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Domestic cat predation on Neotropical species in an insular Atlantic Forest remnant in southeastern Brazil

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The domestic cat *Felis silvestris catus* is considered a potential threat to the native fauna of regions it populates, particularly when it has free access to these areas. Although this problem is known in Brazil, little is known regarding the effects of this species on natural areas. This study aimed to obtain information concerning the diet of domestic cats by identifying the main items found in fecal samples from domestic cats. In addition, the effects of seasonality on the diet were examined, as it has been hypothesized that seasonal variation of food items has little influence of the diet of the domestic cat. These semi-domiciled cats are thought to face a constant and continuous supply food offered by their owners throughout the year. Feces were collected in a remnant fragment of an Atlantic Forest located south of the municipality of Ilha Comprida – SP, Brazil. These samples provided important information regarding the dietary ecology and predation behavior of this species in endangered forest areas. The results of the scat content analyses demonstrated that domestic cats inserted in this biome presented a generalist and opportunist diet with little seasonal variation, even when receiving food from their owners. The most frequently consumed groups of prey were insects (20.8%) followed by mammals (13.9%) and birds (4.0%). Although the cat is not the only factor that impacts the species of the region, management programs need to be established in conjunction with the local community with the aim of minimizing the pressure exerted by these animals on the native fauna.

Generally speaking, the species *Felis silvestris catus* presents an opportunistic predation behavior, irrespective of its dietary and behavioral relationship with man (Barratt 1997). Considered generalist hunters with a well-diversified range of dietary items (Nogales and Medina 1996, Turner and Bateson 2000, Bonnaud et al. 2007, 2011, Medina et al. 2011), they may strongly impact birds, small mammals, reptiles and insects via predation. Therefore, this species is sometimes identified as one of the causes of the decline in certain species in various areas of the world (Fitzgerald 1988, Fitzgerald and Turner 2000, Woods et al. 2003, Nogales et al. 2004, Bonnaud et al. 2007, Medina and García 2007, Medina et al. 2011, Lessa and Bergallo 2012, Loss et al. 2013).

The diet of cats has been studied both in continental areas and many islands where this species has been found. Studies in continental areas have mainly concentrated on the regions of Europe (Liberg 1984, Woods et al. 2003), Australia (Barratt 1997, 1998) and North America (Lepczyk et al. 2003, Loss et al. 2013). However, the activities of this predator have had the most significantly negative impact in insular areas, to the extent that the survival of some species has become impossible (Keitt et al. 2002, Bonnaud et al. 2007, Medina et al. 2011). For example, on Macquarine Island, Australia, feral cats have been noted as being the main cause for the extinction of a subspecies of psittacid *Cyanoramphus novaezelandiae erythrotis* (Taylor 1979). A similar situation occurred with *Geocapromus* spp., a species of rodent that was exterminated in several of the Caribbean islands (Fitzgerald 1988).

Although the agencies responsible for natural environments know about the presence of domestic animals in these as well as in protected areas of Brazil, little action is taken. Consequently, the effects on native wild life have not been sufficiently studied (Galetti and Sazima 2006). A lack of knowledge about the impact caused by these species, even among researchers, and the consequent scarce divulgement of the problem, are likely responsible for the minimal importance that has been attached to the subject. Even fewer studies are related to the presence of cats in Brazilian natural environments, particularly in insular areas. This scarcity is demonstrated in Bonnaud et al. (2011) and Medina et al. (2011), which lack records of studies in Brazilian island territories.

Therefore, the aim of the present study was to obtain information concerning the main items found in the diet of semi-domiciled cats inserted in insular natural environments and observe the effect of seasonal variation on the diet of this species in the municipality of Ilha Comprida. This municipality belongs to the Lagoon Estuarine Complex of Cananéia/Iguape/Paranaguá located on the southern coast of the state of São Paulo, where one of the largest remnant fragments of Atlantic forest in the country – Serra do Mar – is found. We examined items identified in fecal samples of semi-domiciled cats to verify the hypothesis that seasonal variation has little influence on their diet because they receive a continuous and constant supply of food of anthropogenic origin throughout the year.

