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A SURVEY OF THE SMALL MAMMALS OF THE GONJA FOREST RESERVE, TANZANIA

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ABSTRACT

Small mammals were surveyed in the lowland forest of the Gonja Forest Reserve of north-eastern Tanzania. In 565 trap-nights 10 rodents (three species) were captured. In 12.5 net hours 27 bats (11 species) were netted. Comparisons of similar surveys in nearby montane forests indicate a lower density and diversity of rodents and shrews in Gonja than in higher elevation habitats. Information is presented on external measurements, weight and reproductive condition of the specimens collected.

INTRODUCTION

The natural history of the forests of Tanzania has attracted much attention recently, particularly the rainforests of the eastern part of the country (Kingdon, 1990; Lovett, 1985, 1988; Lovett & Wasser, 1993 and references therein; Rodgers & Homewood, 1982; Stanley *et al.*, 1996). This is due to the exceptionally high level of endemism in many of these forests and the increasing human pressure associated with deforestation. Numerous forests in Tanzania are poorly known and even the best studied contain biotas about which little has been documented. Small mammals (insectivores, elephant shrews, bats, and rodents) represent one such fauna.

Over the past few years, we have conducted surveys of small mammals in various forests of the Eastern Arc Mountains. As part of these surveys we sampled the Gonja Forest Reserve, which lies in a valley between the South Pare Mountains and the West Usambara Mountains (figure 1). The purpose of this survey was to examine the small mammals of the Gonja Forest Reserve and its faunistic relation to neighboring montane sites (Goodman *et al.*, 1995; Stanley *et al.*, 1996). As far as known, this is the first published information on a systematic survey of the small mammals of the Gonja Forest Reserve.

