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**ECOLOGIA E HISTÓRIA NATURAL DO ZORRILHO (*CONEPATUS CHINGA*)
NO SUL DO BRASIL.**

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Resumo

Entre agosto de 2007 e dezembro de 2010 foram realizados estudos sobre a ecologia do zorrilho, *Conepatus chinga* (Molina, 1782) (Carnivora: Mephitidae) no sul do Brasil. Estes estudos tiveram como focos principais a investigação de aspectos da ecologia espacial, abundância e dos hábitos alimentares da espécie. Toda a coleta de dados foi realizada nos estados do Rio Grande do Sul e Santa Catarina, extremo sul do Brasil. Estudos sobre a área de vida, padrões de deslocamento e uso de abrigo foram realizados com o uso de radio-telemetria. Como resultado, estimou-se a necessidade de áreas de vida de $1,65 \text{ km}^2 \pm 1,17 \text{ km}^2$ para a espécie, sendo que machos apresentaram áreas de vida 2,5 vezes maiores do que à das fêmeas, além de padrões de deslocamentos significativamente maiores. Identificaram-se seis conformações básicas de abrigos, dos quais buracos no solo foram as mais comumente utilizadas (56% dos locais identificados). O padrão de reutilização dos abrigos foi alto (32%), especialmente entre fêmeas, que apresentaram um padrão significativamente maior do que os machos. Verificou-se a existência de grande sobreposição nas áreas de vida, inclusive nas áreas de uso intenso, embora mantenham grande distância uns dos outros e raramente compartilhem seus abrigos. Os zorrilhos apresentaram neste estudo, hábitos quase exclusivamente noturnos, uma característica comum à família. A abundância de zorrilhos foi analisada em quatro áreas com características distintas, sendo duas na região do Pampa e duas nos Campos de Cima da Serra. Para este estudo, foram realizadas transecções, com aplicação do método “distance sampling”, o que permitiu não apenas o registro de zorrilhos, que sempre foi à espécie-focal, mas também de outros mamíferos de médio e grande porte. Obteve-se o registro de 20 espécies em um total de 620 visualizações, das quais o zorrilho foi à segunda mais registrada, com densidades estimadas em 1,4 to 3,8 indivíduos por km^2 . Esta é a primeira estimativa de densidade baseada em “transect lines” para o gênero na região Neotropical, e apresenta valores duas vezes maiores do que os conhecidos previamente por outros métodos. Obteve-se adicionalmente estimativas preliminares da densidade de *Cerdocyon thous* e

Lycalopex gymnocercus (Carnivora: Canidae), variando entre 0,2 e 1,1 indivíduos por km², e uma estimativa robusta da densidade da lebre-européia (*Lepus europaeus*), com valores de 31,9 indivíduos por km², o que representa a maior estimativa da espécie já obtida na região Neotropical. A dieta da espécie foi avaliada a partir da análise de estômagos de animais atropelados em estradas. Além de zorrilhos, coletaram-se estômagos de todos os outros carnívoros encontrados mortos, o que permitiu uma análise comparativa dos hábitos alimentares de um total de dez espécies. A amplitude de nicho apresentada por estes carnívoros foi comparada à “abundância geral” dos mesmos, baseada na sumarização de observações de campo de 22 localidades. A dieta da maioria das espécies apresentou-se baseada em roedores, à exceção das dietas de *Procyon cancrivorus* (Procyonidae) e *C. chinga*. Por este motivo a sobreposição de nicho alimentar foi muito grande, novamente à exceção das duas espécies citadas. Enquanto *P. cancrivorus* pode ser considerado um verdadeiro omnívoro, *C. chinga* apresenta uma dieta à base de insetos adultos e, sobretudo, larvas de inseto, embora inclua oportunisticamente outros recursos alimentares. Juntamente com *C. thous*, estas três espécies apresentam as maiores amplitudes de nicho e são as espécies mais comumente encontradas na maioria das assembléias de carnívoros. Pelo contrário, pequenos felinos e *G. cuja*, que apresentam amplitudes de nicho reduzidas e são pouco abundantes em praticamente todas as localidades estudadas, o que está de acordo com o alto grau de correlação encontrado ($r = 0,9565$) entre abundância relativa e os hábitos alimentares.

Introdução Geral

O zorrilho *Conepatus chinga* (Molina, 1782) é um carnívoro (ordem Carnivora) pertencente à família Mephitidae. Esta família inclui 13 espécies pertencentes a quatro gêneros: *Conepatus*, *Mephitis*, *Mydaus* e *Spilogale* (Wosencraft 2005). Destes, apenas *Mydaus* ocorre fora do Novo Mundo, sendo considerado o gênero mais basal na filogenia do grupo (Eizirik et al. 2010). Entre os gêneros com distribuição nas Américas, somente *Conepatus* ocorre ao sul do istmo do Panamá, com três espécies: *C. chinga*, *C. humboldtii* e *C. semistriatus* (Nowak 1999). Estas espécies são alopátricas, com *C. humboldtii* restrito a Patagônia e partes da metade do sul do Chile e *C. semistriatus* ocorrendo da região central e nordeste do Brasil ao México (Eisenberg e Redford 1999). A distribuição de *C. chinga* se dá a partir da metade norte da Argentina, Uruguai e sul do Brasil (Cheida et al. 2006) ao Paraguai e sul da Bolívia, além de estender-se a oeste até o sul do Perú e metade norte do Chile (Eisenberg e Redford 1999).

É digno de nota que nenhuma das duas principais referências internacionais como IUCN (Emmons e Helgen 2008) e Eisenberg e Redford (1999) apresente o sul do Brasil como área de ocorrência da espécie. Além disso, tais referências omitem (por desconhecimento) a ocorrência de *C. chinga* na região entre Buenos Aires e Bahía Blanca na Argentina, onde a espécie é comum (Castillo et al. 2011; observações pessoais). Embora não seja objetivo deste estudo, é apresentada na Figura 1 a proposta do que seria a melhor representação da área de ocorrência da espécie. Tal mapa não deve ser considerado definitivo, pois como cita Cheida e Santos (2010), há dúvidas quanto aos limites de distribuição da espécie.

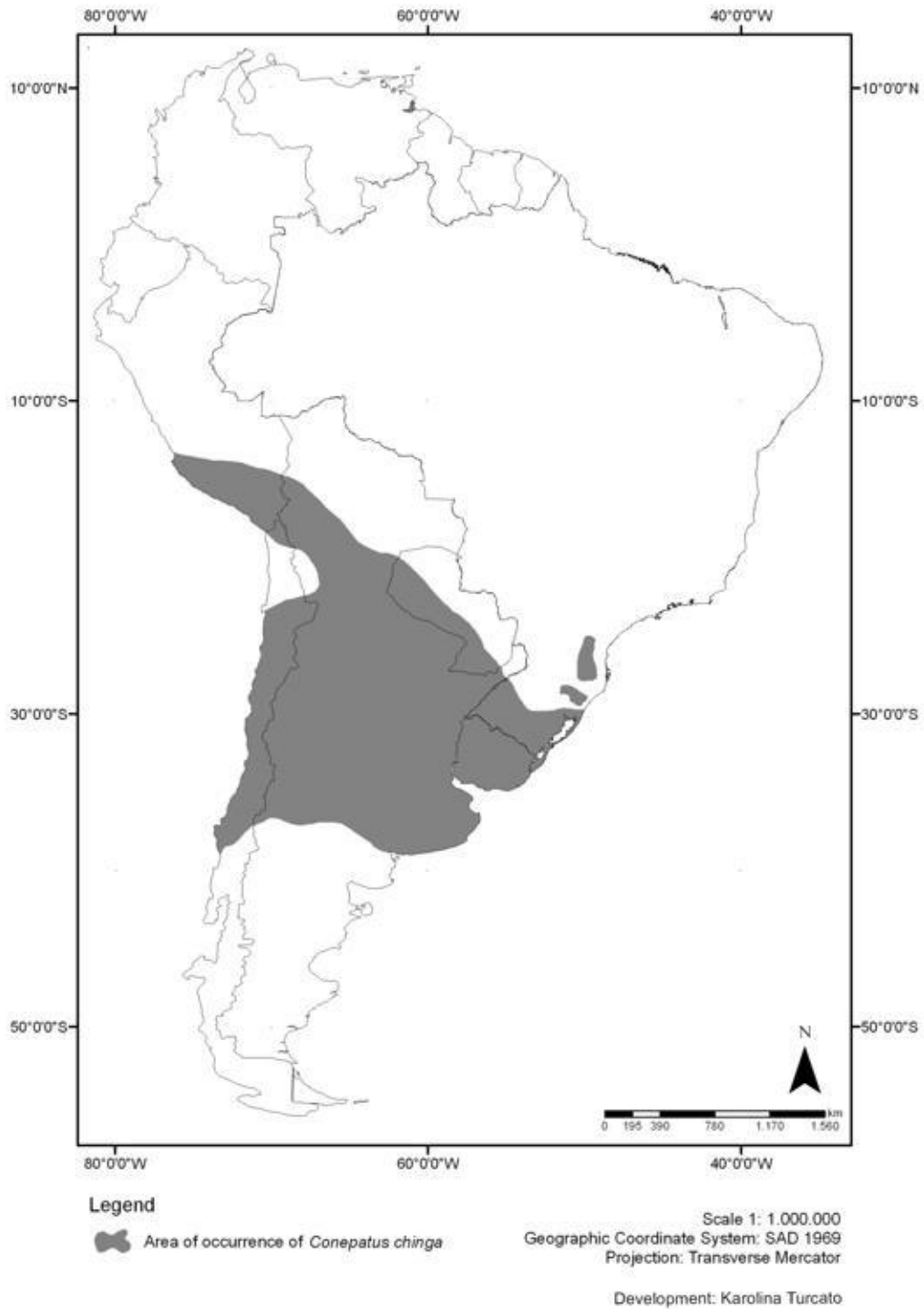


Figura 1: Distribuição de *Conepatus chinga*, modificado com as áreas de ocorrência corrigidas do sul do Brasil e Argentina, a partir de Emmons e Helgen (2008);

Conepatus chinga pode ser considerada uma espécie comum, não constando nas listas de espécies ameaçadas de extinção da IUCN, do Brasil (Chiarello et al. 2008), nem do Rio Grande do Sul (Indruziak e Eizirik 2003). Todavia, a IUCN sugere que a população esteja em declínio, apontando como principais causas a caça para o comércio de peles e a degradação dos campos habitados pela espécie (Emmons e Helgen 2008). Por este motivo, a entidade sugere a inclusão de *C. chinga* no Appendix II da CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Além destas ameaças, são citados o possível impacto dos atropelamentos nas populações de *C. chinga* (Rosa e Mauhs 2004), assim como do uso indiscriminado de pesticidas (Peters et al. 2011).

Conepatus chinga é um carnívoro de pequeno porte, com comprimento total entre 50 e 60 cm e peso de 1,5 a 2,5 kg (Cheida 2006; Eisenberg e Redford 1999). Possuem o corpo atarracado e compacto, medindo cerca de 40 a 45 cm, com a cabeça arredondada e pernas curtas. Sua pelagem é negra, eventualmente marrom escura, com duas listras brancas que iniciam no topo da cabeça e estendem-se pela lateral superior do corpo (Figura 2). A extensão e largura destas listras é amplamente variável, podendo alcançar a base da cauda ou mesmo estar totalmente ausentes. A cauda possui pêlos longos que lhe conferem um aspecto volumoso, podendo possuir pêlos brancos (Cheida 2006).



Figura 2: *Conepatus chinga*, município de Arroio Grande, Rio Grande do Sul, Brasil.

Um dos aspectos mais conhecidos da biologia dos zorrilhos é seu odor característico, oriundo da secreção de glândulas perianais super-desenvolvidas, que evoluíram de forma a produzir, armazenar e expelir, quando necessário, uma substância extremamente fétida, com efeitos tóxicos em altas concentrações (Wood 1999). Esta substância é utilizada como defesa pelo animal quando é agredido ou quando se sente ameaçado, podendo ser esguichado a uma distância de cerca de 2 metros (observação pessoal) pela contração de músculos periféricos à bolsa de armazenamento da secreção (Wood 1999). Tal característica é comum a todos os Mephitidae que, ao contrário da crença popular, não urinam para se defender, mas esguicham essa secreção de defesa.

Conepatus chinga possui hábitos terrestres noturnos/crepuscular (Cheida 2006), habitando áreas abertas, do Chaco paraguaio às estepes da pré-cordilheira (Redford e Eisenberg 1994) e, sobretudo, das formações campestres do Pampa (Kasper et al. 2008). Há registros da espécie utilizando ambientes de mata na Serra do Mar no estado do Paraná (Cáceres 2004). Porém, este registro pode estar associado à proximidade com áreas abertas, já que a vegetação da área tem influência da Floresta Ombrófila Mista. Os Mephitidae, de uma forma geral, e *Conepatus* em especial, são associados a ambientes abertos: *C. humboldtii* ocorre associado a ambientes desérticos; *C. semistriatus* tem sua distribuição associada à Caatinga e ao Cerrado, com registros apenas ocasionais em áreas da mata Atlântica; *C. chinga* tem a maior parte de sua distribuição associada ao Pampa e estepes andinas. Assim sendo, é possível que áreas florestais como a Mata Atlântica representem barreiras à distribuição da espécie. Registros como os apresentados por Cáceres (2004) podem também representar uma ocorrência ocasional ou uma expansão da área de ocorrência devido à fragmentação. Expansões da área de ocorrência da espécie vêm sendo observadas em áreas de mata fragmentadas do Rio Grande do Sul, em que a espécie passou a ser registrada onde não era conhecida pela população (observação pessoal).

A dieta da espécie consiste basicamente de insetos e pequenos vertebrados (Donadio et al. 2004; Medina et al. 2009; Peters et al. 2011; Travaini et al. 1998). A contribuição de vertebrados na dieta é bastante variável, podendo ser expressiva, como no caso citado por Eisenberg e Redford (1999) de um estômago contendo dez anfíbios. A importância do consumo de larvas de insetos é também discrepante entre os poucos estudos disponíveis: Travaini et al. (1998) citam um consumo praticamente

insignificante deste item, enquanto Medina et al. (2009) apresentam dados que demonstram ser o item mais consumido em sua área de estudo. Há um único trabalho disponível para o Brasil, publicado muito recentemente (Peters et al. 2011), realizado com base em dados de animais atropelados no sul do Rio Grande do Sul. Este trabalho apresenta uma dieta baseada em insetos, sobretudo Coleoptera, Orthoptera, e aranhas (Araneae). Como nos demais trabalhos, a dieta é enriquecida com pequenos vertebrados, sobretudo roedores, além de material vegetal. Contudo, Peters et al. (2011) apresentam apenas dados da frequência e abundância dos itens alimentares, o que pode representar uma possível fonte de erro para interpretação dos dados. Itens alimentares muito frequentes e numerosos sugerem que são os mais importantes na dieta da espécie, o que nem sempre é verdade, já que podem não ser os mais representativos em termos de biomassa consumida.

Estudos sobre área de vida de *C. chinga* estimam o uso de territórios de em média 1,2 a 1,96 km² (Castillo et al. 2011; Donadio et al. 2001) com alta sobreposição entre indivíduos (Repucci et al. 2009). Há indicações de que machos utilizem áreas de vida aproximadamente duas vezes maiores que a das fêmeas (Castillo et al. 2011) embora não haja dimorfismo sexual quanto ao tamanho nesta área. Os mesmos autores apresentam dados sobre padrões de deslocamentos em média 269,5 m (\pm 365 m) entre abrigos utilizados em dias consecutivos. Novamente, os autores citam a existência de diferenças significativas nos padrões apresentados por machos e fêmeas. Porém, Donadio et al. (2001) não encontram diferenças no tamanho da área de vida de um macho de uma fêmea monitorados. Ambos os trabalhos são congruentes ao encontrar áreas de vida de tamanhos relativamente semelhantes e muito maiores do que as previamente descritas para *C. humboldtii* (Fuller et al. 1987) e *C. semistriatus* (Sunquist et al. 1989). Porém deve-se destacar que, a despeito de sua importância pelo pioneirismo, todos os primeiros trabalhos sobre *Conepatus* na América do Sul fazem referência a um ou dois animais adultos, tornando difícil a realização de comparações mais aprofundadas. Além disso, a maioria destes trabalhos monitorou animais por períodos de tempo muito curtos, o que aumenta a chance de sub-estimativa das áreas de vida. Somente muito recentemente, Castilho et al. (2011) apresentam um trabalho mais robusto com a amostragem de um maior número de animais monitorados. Todas as informações disponíveis referentes à ecologia espacial da espécie referem-se a áreas na

Argentina, não havendo qualquer informação a respeito do assunto no restante da distribuição.

No que se refere ao uso de abrigos por *Conepatus*, praticamente nada é conhecido, além de uma breve citação no trabalho de Donadio et al. (2001), que faz referência à utilização de fendas entre rochas e buracos no solo, além da utilização de um “abrigo de roedor presumivelmente aumentado”. A falta de informações sobre a utilização de abrigos por *Conepatus*, e *C. chinga* em especial, por já haver trabalhos de telemetria, destoa do conhecimento disponível sobre as espécies Norte-Americanas. Na América do Norte, o estudo da conformação e uso de abrigos é uma prática relativamente difundida, havendo diversos trabalhos versando sobre “denning ecology” de espécies como *Mephitis mephitis* (Larivière e Messier 1998), *Spilogale gracilis* (Doty e Dowler 2006) e *Spilogale putorius* (Lesmeister et al. 2008).

Outro aspecto importante da ecologia de uma espécie refere-se ao número de indivíduos existente em uma população. Como tal informação costuma ser de difícil acesso, usualmente busca-se a determinação da densidade com que as espécies se apresentam no ambiente onde vivem, ou simplesmente por índices de abundância. Neste aspecto, há informações controversas a respeito de *C. chinga*. Na página da IUCN é citada uma densidade de cinco indivíduos por km² (Chofre e Marquet 1999). O artigo em questão apresenta densidades estimadas de inúmeras espécies, incluindo também *C. humboldtii*, a quem atribui uma densidade estimada de 89 indivíduos por km², feita com base no tamanho da espécie entre outros critérios pouco claros. Recentemente, Castillo et al. (2011) apresentaram estimativas de densidade de 0,68 a 1,66 indivíduos por km², baseadas em rádio-telemetria.

Porém, carecem dados sobre a história natural da espécie tais como número de filhotes por ninhada, maturidade sexual, longevidade e dispersão de filhotes, por exemplo. Nem mesmo o popular comportamento defensivo dos zorrilhos está descrito, assim como a maioria dos aspectos etológicos da espécie. Carecem também dados sobre a genética dos zorrilhos sul-americanos, dos quais não há sequer a descrição do cariótipo que, segundo estudos recentes, pode ser bastante variável, com rearranjos cromossômicos (Perelman et al. 2008). Alguns destes estudos estão em curso como a análise filogeográfica dos *Conepatus* na América do Sul (Eizirik comm. pess.), assim como estudos sobre a ecologia de *C. semistriatus* na região central do Brasil (Nunes e Rodrigues com. pess.). Alguns dos resultados preliminares destes estudos foram

publicados recentemente em um artigo publicado no *Small Carnivore Conservation* (Kasper et al. 2008), periódico da IUCN. Portanto, em breve haverá um expressivo aumento no conhecimento dos Mephitidae neotropicais, no qual esta tese fará parte.

Objetivo geral

- Analisar e descrever as principais características ecológicas de *Conepatus chinga* no sul do Brasil, no que se refere à ecologia espacial, abundância e hábitos alimentares desta espécie.

Objetivos específicos

- Estimar, através de rádio-telemetria o tamanho das áreas de vida utilizada por *C. chinga*;
- Caracterizar os tipos de abrigos utilizados por zorrilhos, analisando o padrão de uso dos mesmos;
- Determinar os padrões de movimentação e atividade da espécie;
- Obter medidas morfológicas da espécie, testando a existência de dimorfismo sexual;
- Testar a existência de diferenças entre machos e fêmeas no que se refere às características ecológicas citadas acima;
- Estimar a densidade de *C. chinga* em diferentes ambientes, além da abundância de outros mamíferos de médio porte;
- Descrever os hábitos alimentares de *C. chinga* e de outros carnívoros de pequeno porte, simpátricos no sul do Brasil,
- Testar a sobreposição de nicho alimentar e verificar a existência de possíveis guildas na assembléia de pequenos carnívoros do sul do Brasil;
- Testar de forma generalizada o postulado de que espécies de hábitos generalistas tendem a serem mais abundantes do que espécies especialistas.

Materiais e métodos: considerações gerais

Esta tese está subdividida em três temas gerais: Ecologia espacial, Abundância e Dieta. Cada um destes temas foi abordado com métodos específicos, que serão explicitados de maneira generalizada a seguir e pormenorizadamente nos artigos que correspondem aos capítulos da tese.

Como anexo, é apresentado um artigo de divulgação do projeto, publicado no periódico da IUCN “Small Carnivore Conservation” em 2009, com dados preliminares dos estudos aqui apresentados, além dos estudos de Gitana Nunes e Manoel Ludwig da Fontoura Rodrigues, realizados sob orientação de Flávio Henrique Guimarães Rodrigues e Eduardo Eizirik, respectivamente.

Área de estudo

A maior parte dos estudos para elaboração desta tese foi realizada no estado do Rio Grande do Sul, extremo sul do Brasil. Fora deste Estado, somente uma área de amostragem, localizada no município de Campo Belo do Sul, Santa Catarina, foi incluída. A maioria dos métodos de estudo aplicados só obtém bons resultados quando a espécie é encontrada com uma abundância relativamente alta, condição observada apenas na metade sul do Rio Grande do Sul (Kasper et al. 2009).

A paisagem do Rio Grande do Sul é composta por um mosaico de vegetações, formado pelo encontro de dois Biomas: o Pampa e a Mata Atlântica. O Pampa domina a metade sul do Estado e corresponde à cerca de 63% do território sul-riograndense (IBGE 2004). Este bioma é composto por diferentes formações campestres, incluindo campos abertos, campos rupestres, vegetação savanóide e campos litorâneos (Boldrini 2009). Além das áreas abertas do Pampa, verifica-se a ocorrência de campos naturais de altitude, localizados nas porções mais altas da Serra do Mar geralmente entre 1000 e 1800 m acima do nível do mar (Overbeck et al. 2009). Conhecidos também como Campos de Cima da Serra, estas áreas campestres estão associadas à Mata Atlântica, com a presença marcante do pinheiro-brasileiro *Araucaria angustifolia* (Bertol.), além de outras espécies como o pinheiro-bravo (*Podocarpus lambertii*) e a bracatinga

(*Mimosa scabrella*), que formam fragmentos de mata entremeados aos campos, sobretudo nas encostas e morros. Os componentes de Mata Atlântica *latu sensu* estão representados sob a forma de florestas em toda a encosta da Serra Geral e Serra do Mar e ao longo das bacias dos Rios Jacuí, Ibicuí e Uruguai. Além disso, formações de mata semi-decidual formam um mosaico de campo e matas na Serra do Sudeste do Rio Grande do Sul (Overbeck et al. 2009).

