# DIET AND FORAGING BEHAVIOR OF BLANFORD'S FOXES, *VULPES CANA*, IN ISRAEL

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**Blanford's fox, *Vulpes cana*, was discovered in Israel in 1981, and has not been studied systematically in the wild. Herein we document diet and related aspects of its ecology at two study sites, 300 km apart. Feces ($n$ = 344) collected from known individual Blanford's foxes revealed that invertebrates and plant material were major foods. In Eilat Mountains Nature Reserve (by the Red Sea) 98.1% and in Ein Gedi (by the Dead Sea) 92.5% of all samples contained remains of invertebrates. Frequencies of occurrence of plant material in the feces ranged between 60–70%, and in Eilat Mountains Nature Reserve 50% of those samples contained seeds of the caperbush, *Capparis cartilaginea*. Remains of vertebrates averaged 12%. No differences in diet composition were detected between seasons or sexes within each location, but significant differences were found between the two locations. Diet did not differ significantly between neighboring pairs.**

**Key words:** ***Vulpes*, foraging behavior, diet composition, Israel**

Blanford's fox, *Vulpes cana*, recently was discovered in Israel (Ilany, 1983). Previously, this small canid (ca. 1 kg) had been reported from scattered locations in Afghanistan, Pakistan, and Iran (Heptner and Naumov, 1974), and little was known of the habits and status of *V. cana* (Ginsberg and Macdonald, 1990). Roberts (1977) reported that, in Pakistan, Blanford's fox is confined to warm mountainous regions characterized by barren, rocky hills. In Israel, it occupies steep, rocky, mountain slopes and canyons in the Judaean and Negev deserts (Mendelssohn et al., 1987). In Pakistan, Roberts (1977) reported that it was largely frugivorous. His anecdotal data suggested that Russian olive, *Eleagnus bortensis*, melons, and grapes frequently are eaten by Blanford's foxes. He also reported a single observation of a Blanford's fox consuming locusts. In Israel, Blanford's fox was reported to be highly insectivorous (Ilany, 1983).

Herein, we present comparative data on the diet of Blanford's fox at two sites in Israel. The data were gathered during a 3-year study of radiocollared Blanford's foxes (Geffen, 1990).

## STUDY AREA AND METHODS

The study was conducted during 1986–1988 at the Central Judaean Desert Reserve, near Ein Gedi (31°28′N, 35°23′E, elev. 350–100 m below sea level) and in the Eilat Mountains Nature Reserve near Netafim Creek (29°35′N, 34°53′E, elev. 500–800 m above sea level). Study areas at Ein Gedi and Eilat Mountains Nature Reserve covered 25 km$^2$ and 36 km$^2$, respectively. Both locations were characterized by steep, rocky, mountain slopes, deep canyons, and sheer cliffs. The dominant rock formation at Ein Gedi was limestone, at Eilat Mountains Nature Reserve it was a mixture of limestone, sandstone, metamorphic rock, and granite (Karta, 1985).

The sites differed with respect to water supply. At Ein Gedi, there were four large springs and two canyons with permanent streams. The vegetation was typically Saharo-Arabian and trop-

ical in origin. Along the water courses, vegetation cover reached 100%, but was only 0.5–10% on the surrounding slopes and cliffs. At Eilat Mountains Nature Reserve there was only one dripping spring. The water from that spring was collected into a concrete basin built by Bedouin.

Both sites were located in a hot and dry zone. At Eilat Mountains Nature Reserve, maximum average summer temperatures reached 39°C, mean relative humidity dropped to 24%, and mean annual precipitation was 25 mm. Although Ein Gedi endures similar means in summer temperature (38.9°C) and relative humidity (29%), average annual precipitation was higher (81 mm—Karta, 1985). The Eilat Mountains Nature Reserve site was less productive than the site at Ein Gedi.