Material and methods

Study area

The Environmental Protection Area (APA) of Ilha Comprida is located in the municipality of Ilha Comprida on the southern coast of the state of São Paulo in southeastern Brazil (24°44′S, 47°32′W, altitudes lower than 7 m). The APA comprises 17527 ha and belongs to the Lagoon Estuarine Complex of Cananéia/Iguape/Paranaguá (Ilha Comprida 2005). Its vegetation is primarily consists of 'restinga', mangroves, floodable areas, dunes, beaches and lowland areas of Atlantic forest ('matas de planície atlântica'). The climate in the region is classified as being humid subtropical, with a mean annual temperature of 24°C and a mean annual rainfall of approximately 2300 mm. The highest rainfall months occur between October and March, the season corresponding to spring and summer (monthly mean of 300 mm), while the driest period occurs between October and winter and from April to September (monthly mean of approximately 90 mm) (Instituto de Pesca 2003). Its estimated human population is approximately 9025 inhabitants (IBGE 2010) and is concentrated mainly in the northern part, while the southern part, where the most preserved areas are found, is mainly occupied by several nuclei of traditional fishing communities. In the latter region, specifically the region denominated 'Boqueirão Sul' (25°01′ to 25°03′S and 47°54′ to 47°53′W), includes some residential properties and summer homes. The presence of this (feline) species was recorded by observations and previous contacts in this region and was therefore the area chosen for data collection. This region includes several wild species of mammals belonging to the order carnivore, including three cat species: puma *Puma concolor*, jaguarondi *Puma yagouaroundi* (Nakano-Oliveira 2006) and oncilla *Leopardus tigrinus* (Ferreira et al. unpubl.); two species of Procyonidae: coati *Nasua nasua* and crab-eating raccoon *Procyon cancrivorus*; a species of Mustelidae: river otter *Lontra longicaudis*, and a species of Canidae: hoary fox *Cerdocyon thous* (Nakano-Oliveira 2006).

Methodological procedures

The data on the cats' diet were collected over 13 months from September 2009 to September 2010. During this time, the previously mapped study area (approximately 15 km^2) was traversed on fifteen to twenty days per month, alternating daily between the two points chosen for the study ('Trilha da Trincheira' or 'Praia') with the aim of collecting all encountered cat feces.

Diet quantification and qualification

We collected samples found near properties where animals live, in points previously identified as sites used for defecation, on roads, tracks, and banks of streams and rivers. These locations were chosen because most carnivores tend to use tracks to roam and use feces as visual and scent marks, and they normally deposit feces along the way (Liberg 1980, Crawshaw 1997, Fitzgerald and Turner 2000).

We covered transects measuring 2.915 km long in the 'Trilha da Trincheira' region and 3.940 km long in the 'Praia' region. We covered each transect four to six times per month and collected fecal samples. The residences arranged along the two regions visited were also sampled monthly on the same day shortly after the transects with the aim of collecting fecal samples in the immediate vicinity of properties (gardens and yards) in which the presence of domestic cats was previously identified and verified. We recorded the number of animals found on each property monthly. We identified and photographed each animal for possible comparison and identification. Along transects, we also counted the animals whose owners were not identified (possibly feral animals). We estimated the relative abundance of domestic cats using the 'kilometrical abundance index'. For each survey area, the rate was 3.43 individuals km^{-1} in the 'Trilha da Trincheira' region and 6.60 individuals km^{-1} in the 'Praia' region.

The fecal samples were duly identified, collected and stored in plastic bags. They were labeled with the sample number, date, collection site and the geographic coordinates, which were determined by means of a GPS. The estimated time of defecation (based on characteristics such as the appearance, texture and smell to classify samples as fresh or aged), the presence of footprints and scarifications and other indications that would help to characterize the excrements were also recorded and identified based on comparisons made using identification guides for species of wild felines of Brazil (Oliveira and Cassaro 2005). These identifications were linked to other characteristics of the samples that also served to identify them, such as the behavior of burying feces and presence of scarification, the characteristic odor of the feces of domestic cats and the proximity to anthropic areas.

The feces were washed under running water over a fine-meshed sieve (0.5 mm), sun-dried, and subjected to naked eye examination and triaging (Ferreira et al. 2013). The items found were then separated into seven categories: mammals, birds, amphibians, invertebrates, vegetable matter, domestic food and undigested matter of anthropic origin (e.g. plastic, paper, string, among others). The types of prey were identified to arrive at the lowest possible taxonomic level with the help of specialists, with identification keys found in specialized literature (Quadros and Monteiro-Filho 2006, Martin et al. 2009, Silveira et al.

2013), by comparison with specimens deposited in collections, or by comparison with samples of remains of previously identified types of prey found close to the residence. Microscope slides were prepared of the hairs (medulla and cuticle) according to the methodology described by Quadros and Monteiro-Filho (2006) to confirm the species to which the fecal sample belonged and identify the mammals found in the samples. Thus, we attributed the fecal samples to their origin via the microstructure of 'guard hairs' triage from fecal samples because predators ingest these hairs during self-grooming behavior (grooming, Eckstein and Hart 2000). For comparison, we collected samples of hair from several domestic cats previously authorized by their owners and produced slides for comparison with the samples found in feces. The slides were compared using identification keys (Quadros 2002) to distinguish samples from wild felines.