As formações do Pampa já foram classificadas como “estepes”, quando formam um estrato único, e “savanas” quando da formação de dois estratos. Porém, segundo Overbeck et al. (2009) nenhuma destas classificações está totalmente correta, e nem mesmo o termo Pampa é perfeitamente aplicável as formações campestres do sul do Brasil. De qualquer forma, pela inexistência de uma classificação definitiva, trataremos os campos da metade sul do Rio Grande do Sul por Pampa e os campos associados à Mata Atlântica como campos de altitude.

No estado de Santa Catarina predominam formações associadas à Mata Atlântica, com florestas altamente fragmentadas em toda porção leste do Estado, cobrindo a Serra Geral, também conhecida como Serra do Mar. Nos pontos mais altos do estado, sobretudo na porção sudeste, formam-se campos de altitude. A região Oeste sofre influência das matas pluviais do alto Uruguai, formação associada também com a Mata Atlântica.

O clima do sul do Brasil é classificado como Temperado, Mesotérmico Brando, Super Úmido, com chuvas bem distribuídas ao longo do ano e com temperatura média anual entre 10° e 15°C (IBGE 1978). Noites frias de inverno podem atingir temperaturas de -4° até -8°C na região mais alta da Serra Geral (Nimer 1989). Na classificação internacional de Koeppen's, o Sul do Brasil é considerado como Cfa, que significa um clima sub-tropical úmido, sem período secos. Todavia, o frio intenso observado nos meses de inverno, associado à formação de geadas frequentes, pode provocar uma estacionalidade fisiológica vegetal semelhante à causada pela falta de chuvas (IBGE 2004).

Métodos em Ecologia Espacial

Os estudos referentes à ecologia espacial de *C. chinga* foram realizados em uma área no município de Arroio Grande, nas drenagens da Lagoa Mirim, próximo a

fronteira com o Uruguai (coordenadas 32^o18' S, 52^o54' W). A paisagem na área de estudo é composta por um mosaico de lavouras de arroz, campos utilizados para criação de gado e pequenos fragmentos de matas nativas e exóticas. O ambiente é fortemente antropizado, com vegetação associada ao pampa com forte influência de formações pioneiras.

Neste estudo, foram utilizadas técnicas de rádio telemetria convencional, via VHF (Very High Frequency). Este tipo de telemetria foi escolhido em função dos custos mais baixos de aquisição e pela facilidade de operação.

Na captura dos indivíduos para a colocação das coleiras, foi utilizado um método pouco convencional para mamíferos de médio porte: captura manual utilizando puçá. Para isso, os indivíduos eram procurados a noite, quando em atividade, com o auxílio de um holofote de longo alcance (um milhão de velas) nas imediações de estradas vicinais, que eram percorridas de carro a uma velocidade de aproximadamente 15 km/h. Quando localizado, o animal era perseguido a pé e capturado em um puçá adaptado com uma lona plástica, a fim de evitar o “spray” defensivo. Depois de capturado, o animal era transferido para uma caixa de contenção, onde era anestesiado para colocação do rádio-colar. A anestesia foi realizada com uma combinação de 10mg/kg Ketamina e 2mg/kg Xilazina (Dopalen and Anasedan, VetBrans), por via intramuscular, por um veterinário habilitado. Na ocasião da anestesia, também foram coletados dados morfométricos, além de estimada a idade (jovem, sub-adulto e adulto) com base no desgaste e coloração dentária (Figura 3). As capturas foram realizadas com autorização do Ibama nº 13573-1 de 7 de novembro 2007.



Figura 3: Morfometria de *Conepatus chinga*

Neste estudo, 18 animais foram marcados com rádio colares e monitorados em campanhas mensais de 8 a 12 dias, por períodos variados. As coleiras, modelo 1930 da ATS (Advanced Telemetry Systems), utilizaram frequências entre 150 – 151 Mhz. Cada

coleira pesava 40 gramas, e nunca excedeu a proporção de 3% do peso do animal (Figura 4).



Figura 4: Colocação da coleira de telemetria em *Conepatus chinga*

No monitoramento, buscou-se a coleta de duas localizações diárias, sendo uma a noite, quando os animais estivessem em atividade, e a outra no período diurno, quando os animais estivessem em repouso. Assim, foi possível a obtenção de registros dos locais utilizados como abrigos (Figura 5) e o padrão de reutilização dos mesmos. Além da utilização dos abrigos, foi possível calcular padrões de deslocamento diário entre: 1) locais em atividade em noites consecutivas; 2) a distância entre abrigos utilizados em dias consecutivos; 3) a distância percorrida entre o local de descanso e o local em que foi registrado em atividade, em períodos subsequentes. Estes padrões de deslocamento foram também comparados à distância simultânea entre indivíduos, permitindo assim um entendimento mais completo do quanto os indivíduos se deslocam em suas áreas de vida.



Figura 5: Abrigos utilizados por *Conepatus chinga*

Métodos para estimativa de abundância

Os estudos de abundância de *C. chinga* foram realizados a partir de métodos de “transect lines”, em quatro áreas de estudo, sendo duas na região do Pampa e duas na

região dos Campos de Cima da Serra. As áreas apresentam características bastante distintas, compreendendo as seguintes paisagens: 1) plantação de *Pinus* com algumas áreas de campo e matas nativas; 2) pastagens em campo nativo com fragmentos de Mata com Araucária; 3) área de cultivo de arroz com pastagens (na mesma área utilizada para o estudo de telemetria); 4) campos nativos utilizados para pecuária extensiva.

Em cada área, foram definidas três transecções com comprimento entre três e oito quilômetros ao longo de estradas vicinais e acessos de fazendas. Cada transecto foi percorrido duas vezes por noite, ao longo de duas a quatro noites seguidas, ao menos uma vez por estação climática. Os transectos foram percorridos durante a noite (entre 20h e 3h) de carro a uma velocidade entre 10 e 15 km/h com um observador fora do veículo, procurando por indivíduos de *C. chinga* com o auxílio de um holofote de longo alcance (Cervantes et al. 2002). De cada animal encontrado, foram anotados dados de distância perpendicular à estrada, distância percorrida até o momento da avistagem e horário do registro. Estes dados foram analisados no Software Distance (Thomas et al. 2010), que estima o número de indivíduos potencialmente presentes na área amostrada, com base na distribuição das distâncias perpendiculares dos indivíduos observados e da distância percorrida.

Como sempre acontece neste tipo de estudo, o método permitiu a observação de diversas outras espécies além da espécie focal. Por este motivo, apresentam-se neste trabalho estimativas de abundância de varias espécies de mamíferos de médio porte. Porém, para estimativas de densidade é necessário um número mínimo de cerca de 40 observações (ou avistamentos), para que o programa possa gerar estimativas robustas. Este número mínimo não é facilmente alcançável, e por este motivo os dados se encaixam em três formas de inferência da abundância: 1) Abundância relativa: apresentada para espécies com poucos registros (< 20 avistamentos); 2) Densidade preliminar: estimada para as espécies das quais foram obtidos entre 30 e 40 avistamentos (próximas do número mínimo sugerido para gerar estimativas robustas, com o uso do Distance); 3) Densidade: estimada para espécies com aproximadamente 80 registros, ou mais (número considerado ideal para o cálculo de densidade).

Este método é amplamente utilizado em todo o mundo no cálculo de densidades dos mais diversos táxons, que vão de plantas à baleias (para mais informações veja <http://www.ruwpa.st-and.ac.uk/distancesamplingreferences/> que apresenta uma lista com mais de 200 trabalhos utilizando o método). No Brasil, poucos estudos têm feito

uso deste método de estimativa, onde destacam-se as contagens aéreas de cervos-do-pantanal (ex. Andriolo 2005; Mourão et al. 2000; Pinder 1997; Schaller e Vasconcelos 1978) e contagens de cetáceos a partir de embarcações (ex. Cremer e Simões-Lopes 2008; Flach et al. 2008). Para animais de médio porte, o método só é amplamente utilizado no estudo de primatas (ex. González-Solís et al. 2001; Peres 1997; Santana et al. 2008), existindo apenas uma referência para carnívoros, sobre a densidade da raposa-do-cerrado (Rocha et al. 2008).

Análise de hábitos alimentares de *C. chinga* e carnívoros simpátricos

Os hábitos alimentares de *C. chinga* foram analisados a partir de estômagos coletados de animais atropelados nas estradas do Rio Grande do Sul. Além destes, foram analisados os conteúdos estomacais de outras nove espécies de pequenos carnívoros que ocorrem em simpatria a *C. chinga* no sul do Brasil, de forma a obter uma análise comparativa com os demais membros da ordem Carnivora.

De cada carcaça, retirou-se o aparelho digestivo armazenando-o em álcool 90% ou formol 10% para posterior triagem em laboratório. Em laboratório, foi feito um corte longitudinal ao longo do estômago e intestino, retirando-se todo o conteúdo. Este material foi então lavado em água corrente, sob peneira de malha fina (0,5 mm) e armazenado em álcool 70%, para posterior identificação. A identificação dos itens alimentares deu-se preferencialmente ao nível de ordem, utilizando como referência a bibliografia, uma pequena coleção particular de referência e consulta a especialistas.

Para análise quantitativa dos dados, foram utilizados três índices: frequência de ocorrência (FO), porcentagem de ocorrência (PO) e porcentagem de biomassa (% vol). A frequência de ocorrência reflete o quão frequente é um item, demonstrando em quantos estômagos (percentualmente), o item esteve presente. A porcentagem de ocorrência reflete o quanto determinado item representa na dieta da espécie, somando a ocorrência de todos os itens e dividindo pela ocorrência de cada um. Para cada item encontrado em cada conteúdo estomacal, foi atribuído um valor referente a proporção de volume ocupado na amostra, segundo o que segue: 1 (<1%), 2 (1–5%), 3 (6–10%) 4 (11–25%), 5 (26–50%), 6 (51–75%), 7 (76–98%), e 8 (>98%), seguindo Kruuk e Parish (1981) e Ray e Sunquist (2001). Para o cálculo do valor médio da biomassa consumida,

os valores da escala foram convertidos no ponto médio do intervalo percentual (1=0.5%; 2=3%; 3=8%; 4=18%; 5=38%; 6=63%; 7=87%; 8=99%).

De forma a comparar a dieta do zorrilho e dos demais carnívoros, foram calculadas a amplitude de nicho de cada uma das espécies e sobreposição do nicho alimentar entre elas. Estes cálculos foram feitos com base nas estimativas de biomassa consumida, assim como as análises de componentes principais, que apresentam de forma gráfica quais os itens mais influentes na dieta de cada espécie. Além disso, os dados de biomassa também formaram a base de dados para uma análise de similaridade, através do índice de Morisita, e apresentada sob a forma de dendograma, de forma permitir a identificação de possíveis guildas alimentares entre os pequenos carnívoros simpátricos.

A ocorrência simpátrica de carnívoros no Rio Grande do Sul é apresentada pela síntese de resultados de 22 localidades, juntamente com uma estimativa da “abundância geral” destas espécies. A “abundância geral” foi definida em função da facilidade com que cada espécie foi registrada em cada ambiente. Assim, foram definidas arbitrariamente três categorias de abundância: 1) “Raras”, para espécies registradas apenas uma ou duas vezes em uma localidade, ou encontradas somente após grandes esforços; 2) “Comuns”, para espécies encontradas facilmente por alguma forma de registro, mas usualmente pouco numerosos; 3) “Abundantes”, para espécies facilmente encontradas em todas as amostragens por praticamente qualquer método de amostragem. Esta classificação foi baseada em capturas, visualizações, registros de armadilhas fotográficas, encontro de pegadas, e carcaças de animais atropelados. O esforço amostral, assim como o número de registros para cada espécie em cada área não foi quantificado, mas deriva da experiência do autor e de pesquisadores colaboradores. O objetivo da apresentação destes dados não é a definição de um índice de abundância específico, mas demonstrar onde as espécies ocorrem e quão comuns são elas. Todavia, é necessário deixar claro que as espécies citadas como simpátricas não são necessariamente sintópicas, já que podem utilizar habitats diferenciados em um ambiente, considerando neste caso, o contexto de paisagem.

Os dados da abundância geral foram então comparados à amplitude de nicho estimada para cada espécie. Para tanto, realizou-se um teste de correlação a fim de verificar a validade do postulado geral de que espécies com hábitos generalistas tendem a ser mais abundantes do que às especialistas.

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Artigo I

Ecologia espacial de *Conepatus chinga*

**Differential patterns of home-range, net displacement and resting sites use of
Conepatus chinga in Southern Brazil**

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Abstract: Studies on the spatial ecology of Molina's hog-nosed skunk were conducted in southern Brazil. Between April 2008 and April 2009, 18 individuals were tagged with radio collars and monitored by radio-telemetry (VHF). The average home-range estimated for 12 skunks was $1.65 \text{ km}^2 \pm 1.17 \text{ km}^2$. Males had home-ranges 2.5 times larger than females, and also showed significantly larger patterns of displacement. These differences in space probably were related not only to sexual size dimorphism, but also to differential behavior between sexes. We identified six basic types of resting sites, among which holes in the ground were the most common and comprised more than 50% of the total. Reuse of resting sites was high (32%), especially for females, which had a significantly higher rate than males. Although they showed a large proportion of home-range overlap even in the core areas, skunks exhibited a solitary life style, rarely sharing resting sites and maintaining relatively long distances from each other, equivalent to twice the distance of daily movements. The almost strictly nocturnal activity pattern observed in this study is a common characteristic of the family. Among practically all of the ecological features analyzed, males and females showed significant differences, denoting the importance of a gender-specific approach in ecological studies regarding this species.

Key words: Carnivora; Mephitidae; Neotropical region; spatial ecology; telemetry

Introduction

The Molina's hog-nosed skunk, *Conepatus chinga*, is a small carnivore, measuring ca. 55 cm total length and 2 kg in weight. The geographic distribution of this species ranges from mid-northern Argentina and Chile to Bolivia, Paraguay, Uruguay (Redford and Eisenberg, 1992), and southern Brazil (Cheida et al., 2006). The distribution is primarily associated with open and temperate areas, mainly the Pampas biome, and is apparently present in abundant populations in Argentina (Castillo et al., 2011a) and southern Brazil (Kasper et al., 2009). With a diet based on insects and insect larvae, this skunk is able to use fragmented landscapes, even living near urban areas.

One of the central aspects of spatial ecology is home-range size and the overlap between the home-ranges of individuals. These features are determined by foraging and movement patterns, inter-individual relationships, access to sexual partners, and many other factors such as access to food and water, population density, and the presence of competitors and predators (Gittleman and Harvey, 1982; Sandel, 1989; Gompper and Gittleman, 1991). Another important aspect is the presence and exploitation of den and resting sites, which are used during resting periods and may confer protection and thermoregulation benefits (Endres and Smith, 1993). The availability of this latter resource potentially may limit the distribution and abundance of populations (Crooks, 1994). Several studies addressing the use of den or resting sites by North American Mephitidae have been published (e.g., Larivière and Massier, 1998; Doty and Dowler, 2006; Lesmeister et al., 2008); while only Castillo et al. (2011b) presented some data about *Conepatus* species.

Despite the relatively extensive bibliography regarding North American Mephitidae, especially *Mephitis* and *Spilogale*, little is known about *Conepatus*. Particularly for *C. chinga*, there are only a few published studies, especially in recent years, which describe ecological aspects, such as diet (Travaini et al., 1998; Donadio et al., 2004), home-range (Castillo et al., 2011a), habitat use and activity pattern (Donadio et al., 2001), as well as inter-individual interactions (Reppucci et al., 2009). Most of these studies involved few animals and/or were conducted for short time intervals, not allowing for inferences about the plasticity or variability of ecological requirements. Some of these studies presented conflicting data about different ecological patterns between males and females of *C. chinga*, such as the occurrence of sexual dimorphism reported by Redford and Eisenberg (1992) but not by Castillo et al. (2011a), and the

differential use of home-ranges related by Castillo et al. (2011a) but not by Donadio et al. (2001).

Our objective was to test for the existence of differences in the body measurements, home-range size, use of resting sites, movement, and activity patterns between males and females of *C. chinga*, in southern Brazil.

Material and Methods

Study area

Our study area is located in the southernmost region of Brazil, near the border with Uruguay in the municipality of Arroio Grande (32° 18' S, 52° 54' W). It is a locality of approximately 30 km² near the coastal plain of Rio Grande do Sul state, in the Lagoa Mirim drainage basin. The area is a mosaic composed of open fields used for cattle ranching, extensive areas of irrigated rice fields, marshes, and some forest patches of native and exotic trees (especially *Eucalyptus* spp.). Rice fields are cultivated between October and April and abandoned the rest of the year. Another important aspect of the rice plantations in this locality is the rotation of cultivated areas, where each patch is cultivated for four to five years and then used for another four to five years for cattle ranching. Thus, practically the whole area is affected by rice crops at some time. The field is usually kept clear (without shrubs) by cattle, and it is dominated by native species such as *Andropogon*, *Aristida*, *Paspalum*, *Axonopus*, and *Stipa*, although some exotic species can be found, such as *Anoni* sp. In the wetlands, predominant vegetation is the false screw pine *Eryngium pandanifolium* Cham. (Umbelliferae). The climate is classified as Cfa by Koeppen's international classification, which characterizes a subtropical wet region, without a dry season. Temperatures vary from -8° C to 38° C, with an annual mean from 10 to 15° C (IBGE, 1978).

Animal capture

Skunks were captured with hand nets covered by plastic to avoid the defensive spray. Individuals were located at night with spotlights, during their activity period, along the periphery of secondary roads traveled by car at ca. 10 - 15 km/h. Once located, the animal was captured and immediately transferred to a containment box. Chemical immobilization was made by intramuscular administration of a combination of 10 mg/kg ketamine and 2 mg/kg xylazine (Dopalen and Anasedan, VetBrans). Each

animal was fitted with VHF radio collars (model 1930, Advanced Telemetry Systems, Isanti, USA). Skunks were measured and aged based on a combination of tooth wear, body mass, and overall condition. Only adult individuals, identified by yellowish or brownish teeth and well developed genitals, were fitted with collars. After recovery from the anesthetic, individuals were released at the capture site. All procedures were in accordance with the guidelines of the American Society of Mammalogists (Gannon et al., 2007) and were approved by the Brazilian Ministry of the Environment's enforcement agency (IBAMA, license no. 13573-1 of November 7, 2007).

Data collection and analysis

We tested whether males and females showed differences in body measurements by a MANOVA and Principal Component Analysis. We then performed a t-test to determine which variable had the greatest influence on the first canonical axis. The tests were performed using the software PAST version 1.87 (Hammer et al., 2001).

Field data were collected in monthly campaigns of 8 to 12 days, between April 2008 and April 2009. In each campaign, we recorded two locations per day for each marked individual: one during daytime (resting period) and one at night (activity period). Location data were collected preferentially by the homing technique, and occasionally by triangulation (White and Garrott, 1990).

To calculate home-range area, we used all recorded locations of each individual in an analysis of fixed kernel 95%, to generate the estimates used within this study. For this analysis we adopted a fixed smoothing parameter of $0.8 \cdot \text{href}$ (following Kie et al., 2002). To test if males and females present similar smoothing parameters, we compared the variance with ANOVA in the software BioStat. With this, we avoided over-smoothing caused by the use of crude href (too large for the animals with big areas) and under-smoothing caused by the use of least square cross validation. For the purpose of comparison with a larger number of studies, we estimated the Minimum Convex Polygon. The core area was calculated by kernel 50%. All analyses were performed using the software Biotas 2.0 (Ecological Software Solutions). We compared the home-ranges areas of males and females by Monte Carlo *t*-test, using the Software PAST. The overlap between home-ranges was analyzed with the software Biotas for all contiguous animals. Also, the distance between simultaneous locations of different animals was calculated, and was arbitrarily defined as the distance between the

locations of two individuals having contiguous or overlapping home-ranges obtained within two hours. The significance of the differences in home-range overlap was tested by the Kruskal-Wallis test with the software BioStat (Ayres et al., 2007). Simultaneous distances between male-male, female-female, and male-female pairs were tested by ANOVA with the software PAST.

Diurnal locations permitted us to identify den and resting sites. Because we recorded only two females with cubs during the entire study, the term “resting site” will be used as a synonym of “den site.” All resting sites were described and monitored in order to investigate reutilization by the same or different individuals. Patterns of reutilization by males and females were compared through the use of Student’s *t*-test, with the proportion of resting sites reused in relation to the total number of resting sites described (data transformed by the arcsine of the square root of the proportion). These analyses were performed with Microsoft Excel version 2007 for Windows and the statistical software PAST.

To evaluate displacement patterns, we calculated the mean straight-line distances moved: 1) between resting sites used on consecutive days; 2) between resting site and the location where the individual was observed in activity, during consecutive periods (day to night and night to the following day); 3) between consecutive nights. The displacement patterns of males and females were compared by Mann-Whitney tests, followed by Tukey’s Test with the software BioStat.

Activity pattern data were taken from nocturnal and crepuscular periods. Daytime activity patterns were inferred during the monitoring of resting-site use. Activity record was taken during the survey for locations of individuals by an activity sensor incorporated in the collars that generates a constant 40 pulses per minute when inactive, or variable pulse rates when the animal is moving. We recorded the status of each individual within an interval of 30 min, when the signal was in range.

Results

Twenty-two skunks were captured, and 18 of them (11 females and 7 males) were fitted with radio collars. We found a significant difference between male and female sizes ($F_{6,11} = 8.312$, $P = 0.0014$) (Table 1). The results of PCA indicate that Axis

1 responded by 76.42 % of the observed variation, with a high significant difference between males and females ($t_{10,6} = 2,9986$; $P = 0,0088$).

Skunks were monitored during a variable period of two to twelve months, because several animals were lost. For three individuals, the collar dropped off during the first month. Another seven individuals were killed by the following: three were road-killed, two were killed by dogs, one was killed by a hunter, and one by a grass fire. In April 2009, five animals were recaptured to have the collars removed. The signals of the last three individuals were lost and never found. Another three unsuccessful surveys were made in May to July 2009 to try to locate these animals.

