Z. Säugetierkunde **62** (1997) 129–142

ZEITSCHRIFT FÜR SÄUGETIERKUNDE
INTERNATIONAL JOURNAL OF MAMMALIAN BIOLOGY

Bat community patterns on the Accra Plains of Ghana, West Africa

By J. Decher

Bell Museum of Natural History, University of Minnesota, St. Paul, Minnesota, USA

Receipt of Ms. 02.07.1996
Acceptance of Ms. 28.09.1996

Abstract

Bat communities were sampled with mist nets at eight localities on the Accra Plains and two localities in the Northern Region of Ghana. I encountered five species of fruit bats (Pteropodidae) and 26 species from seven families of Microchiroptera in a total of 252 bats netted.

Glauconycteris poensis, *Hipposideros cyclops*, and *H. abae* were caught only in sacred groves protected by traditional law, whereas *Taphozous perforatus* was netted only near rocky cliffs in the legally protected Shai Hills Resource Reserve. *Myonycteris torquata* and *Myotis bocagei* were caught only at the edge of experimental forest plots in the northeastern part of the Accra Plains near the lower Volta River. There was a statistically significant negative correlation between canopy cover and bat species abundance and diversity.

Relatively open savanna at Shai Hills located close to bodies of water apparently had the greatest diversity and abundance of bats. The diversity of bats on the Accra Plains slightly exceeded published data from other savanna regions in West Africa.

Introduction

It is difficult to determine the "bat community" at any one locality because of the highly mobile nature of bats as compared to other mammals. The association of bat communities with certain plant communities may depend to some extend on the scale chosen; other variables such as presence of water may be more important. A large-scale study of bat communities in phytogeographic zones in Venezuela concluded that there was "little congruence between the floral zones as defined by phytogeographers and the bat species frequenting those zones" and that distribution of "riverine habitats and their associated faunas would tend to diminish the chance of detecting unique bat associations within phytogeographic zones" (Willig and Mares 1989). However, at each locality on the Accra Plains of Ghana it was obvious that a limited-time sample might yield considerable differences in abundance and diversity of bats, and that certain species seemed to be missing completely at some localities. Some species might also be absent during certain times of the year if they are seasonal migrants (Thomas 1983). The present study tested the null-hypothesis that bat communities on the Accra Plains are random assemblages at any given time and locality, versus the alternative hypothesis that bat communities are determined by various biotic and abiotic factors of the environment. Furthermore local bat diversity (= alpha diversity; Whittaker 1972) in Ghana is compared to local diversity calculated for bat communities of neighboring regions in West Africa.

The composition and distribution of bat communities on the Accra Plains of Ghana is not well known. Booth (1959) listed 6 species of fruit bats (Megachiroptera) and 12 insec-

tivorous species (Microchiroptera) with notes on distribution, habitat, and behavior, but did not mention the community structure of bats at the individual localities he mentioned.

There is also very little information on bat communities from elsewhere in Ghana. Marshall and McWilliams (1982) studied three species of epomophorine fruit-bats at Mole National Park in northern Ghana. Most studies to date have dealt with bats at the single-species level (McWilliams 1987, 1988, 1989) or with bat-plant interactions (Ayensu 1974; Baker and Harris 1957, 1959; Harris and Baker 1958, 1959; Lack 1978). Extensive unpublished collections of bats from Ghana, which include some specimens from localities on the Accra Plains, are housed at the British Museum of Natural History (BMNH), London; the Carnegie Museum of Natural History, Pittsburgh (CM); the Field Museum of Natural History (FMNH), Chicago; and the United States National Museum (USNM), Washington, D. C. There are also considerably fewer studies of syntopic bat assemblages from Africa than there are for the New World (Findley 1993). Three species of fruit bats (Pteropodidae) were studied in the Guinea savanna woodland at Lamto, Ivory Coast (Thomas 1982). A major early study of bat ecology was conducted by Verschuren (1957) at Garamba National Park in northeastern Zaire. Subsequently ecological studies were conducted in the Sengwa Wildlife Research Area in Zimbabwe (Fenton et al. 1977), in south-central Kenya (O'Shea and Vaughan 1980), in Lusaka, Zambia (Findley and Black 1983), and in part of Kruger National Park, South Africa (Aldridge and Rautenbach 1987).

Material and methods

During an eight-month study (November 1991 to June 1992; Decher 1996) of small mammal communities on the Accra Plains, bat communities were sampled in eight different habitat types. Two additional localities in the Northern Region of Ghana (Yendi and Bimbila) were sampled also and are included herein for comparison. Depending on topography, vegetation cover, and available time at each locality, I used from two to four mist nets of different sizes for one to four evenings in each habitat, once each during the dry and the early rainy season. Because of this unequal number of nets and sampling hours between habitats and sites, I have attempted to standardize efforts by using relative numbers caught and the proportion of bats caught per net night and net unit ($NN^{-1}NU^{-1}$) for the calculations presented. A net unit was defined as one 7-x-32-foot net (224 ft^2 = 20.8 m^2) resulting in a total of 141.7 net-nights for the study period. This standardization was based on the assumption that every net unit has an equal chance of catching each species of bat, which may not invariably be true, but between locality comparisons are considered to be valid because nets were placed to maximize diversity in all habitats and at each site. In dry forest, nets were set along narrow paths or perpendicular to the forest edge extending into the surrounding savanna. In the savanna, nets were stretched in presumed flyways, between savanna trees or, where possible, along the edge of water holes or ponds.