Data analyses

To quantify and identify the cats' diet, the frequency of occurrence (total number of a particular item found in fecal samples divided by the total number of samples) and percentage of occurrence (total number of a particular item found in fecal samples divided by the total number of items) was calculated according to Rabinowitz and Nottingham (1986) and Maehr and Brady (1986), respectively. The latter number was also used to verify the seasonal variation in the diet. The frequency of occurrence indicates if the item is more or less common (Konecny 1989, Martins et al. 2008), and the percentage of occurrence indicates the importance of each item in the diet (Maehr and Brady 1986, Martins et al. 2008).

The estimated relative biomass consumed is defined as the number of individual main types of prey found in feces multiplied by the mean body mass of each species consumed (Bueno et al. 2003). The aforementioned values were obtained using bibliographic sources about the mass of the respective species (Redford and Eisenberg 1992, Emmons and Feer 1997, Bueno et al. 2003, Gimenes et al. 2007). We determined the minimum number of subjects in each category by counting the anatomical items (legs, head, elytron, skull, etc.), which were the symmetrical anatomic elements counted by peers. We individually accounted for the presence of feathers, hair, and skin scales.

Based on the fecal analyses, medium-sized mammals are unlikely to be consumed entirely. Thus, we followed the criteria proposed by Fitzgerald and Karl (1979) and applied a total biomass of 170 g in these cases. This value was used in the aforementioned situations. Alternatively, the estimated weight of the prey was used when the record referred to a small mammal or bird.

The values were calculated with reference to the relative biomass (corresponding to the proportion of meat of a specific type of prey in the predator's general diet), and the relative number of a prey species consumed (corresponding to the proportion of the number of that type of prey consumed among the number of all the types of prey consumed by the predator). Thus, the estimated relative biomass consumed was calculated for the species of types of prey that form the group of mammals and birds in the diet of *F. s. catus*.

The niche amplitude was calculated by means of the standardized Levins index (Krebs 1989). To this end, eight categories were considered: mammals, bird, amphibians, insects, crustaceans, mollusks, vegetable matter and domestic food. However, materials of anthropic origin (garbage) were not included, as they were considered accidentally ingested instead of consumed. In addition, data with reference to grasses were excluded from the vegetable category, because grasses serve a non-nutritional role in the diet of these felines, as suggested by Fitzgerald (1988).

Items found in the fecal samples were grouped into eight categories (mammals, bird, amphibians, insects, crustaceans, mollusks, vegetable matter and domestic food), and the G-test (Zar 1984) was performed after the frequency of occurrence for each of these was calculated to verify the degree of significance between the two seasons – dry and wet. In general, 2×2 contingency tables were calculated between the number of feces samples with and without a certain item (Brillhart and Kaufman 1995). The level of significance adopted was 5% ($p \leq 0.05$).

Results

Success of fecal sample collection

Of the 222 *Felis silvestris catus* fecal samples collected, 155 were collected in the 'Praia' region and 67 in the 'Trilha da Trincheira' area. All months were represented in the samples.

Although the data collection effort had been the same, more feces were found during the period corresponding to the dry season (Table 1); variation was also perceived with respect to the two sampled areas.

Items found in fecal samples

In these 222 fecal samples analyzed, we identified 43 items in the diet of the domestic cat, and the overall frequency of these items equaled 424 (Table 2); the proportions among the categories are shown in Fig. 1.

The primary item of vegetable origin was grass (89.3%), in addition to some seeds and fruit peels not used in human consumption (10.7%).

With respect to items of animal origin, the vertebrate group consisted of 12 types of mammals, seven birds and one amphibian. Within this category (vertebrates), the proportions found with reference to each subcategory

Table 1. Percentage of feces collected per season in relation to each of the areas sampled in the southern portion of the Municipality of Ilha Comprida – south coast of São Paulo between Sep-2009 to Sep-2010.

Sampled area	Season			
	wet (%)	dry (%)	total (%)	No. of domestic animals found in each region*
Trincheira	27.3	31.7	30.2	10
Praia	72.7	68.3	69.8	26

*number obtained by contact made with residents, not considering feral animals found in the two areas.

Table 2. Dietary items found in the feces of *Felis silvestris catus* in the southern portion of Ilha Comprida.