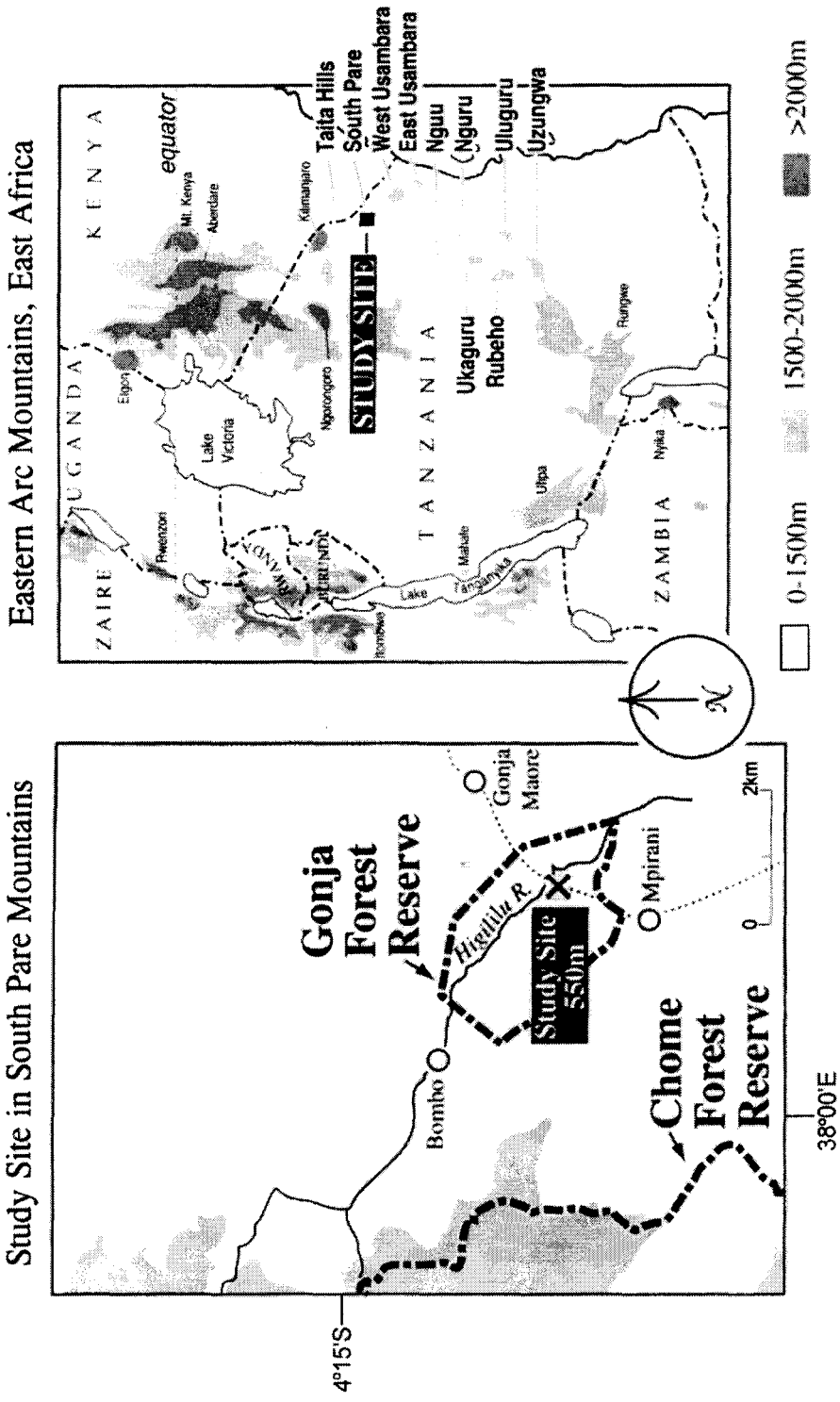

Figure 1. Study sites in the Eastern Arc Mountains, and the Gonja Forest Reserve.

MATERIALS AND METHODS

Study Site

The Gonja Forest Reserve lies between 4°15'50" S–4°17'20" S and 38°00'40" E–38°02'30" E (figure 1). The south-eastern third of the reserve is approximately 500 m in elevation and the western part varies between 500 and 1200 m. Most of the remaining forest is in the lower south-eastern portion, where we conducted our survey, and is a dry lowland forest with little undergrowth and some evidence of logging. The study site was on the southern bank of the Higililu River, 2 km southwest by road of the town of Gonja Maore, 550 m, and was surveyed between 25 August and 31 August 1993 which is a dry time of the year. There was some light precipitation during our survey that was not measurable with our rain gauge.

Trapping Procedure

We sampled the small mammals of the Gonja Forest Reserve using the same techniques employed during our surveys of other Tanzanian forests. Shrews and rodents were captured using pitfall lines and traplines. The pitfall lines consisted of eleven, 15 l buckets spaced 5 m apart, and placed so the upper rim was flush with the ground level. A 50 cm high vertical plastic fence was placed over and bisected the openings of the buckets (Stanley *et al.*, 1996). These lines were placed in different microhabitats within the forest including next to streams and areas of dry, well-drained soil.

Traplines were installed using three types of traps: Museum Special traps, 14x7 cm; Victor rat traps, 17.5x8.5 cm; and medium-sized Sherman live traps, 23x9.5x8 cm. Our traplines consisted of between 50 to 120 traps, with the snap traps making up approximately 85 % of each line. The majority of traps were on the ground, although some were set on vines and limbs. Variables associated with trap placement included height off the ground, distance from the edge of the forest, and distance from water, and general information on the microhabitat. National traps measuring 41x14x14 mm were set under special circumstances and were not part of standard traplines.

All traps and buckets were checked twice each day; once in the early morning and again in the late afternoon. Trap bait consisted of freshly fried small pieces of coconut coated in peanut butter, and traps were rebaited during each afternoon check. A trap or pitfall bucket in use for a 24-hour period from sunrise to sunrise is referred to as a trap-night or bucket-night, respectively. Some animals were brought to us by local residents and these are treated separately in our analyses.

Bats were collected with a 12 m mist net placed diagonally across the Higililu River with the bottom of the net approximately 10 cm above the water. The net spanned the river under an opening in the forest canopy. Between 25 and 30 August, the net was monitored each evening for 2.5 hours starting at 1800 hrs, approximately 1/2 hour before sunset, and was closed at 2030 hrs.

Standard museum measurements and reproductive status were recorded for each specimen, which were prepared as either study skins and skeletons or preserved in 10% formalin. Tissues were preserved in liquid nitrogen. Specimens were deposited in the Field Museum of Natural History (FMNH) and a portion will be returned to the Museum of Zoology, University of Dar es Salaam.

RESULTS

One species of shrew, one species of elephant shrew, 13 species of bats, and seven species of rodents were collected during the survey. These include one shrew, one bat, and three rodent species brought to us by local residents and lack microhabitat information. The number of individuals for each species found in our trap and pitfall lines are presented in table 1.