We recorded 773 locations, varying from nine to 93 per individual. Home-range analyses were performed only for those animals with ≥ 40 locations, totaling 12 individuals (seven females and five males) with a mean of 50 ± 12 locations. Cumulative curves indicated a tendency to stabilization of home-range areas with 35 to 45 point locations. The smoothing parameter calculated for all individuals was 166 (± 57 m Standard Deviation) with no difference in h values related to sex ($F_{1,10} = 2,4453$; $P = 0,1464$).

The mean range area was 1.65 ± 1.17 km² (Standard Deviation, in this and the other estimates of mean area). Females showed home-ranges of 1.00 ± 0.31 km², ranging between 0.74 and 1.48 km², while males showed ranges on average two to three times larger than those of females, with a mean of 2.55 ± 1.37 km² and varying between 1.48 and 4.30 km (Table 2). The difference between home-ranges of males and females was statistically significant ($t_{6,4} = 2,9356$; $P = 0,0029$). The core areas were average 0.39 ± 0.29 km²; for females, the area averaged 0.24 ± 0.06 km², while males had larger areas (0.61 ± 0.36 km²).

The proportion of home-range overlap was highly variable between males and females, as well as between pairs of individuals of the same sex. The mean overlap between males and females was 46% (ranging from 9 to 100%), while pairs of females had a mean of 28% (ranging from 16 to 49%) and males 24% (ranging from 0.5 to 70%). These differences were not statistically significant ($H_2 = 2.9850$; $P = 0.2248$). The distance between simultaneous locations was larger between males with contiguous home-ranges (mean: 1510 ± 744 m) than for pairs of contiguous females (mean of 700 ± 292 m), or males and females with a home-range overlap (mean of 734 ± 416 m). These values differed significantly ($F_{2,185} = 33.608$; $P < 0.0001$), where pairs of males were

more separated than male-female pairs ($P < 0.01$), or pairs of females ($P < 0.01$). The distance between simultaneous locations of neighboring females did not differ from that between pairs of males and females ($P > 0.05$).

Displacement pattern observed for skunks was consistent with differences in home-range size. Mean distance between sites used on subsequent days was higher in males (Table 3) as well as distance between activity locations and distance between den sites and activity locations. All differences in distance were highly significant (Table 3) and generally males showed a net displacement two times greater than females.

We identified 315 resting sites, of six basic types: underground holes (56%), above ground in the middle of low vegetation (20%), under trunks / branches or straw (9%), human buildings (8%), in the middle of bamboo (5%), and in the open (2%). Habitats surrounding the den sites were preferentially open fields (53%), followed by cultivated areas (15 %), borders between open field/cultivated areas (16%), forest patches (11%), and wetlands (5%). Most of the resting sites (68%) were used only once, but each individual had at least one preferred shelter, which was used repeatedly. Rest sites were rarely shared with other skunks. Females tended to reuse the resting sites more than males (38% and 23% respectively), and this difference was statistically significant ($t_6 = 9.1280$; $P < 0.01$). Two females with cubs reused a den site for over a month.

Assessment of activity pattern was determined from the analysis of 952 records. Those records clearly showed that activity for both males and females began after sunset and ended near sunrise, with a peak between 8:00 PM and 3:00 AM, when more than 80% of the records were active (Fig. 1). All tagged animals were recorded in resting sites during daylight for the monitoring period. We recorded individuals out of a resting site during daylight on only four occasions, and in all cases they were unmarked individuals.

Discussion

In this study, we confirmed the observation of Redford and Eisenberg (1992) that males of *C. chinga* were much heavier than females. Although originally referring to individuals from Uruguay, this hypothesis proved to be valid also for southern Brazilian skunks. The Argentinean skunks seem less robust than Brazilian ones, because

they have a similar body length, except for the tail (60 to 70% longer on the skunks from Argentina) but significantly less weight, at least in males. These differences in body mass may be a result of differences in food availability or density. In our study, six animals captured during the winter and recaptured in the late summer had a mean increase of body mass of 216 g (50 to 650 g). Although not assessed, we believe that this variation was probably associated with seasonal changes in food availability.

The home-range areas presented here are practically identical to those described by Castillo et al. (2011a). Our results are also similar to those described in previous studies (Donadio et al., 2001), which reported ranges of about 2km², although these authors also described a female MCP home-range more than three times larger than the mean female range in our study (by MCP). The home-range described for *C. chinga* is much larger than those of other species of *Conepatus*, which probably reflect underestimates for these species. The only study of the Patagonian hog-nosed skunk *C. humboldtii* cited home-ranges of 0.097 km² for three juveniles and 0.164 km² for one adult female (Fuller et al., 1987). In the Venezuelan Llanos, Sunquist et al. (1989) found ranges between 0.18 and 0.53 km² for one individual monitored during a few months. Although they live in very different environments, North American Mephitidae have similar estimated home-ranges. The striped skunk *Mephitis mephitis* had areas ranging from 3.78 km² for females to 5.1 km² for males (Storm, 1972). The hooded skunk *Mephitis macroura*, a species with extensive size variation, weighing from 0.7 to 2.7 kg, has home-ranges of 2.8 up to 5.0 km² (Hwang and Larivière, 2001). In relation to *Spilogale*, Lesmeister et al. (2009) observed the eastern spotted skunk *S. putorius* with home-ranges of 0.54 to 1.35 km² for females and 0.76 to 1.75 km² for males. Similarly to *C. chinga*, males of *S. putorius* have on average a body size/mass 40 % larger than females, and home-ranges 2.5 times larger. *Spilogale gracilis* was found to weigh from 225 to 735 g, and its home-range varied from 0.30 to 0.61 km² (Crooks and Van Vuren, 1995). Together, the results reveal an overall positive relationship between body and home-range sizes, with larger species having larger home-ranges.

However, by comparing our data with those of Castillo et al. (2011a), we have noticed that males with different body sizes had similar home-ranges. Moreover, males had disproportionately larger areas than females, considering the range of body-size variation. Thus, the differences in home-range sizes are probably associated with sexual behavior: males with larger ranges might have access to more females, as postulated by

Sandell (1989). As males have home-ranges two-to-three times larger than females, we expected a high degree of intersexual overlap. In fact, pairs of males and females in contiguous areas had two times more overlap in their home-ranges than did pairs of the same sex. These values are very similar to those found by Reppucci et al. (2009). But, in our study, several unmarked animals were observed inside the home-ranges of monitored individuals, suggesting underestimates of overlapping. As postulated by Powell (2000), in studies of home-range overlap, it is important to consider the time factor. When we analyzed distances of simultaneous locations, pairs of males showed the largest distances from each other, while females and intersexual pairs showed shorter distances. The distances observed were, once again, very similar to those observed by Reppucci et al. (2009), with special consideration for the average distances between males and females, which were identical in both studies. Comparing the locations collected simultaneously with the displacement pattern, we found that each individual stayed away from others, since the mean distance between individuals was two times larger than the mean individual distance moved by night. This pattern seems to indicate that skunks tend to avoid contact with other individuals by using different parts of the home-range.

The resting sites used by *C. chinga* were very similar to those described for other species of Mephitidae (Larivière and Massier, 1998; Crooks, 1994; Doty and Dowler, 2006; Lesmeister et al., 2008). Underground holes were the most common type of den site, as cited by Donadio et al. (2001) and Castillo et al. (2011b) for *C. chinga* in Argentina. On the other hand, there were no rocky formations in our study area, which several reports have described as resting sites for *C. chinga* (Donadio et al., 2001; Castillo et al., 2011b), *C. humboldtii* (Fuller et al., 1989) and the common hog-nosed skunk *C. mesoleucus* (Patton, 1974). In our study area, the burrows used by the Molina's hog-nosed skunk were made predominantly by other species, such as armadillos (*Dasypus* sp. and *Euphractus sexcinctus*), coypus (*Myocastor coypus*), and burrowing owls (*Athene cunicularia*). Inter-specific relationships have been described for other species of Mephitidae, such as *S. putorius* and the striped skunk *M. mephitis* (Doty and Dowler, 2006; Lesmeister et al., 2008), and *C. semistratus* (Sunquist et al., 1989). It is not clear whether *C. chinga* makes its own burrows, because signs of digging in the resting sites were not observed. Skunks are capable of digging burrows, but probably make only small enlargements when necessary. Skunks are not fossorial

animals, and change resting sites continuously. Thus, the energetic cost of digging a burrow is probably not advantageous, as they have many potential dens ready to use.

Aboveground resting sites were used with relatively high frequency, especially those located in the middle of two species of spiny bushes, the false screw pine *Eryngium pandanifolium* Cham. (Umbelliferae), and the beach bromeliad *Bromelia antiacantha* Bertol. (Bromeliaceae). Spiny bushes probably confer protection against some predators, similar to the den sites located in cacti described for *M. macroura* (Reed and Carr, 1949), *M. mephitis* and *S. gracilis* (Doty and Dowler, 2006). These plants are abundant, usually present along roads and marshy areas. The abundance of these spiny bushes, together with the large number of holes in the ground, makes resting sites a non-limiting resource for this population.

The rate of resting-site reuse was estimated at 32%, a proportion that may be considered high for skunks, as Doty and Dowler (2006) recorded no instances of reutilization of den sites by *M. mephitis* or *S. gracilis*. Moreover, Larivière and Messier (1998) estimated the reuse rate of den sites as less than 5% for *M. mephitis*, with the exception of females during the mating season. Conversely, the proportion of reused sites found in our study is identical to that found by Lesmeister et al. (2008) for *S. putorius*, and similar to that found for *C. humboldtii* of 28% (Fuller et al., 1987) and *C. chinga*, with mean values of 25.8% (Donadio et al., 2001) to 24.1% (Castillo et al., 2011b). The rate of resting-site reutilization by males was significantly lower than for females in our study, differing from Castillo et al. (2011b) and *S. putorius*, who showed no differences in reutilization pattern between the sexes (Lesmeister et al., 2008). Such patterns may be the result of the larger home-ranges of males, with a larger number of potential burrows to explore.

Despite the large number of resting sites in overlapping areas between two or more individuals, only 1% of the burrows used by one individual were subsequently used by different individuals. Only one resting site (from the total of 315 shelters) was shared by a male and a female six times (in all cases, the same individuals). These values are identical to those found by Lesmeister et al. (2008) for *S. putorius*. Thus, it seems to be clear that sharing or even the use of a den site by more than one individual of *C. chinga* is very rare. Such behaviors are associated with solitary habits, which are typical of many Mephitidae.

Molina's hog-nosed skunk is a nocturnal animal, showing an activity pattern similar to that reported by Donadio et al. (2001) for *C. chinga* and by Fuller et al. (1987) for *C. humboldtii*. In this respect, males and females showed similar patterns without any marked difference. The active period of *C. humboldtii* extends throughout the entire night until daytime, but it is necessary to consider that the study was conducted during summer in high latitudes, when the nighttime is relatively shorter, in an arid habitat, with presumably less food availability. In our study, we recorded some diurnal activity, but this may be considered insignificant for our study area. On some occasions, the signal was active but individuals remained inside the resting sites.

In conclusion, several differences in the spatial ecology of males and females were found, and are likely associated with differences in body size and sexual behavior. We present differences in home-range size, displacement pattern and the use of resting sites between males and females, denoting the importance of a gender-specific approach in ecological studies regarding this species. In the other hand, *Conepatus chinga* is very similar to other Mephitidae species in many ecological aspects, suggesting that many ecological characteristics are probably phylogenetically determined (or influenced) despite environmental variation.

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Table 1. Body measurements of 18 Molina’s hog-nosed skunks (*Conepatus chinga*) in southern Brazil, with comparisons between males and females. Standard deviation is given in parentheses, weight in kg, and other measurements in cm.

Measurements	Males N = 7	Females N = 11
Weight	2.32 (± 0.30)	1.62 (± 0.40)
Total length	58.8 (± 2.71)	55.4 (± 3.19)
Body length	43.0 (± 2.65)	40.1 (± 2.89)
Tail length	15.8 (± 1.22)	15.2 (± 2.24)
Circumference of thorax	27.1 (± 2.62)	23.8 (± 3.30)
Circumference of neck	17.2 (± 1.04)	14.9 (± 1.28)
Circumference of head	19.7 (± 0.85)	16.9 (± 1.05)
Front foot length	3.6 (± 1.48)	3.4 (± 2.35)
Hind foot length	6.4 (± 3.52)	5.7 (± 3.57)

Table 2. Home-range area estimates (mean and SD) for five males and seven females of Molina’s hog-nosed skunks (*Conepatus chinga*) in southern Brazil. Area in km².

Gender	MCP	Fixed Kernel 95%	Kernel 50%
Males	1.65 ± 0.59	2.55 ± 1.37	0.61 ± 0.36
Females	0.55 ± 0.36	1.00 ± 0.31	0.24 ± 0.06
All animals	1.01 ± 0.72	1.63 ± 1.17	0.39 ± 0.29

Table 3. Comparison between males and females of distances (in meters) traveled by Molina’s hog-nosed skunks (*Conepatus chinga*) in southern Brazil.

	Males			Females			<i>U</i>	<i>P</i>
	mean	sd	range	mean	sd	range		
Between den sites	473	103	25 – 2627	243	143	17 – 1169	1842.0	<0.0001
Between locations of activity	470	196	49 – 2976	265	56	15 – 781	2241.5	<0.0001
Between den sites and locations of activity	512	132	10 – 2605	246	87	2 – 1071	13460.5	<0.0001

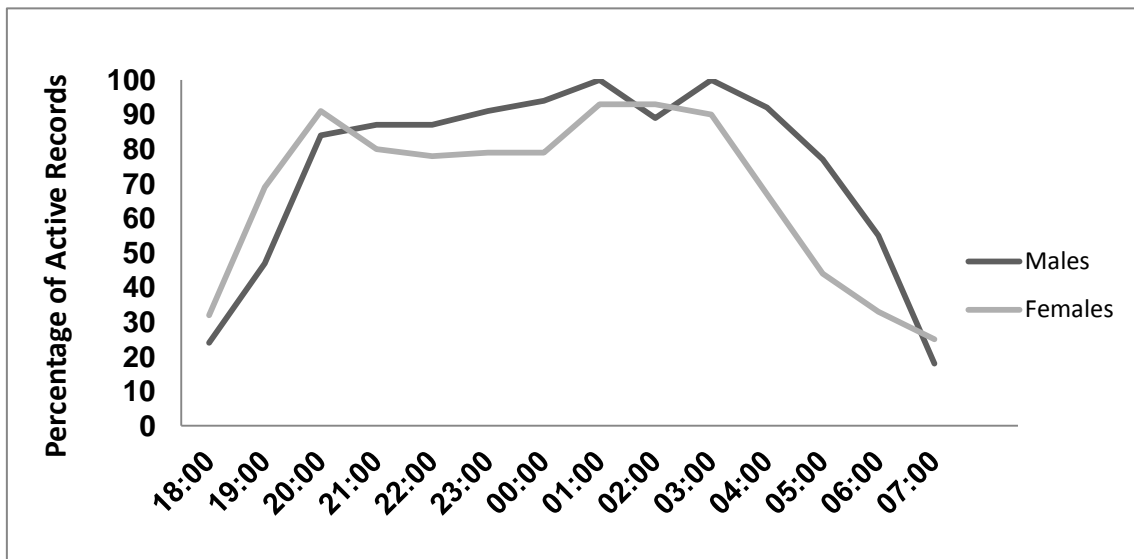


Figure 1: Activity pattern of 7 males and 11 females of Molina's hog-nosed skunks (*Conepatus chinga*) in southern Brazil.

Artigo II

**Abundância *Conepatus chinga* e outros mamíferos de médio porte
no sul do Brasil**

**Abundance of *Conepatus chinga* (Carnivora: Mephitidae) and other
medium-sized mammals from southernmost Brazil**

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Abstract: Between January 2007 and December 2010, the abundance of medium-sized mammals was studied, with special focus on the Molina's hog-nosed skunk, *Conepatus chinga*, at four locations in southern Brazil. In this study, transect line methodology was used to obtain data for Distance Analyses. Transects were traveled by car at night, searching with spotlights along the edges of secondary roads in agricultural landscapes. Along 1,811 km, we obtained 620 observations of 20 mammal species. The most common species was the exotic European hare, *Lepus europaeus*; the highest abundance estimated for South America was observed in one of the study areas, where its density was estimated as 32 individuals / km². Carnivores were the most commonly recorded mammals, represented by 10 species and comprising 51% of all observations. Molina's hog-nosed skunk occurred in all study areas, but occurred in sufficient numbers to obtain density estimates in only two of the areas. We estimated 1.4 to 3.8 individuals / km², in the first density estimate made by the transect method for a member of *Conepatus* in the Neotropics. These values are similar to those estimated for North American species of Mephitidae. In Brazil, *C. chinga* is apparently more abundant in the Pampa biome than in the grasslands of the Atlantic Forest. For two other carnivores, *Lycalopex gymnocercus* and *Cerdocyon thous*, we estimated preliminary densities that were similar to those previously cited for different regions.

Key words: density, Pampa, transect lines, sympatric species

Introduction

Species abundance is a central aspect in population ecology. Abundance can be affected by several ecological factors, including food availability, competition and predation. Two basic and different measures of abundance can be estimated by sampling animal populations: density and abundance. Absolute density refers to a quantitative measure of numbers of individuals per area, which can be converted into an estimate of population size. Abundance refers to population densities relative to a unit other than area, such as records per hour surveyed or observations per kilometer sampled (CASSEY, 1999). Indices are generally based on the assumption that the sample represents a constant but unknown proportion of the population. These indices are easily obtained and useful for comparing different sites or trends with repeated sampling over time (GESE, 2001). CHIARELLO (1990), for example, used abundance indices to evaluate the impact of fragmentation on mammal assemblages in the Atlantic Forest. Yet, in general, there is a lack of knowledge of this aspect for most Neotropical mammals, even for the most common species.

The Neotropical mammal fauna is mostly composed of small species, such as rodents, marsupials and bats. Among medium-sized mammals (> 1 kg), most of the species are arboreal (e.g., primates), which together with small mammals represent nearly 88% of all mammal diversity in South America (FONSECA *et al.*, 1999). However, the Neotropical region has extensive areas of open habitat, often resembling the landscape of African savannas. In contrast to African mammals, the majority of South American mammals are inconspicuous, with a relatively small number of medium- to large-sized species. Most of them have secretive habits and are difficult to observe.

Even relatively common species have been poorly studied, and abundance estimates, especially based on transect lines, are few. In Brazil, this method has been used in aerial counts of marsh deer *Blastocerus dichotomus* (Illiger, 1815) (e.g., ANDRIOLO, 2005; MOURÃO *et al.*, 2000; PINDER, 1997; SCHALLER & VASCONCELOS, 1978), and boat counts for cetaceans (e.g., CREMER & SIMÕES-LOPES, 2008; FLACH *et al.*, 2008). Transect lines on the ground are used basically to estimate densities of primates (e.g., GONZÁLEZ-SOLÍS *et al.*, 2001; PERES, 1997; SANTANA *et al.*, 2008). Carnivores are inherently less abundant than herbivores (EISENBERG, 1999), and usually hard to see, making it difficult to apply these methods. Perhaps because of this, studies

conducted in Brazil to estimate the density of carnivores with transect lines such as that of ROCHA *et al.* (2008), with a fox species *Lycalopex vetulus* (Lund, 1842) in the Cerrado Biome, are rare. On the other hand, some poorly known species can be easily observed in their habitats, for example, the Molina's hog-nosed skunk, *Conepatus chinga* (Molina, 1782). In southern Brazil, *C. chinga* is one of the most common medium-sized mammals occurring in open areas, but despite this, studies of its density or relative abundance are still lacking.

In this study, we aimed to estimate the density of *C. chinga*, as well as the relative abundances of other medium-sized mammals, at two sites in the Pampas grasslands and two sites in the grasslands of the Atlantic Forest, comparing patterns of the composition of assemblages of medium-sized mammals.

Materials and Methods

Study Area

This study was conducted in four areas in southern Brazil. The areas are located in two basic biotic formations, the grasslands of the Atlantic Forest and the Pampas grasslands. In northeastern Rio Grande do Sul State and in southern Santa Catarina State, grasslands occur in Atlantic Forest highlands (800 – 1200 m). This formation is associated with fragments of Atlantic Forest with a conspicuous presence of the Brazilian Pine (*Araucaria angustifolia* (Bert.) O. Ktze). Figure 1 shows the open formations of southern Brazil and the locations of the areas studied. The first area (A), studied between July and December 2007, is located in Santa Catarina in the municipality of Campo Belo do Sul (27°58'S 50°49'W). Transects were located in a large pine forest (*Pinus* spp.) cultivated for timber. This area includes several native fragments of Atlantic Forest along streams and springs. Originally, until the 1950s, the area was occupied by grasslands used for cattle ranching, which were then converted to pine forest. The second area (B), studied between July 2007 and March 2008, is located in Rio Grande do Sul, in the municipality of Bom Jesus (28°19'S 50°43'W). Transects were located on a cattle ranch, comprising large areas of native grasslands with several patches of Atlantic Forest with *Araucaria angustifolia*. The third area (C), located in southeastern Rio Grande do Sul in the municipality of Arroio Grande (33°19'S 53°54'W), near the border with Uruguay, was studied between February 2008 and April

2009. The area is near the coastal plain, in the drainage basin of the Lagoa Mirim. It is composed of a mosaic of open grasslands used for cattle ranching, extensive areas of irrigated ricefields, marshes, and some forest patches of native and exotic trees (mainly *Eucalyptus* spp.). The last area (D), located in southwestern Rio Grande do Sul in the Municipality of Alegrete (30°05'S 55°30'W), also near the border with Uruguay, was studied between July 2009 and December 2010. The landscape is composed of grasslands and some forest patches that occur mainly along watercourses. Transects were established through livestock ranches.

Data collection and analyses

The study was based on line-transect methodology (BUCKLAND *et al.*, 1993; BURNHAM *et al.*, 1980). For this purpose, we established transects along secondary and farm roads. We established three transects at each site, ranging from 3 to 8 km (mean = 4.8 km) long. Transects were sampled during three to five consecutive nights, each month or once per season. Each transect was repeated twice each night, with a minimum interval of one hour between each round trip. As the main goal of this study was to obtain density estimates of *C. chinga*, it was not viable to invest in areas with few animals, since a minimum number of records are needed to perform estimates using the Distance Program. Therefore, 24 samples in each transect during six months were established as the minimum sampling effort at each site. Because we used existing roads, the transects were not linear and they usually followed the smoothest relief. Sampling was carried out at night between 20:00 and 03:00 h by car, driven at a constant speed of 10 – 15 km/h; with one observer using a spotlight, scanning both sides of the road in search of medium-sized mammals, especially *C. chinga* (CERVANTES *et al.*, 2002). When a mammal was located, the driver stopped the car in a perpendicular position, or approximately 20 m distant, if the animal was close to or on the road. If the animal was clearly identified, the observer measured the perpendicular distance to the location of the first visual contact with the animal, using a measuring tape. In cases of doubtful species identity (canids seen at long distances, for example), the sighting was discarded.

