ECOLOGIA E CONSERVAÇÃO DA RAPOSA-DO-CAMPO (*LYCALOPEX VETULUS*) E INTERAÇÕES COM CANÍDEOS SIMPÁTRICOS EM ÁREAS ANTROPIZADAS DO BRASIL CENTRAL

UNIVERSIDADE FEDERAL DE UBERLÂNDIA

INSTITUTO DE BIOLOGIA

PÓS GRADUAÇÃO EM ECOLOGIA E CONSERVAÇÃO DE RECURSOS NATURAIS

ECOLOGIA E CONSERVAÇÃO DA RAPOSA-DO-CAMPO (*LYCALOPEX VETULUS*) E INTERAÇÕES COM CANÍDEOS SIMPÁTRICOS EM ÁREAS ANTROPIZADAS DO BRASIL CENTRAL

FREDERICO GEMESIO LEMOS

2016

Dados Internacionais de Catalogação na Publicação (CIP)
Sistema de Bibliotecas da UFU, MG, Brasil.

L557e
2016

Lemos, Frederico Gemesio, 1981
Ecologia e conservação da raposa-do-campo (Lycalopex vetulus) e interações com canídeos simpátricos em áreas antropizadas do Brasil Central [recurso eletrônico] / Frederico Gemesio Lemos. - 2016.

Orientadora: Kátia Gomes Facure Giaretta.
Tese (Doutorado) - Universidade Federal de Uberlândia, Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais.
Modo de acesso: Internet.
Disponível em: http://dx.doi.org/10.14393/ufu.te.2019.1207
Inclui bibliografia.
Inclui ilustrações.

1. Ecologia. 2. Animais - Comportamento. 3. Animais silvestres. 4. Radiotelemetria. I. Giaretta, Kátia Gomes Facure, 1967, (Orient.) II. Universidade Federal de Uberlândia. Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais. III. Título.

CDU: 574

Angela Aparecida Vicentini Tzi Tziboy – CRB-6/947

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Tese apresentada à Universidade Federal de Uberlândia, como parte das exigências para obtenção do título de doutor em Ecologia e Conservação de Recursos Naturais.

Orientadora
Profa. Dra. Kátia G. F. Giaretta

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ECOLOGIA E CONSERVAÇÃO DA RAPOSA-DO-CAMPO (*LYCALOPEX VETULUS*) E SUAS INTERAÇÕES COM CANÍDEOS SIMPÁTRICOS EM ÁREAS ANTROPIZADAS DE CERRADO DO BRASIL CENTRAL

Doutorando: Frederico Gemesio Lemos

Tese apresentada à Universidade Federal de Uberlândia, como parte das exigências para obtenção do título de doutor em Ecologia e Conservação de Recursos Naturais.

Tese aprovada em: 02/Set/2016

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UBERLÂNDIA
SETEMBRO - 2016

Como expressar em uma tese ou inúmeros artigos todos os registros e sensações, dados e fatos, visualizações e olhares, conclusões e percepções, coletadas e vividas durante as inúmeras noites e dias sob o céu estrelado e sem fim do Brasil Central, nesse caso Goiás? Como medir em transectos as centenas de quilômetros percorridos a pé, de moto, carro e, quando dava sorte, com um companheiro de crina?

Na simplicidade e necessidade de utilizar duas metodologias antigas e para muitos ultrapassadas, a observação direta e a radiotelemetria, ganhei dois dos mais valiosos presentes de minha vida. Itens imprescindíveis e sem valor mensurável para um homem do campo, e que trago fundo no coração: meus companheiros e cada momento com os animais que convivi.

Cada coordenada anotada carrega um pouco de cada um, seja humano, seja animal... em cada caminhada, um longo momento de calor, temperado a cada encontro por um breve momento de frio interior, seja humano, seja animal...

... e se não é possível expressar todas as informações em uma tese e inúmeros artigos, como o fazer com todo o agradecimento aos que fizeram parte dessa história, seja humano, seja animal...?

AGRADECIMENTOS

Agradeço primeiramente, e especialmente, aos meus pais Ana Luiza e Nilson, e à família Gemesio & Lemos, pelas inúmeras portas que abriram em minha vida. Sem eles nada disso seria possível e não existem palavras que possam expressar a minha gratidão;

A meu irmão, Felipe, por cuidar de nosso "esteio" mais importante, enquanto estou a quilômetros em mais uma campanha... mesmo vivendo em universos diferentes o otimismo e o amor nos aproxima.

A Fernanda Cavalcanti, obrigado seria uma palavra pequena perto de tudo o que estamos construindo juntos em nossa vida de jovens pesquisadores. Quando nos unimos pensamos em como poderia ser maravilhoso reunirmos em nossa "casa" pessoas que compartilhassem as mesmas idéias e ideais, que pudessem ver e sentir parte do que vivenciamos todos os dias... hoje isto é uma realidade, e se a raposinha deixa rastos pelo mundo afora, ela também vai com a sua marca de dedicação e amor impressas nela;

Agradeço uma vez mais à mentora Kátia Gomes Facure, que há tempos deixou de ser orientadora para tornar-se uma grande amiga e admiradora dos canídeos brasileiros. Juntos nesta caminhada há 14 anos, tenho certeza de que ainda temos muito que descobrir juntos sobre estas maravilhosas espécies!

Agradeço aos irmãos biólogos e veterinário Alan “Grilo” Nilo da Costa, Ricardo “Rick” Corassa Arrais e Mozart Caetano de Freitas Jr. pelo companheirismo imensurável no campo noites adentro, debaixo de chuva e torrando no sol, com carrapatos e mosquitos, no lombo do cavalo ou da moto, diante do centésimo pneu furado ou percorrendo trilhas lado a lado deste lugar que gostamos tanto e do qual temos orgulho em fazer parte da luta pela sua conservação, que é o Cerrado brasileiro;

Agradeço aos Vingadores do Programa de Conservação Mamíferos do Cerrado - PCMC: Caio Motta, Fabiana Rocha, Fernanda Cavalcanti, Isis Zanini, Mozart Caetano, Ricardo Corassa Arrais e Stacie Castelda, aos quais somente uma frase basta para expressar toda a minha admiração: "É extremamente fácil confiar em quem tem absoluta confiança em sim mesmo". Obrigado amigos, por cada roda de guampa, cada sorriso, cada mão estendida!

Ao parceiro e "professor" Rogério Cunha de Paula, agradeço todo o incentivo e confiança no meu trabalho desde a 1ª vez que nos encontramos. Mesmo quando ele era apenas uma pequena idéia que discutimos lá no alto da Serra da Canastra! Rogério sempre foi fonte inesgotável de exemplo de dedicação a uma espécie;

Aos amigos de campo que também compartilharam comigo o imenso prazer de trabalhar no Limoeiro e que disponibilizaram mais do que seus conhecimentos dos bichos, mas suas impressões do mundo, deixando assim um pedaço seu neste projeto e nas raposinhas do Cerrado: Joares "Magrão" May Jr., Hugo Cardoso, Leandro "Robinho" Abade, Daniel "Gringo" Rocha, Frederico "Cigano" Souza e Carlos Eduardo "Bagual";

Agradeço imensamente aos proprietários das fazendas da região do Limoeiro, e principalmente aos peões e vaqueiros que, além de abrirem suas casas para mim e mais tarde para toda a família PCMC, compartilharam suas visões da vida e o simples, porém valioso, conhecimento sobre as espécies da fauna e da flora que os cerca, complementando este trabalho de maneira fundamental e verdadeira;

Ao mateiro mais fotógrafo que conheço, Adriano Gambarini, agradeço pelo incentivo e apoio em divulgar a raposa-do-campo, e mais ainda por entender e compartilhar a missão apaixonante que é registrar e divulgar a biodiversidade do planeta;

Ao Projeto Ecologia e Conservação da Raposa-do-Campo desenvolvido pelo PCMC e seus parceiros o meu obrigado mais profundo! Sem a coragem e o comprometimento de todos os envolvidos boa parte dos dados coletados estaria apenas em sonho... Com certeza estamos escrevendo um pedaço da história não só da raposa-do-campo, mas da pesquisa em nosso país, pois através da multidisciplinaridade e do entrosamento das pessoas envolvidas em torno de um objetivo em comum caminhamos em direção ao entendimento das relações das espécies do Cerrado. Obrigado especial ao/à :

- Centro para a Pesquisa e Conservação dos Mamíferos Carnívoros - CENAP/ICMBio, nas pessoas de Ronaldo Morato, Rogério Cunha de Paula e Rose Gasparini;
- Fundação Parque Zoológico de São Paulo nas pessoas de Paulo M. Bressan, João B. Cruz e Caio F. M. Lima;
- Instituto Oswaldo Cruz, representado pelos coordenadores e alunos do Laboratório de Biologia de Tripanossomatídeos nas pessoas de Ana Jansen, André Roque e Alena Inignez;

- Laboratório de Ixodologia da Universidade Federal de Uberlândia, nas pessoas de Matias Szabó, Vanessa Ramos e Marlene Martins;
- Laboratório de Biodiversidade Molecular e Conservação da Universidade Federal São Carlos, nas pessoas de Pedro Galetti, André Pereira e Karen Rodriguez;
- Instituto de Biologia da Conservação Smithsoniano, representado pelo *Center for Species Survival* e *GIS Conservation Lab* nas pessoas de Nucharin Songsassen, Melissa Roden, Peter Leimgruber, Christen Fleming e Jared Stabach;

Agradeço aos nossos apoiadores internacionais, Cleveland Metropark Zoo (Scott Neotropical Fund), Neotropical Grassland Conservancy e Idea Wild pela confiança depositada;

Agradeço aos membros da banca examinadora pelo interesse em comparecerem neste dia para "conversarem" comigo sobre esta espécie tão encantadora e desafiadora que é a raposa-do-campo e seus comparsas, os cachorros-do-mato e lobos-guará!

Ao Programa de Pós Graduação em Ecologia e Conservação de Recursos Naturais da Universidade Federal de Uberlândia agradeço pela estrutura e apoio durante esta jornada;

Ao Departamento de Ciências Biológicas da Universidade Federal Goiás - Regional Catalão, agradeço por me conceder o afastamento para este doutoramento e me permitir imergir no que mais gosto de fazer: conhecer nossa biodiversidade;

À Universidade Federal de Goiás, por meio da Pró-Reitoria de Pesquisa e Pós-Graduação, pela concessão da bolsa de apoio vinculada ao Programa Institucional de Bolsas de Pós Graduação Pró-Qualificar;

Por último, e provavelmente mais importante, àquele que deu origem a essa jornada, agradeço ao companheiro da primeira impressão, do primeiro olhar refletido pela luz da minha lanterna, provocador do sentimento mais denso e puro que carrego dentro de mim, que é a curiosidade de aprender sobre a vida que nos cerca, para assim tentar entender quais os passos posso dar para conservá-la... Muito obrigado Nilsão, a eterna primeira raposa-do-campo da Região do Limoeiro.

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Resumo

Lemos, Frederico G. 2016. Ecologia e conservação da raposa-do-campo (*Lycalopex vetulus*) e interações com canídeos simpátricos em áreas antropizadas do Brasil Central. Tese de Doutorado em Ecologia e Conservação de Recursos Naturais. UFU. Uberlândia-MG. 167p.

Palavras-chave: Áreas de vida; armadilhas fotográficas; Carnívoros; *Cerdocyon thous*; *Chrysocyon brachyurus*; comportamento animal; conservação; radiotelemetria

Canídeos selvagens apresentam maior distribuição que qualquer outro grupo de carnívoros no planeta. Tal característica faz deles parte importante na dinâmica de uma variedade de ecossistemas. Para melhor compreensão da história evolutiva dos canídeos sul americanos e como estes compartilham recursos em áreas antropizadas, este estudo teve como objetivos descrever a organização espacial de raposas-do-campo *Lycalopex vetulus* e examinar parte das suas interações com canídeos sintópicos, além de identificar ameaças à sua sobrevivência. A fim de contribuir para a padronização de estratégias de amostragem para monitorar a vida selvagem, foi avaliada a técnica de captura, potencial de armadilhamento e o sucesso no monitoramento de canídeos através de coleiras de alta frequência (VHF). Obtivemos 470 eventos de captura usando armadilhas do tipo caixa iscadas com sardinha. Destes, 347 (74%) corresponderam a capturas de canídeos selvagens (média de sucesso de 10,7 capturas por 100 armadilha*noite). Raposas-do-campo mostraram taxas de captura mais elevadas que as outras espécies, mas foram capturadas quase exclusivamente por armadilhas de porte médio, enquanto cachorros-do-mato tiveram altas taxas de captura por armadilha médias e grandes. O lobo-guará teve altas taxas de captura em armadilhas de grande porte. Para possibilitar o acompanhamento adicional de raposas-do-campo por armadilhas fotográficas e registrar novos indivíduos, desenvolvemos uma técnica para identificar raposas através das marcas no rabo destes animais. Durante este estudo foram monitorados por coleiras rádio-transmissoras 73 canídeos silvestres, sendo possível estimar que o tamanho médio de área de vida da raposa-do-campo é 2,68 km^2, do cachorro-do-mato 8,23 km^2, e de lobos-guará 66,54 km^2. Sabe-se que há uma grande variação no sistema social entre canídeos e isso está diretamente ligado à forma como espécies se organizam no espaço. Os resultados apresentados reforçam que canídeos Lupinae de pequeno porte sul americanos organizam-se em sistemas sociais monogâmicos e territoriais. As três espécies mostraram-se ativas principalmente durante a noite e utilizaram até 11 tipos diferentes de abrigos (n = 417 registros). Tocas de tatu peba (*Euphractus sexcinctus*) foram o abrigo mais usado pela raposa-do-campo, enquanto cachorros-do-mato e lobos-guará utilizaram com maior frequência moitas de capim alto. As principais causas de morte de canídeos na região de estudo são decorrentes de ações humanas (41,3%) como atropelamentos, ataques de cães domésticos, envenenamento e tiro. Predação intraguilda de onças-pardas sobre os canídeos menores é a segunda causa de morte mais frequente. O terceiro capítulo traz ainda uma avaliação do risco de extinção da raposa-do-campo, onde após uma ampla revisão, a espécie foi classificada vulnerável à extinção. No Cerrado, ecossistema prioritário para a conservação da biodiversidade, paisagens alteradas pela ação humana representam o cenário atual. Para melhor compreender como espécies vem lidando com tais mudanças é urgente o aumento de estudos neste sentido.