Ten collapsible Tomahawk traps (80 by 22 by 22 cm) were deployed at each study site. The traps were scattered in canyons and on rocky slopes, and sheltered by large boulders. Most traps were left in situ for 2–3 years. The traps were set at approximately monthly intervals for 3–6 days at a time, baited with dead chicks and monitored during the mornings of each trapping session. Captured foxes were sexed, fitted with numbered ear tags, and released. Eleven adult foxes in Ein Gedi and five in Eilat Mountains Nature Reserve were fitted with radiocollars (transmitter weight, 60 g, Wildlife Materials, Inc.) equipped with motion-sensitive switches. Feces were collected exclusively from trapped animals. Feces from one captured fox were recorded as one sample. We assumed that each sample represented the type of prey consumed by that fox during the 12 h before its capture. The samples were stored in separate plastic bags and frozen until analyzed.

Each sample was washed through a 300 $\mu$m sieve and remains identified using a dissecting microscope. Invertebrates were identified to ordinal level and vertebrates to generic or specific level. The abundance of crushed fragments of invertebrates precluded use of volumetric estimation methods or correction factors (Lockie, 1959; Putman, 1984). The analyses presented herein were based on frequencies of occurrence (presence or absence in samples). This measure of diet composition has been used for insectivorous mammals, for which it is thought to be reliable if data are expressed as the number of individuals shown to eat a particular prey (Dickman and Huang, 1988). In comparing between different locations and seasons, we combined related food categories to insure that sample sizes were adequate for chi-square tests (Siegel and Castellan, 1989).

The relative seasonal availability of invertebrates at Ein Gedi was estimated by use of sticky traps. Sticky traps were made of square yellow plastic plates (15 by 25 cm) covered with a thin layer of glue. The glue had no known pheromonal effect. Sticky traps are assumed to randomly sample ground-dwelling invertebrates. Twice a month, coinciding with the full and new phases of the moon, five sticky traps were set in the evening, within 1 m of bushes, at selected sites in gravel and boulder scree and dry creekbed habitats. These traps were collected at dawn the next morning and all invertebrates identified to ordinal level and counted. The indices of abundance were calculated as monthly percentages of the number of beetles and ants and compared with the occurrence of these groups in feces of foxes (Kolmogorov-Smirnov test—Siegel and Castellan, 1989). Results from October were excluded because only one sample was collected. Mean numbers of beetles and ants collected nightly were transformed to their square root for two-way analysis of variance (Sokal and Rohlf, 1981).

To study foraging behavior of Blanford's foxes we radiotracked a selected individual fox per night from 1 h before sunset to 1 h after sunrise or later if it was still active. A headlamp and binoculars or light-intensifer goggles (El-Op, Rehovot, Israel) were used to watch foxes, which were relatively tame and tolerant to our presence. We also offered food (300–500 g, dead domestic hen chicks and omelets) to wild free-ranging Blanford's foxes. Our aim was to document patterns of food caching behavior in Blanford's foxes. The food was placed on a trail, which was used regularly by the foxes, and observed from a distance of 20 m.

## Results

A total of 241 and 103 fecal samples were collected at the Ein Gedi and Eilat Mountains Nature Reserve study sites, respectively. At Ein Gedi, we collected one to 10 samples from each of 21 different foxes, 10–20 samples from each of another five foxes, and 20–30 samples from each of another three foxes. At Eilat Mountains Nature Reserve, one to 10 samples were collected from

TABLE 1.—*Frequency of occurrence (% in samples) of various types of food found in feces of Blanford's foxes at Ein Gedi and Eilat Mountains Nature Reserve. Summer, April–September; Winter, October–March..*

