghana.
Nous avons examiné la diversité des petits mammifères (insectivores, chauve-souris et rongeurs) dans les fragments de forêt communautaire légalement protégée de la zone des Hauts Plateaux du Togo et du Ghana, une région peu étudiée pour sa faune en comparaison des territoires du Togo et du Ghana situés respectivement à l'est et à l'ouest de la rivière Volta. Nous signalons 34 espèces de petits mammifères : trois espèces de musaraignes (Soricidae Fischer, 1815), 12 espèces de rongeurs, un primate (Galagidae Gray, 1825) et 17 espèces de chauves-souris (Chiroptera Blumenbach, 1779). Le rongeur *Stochomys longicaudatus* (Tullberg, 1893) est apparemment signalé pour la première fois du Ghana. Deux espèces de musaraignes, trois espèces de rongeurs et une espèce de chauve-souris sont signalés pour la première fois de la région de la Volta. En comparant nos captures de petits mammifères et nos données limitées sur les microhabitats de 1999 et 2001 aux cartes de changement de la couverture forestière pour la période 2000-2015, nous discutons des tendances des changements des communautés d'espèces dus à la perte de la couverture forestière et à d'autres régimes de perturbation. En plus de contribuer à notre compréhension de la distribution de plusieurs espèces de petits mammifères, l'étude démontre la perte progressive de l'habitat forestier dans la région de la Volta.

MOTS CLÉS
Inventaire, conservation, sillon dahoméen, Hautes terres du Togo, signalisations nouvelles.

INTRODUCTION

In the last 100 years wildlife abundance and diversity in West Africa have declined on a large scale (Oates 1999; Wilkie *et al.* 2011). This decline has greatly accelerated during the last two to three decades (Visconti *et al.* 2011; Habel *et al.* 2019) with dire projections (Tilman *et al.* 2017). Reasons for this decline are the widespread loss of original habitat due to uncontrolled logging, and species-poor monocultures (cocoa, oil-palms, rubber trees etc.), an increase of local subsistence farms, and increasing bushmeat hunting pressure driven by the growing urban population (Brashares *et al.* 2011; Greengrass 2015). These act in combination with an increasing frequency of uncontrolled fires aggravated by climate change to gradually diminish the remaining forest. In Ghana, the only remains of original forest are found in more remote and inaccessible areas of the forest reserves established between 1919 and 1939 (Oates 1999), in the three high forest National Parks (Bia NP, Kakum NP, and Ankasa Conservation Areas), and in the so-called "sacred groves" – traditionally protected and locally maintained forest patches ranging in size from a few trees to several hundred hectares. Previous studies of small mammal ecology and conservation in Ghana indicated that these traditionally protected sites contained higher small mammal biomass than surrounding areas and that they function as refuges for some small mammal species no longer found anywhere else (Yeboah 1984; Decher 1997b; Decher & Bahian 1999).

In the Volta Region the condition of the forest reserves is especially serious. The forest has been greatly reduced by extensive deforestation for cocoa plantations, rice cultivation and shifting agriculture, accelerated by frequent dry season fires and a relatively dense human population ranging from 26-100 persons per km² (Bakarr *et al.* 2001). A review of forest conservation in Ghana attributed the widespread deforestation in the Volta Region reserves to "…the high demand for farmland, associated partly with movement of dispossessed people before the damming of the Volta Lake in 1966." (Hawthorne 2001: 493).

The Ghana-Togo Highlands, including the Fazao-Malfakassa Wildlife Reserve in Togo, have been classified as an area with "exceptionally high" conservation priority for all organisms and "very high" conservation priority for mammals. This assessment was based on species richness, species endemism, rare and endangered species, and critical habitats (Bakarr *et al.* 2001). Zoogeographically much of the Volta Region belongs to the so-called Dahomey Gap, the interruption of the forest belt in West Africa stretching from Accra, west of the Volta eastward through Benin, formerly called "Dahomey". For a discussion of the Dahomey Gap phenomenon see Booth (1954,

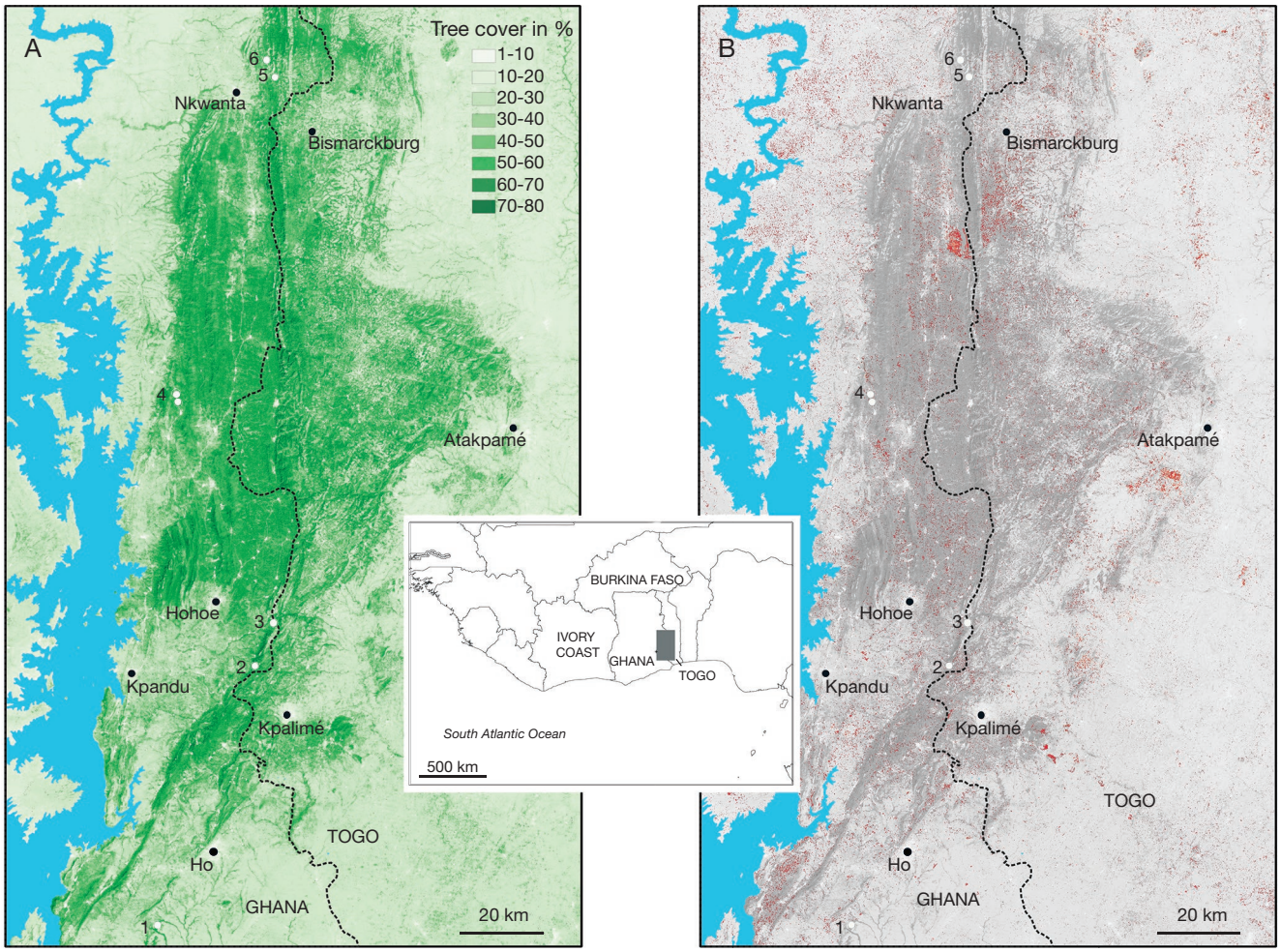

FIG. 1. — Maps of Volta Region, Ghana with the Togo Highlands: **A**, forest cover > 30% in 2010 and study sites: **1**, Kalakpa Resource Reserve; **2**, Tagbo Falls (Liati Wote); **3**, Wli Waterfall (Agumatsa Valley); **4**, Apesokubi (Bedibem Forest); **5**, Shiare village; **6**, Kyabobo Range National Park (KRNP); **B**, elevation (**shading**), Forest cover loss 2000-2018 (**red pixels**) based on online data (Hansen *et al.* 2013).

1958), Robbins (1978) and Decher *et al.* (1997). A number of species unique to the Dahomey Gap were recently described, including the Dahomey Gap Wood Mouse, *Hylomyscus pamfi* Nicolas, Olayemi, Wendelen & Colyn, 2010 and Walter's Duiker, *Philantomba walteri* Colyn, Hulselmans, Sonet, Oudé, de Winter, Natta, Nagy & Verheyen, 2010-(Colyn *et al.* 2010; Nicolas *et al.* 2010b).

There are a number of pre-World War I records from the Volta Region when it was still part of German colonial "Togoland". This includes the historical locality "Bismarckburg", type locality of the famous "lost" Büttner's African Forest Mouse *Leimacomys buettneri* Matschie, 1893b – one of the declared targets of this survey – just a few miles east of today's Ghana-Togo border. Only two specimens of *Leimacomys* Matschie, 1893 were preserved at the Zoological Museum Berlin (ZMB) and were subsequently described as a new species (Matschie 1893b), but they remain the only known specimens today. Several studies have established that *Leimacomys* feeds mostly on insects (Misonne 1966; Dieterlen 1976; Denys 1993), and that its short tail suggests a terrestrial rather than arboreal life style (Dieterlen 1976; D. Kock, pers. comm.). A taxonomic enigma, it has been classified in the subfamilies Murinae Illiger, 1811(e.g. Simpson 1945) or Dendromurinae G. M. Allen , 1939 (e.g. Rosevear 1969) until Musser & Carleton (2005) placed *Leimacomys* in its own subfamily Leimacomyinae Musser & Carleton, 2005 within the family Muridae Illiger, 1811, deeming it sufficiently different from all other muroid rodents. This forest endemic represents an evolutionary lineage that has been long isolated from other rodents (Denys 1993).The only previous "modern" mammal survey in the Volta Region, which included ten sites, was that of the US Smithsonian Institution's African Mammal Project expeditions to Ghana (between 14 July 1967 and 19 August 1969; Schmidt *et al.* 2008). The present study examines small mammal communities in different forest remnants in the Volta Region of Ghana with the following objectives: 1) present a snapshot of the diversity and abundance of small mammal species (shrews, bats, and rodents) in forest remnants along the Togo border in the Volta Region of Ghana based on our 1999 and 2001 capture data; 2) infer subsequent loss of small mammal habitat based on high-resolution 21st century forest cover

change maps (Hansen *et al.* 2013); and 3) provide national and international conservation managers with new data and recommendations to improve, or initiate protection of the remaining forest and wildlife sites in the Volta Region.

Despite some researchers arguing that small mammals may receive adequate protection in reserves set aside for the protection of larger or so-called "flagship species" such as forest elephant, forest buffalo or large antelopes, a recent critique argued that, similar to commercially branded goods and services, focusing on conservation flagships can lead to standards of comparison that may decrease the attractiveness and public acceptance of non-flagship species (Douglas & Winkel 2014). Also, with few exceptions in the Volta Region, such as Kalakpa Resource Reserve, Kyabobo National Park, or the Tafi Atome Monkey Sanctuary (Ormsby & Edelman 2010), forest remnants and sacred groves in the Volta Region may not be large enough and the traditional taboos may not be strong enough to sustain and protect larger mammals, but they may still harbor a diverse medium and small mammal fauna. One review of mammal conservation priorities also concluded, that "…evidence indicates that threats to small mammals are as extensive as those faced by large mammals…" and "[i]t appears that the needs of small mammals, in relation to the degree of threat, are not being met by the current conservation agenda" (Entwistle & Stephenson 2000: 137).

MATERIAL AND METHODS

Study area

Our study area encompassed large parts of the Volta Region of Ghana. This region is part of the Ghana-Togo Highlands and part of the Akwapim-Togo escarpment (Fig. 1B). In Ghana maximum elevation reaches 955 m at Mount Afadjato (Gnielinski 1986) and 986 m at Mount Agou in Togo (IGN Togo Map 1: 500 000). For the purposes of this paper we define the Ghana-Togo Highlands as extending from Akwamufie in the Eastern Region (east bank of lower Volta, near the Volta Dam) north-eastward, including Kalakpa Resource Reserve, Mount Adaklu and Mount Agou in Togo. From there it extends northward to Atakpamé and along the line Sotouboua-Sokodé, including the Faille d'Alédjo region; westward to Bassar, then south to include the Fazao Malfakassa Wildlife Reserve and the new Kyabobo National Park in Ghana, then along the line Pawa – Nkwanta – Worawora – Kpandu back to Akwamufie (Fig. 1). Most of the Ghanaian part of this region is covered by dry semi-deciduous forest of the "fire zone subtype" (Hall & Swaine 1981: 17). For this study, terrestrial and volant small mammals (shrews, and rodents and bats) were captured in 1999 and 2001 at the following six sites in the Volta Region from south to north:

1) Kalakpa Resource Reserve (Fig. 2A). Legal protection. 3.25 km S of Abutia Kloe, near Zitoe Camp (6°27'N, 0°21'E). Elevation: *c.* 90 m. Trapping period: 15-18 November 1999. This is the only site located in the Dahomey Gap in the narrow sense (arid savanna with remaining forest patches).

2) Tagbo Falls near Liati-Wote (Fig. 2B). Traditionally protected narrow valley leading up to a waterfall (7°00'51.6"N, 0°33'41.0"E). Elevation *c.* 282 m. 2 Trapping period: 9-30 August 2001.

3) Agumatsa Wildlife Sanctuary (Wli Waterfall; Fig. 2C, D). Legal and traditional protection. 0.75 km E of Afegame (7°07'49.5"N, 0°35'47.9"E). Elevation: *c.* 262 m. Trapping periods: 18-23 November 1999 and 10-14 August 2001.

