Food habits of the crab-eating-fox, *Cerdocyon thous*, in an altitudinal forest of the Mantiqueira Range, southeastern Brazil

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SUMMARY

The diet of the crab-eating fox, *Cerdocyon thous*, was studied analyzing 301 scats collected year round in an altitudinal forest of southeastern Brazil. The relative abundances of small terrestrial rodents in different sites and seasons were estimated to determine whether the crab-eating foxes preyed on rodent species in proportion to their availability. Thirty-eight main food items (26 animal and 12 plant species) were identified. Fruits constituted the main component of the diet, being found in 84% of the scats, and represented 44% of the total estimated volume. Insects were found in 49% of the scats, mammals in 38%, birds in 27%, snakes in 18%, and frogs in 6%. Fruits and insects were more frequently consumed during the wet season and rodents and rabbits in the dry season. Rodent species were consumed according to their availability in the study area. The most abundant rodent species, *Akodon cursor* (56% of the captures) represented 42% of the murids identified in the scats. In the study area, the crab-eating fox had a generalized diet of fruits, insects and small vertebrates. The proportion of some alimentary categories in the diet shifted seasonally as a result of changes in the availability of resources.

KEY WORDS
Cerdocyon thous, diet, season, fruits, animals, S-E Brazil.

RÉSUMÉ

Le régime du renard crabier, *Cerdocyon thous*, a été étudié à partir de l'analyse de 301 faeces collectées pendant un an environ dans une forêt d'altitude du sud du Brésil. L'abondance relative des petits rongeurs terrestres, selon les sites et les saisons, a été estimée afin de déterminer si la prédation du renard crabier sur telle ou telle espèce de rongeurs était liée à leur abondance. Trente-huit éléments nutritifs de base (28 espèces animales et 12 plantes) ont été identifiés. Les fruits, trouvés dans 84 % des faeces dont ils représentaient 44 % du volume total estimé, représentaient l'élément principal du régime. Des restes d'insectes ont été trouvés dans 49 % des excréments, des mamifères dans 38 %, des oiseaux dans 27 %, des serpents dans 18 %, des grenouilles dans 6 %. Fruits et insectes sont plus fréquemment consommés pendant la saison humide, rongeurs et lagomorphes pendant la saison sèche. Le rongeur le plus abondant, *Akodon cursor* (56 % des captures), représente 42 % des Muridés identifiés dans les faeces. La proportion de certains aliments varie avec les saisons en fonction des variations des ressources alimentaires.

INTRODUCTION

South American foxes and wild dogs include seven genera and eleven species (Berta 1987; Medel and Jaksic 1988; Wilson and Reeder 1993), and represent the most diverse canid fauna in the world (Wayne *et al.* 1997). The species range in size from 2.5 kg (hoary fox, *Pseudalopex vetulus*) to 25 kg (maned wolf, *Chrysocyon brachyurus*) (Dietz 1984; Nowak 1991; Dalponte 1995) and show adaptations to different feeding strategies, including carnivory (*Speothos venaticus* and *Atelocynus microtis*), frugivory (*Chrysocyon brachyurus*, *Cerdocyon thous*) and insectivory (*Pseudalopex vetulus*) (Dietz 1984; Peres 1991; Dalponte 1995; Facure and Monteiro-Filho 1996; Facure and Giaretta 1996). The high diversity found among South American canids provides an interesting model for the evaluation of behavioral trends in canids, particularly in relation to body size (Macdonald and Courtenay 1996).

The crab-eating fox, *Cerdocyon thous*, is a fox-sized canid (4.0 – 7.0 kg), found in a variety of habitats in South America, such as forests, forest edges, open woodlands and wooded savannas (Bisbal 1988). At least five subspecies are recognized (Berta 1982), and are distributed in Colombia, Venezuela, Guyana, Suriname, French Guyana, eastern Bolivia, Paraguay, Uruguay, northern Argentina, and Brazil (except the lowlands of the Amazon basin) (Langguth 1975; Berta 1982).

Most of the information about the habits of the crab-eating fox comes from studies in Venezuela. Montgomery and Lubin (1978) observed that individuals are active at night and forage in couples or family groups. Brady (1979) reported seasonal changes in habitat utilization and territoriality as a function of variations in prey (mainly small vertebrates and crabs) availability. Bisbal and Ojasti (1980) concluded that the food niche of the species is broad, with a preference for small vertebrates, but some populations also show a diet with a predominance of fruits and insects. There are still a number of locations where the diet of *C. thous* has been little studied, with no data comparing food item use and prey availability.

