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Abstract: In this book about the mammals of Nigeria, the cheetah is mentioned several times. In the species description, the cheetah is considered scarce or maybe extinct in Nigeria. Its distribution has always been sparse and uncommon in West Africa compared to East Africa, but its numbers have strongly decreased during these last years. Although, it is considered almost extinct in Nigeria in the 50s, it survives in the Fauna Reserve of Yankari and in localities near Cameroon border. They are present but scarce in several National Park in the northern of Cameroon near the eastern border of Nigeria, in the park of W Niger and Benin. In Nigeria, it is only present in the Sudanian and Sahelian savanna, but in very limited number. A Nigeria distribution map of the species is provided with only three observations.
The author updates his cheetah presence data in the West Africa countries. 14 years after his first list, the cheetah status has worsened. The species is always present in Senegal, Togo, Benin, Nigeria, Cameroon, Mauritania, Mali, Upper Volta and Niger. It is absent in Gambia, Sierra Leone and Liberia and his presence is suspected by local authorities in Guinea Bissau, Guinea, Ivory Coast and Ghana.

Dans ce livre sur les mammifères du Nigeria, le guépard est mentionné à plusieurs reprises. Dans la description de l'espèce, le guépard est déclaré rare voire éteint au Nigeria. Sa distribution a toujours été éparse et rare en Afrique de l'Ouest par rapport à l'Afrique de l'Est, mais ses effectifs ont fortement diminué au cours de ses dernières années. Bien qu'il soit considéré comme quasiment éteint au Nigeria dans les années 1950, ils survivent dans la Réserve de Faune de Yankari et dans des localités proche de la frontière du Cameroun. Ils sont présents mais rares dans plusieurs parcs nationaux au nord du Cameroun près de la frontière est du Nigeria et dans le parc du W du Niger et du Bénin. Au Nigeria, il est uniquement présent dans la savane soudanienne et sahélienne, mais en nombre très limité. Une carte de distribution de l'espèce au Nigeria est fournie avec seulement 3 observations.
Il réactualise ses données de présence du guépard dans les pays d'Afrique de l'Ouest. 14 ans après sa première liste, la situation du guépard s'est aggravée. Il est toujours présent au Sénégal, au Togo, au Bénin, au Nigeria, au Cameroun, en Mauritanie, au Mali, en Haute Volta et au Niger. Il est toujours absent de la Gambie, de la Sierra Léone et du Libéria et sa présence est suspectée par les autorités locales en Guinée Bissau, en Guinée, en Côte d'Ivoire et au Ghana.

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THE MAMMALS OF NIGERIA

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Line Drawings by
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Chapter 17 · Mammals of the Sudan and Sahel savannas

The Sudan and Sahel savanna habitat

Most of the northern third of Nigeria is covered by extensive dry and semi-arid woodland savannas. The boundary with the Guinea savanna to the south (see Chapter 16) is not well defined, but is marked by a progressive change in the composition and structure of the vegetation, and lower rainfall. Many of the features of these savannas are similar to those of the savannas further south, but the short wet season and lower rainfall result in greater seasonality, a longer dry season, lower plant productivity, smaller and more scattered trees and shrubs, and a less luxuriant environment (Plate 17.1).

Adjacent to the Guinea savanna is the Sudan savanna zone which covers most of the northern third of Nigeria. Like the other vegetation zones it forms a band from east to west from about 11 °N to 13 °N; however, the 'rain shadow' effect of the Jos Plateau causes the Guinea–Sudan savanna boundary to dip southwards to about 9.50 °N to the east of the plateau (Fig. 1.2). The Sudan savanna zone consists mainly of sparse open woodlands and grasslands, with swamps or fadamas in some river valleys. The country is mostly flat or gently undulating, although inselbergs form prominent landmarks in some localities. As in the Guinea savanna, trees are larger and more numerous close to rivers and may form quite dense shady forests. The commonest trees are *Combretum* spp., *Acacia* spp., *Balanites*, *Ziziphus*, *Anogeissus*, *Bombax*, *Adansonia*, and *Guiera*, and the dominant grasses belong to the genera *Hyparrhenia*, *Andropogon*, and *Cymbopogon*. Many typical Guinea savanna trees (p. 256) intermingle with Sudan savanna trees along the ecotone of the two vegetation zones (as in Yankari GR), and small patches of Guinea savanna trees (e.g., *Isoberlinia doka*) may occur in suitable habitats well inside the Sudan savanna zone. The open woodlands are quite luxuriant in the wet season, but for the rest of the year, they appear rather arid and unproductive. The generally small stature and low density of the trees, and greater abundance of shrubs, is in marked contrast to the Guinea savanna. The vegetation of some parts of the Sudan savanna has been modified by intensive agriculture, grazing by large herds of Fulani cattle and goats, and irrigation (especially near Lake Chad).

The grasses follow a seasonal cycle similar to those in the Guinea savanna (p. 251), except that their growing season is shorter and their productivity is lower. As a result, the fadamas and other habitats which have a lush growth of grasses and sedges throughout the year are of great importance to many mammals of the Sudan savanna. Fires are not as common as in the Guinea savanna and are probably less damaging because the grasses throughout most of the zone are comparatively sparse.

North of the Sudan savanna zone is the Sahel savanna zone; most of this zone is in the Republic of Niger, but a small part extends southwards into Nigeria in the extreme north-east, close to Lake Chad. The Sahel savanna is the most arid vegetation zone in Nigeria, and its flora and fauna are similar to those of the fringes of the Sahara desert. The density of trees and shrubs is considerably lower than in the Sudan savanna zone, and the grass cover is extremely sparse except for short periods immediately after rain. Much of this zone consists solely of almost bare soil or sand, with a few scattered *Commiphora* and *Acacia* trees whose slender trunks and fine interlacing branches are very characteristic of this landscape. Other areas support only shrubs, such as *Callotropis*, and the salt-bushes *Salvadora* and *Leptadaenia*, which rarely grow more than 1–2 m high. The general impression of the Sahel savanna zone is of low sparse vegetation with few trees, little grass or herb cover except after the rain, low productivity, and virtually no deep shade. Close to the margins of Lake Chad, the density of shrubs and trees may be higher than elsewhere, and some trees may grow to sizes more typical of the Sudan savanna. In the shallow margins of the lake itself, there are many square kilometres of dense papyrus, other sedges, and grasses. This lush, mesic environment is in very marked contrast to most of the Sahel savanna.

Climate and seasons

The climate of the Sudan and Sahel savannas is generally warmer and drier than that of the Guinea savanna (Table 1.1, Fig. 1.2). The annual rainfall in the Sudan Zone is 500–600 mm (20–30 in) and, as in the Guinea savanna, there is considerable variation at different localities; in general, the rainfall is highest close to the Guinea savanna and lowest on the boundary with the Sahel savanna. The wet season lasts from May to September, with most of the rain falling in July and August, but only 3–4 of these months provide 'useful' rain for plant growth. When compared with the Guinea savanna, the wet season is shorter, the dry season is longer, and there is less rainfall. In the Sahel savanna, the pattern of rainfall is similar to that of the Sudan savanna; however, the annual rainfall is only 250–500 mm (10–20 in) and the wet season is shorter. The annual rainfall in the Sudan and Sahel savannas shows more variation from year to year than that in the rainforest and Guinea savanna zones. For example, there may be dry years, such as 1970–72, when widespread drought affected all the Sudan and Sahel savannas of West Africa. Alternatively, there may be wet years when the annual rainfall is much higher than average; in such years, extremely heavy rainfalls may result in flooding—an unusual occurrence in these generally dry environments. These variations profoundly affect the plants and animals.

