FEEDING HABITS OF THE BUSH SQUIRREL *PARAXERUS CEPAPI CEPAPI* (RODENTIA : SCIURIDAE).

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ABSTRACT

Information on feeding habits and ecology of the bush squirrel, *Paraxerus cepapi cepapi*, in the Transvaal was obtained both from analyses of 82 alimentary tracts and by direct observation of animals. Bush squirrels were found to be insectivorous as well as herbivorous, feeding on seeds, leaves, berries and flowers. They preferred ground cover which was not too dense and fed both on the ground and in trees depending on food availability.

INTRODUCTION

This study formed part of a broader project on the life history of the bush squirrel *Paraxerus cepapi cepapi* (A Smith, 1836) (Viljoen 1975). Food requirements and availability form an integral part of such a study, indicating the niche that the animals occupy and influencing their breeding season, population dynamics, behaviour and activity patterns. Much is known of overseas tree sciurids, but no detailed work has been undertaken on any of the African tree squirrels. Feeding habits of *P. cepapi* have been noted by Shortridge (1934), Roberts (1951), Dobroruka (1970) and Smithers (1971). The behavioural part of the present study was undertaken on the farm Mosdene 8 km south-east of Naboomspruit (28°47′E/24°35′S) where 18 to 30 animals (depending on the time of year) inhabited the study area of 5,4 ha of termitaria tree clumps. Animals were also collected from various localities throughout the Transvaal (Table 1), and were aged on tooth eruption and wear (Viljoen 1975).

MATERIALS AND METHODS

Of the 123 days in the field during 1973/74, 103 were spent observing, and the rest collecting, squirrels of which 27 were shot and 55 were live-trapped using apple smeared with peanut butter as bait.

Study area. The study area was flanked 5 km to the west by the non-perennial Nyl River where a vlei as much as 5 km in width and up to a metre deep is formed some time after

substantial rains. Squirrels inhabit the tree clumps and dense thickets in the slightly elevated and well-drained termitaria a short distance from the vlei. Some of these tree clumps are completely surrounded by water during flooding of the plain. Tarboton (1971) gives a more comprehensive description of the vegetation on the farm.

Alimentary tract analysis. Before fixation the following measurements were taken on 47 tracts: length of the stomach, small intestine, caecum and large intestine. Other measurements, such as width of the intestine, were initially also taken but were soon abandoned as they varied a great deal according to the amount of food present in the tract. The mass of entire alimentary tract (from just anterior to the stomach up to the anus) was measured for all the individuals and the tracts were preserved intact in 5 per cent formalin. Partly digested insect remains were removed from the stomach, caecum, and large intestine. Squirrels chew their food into very small particles and only a few intact seeds of the plant material could be identified. However, information on vegetable food was obtained by direct observation and the alimentary tract analysis was therefore aimed at distinguishing relative amounts of plant and insect material and at the identification of insect remains. Only 22 (18 adults, 3 subadults, 1 juvenile) of the shot animals had undamaged stomachs and could be utilized for the more accurate quantitative determination of the plant-to-insect ratio, while the live-trapped animals could not be used at all because they contained large amounts of bait. Prior to analysis the volume of the contents of these 22 stomachs was recorded by water

TABLE 1

Sample sizes of bush squirrels, *P.c.cepapi*, collected from different localities in the Transvaal during 1973/74.

Locality	*Sample size*	*Adults*
Naboomspruit 28°47'E/24°35'S	47	33
Messina, on Limpopo River 30°35'E/22°20'S	16	9
Thabazimbi 27°25'E/25°0'S	8	8
Rustenburg 27°10'E/25°40'S	6	5
Potgietersrus 28°40'E/24°20'S	5	3
TOTAL	82	58

displacement and the mass was determined after the contents had been dried at 35° C for 30 minutes to remove excess water. A point frequency method of analysis was thereafter used as follows: 0,5 g of the contents was suspended in 5 ml 70 per cent alcohol in a petri dish with diameter of 30 mm. A grid (2 x 2 mm) was drawn on the base of the dish. The occurrence of the different items on points of grid intersections was then recorded through a stereo-microscope. In 27 (17 adults, 7 sub-adults, 3 juveniles) of the live-trapped animals which had only been in the traps for a short while, a visual estimate of the ratio of insect to plant material was made. In addition, the frequency of occurrence of vegetable and insect matter in the percentage of large intestines and caeca was noted.