Localities on the Accra Plains (Fig. 1) can be characterized as follows:

1. Adumanya Sacred Grove (ASG): This grove was a 1.5 ha primary forest remnant at the foot of the Akwapim Escarpment on the northwestern edge of the Accra Plains, surrounded by farmland, mainly cassava (manioc) and maize. Three or four nets were set inside the grove perpendicular to each other.

2. Pinkwae Forest (PF): This site was a sacred forest that has been protected by the Ga people of Katamanso since the Ga-Ashanti war in 1826 (Lieberman 1979). Because of the thicket-like nature of this dry forest, three nets were set along narrow forest paths at each of two different sites inside the forest.

3. Kpong Fire Protection Site (KFPS): This site is a secondary forest on the more humid northeastern part of the Accra Plains, the result of savanna succession in a 0.75 ha plot protected from fire since 1957 (Carson and Abbiw 1990; Swaine et al. 1992). Two to four nets were set inside this forest and also perpendicular to the forest edge reaching into the surrounding grassland. In order to check for roof-dwelling species one net also was set apart from this forest near a guest house.

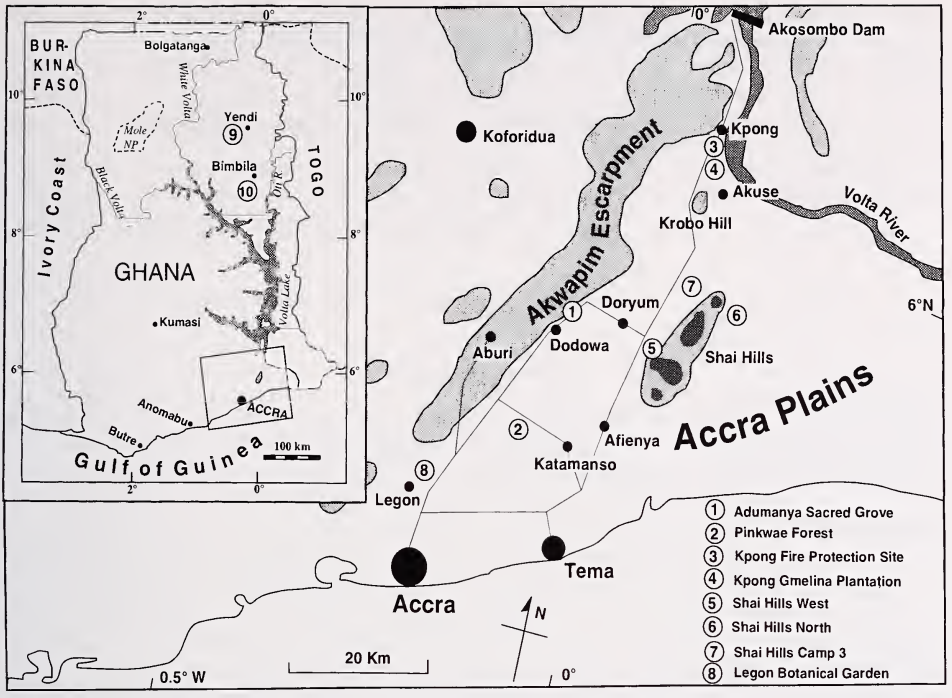

Fig. 1. Map showing 10 bat sampling localities on the Accra Plains and in Northern Ghana (insert).

4. Kpong *Gmelina* Plantation (KGP): Three nets were placed on paths inside this former plantation and perpendicular to the forest edge. This site was originally intended as a replicate for KFPS but will be treated separately because of its different vegetation history.

5. Shai Hills West (SHW): This site is located on the western slope of the Shai Hills Resource Reserve, a protected area enclosing an inselberg formation on the central Accra Plains. Three nets were set in various positions between savanna trees and in front of rocky cliffs.

6. Shai Hills North (SHN): This site is located in a "mosaic of *Vetiveria-Borassus* grassland and *Zanthoxylon-Capparis* thickets" (Schmitt and Adu-Nsiah 1993) in the north-east of Shai Hills Resource Reserve. Two to three nets were set along an artificial water hole bordered on three sides by thicket.

7. Shai Hills Camp 3 (SHC3): Two nets were set near this water hole located in the northwestern *Vetiveria-Brachiaria* grasslands of Shai Hills Resource Reserve for one day during the initial trial phase.

8. University of Ghana, Legon, Botanical Garden (LBG): Two nets were set at the edge of a pond at this locality for one night during the initial trial phase.

The two localities in the Guinea savanna of the Northern Region of Ghana, visited during the first month (November 1991; Fig. 1 insert), were as follows:

9. Yendi District Forestry Station (YEN): Two mist nets were tended for one evening on 1 November 1991 in the garden of the Forestry Station (9°25′ N, 0°04′ W).

10. Bimbila Reservoir (BIM): Two nets were set here at the edge of a water hole (3.5 km west of Bimbila; 8°52′ N, 0°02′ E) during evening hours of 4 November 1991.