The mean monthly maximum temperature ranges from about 35 °C in March, April and May, to 30 °C during the rains in August, and is generally slightly higher than in the Guinea savanna. Mean monthly minimum temperatures are similar to those of the Guinea savanna. Throughout the year, the daily fluctuation in temperature is very great; for example, the fluctuation between the mean monthly maximum and mean monthly minimum temperatures is 17 °C in December and January and 12 °C in August. If extremely high and extremely low temperatures happen to occur on the same day, the daily fluctuation may be as much as 25–30 °C. In the Sudan and Sahel savannas, the lowest temperatures occur in the middle of the dry season (December and January) when the cool harmattan winds blow south from the Sahara.

The pattern of rainfall and temperature in the Sudan and Sahel savannas result in extreme seasonality in the growth and life-cycles of the vegetation. For most of the year, plant growth is suppressed because of the lack of water. During the brief wet season, grasses and herbs germinate, flower, and set seed, but they quickly wither and die when the rainfall decreases at the end of the wet season. The amount of rain, pattern of rainfall, and length of the wet season each year determine plant productivity, and therefore the volume and quality of food available to all primary consumers. The mammals and other animals of the Sudan and Sahel savannas are greatly affected by the extreme seasonal variations in climate and in the availability of food and water; this is reflected in many aspects of their ecology, physiology, and behaviour.

Size and extent of the Sudan and Sahel savannas

These savannas occupy about 38% of the total area of Nigeria (Table 1.1). The Sudan savanna occupies 309 862 km^2 (34%) and the Sahel savanna occupies 36 454 km^2 (4%). Thus, these savanna areas together are less extensive than the Guinea savanna (52%), but much more extensive than the rainforest (10%). Like the other zones described on pp. 245 and 258, the extent and position of both Sudan and Sahel savanna zones have changed during the past. Both zones stretch across sub-Saharan Africa from Senegal and Mauritania to the Sudan, so that the fauna and flora of these zones have a very extensive distribution from west to east.

The mammalian fauna

Tables 1.4 and 18.1 list the 97 species which have been recorded in the Sudan savanna zone. These are comprised of 28 widespread species, which occur throughout most of Nigeria (Table 18.2), 46 species which occur only in the Guinea and Sudan savanna, and 23 'northern' species (Table 17.1) which occur only in the Sudan and Sahel savannas. No typical rainforest species are present in the relic forests in the Sudan savanna. The proportions of each order to the total (bats 25%, carnivores 24%, rodents 17%, and artiodactyls 16%) are similar to those of the Guinea savanna zone; this is due to the loss of 53 species which occur in the Guinea savanna and the gain of 23 'northern' species. This lower number of species in the Sudan savanna follows the general trend of decreasing numbers of species from south to north.

Within the Sudan savanna zone, the mammals of Yankari GR are the best known. Yankari GR covers an area of 2250 km^2 and is situated about 70 km south-east of Bauchi. Most of the reserve is flat or gently undulating and is covered by dry woodland savanna (Plate 17.1). Rocky hills rise up to 100 m above the surrounding savanna in the north, south-east and west. The most prominant feature of the reserve is the Gaji river which flows southwards and divides the reserve almost equally into western and eastern halves. The Gaji river flows throughout the year, and receives some of its water from numerous springs in the Gaji valley. The river is bordered by extensive fadamas (grassy swamps), riverine forests, and rocky escarpments. This varied environment provides many suitable habitats for a wide variety of mammals. Sixty-eight species have been recorded (Table 17.2), but there are probably a few other small species which, so far, have escaped detection. The larger, more obvious, species are the same as those in Kainji Lake NP, simply because these species are found in most woodland savanna habitats. Due to its proximity to the Guinea savanna zone, Yankari GR contains few of the 'northern' species (cf. Tables 17.1 and 17.2) and therefore it is, in some ways, not typical of the Sudan savanna zone. However, the large mammals are the same as those in other reserved areas in the Sudan savanna such as Lame GR, Kogin Kano GR (Hall 1976) and Kwiambana GR (Ajayi *et al.* 1981). Most of this chapter, therefore, will be on the mammals of Yankari GR and their ecological adaptations to the environment of the Sudan savanna.

Table 17.1. 'Northern species' which occur only in Sudan and/or Sahel savanna zones. + = Present; − = absent; R = present, but with restricted distribution

Common name	Scientific name	Sudan	Sahel
Butler's Shrew	*Crocidura butleri*	R	−
Savanna Shrew	*Crocidura fulvastra*	+	+
Mauritian Shrew	*Crocidura lusitania*	+	+
Savanna Path Shrew	*Crocidura viaria*	R	−
Yankari Shrew	*Crocidura yankariensis*	R	−
Etruscan Shrew	*Suncus etruscus*	R	−
Naked-bellied Tomb-bat	*Taphozous nudiventris*	R	R
Egyptian Tomb-bat	*Taphozous perforatus*	R	−
Larger Mouse-tailed Bat	*Rhinopoma microphyllum*	R	−
Rüppell's Pipistrelle	*Pipistrellus rueppelli*	−	+
Midas Bat	*Tadarida midas*	R	+ (?)
Cape Hare	*Lepus capensis*	+	+
Brauer's Dwarf-gerbil	*Desmodillicus braueri*	+	+
Agag Gerbil	*Gerbillus agag*	+	+
Lake Chad Gerbil	*Taterillus lacustris*	−	+
Dainty Fat-mouse	*Steatomys parvus*	+	−
Hausa Mouse	*Mus haussa*	+	+
Lesser Egyptian Jerboa	*Jaculus jaculus*	−	+
Common Jackal	*Canis aureus*	+	+
Zorilla	*Ictonyx striatus*	+	+
Libyan Striped-weasel	*Poecilictis libyca*	+	+
Feline Genet	*Genetta felina*	+	+
Banded Mongoose	*Mungos mungo*	+	+
Striped Hyaena	*Hyaena hyaena*	+	+
Korrigum	*Damaliscus lunatus*	+	+
Red-fronted Gazelle	*Gazella rufifrons*	+	+
Dama Gazelle	*Gazella dama*	−	+
Dorcas Gazelle	*Gazella dorcas*	−	+

Total Northern species: 28
Total Sudan species: 23
Total Sahel species: 21
Total endemic to Sahel: 5

Table 17.2. Mammals of Yankari GR*

Common name	Scientific name
Insectivora (10)	
Bottego's Shrew	*Crocidura bottegi*
Butler's Shrew	*Crocidura butleri*
Doucet's Musk Shrew	*Crocidura douceti*
African Giant Shrew	*Crocidura flavescens*
Savanna Shrew	*Crocidura fulvastra*
Flat-headed Shrew	*Crocidura planiceps*
Black Giant Shrew	*Crocidura odorata*
Savanna Path Shrew	*Crocidura viaria*
Yankari Shrew	*Crocidura yankariensis*
Etruscan Shrew	*Suncus etruscus*

Table 17.2. (*cont.*)