| | Total | | Ein Gedi | | Eilat | | Ein Gedi | | Eilat | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ein Gedi | Eilat | Males | Females | Males | Females | Summer | Winter | Summer | Winter |
| Number of samples | 241 | 103 | 86 | 155 | 58 | 43 | 103 | 138 | 48 | 53 |
| Type of food | | | | | | | | | | |
| Coleoptera | 62.7 | 66.0 | 74.4 | 55.8 | 65.5 | 69.8 | 57.3 | 65.9 | 60.4 | 73.6 |
| Orthoptera | 30.3 | 76.7 | 26.7 | 32.1 | 75.9 | 81.4 | 32.0 | 29.0 | 81.2 | 75.5 |
| Formicidae | 36.9 | 14.6 | 46.5 | 31.4 | 15.5 | 14.0 | 42.7 | 32.6 | 12.5 | 17.0 |
| Isoptera | 24.1 | 12.6 | 17.4 | 27.6 | 12.1 | 14.0 | 31.1 | 18.1 | 18.8 | 7.5 |
| Other insects | 20.7 | 31.1 | 25.6 | 17.9 | 27.6 | 37.2 | 22.3 | 19.6 | 39.6 | 24.5 |
| Scorpions | 19.5 | 10.7 | 24.4 | 16.7 | 8.6 | 14.0 | 22.3 | 17.4 | 8.3 | 13.2 |
| Other invertebrates | 10.8 | 6.8 | 11.6 | 10.3 | 5.2 | 9.3 | 11.7 | 10.1 | 6.2 | 7.5 |
| Vertebrates | 10.4 | 14.6 | 11.6 | 9.6 | 10.3 | 20.9 | 11.7 | 9.4 | 25.0 | 5.7 |
| Plant material | 44.4 | 19.4 | 41.9 | 45.5 | 24.1 | 14.0 | 48.5 | 41.3 | 14.6 | 24.5 |
| Seeds or fruits | 36.9 | 57.3 | 36.0 | 37.2 | 51.7 | 67.4 | 48.5 | 28.3 | 68.8 | 49.1 |
| Trash | 12.4 | 18.4 | 12.8 | 12.2 | 15.5 | 23.3 | 8.7 | 15.2 | 16.7 | 20.8 |

each of 17 different foxes and 10–20 samples from each of another three foxes.

In Ein Gedi and Eilat Mountains Nature Reserve, 92.5 and 98.1% of the fecal samples contained insects, 25.3 and 17.5% contained other invertebrates, and 63.9 and 67.9% contained plant material, respectively (Table 1). In Ein Gedi and Eilat Mountains Nature Reserve, 29.5 and 20.4% of the samples consisted entirely of invertebrates ($Z = 1.74, P > 0.05$), 5.0 and 1.0% consisted only of plant material ($Z = 1.31, P > 0.05$), and 46.5 and 42.7% consisted of a mixture of plant material and invertebrates ($Z = 0.64, P > 0.05$), respectively. Food items eaten by Blanford's foxes were organized into the following food categories.

*Insects and other invertebrates.*—Orthoptera were represented mainly by crickets (Gryllidae) and grasshoppers (Locustidae). Large numbers of winged ants were found in 5.1% of the samples collected at Ein Gedi during the winter (October–March) and large numbers of harvester termites, *Anacanthotermes ubachi,* in 12.6% of the samples collected during the warmer months (April–September). Remains of a large (150–200 mm) species of scorpion, *Nebo hierichonticus,* also were observed.

*Reptiles, birds, and mammals.*—Reptiles were found in 0.4 and 6.8% of the samples collected at Ein Gedi and Eilat Mountains Nature Reserve, respectively. The only reptile that we were able to identify was the dabb lizard, *Uromastyx ornatus.* Its skin fragments were found in three samples collected at Eilat Mountains Nature Reserve. Of the samples collected at Ein Gedi and Elat, 3.7 and 3.9% respectively, contained birds. Identifiable remains principally were blackstart, *Coromela melanura,* and white-crowned black wheatear, *Oenanthe leucopyga,* both being common ground-dwelling species. We also observed a male fox catch a Tristram's grackle, *Onycognattus tristramii.* Mammals were found in 5.4 and 3.9% of the samples collected at Ein Gedi and Eilat Mountains Nature Reserve, respectively. Most mammalian remains were of rodents, principally the Egyptian spiny mouse, *Acomys cahirinus.* Remains of the bushy tailed jird, *Sekeetamys calurus,* were identified once. In Eilat Mountains Nature Reserve, we found remains of Cape hare, *Lepus capensis,* and of a newborn ibex, *Capra ibex nubiana,* near an active den. Remains of another newborn ibex were found in one sample.