4) Apesokubi (Bedibem Forest; Fig. 2E). Traditionally protected forest patch. 4.1 km north of Apesokubi, near Kabo River Forest Reserve (7°36'19.0"N, 0°23'28.2"E). Elevation: *c.* 231 m. Trapping periods: 24-28 November 1999 and 25-29 August 2001.

5) Shiare Village (Fig. 2F). Traditionally protected forest (8°17'32"N, 0°36'34"E). Elevation *c.* 365 m. Trapping period: 21-24 August 2001.

6) Kyabobo Range National Park (KRNP; Fig. 2G, H). Legal protection. Trapping periods: 29 Nov.-1 Dec. 1999: 1 km NE Odome (8°19'N, 0°33'E) and 16-19 August 2001: Laboum Creek (8°19'56.9"N, 0°35'13.6"E). Elevation *c.* 450 m.

Except for site 1 (Kalakpa RR), some microhabitat characterizations based on trap site measurements for sites 2-6 can be found in Table 1.

Field Techniques

Survey techniques followed those published by Voss & Emmons (1996), standard methods for measuring and monitoring mammal diversity in Wilson *et al.* (1996), and complied with guidelines approved by the American Society of Mammalogists (Animal Care and Use Committee 1998) and the Institutional Animal Care and Use Committee (IACUC) of the University of Vermont. Trapping effort varied somewhat for the six sites visited (Tables 2; 3). Only three of the sites could be visited in both years. Kyabobo Range National Park (KRNP) was visited in both years, but the 1999 site in the park (Odome) was replaced by another site (Laboum Creek) in 2001 because it yielded no captures due to recent burning. We used up to 142 traps at each site: 100 standard (LFA) and one large (XLF15) Sherman live traps, seven large and two medium Tomahawk live traps, 20 Museum Special snap traps, and 12 Victor rat traps. Where possible, we also employed lines of pitfall traps using local plastic buckets connected by plastic drift fences in each habitat. Bats were captured using standard 2.6 to 12 metre long mist nets (50 denier/2 ply, 38 mm mesh; Avinet Inc.) at ground level on forest paths, at forest edges and across small streams mostly during evening hours and sometimes all night long. Species were identified, sexed and representative vouchers were kept for all species and of all individuals with uncertain identification. Sex is either denoted as male (♂), female (♀) or unknown (?) in the following list. Preliminary field identification of terrestrial small mammals and bats was based on Rosevear (1965, 1969), Meester & Setzer (1971), Hutterer & Happold (1983) and Happold (1987) and subsequently updated also using more recent sources cited in the species accounts below. Bat and some rodent voucher specimens were identified and deposited at the Senckenberg Museum

FIG. 2. — Selected habitats surveyed in the Volta Region: **A**, grassland and gallery forest at Kalakpa Resource Reserve; **B**, Tagbo Falls at Liati Wote; **C**, Agumatsa Valley with Wli Waterfall showing fire-shaped grassy hilltops and forested valley; **D**, *Eidolon helvum* roost at Wli Waterfall; **E**, Bedibem Forest at Apesokubi, a locally managed forest remnant; **F**, First impression upon entering the Akyode village Shiare looking east towards Togo; **G**, Kyabobo Range National Park (KRNP) forest-savanna mosaic above Laboum Creek; **H**, vegetation in the Laboum Creek valley, KRNP. Photos: M. Weinbrenner 1999 & 2001.

TABLE 1. — 2001 Microhabitat measures summarized by locality, recorded at each small mammal trap that captured an animal. No microhabitat data were obtained for Kalakpa Resource Reserve. Abbreviation: **KRNP**, Kyabobo Range National Park.

Locality	Apesokubi	KRNP	Shiare	Tagbo	Wli
Canopy cover (%)					
N	19	16	15	22	56
Mean	59.74	26.25	37.5	34.09	46.25
Standard deviation	19.9	11.90	16.02	10.53	15.44
Nearest tree: distance (m)					
N	16	16	6	22	56
Mean	1.35	0.41	1.95	1.95	1.33
Standard deviation	1.65	0.96	2.07	1.89	1.39
Nearest tree: diameter at breast height (cm)					
N	19	16	16	22	56
Mean	29.53	15.8	27.13	27.63	14.28
Standard deviation	22.53	15.44	26.52	26.25	8.31
Nearest log: distance (m)					
N	19	16	15	22	56
Mean	0.97	3.03	0.34	0.27	1.43
Standard deviation	1.82	2.57	0.71	1.07	1.86
Near Log: diameter (cm)					
N	19	15	3	22	56
Mean	16.47	9.45	10	1.31	9.96
Standard deviation	26.44	5.66	2	3.61	11.82
Ground cover: herbs (%)					
N	18	16	16	22	56
Mean	26.67	22.81	28.44	50.91	29.46
Standard deviation	21.00	14.37	15.24	18.49	12.88
Ground cover: grass (%)					
N	19	16	16	22	56
Mean	0	0	0	0	0.18
Standard deviation	0	0	0	0	1.33
Ground cover: bare soil (%)					
N	19	16	16	22	56
Mean	48.84	43.44	21.56	4.09	18.84
Standard deviation	31.32	22.56	18.94	7.34	9.29
Ground cover: leaf litter (%)					
N	19	16	16	22	56
Mean	27.37	29.38	29.38	45	44.11
Standard deviation	20.84	17.68	12.89	18.19	13.45
Ground cover: rocky (%)					
N	19	16	16	22	55
Mean	0	4.38	2.5	0	7.18
Standard deviation	0	12.09	5.77	0	12.90

of Natural History, Frankfurt/M. (SMF), and shrews at the Zoological Research Museum Alexander Koenig (ZFMK), Bonn, Germany. Most of the rodent specimens were deposited at the US National Museum mammal collection (USNM). Some rodent specimens and DNA tissue samples were deposited at the Zadock Thompson Natural History Collections (ZTNHC) of the University of Vermont, Burlington. Other abbreviations in the text refer to the collections at the British Museum of Natural History (BMNH), the Royal Ontario Museum (ROM), the Carnegie Museum of Natural History at Pittsburgh (CM), and the American Museum of Natural History (AMNH). Common names were taken from *Mammals of Africa* (Kingdon *et al.* 2013) and the *Handbook of the Mammals of the World* (Mittermeier & Wilson 2009-2019). Information on some of the larger arboreal and diurnal species (squirrels, anomalures, primates, small carnivores) was obtained by interviewing local people and by slow observation walks (Emmons 1980) using binoculars (Zeiss Classic 10 × 40) and a small digital video camera (Sony DCR-PC1). In 2001 we also recorded microhabitat data on standardized habitat data sheets.

MOLECULAR IDENTIFICATION

To facilitate identification, we amplified and sequenced a fragment of the cytochrome b (*Cytb*) gene for 10 individuals from two taxa. DNA was extracted from a small (5-10 mg) piece of liver or kidney that had been stored in 95% ethanol. Ethanol was removed via soaking in distilled water (Kilpatrick 2002) prior to extraction using a Gentra Puregene Mouse Tail Kit (QIAGEN – Germantown, Maryland) according to manufacturer's instructions.

A 401 bp fragment of the *Cytb* mitochondrial gene was amplified with PCR using the primers CytbA and CytbE (Sullivan *et al.* 1997) using PuRe Taq Ready-To-Go PCR Beads (GE

TABLE 2. — Non-flying small mammal species trapped or observed at six sites in the Volta Region of Ghana. Symbols for specimen origin: **1**, specimen brought to us from nearby unspecified locality; **2**, specimen brought to us by local hunter; **3**, observed or signs and local informants. Abbreviations: **F**, forest; **S**, savanna, **F/S**, occurs in forest and savanna. Note: *, relative biomass is calculated from average weights of trapped species × number of individuals caught at that site/100 trap nights.

Locality	**Kalakpa**	**Wli (Agumatsa)**		**Apesokubi**		**KRNP**		**Shiare**	**Tagbo F.**		
Forest protection type	legal	legal & community		comm.		legal		comm.	comm.		**Ecological**
Year	1999	1999	2001	1999	2001	1999	2001	2001	2001	**Total**	**adaptation**
Soricomorpha											
Crocidura olivieri (Lesson, 1827)	–	–	–	–	1	–	–	–	1	2	F/S
Crocidura cf. *eburnea* Heim de Balsac, 1958	–	–	–	1	–	–	–	–	–	1	F
Crocidura cf. *foxi* Dollman, 1915	–	–	–	2	–	–	–	–	–	2	S
Rodentia											
Praomys misonnei Van der Straeten & Dieterlen, 1987	47	12	57	29	14	–	4	6	21	190	F
Malacomys edwardsi Rochebrune, 1885	–	–	–	3	1	–	–	–	–	4	F
Stochomys longicaudatus (Tullberg, 1893)	–	–	–	1	–	–	–	–	–	1	F
Hylomyscus pamfi Nicolas, Olayemi, Wendelen & Colyn, 2010	1	–	1	2	1	–	2	–	–	7	F
Lemniscomys striatus (Linnaeus, 1758)	–	1	2	1	1	–	–	1[3]	–	6	S
Graphiurus nagtglasii Jentink, 1888	–	–	–	3	–	–	–	–	–	3	F
Mus musculoides Temminck, 1853	1	1	1	–	1	–	10	9	–	23	F/S
Gerbilliscus kempi (Wroughton, 1906)[1]	1	–	–	–	–	–	–	–	–	1	S
Cricetomys gambianus Waterhouse, 1840	–	–	–	–	1	–	–	1	–	2	F/S
Anomalurus beecrofti Fraser, 1852[2]	–	1	–	–	–	–	–	–	–	1	F
Paraxerus poensis (A. Smith, 1843)[3]	–	1	–	–	–	–	–	–	–	1	F
Xerus erythropus (É. Geoffroy, 1803)[3]	–	1	–	–	–	–	–	–	–	1	S
Primates											
Galagoides sp.[3]	–	2	–	–	–	–	–	–	–	2	S
No. of species	4	7	4	8	7	0	3	4	2	16	
Nights trapped	5	4	3	2	3	2	3	3	1	26	
Trap set	135	126	111	127	115	66	63	113	50	–	
Trapnights (TN)	675	504	333	254	345	132	189	352	50	2834	
Individuals captured	49	14	61	42	20	0	16	17	22	241	
Trap success	7.3%	2.8%	18.3%	16.5%	5.8%	0.00%	8.5%	4.8%	44.00%	8.5%	
Relative SM biomass* sampled per 100 TN	1437.4	409.4	589.3	1737.7	552.6	0	134.04	462.02	1516.9	–	

Healthcare Life Sciences). Amplification occurred over 35 cycles with denaturation at 94° C for 1 min, annealing at 50° C for 1 min and extension at 72° C for 1 min. Sanger sequencing was performed using both forward and reverse primers at the DNA Analysis Facility, Vermont Integrative Genomics Resource, University of Vermont. Resulting sequences were compared to previously published results using BLASTn for nucleotides (Altschul *et al.* 1990). We have deposited our sequences that were either new or from different localities into GenBank under accession numbers MT311307-MT311314).

DATA ANALYSIS

Trap success was calculated by dividing the number of captured small mammals of each site by the no. of trapnights (= nights trapped × no. of traps) and multiplying by 100 (Table 2). Specimens brought to us by local people were excluded from trap success. For bats the distribution of captures, netting effort and number of bats per net night and net unit for the six localities visited in 1999 and 2001 (Table 3).

Basic statistics (mean, standard deviation) for microhabitat data were generated using SPSS, Version 24 (IBM 2016). Conservation status of each species was taken from the current version of the IUCN Red List (IUCN 2020). Species accumulation curves, diversity and similarity indices were generated using the program EstimateS (Colwell 2013). Although it is perhaps somewhat unorthodox to use the species richness predictor EstimateS for such a large area of the Volta Region, we wanted to facilitate a rough species richness comparison with a previous study on the Accra Plains, also focussing on forest remnants (Decher 1997a, b; Decher & Bahian 1999), and studies in other areas in Ghana (Decher & Fahr 2005). Our sites across the Volta Region were selected to represent the whole partially forested area. All were supposed to be surveyed twice in two different seasons. In spite of some logistical challenges – some sites had to be replaced or added in year 2 – we argue that it is one large study area focussing on at least partially protected forest remnants in the Volta Region.

ABBREVIATIONS

SMF Senckenberg Museum Frankfurt;
USNM United States National Museum, Mammal Collection;
ZFMK Zoological Research Museum Alexander Koenig, Bonn;
ZTNH Zadock Thompson Natural History Collections, University of Vermont, Burlington.

TABLE 3. — Number of bats caught in 6 different locations in the Volta Region of Ghana during the 1999 and 2001 field seasons: **1**, one specimen brought to us by local hunter. Colony of several thousand individuals present on the rock faces flanking Wli Waterfall; **2**, this species was only heard calling in a nearby roost in a mango tree; **3**, 1 net unit = one 2.6 × 2.6 m net area = 6.76 m.