Common name	Scientific name
Chiroptera (10)	
Gambian Epaulet-bat	*Epomophorus gambianus*
Lesser Epaulet-bat	*Micropteropus pusillus*
Mauritian Tomb-bat	*Taphozous mauritianus*
Egyptian Slit-faced Bat	*Nycteris thebaica*
Common African Leaf-nosed Bat	*Hipposideros caffer*
Noack's African Leaf-nosed Bat	*Hipposideros ruber*
Gambian Light-winged Bat	*Scotoecus albofuscus*
White-bellied House-bat	*Scotophilus leucogaster*
Angola Free-tailed Bat	*Tadarida condylura*
Little Free-tailed Bat	*Tadarida pumila*
Primates (4)	
Senegal Galago	*Galago senegalensis*
Anubis Baboon	*Papio anubis*
Tantalus Monkey	*Cercopithecus tantalus*
Patas Monkey	*Erythrocebus patas*
Lagomorpha (1)	
Crawshay's Hare	*Lepus crawshayi*
Rodentia (11)	
Gambian Sun-squirrel	*Heliosciurus gambianus*
Geoffroy's Ground-squirrel	*Xerus erythropus*
Savanna Gerbil	*Tatera valida*
Slender Gerbil	*Taterillus gracilis*
Pygmy Mouse	*Mus minutoides*
Common Spiny-mouse	*Acomys cahirinus*
Striped Grass-mouse	*Lemniscomys barbarus*
Dalton's Mouse	*Myomys daltoni*
Multimammate Mouse	*Mastomys natalensis* (group)
Crested Porcupine	*Hystrix cristata*
Greater Cane-rat	*Thryonomys swinderianus*
Carnivora (14)	
Common Jackal	*Canis aureus*
Side-striped Jackal	*Canis adustus*
Pale Fox	*Vulpes pallida*
Hunting Dog	*Lycaon pictus*
Ratel	*Mellivora capensis*
African Civet	*Viverra civetta*
Pardine Genet	*Genetta pardina*
White-tailed Mongoose	*Ichneumia albicauda*
Spotted Hyaena	*Crocuta crocuta*
Striped Hyaena	*Hyaena hyaena*
Serval	*Felis serval*
Lion	*Panthera leo*
Leopard	*Panthera pardus*
Cheetah	*Acinonyx jubatus*
Tubulidentata (1)	
Aardvark	*Orycteropus afer*
Proboscidea (1)	
African Elephant	*Loxodonta africana*
Hyracoidea (1)	
Western Rock-hyrax	*Procavia ruficeps*
Artiodactyla (13)	
Warthog	*Phacochoerus aethiopicus*
Hippopotamus	*Hippopotamus amphibius*
African Buffalo	*Syncerus caffer*
Bushbuck	*Tragelaphus scriptus*
Red-flanked Duiker	*Cephalophus rufilatus*
Crowned Duiker	*Sylvicapra grimmia*
Waterbuck	*Kobus ellipsiprymnus*
Bohor Reedbuck	*Redunca redunca*
Roan Antelope	*Hippotragus equinus*
Hartebeest	*Alcelaphus buselaphus*
Korrigum	*Damaliscus lunatus*
Oribi	*Ourebia ourebi*
Red-fronted Gazelle	*Gazella rufifrons*

*includes records from Futuk and Wikki.

Population numbers

Although Table 17.2 lists the species of mammals in Yankari GR, no indication is given of the abundance of each species. Such information is not as well known as for Kainji Lake NP; in fact, there are no estimates of total numbers of each species in the game reserve, nor how these have changed since the area was declared a game reserve in 1957. However, casual observations indicate that the population numbers of the larger species have increased substantially, but no information is available for the smaller species. Some idea of the abundance of the large species in the early wet season is given in Table 17.3. Buffalo, Hartebeest, Warthog, Roan Antelope, and Waterbuck appear to be the commonest species, or at least the most visible and easily counted species, early in the wet season; Baboons probably would also be included in this list if they had been counted as well. Table 17.3 also shows that more individuals occur in the fadamas and riverine forests than elsewhere in the reserve.

Within the Gaji river valley, numbers of individuals vary in different regions of the valley. The species composition and number of individuals at any particular locality is related to the width across the valley, the size of the fadamas, the extent of the riverine forest bordering the valley, and the type of vegetation. Table 17.4 shows the results of a 5-day survey at the end of the dry season. The importance of the fadamas is very evident, but the swamp forests and *Combretum* woodlands where they border the valley, are also favourite habitats at this time of year. Table 17.4 also shows the preferred

Table 17.3. Mammals seen during 9 days on three 24-km drives (beginning at 08.00 h) in Yankari GR in May–June 1970. Figures show the numbers of each species seen on the outward journey only. This table gives the total number of sightings during the 9 days, not the number of individuals actually present in each habitat (from Henshaw 1975)

Species	Riverine forests and fadamas	*Afzelia* woodlands 0–24 km west of River Gaji	*Combretum* shrub savanna and *Afzelia* woodlands 0–24 km east of River Gaji	Total of each species
African Elephant	8	0	0	8
Warthog	24	35	29	88
African Buffalo	212	50	9	271
Bushbuck	7	0	0	7
Red-flanked Duiker	6	0	0	6
Crowned Duiker	0	2	2	4
Waterbuck	32	1	0	33
Roan Antelope	8	4	43	55
Hartebeest	84	19	70	173
Oribi	1	2	0	3
Totals	382	113	153	648

Note: Baboon, Tantalus Monkey and Patas Monkey not included in this survey.

habitats of each species; Warthogs, for example, prefer the fadamas whereas Hartebeest prefer the swamp forests. A similar study at, say, the beginning of the wet season, when many mammals move away from the rivers, would show far fewer individuals and a different species composition in each habitat in the river valley.

These figures were recorded in a well-established game reserve and are considerably higher than would be expected in non-protected areas at the present time. They indicate that those regions of the Sudan savanna which provide optimum habitats can support large numbers of many species of mammals. Other regions,

Table 17.4. Distribution of mammals in seven habitats along the Gaji and Yashi river valleys in Yankari GR during 5 days in March 1975 (from Shotter *et al.* 1975)

Species	Habitats							Total of each species
	Swamp forest	*Pteleopsis* woodland	Fadama	Riverine forest	Riverine woodland	*Combretum* woodland	*Acacia* woodland	
Anubis Baboon	10	1	9	12	6	6	0	44
Tantalus Monkey	2	1	27	18	4	0	1	53
Patas Monkey	0	0	1	0	0	0	0	1
African Elephant	0	0	15	0	4	10	0	29
Warthog	16	1	47	4	11	11	5	95
African Buffalo	7	0	43	0	1	0	25	76
Bushbuck	11	2	14	1	0	4	1	33
Red-flanked Duiker	3	1	0	2	3	2	0	11
Waterbuck	19	0	161	0	3	20	0	203
Roan Antelope	0	0	5	0	0	0	0	5
Hartebeest	27	0	15	0	1	0	0	43
Oribi	0	0	1	0	0	2	0	3
Totals	95	6	338	39	33	56	32	599

far from permanent water, support fewer individuals, and therefore the distribution of each species is localized and patchy. Habitats close to the Guinea savanna zone are likely to have more individuals and more species than those close to the Sahel savanna zone. The number of individuals, like the number of species (p. 289), tends to decline with increasing latitude.

The biomass of mammals in the woodland and shrub savannas of the Sudan savanna zone is usually much lower than that of the Guinea savanna. In contrast, the fadamas and other regions close to rivers may have a higher biomass than in the woodlands, especially when individuals congregate in these habitats in the dry season. The overall biomass of large mammals in Yankari GR in 1975 was 349 kg/km (Henshaw 1975, in Afolayan 1980); this is an average figure which does not take into account the low biomass in some woodland savannas and the much higher biomass in the fadamas. The biomass in the Gaji valley, using the average individual number of animals seen each day (Table 17.3), average individual weights (Table 16.5), and assuming the area surveyed was 12 km^2, is about 1500kg/km^2; this is about twice the biomass in the Oli river valley in Kainji Lake NP.

No precise information is available on biomass for the Sahel savanna. The general trend of decreasing numbers of species and individuals suggest that biomass is much lower than in the Sudan savanna zone.

Ecological separation of mammals in Yankari Game Reserve

Each species selects and utilizes those parts of the habitat which suit its own requirements at different times of the day and at different times of the year. The mammals of Yankari GR may be classified according to their principal habitat(s) (Table 17.5). The woodland savanna, which is the most extensive habitat in the reserve, supports the majority of species. However, many of the larger species move in to the fadamas for food and water, and at certain times of the year are more likely to occur in the fadamas than in the woodlands (p. 281). In contrast, the smaller woodland species are sedentary and remain in the woodlands at all times of the year. Few species live permanently in the riverine forests, although many of the woodland and fadama species may seek shade there during the hottest part of the day. Rocky and aquatic habitats support relatively few species, and, similarly, arboreal species are not as numerous as might be expected considering the variety, number and density of trees in the reserve. The pattern of ecological separation by habitat is fairly similar to that of Kainji Lake NP (Table 16.2); the total number of species is similar (66 and 71), but there appear to be fewer arboreal and aquatic species in Yankari GR. Kob, Four-toed Hedgehogs, Mona Monkeys and Western Black-and-white Colobus are present in Kainji Lake NP but not in Yankari, whereas several species of shrews, Common Spiny Mice, Striped Hyaenas, Pale Foxes, Korrigum, Red-fronted Gazelles, and perhaps Cheetahs are present in Yankari but not in Kainji Lake NP. The similarities between Yankari GR and Kainji Lake NP are not surprising as the two areas are at similar latitudes; however, the presence of some typical Sudan savanna mammals in Yankari GR indicates that the total fauna is tending towards a Sudan savanna fauna rather than a typical Guinea savanna fauna.

