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**ANÁLISE COMPARATIVA DE NICHOS TRÓFICOS DE CARNÍVOROS
(MAMMALIA, CARNIVORA) DA REGIÃO DE ALTA FLORESTA,
ESTADO DO MATO GROSSO, BRASIL**

Dissertação apresentada ao Programa de Pós-Graduação em
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Orientador: Prof.Dr. Thales R. O. de Freitas

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CARNIVORA) DA REGIÃO DE ALTA FLORESTA, ESTADO DO MATO GROSSO,
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“Nunca o homem inventará nada mais simples nem mais belo do que uma manifestação da natureza. Dada a causa, a natureza produz o efeito no modo mais breve em que pode ser produzido.”

Leonardo da Vinci

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RESUMO

Estratégias alimentares de espécies de carnívoros simpátricos são moldadas pela competição associada à flexibilidade alimentar. Neste estudo, foram utilizadas amostras fecais para analisar a dieta de carnívoros simpátricos em região altamente fragmentada da Amazônia brasileira. Com esse intuito, foram necessárias identificações confiáveis das espécies predadoras, realizadas através de duas técnicas: seqüenciamento de DNA e microscopia óptica. Estes métodos foram comparados resultando em congruência de 92% nas identificações de predadores. Deste modo, foram identificadas nove espécies de carnívoros (*Leopardus pardalis* (n=18), *Panthera onca* (n=16), *Puma concolor* (n=7), *Puma yagouaroundi* (n=3), *Lontra longicaudis* (n=2), *Pteronura brasiliensis* (n=2), *Eira barbara* (n=2), *Cerdocyon thous* (n=30) e *Speothos venaticus* (n=1)). O estudo alimentar de cinco destas espécies foi apenas descritivo devido ao pequeno número de amostras. As demais quatro espécies apresentaram um número amostral suficiente para a realização das análises estatísticas. O canídeo *C. thous* foi a espécie de hábitos alimentares mais generalista; além disso, o graxaim-do-mato mostrou-se altamente flexível, alimentando-se também de outras fontes que não predando animais; esta espécie apresentou sementes como itens mais freqüentes, além disso registrou-se consumo de plástico nas amostras fecais. A jaguatirica apresentou a dieta mais generalista dentre as espécies de felinos, contendo itens de pequeno e médio porte; e tendo como presas de maior importância para sua dieta roedores de pequeno porte (<1Kg). A onça-pintada apresentou-se mais especialista em sua dieta que as outras espécies citadas anteriormente, sendo sua principal presa a queixada (*Tayassu peccarí*), resultado encontrado utilizando-se o Índice de Importância Relativa (IIR); de forma geral, sua dieta foi baseada predominantemente em presas de grande porte (>15Kg). Diferentemente, os pumas apresentaram alto consumo de presas de médio porte (1Kg – 15Kg), e além disso as presas foram consumidas em proporções semelhantes. Com esses dados, podemos corroborar a hipótese de que o uso de diferentes recursos alimentares permite a coexistência entre espécies carnívoras. Adicionalmente, a maior sobreposição de nichos tróficos foi registrada entre *L. pardalis* e *Puma concolor*. Um dos fatores influenciáveis para esse resultado foi o consumo de roedores de pequeno porte por ambas as espécies predadoras. Uma explicação provável para esta competição por recursos alimentares é a presença de *P. onca*, pois, em situação de simpatria com esta última, *P. concolor* acaba por modificar seus padrões de seleção de presas utilizando as de médio e menor porte, que, similarmente, servem como base alimentar para a dieta das jaguatiricas. Os resultados gerados com este estudo fornecem dados sobre a ecologia das espécies de carnívoros para esta região fragmentada da Amazônia e com isso contribui de uma forma significativa para seu melhor conhecimento, o que pode auxiliar na elaboração de estratégias adequadas para o manejo e conservação dessas espécies em campo.

CAPÍTULO INTRODUTÓRIO

A competição por espaço e por recursos alimentares está entre os maiores determinantes da estrutura de uma comunidade (McGrandy-Steed et al. 1997). Estudos com carnívoros simpátricos têm observado que uma espécie predadora pode influenciar outro predador em sua seleção de presas. Como exemplo, alguns autores reportam uma provável pressão da onça (*Panthera onca*) sobre puma (*Puma concolor*) (Azevedo 2008, Moreno et al. 2006, Scognamillo et al. 2003). Estudos alimentares com puma observam uma variação muito grande de tamanhos de presas de acordo com sua distribuição geográfica. Em áreas próximas a linha do Equador, onde possuem simpatria com onças, alimentam-se de presas com tamanho e peso menores que em áreas distantes. É importante observar que subespécies de puma possuem peso significativamente menor quando co-habitam com onças (Azevedo 2008; Iriarte et al. 1990; Scognamillo et al. 2003). Alguns estudos observaram que existe uma tendência à variação no tamanho corporal e/ou divergência em caracteres nas diferentes espécies de carnívoros simpátricos conferindo-lhes a capacidade de explorar diferentes categorias de recursos alimentares (Arjo et al. 2002; Davies et al. 2007; Friscia et al. 2007; Moreno et al. 2006). Espécies que possuem uma maior maleabilidade em suas estratégias de alimentação podem se adaptar mais facilmente a habitats distintos. O graxaim-do-mato (*Cerdocyon thous*), por exemplo, é uma espécie altamente adaptável (Berta 1987; Bisbal & Ojasti 1980; Cordero-Rodríguez & Nassar-H. 1999; Delgado-V & Zurc 2007; Facure & Monteiro-Filho 1996; Gatti et al. 2006; Juarez & Marinho-Filho 2002; Maffei & Taber 2003; Martínez 1996; Martínez & Cadena 2000; Montgomery & Lubin 1978; Motta-Junior et al. 1994; Novaes 2002; Olmos 1993; Pedó et al. 2006), devido a seu hábito alimentar generalista, o que provavelmente influencia sua sobrevivência em ambientes alterados (Rocha et al. 2008).

Os carnívoros, comparados a outros mamíferos, ocorrem em baixa densidade demográfica e possuem hábitos arredios. Além disso, a captura desses animais é dispendiosa em relação ao tempo em campo e ao custo elevado, pois exige equipe experiente e pelo menos um Médico Veterinário (Ernest et al. 2000; Mazzolli & Hammer 2008; Johnson et al. 2001; Taberlet et al. 2001). Deste modo, técnicas não-invasivas, onde a captura dos animais não é necessária, utilizam fezes e pêlos

deixados pelo animal em seu habitat como fonte de informação (Cullen Jr. et al. 2006). Amostras fecais permitem identificar a presença de espécies em uma área, e fornecer informações sobre distribuição, abundância, estudos alimentares, movimentação espaço-temporal e enfermidades (Kohn & Wayne 1997). Existem diversos métodos de identificação de espécies predadoras a partir de amostras não-invasivas. No entanto, nem todos apresentam confiabilidade nessas identificações, existem métodos que utilizam tamanho das fezes, odor, pegadas próximas a fezes, etc. Os resultados de determinadas técnicas podem gerar dados imprecisos e confusos. Os métodos mais confiáveis de identificação de espécies são o seqüenciamento de DNA e a microscopia óptica de pêlos. O método molecular consiste em extrair o DNA das células intestinais desprendidas durante a passagem do bolo fecal em predadores conseqüentemente sendo encontradas na parte externa das fezes (Albaugh et al. 1992; Höss et al. 1992; Paxinos et al. 1997). A microscopia óptica de pêlos é desenvolvida a partir de técnicas de preparação de lâminas de pêlos-guarda ingeridos pelo predador no processo de auto-limpeza, e que assim podem ser encontrados em suas fezes (Teerink 1991; Quadros & Monteiro-Filho 2006a). O primeiro método pode atingir melhor desempenho, em relação à qualidade e quantidade de informações; no entanto, apresenta maior custo e exige técnicas laboratoriais mais complexas que o último (Graeff 2008). A utilização destas duas técnicas tem sido crescente, especialmente tendo em vista que estudos recentes enfatizam a falta de confiabilidade em métodos tradicionais de identificação de fezes a partir do seu tamanho – por exemplo, perímetro – odor, pegadas próximas aos dejetos fecais, etc. (Becker & Dallponte 1999; Brunner & Wallis 1986).

Assim sendo, este estudo tem por objetivo analisar os hábitos alimentares de carnívoros simpátricos da região de Alta Floresta no Estado do Mato Grosso, área que contém um dos maiores níveis locais de biodiversidade, entretanto vem sofrendo uma das maiores taxas de desmatamento já registradas na Amazônia Brasileira desde o início da década de 1980 (Michalski et al. 2006). O presente estudo também enfoca a importância da utilização de métodos mais confiáveis para a uma correta identificação dos predadores através de amostras não-invasivas. Trata-se do primeiro estudo de dieta na Amazônia brasileira com identificação molecular e tricológica de amostras fecais.

Foram coletadas 108 fezes, entre outubro de 2007 e dezembro de 2008. Desse total, foram identificadas 81 amostras, 64 (79%) utilizando-se dados moleculares (Michalski et al. em prep.) e 17 (21%) identificadas somente por microscopia de pêlos.

Para todas as amostras fecais que apresentavam pêlos de auto-limpeza do predador foram preparadas lâminas para visualização em microscópio óptico. Este método, conhecido como tricologia, foi utilizado para testar sua confiabilidade, comparando-o com os dados gerados pelo seqüenciamento de DNA e também para aumentar a possibilidade de identificar as espécies de predadores, caso estes não pudessem ser identificados pela análise molecular. Para obter bons resultados do método molecular, a “idade” das fezes é importante, pois quanto mais antiga, mais difícil se torna a amplificação do DNA, uma vez que o material genético, quando exposto às condições ambientais, como umidade e calor, tende a degradar, dificultando ainda mais a obtenção de dados a partir deste tipo de material. (Haag et al. 2009, McCarthy et al. 2009; Ruell & Crooks 2007, Santini et al. 2007). Do total de fezes coletadas, 93 amostras (86.1%) foram consideradas viáveis para a utilização do método, das quais 64 foram identificadas. No método de identificação por microscopia de pêlos, realizado independentemente das análises moleculares, foram encontrados pêlos-guarda de auto-limpeza do predador em 64 amostras (59.25%); destas, 44 foram identificadas até o nível de espécie e apenas 5 foram identificadas até o nível de família (todas pertencentes à família Felidae). Vinte e sete amostras foram identificadas pelos dois métodos, resultando em 92% de concordância na identificação. Apenas duas amostras apresentaram discrepância: uma delas foi identificada como *Cerdocyon thous* pelo método molecular e *Puma yagouaroundi* pelo o tricológico; a outra como *P.yagouaroundi* pelo molecular e *C. thous* pelo tricológico (ou seja, identificações perfeitamente invertidas). É válido observar que a preparação das lâminas para microscopia destas duas amostras foi realizada no mesmo dia, podendo ter ocorrido uma troca de amostras. Além disso, a título de curiosidade, foram medidos os perímetros das fezes coletadas com uma fita métrica. E a partir das identificações moleculares e tricológicas pudemos observar que existem sobreposições nos tamanhos de perímetro nas espécies, além da deformidade encontrada em diversas fezes, onde a medição não foi possível.

Assim, este trabalho utilizou primariamente as identificações moleculares (n=64) de espécies e as tricológicas (n=17) somente para as amostras que não foram identificadas por seqüenciamento de DNA. Desde modo, foram identificadas nove espécies de predadores: *Leopardus pardalis* (n=18) *Panthera onca* (n=16), *Puma concolor* (n=7), *Puma yagouaroundi* (n=3), *Lontra longicaudis* (n=2), *Pteronura brasiliensis* (n=2), *Eira barbara* (n=2), *Cerdocyon thous* (n=30) e *Speothos venaticus* (n=1).

O estudo da dieta foi realizado nas espécies de predadores identificadas. Todavia, para algumas espécies (*Puma yagouaroundi*, *Lontra longicaudis*, *Pteronura brasiliensis*, *Eira barbara*, *Speothos venaticus*) um pequeno número de amostras foi obtido, resultando em um estudo de hábito alimentar com enfoque apenas descritivo. Todos os índices e análises estatísticas mensurados no presente estudo (frequência de ocorrência (FO), proporção de ocorrência (PO), fator de correção (Y), biomassa relativa (BR), Amplitude de nicho trófico (BA) e sobreposição de nicho (O)), foram aplicados somente nas espécies de felídeos representadas por maior número amostral (*Leopardus pardalis*, *Panthera onca*, *Puma concolor*).