The perpendicular distances were measured with the maximum possible precision, based on visual characteristics of each site, such as shrubs, rocks, fences or anything that could help the observer to identify the first location of visual contact. Data collected were analyzed using the software Distance (THOMAS *et al.*, 2010).

Perpendicular sighting data were modeled according to the Akaike Information Criterion (AIC). We present point density estimates with a confidence interval of 95%, standard error, coefficient of variation, and the probability of detection.

Density was calculated for all species with 60 (or more) sightings, which is considered suitable for robust estimates (BUCKLAND *et al.*, 1993). For all species with about 30 sightings, we estimated “preliminary densities”. These preliminary estimates represent an approximation, derived from data sets that did not allow robust analyses because of the small number of records. For other species, we present only abundance indices, based on the number of sightings divided by the distance traveled.

Results

General results

In the entire study, 1,811 km of transects were sampled, and 620 sightings of 20 mammal species were recorded. The most common species was the European hare *Lepus europaeus* (Pallas, 1778), which comprised 41% of the total observations. Carnivores were the most common order recorded, represented by 10 species and 51% of all observations.

On Gateados farm, 223 km were sampled with 65 records of eight species, i.e., one sighting for every 3.66 km of transect (Table 1). *Cerdocyon thous* (Linnaeus 1766) was the most common species recorded, with 48% of the observations (12.1 sightings for each 100 km of transect), followed by *Mazama gouazoubira* (Fisher 1814) with 29% (8.52 sightings / 100 km), and *L. europaeus* with 15% (4.48 sightings / 100 km). Other species, including *C. chinga*, were recorded only once.

At Bom Jesus, 276 km were sampled, along which we obtained 66 records of nine species, representing one sighting for every 4.18 km of transect (Table 1). In this area, *Lycalopex gymnocercus* (Fisher, 1814) was the most abundant species, with 57% of the observations (13.77 sightings / 100 km), followed by *L. europaeus* with 18% (4.35 sightings / 100 km). Two other species showed intermediate abundances, *C. thous* and *Procyon cancrivorus* (Cuvier, 1789), each with 8% (1.81 sightings / 100 km) of the observations. Again, *C. chinga* was recorded only once.

At Arroio Grande, 1,052 km were sampled, with 205 records of 9 species, representing one sighting for every 5.13 km of transect (Table 1). The most common species in this area was *C. chinga*, with 30% of the observations (5.80 sightings / 100 km), followed by *L. europaeus* (18%; 3.52 sightings / 100 km), *C. thous* (16%; 3.14 sightings / 100 km) and *L. gymnocercus* (15%; 2.95 sightings / 100 km) with relatively high abundances. In this area, *Leopardus geoffroyi* (d'Orbigny & Gervais, 1844), *P. cancrivorus* and *Myocastor coypus* Kerr, 1792 showed intermediate abundances.

At Alegrete, 260 km were sampled, along which 284 records of 11 species were obtained, representing one sighting for each 0.91 km of transect (Table 1). *Lepus europaeus* was recorded in very high frequency, representing 68% of the observations (73.85 sightings / 100 km), followed by *C. chinga* in high abundance, with 25% of the records (26.92 sightings / 100 km). All other species showed low abundances, with the exception of *C. thous* and *L. gymnocercus*, which had intermediate abundances (1.54 and 3.08 sightings / 100 km respectively).

Density Estimates

We generated two density estimates for four species: *C. chinga*, *C. thous*, *L. gymnocercus* and *L. europaeus*. We were able to make a robust estimate of density for *C. chinga* in two areas, and for *L. europaeus* in only one area. Two other species had only a small number of records, compelling us to consider our estimates as preliminary with respect to two of the study areas.

Conepatus chinga was the most common carnivore species in two areas, Arroio Grande and Alegrete, with densities ranging from 1.1 (0.7 – 1.2) to 3.8 (2.9 – 5.1) individuals / km² (Table 2). The coefficients of variation of these analyses were 16.5% and 14.4% respectively.

Cerdocyon thous and *L. gymnocercus* showed similarly low estimated densities (Table 2). For *C. thous* the estimates ranged from 0.4 (0.2 – 0.6) to 0.9 (0.6 – 1.3) individuals / km² at Arroio Grande and Gateados farm, respectively. For *L. gymnocercus* the estimates ranged from 0.2 (0.15 – 0.35) to 1.1 (0.7 – 1.6) individuals / km² in Arroio Grande and Bom Jesus, respectively. However, these estimates are preliminary, with relatively high coefficients of variation, varying from 21.4% to 24.1%.

European hare densities varied dramatically between the study areas. Because few animals were observed in two of the areas, it was not possible to estimate their

density. Yet in two other areas, hares were present in intermediate and very high abundances (Table 2). For Arroio Grande, we made only a preliminary estimate because of a small number of records, of 0.3 (0.2 – 0.4) individual / km² with a 21.7% coefficient of variation. On the other hand, a robust analysis was possible for Alegrete, for which we estimated a density of 31.9 (23.7 – 42.9) individuals / km², with a 15.1% coefficient of variation.

Discussion

Relative abundance

Each area showed a singular assemblage, varying between one and four “exclusive species”. This term is in quotes because the failure to record a species does not imply that it is absent in the environment. In fact, the nine-banded armadillo *Dasypus novemcinctus* Linnaeus 1758 and the pampas fox *L. gymnocercus* are very common in southern Brazil, and certainly occur in all the study areas; as is the grison *Galictis cuja* (Molina, 1782), although it always occurred in low abundance (Kasper, unpublished data).

The four study areas are strongly impacted by humans. The main impacts are caused by agricultural activities, especially livestock at Bom Jesus, Arroio Grande and Alegrete. Gateados farm is used for timber production, and therefore has the most distinct fauna. In this area the crab-eating fox *C. thous* was the most abundant species, with 31 records, followed by the gray brocket deer *Mazama gouazoubira*, which is remarkable. In this case, the abundance of the gray brocket deer is probably associated with an absence of hunting at the farm. Paradoxically, this exotic pine-forest environment harbors a large number of species, including some locally endangered species (FONTANA *et al.*, 2003), such as the white-lipped peccary *Tayassu peccary* (Link, 1795), collared peccary *Pecary tajacu* (Linnaeus, 1758), ocelot *Leopardus pardalis* (Linnaeus, 1758), and mountain lion *Puma concolor* (Linnaeus, 1771). It is likely that these species can persist only because of the preservation of native forest in the ravines. However, it seems clear that the mosaic formed by patches of native and exotic forests, and the absence of hunting are beneficial to several species, especially larger species that require extensive areas to maintain their populations.

Bom Jesus, located only 80 km from area A, is very different in terms of soil and landscape usage. The area is used for cattle ranching, and the landscape includes several forest patches in the middle of open grasslands, on the hilltops, and bordered by the Atlantic Forest in the ravines. Therefore, some forest species are present in the patches and ravines, although the assemblage of mammals is characteristic of open areas. The most abundant species in this area was the Pampas fox, followed by the European hare, two species typical of open environments. It is interesting to note the numerical dominance of *L. gymnocercus* over *C. thous*, which many studies have found to be the dominant species (DI BITETTI *et al.*, 2009; FARIA-CORREA *et al.*, 2009). This is not always necessarily true, and this relationship is probably more complex than it appears.

In Arroio Grande (Area C), a greater field effort was employed, using transects concomitantly with telemetry studies of *C. chinga* (KASPER *et al.*, in press). In this area, *C. chinga* was the most abundant species, with 61 records (one sighting for every 17.2 km of transect), nearly twice that of the next most abundant species, *L. europaeus*, with 37 records. The area showed the lowest encounter indices of all four areas, with 19 sightings every 100 km. This probably reflects the high level of disturbance in the area, which is used intensely for agriculture, especially rice farming and cattle ranching. This is the only study area that had vehicular traffic on the roads used as transects, which certainly affected detectability, because some species or individuals may avoid areas adjacent to busy roads. Aside from detectability, density itself can be affected, as suggested by the observation of several road-killed individuals.

Alegrete showed the highest encounter indices, with 109 records every 100 km, many more than in the other areas. This number can be explained by the enormous local abundance of the European hare, which alone represented 74 encounters per 100 km traveled. Yet even after this exotic species was excluded from the analysis, Alegrete still showed the highest abundance in terms of mammals, because we also found the highest abundance of *C. chinga*, nearly five times higher than in Arroio Grande, with 27 encounters every 100 km. The two sympatric canids were found at intermediate levels, with a predominance of *L. gymnocercus*. A possible explanation for the large number of animals in this area is landscape use. Pampas grasslands are used primarily for cattle ranching, an activity that began in the 1800s and has not changed much since then. Cattle ranching is so intimately associated with this region that several investigators have argued that the landscape is modulated by this activity, and that the maintenance of

biodiversity is dependent on the regime of disturbances such as grazing and burning to improve pasture (OVERBECK *et al.*, 2009). Obviously, there is a threshold for the intensity of these disturbances, leading to decreases in biodiversity and the loss of ecological processes (PILLAR *et al.*, 2009). However, the region can be considered relatively well preserved, although humans have made use of practically all the available space.

Densities

There is little published information about the abundance of skunks, and no data for the southern species. The South American species exhibit parapatric distributions, in contrast to North American skunks. Therefore, in South America each skunk species shares its habitat with carnivores of other families, but not with other mephitids, which in theory reduces the potential for competition among them. The abundance of *C. chinga* should be higher than those of species living in sympatry and sharing resources, as in the case of northern skunks. However, the densities estimated in our study are similar to those commonly observed for *Mephitis mephitis* (Schreber, 1776) (WADE-SMITH & VERTS, 1982), a larger animal than *C. chinga*. On the other hand, densities were much lower than for *Spilogale putorius* (Linnaeus, 1758), found in numbers of 8.8 to 40 individuals / km² (KINLAW, 1995), although they have only 1/3 the body mass of *C. chinga*. In Arroio Grande, the estimated density of *C. chinga* is similar to densities of the most common of three sympatric species studied in Mexico (CERVANTES *et al.*, 2002).

The only density estimate available for *Conepatus* in South America was derived from telemetry studies, and was 0.68 – 1.66 individuals / km² in croplands and protected areas respectively (CASTILLO *et al.*, 2011). These authors used spotlight surveys to estimate density, but did not succeed because of the small number of sightings. It is very difficult to compare results derived by different methods, as each technique has different sources of bias. Density estimates based on telemetry data are only valid if no other animal lives within the total area used by the marked animals (GESE, 2001). Individuals of *C. chinga* show considerable overlap in their home ranges, even among individuals of the same sex (CASTILLO *et al.*, 2011; KASPER *et al.*, in press; REPUCCI *et al.*, 2009), making it nearly impossible to mark all the animals in a given area. In a similar study, for example, KASPER *et al.* (in press) could not use this method of analysis because several non-marked individuals were sharing the areas of the

monitored animals. However, CASTILLO *et al.* (2011) did not mention the possibility that their analyses could have produced underestimates, so we will assume that their numbers are valid. In this case, our estimates are higher than those in Argentina, despite the wide variability observed. This is interesting because Brazilian skunks are larger than the specimens from Argentina (KASPER *et al.* in press), which in theory implies that they should have lower densities. We suggest that these differences may be related to the availability of food, which generally correlates with precipitation. In southern Brazil, the annual mean precipitation is around 1200 – 1600 mm (CABRERA & WILLINK, 1980), while in Argentina it is around 500 – 1000 mm. Therefore, it is possible that southern Brazil has greater resource availability, allowing for higher densities. Another reference available for South American skunks is CHOFRE & MARQUET (1999), who reported densities of 5 individuals / km² for *C. chinga* and 89 individuals / km² for *Conepatus humboldtii* Gray, 1837. However, these estimates were included among those for several other species, and it is not clear how the authors determined the values. Therefore we do not consider this information sufficiently reliable for comparison with our study.

The observed abundance of *C. chinga* in our study areas varied widely, from very low levels, where we could not estimate the density, to areas with relatively high densities. One possibility is the difference in availability of certain resources, especially insect larvae, which is the main item in this species' diet (PETERS *et al.*, 2011; MEDINA *et al.*, 2009). This hypothesis should be tested in the future, to better understand the processes affecting its abundance. However, in Arroio Grande the abundance of *C. chinga* is probably strongly affected by human disturbances, including road mortality and hunting. In this area, seven of 18 marked animals were killed as a consequence of human activities in a period of 12 months, representing an almost 40% decrease of the known population (Kasper *et al.* in press). The low levels of abundance in the Atlantic Forest highlands may be a particular characteristic of this population.

The density of *Lycalopex gymnocercus* was estimated first by CRESPO (1971), who found 1.04 individuals/km² in the Argentine Pampas, very similar to our estimate in the highlands of the Atlantic Forest. In the Paraguayan Chaco, BROOKS (1992) found a density of 0.64 fox groups/km², while the highest density estimate is from the Bolivian Chaco, with 1.8 individuals/km² (AYALA & NOSS, 2000). These estimates are similar to ours, despite the very different habitats. The values are also similar to a report for

Lycalopex vetulus in “campo sujo” of the Brazilian Cerrado (1.21 individuals/km²) (ROCHA *et al.*, 2008), although estimates for pasture fields at the same location were very different, with up to 4.28 individuals / km² (ROCHA *et al.*, 2008). However, we cannot directly compare these two species, because *L. vetulus* has a diet specialized in termites and other insects, whereas the diet of *L. gymnocercus* is more generalized (CHEIDA & SANTOS, 2010). The several density estimates for different species of the genus *Pseudalopex* compiled by HOFFMANN & SILERO-ZUBIRI (2004) indicate densities of 0.5 to 2.0 individuals/km² as a common pattern for Neotropical foxes.

The numbers of *L. gymnocercus* in our study were probably influenced by hunting, as we found low abundances in the areas with high hunting pressure such as at Arroio Grande and especially at Alegrete. Arroio Grande is more densely occupied, which generates more conflict with carnivores in general. At Alegrete, which has large cattle and sheep ranches, there is an effective and illegal control of canids (*C. thous* and *L. gymnocercus*), which supposedly serves to reduce the loss of lambs to predation. At Bom Jesus, which is used exclusively for cattle, hunting pressure is lower than at Arroio Grande and Alegrete, allowing more Pampas foxes to survive.

The crab-eating fox (*C. thous*) is the most common carnivore in southern Brazil, although not always the most abundant. This species is more associated with forested areas and gallery forests, but also occupies open areas, agricultural landscapes, highly fragmented environments, and even suburban areas. The densities estimated in our study are similar to that estimated for a dry forest in Santa Cruz (Bolivia) of 1 individual/km² (MAFFEI & TABER, 2003). *Cerdocyon thous* occurs in all areas of southern Brazil, while *L. gymnocercus* is restricted to open areas of the Pampas grasslands and the open grasslands of the Atlantic Forest. These species are very similar in size, and recent studies have revealed extensive overlap in their feeding habitats. The coexistence of these foxes was the subject of some studies (e.g., ABREU *et al.*, 2010; DI BITETTI *et al.*, 2009; FARIA-CORRÊA *et al.*, 2009) that have suggested that niche overlap is attenuated by differences in activity period or by their differential use of microhabitats to forage. We believe that these two species affect each other’s abundance reciprocally. How this occurs, at what intensity, and what affects this relationship are still-unanswered questions. However, this relationship is probably not linear, with *C. thous* always being the dominant species, since in some areas *Lycalopex* shows similar or even higher abundances.

The European hare *Lepus europaeus* is an introduced species that is thriving in southern Brazil, Uruguay and Argentina. We estimated two levels of density for southern Brazil, at two different abundance levels. In two other areas in the highlands of the Atlantic Forest, its abundance was very low and was not calculated. However, this hare has probably become one of the most common medium-sized mammals in southern Brazil, especially in the Pampas grasslands, where densities equaling our highest estimate are common. This abundance of hares is high even when compared to their original habitat in Poland, with densities of 10 – 28 individuals / km² (PANEK, 2009), and the Netherlands, where the density is around 25 individuals/km² (CHAPMANN & FLUX, 1990). Although this hare can reach 200 – 300 individuals/km² in some cases, its density is usually low, even in non-native habitats such as New Zealand, with densities around 10-20 individuals (CHAPMANN & FLUX, 1990). In South America, density estimates range from 2.6 – 5.1 hares/km² (AMAYA, 1979) to 9.5 (±4.5) – 12.6 (± 1.9) (PIA *et al.*, 2003), both from Argentina. Therefore, our estimate is the highest reported to date for South America, and amplifies our understanding of this exotic species' potential to occupy southern Brazil.

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Table 1: Sightings per 100 km of transects at Gateados farm (area A), Bom Jesus (area B), Arroio Grande (area C) and Alegrete (area D) in southern Brazil.

Species	Study areas			
	Gateados farm	Bom Jesus	Arroio Grande	Alegrete
<i>Didelphimorphia</i>				
<i>Didelphis albiventris</i> Lund, 1840			0.29	0.77
<i>Cingulata</i>				
<i>Cabassous totoay</i> (Desmarest, 1804)		0.36		
<i>Dasypus hybridus</i> (Desmarest, 1804)				0.77
<i>Dasypus novemcinctus</i> Linnaeus, 1758				0.77
<i>Carnivora</i>				
<i>Leopardus colocolo</i> (Molina, 1782)				0.38
<i>Leopardus geoffroyi</i> (d'Orbigny & Gervais, 1844)			1.52	0.38
<i>Leopardus pardalis</i> (Linnaeus, 1758)	0.45			
<i>Puma concolor</i> (Linnaeus, 1771)	0.45			
<i>Cerdocyon thous</i> (Linnaeus, 1766)	12.11	1.81	3.14	1.54
<i>Lycalopex gymnocercus</i> (Fisher, 1814)		13.77	2.95	3.08
<i>Lontra longicaudis</i> (Olfers, 1818)			0.10	
<i>Galictis cuja</i> (Molina, 1782)				0.38
<i>Conepatus chinga</i> (Molina, 1782)	0.45	0.36	5.80	26.92
<i>Procyon cancrivorus</i> (Cuvier, 1798)		1.81	0.86	
<i>Cetartiodactyla</i>				
<i>Pecari tajacu</i> (Linnaeus, 1758)		0.36		
<i>Tayassu pecari</i> (Link, 1795)	0.45			
<i>Mazama gouazoubira</i> (Fisher, 1814)	8.52	0.72		
<i>Rodentia</i>				
<i>Hydrochoerus hydrochaeris</i> Brisson, 1762	0.45			
<i>Myocastor coypus</i> Kerr, 1792		0.36	1.33	0.38
<i>Lagomorpha</i>				
<i>Lepus europaeus</i> (Pallas, 1778)	4.48	4.35	3.52	73.85
Total	27.35	23.91	19.49	109.23

Table 2: Density estimates of four species in southern Brazil. D – Density estimate (individuals / km²); CI – 95% Confidence Interval (individuals / km²); SE – Standard Error; CV – Coefficient of Variation (%); DP – Detection Probability (%).

Species	Area	D	CI	SE	CV	DP
<i>Conepatus chinga</i>	Arroio Grande	1.1	0.7 – 1.2	0.18	16.5	43.9
	Alegrete	3.8	2.9 – 5.1	0.55	14.4	22.1
<i>Cerdocyon thous</i>	Gateados	0.9 *	0.6 – 1.3	0.19	21.7	27.9
	Arroio Grande	0.4 *	0.2 – 0.6	0.09	24.1	47.1
<i>Lycalopex gymnocercus</i>	Bom Jesus	1.1 *	0.7 – 1.6	0.23	21.4	25.7
	Arroio Grande	0.2 *	0.15 – 0.35	0.05	22.2	41.4
<i>Lepus europaeus</i>	Arroio Grande	0.3 *	0.2 – 0.4	0.06	21.7	19.6
	Alegrete	31.9	23.7 – 42.9	4.81	15.1	38.3

* Preliminary estimates

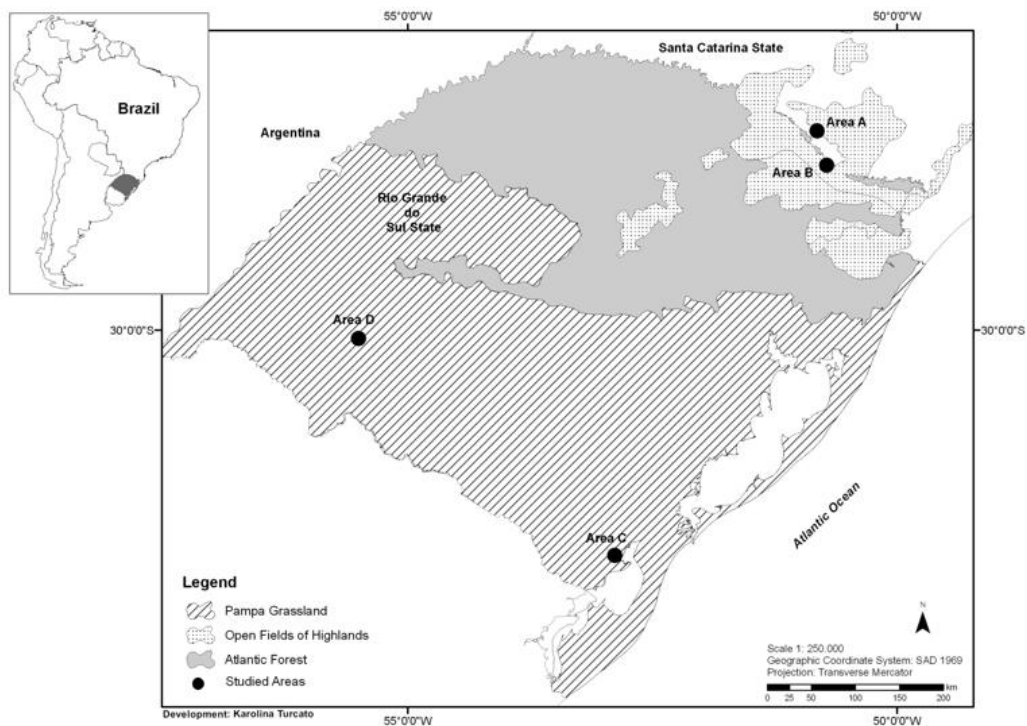


Figure 1: Locations of areas studied in southern Brazil.