In Yankari GR, the distribution of mammals has been analysed in relation to the four main types of woodland savanna. These are:

(1) *Afzelia* woodlands (mainly *Afzelia*, *Burkea*, *Detarium*, and *Combretum* trees);

(2) Combretaceous woodlands (mainly *Burkea–Combretum* and *Anogeissus–Combretum* associations);

(3) Combretaceous shrub savannas (mainly *Guiera*, *Balanites*, *Anogeissus* trees and shrubs), and

(4) *Detarium* woodlands (mainly *Detarium*, *Combretum*, and *Crossopteryx*).

Some species of trees are fairly widespread, but their abundance and relative proportions change in each of these main vegetation types. Grass species and grass cover also vary in each vegetation type. As in Kainji Lake NP (p. 260), the mammalian species, numbers, and biomass varies according to the precise characteristics of the savanna woodlands, their distance from permanent water, and the season of the year. Areas furthest from the Gaji river are the least utilized, regardless of vegetation type. *Afzelia*, *Burkea*, and *Combretum* woodlands up to 12 km from the Gaji river are well utilized because they have a good growth of perennial grasses due to the deep relatively rich soils. In contrast, the *Anogeissus–Combretum* woodlands and Combretaceous shrub savannas, which occur on

Table 17.5. Habitat selection of mammals in Yankari GR. Arrows indicate range of habitats when more than one habitat is used.

Average adult weight	Woodland savanna	Fadama	Riverine forest	Inselberg and rocky habitats	Aerial	Aquatic	Arboreal
Less than 10 g	Pygmy Mouse →		Butler's Shrew Doucet's Musk Shrew Flat-headed Shrew Etruscan Shrew Bottego's Shrew	Pygmy Mouse	Egyptian Slit-faced Bat Common African Leaf-nosed Bat Noack's African Leaf-nosed Bat Little Free-tailed Bat		
11–100 g	Savanna Shrew Savanna Path Shrew Savanna Gerbil Slender Gerbil Shaggy Rat → ? Striped Grass-mouse Dalton's Mouse Multimammate Mouse		African Giant Shrew Black Giant Shrew Yankari Shrew	Common Spiny-mouse Slender Gerbil	Gambian Epaulet-bat Lesser Epaulet-bat Mauritian Tomb-bat Gambian Light-winged Bat White-bellied House-bat Angola Free-tailed Bat		Common African Dormouse
101–1000 g	Geoffroy's Ground-squirrel						Senegal Galago Gambian Sun-squirrel
1–10 Kg	Crawshay's Hare Greater Cane-rat Common Jackal Side-striped Jackal Pale Fox White-tailed Mongoose Crowned Duiker			Western Rock-hyrax Crested Porcupine			Tantalus Monkey Patas Monkey Pardine Genet
11–50 Kg	Anubis Baboon Hunting Dog Ratel Spotted Hyaena Striped Hyaena Serval Cheetah Oribi Red-fronted Gazelle	Bushbuck → Bohor Reedbuck	African Civet Red-flanked Duiker				
51 Kg +	Lion Leopard Aardvark African Elephant → Warthog → African Buffalo → ← Waterbuck Roan Antelope → Hartebeest → Korrigum		Leopard →			Hippopotamus	
Totals	35	3	11	5	10	1	6

Pygmy Mouse, Slender Gerbil, and Leopard are included in two habitat categories. Many of the larger woodland savanna species may temporarily inhabit the riverine vegetation on their way to and from the fadamas.

poorer soils, do not support a rich growth of perennial grasses and therefore do not attract so many grazing mammals. The *Detarium* woodlands occur on the poorest soils, and support even fewer mammals than the other woodland savanna habitats (Geerling 1973; Henshaw 1975). Thus, good soil, moderate tree cover (to protect the soil but not suppress plant growth), dense growth of perennial grasses, and closeness to water, provide the best conditions for herbivorous mammals. These conditions are found in many habitats close to the Gaji river and these habitats are usually preferred to the poorer more distant woodland savannas. However, some mammals, such as Hartebeest, Oribi and Crowned Duiker prefer the drier habitats and are less likely to occur close to the Gaji river. These patterns of distribution in relation to habitat are very obvious when one is looking for animals in different parts of the game reserve (Tables 17.3 and 17.4).

As a result of habitat selection, each habitat within an area is occupied by a particular species or group of species. Similarly, the available food resources are utilized in such a way that competition is minimized. The mammals of Yankari GR may be broadly considered as herbivores, omnivores, insectivores, and carnivores. Food preferences are also related to the size of food which can be ingested and chewed; small carnivores, for example, will only eat insects and other small animal foods, and therefore will not compete with the large carnivores. Table 17.6 shows the various feeding habits of the mammals of Yankari GR. Some foods are utilized by several species which implies that these species may compete with each other unless the food is abundant. Other food resources are utilized by only a few species, either because the type of food is not readily available, or because it does not provide enough energy in relation to the size of the mammal or in relation to the energy needed to obtain it. Where several species appear to overlap in their food requirements, other characteristics of each species may result in a finer separation between them. The insectivores of less than 10 g include five terrestrial shrews and four aerial bats; clearly, the terrestrial and aerial species will not overlap, and there is some evidence (but not from Nigeria) that each species of insectivorous bat tends to select different types and sizes of insects, thereby minimizing competition for any particular food. Similarly, the carnivores in the 1–10 kg group feed at different times of day and in different habitats.

In Yankari GR, plant foods support 28 species; 17 of these feed on grass, five browse on leaves, and six feed on fruit, leaves, and nectar. Grass, therefore is the most important plant food in Yankari GR and any ecological change which reduces grass cover and abundance will be very detrimental to most of the mammals. Fruit, leaves, and nectar, in contrast, support relatively few species. Eight species are omnivorous and their diets tend to vary as food availability changes at different seasons. The incredible abundance of insectivorous and carnivorous species is due to the wide variety of animal foods in the Sudan savanna. The 19 species of mammals which are insectivorous feed on the abundant insect fauna of bark, soil, vegetation, and termitaria, and on the wealth of small nocturnal flying insects. The 13 species of carnivores feed mainly on a wide range of reptiles, birds, and mammals.

The food resources and feeding habits of mammals in Yankari GR are broadly similar to those in Kainji Lake NP. This is not unexpected considering the similarities of the two faunas, and emphasizes the importance of grass and insects during the evolution of savanna mammals. Both forms of food are abundant, have short generation times, and increase rapidly when there is adequate rainfall. It is not surprising that many species of mammals have taken advantage of these foods. However, compared with the Guinea savanna, available food in the Sudan savanna is generally less abundant and restricted to fewer months of the year, and thus the numbers of species and individuals are lower, although the patterns of food utilization are very similar.

These examples of ecological separation show how a particular resource, whether it be habitat, food, shelter, space, or time, is used in a different way by each species in the community. When several of these resources are considered together with characteristics such as social organizations, domiciles, and movements, an even greater degree of ecological separation between species is apparent. Thus, many species of mammals can live together in Yankari GR, or in any other part of the Sudan savanna, because each uses different resources or different proportions of the same resource.