RESULTS

Vegetation of the study area at Naboomspruit and its utilization by the squirrels.
The tambotie, *Spirostachys africana,* is the dominant tree in this area, supplying much of the food and nesting requirements of the squirrels. Other common trees are *Boscia rehmanniana, Acacia tortilis* and *A. mellifera* subsp. *detinens.* Vegetation was divided into four distinct classes:
Class A. This ground cover of herbs and short grass in the centre of the termitaria is very sparse even in good rainy seasons and in drought years these areas are nearly devoid of vegetation. (E A Galpin, pers. comm.). The grasses attain a height of 12 cm but are too sparse to obscure the vision of squirrels. The most common plants occurring are *Blepharis integrifolia; Commelina subulata; Portulaca* sp. cf. *P. collina; Chloris virgata; Schkuhria pinnata; Dactyloctenium aegyptium.*
Class B. This vegetation type of dense, green bushes, short grass and herbs beneath the trees, provides a greater proportion of the squirrel's food than any other class. Plants identified include *Commelina erecta; C. africana; Plectranthus neochilus; Justicia flava; Senecio radicans.*
Class C. The unshaded short-grass-and-herbs regions surrounding the tree clumps to a width of 4 m has denser vegetation with longer grass than in the middle of the termitaria but less dense and not as tall as in the following class. Plants are *i.a. Commelina erecta; Ocimum canum; Justicia cheirauthifolia; Gomphrena celosioides.*
Class D. This constitutes the very dense, tall grass (up to 2 m high) surrounding the termitaria and it is impossible to see through this vegetation when eye-level is a few centimetres above the ground. Plants occurring are *Eragrostis trichophora; E. atrovirens; Elionurus argenteus; Cyperus denudatus; Digitaria setivalva; Londetia pedicellata.*

The frequency with which squirrels were seen in these different vegetation classes reflects their habitat and feeding preference to a certain extent. In a total of 268 sightings, squirrels were observed in Class A vegetation 54 per cent of the times; in Class B, 44 per cent; in Class C, 2 per cent and never in Class D, although they would have had to move through it when roaming. All four vegetation types could always be seen from any observation point and are therefore equally represented.

Table 2 presents all the vegetable matter in the feeding records obtained by direct observation. In April, May and to a lesser extent June of 1973 the squirrels were mostly observed feeding in *Acacia tortilis* trees - they opened the pods and ate the seeds. They would even take the seeds from impala droppings and such intact seeds were identified in the large intestine and caecum of many individuals. In May they often ate aloe flowers and *Euclea* berries, but by June, supplies of these had become depleted and they spent more time on the ground. In July they were frequently seen in tambotie trees feeding on the stick-like flowers. In August, aloe seeds were consumed and from September to November tambotie seeds, and flowers of *Acacia* trees. Squirrels were also seen eating fruit of *Mimusops zeyheri* at Rustenburg by McDonald (pers. comm.) and berries of *Burkea africana* at Naboom-

TABLE 2

Identified plant food of bush squirrels, *P.c.cepapi*, during 1973/74 in the Transvaal.