Em meio às espécies que apresentaram um pequeno número amostral, está o *P. yagouaroundi*, ou gato-mourisco, o qual demonstrou ter uma dieta essencialmente baseada em itens de origem animal, onde os mamíferos foram encontrados em todas as amostras e foram os itens mais freqüentes (FO=100% e PO=80%). *Lontra longicaudis* (lontra) apresentou uma dieta bastante variada, treze itens diferentes foram identificados, os quais apresentaram igual proporção de ocorrência em sua dieta. Em contrapartida, a análise das fezes de *P. brasiliensis* (ariranha), um outro mamífero semi-aquático como a lontra, indicou somente a presença de peixes (100% FO e PO) na dieta deste mustelídeo. *Eira barbara* (irara) apresentou alta variedade de itens em sua dieta, sendo doze categorias distintas, e, como observado em *L. longicaudis*, todos ocorrendo em mesma proporção. O oposto foi observado para *S. venaticus* (cachorro-vinagre), que apresentou uma espécie de roedor de porte médio (*Cuniculus paca*) como único item alimentar.

Dentre as espécies com maior número amostral disponível, *Cerdocyon thous* apresentou 34 categorias distintas de itens alimentares, sendo a espécie predadora com maior diversidade de presas. Além dos itens de origem animal e vegetal, foram encontrados também restos de lixo humano (plástico). Dentre os itens de origem

animal, a ordem Coleoptera foi a mais freqüente (FO=80% e PO=28.23%). Entre os vertebrados, os répteis foram as presas mais freqüentes (FO=53,33% e PO=60%), sendo que 40% (PO) destes eram lagartos. No entanto, considerando todas as categorias alimentares identificadas, as sementes foram os itens mais consumidos por *C. thous* (FO=40% e PO=53.9%). A identificação das presas do graxaim-do-mato não chegou a um nível taxonômico detalhado o suficiente para que fosse possível analisar sua biomassa ingerida. Quanto à amplitude de nicho (BA), *C. thous* apresentou o valor mais alto dentre as quatro espécies em que este índice foi aplicado (BA =0.52).

Foram determinadas para *L. pardalis* 32 categorias diferentes de presas. Dentre os vertebrados, *Proechimys* sp. foi a presa mais freqüente encontrada na dieta da jaguatirica (FO=27.8% e PO=17.24%), porém, o cálculo de biomassa relativa indicou que *Dasytus* sp. apresentava um percentual mais elevado (29.2%). Para saber qual destes itens realmente foi o de maior importância relativa calculou-se o IIR (Índice de Importância Relativa), o qual indicou que *Proechimys* sp. foi, de fato, o item de maior relevância na dieta de *L. pardalis*. Adicionalmente, a jaguatirica apresentou a segunda maior amplitude de nicho encontrada (BA =0.46).

Panthera onca apresentou 18 diferentes itens em sua dieta, todos de origem animal. Os mamíferos foram o grupo de vertebrados mais freqüente; dentre esses, as presas que apresentaram maior freqüência e proporção de ocorrência foram *Tayassu pecari* e *T. tajacu* (FO=25% e PO=21.05%). A maior biomassa relativa foi de *T. pecari* (29.8%) e o cálculo de IIR também indicou esta espécie como a presa mais importante na dieta da onça-pintada. O BA encontrado para a onça-pintada (BA 0.37) é resultado de um hábito alimentar mais especialista desta espécie, em comparação com aquelas citadas anteriormente.

Foram encontrados quinze diferentes categorias na dieta do puma. Destas 86.7% (PO) eram de origem animal e 13.3% (PO) de origem vegetal. Dentre os vertebrados, os roedores foram os mais freqüentes (57.12% FO e PO); em níveis taxonomicamente mais restritos, todos os vertebrados tiveram as mesmas freqüências e foram utilizados em igual proporção (FO=14.3% e PO=14.3%). A biomassa relativa foi maior para *Cuniculus paca* (45.76%), porém ao calcularmos o IIR as duas presas de maior importância foram *Dasytus* sp. e *C. paca*. Finalmente, *P. concolor* apresentou a menor amplitude de nicho observada entre as quatro

espécies analisadas (BA=0.24), no entanto, deve-se destacar que o número de amostras disponíveis para esta espécie era menor que as demais, o que pode ter influenciado o resultado da análise. Por este motivo não podemos postular que este predador seja mais especialista que generalista, já que apresentou consumo proporcional entre as presas, e diversos itens consumidos.

A sobreposição de nicho trófico foi analisada para as três espécies de felinos, excluindo os invertebrados e o material vegetal das análises. Utilizou-se a proporção de ocorrência (PO), para calcular o grau de sobreposição dos vertebrados na dieta das três espécies predadoras, e a biomassa relativa (BR) para calcular a sobreposição de nicho em relação à categoria de presas 'mamíferos'. Para o cálculo de PO, a menor sobreposição de nicho encontrada foi entre onça-pintada e jaguatirica (Pianka=0.17 e Czekanowski= 0.15) e a maior foi entre puma e jaguatirica (Pianka=0.65 e Czekanowski= 0.45). Na análise com biomassa relativa (BR), também se observou um menor grau de sobreposição de nicho entre onça-pintada e jaguatirica (Pianka= 0.19 e Czekanowski= 0.17), e o maior entre puma e jaguatirica (Pianka=0.52 e Czekanowski= 0.40). Para saber se poderia haver diferença significativa na dieta das três espécies de felinos tanto no cálculo da PO dos itens vertebrados, como na BR das presas mamíferos; utilizamos o programa computacional EcoSim 7.0 para fazer a randomização dos resultados observados gerando, através das simulações realizadas pelo programa, "resultados esperados". Assim, foi possível comparar as médias observadas com as simuladas. Deste modo, todos os resultados da comparação das médias calculadas pelo programa obtiveram o valor de p próximo ou igual a 1, o que indica que não há evidência suficiente para se rejeitar a hipótese de que os três felídeos teriam dietas similares.

**Comparative dietary analysis of Neotropical carnivores
(Mammalia, Carnivora) in a fragmented region of the
Brazilian Amazon**

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5 Running head: Diet of Amazonian carnivores

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9 **Comparative dietary analysis of Neotropical carnivores (Mammalia, Carnivora)**
10 **in a fragmented region of the Brazilian Amazon**

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1 **ABSTRACT**

2
3 Competition associated with dietary flexibility molds the feeding strategies of
4 coexisting carnivore species. In this study, we used faecal analysis to document the
5 diets of sympatric carnivores in a highly deforested region of the Brazilian Amazon.
6 To do so, reliable identifications of the predator species using DNA sequencing and
7 hair microscopy were needed. Nine carnivore species were identified, out of which
8 four (*Cerdocyon thous*, *Leopardus pardalis*, *Panthera onca* and *Puma concolor*)
9 presented a sufficient number of samples to make statistical analyses possible. The
10 crab-eating fox (*C. thous*) was the most generalist species among the four; they
11 showed a high flexibility in their diet, looking for a variety of items in addition to animal
12 prey. Seeds were the most frequent item in *C. thous* diet, and they consumed plastic
13 material as well. The ocelot (*L.pardalis*) diet was more generalist than those of the
14 other analyzed felids, preying medium-and-small sized prey; the most important prey
15 for this predator was *Proechymis* sp., a small rodent (<1Kg). On the other hand,
16 jaguars (*P. onca*) showed specialized feeding habits. *Tayassu pecari* was the main
17 prey for this species, as *P. onca* presented mostly large-sized prey (>15Kg) in its diet.
18 Differently, pumas (*P. concolor*) preyed mostly on medium-sized prey. *Dasypus* sp.
19 and *Cuniculus paca* were the most important items for the puma. Our study concurs
20 with the hypothesis that the use of different resources – food, for instance – allowed
21 the coexistence of carnivore species. A considerable trophic niche overlap was
22 observed between ocelots and pumas in all niche overlap calculations. This
23 competition can be explained by the presence of jaguars in the same region, as this
24 sympatry probably forces pumas to shift their patterns of prey selection to medium-
25 and small-sized ones, which may lead to increased overlap with the ocelot.

26
27
28 Keywords: carnivores, dietary, Brazilian Amazon, faecal DNA, trichology.

1 INTRODUCTION

2 Getting to know the trophic structure of vertebrate communities comes with the
3 understanding of the relationships between predator vs. predator, predator vs. prey
4 and their interactions with the environment. Mammalian carnivores are considered to
5 be very important to the ecosystem's proper balance (Miller and Rabinowitz 2002)
6 and the absence of mammalian predators results in ecological changes, such as
7 biodiversity loss and modifications in the ecosystem's structure (Terborgh et al.
8 2001). Competition among predators might be heavier in fragmented regions,
9 possibly affecting the whole community, since its structure is strongly influenced by
10 the predators' partitioning of space and food resources (McGrandy-Steed et al. 1997).

11 Competition for food resources associated with dietary flexibility has been
12 inferred to play a relevant role in various carnivore guilds. For instance, in Iguazu
13 National Park, southern Brazil, large and medium-sized wild prey species comprised
14 the bulk of the jaguar (*Panthera onca*) diet, while that of pumas (*Puma concolor*) was
15 concentrated on medium-sized items, the main difference between the two being the
16 high consumption of collared peccaries (*Tayassu tajacu*) by jaguars, this study used
17 scats (Azevedo 2008). Similarly, in a mosaic landscape of the Venezuelan llanos,
18 jaguars hunted large prey whilst pumas went for medium-sized ones, the results were
19 obtained using scats and kills (Scognamillo et al. 2003). In areas where both species
20 are sympatric, jaguars may influence prey selection by pumas, and in the same way,
21 puma subspecies weigh less in those regions close to the equator, which is likely
22 connected to their preying on smaller species in those regions (Iriarte et al. 1990).
23 Another study carried in Panama Canal reported an alteration in the patterns of puma
24 prey. They suggested that prey consumed by pumas were larger in this study than in
25 most others, which was interpreted as being a consequence of a recent decline or

1 local extinction of jaguars in the region. Fecal analyses were used in this study that
2 observed dietary differences between pumas and ocelots (*Leopardus pardalis*) are
3 chiefly associated with their relative body size. The most important food items for
4 puma were collared peccaries and red brocket deer (*Mazama temama*), whereas
5 agoutis (*Dasyprocta punctata*) and sloths (*Choloepus hoffmanni* and *Bradypus*
6 *variegatus*) were the main items for ocelots (Moreno et al. 2006). A similar pattern
7 was observed in the Ecological Station of Juréia - Itatins, in São Paulo, southeastern
8 Brazil, where jaguars do not occur. The same relationship between diet and body size
9 of pumas and ocelots was reported. The study showed consumption of collared
10 peccaries and greater naked-tailed armadillos by pumas, while ocelot preyed more on
11 marsupials (Martins et al. 2008).

12 In addition to felids, other Neotropical carnivores have been the focus of
13 dietary studies. The crab-eating fox (*Cerdocyon thous*) is a medium-sized animal of
14 family Canidae. The species predation strategy is opportunistic, being considered a
15 generalist and frequently consuming small vertebrates, insects and fruits (Delgado-V
16 and Zurc 2000; Juarez and Marinho-Filho 2002; Maffei and Taber 2003; Martínez
17 1996; Martínez and Cadena 2000; Motta-Junior et al. 1994; Novaes 2002). Gatti et al.
18 (2006) observed in Espírito Santo state, Brazil, that the most important items in the
19 scats of the *C. thous* were, by order of frequency of occurrence, fruits, arthropods and
20 small vertebrates. A fruit from a palm species (*Allagoptera arenaria*) was found in
21 88.6% of the samples. According to Pedó et al. (2006), in a study carried out in
22 southern Brazil, the crab-eating fox was essentially carnivorous (87.62% of
23 vertebrates), with seasonal variation and absence of fruits. The difference between
24 diets is due to the malleability of the species in different environments and its food
25 resources. Its generalist feeding habits may influence positively its survival in altered

1 environments (Rocha et al. 2008). Another important observation about the variable
2 diet of this species among diverse regions is that it depends on the correct
3 identification of the faecal samples. Without a reliable identification of the predator,
4 the results of its diet could be incorrect (Becker and Dalponte 1999).