Dietary items	Wet season (n = 76)	FO	PO	Dry season (n = 146)	FO	PO	Total (n = 222)	FO	PO
Vertebrates									
Mammalia	19	25.00	12.67	40	27.40	14.60	59	26.58	13.92
Didelphimorphia. Didelphidae: *Didelphis aurita*	3	3.95	2.00	3	2.05	1.09	6	2.70	1.42
Rodentia. Erethizontidae: *Coendou prehensilis*	1	1.32	0.67	–	–	–	1	0.45	0.24
Rodentia. Cricetidae: *Delomys dorsalis*	1	1.32	0.67	4	2.74	1.46	5	2.25	1.18
Rodentia. Cricetidae: *Oxymycterus* sp.	1	1.32	0.67	1	0.68	0.36	2	0.90	0.47
Rodentia. Cricetidae: *Euryoryzomys russatus*	6	7.89	4.00	8	5.48	2.92	14	6.31	3.30
Rodentia. Echimyidae: *Kannabateomys amblyonyx*	1	1.32	0.67	–	–	–	1	0.45	0.24
Rodentia. Muridae: *Mus musculus*	3	3.95	2.00	8	5.48	2.92	11	4.95	2.59
Rodentia. Muridae: *Rattus rattus*.	1	1.32	0.67	3	2.05	50.00	4	1.80	66.67
Rodentia. Cricetidae: *Oligoryzomys* sp.	1	1.32	0.67	5	3.42	1.82	6	2.70	1.42
Rodentia. Cricetidae: *Calomys tener*	–	–	–	1	0.68	0.36	1	0.45	0.24
Rodentia. Cricetidae: *Sooretamys angouya*	1	1.32	0.67	–	–	–	1	0.45	0.24
Rodentia. not identified	–	–	–	1	0.68	0.36	1	0.45	0.24
Mammals not identified	–	–	–	6	4.11	2.19	6	2.70	1.42
Birds	6	7.89	4.00	11	7.53	4.01	17	7.66	4.01
Passeriform. Thraupidae: *Thraupis palmarum*	1	1.32	0.67	–	–	–	1	0.45	0.24
Passeriform. Tyrannidae: *Flavicola nengeta*	1	1.32	0.67	–	–	–	1	0.45	0.24
Passeriform. Troglodytidae: *Troglodytes musculus*	2	2.63	1.33	–	–	–	2	0.90	0.47
Passeriform. Icteridae *Molothrus bonariensis*	–	–	–	3	2.05	1.09	3	1.35	0.71
Passeriform. Emberizidae: *Zonotrichia capensis*	2	2.63	1.33	2	1.37	0.73	4	1.80	0.94
Passeriform. not identified	–	–	–	4	2.74	1.46	4	1.80	0.94
Birds not identified	–	–	–	2	1.37	0.73	2	0.90	0.47
Amphibians	0	0.00	0.00	1	0.68	0.36	1	0.45	0.24
Anura. Hylidae: not identified	–	–	–	1	0.68	0.38	1	0.45	0.24
Invertebrates									
Insects	32	42.11	21.33	56	38.36	20.44	88	39.64	20.75
Blattaria. Blattodea: Blatidae	3	3.95	2.00	5	3.42	1.82	8	3.60	1.89
Coleoptera.	4	5.26	2.67	8	5.48	2.92	12	5.41	2.83
Orthoptera. Grillotalpidae	–	–	–	11	7.53	4.01	11	4.95	2.59
Orthoptera. Acrididae	12	15.79	8.00	11	7.53	4.01	23	10.36	5.42
Hemiptera	6	7.89	4.00	3	2.05	1.09	9	4.05	2.12
Odonata	1	1.32	0.67	–	–	–	1	0.45	0.24
Lepidoptera	–	–	–	2	1.37	0.73	2	0.90	0.47
Hymenoptera. Formicidae	–	–	–	1	0.68	0.36	1	0.45	0.24
Insect not identified	6	7.89	4.00	15	10.27	5.47	21	9.46	4.95
Crustaceans	0	0.00	0.00	5	3.42	1.82	5	2.25	1.18
Ocypodidae: *Ucides cordattus*	–	–	–	3	2.05	1.09	3	1.35	0.71
Ocypodidae: *Ocypode quadrata*	–	–	–	1	0.68	0.36	1	0.45	0.24
Grapsidae: *Giniopsis cruentata*	–	–	–	1	0.68	0.36	1	0.45	0.24
Mollusks	0	0.00	0.00	1	0.68	0.36	1	0.45	0.24
Gastropods	–	–	–	1	0.68	0.36	1	0.45	0.24
Vegetable matter	43	56.58	28.67	79	54.11	28.83	122	54.95	28.77
Poales: Poaceae	36	47.37	24.00	73	50.00	26.64	109	49.10	25.71
Seeds and fruits	7	9.21	4.67	6	4.11	2.19	13	5.86	3.07
Domestic food	46	60.53	30.67	70	47.95	25.55	116	52.25	27.36
Rations	25	32.89	16.67	36	24.66	13.14	61	27.48	14.39
Fish	10	13.16	6.67	5	3.42	1.82	15	6.76	3.54
Shrimp	–	–	–	6	4.11	2.19	6	2.70	1.42
Chicken	1	1.32	0.67	2	1.37	0.73	3	1.35	0.71
Other types of domestic foods	10	13.16	6.67	21	14.38	7.66	31	13.96	7.31
Material of anthropic origin	4	5.26	2.67	11	7.53	4.01	15	6.76	3.54
Plastic	3	3.95	2.00	3	2.05	1.09	6	2.70	1.42
Nylon	1	1.32	0.67	1	0.68	0.36	2	0.90	0.47
Paper	–	–	–	1	0.68	0.36	1	0.45	0.24
String/line/fibers	–	–	–	6	4.11	2.19	6	2.70	1.42
Total occurrence of items	150	197.37		274	187.7		424	190.99	