Month	*Plant species*	*Part eaten*
January	*Acacia* sp.	gum
	Aloe sp.	leaf
	Justicia angalloides	flower
	Justicia flava	flower
	Menodora africana	leaf & stem
	Commelina erecta	flower
	Portulaca sp. cf. *P. hereroensis*	flower
	Urochloa panicoides	seeds
	Dactyloctenium aegyptium	leaves
	Panicum maximum	seeds
February	*Sarcostemma viminale*	stem
	Justicia flava	flower
	Commelina africana	flower
	Asparagus virgatus	stem
March	*Diospyros* sp.	green berries
	Spirostachys africana	leaves
	Aloe sp.	flowers
	Carissa bispinosa	red berries
	Nidorella resedifolia	leaves
	Gomphrena celosioides	flower
	Lichen	
April	*Acacia tortilis*	seeds
	Ziziphus mucronata	berries
	Aloe sp.	seeds
May	*Euclea undulata*	green berries
	Acacia tortilis	seeds
	Spirostachys africana	pollen
	Securidaca longipedunculata	seeds
	Grewia sp. cf. *G. hexamita*	berries
	Solanum capsicastrum	berries
	Senecio radicans	flower
	Dicliptera micranthes	leaves
	Lichen	leaves
	Aloe sp.	leaves & flowers
June	*Acacia tortilis*	seeds
	A. robusta	gum
	A. giraffae	seed
	Acacia sp.	knob in branch
	Euclea undulata var. *myrtina*	berries
	Aloe maculatae group	leaf
July	*Spirostachys africana*	flowers & pollen
	Aloe sp.	flowers
	Lycium tenue	leaves
September	*Spirostachys africana*	bark, seeds
	Acacia sp. cf. *A. mellifera* Benth. subsp. *detinens*	flowers
	Acacia sp.	flowers
	Aloe sp.	seeds
	Monechma fimbriatum	seeds
December	*Spirostachys africana*	seeds bark & leaf
	Boscia rehmanniana	berries (not the skin)
	Ehretia rigida	both green & orange berries
	Loranthus zeyheri	flowers
	Crassula sessile-cymula	leaves

spruit. Throughout the year they chewed on lichen and *Acacia* gum and also picked at bark and knots in branches with their teeth, probably to get at insects. They often nibbled ant-infested twigs and one squirrel removed termites from cow dung. Tinley (pers. comm.) has also seen squirrels removing insects from elephant dung.

At one-and-a-half months of age, while still suckling, the pups were mostly seen in their nest trees venturing only short distances, eating leaves and bark of tambotie trees and possibly insects. In the stomachs of squirrels of one-to-three months of age all components of the adult diet could be found: insects, *Acacia* leaves, a louse, bark, seeds and a stone. When feeding in a tree, squirrels display great agility, hanging by their feet and twirling their fluffed tails to maintain balance. But they are also often seen on the ground, food availability probably determining the distribution of time between ground and tree feeding.

Alimentary tract analyses.

The average volume of the stomach contents of 23 of the shot squirrels (juveniles excluded) was 8,39 ml, and the average stomach content mass was 5,39 g. In 31 adults (older than 12 months: Viljoen 1975) the mean mass of the entire tract from anterior of the stomach to the anus was 25,9 g $\pm$ 8,7 g (SD) and measurements for the different parts of the alimentary tract were as follows: small intestine 960,8 mm (75% of total length); caecum 48,5 mm (4%); large intestine 274,6 mm (21%).

All the caeca and 48 per cent of the large intestines even of squirrels one-to-four months old, were heavily infected with the parasitic nematode, *Syphacia paraxeri* Sandground, 1933. Their omnipresence probably results from the absence of an intermediate host for the species (Verster, pers. comm.)

Ratio of vegetable to insect remains.

The stomach contents consisted mainly of vegetable matter. However, insects played an important part in the squirrel diet especially in the July sample from Naboomspruit, the August stomachs from the Limpopo River and the November stomachs from Northam, Thabazimbi (Table 3). Of the 49 stomachs estimated visually (live-trapped animals) or analysed by point frequency (shot animals), 79 per cent contained insects and 96 per cent contained plant material, both divisions contributing from 0 - 100 per cent of the total contents. In the 22 stomachs analysed by the point frequency method, an average of 31 per cent of the contents consisted of insect remains and 69 per cent of vegetable matter; 76 per cent of the caeca and 57 per cent of the large intestines contained insect remains whereas all had vegetable matter.