5 The detection and the study of mammalian carnivores are hindered by their low
6 demographic density, their elusive behavior and the fact that some of the species are
7 threatened of extinction (Johnson et al. 2001). These animals are difficult to capture
8 in traps, requiring an experienced team of researches. All these events and
9 characteristics increase the difficulty of studying mammals in general (Ernest et al.
10 2000; Kohn and Wayne 1997; Mazzolli and Hammer 2008; Taberlet et al. 2001). A
11 new possibility for studies with species not easily observed or captured is the use of
12 non-invasive samples (organic materials left behind by these organisms, such as
13 hairs and scats) (Cullen Jr. et al. 2006; Taberlet et al. 1999). Non-invasive sampling
14 methods provide means of studying species which are difficult to survey using
15 traditional techniques (e.g., captures). Therefore, faecal samples can provide
16 information about species identification, distribution, abundance, dietary studies, and
17 pathologies (Kohn and Wayne 1997).

18 The use of faecal samples to study the diet of carnivore species requires the
19 reliable identification of the predator as well as the prey. There are some techniques
20 available to identify mammalian carnivores in the field and in the laboratory. In the
21 field, the identification can be carried out in several ways, such as latrine sites, tracks
22 around the scat, odor, etc. In the laboratory, features of the scats such as morphology
23 (size, shape) or food components have been used in the past for identification of the
24 predator source. However, several of these techniques may not be reliable, since
25 there are overlaps between many characteristics of latrine sites, tracks and scats

1 from these carnivore species (Becker and Dalponte 1999; Brunner and Wallis 1986).
2 Currently, the most reliable techniques carried out in the laboratory would be the
3 DNA-based identification (especially DNA sequencing) and trichology.

4 In the 1990s, previous studies have demonstrated that epithelial cells from the
5 colon wall, which were sloughed off and deposited in scats, could be a reliable source
6 of DNA to determine which to species they belong. By isolating DNA from scats and
7 using molecular assays that can be compared against reference samples, it is
8 possible to accurately determine species identity, especially with the use of direct
9 DNA sequencing (Albaugh et al. 1992; Höss et al. 1992; Paxinos et al. 1997).
10 Afterwards, some studies have used this approach to identify mammalian carnivore
11 species in dietary studies (Farrell et al. 2000; Napolitano et al. 2008; Weckel et al.
12 2006; Zuercher 2005).

13 Predators can also be identified with a trichologic method. This method
14 consists in collecting overhairs (ingested by the predator during its self-grooming)
15 from their scats. Those hairs are prepared on slides and then visualized under light
16 microscopy (Quadros and Monteiro-Filho 2006a; Teerink 1991). The hairs have some
17 microstructural patterns of the cuticle and medulla (concentric layers in the core of the
18 hair shaft) (Teerink 1991), and those patterns, that are often different between
19 species, can be used to carry out the identification (Fig. 2). The comparison among
20 hairs can be made with a reference collection and/or identification key. Some species
21 of Brazilian mammals were included in an identification key developed by Quadros
22 and Monteiro-Filho (2006a, 2006b).

23 Several species of Carnivora occur in sympatry in northern Mato Grosso, Brazil
24 (Peres and Michalski 2006). The study area, located in the Amazon biome, has been
25 highly deforested and fragmented in the last thirty years, this is due the anthropogenic

1 activities with livestock cattle. The rates of livestock depredation and human-wildlife
2 conflicts increases with the proximity between large cats and agro-pastoral lands
3 located in tropical deforestation frontiers (Michalski et al. 2006). Only a few studies
4 analyzed the mammalian carnivore diet in the Amazon forest (Astete and Silveira
5 2008; Carter et al. 1999; Rosas et al. 1999), and this is the first study in the Brazilian
6 Amazon that aims to describe the diet and analyze the competition among various
7 mammalian carnivores, which were identified with molecular and/or hair microscopy
8 methods.

9

10 **MATERIALS AND METHODS**

11 **Study area** - We carried this study in Alta Floresta (09°53'S, 56°28'W), northern Mato
12 Grosso state, located in the southern Brazilian Amazon (Fig. 1). The climate was
13 classified by Köpper (1948) as Ama zone (tropical monsoon climate), also known as a
14 "Tropical wet climate". The average annual precipitation is 2350 mm, but due to
15 evapotranspiration of 1000 mm/year, the hydric exceeding ranges from 1350 to 1400
16 mm/year. The annual temperature is 24.5°C on average, and there is high relative air
17 humidity (80-85%) (RADAM BRASIL 1983).

18 The vegetation is composed of many different plant species, such as *Apuleia*
19 *moralis*, *Bagassa guianensis*, *Astronium gracilis*, and *Bertholletia excelsa* (Michalski
20 et al. 2007). This region is included in the Submontane Ombrophilous Rainforest
21 (RADAM BRASIL 1983). The mammalian fauna is still diversified, in spite of intense
22 human intervention; among mammals there are at least fifteen carnivore species:
23 *Potos flavus* (kinkajou), *Eira barbara* (tayra), *Nasua nasua* (coati), *Galictis vittata*
24 (greater grisson), *Procyon cancrivorus* (crab-eating raccoon), *Cerdocyon thous* (crab-
25 eating fox), *Atelocynus microtis* (small-eared dog), *Speothos venaticus* (bush dog),

1 *Puma yagouaroundi* (jaguarundi), *Leopardus wiedii* (margay), *Leopardus pardalis*
2 (ocelot), *Puma concolor* (puma), *Panthera onca* (jaguar), *Pteronura brasiliensis* (giant
3 otter), *Lontra longicaudis* (neotropical river otter) (Peres and Michalski 2006).

4 Despite its high levels of biodiversity, the region of Alta Floresta has been
5 highly fragmented, being one of the most deforested areas in the Brazilian Amazon.
6 That results both in habitat loss and in subdivision of the remaining habitat. Michalski
7 et al. (2006) reported high deforestation rates since the early 1980s, with the original
8 forest coverage declining from 91% in 1984 to 42% in 2004 on the southern bank of
9 the Teles Pires River, driven by economic activities such as cattle ranching and
10 farming.

11 **Faecal sampling** - Carnivore scats were collected opportunistically between October
12 2007 and December 2008. For DNA analyses, a portion of approximately 5 cm in
13 length of each scat was collected, immersed in 96% ethanol, and stored at -20°C
14 prior to extraction. The remaining portion of each scat was then stored in a zip lock
15 bag for carnivore identification using hair microscopy, and also for the dietary
16 analysis.

17 **Identification of predator species from scats** - Faecal samples were identified at
18 species level using two different approaches: a molecular assay based on
19 mitochondrial DNA (mtDNA) sequencing, and a light microscopy analysis based on
20 guard hairs. For the molecular assay, genomic DNA was extracted from each sample
21 using the QIAamp Stool DNA Mini Kit (Qiagen Inc.), following the supplier's
22 instructions, and then used to amplify a short segment of the mtDNA *ATP synthase*
23 *subunit 6 (ATP6)* gene (Haag et al. 2009), whose sequence was compared to a data
24 base containing reference samples from many carnivore species (Chaves et al., in
25 preparation). The primary results from these analyses will be reported elsewhere

1 (Michalski et al., in preparation), but will also be used here to provide species-level
2 identification of the predators for use in the dietary studies; we will also use these
3 molecular data to perform a comparative assessment with the trichological approach
4 (described below).

5 The identification using hair microscopy was performed independently from the
6 DNA-based identification. Predator hairs contained in scats were separated from the
7 remaining portion; subsequently they were cleaned and dried. Overhairs found in the
8 samples were prepared on slides for observation with optical microscopy, following
9 the technique developed by Quadros and Monteiro-Filho (2006b). The hair
10 microstructure (hair medulla and cuticular scales) (Fig. 2) was compared to a
11 collection of slides fixed by ourselves with hairs from a reference collection from
12 Museu de Ciências Naturais – Fundação Zoobotânica do Rio Grande do Sul (MCN-
13 FZB/ RS).

14 As an additional assay, we tested the identification method based on the
15 perimeter of scats, with a tape measure on all scat samples that weren't deformed.
16 Using the identifications originated by molecular and hair microscopy methods, we
17 attempted to assess the reliable occurrence of size differences among scats from
18 distinct species.

19 ***Diet data – Material separation*** – Faecal samples stored in zip lock bags were
20 washed with flowing water using two different sizes of fine-mesh filters (1.0 and 0.5
21 mm). The organic material was then separated, with remaining muscles of
22 vertebrates and invertebrates being immersed in ethanol 70%, whilst feathers, plants,
23 teeth, claws, bones, etc were sun dried in thin paper bags for 3 days to avoid fungal
24 growth (adapted from Carss and Parkinson 1996). Every scat sample received a

1 record with all food items collected from it. These items were initially identified to a
2 broad taxonomic level (i.e. mammal, bird, reptile (non-avian), amphibian, etc).

3 **Identification of prey species from scats** – We identified food items by examining
4 the undigested material, which varied among prey groups. Small mammals were
5 identified through teeth, claws and hairs. Medium-sized and large mammals were
6 identified using a hair reference collection from the following museums: Museu de
7 Ciências e Tecnologia – Pontifícia Universidade Católica do Rio Grande do Sul
8 (MCT-PUCRS), Museu de Ciências Naturais – Fundação Zoobotânica do Rio Grande
9 do Sul (MCN-FZB) and Museu Nacional – Universidade Federal do Rio de Janeiro
10 (MN-UFRJ). Bird feet, beaks and feathers were compared macroscopically to a
11 reference collection from MCT-PUCRS, in addition to slides with feathers used in
12 microscopical identification compared to an identification key (Brom 1986). A
13 reference collection from the Ichthyology Laboratory of Universidade Federal do Rio
14 Grande do Sul (UFRGS) was consulted for fish identification. Reptiles and
15 invertebrates were identified by zoologists from UFRGS working on these groups.

16 **Dietary analysis** – The frequency of occurrence (FO) was quantified by the presence
17 of the food item in the total of faecal samples; it is obtained by dividing the total
18 number of occurrences of a particular prey item by the number of samples. By
19 counting teeth, beaks, feet, legs, etc, in each faecal sample we could estimate the
20 minimum number of consumed individuals. These previous data was used to
21 measure the proportion of occurrence (PO) of a given item compared to the others in
22 the samples, obtained by dividing the total number of occurrences of a particular prey
23 by the total number of items (Konecny 1989; Wang 2002).

24 The frequency of occurrence tends to overestimate the relative consumption
25 of small items (Cobertt 1989; Villa-Meza et al. 2002) and underestimates the relative

1 consumption of large prey (Weaver 1993). To overcome this problem, some studies
2 with pumas, *Puma concolor*, (Ackerman et al. 1984), wolves, *Canis lupus*, (Floyd et
3 al. 1978) and bobcat, *Lynx rufus* (Baker et al. 1993, 2001) developed a correction
4 algorithm based on feeding trials in captivity using known prey of different body sizes.
5 Studies with Asian and South American fauna have used these equations in
6 mammalian carnivores with similar body size from the original species (Andheria et al.
7 2007; Martins et al. 2008; Villa-Meza et al. 2002; Zapata et al. 2008). In the present
8 study, the correction algorithm for *P. concolor* was used for the *P. concolor* and *P.*
9 *onca* samples ($Y = 1.98 + 0.035X$), while the *L. rufus* correction was used for the *L.*
10 *pardalis* ($Y = 16.63 + 4.09X$), where X is the live weight of the prey (Ackerman et al.
11 1984; Azevedo 2008; Martins et al. 2008; Villa-Meza et al. 2002). We only applied the
12 index to the mammalian prey in the felid diets, since this was the category for which
13 we were able to perform the most precise identification. It was also the most frequent
14 category of vertebrate prey in the diet of all three cats. Live weight estimates of prey
15 items were based on published references (Ackerman et al. 1984; Bonvicino et al.
16 2008; Emmons 1987; Crawshaw 1995). Regarding the smaller prey (<1Kg), we did
17 not calculate the correction factor because predators usually eat the entire animal
18 (Ackerman et al. 1984; Campos 2009).

19 The relative biomass (RB) was calculated using the correction factor (Y) and
20 frequency of occurrence (FO) (Ackerman et al. 1984; Andheria et al. 2007; Villa-Meza
21 et al. 2002): $RB = (FO \cdot Y) / \sum(FO \cdot Y) \cdot 100$. Prey items were divided into three size
22 categories: small (<1 kg), medium (1–15 kg), and large (>15 kg) (Iriarte et al. 1990).
23 To evaluate the importance of each prey item in the diet of *P. onca*, *P. concolor*, and
24 *L. pardalis*, the Index of Relative Importance (IRI) (Pinkas et al. 1971) was measured
25 as: $IRI = (PO + RB) FO$.