TABLE 2.—*Frequency of occurrence (% in samples) of various types of food found in feces of five pairs of Blanford's fox at Ein Gedi and two pairs at Eilat Mountains Nature Reserve.*

| | Ein Gedi | | | | | Eilat | |
|---|---|---|---|---|---|---|---|
| Type of food | Pair 1 | Pair 2 | Pair 3 | Pair 4 | Pair 5 | Pair 1 | Pair 2 |
| Coleoptera | 67.4 | 62.5 | 76.9 | 59.1 | 53.1 | 47.1 | 75.8 |
| Orthoptera | 28.6 | 41.7 | 30.8 | 36.4 | 18.8 | 100.0 | 66.7 |
| Formicidae | 36.7 | 45.8 | 38.5 | 18.2 | 31.2 | 23.5 | 15.1 |
| Vespeidae | 4.1 | 8.3 | 23.1 | 13.6 | 15.6 | 29.4 | 15.1 |
| Isoptera | 20.4 | 16.7 | 30.8 | 36.4 | 31.2 | 17.6 | 15.1 |
| Diptera | 2.0 | 8.3 | 0.0 | 9.1 | 0.0 | 5.9 | 0.0 |
| Other insects | 8.2 | 12.5 | 0.0 | 4.5 | 0.0 | 29.4 | 27.3 |
| Scolopendromorpha | 12.2 | 12.5 | 0.0 | 0.0 | 0.0 | 17.6 | 12.1 |
| Araneae | 0.0 | 8.3 | 0.0 | 0.0 | 3.1 | | |
| Scorpions | 32.7 | 41.7 | 0.0 | 9.1 | 6.2 | 17.6 | 15.1 |
| Solifugae | 0.0 | 0.0 | 0.0 | 4.5 | 0.0 | | |
| Reptilia | 0.0 | 4.2 | 0.0 | 0.0 | 0.0 | 29.4 | 3.0 |
| Aves | 0.0 | 8.3 | 7.7 | 9.1 | 6.2 | 5.9 | 6.1 |
| Mammalia | 8.2 | 0.0 | 0.0 | 9.1 | 0.0 | 5.9 | 3.0 |
| Plant material | 32.7 | 41.7 | 30.8 | 40.9 | 37.5 | 5.9 | 33.3 |
| Seeds or fruits | 28.6 | 20.8 | 38.5 | 40.9 | 18.8 | 76.5 | 33.3 |
| Trash | 12.2 | 8.3 | 7.7 | 0.0 | 6.2 | 11.8 | 21.2 |
| *Ibex* feces | 2.0 | 0.0 | 7.7 | 13.6 | 9.4 | | |
| Number of samples | 49 | 24 | 13 | 22 | 32 | 33 | 18 |

*Plant material and trash.*—The most common plant remains were seeds of the caperbush, *Capparis spinosa,* in Ein Gedi and *Capparis cartilaginea* in Eilat Mountains Nature Reserve, represented in 50% of the samples in Eilat Mountains Nature Reserve containing plant material. Fruits and plant material of *Phoenix dactylifera, Ochradenus baccatus, Fagonia mollis* and various species of Gramineae also were found. Undigested remains of food scavenged from the leftovers of occasional hikers included plastic bags, silver paper, and seeds of apples or melons.

Within each site no statistically significant differences in diet composition were detected between sexes ($\chi^2 = 10.95$, $d.f. = 10$, $P > 0.05$ at Ein Gedi and $\chi^2 = 5.07$, $d.f. = 10$, $P > 0.05$ at Eilat Mountains Nature Reserve) or seasons ($\chi^2 = 12.34$, $d.f. = 10$, $P > 0.05$ at Ein Gedi and $\chi^2 = 14.60$, $d.f. = 10$, $P > 0.05$ at Eilat Mountains Nature Reserve), but significant differences were detected between sites ($\chi^2 = 52.48$, $d.f. = 10$, $P < 0.001$ in summer and $\chi^2 = 33.65$, $d.f. = 10$, $P < 0.001$ in winter; Table 1). Blanford's foxes were socially organized into pairs where both members of each pair shared the same home range (Geffen, 1990). Size of home range and configuration was known for most of the foxes from which we collected samples. Significant differences in diet composition between pairs were not detected at Ein Gedi (five pairs; Kolmogorov-Smirnov test, $nmD \leq 126$, $n = m = 18$, $P > 0.05$) or at Eilat Mountains Nature Reserve (two pairs; Kolmogorov-Smirnov test, $nmD = 60$, $n = m = 15$, $P > 0.05$; Table 2).