ABSTRACT

Lemos, Frederico G. 2016. Ecology and conservation of the Hoary fox (*Lycalopex vetulus*) and interactions with sympatric canids in anthropized areas of Central Brazil. Doctorate Thesis on Ecology and Conservation of Natural Resources. UFU. Uberlândia-MG. 167p.

Key words: Animal behavior; Carnivores; camera trapping; *Cerdocyon thous*; *Chrysocyon brachyurus*; conservation; radio telemetry; home range

Wild canids have the widest distribution than any other group of carnivores on the planet. Such characteristic makes them an important part in the dynamics of a variety of ecosystems. To better understand the evolutionary history of South American canids and how they share resources along disturbed areas, this study aimed to describe the spatial organization of hoary foxes *Lycalopex vetulus*, and examine part of their interactions with sintopic canids, besides identifying threats to its survival. To contribute to the standardization of sampling strategies to monitor wildlife, capture technique was evaluated, and also trapping potential and success in monitoring canids through high frequency collars (VHF). We obtained 470 capture events using box traps baited with sardines. Of these, 347 (74%) corresponded to wild canids captures (mean success of 10.7 captures per 100 trap* night). Hoary foxes showed higher capture rates than other species, but were captured almost exclusively by medium-sized traps, while crab-eating foxes had high capture rates on medium- and large-sized traps. The maned wolf had high capture rates in large-sized traps. To allow additional monitoring of hoary foxes by camera trapping and register new individuals, we developed a technique to identify foxes through marks on the tail of these animals. During this study 73 wild canids were monitored by radio-collars and was possible to estimate that mean home range hoary foxes is 2.68 km^2, of crab-eating fox 8.23 km^2, and of maned wolves 66.54 km^2. It is known that there is a wide variation in the social system of canids and that this is directly linked to how species are organized in space. The results presented reinforce that small South American Lupinae canids live in monogamous and territorial social systems. The three species were active mainly during the night and used up to 11 different types of shelters ($n = 417$ records). Yellow armadillo holes (*Euphractus sexcinctus*) were the most used shelter by the hoary fox while, while crab-eating foxes and maned wolves used more often clumps of tall grass. The main causes of canids deaths in the study area are result of human actions (41.3%) as road kill, domestic dog attacks, poisoning and shooting. Intraguild predation of smaller canids by pumas is the second most frequent cause of death. The third chapter also contains an assessment on the risk of extinction of the hoary fox, where after a wide review, the species was classified as vulnerable to extinction. In the Cerrado, a priority ecosystem for biodiversity conservation, landscapes altered by human action represent the current scenario. To better understand how species have been dealing with these changes it is urgent to increase studies in this direction.

APRESENTAÇÃO GERAL

Esta tese, que tem como título "Ecologia e conservação da raposa-do-campo (*Lycalopex vetulus*) e interações com canídeos simpátricos em áreas antropizadas do Brasil Central", é parte dos requisitos indispensáveis à obtenção do título de Doutor, exigido pelo Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais, da Universidade Federal de Uberlândia.

A fim de contribuir para o melhor entendimento da história evolutiva dos canídeos sul-americanos, como estes compartilham recursos quando ocorrem em simpatria e como têm utilizado áreas alteradas pela ação humana, o objetivo central deste estudo foi descrever a organização espacial e social da raposa-do-campo (*Lycalopex vetulus*), examinar suas interações com outros canídeos sintópicos, e identificar as ameaças à sua sobrevivência em ambientes alterados de Cerrado.

Embora apresente aqui um conjunto de dados coletados durante o período de doutoramento (2012 – 2016), parte considerável das informações é proveniente de um projeto mais amplo, iniciado em 2007, na região do Limoeiro, município de Cumari, Goiás. A iniciativa "Ecologia e conservação da raposa-do-campo em áreas de Cerrado do Brasil Central" foi embasada em dois objetivos principais, entrelaçados por um fato comum: o pouco conhecimento disponível sobre a raposa-do-campo, espécie de ocorrência única no Brasil e endêmica do Bioma Cerrado (Lemos et al. 2013). Considerada um dos sete canídeos menos estudados do mundo pelo grupo de especialistas em canídeos da UICN (União Internacional para a Conservação da Natureza), pouquíssimos trabalhos científicos foram realizados com foco na raposa-do-campo, exceto pelas clássicas e ricas contribuições escritas pelo naturalista Júlio C. Dalponte (Dalponte 1995, 1997, 2003, 2009; Dalponte e Lima 1999; Dalponte e

Courtenay 2004), e algumas publicações pontuais (Jácomo et al. 2004; Courtenay et al. 2006; Ferreira-Silva e Lima 2006, Rocha et al. 2008). O desconhecimento científico sobre aspectos biológicos básicos da espécie é ainda evidente e se reflete nas inúmeras identificações errôneas presentes em artigos publicados recentemente (Lemos et al 2013). Se para a comunidade científica a raposa-do-campo segue pouco conhecida, para o público leigo nacional e internacional ela passa despercebida, embora comumente avistada em fazendas no interior de Minas Gerais, Goiás e outros estados. Assim, os objetivos principais da iniciativa "Ecologia e conservação da raposa-do-campo em áreas de Cerrado do Brasil Central" são levantar informações em médio e longo prazo sobre a história natural da raposa-do-campo e, tão importante quanto em termos conservacionistas, divulgar e promover sua existência para diferentes públicos a fim de aumentar o conhecimento e visibilidade deste canídeo exclusivamente brasileiro.

A raposa-do-campo é um canídeo de pequeno porte (2, 5 – 4 kg), que ocorre em fitofisionomias abertas de Cerrado (Dalponte 2009). Distribuída pelos estados de Minas Gerais, São Paulo, Mato Grosso do Sul, Mato Grosso, Goiás, Tocantins, Bahia, Piauí, Maranhão e Ceará (Lemos et al. 2013; Olifiers e Delciellos 2013), grande parte da sua distribuição é simpátrica com outros canídeos silvestres como o cachorro-do-mato (*Cerdocyon thous*), o lobo-guará (*Chrysocyon brachyurus*) e o cachorro-vinagre (*Speothos venaticus*) (Sillero-Zubiri 2009).

Juntamente com outras espécies dos gêneros *Lycalopex*, *Cerdocyon* e *Atelocynus*, a raposa-do-campo faz parte de um grupo específico conhecido como *raposas sul-americanas* (Sillero-Zubiri 2009). O ancestral destas espécies teria deixado a América do Norte juntamente com uma segunda linhagem (representada por um possível ancestral dos gêneros *Chrysocyon* e *Speothos*) e chegado à América do Sul há aproximadamente 3.4 milhões de anos, durante o evento conhecido como "grande intercâmbio de fauna" (Perini et al. 2010). Uma vez estabelecidas, ambas linhagens teriam se dispersado por todo o continente e ocupado nichos até então disponíveis, representados principalmente por grandes campos abertos, diferenciando-se então nos gêneros conhecidos atualmente (Perini et al. 2010; Favarini 2011; Garcez 2015). Análises genéticas recentes não só tem corroborado a hipótese de que o gênero *Lycalopex* de fato constitui um grupo originalmente sul-americano, mas também sugerem que *Lycalopex vetulus* seja a espécie mais basal do gênero (Favarini 2011; Garcez 2015).

Apesar de trabalhos anteriores tratarem principalmente de sua dieta (Dalponte 1997; Dalponte e Lima 1999; Jácomo et al. 2004; Ferreira-Silva e Lima 2006), e alguns abordarem rapidamente a ecologia espacial da espécie (Juarez e Marinho-Filho 2002; Dalponte 2003; Courtenay et al. 2006), poucos aspectos da sua história natural e conservação foram descritos até recentemente, como por exemplo, o tamanho de grupo de forrageio (Lemos e Facure 2011), a interação com outros canídeos sintópicos (Lemos et al. 2007, 2011b) e algumas causas de ameaça (Lemos et al. 2011a). Faltam estudos quantificando tamanho e organização de áreas de vida, descrevendo como a espécie utiliza diferentes tipos de habitat disponíveis (sejam naturais ou antropizados), longevidade e tendências populacionais, partilha de nicho temporal e espacial com outros canídeos, papel de doenças nas populações, entre outros.

Conhecer a biologia básica da raposa-do-campo vai além de entender suas relações ecológicas, pois pode contribuir para compreendermos melhor a história evolutiva da família Canidae na América do Sul, como se deu a irradiação deste grupo pelo continente sul-americano, e também representa um ótimo modelo de como se comportam canídeos do grupo Lupinae de pequeno porte (para revisões do tema veja Wang et al. 2004; Wang e Tedford 2008). Todos esses aspectos, além de serem importantes para entender a espécie também podem subsidiar a elaboração de futuras estratégias para a conservação da raposa-do-campo. Assim, organizei a tese em três capítulos, já apresentados no formato de artigo científico, precedidos por esta apresentação geral:

No primeiro capítulo, *Monitoring methods success for the hoary fox Lycalopex vetulus and other syntopic wild canids in the Brazilian Cerrado*, apresento e discuto os resultados de 28 campanhas de captura realizadas entre 2008 e 2015 em uma região conhecida como Limoeiro, no município de Cumari, Goiás, e como se deu o monitoramento (captura em armadilhas, radio-telemetria e armadilhas fotográficas) das populações de canídeos em uma área de agroecossistema de criação de gado bovino. Neste trabalho, comparo o sucesso de captura entre diferentes tipos de armadilhas, as vantagens e desvantagens de cada uma, e a eficiência de coleiras rádio-transmissoras, além de apresentar um método de individualização de raposas-do-campo não-invasivo, passível de ser utilizado em diferentes trabalhos de estimativas populacionais.

O segundo capítulo, *Spatial dynamics and conservation of the hoary fox Lycalopex vetulus and syntopic canids in an anthropized landscape at Central Brazil*, é o que mais avança no conhecimento da raposa-do-campo em relação à sua história natural. Este trabalho representa o maior esforço já realizado de monitoramento de uma população dessa espécie, não só em número de indivíduos acompanhados mas também duração do monitoramento. Entre 2008 e 2015 monitoramos 38 indivíduos a fim de conhecer sua área de vida e como raposas se organizam no ambiente. Apesar de este capítulo ter como enfoque principal a dinâmica espacial da raposa-do-campo, nele discuto também informações sobre seu horário de atividade, uso de abrigos, e como a raposa-do-campo compartilha certos nichos com outros canídeos na região do Limoeiro, principalmente o cachorro-do-mato e o lobo-guará. Este capítulo apresenta também os primeiros dados quantificados de causas de mortalidade da espécie em um ambiente antropizado.

Por fim, o terceiro capítulo, *Avaliação do risco de extinção da raposa-do-campo, Lycalopex vetulus (Lund, 1842) no Brasil*, discorre sobre o estado de conservação da raposa-do-campo no Brasil. O trabalho é fruto da *Oficina de Avaliação do Estado de Conservação de Carnívoros do Brasil*, realizada pela Diretoria de Pesquisa, Avaliação e Monitoramento da Biodiversidade/Coordenação Geral de Manejo para a Conservação/ICMBio, em parceria com o Centro Nacional para a Pesquisa e Conservação dos Mamíferos Carnívoros/ICMBio. Realizada em novembro de 2011, a oficina teve como objetivo avaliar o risco de extinção dos mamíferos carnívoros brasileiros utilizando a metodologia sugerida pela UICN. O evento contou com a presença de vários especialistas em carnívoros que, munidos de informações já publicadas, relatórios, e experiência com as espécies em questão, puderam avaliar o grau de ameaça a que estão sujeitas espécies brasileiras, dentre elas a raposa-do-campo. Compiladas e discutidas as informações disponíveis, a espécie foi avaliada quanto a seu risco de desaparecimento. O resultado do trabalho encontra-se publicado na forma de artigo científico no periódico *Biodiversidade Brasileira*.