I calculated Simpson's Index of diversity ($D = \Sigma p^2$), expressed as 1-D, defined as the probability of picking two individuals that are different species. I also calculated the Shannon-Wiener function of diversity ($H' = -\Sigma(p)(\log_2 p)$), the number of equally common species with the same diversity as H′ ($N1 = e^{H'}$), and the evenness index $J' = H'/H'_{Max}$ (Krebs 1989). These diversity indices and the number of species netted were then compared to map measurements of distance to open water, distance to nearest forested hillside or escarpment, and tree canopy closure at the site using the SAS procedure for Pearson's correlation coefficient, PROC CORR (SAS Institute 1982). The choice of these variables

Table 1. Summary of bats sampled on the Accra Plains (1991–92) and at Yendi and Bimbila in northern Ghana (Nov. 1991). See text for abbreviations.

	Locality										Tot.
	ASG	PF	KFPS	KGP	SHW	SHN	SHC3	LBG	YEN	BIM	
No. of Nights (NN) netted:	4	8	4	2	6	6	1	1	1	1	34
Net Units (NU)[a]:	5.3	3.8	4.3	4.8	4.1	4 .4	4.6	4.6	2.9	4.6	
Species											
MEGACHIROPTERA											
Eidolon helvum[b]	>1000										
Epomophorus gambianus				1			1	9	1	3	15
Epomops franqueti	1		2								3
Micropteropus pusillus	1	3	6	4	20	9	1		1		45
Myonycteris torquata			2								2
MICROCHIROPTERA											
Eptesicus capensis						1	3				4
Eptesicus guineensis					1	2		1	1		5
Eptesicus rendalli						3					3
Glauconycteris poensis	2										2
Glauconycteris variegata						2					2
Hipposideros abae		2									2
Hipposideros beatus						12					12
Hipposideros commersoni						5	1				6
Hipposideros cyclops	4										4
Hipposideros ruber				2		3			1		6
Lavia frons					1	6					7
Myotis bocagei				1							1
Nycteris hispida		3		1		5					9
Nycteris macrotis		10	3	1	2						16
Nycticeinops schlieffenei						1					1
Pipistrellus aegyptiacus						1					1
Pipistrellus nanulus						5					5
Rhinolophus landeri		1		3	3	2					9
Scotoecus albofuscus						4					4
Scotophilus dinganii					2			3			5
Scotophilus leucogaster									2		2
Scotophilus viridis nigritellus					2	10	1				13
Tadarida condylura[c]			52								2
Tadarida nigeriae										12	12
Tadarida pumila									2		2
Taphozous perforatus					2						2
Total individuals per Habitat:	8	19	13	13	33	71	7	13	8	15	252
Total No. of Species:	5	5	5	7	8	16	5	3	6	2	31

[a] one net unit = one 7×32 ft net = 224 ft^2 (20.8 m^2)

[b] *Eidolon helvum* numbers in the canopy of Adumanya Sacred Grove Canopy were estimated at >1 000 individuals and have been excluded from totals.

[c] *Tadarida condylura* was excluded from totals because this species was caught emerging from a building at Kpong Agricultural Research Station (most of the 52 individuals caught were released).

was based on the assumptions that many species of bats are attracted to water for drinking and for hunting insects, forested hillsides and rock outcrop provide better opportunities than the open grasslands for finding roosting places for most species, and dense vegetation and a closed canopy create conditions better suitable for complex "syntopic assemblages of bats" (Findley 1993). For a tentative functional analysis of community structure, I grouped the bat species sampled in each habitat into foraging-trophic groups as defined by Findley (1993) and calculated the percentage of each group occurring in each habitat. Finally, I compared the bat communities of the Accra Plains to those reported in the literature from other areas in Ghana and West and Central Africa. A discussion of new records of bat species from Ghana has been published elsewhere (Decher et al. 1997).

Results

Numbers caught

A total of 252 bats assignable to 31 species was caught (Tab. 1). Of these, 229 bats (28 species) were caught on the Accra Plains and 23 (7 species) were caught at Yendi and Bimbila in Northern Ghana. Five species were fruit bats (Megachiroptera: Pteropodidae) and the remaining 23 species belonged to seven families of Microchiroptera (Fig. 2). Of all bats captured on the Accra Plains, 31% were caught at the Shai Hills North savanna site adjacent to a water hole. This site also had the highest number of different species (16) of all sites. Bimbila in northern Ghana had the highest capture rate of 3.26 bats per net night and net unit ($NN^{-1}NU^{-1}$), followed closely by Shai Hills North with 3.23 bats $NN^{-1}NU^{-1}$. The lowest capture rate, 0.38 bats $NN^{-1}NU^{-1}$, occurred at Adumanya Sacred Grove. Capture rates inside forests were generally lower than those in open savanna habitats and those near water surfaces. Large numbers (>1000 individuals) of straw-colored fruit bats (*Eidolon helvum*) were present in the canopy of Adumanya Sacred Grove twice during the study period but the species was not included in the calculations because *E. helvum* could not be sampled with the mist nets set on the forest floor. Colonies of many thousand individuals of *E. helvum* also appeared in the capital city of Accra during part of the study period (1991/92) near the Sankara Circle and the Military Hospital area. Also not included in the diversity calculations were 52 roof-dwelling molossids (*Tadarida*