Table 4 shows monthly variation of insects and seed. The number of seeds in the 22 point frequency analysed stomachs reached a maximum in April when they made up 59 per cent of the total stomach contents, and occurred in 41 per cent of these stomachs, 23 per cent of the caeca and in 11 per cent of the large intestines. Seeds were mainly present from December to May. Bark and leaf remains and hair were seen in any part of many tracts. Bark occurred in 31 per cent of the 22 point frequency analysed stomachs and identifiable leaf remains in nine per cent. Table 5 presents the insects removed from the alimentary tracts throughout the year. Additional insect records from the stomachs are of Staphilinidae (Coleoptera), Blattidae (Dictyoptera) and a Lepidoptera larva.

DISCUSSION

Bush squirrels are omnivorous which is not exceptional in tree squirrels as *Paraxerus boehmi* (Delany 1972) and *Sciurus carolinensis* (Nixon 1970) feed on insects in certain seasons and Rahm (1972) also mentions various central African squirrels which include insects in their diet. Rahm investigated the food habits of seven species of Zaïre tree squirrels and concluded that the more frugivorous *Funisciurus carruthersi, Protoxerus stangeri* and *Heliosciurus rufobrachium* have longer caeca and small intestines than the predominantly insectivorous *Funisciurus pyrrhopus, F. anerythrus, Paraxerus boehmi,* and *P. alexanderi.* The caecum and small intestine in *Paraxerus cepapi* of the present study are very short compared with those of the above-mentioned squirrels and if Rahm is correct this would indicate a relatively large insectivorous component in the bush squirrel's diet. Shortridge (1934) mentioned that bush squirrels occasionally feed on eggs and young of

TABLE 3

Percentage frequency of occurrence of insect and plant remains in stomachs of 22 shot (point-frequency analysis) and 27 live-trapped (visual estimate) bush squirrels, *P.c.cepapi*, from the Transvaal.

*Month**	*Point frequency analysis*			*Visual estimate*		
	Sample Size	*Percentage*		*Sample size*	*Percentage*	
		Plant	*Insect*		*Plant*	*Insect*
January	3	99	1	0		
March	1	79	21	0		
April	4	99	1	5	80	20
May (Rustenburg)	0			6	91	9
June	0			2	63	37
July	0			1	15	85
August (Limpopo River)	3	42	58	2	25	75
September	0			7	77	23
October (Potgietersrus)	2	85	14	2	100	0
November (Thabazimbi)	6	28	70	0		
December	3	91	9	2	95	5
TOTAL	22	69	31	27	68	32

* All stomachs from Naboomspruit except where otherwise mentioned.

birds, and Stutterheim (pers. comm.) suspected them of taking eggs and nestlings of red-billed oxpeckers *(Buphagus erythrorhynchus)* in the Kruger National Park. In the present study a captive adult female who escaped once fed on a laughing dove nestling *(Streptopelia senegalensis).* However, such items probably occur rarely in the diet and bird remains were not found in any of the alimentary tracts of the present study. Jacobson (pers. comm.) noted that bush squirrels in Rhodesia fed on mopani seeds, *Colophospermum mopane,* flower buds, grass seeds, culms and bulbs and the sugary exudate of a bug on mopani leaves. He also observed them drink during the day. Dobroruka (1970) found that bush squirrels in Zambia fed on fruits of *Gyrocarpus americanus* and seeds of *Commiphora edulis.* The hair and one or two ticks in the alimentary tract of bush squirrels were probably present as a result of grooming while the bark could possibly be roughage as it appeared undigested throughout the tract in some instances, but could also have a nutritive value as Gunter & Eleuterius (1971) saw grey squirrels feed on the bark of felled water oaks, also eating lichen growing on it.

The many sightings in Class A vegetation were probably due partly to the fact that squirrels were more easily observed there. But they rarely fed in this vegetation type and merely crossed it between bush clumps. Similarly, the absence of sightings in Class D could have been due to difficulty in observing squirrels in this vegetation type and they were only once seen nervously entering this tall grass. However, the scarcity of sightings in Class C

TABLE 4

Percentage of caeca and large intestines which contained insects and seeds in 82 bush squirrels, *P.c.cepapi*, from the Transvaal.