FO = frequency of occurrence; PO = percentage of occurrence of categories.

represented were as follows: 76.6% mammals, 22.1% birds and 1.3% amphibians.

The invertebrate group primarily consisted of insects (93.6% of the 94 items found in this category), followed by crustaceans (corresponding to 5.3% within the category) and mollusks (1.1%).

In addition, the presence of minuscule fragments of maize pericarp (*Zea mays*) was found, which is characteristic

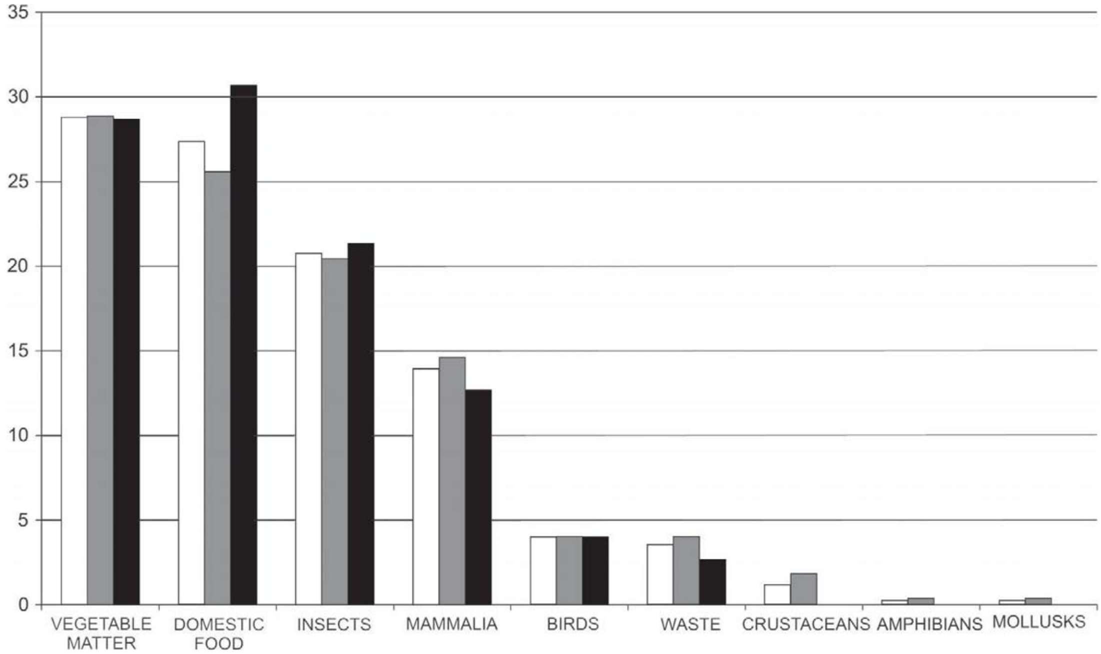

Figure 1. Relative frequency of the occurrence of items found in the fecal samples of domestic cats *Felis silvestris catus* collected in the Boqueirão Sul region in the Municipality of Ilha Comprida on the southern coast of São Paulo. White columns: total samples over the thirteen months of collection (n = 222); gray columns: total samples during wet season (n = 76); and back columns: total sampled during dry season (n = 146).

of the presence of industrialized animal rations provided by some owners. These fragments were included in the category of domestic food. This category also included cooked chicken bones (*Gallus gallus domesticus*), marine fish scales and vertebrae (*Mugil* sp., *Centropomus* sp., *Micropogonias furnier*), shrimp remains, cooked beans (*Phaseolus vulgaris*), and seeds and fruit peels used in the human diet, such as orange (*Citrus* sp.), tomato (*Solanum lycopersicum*), mango (*Mangifera* sp.). All of these items were grouped in a single subcategory: other types of domestic foods. Among the 106 items identified, the proportions were calculated as follows: 48.1% rations, 14.2% fish, 5.7% shrimp, 2.8% chicken and 29.3% other types of domestic foods.

Undigested materials of anthropic origin were also found. These items most likely originated from garbage ingestion.

