Diet of crab-eating fox, *Cerdocyon thous* (Linnaeus) (Carnivora, Canidae), in a suburban area of southern Brazil

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ABSTRACT. The crab-eating fox, *Cerdocyon thous* (Linnaeus, 1766), is a small canid with twilight and nocturnal habits from savannas and forests of South America. In this study, we seasonally determined and quantified the diet of *C. thous* in Lami Biological Reserve, a conservation unit with 179.78ha situated in a suburban area in the municipality of Porto Alegre, southern Brazil. During the year 2000, we collected 80 fecal samples – 20 for each season – in two or three week sampling intervals, along trails inside the Reserve. Samples were dried in an oven for 24h at 60°C, immersed in 70% alcohol, and prey items were identified using a stereomicroscope. The diet of the crab-eating fox was essentially carnivorous (87.62% composed by vertebrates), with seasonal variation (p = 0.0009) and absence of fruits. Small non-flying mammals and birds were the most frequent prey, being proportionally more preyed in autumn and summer, respectively. Arthropods were more preyed in winter and spring and bird/reptile eggs only in summer and spring, in the reproduction period of these groups.
KEY WORDS. Canids; food habits; Rio Grande do Sul; seasonality; South America.

RESUMO. **Dieta de graxaim-do-mato, *Cerdocyon thous* (Linnaeus) (Carnivora, Canidae), em uma região suburbana do sul do Brasil.** O graxaim-do-mato, *Cerdocyon thous* (Linnaeus, 1766), é um canídeo de pequeno porte de hábito crepuscular e noturno que ocorre nas savanas e florestas da América do Sul. Neste estudo foi avaliada a sazonalidade e a dieta de *C. thous* na Reserva Biológica do Lami, uma unidade de conservação com 179,78ha, situada na região suburbana do município de Porto Alegre, no sul do Brasil. Durante o ano de 2000 foram coletadas 80 amostras fecais – 20 por estação do ano – em coletas realizadas a cada duas ou três semanas, percorrendo as trilhas existentes na Reserva. As amostras foram desidratadas em estufa por 24h a 60°C, imersas em álcool a 70%, e as presas foram identificadas com auxílio de estereomicroscópio. A dieta do graxaim-do-mato apresentou-se essencialmente carnívora (87,62% composta por vertebrados), com variação sazonal (p = 0,0009) e ausência de frutos. Pequenos mamíferos não-voadores e aves foram os itens mais freqüentes, sendo proporcionalmente mais predados no outono e no verão, respectivamente. Artrópodos foram mais predados no inverno e na primavera e ovos de aves e/ou répteis somente no verão e na primavera, período de reprodução nestes dois grupos.
PALAVRAS-CHAVE. América do Sul; canídeos; hábitos alimentares; Rio Grande do Sul; sazonalidade.

Animal trophic ecology can provide relevant information for conservation programs. Feeding permeates several aspects of species biology, as habitat preferences, morphological and physiological adaptations, behavioral aspects and interactions with other species. The crab-eating fox, *Cerdocyon thous* (Linnaeus, 1766), is a small canid with body mass between 4 and 13kg (Moehlman 1986, Motta-Junior *et al.* 1994). It presents twilight and nocturnal habits, with extensive distribution in the savannas and forests of South America, from Uruguay and northern Argentina to northern of South American continent (Berta 1987, Medel & Jaksic 1988, Eisenberg & Redford 1999). Its predation strategy is opportunistic, with an omnivore diet, including mainly small mammals, birds, insects and fruits, and consuming the most abundant food resources in each season (Bisbal & Ojasti 1980, Berta 1987, Motta-Junior *et al.* 1994). In southern Brazil, the crab-eating fox is probably the carnivore species that lives closest to man, bringing itself benefits (it sometimes feeds on human food, domestic animals, carrion) and injuries (many die overruned and suffer man persecution) (Dotto *et al.* 2001).

The objective of this study is to present quali-quantitative information on food items and to check for the existence of seasonallity in the diet of crab-eating foxes in the Lami Biological Reserve.

MATERIALS AND METHODS

Study area

Field work was conducted in the Lami Biological Reserve (30°15'S, 51°05'W), located in the suburban zone of Porto Alegre municipality, in Rio Grande do Sul State. The reserve presents a total area of 179.78ha (Brack *et al.* 1992). This area is localized in Savannah/ Seasonal Semideciduous Forest contact (Teixeira & Coura-Neto 1986), encompassing a mosaic of wetlands (wet grasslands and swamps), sandy coastal forest ("restinga"), semideciduous forest and water bodies, including a stream and a large lake that surrounds 60% of reserve perimeter.