Table 17.6. Mammals of Yankari GR to show feeding habits in relation to weight. Arrows indicate additional feeding habits for some species

Average adult weight	Plant foods					Mixed diet	Animal foods	
	Fruit and leaves	Seeds and grasses	Grazers on Grasses	Browsers on leaves, twigs, bark	Fruit and nectar	Omnivore (Fruit, leaves, nuts, gums, insects, seeds)	Insects and small invertebrates	Carnivores (mostly vertebrates)
Less than 10 g		Pygmy Mouse					5 species shrews 4 species insectivorous bats	
11–100 g	Common African Dormouse	Slender Gerbil Shaggy Rat Striped Grass-mouse Dalton's mouse Multimammate Mouse			Gambian Epaulet-bat Lesser Epaulet-bat	Savanna Gerbil	5 species shrews 4 species insectivorous bats	
101–1000 g	Senegal Galago					Gambian Sun-squirrel Geoffroy's Ground-squirrel		
1–10 Kg	Crested Porcupine Western Rock-hyrax		Crawshay's Hare Greater Cane-rat ← Crowned Duiker			Tantalus Monkey Patas Monkey	← Common Jackal ← Side-striped Jackal ← Pale Fox ← Pardine Genet ← White-tailed Mongoose	
1–50 Kg			Bohor Reedbuck Oribi Red-fronted Gazelle ← Red-flanked Duiker	Bushbuck		Anubis Baboon Ratel	← Serval ← African Civet	Hunting Dog Spotted Hyaena Striped Hyaena Cheetah
51 Kg +			← African Elephant ← Roan Antelope Warthog Hippopotamus African Buffalo Hartebeest Korrigum Waterbuck				Aardvark	Lion Leopard
Totals	4	6	11	5	2	7	19	13
%	6	9	16	7	3	12	28	19

Living in the Sudan savanna

Living in the Sudan savanna is similar to living in the Guinea savanna although the lower rainfall, lower plant productivity, longer dry season, and higher daytime temperatures pose even greater problems for all forms of animal life. The most stressful period of the year is the dry season, which may last for 9 months each year, when water is scarce, food is in short supply and of poor quality, and overheating during the day is likely unless shady, relatively cool environments are available. Mammals overcome these difficulties in much the same ways as those in the Guinea savanna; for example, habitats close to water are preferred to those far away, shady habitats are preferred to open ones, and activity is reduced and usually confined to the coolest periods of the day or night. When good quality foods become scarce, mammals eat foods which are less palatable and nutritious, and they may need to eat greater quantities in order to obtain adequate energy. When conditions are particularly stressful, reproductive activities cease. Each species responds differently to environmental stresses and there are many solutions to the problems of survival in the dry season.

In Yankari GR, the effects of the different seasons on the distribution of mammals is extremely obvious. During the dry season, when most of the woodland savannas are hot and dry, Elephants, Buffalo, Roan Antelope, Bushbuck, Waterbuck, Warthog, and (to a large extent) Hartebeest feed and drink in the fadamas of the Gaji river valley. Most of these species form large herds in the fadamas, and these are a very distinctive feature of Yankari GR in the dry season. During the wet season, many (but not all) large herbivores move away from the valley into the woodland savanna where they feed on the young annual and perennial grasses, and on the new shoots of shrubs and trees. Species which require drinking water can rely on waterholes and are therefore able to utilize food resources far from the Gaji river. The different ways in which the Gaji river valley is used by large mammals at different seasons of the year (Henshaw 1975, 1979) are well illustrated by Waterbuck, Buffalo, Elephant, Roan Antelope, Warthog, and Hartebeest.

Waterbuck are more dependant on the water supplies and green forage of the Gaji valley than any of the other large herbivores. As their name suggests, Waterbuck require a lot of water and need to drink everyday; consequently, the woodland savanna is unsuitable for this species for most of the year. In the dry season especially, Waterbuck lose a lot of water each day through the skin and the lungs as a means of keeping cool; each day, this loss must be replaced by drinking. Consequently, water, shade, and succulent forage, such as the common *Jardinea* grass in the valley, are essential for Waterbuck. These requirements mean that Waterbuck stay in or very close to the Gaji river at all times of the year. In the wet season, they may move a few kilometres into the woodland savanna to graze, but they never reside there permanently. The social organization, home range, and territoriality of male Waterbuck, is partly related to their environmental requirements. Bushbuck are similar because they, too, require succulent forage, shade, and water, and like Waterbuck, are mostly confined to the Gaji valley.

Buffalo are also very dependent on the fadamas and form large herds, particularly in the dry season. The daily movements of Buffalo reflect their need for shade during the hottest part of the day and for abundant forage. In the early morning, late afternoon, and night, they feed in large herds on *Jardinea* grass in the fadamas, and on perennial grasses in the woodland savanna up to 5 km from the river. During the hottest part of the day, they rest in the riverine forests and other well-shaded habitats. In the wet season, Buffalo feed more extensively in the woodland savanna on annual and perennial grasses, although they often return to drink in the fadamas. Thus, Buffalo utilize the fadamas very extensively at all seasons, but their daily and seasonal movements away from the valley are more extensive than those of Waterbuck (Table 17.3).

African Elephants utilize the fadamas and riverine forests to a large extent. In Yankari GR, herds of Elephants move up and down the Gaji valley and its tributaries, and are not often found far from the river. Elephants require water every 1–3 days, depending on the temperature and season of the year. Although they require comparatively little water in relation to their size, they need to drink about 50 gal/d (Moss 1976). Although Elephants can travel many kilometres each day, and could easily utilize food in the woodland savanna and return to the Gaji river for water, the Elephants of Yankari prefer to remain almost totally in the fadamas, riverine woodlands, and nearby shady *Pteleopsis* woodlands. Elephants in general browse on a wide variety of shrubs and trees, including those which

grow in the woodland savanna, but they appear to have a particular liking for the *Ficus* and *Mimosa* trees and the *Jardinea* grass which grow in the valley. During the dry season, Elephants tend to congregate in large herds (Table 11.1), and at this time their local effects on the vegetation of the fadamas can be quite devastating. During the wet season, they disperse in smaller herds and they utilize, at least to some extent, the woodland savanna near the fadamas.

Roan Antelope, Warthog, and Hartebeest are less dependent on the fadamas than the three species described above. Roan Antelope are primarily browsers and in the wet season they feed mainly on shrubs up to 15 km from the river (p. 232). Their water requirements are low and they do not need to make regular frequent visits to the Gaji river at any time of the year. However, when they visit the fadamas in the dry season, they feed extensively on the shoots of *Mimosa* shrubs which remain green and succulent throughout the year and which, presumably, have a high water content. In the wet season, Roan Antelope rarely visit the fadamas. Warthogs occur in many habitats, including those far from the river valley. Individuals which live close to the valley feed on grass shoots, bulbs, and roots in the fadamas at all times of the year; those living far away, obtain adequate water from their food and from waterholes in the wet season, but may make infrequent visits to the fadamas in the dry season. Hartebeest use the fadamas less than any other large herbivore. Even during the dry season, most Hartebeest remain in the shrub savanna which is rarely utilized by other large herbivores. They are able to survive in this harsh habitat because of their ability to conserve water, tolerate high temperatures, and locate the shoots of those perennial grasses which sprout during the dry season. The few Hartebeest which do move into the fadamas during the dry season feed on the short grasses not favoured by other species.

These brief descriptions show that each species uses the fadamas to a different extent, and that seasonal changes in the availability of food and water determine where each species is most likely to occur. The congregation of many individuals in the fadamas and riverine forests in the dry season (Table 17.4) puts enormous grazing pressure on the vegetation, even though in this moist habitat, the vegetation continues to grow throughout the dry season (Plate 17.2). Up until now, the vegetation has not been over-exploited, in spite of the large numbers of animals. However, further increases in population numbers could lead to a deterioration of the habitat and irreversible changes which would seriously affect the whole fadama ecosystem. The foraging behaviour, social organization, biomass, and total numbers of each species determine the overall effect on the fadama. The territorial system and small herd size of Waterbuck mean that its grazing pressure is not concentrated in one particular area; the same is probably true for Bushbuck because of its dispersed social organization and the fact that the home ranges do not overlap (p. 215). However, Elephants and Buffalo which live in large herds have a much greater and more concentrated effect on the ecosystem; increased numbers of these two species could result in severe over-exploitation of the vegetation which would be detrimental to themselves and to other species. The problems associated with too many large mammals in reserved areas are considered in more detail on pp. 267 and 324.