Locality	**Kalakpa**	**Wli**		**Apesokubi**		**KRNP**		**Shiare**	**Tagbo F.**	**Ecology**	**Total**
Forest protection type	legal	legal & comm.		community		legal		comm.	comm.		
Period of collect	XI.1999	XI.1999	VIII.2001	XI.1999	VIII.2001	XI.1999	VIII.2001	VIII.2001	VIII.2001		
Season	dry	dry	wet	dry	wet	dry	wet	wet	wet		
Species											
Epomops franqueti (Tomes, 1860)	2	1	–	–	–	–	–	–	–	F	3
Epomops buettikoferi (Matschie, 1899)	–	–	–	–	1	–	–	–	–	S	1
Epomophorus gambianus (Ogilby, 1835)	1	–	–	–	–	–	–	–	–	S	1
Micropteropus pusillus (Peters, 1868)	–	1	3	9	–	–	1	9	–	F/S	23
Nanonycteris veldkampi (Jentink, 1888)	–	1	–	1	–	–	–	–	–	F	2
Eidolon helvum (Kerr, 1792) [1]	–	1[1]	×[1]	–	–	–	–	–	–	F/S	1[1]
Myonycteris angolensis smithii (Thomas, 1908)	–	1	1	–	3	–	2	–	2	F	9
Megaloglossus azagnyi Nesi, Kadjo & Hassanin, 2013	–	–	3	–	–	–	–	2	–	F	5
Hypsignathus monstrosus H. Allen, 1861[2]	–	–	×[2]	–	–	–	–	–	–	F	×[2]
Nycteris arge Thomas, 1903	–	–	–	–	1	–	–	–	–	F	1
Rhinolophus alcyone Temminck, 1853	1	3	4	–	1	–	–	–	–	F	9
Rhinolophus landeri Martin, 1838	–	1	–	–	–	–	–	–	–	F	1
Hipposideros cf. *ruber* (Noack, 1893)	–	2	1	1	1	–	–	1	–	F	6
Doryrhina cyclops (Temminck, 1853)	–	–	–	–	–	–	–	1	–	F	1
Macronycteris gigas (Wagner, 1845)	–	–	1	–	–	–	–	–	–	F	1
Scotophilus livingstonii Brooks & Bickham, 2014	–	–	1	–	–	–	–	–	–	F/S	1
Myotis bocagii cupreolus Thomas, 1904	–	1	1	–	–	–	–	–	–	F	2
Total captured	4	12	15	11	7	0	3	13	2	–	67
Number of species	3	9	10	3	5	0	2	4	1	–	17
No. of nights netted	1	3	1	3	3	1	3	3	1	–	19
No. of bats per net unit[3]	9.2	9.2	11.5	11.5	7.9 - 9.2	6.9	6.9-11.5	14.8	6.9	–	–

RESULTS

During a total of 26 days of fieldwork covering the 1999 and 2001 expeditions, we captured 308 individual small mammals from 33 species (Tables 2; 3).

TERRESTRIAL SMALL MAMMALS

Table 2 summarizes the non-volant small mammal species found during the study including species that were only observed and specimens brought to us by local people from unspecified localities nearby. Trapping success ranged from 2.8% at Agumatsa in 1999 to 44% at Tagbo Falls in 2001. The locally protected forest at Apesokubi yielded the highest relative biomass (1738 g, in 1999) and KRNP had the lowest relative biomass (134 g; 2001) per 100 trap nights (Table 2). There were no captures at the first site at KRNP (Odome) in 1999, probably because of the extremely dry conditions and recent fires.

LIST OF MAMMAL SPECIES RECORDED FROM THE VOLTA REGION

Order SORICOMORPHA Gregory, 1910
Family SORICIDAE G. Fischer, 1814

REMARK

Only five shrews belonging to three species were captured during both expeditions (Table 2). However, according to Grubb *et al.* (1998) only one of these species has previously been recorded from the Volta Region.

Crocidura olivieri (Lesson, 1827)

Sorex olivieri Lesson, 1827: 121.

COMMON NAME. — African Giant White-toothed Shrew, Olivier's Shrew.

MATERIAL EXAMINED. — **Apesokubi** • 1 ♀; Sherman trap in forest; ZFMK 2003.1089. **Liati Wote (Tagbo Falls)** • 1?; Sherman trap between buttress roots in forest; ZFMK 2003.1090.

REMARK

This species was previously known from several localities in the Volta Region (Grubb *et al.* 1998). In their Kyabobo expedition report Hurst *et al.* (1995) mention several individuals of this large shrew (as *C. flavescens*) from KRNP, but we did not encounter it there. Our specimen from Liati Wote (ZFMK 2003.1090) was included in a recent phylogeographic study of *C. olivieri* (Jacquet *et al.* 2015) and grouped with their Clade IIB with Dahomey Gap specimens from Togo and Benin.

CONSERVATION STATUS. — *Crocidura olivieri* is listed as "Least Concern" on the IUCN Red List.

Crocidura cf. *eburnea* Heim de Balsac, 1958

Crocidura (*bottegi*) *eburnea* Heim de Balsac, 1958: 327.

COMMON NAME. — Ivory Coast White-toothed Shrew.

MATERIAL EXAMINED. — **Apesokubi** • 1 ♀; pitfall; 27.XI.1999; ZFMK 1999.1144.

REMARK
Initially identified as *Crocidura* cf. *douceti* Heim de Balsac, 1958, this tiny shrew has been re-assigned to *Crocidura eburnea*, which has only recently been elevated from a synonym of *C. obscurior* (Hutterer 2005) to species level (Jacquet *et al.* 2014). This is the first record of *C.* cf. *eburnea* from the Volta Region and since the Volta River is considered the eastern boundary of the *C. obscurior* complex (Jacquet *et al.* 2014), this possible range extension awaits further study.

CONSERVATION STATUS. — *Crocidura eburnea* was included in the IUCN Red List in 2019 and assessed as "Least Concern".

Crocidura cf. *foxi* Dollman, 1915
(Fig. 3)

Crocidura foxi Dollman, 1915: 514.

COMMON NAME. — Fox's White-toothed Shrew.

MATERIAL EXAMINED. — **Apesokubi** • 1 ♀; 26.XI.1999; ZFMK 1999.1145 • 1?; Sherman traps; 27.XI.1999; ZFMK 1999.1146.

REMARK
Known initially just from Nigeria *C. foxi* is now known to occur in the Guinea savanna zone and secondary bushland from Senegal to Sudan (Duplantier & Granjon 2013). Our captures are the first from the Volta Region of Ghana, listed as *Crocidura* cf. *foxi*, as the identification has not yet been confirmed by molecular genetics. An earlier capture from KRNP, reported by Hurst *et al.* (1995) as *C. foxii* [sic], was later re-identified as *C. fuscomurina* (Heuglin, 1865) (Hutterer 1983; Grubb *et al.* 1998).

CONSERVATION STATUS. — *Crocidura foxi* is listed as "Least Concern" on the IUCN Red List.

Order RODENTIA Bowditch, 1821

REMARK
A total of 238 individuals from 12 rodent species were verified by us during both expeditions to the Volta Region (Table 2).

FIG. 3. — Fox's White-toothed Shrew *Crocidura* cf. *foxi* Dollman, 1915 from Apesokubi. Photo: M. Weinbrenner 1999.

FIG. 4. — Northern Giant Pouched Rat *Cricetomys* cf. *gambianus* Waterhouse, 1840 ♀ from Shiare (SMF 91437). Photo: M. Weinbrenner 2001.

Family NESOMYIDAE Major, 1897

Cricetomys cf. *gambianus* Waterhouse, 1840
(Fig. 4)

Cricetomys gambianus Waterhouse, 1840: 2.

COMMON NAME. — Northern Giant Pouched Rat; Ewe: *Alegeli.*

MATERIAL EXAMINED. — **Shiare** • 1 adult ♀; 24.VIII.2001; Tomahawk trap along Sabu creek; SMF 91437.
Apesokubi • 1 subadult ♀; Tomahawk trap; 28.VIII.2001; ZT-NHC 970.

REMARK
The zygomatic width of the Shiare specimen is 48.2% of occipito-nasal length, which is above the range of "*C. emini*", following Genest-Villard (1967) (D. Kock pers. comm.), a species that is currently labeled *Cricetomys* sp. 1 from the region including our study area following the molecular and craniometric study by Olayemi *et al.* (2012). There is a specimen from the Volta Region at the USNM (USNM 436298, as. *C. gambianus*), a female from Odomi Jongo (1 miles E Nkwanta), caught during the African Mammal Project in 1968.

CONSERVATION STATUS. — *Cricetomys gambianus* is listed as "Least Concern" on the IUCN Red List.

Family MURIDAE Illiger, 1811
Subfamily GERBILLINAE Gray, 1825

Gerbilliscus kempi (Wroughton, 1906)

Tatera kempii Wroughton, 1906: 375.

COMMON NAME. — Kemp's Gerbil.

MATERIAL EXAMINED. — **Kalakpa Resource Reserve** • 1 ♂; brought to us by a Ghana Wildlife Division game scout; 18.XI.1999; ZTNHC 973.

REMARK
This species is known from other locations in the Volta Region and the Togo Highlands (Robbins & Van der Straeten 1996; Grubb *et al.* 1998). Notwithstanding the debate voiced in Granjon *et al.* (2012) regarding the identity of West African *G. kempi*, we retain the name here, due to the far southern Dahomey Gap occurrence of our single specimen from Kalakpa Resource Reserve.

CONSERVATION STATUS. — *Gerbilliscus kempi* is listed as "Least Concern" on the IUCN Red List.

Subfamily MURINAE Illiger, 1811

Praomys misonnei
Van der Straeten & Dieterlen, 1987
(Fig. 5)

Praomys misonnei Van der Straeten & Dieterlen, 1987: 3.

COMMON NAME. — Misonne's Soft-furred Rat.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 5 ♂; USNM 590095-590098, SMF 91365 • 12 ♀; USNM 590093, 590094, USNM 590115, 590116, SMF 91435, 91363, 91366, 91367-91369, 93747, ZTNHC 953 • 1?; USNM 590117. **Apesokubi** • 7 ♂; USNM 590099, SMF 91374 + 91377, ZTNHC 961, 962, 964, UVM VR062 • 5 ♀; USNM 590100, USNM 590118 – 590120, SMF 91375. **Kalakpa Resource Reserve** (see Fig. 5) • 8 ♂; USNM 590080 + 590081, USNM 590083-590085, USNM 590088, USNM 590091, USNM 590113, ZTNHC 949 • 6 ♀; USNM 590082, USNM 590086 + 590087, USNM 590089 + 590090, USNM 590114 • 1?; USNM 590079. **Kyabobo National Park** • 3 ♀; USNM 590121-590123. **Shiare** • 1 ♀; USNM 590124 • 2 ♀; SMF 91372 + 91373. **Tagbo-Falls** • 1 ♂; USNM 590103; 1 ♀; USNM 590125.

REMARK
With 190 captured individuals, *Praomys misonnei* was the most frequently caught species in the Volta Region, followed by *Mus* (*Nannomys*) *musculoides* Temminck, 1853 (n = 23) and *Hylomyscus pamfi* (n = 7). All *Praomys* had been tentatively identified as *P. tullbergi* in the field, but a recent molecular follow-up study included seven of our specimens from Agumatsa, Apesokubi and Shiare and showed that they all belonged to *P. misonnei*, reinforcing that *P. tullbergi* is limited to the Upper Guinea Region, west of the Volta River and *P. misonnei* to the Dahomey Gap region into Central Africa (Nicolas *et al.* 2010a, 2011) with the Volta River forming the zoogeographic barrier between the two species. Our specimens were part of their Clade II, which is restricted to the Ghana-Togo Highlands and Dahomey Gap area.

CONSERVATION STATUS. — *Praomys misonnei* is listed as "Least Concern" on the 2019 IUCN Red List, but the species range has not yet been updated to include the Lower Guinea Region based on Nicolas *et al.* (2010a, 2011).

Hylomyscus pamfi
Nicolas, Olayemi, Wendelen & Colyn, 2010
(Fig. 6)

Hylomyscus pamfi Nicolas, Olayemi, Wendelen & Colyn, 2010b: 38.

COMMON NAME. — Dahomey Gap Woodmouse.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 1 ♀; SMF 91364; 4.5 km N. **Apesokubi** (Fig. 6)• 1 ♂; ZTNHC 965 • 2 ♀; SMF 91434, USNM 590074. **Kyabobo National Park** • 1 ♂; SMF 91371• 1 ♀; SMF 91370. **Kalakpa Resource Reserve** • 1 ♂; USNM 590073.

REMARK
We follow Nicolas *et al.* (2010b, 2020), Monadjem *et al.* (2015) and Denys *et al.* (2017) in assigning all Volta Region *Hylomyscus* Thomas, 1926 to the Dahomey Gap Woodmouse, *H. pamfi*, which we cross-checked by examining cytochrome b (*Cytb*) sequences for six of our seven specimens. Three *Cytb* haplotypes MT311308-MT311310 were detected at the Apesokubi site, one at Kyabobo (MT311311) and one at Kalakpa (MT311307). These *Cytb* haplotypes showed a 100-95% identity to sequences reported from *H. pamfi* by Nicolas *et al.* (2020) from Benin. The nearest locality in Nicolas *et al.* (2010b) to our Volta Region study sites was Palimé in Togo, which is about 23 km from Wli Waterfall. Our study represents the first verification that *H. pamfi* is present in Ghana. There are four additional *Hylomyscus* specimens from the Volta Region at the USNM (listed as *H. alleni* (Waterhouse, 1838)), collected in 1968 by the African Mammal Project at Leklebi Agbesia. *Hylomyscus pamfi* is a forest species with good climbing ability. At least four of our specimens were captured on traps set on horizontal branches above ground, one at Apesokubi in an Umbrella tree (*Musanga cecropioides* R.Br.).

CONSERVATION STATUS. — *Hylomyscus pamfi* is currently listed as "Data Deficient" on the IUCN Red List.

Lemniscomys striatus (Linnaeus, 1758)

Mus striatus Linnaeus, 1758: 62.

FIG. 5. — Misonne's Soft-furred Rat *Praomys misonnei* Van der Straeten & Dieterlen, 1987 from Kalakpa Resource Reserve. Photo: M. Weinbrenner 1999.

FIG. 6. — Dahomey Gap Woodmouse *Hylomyscus pamfi* Nicolas, Olayemi, Wendelen & Colyn, 2010 from Apesokubi. Photo: M. Weinbrenner 1999.

COMMON NAME. — Striated Grass-Mouse; Ewe: *Gbaxlé.*

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 1 ♂; USNM 590104; 22.XI.1999 • 1 ♂; USNM 590075; 13.VIII.2001. **Shiare** • 1 ♀; SMF 91436 with 7 embryos; 22.VIII.2001; by hunter. **Apesokubi (Site 1)** • 1 ♀; ZTNHC 963; 26.XI.1999 • 1 ♀; SMF 91376; 28.VIII.2001.

REMARK
A grassland and farmbush species that also occurs along roads in the forest. There are 43 additional *Lemniscomys striatus* from the Volta Region at the USNM, collected by the African Mammal Project at Leklebi Agbesia and Odomi Jongo (2 miles E Nkwanta). Hurst *et al.* (1995) also caught four individuals in riparian forest and tree savanna at KRNP. Although not genetically tested our *Lemniscomys striatus* east of the Volta River should belong to what Nicolas *et al.* (2008) called Clade III.

