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# WINTER DIET OF THE SMALL INDIAN MONGOOSE, *HERPESTES AUROPUNCTATUS*, ON AN ADRIATIC ISLAND

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The diet of the small Indian mongoose, *Herpestes auropunctatus* (Carnivora: Herpestidae), was studied by analysis of feces in winter 1992–1993 on a northern Mediterranean island, at the northern limit of distribution of the species. Vertebrates (46% by volume, mostly murine rodents) and plant matter (43%, mostly fruit) dominated the diet. The entire small-mammalian fauna of the island, except for shrews, was represented in the diet. The diet differs significantly from what has been reported previously. We suggest this species be classified as a generalist rather than as an insectivorous or a vertebrate feeder, as has been done previously.

Key words: feeding habits, distribution, small Indian mongoose, *Herpestes auropunctatus*

Interrelations between various aspects of the life history have been investigated in several groups of animals, including the order Carnivora (e.g., Gittleman, 1993). It often is difficult to identify these relations because we have incomplete data for many species (e.g., Rood, 1986). As a consequence, the small Indian mongoose, *Herpestes auropunctatus* (Carnivora: Herpestidae), has been described both as insectivorous (Gittleman, 1989) and as a vertebrate feeder (McNab, 1989) within the same volume of literature. Gittleman (1989) did not find a relationship between sociality and diet in the Carnivora, perhaps due to incorrect classifications on diet. Therefore, further research is needed to conduct comparative studies.

Earlier accounts described mongooses as "omnivorous carnivores" (Hinton and Dunn, 1967). Whereas this is not true for some species (e.g., suricates, *Suricata suricatta*, dwarf mongooses, *Helogale parvula*, and banded mongooses, *Mungos mungo*—Hiscocks and Perrin, 1991; Lynch, 1980; Rood, 1975), new data confirm this view for the small Indian mongoose.

Diet of the small Indian mongoose in the Fiji Islands consists of a wide variety of foods, both invertebrates (crabs and insects) and vertebrates (amphibians, reptiles, birds, and mammals), none of which were consistently dominant across habitats (Gorman, 1975). Studies on Atlantic tropical islands based on smaller samples (Nellis, 1989) reported comparable findings. Its basal rate of metabolism is close to the value predicted for a member of Carnivora of its size, being neither higher (as predicted for a flesh-eating species) nor lower (like insectivores—McNab, 1989). However, higher metabolic rates have been recorded (Nellis and Everard, 1983).

Small Indian mongooses were introduced on the Croatian island of Korcula ca. 1924, have thrived there since then, and, according to local hunters, now are relatively common (Krystufek and Tvrtkovic, 1992; Tvrtkovic and Krystufek, 1990). Their success is particularly surprising because the northern limits of the natural distribution are far to the south, in northern Iraq (Nellis, 1989). This species is tolerant of high temperatures (Matsuura et al., 1977), but temperatures <0°C severely stress it (Nellis and Everard, 1983; Nellis and McManus, 1974). As a result, the most northerly distribution predicted for it corresponds to the January

10°C isotherm (Ebisu and Whittow, 1976; Nellis and McManus, 1974). Average winter temperature on Korcula is lower. No information is available on the diet of this species in cool climates. The aims of this study were to collect data on the feeding habits of the northernmost populations of the small Indian mongoose in the winter and to compare its diet in temperate and tropical areas.

## Study Area

The island of Korcula (in southern Dalmatia, Croatia, the former Yugoslavia; 42°55'N, 17°10'E) is ca. 45 km (east to west) by 8 km (north to south). It has karst topography, with chemical erosion and bleak surfaces. The highest elevation is 569 m. The climate is Mediterranean. In winter, cold winds from the Dinaric Alps bring temperature <0°C up to five times per year; mean January temperatures are 4–8°C, and annual temperature amplitude averages 16°C; the total rainfall in Vis, ca. 30 km west, is ca. 676 mm, with the greatest in November and the least in July; the summer dry season is from May to November; snow falls only rarely (Krystufek and Tvrtkovic, 1988, 1992).

