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SHORT COMMUNICATION

Diet of two sympatric carnivores, *Cerdocyon thous* and *Procyon cancrivorus*, in a restinga area of Espirito Santo State, Brazil

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The crab-eating fox (*Cerdocyon thous* (Linnaeus, 1766)) and the raccoon (*Procyon cancrivorus* (Cuvier, 1798)) are medium-sized nocturnal carnivores (3–8 kg) belonging, respectively, to families Canidae and Procyonidae (Berta 1982, Langguth 1975, Yanosky & Mercolli 1993). Both are widely distributed over the Neotropical Region (Colombia, Venezuela, Guyana, Surinam, French Guiana, Paraguay, Uruguay, northern Argentina and the greater part of Brazil) (Berta 1982, Brady 1979, Langguth 1975, Santos & Hartz 1999), being sympatric over most of their range. In Brazil both species are found in various different habitats, including the coastal plains (*restingas*) (Berta 1987, Langguth 1975, Motta-Junior *et al*. 1994, Novaes 2002, Santos & Hartz 1999, Wang & Sampaio 2001).

Restinga is a typical Brazilian coastal plain that occurs between the beach and the mature rain forest. It consists of xerophytic vegetation, including salt-adapted upper beach species, grassland, brush and scrub forest (Rizzini 1979).

Cerdocyon thous and *P. cancrivorus* are considered to be omnivorous species, feeding opportunistically on fruits, arthropods and small vertebrates (Bisbal & Ojasti 1980, Jácomo *et al*. 2004, Macdonald & Courtenay 1996, Montgomery & Lubin 1978, Motta-Junior *et al*. 1994, Novaes 2002, Olmos 1993, Santos & Hartz 1999).

The description of resource sharing between sympatric species can be used to determine the factors that allow species to coexist (Konecny 1989). According to Jaksic *et al*. (1981), prey partitioning is one way by which sympatric carnivores partition their resources, and it may be spatial, temporal or trophic.

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The purpose of this work is thus to investigate the relations between trophic niches of these two carnivores, which occur sympatrically in the Paulo Cesar Vinha State Park (PEPCV), Espirito Santo State, south-eastern Brazil, checking for overlap in their diets, identifying and quantifying the main food items taken by these carnivores, and checking whether there is seasonal variation in their diets.

Paulo Cesar Vinha State Park, formerly Setiba State Park, comprising approximately 1500 ha, is located in Guarapari Municipality, on the southern coast of Espirito Santo State, between 20°33′ and 20°38′S, and 40°23′ and 40°26′W. The region's climate, following Köppen, is Aw, tropical with rainy summers and a dry period in winter, and average yearly temperature of 23.3 °C (Fabris & César 1996).

The park comprises several plant communities that are related to the presence of lakes, to the unevenness of the terrain, which brings the water table close to the surface, as well as to wind direction, distance from the sea and geological formation (Pereira 1990).

The feeding habits of the crab-eating fox and of the raccoon were determined on the basis of scats collected, every 2 wk, in different plant formations and along the PEPCV trails, from June 2000 to September 2002. In the laboratory, each scat was oven-dried and washed on a sieve under running water. The material was sorted, and food item remains such as seeds, arthropod fragments, teeth, hair, nails, feathers, and scales, among others, were selected for analysis. Predator scat identification included a structural micro-analysis (scale type and medular pattern) of the guard-hairs ingested during self-cleaning (Quadros 2002), in addition to identification of the footprints associated with the scats. Seeds were identified by comparison with seed collections representative of the fruits available in the study area. Animal structures were compared with specimens deposited in the Universidade Federal do Espírito Santo (UFES) and Museu de Biologia Professor Mello Leitão (MBML) zoological collections.

The importance of each prey type was analysed based on the frequency of its occurrence in the scats (percentage of the total scats in which a certain item was found) (Crawshaw 1995). For the study of niche width of both species, the standardized index of Levins (Krebs 1998) was calculated. Standardized trophic niche widths allow for comparisons of diets with different numbers of prey categories. Diet overlap was calculated using the index of Pianka (Krebs 1998). Values may range from zero (no resource shared) to 1.0 (total overlap). To calculate the difference in the use of certain items between seasons of the year (dry or rainy season), the chi-square test was used (Zar 1999).