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CAPÍTULO I

Monitoring methods success for the hoary fox (*Lycalopex vetulus*) and other syntopic wild canids in a Neotropical agroecosystem

Artigo formatado de acordo com as normas para submissão ao periódico *Journal of Applied Ecology*

Monitoring methods success for the hoary fox (*Lycalopex vetulus*) and other syntopic wild canids in a Neotropical agroecosystem

Running headline: Monitoring success of wild canids in an agroecosystem

ABSTRACT

1. Capture and marking species has become an important tool for monitoring wildlife populations and technological advances have led to widespread adoption of innumerous methods to survey wildlife. However, many researches discuss the feasibility and cost-effectiveness of these methods for long-term monitoring. To address this query, more studies are needed that simultaneously evaluate the efficiency of capture methods, considering possible sampling error such as imperfect detection or risks when handling wild animals.

2. To contribute to the standardization of sampling strategies to monitor wildlife, our goal was to evaluate a capture technique for, trapping potential and radio-tracking success of wild canids from an eight-year project that studied the ecology and conservation of the hoary fox (*Lycalopex vetulus*) and its interactions with other syntopic canids.

3. We obtained 470 capture events using cage-traps baited with sardine. Of these, 347 (74 %) events corresponded to wild canids captures (mean success of 10.7 captures per 100 trap/nights). We carried out 171 anesthetic procedures and blood collection without any serious emergencies. Hoary fox showed higher capture rates than crab-eating foxes and maned wolves, but it was captured almost exclusively by medium-sized traps, whereas crab-eating foxes had high rates of capture by both trap sizes. Maned wolf had higher capture rates in large-sized traps. Capture rates were independent of the sex of

the captured individual or the season of the year. Wounds in the mouth and teeth were the most common injuries in captures using cage-traps.

4. We radio-collared and monitored 73 wild canids; VHF radio collars constituted an excellent tool for monitoring wild canids, especially hoary foxes, in altered landscapes of Cerrado with accentuated relief.

5. To allow additional monitoring of the hoary foxes by camera trapping, and to register new individuals for captures, we developed a technique to identify individuals via fur markings. Through our camera trapping method it was possible to record and sex 87.5% (n = 7) of the potential number (n = 8) of hoary foxes living in the sampled area.

Synthesis and applications. This approach provides a framework for capture and monitoring wild canids, accounting for imperfect detection and varying sampling effort, issues of fundamental importance in wildlife populations monitoring.

KEY WORDS

Capture-recapture methods; Carnivores; population ecology; camera trapping; radio telemetry; South American canids

INTRODUCTION

The Cerrado, nestled in the center of Brazil, is the second largest Neotropical ecosystem (cover approximately 2 million square kilometers), being composed by a mosaic of physiognomies varying from open grasslands to wet forests (Oliveira-Filho & Ratter 2002).This heterogeneity through the landscape promotes a high biodiversity, sustaining over 160,000 species (Klink & Machado 2005), including a rich fauna of mammals (Marinho-Filho, Rodrigues & Juarez 2002a). Of the 199 mammalian species found in the Brazilian Cerrado, 85% have body mass less or equal to 5kg and only 5 species weigh more than 50kg, making this wildlife essentially composed of small-sized animals (Marinho-Filho, Rodrigues & Juarez 2002b). Twenty species are Carnivores, which can be found in all Cerrado microhabitats: woodlands, savannas, grasslands, gallery forest, and dry forest (Mamede & Alho 2008). However, only one species of such taxa is considered endemic to the biome, the canid know as hoary fox (*Lycalopex vetulus;* Marinho-Filho, Rodrigues & Juarez 2002; Lemos *et al.* 2013).

The hoary fox is a small canid (3-4.6 kg), predominantly nocturnal, that lives as breeding pairs, but forages mainly individualy (Courtenay *et al.* 2006; Dalponte 2009; Lemos & Facure 2011; Lemos 2016a). Apparently, the hoary fox uses exclusively open grassland areas of Cerrado and pasturelands (Juarez & Marinho-Filho 2002; Jácomo, Silveira & Diniz-Filho 2004a; Courtenay *et al.* 2006; Lemos, Facure & Azevedo 2011). Juarez & Marinho-Filho (2002) suggest a home range for a female of 385ha and Courtenay *et al.*(2006) 456ha for a breeding pair, although both studies had monitored three individuals for a short period. Hoary foxes are sympatric with other canid species, as the crab-eating fox (*Cerdocyon thous*), the maned wolf (*Chrysocyon brachyurus*) and the bush dog (*Speothos venaticus*), and in many regions of open cerrado habitats are also syntopic with at least two of these species (Juarez & Marinho-Filho 2002; Jácomo, Silveira & Diniz-Filho 2004a).

The order Carnivora is one of the most endangered taxa among mammals in Brazil (Machado et al. 2005). Considering the past and current deforestation trends of the Brazilian Cerrado, it has been predicted that human activities may further influence population trends of maned wolves, for example (Paula *et al.* 2007; Paula *et al.* 2013). Recently, the hoary fox was classified as "Vulnerable to Extinction", due to rates of habitat loss and high human causes mortality (Lemos *et al.* 2013). Based on the ecological importance and conservation status of most Cerrado's wild canids, research efforts towards some species have been increasing (Jácomo, Silveira & Diniz-Filho 2004b; Curi & Talamoni 2006; Lemos, Facure & Azevedo 2011; Lima *et al.* 2012, 2015). However, ecological and biological parameters from monitoring programs and/or mid-long term projects are still necessary for developing effective and appropriate conservation and management strategies for canid species. To access such information a variety of methodologies for capturing, handling, marking and monitoring wild canids have been developed, tested, and applied in different arranges, species and conditions (Wilson *et al.* 1996; Macdonald & Sillero-Zubiri 2004). However, the methods used to capture and monitor the Cerrado's canid species remains poorly discussed in ecological studies and their effectiveness remains poorly knowledge.

To contribute to the development of standardized field methods and sampling strategies for a long-term effort to monitor hoary foxes populations, which may also be applied to other sympatric and syntopic canids, our general goal was to present a methodological discussion on capture techniques, capturing potential reached and radio-tracking success, which we have used to study the ecology and some population aspects of the hoary fox, crab-eating fox and maned wolf. In addition, we present an individual identification method via fur marking to hoary foxes identification.

MATERIAL AND METHODS

Study area

The data presented here is part of a project developed from 2008 to 2015 focused on the ecology and conservation of the hoary fox and two sympatric/syntopic canids (*C. thous* and *C. brachyurus*) in altered Cerrado areas of Central and Southeast Brazil. During this period, we carried out captures on hoary foxes, crab-eating foxes and maned wolves, and continuously monitored part of captured animals through two methods: Very High Frequency (VHF) radio telemetry and camera trapping. Fieldwork was conducted in three study sites in the states of Goiás (GO) and Minas Gerais (MG; Fig. 1). All study sites are characterized by a tropical climate with two well-defined seasons, one wet (October-April) and the other dry (May-September). Mean annual temperature and precipitation varied between 22-25°C and 1,600-1,800-mm, respectively (data from period 2008-2013 available by CPTEC/INPE).

One area was the Serra de Caldas Novas State Park (PESCaN; 17°43'S/48°40'W), a reserve of 124 km^2 at municipality of Caldas Novas-GO, dominated by open savanna physiognomies typical of the Cerrado biome (Oliveira-Filho & Ratter 2002; Ribeiro & Walter 2008). The second area was formed by contiguous cattle ranches (approx. of 150km^2;18°33'-18°43'S/48°07'-48°20W) in a region called Limoeiro at the municipality of Cumari-GO. The third area was also formed by contiguous cattle ranches (approx. of 120km^2; 18°56'-18°74'S/48°25'-48°30W) in the Araguari River's valley at municipality of Araguari-MG. In these last two sites, up to three-quarters of the landscape was modified for exotic pastures and agricultural fields. The remaining area is covered by small- and medium-sized (1-500 ha) scattered natural patches, which includes mainly closed physiognomies (i.e., gallery and seasonal forests; ~21%) and in less extent Cerrado open physiognomies (~4%; Lemos *et al.* 2016). In part, the predominance of forest habitat may be attributed to the geographical location of the study sites, which are under influence of two large rivers (i.e., in Paranaiba and Araguari rivers, respectively; Fig.1), whose basins were considered as ecotones between the Cerrado and Atlantic Forest biomes(Lopes *et al.* 2012).

Trapping and procedures

To evaluate capture technique and capturing potential, we summarized and compared data of capture success from 28 capture campaigns (range: 4-50 days) performed over seven years (Table 1). Two pilot campaigns were carried at 2008, one at PESCaN (April) and other at Limoeiro region (May). Afterwards, from July 2009 to June 2011, 17 campaigns were conducted simultaneously at Limoeiro region and Araguari River's valley. Between January 2012 and September 2015 other 9 campaigns were developed only at Limoeiro region. Gathered data comprised the length (days) of capture campaigns, number and size of traps used, total number of capture events per capture campaign, and total number of individuals captured. Once number of traps armed and baited per night varied, the trapping effort performed in each campaign was the sum of the number of traps armed every night during the campaign; traps found defused in the day after were removed of counts (i.e., trap-event failed by unknown reasons). The capture success responded to the ratio between total captures-recaptures of wild canids by trapping effort. To compare capture success rates, we assumed random selection by the individual as to which trap to enter once multiple traps were distributed over potential territories of previously sighted animals, to account for their movement through sections of home-ranges.

Canids were captured in baited Tomahawk cage-traps of two different sizes (Fig. 2), both made with galvanized wire mesh (space between bars lesser than 2-cm). Medium-sized traps were115-cm long, 60-cm high and 40-cm wide (Gabrisa™), and large-sized traps were 205-cm long, 105-cm high and 85-cm wide (custom-made by a local metalworker).Medium-sized traps used a simple trigger, with the door held open by a latch connected by a nylon thread to the foot pedal. Large-sized traps used a dual trigger system, with the door supported and kept opened by a wooden pole linked to two nylon threads, one tied to the foot pedal and other to suspended bait, at the trap background. Canned sardines and cooked chicken were used as bait. In both trap types, 90g of sardines were placed on and after the pedal, while a chicken leg or wing (~100-g) was used as suspended bait; only in the large-sized traps chicken bait was tied to the trigger system.

Traps were distributed non-systematically way over the studied sites at locations near areas where focal species were sighted (i.e., during night spotlighting surveys before each capture campaign) or signs were found (e.g., feces and tracks). Each trap was positioned close to cattle trails (constantly used by canids when moving) whenever possible, and always under vegetation so that the captured animal would be protected from the morning sun; we carefully choose areas avoiding the presence of aggressive ants (such as fire ants and leaf-cutter ants which are very common in the Cerrado; Costa & Vieira-Neto 2016) to reduce injuries to captured animals. Each trap was checked daily before 08:00 am and baits were replaced every three days or after a capture.

Capturing procedures consisted on the immobilization, complete clinical examination, blood sampling and biometrical measurement. Captured wild animals were immobilized with a handling intramuscular injection with a combination of different anesthetics and protocols. Vital signs (heart and respiratory rates, and body temperature) were recorded every 15 min during anesthesia (May-Junior *et al.* 2009).Each anesthetized animal passed by a complete clinical examination (teeth, skin, ears, footpads and toes, abdominal organs, and reproductive organs). Blood samples for several studies on epidemiological and genetic aspects were collected via the cephalic vein and stored in Vacutainer tubes without EDTA (e.g., Rocha *et al.* 2013). Thereafter, we performed the biometrical measurement, and took weight using portable scales (Pesola®, Switzerland). Frequencies of injuries (e.g., broken teeth, mouth wounds, skin lesions, limbs harms) in canids caused by traps (likely when trying to escape) were also registered.

All captured wild canids were marked with colored and numbered plastic ear-tags (Alflex ©) positioned in the center of right ear for males and left ear for females (Fig. 3). Part of the captured animals were also fitted with a VHF radio-collar to continuously monitoring (Fig. 3). Finally, animal was photographed to record individual marks as spots, scars, injuries, fur color, face and general body shape. Once finished the procedure, the animal was placed back into the trap, allowed to fully recover from the anesthesia (typically 2-3 hours post injection) and then released at its capture point/area. Individuals recaptured during the same campaign were released without anesthesia. Through the entire study, animals recaptured in campaigns apart by at least six months were re-evaluated.

All captures and samples collection of the wild carnivores followed the American Society of Mastozoology procedures (Sikes & Gannon 2011), and were approved by the Brazilian government (Instituto Chico Mendes de Conservação da

Biodiversidade – ICMBio/SISBIO license number 14576-2 of 2008-2015), and the Ethics Committees on Animals Using (CEUA) of Universidade Federal de Goiás (UFG; process number 086/14) and Universidade Federal de Uberlândia (UFU; process number 089/14).

Radio-tracking

To evaluate the radio-tracking method we summarized the success of animals monitoring (i.e., number of monitored animals, length of monitoring, and number of locations recorded per animal). Juvenile and adult canids (≥ 7 months of age) were fitted with Advanced Telemetry System radio-collars (ATS™, Isanti, Minnesota, USA) equipped with activity and mortality sensors (mortality triggered after 8 h without movements). Hoary foxes and crab-eating foxes were fitted with collars models 1950 and 2320 (Hoary foxes exclusively with the first model and crab-eating foxes with both), and maned wolves with model 2510. Collars weighted no more than 3% of animal body weight. Terrestrial monitoring was performed though conventional telemetry method, with most locations obtained by hoaming (sighting), besides triangulation on the ground without fixed bases. Monitoring were performed daily, alternating day periods (morning, afternoon and night) and individuals in order to find the animals at different moments of the day and their home range.