Table 1. Species of mammals trapped or netted during the survey of the Gonja Forest Reserve. (Animals caught by informants not included).

SPECIES	MALE	FEMALE	TOTAL
MACROSCELIDIA			
Petrodromus tetradactylus	2	1	3
CHIROPTERA			
Rhinolophus fumigatus	2	0	2
Rhinolophus hildebranti	1	0	1
Hipposideros caffer	0	1	1
Nycteris grandis	3	3	6
Nycteris hispida	1	0	1
Chalinolobus argentatus	3	2	5
Myotis bocagei	1	0	1
Pipistrellus nanus	1	1	2
Scotoecus hirundo	1	4	5
Miniopterus schreibersi	1	2	3
RODENTIA			
Cricetomys gambianus	1	0	1
Grammomys dolichurus	0	5	5
Mastomys natalensis	0	4	4
Mus minutoides	1	1	3*

* one specimen found partially eaten in trap; sex unknown

Trap success was low in comparison to other surveys using the same techniques (Stanley *et al.*, 1996; Stanley *et al.*, in press). In 441 bucket-nights we trapped two *Mus minutoides* (0.5% trap success), and in 585 trap-nights we captured 10 individuals (1.7% trap success), which included five *Grammomys dolichurus*, four *Mastomys natalensis*, and one *Mus minutoides*. In a total of 12.5 net-hours 27 bats were captured, representing 11 species (table 1). The following accounts summarize the reproductive and ecological information for the species collected. Generally animals preserved in formalin were not examined for reproductive activity. External measurements of bats, insectivores and rodents are presented in tables 2 and 3.

Insectivora

Crocidura cf. *hirta*. One specimen was brought to us by a local resident who caught it in his garden, near Gonja Maore. It was a female with a perforate vagina that was not pregnant and had no apparent placental scars. The specific identification of this individual is tentative. The specimen is not typical of *C. hirta* (R. Hutterer, pers. comm.) and is smaller than FMNH specimens of *C. hirta* from Tanzania.

Chiroptera

Epomophorus wahlbergi. Three males and one female were brought to us by local residents who found the bats roosting in a mango tree (*Mangifera indica*). Of the two males examined,

Table 2. Means, ranges, and standard deviations of external measurements of bats collected during survey. Measurements include total length (TL), tail length (TV), hindfoot length (including claw) (HF), length of ear (E), forearm length (FA) and weight (W). All measurements are in mm except weight, which is in grams.

Species	Sex	N	TL	TV	HF	E	FA	W
Epomophorus wahlbergi	F	1	134	4	20	25	80.67	
	M	3	155.7	4	22.7	25.3	84.7	98.7
			(150-159)	(3-5)	(21-25)	(25-26)	(83-86)	(93-106)
			4.0	0.8	1.7	0.5	1.2	5.4
Rhinolophus fumigatus	M	2	90.5	25.5	12	23.5	51.0	12.2
			88-93)	(25-26)	(12-12)	(23-24)	(50-52)	(11.5-13)
			2.5	0.5	0	0.5	1	0.7
Rhinolophus hildebranti	M	1	116	38	14	33	64	21
Hipposideros caffer	F	1	85	33	9	13	49	6.4
Nycteris grandis	M	3	67	15.3	31.7	63.3	27.2	
			152.3	(64-69)	(15-16)	(30-33)	(62-64)	(24-31.5)
			(144-157)					
			5.9	2.2	0.5	1.2	0.9	3.2
	F	3	153.3	72.7	15.3	32.3	64.3	29.8
			(151-158)	(70-74)	(15-16)	(31-34)	(64-65)	(27.5-34)
			3.3	1.9	0.5	1.2	0.9	2.9
Nycteris hispida	M	1	93	46	9	22	42	5.3
Chalinolobus argentatus	M	3	100.0	43.7	7.7	12.0	41.3	6.8
			(96-106)	(42-47)	(7-8)	(12-12)	(40-43)	(6.7-7)
			4.3	2.4	0.5	0	1.2	0.1
	F	2	103.0	47.0	8	13.0	43.5	7.8
			(102-104)	(46-48)	(8-8)	(13-13)	(43-44)	(7.5-8.2)
			1	1	0	0	0.5	0.3
Myotis bocagei	M	1	98	43	11	16	38	7.2
Pipistrellus nanus	M	81	38	6	11	33	2.8	
	F	1	79	37	6	11	33	2.8
Scotoecus hirundo	M	1	102	35	8	13	37	11.5
	F	4	93.7	33.2	8.2	13.3	34.5	9.6
			(87-97)	(30-35)	(8-9)	(13-14)	(34-35)	(8.8-9.9)
			4.0	0.8	0.4	0.4	0.5	0.4
Miniopterus schreibersi	M	1	107	48	8	11	41	7.3
	F	4	106.5	47.5	9	11.5	44	6.7
			(106-107)	(47-48)	(9-9)	(11-12)	(43-45)	(6.6-6.8)
			0.5	0.5	0	0.5	1.0	0.1
Mops condylura	M	1	132	46	12	20	48	30

