# Diet of bat-eared foxes *Otocyon megalotis* in the Karoo

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The diet of bat-eared foxes *Otocyon megalotis* was studied from March 1988 to September 1989 at two sites near Beaufort West in the central Karoo. In a near-natural habitat (Karoo National Park), insects and wild fruit contributed almost equally to the diet, while more insects than plant material were consumed on a sheep farm (Saucyskuil). Adult and larval Coleoptera (KNP) and Orthoptera (Saucyskuil) were predominantly preyed upon in an opportunistic manner, influenced by food availability. A higher volume of Isoptera was consumed at Saucyskuil, suggesting higher availability in the farming area.

Key words: diet, bat-eared foxes, *Otocyon*, Karoo.

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## Introduction

Bat-eared foxes, *Otocyon megalotis* (Desmarest), are distributed throughout the semi-arid regions of East and southern Africa (Kingdon 1977; Smithers 1983). Their habitats range from dry open plains (Lamprecht 1979) and shrubby grassland (Malcolm 1986) to karoo scrub and open woodland (Smithers 1983). As the only truly insectivorous member of the Canidae (Gittleman 1985) they prey predominantly on harvester termites *Hodotermes mossambicus* (Hagen) (Bothma 1966; 1971; Nel 1978; Lamprecht 1979; Smithers 1983; Malcolm 1986; Nel & Mackie 1990) or *Microhodotermes viator* (Latreille)(Macdonald & Nel 1986). Ants and beetles, sunspiders, and plant material e.g. berries of *Grewia flava* D.C., form a lesser proportion of their diet (Waser 1980; Berry 1981; Macdonald & Nel 1986). The Karoo is the largest and "most characteristically South African ... terrestrial ecosystem" (Cowling *et al.* 1986) and with an average annual rainfall of less than 500 mm (Venter *et al.* 1986) it is a suitable habitat for harvester termites (Coaton & Sheasby 1975).

Harvester termites, *Hodotermes mossambicus*, are responsible for widespread losses in pasture (Coaton 1958; Nel 1967; Nel & Hewitt 1969) and any significant impact of bat-eared foxes on populations of these termites would be of great economic importance. Nel & Mackie (1990) estimated that, in the Orange Free State, foxes consume approximately 40 500 termites per ha per year and because they feed on these termites throughout the year they should be conserved as natural predators of a significant part of the foodchain in semi-arid regions (Kok 1989; Kok & Hewitt 1990). The present study aimed to determine (a) whether in the Karoo, as in other areas previously reported on, bat-eared foxes feed predominantly on harvester termites, and (b) what the magnitude of this predation amounts to. To establish this, faecal droppings of bat-eared foxes were analysed to compare the foxes' diet under farming and near-natural conditions. Food availability was also documented to determine whether, as stated by previous authors, any prey preference existed, or whether the foxes fed opportunistically.

This study was part of a project on harvester termites initiated by the Department of Agriculture, South Africa.

## Study area

The study was conducted during 1988 and 1989 on the Sandrivier section of the Karoo National Park near Beaufort West (32°21′S, 22°35′E) and on the sheep farm Saucyskuil ca. 30 km southeast of Beaufort West. The mean annual rainfall at Beaufort West amounts to about 200 mm, mostly in summer.

The mean daily minimum and maximum temperatures for January and July are 15,8°C and 32,1°C and 4,7°C and 18,2°C respectively (Weather Station, Beaufort West).

Sandrivier was proclaimed part of the Karoo National Park in 1987 and is situated west of the Nuweveld mountain range. The plant cover can be divided into plains veld (mainly *Stipagrostis obtusa* (Del.) Nees and *S. ciliata* (Desf. ) De Winter), riverine bush (predominantly *Acacia karroo* Hayne, *Lycium* L. sp. and *Diospyros* L. sp.,) grasses like *Cenchrus ciliaris* and *Fingerhuthia africana*Lehm.) and ridge veld (*Grewia robusta* Burch.) (H.H. Braack *pers. comm.*).

Saucyskuil represents a farming area and is covered by plains veld only. The most common plants include *Stipagrostis* sp., the "kriedoring" (*Lycium* sp.) and "doringvygie" (*Eberlanzia triticiformis* (L. Bol.) L. Bol.).

## Materials and methods

Only fresh, i.e. wet and glistening, or still moist underneath where in contact with the soil and thus less than 1 week old, and intact faecal droppings of bat-eared foxes, identified by the size and blunt ends, were collected. This was done once a month from June 1988 to March 1989 at the two study areas. The scats were oven dried at 70°C to a constant mass, teased apart and 10% of the volume subsequently examined under a stereomicroscope. Prey present was analised to order and, whenever possible, to family level. Termites (Isoptera) were identified to species, while ants (Hymenoptera) were recognisable to genus. Both orders were identified using head capsules, mandibles, or both. Harvester termite mandibles (both soldier and worker castes) were counted to estimate numbers consumed by foxes.

