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Diet of free-ranging cats and dogs in a suburban and rural environment, south-eastern Brazil

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Abstract

In spite of the worldwide occurrence of domestic cats and dogs, and their close relationship with humans, the number of published papers on free-ranging cats *Felis catus* and dogs *Canis familiaris*, is small. The diet of both species was estimated in a suburban and rural environment in July 2002 and January 2003. Visual observations and scat collection of both species were accomplished along a 10 km transect line in the Campus 'Luiz de Queiroz', University of São Paulo, Piracicaba, south-eastern Brazil. The diet of both species was determined by analysis of sterilized, washed, dried and sorted scats. Estimated abundances of free-ranging cats and dogs in the sampled area were 81 (± 4.32) and 42 (± 2.96), respectively. Cats and dogs were more abundant in the suburban than in the rural environment ($t = 3.78$, $P < 0.001$, $N = 55$; $t = 8.38$, $P < 0.001$, $N = 55$, respectively) and cats were more abundant than dogs in the suburban environment ($t = 6.76$, $P < 0.001$, $N = 55$), even though there was no significant difference between the abundance of both species in the rural environment ($t = 0.82$, $P = 0.46$, $N = 55$). Invertebrates were the most commonly consumed item by both species, followed by mammals (cats: 63.24 and 20.51%; dogs: 57.05 and 25.15%, respectively). Niche breadth was 0.4892 for cats and 0.4463 for dogs. Niche overlap was almost complete (0.97108). The consumption of mammals was estimated to be between 16.76 and 25.42 kg individual^{-1}year^{-1} for dogs and between 2.01 and 2.9 kg individual^{-1}year^{-1} for cats. These data might be useful to establish a management program to minimize the predation pressure of free-ranging cats and dogs on wildlife.

Introduction

Despite the worldwide distribution of cats and dogs and their close relationship with humans, the number of published papers on free-ranging cats *Felis catus*, and dogs *Canis familiaris*, is small (Serpell, 1995). Information on their biology and ecology, and their interaction with wildlife is extremely important for adequate management actions. The increase in abandoned and mistreated domestic cats and dogs in major Brazilian cities has caused serious problems for the public health authorities due to the fact that only a few are vaccinated or are under the control of a responsible owner (Coelho *et al.*, 2001).

According to Nesbitt (1975), a domestic dog that is allowed out on its own will often become free ranging or even feral. The difference between the terms 'feral' and 'free-ranging' is a problem of nomenclature, or level of independence from humans. According to Boitani *et al.* (1995), a feral dog can be considered wild due to the fact that they can live without any contact with humans. Free-ranging dogs, on the other hand, maintain a social relationship with humans. Both are efficient predators of small- and medium-sized animals (Nesbitt, 1975) and even on farm animals such as year-old calves (Scott & Causey, 1973).

The domestic cat is distributed world wide and is found in a commensal relationship with humans everywhere (Coleman, Temple & Craven, 1997). Feral cats often occur in higher densities than native predators in some environments (Fitzwater, 1994). Small- and medium-sized mammals and some birds are often consumed by domestic cats (Jackson, 1951; Coleman & Temple, 1989). One of the methods to obtain information on a species' diet is to collect and analyze scats (Crawshaw, 1997). The analysis of prey items in scats has been of fundamental importance in carnivore research (Reynolds & Aebischer, 1991). In spite of the potential damage by domestic carnivores on local wildlife, research on the feeding habits of free ranging or feral cats and dogs is still limited in Brazil.