1 We used the Levins's measure of standardized niche breadth (Krebs 1999) to
2 estimate the food niche breadth for each of the carnivore species, as follows:

$$3 \quad BA = (B-1)/(n-1),$$

4 where B is Levins' measure ($B = 1 / \sum p_i^2$), p_i is the fraction of items in the diet
5 that belong to food category i ; and n is the number of possible resource states. The
6 values of niche breadth can range on a scale from 0 (small diversity of prey
7 consumed at high frequencies), where the predator is more specialist than generalist,
8 to 1 (resources are used in similar frequencies), which would imply that the predator
9 is more of a generalist (Krebs 1999).

10 The dietary niche overlap between the felid species that presented a
11 reasonably large sample size (*L. pardalis*, *P. onca* and *P. concolor*) was calculated
12 using Pianka's measure (1973):

$$13 \quad O_{12} = O_{21} = \sum p_{1i} p_{2i} / (\sum p_{1i} \sum p_{2i})^{1/2},$$

14 and Czekanowski's index (1913), better known as referred to by Sørensen
15 (1948):

$$16 \quad O_{12} = O_{21} = 1.0 - 0.5 \bullet \sum_{i=1}^n |p_{1i} - p_{2i}|,$$

17 where p_{1i} and p_{2i} are the proportions of resource i in the diet of the species 1
18 and 2, respectively.

21 These indices range from 0 (no overlap) to 1 (complete overlap) (Gotelli and
22 Entsminger 2006; Krebs 1999; Sørensen 1948). The niche overlap was measured
23 considering the proportion of occurrence (PO) of overall vertebrate items and using
24 the relative biomass (RB) of mammalian prey for both indices. We tested for
25 significance of niche overlap by comparing the observed values with values obtained
26 by randomizing the original matrices (1000 iterations), using the default procedure
27 (RA3) implemented in the ECOSIM 7 software (Gotelli and Entsminger 2006).

1 Arthropod fragments and plant material were not included in the analyses of
2 the three felid species (Villa-Meza et al. 2002). However, these items were included in
3 the analysis of the *C. thous* diet, once they may play a more important role in its
4 nutrition (Gatti et al. 2006; Jácomo et al. 2004; Rocha et al. 2008). This is the reason
5 why the niche overlap between the felid species and *Cerdocyon thous* was not
6 calculated in this study.

7

8 **RESULTS**

9 ***Predator species identification*** – A total of 108 faecal samples was collected
10 between October 2007 and December 2008. Eighty-one samples (75%) could be
11 identified at species level. From these samples, using the molecular method, 64
12 samples (59.26%) were identified (Michalski et al. unpublished data), while 44
13 (40.74%) were identified through hair microscopy. Twenty-seven samples could be
14 identified with both methods (table 1), allowing a comparison of their performance.

15 The hair microscopy analyses were carried out independently from the
16 molecular analyses. From all scats (n=108), sixty-four samples (59.26%) contained
17 overhairs of likely predator origin. We identified five samples at family level (all
18 Felidae) and 44 (68.75%) at species level; fifteen were unidentified due the high level
19 of hair degradation and/or equivocal microstructural patterns of the cuticle and
20 medulla. Seventeen (38.64%) of the 44 samples were identified only by using the hair
21 microscopy approach. Twenty-seven were also determined by the DNA extraction,
22 with both methods showing a concordance of 92% at species identification, and only
23 8% (n=2) discrepancy in the identifications. We used those scats from which mtDNA
24 was successfully isolated (64) plus just those samples that were only hair
25 identification (17) to compare diets between predator species.

1 Slides prepared with hairs collected in museum collections showed a unique
2 pattern for each species providing diagnostic characters in medullar and cuticular
3 patterns. Overall, we identified nine predator species using the combination of both
4 analytical approaches (table 1).

5 The perimeter measure of feces using the samples already identified by the
6 other methods (molecular and hair microscopy) showed overlap in the size among
7 species, such as *P. onca* and *L. pardalis*; in addition, several scat samples were
8 deformed (table 2), precluding adequate measurement.

9 **Dietary analysis** – Because of the low number of samples for some predator species
10 (*Puma yagouaroundi*, *Lontra longicaudis*, *Pteronura brasiliensis*, *Eira barbara*,
11 *Speothos venaticus*) we just described their diet. The dietary analyses were
12 performed for *Leopardus pardalis*, *Panthera onca*, *Puma concolor* and *Cerdocyon*
13 *thous*.

14 **Diet description and frequencies - *Leopardus pardalis*** - From ocelot scats, we
15 could determinate 32 different categories of food resource. Twenty-nine (PO= 90.6%)
16 of these items were of animal origin and three (PO= 9.4%) were of plant origin. We
17 clustered these two groups in six categories (PO): mammals (20%), birds (2.86%),
18 reptiles (4.76%), fishes (1.92%), invertebrates (54.28%) and seeds (16.19%).
19 Invertebrates and seeds were not included in analyses due to their low biomass.
20 Regarding vertebrate prey (Fig. 3), *Proechimys* sp. was most frequent one in the
21 ocelot diet (FO=27.8% and PO=17.24%), followed by *Dasypus* sp. (FO= 22.22 and
22 PO=13.8%). Relative biomass was higher for *Dasypus* sp. (29.2%), however the
23 Index of Relative Importance (IRI) showed *Proechimys* sp. as most important prey
24 category in the ocelot diet in this region (Table 3).

1 ***Panthera onca*** - A total of 18 categories of prey items were detected in the jaguar
2 diet, and all of them were of animal origin (FO=100%). The categories of the jaguar
3 diet were: mammals (PO=38.09%), birds (PO=4.77%), reptiles (PO=2.38%) and
4 invertebrates (PO=54.76%). Even with the high invertebrate percentage, the biomass
5 of this entire category is much lower than the one of vertebrate prey, and they were
6 excluded from the subsequent analysis. Within the vertebrate prey category (Fig. 3),
7 the item that appeared in all scat samples and had the largest percentage in the
8 jaguar diet was mammal (FO=100% and PO=84.21%), where 68.75% were large
9 mammals, 31.25% were medium-size prey; and small mammals were not found. The
10 most frequent items found in the jaguar diet were *Tayassu pecari* and *Tayassu tajacu*
11 (FO=25% and PO=21.05% for both species). The highest relative biomass was found
12 for *Tayassu pecari* (29.8%), which was also corroborated by the IRI that showed
13 *Tayassu pecari* as the most important prey item for this species (Table 3).

14 ***Puma concolor*** - Fifteen categories of prey were found in the puma scats. Of these,
15 thirteen (PO=86.67%) were animal in origin and two (PO=13.3%) were of plant origin.
16 The items were clustered in four classes with the following percentages: mammals
17 (PO=16.67%), birds (PO=2.78%), invertebrates (PO= 22.22%) and seeds
18 (PO=58.33%). These latter two items had a high frequency, as it happened in jaguars
19 and ocelots, but a very low biomass and so were excluded from the subsequent
20 analysis. Among the vertebrate prey (Fig. 3), rodents were the most frequent item in
21 the puma diet (57.12% FO and PO). As an interesting point, we found one sample
22 that had only one unidentified arthropod and leaves from Poaceae. The prey with the
23 highest relative biomass was *Cuniculus paca* (45.76%). Finally, the items that
24 represented the two highest IRI in the puma diet were *Dasypus* sp. and *Cuniculus*
25 *paca* (Table 3).

1 ***Puma yagouaroundi*** - Only animals were found in the jaguarundi diet. We found
2 Poaceae in all samples, but only its leaves, probably used to help them in the
3 digestion. Two classes were observed: mammals (FO=100% and PO=80%) and
4 arthropods (FO=33.33% and a PO=20%). Among mammals, rodents were the most
5 frequently found item (PO=60%), as follows: *Dasyprocta azarae* (FO=66.67% and
6 PO=40%), *Oxymycterus* sp. (FO=33.33% and PO=20%) and *Dasypus* sp.
7 (FO=33.33% and PO=20%) (see Table 5).

8 ***Lontra longicaudis*** - We found a total of 13 different items from otters scats, where
9 nine (PO=69.24%) had an animal origin and four (PO=30.76%) had a plant origin.
10 The animal items were divided in: mammals (PO=8.33%), identified to species level
11 (*Necomys lasiurus*); birds (PO=16.67%), where one was unidentified and the other
12 was identified as belonging to order Passeriformes; reptiles (PO=8.33%), identified to
13 family level (Teiidae); fishes (PO=8.33%), all being to Actinopterygii; and arthropods
14 (PO=33.32%), in which case one was unidentified and the three others were identified
15 as belonging to the Trichodactylidae and Scarabaeidae families and the order
16 Orthoptera. All 13 different items occurred in equal proportion, 8.33 % each one
17 (Table 5).

18 ***Pteronura brasiliensis*** – Three different categories were found in the giant otter
19 faecal samples, all of which were vertebrate animals. Fishes were the only class
20 (100% FO and PO) and two families were identified; Erythrinidae was the most
21 frequent (PO=75%), followed by Characidae (PO=12.5%) and an unidentified fish
22 (PO=12.5%) (Table 5).

23 ***Eira barbara*** – We identified a total of twelve prey items in the tayra diet. Eleven
24 (PO=91.7%) of these were animal matter and only one (PO=8.33%) was plant matter.
25 These categories were divided into mammals (PO=50%), birds (PO=16.67%), reptiles

1 (PO=8.33%), fishes (PO=8.33%), arthropods (PO=8.33%) and seeds (PO=8.33%).
2 Among animal items, rodents were the most frequent one (PO= 45.45%), divided into
3 *Sphiggurus* sp., *Proechimys* sp., *Akodon* sp., *Oligoryzomys* sp., and *Euryoryzomys*
4 *russatus*. A didelphid marsupial, *Cryptonanus* sp., was identified as well. Bird items
5 were identified as family Rallidae and order Passeriformes, respectively. A snake was
6 the only reptile found. The others items were not identified precisely. The same
7 percentage of occurrence (8.33%) was found for all twelve categories, meaning that
8 prey were consumed in the same proportion (Table 5).

9 ***Cerdocyon thous*** - Thirty-four different items were recognized in the crab-eating fox
10 scats (Fig. 4). Twenty-six were animal matter (76.48%), seven were plant matter
11 (20.59%) and one was human waste (2.9%). Among the animal items, we identified
12 mammals (2.2%), birds (2.7%), reptiles (8.7%), and invertebrates (86.4%). In the
13 most frequent vertebrate category (reptiles) we found Colubridae, Teiidae, Lacertilia,
14 snakes and an unidentified Squamata. The insect order Coleoptera was the most
15 frequent (FO=80% and PO=28.23%) among all animal matter. Seeds were the most
16 consumed item by the crab-eating fox (FO=40% and PO=53.9%), which was the
17 predator species that presented the most variety of items (Table 4).

18 ***Speothos venaticus*** - One medium size mammal (*C. paca*) was found in the only
19 sample of bush dog, as well as some Poaceae leaves (Table 5).

20 ***Niche breadth and overlap*** - The calculated niche breadth (B and BA) of ocelot,
21 jaguar, puma and crab-eating fox can be found in Table 6 The largest niche breadth
22 was presented by the crab-eating fox (BA= 0.52), follow by ocelot (BA= 0.46). The
23 puma showed the narrowest niche breadth (BA=0.24), probably because of the fact
24 that the number of samples for *P. concolor* is much smaller than in the other three

1 species assessed with this estimate. It is important to note that the items were
2 consumed in proportion by puma, and this is not characteristic of low niche breadth.

3 The highest niche overlap occurred between ocelot and puma, while the lowest
4 happened between ocelot and jaguar. These results occurred using both indices, and
5 using PO and RB (Table 7). By comparing the observed mean and the mean of
6 simulated indices, we observed the values of p were 1 or almost 1, this showed that
7 are not sufficient evidences to reject the hypothesis that the felids have a similar diet.

9 **DISCUSSION**

10 ***Identification methods for predators*** –The molecular method was more successful
11 than the hair microscopy approach, due the highest number of samples identified by
12 this method in relation to the hair microscopy. The identifications worked effectively
13 using both methods. The DNA based-method was affected by the scat age (e.g. if it
14 was old or dry) in some samples (n=15); the molecular analyses considered 93
15 samples as feasible for identification. The hair microscopy depended on finding
16 predator overhairs in the faecal sample, and on the level of degradation of these hairs
17 to verify the identification. Both methods faced some obstacles, but presented
18 consistency in the identifications.