Artigo III

**Dieta de *Conepatus chinga* e carnívoros simpátricos
no sul do Brasil**

**Trophic relations of sympatric small carnivores in fragmented landscapes
of southern Brazil: niche overlap and potential for competition**

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Abstract: Between 2000 and 2010, digestive tracts were collected of roadkilled carnivore along roads of Rio Grande do Sul State, in southern Brazil. These digestive tracts were analyzed to determine frequency and proportion of items in the diets of each species. Material was collected and analyzed from 194 animals of 10 species: *Cerdocyon thous*, *Lycalopex gymnocercus* (Canidae), *Procyon cancrivorus* (Procyonidae), *Galictis cuja* (Mustelidae), *Conepatus chinga* (Mephitidae), *Leopardus colocolo*, *Leopardus geoffroyi*, *Leopardus tigrinus*, *Leopardus wiedii* and *Puma yagouaroundi* (Felidae). Most of these species are sympatric in their distribution, which makes them potential competitors when sharing, to a greater or lesser degree, the same resources. We have summarized data about the sympatry of Carnivora at 22 sites of southern Brazil, and hereby present the general abundance levels of all species found in this region, based on personal observations along fifteen years of fieldwork. The local assemblages of carnivores in southern Brazil were composed of a mean of ten species (range of 7 to 13); the most common species being the Crab Eating Fox and the Crab Eating Raccoon, which were present in all studied areas, in relatively high abundances. The food niche breadth was relatively narrow, demonstrating that even generalist species, such as the Crab Eating Raccoon, use alimentary resources rather unequally. A great overlap (>90%) was found in food niches between species, especially among the cat species, grison and the Pampas fox, who have diets based on and dependent upon rodents. *P. cancrivorus* occupied a different food niche, based on aquatic or semi-aquatic prey and fruits. Yet, *C. chinga* proved to be unique in that it explores arthropods and insect larvae, in particular, as basic items in the diet. As expected, generalist species

are more abundant, although most species are specialists and occur in relatively low abundance.

Key words: food habitats, Neotropical region, niche breadth, niche overlap, sympatric species

Introduction

Southern Brazil is composed of a mosaic of Pampas Grasslands in the southern part of the state and of Atlantic Forest formations further to the north. The east of Rio Grande do Sul State, influenced by the Atlantic Coast, is composed of Pioneer Vegetation in a succession of coastal lagoons (IBGE 1986). This mix of influences from tropical and temperate regions makes southern Brazil a distinctive place, representing the southern limit of several species and a unique distribution location in the country, for others. However, this region also constitutes one of the most fragmented parts of Brazil, with very few protected areas, representing just 1% of the total area of Santa Catarina and Rio Grande do Sul States.

Animal communities in southern Brazil suffer practically no influence from top predators. The jaguar (*Panthera onca*) is restricted to one protected area, while the Maned Wolf (*Chrysocyon brachyurus*) was recently rediscovered, probably very close to extinction. The Giant River Otter (*Pteonura brasiliensis*) disappeared from this region since the 1950s, as well as the Bush Dog (*Speothos venaticus*), having probably occurred in southern Brazil and northeastern Argentina in the past (Fontana et al. 2003). The mountain lion (*Puma concolor*) continues to occur in some parts, but probably in low abundance over the region (Castilho et al. 2010; Mazzolli 1993). Thus, this assemblage of carnivores lives in a state of “mesopredator release” (Crooks and Soulé 1999), most likely without the effect of predators regulating their populations. This theory predicts that top predators can regulate the abundance of mesopredators, affecting prey base as well. The absence of top predators in the environment, then, can promote an explosion in the numbers of smaller predators, placing increased pressure upon their prey. However, another possible consequence of mesopredator release, usually not taken into account, is the increase of potential competition caused by an increase in predator abundance and the reduction of prey numbers.

Sympatry of carnivores is mediated by several ecological aspects which permit the coexistence of related species. Several studies have indicated that one of the most important features in ecological separation is related to dietary differences (Juarez and Marinho-Filho 2002; Konecny 1989; Ray and Sunquist 2001). These differences can be associated not specifically with how items are consumed but with what frequency, and with what each item represents in terms of acquired energy. Evidently, other features, like the differential use of micro habitats and time partitioning, hold great importance in the coexistence of sympatric species (Di-Bitetti et al. 2009; Faria-Correa et al. 2009; Vieira and Port 2007). However, knowledge of niche breadth and the degree of overlap of food habits among sympatric species can be considered one of the first steps in understanding the ecological structure of communities (Zapata et al. 2007).

The concept of guild was created to define groups of species that use the same resources in a similar way (Terborgh and Robinson 1986). This procedure simplifies the analysis of food webs, grouping species according to feeding habit similarities. These similarities can be interpreted as potential for competition, but never as a synonym, since many other factors are involved in the Competition Theory. One way to identify the existence of guilds is analyzing niche overlap among sympatric species (Pianka 1980).

In this study, we aimed to describe the food habits of 10 carnivores, analyze the niche breadth and niche overlap between sympatric species, and determine guild structure pattern. We also aimed to summarize the knowledge about general abundance of carnivores in southern Brazil and discuss the potential for competition among these species. We test the general assumption that species with generalist habits (food habits, in this case) are more common than specialist feeders.

Materials and Methods

Study Area: Southern Brazil comprises three states, of which Rio Grande do Sul is the southernmost; limited to the west by Argentina, the south by Uruguay, and the east by the Atlantic Ocean. Its position offers unique characteristics to the region, which represents the southern limit of the Atlantic Forest and the northeastern limit of distribution for the Pampas Grassland. To the east, along the coastal region is a strip of c.a. 50km wide that presents a succession of lagoons with a typical vegetal formation

called Pioneer Formations. Finally, in the northeastern portion of the state there exists the formation of open fields in the Highlands of the Atlantic Forest, at altitudes of 800 – 1200 m above sea level. All variables of these environments, including the transition zones, occur in an area less than 300,000 km².

Carnivore Surveys: Data from the carnivore assemblage was collected along 15 years (1995 – 2010) during several team activities. The surveys, which usually focused on medium-sized mammals, were done for scientific studies (e.g. Kasper *et al.* 2007a; Kasper *et al.* 2007b), and to analyze the impact of big enterprises, such as Thermolectric or Hydroelectric. We define as “sympatric” those species occurring in the same region from a landscape perspective. Species in sympatry in this manuscript should not be interpreted as “syntopic species” because specific preferential habitats could be potentially shared by more than one species, permitting various carnivore species to coexist. However, a particular species can be considered sympatric once part of its habitat is shared with other species existing in the same region.

We arbitrarily defined three categories of abundance: 1 – rare; 2 – common; 3 – abundant. These categories reflect the “general abundance” of species, which is determined by the perception of the researcher regarding the possibility of recording the species. Therefore, species were considered “rare” when they were recorded once or twice in a location, or sighted only after great effort; “abundant” species were found during practically all sampling by any method; “Common” refers to species easily found during sampling but usually in low numbers. The classification was based on direct visualizations, camera trap records, tracks, and carcasses of road kill. The effort of each location, as well as the number of records of each species was not quantified, but derived from the experience of the authors. We did not wish to define absolute abundance or specific indexes, but aimed to demonstrate which species occurred at each location, as well as and how common they were. Moreover, the objective was to present the composition of carnivore assemblages of southern Brazil, showing which species were sympatric, with potential of sharing resources.

Diet analysis: Between 2000 and 2010, we collected the digestive tracts of carnivore roadkill along highways in Rio Grande do Sul state. Stomachs and intestines were collected only from fresh carcasses (< 48 hs), and stored in 70% alcohol. At the laboratory, digestive tracts were opened to remove all contents, which were washed in current water over a mesh with openings of about 0.5mm diameter in order to remove

soluble parts. The macroscopic residuals were analyzed and compared to the reference collection and general literature, and were subjected to expert consultation. They were then identified to order level.

For diet analysis, we grouped trophic items into 11 main groups, which were then subdivided into 33 groups: Mollusk; Insect larvae; Adult Insects and Chelicerates (subdivided into Coleoptera, Orthoptera, Ephemeroptera, Homoptera, Hymenoptera, Isoptera, Dermaptera, Hemiptera, Ditera, Blataria, Lepidoptera, Opiliones, Spider and Scorpion); Crustaceans; Fish (Perciforme, Characiforme, Siluriforme and Symbrachiforme); Amphibians (Anura, Gymnophiona); Reptiles (Lizards, Snakes, Testudines); Birds; Mammals (Rodents, Marsupials, Carnivores, Carrion); Fruits; and Vegetal material (basically grass leaves). Representation of each food type in the diet was expressed as frequency of occurrence FO (the percentage of stomachs that presented that item, in relation to the total number of examined stomachs x 100); and percentage of occurrence PO (the frequency of each food item divided by the sum of the frequency of all items x 100). The FO% indicates how common an item was in the diet, while the PO% indicates the relative importance of an item in the diet. We also estimated the relative biomass of each item present in the diet. Percent Volume of each prey type in a particular stomach was estimated “by eye” (following Kruuk and Parish 1981 and Ray and Sunquist 2001) and scored on a nine-point scale: 0 (absence), 1 (<1%), 2 (1–5%), 3 (6–10%), 4 (11–25%), 5 (26–50%), 6 (51–75%), 7 (76–98%), and 8 (>98%). For calculations, scores were converted to the midpoint of each percent interval (1=0.5%; 2=3%; 3=8%; 4=18%; 5=38%; 6=63%; 7=87%; 8=99%). This analysis was done to prevent some possible bias in the interpretation of the other indexes (FO and PO), such as the constant presence of a small item with insignificant contribution in terms of biomass.

Food niche breadth was calculated using Levin’s (1968) index. The measurement of food niche breadth was standardized on a scale ranging from zero to one (Cowell and Futuyma 1971). A value close to one indicates a generalist habit, meaning a more equally distributed diet (i.e. prey items are consumed in more equal proportions to one another). A value close to zero means that very few prey categories are eaten at greater frequency, while most of the prey categories are eaten at lower frequency, characterizing a specialized diet. The overlap, or similarity of food habits between pairs of species was calculated using the Pianka index (Pianka 1973), defining

values ranging from 0 (total differentiation of food habits) to 1 (total overlap of food niche). The raw data for these analyses consists of the proportion in the diet of each food eaten, calculated from volumetric measurements for the 33 prey types. This is because quantification methods based on the biomass of prey are more adequate to estimate trophic relationships among vertebrate predators when prey sizes are variable (Fedriani and Travaini 2000). We have compared only the niche overlap of species with at least 10 stomach samples.

The matrix of biomass percentage of the 11 main food groups of all species was clustered through a technique called UPGMA, using the Morisita index, to identify which groups of species were similar in terms of food habits. We adopted a similarity of 50% as a cut-off point in order to determine a guild; following Fedriani and Travaini (2000), and similar to the value adopted by Zapata et al. (2007). We also identified the major axes of dietary variation based on the 11 main groups of prey items among carnivore species, using correspondence analysis (following Ray and Sunquist 2001).

We tested the correlation between our general abundance index of each species and its niche breadth. To this end, a Pearson's Correlation Test was performed using GraphPad InStat (GraphPad 2003).

Results

Carnivore Surveys: We present data from 22 carnivore surveys in Rio Grande do Sul (Figure 1), including the four major vegetal formations of the state: Coastal Region, Pampas Grassland, Atlantic Forest and high grasslands of the Atlantic Forest. For one location only, Aparados da Serra National Park, we used data from the literature (Santos et al. 2004). Table 1 summarizes our data of occurrence and general abundance of carnivores (systematic and phylogenetic ordering follows Wilson and Reeder 2005). Carnivore assemblages were composed of a mean of 10.5 sympatric species, ranging from 7 to 13 species. All 17 carnivore species occurring in Rio Grande do Sul were recorded in this survey. The top predators (*Chrysocyon brachyurus*, *Puma concolor* and *Panthera onca*) are almost extinct in the greater part of the region, and occur in low abundance where they persist.

The most common species were the crab eating fox (*Cerdocyon thous*) and the crab eating raccoon (*Procyon cancrivorus*), present in all studied areas in high

abundance. Two other species present in high abundance are the Pampas Fox (*Lycalopex gymnocercus*) and the Molina's Hog Nosed Skunk (*Conepatus chinga*), but are restricted to open areas or boundaries between forests / savannas. Two other very common species are: the Neotropical River Otter (*Lontra longicaudis*), present in practically all bodies of water (more than three to five meters wide); and the Grison (*Galictis cuja*), which occurs in all areas, but generally in low abundance. The Coati (*Nasua nasua*) is relatively common in the Atlantic Forest, but also occurs in some areas of wooded savanna, while the Tayra (*Eira barbara*) seems to be relatively rare and restricted to the Atlantic Forest.

All cats occur in relatively low abundance. Geoffroy's Cat (*Leopardus geoffroyi*) and the Pampas Cat (*Leopardus colocolo*) are restricted to Pampas Grassland; and the Little Spotted Cat (*Leopardus tigrinus*) and Ocelot (*Leopardus pardalis*) are restricted to the Atlantic Forest and associated formations. Margay (*Leopardus wiedii*) and the Jaguarundi (*Puma yagouaroundi*) are widely dispersed but occur in low abundance.

The richest areas are those formed by the association of Atlantic Forest with open fields, which occurs in the northeast of the state. In these areas, species restricted to forests mingle with species associated with open areas (but not restricted to the Pampa), such as *C. chinga*, *L. gymnocercus* and *C. brachyurus*. At the other extreme of carnivore diversity is the coastal region, where no species associated with forests occurs. The Atlantic Forest areas are highly diverse at conserved sites (as P.E. Turvo and Maquiné), but at altered sites there is a loss of several species. The Pampas region shows similar carnivore diversity among most sites investigated, despite landscape use.

General aspects of diet: We collected 198 digestive tracts of 10 carnivore species, of which 165 were analyzed to study food habits. Sixteen of that were totally empty. Another 17 contained remains of some items, such as a few hairs, small fragments of bones and exoskeleton. The quantities of these proved insufficient to indicate the taxon preyed upon (to order level), and to estimate a proportion of biomass ingested. The number of stomachs for each species was variable, ranging from 2 to 38, as well as the proportions of items that composed each diet (Table II). In these digestive tracts, we identified 520 items divided in 33 groups, summarized in table II.

Just four main groups of alimentary items were present in all diets: Insects, Birds, Mammals and Vegetal material. Insects, despite their conspicuous presence, are a vital component only for *C. chinga*, as the other species prey on few individuals, contributing in low amounts to biomass ingested (Table II). Birds are viewed in intermediary (or low) proportions, usually representing less than 15% of biomass ingested. This is surprising, as five of the studied species were cats. Mammals, on the other hand, are highly representative in the diets of most species, except *C. chinga* and *P. cancrivorus*, representing a mean of 75% biomass ingested for the other eight species (Table II). Grass was found in all diets analyzed, occurring at frequencies of 30% to 77% of the stomachs; but with very little participation in the biomass studied, representing less than 1% of biomass intake for all species.

The niche breadth of species was relatively narrow (Table III), indicating a non-equivalent use of food resources. The broadest niche was found for *P. cancrivorus*, followed by *C. thous*, *C. chinga* and *L. gymnocercus* with intermediary values. The narrowest niche was found for the cat species and for *G. cuja*. There is a small niche overlap between *C. chinga* and all species, suggesting a different food source. The same occurs with *P. cancrivorus*, presenting the least mean overlap (0.18 ± 0.18). Overlap in the feeding habits of *P. cancrivorus* was just as intermediary when paired with *C. thous* and *L. gymnocercus*. The feeding habits of *Cerdocyon thous* and *L. gymnocercus* overlapped extensively, as well as with *G. cuja*. The cat species exhibited the greatest overlap in food habits of all pairs of species, with values of >90% similarity, along with *L. gymnocercus*.

The correlation test indicates a high, positive correlation between niche breadth and the general abundance of species ($r = 0.9565$). Species with wider niche breadth tend to be more abundant than species with narrower niches.

After analyzing the food habits of these ten carnivores, the formation of three groups with similar food habits emerge (Figure 2), which can be interpreted as guilds. These divisions also become clear in correspondence analysis (Figure 3): the *C. chinga* is associated with insects; *P. cancrivorus* is associated with fruits, mollusks, crustaceans and fish; cats and *G. cuja* are associated with mammals. Foxes are grouped into the Cats/Grison group, but in intermediary position, influenced by the consumption of fruits, amphibians and mammals. Therefore, three basic guilds have been determined:

Insectivorous, Omnivorous, and Carnivorous/Frugivorous. The details of diet presented by each species of these groups of species are described below.

Conepatus chinga: The diet of the Hog Nosed Skunk was composed primarily of Insect Larvae and Insects / Chelicerates, together representing 72% of all biomass ingested. The main group found in the larvae was Coleoptera, with more than 90% of individuals. Into insects, the main groups found were Coleoptera (present in 63.0% of samples), Orthoptera (40.7%), Spiders (37.0%), Homoptera (22.2%), Ephemeroptera (18.5%) and Hymenoptera (14.8%). With intermediary importance in the skunk diet, the amphibian (Anura) was found present in 37.0% of stomachs, as well as mammals (basically Rodentia) (18.5%). The consumption of other items appears occasional, occurring in less than 10% of samples.

Procyon cancrivorus: The food habits of the Crab Eating Raccoon are highly associated with the use of wet habitats, evidenced by the consumption of crustaceans and amphibians, both present in 52.9% of stomachs. Along with the presence of mollusks (41.2%) and fish (29.4%), they represent more than 53% of all consumed items. This species is unique in that it consumes the amphibian Gymnophiona, an animal that lives in the middle of mud marshes, as well as *Symbrachus marmoratus* (Pisces: Symbranchiforme), occurring only in the raccoon diet. Fruits were consumed more frequently by the raccoons, than any other carnivore with an occurrence of 41.2%, and the greatest volume of biomass (almost 30%). Insects were present in 47.1% of stomachs, including the orders Coleoptera (present in 29.4% of samples), Orthoptera (23.5%), Ephemeroptera and Hemiptera (11.8% each one); but with very little contribution to the biomass ingested. Items of great importance for other species, such as mammals and birds, can be considered occasional in the raccoon diet, representing less than 10% of biomass intake.

Cerdocyon thous and *Lycalopex gymnocercus*: The Crab Eating Fox and the Pampas Fox have relatively similar diets. Both are based on mammals, representing nearly 50% of the biomass intake. Rodentia represents 68% of mammals ingested by *L. gymnocercus* and 75% by *C. thous*, and both species include some proportions of carrion in their diets. Fruits are an important item in the fox's diet, present in 42.3% of stomachs of the Crab Eating Fox and 38.9% of the Pampas Fox. However, the *C. thous* presented a wider niche breadth, consuming a bigger assortment of items. Another difference in the diets of these two species was evident in the proportion of amphibians

consumed, which represented one the most important items in the diet of the Crab Eating Fox. Insects are frequent in the diets of both species (present in 55.6% to 69.2% of the stomachs), but only for *L. gymnocercus* do they show importance in terms of biomass (12.6%). In two stomachs of Pampas Fox, Coleoptera and Orthoptera were the main food items, representing 75% – 99% of the biomass ingested.

Galictis cuja and Cat species: The Grison presents a diet based on mammals, especially Rodentia (representing more than 80% of predated mammals) and Dildelphimorphia (representing almost 70% of the biomass intake). The diet of *G. cuja* includes carrion. The species also presents a unique case in this study, consisting of intraguild (considering Carnivora as guild in this case) predation upon a juvenile *Conepatus chinga*. Prey with intermediary importance includes amphibians (Anura) present in 18.4% of stomachs, birds present in 15.8%, and reptiles (snakes in 7.9 % and lizards in 5.3% of samples). Other prey can be considered occasional, occurring in less than 10% of the samples.

As expected, cats show the narrowest niche breadth and the largest overlap in food niche. All five species have diets based on vertebrates, especially mammals that occur in 80% – 100% of stomachs. Birds were the second item of importance, but only with an intermediary frequency of occurrence, varying from 0% in *L. wiedii* and *L. colocolo* diets, to 40.0% in *Puma yagouaroundi*. Other items were occasional in the analyzed diets of cats, occurring in less than 10% of stomachs.

Discussion

Trophic guild relationships reveal an interesting pattern in which several species use very similar alimentary resources. Rodents comprise the most common taxon preyed upon, usually present in more than 75% of stomachs with great representation in terms of biomass. In part, this fact is related to the conspicuous presence of cats in the local assemblage of carnivores. Although not all species of cats occur in sympatry, Rio Grande do Sul State is the only region in which all cat species occur that are present in Brazil (Oliveira 1994). Originally, six cat species occurred in sympatry south of the state, and six species occurred in the northern part of the state, with the substitution of *L. geoffroyi* and *L. colocolo* in the south by *L. tigrinus* and *L. pardalis* in north.

Actually, the occurrence of small species is sustained, but big cats (*Panthera onca* and *Puma concolor*) are extinct in most of the original distribution.

Cat species (*Leopardus colocolo*, *L. geoffroyi*, *L. tigrinus*, *L. wiedii* and *Puma yagouaroundi*) feed almost exclusively on rodents, as well as *Galictis cuja* and *Lycalopex gymnocercus*. As a result, niche overlaps among these species are very high, with a 94.3% mean of similarity. The Pampas Fox (*L. gymnocercus*) shows great overlap (97%) in its feeding habits with the related species *C. thous*. Altogether, these eight species form a large guild, (dependent on the large scale of rodent consumption) that can be considered here as “Carnivorous/Frugivorous”. The degree of similarity found by this study shows the need for deeper analysis, probably to species level, as an attempt at understanding how these animals share alimentary resources. Obviously, other ecological and behavioral aspects play important roles in the coexistence of these species, such as time partitioning and the use of micro habitats (for living or foraging) on the landscape scale. However, this large group has at least one important subdivision, which is the grouping of foxes in a separate clade. This division is clearly associated with the consumption of fruits and amphibians by these fox species, differing from the rest. Therefore, it is possible to identify two guilds: Strictly Carnivorous (composed of *G. cuja* and the cat species), and the Carnivorous/Frugivorous (composed of the fox species).

The consumption of mammals, especially rodents, by small cats follows the general pattern observed in several studies (see Kruuk 1986) and is in accordance with that suggested by Van Val Kendburgh (1989), that cats specialize in the predation of mammals. However, no species included in this study can be considered well documented in terms of food habits as the bigger species like *Panthera onca*, *Puma concolor* and *Leopardus pardalis*. Moreover, very few studies have addressed the diets of small cats living in sympatry and their relationships to each other.