In addition to being a potential competitor of native predators, cats and dogs carry a great variety of diseases

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(Coleman *et al*., 1997). According to the Zoonosis Control Center of São Paulo, there are, respectively, 25 and 11 million domestic dogs and cats in Brazil. Piracicaba, a city with 360 000 inhabitants, is estimated to have about 40 000 cats and dogs, of which 15 000 are free ranging. Campus 'Luiz de Queiroz' of the University of São Paulo occupies an area of about 860 ha in Piracicaba, State of São Paulo, including suburban and rural environments with wildlife populations. According to Gheler-Costa, Verdade & Almeida (2002), the hunting pressure by free-ranging cats and dogs is one of the possible reasons for the low densities of small mammals in Campus 'Luiz de Queiroz'. Considering this situation, the present study aimed to conduct a survey of free-ranging cats and dogs, describe their diet and estimate their mammal consumption.

Methods

Study area

Campus 'Luiz de Queiroz' of the University of São Paulo is located in Piracicaba, State of São Paulo, south-eastern Brazil (22°42′S, 47°38′W, 546 m average altitude). This area encompasses 860 ha (67 ha of native forest) with a great variety of land use/land cover being characterized as an agroecosystem (Sparovek, 1993). The predominant original vegetation in the Piracicaba region is semi-deciduous Atlantic Forest (IBGE, 1992), adapted to cool dry winter and warm wet summer. In respect of its peripheral location in relation to the city, the Campus was classified as a peri-urban area including a rural area with unsealed roads and crops, and a suburban area, including buildings, gardens and sealed roads.

Cat and dog surveys

The data collection on cat and dog abundance and diet was carried out in July 2002 (winter) and January 2003 (summer) by diurnal direct counts from 07:00 to 12:00 h, and from 13:00 to 17:00 h in a previously established line transect 30 m wide and 4.5 km long (0.135 km^2) in the rural area and 4.7 km long (0.141 km^2) in the suburban area, totaling 9.2 km. The sampled area represented 0.276 km^2 or 3.2% of the Campus, with 506 km walked during 55 days by two observers at an average walking speed of 2 $km\,h^{-1}$ (Emmons, 1984). Individual animal identity was based on natural markings, sex and breed.

Diet qualification and quantification

The diet of domestic carnivores was studied through scat analysis (Reynolds & Aebischer, 1991). During scat collection on the transect survey, the location, date and the occurrence of tracks around scats were recorded. Scats were washed with water over a sieve of 1 mm screen, dried in an oven at 70° for 24 h and examined under a stereomicroscope to separate the contents into birds, fish, invertebrates, mammals, reptiles, vegetable matter and non-food items. Mammal remains were separated into hair, jaws and other bones. All parts were compared with our collection or museum references. Microscopic hair characteristics (medulla and cuticle) were compared with our reference collection.

Data analysis

Free-ranging cat and dog abundance was estimated by direct animal count in the sampled area. Estimated density was based on the number of individuals by species by habitat (rural or suburban) by season (winter and summer). Habitat use and frequency of occurrence were analyzed by the *t*-test (Krebs, 1999; Zar, 1999).

The quantification and identification of food habits of cats and dogs were made according to Bisbal (1986) and Crawshaw (1997) for each habitat and period sampled as follows: (1) quality and quantity of items identified by species; (2) relative frequency of occurrence; (3) percentage of occurrence; (4) niche breadth, with Levin's standardized niche breadth (Krebs, 1999); (5) niche overlap (Pianka's measure) (Krebs, 1999); (6) estimation of biomass consumed: number of individuals of main prey in the scat multiplied by the average body mass of each species (Bueno, Belentani & Motta, 2003). As it is difficult to assume over scat analysis that medium mammals are consumed entirely, we used three-quarters of the weight of an average adult times the number of animals to obtain the biomass figure for a species (Schaller, 1972). Based on biomass consumed, the dietary and annual mammal consumption was estimated.

Results

Distribution and abundance

As a result of the total sampling effort of 506 km walked in 55 days, 42 dogs (25 males, 17 females) and 81 cats (15 males, 41 females and 25 of unknown sex) were detected in the study area. Estimated density of cats and dogs in the study period was 445.65 individuals km^{-2}. There were more cats than dogs in both winter and summer samples (181.15 and 112.31 cats km^{-2}, respectively, vs. 76.8 dogs km^{-2} in both winter and summer samples).