Although the crab-eating fox is a relatively common species, few investigations have been done in Brazil (Coimbra-Filho 1966; Schaller 1983; Motta-Junior *et al.* 1994; Facure and Monteiro-Filho 1996; Facure and Giaretta 1996), and none specific to the Mantiqueira Range. Considering that seasonal and local varia-

tions have been documented in its diet, more detailed studies are necessary to accurately describe the foraging behavior of this species. The objective of this study was to obtain data on the diet of the crab-eating fox in an altitudinal forest of the Mantiqueira Range, in southeastern Brazil, and to evaluate the selectivity and seasonal variations in the use of food items.

MATERIALS AND METHODS

Study area. – This study was done in the Parque Florestal do Itapetinga, in the Mantiqueira Range, municipality of Atibaia (23°00'-23°15'S; 46°25'-46°45'W), São Paulo State, southeastern Brazil. The study area comprised approximately 1,800 ha at altitudes between 800 m and 1,350 m. The vegetation type is altitudinal semideciduous forest (Meira-Neto *et al.* 1989). At the periphery of the forest there are anthropic areas, including orchards, pastures and agricultural fields.

The climate is characterized by a dry, cold season, from April to September (minimal temperature: -3.8 °C), with frequent frosts in June and July, and a wet, warm season, from October to March (maximal temperature: 37.6 °C). The annual mean temperature is 18.7 °C, July is the coldest month (mean = 14.5 °C) and February is the warmest (mean = 21.7 °C). The annual mean precipitation is around 1,500 mm, with the monthly mean precipitation ranging from 37 mm in August to 244 mm in January.

Besides the crab-eating fox, there are other carnivores in the study area, including four felids (*Puma concolor*, *Leopardus pardalis*, *Leopardus tigrinus* and *Herpailurus yaguarondi*), two mustelids (*Eira barbara* and *Galictis cuja*) and two procyonids (*Nasua nasua* and *Procyon cancrivorus*). Based on sightings and on the number of scats collected, the crab-eating fox is one of the most abundant carnivore species in the area.

Food habits. – The diet of the crab-eating fox was studied by analyzing 301 scats, which were collected opportunistically along roads and trails within the study area from December 1991 to November 1998. Combined monthly samples ranged in number from 15 to 44. The scats were identified as belonging to crab-eating foxes mainly by their smell, size, shape, and the presence of the species hair, ingested while grooming. When combined, these characteristics made it possible to distinguish the scats of every carnivore species found in the study area (Facure and Giaretta 1996).

The scats found in the field were labeled (date and site) and stored in 70% alcohol until analysis. Each sample was washed in flowing water on a sieve of fine mesh (0.5 mm) to separate the identifiable items (bones, teeth, hair, feathers, scales, arthropod fragments, seeds). Small parts were examined under a stereoscopic microscope.

Plant species found in the scats were identified from a reference collection of fruits available in the study area. To compare fruit use and availability, the presence of ripe fruits in the study area was recorded opportunistically during scat collection. Vertebrate remains found in the scats were compared with reference specimens collected in the area and deposited in the Museu de História Natural da Universidade Estadual de Campinas (ZUEC). Fragments of insects were identified to family level using a field guide (Borror and White 1970). Frogs were recognized by their bones, mainly the radio-ulna compound bone (Duellman and Trueb 1986). Viperidae and Colubridae snakes were distinguished from each other by features of their scales. Birds were identified to order level based on the downy barbules of the feathers (Day 1966). Downy barbules were obtained by microscopically (400 x) examining the sediments of the alcohol solution in which the scats were stored (Cavallini and Volpi 1995). Hair was identified using macroscopic characteristics such as length, thickness, coloration and pattern of bands, and microscopic features such as the type of the cuticular scale and pattern of the medulla (Chehébar and Martín 1989).

For comparison with other studies, food items were grouped in the following categories: fruits, insects, frogs, squamates, birds, and mammals (Bisbal and Ojasti 1980; Facure and Monteiro-Filho 1996). The importance of each food type in the diet was based on its frequency of occurrence, expressed as the percentage of samples that contained a given item or category (Brillhart and Kaufman 1995). To assess the relative abundance of the items in the diet, the percentage of volume of each food item in a sample was estimated

based on measurements of whole specimens in reference collections (Kruuk and Parish 1981; Mouches 1981).