CONSERVATION STATUS. — *Lemniscomys striatus* is listed as "Least Concern" on the IUCN Red List.

Malacomys edwardsi Rochebrune, 1885

Malacomys edwardsi Rochebrune, 1885: 87.

COMMON NAME. — Edwards' Swamp Rat.

MATERIAL EXAMINED. — **Apesokubi** • 1 ♀; USNM 59078; 28.VIII.2001; with four embryos (USNM 590105) with a crown -rump length of 19 mm • 2 ♂; USNM 590076, ZTNHC 960 • 1 ♀; USNM 590077.

REMARK
An obligate forest species in the Upper Guinea and an indicator of intact forest. A recent phylogeographic study confirmed the identification of all four of our *M. edwardsi* from Apesokubi but showed that these Volta Region specimens represent a lineage (F2) separate from the southwestern Ghanaian lineage (F1), "which may suggest the presence of multiple forest refugia" in Ghana (Bohoussou *et al.* 2015: 9). Hurst *et al.* (1995) reported 5 captures of *M. edwardsi* from moist semi-deciduous and secondary forest in KRNP which appears to be the only previous record of this species from the Ghana-Togo Highlands. We were not able to verify this species again at KRNP.

CONSERVATION STATUS. — *Malacomys edwardsi* is currently listed as "Least Concern" on the IUCN Red List, but - already limited to the densest and best preserved forest in the Volta Region - it would be one of the first rodent species to disappear with continued deforestation.

Stochomys longicaudatus (Tullberg, 1893)

Dasymys longicaudatus Tullberg, 1893: 36.

COMMON NAME. — Target Rat.

MATERIAL EXAMINED. — **Apesokubi** • 1 ♀; 4.5 km N Apesokubi; USNM 590072; Sherman trap; 27.XI.1999.

REMARK
Initially identified as *Dephomys defua* (Miller, 1900) we recently re-identified this specimen as *Stochomys longicaudatus* using molecular methods as part of another study (Pradhan *et al.* in prep; GenBank MT311314). Robbins & Van der Straeten (1996) previously stated that *D. defua* occurs only west of the Volta River. East of the Volta and in the Dahomey Gap it is replaced by the lower Guinean species *S. longicaudatus*. Van der Straeten (1984) lists 15 specimens from Dzogbégan, Misahohé and Palimé in Togo. There is also one specimen from Agou, Togo at the USNM (USNM 438334). Based on Grubb *et al.* (1998) and the latest monograph of this species (Uebbing 2019), our specimen appears to be the first capture of *S. longicaudatus* from Ghana.

CONSERVATION STATUS. — *Stochomys longicaudatus* is listed as "Least Concern" on the IUCN Red List, but, being mostly a forest species with a preference for dense understory vegetation close to water (Uebbing 2019), it should be highly sensitive to further deforestation and bush fires in the Volta Region.

Mus (***Nannomys***) cf. ***musculoides-minutoides*** Temminck, 1853
(Fig. 7)

Mus musculoides Temminck, 1853: 161.

COMMON NAME. — Pygmy Mouse.

MATERIAL EXAMINED. — **Kalakpa Resource Reserve** • 1 ♂; USNM 590107. **Agumatsa Wildlife Sanctuary** • 1 ♂; ZTNHC 956 • 1 ♀; UVM VR96. **Apesokubi** • 1 ♂; UVM VR143. **Kyabobo National Park** (Fig. 7) • 1 ♂; UVM VR108 • 5 ♀; USNM 590108-590110, UVM VR 112+VR114. **Shiare** • 3 ♂; USNM 590111, UVM VR 125, 128 • 3 ♀; USNM 590106, 590112, UVM VR130.

REMARK
Curators of collaborating collections (USNM & SMF) independently identified our Pygmy mice as *M.* (*Nannomys*) *musculoides* following traditonal morphological approaches (M. Carleton & D. Kock in litt.). However, we acknowledge that recent molecular, cytogenetic and morphological studies have made identification of these taxa less straightforward, with both *M. musculoides* and *M. minutoides* occurring sympatrically in West Africa (Kan Kouassi *et al.* 2008, Monadjem *et al.* 2015). For this reason we label our Pygmy Mice *M.* cf. *musculoides-minutoides* Pygmy mice were caught at all sites except Liati Wote. They replaced *Praomys* Thomas, 1915 as the most common species in the forest-savanna mosaic and the rough hilly terrain of KRNP and Shiare, making up 62.5 and 56.25% of the total catch, respectively. This is consistent with the findings of Hurst *et al.* (1995) in whose survey at KRNP the Pygmy Mouse (as *M. minutoides*) made up 39.5% of the total catch.

CONSERVATION STATUS. — *Mus musculoides and M. minutoides* are both listed as "Least Concern" in the IUCN Red List.

FIG. 7. — Pygmy Mouse *Mus* cf *musculoides-minutoides* Temminck, 1853 from Kyabobo Range National Park. Photo: M. Weinbrenner 2001.

Family GLIRIDAE Muirhead, 1819

Graphiurus nagtglasii Jentink, 1888
(Fig. 8)

Graphiurus nagtglasii Jentink, 1888b: 38.

COMMON NAME. — Nagtglas's Dormouse; EWE: *Kade.*

MATERIAL EXAMINED. — **Apesokubi** (Fig. 8) • 1 ♂; USNM 590101; 26.XI.1999; Sherman trap on a horizontal branch at 1.5 m height • 2 ♀; USNM 590102; ZTNHC 972; 27.XI.1999; Sherman and Victor Rat traps.

REMARK

All three specimens were caught in this dense traditionally protected forest at Apesokubi. There are 22 specimens from Leklebi Agbesia and one specimen from Odomi Jongo (2 miles E Nkwanta), all in the Volta Region in the USNM. Grubb *et al.* (1998) show two other localities in the Volta Region. The species has also been reported from several localities in the Togo Highlands (Roche 1971; Robbins & Van der Straeten 1996).

CONSERVATION STATUS. — *Graphiurus nagtglasii* is listed as "Least Concern" on the IUCN Red List, however, progressive forest loss will marginalize this arboreal species.

Family ANOMALURIDAE Gervais, 1849

Anomalurus beecrofti Fraser, 1852

Anomalurus beecrofti Fraser, 1852: 17.

COMMON NAME. — Beecroft's Anomalure; EWE: *Kasanui*, *Vava.*

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 1 ♀; ZTNHC 950.

REMARK

This specimen was brought to us by a local hunter, on 19 November 1999. In the Volta Region a previous record is from the vicinity of Jasikan (Grubb *et al.* 1998) and it was observed at Kyabobo National Park by Hurst *et al.* (1995). In the Togo Highlands *A. beecrofti* was previously recorded from Apéyémé, Edifou, Ezimé and Misahohé (Robbins & Van der Straeten 1996; USNM). Grubb *et al.* (1998) followed Rosevear (1969) in using the generic name *Anomalurops* Matschie, 1914 for this species; we follow Dieterlen (2005) and Kingdon (2013) in the use of *Anomalurus* Waterhouse, 1843.

CONSERVATION STATUS. — *Anomalurus beecrofti* is listed as "Least Concern" on the IUCN Red List, however, progressive forest fragmentation with the loss of mature trees, specifically oil palms (*Elaeis guineensis*), will greatly compromise the habitat of this tree-dependent glider.

Order Chiroptera Blumenbach, 1779

Remark
Seventeen bat species were recorded from the Ghana-Togo Highlands based on our two expeditions in the Volta Region (19 nights netted). We list all species and their localities encountered in their zoogeographic context.

Family Pteropodidae Gray, 1821

Remark
Nine species of Old World fruit bats (Pteropodidae) were encountered during the two field seasons. The maximum number of pteropodid species encountered at one site was five during a single field season (dry) and seven during both field seasons in the Agumatsa valley (Wli). The latter number is identical to what Yeboah (2001) found at Mt. Afadjato Forest (near Tagbo Falls).

Eidolon helvum (Kerr, 1792)

Vespertilio vampyrus helvus Kerr, 1792: xvii: 91.

Common name. — Straw-colored Fruit Bat; EWE: *Aguto.*

Material examined. — **Agumatsa (Wli)** • 1 ♀; SMF 89666; brought to us by a local hunter; 19.XI.1999.

Remark
A large colony of this gregarious and migratory fruit bat roosts on the trees and rock faces next to Wli Waterfall, recently estimated to include 250 000 individuals (Hayman *et al.* 2012) with an earlier report estimating the colony to include half a million *E. helvum* (Rice 1973), which would probably make it the most abundant fruit bat species in the area. Estimating the ecosystem services provided by the seed dispersal activities of *E. helvum* in Ghana and elsewhere in Africa was the subject of a recent study (van Toor *et al.* 2019).

Conservation status. — *Eidolon helvum* has been listed as "Near Threatened" on the IUCN Red List because of significant population declines probably resulting from habitat loss and hunting for food and medicine (Peel *et al.* 2017).

Epomops franqueti (Tomes, 1860)

Epomophorus franqueti Tomes, 1860: 54.

Common name. — Franquet's Epauletted Fruit Bat; EWE: *Aguto.*

Material examined. — **Kalakpa Resouce Reserve** • 1 ♀; SMF 89662). **Agumatsa Valley** • 2 ♀; SMF 89663, ZTNHC 959.

Remark
Although this is a mostly forest-dwelling fruit bat distributed from eastern Côte d'Ivoire into Central Africa (Happold 2013a), our specimen from Kalakpa Resource Reserve shows that it can cope with forest remnants and gallery forest in more savanna-dominated areas. *Epomops franqueti* was previously known in the Volta Region from Amedzofe, Bator, Leklebi Agbesia, and Odomi Jongo (Bergmans 1989).

Conservation status. — *Epomops franqueti* is listed as "Least Concern" on the IUCN Red List.

Epomops buettikoferi (Matschie, 1899)

Epomophorus büttikoferi Matschie, 1899: 45.

Common name. — Büttikofer's Epauletted Fruit Bat; EWE: *Aguto.*

Material examined. — **Apesokubi** • 1 adult ♀ with a 53 mm long embryo; 27.VIII.2001; SMF 92116.

Remark
Essentially an Upper Guinea forest species with some disjunct populations east of the Dahomey Gap in Nigeria (Bergmans 1989; Thomas & Henry 2013). All previous Ghanaian specimens were from the rainforest zone in SW Ghana west of the Volta River (Bergmans 1989; Grubb *et al.* 1998). Thus, our specimen is the first record east of the Volta in Ghana.

Conservation status. — *Epomops buettikoferi* is listed as "Least Concern" on the IUCN Red List.

Epomophorus gambianus (Ogilby, 1835)

Pteropus gambianus Ogilby, 1835: 100.

Common name. — Gambian Epauletted Fruit Bat; EWE: *Aguto.*

Material examined. — **Kalakpa Resource Reserve** • 1 ♂; ZTNHC 971; 16.XI.1999.

Remark
Only one specimen of this savanna species was captured at a thicket edge in Kalakpa Resource Reserve, a mostly savanna-covered legally-protected area in the south of the Volta Region, southeast of the Abutia Hills. *Epomophorus gambianus* is well documented from Eastern Ghana and Togo and is most common in savanna or secondary savanna areas. During three Belgian expeditions to Togo, including many localities in the Togo Highlands, it was the second most abundant fruit bat after *Micropteropus pusillus* (Peters, 1868) (DeVree *et al.* 1969; 1970; De Vree & Van der Straeten 1971). In the Volta Region *E. gambianus* was previously recorded from Bator, Ho, Keta, Kete Krachi (= Kradji), and Odomi Jongo, 2 miles E Nkwanta (Bergmans 1988).

Conservation status. — *Epomophorus gambianus* is listed as "Least Concern" on the IUCN Red List. Although rare during our survey, the high abundance of this fruit bat in surveys that included savanna areas make it a species of less concern.

FIG. 8. — Nagtglas's Dormouse *Graphiurus nagtglasii* Jentink, 1888 from Apesokubi. Photo: M. Weinbrenner 1999.

Micropteropus pusillus (Peters, 1868)

Epomophorus pusillus Peters, 1868: 870.

COMMON NAME. — Peters' Lesser Epauletted Fruit Bat.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 3 ♀; ZTNHC 957, SMF 92112, 92113. **Apesokubi** • 1 ♂; 0.5 km N Apesokubi; USNM 590071 • 4 ♀; USNM 590070, ZTNHC 966, SMF 89660, 89661. **Kyabobo NP** • 1 ♂; SMF 92114. **Shiare Schoolyard** • 1 ♀; SMF 92115.

REMARK

As in previous studies from Ghana and Togo (De Vree *et al.* 1969, 1971; Decher 1997a), with 23 individuals caught, *Micropteropus pusillus* was the most common small fruit bat in our survey, perhaps outnumbered locally only by large colonies of the high-flying *Eidolon helvum* (Kerr, 1792). It is a typical species of the rainforest-savannah mosaic characteristic for much of the Volta Region. In Ghana east of the Volta River, *M. pusillus* was previously captured at Akwamufe, Amedzofe, Kalakpa Game Production Reserve, Leklebi Agbesia and Odomi Jongo (Bergmans 1989). In Ghana and Togo, *M. pusillus* shares a similar distribution pattern with *Epomophorus gambianus* (see maps in Bergmans [1988, 1989] and Grubb *et al.* [1998]) but it seems to occur more commonly in or near forest remnants than the latter species, suggesting a greater dependence on forest. In our survey up to eight individuals would hit the nets at the same time indicating that they fly and forage in groups.

CONSERVATION STATUS. — *Micropteropus pusillus* was classified as "Least Concern" on the IUCN Red List. It remains a common fruit bat species in the Ghana-Togo Highlands. However, this species may depend on forest remnants during its foraging flights (Fahr 1996).

Myonycteris angolensis smithii (Thomas, 1908)

Rousettus smithi Thomas, 1908: 375.

COMMON NAME. — Angolan Fruit Bat.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 2 ♀; SMF 89667 + 92121. **Apesokubi** • 1 ♀; SMF 92122. **Kyabobo NP** • 1 ♀; SMF 92123. **Liati-Wote** • 2 ♀; SMF 92124 + 92125.