Habitat use

Free-ranging cats and dogs were more abundant in the suburban than in the rural environment ($t = 3.78$, $P < 0.001$, $N = 55$; $t = 8.38$, $P < 0.001$, $N = 55$, respectively). Cats were more abundant than dogs in the suburban environment ($t = 6.76$, $P < 0.001$, $N = 55$), but not in rural areas ($t = 0.82$, $P = 0.46$, $N = 55$). The highest number of cats in the suburban environment was during the winter (4.57 ± 2.64 cats day^{-1}) and the lowest in summer (0.10 ± 0.40 cats day^{-1}).

Diets of free-ranging cats and dogs

After the analysis of 234 scats, 137 dog (99 collected in the winter and 38 in the summer) and 97 from cats (48 in winter and 49 in summer), 57 dietary items were identified: 68.4% of animal origin, 15.8% of vegetable origin and 15.8% formed by non-food items.

Fifty-two items were identified in the dogs' scats: 65.38% of animal origin, 17.31% of vegetable origin and 17.31% of non-food items. In the scats collected in winter, 49 items were identified: 63.26% of animal origin, 18.37% of vegetable and 18.37% of non-food items. In this period, vegetation material was the most frequent item, representing 28% of occurrence, followed by 18% of invertebrates. In the summer, 38 items were identified in scats: 68.42% of animal origin, 18.42% of non-food items and 13.16% of vegetable. In this period, the vegetable material was the most frequent item, representing 27.61% of occurrences, followed by 22.38% of invertebrates. Considering items of animal origin in the two seasons, invertebrates were more often consumed (57.05%), followed by mammals (25.15%), birds (16.56%) and reptiles (1.23%). Considering the mammals, rodents were consumed more often (45.1%), followed by Carnivora (23.53%), Didelphimorphia (15.68%), Lagomorpha and unidentified mammals (5.88% each) and Xenarthra (3.92%).

Forty-four items were identified in the cats' scats: 70.45% of animal origin, 15.90% of vegetable origin and 13.64% of non-food items. In scat collected in winter, 33 items were identified: 63.64% of animal origin, 21.21% vegetable and 15.15% non-food items. In this period, vegetable material was more abundant, representing 30.40% of the total, followed by 20.27% of invertebrates. In summer, 39 items were identified in scats: 66.67% of animal origin, 17.95% vegetable and 15.38% non-food items. In this period, vegetable material was the most frequent item, representing 25.96% of the total amount, followed by 24.30% of invertebrates. Considering items of animal origin in the two seasons, invertebrates were more frequents (63.24%), followed by mammals (20.51%), birds (12.82%), fish and reptiles (1.7% each). Of the mammals, rodents were the most common item (37.03%), followed by Didelphimorphia (33.33%), Carnivora and Lagomorpha (11.11% each) and Xenarthra and unidentified mammal (3.7% each).

Niche breadth and overlap

Both species were similar in relation to the niche breadth (*B*) $B_{\text{dogs}} = 0.4463$ and $B_{\text{cats}} = 0.4892$). The niche overlap (*O*) was *c*. 97% for both winter and summer samples. Dogs' and cats' diets were not significantly different in the winter season ($\chi^2 = 6.43$; d.f. 7; $P = 0.49$), summer ($\chi^2 = 4.19$; d.f. 6; $P = 0.65$) and both seasons combined ($\chi^2 = 6.18$; d.f. 7; $P = 0.51$).