Food availability was determined using the following methods:

- a light-trap, consisting of a 200 W bulb centred on a partially covered aluminium pot, the walls of which were sprayed with "Antguard" (Coopers, South Africa). The light-trap stood 300 mm above ground near riverine vegetation (the bat-eared foxes' habitat) and was operated, weather permitting, three nights per month. Insects captured were transferred to bottles and later identified. Changes in ambient temperature and wind speed during these nights (which resulted in changing prey availability) were noted and compared with the feeding behaviour of bat-eared foxes.
- sticky-traps; 10 linoleum tiles (250 mm x 250 mm) covered with "Plantex" (ICI-Kynoch Agrochemicals Pty (Ltd.), South Africa) were set each month for a 24-h period. The traps were placed 30 m apart in riparian vegetation and plains veld, in the known home ranges of bat-eared foxes.
- yellow plastic bowls (diameter = 160 mm, depth = 40 mm); 10 bowls were filled with water and a few drops of dishwashing liquid added to break the surface tension of the water. They were placed on the same transect as the sticky-traps.

Organisms collected were identified to family level if possible and subsequently used for comparison with items in the scats. Plant material, e.g. berries occurring on bushes or trees in the home range of the foxes, was regarded as available when ripe and accessible.

The results from the two study sites were compared statistically to indicate possible differences in prey composition of foxes living under near-natural conditions and in a farming region. Seasonal differences in the diet were also analysed statistically. Owing to the heterogeneity (*F*-test for heterogeneity of variances) of some samples the *U*-test of Mann-Whitney was regarded as most suitable, while the *t*-test was used for remaining data.

The data were divided into winter (May-September) and summer (October-April).

## Results

### *Diet*

The diet consisted of invertebrates (mainly insects) and berries but not in equal amounts at the two study sites (Figures 1 and 2). Particular prey taxa also did not have the same percentage occurrence at a particular time at the two sites (Figure 3).

### Sandrivier

Based on volumetric analysis the overall diet of foxes at Sandrivier consisted of nearly equal amounts of insects and plant material (Figure 1). Coleoptera, both adults and larvae, contributed the bulk of the insect component in both winter and summer, while the amount of Isoptera and Orthoptera dropped substantially from winter to summer. Ants (Fam. Formicidae) contributed little to the diet. On a percentage occurrence basis (Figure 3) Isoptera, Orthoptera and Coleoptera (adults and larvae) were eaten most fre-