The mammals *Didelphis aurita* constituted the major biomass consumed in the dietary composition of *F. s. catus* (25.3%), while *Euryoryzomys russatus* was the dominant species of prey in its diet in terms of the relative number of individuals consumed, followed by *Mus musculus* (22.6% and 17.7%, respectively), as shown in Table 3.

High niche amplitude and little seasonal difference in diet

The niche amplitude of the domestic cat in the region of Boqueirão Sul in the Municipality of Ilha Comprida showed little variation by season, attaining its highest value in the dry season ($B_A = 0.86$) and slightly lower values in the wet season ($B_A = 0.71$). Over the period of one year, the amplitude was 0.81. This value is considered high and indicates that many items were consumed at high frequencies and few were consumed at low frequencies, which characterizes a generalist diet.

The frequency of the items identified in the analyzed samples did not vary by season (G-test G = 4.29; DF = 7; p = 0.75). The frequencies observed for the majority of the species of birds, mammals and insects identified in the two seasons were very similar. However, amphibians, crustaceans and mollusks were consumed only in the period corresponding to the dry season, and only the second item showed a significant difference between the seasons (Fig. 1, Table 4).

Discussion

Because the sampling effort devoted to both regions was the same, we could correlate the difference found in the number of samples between the two regions with the number of specimens of domestic cats found in the two regions.

The diet of the domestic cats in the study area consisted of a large variety of food items, which confirmed a generalist diet (Nogales and Medina 1996, Turner and Bateson 2000, Bonnaud et al. 2007) and an opportunistic predation behavior (Barratt 1997).

The constant presence of vegetable matter, particularly grass, in the analyzed samples may be correlated with sanitary aspects and help to promote intestinal transit as well as the cohesion of ingested material and the elimination of parasites (Fitzgerald 1988).

The proportion of dietary items of anthropic origin, invertebrates and vertebrates was relatively balanced. The 41% of items that were identified to be of animal origin

Table 3. Biomass relative (BR) and number of types of prey consumed individually (NR) by the domestic cat (*F. s. catus*), based on feces collected during the course of thirteen months in the southern portion of Ilha Comprida.

Dietary items	Total (n = 222)	BP (kg)	CF (kg)	BC (kg)	BR (%)	NR (%)
Mammalia		–	–	–	–	–
Didelphimorphia. Didelphidae: *Didelphis aurita*	6	0.940	0.170	1.020	24.7	9.5
Rodentia. Erethizontidae: *Coendou prehensilis*	1	3.360	0.170	0.170	4.1	1.6
Rodentia. Cricetidae: *Delomys dorsalis*	5	0.030	0.030	0.150	3.6	7.9
Rodentia. Cricetidae: *Oxymycterus* sp.	2	0.067	0.067	0.134	3.2	3.2
Rodentia. Cricetidae: *Euryoryzomys russatus*	14	0.085	0.085	1.190	28.8	22.2
Rodentia. Echimyidae: *Kannabateomys amblyonyx*	1	0.383	0.170	0.170	4.1	1.6
Rodentia. Muridae: *Mus musculus*	11	0.020	0.020	0.220	5.3	17.5
Rodentia. Muridae: *Rattus rattus*.	4	0.127	0.127	0.508	12.3	6.3
Rodentia. Cricetidae: *Oligoryzomys* sp.	6	0.022	0.022	0.132	3.2	9.5
Rodentia. Cricetidae: *Calomys tener*	1	0.020	0.020	0.020	0.5	1.6
Rodentia. Cricetidae: *Sooretamys angouya*	1	0.116	0.116	0.116	2.8	1.6
Birds		–	–	–	–	–
Passeriform. Thraupidae: *Thraupis palmarum*	1	0.036	0.036	0.036	0.9	1.6
Passeriform. Tyrannidae: *Flavicola nengeta*	1	0.020	0.020	0.020	0.5	1.6
Passeriform. Troglodytidae: *Troglodytes musculus*	2	0.012	0.012	0.024	0.6	3.2
Passeriform. Icteridae *Molothrus bonariensis*	3	0.048	0.048	0.144	3.5	4.8
Passeriform. Emberizidae: *Zonotrichia capensis*	4	0.020	0.020	0.080	1.9	6.3

n = number of feces samples; BP = biomass of prey; CF = correction factor; BC = biomass consumed);
BR = Biomass relative; and NR = number of types of prey consumed individually.

confirm the natural predatory behavior of this group of animals (Warner 1985). However, this figure also corroborates that the diet may vary according to the degree of relationship with humans (Liberg 1984) because approximately 27% of the items consumed corresponded to some type of food provided directly or indirectly by people.