A total of 345 sticky traps were used to assess availability of invertebrates during 1988 (autumn was sampled only five times; Table 3). Although a large variety of invertebrates were trapped, we only used ants and beetles as indices for food availability because these orders were the only terrestrial invertebrates that were both frequently trapped and eaten by the foxes. Our results demonstrated significant differences in abundance of beetles ($F = 16.55$, $d.f. = 2,57$, $P < 0.001$) and ants ($F = 11.69$, $d.f. = 2,57$, $P < 0.001$) among the three habitats sam-

TABLE 3.—*Mean numbers of beetles and ants collected per night for each season at Ein Gedi.* n = *number of sampling nights for each habitat in each season.*

| | Autumn | | Winter | | Spring | | Summer | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $\bar{X}$ | *n* | $\bar{X}$ | *n* | $\bar{X}$ | *n* | $\bar{X}$ | *n* | $\bar{X}$ | *n* |
| Coleoptera | | | | | | | | | | |
| Creekbed | 2.22 | 5 | 8.17 | 6 | 8.17 | 6 | 1.33 | 6 | 5.08 | 23 |
| Gravel scree | 0.20 | 5 | 0.50 | 6 | 1.33 | 6 | 1.83 | 6 | 1.00 | 23 |
| Boulder scree | 0.40 | 5 | 0.67 | 6 | 0.68 | 6 | 0.50 | 6 | 0.56 | 23 |
| Average | 0.93 | 5 | 3.11 | 6 | 3.39 | 6 | 1.22 | 6 | | |
| Hymenoptera (Formicidae) | | | | | | | | | | |
| Creekbed | 15.00 | 5 | 1.67 | 6 | 6.50 | 6 | 9.17 | 6 | 7.78 | 23 |
| Gravel scree | 1.00 | 5 | 0.50 | 6 | 2.83 | 6 | 2.83 | 6 | 1.82 | 23 |
| Boulder scree | 4.60 | 5 | 0.67 | 6 | 2.50 | 6 | 7.67 | 6 | 3.82 | 23 |
| Average | 6.87 | 5 | 0.94 | 6 | 3.94 | 6 | 6.55 | 6 | | |

pled (gravel scree, boulder scree, dry creekbed). Comparison between seasons revealed a significant annual fluctuation ($F = 3.72$, $d.f. = 3,57$, $P < 0.05$; $F = 9.84$, $d.f. = 3,57$, $P < 0.001$) for beetles and ants, respectively. At night, the number of beetles (Coleoptera) declined in summer and the number of ants (Formicidae) declined in winter (Table 3). The largest number of beetles and ants were trapped in the creekbed habitat. The monthly percentage of beetles or ants found in feces of Blanford's foxes and those collected with sticky traps in the creekbed habitat were significantly different (Kolmogorov-Smirnov test, $nmD = 121$, $n = m = 11$, $P < 0.01$ and $nmD = 121$, $n = m = 11$, $P < 0.01$) for beetles and ants, respectively.

Wild free-ranging Blanford's foxes were observed in the field on 463 occasions. Only on 44 times were foxes observed to be clearly hunting or eating. The observed foraging behaviors of the Blanford's fox were of three types: Moving back and forth between rocks in a small area (0.01–0.03 km$^2$) involving unhurried movements, sniffing, looking under large stones, and occasionally digging a shallow scrape; standing near a bush for a few seconds, alert with ears erected (listening), prior to circling the bush or pouncing upon prey within, before walking to another bush to repeat the sequence (in four cases we observed two members of a pair using this type of foraging behavior simultaneously around the same bushes); a short and fast sprint after a small terrestrial or low-flying prey.

## DISCUSSION

Our results indicate that Blanford's foxes mainly were insectivorous and frugivorous. Vertebrates were uncommon in the diet, but were common in the habitat of the foxes (average of 20.7 rodents per 400 m census line—Abramsky et al., 1985). Although the diets of Blanford's foxes were broadly similar at both locations, grasshoppers and fruit were much more common in the diet of foxes at Eilat Mountains Nature Reserve, while ants, termites and plant material were more common in feces collected at Ein Gedi. These differences in diet might reflect prey availability at each site.