Interactions between species in the fadamas

In the dry season, many mammals congregate in the fadamas and in other habitats, provided that territories and exclusive home ranges are not threatened. Individuals of most species are remarkably tolerant of conspecifics. Spacing behaviour rarely allows overcrowding. The minimum space between individuals varies for each species; Buffalo, for example, can tolerate higher densities than Bushbuck or Waterbuck.

In contrast, when individuals of different species are crowded together, there are two possible outcomes: tolerant associations or some form of conflict. The former is frequently seen when groups or herds of different species feed or rest close to each other with little or no interaction between them. Occasionally, small groups of one species may quietly move out of the way of large groups of a second species. Sometimes, one species may even gain advantage by the close proximity of another species: for example, in Yankari GR, as in other parts of Africa, Bushbuck and Tantalus Monkeys are sometimes seen together and it is presumed that both species benefit from their combined sensory perception of potential predators (Henshaw 1972).

The second outcome is some form of conflict; for example, in Yankari GR, Elephants sometimes chase herds of grazing Buffalo, Waterbuck and Hartebeest from the fadamas into the adjacent woodlands (Henshaw 1972). Disturbances of this kind are usually uncommon and are more likely to occur in densely crowded regions such as national parks and game reserves than in less crowded areas.

Mineral licks

Minerals are necessary for many metabolic processes and an adequate supply of them is essential for good health. Many species of mammals obtain them from mineral licks which are deposits of soil containing high concentrations of calcium, magnesium, potassium, sodium, and phosphorus (Henshaw and Ayeni 1971). Mineral licks are often associated with waterholes and, typically, they are areas of bare compacted soil surrounding one or more irregularly shaped holes which may contain water even during the dry season. Well-worn trails made by mammals travelling to and from the licks radiate into the surrounding grasslands and woodlands.

Table 17.7 lists the species of mammals which regularly visit licks in Yankari GR. The most frequent visitors are Warthog, Baboon, Hartebeest, and Waterbuck, but six other species make less frequent visits. Some quite common species (Table 17.3) do not seem to use mineral licks at all. The frequency of visits of any particular species is not related to its abundance which suggests that usage of mineral licks is not just a chance affair. The reasons why certain species of mammals eat soil at mineral licks, and others do not, is uncertain. It is possible that those species which use the licks do not obtain adequate minerals in their normal diet, and so the licks provide a useful supplementary source of minerals. If this is correct, it would suggest that some foods are deficient in minerals or that some mammals require more minerals than others.

Individuals usually visit mineral licks in small groups, although there is great variation within and between species. Similarly, the length of each visit to a mineral lick varies from an average of 5 min for Oribi to an average of 62 min for Hartebeest (Table 17.7). Mineral licks are visited less often at night than during the day; at dawn, the first animals arrive and the numbers gradually increase to a maximum between 12.00 and 14.00 h when the rate of visitation is seven to nine individuals per h (Ayeni 1979). Hartebeest visit the licks during more hours of the day and night than

Table 17.7. Utilization of mineral licks by mammals in Yankari GR (from Ayeni 1972; Henshaw and Ayeni 1971)

Species	Number of groups observed	Number of individuals observed	Mean and range of group size	Mean length of visit (min)	Individual visits (% frequency)	Status in reserve†
Anubis Baboon	48	310	7 (1–30)	18	22	C
African Elephant	1	10	10	23	*	C
Warthog	276	608	2 (1–9)	16	43	A
African Buffalo	21	50	2 (1–4)	13	4	A
Bushbuck	2	4	2	18	*	R
Red-flanked Duiker	2	3	2 (1–2)	7	*	R
Waterbuck	53	154	3 (1–8)	11	11	A
Roan Antelope	3	3	1	6	*	C/R
Hartebeest	51	236	4 (1–16)	62	17	C
Oribi	1	3	3	5	*	C/R

*less than 1%.

†A = abundant, C = common, R = rare.

The following large mammals have not been seen at mineral licks: Tantalus Monkey, Patas Monkey, Hunting Dog, Lion, Leopard, Giraffe, Hippopotamus, Crowned Duiker, and Red-fronted Gazelle.

other species (Table 17.8). Buffalo, Waterbuck, and Warthog visit only during daylight hours, with the maximum number of visits around noon. Baboons also use licks during the daytime, but mostly from dawn to noon. Because species which use licks tend to remain for many minutes, and because visibility is good, mineral licks are excellent places for observing the larger herbivorous mammals of the savannas.

There are many types of activity at mineral licks (Ayeni 1979). Most species drink the mineral-rich waters. Buffalo and Waterbuck lick the soil, and Baboons pick up small lumps of soil with their hands before chewing them with their teeth. Elephants, Hartebeest, and Warthogs break up the hardened soil around the edges of existing holes; Elephants use their forefeet and sometimes their tusks to break the soil, whereas Hartebeest and Warthogs use their incisor teeth and sometimes the hooves of their forefeet. The broken fragments of soil can then be licked or chewed, or if they fall back into the water, they dissolve and enrich the mineral content of the water. Besides ingesting minerals, many individuals stand close to the licks apparently doing very little. All species may defaecate or urinate, thereby adding further nutrients to the soil. Elephants spray their bodies with dust, Buffalo, Hartebeest, and Warthog roll in the soil, and when the lick is full of water or mud Buffalo and Warthog immerse themselves so their bodies become encrusted with a coating of fine mud.

Mineral licks form an important part of the ecology of certain species especially in the dry season when water may not be available elsewhere and when the licks are not too muddy and sticky. Although the need for mineral licks may result in the removal of soil and prevention of plant growth in some areas, these effects are very localized and not detrimental. However, there is always the possibility in national parks and game reserves, that increases in population numbers may result in over-utilization of mineral licks and local degrading of the habitat.

Table 17.8. Visits to mineral licks by five species of mammals in Yankari GR. Numbers indicate the average number of individuals seen each hour, from 30 min before the hour to 30 min after (after Ayeni 1972, 1979)

Time*	Baboon	Warthog	African Buffalo	Waterbuck	Hartebeest	Total†
01.00 (2)	0	0	0	0	0	1.0
02.00 (2)	0	0	0	0	0.5	1.0
03.00 (4)	0	0	0	0	2.0	2.0
04.00 (6)	0	0	0.2	0	0.8	1.3
05.00 (9)	0	0	0	0	0.3	1.0
06.00 (14)	0	0	0	0	0.9	1.0
07.00 (15)	1.6	0.4	0.2	0	0.7	2.7
08.00 (20)	1.5	0.5	0.4	0	0.2	2.3
09.00 (31)	2.8	1.3	0.3	0.1	0.9	5.6
10.00 (35)	1.3	2.8	0.1	0.3	0.2	5.8
11.00 (35)	0.7	2.6	0	0.4	1.6	5.4
12.00 (40)	1.9	3.8	0.1	1.0	0.9	7.6
13.00 (36)	1.6	4.6	0.3	0.9	1.4	8.8
14.00 (33)	0.6	4.5	0	1.7	2.1	9.1
15.00 (31)	0.9	2.8	0.3	0.8	1.5	6.1
16.00 (24)	0.2	0.8	0	0.2	1.3	1.9
17.00 (15)	0.7	0.3	0	0	1.0	1.7
18.00 (11)	0	0.3	0	0	0.6	1.1
19.00 (3)	0	0	0	0	0	0
20.00 (2)	0	0	0	0	0	0
21.00 (2)	0	0	0	0	0	0
22.00 (2)	0	0	0	0	0	0
23.00 (2)	0	0	0	0	0	0
24.00 (2)	0	0	0	0	0	0
Totals	13.8	24.7	1.9	5.4	16.9	65.4

†Including other species which visit mineral licks infrequently.
*Number of hours of observation given in parentheses.