Table 3. Means, ranges, and standard deviations of selected external measurements of shrews, elephant-shrews and rodents collected during the survey. Measurements include total length (TL), head and body (HB), tail length (TV), hindfoot length (including claw) (HF), length of ear (E), and weight (W). All measurements are in mm except W, which is in grams.

Species	Sex	N	TL	HB	TV	HF	E	W
Crocidura hirta	F	1	126	77	51	13	9	5.9
Petrodromus tetradactylus	M	2	356	202.5	166.5	60	35	193.5
			(352-360)	(200-205)	(162-171)	(59-61)	(35-35)	(183-204)
			4.0	2.5	4.5	1.0	0	10.5
	F	1	323	185	146	54	33	123
Cricetomys gambianus	M	1	790	390	400	77	43	1800
Mastomys natalensis	M	1	231	123	111	25	19	46
	F	4	191.3	94	98.7	22.5	17	23.5
			(167-205)	(87-99)	(80-110)	(21-24)	(16-18)	(17.5-27)
			17.2	4.6	13.3	1.1	0.8	3.9
Mus minutoides	M	2	105*	59	47*	12	10	4.9
				(57-61)		(12-12)	(10-10)	(4.6-5.3)
				2.0		0	0	0.3
	F	4	98.7	59	43.7	13	9.5	5.1
			(91-105)	(55-62)	(35-48)	(13-13)	(9-10)	(4.2-6.2)
			5.8	2.7	6.1	0	0.5	0.8
Rattus rattus	M	1	320		157	31	20	90
Graphiurus parvus	M	1	153	87	70	15	14	10.5

*measurement available from only one specimen

one had testes measuring 3x3 mm with non-convoluted epididymides and the other had testes measuring 6x4 with convoluted epididymides. The female had small teats and a closed pubic symphysis.

Rhinolophus fumigatus. Two males were collected. The one male examined for reproductive status had abdominal testes measuring 2.5x2 mm and non-convoluted epididymides.

Rhinolophus hildebranti. The single specimen collected was a male with abdominal testes (1x1 mm), and non-convoluted epididymides.

Hipposideros caffer. One female was brought to us by a local resident who collected the bat by hand in a tree at the ecotone between the forest and farmland.

Nycteris grandis. Three males and three females were captured. Two males had abdominal testes that measured 6x4 mm and 4x2.5 mm and neither had convoluted epididymides. All three of the females captured were pregnant with one embryo each. Two specimens had embryos in the left oviduct that measured 20 and 16 mm (crown-rump length), respectively. The third specimen had one embryo in the right oviduct with a crown-rump length of 18 mm.

Nycteris hispida. We caught one male that had scrotal testes measuring 3x3 mm.

Chalinolobus argentatus. Three males and two females were collected. Both of the females were nulliparous. The males all had abdominal testes.

Myotis bocagei. One male was collected with abdominal testes that measured 6x4 mm and convoluted epididymides.

Pipistrellus nanus. One female and one male were captured. The male had abdominal testes and the female had a closed pubic symphysis.

Scotoecus hirundo. Four females and one male were netted. Two of the females were examined for reproductive activity and both were nulliparous. The male had abdominal testes measuring 3x2 mm with non-convoluted epididymides.

Miniopterus schreibersi. Two females and one male were collected. The male had abdominal testes. One female had a closed pubic symphysis; the other had a slightly open symphysis.

Mops condylura. One male was collected by local residents inside a schoolhouse.

Rodentia

Cricetomys gambianus. One male with scrotal testes was captured in a National trap in an area of forest with heavy undergrowth.