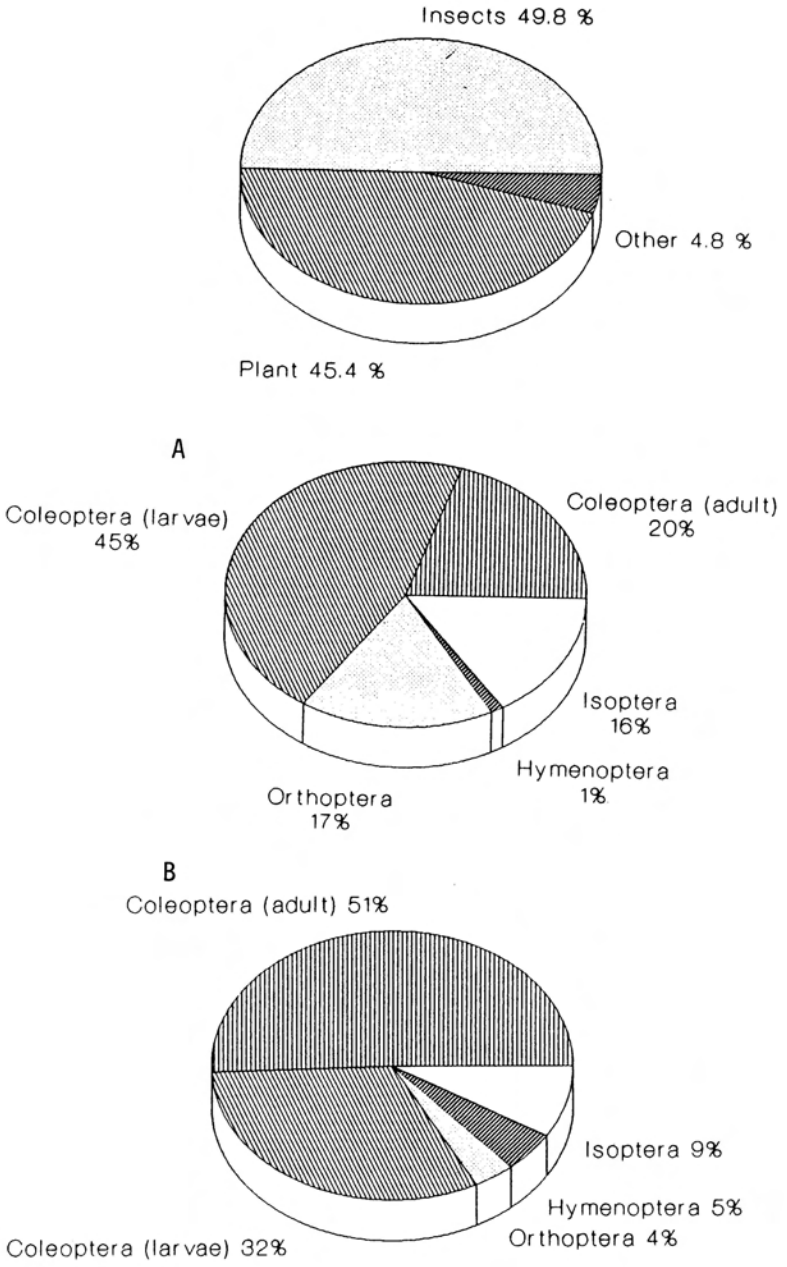



Fig. 1. The diet of bat-eared foxes at Sandrivier, Karoo National Park. "Other" includes own hair, sand, and reptile remains. The top diagram shows overall diet. The composition of the insect component in the diet is shown for the winter of 1988 (A) and the summer of 1988/1989 (B).

Table 1
*Mean volume (%) of food items in the faeces of bat-eared foxes at Sandrivier during winter 1988 and summer 1988/89. Standard deviations in parentheses.* n = *number of faecal droppings*

| | Winter | Summer | |
|---|---|---|---|
| *n* | 39 | 67 | |
| Total insects | 33.4 (28.3) | 58.6 (30.1) | $t = 4.07$, $df = 104$, $P < 0.001$ |
| Plant material | 64.0 (28.6) | 35.4 (29.5) | $t = 4.48$ $df = 104$ $P < 0.001$ |
| Isoptera | 5.1 (10.0) | 5.1 (9.0) | $t = 0.36$ $df = 104$ $P > 0.05$ |

Table 2
*Mean volume (%) of food items in the faeces of bat-eared foxes at Saucyskuil during winter 1988 and summer 1988/89. Standard deviations in parentheses.* n = *number of faecal droppings*

| | Winter | Summer | |
|---|---|---|---|
| *n* | 39 | 12 | |
| Total insects | 55.6 (39.4) | 75.8 (23.5) | $t = 1.73$ $df = 49$ $P > 0.05$ |
| Plant material | 37.6 (37.3) | 15.5 (9.8) | $t = 3.33$ $df = 49$ $P < 0.01$ |
| Isoptera | 9.9 (22.6) | 9.0 (10.3) | $U = 161$ $df$ -39 $P > 0.05$ |

quently throughout the year, but as Figure 1 shows, not always in large amounts.

Of the plant material wild fruits (generally *Diospyros* sp., some *Lycium* sp.) formed the bulk of the plant material. In winter plant material predominated significantly (by volume) in the diet (Table 1) but in summer nearly 60% of the faecal droppings consisted of insects.

Saucyskuil

At Saucyskuil an even larger volume of the overall diet consisted of insects (Figure 2). Wild fruit — 64% of the plant material — belonged to the "kriedoring" (*Lycium* sp.), which is widespread in the Karoo. The same berries were also present in the stomach of the road mortality, making up approximately 95% of its contents; the rest were ants (*Camponotus* Mayr sp.). The contribution of insects to the food of bat-eared foxes at Saucyskuil varied from 55% by volume in winter to 75% by volume in summer. The seasonal difference in the consumption of insects was not significant (Table 2), but the volume of plant material in droppings decreased significantly from winter to summer. Unlike the situation at Sandrivier, however, plant material always contributed less than 50% to the total volume. As at Sandrivier, berries were the single most important food item during winter (Table 3), while Orthoptera (Acrididae) and Coleoptera larvae were the most common insects ingested during winter and summer respectively (Figure 2).

On a volumetric basis the winter diet of bat-eared foxes in the two localities differed significantly. Insects contributed a higher volume to the food intake at Saucyskuil, while plant remains, mainly wild fruit, were more heavily utilised at Sandrivier (Table 4). During summer the bat-eared foxes at both sites preyed mostly on insects. The various insect orders, in frequency of occurrence (Figure 3) and on a volumetric basis differed

Table 3
*Mean volume of the main prey items in the faecal droppings of bat-eared foxes (to the nearest %). Standard deviations in parentheses.* n = *number of faecal droppings*

| | Sandrivier | | Saucyskuil | |
|---|---|---|---|---|
| | Winter | Summer | Winter | Summer |
| *n* | 39 | 67 | 39 | 12 |
| Isoptera | 5 (10) | 5 (9) | 10 (23) | 9 (10) |
| Orthoptera | 6 (17) | 2 ( 7) | 23 (37) | 6 ( 9) |
| Coleoptera[a] | 7 (12) | 30 (31) | 4 ( 9) | 7 ( 8) |
| Coleoptera[b] | 16 (27) | 19 (26) | 13 (21) | 37 (25) |
| Wild fruit | 64 (29) | 36 (29) | 38 (37) | 16 (10) |