The *G* test (Zar 1984) was used to compare the frequency of each food category between the dry/cold (April to September) and the wet/warm (October to March) seasons. The values of *G* were calculated from 2 x 2 contingency tables of the number of scats with and without a given item (Brillhart and Kaufman 1995). Scats of unknown age were excluded from this analysis.

Insect abundance in the study area is influenced by the rains (Giaretta *et al.* 1999). The relationship between the monthly variation in local rainfall and the frequency of insects in the scats was tested using the Spearman rank correlation coefficient (r_s) (Zar 1984). Precipitation data were obtained from a weather station in Atibaia (altitude of 770 m), about 11 km from the study area.

The number and relative abundance of the small terrestrial rodents in the study area (800-1,000 m altitude) were assessed trimestrially, from August/1997 to May/1998. Captures were made in three vegetation types (forest, forest border, and open areas). In each area, two transects were run per sampling, each one with 50 rat-traps placed on the ground 4-6 m from one another, from 17:00 p.m. to 6:00 a. m. The traps were baited with guava jelly soaked in vanilla essence. The total effort of capture was 1,200 trap/night.

The mean values are given followed by the standard deviations. The level of statistical significance for the tests of hypotheses was chosen a priori as being 0.05.

RESULTS

Thirty-eight food types (26 animal and 12 plant species) were identified in the diet of *Cerdocyon thous* in the study area (Table 1). A maximum of eight food items and a minimum of one were found in a single scat (mean = 2.7±1.4). Fruits constituted the most frequent category in the diet, being found in 83.7% (monthly mean = 82.4±12.7) of the scats and representing 43.8% (42.5±15.9) of the total estimated volume. Four species (*Maclura tinctoria*, *Psidium guajava*, *Hovenia dulcis* and *Syagrus romanzoffiana*) were used during the entire period of fruiting, whereas the others were used infrequently (Table 2). The most frequent fruit species in the diet was *S. romanzoffiana*, an ovoid (2.5 cm long) drupe with a soft exocarp and woody endocarp. Consumption of *S. romanzoffiana* was lower in the months when crab-eating foxes were eating large amounts of *P. guajava* (from March to April) and *H. dulcis* (from May to June) (Fig. 1). Each one of the nine remaining fruit species had a frequency of occurrence ≤ 5.0%. The monthly number of available fruit species was correlated with rainfall (r_s = 0.82; n = 12; P < 0.01). The largest occurrence of fruits in the diet occurred in December and January (Fig. 2), coinciding with the highest values of precipitation.

Although insects were found in 49.5% of the scats (50.2 ±15.3), they contributed little to the volume consumed (monthly mean = 5.8 ±2.6). Among the insects eaten, coleopterans (mainly Scarabaeidae) were the most frequent group in the diet, being present in 20.3% of the scats, with a peak in November (42.9%). Other important groups were cockroaches (Blaberidae) (15.9%) and grasshoppers (Acrididae) (15.3%) (Table 1). The frequency of insects in the scats was lowest in July and highest in December (Fig. 2). The monthly frequency of insects in the scats was positively correlated with the rainfall (r = 0.53; n = 12; P < 0,05).

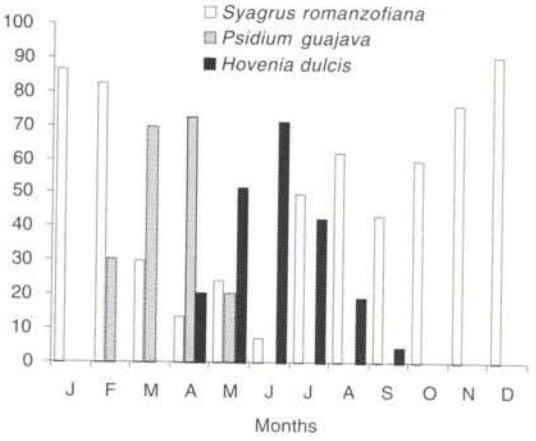

Fig. 1. – Frequency of the monthly occurrence of the three most common fruit species in the diet of *Cerdocyon thous* in the Parque Florestal do Itapetinga (Atibaia-SP).

TABLE 1. – Frequency of occurrence (number and % of scats containing a particular food item) and percentage of estimated volume of food items in the diet of the crab-eating fox, *Cerdocyon thous*, in the Parque Florestal do Itapetinga (Atibaia, São Paulo, Brazil). N = 301 scats.