Grammomys dolichurus. This species was the most commonly trapped rodent. We captured five juvenile females, all nulliparous. The microhabitats in which the animals were caught (all in Museum Specials) included: at the junction of two tree limbs, approximately 50 cm off the ground; on the ground under a tangle of 1 cm diameter vines covered with dry leaves; on top of an 80 cm high dirt mound in an area of forest with relatively light undergrowth; between a 4 cm diameter vine and a 7 cm diameter tree, 1.5 m off the ground (the trap was wedged between tree and vine); and on a 4 cm diameter vine, 1 m off the ground and running from ground to mid-canopy.

Mastomys natalensis. Four specimens, all females, were caught in our traplines. The trap sets and microhabitats in which these specimens were caught included: a Museum Special set on the ground in 20 cm high herbaceous undergrowth; a Victor trap in open understory with thick dry leaf litter; a Victor trap under a partially buried rotting log; and a Museum Special set on the ground in 30 cm high herbaceous undergrowth and 30 cm from the edge of the Higililu River. Two specimens examined for reproductive activity were nulliparous. One male was brought to us by local residents. The testes were abdominal and measured 12x7 mm with convoluted epididymides.

Mus minutoides. Four specimens (3 females, 1 male) were brought to us by local residents, and three (1 female, 1 male, and one unsexed specimen found partially eaten) were caught in our traplines. The individuals captured in our trap sets and the respective microhabitat included: one in a pitfall bucket line placed in an area with 1—3 m high saplings; one in a pitfall bucket line placed along the bank and about 10 m from Higililu River; and a Museum Special on the ground under a 30 cm diameter rotting log in a grassy area with open canopy. Two females were examined and both were nulliparous. Of the two males, one had abdominal testes, and the other had scrotal testes.

Rattus rattus. A male black rat with scrotal testes measuring 20x10 mm and convoluted epididymides was collected in Gonja Maore. This species was not caught in our traplines.

Tatera robusta. Two males were brought to us by local residents, including a juvenile captured in the forest near a farm along the Higililu River (downstream from our camp) and an adult obtained in an agricultural area. The testes of the juvenile were abdominal, measured 5x3 mm with non-convoluted epididymides, and the adult had abdominal testes measuring 12x7 mm and non-convoluted epididymides.

Graphiurus parvus. One male was brought to us that was caught in a corn field near Gonja Maore. The testes were abdominal.

Table 4. A comparison of the trap line and pitfall line capture rates during 1993 surveys in three different forests of north-eastern Tanzania. Results are given as totals after four days of each survey with the overall total in parentheses. Total number of days for each survey was 10 for the South Pare Mountains, five for the West Usambara Mountains, and six for the Gonja Forest Reserve.

	Gonja Forest Reserve (550 m)	Chome (South Pare Mts,1100m)	Ambangulu Forest (West Usambara Mts, 1300 m)
Traplines			
Number of trap-nights	387 (585)	750 (2074)	240 (240)
Number species captured	2 (3)	5 (8)	5 (5)
Number individuals captured	8 (10)	32 (72)	29 (29)
Trap success for traplines (%)	2.1 (1.7)	4.3 (3.5)	12.1 (12.1)
Pitfall lines			
Number of bucket-nights	287 (440)	209 (671)	205 (259)
Number species captured	0 (1)	4 (6)	3 (3)
Number individuals captured	0 (2)	18 (36)	21 (22)
Trap success for pitfall lines (%)	0 (0.4)	8.6 (5.4)	10.2 (8.3)
Totals of both trap and pitfall lines			
Number of shrew species captured	0 (0)	2 (4)	3 (3)
Number of shrew individuals captured	0 (0)	17 (36)	21 (22)
Number of rodent species captured	2 (3)	4 (6)	5 (5)
Number of rodent individuals captured	8 (10)	33 (72)	29 (29)

DISCUSSION

The species accumulation curve for combined captures from the trap and pitfall lines is presented in figure 2. Although the species recorded during the survey increased by one the second to last night (the first *Mus minutoides* was caught in a pitfall bucket), we conclude that the majority of small mammal species occurring in the Gonja Forest Reserve were recorded during our study. It is difficult to comment on squirrels and other mammals not typically caught with our trapping protocol.