The island is covered mainly by low (<2 m) Mediterranean scrub, mostly of the *Quercetum ilicis adriaeprovincialis* community. Common species of plants are *Myrtus communis, Juniperus oxycedrus, Cistus, Pistacia lentiscus, Erica arborea,* and *Rosmarinus officinalis.* The island also has vineyards and olive groves, although some have been abandoned.

Small terrestrial mammals recorded on the island are *Apodemus mystacinus, Apodemus sylvaticus, Rattus rattus, Rattus norvegicus, Mus domesticus, Myoxus* (formerly *Glis*) *glis, Crocidura suaveolens,* and *Erinaceus concolor.* The presence of *Suncus etruscus* also is likely. The only other carnivores present are jackals, *Canis aureus,* and stone martens, *Martes foina* (Tvrtkovic and Krystufek, 1990; B. Krystufek, pers. comm.). No information is available on the density of mongooses on the island, although they appeared to be abundant (P. Cavallini, pers. obser.). The main predators of the mongoose on the island are humans (trapping and shooting), eagle owls (*Bubo bubo*), and possibly jackals (Tvrtkovic and Krystufek, 1990; pers. obser.).

## Materials and Methods

During December 1992 and January 1993, the first author collected all visible feces of mongooses along a 3.7 km, 2-m wide road, in the eastern end of the island, ca. 5 km from the village of Lumbarda. The winter season was selected to increase the environmental differences from previous studies. There is no evidence that mongooses defecate selectively on roads (e.g., *Herpestes pulverulentus*—Cavallini and Nel, 1990*a*; *Cynictis penicillata*—Cavallini, 1993). If density and home-range size were similar to those in the Caribbeans (density of one to 10 individuals per ha; home-range size of 3.1 ha; home-range diameter of 200 m—Nellis and Everard, 1983), the sampling area may have been ca. 74 ha, and the transect may have crossed the ranges of 70–700 individuals. Feces of mongooses were distinguished from those of stone martens on the basis of size, the marten being much larger and having correspondingly larger feces (ca. 1.2 cm in diameter—Bang and Dahlstrom, 1974). Furthermore, feces from martens usually are twisted and pointed (Bang and Dahlstrom, 1974), while feces from mongooses are cylindrical and more blunt (pers. obser.). The road was divided into three sections, and each section of the road was examined on both sides once, on three different days, for a total transect length of 7.4 km (as subsequently verified by the odometer of a car). Narrow tracks approximately perpendicular to the road also were examined for a length of 6 km, but only one feces was found, probably because thick vegetation made the sighting of feces difficult. We selected this area because of accessibility and suggestions from local hunters and because we sighted two mongooses in the area during an initial survey by car. The ongoing Serbo-Croatian war made further sampling impossible.

The first author stored, in individual plastic bags, fecal droppings attributed to the same defecation (on the basis of shape and placement on the ground), and the second author subsequently processed them. The sampling unit was the entire defecation, which was broken up, washed through a 1-mm mesh sieve, and examined macro- and microscopically in a large, white dish. We found a total of 126 fecal samples (an average of 17 samples/km), from which 184 food items were identified. Most samples of excrement contained one or two food items.

We identified seeds and plant material by

comparison with material we collected in the field. We identified mammals to genus and, when possible, to species, from the cuticular scale pattern and the medulla of the hair (Debrot et al., 1981). Birds were identified to order by the down barbules (Day, 1966).

To allow direct comparison with past and future studies, results of the fecal analysis are presented in several ways. Absolute frequency was calculated as the percentage of samples in which a given food item was present. Because some feces contained more than one food item, the sum of percentages exceeded 100. Relative frequency is the percentage of each food item of the total sample items. To estimate percentage volume, the total number of each kind of prey were counted (or estimated from the number of remains) for each sample, the number of prey items was multiplied by the bulk of each prey before ingestion (known from reference material), and the proportion of total bulk for each food category was estimated. The average proportion across samples is, therefore, an estimate of the volume of ingested food (Cavallini and Nel, 1990*b*; Kruuk and Parish, 1981). The average volume when present is an estimate of average meal size rather than of relative importance in the diet, so a food item always eaten in large quantities will have a high average volume, even if its overall contribution to the diet is small. The lack of published correction factors (Lockie, 1959) for many of the food items eaten by mongooses in Korcula (Gorman, 1975) prevented us from making a direct estimation of actual amounts of food consumed.