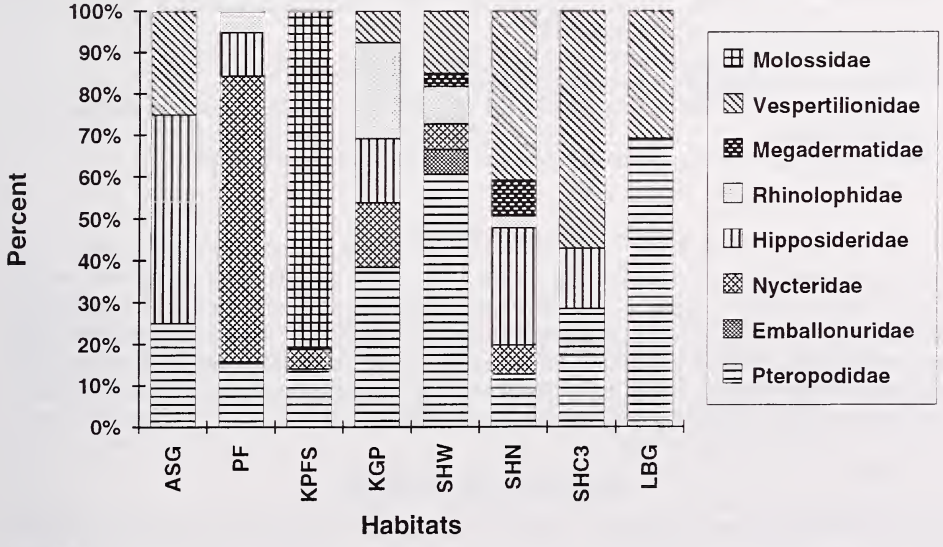

Fig. 2. Distribution of bat families among Accra Plains localities. (See text for abbreviations).

condylura) caught near the Kpong Fire Protection Site as they emerged from underneath the roof of a guest house. The two northern Ghanaian sites included three species that I did not find on the Accra Plains, two molossid bats (*Tadarida nigeriae* and *T. pumila*) and one vespertilionid (*Scotophilus leucogaster*).

Diversity Indices

Diversity was highest in the Shai Hills Resource Reserve where I found 8 species (1-D = 0.61; H′ = 2.04) at the southwestern end (SHW) of the reserve and 16 species (1-D = 0.90; H′ = 3.36) at the northeastern end (SHN, also called "Pillar 14"). Diversity was lowest at Bimbila in Northern Ghana with two species (1-D = 0.32; H′ = 0.72) and at the Legon Botanical Garden where only three species were caught (1-D = 0.46; H′ = 1.14). The number of equally common species (N1) was 10.3 for Shai Hills North and 2.2 for Legon Botanical Garden (Tab. 2). It should be noted here that the diversity indices are highly sensitive to one very abundant species. For example, if an arbitrary estimate of 1 000 individuals of the canopy-roosting *E. helvum* were included at Adumanya Sacred Grove, Simpson's diversity index (1-D) would be reduced from 0.66 to 0.016.

Table 2. Numbers per net night and net unit, diversity, and evenness indices for bats caught at ten localities in Ghana. (See text for abbreviations).

	Locality									
	ASG[a]	PF	KPFS	KGP	SHW	SHN	SHC3	LBG	YEN	BIM
Average No. of Bats $NN^{-1}NU^{-1}$	0.38	0.63	0.76	1.35	1.34	2.69	1.52	2.83	2.76	3.26
S = Total No. of species caught	5	5	5	7	8	16	5	3	6	2
Simpson's Index $D = \Sigma m^{2}$[b]	0.34	0.34	0.31	0.20	0.39	0.10	0.27	0.54	0.19	0.68
1-D[c]	0.66	0.66	0.69	0.80	0.61	0.90	0.73	0.46	0.81	0.32
Shannon-Wiener Index $H' = -\Sigma (p_i) (\log_2 p_i)$[d]	1.75	1.89	1.83	2.57	2.04	3.36	2.13	1.14	2.50	0.72
$N1 = e^{H'}$[e]	3.4	3.7	3.6	5.9	4.1	10.3	4.4	2.2	5.7	1.6
$H'_{Max} = \log_2 S$	2.32	2.32	2.32	2.81	3.00	4.00	2.32	1.58	2.58	1.00
Eveness $J' = H'/H'_{Max}$	0.75	0.82	0.79	0.91	0.68	0.84	0.92	0.72	0.97	0.72

[a] *Eidolon helvum* excluded from calculations.
[b] Probability of picking two organisms that are the same species.
[c] Probability of picking two organisms that are different species.
[d] Average degree of uncertainty in predicting to what species an individual chosen at random from a sample will belong.
[e] Number of equally common species that would produce the same diversity as H′.

Correlations

Pearson's correlation coefficients for distance to water and distance to nearest escarpment versus species number and diversity indices were not statistically significant ($p > 0.05$; Tab. 3). Only between canopy cover and number of individuals per net night and net unit was there a statistically significant negative correlation at the 0.05 level ($r = -0.77$; $p = 0.041$). Thus, 59% ($r^2 = 0.593$) of the variation in number of individuals $NN^{-1}NU^{-1}$ could be explained by variation in canopy cover.

Foraging-trophic categories

Figure 3 shows how the species at each locality fall into five foraging-trophic categories. The two sacred groves differed greatly from each other in species composition. The dense

Table 3. Pearson's correlation coefficients of distance to water, distance to nearest escarpment, and canopy cover, versus number of species and diversity indices of bats. For definitions see text.