On the basis of the results of Gonja Forest survey, the non-volant small mammal fauna of the reserve is impoverished both in abundance and species richness in contrast to the montane

and submontane forests of the nearby Eastern Arc Mountains. A comparison of results from two other surveys in the South Pare and West Usambara Mountains (on either side of the Gonja Forest Reserve) within the same season and using identical techniques illustrate this point. In the Gonja Forest Reserve we accrued 585 trap-nights and 441 bucket-nights and caught twelve individuals representing 4 species of rodent and no shrews (mammals such as

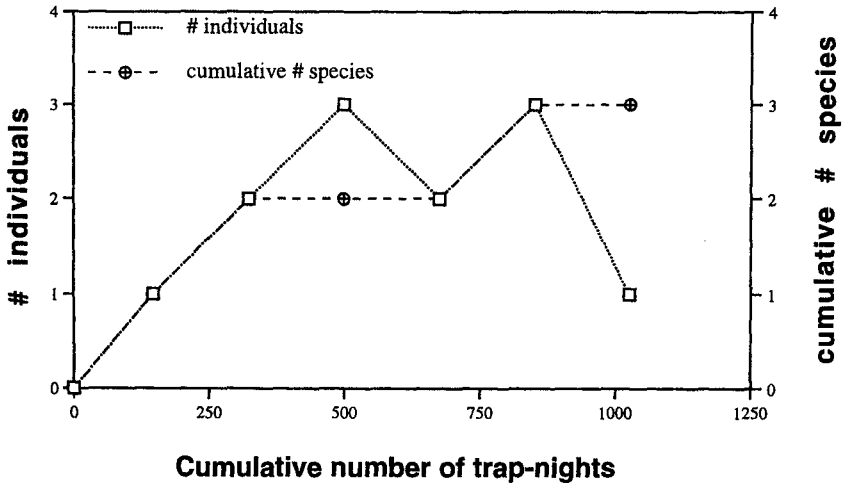

Figure 2. Individuals trapped compared to cumulative species over cumulative trap nights

Petrodromus and *Cricetomys* were caught in traps not part of the standardized trapping regime are excluded in this comparison). While we accrued many more trap and bucket-nights in both the South Pare and the West Usambara Mountains, levels of trap success at these sites after comparable numbers of trap-nights were much greater than what was recorded at Gonja (table 4). After four days of trapping at 1100 m in the Chome Forest Reserve we had accrued 209 bucket-nights resulting in the capture of 18 mammals (16 shrews and two rodents) and 750 trap-nights which caught 32 mammals (31 rodents and one shrew). In total we captured 50 individuals representing three species of crocidurine shrew and four species of murid rodent (Stanley *et al.*, 1996; Stanley *et al.*, in press). In four nights in the West Usambara Mountains at 1300 m, the cumulative number of bucket-nights was 205 bucket-nights and trap-nights 240, resulting in the capture of 37 small mammals, representing three species of shrew and five species of rodent (Stanley *et al.*, in press). All of these surveys were conducted in July and August 1993 (the dry season), suggesting that seasonal variation was not a significant factor in the differences observed. Further inventories are required to determine if the period of our survey of the Gonja Forest Reserve coincided with low points in the population levels of certain mammal species that were not captured, and if during the rainy season an equivalent survey might reveal other small mammal species. The non-volant species we captured in Gonja have broad distributions across eastern Africa, which presumably reflects their dispersal ability. No endemic rodents are known from the area and all of the species captured are typical of disturbed areas (Kingdon, 1974). *Mastomys natalensis* and *Mus minutoides* are widespread and common in agricultural areas.

While our sampling of bats in different Eastern Arc forests has been less systematic than for non-volant small mammals, the species richness of microchiroptera found at Gonja was higher (nine species) than in nearby montane forests. At two different sites in the Chome Forest at 1100 and 2000 m, we recorded a total of three species of microchiroptera and after three seasons of work in the Ambangulu Forest we have netted seven species of microchiroptera (Stanley *et al.*, in press). However, given the dry nature of the Gonja Forest, the stream we netted bats over may have had a greater concentration of species and individuals simply because it was the only water source for some distance and attracted more bats. Further surveys will reveal whether our observed differences reflect a relationship between species diversity and elevation as seen in other areas of the tropics (e.g. Heaney *et al.*, 1989).

While our results suggest the Gonja Forest may be depauperate in terms of non-volant small mammals during a dry season, further surveys are needed to determine if this pattern is consistent during other seasons. The Gonja Forest is one of the last lowland forests in this region of Tanzania, and for this reason alone warrants protection against further habitat degradation.

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