[a] adult Coleoptera, [b] Coleoptera larvae

Table 4
*Mean volume (%) of food items in the faeces of bat-eared foxes at Saucyskuil and Sandrivier during winter 1988. Standard deviations in parentheses.* n = *number of faecal droppings*

| | Saucys-kuil | Sand-rivier | |
|---|---|---|---|
| *n* | 39 | 39 | |
| Total insects | 55,6 (39,4) | 33,4 (28,3) | $t = 2{,}73$ $df = 76$ $P < 0{,}01$ |
| Plant material | 37,6 (37,3) | 64,0 (28,6) | $t = 3{,}23$ $df = 76$ $P < 0{,}01$ |
| Isoptera | 9,9 (22,6) | 5,1 (10,0) | $U = 641{,}5$ $df = 39$ 39; $P > 0{,}05$ |

Table 5
*Mean volume (%) of food items in the faeces of bat-eared foxes at Saucyskuil and Sandrivier during summer 1988/1989. Standard deviations in parenthese.* n = *number of faecal droppings*

| | Saucys-kuil | Sand-rivier | |
|---|---|---|---|
| *n* | 12 | 67 | |
| Total insects | 75,8 (23,5) | 58,6 (30,1) | $t = 1{,}95$ $df = 77$ $P < 0{,}05$ |
| Plant material | 5,5 (9,8) | 35,4 (29,5) | $t = 4{,}33$ $df = 52$ $P < 0{,}001$ |
| Isoptera | 9,0 (10,3) | 5,1 (9,0) | $t = 1{,}33$ $df = 77$ $P > 0{,}05$ |

between the farming and near-natural areas; a higher volume of adult Coleoptera was present in the latter case (Table 3). Plant material was ingested significantly more at Sandrivier than at Saucyskuil (Table 5).

Variation in the utilisation of some prey species, between the two areas, is possibly explained by differing preference for, and availability of, these food items (see below). Although there are no data for prey availability at Saucyskuil for the second quarter of 1989, a trend of increasing frequency of termite occurrence in the faeces of foxes at Saucyskuil, and a simultaneous decrease at Sandrivier, is apparent. As all the other prey types occurred fairly constantly throughout the seasons, higher harvester termite incidence is possibly related to greater availability. Statistically there was no significant difference in the consumption of termites between summer and winter at both sites, nor between the study areas themselves (Tables 1, 2, 4, 5). A maximum of 1 300 harvester termites per scat was found at Saucyskuil, but this was an exception as termites did not form the bulk of the diet. Their frequency of occurrence was relatively high (58% - 100% at Saucyskuil, Figure 3A), but just one dropping contained only termites.

*Food availability*

Most species caught in the light-trap belonged to the Lepidoptera. One night, however, yielded an almost exclusive catch of Coleoptera (Scarabaeidae) and another nearly only Orthoptera (Acrididae). One night 854 brown locusts *Locustana pardalina* (Walker) were attracted to the light-trap, as well as five noctuid moths. During the winter months, as well as during nights with a wind speed exceeding 5 m/s, trapping success with the light-trap was poor, i.e. <50 insects trapped per night. Catches with the sticky-traps and the water bowls indicated that wind also influenced the activity patterns of crawling insects, e.g. ants, so that few were available to the foxes. An increase in the number of insects was apparent during the warmer months, changing from approximately six families trapped per night in winter to >30 in summer (Figure 4). September 1988 and March 1989 were characterised by a high incidence of Orthoptera (Acrididae) in the light traps. Based on visual estimates locust numbers were higher at Saucyskuil, possibly because this farm lay in the flight path of swarms while Sandrivier, with surrounding mountains, was relatively protected. Scarabaeidae were most common during November to January while Carabidae peaked

(135 beetles/trap) in December at Sandrivier. Tiny spiders (Arachnida : Araneae) were commonly snared on the sticky-traps, while the more than 3 000 ants (Hymenoptera: Formicidae, mostly Dorylinae or Campinotinae) accounted for 93,5% of the total caught in the water bowls. Most Formicidae (47%) were caught during January and February.

As a result of the methods used to determine prey availability not all insects preyed upon by bat-eared foxes were collected. For example, certain beetle larvae occurred underground and were not trapped; termites, although regularly present in the scats, were seldom encountered when walking transects, and never trapped. During the study period only one termite colony was encountered at Sandrivier and two at Saucyskuil. Food availability changed markedly over relatively short periods and prevailing weather conditions (temperature, wind) and the amount of rain during the larval stages of some insects (e.g. brown locusts) were probably the decisive factors (H. Geertsema *pers. comm.*).