Individual identification by camera trapping

To allow hoary foxes monitoring by camera trapping we developed a technique to identify individuals via fur markings based on direct sightings of several foxes followed in the field. Between December 2012 and March 2013, a grid with 35 camera traps (30 Bushnell™ Trophy Cam DIGITALmodel-119736 and five Tigrinus®model-

6.0D) was established at Limoeiro region (Fig. 4). Camera trap stations were distributed 1.0km apart (distance based on hoary foxes' smaller home-ranges at Limoeiro, according to preliminary analysis on spatial ecology, i.e. 100 ha) and installed in sites where a) we had sightings and signs (tracks, scats, and holes/dens) of hoary foxes, or b) habitat was suitable for the species. At each station, attached (60-cm height) to a wood-pole, a camera trap was positioned 2.5 m away faced to a tree. Visual bait (fried chicken head, neck, thigh, wing, or foot) was suspended 2 m above the ground in a steam of the focal tree. Scent bait (oil from the fried bait and canned sardines) was poured around visual bait on nearby cattle trails, termite mounds, and shrubs in order to attract individuals to the local. With camera trap configured to movie-record, such frame-method enabled to record the animal passing many times in front of the cameras. When trying to access the visual bait in the tree, the fox would use the tree to support itself, thereby, positioning its back to the camera and revealing its tail spot (Fig. 5). As other species of the *Lycalopex* group, hoary foxes have a dark (mostly black) spot at the base of the tail, which can be unique for each animal. Based on this individual mark we roughly estimated the number of different hoary foxes present in the sampled grid. Our estimate was tested in the subsequent capture campaign (April-May 2013), which represented the longest capture effort in the study.

RESULTS

Capture success

After 28 capture campaigns carried between April 2008 and September 2015, we summed an effort of 3,246 trap-nights (Table 1). Of the 347 wild canid captures events, we carried 171 capturing procedures (71 of hoary foxes, 89 of crab-eating-foxes, 11 of maned wolves). Of total installed traps, 10.6% (n = 385) were found unset for unknown reasons and then removed from total effort and estimate of capture rates. With such effort, vertebrates accounted for 470 capture events (Table S1), from which 347 (74.0%) were wild canids, reaching an overall rate of 11 captures per 100 traps/night for this group (Table 1). Such capture rate varied strongly over the campaigns, but it was not significantly distinct between campaigns performed in wet or dry seasons (t = 0.009, df = 27, P = 0.993). However, capture rate showed a significant difference between canid species and trap sizes (Generalized Linear Model for interaction effect of canid species and trap-size, P < 0.001; Table S2). Hoary foxes had higher capture rates, but were captured almost exclusively by medium-sized traps (Fig. 6) and had the second captured success (Table 2). Whereas, crab-eating foxes were captured by both trap sizes in similar rates, with a slight trend for more captures in large-sized traps (Fig. 6). Because of this, crab-eating fox totalized practically the same number of captures observed for hoary fox, and had the highest capture success (Table 2). The less captured canid was the maned wolf, whose capture rates were higher in large-sized traps (Fig. 6). Capture rate per campaign was not significantly different among sexes regarding the three species (student t-test paired with data from campaigns where at least one individual of the species was captured; for hoary fox, t = 0.071, df = 24, P = 0.597; for crab-eating fox, t = 1.610, df = 18, P = 0.125; for maned wolf, t = 0.033, df = 5, P = 0.975).

The number of different individuals captured along the study was higher for *C. thous* than *L. vetulus* and *C. brachyurus* (Table 2). However, the overall capture success per species was practically the same for hoary foxes and crab-eating foxes, with maned wolves accounting for only 4% of the captures (Table 2). Such results may indicate differences in trapness (i.e., catch effectiveness of trap-capture method, bait used) among the study species. Indeed, 37% of hoary foxes were caught just once, while 53% and 78% of crab-eating foxes and maned wolves, respectively, were not recaptured (Fig. 7). Individuals captured three or more times in the same campaign (i.e., potential "trap-happy" animals) were not unusual in *L. vetulus* (n = 12 foxes) and *C. thous* (n = 14 foxes), but were less common in *C. brachyurus* (n = 1). We also observed a large difference between the three species regarding the number of animals captured through subsequent campaigns in the same locality. Twenty-one hoary foxes (46%) and 12 crab-eating foxes (15%) were caught over 2-6 different campaigns. The time interval between the first and last captures was below one year for most individuals of these two species, while for the remaining animals such interval ranged from 16 to 69 months (Fig. 8). A unique maned wolf was captured in 4 campaigns over an interval of 51 months (Fig. 8).

No serious anesthetic emergencies such as cardiac arrest or apnea have occurred during immobilizations. Injuries of different types and gravity (n = 70) caused by the capture were recorded on 61 procedures (35.7%). Most of these traumas were oral injuries composed by dental fractures and lacerations (mainly cuts in lips or gingiva). The exceptional case of oral injury corresponded to a male crab-eating fox, which had its palate fractured. Dental fractures were more common in crab-eating foxes, especially in animals captured through medium-sized traps (recorded in 43% of 72 occasions), when compared to large-sized traps (18% of 17 procedures). In contrast, dental fractures were recorded only in 18% of 70 procedures carried with hoary foxes captured by medium-sized traps, while maned wolves didn't present any oral injury. In addition, we recorded some superficial skin lesions (i.e., excoriates and cuts) in face or/and members, and member traumas (i.e., broken finger and nail torn). It was also registered a male crab-eating fox which performed self-mutilation in two different occasions, biting the tip of the tail.

Radio tracking monitoring success

From 171 canids captured and processed during the study, 69 were radio-collared and monitored between 2008 and 2015 at the study site of Cumari, Goiás. Hoary fox was the species with more animals monitored (n = 35), followed by crab-eating fox (n = 26) and maned wolf (n = 8; Table 3). During the monitoring, the number of locations recorded strongly varied per animal (between 1 and 111), but a similar mean number per individual was obtained for the three canid species (Table 3). Hoary fox have shown the highest rate of locations obtained by animal visualizations, with a similar pattern observed for crab-eating fox, while for maned wolf most data was obtained by triangulations (Table 3). In great part, the variation in number of locations recorded per animal was the result of the monitoring period length, which varied between 15 and 2288 days (Table 4). On average, the monitoring length was not significantly different among species and sex (Generalized Linear Model for effect interaction of canid species and animal sex, P = 0.742; Table S3). However, there was a trend to a shorter monitoring period for hoary fox, being most of individuals of this species monitored for less than one year; in contrast, most crab-eating foxes and maned wolves were monitored by two or more years (Table 4). Radio-collars were changed in 7 hoary foxes, 3 crab-eating foxes and 1 maned wolf (due the end of battery or eventual defect), allowing to extend the monitoring.

Camera trapping identification

During the four months of sampling (December 2012 to March 2013), each camera trap worked on average 39 days (varying between 2 to 85 days) and totalized an effort of 1324 trap/nights. All camera traps were installed in exotic pastures and the cattle affected the sampling; in some stations, these animals brought down the cameras or filled the memory card of the trap in few days stopping in front of it, thereby hindering the records of hoary foxes. Although some stations hadn´t work properly, we obtained 18 film-records in five stations (Fig. 4). Based on the tail mark (Fig. 10) seven different hoary foxes were identified, and analyzing their behavior (e.g., territory marking) it was possible to identify four males and three females. In the subsequent capture campaign (April to June 2013), only one animal not recorded by the camera trap sampling was captured in the area, while two recorded foxes were not caught (Fig. 4). Therefore, through our camera trapping identification method it was possible to record and sex 87.5% (n = 7) of the potential number (n = 8) of hoary foxes living in the sampled area; our sampling effort didn't allow to estimate the hoary fox population properly in the entire sampled area in 2013.

DISCUSSION

The knowledge on the ecology of wild canids in the Cerrado is scarce, being the hoary-fox the least studied (Lemos et al. 2013). Our study is the first long-term assessment comparing the success of capture and monitoring of the hoary fox and two syntopic canids in the Cerrado. Results showed that these canids differ largely in many aspects (e.g., trapping potential, chance of recapturing, risk of injuries, and radio-tracking time period). Information of this nature is very important for the planning and success of future monitoring projects, besides the establishment of conservation and management actions. Moreover, we present an individual identification method via fur markings to hoary foxes, which may allow a rapid and efficient population estimating for this species.

On overall, we have reached a high capture rate for the Cerrado canid species studied (11 captures per 100 traps/night), while non-target species corresponded approximately to just one-quarter of total captures. However, the number of different individuals captured by effort was different among the three canid species. The capture success for crab-eating foxes was almost 1.7 fold higher than for hoary foxes (2.40% and 1.42%, respectively). A similar difference in capture success among these two foxes species was also found in the Serra do Cipó National Park, Brazil (capture success of 4.36% for crab-eating and 0.72% for hoary foxes; Curi & Talamoni 2006). Such results may indicate a higher density of *C. thous* related to *L. vetulus* in the Cerrado. This pattern is different to the recorded in the Bolivian Chaco, other Neotropical savanna where pampas foxes (*Lycalopex vetulus*) – the ecological substitute of hoary fox – may be more abundant than crab-eating foxes (capture success of 1.25% and 0.34%, respectively; Maffei *et al.* 2007). For maned wolves, the capture success was lower (0.28%), when compared to the registered in the Serra do Cipó National Park (2.54%; Curi & Talamoni 2006), suggesting a possible low density of this canid in our study sites.

Many different factors related with trapping features (e.g., trap model, trigger sensibility, bait type), trappers' experience, weather, and biological variables (e.g., species behavior, home-range size) can affect trapping efficiency (target captures/trap-night) and selectivity (avoid non-target species) for capturing wild carnivores species (Boitani & Powell 2012). The fact hoary foxes were more recaptured may be explained by an apparently higher tolerance to humans. These small foxes were generally calm during the researchers approach to the trap for anesthetizing, in the other hand crab-eating foxes most times showed aggressive/scare behavior during the team approach, many times biting the trap, barking to the researchers, and charging towards the door of the trap. We didn't observe capture technique bias related to sex. In some carnivores species sexes can present different capture rates due different habitat use or to different responses to trapping (Logan *et al.* 1999; Austin *et al.* 2004; Lofroth *et al.* 2008; Conde *et al.* 2010).

Although the overall capture success varied between campaigns, there was no differences in capture success among seasons for the three species as would be expected, suggesting canids at our study sites, may be captured at any period of the year, independent of season, resource availability (i.e. food) and reproduction period. There were no differences in capture success among sexes for the three species neither, as expected at least for the foxes. Although both fox species are considered monogamic (Macdonald & Courtenay 1996; Courtenay *et al.* 2006) few is known on their sociality and resource sharing. In spite of the fact that pairs stay together along the year (Brady 1979; Sunquist, Sunquist & Daneke 1989; Macdonald & Courtenay 1996) or the reproductive season (Dalponte 2003; Courtenay *et al.* 2006; Lemos, Facure & Azevedo 2011). Hoary foxes forage alone (Lemos & Facure 2011), thus individuals of both sex must find their own food. Therefore, it's expected that both sexes be attracted to the trap bait, consequently no difference in capture rate among sexes. Regarding crab-eating foxes, it's known that couples forage in pairs most part of time (Brady 1979; Lemos & Facure 2011) and apparently both sexes search for food (more details on food share are still a gap in the knowledge of the natural history of the species), with no sex being specifically the one responsible for searching food.

Hoary foxes were the species with the highest capture success. This may suggest a higher degree of "captureness" for the species. If so, the hoary fox can be a great model for future capture-recapture studies focused on better understand population dynamics of carnivores in savanna environments. Hoary foxes were probably more captured in medium-sized traps due to differences on sensibility among traps. Large traps were much less sensible to light animals, as the hoary fox, though it would be difficult for foxes to disarm the trap. In the other hand, high capture success of crab-eating foxes could be explained by the population size of the species, which is suggested to be the most common canid along South America. Although common, lower recapture rates suggest the species may be less prone to enter traps for the second time than the hoary fox, though affecting it's captureness. Lastly, as expected, wolves were the less captured canid, what could reflect the animals density in the study sites. As a large predator, maned wolves are expected to occur in lower densities than smaller canids. Besides, the species have large home ranges with low degree of overlapping among couples (Azevedo 2008; Jácomo *et al.* 2009; Paula 2016), thus, considering our sampling grid, it's possible that few individuals were possible to be captured.