Leopardus geoffroyi is probably the best known among the small cats cited here. Studies in Argentina present diets based on small mammals, the most frequent item preyed upon by three groups, although “large mammals” and “large birds” are the categories most representative in terms of biomass (Manfredi et al. 2004), similarly to observed at coastal region of southern Brazil (Souza and Bager 2007). In accordance with our data, both works cited present the consumption of fish, amphibians, reptiles and insects in low proportion. Therefore, the Geoffroyi’s Cat seems to present a diet

based on small rodents, the most common item in practically all studied areas. However, the diet of *L. geoffroyi* includes bigger mammals whenever possible, such as Coypus (*Myocastor coypus*) and the European Hare (*Lepus europaeus*), as well as birds. Other items are occasional, and are eaten as a complement to the diet. This species shows some association to wetlands, such as marshes, riparian forests, and even rice crops (personal observation), which explains the occurrence of several aquatic and semi-aquatic prey like fish, amphibians, water snakes, aquatic birds, and mammals associated with marshes. The use of this specific habitat can help to explain the co-existence with other carnivores that show great values of niche overlap.

The diet of Jaguarondi described in this study is very similar to that previously published (Cheida et al. 2006; Manzani and Monteiro-Filho 1989; Oliveira 1994; Silva-Pereira 2011), including the preferential consumption of small mammals, birds and reptiles. Similarly to that found in Belize (Konecny *et al.* 1989), mammals were the most important item, representing almost 70% of biomass ingested, followed by birds, corresponding to more than 20% of biomass. The frequency of mammals is also similar to that described by Silva-Pereira (2011) in Brazil. We found clear indications of carcass consumption, also including remains of garbage in the stomachs, which demonstrates the potential for this cat to adapt. This plasticity of food habits of *P. yagouaroundi* can be further noted by the range of prey used, varying from small rodents to medium-sized mammals like as *Agouti* and *Mazama* (Cheida et al. 2006); and by the high rates of reptile consumption (Bisbal 1986) or bird consumption (Tewes and Schmidly 1987), representing important items in the diet. These variations are probably associated to the differences in food availability of different habitats used by this opportunistic predator.

The other *Leopardus* (*L. tigrinus*, *L. wiedii* and *L. colocolo*) present diets based almost exclusively on rodents. The dominance of rodents in the cat diet differs from the Wang study (2002) that presents diets with a conspicuous presence of marsupials, but is congruent with the studies of Silva-Pereira et al. (2011). It is hereby very important to cite that southern Brazil is relatively poor in species and abundance of small marsupials, especially in the Pampa biome from which comes the majority of carnivore samples. Differing from the Atlantic Forest of southeastern Brazil, Cerrado and Amazonia, few Didelphimorphia occur in southern Brazil. This reflects in the low occurrence of these animals in carnivore diets dominated by rodents. Although we had collected few

samples of Margay and the Pampas cat, only *L. tigrinus* included birds in its diet, though in low proportion. This is remarkable as all previous studies cited birds as an important alimentary resource. An interesting fact was observed with *L. tigrinus*, as the content of one sample consisted exclusively of butterflies (Lepidoptera). The consumption of insects by this species was also described by Olmos (1993) in the Caatinga. However, as cited by Oliveira (1994), it probably represents little in terms of energetic contribution. In the Caatinga, the Little Spotted Cat preys extensively on lizards (mainly *Ameiva ameiva* and *Tropidurus hispidus*) (Olmos 1993). Once again, it is necessary to pay attention to regional differences, as southern Brazil is much colder than the northern portion, and lizards are rare in comparison to the northeastern region (personal observations). The opposite is true for rodents; that they are more abundant in the south than in Caatinga, where the density of rodents tends to be low (Oliveira, 1994).

In southern Brazil, *G. cuja* bases its diet on rodents, although other small vertebrates are included, such as amphibians, reptiles and birds, aside from insects in low proportions. Studies from Argentina describe the Grison diet as being based on rodents and introduced lagomorphs, composing more than 95% of biomass intake (Delibes et al. 2003). Similarly, Zapata et al. (2005) found a diet based on rodents (56% of biomass) and lagomorphs (34.5%) from the southern limit of species distribution, while Ebensperger et al. (1991) described *G. cuja* as preying upon rabbits, rodents and small marsupials in central Chile. Therefore, all studies are congruent in that Grisons basically feed on small mammals, and their efforts are improved opportunistically by other small vertebrates. All studies also agree that insects and vegetal items do not have appreciable energetic contribution.

The overlap of food niches between *G. cuja* and the small cats cited here are remarkable, with indexes of up to 95% similarity. However these species probably have very different foraging strategies. While cats in general are known for preparing traps and ambushing, the Grison is known locally for the behavior of tirelessly following *Cavia* spp. (Silva 1994), sometimes for hours (personal observations). The majority of rodents found in the stomach contents were of the Muridae species which is mostly known to have nocturnal habits. This is interesting because the activities of *G. cuja* in southern Brazil can be considered predominantly diurnal (personal observations). These facts permit us to hypothesize that foraging strategies of this species can be associated

with locating and attacking den sites and nests of its preys. This hypothesis is also cited by Delibes et al. (2003), and supported by some stomach contents that have included rat cubs just a few days old.

However, the dependence of mammal consumption extends to fox species, especially *L. gymnocercus*. About 50% of the biomass intake of foxes was mammals, in contrast to the other species cited above, which are more dependent on rodents (mean of 84%). As a result, we have interpreted foxes to be separate from the strict carnivores, as their diets include a great amount of other food sources. The similarities of food habits also become clear in niche overlap, which is greater between each other than among any other species. The Crab Eating Fox shows a niche breadth a little larger than *L. gymnocercus*, including more items consumed more equitably. The Pampas Fox eats more insects / chelicerates than *C. thous*, as well as rodents and carcasses. On the other hand, *C. thous* eats more amphibians, reptiles and (principally) fruits than *L. gymnocercus*. We classified the foxes as Carnivorous / Frugivorous in southern Brazil, because their diet is dominated by rodents (although not as exclusively as cats and the Grison), and includes fruits, which can be very important in some areas. We not classify foxes as omnivorous because the proportion of food items consumed are very unequal, presenting the narrowest niche breadth in comparison with the Crab Eating Raccoon.

The Pampas Fox in our study presents a diet similar in many ways to the studies of Vieira and Port (2006), conducted at a location including our entire study area. In both studies, rodents were the basic prey of *L. gymnocercus*, which also preys on insects, fruits, birds and reptiles. The predominance of rodents in the diet is not a constant in the studies of this species, as observed in Argentine studies (Farias and Kittlein 2008; Garcia and Kittlein 2005; Varela et al. 2008). Insects are important items in the diet of this species, usually present in more than 50% of samples, (Farias and Kittlein 2008; Vieira and Port 2007), and may possibly be the most important item of its diet in some regions (Varela et al. 2008). The proportion of insects in the Pampas Fox diet was larger than all other carnivores in our data, except for *C. chinga* which presented a diet specialized in this item, as discussed below. Amphibians are an item rarely cited in the diet of this species, but occur in intermediary frequency in our study. This can be associated to relatively dry and cold habitats; the environments in which the studies on *L. gymnocercus* were usually conducted. Fruits were frequent in the diet of the Pampas Fox, but were little represented in terms of biomass consumed. This kind of

food can be the most important in the diet of this species, as observed by Varela et al. (2008) but in southern Brazil it is usually less frequent than the observed diets of *C. thous* and *Procyon cancrivorus* (Cheida et al 2006).

In the diet of the Crab Eating Fox, fruits are an important resource, cited by many authors along species ranges, although there is great variation in the consumption rate. This species is characterized as an opportunistic predator that presents a diet varying according to availability, seasonality, and social aspects (Courtenay and Maffei 2004). To exemplify the plasticity of food habits of the Crab Eating Fox, we can cite some works concentrating only on the southern and southeastern regions of Brazil. In the Restinga of the Atlantic Forest, Raíces and Bergallo (2010) found fruits in 89% of fecal samples, and reptiles in more than 40%, while mammals were present in 50% of samples. In a mosaic of the Atlantic Forest with Araucaria and Natural Grasslands, vertebrates were present in only 36% of stomachs analyzed, while fruits were present in 93% of samples (Rocha et al. 2008). In Rio Grande do Sul State, the southernmost region of Brazil, fruits were totally absent in the *C. thous* diet at one locality (Pedó et al. 2006) and were present only in intermediary importance in our study. It is important to note that the lack of fruit in this population's diet probably doesn't represent any availability of the resource, as the diet of the Crab Eating Raccoon at a location near the study area related by Pedó et al. (2006) was composed of fruits by more than 50% (Pellanda et al. 2010). Moreover, in our study *P. cancrivorus* eats fruits in high frequency, using basically the same habitat of *C. thous*.

Analysis of diet similarity and niche breadth reveals that *P. cancrivorus* has the widest niche breadth among studied species. The Crab Eating Raccoon presents a diet very different from the others species, beginning with the least consumption of mammals among all species; a characteristic common to other study sites (Gatti et al. 2006; Pellanda et al. 2010; Santos and Hartz 1999). For this reason the species is alone in a clade with the least mean overlap in alimentary habits; except for *C. thous* which presents relatively high similarity (0.56%), but much less than previously reported by Gatti et al. (2006) of 96%. *Procyon cancrivorus* presents the most frugivorous food habits in this study, although the frequencies of occurrence were lower than in previous reports from southern Brazil (Gatti et al. 2006; Pellanda et al. 2010; Santos and Hartz 1999). On the other hand, our data shows a consumption of amphibians and crustaceans much higher than reported by the same authors. Moreover, we present here a

representative consumption of mollusks not reported by cited works. The consumption of this item is probably even more important than we estimate, as this group of prey was identified only by the operculum, consisting of little in terms of biomass (by the method adopted here). Therefore, the Crab Eating Raccoon can be considered omnivorous, as it consumes from a great variety of alimentary resources. This diet is associated with wet habitats, as aquatic animals, such as mollusks, crustaceans, fish and amphibians, represent more than 55% of biomass intake.

Finally, the least identified clade is represented by *C. chinga*, which presents a diet based on insect larvae and other arthropods. Many authors set these two items together under the grouping Insect, but we prefer to separate them by Larvae and Adults, as they represent two different ways of foraging. The foraging behavior of the Molina's Hog Nosed Skunk in southern Brazil seems to be based on actively looking for insect larvae. The skunk continually moves through open fields, stopping every few meters to dig little holes so that it can catch larvae and insects buried underground (personal observations). The importance of insects and insect larvae is reported in all previous studies (Donadio et al. 2004; Medina et al. 2009; Peters et al 2011; Travaini et al. 1998), with frequencies of occurrence greater than 80%. However, the importance of insect larvae is variable in these studies, varying from insignificant levels (Travaini et al. 1998) to being the main prey (Medina et al. 2009). In southern Brazil we believe that its basic foraging strategy focuses on the search for larvae, representing the main food item of the skunk's diet in this region, responsible for almost 50% of biomass intake. Our data are congruent with the study of Peters et al (2011), about the feeding habits of *C. chinga* in southern Brazil, which cited Insects (mostly Coleoptera and Orthoptera), as the most important item of the skunk diet. Unfortunately this study, don't separate larvae from adult insects, although the authors cite the consumption of this item.

Although they forage for insects and larvae, skunks are clearly opportunistic predators, and several other food items found in their search can be included in the diet, such as mammals, reptiles, and amphibians. Vertebrate prey occurs mainly in low frequency compared to arthropods, but probably has great importance in terms of biomass and energetic profit. The foraging of vertebrates probably does not expend greater energetic cost than that usually spent in the search for arthropods, as it probably does not involve the pursuit of prey; but only locating it in burrows or discovering inactive prey (in the case of reptiles and amphibians). Another important source of food

is carrion, found in only one stomach in our study, but important in other study sites, generally arid habitats (Donadio et al. 2004; Medina et al. 2009; Travaini et al. 1998). Moreover, skunks take advantage of some temporarily available resources, such as eggs of fresh water turtles during the nesting season and ground birds. The consumption of eggs was not recorded in our samples, but probably represents an important energetic supply in some regions, such as the coastal region of southern Brazil and Uruguay where a study reported the predation of 98% of turtle nests, 31% of it done by *C. chinga* (Gonçalves et al. 2007). In a study of the spatial ecology of *C. chinga* (Kasper et al. submitted.), several observations were made on skunks preying on turtle and bird nests to eat eggs, mainly in Summer. Nest predation is the subject of studies and management of other Mephitidae species like *Mephitis mephitis* and the waterfowl in Canadian prairies (Larivière and Messier 1998).

The consumption of vegetal material by carnivores is a controversial theme. Almost all studies refer to the inclusion of vegetables in the carnivore's diet, but there is great doubt regarding the function of this material. The use of some indexes can lead to erroneous interpretation as well. In our study, for example, if we consider only the percentage of occurrence (PO), a common method in diet studies, we may conclude that cats have diets composed of 22.2 to 50.0% vegetables. This is an indication of frugivorous species, more so than of *C. thous* and *P. cancrivorus*. These values are totally far from reality, as the biomass ingested of vegetal material represents less than 1%, because it is composed exclusively of grass leaves. Therefore, it is necessary to use caution when interpreting some indexes. An example of this is an observation by Trovati et al. (2008) who cited that vegetal material composed 29% of the diet of felids (using PO); a result that certainly affected their analysis of convergence / divergence between the diets of canids and felids.

As expected, abundance of small carnivores seems related to alimentary niche breadth, as is seen in the correlation test. Species with wider niche breadth are apparently more abundant than species with narrower niche amplitude. However, it is interesting to note that several species base their diets on the same specific item - rodents. This was not expected, as it would be assumed that specialist species specialize in different food resources to avoid competition. The coincidence in the use of the same resources can be associated with super-abundance in availability, but this hypothesis was not tested by us. In any case, it seems clear that the small carnivores evaluated in

this study present a high potential for resource competition, especially among cats, the Grison and the Pampas Fox; between the Pampas Fox and the Crab Eating Fox; and in smaller amounts between the Crab Eating Fox, the Grison and Crab Eating Raccoon. The means by which these species exploit available resources and how they avoid competition must be studied more in depth. This work merely represents a small step toward understanding how carnivore assemblages are structured.

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Table I: General Abundance of sympatric carnivores in 22 localities of Southern Brazil; 1 - Rare; 2 – common; 3 – Abundant.

Locations	<i>Leopardus colocolo</i>	<i>Leopardus geoff royi</i>	<i>Leopardus pardalis</i>	<i>Leopardus tigrinus</i>	<i>Leopardus wiedii</i>	<i>Puma concolor</i>	<i>Puma yagouaroundi</i>	<i>Panthera onca</i>	<i>Cerdocyon thous</i>	<i>Chrysocyon brachyurus</i>	<i>Lycalopex gymnocercus</i>	<i>Eira barbara</i>	<i>Galictis cuja</i>	<i>Lontra longicaudis</i>	<i>Conepatus chinga</i>	<i>Nasua nasua</i>	<i>Procyon cancrivorus</i>	Number of species
Taim ⁺		2							3		3		2	2	3		3	7
Arroio Grande *		2			1		1		3		3		1	2	3		3	9
Capão do Leão *			1		1		1		3		3		1	2	3	1	3	10
Cerrito *			1		1		1		3		3		1	2	3	1	3	10
Piratini *	1	1			1		1		3		3		1	2	3	1	3	11
Pinheiro Machado *	1	1			1		1		3		3		1	2	3		3	10
Pedras Altas *	1	1			1		1		3		3		1	2	3		3	10
Canguçu *			1		1		2		3		3		1	2	3		3	9
Pelotas *			1		1		2		3		3		1	2	3		3	9
Bagé *	1	1			1		1		3		3		1	2	3		3	10
Candiota *	1	1			1		1		3		3		1	2	3		3	10
Hulha Negra *	1	1			1		1		3		3		1	2	3		3	10
Caçapava *	1	1			1	1	1		3	?	3		1	2	3		3	11
Alegrete *	1	1			1		1		3		3		1	2	3		3	10
Encruzilhada do Sul *	1	1			1	1	1		3	?	3		2	2	3	2	3	12
Bom Jesus **			2	1	1	1	1		3		3	1	1	2	2	2	2	13
S. Francisco de Paula **			2	2	1	1	1		3	1	3	1	1	2	2	2	3	13
P. N. Aparados da Serra **			3	2		2	1		3	1	3	1	1	1	2	2	3	13
Maquiné ***			2	1	1	1	1		2			1	1	2	1	2	3	12
P.E. do Turvo ***			3	1	1	1	2	1	1			2	1	1		3	2	12
Morro Gaúcho ***				2	2		1		3			1	1			2	2	8
Cruzeiro do Sul ***				2	1		2		3			2	2	2	1		3	9
Abundance index	9	17	12	10	22	8	25	1	63	(4)	54	9	26	40	53	18	63	

⁺ Costal region; * Pampas Grassland; ** Open fields of the Atlantic Forest Highlands; *** Atlantic Forest; P.N. Aparados da Serra (Santos et al. 2004)

Table II: Frequency of occurrence / Percentage of Occurrence / Proportional Volume (all values expressed in %) of 11 prey classes in carnivore diets of eight species in southern Brazil.

Prey class		<i>Leopardus colocolo</i> (2)	<i>Leopardus geoffroyi</i> (14)	<i>Leopardus tigrinus</i> (10)	<i>Leopardus wiedii</i> (3)	<i>Puma yagouaroundi</i> (10)	<i>Cerdocyon thous</i> (26)	<i>Lycalopex gymnocercus</i> (18)	<i>Galictis cuja</i> (38)	<i>Conepatus chinga</i> (27)	<i>Procyon cancrivorus</i> (17)
Mollusks	FO	-	-	-	-	-	-	-	-	-	41.2
	PO	-	-	-	-	-	-	-	-	-	12.5
	% vol	-	-	-	-	-	-	-	-	-	7.1
Insect larvae	FO	-	-	10.0	-	-	11.5	16.7	2.6	81.5	5.9
	PO	-	-	5.6	-	-	3.0	5.4	1.5	29.7	1.8
	% vol	-	-	0.1	-	-	0.7	1.1	0.1	44.7	0.1
Insects and Chelicerates	FO	-	21.4	20.0	-	10.0	69.2	55.6	2.6	81.5	47.1
	PO	-	11.1	11.1	-	4.3	18.2	17.9	1.5	29.7	14.3
	% vol	-	0.1	10.2	-	0.1	3.4	12.6	0.1	27.2	5.0
Crustaceans	FO	-	-	-	-	-	3.8	-	-	-	52.9
	PO	-	-	-	-	-	1.0	-	-	-	16.1
	% vol	-	-	-	-	-	0.1	-	-	-	12.8
Fish	FO	-	-	-	-	-	7.7	-	2.6	-	29.4
	PO	-	-	-	-	-	2.0	-	1.5	-	8.9
	% vol	-	-	-	-	-	0.8	-	1.0	-	11.6
Amphibians	FO	-	7.1	-	-	-	53.8	22.2	18.4	37.0	52.9
	PO	-	3.7	-	-	-	14.1	7.1	10.8	13.5	16.1
	% vol	-	7.1	-	-	-	12.2	5.1	6.1	10.5	23.6
Reptiles	FO	-	7.1	-	-	10.0	19.2	11.1	13.2	11.1	-
	PO	-	3.7	-	-	4.3	5.1	3.6	7.7	4.1	-
	% vol	-	0.6	-	-	6.3	6.2	2.6	8.3	2.4	-
Birds	FO	-	21.4	10.0	-	40.0	26.9	16.7	15.8	3.7	17.6
	PO	-	11.1	5.6	-	17.4	7.1	5.4	9.2	1.4	5.4
	% vol	-	6.8	3.8	-	22.2	8.8	7.7	13.7	0.1	6.6
Mammals	FO	100	92.9	90.0	100	90.0	76.9	77.8	78.9	18.5	17.6
	PO	66.7	48.1	50.0	50.0	39.1	20.2	25.0	46.2	6.8	5.4
	% vol	99.0	83.7	84.3	99.0	68.3	46.0	53.2	69.9	14.2	6.5
Fruits	FO	-	-	-	-	-	42.3	38.9	-	-	41.2
	PO	-	-	-	-	-	11.1	12.5	-	-	12.5
	% vol	-	-	-	-	-	24.3	12.5	-	-	28.7
Vegetal material	FO	50.0	42.9	50.0	100	80.0	69.2	72.2	36.8	40.7	23.5
	PO	33.3	22.2	27.8	50.0	34.8	18.2	23.2	21.5	14.9	7.1
	% vol	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.2	0.2	0.3

Table III: Niche Breadths*, Standardized niche breadth (B_{sta}) †, food niche overlap, between pairs of eight carnivores in Southern Brazil.

Carnivores species	<i>Leopardus geoffroyi</i> (14)	<i>Leopardus tigrinus</i> (10)	<i>Puma yagouaroundi</i> (10)	<i>Cerdocyon thous</i> (26)	<i>Lycalopex gymnocercus</i> (18)	<i>Galictis cuja</i> (38)	<i>Conepatus chinga</i> (27)	<i>Procyon cancrivorus</i> (17)	Mean niche overlap (± SD)	Niche breadth (B)	Standardized niche breadth (B_{sta})
<i>Leopardus geoffroyi</i>	X								0.69±0.35	1.39	0.04
<i>Leopardus tigrinus</i>	---	X							0.63±0.38	1.50	0.04
<i>Puma yagouaroundi</i>	0.94	0.92	X						0.69±0.35	2.46	0.09
<i>Cerdocyon thous</i>	0.79	0.76	0.79	X					0.71±0.21	4.58	0.25
<i>Lycalopex gymnocercus</i>	0.93	0.92	0.92	0.97	X				0.75±0.29	4.06	0.19
<i>Galictis cuja</i>	0.98	0.96	0.97	0.81	0.94	X			0.71±0.35	2.69	0.09
<i>Conepatus chinga</i>	0.23	0.21	0.21	0.26	0.29	0.23	X		0.23±0.04	4.23	0.23
<i>Procyon cancrivorus</i>	0.06	0.01	0.08	0.56	0.30	0.10	0.16	X	0.18±0.18	6.01	0.45

* Niche Breadth (B) was calculated for 34 prey types, ranging from 1 (the narrowest niche) to 34 (the broadest niche); † B_{sta} was calculated for the 11 main groups of prey; --- does not occur in sympatry

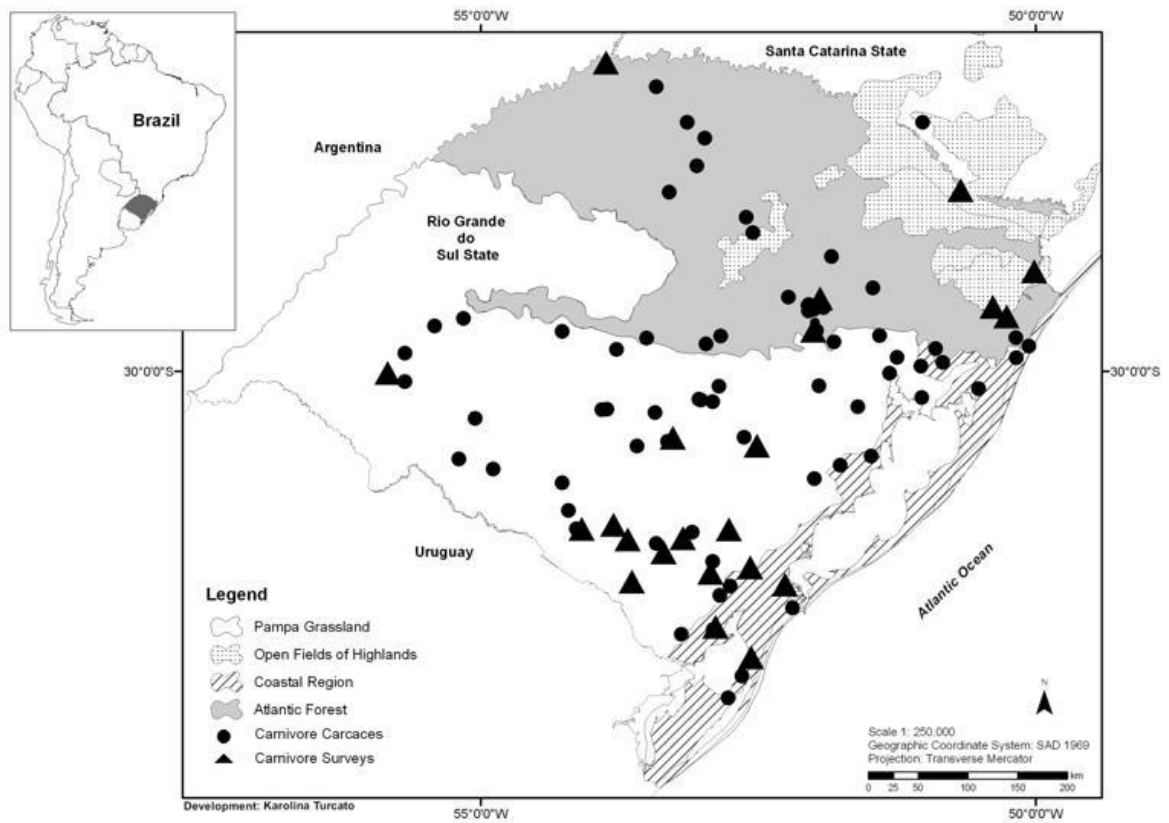


Figure 1: spatial distribution of Carcasses collected and Carnivore Surveys, at southern Brazil.