Wild fruit, including berries of the "kriedoring" (*Lycium* sp.), a low (<1 m) deciduous shrub, and berries belonging to a tall (>2 m) evergreen shrub (*Diospyros* sp.) ripened during summer. Plant material at Saucyskuil consisted entirely of berries of the "kriedoring" (*Lycium* sp.), while the berries at Sandrivier were almost exclusively of the genus *Diospyros*.

*Food availability and diet*

The marked changes in food availability over short periods probably explains the marked differences in contents between individual scats. On a seasonal basis particular prey species present in the faeces varied greatly (standard deviation repeatedly greater than the mean) in contributing to the total volume of scats. When comparing the abundance of the major prey items with their occurrence in faecal droppings, a general preference for insects was noticeable in the diet during the summer months, when these were more abundant. A strong correlation ($r > 0,9$ $P < 0,1$) between food availability and composition of the diet at Saucyskuil and Sandrivier was evident only in the case of ants (Formicidae) and to a lesser degree ($r = 0,851$ $P < 0,25$) at Saucyskuil as far as locusts (Orthoptera) are concerned. A relationship between the availability of beetles and their consumption was lacking ($r < 0,7$ $P > 0,5$). High availability (> 10% of total insects trapped) of specific Coleoptera families during single months, however, was reflected in increased consumption of those beetles by the foxes. During December 1988, for example, beetles belonging to the family Scarabaeidae were caught in large numbers (215 / trapnight) in the light-trap and a significant increase (22% to 64% by volume) in scarabaeid remains ($\chi^2 = 158,44$ $df = 4$ $P \approx 0$) in the faeces compared to the previous month was evident at Sandrivier. A less marked increase occurred at the same site when brown locusts (Orthoptera: Acrididae) were readily available. The drop in the amount of locusts eaten during March 1989, when trapping indicated exceptionally high locust numbers, could be explained by the simultaneous high availability and consequent abundance of berries (*Diospyros* sp.) in the diet (61% average volume, $n = 8$). At Saucyskuil, however, Orthoptera occurred in all faecal droppings collected during the first quarter of 1989 (Figure 3B). Here, no berries were available at that stage and the foxes had to rely on other prey, e.g. locusts.

The difference in the availability to foxes of berries at the two sites could be accounted for by the varying height of shrubs carrying the fruit. At Saucyskuil the "kriedoring" bushes were relatively low (< 500 mm) and once the berries were ripe, they were readily accessible. At Sandrivier, on the other hand, *Diospyros* was a tall shrub (> 2 m) and berries were only eaten once they fell to the ground. This also explained the absence of berries during the fourth quarter of 1988 in the scats of bat-eared foxes at Saucyskuil (Figure 3F).

At Saucyskuil a swarm of brown locusts led to an increase in volume of Orthoptera in faeces from 17% ($n = 10$) in August to 32% ($n = 11$) during September 1988, with a subsequent drop to 1% ($n = 7$) in November, after