Small mammals

In Yankari GR, there are 31 species of mammals (47% of the total) with an adult weight of less than 1 kg. These small mammals are rarely seen or studied, and their effects on the ecosystem are not as obvious or significant as those of the larger species. However, small mammals often occur in large numbers, and they are important for the following reasons.

(1) Small herbivorous species recycle nutrients in grasses, remove and transport seeds, and aerate the soil by burrowing and digging.

(2) Small insectivorous species (shrews, bats) consume many sorts of insects, which themselves feed on many sorts of grasses, leaves, bark, and fruits, and thereby assist in the cycling of nutrients in the ecosystem.

(3) Small herbivorous species (rodents) and some small insectivorous species (shrews) provide food for a wide variety of predators such as mongooses, genets, African Civets, jackals, hawks, and owls.

(4) Some, if not all, fruit-bats assist in the pollination of many species of savanna trees. Fruit and seeds from these trees provide food for some monkeys, fruit-bats, small terrestrial mammals, and some large herbivores. Many of these mammals help in the distribution of seeds, which pass unharmed through the alimentary canal and are then deposited in the faeces far from where they were eaten.

Small mammals, like large mammals, have very specific habitat requirements (Table 17.5). Areas of long grass which provide cover, food, and protection from excessive heat during the day, are preferred by many small terrestrial species. Consequently, grasslands which are damaged by fire support few species and individuals until the grasses regenerate. This also results in fewer predators because of the lack of prey. Similarly, regions with abundant large mammals do not have flourishing populations of small mammals due to the reduction in grass cover, the effects of trampling, and lack of food.

In Yankari GR, many of the woodland and grassland savannas close to the Gaji river have rather low numbers of small rodents, probably because of the scarcity of good cover and the high population numbers of large mammals. However, Common Spiny-mice, and Slender Gerbils live amongst the rocky sandstone cliffs and boulders near the Gaji river, and Dalton's Mice, Multimammate Mice, and Pygmy Mice occur in buildings at Wikki and in other human habitations (Happold 1970b). In many woodland savanna habitats throughout the Guinea and Sudan savanna zones, inselbergs and other rocky habitats usually support higher numbers of small mammals than the surrounding grasslands, especially if these grasslands are regularly burned, or disturbed by human activities or by large herds of herbivores (p. 268). Dalton's Mice, Multimammate Mice, Spotted Grass-mice, Striped Grass-mice, and Pygmy Mice occur on many of these inselbergs where the long, dense (and usually unburned) grasses, rocky crevices, and shaded gullies with trees provide ideal habitats. Similarly, crevices, cracks, and small caves on inselbergs provide roosting sites for some species of insectivorous bats, and domiciles for Western Rock-hyraxes. These undisturbed habitats are of great importance for small mammals and ultimately for the whole savanna ecosystem.

One indication of the importance of small mammals as food for predators is shown by analysing the pellets produced by owls (Demeter 1978, 1981). After owls have ingested their prey, they regurgitate fur, feathers, and bones in egg-shaped pellets. These frequently contain parts of the skulls of the prey which can be identified. Such studies provide useful information about the species of prey present where the owl has been feeding (Table 17.9). Owls are much better at finding small mammals than are humans! For example, in Yankari GR in 1979, the pellets from Barn Owls and Spotted Eagle-owls contained the remains of 11 species of rodents and bats which had not previously been recorded from the game reserve. Small mammals (as well as reptiles and insects to a lesser extent) form the major part of the diet of many of the small and medium-sized predators of the savannas. Their role in the savanna ecosystem is of great importance, although seldom appreciated; any change which reduces the numbers of small mammals (or any other small animal) could be detrimental to the system. The maintenance of the correct balance (whether numbers of species or numbers of individuals) between the different components of the ecosystem is essential if the ecosystem is to remain stable and self perpetuating. Very little is known about all these complex inter-relationships, but they are worthy of detailed investigation in their own right, and for sensible conservation or management of the ecosystem.

Table 17.9. Prey of Barn Owls and Spotted Eagle-owls in Yankari GR at three locations. Figures show the number of individuals of each prey item, as a percentage, in pellets at the roosts of each species of owl. The variability between the prey of the two species of owls indicates differences in prey selection. Similarly, the differences between the prey at different locations reflects prey availability (from Demeter 1981). The number of prey items are given after the locations in parentheses.

Prey Species	Barn Owls		Spotted Eagle-owls	
	Wikki (25)	Futuk (238)	Wikki (223)	Kalban Hills (67)
Shrews	25	29	31	0
Mauritian Tomb-bat	0	0	0	1
Slit-faced Bat	0	0	*	0
Pipistrelle Bat	0	0	*	0
Savanna Gerbil	12	8	19	0
Slender Gerbil	12	2	5	1
Pygmy Mouse	4	9	3	0
Nile Rat	0	1	0	0
Striped Grass-mouse	0	1	2	0
Common Spiny-mouse	0	0	5	0
Shaggy Rat	0	0	1	0
Dalton's Mouse	0	0	5	0
Multimammate Mouse	12	31	5	0
Common African Dormouse	4	0	1	0
Other prey	31	19	23	2

* = Less than 1%.

Predators

Predators are a natural and important component of all mammalian communities. In the Sudan zone, the predators are about 10 species of shrews, nine species of insectivorous bats, and 14 species of carnivores; together these comprise 49% of all mammalian species in the Sudan zone. Similar proportions of predators also occur in the Guinea and Sahel savanna zones.

Predators can only survive if there is an adequate supply of their prey throughout the year. Consequently, the number of predators is related to the numbers of their prey, and there is usually a dynamic balance between the two. As prey numbers increase (for whatever reasons), predator numbers also increase; but this does not happen immediately because the predators need time to increase their numbers by reproduction and immigration. Conversely, when prey numbers decrease, predator numbers also decrease in due course. The increases and decreases of prey and predators, therefore, are not synchronous, because the prey and the predators have different relative rates of population growth, reproduction and speed of response to the changing conditions. There are many theories about predator–prey relationships, but the basic point is that the numbers of predators are governed by the changes in the numbers of prey.

It is sometimes thought that predators are a nuisance, and it would be much better if they were reduced in number or eliminated completely. This viewpoint arises from a misunderstanding of the role of predators in the ecosystem. Predators remove sick, old, weak, and injured individuals from the population, and they play a crucial role in preventing the prey species from becoming so abundant that they overexploit the environment. In other words, predators help to keep the populations of herbivores healthy, and help to maintain the numbers of herbivores at a level which can be continuously sustained by the ecosystem. This level, the 'carrying capacity', changes with season and year, and is never constant. Several years of above average rainfall in the Sudan savanna result in better growth of grasses, shrubs and trees; more herbivores can be supported, but as their numbers increase they consume more vegetation, and in time there could be more herbivores than can be supported. However, in healthy ecosystems,

predators gradually increase in number when their prey becomes numerous, and this helps to reduce the numbers of prey before they do irreparable damage to the vegetation.

The importance of predators is also illustrated by the changes which occur in the ecosystem when predators are removed. For example, in parts of West Africa where Leopards were exterminated, Baboons became so numerous that they caused very extensive damage to crops. Removal of predators, therefore, upsets the balance of the ecosystem, and may produce totally unexpected and undesired results.

Mammals of the Sahel savanna

The Sahel savanna zone in the extreme north-east of the country is a semi-arid environment, and contains fewer species of mammals than any of the other vegetation zones. Although there is only a small area of the Sahel savanna zone in Nigeria, the mammalian fauna of this area is fairly typical of the whole zone (p. 1,7). However, the waters and marshes of Lake Chad are inhabited by several species which are typical of the Guinea and Sudan savannas, and which are not found elsewhere in the Sahel zone.