19 As for the test of identification method based on the perimeter of scats, the
20 results showed little reliability. Deformation in faecal samples and an overlap between
21 the measurements among species (Table 2) are the main reasons why we would not
22 recommend this method (Brunner and Wallis 1986; Farrell et al. 2000; Foran et al.
23 1997; Prugh and Ritland 2005).

24 The success rate (92%) of correspondence between molecular and hair
25 microscopy data in this study (Table 1), along with several cases of congruence

1 between these methods observed by Graeff (2008) indicates that both methods are
2 reliable. Regarding the hair microscopy analysis, the use of slides fixed by ourselves
3 with predator hairs from collections showed better results in comparison with the
4 identification key procedure. The DNA based-method has been successful in diet
5 studies (Farrell et al. 2000; Napolitano et al. 2008; Weckel et al. 2006; Zuercher
6 2005), and so has the hair microscopic approach (Graeff 2008; Inagaki and
7 Tsukahara 1993; Silva-Pereira 2009). It is critical in dietary studies to have a good
8 accuracy in the identification of the predator species, so that their real trophic niches
9 can be studied.

10 ***Diet differentiation among predators*** – Among all studies, there is an agreement
11 that ocelots prey primarily on small to medium-sized mammals.
12 Ocelots most frequently prey on rodents, as shown in almost all studies about this
13 species (Moreno et al. 2006; Silva-Pereira 2009; Villa-Meza et al. 2002; Wang 2002).
14 *Proechimys* sp. was the most important prey for *L. pardalis* in our results, and it was
15 significant in other study sites as well. In Peru, the consumption of *Proechimys* sp.
16 was high and it was correlated to their abundance in the area (Emmons 1987).
17 Chinchilla (1997), in Costa Rica, observed that *Proechimys semispinosus* was
18 consumed more frequently than other prey categories. In the Panama canal area,
19 Moreno et al. (2006) found that rodents of this genus were the third most important
20 item in the ocelot diet. Our results showed, in one particular case, that an ocelot had
21 preyed upon a juvenile white-lipped peccary, probably as an opportunistic event.
22 Nevertheless, the consumed biomass of this prey was considered to be medium-
23 sized. This predator did not extend their use of large prey (>15kg), suggesting that the
24 presence of bigger felids in the area is still constraining their diet (Table 3). Regarding
25 their size, some authors, such as Ludlow and Sunkist (1987), suggested that adult

1 males can attack large-bodied animals, therefore we should not ignore the idea that
2 they could be able to prey upon animals such as peccaries. *Tamandua tetradactyla*
3 was also consumed by ocelots, this may indicate some degree of ability of *L. pardalis*
4 to prey on the arboreal stratum, the consumption of essentially arboreal species has
5 been observed by other authors (Bianchi and Mendes 2007; Miranda et al. 2005;
6 Moreno and Giacalone 2006).

7 In general, the results presented here agree with the ones reported by other
8 authors regarding the diet of *P. onca*. Mammals comprised the bulk of jaguar's diet,
9 while birds and reptiles were consumed occasionally (Azevedo 2008; Azevedo and
10 Murray 2007; Chinchilla 1997; Rabinowitz and Nottingham 1986; Scognamillo et al.
11 2003; Weckel et al. 2006). The proportion of occurrence and relative biomass were
12 higher for large mammalian prey, showing the same results as other studies carried
13 out in Brazil (Paraná and Mato Grosso do Sul states), as well as in Venezuela
14 (Azevedo 2008; Azevedo and Murray 2007; Scognamillo 2003). In addition, when
15 given a choice of larger prey, jaguars seem to select for these prey types (Farrell
16 2000). The most important prey item for jaguars was the white-lipped peccary (*T.*
17 *pecari*), followed by the collared peccary *T. tajacu* (Table 3), both of which were
18 recorded among the three most important items in almost every dietary studies for
19 this species (Azevedo 2008; Huggard 1993; Scognamillo et al. 2003; Sunquist and
20 Sunquist 1989; Weckel et al. 2006). Peccaries are group-living species; it might be a
21 high injury risk for their predators. This risk is documented in some studies (Huggard
22 1993; Scognamillo et al. 2003; Sunquist and Sunquist 1989). According to
23 Scognamillo et al. (2003), a sub-adult female jaguar was killed by collared peccaries.
24 Even with these risks, the results provided by the present study suggest that jaguars
25 prefer an effective energy gain by preying upon these peccaries.

1 Regarding pumas, they can range from desert environments to temperate and
2 tropical rain forests. This predator has an enormous diversity of body size and feeding
3 strategy, and likewise for its diet throughout its geographic distribution in the
4 Americas. The results of this study concur with previous ones, in tropical regions as
5 well, which found puma to prey primarily on medium-size mammals (Emmons 1987,
6 Courtin et al. 1980). The most important prey items for pumas were *Dasypus* sp. and
7 *C. paca*, probably due to their slow mobility and the consequent ease of capturing
8 them (Table 3). The absence of large mammalian prey in the diet of *P. concolor*
9 seems to be related to the study area – Brazilian Amazon – where they are sympatric
10 with *P. onca*. According to Iriarte et al. (1990), the puma subspecies weigh less in
11 areas close to the equator and, perhaps as a consequence, the average weight of
12 their vertebrate prey is lower. In addition to that, the puma prey selection is likely
13 influenced by competition with the jaguar.

14 Our results for *P. yagouaroundi* showed a high consumption of small
15 mammals, especially rodents. These results agree with previous studies with this
16 species (Graeff 2008; Konecny 1989; Silva-Pereira 2009; Tófoli et al. 2009); however
17 the PO of rodents in this study (Table 5) was higher than in others, perhaps due to
18 the low number of faecal samples.

19 Surprisingly, different components, including birds, fruits and insects, were
20 observed in the diet of *L. longicaudis*. Despite the knowledge that the otter diet is
21 composed mostly of fishes, and the consumption of this prey item is disproportional
22 comparing to other items (Kasper et al. 2008; Pardini 1998; Quadros and Monteiro-
23 Filho 2000; Silva et al. 2008), the results in this study showed that all items were
24 consumed in the same proportion (Table 5). This could be explained given the fact
25 that this study was placed in a different region, and all studies cited above were

1 carried out in southern and southeastern Brazil. Differently, studies carried out in
2 Costa Rica and Mexico verified a considerable number of crustaceans in the otter diet
3 (Sánchez and Aranda 1999; Spinoma-Parallada and Vaughan-Dickhaut 1995).
4 According to Spinoma-Parallada and Vaughan-Dickhaut (1995), fishes and
5 crustaceans were consumed in similar proportions in Costa Rica. These results are
6 analogous to the present study, possibly because they were carried out in tropical
7 areas. It is important to observe that the fragmentation of the study area and the
8 presence of the giant otter (that is extinct in some regions) in the same habitat might
9 have led the otter to develop a more flexible diet. However, these hypotheses would
10 need further studies to be thoroughly tested.

11 Several studies have revealed that fish constitute the majority of the Giant
12 Otter diet, and they observed *P. brasiliensis* generally fishing on the shallow margins
13 of lakes and rivers (Carter and Rosas 1997; Defler 1983; Duplaix 1980; Schweizer
14 1992). In the present study, the most frequent taxonomic family consumed by *P.*
15 *brasiliensis* was Erythrinidae, found in samples collected in October. Members of this
16 family of fishes have a characteristic behavior during the ebb period (dry season),
17 being encountered close to the margins as they seek food. In addition, these fishes
18 are usually slow (Machado and Sazima 1992; Oliveira 1994). Given these facts –
19 predator and prey behavior and dry season – it helps us to understand why there
20 were six fishes from this family in just one faecal sample, for instance. In addition,
21 according to Carter and Rosas (1997), Characoids seem to be the most widely
22 consumed prey of the giant otter. Characoids are Characiiformes, the order where
23 Erythrinidae and Characidae (another family consumed by giant otter in this study)
24 are included (Table 5).

1 As in other studies, *E. barbara* consumed a wide variety of prey, including
2 small rodents, reptiles, small birds, arthropods, and fruits (Konecny 1989; Nowak
3 1999; Presley 2000; Sunquist et al. 1989). In the present one, an interesting item
4 observed was fish, as we could not find records of consumption of this item by tayras
5 in the literature (Table 5). A study in northeastern and northern Brazil reported
6 predation by tayra on a common marmoset (*Callithrix jactchus*) and a neonate pale-
7 throated three-toed sloth (*Bradypus tridactylus*) (Bezerra 2009). The species has
8 been recorded taking a wide variety of prey items both in trees and on the ground.
9 Differently, our study showed this predator consuming prey found in the water,
10 pointing out that the tayra is a really an opportunistic omnivore (Presley 2000), and
11 that additional studies are required to better understand its dietary composition.

12 As expected, *C. thous* was the species with the largest number of prey
13 categories (Fig. 4). Insects were the most consumed animals per scat, and the
14 Coleoptera, as in other studies, was the most commonly observed order (Facure and
15 Monteiro-Filho 1996; Graeff 2008; Juarez and Marinho-Filho 2002; Rocha et al.
16 2008). Among the vertebrate prey, we found different results with respect to other
17 studies, with Squamata being more frequent than mammals. The species' predation
18 strategy is opportunistic, and in this study the sympatry with various felid species in a
19 fragmented region possibly influenced its strategy and its diet as well. The most
20 frequent items in proportion of occurrence amongst all items were seeds/fruits (Table
21 4), which agrees with other studies conducted in tropical areas as well (Facure et al.
22 2004; Gatti et al. 2006; Jácomo et al. 2004; Redford and Eisenberg 1992). An
23 interesting data concerned the human manufactured waste (plastic). Since the
24 advance of the city and farms over the forest, the contact with humans has increased.

1 Therefore, when the crab-eating fox moves from one fragment to another it might find
2 garbage, and, being an opportunistic species, it might consider it a dietary resource.

3 Paca, agouti, and capybara are considered to be the main prey of the bush
4 dog *Speothos venaticus* (Aquino and Puertas 1997; Beisiegel and Zuercher 2005;
5 Cabrera and Yepes 1940; Deutsch 1983; Peres 1991; Silveira et al. 1998; Strahl et al.
6 1992; Zuercher et al. 2005), a fact that was corroborated by this study, in which we
7 found evidence of consumption of *Cuniculus paca* by this predator (Table 5).
8 According to some studies, members of bush dog groups hunt cooperatively (Aquino
9 and Puertas 1997, Peres 1991, Strahl et al. 1992). Cabrera and Yepes (1940)
10 observed that when they are hunting a paca, part of the group chases it on land and
11 part waits for it in the water.

12 Our results are in accord with the hypothesis that the use of different resources
13 – food in this case – allowed the coexistence of carnivore species (Schaller 1972).

14 **Niche differentiation** – The *C. thous* niche breadth can vary drastically in different
15 regions. In Goiás state, central Brazil, for instance, the species presented a BA of
16 0.14 (Jácomo et al. 2004), however, in Rio Grande do Sul state, southern Brazil, it
17 showed BA=0.93 (Graeff 2008). In the present study it was 0.52 (Table 6), as the
18 results observed here as well as in other studies concur with their generalist food
19 habits and especially with their flexibility in many different regions. The crab-eating
20 fox's diet had the highest niche breadth comparing with the other analyzed species.
21 This study evidenced once more the opportunistic behavior of *C. thous*. Among the
22 three felids species, ocelots, as expected, presented the largest niche breadth, being
23 more generalist than the other two species (Table 6). Ocelots seem to have a diverse
24 BA among different study sites (Martins et al. 2008; Silva-Pereira 2009; Villa-Meza et
25 al. 2002). We can notice that they presented flexible patterns. As far as the jaguar is

1 concerned, the niche breadth was similar to other studies, with values ranging from
2 0.35 to 0.56 (Azevedo 2008; Azevedo and Murray 2006; Scognamillo et al. 2003).
3 This observation suggests that jaguars don't change their pattern of predation, once
4 they tend to hunt large-sized prey in a certain proportion in order to fulfill their
5 nutritional needs. The low BA of pumas might be a consequence of the small sample
6 size for this predator. In Brazil, studies reported a large niche breadth for pumas
7 (Graeff 2008; Martins et al. 2008). However, while analyzing other studies we found a
8 variety of values for the puma's niche breadth (Ackerman et al. 1984; Courtin et al.
9 1980; Hass 2009, Maehr et al. 1991; Spalding and Lesowski 1971). Additionally,
10 according to Iriarte et al. (1990) the BA along the Americas was significantly different,
11 with BA=0.46 in Central and South America, and BA=0.16 in North America.
12 Therefore, the large geographic distribution and all external pressure probably have
13 influenced the puma diet; this shows the trophic niche flexibility of this predator in
14 different environments.