The climate is characterized by four well-limited seasons, being characterized by high humidity (annual mean 76%) and dry season absence. The annual mean temperature is 19.4°C, with maximal temperature in January (37.8°C) and minimal in July (1.4°C). The annual mean precipitation is 1,324mm (mean between years 1912 and 1997) (Livi 1998). Flooding occurs occasionally during the winter, particularly in areas bordered by the Guaíba Lake, probably because of a smaller evaporation rate during this period.

Sampling

During the year 2000, about 300 fecal samples were collected in field expeditions at two or three-week sampling intervals, along trails representing distinct vegetation types in the Lami Biological Reserve. From the 300 fecal samples, 80 were randomly sampled (20 for each season) and analyzed. It is important to point out that all days of field work were represented.

Sample scats were identified from their size, form, odor, presence of tracks in the immediate area and, eventually, by presence of hairs (identified by microscope). The absence of other similar wild canids with similar scats in the study area – as *Lycalopex gymnocercus* (Fischer, 1814), a sympatric species in Rio Grande do Sul – reduced uncertainty in the identification. Scats of doubtful origin were discarded. We dried the samples in an oven at 60°C for 24h, immersed them in 70% alcohol and identified food items under a stereomicroscope (adapted from Korschgen 1987).

Data analysis

To describe the diet of the crab-eating foxes, data were analyzed using the percentage of occurrence frequency (OF% – proportion of the total number of samples in which a certain food item is present) and percentage of relative frequency (RF% – proportion of a food item in relation to all food items in the sample). The seasons were statistically analyzed by the contingency data of presence or absence (binary data) of food items in 80 fecal samples. To compare the diet between seasons, resemblance measures and analysis of variance with randomization testing (hypothesis test) were applied to explore variation in the data, as proposed by Pillar & Orlóci (1996), using a multivariate statistics software, MULTIV, 2.1.1 version (Pillar 2001). The analisys of variance involves a division of total variation in "between groups" and "within groups" (Pillar & Orlóci 1996). The objective of this division was to evaluate the variation magnitude "between groups" and if groups are different or not, through a probability obtained with a randomization testing. The division was realized through sum of squares of Euclidean distance between sampling units. The randomization testing produces a probability (QbNull ≥ Qb, the null sum of squares is larger or equal than the sum of squares observed), and the Null Hypothesis (H_0) is rejected when probability is lesser or equal than α (0.1). The Null Hypothesis (H_0) stated that there is not significant difference in the diet of the crab-eating fox between the seasons of the year 2000 in Lami Biological Reserve. To test the hypothesis, 10,000 iterations were applied.

RESULTS AND DISCUSSION

Eighteen taxa were identified in the diet of the crab-eating fox (Tab. I). This number is underestimated because some taxa were not possible to identify to species level. The diet of the crab-eating fox was essentially carnivorous (87.62% of the diet was composed by vertebrates), a higher proportion than previously reported. The most similar data was reported in a study at the Colombian Andes, where 68.9% of the diet of crab-eating foxes was composed by vertebrates (Delgado-V 2002). In other studies with this species, the percentage of vertebrates in the diet was always lower: Venezuela, 58% (Bisbal & Ojasti 1980); in Brazilian Cerrado, 49.9% (Juarez & Marinho-Filho 2002); and in an altitudinal forest in southeastern Brazil, 34.23% (Facure *et al.* 2003). In study sites with similar conditions – urban influence – the diet of the crab-eating fox was composed by 43.86% (Motta-Junior *et al.* 1994) and 41.20% (Facure & Monteiro-Filho 1996) of vertebrates, and the species was classified as omnivorous.