Unlike the insectivorous bat-eared fox, *Otocyon megalotis* (Bothma et al., 1984; Malcolm, 1986), Blanford's foxes in our study showed a broad prey-base. In its diet, the Blanford's fox in Israel resembles the population of gray fox, *Urocyon cinereoargenteus,* studied in Zion National Park, Utah (Trapp, 1978). The North American and Israeli study sites were topographically similar, although the latter was more arid. The island grey fox, *Urocyon littoralis,* also subsists primarily on fruit and insects (Laughrin, 1977). The change in diet of gray foxes

from carnivory in woodland to insectivory and frugivory in semidesert rocky habitat may be related to prey availability.

Other small species of desert fox, like *Vulpes macrotis* (O'Farrell, 1987) and *Vulpes ruppelli* (Lindsay and Macdonald, 1986), mainly feed on rodents. This suggests that Blanford's foxes are capable of locating and eating small vertebrates; nonetheless, our results indicate that they feed mainly on invertebrates and fruits. In flat, sandy habitat, rodent burrows are sporadic, occurring mainly around bushes, thus, rodents moving above ground between burrows probably are more vulnerable to predation (Kotler et al., 1988). Rocky habitat with rock piles and stone fields, however, provides continuous cover for rodents, thus making them harder to capture. Kotler et al. (1988) demonstrated that rates of predation by barn owls were higher on rodents foraging in the open than on rodents foraging under cover. We suggest that, in rocky environments, preying heavily upon rodents by foxes would be prohibitively time consuming. A more efficient strategy for Blanford's foxes, which requires relatively small quantities of food daily (because of its relatively small body mass—McNab, 1986), would be to forage for smaller, but more available and predictable food.

Desert-dwelling species of foxes can survive for long periods without drinking water (Golightly and Ohmart, 1984; Noll-Banholzer, 1979*a*). Although permanent water sources were available at both study sites, much of the distribution of this species in Israel spans extremely dry habitats where drinking water is available only occasionally and during winter. Several traits may be linked in an adaptive complex—invertebrate-, fruit- and leaf-eaters have rates of basal metabolism less than expected from the Kleiber relation (McNab, 1986) and rates of basal metabolism are directly correlated with water loss (Noll-Banholzer, 1979*b*). The problem of water balance will be exacerbated by the large surface-to-volume ratio of this species. The frequent presence of plant material in the diet of the Blanford's foxes may reflect foraging for water.

The inconsistency between the monthly indices of prey abundance and the occurrence of those same prey groups in feces of Blanford's foxes in Ein Gedi might be explained by the ability of the foxes to locate the same prey at all seasons. We saw foxes locating invertebrates by excavation under rocks. The ability of these foxes to seek ants and beetles may be reflected by the similarity in diet composition between seasons within each location, despite the existence of such differences in the activity patterns of these invertebrates. This is in contrast with other species, especially those that occupy northern zones where climatological variations have strong influences on food availability (Doncaster et al., 1990; Green and Osborne, 1981; Halpin and Bissonette, 1988; Hockman and Chapman, 1983).

Macdonald (1977, 1981) found differences in the diets of foxes living in neighboring territories, and these probably were related to differences in prey availability even between neighboring territories. We did not detect such differences although significant differences in habitat composition were found between home ranges of neighboring pairs at Ein Gedi (Geffen, 1990). Its is possible that our methods and small sample preclude detection of such differences.

Foraging behavior of Blanford's foxes resembles that of the bat-eared fox (Malcolm, 1986) and of red foxes foraging for earthworms (Macdonald, 1980). Our observations suggest that some invertebrate groups are located by the sound they produce. Apparently, food caching is rare or absent in the behavioral repertoire of Blanford's foxes, contrary to other fox species (Macdonald, 1976). Food offered to foxes was either consumed on the spot or carried away and eaten. Food was never cached, although on one occasion a fox left a few chicks under a boulder, returning after a few minutes to pick them up. Food caching behavior is lacking in the insectivorous bat-eared fox (Lamprecht, 1979). This might be a con-

sequence of feeding on small prey items that are of low energetic value and neither easily stored nor easily recovered (Macdonald, 1976).

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