15 The *L. pardalis* and *P. onca* trophic niches were the least overlapping of the
16 three pairs tested (Table 7), meaning that they are not strongly competing for the
17 same food resources. This could be explained by the fact that jaguars hunt large-size
18 prey, forcing the other felids to look for smaller ones; or simply by noticing the big
19 differences in their body-size. We observed a large overlap between *L. pardalis* and
20 *Puma concolor*, even though they presented different body-size. In regions where
21 pumas are sympatric with jaguars, they tend to change their patterns of prey to
22 medium- and small-sized ones, and those are the prey items consumed by ocelots as
23 well. Other studies analyzing the diets of ocelots and pumas observed that when
24 jaguars do not coexist with them the two species presented less diet overlap (Martins
25 et al. 2008; Moreno et al. 2006).

1 The results presented here can help with the understanding of the interaction
2 between predators and prey, as well as that among predator species. The data
3 concerning ecology of these species can contribute, in a significant way, to a higher
4 awareness about them, furthermore facilitating the design of effective strategies for
5 their management and conservation in the field.

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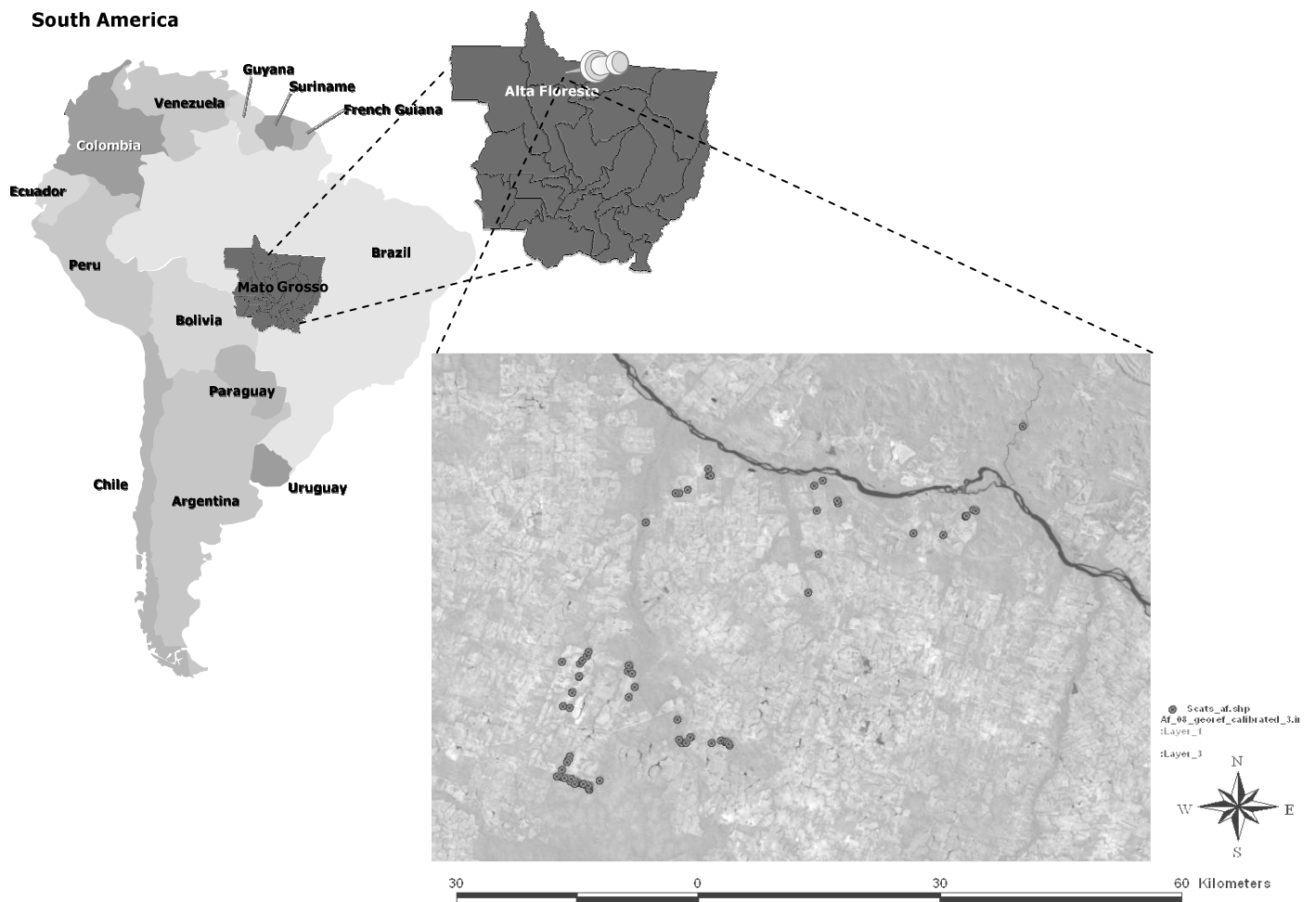


FIG. 1. — Map of the study area in Alta Floresta, Mato Grosso state, Brazil (09°53'S, 56°28'W), and the classified Landsat 5 TM image from 10/08/2008 showing the location of the 108 scat samples included in the analyses. Grey and white areas represent forest and non-forest cover, respectively.

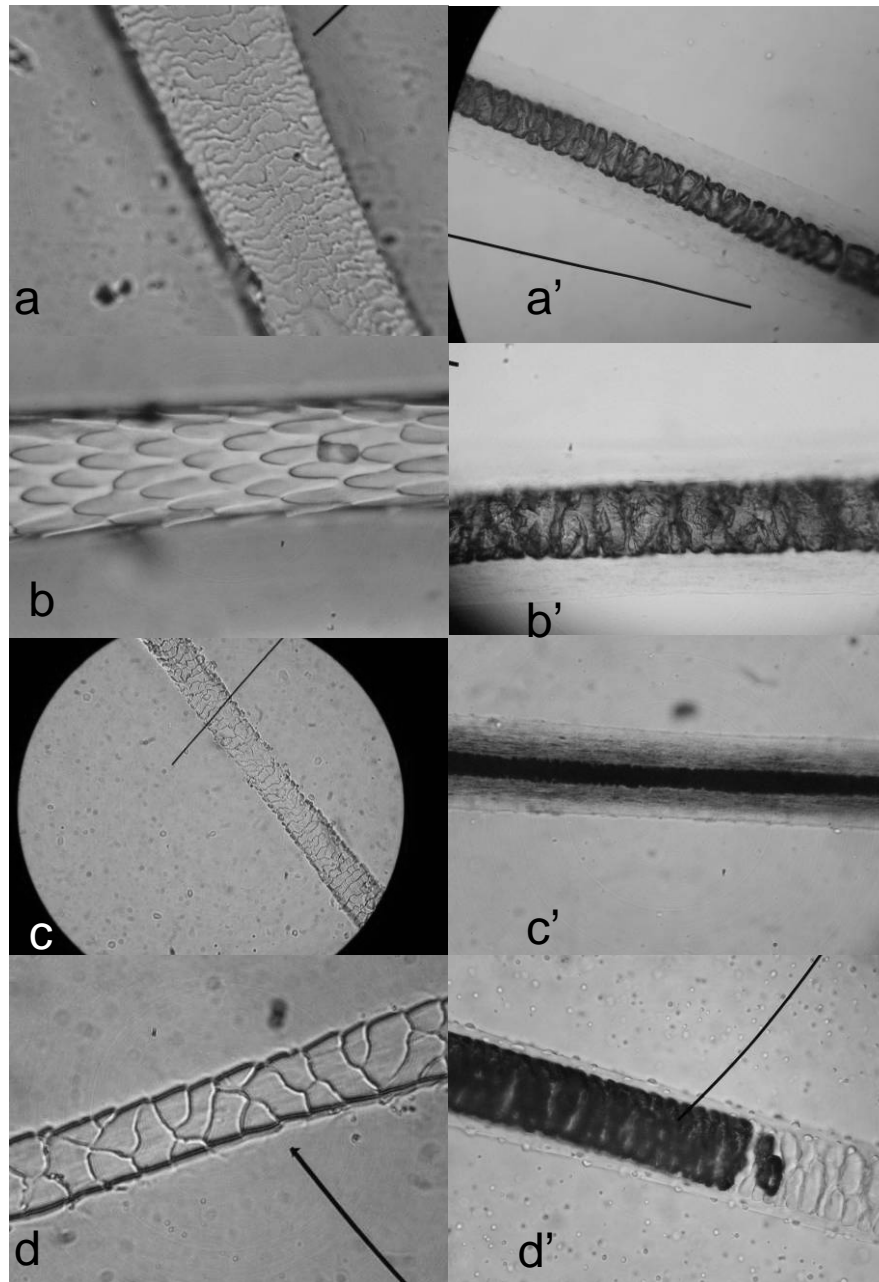


FIG. 2. Cuticular and medular patterns of some carnivore species identified in this study. a) and a') *Eira barbara*, b) and b') *Lontra longicaudis*, c) and c') *Panthera onca*, d) and d') *Puma yagouaroundi*.

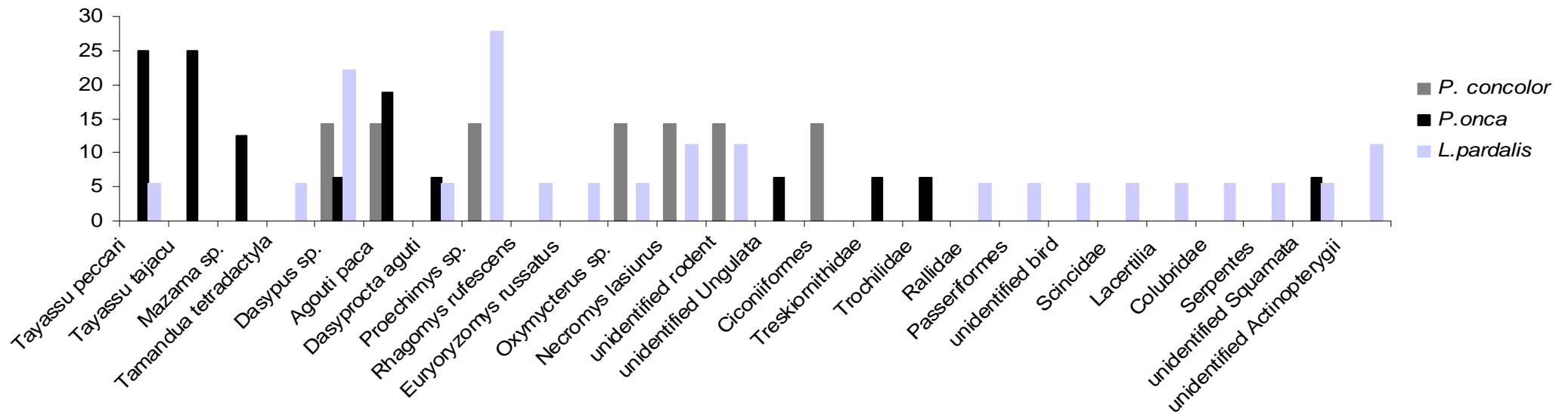


FIG. 3. — Frequency of occurrence (FO) of all vertebrate prey consumed by *P. concolor*, *P. onca*, and *L. pardalis*.