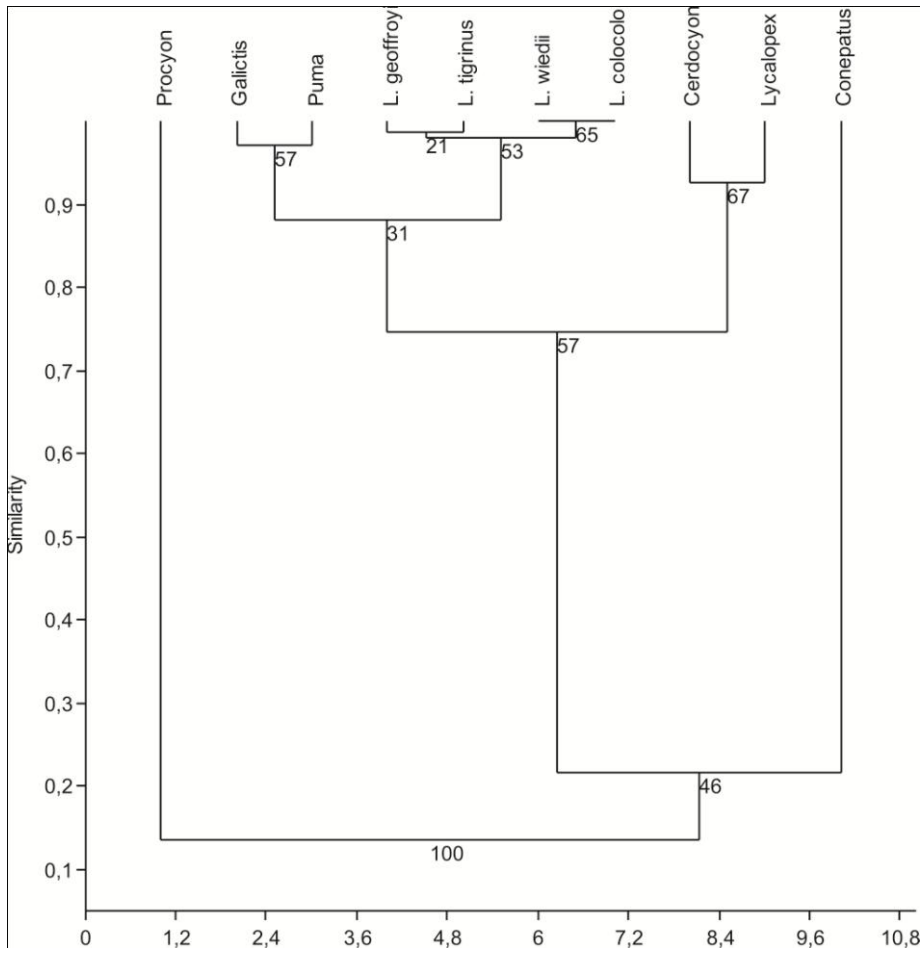


Figure 2: Analysis of similarity (Morisita Index) in the diets of 10 carnivore species of Southern Brazil, calculated by the biomass percentage of 11 main food groups; Values under nodes are the percentages of correspondence in a Bootstrap of 1000 repeats.

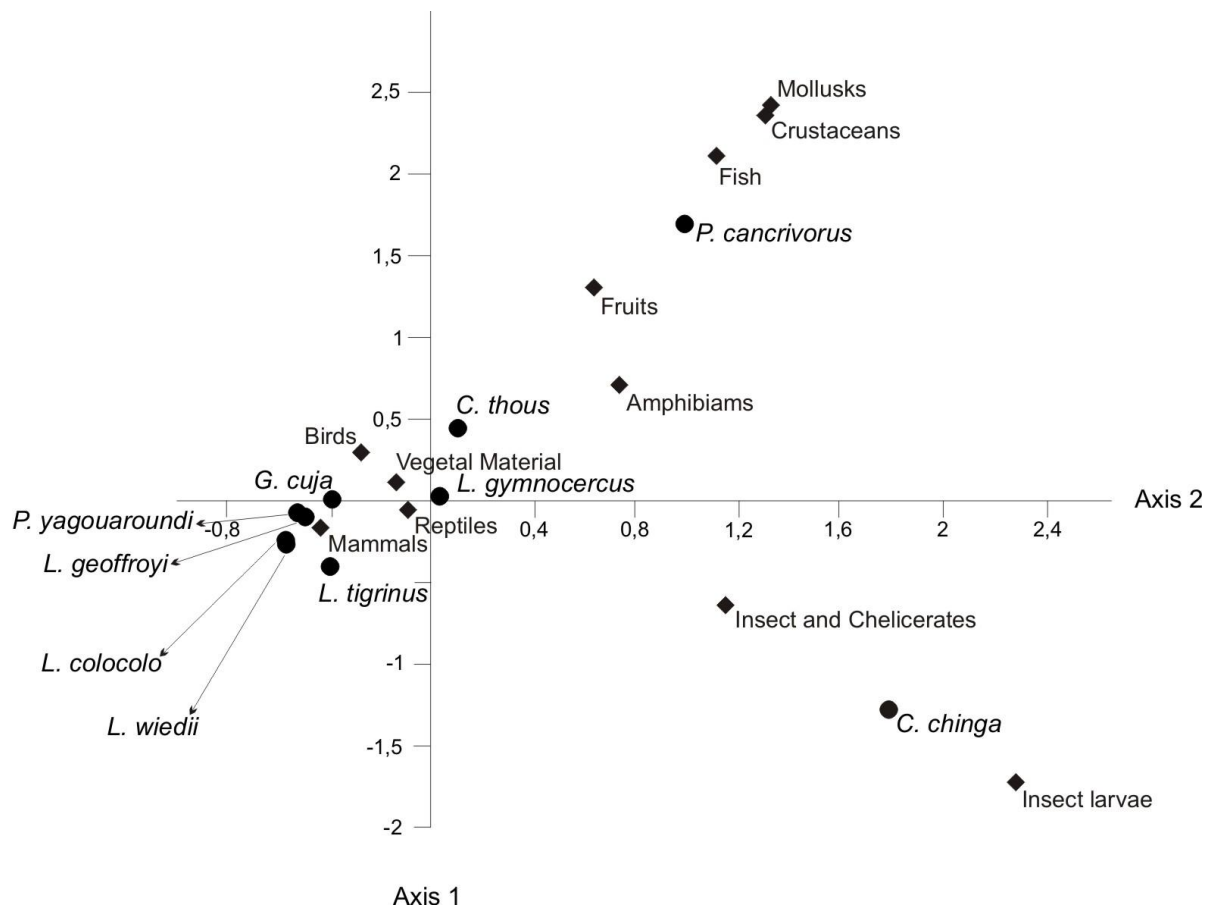


Figure 3: Correspondence analysis of the main food groups (lozenges) in the diet of 10 carnivores (circles) of southern Brazil. The first axis accounts for 44.9% of the total variation (84.4%); the second axis accounts for 39.5%.

Síntese dos resultados

Ecologia Espacial

- Foram capturados 22 zorrilhos, dos quais em 18 foram colocados rádio colares para monitoramento por telemetria;

- Embora não tenha sido encontrada diferença na proporção sexual ($\chi^2_1 = 2.909$; $P = 0.0881$), foi encontrado dimorfismo sexual em relação ao tamanho, sobretudo no que se refere ao peso, com machos sendo 40% mais pesados que as fêmeas;

- Neste estudo, o peso dos zorrilhos machos foi significativamente maior que o dos machos que ocorrem na Argentina ($t_{12}=5.3513$; $P = 0.0002$). Embora não apresentem diferença no comprimento total, os zorrilhos brasileiros possuem o comprimento da cauda significativamente menor ($t_8=8.0398$; $P < 0.0001$) do os indivíduos medidos por Castillo et al. (2011);

- A área de vida média estimada para a espécie foi de $1.65 \pm 1.17 \text{ km}^2$, com machos utilizando áreas significativamente maiores que a das fêmeas ($P = 0,0035$), correspondendo a $2.55 \pm 1.37 \text{ km}^2$ para machos e $1.00 \pm 0.31 \text{ km}^2$ para fêmeas. Os valores encontrados são similares àqueles encontrados por Castillo et al. (2011) na Argentina, tanto na comparação entre machos ($t_{10}=0.1793$; $P=0.8613$) quanto entre fêmeas ($t_{14}=0.7615$; $P=0.4590$);

- A sobreposição das áreas de vida foi altamente variável, sendo em média 46% (variando de 9 a 100%) entre pares de machos e fêmeas, 28% (variando de 16 a 49%) entre fêmeas vizinhas, e 24% (variando de 0.5 a 70%) entre machos com sobreposição de áreas, sendo estas diferenças não significativas ($H_2 = 2.9850$; $P = 0.2248$);

- A distância entre animais em localizações simultâneas demonstrou diferença significativa ($F_{2,185} = 33.608$; $P < 0.0001$), com machos mais distantes entre si (média de $1510 \pm 744 \text{ m}$) do que entre pares de fêmeas (distantes em média $700 \pm 292 \text{ m}$) e pares de machos e fêmeas (distantes em média $734 \pm 416 \text{ m}$), ambos com valor $P <$

0,01. Já entre pares de machos e fêmeas e pares de fêmeas com áreas contíguas, não houve diferença significativa ($P > 0.05$);

- Os padrões de deslocamentos são congruentes com a diferença de tamanho das áreas de vida, com machos apresentando deslocamentos em média cerca de duas vezes maiores que as fêmeas. A distância entre abrigos utilizados em dias subsequentes foi de em média 473 ± 103 m para machos e 243 ± 143 m para fêmeas; a distância percorrida entre os locais em que os indivíduos foram registrados em atividade em noites subsequentes foi de em média 470 ± 196 m para machos e 265 ± 53 m para fêmeas; A distância entre o local de descanso e a área onde foi registrada em atividade em dois períodos subsequentes foi de em média 512 ± 132 m para machos e 246 ± 87 m para fêmeas; Todas as comparações entre machos e fêmeas foram altamente significativas ($P < 0,0001$);

- De um total de 315 abrigos, foram identificados seis tipos básicos de abrigos: buracos no solo (56% dos abrigos utilizados), em meio à vegetação (20%), sob troncos, galhos ou palha (9%), construções humanas (8%), em meio a bambuzais (5%) e a céu aberto (2%);

- Os abrigos localizaram-se majoritariamente em campo aberto (53%) e foram utilizados na maioria dos casos (68%) durante apenas um dia;

- Fêmeas tendem a reutilizar mais os abrigos do que machos (38% e 23% respectivamente), sendo esta diferença significativa ($t_6 = 9.1280$; $P < 0.01$);

- Os hábitos dos zorrilhos mostram-se quase que exclusivamente noturnos, iniciando sua atividade logo após o por do sol e cessando antes do dia raiar; O pico de atividade ocorre entre 20:00 e 03:00 h, período no qual mais de 80% das leituras de atividade dos indivíduos monitorados se mostraram “ativos”.

Abundância de *C. chinga* e outros mamíferos de médio porte

- Em um total de 1811 km de transectos percorridos, foram obtidas 620 visualizações de 20 espécies de mamíferos de médio e grande porte, 41% das quais da lebre (*Lepus europaeus*).

- Carnívora foi o grupo mais comumente registrado, correspondendo a 51% das visualizações, com 10 espécies registradas;

- O zorrilho foi à espécie mais comum em uma das quatro áreas estudadas e o carnívoro mais abundante em duas das áreas estudadas;

- O graxaim-do-mato (*Cerdocyon thous*), o graxaim-do-campo (*Lycalopex gymnocercus*) e a lebre (*Lepus europaeus*) foram às espécies mais registradas nas áreas A, B e D deste estudo respectivamente;

- A densidade de *L. europaeus* foi estimada em 31.9 indivíduos por km² em uma das áreas do estudo, sendo esta a maior estimativa de densidade já registrada para América do Sul;

- Foram feitas estimativas preliminares da densidade de *C. thous* e *L. gymnocercus* para duas áreas de estudo, obtendo valores de 0,4 a 0,9 indivíduos por km² e 0,2 a 1,1 indivíduos por km², respectivamente. Estas estimativas são congruentes às previamente descritas na literatura;

- A densidade populacional de *C. chinga* foi estimada em 1,1 a 3,8 indivíduos por km², sendo estas as primeiras estimativas geradas com a utilização de métodos de “Distance Sampling”;

- As estimativas da densidade de *C. chinga* apresentam valores duas vezes maiores do que os obtidas por Castillo et al. (2011), na Argentina, com o uso de dados de telemetria;

- Estas estimativas apresentam um valor bastante inferior ao citado por Emmons e Helgen (2008) no site da IUCN, e por este motivo de grande importância para conservação;

- Aparentemente, a abundância de *C. chinga* no Pampa, especialmente na região da campanha, é muito superior ao encontrado nos campos de altitude dos Campos de Cima da Serra.

Dieta de *C. chinga* e de carnívoros simpátricos

- A simpatria de carnívoros no sul do Brasil é demonstrada na apresentação de dados de ocorrência da assembléia de carnívoros de 22 áreas no Rio Grande do Sul;

- A maioria das espécies ocorre em todo estado à exceção de algumas espécies exclusivas de áreas campestres como *Conepatus chinga*, *Lycalopex gymnocercus* (sendo que estas espécies ocorrem tanto no pampa como nos campos de altitude da Mata Atlântica) *Leopardus geoffroyi* e *Leopardus colocolo* (restritas ao Pampa), ou a áreas florestais como *Eira barbara*, *Leopardus tigrinus* e *Leopardus pardalis*;

- Foram analisados 198 conteúdos estomacais de 10 espécies de carnívoros: *Leopardus colocolo*, *Leopardus geoffroyi*, *Leopardus tigrinus*, *Leopardus wiedii*, *Puma yagouaroundi* (Felidae), *Cerdocyon thous*, *Lycalopex gymnocercus* (Canidae), *Galictis cuja* (Mustelidae), *Conepatus chinga* (Mephitidae) e *Procyon cancrivorus* (Procyonidae);

- Foram encontrados 520 itens alimentares, pertencentes a 11 grandes grupos de presas e a 33 táxons (identificados na maioria ao nível de ordem), a saber: Moluscos, Larvas de inseto, Insetos adultos Quelicerados (subdivididos em Colleoptera, Orthoptera, Ephemeroptera, Homoptera, Hymenoptera, Isoptera, Dermaptera, Hemiptera, Diptera, Blatária, Lepidoptera, Opiliones, Aranhas e Escorpiões), Crustáceos, Peixes (Perciforme, Characiforme, Siluriforme e Symbrachiforme), Anfíbios (Anura, Gymnophiona), Répteis (Lagartos, Serpentes, Tartarugas), Aves, Mamíferos (Rodentia, Didelphimorphia, Carnivora, carniça), Frutas e material vegetal (composto basicamente por folhas de gramíneas);

- Apenas três grandes grupos de itens alimentares estiveram presentes em todas as dietas: Insetos (pouco importantes para maioria das espécies), Aves (ocorrendo geralmente em proporções intermediárias) e Mamíferos destacando, sobretudo os roedores (que formam a base da dieta da maioria das espécies analisadas);

- Folhas de gramíneas, classificados neste estudo como “Material vegetal”, também foram encontradas em todas as dietas, ocorrendo em 30 a 77% dos estômagos, mas provavelmente com pouquíssima participação em termos energéticos, já que representam menos de 1% da biomassa consumida;

- A amplitude de nicho se mostrou relativamente estreita, indicando que as espécies utilizam seus recursos alimentares de forma não-equivalente. A maior amplitude de nicho encontrada foi à de *P. cancrivorus*, seguido por *C. thous*, *C. chinga* e *L. gymnocercus* com valores intermediários. Como esperado, *G. cuja* e os pequenos

felinos apresentaram as menores amplitudes de nicho, o que demonstra sua maior especialização quanto aos hábitos alimentares;

- No que se refere à sobreposição de nicho, *P. cancrivorus* e *C. chinga* apresentaram os menores índices, podendo ser consideradas quase isoladas quanto a seus hábitos alimentares. Por outro lado, os dois canídeos, assim como *G. cuja* e os pequenos felinos sobrepõem extensivamente suas dietas;

- A correlação entre amplitude de nicho e a abundância generalizada da espécie é alta e positiva relacionada com $r = 0.9565$, confirmando o pressuposto geral;

- Os hábitos alimentares dos dez carnívoros analisados podem ser divididos em três categorias, equivalentes a guildas alimentares, que ficam claras tanto no dendograma de similaridade quanto na análise de correspondência. Estas guildas correspondem a dietas essencialmente carnívoras, observadas nos pequenos felinos, nos Canídeos e em *G. cuja*; dieta omnívora de *P. cancrivorus*; a dieta insetívora de *C. chinga*;

- Dentre os essencialmente carnívoros, *G. cuja* e os pequenos felinos alimentam-se quase que exclusivamente de mamíferos (sobretudo roedores), que perfazem 68,3 a 99% da biomassa consumida;

- Os canídeos agrupam-se junto as espécies de hábitos mais especializados pois cerca de 50% da biomassa consumida em suas dietas é composta por mamíferos, o que difere da dieta de *C. thous* em outras regiões do Brasil onde são consumidas grandes quantidades de frutas;

- *Procyon cancrivorus* apresentou uma dieta tipicamente omnívora, na qual destaca-se a grande importância de alimentos associados a ambientes aquáticos, como moluscos, crustáceos, peixes e anfíbios que juntos perfazem mais de 55% da biomassa consumida. Além destes, destaca-se também o consumo de frutas (28,7% da biomassa) que foi o maior entre todas as espécies avaliadas neste estudo;

- A dieta de *C. chinga* mostrou-se primariamente insetívora, com larvas e insetos adultos / quelicerados compreendendo 72% da biomassa consumida. Destaca-se o consumo de larvas, representando cerca de 45% de toda a biomassa consumida, uma vez que é importante diferenciá-lo do consumo de insetos adultos, pois são o resultado de formas de forrageio bastante distintas;

- O consumo de mamíferos e anfíbios por *C. chinga* pode ser considerado ocasional, mas importante em termos de biomassa, representando respectivamente 14,2 e 10,5% do total encontrado;

- *Conepatus chinga* pode ser considerado um predador oportunista que usufrui de recursos alimentares local ou temporalmente abundantes, embora forrageie sobre insetos e, sobretudo, larvas de inseto.

Considerações finais

O trabalho ora apresentado traz dados inéditos e faz uma contribuição significativa ao conhecimento da ecologia de *Conepatus chinga*, um dos carnívoros mais desconhecidos da fauna brasileira.

Neste manuscrito, apresento dados robustos sobre as necessidades espaciais da espécie, assim como a forma de utilização de seu território. São apresentados dados inéditos sobre o uso de abrigos por *C. chinga*, um aspecto até então negligenciado por outros pesquisadores. No que se refere à abundância da espécie, são apresentadas estimativas robustas de densidade para duas localidades no sul do Brasil, que representam o primeiro estudo com o uso de “transect lines” para o gênero na América do Sul. Concomitantemente, são apresentados dados da abundância de outras 20 espécies de mamíferos de médio porte simpátricas a *C. chinga*. Dados de abundância voltam a ser tratados nos estudos de dieta de carnívoros simpátricos, onde são apresentados de forma generalizada exclusivamente para os carnívoros. Neste estudo apresentamos dados de ocorrência das 17 espécies da ordem Carnivora ocorrentes em 22 localidades no Rio Grande do Sul, além da análise dos hábitos alimentares de 10 destas espécies. A dieta de *C. chinga* mostrou-se baseada em insetos e, sobretudo, larvas de insetos, embora com a importante contribuição de pequenos vertebrados. De forma geral identificou-se a existência de três guildas alimentares entre os carnívoros avaliados, na qual o zorrilho encontra-se sozinho com hábitos insetívoro/omnívoros, *Procyon cancrivorus* encontra-se sozinho como um omnívoro “strictu sensu”, enquanto os pequenos canídeos, os pequenos felinos e o furão foram classificados como carnívoros mais estritos.

Obviamente os estudos realizados não podem ser considerados como definitivos, mas sim, como ponto de partida para o aprofundamento de diversas questões, como por exemplo:

- Qual a variação no tamanho das áreas de vida em diferentes ambientes, sobretudo na interface Campos de Cima da Serra / Pampa?

- Qual a variação no tamanho das áreas de vida sob diferentes densidades populacionais?