REMARK

We follow Nesi *et al.* (2013) in the use of the name *Myonycteris* Matschie, 1899 instead of *Lissonycteris* K. Andersen, 1912 for this fruit bat. *Myonycteris angolensis smithii* has previously been recorded in the Volta Region from Leklebi Agbesia, Akaniem, and Odomi Jongo (Bergmans 1997) and in neighboring Togo from Bismarckburg, Ahoué-houé, Aledjo, Odjolo, Pewa, and the Région d'Atakpamé (De Vree *et al.* 1969, 1970; Robbins, 1980; Grubb *et al.* 1998). *Myonycteris a. smithii* appears to be a relatively common forest and forest edge species throughout the Ghana-Togo Highlands and does not appear too affected by the widespread forest fragmentation. Most specimens in Ghana, Togo and Côte d'Ivoire have been recorded from the forest savanna mosaic and dry forests, but only a few from evergreen rain forest (Fahr 1996). We captured no males and only one female

Fig. 9. — Western Woermann's Fruit Bat *Megaloglossus azagnyi* Nesi, Kadjo & Hassanin, 2013, ♀ from Shiare schoolyard (SMF 92119). Photo: M. Weinbrenner 2001.

during the dry season in 1999 versus eight females from four localities in 2001. This may resemble the migration and possibly sexual segregation in this species observed at Mount Nimba, Liberia (Wolton *et al.* 1982) but details have to be verified for the Ghana-Togo Highlands. This fruit bat quickly attenuates to human handling. A female which stayed around our field camp at Apesokubi after release readily took banana pieces from our hands while hanging on a laundry line. An ectoparasite found on a *M. s. smithii* from Liati-Wote was a male *Dipseliopoda biannulata* (Oldyroyd, 1953) [Diptera: Nycteribiidae].

Conservation status. — *Myonycteris angolensis* is listed as Least Concern on the IUCN Red List (as *Lissonycteris angolensis* (Bocage, 1898)). Though not strictly a high forest species, it seems to be associated with dry forest of different types or gallery and island forests in the savanna zone and may depend on the existence of forest remnants in the Volta Region to survive.

Megaloglossus azagnyi Nesi, Kadjo & Hassanin, 2013 (Fig. 9)

Megaloglossus azagnyi Nesi, Kadjo & Hassanin *in* Nesi *et al.* 2013: 134.

Common name. — Western Woermann's Fruit Bat.

Material examined. — **Agumatsa Wildlife Sanctuary** • 2 ♂; SMF 92117 + 92118; 11.IX.2001. **Shiare schoolyard** (Fig. 9) • 1 ♀; SMF 92119; 22.VIII.2001 • 1 ♂; SMF 92120; 22.VIII.2001.

Remark

We follow Nesi *et al.* (2013) in the use of the name *M. azagnyi* as a species separate from *M. woermanni* Pagenstecher, 1885 for Upper Guinea and the Volta Region of Ghana, which we confirmed with BLAST searches of *Cytb* sequences for our four specimens. While all four *Cytb* sequences were of sufficient quality to allow species identification; only two sequences, one from each locality, were of sufficient quality to be entered into Genbank (MT311312 from SMF 92117 and MT311313 from SMF 92120. These sequences had a 100-96% sequence identities to sequences reported from *M.azagnyi* from the Cote d'Ivoire by Nesi *et al.* (2013). The sequences obtained from specimens SMF 92118 and 92119 contained numerous "no calls" or "N" resulting from the detection on more than a single nucleotide at a site. Previous records of *Megaloglossus* Pagenstecher 1885 in the Volta Region were from Amedzofe and Odomi Jongo, 2 miles E Nkwanta (Bergmans 1997).

Conservation status. — The IUCN Red List map shows the distribution to include the Ghana-Togo Highlands (Monadjem 2016) but how far this nectar-feeding species extends into the Dahomey Gap before it is replaced by *M. woermanni* in Lower Guinea is still unknown. The IUCN Red List classification is "Least Concern".

Nanonycteris veldkampi (Jentink, 1888)

Epomophorus veldkampii Jentink, 1888a: 51.

Common name. — Veldkamp's Bat.

Material examined. — **Agumatsa Wildlife Sanctuary** • 1 ♀ with 1 embryo; SMF 89665. **Apesokubi** • 1 ♀ with 1 embryo; SMF 89664.

Remark

Previous records of this species were from Odomi Jongo in the Volta Region (USNM) and from Bismarckburg, Misahohé, Aledjo, Atakpamé, Evou, Ezimé, Fazao, Odjolo, Plateau Akpossi in Togo (De Vree *et al.* 1969, 1970; De Vree & Van der Straeten 1971). This is a small fruit bat similar in appearance to *Micropteropus pusillus* from which it can be distinguished by its slender snout and the nine undivided and thinner palatal ridges (see drawings in Bergmans [1997] and Happold [1987]). With just two specimens captured at the beginning of dry season in 1999, *N. veldkampi* was much less common than *M. pusillus* (23 specimens; Table 2). The seasonal occurrence could be explained by the migratory behavior of this species, which was shown to follow the progression of the rains northward to savanna areas (Fahr 1996, Thomas 1983). Similarly, at Mount Nimba, Wolton *et al.* (1982) did not obtain this species at all between early July and early September, whereas it was common there at other times of the year (Monadjem *et al.* 2016). During the

African Small Mammal Project, between January and June 1968 (Robbins 1980), no *N. veldkampi* were encountered, yet the same Project captured 20 *M. pusillus* in Togo and Benin. During a study on the Accra Plains between November 1991 and June 1992 no *N. veldkampi* were encountered, but 45 *M. pusillus* were captured (Decher 1997a).

CONSERVATION STATUS. — *Nanonyteris veldkampi* is classified as "Least Concern" on the IUCN Red List. Its migratory behavior and dependence on forest remnants still need to be investigated in more detail in the Ghana-Togo Highlands.

Hypsignathus monstrosus H. Allen, 1861

Hypsignathus monstrosus H. Allen, 1861: 157.

COMMON NAME. — Hammer-headed Bat.

REMARK
Males of this species were only heard performing their characteristic lek-calling behaviour (Bradbury 1977) in a nearby mango tree at Agumatsa Wildlife Sanctuary in August 2001. *Hypsignathus monstrosus* has been previously recorded in the Volta Region from Odomi Jongo, 2 miles E Nkwanta and Leklebi Agbesia (USNM).

CONSERVATION STATUS. — *Hypsignathus monstrosus* is listed as "Least Concern" on the IUCN Red List.

Family NYCTERIDAE Van der Hoeven, 1855

Nycteris arge Thomas, 1903

Nycteris arge Thomas, 1903: 633.

COMMON NAME. — Bate's Slit faced Bat.

MATERIAL EXAMINED. — Apesokubi • 1 ♀; SMF 92126; 26.VIII.2001.

REMARK
Although this bat is known from the Upper Guinea Region west of the Volta River and from central and southern Nigeria (Happold 1987), it does not seem to have been recorded from the Volta Region, or in the Dahomey Gap. The closest records are two BMNH specimens from Akaniem (Akaniem, Buem) between the Volta and Oti River branches of present-day Lake Volta (Grubb 1971). Van Cakenberghe & De Vree (1985) apparently list these specimens as being from "Akenim", Togo. In Côte d'Ivoire, Fahr (1996) recorded six out of seven specimens of *N. arge* within the rainforest zone and one in forest-savanna mosaic. Our specimen of *N. arge* appears to be the first one reported from the Volta Region.

CONSERVATION STATUS. — Although classified as a species of "Least Concern" on the IUCN Red List, as a mostly forest-dependent species, *N. arge* is of some conservation concern in the Ghana-Togo Highlands.

FIG. 10. — Halcyon Hoseshoe Bat *Rhinolophus alcyone* Temminck, 1853, ♀ from Apesokubi (SMF 92130). Photo: M. Weinbrenner 2001.

Family RHINOLOPHIDAE Gray, 1825

Rhinolophus alcyone Temminck, 1853
(Fig. 10)

Rhinolophus alcyone Temminck, 1853: 80.

COMMON NAME. — Halcyon Horseshoe Bat.

MATERIAL EXAMINED. — **Kalakpa Resource Reserve** • 1 ♀; SMF 89668. **Agumatsa Wildlife Sanctuary** • 4 ♂; ZTNHC 952+958, SMF 89669+92129 • 2 ♀; SMF 92127+92128. **Apesokubi** • 1 ♀; SMF 92130.

REMARK
Larger than *R. landeri* Martin, 1838 (weight: 12.5-14.6 g; forearm: 47.5-53 mm). Our specimens confirm that *R. alcyone* is widely distributed in forest and forest-savanna mosaic. The closest previous records are from Akaniem north of Kete Krachi and from Breniasi and Worawora south of Apesokubi (Grubb 1971). In Côte d'Ivoire Fahr (1996) captured three out of five specimens in savanna.

CONSERVATION STATUS. — Listed as "Least Concern" on the IUCN Red List, this species was the most common rhinolophid bat in our survey and is probably of lesser conservation concern in the Ghana-Togo Highlands.

Rhinolophus landeri Martin, 1838

Rhinolophus landeri Martin, 1838: 101.

COMMON NAME. — Lander's Horseshoe Bat.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 1 ♂; SMF 89670; 22.XI.1999.

Fig. 11. — Noack's Roundleaf Bat *Hipposideros* cf. *ruber* (Noack, 1893), ♂ from Shiare (SMF 92133). Photo: M. Weinbrenner 2001.

Fig. 12. — Cyclops Roundleaf Bat *Doryrhina cyclops* (Temminck, 1853) ♂ from Shiare (SMF 92134). Photo: M. Weinbrenner 2001.

Remark

The single specimen of *R. landeri* could be distinguished from *R. alcyone* by its smaller size (weight 7.8 g; forearm 43.2 mm). A British Museum specimen of *R. landeri* is labeled as originating from "Wraura" (BMNH 55.378, leg. A. H. Booth), which may be the same as Worawora (near Apesokubi). A review of the bats of Côte d'Ivoire, showed that *R. landeri* occurs in all savanna formations to the northern edge of the Sudan savanna and that rainforest is actually being avoided (Fahr 1996; Fahr & Kalko 2011), contrary to Rosevear's (1965) assessment of *R. landeri* as a rainforest species, which at his time included *R. guineensis* Eisentraut, 1960 as a subspecies. This is also supported by captures from Togo with just one specimen from the eastern edge of the Ghana-Togo Highlands at Atakpamé (De Vree *et al.* 1969) and 22 specimens caught in Northern Togo at Namoundjoga (De Vree *et al.* 1970). On the Accra Plains nine *R. landeri* were caught in forest remnants and in more open savanna (Decher 1997a).

Conservation status. — *R. landeri* is listed as "Least Concern" by IUCN Red List. However, its uncommon occurrence in the Ghana-Togo Highlands and the fact that we found just one specimen in a forested valley make it of some conservation concern for the Volta Region.

Family Hipposideridae Lydekker, 1891

Hipposideros cf. ***ruber*** (Noack, 1893) (Fig. 11)

Phyllorhina ruber Noack, 1893: 586.

Common name. — Noack's Roundleaf Bat.

Material examined. — **Apesokubi** • 1 ♂; SMF 92132 • 1 ♀; SMF 89671. **Agumatsa (Wli Waterfall)** • 1 ♂; SMF 89672 • 2 ♀; ZTNHC 951, SMF 92131. **Shiare Schoolyard** • 1 ♂; SMF 92133.

Remark

Previous specimens from Ghana-Togo Highlands were from Breniasi, Worawora and Jasikan (AMNH; BMNH; Grubb 1971) and from Ahoué-houé, Agou, Aledjo, Fazao, Misahohé and Palimé in Togo (De Vree *et al.* 1969, 1970; Robbins 1980). We tentatively label these bats *Hipposideros* cf. *ruber* as at least three different lineages of bats affiliated with *H. ruber sensu strictu* from East Africa occur in Ghana, lineages B1, and D2 (Vallo *et al.* 2008, 2011), or what Monadjem *et al.* (2013) called lineage E2, or possibly lineage B1 also reaching into the Dahomey Gap (Benin) since our specimens are all from east of the Volta River. The distribution of specimens from West Africa weakens the assumption that *H.* cf *ruber* is a forest species.. In Côte d'Ivoire Fahr (1996) made 70 captures of *H.* cf. *ruber*, 69.2% of which were in the moist forest zone, 15.4% in forest savanna mosaic and 15.4% in savanna formations.

Conservation status. — Listed as "Least Concern" on the IUCN Red List, *Hipposideros* cf. *ruber* appears to be still relatively common as our findings from three localities indicate.

Doryrhina cyclops (Temminck, 1853) (Fig. 12)

Phyllorrhina cyclops Temminck, 1853: 75.

Common name. — Cyclops Roundleaf Bat.

Material examined. — **Shiare** • 1 ♂; SMF 92134; 24.VIII.2011; over a small creek in a side valley of the Sabu Creek valley of Shiare.

Remark

The closest previous localities from the Volta Region are from Akaniem, Breniasi and Odomi Jongo in Ghana (Grubb 1971; USNM) and from Bismarckburg, Ezimé and Odjolo in Togo (Matschie 1893a; De Vree *et al.* 1969; Robbins 1980). We follow Foley *et al.* (2017) in the use of the name *Doryrhina* Peters, 1871 instead of *Hipposideros* Gray, 1831. *Doryrhina cyclops* seems to be most often associated with rainforest, which was also recently shown at Liberian Mount Nimba (Monadjem *et al.* 2016). This

bat uses a perch-hunter foraging strategy and it requires large hollow trees for its day roosts. On the Accra Plains this species was found only in a traditionally protected sacred grove that was a remnant of high forest (Decher 1997a). In Côte d'Ivoire 70% of localites were in the area of moist forests, 10% in forest-savanna mosaic and 20% in savanna formations (Fahr 1996).

CONSERVATION STATUS. — Listed as "Least Concern" on the IUCN Red List, its dependence on large and hollow trees and preference for gallery forest (Decher & Fahr 2005) make this a species of high conservation concern in the Ghana-Togo Highlands.