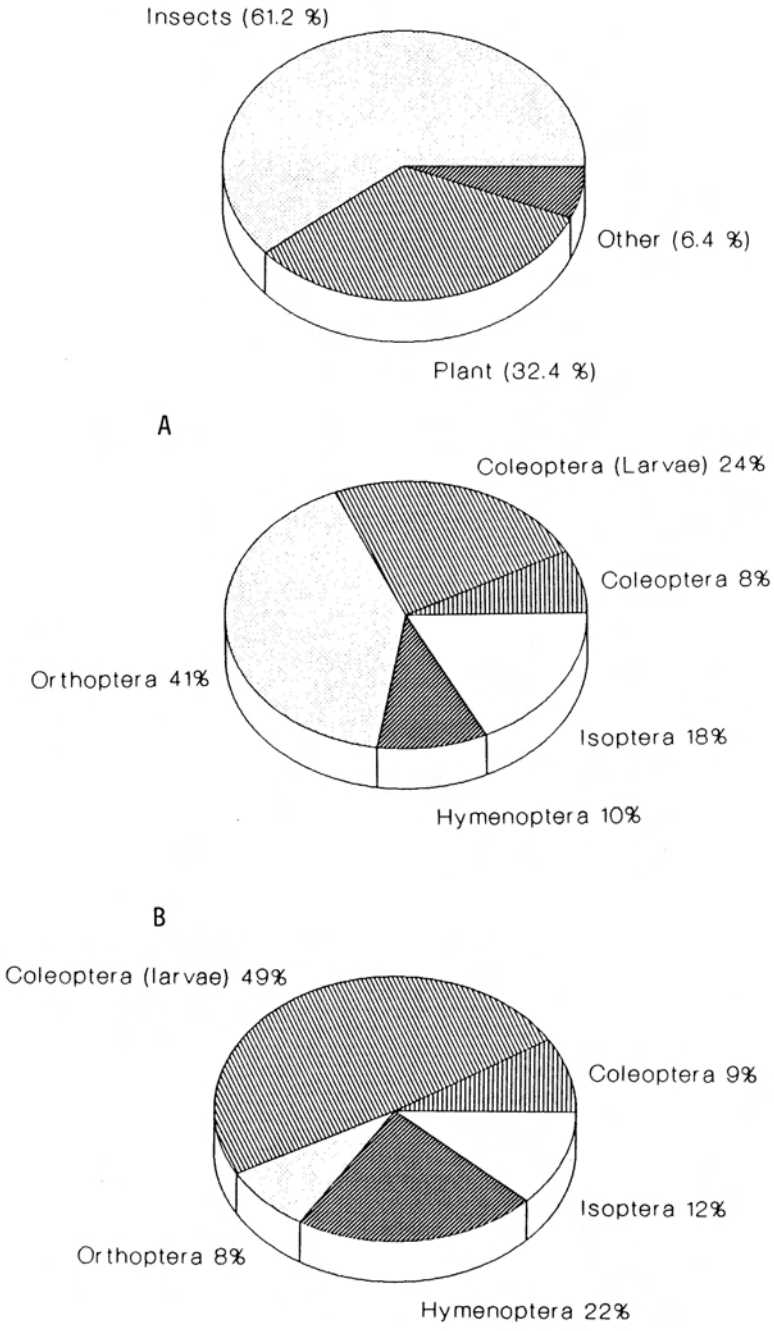



Fig. 2. The diet of bat-eared foxes at Saucyskuil. "Other" includes own hair, sand, and reptile remains. The top diagram shows overall diet. The composition of the insect component in the diet is shown for the winter of 1988 (A) and the summer of 1988/1989 (B).

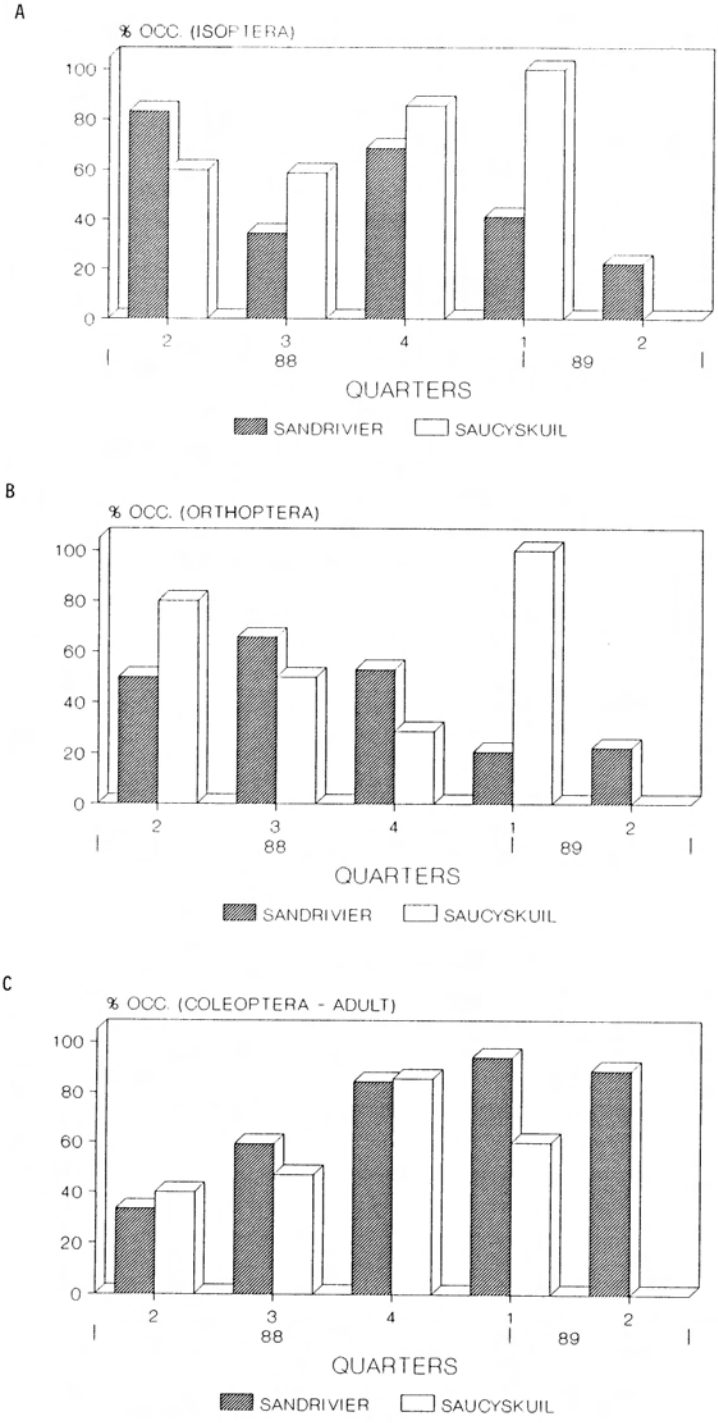
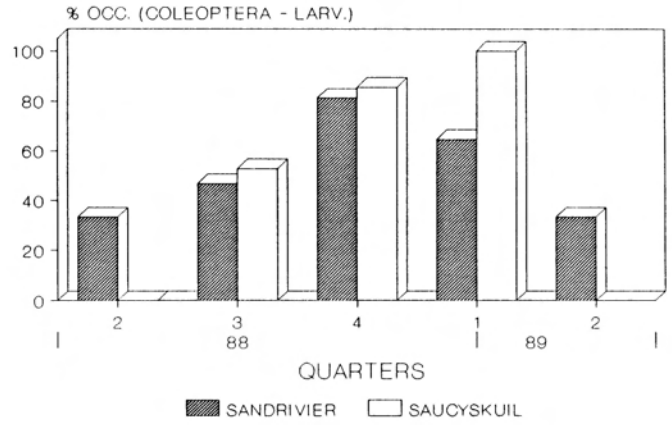