Item	Number of scats	Percentage of scats	Percentage of volume
FRUIT			
Arecaceae			
Syagrus romanzoffiana	146	48.5	20.63
Musaceae			
*Musa acuminata**	6	2.0	0.55
Moraceae			
Ficus sp.	2	0.7	0.43
Maclura tinctoria	15	5.0	2.04
Myrtaceae			
Eugenia uvalha	1	0.3	0.03
*Myrciaria jaboticaba**	7	2.3	0.63
*Psidium guajava**	65	21.6	8.02
*Syzygium cumini**	10	3.3	1.33
Rhamnaceae			
*Hovenia dulcis**	60	19.9	8.17
Solanaceae			
Solanum spp. (2 species)	13	4.3	1.03
Vitaceae			
*Vitis vinifera**	1	0.3	0.02
Others	12	4.0	0.97
INSECTS			
Blattodea			
Blaberidae	48	15.9	1.56
Coleoptera	61	20.3	1.61
Orthoptera			
Acrididae	46	15.3	1.39
Tettigoniidae	13	4.3	0.30
Insecta n. i.	31	10.3	0.92
FISH			
Characidae	1	0.3	0.17
FROGS			
Anura (2 families)	18	6.0	2.66
SQUAMATES			
Colubridae (3 species)	46	15.3	6.96
Viperidae (2 species)	7	2.3	1.20
Tropiduridae (*Tropidurus itambere*)	1	0.3	0.15
Teiidae (*Tupinambis merianae*)	1	0.3	0.17
Squamata n. i.	1	0.3	0.10
BIRDS			
Galliformes	37	12.3	8.49
Passeriformes	20	6.6	3.02
Others	24	8.0	3.64
MAMMALS			
Didelphimorphia			
Didelphidae			
Didelphis (2 spp.)	14	4.7	3.55
Others	5	1.7	0.83
Artiodactyla			
Cervidae			
Mazama americana	2	0.7	0.50
Lagomorpha			
Leporidae			
Sylvilagus brasiliensis	19	6.3	4.37
Rodentia			
Caviidae			
Cavia aperea	3	1.0	0.83
Muridae			
Akodon cursor	14	4.7	2.19
Bolomys lasiurus	2	0.7	0.32
Calomys sp.	5	1.7	0.81
Oligoryzomys nigripes	12	4.0	2.27
Muridae n. i.	40	13.3	6.59
Echimyidae			
Euryzygomatomys spinosus	1	0.3	0.20
Mammalia n. i.	6	2.0	1.49

* Cultivated plant species

Mammals occurred in 37.9% of the scats (38.9±19.9) and were more frequent between May and November, with a peak in August (Fig. 3). About 63% of the identified mammals were murid rodents of small size (≤ 50 g). The largest mammalian prey were rabbits, *Sylvilagus brasiliensis* (adults between 950 and 1,200 g), opossums, *Didelphis albiventris* and *D. marsupialis* (about 1,500 g) and cavies, *Cavia aperea* (250-700 g). Two samples contained hairs of the red brocket deer, *Mazama americana* (around 29 kg). Based on the bone fragments found in these scats, one deer was a juvenile and the other was an adult. Sarcophagidae larvae were found in the sample containing the remains of the adult deer.

Birds were found in 26.9% of the scats (28.2±14.9), with a higher frequency in September and October (Fig. 3). The domestic chicken, *Gallus gallus*, represented 45.7% of the birds identified in the scats. Passeriformes occurred in 6.6% of the scats. Squamates were found in 18.6% of the scats (19.2±10.1) and were more frequent in October (Fig. 3). Frogs were identified in 6.0% of the scats and were more frequent between September and November (Fig. 3).

TABLE 2. – Fruit availability and consumption by the crab-eating fox *Cerdocyon thous* in the Parque Florestal do Itapetinga (Atibaia, São Paulo, Brazil). *used by crab-eating foxes; --- presence of ripe fruits.

Species/months	J	F	M	A	M	J	J	A	S	O	N	D
Maclura tinctoria	* ---										* ---	* --- *
Vittis vinifera	---	--- *						*	*		--- *	--- *
Myrciaria jaboticaba	--- *	---						---	---	---	---	--- *
Ficus sp.	--- *	--- *								---	---	---
Solanum palinacanthum	---	--- *	--- *	--- *	---				---	---	---	---
Solanum viarum	---	--- *	--- *	--- *	--- *				---	---	---	---
Psidium guajava		---	--- *	--- *	--- *							
Syzygium cumini[a]			---	--- *	--- *	--- *	*	*	*			
Hovenia dulcis[a]				---	---	---	---	---	--- *			
Eugenia uvalha				*					--- *	---	---	
Musa acuminata	--- *	--- *	--- *	--- *	--- *	--- *	--- *	--- *	--- *	--- *	--- *	--- *
Syagrus romanzoffiana	---	---	---	---	---	---	---	---	---	---	---	---
Total number of species	8	8	6	7	7	4	3	4	7	6	9	8