Macronycteris gigas (Wagner, 1845)

Rhinolophus gigas Wagner, 1845: 148.

COMMON NAME. — Giant Leaf-nosed Bat.

MATERIAL EXAMINED. — **Agumatsa Wildlife Sanctuary** • 1 ♀; SMF 92135; 11.VIII.2001.

REMARK

This is the second largest insectivorous bat in West Africa, exceeded in size only by the emballonurid *Saccolaimus peli* (Temminck, 1853). We follow Foley *et al.* (2017) in the use of the name *Macronycteris* Gray, 1866 instead of *Hipposideros* Gray, 1831. This *Macronyteris* female was identified as *M. gigas* by the late D. Kock (in litt.) based on its large forearm measurement of 102 mm. The mean for ♀ *M. vittatus* (Peters, 1852) is 93.9 mm with a Range of 84-101mm (Happold 2013b). Only one individual of this large hipposiderid bat was collected during the rainy season. Four other Volta Region specimens are known from Odomi Jongo, 2 miles E Nkwanta (USNM 424858-61). Togo highlands specimens are known from Adjido, Agou, and Ezimé (De Vree *et al.* 1969; Robbins 1980). Our record confirms previous observations (Grubb *et al.* 1998) that in Ghana this species often occurs in forests, although it is also found in Guinea woodland and even in the coastal savanna like the Accra Plains (Decher 1997a). In Côte d'Ivoire, Fahr (1996) made six of his eight captures in the rain forest zone. Six ectoparasitic *Ascodipteron variisetosum* Maa, 1965 [Diptera: Streblidae] with (2 × 3) were found on the ventral side of the upper arm on the specimen from Agumatsa.

CONSERVATION STATUS. — Listed as "Least Concern" on the IUCN Red List, this species is of some conservation concern in the Ghana-Togo Highlands because it appears to be patchily distributed and may be limited not so much by the availability of large tracts of forest as by the presence of large hollow trees and caves for its roosts (Grubb *et al.* 1998).

Family VESPERTILIONIDAE Gray, 1821

Scotophilus livingstonii Brooks & Bickham, 2014

Scotophilus livingstonii Brooks & Bickham, 2014: 11.

COMMON NAME. — Livingstone's House Bat.

FIG. 13. — Rufous Mouse-eared Bat *Myotis bocagii cupreolus* Thomas, 1904 from Agumatsa (Wli Waterfall) valley. Photo: M. Weinbrenner 1999.

MATERIAL EXAMINED. — **Agumatsa (Wli Waterfall)** • 1 ♀; SMF 92137; caught on 11.VIII.2001.

REMARK

Originally identified as *Scotophilus dinganii* (A. Smith, 1833) due to its bright yellow ventral side side and its forearm length of 57.8 mm, the West African form, which also occurs in western Kenya, has been recently renamed *S. livingstonii* based on phylogenetic and morphological distinct *S. dinganii*-like clades (Brooks & Bickham 2014). Our specimen was caught in a net set across the Agumatsa River flanked by secondary forest and nearby small cassava fields. Other Ghana-Togo Highlands specimens are known from Odomi Jongo, 12 Miles E Nkwanta in Ghana (USNM 424888) and from Atakpamé and Ezimé in Togo (Robbins 1980; Robbins *et al.* 1985). The species was also caught at three locations on the Accra Plains (Decher 1997a and USNM, as *S. dinganii*) and seems to be most commonly associated with Guinea savanna, forest savanna mosaic, and high forest edge. Records from Côte d'Ivoire are all from the northern tree savanna (Fahr 1996, as *S. dinganii*). This species also seems to adapt to rooftops and thatched huts for its roosts.

CONSERVATION STATUS. — The conservation classification of *S. livingstonii* on the IUCN Red List is "Least Concern".

Myotis bocagii cupreolus Thomas, 1904
(Fig. 13)

Myotis bocagei cupreolus Thomas, 1904: 407.

COMMON NAME. — Rufous Mouse-eared Bat.

MATERIAL EXAMINED. — **Agumatsa (Wli Waterfall)** • 2 ♀; SMF 89673, SMF 92136.

Remark

Only two specimens were collected at the same river crossing at Agumatsa, one in the dry season on 22 Nov. 1999 and one in the wet season on 11.VIII.2001. These appear to be the first record of *M. bocagii* from the Volta Region and from the Ghana-Togo Highlands. The closest records in Ghana are from the lower Volta River near Kpong (Decher *et al.* 1997), from Jukwa in the Central Region (USNM 4215; 4216) and from Boti Falls in the Eastern Region (ROM 55137, 60227). The only known record from Togo is from Borgou in Northern Togo (De Vree & Van der Straeten 1971).

Conservation status. — Classified as "Least Concern"on the IUCN Red List. This bat depends on water for its foraging flight (Brosset 1976), as well as riverine forest vegetation and banana and other musaceous plants whose furled leaves it uses as a roost (Happold 2013c). Its survival in the Ghana-Togo Highlands is thus of some conservation concern if forest loss continues.

Other Mammal species encountered and the Search for *Leimacomys* in the Volta Region

Remarks

At AgumatsaValley (Wli Waterfall), we observed two squirrel species, *Paraxerus poensis* (A. Smith, 1843) and *Xerus erythropus* (É. Geoffroy, 1803) both known from the Volta Region (Grubb *et al.* 1998), and a small nocturnal primate, initially identified as Demidoff's Galago (*Galagoides demidoff* (G. Fischer, 1908)) but possibly also *G. thomasi* (Elliot, 1907), the common Dahomey Gap galago, which was discovered by Simon Bearder at Kalakpa in 2005 (Dowsett-Lemaire & Dowsett 2011a).

Both the 1994 Oxford University Expedition study (Hurst *et al.* 1995) and the present study attempted to rediscover the enigmatic rodent species *Leimacomys buettneri* Matschie, 1893 on the Ghana side, but so far without success. *Leimacomys* was first collected by R. Büttner or his local assistant in 1890 at Bismarckburg, which was then the German colonial district headquarter located near the modern town of Yegué, about 20 km east of KRNP in Togo located at 08°11'06"N, 00°38'57"E, 707 m above sea level and only 5 km from the Ghanaian border (Krell 1994).

Local Wildlife Division field staff at Kyabobo National Park who were shown pictures of *Leimacomys* claimed they knew the species, but we did not succeed in obtaining additional specimens. Similarly, at Shiare, which is even closer to the original Togo locality, people seemed to know this rodent from our description by the local name "Yefuli" or "Yiefuni". Attempts to obtain *Leimacomys* in the hills near Shiare have so far been unsuccessful. Future searches will have to include further probing of the indigenous knowledge of this species, various trapping methods, and local participation to eventually rediscover it on the Ghana or Togo side of the border.

DISCUSSION

Volta region terrrestrial small mammal richness and diversity

Twenty-four nights of trapping in the Volta Region, amounting to 2399 trap nights (two field seasons) resulted in a total of 247 individuals from 16 species captured (Table 1). The species extrapolation curve calculated in EstimateS 9 (Colwell *et al.* 2012; Colwell 2013) and the cumulative number of species over the individuals captured show no asymptotic levelling off (Fig. 14A). The maximum value of the classic (non bias-corrected) Chao 1 richness estimator, defined as the "absolute number of species in an assemblage," is a function of the ratio of species represented by a single individual (F1 = singletons) and species represented by only two individuals (F2 = doubletons) (Magurran 2004): SChao1 = Sobs + (F12 / 2*F2). In this case: SChao1 = 17 + (82 / 2*3) = 27.7 species. This shows that our two-season sampling in the Volta Region did not get close to the maximum number of terrestrial small mammal species to be expected in the Volta Region. With 39.3%, capture success was highest during the one night of trapping at Tagbo Falls, but with just two species caught, diversity (Simpson's 1 – D = 0.12) was lowest. The locally managed Bedibem Forest at Apesokubi yielded more terrestrial small mammal species (11) than any of the other sites with several species only encountered there.

Volta region bat richness and diversity

In 18 nights of bat netting in the Volta Region we captured 63 individuals from 17 species (Table 2). For microbats the Agumatsa Valley (Wli) topped the list with six species caught, of which *Rhinolophus landeri*, *Macronycteris gigas*, *Scotophilus livingstonii* and *Myotis bocagii* were caught only at Agumatsa. The only nycterid, *Nycteris arge*, was caught at Apesokubi and *Doryrhina cyclops* was only caught at Shiare. The most widely distributed bats were *Micropteropus pusillus* (four localities) and *Myonycteris angolensis* (four localities). Figure 3B shows the species extrapolation curve calculated in EstimateS 9 (Colwell *et al.* 2012; Colwell 2013), the cumulative number of species over the individuals captured, and the maximum value of the classic (non bias-corrected) Chao 1 richness estimator as defined above (Magurran 2004): SChao1 = Sobs + (F12 / 2*F2). In the case of bats (see Table 2): SChao1 = 17 + (82 / 2*2) = 33 species. This indicates that our two-season sampling of bats in the Volta Region was not an exhaustive sampling of the bat species to be expected in the region.

Comments on the zoogeography of the Ghana-Togo highlands

Our results show that the Ghana-Togo Highlands are a crossroads of Upper Guinea and Lower Guinea elements and highlight the presence of species and intraspecfic clades that are restricted to the Dahomey Gap Region. Several of our forest taxa could be categorized into at least one of the following groups: 1) endemic to the Dahomey Gap region; 2) allied to Upper Guinea forests; 3) allied to Lower Guinea and Central African forests; 4) found throughout West Af-

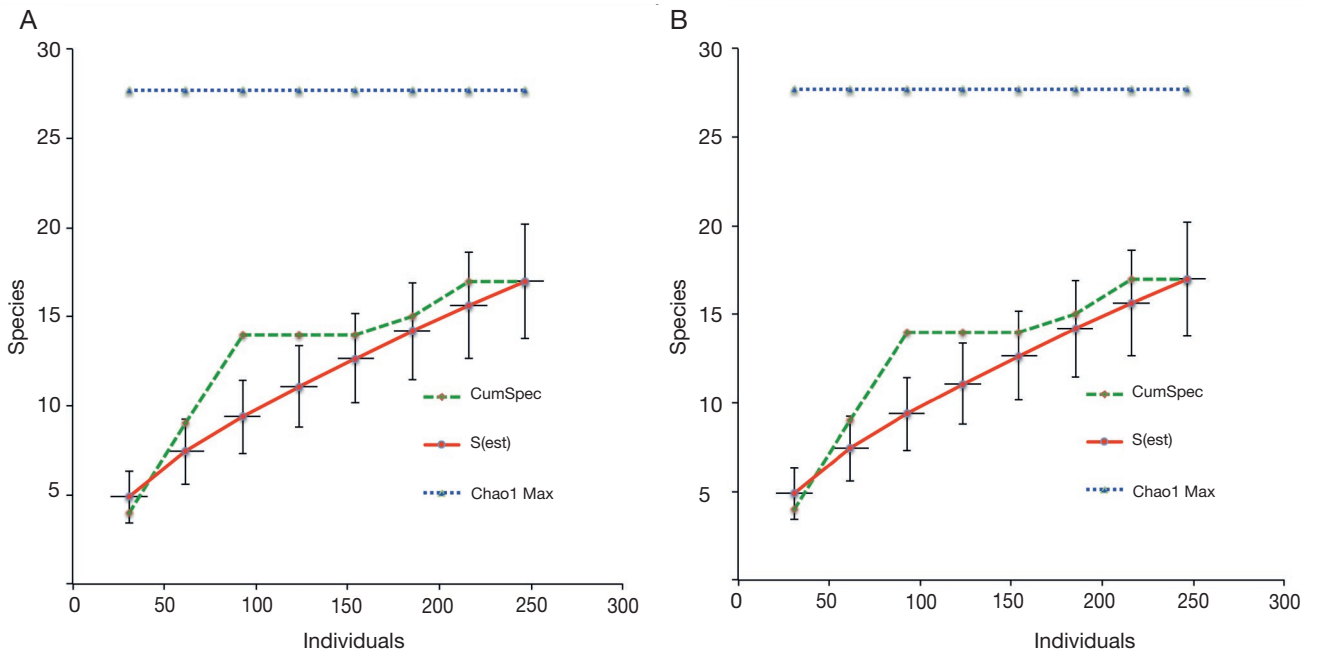

FIG. 14. — Species accumulation and richness: **A**, terrestrial small mammal species accumulation curve; **B**, bat species accumulation curve. Dashed (**green**) line, cumulative number of species; solid (**red**) line, sample-based extrapolation curve using EstimateS (Colwell *et al.* 2012). Dotted (**blue**) line, maximum value of the Chao 1 richness estimator (see text).

rican forests – defined here as closed-canopy forest from the Senegal-Guinea border to the Sanaga River in Cameroon –; and 5) tolerant of savanna and exhibiting weaker zoogeographic patterns.

One of our captured species (*Hylomyscus pamfi*) is endemic to the Togo Highlands and Dahomey Gap region, while three exhibit intraspecific patterns wherein populations from the region form a distinct clade. *Crocidura olivieri* from the region is distinct at an intraspecific level as Clade II-B in the Dahomey Gap and the Sudanian savanna zone of Benin, Togo, Burkina Faso and Niger (Jacquet *et al.* 2015). Nicolas *et al.* (2011) recovered *Praomys misonnei* from the Dahomey Gap region as a unique clade (II). *Malacomys edwardsi* from the area is unique at an intraspecific level as lineage F2, separate from south-central Ghanaian lineage F1 (Bohoussou *et al.* 2015).

Five forest taxa exhibit affinities to Upper Guinea. The aforementioned *Malacomys edwardsi* is an otherwise Upper Guinea species. *Crocidura eburnea* is part of the Upper Guinean *C. obscurior* complex (Jacquet *et al.* 2014). *Epomops buettikoferi is* an Upper Guinean fruit bat with a few populations reaching Lower Guinea. *Megaloglossus azagnyi* is a newly described Upper Guinean nectar-feeding fruit bat with as yet unknown ability to penetrate the Dahomey Gap (Nesi *et al.* 2013). Finally, according to Nicolas *et al.* (2010b; 2020), the sister species to *Hylomyscus pamfi* is *H. simus*, which is an Upper Guinea endemic.