Bat Species Diversity Measures	Habitat Variables		
	Distance to Water	Distance to Escarpment	Percent Canopy Cover
No. of Species S	–0.04	–0.49	–0.56
Simpson's Index 1-D	0.08	–0.43	–0.49
Shannon-Wiener H′	0.07	–0.48	–0.55
Eveness Index	–0.25	0.04	–0.25
Numbers of bats per net night per net unit	–0.57	0.11	–0.77*

* $p < 0.05$

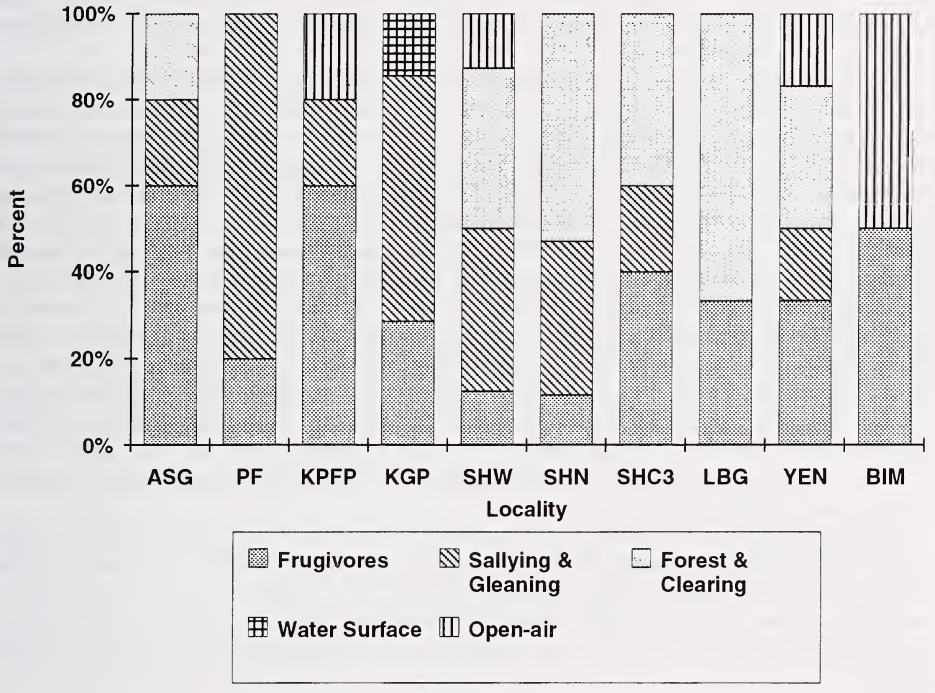

Fig. 3. Foraging-trophic groups of 31 species of bats at 10 localities in Ghana. (See text for abbreviations).

thicket of Pinkwae Forest was characterized by sallying-and-gleaning bats, mainly Nycteridae, and by the absence of the Vespertilionidae. The more open primary forest character of Adumanya Sacred Grove permitted the presence of more frugivores and forest-and-clearing species. Three of the five species present at Adumanya Sacred Grove were frugivores. *Hipposideros cyclops* represents the sallying-and-gleaning insectivores and *Glauconycteris poensis* the forest-and-clearing aerial insectivores. At Pinkwae Forest, frugivores were represented only by *Micropteropus pusillus*, whereas the sallying-and-gleaning insectivores dominated in the dense thicket vegetation and consisted of one hipposiderid, two nycterids, and one rhinolophid.

The two fire-protected sites on the northeastern Accra Plains were also quite different in origin and vegetational history. Inside the relatively recent (1957) Kpong Fire Protection Site the sallying-and-gleaning bats were only represented by *Nycteris macrotis*, and the frugivores only by the ubiqituous *Micropteropus pusillus*, whereas at the forest edge I also caught *Epomops franqueti* and *Myonycteris torquata*. Outside of the forest the open-air aerial insectivore category was represented by *Tadarida condylura*, which had many roosting opportunities in the buildings of the Agricultural Research Station. At the Kpong Gmelina Plantation the sallying-and-gleaning insectivores were represented by the same three families as at Pinkwae Forest. Here, all frugivores were caught just outside the forest. *Myotis bocagei*, a water-surface forager, was caught only at this location, perhaps because of proximity to the Volta River and Kpong Reservoir. Another reason may be that certain plant species that serve as roosting places for *M. bocagei* are more abundant in this northeastern part of the Accra Plains than in the remaining parts that receive less rainfall. Examples of such plants reported in the literature are the young rolled-up leaves of the banana plant (*Musa* sp.; Brosset 1976) and the funnel-shaped leaves of certain Araceae (for example, *Cytrospermum senegalense*; Sanborn 1949; Rosevear 1965).

The more open sites in the Shai Hills Reserve were characterized by high diversity that resulted mainly from the presence of several vespertilionids. Sallying-and-gleaning and forest-and-clearing species share the habitat at all localities with frugivores. The northwestern site at Camp III (SHC3), sampled for one night at the beginning of the field season, was similar to the northeastern Shai Hills site (SHN). The sallying-and-gleaning *Hipposideros commersoni* was caught only at these two sites. This bat has been characterized as a species that "will forage in moderate clutter, but will not be capable of entering thick vegetation" (Aldridge and Rautenbach 1987). This is one of the largest insectivorous bats of Africa, second in size only to *Saccolaimus peli* (Rosevear 1965), which is found in Ghanaian forests but has not yet been collected on the Accra Plains. Near rock faces on the slope I also caught *Taphozous perforatus*, an open-air-aerial insectivore that roosts in caves and rock-crevices. A large colony of this species roosted in a cave formed by huge boulders in the northern Shai Hills. Judging from the guano stain on the ceiling inside some of the park buildings, other open-air-aerial insectivores (e. g. *Tadarida* sp.), must have been present at the Shai Hills Resource Reserve, but they were never caught.