## Results

The winter diet of the small Indian mongoose in Korcula was varied, but it was dominated by vertebrate and plant material (Table 1). Plant matter was present in most samples and accounted for 43% of the volume. It consisted mostly of fruits of two species, the juniper (*Juniperus oxycedrus*) and the strawberry tree (*Arbutus unedo*). Vertebrate items, present in one-half of the samples, made up 46% of the volume and were mostly from mammals. All the small mammals of the island except shrews were represented, with wood mice (*Apodemus*) and rats (*Rattus*) predominating (Table 1). Birds, mostly passerines, also were represented in the feces, although to a lesser extent than mammals. Reptilian material was found in only one fecal sample. Invertebrate remains were less abundant in the feces, making up only 7.5% by volume. These were orthopterans and adult and larval coleopterans. The average volume when present in each fecal sample was large for vertebrates (87%), but small for invertebrates (33%). Mammals, birds, and, to a lesser extent, fruits, therefore, were eaten in large quantities per meal, whereas rarely more than a few invertebrates were eaten together.

## Discussion

This study is based on a small sample of feces collected over a small area in a limited period. Further sampling, therefore, is needed before definite conclusions can be drawn. In spite of this, the differences between the diets of *H. auropunctatus* in our temperate study area and on tropical oceanic islands (Table 2; studies with sample sizes $\leq 10$ have been excluded, i.e., Amaresekare, 1994; Vilella and Zwank, 1993) are too large to be due to chance alone; more plant matter, the majority of which was fruit, are eaten on Korcula than elsewhere. This has the advantage for the mongooses of providing more sugar and fats, which can be used for the additional thermogenesis required in this climate. The difference is even greater considering that on Fiji, the only other area where fruits were consumed in appreciable quantities, they were eaten half as often and in much smaller quantities (average across areas = 1.8% by weight—Gorman, 1975). Being more fleshy, tropical fruits may have been underestimated in most studies. By contrast, arthropods and cold-blooded vertebrates were less common on Korcula. Invertebrates and cold-blooded vertebrates, being strongly affected by environmental temperature, are probably much scarcer in the Adriatic winter than in tropical climates. Vertebrates were an important food item everywhere, although the most frequently eaten taxa were different in the various areas.

TABLE 1.—*Diet composition of the small Indian mongoose (*Herpestes auropunctatus*) on Korcula, in the Adriatic Sea, in winter. Figures represent the number of feces in which each food item was found, the absolute and the relative frequency of occurrence in samples, the estimated percentage of volume (following Kruuk and Parish, 1981) and the average volume when present. Unidentified items are included in major categories. Figures in columns do not always sum up because more than one item may be present in each sample and because items are reported for individual species as well as for higher taxonomic groupings.*