[a] cultivated species

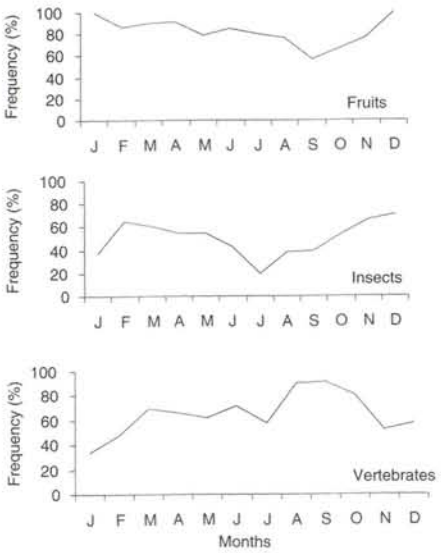

Fig. 2. – Frequency of the monthly occurrence of the main food categories in the diet of *Cerdocyon thous* in the Parque Florestal do Itapetinga (Atibaia-SP).

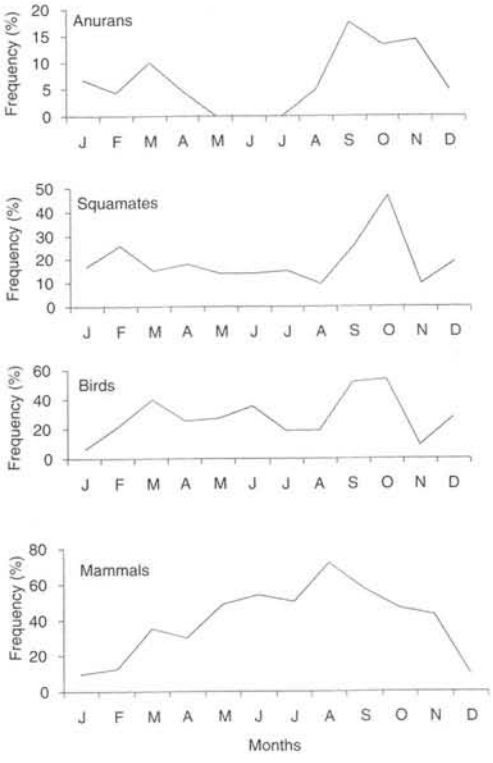

Fig. 3. – Frequency of the monthly occurrence of the main vertebrate groups in the diet of *Cerdocyon thous* in the Parque Florestal do Itapetinga (Atibaia-SP).

TABLE 3. – Frequency of occurrence of the food categories in the diet of *Cerdocyon thous* at the Parque Florestal do Itapetinga (Atibaia, São Paulo, Brazil) by season. *G* = *G* statistic.

Food category	Dry season (N = 145)	Wet season (N = 89)	*G*	P
Fruits*	80.1	88.5	3.885	0.049
Insects*	43.3	57.7	6.162	0.013
Frogs	4.1	8.5	2.480	0.115
Snakes	16.4	20.8	0.949	0.330
Galliformes	14.6	9.2	2.04	0.153
Birds	29.2	23.8	1.100	0.294
Opossums	8.2	4.0	2.476	0.116
Muridae rodents*	41.3	16.1	7.223	0.007
Rabbits*	8.8	3.1	4.378	0.036

*significant difference between seasons

There were significant seasonal differences in the frequency of occurrence of some food categories. Fruits and insects were more frequent during the wet season and murid rodents and rabbits in the dry season (Table 3). Fruit consumption was negatively correlated with the frequency of mammals in the scats (r_s = -0.608; n = 12; P < 0.025).

Considering simultaneously the frequency of occurrence and the percentage of volume, fruits were consumed more frequently, and in larger amounts, during the wet season, with a decrease in frequency and volume in the dry season. In contrast, the frequency of occurrence and the percentage of volume of mammals were low in the wet season and high in the dry season. The volume of insects was small in both seasons, despite their higher frequency during the wet season.