		Large intestine		*Caecum*	
Month	*Sample size*	*Insects*	*Seeds*	*Insects*	*Seeds*
January	4	0	0	75	75
February	2	100	0	100	0
March	1	5	0	100	100
April	12	50	33	66	50
May	9	56	22	67	33
June	6	67	0	83	0
July	5	100	0	100	20
August	16	50	0	63	0
September	8	88	13	100	13
October	5	80	40	40	20
November	8	57	0	100	14
December	6	0	0	100	50

vegetation which encircled the tree clumps dividing them from Class D, suggests that bush squirrels are wary of tall, dense grass.

Sheppe & Osborne (1971) also observed bush squirrels in Zambia to inhabit the termite zone surrounding a flood plain. According to Roberts (1951) bush squirrels inhabit savannas rather than dense forests, and this holds true for the present study. Squirrels occurred on many other parts of the farm Mosdene, for example in the sandy areas where *Terminalia sericia* and *Burkea africana* were the dominant trees and where grass was relatively tall and dense though not as dense as the vlei grass (Class D above), and in Rhodesia they are partial to mopani woodland (Jacobson, pers. comm.) Bush squirrels are highly adaptable and were seen on stony hillocks with few large trees at Potgietersrus where an old inhabitant claimed they also lived in holes in the ground, in rocky crevices and in the roofs of houses. Similar adaptability was observed in American red squirrels, *Tamiasciurus hudsonicus,* nesting both in trees and holes in the ground (Smith 1968).

TABLE 5

Insect food from stomach contents of 82 bush squirrels, *P.c.cepapi*, collected during 1973/74 in the Transvaal.

Month	*Insects*		
April	Isoptera	:	Probably *Hodotermes* workers
June	Isoptera	:	Termitidae
	Hemiptera	:	Aphididae
July	Isoptera	:	Termitidae
	Hymenoptera	:	Formicidae
August	Isoptera	:	Termitidae
	Hemiptera	:	Aphididae
September	Isoptera	:	Termitidae
	Odontotermes latericius		
October	Isoptera	:	Termitidae
	-winged *Hodotermes*		
November	Isoptera	:	Termitidae
	Odontotermes latericius		
	Diptera	:	Muscaridae and Calliphoridae
	Coleoptera	:	Chrysomelidae
	Hymenoptera	:	Formicidae

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REFERENCES

DELANY, M J 1972. The ecology of small rodents in tropical Africa. *Mammal Rev.* 2: 1-42.

DOBRORUKA, L J 1970. Behaviour in the bush squirrel, *Paraxerus cepapi* (A Smith, 1836). *Revue Zool. Bot. afr.* 82: 131-141.

GUNTER, G & ELEUTERIUS, L 1971. Bark-eating by the common gray squirrel following a hurricane. *Am. Midl. Nat.* 85:235.

NIXON, C M 1970. Insects as food for juvenile gray squirrels. *Am. Midl. Nat.* 84: 283.

RAHM, U 1972. Note sur la répartition, l'écologie et le régime alimentaire des Sciuridés au Kivu (Zaïre). *Revue Zool. Bot. afr.* 85: 321-339.

ROBERTS, A 1951. *The mammals of South Africa.* Johannesburg: the mammals of South Africa book fund.

SHEPPE, W & OSBORNE, T 1971. Patterns of use of a flood plain by Zambian mammals. *Ecol. Monogr.* 41: 179-205.

SHORTRIDGE, G C 1934. *The mammals of South West Africa.* Vol. 1. London: Heinemann.

SMITH, C C 1968. Adaptive nature of social organization in the genus of tree squirrels *Tamiasciurus. Ecol. Monogr.* 38: 31-63.

SMITHERS, R H N 1971. *The mammals of Botswana.* Salisbury: National Museums of Rhodesia.

TARBOTON, W 1971. Birds of Mosdene Private Nature Reserve, Naboomspruit. *S. Afr. Avifauna Ser. P. Fitzpatrick Inst. afr. Orn.* 78: 1-52.

VILJOEN, S 1975. Aspects of the ecology, reproductive physiology and ethology of the bush squirrel, *Paraxerus cepapi cepapi* (A Smith, 1836). MSc. thesis, University of Pretoria.