Biomass consumed

Dogs

The most abundant item in the diet of dogs during the sampling period was *Nasua nasua*, (17.02%), followed by *Myocastor coypus* (12.76%). In winter, *N. nasua* represented 24% of the total items consumed, followed by *Galictis cuja* and *M. coypus* (12% each). However, in summer, *Didelphis albiventris* and *M. coypus* were the most abundant consumed item (13.65% each), followed by *Coendou prehensilis*, Muridae not identified (n.i.), *Mus musculus* and Leporidae (9.09% each). The total estimated biomass consumed in winter was 59.33 kg, with *N. nasua* representing 50.1%, followed by *M. coypus* (21.2%) and *Dasypus novemcinctus* (12.3%). In summer total estimated consumption was 39.12 kg, with *M. coypus* representing 32.13%, followed by *N. nasua* (25.56%) and *C. prehensilis* (17.17%) (Table 1).

Cats

Didelphidae n.i. was the most abundant mammal consumed by cats, representing 19.23% of the total items, followed by *Cavia aperea* (15.38%). In winter, *Olygoryzomys nigripes* was the most abundant species item consumed (21.43%), followed by *Da. novemcinctus* and *D. albiventris* (14.29% each). In summer, Didelphidae n.i. was the most abundant consumed species (33.33%), followed by *C. aperea*, *G. cuja* and Leporidae (16.67% each). Of the estimated biomass consumed in the winter (11.21 kg), *D. novemcinctus* represented 32.53%, followed by *D. albiventris* (22.30%) and *G. cuja* (14.08%), and in summer (10.20 kg), Didelphidae n.i. represented 36.85%, followed by *G. cuja* (30.97%) and Leporidae (18.3%) (Table 2).

The mammals consumed by dogs had an estimated value ranging from 16.76 to 25.42 kg year individual^{-1}, and for cats ranging from 2.01 to 2.95 kg year individual^{-1}, a total value ranging from 63.9 to 96.8 kg km year^{-1} consumed by dogs and a value ranging from 14.9 to 16.4 kg km year^{-1} consumed by cats (Table 3).

Discussion

The feline population was higher than the canine population during all the sampling periods. The fact that free-ranging cats can reproduce more rapidly than dogs might explain this difference. In addition, dogs normally have a larger home range than cats (Macdonald & Carr, 1995), and this could result in territory competition among dogs, preventing a higher population density of dogs in a site.

The higher abundance of cats and dogs in the suburban environment could also be related to their close association with humans. Food provided by humans in a suburban environment is higher than in the rural ones. Churcher & Lawton (1987) reported a similar situation in an English village where some individuals were frequently observed close to places that provided easy access to food such as grocery stores and restaurants. Suburban areas of the Campus 'Luiz de Queiroz' have a large daily pedestrian traffic providing large amounts of garbage used by cats and dogs as food.

The number of free-ranging cats and dogs observed in the sampling area was considered as the total population in the Campus. This is a more conservative estimation of their

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Table 1 Estimation of mammals consumed biomass in 137 scats of free-ranging dogs *Canis familiaris* at Campus 'Luiz de Queiroz', Piracicaba, SP, south-eastern Brazil

		Winter (N=99)				Summer (N=38)			
		Individual number		Estimated biomass		Individual number		Estimated biomass	
Prey species	Medium mass (g)	*n*	%	g	%	*n*	%	g	%
Cavia aperea	349	2	8	698	1.2	1	4.54	349	0.89
Calomys tener	20	2	8	40	0.06	–	–	–	–
Coendou prehensilis	3360	–	–	–	–	2	9.09	6720	17.17
Dasypus novemcinctus	3650	2	8	7300	12.3	–	–	–	–
Didelphidae n.i.	940	1	4	940	1.6	1	4.54	940	2.4
Didelphis albiventris	1250	1	4	1250	2.1	3	13.65	3750	9.58
Galictis cuja	1580	3	12	4740	8	1	4.54	1580	4.04
Lutreolina crassicaudata	537	1	4	537	1	1	4.54	537	1.37
Muridae n.i.	127.22	1	4	127.22	0.21	2	9.09	254.44	0.65
Murinae n.i.	179.33	1	4	179.33	0.3	–	–	–	–
Mus musculus	15.5	1	4	15.5	0.02	2	9.09	31	0.08
Myocastor coypus	4190	3	12	12570	21.2	3	13.65	12 570	32.13
Nasua nasua	5000	6	24	30 000	50.1	2	9.09	10 000	25.56
Rattus novergicus	352.5	–	–	–	–	1	4.54	352.5	0.9
Rattus rattus	170	–	–	–	–	1	4.54	170	0.43
Leporidae	934	1	4	934	1.6	2	9.09	1868	4.77
Total		25	100	59331.10	99.69	22	95.45	39121.90	99.08