Four forest taxa are primarily allied with Lower Guinea. *Stochomys longicaudatus* is the Lower Guinea "replacement" of *Dephomys defua*. *Epomops franqueti* is an essentially Lower Guinean/Central Africa fruit bat that has been able to penetrate the Upper Guinea forest block just to western Côte d'Ivoire. *Praomys missonei* is a species of Lower Guinea and Central African forests. Finally, although *Crocidura olivieri* is known from both sides of the Dahomey Gap, Jacquet *et al.* (2015) showed that populations from the Dahomey Gap region are more closely related to Lower Guinea populations than those in Upper Guinea.

Several forest species are found across West Africa, but their distributions are interrupted by the arid Dahomey Gap. These include *Graphiurus nagtglasii*, *Rhinolophus alcyone*, *Doryrhina cyclops*, and *Myotis bocagii*. None have been the subject of detailed phylogeographic study, although, in spite of limited geographic sampling, the results of Patterson *et al.* (2019) might suggest that a strong geographic pattern in *M. bocagii* is unlikely. For *D. cyclops* mitochondrial results for Afrotropical Hipposideridae clearly separate Upper Guinean (Liberia and Senegal) from central African specimens (Patterson *et al.* 2020) In contrast to forest species, savanna-tolerant species appear to occur more or less across arid West Africa including the Dahomey Gap. These include *Crocidura foxi*, *Cricetomys gambianus*, *Gerbilliscus kempi*, *Lemniscomys striatus*, *Mus musculoides*, and *Epomophorus gambianus*. Clearly the region's forest-dwelling terrestrial mammals are more easily isolated by zoogeographic barriers such as the Volta River or stretches of unsuitable habitat when compared to most savanna or bat species.

UNCERTAIN FUTURE OF SMALL MAMMALS IN THE VOLTA REGION OF GHANA

Our maps of the Volta Region of Ghana and the Togo Highlands (Fig. 1) illustrate the extent of the forest cover and the location of our study sites (Fig. 1A) and the gen-

eral topography, overlaid with red pixel clusters (Fig. 1B) illustrating the forest cover loss for the 18-year period from 2000 to 2018, thus mostly in the period since our two data collection events (1999 & 2001). This forest cover loss is based on online earth observation satellite data (Hansen *et al.* 2013). Another source reports that Ghana's dense evergreen rain forest and moist deciduous forest "shows a small decline in area from about 16 400 sq km in 1975 to 15 500 sq km in 2000, a reduction of 5 percent. This decline accelerated rapidly between 2000 and 2013, as forests were reduced by an additional 20 percent, to 12 400 sq km in 2013" (CILSS 2016).

Most of the mapped forest cover loss is in addition to the signs of forest loss observed during our study periods, as exemplified by our Figure 3C at Wli Waterfall, bare stretches of fragmented forests on hillsides east of Apesokubi (Kabo River Forest Reserve) and encounters with burned areas and active bushfires during our dry season expedition in 1999. Both the legally protected and savanna-dominated study sites, Kalakpa Resource Reserve and Kyabobo National Park are highly susceptible to the spread of bush fires in the dry season. For the years following our study, Dowsett-Lemaire & Dowsett (2011a: 25) report that "Most of the savanna sections burn every dry season, more or less severely. The wide galleries of forest crossing Kalakpa from north to south need protection through a policy of early burning". Dowsett-Lemaire & Dowsett (2011b: 15) also documented "…a lack of coordination between farmers on the one hand, and those members of the communities who wish to develop ecotourism and protection" both at Wli and Tagbo Falls. Further alarming recent data from the World Resources Institute (WRI) document that "Ghana and Côte d'Ivoire experienced the highest percent rise in primary forest loss between 2017 and 2018 of any tropical country (60% and 26%, respectively)" with illegal mining and expansion of cocoa farms causing some of the loss (Weisse & Goldman 2019). While forest loss is not as rapid in the Volta Region as in southwestern and central Ghana based on Global Forest Watch data (Fig. 1) even in the current view (https://www.globalforestwatch.org/map), there is concern for the future of the mammal fauna of the region, an urgent need to strengthen the conservation function of protected areas like Kalakpa Resource Reserve and Kyabobo NP, but also a need to strengthen local efforts to manage and preserve community forests and sacred groves.

Our Volta Region survey has shown how much of a Dahomey Gap and Lower Guinean faunal element is already present in the Volta Region part of the Togo Highlands, with species like *Hylomyscus pamfi*, *Praomys misonnei* and *Stochomys longicaudatus*. Some details were only unraveled in recent years through molecular phylogeographic studies on various rodent and bat genera (Nicolas *et al.* 2010 a, b, 2020; Olayemi *et al.* 2012; Nesi *et al.* 2013). Clearly the Volta River is an important geographic barrier between Upper Guinea and the Dahomey Gap, particularly for rodents (Nicolas *et al.* 2011). Appendix 1 summarizes these findings.

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APPENDIX

Appendix 1. — Voucher Specimens from the Volta Region, Ghana (1999 & 2001). Abbreviations and measurements: **FA**, forearm (bats only); **HF**, hindfoot; **Length**, head & body length; **SMF**, Senckenberg Museum Frankfurt; **USNM**, United States National Museum, Mammal Collection; **UVM TCN**, University of Vermont, Tissue control number **ZFMK**, Zoological Research Museum Alexander Koenig, Bonn; **ZTNH**, Zadock Thompson Natural History Collections, University of Vermont.

								Field measurements (in mm, weight in g)					
Museum No.	**Field-N°**	**UVM TCN**	**Species**	**Order**	**Specific locality**	**Date**	**Sex**	**Length**	**Tail**	**HF**	**Ear**	**FA**	**weight**
SMF 89666	VR 024	1517	*Eidolon helvum*	CHIR	Agumatsa (Wli Waterfall)	19.XI.99	♀	160	12	27	29	121.0	?
ZTNHC 971	VR 012	1506	*Epomophorus gambianus*	CHIR	Kalakpa Resource Reserve	16.XI.99	♂	162	0	21	22	92.0	109.6
SMF 92116	VR 150	1674	*Epomops buettikoferi*	CHIR	Apesokubi, Site I	27.VIII.01	♀	142	0	21	24	86.0	82.0
ZTNHC 959	VR 048	1541	*Epomops franqueti*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♀	142	0	21	23	84.7	81.3
SMF 89663	VR 049	1542	*Epomops franqueti*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♀	120	0	21	20	76.8	53.7
SMF 89662	VR 011	1505	*Epomops franqueti*	CHIR	Kalakpa Resource Reserve	16.XI.99	♀	142	0	19	22	87.0	85.1
SMF 92134	VR 134	1692	*Doryrhina cyclops*	CHIR	Shiare, schoolyard	24.VIII.01	♂	85	24	19	32	69.0	29.0
SMF 92135	VR 081	1693	*Macronycteris gigas*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	115	36	25	31	102.0	109.0
SMF 92133	VR 135	1690	*Hipposideros* cf. *ruber*	CHIR	Shiare, schoolyard	24.VIII.01	♂	57	35	11	14	54.0	10.5
SMF 89671	VR 073	1564	*Hipposideros* cf. *ruber*	CHIR	4.5 KM Apesokubi	26.XI.99	♀	89	31	7	16	52.8	7.8
SMF 92131	VR 090	1689	*Hipposideros* cf. *ruber*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	61	25	10	14	–	10.0
SMF 92132	VR 138	1691	*Hipposideros* cf. *ruber*	CHIR	Apesokubi	26.VIII.01	♂	58	34	10	13	51.5	8.6
SMF 89672	VR 032	1525	*Hipposideros* cf. *ruber*	CHIR	Agumatsa (Wli Waterfall)	20.XI.99	♂	76	21	7	15	48.1	8.6
ZTNHC 951	VR 033	1526	*Hipposideros* cf. *ruber*	CHIR	Agumatsa (Wli Waterfall)	20.XI.99	♀	85	24	8	16	49.0	8.4
SMF 92118	VR 095	1676	*Megaloglossus azagnyi*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♂	120	9	18	19	41.5	58.5
SMF 92117	VR 093	1675	*Megaloglossus azagnyi**	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♂	69	0	9	11	41.0	10.5
SMF 92119	VR 131	1677	*Megaloglossus azagnyi**	CHIR	Shiare, schoolyard	22.VIII.01	♀	73	0	11	13	42.1	12.0
SMF 92120	VR 132	1678	*Megaloglossus azagnyi*	CHIR	Shiare, schoolyard	22.VIII.01	♂	65	0	11	12	38.4	[9.7]
SMF 89660	VR 076	1567	*Micropteropus pusillus*	CHIR	0.5 KM N Apesokubi	26.VIII.99	♀	83	0	12	13	52.2	21.6
SMF 89661	VR 079	–	*Micropteropus pusillus*	CHIR	0.5 KM N Apesokubi	26.VIII.99	♀	73	0	10	13	46.4	13.4
ZTNHC 966	VR 077	1568	*Micropteropus pusillus*	CHIR	0.5 KM N Apesokubi	26.VIII.99	♀	78	0	13	13	46.4	15.6
USNM 590070	VR 074	1565	*Micropteropus pusillus*	CHIR	4.5 KM N Apesokubi	26.VIII.99	♀	94	0	15	15	51.6	27.2
USNM 590071	VR 075	1566	*Micropteropus pusillus*	CHIR	4.5 KM N Apesokubi	26.VIII.99	♂	88	0	12	15	49.7	25.2
ZTNHC 957	VR 045	1538	*Micropteropus pusillus*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♀	76	2	15	14	45.3	18.5
SMF 92112	VR 084	1670	*Micropteropus pusillus*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	98	0	14	16	56.0	31.5
SMF 92113	VR 092	1671	*Micropteropus pusillus*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	79	0	13	15	52.0	22.0
SMF 92114	VR 120	1672	*Micropteropus pusillus*	CHIR	Kyabobo NP, Laboum Creek	18.VIII.01	♂	96	0	16	17	54.0	29.0
SMF 92115	VR 136	1673	*Micropteropus pusillus*	CHIR	Shiare, schoolyard	24.VIII.01	♀	79	0	14	15	48.0	23.5
SMF 89667	VR 035	–	*Myonycteris angolensis smithii*	CHIR	Agumatsa (Wli Waterfall)	20.XI.99	♀	126	14	17	21	75.0	52.8
SMF 92121	VR 094	1679	*Myonycteris angolensis smithii*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	120	9	18	19	71.0	58.5
SMF 92122	VR 140	1681	*Myonycteris angolensis smithii*	CHIR	Apesokubi	26.VIII.01	♀	129	11	21	20	77.0	73.0
SMF 92123	VR 119	1680	*Myonycteris angolensis smithii*	CHIR	Kyabobo NP, Laboum Creek	18.VIII.01	♀	121	11	20	17	73.0	68.0
SMF 92124	VR 153	1682	*Myonycteris angolensis smithii*	CHIR	Liati-Wote (Tagbo Falls)	29.VIII.01	♀	107	10	21	19	68.2	51.0
SMF 92125	VR 154	1683	*Myonycteris angolensis smithii*	CHIR	Liati-Wote (Tagbo Falls)	29.VIII.01	♀	125	12	17	19	72.8	63.0
SMF 89673	VR 050	1543	*Myotis bocagii cupreolus*	CHIR	Agumatsa (Wli Waterfall)	20.XI.99	♀	92	37	7	14	38.1	7.7
SMF 92136	VR 083	1694	*Myotis bocagii cupreolus*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	61	34	10	13	39.4	6.9
SMF 89664	VR 078	1569	*Nanonycteris veldkampi*	CHIR	0.5 KM N Apesokubi	26.XI.99	♀	82	0	11	16	49.5	24.2
SMF 89665	VR 039	1532	*Nanonycteris veldkampi*	CHIR	Agumatsa (Wli Waterfall)	21.XI.99	♀	79	0	13	15	51.3	24.4
SMF 92126	VR 137	1684	*Nycteris arge*	CHIR	Apesokubi	26.VIII.01	♀	66	51	9	26	42.0	9.3
ZTNHC 952	VR 034	1527	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	20.XI.99	♂	90	28	12	22	52.5	14.6
ZTNHC 958	VR 046	1539	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♂	87	25	11	21	53.0	14.6
SMF 89669	VR 047	1540	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♂	89	23	11	21	51.6	13.8
SMF 92129	VR 082	1685	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♂	68	21	12	22	47.5	14.5
SMF 92127	VR 105	1686	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	13.VIII.01	♀	70	23	13	22	51.0	14.5
SMF 92128	VR 106	1687	*Rhinolophus alcyone*	CHIR	Agumatsa (Wli Waterfall)	13.VIII.01	♀	88	25	13	21	53.0	14.5
SMF 92130	VR 139	1688	*Rhinolophus alcyone*	CHIR	Apesokubi	26.VIII.01	♀	64	24	13	21	51.0	12.5
SMF 89668	VR 013	1507	*Rhinolophus alcyone*	CHIR	Kalakpa Resource Reserve	16.XI.99	♀	66	25	13	22	52.0	13.5
SMF 89670	VR 044	1537	*Rhinolophus landeri*	CHIR	Agumatsa (Wli Waterfall)	22.XI.99	♂	78	21	8	17	43.2	7.8
SMF 92137	VR 091	1695	*Scotophilus livingstonii*	CHIR	Agumatsa (Wli Waterfall)	11.VIII.01	♀	93	47	12	15	57.8	31.0
ZTNHC 950	VR 023	1516	*Anomalurus beecrofti*	ROD	Agumatsa (Wli Waterfall)	19.XI.99	♀	311	245	57	31	–	?

Appendix 1. — Continuation.