Trapping resulted in 66 captures of six murid species. Open areas had the greatest abundance of rodents (G = 6.97; d. f. = 2; P = 0.031), and two exclusive species (*Calomys* sp. and *Bolomys lasiurus*). Rodent species were consumed according to their availability in the study area (X^2 = 2,187; d. f. = 2; P = 0.335). The most abundant species, *Akodon cursor* (56% of the captures) represented 42% of the murids identified in the scats.

DISCUSSION

The crab-eating fox showed a generalized diet in the study area, feeding on fruits, insects and small vertebrates, thus corroborating the findings of previous studies in other geographic areas (Brady 1979; Bisbal and Ojasti 1980; Motta-Junior *et al.* 1994; Facure and Monteiro-Filho 1996). However, the frequency of fruits in the diet (84%) was higher than previously reported, and may be related to a greater availability of cultivated species. Most of the fruit species identified in the scats had a low occurrence and contributed little to the total volume of the diet. On the other hand, *Psidium guajava* and *Hovenia dulcis*, two cultivated species, were consumed in great quantities and throughout the fruiting period. The use of cultivated fruits indicated the presence of the crab-eating fox near human settlements, as also reported for other canids (*e.g.* Doncaster *et al.* 1990; McClure *et al.* 1995).

The crab-eating fox does not show adaptations for insect consumption, such as seen in the predominantly insectivorous South American canid, the hoary fox, *Pseudalopex vetulus* (Dalponte 1995). In fact, insects were consumed only in small quantities (volume and number of individuals) (see also Facure and Monteiro-Filho 1996), thus dismissing the idea of specialized behavior and suggesting that insects were obtained opportunistically. Some insects (*e.g.* Coleoptera) may be ingested accidentally with fruit or carrion.

Among the mammalian prey, murid rodents were the most frequent in the diet. Similar results were obtained in previous studies (Bisbal and Ojasti 1980; Motta-Junior *et al.* 1994; Facure and Monteiro-Filho 1996). The rodents identified in the scats were small (< 50 g) and predominantly terrestrial. Murid species were preyed upon according to their availability, indicating that crab-eating foxes were not selective feeders on this type of prey.

The red deer (*Mazama americana*), opossums (*Didelphis* spp.), rabbits (*Sylvilagus brasiliensis*) and cavies (*Cavia aperea*) were the largest prey of the crab-eating fox in the study area. Despite the fact that crab-eating foxes usually forage in pairs or family groups (Brady 1979, pers. obs.), there are few observations of cooperative hunting

(Montgomery and Lubin 1978). This excludes the possibility of capturing large-sized prey. The consumption of medium-sized mammals (≥ 1.5 kg) by crab-eating foxes was generally interpreted as being carrion ingestion (Bisbal and Ojasti 1980; this study). The presence of Sarcophagidae larvae in the scats containing the remains of the adult deer indicate that it was taken as carrion.

The seasonal variation in the diet was probably related to changes in resource availability. In the study area, fruits and insects are more frequent in the wet season (Giaretta *et al.* 1999; this study), and murid rodents in the dry season (this study).

Some human activities increase food availability to the crab-eating foxes (Bisbal 1993; this study). In rural and in some suburban areas, these canids may forage near human habitations (pers. obs.). The main food categories (fruits, birds and mammals) used by the crab-eating fox at the study site (Atibaia) were also consumed in similar proportions in a suburban locality (municipality of Campinas) (Facure and Monteiro-Filho 1996). Despite the differences in the study methods (scat analysis *versus* stomach contents), fruits represented 43% of the volume in Campinas and 44% in Atibaia. Similarly, mammals constituted 20% of the volume in Campinas and 24% in Atibaia; birds constituted 17% in Campinas and 15% in Atibaia. Some items related to human activities (*e.g.* guava and chicken) reported here were also used in Campinas. The generalized food habits of the crab-eating foxes allow them to adapt to the human-generated changes in the environment. However, the occurrence of the crab-eating fox in southeastern Brazil depends on the presence of forests (Langguth 1975, pers. obs.), which is probably used as a diurnal shelter.

Acknowledgments

J. R. Stehmann, J. Semir and J. Vasconcellos-Neto identified the plant species; P. R. Manzani helped in the identification of snakes; J. H. M. Meyer, R. Bredariol, R. Nunes, R. J. Sawaya, G. Machado, V. Bonato and W. Zacca helped in the field work; and A. S. Abe, I. Sazima, M. Galetti, M. E. Sunquist, M. V. Vieira and S. F. dos Reis critically read drafts of the manuscript. Two anonymous reviewers made useful comments about the manuscript. AAG and ELAMF were supported by CNPQ and KGF by CAPES.

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