Only the frugivore *Epomophorus gambianus* and two forest-and-clearing vespertilionids, *Scotophilus dinganii* and *Eptesicus guineensis*, were caught at Legon Botanical Garden. Foraging-trophic communities at the northern Ghanaian garden site at Yendi resembled those at Shai Hills West, whereas the Bimbila site was shared by *E. gambianus* and one open-air-aerial insectivore, *Tadarida nigeriae*, a common savanna species.

Reproductive condition

Sixty-eight percent of male and female bats caught on the Accra Plains during the dry season (November to March) were non-breeding and 32% were in breeding condition. At the beginning of the rainy season (April to June) the values were 54.5% and 45.5%, respectively, but the difference was not statistically significant ($X^2 = 2.55$, $p = 0.11$, 1 d. f.). More conservative estimates using only lactation and embryos in female bats preserved as vouchers were 34.1% breeding and 65.9% non-breeding during the dry season versus 60% and 40%, respectively, during the rainy season ($X^2 = 3.67$, $p = 0.055$, 1 d. f.). During November 1991, 90% (18) of the female bats collected in Northern Ghana were non-breeding and 10% (2) were in breeding condition.

Discussion

My observations on the Accra Plains confirmed the presence of five of the 13 species of fruit bats known from Ghana (Tab. 4; Mickleburgh et al. 1992). Most common were the small *Micropteropus pusillus* in more forested habitats and *Epomophorus gambianus* in more open habitats. The seasonal appearance of large colonies of *Eidolon helvum* on the Accra Plains seems to be part of the migration pattern of this species which has been discussed by Thomas (1983) for the Ivory Coast and other areas of Africa. One species not reported by Booth (1959), a male *Myonycteris torquata*, was caught at the beginning of the rainy season near the Kpong Fire Protection Site on 2 June 1992. Other specimens of this species known from the Accra Plains include two males caught at Legon on 30 November and 1 December 1967 (USNM unpubl. records). In his study of the migration of fruit bats, Thomas (1983) observed that during the rainy season predominantly male *M. torquata* migrate from the forest into the savanna. *Epomops franqueti* was characterized as "a rare visitor occurring mainly in the sub-scarp zone" (Booth 1959), but there are several specimens from Legon and Achimota at the USNM that also were reported in a taxonomic work by Bergmans (1989). *Rousettus aegyptiacus* and *Nanonycteris veldkampi* were not encountered during this study. Booth (1959) described *R. aegyptiacus* as limited to "Krobo Hill, where it roosts in caves." This fruit bat is known from several localities in the forest zone surrounding the Accra Plains (USNM, unpubl. records) and also from Mole National Park (Marshall and McWilliams 1982). *Nanonycteris veldkampi* was observed and collected at Legon from July to September 1967 (USNM, unpubl. records). In his study of the migration of fruit bats in the Ivory Coast, Thomas (1983) observed that this species was "rare or absent" at two savanna sites during the dry season but common in the forest zone. Similarly, this species was the most abundant fruit bat (followed by *Micropteropus pusillus*) during the rainy season at Mole National Park in Northern Ghana, but was found to be absent during the dry season and "to fly higher and thus may be less likely to be netted" (Marshall and McWilliams 1982). Findley (1993) also warned that "In arid regions, samples may be heavily biased in favor of species that visit water sources."

Table 4. Species of fruit bats (Pteropodidae) occurring in Ghana.

Species	Accra Plains	Mole National Park[c]	Other localities
Eidolon helvum	✔ [a, b]	✔	
Epomophorus gambianus	✔ [a, b]	✔	
Epomops buettikoferi			✔
Epomops franqueti	✔ [a, b]		
Hypsignathus monstrosus			✔
Megaloglossus woermanni			✔
Micropteropus pusillus	✔ [a, b]	✔	
Myonycteris torquata	✔ [a]	✔	
Nanonycteris veldkampi	✔ [b]	✔	
Rousettus angolensis		✔	
Rousettus aegyptiacus	✔ [b]	✔	
Scotonycteris ophiodon			✔
Scotonycteris zenkeri			✔

[a] this study
[b] Booth (1959)
[c] Marshall and McWilliams (1982)

Three microchiropteran species were caught only in the sacred groves. *Hipposideros cyclops* was collected previously on the Accra Plains at the Shai Hills and at Krobo Hill (Booth 1959; USNM unpubl. records). *Glauconycteris poensis* was known only from various southern Ghanaian localities outside the Accra Plains, whereas *Hipposideros abae* was recorded previously only from Butre in the Western Region of Ghana (4°49′ N 1°55′ W; USNM No. 414 239, unpubl. record) and from the coastal town of Anomabu (= Anomabo) in the Central Region (Cansdale 1948; Hayman 1945).