Fifty-one species have been recorded in the Sahel savanna zone of Nigeria (Tables 17.10 and 1.4). As in the other savanna zones described above, the bats (10 species, 20%), rodents (eight species, 16%), carnivores (16 species, 31%), and artiodactyls (eight species, 16%) form the majority of the fauna. Nearly half of the mammals (21 species, 41%) are 'northern' species; the other species (30 species, 59%) occur throughout the savanna zones. The trend of decreasing numbers of species from south to north applies to the Sahel savanna zone, as it does to the other vegetation zones. Of the 97 species of mammals in the Sudan savanna zone, about 48 species do not appear to reach the Sahel savanna zone, at least in Nigeria. However, there are four species (Rüppell's Bat, Lesser Egyptian Jerboa, Dama Gazelle, and Dorcas Gazelle) which, in Nigeria, are found only in the Sahel savanna although they are widely distributed in the Sahara and sub-Saharan regions, and one species (Lake Chad Gerbil) which occurs in the mesic habitats close to Lake Chad, but nowhere else in Nigeria (Table 17.1).

Mammals of the Sahel savanna zone experience a very severe environment characterized by high daytime temperatures, cool or cold nights, high insolation, low unpredictable rainfall, and low plant productivity. For all species, the problems of obtaining adequate water and food, and maintaining the body temperature at a constant level in spite of the widely fluctuating ambient temperature, determine all aspects of their ecology and behaviour. Little is known about most of these mammals in Nigeria, but many of their characteristics are similar to those of mammals from other semi-arid regions of Africa. These may be summarized as follows.

(1) Population numbers of small mammals fluctuate greatly from very low numbers during droughts to high numbers after good rain when food is plentiful.

(2) All small mammals are nocturnal; during the heat of the day, they remain in burrows, hollow trees, caves, and other micro-habitats which are comparatively cool and moist.

(3) Efficient conservation of body fluids is essential for survival. All mammals combine a number of methods to ensure that the limited water in their food is not wasted. These include the production of dry faeces and very small volumes of concentrated urine, the selection of foods which contain relatively high amounts of water, the production of metabolic water, and the minimal use of water for evaporative cooling.

(4) Reproduction occurs only when food and water are plentiful. Consequently, several years of drought can mean the cessation of reproduction for several years, and therefore a dramatic fall in population numbers.

(5) Some large mammals which are unable to shelter completely from the high daytime temperature and high insolation, can withstand slight temporary increases in their body temperature. As the ambient temperature cools at night, the excess heat load of the body is lost to the surrounding cooler air.

(6) Larger mammals, both herbivores and carnivores, tend to be very nomadic so they search efficiently for widely distributed food resources.

Although some mammals in the Sudan savanna zone also show these characteristics, they are better developed (and more necessary) for mammals in the Sahel savanna zone. Relatively few species of mammals have the necessary specializations for survival in arid and

Table 17.10. Mammals of the Lake Chad region*

Common name	Scientific name
Insectivora (2)	
African Giant Shrew	*Crocidura flavescens*
Savanna Shrew	*Crocidura fulvastra*
Chiroptera (8)	
Mauritian Tomb-bat	*Taphozous mauritianus*
Hairy Slit-faced Bat	*Nycteris hispida*
Yellow-winged Bat	*Lavia frons*
Lander's Horseshoe-bat	*Rhinolophus landeri*
Banana Bat	*Pipistrellus nanus*
Rüpell's Pipistrelle	*Pipistrellus rueppelli*
Butterfly Bat	*Glauconycteris variegata*
Little Free-tailed Bat	*Tadarida pumila*
Primates (2)	
Tantalus Monkey	*Cercopithecus tantalus*
Patas Monkey	*Erythrocebus patas*
Rodentia (7)	
Geoffroy's Ground-squirrel	*Xerus erythropus*
Agag Gerbil	*Gerbillus agag*
Savanna Gerbil	*Tatera valida*
Slender Gerbil	*Taterillus gracilis*
Lake Chad Gerbil	*Taterillus lacustris*
Nile Rat	*Arvicanthis niloticus*
Lesser Egyptian Jerboa	*Jaculus jaculus*
Carnivora (15)	
Common Jackal	*Canis aureus*
Side-striped Jackal	*Canis adustus*
Pale Fox	*Vulpes pallida*
Hunting Dog	*Lycaon pictus*
Zorilla	*Ictonyx striatus*
Ratel	*Mellivora capensis*
Spotted-necked Otter	*Lutra maculicollis*
Cape Clawless Otter	*Aonyx capensis*
African Civet	*Viverra civetta*
Feline Genet	*Genetta felina*
White-tailed Mongoose	*Ichneumia albicauda*
Striped Hyaena	*Hyaena hyaena*
Caracal	*Felis caracal*
Serval	*Felis serval*
Cheetah	*Acinonyx jubatus*
Proboscidea (1)	
African Elephant	*Loxodonta africana*
Artiodactyla (7)	
Hippopotamus	*Hippopotamus amphibius*
Sitatunga	*Tragelaphus spekei*
Oribi	*Ourebia ourebi*
Kob	*Kobus kob*
Red-fronted Gazelle	*Gazella rufifrons*
Dama Gazelle	*Gazella dama*
Dorcas Gazelle	*Gazella dorcas*

*Includes Baga, Baga-Kawa, Dikwa, Kukawa, Malamfatori, Wulgo, and Yo.

Note. The following species are likely to occur near Lake Chad although no definite records are available: Four-toed Hedgehog, Straw-coloured Fruit-bat, Senegal Galago, Cape Hare, Multimammate Mouse, Banded Mongoose, and Crowned Duiker.

semi-arid environments; this is clearly reflected in the smaller number of species in the Sahel zone compared with other vegetation zones.

Lake Chad provides a mesic habitat in an otherwise arid environment (Plate 17.3). Water is plentiful, sedges and papyrus around the edges of the lake provide cover and a regular supply of fresh vegetation, aquatic and aerial insects are fairly abundant, and the high water table provides moisture for trees and shrubs growing close to the lake. Forty-two species of mammals have been recorded close to the lake (Table 17.10); most are typical 'northern species', but the presence of two species of rodents, two species of otters, Elephant, Hippopotamus, Sitatunga, and Kob is only possible because of the mesic environment around the lake. In the past, when the climate of this part of Africa was wetter, and Lake Chad was more extensive and surrounded by swamps and savanna woodland (p. 292), these mesic species were probably quite widespread. Now, they are isolated from other populations of their species by the semi-arid habitats which surround the Lake.

Water and rainfall are probably the most important limiting factors in dry savannas. Consequently, any increase in the availability of water will result in increased primary production and higher population numbers of all animals which directly or indirectly depend on the vegetation. Irrigation in the Sahel (and Sudan) savanna provides a dramatic example of the responses of animals to an abundance of vegetation, even though other characteristics of the environment remain as before. Fields irrigated by water from Lake Chad and from the Hadejia, Gana, and Yobe river systems (which would normally flow into the lake), or from bores in the Lake Chad basin, provide mesic environments for insects and many small terrestrial vertebrates. Many species of rodents, such as Nile Rats, Slender Gerbils, and Agag Gerbils which are relatively uncommon in the Sahel savanna, sometimes become very numerous in irrigated fields and on irrigation banks (Brei 1976). Under these conditions, they can become pests and cause serious damage to crops. From an ecological point of view, irrigation in environments which are naturally arid highlights the importance of water as a limiting factor; it also demonstrates that when humans alter the ecosystem, the results are often unexpected and damaging.

In spite of the small area of the Sahel savanna in Nigeria, the mammals of this vegetation zone are an extremely interesting community of arid and mesic species, totally different from any other in Nigeria.