| Food item | Number of samples | Absolute frequency of occurrence (%) | Relative frequency of occurrence (%) | Estimated volume ingested (%) | Average volume when present |
|---|---|---|---|---|---|
| Vertebrata | 66 | 53 | 36 | 46 | 87 |
| Mammalia | 47 | 38 | 26 | 33 | 89 |
| *Apodemus* | 16 | 13 | 9 | 12 | 89 |
| *Rattus* | 13 | 10 | 7 | 10 | 93 |
| *Mus domesticus* | 4 | 3 | 2 | 3 | 93 |
| *Myoxus glis* | 1 | 1 | 1 | 1 | 95 |
| *Erinaceus concolor* | 2 | 2 | 1 | 1 | 75 |
| Aves | 18 | 14 | 10 | 13 | 88 |
| Passeriformes | 13 | 10 | 7 | 9 | 87 |
| Galliformes | 2 | 2 | 1 | 2 | 95 |
| Reptilia | 1 | 1 | 1 | 0.2 | 20 |
| Arthropoda | 29 | 23 | 16 | 8 | 33 |
| Insecta | 28 | 22 | 15 | 7 | 34 |
| Coleoptera (larvae) | 14 | 11 | 8 | 5 | 43 |
| Coleoptera (adults) | 6 | 5 | 3 | 1 | 18 |
| Orthoptera | 8 | 6 | 4 | 2 | 30 |
| Arachnida | 1 | 1 | 1 | 0.04 | 5 |
| Plantae | 82 | 66 | 45 | 43 | 67 |
| Fruit | 71 | 57 | 39 | 40 | 70 |
| *Juniperus oxycedrus* | 36 | 29 | 20 | 22 | 76 |
| *Arbutus unedo* | 16 | 19 | 9 | 9 | 71 |
| *Myrtus communis* | 12 | 10 | 7 | 5 | 53 |
| Cultivated fruits | 2 | 2 | 1 | 0.5 | 30 |
| Other vegetative matter | 11 | 9 | 6 | 4 | 44 |
| Refuse | 7 | 6 | 4 | 3 | 60 |

These differences are more consistent with opportunistic feeding habits than with feeding specialization. We, therefore, suggest, in accordance with Nellis (1989), that this species of mongoose should be classified as a generalist rather than as insectivorous (Gittleman, 1989) or a vertebrate feeder (McNab, 1989). The high percentage of fruit in the winter diet of mongooses in Korcula is similar to that of another typically generalist predator in a similar habitat, the red fox in the Maremma Natural Park (Cavallini and Lovari, 1991; Ciampalini and Lovari, 1985). All small, diurnal mongooses that are insectivorous are social. Opportunistic feeding habits, therefore, are more compatible than insectivory with the relative asociality of this species (Nellis, 1989; Rood, 1986).

Mongooses are often a concern in wildlife management. Local hunters on Korcula complain that mongooses damage wild fowl (Tvrtkovic and Krystufek, 1990), which may be partly justified in view of the number of bird remains we found in the feces. However, probably not all birds eaten were captured by mongooses, because bird traps

TABLE 2.—*A comparison of the diet (relative frequency of occurrence) of the small Indian mongoose (*Herpestes auropunctatus*) from different studies. Sample sizes are given in parentheses.*

| Food category | St. Croix (36) | Puerto Rico[b] (56) | Hawaii[c] (86) | Fiji[d] (4,404) | Korcula (126) |
|---|---|---|---|---|---|
| Vertebrata | 30 | 19 | 37 | 33 | 36 |
| Mammalia | 18 | 3 | 29 | 10 | 26 |
| Aves | 4 | 0 | 8 | 4 | 13 |
| Reptilia | 0.3 | 15 | 0 | 10 | 0.2 |
| Amphibia | 9 | 1 | 0 | 9 | 0 |
| Arthropoda | 59 | 69 | 45 | 44 | 16 |
| Insecta | 52 | 50 | 45 | 38 | 15 |
| Arachnida | 0 | 7 | 0 | 0 | 0.5 |
| Myriapoda | 0 | 11 | 0 | 0 | 0 |
| Decapoda | 7 | 1 | 0 | 5 | 0 |
| Echinodermata | 0 | 1 | 0 | 0 | 0 |
| Plantae | 11 | 11 | 18 | 23 | 45 |
| Refuse | 0 | 0 | 0 | 0 | 4 |

[a] Recalculated from Nellis and Everard (1983); season unknown.

[b] Recalculated from Pimentel (1955); season unknown.

[c] Recalculated from Baldwin et al. (1952); season unknown.

[d] Recalculated average from Gorman (1975); year-round data.

are widely used in the island (pers. obser.). This makes available to mongooses a number of trapped (dead or alive) birds. Trapped birds that are alive are attractive to mongooses (Baldwin et al., 1952). By contrast, the high level of predation on rats by mongooses, which may limit populations of rats (Hoagland et al., 1989), is beneficial to humans.

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