The capture rate between subsequent campaigns was higher for hoary foxes than for the other species, even with this species being the one that lives less. Based on radio telemetry monitoring data, hoary foxes have a high mortality and among the three species is the one with shorter life expectancy (Lemos 2016a). A lower number of crab-eating foxes (15%) were recaptured in the next campaign, although the grid hadn't change significantly, and many individuals were alive and with traps settled on their home ranges (many times close to their dens). This reinforces the suggested that, at Limoeiro region at least, crab-eating foxes are more averse to traps than hoary foxes. Such result may probably be related to the higher percentage of crab-eating foxes that had injuries during the capture (43% in medium-sized traps, and 18% in large ones) (especially dental trauma). Though, a shyer species that also suffer an injury inside the trap will probably have its captureness quite affected. Still, crab-eating foxes are nocturnal animals that uses more covered habitats, and It's known that in different regions of its distribution the species inhabits borders of forest and swamps, dense cerrado, mangroves, among others, different from the hoary fox and the maned wolf, which are more associated to open environments. This may suggest that crab-eating foxes may not tolerate (or are more stressed) to be exposed in an open area during the capture in medium-sized traps, increasing though its aggressiveness when inside the trap and the chances of getting hurt, and as consequence not return to the trap. Maned wolves recapture rate in subsequent campaigns may also be related with the number of individuals of the study site (which is probably low) and how the species use the space. Maned wolves have extensive home ranges with low degree of overlap between couples, then fewer animals would be captured in relation to the most numerous species with smaller home ranges, though more sampled.

Regarding the frequency of injuries, crab-eating foxes not only had the highest frequencies but also the only three exceptional cases during the project. We believe that some of the injuries resulted from the capture reflect the condition of higher aversion of crab-eating foxes to human presence, especially during the day, when the species is less active. Practically any study involving captures and monitoring of wild canids in Brazil provides information on injuries resulted from the capture, but Curi & Talamoni (2006) mentions crab-eating foxes were more stressed during approaches too. Exceptional cases of injuries reinforce this, once this species was the only to perform self-mutilation inside the trap. Maned wolves had few injuries and no broken teeth during captures. Sollmann *et al.* (2010) mention that from 19 wolves captured in Emas National Park only three had lacerations in the gingiva and no broken teeth was registered, suggesting that maned wolves in fact are less subject to more serious injuries during handling. The posterior monitoring of several individuals of the three species, including the two crab-eating foxes involved in the exceptional cases, allowed to know that none animal died from the injuries or handling during the monitoring period. The two male crab-eating foxes mentioned were monitored for six years and had different litters during this period. However, we consider the general percentage of injuries for the three species high and strongly reinforce that researchers must be prepared for emergencies that may eventually show up during the capture/handling. For that, besides taking all the cares when setting the traps, the presence of a trained wildlife veterinarian is vital to guarantee the well being of captured animals and also the team (Curi & Talamoni 2006).

The VHF radio collars proved to be a efficient tool to study hoary foxes. Cheaper VHF collars allowed us to monitor a larger number of individuals for longer periods than provided by Global Positional System (GPS) collars, as the autonomy of the batteries of VHF collars were higher than the GPS available from wildlife monitoring companies. Due to the use of small home ranges at open areas by hoary foxes (for details see chapter 3), most locations (about 70%) were obtained by direct views of animals during hoaming, this also allowed researchers to collect other types of information (such as group size, activity period, shelters used, reproductive condition, intraspecific and interspecific relationships, habits and feeding behavior, among others). Crab-eating foxes and maned wolves showed to be shier and didn't allow the same approach in terms of distance from the observer and duration of observation, such as hoary foxes, confirming that this species can be an excellent model for behavioral studies on savanna canids. Also, VHF collars proved to be extremely resistant to traumas suffered by monitored animals. Several individuals were roadkilled on highways and railways and yet transmitters continued working, allowing us to find the animal's carcasses and register the cause of the death.

The monitoring of hoary foxes through camera trapping also proved to be feasible and efficient, as we recorded and identified almost 90% of the potential individuals to live in the sampled area. Camera traps and individual marks have been used in several studies of population ecology (Carbone *et al.* 2001; Trolle & Kéry 2003; Silver *et al.* 2004). However, besides most of these studies have been focused on spotted cats such as jaguars (*Panthera onca*) and ocelots (*Leopardus pardalis*), some have been done with carnivores with less marked signs that may allow the individuals differentiation (Mace *et al.* 1994; Magoun *et al.* 2005). Besides non-invasive and easy to use, our method to film hoary foxes tails' mark may be useful for future studies on population assessments along different areas, where the current population size of hoary foxes is unknown.

Capture and marking animals has become an important tool for monitoring wildlife populations, however technological advances have led to widespread adoption of innumerous methods to survey wildlife distribution, abundance and behavior. In this scenario many researchers question the feasibility and cost-effectiveness of these methods for long-term monitoring. Based on two traditional methods (box traps and VHF radio telemetry) and a relatively modern one (camera trapping), our work evaluated the success of these methods for monitoring some population aspects of three Cerrado wild canids. We also provide important data on the risks of injuries associated to the manipulation of these carnivores. The main question to be answered regarding species threatened of extinction, such as the hoary fox, is how many individuals are there in the environment, though future studies on this aspect are urgent for Cerrado canid's conservation.

ACKNOWLEDGMENTS

We thank Centro Nacional para Pesquisa e Conservação de Mamíferos Carnívoros (CENAP/ICMBio) and Fundação Parque Zoológico de São Paulo for their partnership, and Idea Wild, Cleveland Metropark Zoo (Scott Neotropical Fund), Neotropical Grassland Conservancy, Smithsonian Conservation Biology Institute and Capim Branco Energy Company for providing the equipment used in the project. Carlos E. *Bagual* Fragoso, Hugo C. M. Costa, Frederico A. *Cigano* Souza, Daniel G. Rocha, and Leandro A. Abade provided invaluable assistance during fieldwork. We are also grateful to the landowners and protected areas' staff for providing logistical support.

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Tables

Table 1. Summary of capture campaigns (length, trapping effort and capture success) carried in the municipalities of Araguari (Minas Gerais), and Caldas Novas and Cumari (Goiás), Brazil, between 2008 and 2015. Canids capture success was calculated through the ratio between the numbers of canid captures by trapping effort

Municipality	**Length**	**Number of Traps***		**Effort in**	**Total Captures (success)**	
Campaign period	**in days**	Medium	Large	**traps/night****	Vertebrates	Canids
Araguari - MG						
2009, July	10	5	0	44	8	7 (0.16)
2009, August	8	7	0	56	7	6 (0.11)
2009, December	10	1	0	8	1	1 (0.13)
2010, March-April	14	5	0	54	13	4 (0.07)
2010, July-August	32	2	0	56	9	4 (0.07)
2011, May	15	5	0	34	2	1 (0.03)
2011, September	10	5	0	45	1	1 (0.02)
Caldas Novas - GO						
2008, April	10	5	0	45	4	3 (0.07)
Cumari - GO						
2008, May	6	6	0	27	4	4 (0.15)
2009, September	10	7	0	77	4	2 (0.03)
2009, November	10	6	0	44	13	6 (0.14)
2009, December	10	6	3	81	2	2 (0.02)
2010, February	10	7	3	99	7	6 (0,06)
2010, March-April	14	5	4	118	5	3 (0.03)
2010, July	10	10	3	107	14	9 (0.08)
2011, February	10	10	0	90	5	5 (0,06)
2011, April	10	4	0	36	6	6 (0.17)
2011, June	10	14	6	119	26	21 (0.18)
2011, July	5	0	4	20	1	1 (0,05)
2012, January	6	15	0	81	15	15 (0.19)
2012, March	4	10	0	36	5	5 (0.14)
2012, May	4	10	1	39	4	4 (0.10)
2012, June	4	10	0	36	4	4 (0.11)
2013, April-May	50	24	8	1119	173	129 (0.12)
2013, July	10	20	6	169	22	16 (0.07)
2014, March	20	24	6	347	66	53 (0.21)
2014, July	5	8	0	31	11	7 (0.23)
2015, September	18	16	6	228	38	22 (0.10)
Total	336			3,246	470	347 (0.11)

*Maximum number of traps opened and baited per day;
**Total amount of functional traps/nights.

Table 2. Summary of captures using medium- and large-sized cage-traps for hoary fox (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*), from April 2008 to September 2015 in three study sites at Central and Southeast Brazil (n = 28 capture campaigns). Capture success = ratio between the number of different individuals captured by effort.

Species	Number of captures		Individuals captured	Capture rate per individual	Capture success (%)
	Medium trap	Large trap			
L. vetulus	163	4	46	3.63	1.42%
C. thous	116	50	78	2.13	2.40%
C. brachyurus	5	9	9	1.56	0.28%

Table 3. Summary of location record success obtained for hoary fox (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*), monitored between 2008 and 2015 at Cumari-GO, Brazil.

	No. of individuals		No. of Locations		Method of location record (%)	
Species	Male	Female	Range	Mean ± SE	Visualizations	Triangulations
L. vetulus	18	17	1-111	34.0 ± 5.5	89.0	11.0
C. thous	14	12	1-82	38.9 ± 4.4	60.4	39.6
C. brachyurus	3	5	1-103	40.7 ± 9.6	43.6	56.4

Table 4. Summary of monitoring success for hoary foxes (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*), monitored between 2008 and 2015 at Cumari-GO, Brazil.

	Number of animals monitored (%)			Monitoring length in days	
Species	< 90 days	91-365 days	> 365 days	Range	Mean ± SE
L. vetulus	10 (28.5)	15 (43.0)	10 (28.5)	15-1.649	413.1 ± 77.9
C. thous	5 (19.2)	5 (19.2)	16 (61.6)	15-2.288	561.5 ± 100.4
C. brachyurus	0	1 (12.5)	7 (87.5)	127-1.399	550.5 ± 130.5

Figures

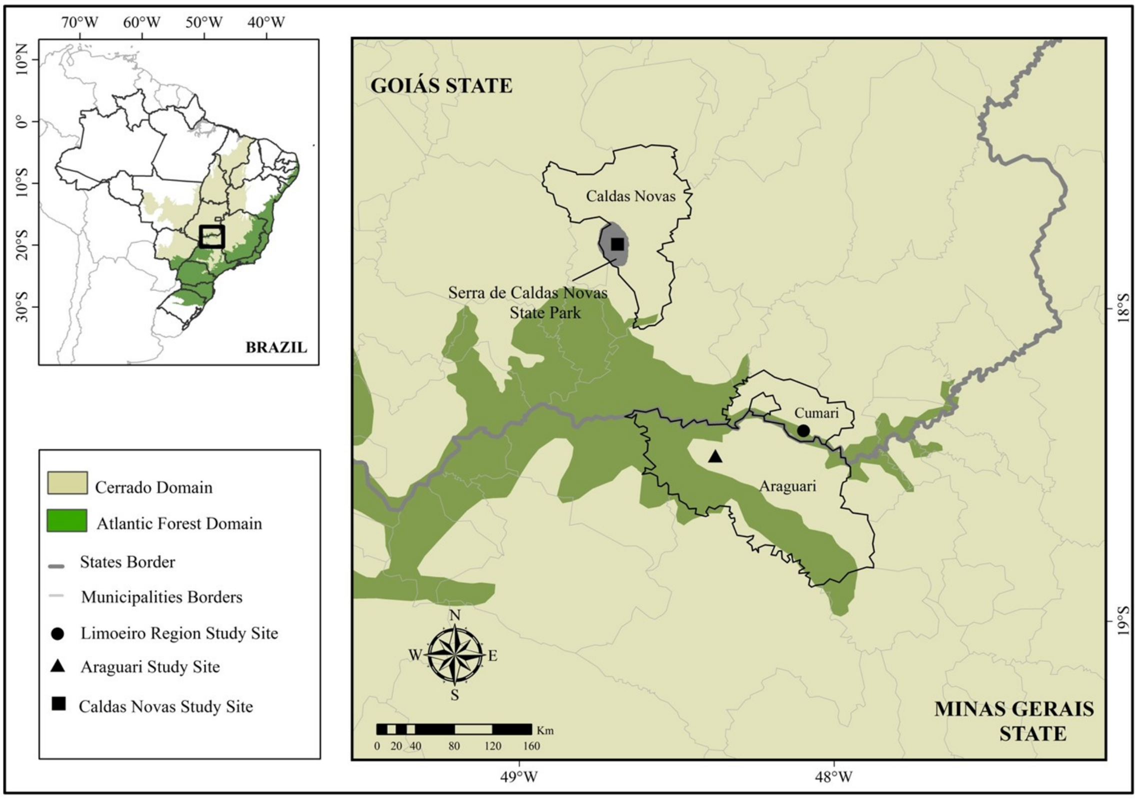


Figure 1. Map of the three study sites where hoary foxes (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*) were monitored between April 2008 and September 2015.