Of the scat samples collected, 131 were identified as crab-eating fox scats and 60 as raccoon scats, confirmed through the presence of the predator's hair in the samples. A total of 56 taxa was detected in the diet of *C. thous*, of which 28 were of animal origin and 28 of vegetable origin, totalling 484 occurrences, and 46 taxa in the diet of *P. cancrivorus*, 21 of animal origin and 25 of vegetable origin (Table 1). In terms of occurrence, 220 items were recorded. Fruits were the item most often found in scats of both *C. thous* and *P. cancrivorus*, the most frequent being the fruit of the palm *Allagoptera arenaria*, which occurred in 88.6% of *C. thous* scats and in 80% of *P. cancrivorus* scats. The fruits of other plant species, such as *Cereus fernambucensis*, *Neomithranthes obscura* and *Marlierea neuwiedeana* were also found several times in the scats of both species. Crustaceans (*Ocypode quadrata*) were found in the fox and raccoon scat samples, but there was no significant difference in the consumption of crustacea by the two species ($\chi^2 = 0.678$; $P = 0.172$). The vertebrates most frequently found in both species' scats were those of order Squamata, and *Tropidurus* gr. *torquatus* the lizard most often found. The most important items in the diet of *C. thous* and *P. cancrivorus* at the PEPCV were, by order of frequency, fruits, arthropods and small vertebrates.

According to Levins' index, the raccoon presented a smaller niche width (0.005) than the crab-eating fox (0.17), i.e. the former concentrated its feeding on a smaller number of prey items. Analysis of the degree of diet overlap between the two species revealed a 0.96 overlap. This value is quite close to 1.0, indicating an almost complete overlap of the food resources used.

The high consumption of *A. arenaria* fruit by the crab-eating fox and the raccoon may be related to this item's constant availability in the area. In other localities, *C. thous* eats fruits of other palm tree species such as *Syagrus romanzoffiana* in São Paulo State (Facure & Monteiro-Filho 1996) and Rio Grande do Sul State (Santos & Hartz 1999), and *Copernicia tectorum* in Venezuela (Montgomery & Lubin 1978). Arthropods, mainly insects, constituted a significant part of the diet of the two carnivores. These data agree with most previous studies, which indicate arthropods as the most frequent food item after fruits (Bisbal 1986, Brady 1979, Facure & Monteiro-Filho 1996, MacDonald & Courtenay 1996, Montgomery & Lubin 1978, Olmos 1993, Santos & Hartz 1999).

Amphibians and fishes were infrequent food items in the diet of *C. thous*, which is in agreement with previous observations that those vertebrates comprise a small part of this canine's diet in the Venezuelan llanos (Bisbal & Ojasti 1980) and in south-east Brazilian (Facure & Monteiro-Filho 1996, Motta-Junior *et al.* 1994). The same was observed for *P. cancrivorus* in this and in other studies (Bisbal 1986, Santos & Hartz 1999). According to Novaes (2002), crustaceans constituted the main food item in the diet of *P. cancrivorus* in the mangroves in Cubatão, São Paulo State. Some studies also cite crustaceans as the food item most utilized by *C. thous* (Bisbal & Ojasti 1980, Brady 1979). Such findings diverge from what was observed in the present study, where crustaceans were present in approximately 20% of scat samples analysed for each species.

The low niche width values for these carnivores domonstrate that, while consuming a wide range of items, they tend to concentrate their diets on a few resources, which can be confirmed by the high consumption of *A. arenaria* in relation to the other items. Bisbal & Ojasti (1980) concluded that the wide trophic niche of the crab-eating fox probably overlaps those of other sympatric carnivores, something which also occurs in the case of the raccoon (Santos & Hartz 1999). This was confirmed by the present study, which showed a nearly total overlap in these species' diets. One of the main mechanisms to avoid competition in vertebrates that use the same area is the existence of different feeding habits and predator body sizes, which may be an indication of resource partitioning for food (Johnson & Franklin 1994). Biometric data on *C. thous* and *P. cancrivorus* individuals indicate that there is no difference in these predators' body sizes, since both presented similar weights. Resource partitioning by prey size was not observed for these species in the study area, where both used similar-sized resources, such as rodents, marsupials and lizards, among others. Thus, it is likely that these variables have little influence on the segregation of these carnivores' diets. A comparison of the habitats used for deposition of scats might indicate a differential use of habitat by the species occurring in the Park, which would be one way for them to coexist in the area. However, more refined techniques yielding more consistent data on the ecological segregation of these species are needed, such as the use of plots for footprint

Table 1. Food items found in 131 crab-eating fox (*Cerdocyon thous*) and 60 raccoon (*Procyon cancrivorus*) scats at PEPCV, Guarapari, Espírito Santo State. N = number of times each item occurred in scats; % scats = percentage of the total scats in which item was found.