The presence of lagomorph mammals, which has been noted as an important factor in the consumption of other species (particularly rodents) in insular environments (Liberg 1984, Fitzgerald and Turner 2000), did not seem to affect the results of the present study. Specifically, European rabbits *Oryctolagus cuniculus* were found living freely in the studied area (Ferreira et al unpubl.), and their vestiges were not found in any of the analyzed samples.

The presence of introduced species of prey, such as rats *Rattus* sp., mice *Mus musculus* and rabbits *O. cuniculus*, in the cat's diet may signify sustenance (source of food) throughout the entire year, particularly for feral felines, and also reduce the impact on native species (Taylor 1979, Keitt et al. 2002, Bonnaud et al. 2007, 2011). However, the consumption of muridae, which was greater in the dry season than in the wet season in this study, was less frequent than the consumption of all native rodent species found in the region in both seasons. Nevertheless, *M. musculus* represented the second-ranked dominant species of prey in terms of the relative number of individuals consumed. This fact may corroborate the findings of Courchamp et al. (1999), who suggested that the presence of alternative species, such as *Euryoryzomys russatus,* allows the population to sustain itself as the native population diminishes. In this study, *Euryoryzomys russatus* was the main species consumed throughout the studied period. However, Baker et al. (2003) suggested that the abundance of cats in areas with residential gardens in Bristol (United Kingdom) negatively correlated with the abundance of *Apodemus sylvaticus*, which highlights the pressure of predation exerted by the cats on the dynamics of populations of small mammals.

Table 4. Frequency of the occurrence of food items found in fecal samples of *F. s. catus*, in the southern portion of Ilha Comprida (São Paulo, Brazil) per season. G-test = G.

Dietary items	Wet season (n = 76)	Dry season (n = 146)	G	p
Mammals	25.00	27.40	0.15	0.70
Birds	7.89	7.53	0.01	0.92
Amphibians	0.00	0.68	0.95	0.33
Insects	35.53	38.36	0.17	0.68
Crustaceans	0.00	3.42	4.80	*0.03
Mollusks	0.00	0.68	0.95	0.33
Vegetable matter	50.00	54.11	0.34	0.56
Domestic food	60.53	47.95	3.20	0.07
Material of anthropic origin	5.26	7.53	0.43	0.51

The results found in the present study indicated that birds are of little importance in a cat's diet, which may be related to the large availability of mammals according to Millán (2010). Moreover, these authors found that predation on birds was greater in autumn and winter than in the rest of the year. Nevertheless, the percentage of birds predated both in the dry (autumn and winter) and wet season (summer and spring) remained balanced in this study, which may be explained by the low climatic variation found between the two seasons.

Although present in the studied region, estuarine birds were also absent in the analyzed samples, which differed from the observations of other authors who studied insular areas (Nogales and Medina 1996).

The over-consumption of estuarine birds and rabbits may be masked because cats can fully digest the bones and feathers of young birds in their digestive tract, as noted by Liberg (1982). In the case of adult rabbits, the cat might have adopted similar strategies to those adopted when they consume adult hares: cats may only consume the meat and interior parts of the animal without ingesting hair or bones.

The majority of studies indicate that cats primarily consume mammals in insular environments (Fitzgerald and Karl 1979, Fitzgerald 1988, Nogales and Medina 1996, Fitzgerald and Turner 2000, Medina et al. 2006, Millán 2010). However, invertebrates comprised a larger fraction of the diet than mammals in this study. Lessa and Bergallo (2012) conducted a study in another Brazilian island environment, but only evaluated the number of prey brought to properties by cats. They also observed that invertebrates were the most common prey, followed by mammals, birds, reptiles and amphibians. This difference may be related to the fact that the animals received food support provided from the owners in both studies, which may have influenced the hunting behavior of larger animals as a means of supplying the nutritional needs of cats.

Here, the proportion of insects among the invertebrates was also higher, which agrees with the literature (Hess et al. 2007, Medina and García 2007). Thus, *Orthoptera* and *Coleoptera* were most frequently consumed, as in the studies conducted by Nogales and Medina (1996), and Medina and Garcia (2007). However, Medina and García (2007) reported that *Hemiptera* was more abundant than *Lepidoptera*, which represented the third highest value.

Nevertheless, the contribution by insects to the total biomass consumed was considered insignificant in the cat's diet by Medina et al. (2006) and Millán (2010), and the consumption of insects is related to the generalist opportunistic predatory behavior of cats, which feed on any available item according to Fitzgerald (1988). However, a study conducted on feral cats in Hawaii (USA) demonstrated that the abundance of small types of prey (invertebrates) allowed their survival in the scarcity of certain items and helped to maintain populations at high densities, even outside the periods of abundance of seasonal types of prey, such as birds (Hess et al. 2007). However, we believe that the auditory and visual stimuli produced by these prey may have been the main reason to justify the large amount of invertebrates consumed by domestic cats in this study because domestic food was directly and indirectly available throughout the year.