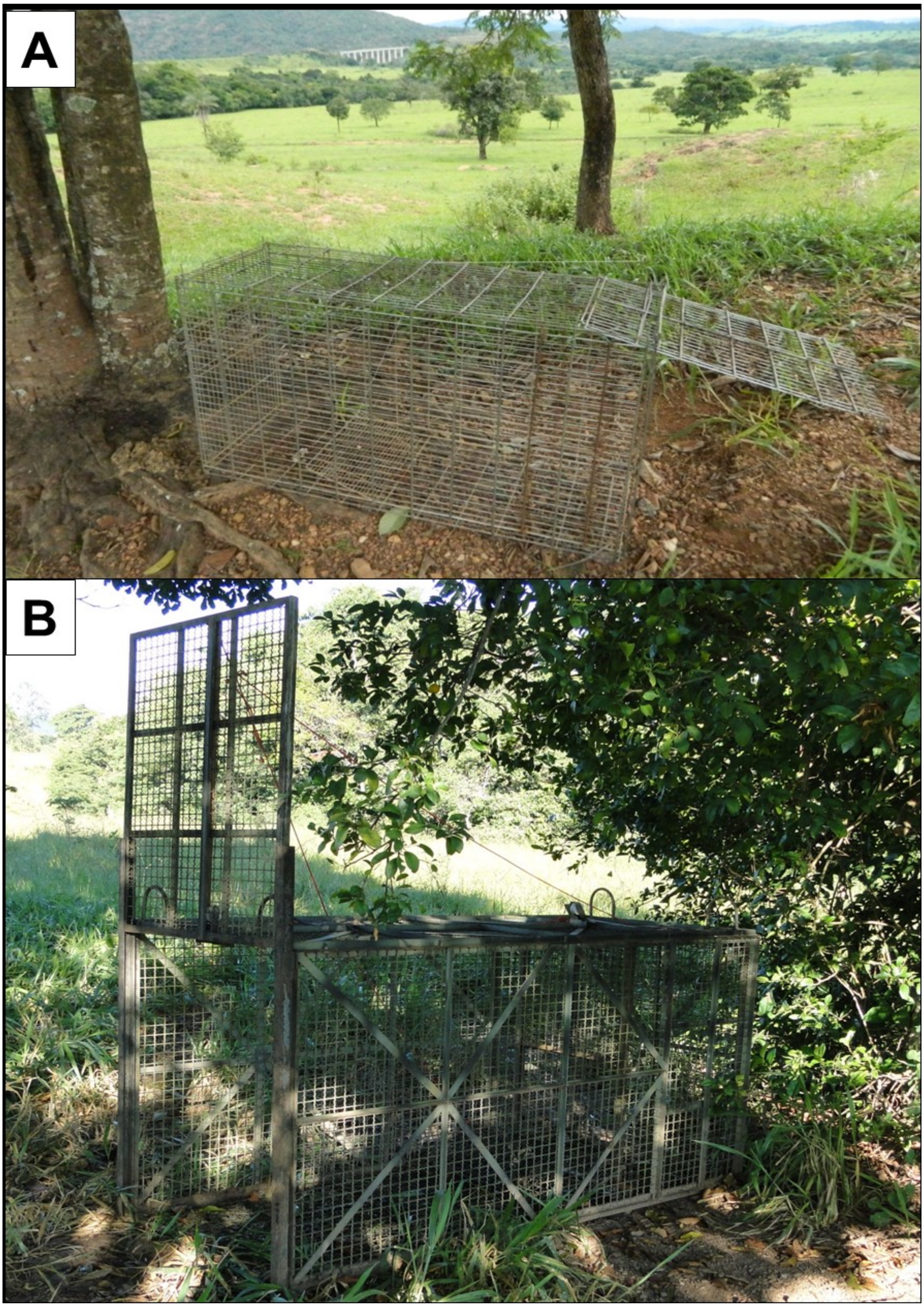


Figure 2. Medium- (A) and large-sized (B) cage-traps used to capture three species of canids (hoary fox *Lycalopex vetulus*, crab-eating fox *Cerdocyon thous* and maned wolf *Chrysocyon brachyurus*) at three study sites in Central and Southeast Brazil.

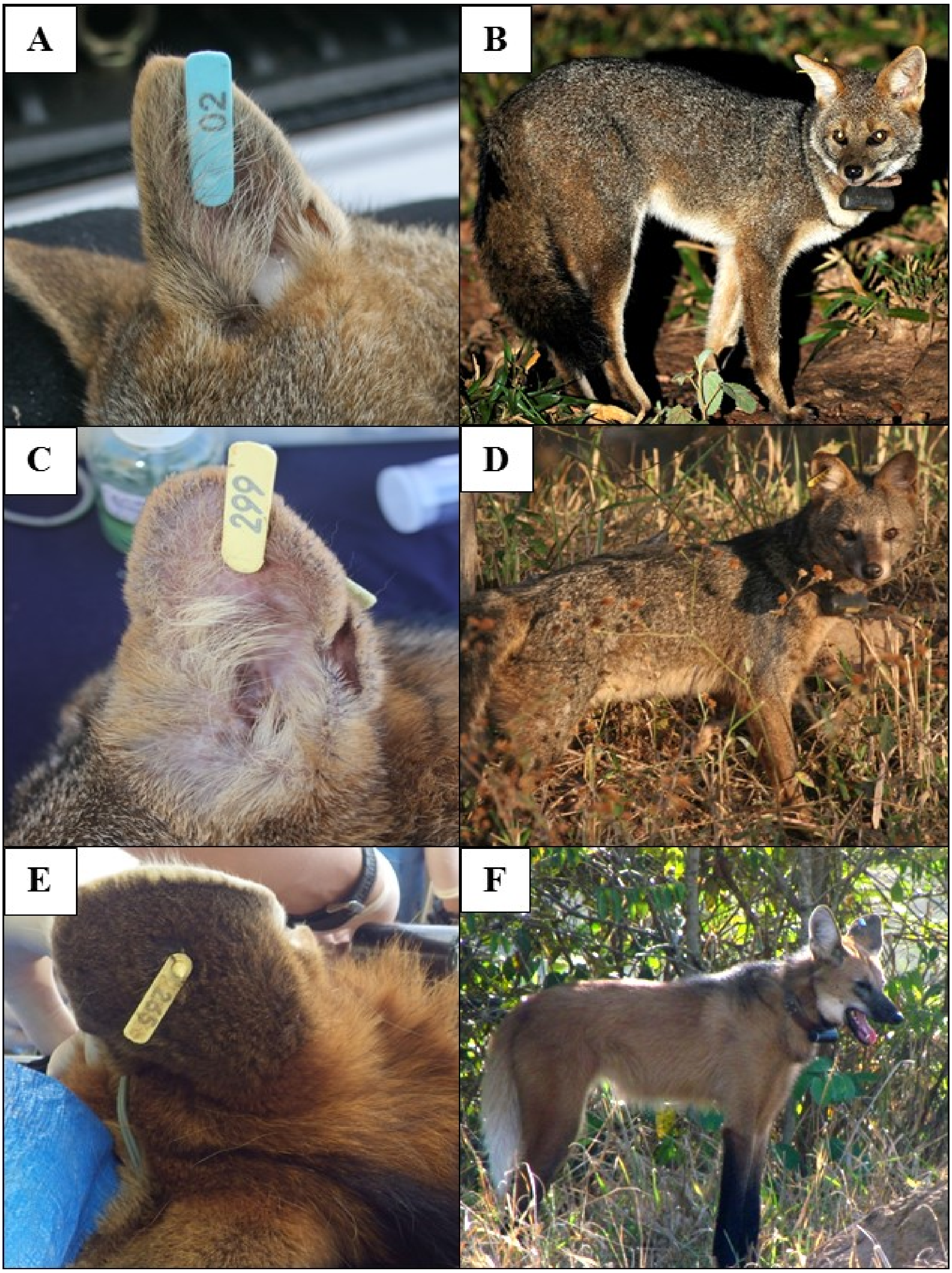
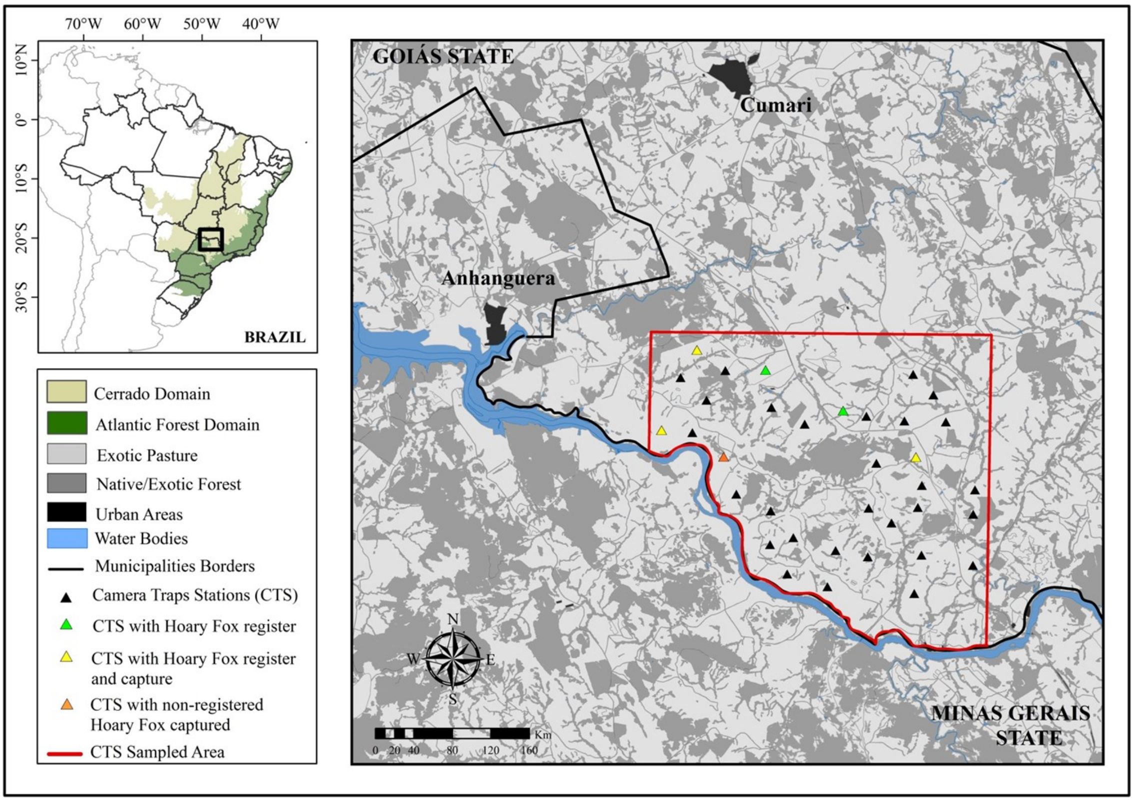


Figure 3. Colored and numbered ear-tags and Very High Frequency transmitters used to mark and monitor individuals of three wild canids in the Brazilian Cerrado: Hoary fox *Lycalopex vetulus* (A and B), crab-eating fox *Cerdocyon thous* (C and D) and maned wolf *Chrysocyon brachyurus* (D and E).



1028

1029 **Figure 4**. Camera trap grid (n = 35) established to record resident individuals of hoary
1030 fox *Lycalopex vetulus* in 2012 and 2013 within the study area at Limoeiro region,
1031 municipality of Cumari – Goiás state, Brazil.
1032

Figure 5. Tail spots of different hoary foxes *Lycalopex vetulus* captured in Cerrado areas of Goiás and Minas Gerais states, Brazil, between 2008 and 2015.

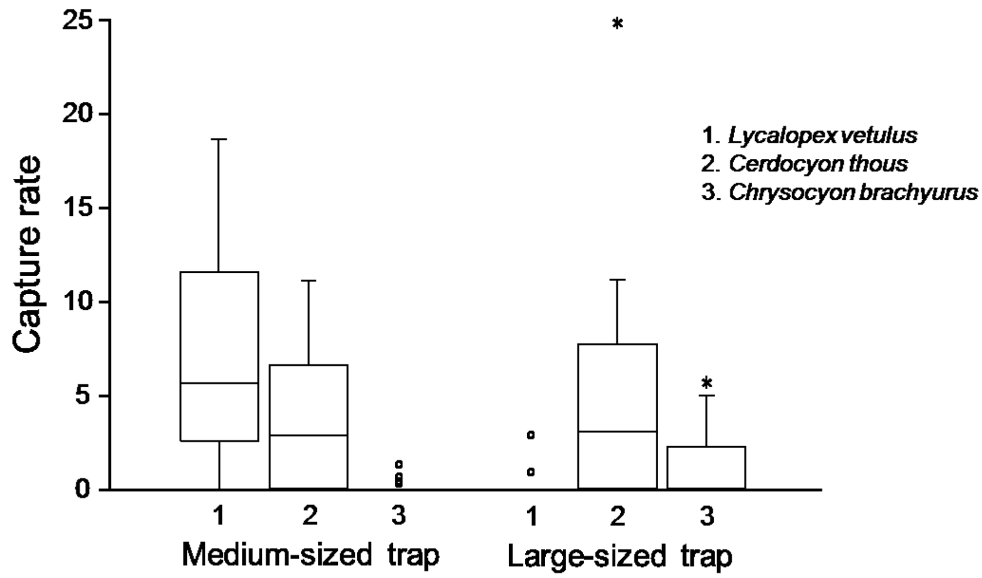


Figure 6. Capture success of three canid species using medium and large-sized cage-traps from April 2008 to September 2015 in three study sites at Central and Southeast Brazil (n= 28 capture campaigns).