	Cerdocyon thous		*Procyon cancrivorus*	
Item	N	% scats	N	% scats
Fruits				
Allagoptera arenaria (Gomes) O. Kuntze (Arecaceae)	116	88.6	48	80.0
Cereus fernambucensis Lemaire (Cactaceae)	30	22.9	11	18.3
Eugenia sp. (Myrtaceae)	13	9.9	2	3.3
Neomithranthes obscura (DC.) N. J. E. Silveira (Myrtaceae)	12	9.2	6	10
Marlierea neuwiedeana Niedenzu (Myrtaceae)	7	5.3	4	6.7
Schinus terebinthifolius Raddi (Anacardiaceae)	4	3.1	3	5.0
Psidium cattleianum Sabine (Myrtaceae)	2	1.5	1	1.7
Tocoyena bullata (Vell.) Mart. (Rubiaceae)	2	1.5	4	6.7
Ocotea notata (Ness) Mez (Lauraceae)	1	0.8	–	–
Smilax rufescens Griseb. (Smilacaceae)	1	0.8	–	–
Scaevola plumieri (L.) Vahl (Goodeniaceae)	1	0.8	4	6.7
Seeds indet.	37	28.2	19	31.8
Arthropods				
Insects indet.	61	46.6	18	30.0
Orthoptera	33	25.2	14	23.3
Coleoptera	32	24.4	23	38.3
Ocypode quadrata (Fabricius, 1787) (Ocypodidae)	25	19.1	13	21.7
Molluscs				
Molluscs indet.	1	0.8	1	1.7
Lizards and snakes				
Tropidurus gr. *torquatus* (Wied, 1820) (Tropiduridae)	12	9.2	4	6.7
Colubridae indet.	11	8.4	7	11.7
Mabuya agilis Boulenger, 1887 (Scincidae)	9	6.9	2	3.3
Lacertilia indet.	6	4.6	3	5.0
Ophidia indet.	6	4.6	1	1.7
Bothrops jararaca (Wied, 1824) (Viperidae)	2	1.5	1	1.7
Ameiva ameiva (Linnaeus, 1758) (Teiidae)	2	1.5	3	5.0
Teiidae indet.	1	0.8	–	–
Mammals				
Rodents indet.	3	2.3	1	1.7
Akodon sp. (Muridae)	1	0.8	–	–
Bolomys sp. (Muridae)	2	1.5	–	–
Cavia fulgida Wagler, 1831 (Caviidae)	–	–	2	3.3
Oryzomys sp. (Muridae)	–	–	1	1.7
Rattus rattus (Linnaeus, 1758) (Muridae)	–	–	1	1.7
Didelphimorphia indet.	2	1.5	1	1.7
Caluromys philander (Linnaeus, 1758) (Didelphidae)	2	1.5	–	–
Metachirus nudicaudatus (Desmarest, 1817) (Didelphidae)	2	1.5	–	–
Gracilinanus microtarsus (Wagner, 1842) (Didelphidae)	1	0.8	–	–
Marmosops sp. (Didelphidae)	1	0.8	–	–
Monodelphis sp. (Didelphidae)	1	0.8	–	–
Sylvilagus brasiliensis (Linnaeus, 1758) (Leporidae)	1	0.8	–	–
Chiroptera indet.	1	0.8	–	–
Dasypus sp. (Dasypodidae)	–	–	1	1.7
Birds				
Birds indet.	8	6.1	3	5.
Fishes				
Fishes indet.	7	5.3	4	6.7
Amphibians				
Amphibians indet.	5	3.8	1	1.7
Vertebrates indet.	13	9.9	4	6.7

records and camera traps, before such a comparison is made.

The data suggest that the crab-eating fox and the raccoon have basically frugivorous diets, complemented by arthropods, mainly insects, and small vertebrates. The generalist diets suggest that they take part in several ecological interactions in the environment, whether as primary or secondary consumers, and since most of their diets overlap, ecological segregation may be spatial or temporal.

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