The present study represents only a tentative analysis of the composition of bat communities in different habitat types because I was unable to sample bats with mist nets above a height of three meters. The overall number of 28 species from the Accra Plains is comparable to numbers from other studies of geographically restricted localities in Africa. Verschuren (1957) found 38 species of bats in two years at Garamba National Park in northeastern Zaire, a savanna and grassland area about twice the size of the Accra Plains. A study in the thornscrub and riverine vegetation of southern Kenya found strong seasonal differences of faunal composition for 25 species of bats and led the authors to suspect a seasonal migration pattern for many species (O'Shea and Vaughan 1980). Diversity indices in African primary forest is not much higher than in the savanna. For example, Brosset (1966) found 27 species in 11 months in northeastern Gabon, and Jones (1971) found 22 species throughout Rio Muni in central Africa. I compared local (alpha) diversities on the Accra Plains with diversities calculated from published survey results from Benin, Burkina Faso, Ivory Coast, and Togo (Tab. 5; De Vree 1971; Koopman et al. 1978; Robbins 1980). In this comparison Shai Hills North (SHN) on the Accra Plains had the highest diversity with 16 species, a Simpson's Index 1-D of 0.9, and a Shannon-Wiener Index of H′ of 3.36 compared to the highest non-Ghanaian diversity values of 15 species, 0.86, and 3.23, respectively, for Nobere, Burkina Faso (Koopman et al. 1978), and 15 species, 0.86, and 3.13, respectively, for Bimbereke, Benin (Robbins 1980). Although this comparison has to be viewed with caution, because numbers of net nights and net units are not available for the non-Ghanaian sites, it can be concluded that in comparison with other savanna localities in West Africa the Accra Plains host an abundant chiropteran fauna. The reproductive data suggest that the strong seasonal climate of northern Ghana might lead to a more seasonal breeding pattern than on the Accra Plains. In an earlier study at Mole National Park the fruit bats *Micropteropus pusillus*, *Epomophorus gambianus*, and *Nanonycteris veldkampi* gave birth "towards the beginning of the rainy season" (Marshall and McWilliam 1982) but at least one of the microchiropteran species at Mole (*Tadarida pumila*) may be a less seasonal breeder with polyoestrus females having up to five successive pregnancies per year (McWilliam 1987).

Figure 4 demonstrates how the cumulative number of species leveled off during six nights of netting at Shai Hills North between 13 January and 18 May 1992. Only three species were added to the total after the first night of netting and no new species were found after the third night. There is no method for determining the absolute number of bats at a site (Findley 1993). Referring to a note Grinnell (1922) made about bird communities, Findley (1993) contended that we would eventually find every species at every location given enough time and the mobile nature of bats.

My results from the Accra Plains seem to support the hypothesis that local diversity can be highly variable within a relatively small region depending on the structure of the habitat. We can reject the hypothesis that bat communities on the Accra Plains are randoms assemblages. More complex communities seem to be determined by more than one habitat factor. Numbers of species and diversity indices appeared to be negatively correlated with canopy cover. If degree of canopy closure is indicative of dense vegetation, this is contrary to findings at Mole National Park in Northern Ghana where "denser vegetation apparently favoured netting bats" (Marshall and McWilliams 1982). On the Accra Plains, most species seemed to coexist near water holes in patchy habitat of open grass-

Table 5. Local (alpha) diversities of bat communities in central West Africa

Locality	Country	Coordinates	Total No. of bats caught	No. of species	Simpson's Index 1-D	Shannon-Wiener H′	Source
Bimbereke	BENIN	10°14′ N 02°40′ E	113	15	0.86	3.13	Robbins (1980)
Guene	BENIN	11°44′ N 03°13′ E	106	10	0.80	2.63	Robbins (1980)
Segbana	BENIN	10°56′ N 03°42′ E	40	10	0.78	2.60	Robbins (1980)
Djipologo	BURKINA FASO	10°56′ N 3°07′ W	47	8	0.76	2.41	Koopman et al. (1978)
Konankira	BURKINA FASO	12°54′ N 3°53′ W	52	8	0.73	2.27	Koopman et al. (1978)
Nobere	BURKINA FASO	11°26′ N 1°10′ W	73	15	0.86	3.23	Koopman et al. (1978)
Adiopodoumé	COTE D'IVOIRE	05°19′ N 04°01′ W	38	12	0.84	3.04	de Vree (1971)
Kpong	GHANA	6°08′ N 0°04′ E	13	7	0.81	2.57	this study
Shai Hills North	GHANA	5°57′ N 0°04′ E	71	16	0.90	3.36	this study
Yendi	GHANA	9°25′ N 0°04′ W	8	6	0.81	2.50	this study
Ezime	TOGO	07°29′ N 00°56′ E	59	11	0.71	2.38	Robbins (1980)
Pewa	TOGO	09°17′ N 01°14′ E	94	8	0.66	1.58	Robbins (1980)