Small rodent species were the most important food item in the diet of the crab-eating fox at the Lami Biological Reserve, with a 52.8% relative frequency, including at least seven species. These species have distinct habits, from open areas, as *Cavia aperea* Erxleben, 1777, to semi-aquatic – *Holochilus brasiliensis* (Desmarest, 1819), cursorial of forest and open areas – *Akodon* sp., semi-arboreal – *Oligoryzomys* sp., arboreal – *Phyllomys dasythrix* Hensel, 1872, semi-fossorial of forest and open areas – *Oxymycterus* sp., and peridomiciliary, like *Mus musculus* Linnaeus, 1758. This variety of prey habits indicates that crab-eating foxes are versatile predators. Occurrence of an arboreal species (*P. dasythrix*) in the diet could be explained by its eventual movement in the ground or due to the ingestion of this prey previously dead (by disease or attack of other predators, like birds of prey, etc.). It is important to note that the carnivorous habits of the local crab-eating foxes could be related to the absence of autochthonous felines, which are locally extinct.

Table I. Diet of the crab-eating fox (*Cerdocyon thous*) in Lami Biological Reserve, southern Brazil, during the year 2000 (N = 80 fecal samples, 20 per season).

Food items	Occurrence frequency (Relative frequency) (%)				
	Summer	Autumn	Winter	Spring	Total
Plants					
Bryophyta	0 (-)	0 (-)	0 (-)	10 (-)	2.5 (-)
Grasses (Graminae e Ciperaceae)	45 (-)	35 (-)	25 (-)	25 (-)	32.5 (-)
Mimosoideae (Leguminosae)	10 (-)	45 (-)	10 (-)	35 (-)	25 (-)
Plants NI	40 (-)	75 (-)	35 (-)	80 (-)	57.5 (-)
Arthropods NI	0 (0)	0 (0)	0 (0)	5 (1.64)	1.25 (0.56)
Insects					
Coleoptera	5 (2.56)	5 (2.70)	15 (7.32)	15 (4.92)	10 (4.49)
Lepidoptera	0 (0)	0 (0)	0 (0)	10 (3.28)	2.5 (1.12)
Hemiptera	0 (0)	0 (0)	0 (0)	5 (1.64)	1.25 (0.56)
Hymenoptera	0 (0)	0 (0)	0 (0)	5 (1.64)	1.25 (0.56)
Insects NI	0 (0)	0 (0)	5 (2.44)	0 (0)	1.25 (0.56)
Fishes					
Cichlidae	0 (0)	0 (0)	0 (0)	5 (1.64)	1.25 (0.56)
Fishes NI	5 (2.56)	0 (0)	0 (0)	0 (0)	1.25 (0.56)
Reptiles					
Testudines	0 (0)	10 (5.41)	0 (0)	15 (4.92)	6.25 (2.81)
Birds					
Dendrocygna viduata (Linnaeus, 1766)	5 (2.56)	0 (0)	0 (0)	5 (1.64)	2.5 (1.12)
Passeriformes	0 (0)	0 (0)	0 (0)	5 (1.64)	1.25 (0.56)
Birds NI	40 (20.51)	15 (8.11)	35 (17.07)	55 (18.03)	36.25 (16.30)
Mammals					
Cavia aperea Erxleben, 1777	0 (0)	15 (8.11)	0 (0)	0 (0)	3.75 (1.69)
Phyllomys dasythrix Hensel, 1872	0 (0)	5 (2.70)	15 (7.32)	20 (6.56)	10 (4.49)
Akodon sp.	25 (12.82)	25 (13.51)	5 (2.44)	20 (6.56)	18.75 (8.43)
Holochilus brasiliensis (Desmarest, 1819)	20 (10.26)	30 (16.22)	5 (2.44)	40 (13.11)	23.75 (10.67)
Oligoryzomys sp.	30 (15.38)	30 (16.22)	50 (24.39)	30 (9.84)	35 (15.73)
Oxymycterus sp.	0 (0)	5 (2.70)	0 (0)	0 (0)	1.25 (0.56)
Mus musculus Linnaeus, 1758	5 (2.56)	0 (0)	0 (0)	0 (0)	1.25 (0.56)
Cricetidae/Muridae NI	15 (7.69)	20 (10.81)	25 (12.20)	35 (11.48)	23.75 (10.67)
Didelphidae NI	10 (5.13)	0 (0)	0 (0)	0 (0)	2.5 (1.12)
Small non-flying mammals NI	25 (12.82)	15 (8.11)	40 (19.51)	15 (4.92)	23.75 (10.67)
Bird/reptile eggs	5 (2.56)	0 (0)	0 (0)	5 (1.64)	2.5 (1.12)
Items NI	5 (2.56)	10 (5.41)	10 (4.88)	15 (4.92)	10 (4.49)

The identification of some rodents to species level (as *C. aperea*, *P. dasythrix*, *H. brasiliensis* and *M. musculus*) was possible because only one species of each genus occurs in the region. Molar teeth in the samples allowed identification only to generic level. The following references were used for determining rodent species: Emmons *et al.* (2002) for *P. dasythrix*, Christoff *et al.* (2000) for *Akodon* sp., Hershkovitz (1955) for *H. brasiliensis*, Carleton & Musser (1989) for *Oligoryzomys* sp., Hershkovitz (1994) for *Oxymycterus* sp. and Eisenberg & Redford (1999) for *M. musculus*.