N, number of scats collected in each season; n.i., non identified.

Table 2 Estimation of mammals consumed biomass in 97 scats of free-ranging cats *Felis catus* at Campus 'Luiz de Queiroz', Piracicaba, SP, south-eastern Brazil

		Winter (N=48)				Summer (N=49)			
		Individual number		Estimated biomass		Individual number		Estimated biomass	
Prey species	Medium mass (g)	*n*	%	g	%	*n*	%	g	%
Cavia aperea	349	2	14.29	698	6.22	2	16.67	698	6.85
Dasypus novemcinctus	3650	1	7.14	3650	32.53	–	–	–	–
Didelphidae n.i.	940	1	7.14	940	8.39	4	33.33	3760	36.85
Didelphis albiventris	1250	2	14.29	2500	22.30	–	–	–	–
Galictis cuja	1580	1	7.14	1580	14.08	2	16.67	3160	30.97
Lutreolina crassicaudata	537	1	7.14	537	4.78	1	8.33	537	5.26
Muridae n.i.	127.22	1	7.14	127.22	1.13	–	–	–	–
Murinae n.i.	179.33	1	7.14	179.33	1.60	1	8.33	179.33	1.77
Olygoryzomys nigripes	24.5	3	21.43	73.5	0.65	–	–	–	–
Leporidae	934	1	7.14	934	8.32	2	16.67	1868	18.3
Total		14	100	11 219.05	100	12	25	10 202.33	100

N, number of scats collected in each season; n.i., non identified.

Table 3 Estimation of mammal biomass consumption per day and per year by free-ranging cats *Felis catus* and dogs *Canis familiaris* at Campus 'Luiz de Queiroz', Piracicaba, SP, south-eastern Brazil

	Winter (N=26 days)					Summer (N=29 days)				
Species	*n*	kg individual^{-1} day^{-1}	kg individual^{-1} year^{-1}	kg km^2 day^{-1}	kg km^2 year^{-1}	*n*	kg individual^{-1} day^{-1}	kg individual^{-1} year^{-1}	kg km^2 day^{-1}	kg km^2 year^{-1}
Canis familiaris	21	0.069	25.420	0.265	63.90	21	0.045	16.760	0.174	96.80
Felis catus	50	0.005	2.010	0.044	14.90	31	0.008	2.956	0.040	16.40
Total	71	0.074	27.430	0.309	78.80	52	0.053	19.716	0.214	113.20

N, number of days sampled; *n*, number of animals counted during the study period.

total population as there is no evidence that rural environments support such a dense populations.

The diet of free-ranging cats and dogs in the study area consisted of a great variety of items of plant and animal origins. The opportunistic behavior of free-ranging dogs in the study area is similar to that described in other regions such as Italy (Macdonald & Carr, 1995), North America (Daniels & Bekoff, 1989) and Asia (Corbett, 1995).

The frequent presence of grass in the scat could be related to nutritional and health aspects (Fitzgerald, 1988). The high frequency of Hymenoptera could be related to their high frequency in the garbage, being possibly ingested accidentally. Considering the consumption of mammals by dogs, our results are similar to those presented by Butler & du Toit (2002).

The capybara *Hydrochoerus hydrochaeris* item was excluded from the biomass estimation due to its high body mass and low occurrence ($n = 1$). We presumed that it was more likely an opportunistic consumption rather a predation event.