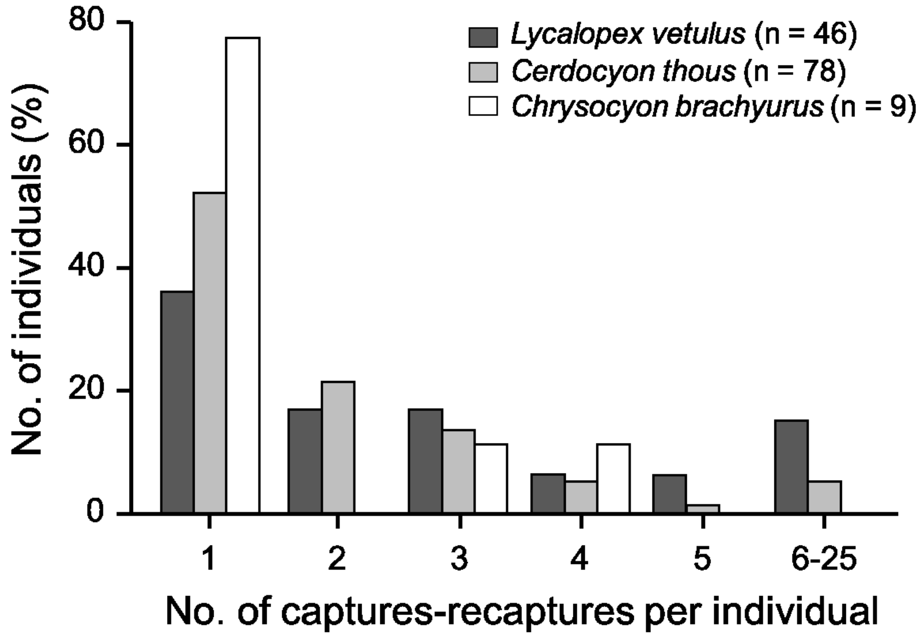


Figure 7. Frequency of individuals of three canid species by the number of captures-recaptures per individual along capture campaigns carried in three Cerrado study sites, Brazil.

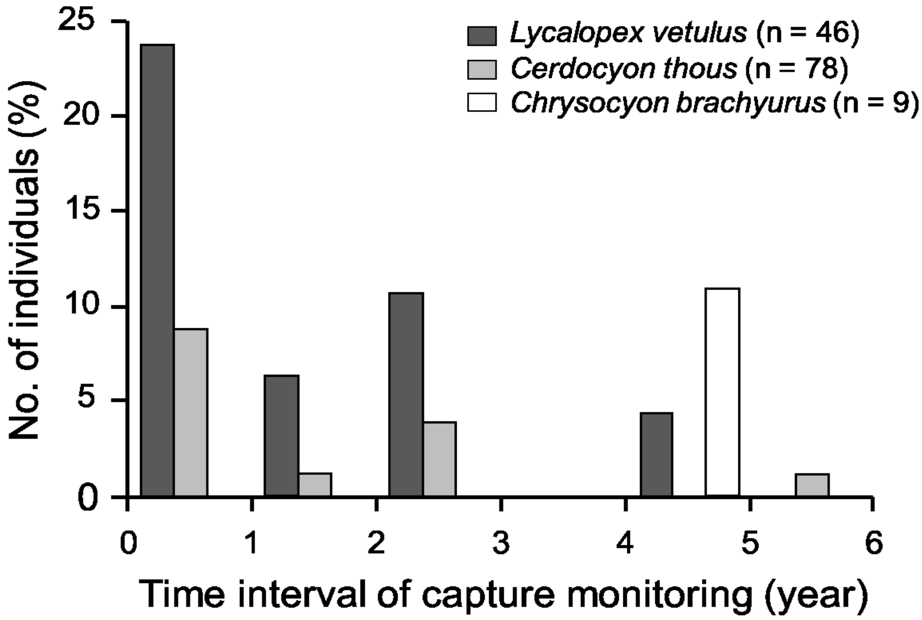


Figure 8. Frequency of individuals of three canid species captured in two or more campaigns by the time interval between the first and last captures in different campaigns.

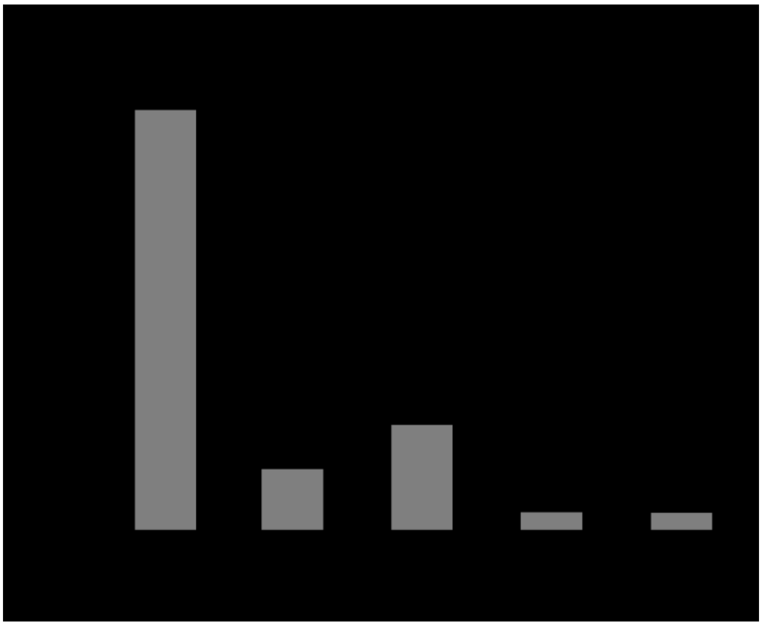


Figure 9. Frequencies of injuries (n = 70) recorded as a secondary result of the catch in 171 capture procedures of three wild canid species. Twenty-eight capture campaigns were carried between 2008 and 2015 in three Cerrado study sites, Brazil. Oral lacerations: cuts in lips or gingiva, and fracture of palate; Skin lesions: superficial excoriates and cuts in the face or/and members; Member traumas: broken finger and nail torn; Self-mutilation: biting the tip of the tail.

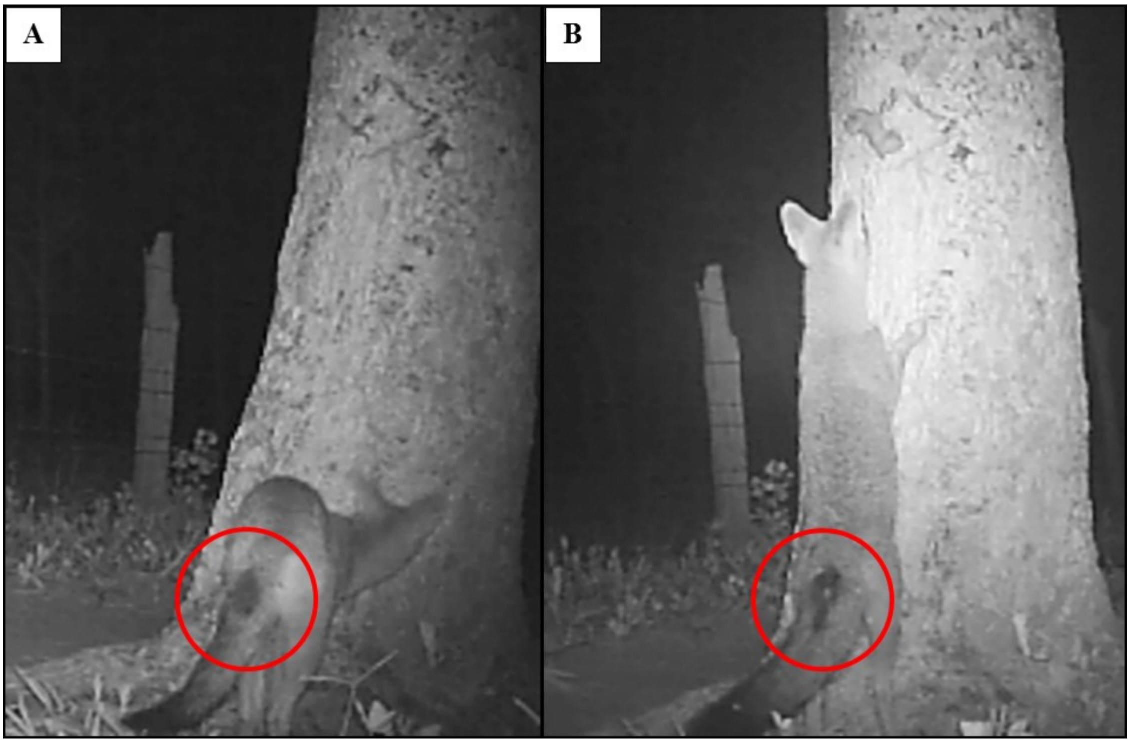


Figure 10. Two different individuals of hoary fox *Lycalopex vetulus* recorded at one of the 35 camera trap stations between 2012-2013 at Limoeiro region, municipality of Cumari – Goiás state, Brazil. Red circles evidence tail spot of the foxes.

ONLINE SUPPLEMENTARY MATERIAL

Table S1. List of Vertebrate species and number of captures – excluding wild canids – during 28 campaigns carried in three Cerrado study sites from April 2008 to September 2015.

Species	**Common name**	**Number of captures**	
		Mediumtrap	**Largetrap**
Domestic mammals			
Bos taurus Linnaeus 1758	Calf	0	1
Canis lupus familiaris Linnaeus 1758	Domestic dog	19	5
Felis catus Linnaeus 1758	Domestic cat	15	0
Wild mammals			
Conepatus semistriatus Boddaert, 1785	Hog-nosed skunk	43	0
Didelphis albiventris Lund, 1840	White-eared opossum	2	0
Euphractus sexcinctus Linnaeus 1758	Yellow armadillo	6	0
Myrmecophaga tridactyla Linnaeus 1758	Giant anteater	0	1
Nasua nasua Linnaeus 1766	Coati	1	0
Procyon cancrivorus F. Cuvier 1798	Crab-eating raccoon	1	0
Tamandua tetradactyla Linnaeus 1758	Lesser anteater	1	0
Birds			
Cariama cristata Linnaeus, 1766	Red-legged seriema	17	0
Milvago chimachima Vieillot, 1816	Yellow-headed caracara	3	0
Squamata			
Tupinambis merianae Linnaeus 1758	Lizard	7	0
Total		115	7

Table S2. Results of Generalized Linear Models testing the effect of species identity and trap size on capture rates for hoary fox (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*) in 28 capture campaigns carried out in three Cerrado sites between 2008 and 2015, Brazil

Source	**Sum-of-Squares**	**DF**	**Mean-Square**	**F-ratio**	**P**
Species	263.993	2	131.997	8.558	0.000
Trap size	40.328	1	40.328	2.615	0.109
Trap size*Species	363.198	2	181.599	11.774	0.000
Error	1711.986	111	15.423		

Table S3. Results of Generalized Linear Models testing the effects of species and sex on monitoring period length success for hoary fox (*Lycalopex vetulus*), crab-eating foxes (*Cerdocyon thous*) and maned wolves (*Chrysocyon brachyurus*), monitored between 2008 and 2015 at Araguari-MG and Cumari-GO, Brazil.

Source	**Sum-of-Squares**	**DF**	**Mean-Square**	**F-ratio**	**P**
Species	379248.367	2	189624.184	0.828	0.442
Sex	226664.714	1	226664.714	0.989	0.324
Species*Sex	137142.652	2	68571.326	0.299	0.742
Error	1.44362	63	229145.833		

Figure S1. Captured wild canids in medium and large-sized cage-traps at three study sites in Central and Southeast Brazil: hoary fox, *Lycalopex vetulus* (A); maned wolf, *Chrysocyon brachyurus* (B and C); and crab-eating fox, *Cerdocyon thous* (D).

CAPÍTULO II

Spatial dynamics and conservation of the hoary fox (*Lycalopex vetulus*) and wild canids in an anthropized landscape at Central Brazil

Artigo formatado de acordo com as normas para submissão ao periódico *Journal of Mammalogy*

Spatial dynamics and conservation of the hoary fox (*Lycalopex vetulus*) and wild canids in an anthropized landscape at Central Brazil

ABSTRACT

There is a great variation in social system among canids and this is directly linked to how species are organized in space. However, lack of information makes difficult to understand the role of each factor to canid societies. Three sympatric species, the hoary fox (*Lycalopex vetulus*), crab-eating fox (*Cerdocyon thous*) and maned wolf (*Chrysocyon brachyurus*), were studied through radio telemetry and direct observations between 2008 and 2015 at Limoeiro region, municipaly of Cumari, Goiás, an agroecosystem landscape at Central Brazil. The main objective of this study was to describe the spatial organization of the hoary fox, examine its interactions with other sympatric canids, and identify threats to their survival in a disturbed habitat of Cerrado. Throughout this study, 115 wild canids were captured and marked, and 73 equipped with Very High Frequency radio transmitters. Of these, 38 were hoary fox, 27 were crab-eating fox and 8 maned wolves. Mean home range sizes for hoary foxes were 2.68 km^2, 8.23 km^2 for crab-eating foxes, and 66.54 km^2 for maned wolves. All species were active primarily during the night, with highest percentage of active fixes from 19:00 hours to 04:00 hours. Wild canids used up to 11 types of shelters (n = 417 registers); yellow armadillo (*Euphractus sexcinctus*) holes were the most frequent shelter for hoary foxes, whereas crab-eating foxes and maned wolves were most found using clumps of tall grass. We were able to identify at least eight death causes of nearly 70% of the monitored canids and human-related threats represented almost half of the causes (41.3%). At Limoeiro region, the three canids overlap their home-range and activity at

some degree. Apparently the three species overlap different niches, however occur sintopically, being indeed subject to the same threats.