Absence of fruits, an important resource mentioned in the literature (Bisbal & Ojasti 1980, Motta-Junior *et al.* 1994, Paz *et al.* 1995, Facure & Giaretta 1996, Facure & Monteiro-Filho 1996, Facure *et al.* 2003, MacDonald & Courtenay 1996), could be associated to a particular characteristic of the local population of crab-eating foxes, which aggregates efforts and directs skills to prey on small mammals, only occasionally feeding on fruits. Only in the year 2001, consequently after this study, scats (three) of crab-eating fox were found containing fruits of palm trees: *Syagrus romanzoffiana* (Cham.) Glassm. and *Butia capitata* (Mart.) Becc. Motta-Junior *et al.* (1994) described the crab-eating fox as potential seed disperser by endozoochory for many fructiferous plant species they consumed, and Paz *et al.* (1995) reported this species as a great consumer and a probable disperser of a palm tree species (*B. capitata*) in Uruguay. However, through a field test with *Lycalopex culpaeus* (Molina, 1782), Bustamante *et al.* (1992) affirmed that foxes are inefficient and possibly ineffective dispersers because they defecate viable seeds where germination is unlikely to be successful.

During the bird reproductive season (spring and summer) the bird migration from other regions of the continent occurs to nest in the Lami Biological Reserve (Albuquerque *et al.* 1986, Tomazzoni *et al.* 2004). Birds were more frequent in the diet during this period, probably because of crab-eating fox predation on nestlings, resource that not seem to be so available in other seasons.

Other prey resources available to the crab-eating fox – frogs, snakes and lizards – were not observed in the sample, although they are relatively abundant in the study area. The crab-eating fox, however, preyed a large number of turtle eggs during spawning and incubation period. The local turtle species (Testudines) lay eggs in the warmer months, spring and summer (Bujes 1998). However, evaluating the amount of preyed eggs from fecal contents yields underestimated values.

Plants occurred in the diet only as vegetative parts, except by some Gramineae seeds. They are considered food items because it is possible that they aid food digestion (Dietz 1984). However, they are not included in the diet analysis because they do not have nutritional value if compared to other preys (MacDonald & Courtenay 1996).

The randomization testing indicated the occurrence of seasonal variation in the diet (p = 0.0009 between groups), but contrasts between summer/winter and autumn/spring were not significant (Tab. II). Nevertheless, greater incidence of some food items was observed in some seasons (arthropods in winter and spring, birds and bird/reptile eggs in summer and spring, small non-flying mammals in autumn). Other studies in which diet of the crab-eating fox was observed to be seasonally variable (Brady 1979, Bisbal & Ojasti 1980, Motta-Junior *et al.* 1994, Facure *et al.* 2003), comparisons were made between dry and wet seasons.

According to the results, during the year 2000 the crab-eating foxes of the Lami Biological Reserve presented a carnivorous and seasonally variable diet, acted predominantly as predators of small mammal populations and could not be considered potential seed dispersers.

Table II. Results of analysis of variance with randomization testing applied for multivariate data of food items, comparing the seasons of the year 2000 for crab-eating fox (*Cerdocyon thous*) diet in the Lami Biological Reserve, southern Brazil, during the year 2000 (20 samples per season, 10,000 iterations, (= 0.1).

Seasons	Sum of squares (Q)	P (QbNull > = Qb)
Between groups	13.687	0.0009
Summer-Autumn	4.275	0.0432*
Summer-Winter	2.375	0.4576
Summer-Spring	5.075	0.0150*
Autumn-Winter	5.900	0.0044*
Autumn-Spring	3.300	0.1738
Winter-Spring	6.450	0.0016*
Within groups	178.950	
Total	192.640	

*Values that rejected null hypothesis (H_0), indicating that differences between seasons are significant.

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