The high amount of vertebrate animal items in the cats scats corroborates their natural predatory behavior. However, cat diet could vary in relation to their association with humans (Fitzgerald, 1988).

Fitzgerald & Karl (1979) and Churcher & Lawton (1987) reported that mammals and birds are the main prey of cats. However, in this study, non-food items were present in a similar proportion to mammalian items. In the cat diet, the most frequent item was *O. nigripes*, possibly due to its abundance in site (Bailey, 1993; Gheler-Costa *et al.*, 2002).

The identification of *G. cuja*, *M. musculus* and *Rattus novergicus* in the scats during this study indicated the presence of these species in the study site, although they have not been detected previously.

The niche breadth suggests that the items in the dogs' diet are equally distributed in both seasons, confirming the variable use of available resources in the Campus and an omnivorous pattern. Cats exhibited higher niche breadth in winter than in summer, similar to the pattern previously described by Karl & Best (1982) and Fitzgerald, Karl & Veitch (1991).

Despite the difference in the body mass of cats and dogs, the niche overlap between the two species is almost complete (*c.* 97%). This could be explained by their opportunistic behavior in anthropogenic habitats such as this study site.

The estimated biomass consumed by dogs and cats in this study ranged from 45.93 to 69.99 and from 5.53 to 8.10 g individuals day^{-1}, respectively, suggesting a low consumption of mammals in the study area. Studies on maned wolves (*Chrysocyon brachyurus*, body mass: 20–26 kg) estimated a biomass consume near to 70 g individuals day^{-1} (Motta *et al.*, 1996; Silva & Talamoni, 2003). Considering a body mass of 1–20 kg for the free-ranging dogs in site, their relative consumption is similar, suggesting a possible competition between these species. The high frequency of *N. nasua* confirms the predation of large-sized animals by free-ranging dogs (Boitani *et al.*, 1995; Butler & du Toit, 2002).

Prey numbers consumed by cats were similar to those described by Bradt (1949) and George (1974), resulting in an average of 26 and 92 preys per month, respectively. The biomass consumed by cats in this study was lower than 240–270 g day^{-1} in Sweden (Liberg, 1982). However, the relatively large variety of prey species consumed by the relatively large cat population in this study suggests that feral cats could have a significant impact on biodiversity in south-eastern Brazil.

Final considerations

This is the first study on the diet of free-ranging cats and dogs in Brazil. Despite the fact that the study area has a subtropical climate, the results obtained here were very similar to those obtained by other authors in temperate zones, with the exception of the larger prey size taken by the dogs (*N. nasua*). This pattern stresses the high adaptive capacity of free-ranging cats and dogs to suburban environments throughout the world, potential competitive relationships with wild carnivores and their additive predation pressure on local wildlife.

In anthropic landscapes such as the one in the present study, predation on wildlife caused by free-ranging dogs and cats may be relevant. Therefore, the following management actions should be taken:

(1) Informing people about diseases transmitted by free-ranging dogs and cats: This would lead people to understand the risks involved in the maintenance of those species in site.
(2) Educating people about local biological diversity: This would lead people to value wildlife instead of dogs and cats.
(3) Prohibiting people from abandoning and feeding free-ranging dogs and cats in site: This would prevent local habitat carrying capacity to increase.
(4) Allowing people to walk only leashed domestic dogs in site: This would lead dog owners to appreciate and support the exclusion of free-ranging dogs and cats.
(5) Establishing a deadline (e.g. 6 months) after which an exclusion program of free-ranging dogs and cats would take place: This would prepare local people for the management actions, avoiding emotional individual responses based on lack of knowledge.
(6) Enforcing management measures above.

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Supplementary material

The following material is available for this article online:

Table S1. Items of 234 scats of free-ranging cats and dogs collected in the winter/2002 and summer/2003 at Campus 'Luiz de Queiroz'.

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