Fig. 3. The percentage frequency of occurrence of the major food items in the faeces of bat-eared foxes in the Karoo: A) Isoptera, B) Orthoptera, C) Coleoptera (adults), D) Coleoptera (larvae), E) Hymenoptera and F) berries. Quarters: 1= January-March; 2= April-June; 3= July-September; 4= October to December.

D

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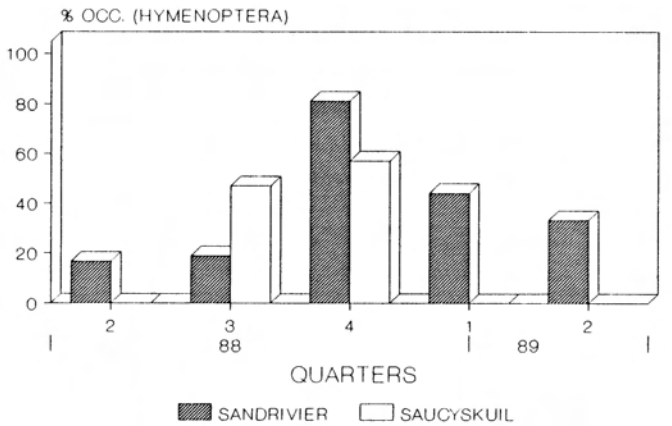


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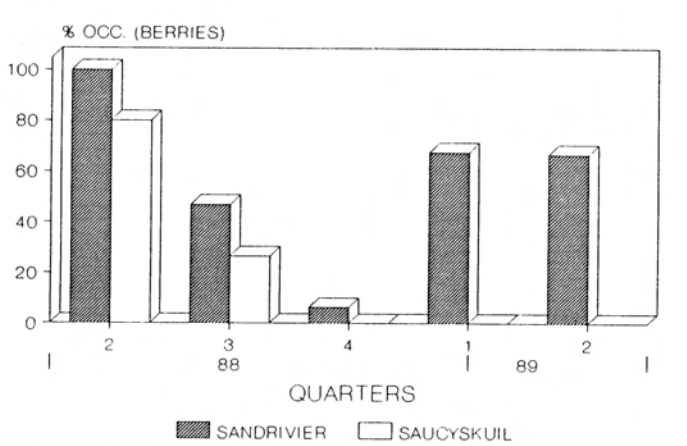


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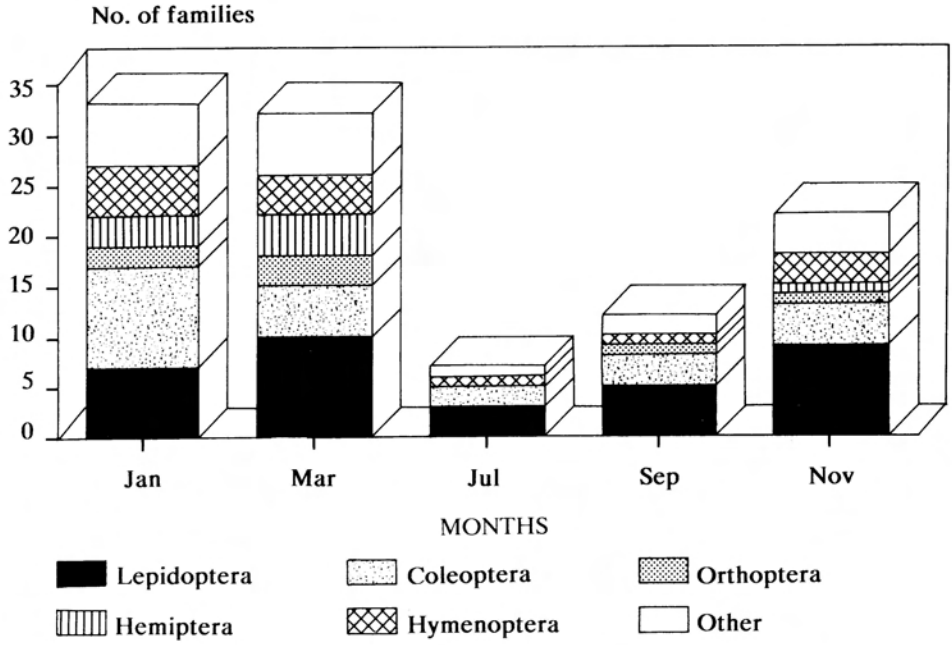