								Field measurements (in mm, weight in g)					
Museum No.	**Field-N°**	**UVM TCN**	**Species**	**Order**	**Specific locality**	**Date**	**Sex**	**Length**	**Tail**	**HF**	**Ear**	**FA**	**weight**
ZTNHC 970	VR 146	1697	*Cricetomys* cf. *gambianus*	ROD	Apesokubi, Site II	28.VIII.01	♀	285	337	63	34	–	600.0
SMF 91437	VR 133	1696	*Cricetomys* cf. *gambianus*	ROD	Shiare, ravine forest	24.VIII.01	♀	332	403	68	35	–	1100.0
USNM 590101	VR 063	1554	*Graphiurus nagtglasii*	ROD	4.5 KM N Apesokubi	26.XI.99	♂	130	105	27	19	–	61.7
ZTNHC 972	VR 065	1556	*Graphiurus nagtglasii*	ROD	4.5 KM N Apesokubi	27.XI.99	♀	123	100	25	17	–	66.2
USNM 590102	VR 071	1562	*Graphiurus nagtglasii*	ROD	4.5 KM N Apesokubi	27.XI.99	♀	123	100	25	17	–	49.0
USNM 590074	VR 061	1552	*Hylomyscus pamfi*	ROD	4.5 KM N Apesokubi	26.XI.99	♀	93	123	19	19	–	19.9
ZTNHC 965	VR 070	1561	*Hylomyscus pamfi**	ROD	4.5 KM N Apesokubi	27.XI.99	♂	104	127	19	14	–	28.2
SMF 91364	VR 089	1721	*Hylomyscus pamfi*	ROD	Agumatsa Wildlife Sanctuary	12.VIII.01	♀	86	119	19	13	–	23.5
SMF 91434	VR 145	1698	*Hylomyscus pamfi*	ROD	Apesokubi, Site I	27.VIII.01	♀	97	119	19	12	–	25.0
USNM 590073	VR 009	1504	*Hylomyscus pamfi**	ROD	Kalakpa Resource Reserve	16.XI.99	♂	95	118	19	13	–	22.6
SMF 91370	VR 110	1730	*Hylomyscus pamfi*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	84	105	18	11	–	18.5
SMF 91371	VR 116	1732	*Hylomyscus pamfi*	ROD	Kyabobo NP, Laboum Creek	19.VIII.01	♂	95	119	19	13	–	26.5
ZTNHC 963	VR 060	1551	*Lemniscomys striatus*	ROD	4.5 KM N Apesokubi	26.XI.99	♀	129	140	29	14	–	49.1
USNM 590104	VR 040	1533	*Lemniscomys striatus*	ROD	Agumatsa (Wli Waterfall)	22.XI.99	–	230	119	27	x	–	32.5
USNM 590075	VR 102	1699	*Lemniscomys striatus*	ROD	Agumatsa (Wli Waterfall)	13.VIII.01	♂	245	125	27	14	–	47.0
SMF 91376	VR 148	1701	*Lemniscomys striatus*	ROD	Apesokubi, Site I	28.VIII.01	♀	110	108	28	14	–	31.0
SMF 91436	VR 124	1700	*Lemniscomys striatus*	ROD	Shiare, ravine forest	22.VIII.01	♀	136	151	31	19	–	83.0
USNM 590076	VR 055	1546	*Malacomys edwardsi*	ROD	4.5 KM N Apesokubi	26.XI.99	♂	95	101	29	21	–	17.3
USNM 590077	VR 059	1550	*Malacomys edwardsi*	ROD	4.5 KM N Apesokubi	26.XI.99	♀	147	173	35	27	–	53.4
ZTNHC 960	VR 072	1563	*Malacomys edwardsi*	ROD	4.5 KM N Apesokubi	27.XI.99	♂	139	165	34	25	–	65.6
USNM 590078	VR 149a	1702	*Malacomys edwardsi*	ROD	Apesokubi, Site I	28.VIII.01	♀	154	156	34	27	–	74.0
USNM 590105	VR 149b	–	*Malacomys edwardsi*	ROD	Apesokubi, Site I	28.VIII.01	?	–	–	–	–	–	–
ZTNHC 956	VR 041	1534	*Mus musculoides*	ROD	Agumatsa (Wli Waterfall)	21.XI.99	♂	63	[27]	13	7	–	6.6
UVM	VR 096	1703	*Mus musculoides*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♀	61	54	13	9	–	6.8
UVM	VR 143	1716	*Mus musculoides*	ROD	Apesokubi, Site I	27.VIII.01	♂	61	52	14	9	–	5.7
USNM 590107	VR 021	–	*Mus musculoides*	ROD	Kalakpa Resource Reserve	18.XI.99	♂	64	[4]	12	X	–	7.5
USNM 590108	VR 109	1705	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	17.VIII.01	♀	65	48	13	8	–	7.2
UVM	VR 108	1704	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	17.VIII.01	♂	62	44	12	8	–	7.0
UVM	VR 112	1706	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	64	53	14	8	–	6.3
USNM 590109	VR 113	1707	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	65	49	13	8	–	7.0
UVM	VR 114	1708	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	56	51	14	8	–	6.3
USNM 590110	VR 115	1709	*Mus musculoides*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	69	48	14	9	–	6.4
UVM	VR 125	1710	*Mus musculoides*	ROD	Shiare, ravine forest	22.VIII.01	♂	63	51	13	8	–	6.9
USNM 590111	VR 126	1711	*Mus musculoides*	ROD	Shiare, ravine forest	22.VIII.01	♂	63	51	14	8	–	7.4
UVM	VR 128	1713	*Mus musculoides*	ROD	Shiare, ravine forest	22.VIII.01	♂	63	50	14	8	–	6.1
USNM 590112	VR 127	1712	*Mus musculoides*	ROD	Shiare, ravine forest	22.VIII.01	♀	62	50	13	8	–	6.3
UVM	VR 130	1715	*Mus musculoides*	ROD	Shiare, ravine forest	23.VIII.01	♀	67	48	14	9	–	6.2
USNM 590106	VR 129	1714	*Mus musculoides*	ROD	Shiare, ravine forest	23.VIII.01	♀	65	44	13	8	–	8.0
USNM 590115	VR 025	1518	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♀	109	134	24	17	–	36.0
USNM 590092	VR 026	1519	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♂	86	101	22	16	–	16.4
USNM 590093	VR 027	1520	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♀	100	131	24	16	–	24.7
USNM 590094	VR 028	1521	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♀	110	128	22	15	–	31.4
USNM 590095	VR 029	1522	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♂	116	128	23	17	–	35.9
USNM 590096	VR 030	1523	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♂	98	119	21	15	–	23.5
USNM 590097	VR 031	1524	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	20.XI.99	♂	125	[120]	25	17	–	47.3
ZTNHC 953	VR 036	1529	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	21.XI.99	♂	122	[133]	25	18	–	41.9
ZTNHC 954	VR 037	1530	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	21.XI.99	♀	115	133	24	16	–	35.8
ZTNHC 955	VR 038	1531	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	21.XI.99	♂	111	132	23	17	–	33.1
USNM 590116	VR 042	1535	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	22.XI.99	♀	111	132	24	X	–	35.3
USNM 590117	VR 043	1536	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	22.XI.99	?	66	67	16	11	–	9.0
ZTNHC 967	VR 085	1717	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♂	112	150	24	[ ]	–	41.0
USNM 590098	VR 086	1718	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♂	103	136	23	17	–	24.6
SMF 91435	VR 087	–	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♀	77	101	21	13	–	18.0

Appendix 1. — Continuation.

								Field measurements (in mm, weight in g)					
Museum No.	**Field-N°**	**UVM TCN**	**Species**	**Order**	**Specific locality**	**Date**	**Sex**	**Length**	**Tail**	**HF**	**Ear**	**FA**	**weight**
SMF 91363	VR 088	1720	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♀	93	116	20	[ ]	–	18.0
SMF 91365	VR 097	1722	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♂	116	119	22	15	–	42.5
SMF 91366	VR 098	1723	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	12.VIII.01	♀	84	110	23	15	–	18.5
ZTNHC 968	VR 099	1724	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	13.VIII.99	♂	107	120	28	17	–	32.0
ZTNHC 969	VR 100	1725	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	13.VIII.01	♂	111	125	23	15	–	42.0
SMF 91367*	VR 101	1726	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	13.VIII.01	♀	126	154	21	19	–	40.0
SMF 91368	VR 103	1727	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	13.VIII. 01	♀	186	113	22	14	–	16.0
SMF 93747*	VR 104	1728	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	13.VIII.01	♀	112	143	23	16	–	29.7
SMF 91369	VR 107	1729	*Praomys misonnei*	ROD	Agumatsa (Wli Waterfall)	14.VIII.01	♀	94	115	23	[ ]	–	20.7
SMF 91374*	VR 141	1738	*Praomys misonnei*	ROD	Apesokubi	27.VIII.01	♂	106	124	24	17	–	27.5
USNM 590118	VR 052	1544	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♀	117	140	24	[15]	–	41.5
USNM 590119	VR 053	1545	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♀	113	[52]	23	17	–	34.1
UVM	VR 054	–	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	?	–	–	–	–	–	–
ZTNHC 961	VR 056	1547	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♂	125	149	24	17	–	44.8
ZTNHC 962	VR 057	1548	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♂	116	141	24	16	–	41.3
UVM	VR 062	1553	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♂	126	157	25	16	–	49.3
USNM 590120	VR 064	1555	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	26.XI.99	♀	115	138	24	19	–	31.8
ZTNHC 964	VR 069	1560	*Praomys misonnei*	ROD	Apesokubi, 4.5 KM N	27.XI.99	♂	137	139	26	17	–	43.7
USNM 590099	VR 142	1739	*Praomys misonnei*	ROD	Apesokubi, Site I	27.VIII.01	♂	127	152	26	19	–	45.0
USNM 590100	VR 144	1740	*Praomys misonnei*	ROD	Apesokubi, Site I	27.VIII.01	♀	113	[120]	24	17	–	41.0
SMF 91375*	VR 147	1741	*Praomys misonnei*	ROD	Apesokubi, Site I	28.VIII.01	♀	117	145	23	[19]	–	43.0
SMF 91377*	VR 151	1742	*Praomys misonnei*	ROD	Apesokubi, Site I	29.VIII.01	♂	115	158	24	18	–	44
USNM 590079	VR 001	–	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	?	–	–	–	–	–	–
USNM 590080	VR 002	1498	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	♀	116	147	23	[12]	–	38.4
USNM 590113	VR 003	–	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	♂	112	153	23	[15]	–	38.6
USNM 590081	VR 004	1499	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	♂	120	150	24	18	–	46.9
USNM 590082	VR 005	1500	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	♀	117	149	23	17	–	37.7
USNM 590083	VR 006	1501	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	15.XI.99	♂	117	[135]	23	[14]	–	39.6
USNM 590084	VR 007	1502	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	16.XI.99	♂	93	126	21	18	–	28.2
USNM 590085	VR 008	1503	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	16.XI.99	♂	124	159	24	17	–	43.6
USNM 590114	VR 010	–	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	16.XI.99	♀	107	133	21	17	–	27.4
USNM 590086	VR 014	1508	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♀	81	100	21	16	–	16.7
ZTNHC 949	VR 015	–	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♂	109	138	24	17	–	30.2
USNM 590087	VR 016	1510	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	16.XI.99	♀	105	[110]	24	17	–	27.3
USNM 590088	VR 017	1511	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♂	72	82	20	12	–	10.1
USNM 590089	VR 018	1512	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♀	70	81	20	12	–	9.0
USNM 590090	VR 019	1513	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♀	99	113	21	16	–	21.8
USNM 590091	VR 020	1514	*Praomys misonnei*	ROD	Kalakpa Resource Reserve	17.XI.99	♂	97	129	22	15	–	26.7
USNM 590121	VR 111	1731	*Praomys misonnei*	ROD	Kyabobo NP, Laboum Creek	18.VIII.01	♀	100	140	23	15	–	35.0
USNM 590122	VR 117	1733	*Praomys misonnei*	ROD	Kyabobo NP, Laboum Creek	19.VIII.01	♀	95	133	24	16	–	31.0
USNM 590123	VR 118	1734	*Praomys misonnei*	ROD	Kyabobo NP, Laboum Creek	19.VIII.01	♀	108	146	25	16	–	35.0
USNM 590103	VR 156	1743	*Praomys misonnei*	ROD	Liati-Wote (Tagbo Falls)	30.VIII.01	♂	108	137	25	16	–	41.0
USNM 590125	VR 157	1744	*Praomys misonnei*	ROD	Liati-Wote (Tagbo Falls)	30.VIII.01	♀	115	145	24	18	–	36.0
SMF 91372*	VR 121	1735	*Praomys misonnei*	ROD	Shiare, ravine forest	22.VIII.01	♀	121	133	24	14	–	47.0
USNM 590124	VR 122	1736	*Praomys misonnei*	ROD	Shiare, ravine forest	22.VIII.01	♀	89	118	18	13	–	25.5
SMF 91373*	VR 123	1737	*Praomys misonnei*	ROD	Shiare, ravine forest	22.VIII.01	♂	102	122	25	15	–	33.0
USNM 590072	VR 067	1558	*Stochomys longicaudatus*	ROD	4.5 KM N Apesokubi	27.XI.99	♀	107	163	28	18	–	40.4
ZTNHC 973	VR 022	-	*Gerbilliscus kempi*	ROD	Kalakpa Resource Reserve	18.XI.99	♂	175	[155]	35	18	–	35.5
ZFMK 1999.1144	VR 066	1557	*Crocidura eburnea*	SORIC	Apesokubi	27.XI.99	?	61	32	4	4	–	2.6
ZFMK 1999.1145	VR 058	1549	*Crocidura foxi*	SORIC	4.5 KM N Apesokubi	26.XI.99	♀	89	59	16	7	–	14.9
ZFMK 1999.1146	VR 068	1559	*Crocidura foxi*	SORIC	Apesokubi	27.XI.99	?	89	65	15	9	–	13.3
ZFMK 2003.1089	VR 152	1668	*Crocidura olivieri*	SORIC	Apesokubi, Site I	29.VIII.01	♀	134	76	21	11	–	41.0
ZFMK 2003.1090	VR 155	1669	*Crocidura olivieri*	SORIC	Liati-Wote (Tagbo Falls)	30.VIII.01	?	134	76	21	11	–	41.0