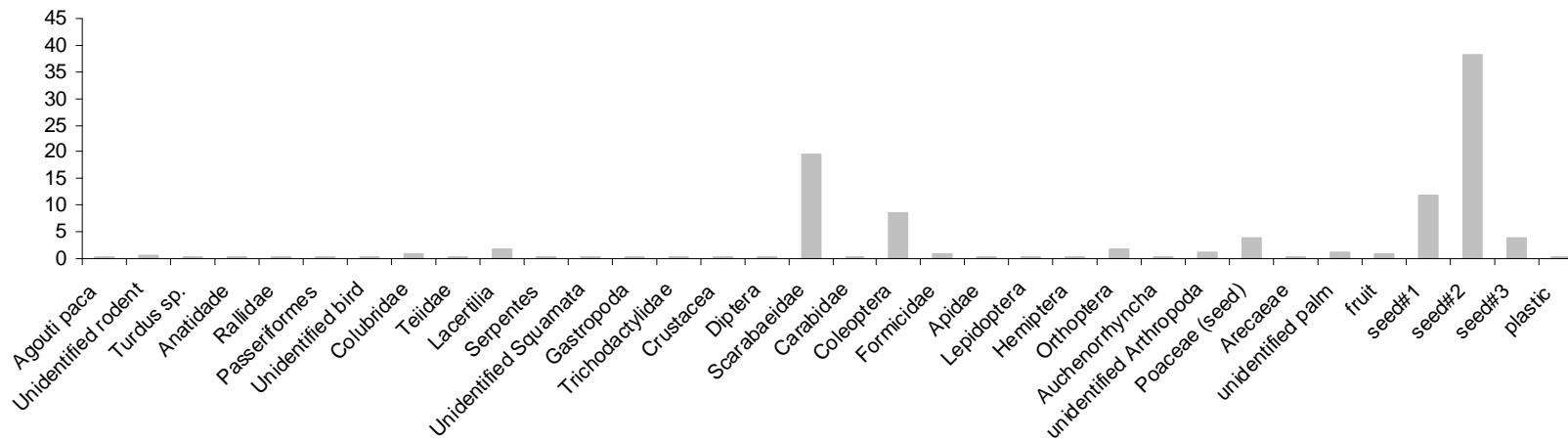
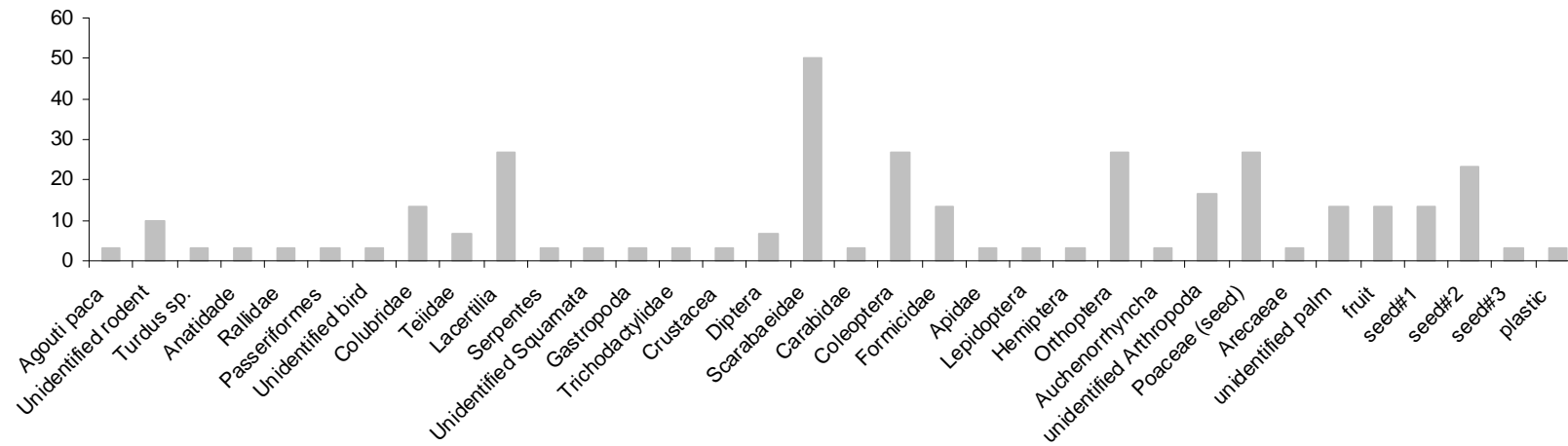


FIG. 4. — Diet of *Cerdocyon thous*. a) Frequency of occurrence (FO) of overall items, b) proportion of occurrence (PO) of overall items.

TABLE 1. – Number of faecal samples whose source predator species could be successfully identified with a molecular approach (DNA sequencing), with trichology (hair microscopy) and with both methods.

Predators	Molecular ^A	Trichology	Both methods	Total
Felidae				
<i>Leopardus pardalis</i>	16	11	9	18
<i>Puma concolor</i>	6	1	0	7
<i>Puma yagouaroundi</i>	1	2	0*	3
<i>Panthera onca</i>	13	7	4	16
Mustelidae				
<i>Lontra longicaudis</i>	1	1	0	2
<i>Pteronura brasiliensis</i>	2	0	0	2
<i>Eira barbara</i>	0	2	0	2
Canidae				
<i>Speothos venaticus</i>	1	0	0	1
<i>Cerdocyon thous</i>	24	20	14**	30
Total	64	44	27	81

NOTE: there was a discrepancy in the identification of two samples among the two methods; we used the molecular method result in these cases: *Identified with the molecular analysis as *Puma yagouaroundi* and with trichology as *Cerdocyon thous*. **Identified with the molecular analysis as *Cerdocyon thous* and with trichology as *Puma yagouaroundi*.

^A Data from (Michalski et al. unpublished data).

TABLE 2. – Size variation in carnivore scats (n=81). The table indicates the perimeter of faecal samples identified with the molecular and hair microscopy approaches.

Predators	min - max (mm)	n (perímeter)	deformed	n (deformed)
Felidae				
<i>Panthera onca</i>	60 - 140	8	deformed	8
<i>Puma concolor</i>		0	deformed	7
<i>Puma yagouaroundi</i>		0	deformed	3
<i>Leopardus pardalis</i>	35 - 85	10	deformed	8
Canidae				
<i>Cerdocyon thous</i>	40 - 110	13	deformed	17
<i>Speothos venaticus</i>		0	deformed	1
Mustelidae				
<i>Eira barbara</i>	70	1	deformed	1
<i>Lontra longicaudis</i>	63	1	deformed	1
<i>Pteronura brasiliensis</i>		0	deformed	2
Total		33		48

TABLE 3. — Frequency of occurrence (FO), proportion of occurrence (PO), correction factor (Y), relative biomass consumed (RB), and Index of Relative Importance (IRI) for different mammals prey size items in faecal samples of pumas (*Puma concolor*), jaguars (*Panthera onca*) and ocelots (*Leopardus pardalis*).

Prey Item	<i>Panthera onca</i>						<i>Puma concolor</i>						<i>Leopardus pardalis</i>					
	FO %	PO %	weight Kg	Y Kg/scat	RB %	IRI	FO %	PO %	weight Kg	Y Kg/scat	RB %	IRI	FO %	PO %	weight Kg	Y Kg/scat	RB %	IRI
Mammals																		
Large prey size (>15kg)																		
<i>Tayassu peccari</i>	25	21.1	33.5	3.153	29.75	1270												
<i>Tayassu tajacu</i>	25	21.1	19.5	2.663	25.13	1154												
Mazama sp.	12.5	10.5	22.6	2.771	13.07	295												
Unidentified ungulate	6.25	5.2	20	2.68	6.323	72												
Médium prey size (1-15Kg)																		
<i>Tayassu peccari</i> (young)*													5.6	3.4	3	0.289	7.409	60.1
<i>Tamandua tetradactyla</i>													5.6	3.4	5.5	0.40	10.03	74.67
<i>Dasybus sp.</i>	6.25	5.2	3.5	2.103	4.96	63.5	14.3	14.3	3.5	2.103	45.76	857.4	22	13.8	3.5	0.309	31.71	1011
<i>Cuniculus paca</i>	18.8	15.8	7.5	2.243	15.87	593	14.3	14.3	7.5	2.243	45.76	857.4						
<i>Dasyprocta azarae</i>	6.25	5.2	2.7	2.075	4.894	63.1							5.6	3.4	2.7	0.277	7.095	58.35
Small prey size (<1Kg)																		
<i>Proechimys sp.</i>							14.3	14.3	0.253	0.253	4.669	270.6	28	17.2	0.253	0.253	32.41	1379
<i>Rhagomys rufescens</i>													5.6	3.4	0.022	0.022	0.564	22.04
<i>Euryoryzomys russatus</i>													5.6	3.4	0.085	0.085	2.179	31.02
<i>Oxymycterus sp.</i>							14.3	14.3	0.076	0.076	1.403	223.9	5.6	3.4	0.076	0.076	1.948	29.74
<i>Necromys lasiurus</i>							14.3	14.3	0.06	0.06	1.107	219.7	11	6.9	0.06	0.06	3.074	110.8
Unidentified small rodent							14.3	14.3	0.07	0.07	1.292	222.4	11	6.9	0.07	0.07	3.586	116.5

NOTE: The others items are not included in this table, this is the reason the PO is not 1.

TABLE 4. — Frequency of occurrence and proportion of occurrence of prey consumed by *Cerdocyon thous*.

	FO (30 scats)		PO (464 items)	
	N	%	N	%
Mammals				
<i>Agouti paca</i>	1	3.33	1	0.22
Unidentified rodent	3	10	3	0.65
Birds				
<i>Turdus</i> sp.	1	3.33	1	0.22
Anatidade	1	3.33	1	0.22
Rallidae	1	3.33	1	0.22
Passeriformes	1	3.33	1	0.22
Unidentified bird	1	3.33	1	0.22
Reptiles				
Colubridae	4	13.3	4	0.86
Teiidae	2	6.67	2	0.43
Lacertilia	8	26.7	8	1.72
Serpentes	1	3.33	1	0.22
Unidentified				
Squamata	1	3.33	1	0.22
Invertebrates				
Gastropoda	1	3.33	1	0.22
Arthropods				
Trichodactylidae	1	3.33	1	0.22
Crustacea	1	3.33	1	0.22
Diptera	2	6.67	2	0.43
Scarabaeidae	15	50	90	19.4
Carabidae	1	3.33	1	0.22
Coleoptera	8	26.7	40	8.62
Formicidae	4	13.3	4	0.86
Apidae	1	3.33	1	0.22
Lepidoptera	1	3.33	1	0.22
Hemiptera	1	3.33	1	0.22
Orthoptera	8	26.7	8	1.72
Auchenorrhyncha	1	3.33	2	0.43
unidentified				
Arthropoda	5	16.7	6	1.29
Plants				
Poaceae (seed)	8	26.7	18	3.88
Arecaeae	1	3.33	2	0.43
unidentified palm	4	13.3	5	1.08
fruit	4	13.3	4	0.86
seed#1	4	13.3	55	11.9
seed#2	7	23.3	177	38.1
seed#3	1	3.33	18	3.88
Human waste				
plastic	1	3.33	1	0.22

TABLE 5. – Frequency of occurrence (FO) and Proportion of occurrence (PO) of the prey items in the diet of five carnivore species.

	<i>Puma yagouaroundi</i>		<i>Lontra longicaudis</i>		<i>Pteronura brasiliensis</i>		<i>Eira barbara</i>		<i>Speothos venaticus</i>	
	(n=3) FO(%)	PO(%)	(n=2) FO(%)	PO(%)	(n=2) FO(%)	PO(%)	(n=2) FO(%)	PO(%)	(n=1) FO(%)	PO(%)
Mammals										
<i>Cryptonanus</i> sp.							50	8.33		
<i>Dasypus</i> sp.	33.33	20								
<i>Cuniculus paca</i>									100	100
<i>Dasyprocta azarae</i>	66.67	40								
<i>Proechimys</i> sp.							50	8.33		
<i>Akodon</i> sp.							50	8.33		
<i>Oligoryzomys</i> sp.							50	8.33		
<i>Euryoryzomys russatus</i>							50	8.33		
<i>Oxymycterus</i> sp.	33.33	20								
<i>Necomys lasiurus</i>			50	8.33						
<i>Sphiggurus</i> sp.							50	8.33		
Birds										
Rallidae							50	8.33		
Passeriformes			50	8.33			50	8.33		
Bird NI			50	8.33						
Reptiles										
Teiidae			50	8.33						
Snake							50	8.33		
Fishes										
Caracidae					50	12.5				
Erythrinidae					50	75				
Actinopterygii			50	8.33	50	12.5	50	8.33		
Invertebrates										
Arthropods										
Arthropoda			50	8.33						
Crustaceous										
Trichodactylidae			50	8.33						

TABLE 5. (CONT.)

	<i>Puma yagouaroundi</i>		<i>Lontra longicaudis</i>		<i>Pteronura brasiliensis</i>	<i>Eira barbara</i>		<i>Speothos venaticus</i>	
	(n=3)		(n=2)		(n=2)	(n=2)		(n=1)	
Coleoptera	33.33	20							
Scarabaeidae			50	8.33					
Orthoptera NI			50	8.33					
Insecta NI						50	8.33		
Plants									
Fruit			50	8.33					
Poaceae (seed)			50	8.33		50	8.33		
Solanaceae (seed)									
seed#2*			50	8.33					

NOTE: The item “seed#2” is the same type of seed observed in the diet of *Cerdocyon thous* diet.