Fig. 4. The availability of insects to bat-eared foxes, as indicated by the number of insect families trapped per 24-h period in the Karoo during 1988-1989 using a light-trap, sticky-traps, and yellow bowls filled with water. "Other" includes the families Mantodea, Blattodea, Neuroptera, Diptera and Phasmatodea.

the swarm had passed. This locust infestation contributed 41% to the estimated volume of faeces analysed for winter 1988 at Saucyskuil (Figure 2). During the same period locusts occurred in 66% of the faecal droppings at Sandrivier (Figure 3B), and contributed 17% to the volume of the droppings.

Ants (Hymenoptera: Formicidae) were increasingly common throughout summer, showing a peak in activity during January and February. This abundance was clearly reflected by their contribution to the diet of the foxes during summer at Sandrivier and Saucyskuil (Figures 1 and 2 respectively). During winter when insect abundance was relatively low (i.e. < 400 insects trapped per 24h), bat-eared foxes in the Karoo National Park relied mainly on subterraneous beetle larvae, which they dug out.

## Discussion

In this study both volumetric composition and frequency of occurrence methods were used during analysis of droppings. Composition by volume, even though prone to serious bias (Kruuk & Parish 1981) because the size of prey items and their digestibility vary greatly, (thus leading to higher contributions by large and poorly digestible prey), in conjunction with percentage frequency of occurrence does indicate the amount (if not numbers) eaten. Although the families of insects eaten by bat-eared foxes in the Great Karoo are similar to earlier findings in other regions (e.g. Bothma 1966; Nel 1978; Lamprecht 1979; Waser 1980; Smithers 1983; MacDonald & Nel 1986; Malcolm 1986; Mackie 1988) their degree of importance differed, while the high occurrence of

wild fruit was unusual. Although plant material has been mentioned as part of the foxes' diet (Nel 1978; MacDonald & Nel 1986) and the contents of the single stomach from Fraserburg in the Karoo, analised by Viljoen & Davis (1973), contained mostly berries, usage was not to such an extent as found in this study. Wild fruits contributed the bulk of the diet during winter in the Sandrivier section of Karoo National Park. Although the decrease in plant material from winter to summer was similar at both study sites, bat-eared foxes at the sheep farm Saucyskuil always fed on a higher proportion of insects. The only significant difference in the diet of foxes in the two sites was the high occurrence of wild fruit in the diet of those at Sandrivier. The feeding habits of bat-eared foxes in the Great Karoo seems to be catholic to such an extent that it would be incorrect to classify them as "truly insectivorous" (Gittleman 1985). This is substantiated by their selective feeding behaviour during the first quarter of 1989, for example, when locusts were present in large quantities, but preference was given to wild fruit.

Bat-eared foxes, therefore, are not specialised feeders, which could limit the range of acceptable food items on which they could depend throughout the year. This is the case with e.g. the aardwolf *Proteles cristatus* (Sparrman) which feeds almost exclusively on *Trinervitermes* Holmgren termites and subsequently suffers from a food shortage during winter as they are unsuccessful in exploiting other resources (Richardson 1987a, 1987b).

A preference for the harvester termite *Hodotermes mossambicus* has been noted previously for bat-eared foxes (Bothma 1966; Nel 1978; Berry 1981; Malcolm 1986). A "close ecological association" (Berry 1981) has been suggested to exist between foxes and harvester termites and Mackie (1988) showed the large overlap in their respective distributions, while Nel (1990) pointed out that foraging activity in bat-eared foxes coincides with the temporal availability of these termites. As harvester termites formed only a small part of the foxes' diet in the Karoo, a preference for this prey type was not apparent in the present study. In our study area, in contrast to the southeastern Orange Free State (Nel & Mackie 1990), therefore, bat-eared foxes are not major predators on termites even though they feed on them throughout the year. This could be due to fewer termites being available in the central Karoo, or alternatively a larger variety of other insects, or wild fruits available to the foxes. Direct observations indicated that foxes, when berries were available at Sandrivier, moved in a straight line from their den to the berry trees, even lying down underneath these trees till berries dropped. This is of course energetically far less expensive than foraging for termites or other insects, even though berries could be lower in energy value than insects.

## Acknowledgements

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