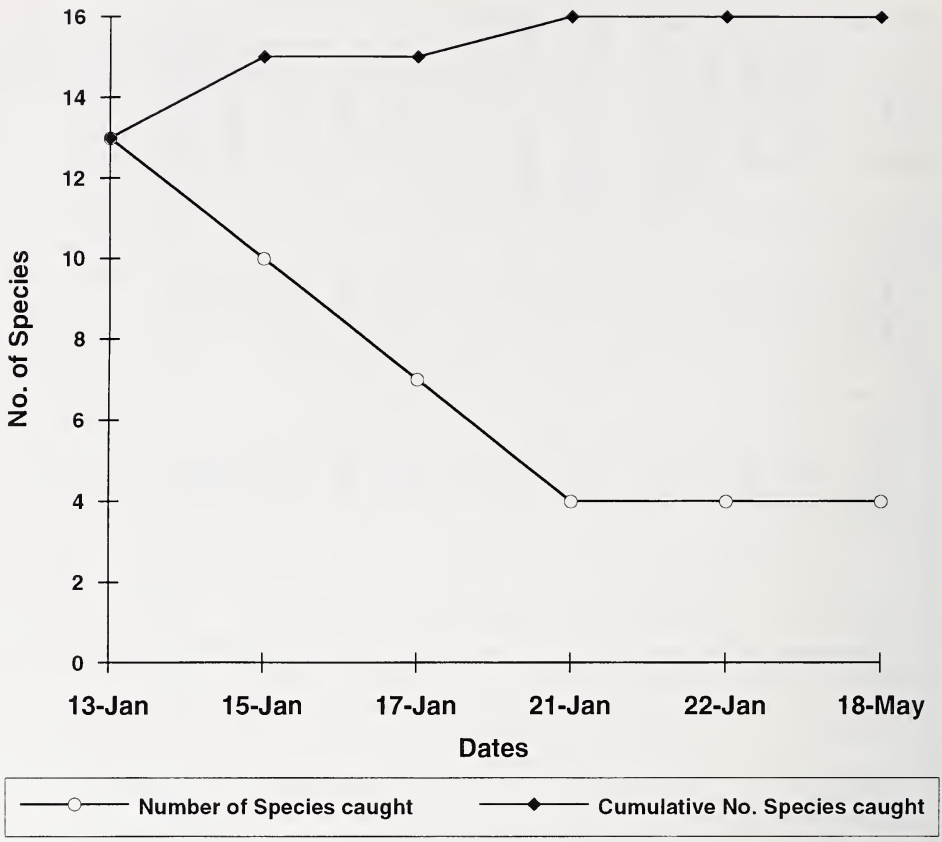

Fig. 4. Cumulative increase of number of bat species at Shai Hills North (SHN; "pillar 14") during six nights of netting.

land, thicket, and dry forest edge. Closed forest, which on the Accra Plains is best preserved in the sacred groves, was less species-rich but seemed to be the preferred habitat for a few species that were not captured elsewhere.

Acknowledgements

Thanks to L. K. Bahian of Mole National Park and D. A. Schlitter, Carnegie Museum of Natural History, for assistance in the field and invaluable discussions and to my advisor, E. C. Birney, at the Bell Museum of Natural History for many helpful comments on the manuscript. I am grateful to G. Punguse, Ghana Department of Game and Wildlife, for permission to work in the Shai Hills Game Production Reserve; to S. Effah of the Yendi District Forestry Station; E. O. Darkwa and J. W. Oteng for permission to work at the Kpong Agricultural Research Station and housing; Chief Nii Laryea Akuete VIII and J. O. Laryea of Katamanso for access to Pinkwae Forest; and chief Nana Opata III of Doryum and Mr. Nathan Narh Nanoo for access to Adumanya Sacred Grove. Special thanks to E. C. Briandt of Mamobi, Accra; to A. and K. Hofmann-Landis of Katamanso; and my wife, Laurel Decher.

Financial support was provided by the Dayton/Wilkie and Sigerfoos Funds of the University of Minnesota, and the M. Graham Netting Research Fund of the Carnegie Museum of Natural History, Pittsburgh.

Zusammenfassung

Fledermausgesellschaften und ihre Verbreitung auf der Accra-Ebene Ghanas, Westafrika

Die Fledermaus-Fauna Ghanas wurde mit Hilfe von Japannetzen an acht verschieden Lokalitäten der Accra-Ebene sowie zwei Lokalitäten in Nord-Ghana untersucht. Insgesamt wurden 252 Fledermäuse gefangen, fünf Arten von Flughunden (Pteropodidae) und 26 Arten aus sieben Familien der Microchiropteren. *Glauconycteris poensis*, *Hipposideros cyclops* und *Hipposideros abae* wurden nur in von traditionellen Tabus geschützten „heiligen Hainen" (sacred groves) gefangen. *Taphozous perforatus* fand sich nur in der Nähe von Felskliffen im staatlich geschützten Shai Hills Wildreservat, während *Myonycteris torquata* und *Myotis bocagei* nur am Rande einer *Gmelina*-Monokultur im Nordostteil der Accra Ebene, am Unterlauf des Volta Flusses, vorkamen. Obwohl Korrelationen zwischen Biotopeigenschaften und Artenzahl und Diversität nicht statistisch signifikant waren, schien verhältnismäßig offene Savanne und Wassernähe die Diversität und Abundanz der Fledermäuse zu begünstigen. Artenzahl und Diversitätsindices waren geringfügig höher als in anderen Savannenregionen Westafrikas. Es wird dringend empfohlen den anhaltenden Schutz der „heiligen Haine" auf lokaler Ebene, möglichst mit Hilfe eines landesweiten Schutzprogrammes zu unterstützen.

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Author's address: Jan Decher, Ph. D., Bell Museum of Natural History, University of Minnesota, 100 Ecology, St. Paul, Minnesota 55108, USA