TABLE 6. – Levin’s measure of niche breadth (B) and standardized niche breadth (BA) in four predators from Alta Floresta, MT.

	B	BA
<i>Leopardus pardalis</i>	12.62104	0.464842
<i>Panthera onca</i>	10.36247	0.374499
<i>Puma concolor</i>	7.005603	0.240224
<i>Cerdocyon thous</i>	6.72043	0.520039

TABLE 7. – Pianka and Czekanowski ‘s indices of niche overlap between *L. pardalis*, *P. onca*, and *P. concolor* calculated with two categories: proportion of occurrence of vertebrate prey (PO), and relative biomass of mammalian prey (RB).

	PO (vertebrates)		RB (mammals)	
	Pianka	Czekanowski	Pianka	Czekanowski
<i>P. concolor</i> x <i>P. onca</i>	0.211	0.195	0.326	0.208
<i>P. concolor</i> x <i>L. pardalis</i>	0.648	0.455	0.519	0.402
<i>P. onca</i> x <i>L. pardalis</i>	0.169	0.155	0.191	0.173

CAPÍTULO CONCLUSIVO:

Os métodos utilizados para identificação das espécies predadoras – seqüenciamento de DNA e microscopia de pêlos – apresentaram sucesso nos resultados. Obter uma congruência substancial na detecção de espécies de carnívoros através da combinação dos métodos moleculares e análises tricológicas de uma mesma amostra fecal é um objetivo que vêm sendo alcançado no Brasil (Graeff 2008). No presente estudo, a alta taxa de congruência na comparação dos dois métodos sugere que são métodos de alta confiabilidade. Apenas 8% (n=2) das amostras apresentaram discrepância na identificação e, quanto a estas, devemos levar em consideração uma provável troca de amostras de pêlos durante a preparação das lâminas, já que foram preparadas no mesmo dia e possuem identificação inversa das espécies. Provavelmente, se esta troca não tivesse ocorrido teríamos um sucesso de 100% de congruência nas identificações. Deste modo, é importante enfatizarmos que a atenção durante o processo de preparação de lâminas é crucial. Em relação à comparação dos perímetros das amostras fecais, podemos observar, através das sobreposições nos tamanhos de perímetro nas espécies e da deformidade encontrada em diversas fezes que este método, aparentemente, não apresenta sustentabilidade suficiente para identificar os predadores em nível de espécie (Brunner & Wallis 1986; Farrell et al. 2000; Foran et al. 1997; Prugh & Ritland 2005).

O método de identificação de espécies predadoras através de análises moleculares vem alcançando considerável sucesso em estudos de dieta (Farrell et al. 2000; Napolitano et al. 2008; Weckel et al. 2006; Zuercher 2005), assim como estudos que realizam a identificação através da tricologia (Graeff 2008; Inagaki & Tsukahara 1993; Silva-Pereira 2009). Métodos confiáveis para a identificação de espécies predadoras são muito importantes, pois somente assim podemos analisar seus reais nichos tróficos e todos os processos que estão associados a eles.

Em relação aos hábitos alimentares, cinco espécies apresentaram um baixo número amostral e quatro um maior número de amostras. Dentre as espécies que apresentaram um baixo número amostral está o *P. yagouaroundi*, que teve uma dieta baseada em pequenos mamíferos, principalmente roedores, concordando com outros estudos alimentares realizados para a mesma espécie (Graeff 2008; Konecny 1989; Silva-Pereira 2009; Tófoli et al. 2009). A dieta de *L. longicaudis* apresentou-se

bem diversa e, portanto, diferente das descritas para a maioria dos outros estudos com esta espécie. Isto, provavelmente, se deve ao fato de que o presente trabalho foi realizado em região distinta da maior parte dos outros estudos que, em sua maioria, foram realizados na região sul e sudeste do Brasil (Kasper et al. 2008; Pardini 1998; Quadros & Monteiro-Filho 2000; Silva et al. 2008). Entretanto, estudos realizados na Costa Rica e México apresentaram resultados mais semelhantes (Sánchez et al. 1999; Spinoma-Parallada & Vaughan-Dickhaut 1995), é interessante notarmos que estes últimos eram situados no âmbito da Zona Tropical, assim como o presente estudo. Além disso, essa dieta mais variada pode ser explicada pelo fato de estar em região muito fragmentada ou pela presente simpatria com espécies de carnívoros que não ocorrem em outras regiões. Estas hipóteses poderão somente ser sustentadas com mais estudos sobre esta espécie na região. Para *P. brasiliensis* diversos estudos têm revelado uma dieta baseada principalmente em peixes, o que não foi diferente em nossos resultados (Carter & Rosas 1997; Duplaix 1980; Defler 1983; Schweizer 1992), onde a família mais freqüente foi Erythrinidae, inserida na ordem Characiiformes, a mais consumida dentre outros registros (Carter & Rosas 1997). *Eira barbara* apresentou uma dieta bem variada, assim como descrita por outros autores (Konecny 1989; Sunquist & Sunquist 1989). Estudos têm registrado que iraras podem forragear em diversos estratos, como no alto das árvores e também no chão (Nowak 1999; Presley 2000), em adição, nosso estudo observa um novo local, a água, através do registro de peixe em sua dieta. Estas evidências indicam, novamente, um comportamento oportunista e generalista de uma espécie onívora (Presley 2000). O consumo de *C. paca* por cachorros-vinagre já havia sido observado em outros estudos que também registram outras presas de porte avantajado em relação ao porte de *S. venaticus* (Aquino & Puertas 1997; Cabrera & Yepes 1940; Deutsch 1983; Peres 1991; Silveira et al. 1998; Strahl et al. 1992; Zuercher et al. 2005). Estudos que descrevem o modo de caça dessa espécie observaram que esses canídeos podem viver em grupos e que os membros desses grupos caçam cooperativamente (Aquino & Puertas 1997, Cabrera & Yepes 1940; Peres 1991, Strahl et al. 1992).

Dentre as espécies com número amostral mais elevado, *Cerdocyon thous*, apresentou, como esperado, o maior número de categorias de presas, apresentando a amplitude de nicho (BA) mais elevada, sugerindo ser uma espécie de hábitos

alimentares generalistas. Esta espécie é naturalmente oportunista em sua estratégia alimentar. Em situação de simpatria com demais espécies carnívoras de tamanho superior, o graxaim-do-mato parece modificar sua dieta, voltando-se para itens em que atenua a competição com demais predadores. Por exemplo, o presente estudo observou como itens mais freqüentes na dieta desta espécie: sementes, frutos e invertebrados (Facure et al. 2003; Gatti et al. 2006; Jácomo et al. 2004; Redford & Eisenberg 1992). Do mesmo modo, devemos enfatizar a presença de resíduos provenientes de atividades humanas (plástico) nas fezes desta espécie, observado por outro estudo (Rocha et al. 2008). Com o avanço da cidade e das propriedades rurais sobre a floresta, o contato desta espécie com humanos e seu lixo pode aumentar, ocasionando situações como a apresentada neste estudo. Sugerindo, mais uma vez, a maleabilidade desta espécie em diferentes situações.

Nossos resultados para *L. pardalis*, concordam com outros estudos ao apresentarem roedores como presas mais freqüentes em sua dieta (Moreno et al. 2006; Silva-Pereira 2009; Villa-Meza et al. 2002; Wang 2002). Dentre os roedores, o gênero mais freqüente e mais importante encontrado para jaguatirica foi *Proechimys* e este foi reportado em diversos estudos realizados em diferentes regiões como Costa Rica, Canal do Panamá e Peru (Chinchilla 1999; Emmons 1987; Moreno et al. 2006). Nossos resultados também mostram o consumo de um filhote de queixada (*T. pecari*) por jaguatirica, o que possivelmente foi uma situação oportunista, onde o filhote poderia estar doente, separado do grupo ou mesmo ser uma carcaça. Mesmo alimentando-se de um filhote de queixada *L. pardalis* não apresentou presas consideradas de grande porte em sua dieta, sugerindo que a dieta desta espécie é moldada pela pressão das duas espécies de grandes felinos (*P. onca* e *P. concolor*). No que tange a amplitude de nicho, a jaguatirica atingiu um valor que indica ser o felino de hábito mais generalista.

Quanto à dieta de onça-pintada, as principais presas encontradas foram os mamíferos de grande porte, este resultado é o mesmo para a maioria dos estudos com esta espécie (Azevedo 2008; Azevedo & Murray 2007; Chinchilla 1997; Rabinowitz & Nottingham 1986; Scognamillo et al. 2003; Weckel et al. 2006). Dentre as principais presas, *T. pecari* foi a de maior importância, desde modo, é interessante notar que esta espécie de presa vive em grupos, o que eleva os riscos para o predador ao tentar caçar um membro do grupo. Por conseguinte, nossos resultados

indicam que as onças enfrentam estes riscos para alimentarem-se de presas de maior biomassa. Em relação ao B_{STA} a onça apresentou valor inferior às duas espécies citadas anteriormente, aparentemente possuindo hábitos mais especialistas que generalistas.

Puma concolor apresentou maior consumo de presas mamíferos de médio porte (Courtin et al. 1980; Emmons 1987), onde os itens de maior importância relativa foram *Dasypus* sp. e *C. paca*. Em adição, esta espécie predadora não apresentou consumo de presas de grande porte. Provavelmente, isto ocorre devido à coexistência com onças. Alguns trabalhos observam que a procura por presas de porte médio ou pequeno por pumas, se deve ao fato de evitarem o encontro com onças-pintadas, já que estas predam animais de grande porte e possuem peso mais elevado (Iriarte et al. 1990; Scognamillo et al. 2003). Quanto à amplitude de nicho, *Puma concolor* apresentou o menor valor em relação às demais espécies, isto pode ter ocorrido devido ao seu menor número amostral. Esta espécie possui uma vasta variedade de valores do índice de B_{STA} ao longo de sua vasta distribuição nas Américas, segundo Iriarte et al. (1990), as subespécies de pumas que habitam áreas tropicais apresentam índices mais elevados que as que habitam áreas distantes na linha do Equador.

As presas de maior importância para as três espécies de felinos foram equivalentes aos seus tamanhos corporais, onde jaguatirica apresentou como principal presa em sua dieta um gênero roedor de porte pequeno (<1Kg), já para pumas, as presas de maior importância tinham porte médio (1Kg - 15Kg) e as onças-pintadas apresentaram preferência pelas presas de grande porte (<15Kg). O presente estudo concorda com a hipótese de que o uso de diferentes recursos, como, por exemplo, alimentos, permitem a coexistência entre espécies carnívoras simpátricas (Schaller 1972).

A sobreposição de nicho obteve resultados muito semelhantes para as duas diferentes variáveis (PO e BR) e em ambos índices (Pianka e Czekanowski). Em todos os cálculos *L. pardalis* e *P. onca* apresentaram a menor sobreposição de nicho, indicando que praticamente não competem pelos mesmos recursos alimentares, o que pode estar relacionado com a preferência da onça-pintada por presas de grande porte, pressionando os demais felinos a alimentarem-se de presas menores; além disso, o consumo de presas menores por *L. pardalis* e o de presas

maiores para *P. onca* pode simplesmente estar relacionado aos seus tamanhos corporais. O maior grau de sobreposição de nicho encontrado, também em todos os cálculos, foi entre *L. pardalis* e *Puma concolor*, nota-se que estas duas espécies possuem diferença corporal, já que a primeira apresenta-se como felino de médio porte e a segunda como de grande porte. Entretanto, aparentemente o que explica esta competição por recursos alimentares é a presença da onça-pintada. Estudos de dieta realizados com jaguatiricas e pumas, em regiões onde a onça-pintada não ocorre ou está em extinção, apresentam grau de competição menor entre as duas espécies. Pumas optam por presas de maior porte e jaguatiricas consomem as de médio e pequeno porte (Martins et al. 2008; Moreno et al. 2006). Essas evidências mostram que a presença ou ausência de *P. onca* influencia na competição por presas entre *L. pardalis* e *Puma concolor*.

Os resultados gerados com este estudo fornecem dados sobre a ecologia das espécies de carnívoros para esta região fragmentada da Amazônia e com isso contribui de uma forma significativa para seu melhor conhecimento, o que pode auxiliar na elaboração de estratégias adequadas para o manejo e conservação dessas espécies em campo.

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