Moreover, the results showed a slightly higher niche amplitude in the dry season than in the wet season because the study was conducted in an area where climatic variations are much less severe between seasons. These findings are similar to those found in other studies conducted in Brazil by Campos et al. (2007). Although this variation is not significant between the two seasons, as was also perceived on the Island of Majorca (Spain) (Millán 2010), which diverges from the results presented by Liberg (1984), which state that climatic variations in the studied areas were more severe.

Although small, the difference in the number of species consumed between the seasons may be a reflection of the larger selection when the availability of food is greater (Fitzgerald et al. 1991, Campos et al. 2007).

Factors such as prey size, the size and composition of the food, and the frequency of ingestion of prey may affect the digestive process and the passage of food through the intestine (Helm 1984). These factors also affect the degree to which bones and teeth are digested (Kelly and Garton 1997). Furthermore, Pires et al. (2011) showed that the digestion of bones and teeth may also vary from one individual to another, which suggests that these items are not reliable indicators of prey in feces. Alternatively, several authors suggest that the identification of hairs of prey provides a good basis for reconstructing the diet (Liberg 1982, Gamberg and Atkinson 1988, Kelly and Garton 1997) because hair is more difficult to digest (Leprince et al. 1980). Stahl et al. (1992) also defended the use of prey hair to estimate the proportion of rodents in the diet of wildcats. In the latter case, the results obtained from hair facilitated more accurate estimates compared to the alternative method, such as the number of molars recovered from fecal samples. In this sense, we agree with Weaver and Hoffman (1979) that we must record more than one type of prey only when we identify different species or individuals by their hair in the absence of bones and teeth in the feces.

Various tests on feral cats in captivity showed that the elimination time differs by prey species, and some prey can take a long time to be expelled, which leads to errors in research involving diet analysis (Liberg 1982). Many of the differences in the proportion of indigestible matter, such as the differences in bone or hair/feathers between prey, seem to affect prey detection (Pires et al. 2011). Nevertheless, we agree that all authors and determination methods of the diet, such as analyzing the stomach contents and fecal samples, are subject to errors because digestion is a destructive process that does not preserve all the desired information. However, knowledge of the diet is essential for developing conservation and management programs (Korschgen 1987).

Studies in other regions indicate that the domestic cat can act as a possible competitor for resources with various other predators, such as the raccoon *Procyon lotor*, striped skunk *Mephitis mephitis* (Coleman et al. 1997, Lepczyk et al. 2003), coyote *Canis latrans*, lynx *Lynx* spp., least weasel *Mustela nivalis* (Fitzwater 1994), fox *Vulpes* spp. (Coleman et al. 1997), island fox *Urocyon littoralis* (Phillips et al. 2007), and birds of prey, such as hawks and falcons (Coleman et al. 1997). The domestic cat could also compete with many other species with similar ecological niches. While samples from wild felines were not collected, indications and traces of their presence in the region have been recorded. Therefore, the trophic niches of these species may superimpose in this region, especially among small wild cats found in the region (*L. tigrinus* and *P. yagouaroundi*), as observed by Nakano-Oliveira (2006). We also believe that cats may overlap with other carnivorous species with similar niches that are also found in the region, such as the coati *N. nasua*, crab-eating raccoon *P. cancrivorus*, hoary fox *C. thous* and river otter *L. longicaudis*.

Although most of the animals studied in this work are considered domestic and have a fixed and constant source of food, they presented opportunistic predation behavior on some species of local fauna. Thus, these results contribute to primary information that is important for understanding the behavior of this species in the insular natural environment of the Atlantic Forest. Furthermore, although little is known regarding the state of preservation of the majority of these species, the pressure exerted on these species reinforces the importance of devising measures to minimize the potential risks caused by the presence of

F. s. catus in this area. Such measures could include the following: 1) Educational campaigns directed at the local human population should be developed that emphasize the importance of responsible possession of pets, such as the sterilization of domestic and feral cats to prevent the uncontrolled growth of the domestic animal population in the region; vaccination and feline healthcare; the consequences of abandoning these animals in natural areas, and impact of inadequate management of garbage produced by the municipality. These educational campaigns should be linked to sterilization, vaccination and de-worming campaigns that are offered to the local population via partnerships between public powers, research institutes, NGOs acting in the area, and faculties of Veterinary Medicine in the region. 2) Studies on local diversity should be developed with the aim of identifying the richness and abundance of species in the region and their true state of conservation. This knowledge would enable the verification of the influences of anthropic actions caused by the introduction of exotic species, such as cats, dogs, rabbits and other species, as well as illegal hunting activities, palm heart extraction and uncontrolled real estate growth in the region.

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