- Quais fatores determinam a densidade populacional da espécie?

- Existe variação na alimentação de *C. chinga* em diferentes ambientes? Qual a influência disso no uso de espaço e nos padrões corporais da espécie?

- A espécie realmente encontra-se numa guilda alimentar diferenciada dos demais carnívoros? As guildas identificadas neste estudo se mantêm se forem incluídos nas análises os demais carnívoros do sul do Brasil?

- Qual a intensidade da sobreposição do nicho alimentar, se aprofundadas as análises ao nível de espécie das presas, sobretudo entre os pequenos felinos e o furão?

- Que outros mecanismos ecológicos estão envolvidos, e qual a intensidade destes processos, na separação de nicho entre espécies com hábitos alimentares tão semelhantes?

De qualquer forma, acredito que esta tese tenha alcançado seus objetivos, gerando inúmeros avanços no entendimento da ecologia de *C. chinga* no Brasil. Antagonicamente (ou complementarmente) estes quatro anos de estudo serviram para gerar mais questões do que afirmações. Porém, imagino que este deva ser o processo científico e filosófico, ou ao menos assim pensava Sócrates, 2410 anos antes do presente: “quanto mais sei, mais sei que nada sei”.

Anexo I

Artigo de divulgação do projeto

publicado no periódico Small Carnivore Conservation

Recent advances in the knowledge of Molina's Hog-nosed Skunk *Conepatus chinga* and Striped Hog-nosed Skunk *C. semistriatus* in South America

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Abstract

Biological knowledge of South American hog-nosed skunks *Conepatus* remains scarce. Although common in several regions, even basic life-history aspects are poorly known, and important issues of taxonomy and biogeography are yet to be resolved. A better understanding of these species' evolutionary history, biology and ecology would provide a solid basis for conservation planning. Here we provide an overview of current research efforts targeting these issues in Molina's Hog-nosed Skunk *Conepatus chinga* and Striped Hog-nosed Skunk *C. semistriatus*. Preliminary data corroborating these species' evolutionary distinctiveness, and concerning distribution, habitat use, food habits, spatial ecology, life history, and reproductive biology are provided. We hope that these will serve as a basis for in-depth studies targeting these species and the role they play in Neotropical carnivore communities.

Keywords: conservation planning, distribution, ecology, life history, morphology, reproductive biology, taxonomy

Avances recientes en el conocimiento sobre *Conepatus chinga* y *C. semistriatus* en Suramérica

Resumen

El conocimiento biológico sobre las mofetas de Suramérica aún permanece escaso. A pesar de ser comunes en muchas regiones, aún se conoce muy poco incluso de aspectos básicos de su historia natural, y asuntos importantes todavía necesitan ser resueltos con respecto a su taxonomía y biogeografía. Por esta razón existe una necesidad urgente de llenar estos vacíos y de tener un mejor entendimiento de la historia evolutiva, Biología y ecología de estas especies, con el fin de proveer una base sólida para la planificación de su conservación. Aquí proveemos un vistazo a los esfuerzos de investigación actuales enfocados a estos aspectos relacionados con *Conepatus chinga* y *C. semistriatus*. Reportamos datos preliminares corroborando la distinción evolutiva entre estas dos especies y proveemos algunos datos sobre su distribución, uso de hábitat, hábitos alimenticios, ecología espacial y Biología reproductiva. Esperamos que estos esfuerzos puedan servir como base para estudios más profundos enfocados en estas especies y en el rol que juegan en las comunidades de carnívoros neotropicales.

Palabras clave:

Introduction

The family Mephitidae (skunks) comprises four genera, of which three occur exclusively in America: *Mephitis*, *Spilogale* and *Conepatus*. *Conepatus* (the hog-nosed skunks) is the only genus with species in both North (American Hog-nosed Skunk *C. leuconotus* and Striped Hog-nosed Skunk *C. semistriatus*) and South America (Molina's Hog-nosed Skunk *C. chinga*, *C. semistriatus* and Humboldt's Hog-nosed Skunk *C. humboldtii*); *Mephitis* and *Spilogale* occur exclusively in North America (Nowak 1999, Wozencraft 2005). In contrast to these two latter genera, *Conepatus* has received little attention from researchers, especially for the three South American species. In the last few years, our research group initiated studies concerning basic behaviour, distribution and ecology of *C. chinga* (Fig. 1) and *C. semistriatus* in Brazil. Molecular approaches are being employed to clarify taxonomy, biogeography and evolutionary history of the genus. Here we report first results of these ongoing efforts and project the future steps.

Distribution, habitat use and taxonomy

One basic aspect is the geographic range of the two species. Ac-

cording to Redford & Eisenberg (1992) and Eisenberg & Redford (1999), *C. chinga* occurs from the northern region of Argentina to Uruguay, southern Bolivia, western Paraguay and central Chile. Recently, Cheida *et al.* (2006) and Cáceres (2004) reported it from the southern limits of Brazil to the Paraná (PR) and São Paulo (SP) states. However, records in the latter two states are rare, despite the fact that this region is one of the most studied in Brazil. Conspicuous, confirmed occurrence of *C. chinga* in Brazil is restricted to its southernmost states, Rio Grande do Sul (RS) and Santa Catarina (SC). The species's distribution in this region seems discontinuous, associated with two grassland regions historically separated by a broad patch of Atlantic Forest: the Brazilian Pampa in the southern part of RS and the Campos de Altitude region in Southern SC and northern RS. In sum, the species's occurrence seems strongly associated with Pampa and Chaco biomes, both characterised by open vegetation, cold temperatures and well-defined climatic seasons.

Use of forest areas by *C. chinga* is reported by Cáceres (2004) and Cheida *et al.* (2006) but is controversial. Cáceres (2004) suggested that its range is continuous along the mountains of the Serra do Mar, covered by dense Atlantic Forest. However, the record reported by Cáceres (2004), and many of our own records, suggest restriction to forest borders and to the *Araucaria* Forest, habitats



Fig. 1. *Conepatus chinga* (photograph by Benhur Kasper).

associated with grassland environments. In addition, it is possible that current fragmentation within forested regions is allowing the species's range to expand, a process also observed in species such as the Maned Wolf *Chrysocyon brachyurus* (R. de Paula verbally 2009). Thus, our view is that *C. chinga* is a grassland-dweller, not adapted to forested areas that may even bar its dispersal.

Regarding *C. semistriatus*, Eisenberg (1989) and Eisenberg & Redford (1999) suggested a geographic range from Mexico to northern Colombia, northern Venezuela, Peru and northeastern Brazil. Regarding this latter country, Cheida et al. (2006) extended the species's distribution to SP and also reported occurrence in the Cerrado (central Brazil) and Caatinga (northeastern Brazil) biomes. In agreement, our own records include the states of Maranhão, Goiás, Minas Gerais, São Paulo, Piauí, Bahia and Distrito Federal, all of which encompass a large portion of the Cerrado and/or Caatinga biomes, where the species seems relatively abundant. As reported by Cheida et al. (2006), the species does not seem to use forested areas, although some individuals could use densely covered sites as refuges, mainly in the dry season (Ferreira 2008). Some records point to use of Cerrado patches inside the Amazonian Forest and to transitional regions between the Cerrado and the Atlantic Forest, where open vegetation areas can be found.

Therefore, extensive forests probably constitute a barrier for *C. semistriatus* as well, raising the hypothesis that *C. semistriatus* and *C. chinga* populations could have been historically isolated by the broad extension of Atlantic Forest that covers most of the land between the Cerrado and the grassland environments of RS and SC states. This may also be so for other open-environment carnivores, such as Pampas Fox *Lycalopex gymnocercus* (RS and SC grasslands) and Hoary Fox *L. vetulus* (Cerrado).

However, uncertainties concerning the total geographic and reproductive isolation between *C. chinga* and *C. semistriatus* still persist. It is still uncertain which species has been recorded in SP state. Furthermore, the distribution limits of *C. semistriatus* in Brazil are also unclear. As *C. chinga* is thought to occur in the southern region of Bolivia and Paraguay, the possibility of additional contact zones cannot be discarded. Consequently, there may be some sympatry and gene flow between these two recognised species. Indeed, taxonomic delimitation within this genus has few systematic studies to confirm the traditionally described species (Cabrera 1958, Kipp 1965, Wozencraft 2005). A recent phyloge-

netic overview showed that two North American *Conepatus* species previously recognised through morphology (*C. leuconotus* and *C. mesoleucus*) actually comprise a single species (Dragoo et al. 2003). Similar taxonomic confusion could be involved with other species in the genus and should be investigated.

To elucidate these issues, we are initiating phylogenetic and phylogeographic studies based on molecular data. Our preliminary results, employing nucleotide sequences spanning about 550 base pairs (bp) of the mitochondrial DNA *NADH dehydrogenase 5* (*ND5*) gene from *Conepatus* individuals sampled in the grassland environments of RS and SC states, and also from three different points in the Cerrado, corroborate the recognition of two taxonomic entities. One clade, corresponding to *C. chinga*, seems to be restricted to the RS and SC grassland domains, while another, corresponding to *C. semistriatus*, was sampled only in the Cerrado field sites. The genetic distance between these two groups indicates that they diverged at least one million years ago. Additional genetic markers and more individuals have to be added to this survey to confirm the two clades and date their evolutionary divergence more precisely. Also, we aim to identify the limits of occurrence of both species and to investigate the possibility of any degree of gene flow, which is most likely in potential zones of sympatry. Furthermore, a broader taxonomic investigation of all *Conepatus* species, aiming to identify the number of valid taxa and to shed light on their evolution and phylogenetic relationships, is also of great interest for the design of adequate conservation strategies for this group, and may soon be feasible. For example, the validity of *C. humboldtii* demands investigation: there are no apparent ecological barriers between its range (Patagonian grasslands) and that of *C. chinga*.

Ecology

There is currently very little information on the ecology of South American skunks. *Conepatus* is a specialised feeder of arthropods, mainly insects on the vegetation and within the soil (Redford & Eisenberg 1992). It is also an opportunistic predator, of small vertebrates and at carcasses of larger animals (Travaini et al. 1998, Donadio et al. 2004). Our field observations show that the foraging strategies of *C. chinga* and *C. semistriatus* mainly involve an active search for large insects such as beetles and larvae that live underground, digging the soil throughout almost their entire activity period. In some areas the consumption of vertebrates can be very important, as we observed for *C. chinga* in southeastern Brazil, where we have records of individuals feeding on fish (these being the first records of this item in their diets), amphibians, and eggs of both freshwater turtles and ground birds. Ingestion of eggs seems very frequent, with many turtle nests presenting characteristic signs of Molina's Hog-Nosed Skunk predation. In agreement, Gonçalves et al. (2007) noted that *C. chinga* is an important predator of nests of the turtle *Trachemys dorbigni* in southern Brazil. Regarding *C. semistriatus*, in addition to the high consumption of invertebrates (mainly beetles), some vertebrates have been recorded as being part of its diet as well. One individual was reported to feed on a dead bird, after attacking an owl nest. Silveira (1999) also reported the consumption of rodents and toads *Bufo* in the same region of the Cerrado.

Behavioural studies of both species are scarce. Rodrigues & Auricchio (1994) described *C. semistriatus* as solitary and non-territorial, with many individuals living in the same area, and males

and females appearing together only in the breeding season. Data from a capture effort in Bahia state (Brazil) support these observations, with many individuals caught in a small area, where they seemed to have resting dens. Also, two individuals were caught at one time, in one trap. Behavioural observations of *C. chinga* are also very few, but nest sharing seems to be rare.

Concerning abundance estimates of *C. chinga*, there are two distinct patterns in the two different environments occupied in Brazil. In the Pampas it is among the most common carnivores, preliminary data showing 1.5 individuals/km². Conversely, *C. chinga* in the Campos de Altitude region seems to be very sparse: 280 km of line transects yielded only one sighting, and a 450 trap-night effort only one capture. It is not clear which factors cause this extreme variation in abundance, but they may relate to food availability and/or climate. Although *C. semistriatus* seems relatively abundant in Cerrado and Caatinga, there are no precise abundance estimates.

Other issues being studied are the spatial structure of home ranges and the activity patterns of *C. chinga*. The first survey found a home range of 1.9 km², shared by a male and a female, in Argentina (Donadio *et al.* 2001). Similarly, our preliminary observations indicate a mean home range of 1.9 km² (0.8 to 2.45 km²) for four males, with females showing much smaller home ranges (mean 0.8 km², range 0.3 to 1.2 km²), as measured for three individuals. The home ranges observed for *C. chinga* are much larger than those estimated for *C. humboldti* (0.074–0.16 km²; Fuller *et al.* 1987) and *C. semistriatus* (0.18–0.53 km²; Sunquist *et al.* 1989), although caution should be taken in comparisons due to the limited number of sample individuals so far. More detailed survey might drastically change these preliminary results, especially for *C. semistriatus*, because it is larger than *C. chinga* and could plausibly use a larger home range.

Concerning activity patterns, as reported by Donadio *et al.* (2001), *C. chinga* in southern Brazil is almost exclusively nocturnal. Our first data indicate that it leaves its resting site about 30 minutes before sunset, remaining active until approximately 30 minutes before sunrise. At night, the activity is almost continuous, with few resting moments. Daytime activity is negligible, generally involving sleeping all day in resting or den sites. In the same study, Donadio *et al.* (2001) cited use of burrows as cover, each generally reused a few times. Our observations identified 14 types of resting sites, divided into four larger groups: burrows in the soil; under trunks and branches; within vegetation; and inside human-made structures. It seems to use several types of cover present in its home range, with different degrees of reuse. Further, each individual seems to use a central area, with several resting sites around it. The reuse of some resting sites may be intense, especially in the breeding season, when we recorded use of the same den for more than a month. Observations on the activity patterns on *C. semistriatus* in Mesoamerica are reported by González-Maya *et al.* (2009).

The proximity of hog-nosed skunks to houses or other human-made structures, along with high tolerance of people and domestic animals, seems strongly to affect their mortality rate. In our telemetry study focusing on *C. chinga*, of seven monitored individuals with home ranges near human dwellings, six died through human activity within six months of capture. Although usually not directly hunted or persecuted by farmers or other local people, the species is often killed by vehicles on roads and also by hunting dogs. In some roads of southernmost RS, *C. chinga* is one of the

most frequent road-killed carnivores (F. Mazim verbally 2009). A similar situation may occur with *C. semistriatus*, which also seems to occupy human-modified landscapes and tolerates areas near town centres. The major observed threat is the high number of individuals killed on roads throughout the species's distribution. These data suggest that the species are very abundant in these areas; the impact of such mortality on populations is unknown.

Our observations indicate that *C. chinga* does not avoid the proximity of domestic dogs, nor of native wild canids such as Crab-eating Fox *Cerdocyon thous* and Pampas Fox. There is mortality from domestic dog attacks, but this overall proximity suggests no history of strong intraguild predation between these skunks and canids. This observation seems also to fit *C. semistriatus*, which may live near Crab-eating Fox and Maned Wolf, occasionally even chasing them off.

Biology

Our *C. chinga* studies are also shedding some light on aspects of its biology and natural history. During capture for placement of radio-collars, we recorded morphometric data including body mass. In one studied population in southern Brazil there were significant differences between males and females in mean total length (58.8 cm for males and 55.3 cm for females) and mean body mass (2.26 kg and 1.58 kg), giving a remarkable sexual difference of 43%. Van Gerdal's (1968, *apud* Redford & Eisenberg 1992) assertion of sexual size dimorphism in Molina's Hog-nosed Skunk in Uruguay is therefore corroborated by our data.

Regarding reproduction of *C. chinga*, we recorded six litters, ranging from two to three pups (mean, 2.5). The reproductive period of *C. chinga* seems related to climatic seasons. Several matings were recorded in late winter and early spring (July–October), when we also found road-killed individuals carrying fetuses. In our telemetry survey, two females were observed with pups in the spring and early summer (October–January); one seemed to have given birth in September, being always seen with its pups until February, when the pups were no longer observed. In the summer (January and February), there were many observations of young individuals, apparently dispersing or searching for territories. Thus, we believe that birthing coincides with the beginning of the spring, and that the juveniles disperse in summer, after living 4–5 months with their mothers. There are still no such data for *C. semistriatus*, but our ongoing field efforts are also designed to address issues of this species's biology.

Conclusions

Considering information from literature and our first surveys, we can recognise that *C. chinga* and *C. semistriatus* are: (i) two separate species—genetically and morphologically distinct and apparently occurring in two different (and perhaps isolated) habitats: Cerrado (*C. semistriatus*) and Pampa/Chaco (*C. chinga*); (ii) closely associated with grassland habitats; (iii) feeders mainly on insects, but also opportunistically on small vertebrates, larger carcasses and vertebrate eggs; (iv) nocturnal, solitary, with an apparently defined breeding season associated with warmer weather (early spring), and showing some degree of parental care (pups spend 4–5 months with their mothers) prior to juvenile dispersal; and (v) tolerant of human disturbance, although this is a major cause of mortality.

All these studies and field observations are in a very initial phase, and some current impressions may need to be re-evaluated as we gather more data. Moreover, it is also clear that these are very poorly known species, still requiring many studies to refine current understanding of ecology, behaviour, evolution and taxonomy. We hope that our ongoing efforts will enhance understanding of the biology of *Conepatus*, allowing design and implementation of effective conservation strategies.

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Anexo II

Normas do periódico científico Journal of Mammalogy

Author Instructions

The Journal of Mammalogy is a research-oriented, peer-reviewed journal dealing with all responsible types of research on biology of mammals. Papers of any reasonable length that can be justified by their purpose, design, and outcome will be considered. Manuscripts must be submitted online via AllenTrack at <http://jmamm.allentrack.net>.

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Your manuscript should include the following parts, in this order:

1. Title Page

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- Running Heading (a short identification, not a title, 40 characters or less including spaces; use normal font);
- Title (Bold, left-justified text; capitalize only the first word and formal names, taxa, geographic locations, etc.; restrict to 15 words or less);
- Names of authors (Use normal font or small caps, NOT ALL CAPS!, left-justified text, with asterisk to identify corresponding author);
- Affiliations of authors (Normal font in italics, left-justified);
- Abstract, no longer than 5% of the length of the text (introduction through discussion; multiply number of lines of text by .05 to find correct length for abstract...longer abstracts will be sent back for shortening) summarizing key findings...note: NO heading for "ABSTRACT";
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- Introduction...note: NO heading for "INTRODUCTION";
- Materials and Methods;
- Results;
- Discussion...note: NO "Summary" or "Conclusion" sections, include relevant syntheses in the Discussion;
- Acknowledgments (note the spelling);
- A summary in another language, usually a translation of the abstract, may be included at end of text if appropriate. Translations of abstracts in Spanish or Portuguese are REQUIRED for all studies conducted in Latin America;
- Literature Cited; put authors' names in upper and lower case letters (NOT all capitals) or small caps;

3. Figure legends, on a separate page following Literature Cited

4. Appendix, if necessary

5. Tables. Each table on a separate page WITH the table legend.

6. Figures. Figures should be submitted as a SEPARATE FILE. All other text, including tables, can be in the "article file."

All parts of the manuscript, including Literature Cited, should follow style and format of papers in the most recent volume of *Journal of Mammalogy*. The Journal standard for style is the CSE style manual (2006. *Scientific Style and Format--The CSE Manual for Authors, Editors, and Publishers*. 7th ed. Council of Science Editors, The Rockefeller University Press.)

ALL written and tabular material must be double spaced (3 lines/2.5 cm) and in 12 pt Times New Roman font. Italicize all scientific names. In general, 2 levels of organization are used: primary headings (centered and in uppercase) and secondary headings (indented at beginning of paragraph, italicized, and followed by period and dash). Italicized scientific names (genus and species) of all organisms other than

domesticated animals should be given with the common name at 1st use, in both abstract and body of paper. Use Arabic for all numbers, even those <10.

In Materials and Methods, include a statement indicating whether research on live animals followed ASM guidelines (Journal of Mammalogy 88:809-823, 2007) and was approved by an institutional animal care and use committee. All DNA sequences must be submitted to GenBank, and accession numbers provided in the manuscript before publication. Museum catalogue numbers for all voucher specimens (including associated tissue) examined must be included in the manuscript (in an Appendix if numerous). Consult recent issues of the Journal of Mammalogy for examples. DO NOT SUBMIT MATERIALS IN OFFICE 2007 FORMATS. NOT ALL REVIEWERS CAN PROCESS .docx, .xlsx, OR .pptx FILES AT THIS TIME.>

Tables should conform to JM format: horizontal lines across the top, bottom, and underneath column headings. Do NOT use vertical lines to separate columns, add extra horizontal lines to separate parts of the table, or use grid cells. Tables need to be formatted as text for publication, thus do not submit them as pdfs.

Figures will be reduced to 9 cm width for publication, so lettering and symbols must be large enough to withstand reduction and be legible. Put figure number on figures. Do not present the same data in both graphs and tables. There should be at least 2 (preferably 3) pages of text for each figure or table.

Below are the formats of common types of references listed in the Literature Cited. See a recent issue of the Journal for other examples.

a. Journal Articles

HARRIS, R. B., W. J. CRESSWELL, P. G. FORDE, W. J. TREWHELLA, T. WOOLLARD, AND S. WRAY. 1990. Home-range analysis using radio-tracking data- a review of problems and techniques particularly as applied to the study of mammals. Mammal Review 20:97-123.

NEVO, E., V. SIMONSEN, AND A. R. TEMPLETON. In press. Starch gel electrophoresis of enzymes—a compilation of recipes. *Biochemical Genetics*.

b. Books

HALL, E. R. 1981. *The mammals of North America*. 2nd ed. John Wiley & Sons, Inc., New York 1:1-600 + 90. [OR -2:601-1181 + 90.]

NEAL, E. G., AND C. CHEESEMAN. 1996. *Badgers*. Poyser Natural History, London, United Kingdom.

c. Chapter in Edited Books

PATTON, J. L., ET AL. 1977. Optimal habitat selection in two-species competitive systems. Pp. 282-293 in *Population ecology* (U. Halbach and J. Jacobs, eds.). Gustav Fischer Verlag, Stuttgart, West Germany.

d. Technical Reports

HENDRIX, P. F. 1996b. Earthworms, biodiversity, and coarse woody debris in forest ecosystems of the Southeastern U.S.A. Pp. 43-48 in *Biodiversity and coarse woody debris in southern forests, proceedings of the workshop on coarse woody debris in southern forests: effects on biodiversity* (J. W. McMinn and D. A. Crossley, Jr., eds.). United States Department of Agriculture, Forest Service, General Technical Report SE-94:1-146.

e. Theses or Dissertations

STEWART, P. D. 1997. *The social behaviour of the European badger, *Meles meles**. Ph.