Key-words: animal behavior, *Cerdocyon thous*, *Chrysocyon brachyurus*, continuous time movement modeling, fragmentation, home range, *Lycalopex vetulus*, Neotropical ecology, telemetry, space use

RESUMO

Dinâmica espacial e conservação de raposa-do-campo (*Lycalopex vetulus*) e canídeos selvagens em uma paisagem antropizada do Brasil Central

Há uma grande variação no sistema social de canídeos e isso está diretamente ligado à forma como as espécies se organizam no espaço. No entanto, a falta de informação torna difícil compreender o papel de cada fator nas sociedades de canídeos. Três espécies simpátricas, a raposa-do-campo (*Lycalopex vetulus*), o cachorro do mato (*Cerdocyon thous*) e o lobo-guará (*Chrysocyon brachyurus*) foram estudadas por meio de rádio telemetria e observações diretas entre 2008 e 2015 na região do Limoeiro, Cumari, Goiás, uma paisagem agroecossistêmica na região central do Brasil. O principal objectivo deste estudo foi descrever a organização espacial das raposas, examinar suas interações com outros canídeos simpátricos, e identificar as ameaças à sua sobrevivência em um habitat perturbado de Cerrado. Ao longo deste estudo, 115 canídeos silvestres foram capturados e marcados, e destes 73 foram equipados com transmissores de rádio de alta frequência (VHF), sendo 38 raposas-do-campo, 27 cachorros-do-mato e 8 lobos-guará. Áreas de vida médias de raposas-do-campo tiveram 2,68 km^2, 8,23 km^2 as de cachorro-do-mato, e 66,54 km^2 as de lobos-guará. Todas as espécies apresentaram hábito principalmente noturno, com a maior percentagem de pontos ativos entre 19:00 horas e 04:00 horas. Esses canídeos silvestres usaram até 11 tipos de abrigos (n = 417 registros); tocas de tatu-peba (*Euphractus sexcinctus*) foram o abrigo mais usado por raposas-do-campo, enquanto cachorros-do-mato e lobos-guará foram mais encontrados no interior de moitas de capim alto. Fomos capazes de identificar pelo menos oito causas de morte para quase 70% dos canídeos monitorados,

sendo que ameaças relacionadas a humanos representaram quase metade dessas causas (41,3%). Na região do Limoeiro, os três canídeos têm áreas de vida estáveis que podem se sobrepor em algum grau, estando mais ativos durante a noite. Aparentemente, as três espécies se sobrepõe em diferentes nichos, no entanto ocorrem sintopicamente e estão sujeitas às mesmas ameaças.

Palavras-chave: área de vida, *Cerdocyon thous*, *Chrysocyon brachyurus*, comportamento animal, fragmentação, *Lycalopex vetulus*, modelo de movimento de tempo-contínuo, Neotropical, uso do espaço, telemetria

INTRODUCTION

There is a great variation in social system among canids and this is directly linked to how species are organized in space (Burt 1943; Moehlman 1989). Such variation may occur according to intrinsic (e.g. phylogeny, behavior) and extrinsic relationships (e.g. intra and interspecific competition, food, opposite sex availability) (Moehlman 1989; Macdonald and Sillero-Zubiri 2004; Sillero-Zubiri 2009), however the lack of information about several species makes difficult to understand the role of each factor to canid societies. In this scenario, knowledge on poor-known South American canids may contribute to better understand how social systems work in the Canidae, and also how some traits evolved in this family.

Currently, six genera and 11 Canidae species are recognized to occur in South America (Sillero-Zubiri 2009). Phylogenetic studies have shown that two lineages of canids derived from the lupine stock and arrived at South America during the Great American Biotic Interchange, between the end of the Pliocene period and early Pleistocene (approximately 3 million years ago) (Langguth 1975; Wang and Tedford 2008; Perini et al. 2010; Tchaicka et al. 2016). From this on, species differed and occupied available habitats (specially open grasslands) and niches (e.g. consuming small prey and fruits) (Berta 1987; Sillero-Zubiri 2009). One of these lineages, the South American foxes (composed by genus *Lycalopex*, *Cerdocyon*, *Atelocynus* and *Dusicyon*), has as common trait small-sized species which, despites resembling "foxes" from the Old World (lineage Vulpinae), are much more related to Lupinae species. Therefore, this particular represents a good opportunity to understand what may be shaping social systems and other aspects of small-sized Lupinae species (Macdonald and Courtenay 1996; Courtenay et al. 2006).

Six canid species occur across the Brazilian territory in different biomes (Sillero-Zubiri 2009). Of these, four are originally sympatric along the second largest ecosystem of the Neotropical region, the Cerrado: the maned wolf (*Chrysocyon brachyurus*), the bush dog (*Speothos venaticus*), the crab-eating fox (*Cerdocyon thous*) and the hoary fox (*Lycalopex vetulus*) (Marinho-Filho et al. 2002; Paglia et al. 2012). To occur sympatrically species must occupy different niches, whether spatial, temporal, or trophic, and this is the result of thousands of years evolving (Pianka 1981). The ecological coexistence of sympatric species depends on the segregation of niches, which may lead to the partition of resources (Pianka 1974; Underwood 1986). When this doesn't happen the stage is armed for competition, which in higher intensity may lead to a major component of Canidae ecology, the interference competition (Tannerfeldt et al. 2002; Macdonald and Sillero-Zubiri 2004; Kamler et al. 2012). However, few is known on how Cerrado canids structure their community under this ecological aspect.

Great part of studies on Brazilian canids focused on single species, and most of these on trophic or temporal niche aspects (e.g. Dalponte 1997; Aragona and Setz 2001; Facure et al. 2003; Vieira and Port 2007). Furthermore, many are of short duration and based on few individuals (e.g. Courtenay et al. 2006; Melo et al. 2007; Lima et al. 2015). Although some studies had quantified the overlap among species regarding habitat use, diet, or activity period (Jácomo et al. 2004; Faria-Corrêa et al. 2009), few evaluated other aspects such as home range (Azevedo 2008; Jácomo et al. 2009), specially along anthropized landscapes where resources may no more be available on the same proportion as in natural habitats (Juarez and Marinho-Filho 2002). Within this scenario, while crab-eating foxes, maned wolves and bush dogs are better known, the small and endemic to the Cerrado hoary fox remains as one of the least known canid of the Lupinae lineage.

Powell and Mitchell (2012) recently suggested that home range is that part of the cognitive map of an animal formed by the set of information about the resources it needs to survive and where it needs to go to meet these requirements. Several studies also have shown that resources should not be restricted to food, once shelter, potential partners, den sites, secure areas, among other examples are also directly linked to animals' life histories and how they use the space (Logan and Sweanor 2001; Tannerfeldt et al. 2002; Kamler et al. 2003b; Spencer 2012). Meet these demands must be done while avoiding encounters with predators and rivals (Kamler et al. 2003a). In this sense, understanding how species are organized in space (e.g. home range size, overlapping degree) allows to estimate population size and dynamics and the minimum areas necessary to maintain viable populations. For Cerrado canids, studies have begun to shed light on how these species use the space (Dalponte 2003; Trovati et al. 2007; Jácomo et al. 2009; Lima et al. 2012), and while most of these have been carried inside protected areas (Melo et al. 2007; Azevedo 2008; Paula 2016), more data is necessary from the other side of the fence (Juarez and Marinho-Filho 2002; Lima et al. 2015).

Although studies on the natural history of species contribute to understand their evolution, these are also important on the other end of the time scale, the future. Knowing what factors affect species occurrence and abundance can be a guide for establishing conservation priorities and efficient management programs. Currently, more than half of the Neotropical canids are under some risk of extinction (Sillero-Zubiri 2009), including the hoary fox, the maned wolf and the bush dog (Jorge et al. 2013; Lemos et al. 2013; Paula et al. 2013). Although studies developed in natural areas (e.g. national and state parks) are very important for learning how species originally behave and interact, this condition doesn't reflect the actual scenario of most Neotropical ecosystems, as the Cerrado (Chazdon et al. 2009; Davies-Mostert 2014).

Most of this savannah biome encompasses private lands, where wildlife is forced to live and interact directly with domestic animals and humans. Therefore, it is vital to know which threats may arise from this new dynamics and understand how species are sharing the available resources.

Our work represents the largest effort conducted to understand the spatial ecology of the hoary fox and part of its relations with other sintopic canids at an anthropized landscape of Central Brazil. After a long term monitoring of several individuals we were able to 1) estimate the home-range size of the hoary fox, the crab-eating fox and the maned wolf at Limoeiro region, Central Brazil; 2) examine if sex and weight affect home range size, and 3) determine the activity period and most used shelters for each species. We also describe death causes of wild canids at the studied community.

MATERIALS AND METHODS

Study area – This work is part of a broader project focused on the ecology and conservation of the hoary fox and its relationship with syntopic canids in altered Cerrado of Central and Southeast Brazil. We present data collected from hoary foxes, crab-eating foxes and maned wolves monitored between 2008 and 2015.

The study area comprises 45 contiguous private cattle ranches (~ 150 km^2) in a region called Limoeiro, municipality of Cumari, Goiás State, Brazil (18°33'–18°43'S / 48°07'– 48°20W; Fig. 1). Cumari is inserted in the Cerrado biome and its original vegetation is characterized by a mosaic of closed physiognomies (i.e., gallery and seasonal forests) and open ones (i.e., open fields, cerrado *stricto sensu*; Lemos 2016a). Particularly, in Limoeiro region there is the predominance of forested habitat, which may be attributed to the influence of Paranaíba River (Fig. 2), whose basin is regarded as an ecotone between Cerrado and Atlantic Forest biomes (Lopes et al. 2012).

Currently, up to three-quarters of the landscape was modified for exotic pastures and other cultures (for details see Lemos 2016a). The area is covered mainly by *Urochloa* sp. that has been supporting about 10,000 of cattle (*Bos taurus*) for ranching (Fig. 3). Remaining natural vegetation represents about 25% of the area and is dispersed in small and medium-sized patches (1-–500 ha) of original and secondary semideciduous and gallery forest (Lemos 2016a). Domestic dogs (*Canis lupus familiaris*) are kept mainly for properties guard and to help cowboys with cattle work. As cattle and horses, dogs are widely distributed along the entire study site (Lemos 2016a).

The study area is crossed by two paved roads, several dirt roads and a railway (Figs.1 and 4). Federal highway BR-–050 borders the eastern portion of the area and is one of the most important Brazilian roads for agricultural production from western and northern regions of the country, though presenting a heavy nighttime traffic. The state road GO-–402 has a less intense vehicle flow but is important once crosses the study area and the range of the three studied species. As the state road, Centro-Atlântica railway cross the region right in the center and may also play a threat role due its whole day traffic. Although with less traffic movement, dirty roads cut the entire study site and are commonly used by wild species for traveling (apparently more than paved roads).

The study region is characterized by a tropical climate with two well-defined seasons, one wet (October-–April) and one dry (May-–September). Mean annual temperature and precipitation varied between 22-–25°C and 1,600-–1,800 mm, respectively (data from period 2008-–2013 available by CPTEC/INPE).

Capture, handling and monitoring – Wild canids were captured using Tomahawk cage-traps baited with canned sardines and cooked chicken (for details see Lemos 2016a). Traps were distributed non-systematically over the study area, and placed at locations where focal species were registered by direct observations (during spotlighting surveys) or indirect signs of its presence (e.g., dens, feces and footprints; see Lemos 2016b). Each trap was positioned under vegetation so that the captured animal would be protected from the morning sun; we also carefully choose areas avoiding the presence of aggressive ants (such as fire ants and leaf-cutter ants which are very common in the Cerrado; Costa and Vieira-Neto 2015) to reduce injuries to captured animals. Each trap was daily checked before 08:00 am and baits were replaced every three days or after each capture.

Animals were immobilized with a handling intramuscular injection with a combination of different anesthetics and protocols (Lemos 2016b). Each individual was weighed using a portable scale and its age estimated by physical characteristics such as teeth wear, body measurements, appearance of fur and teats (nulliparous or breast feeding signals). Based on these features we placed it on one of three age categories: pups, subadults, and adults. All captured canids were assumed to be born on August 15th and the period between August 15th to August 14th a fox-year. The animal was classified as a pup if it was < 6 months old (August 15th to Februay 14th), subadults when with presumed > 6-12 months old (February 15th to August 14th), and adults when presumed >12 months old (Baker et al. 2001). In general, pups and subadults are referred to as juveniles, but following Courtenay et al. (2006) we kept the division between these two classes. Foxes and wolves were marked with colored and numbered plastic ear-tags positioned in the center of right ear for males and left ear for females, and when a target animal fitted with a Very High Frequency radio-collar (ATS, Isanti, Minnesota, USA -–

Models 1950 for hoary foxes and crab-eating foxes, 2320 for crab-eating foxes, and 2510 for maned wolves). Finally, the animal was photographed to record individual marks as spots, scars, injuries, fur color, and general body shape. Once finished the procedure, the animal was placed back into the trap, allowed to fully recover from the anesthesia, and then released at its capture point/area. Individuals recaptured during an interval of six months were not submitted to a procedure and were released without anesthesia. Through the entire study, animals recaptured in campaigns separated by at least six months were anaesthetized, re-evaluated and had biological samples collected, which are part of ongoing research lines focused on the epidemiology and genetics of the studied species.

All captures followed the procedures recommended by the American Society of Mastozoology (Sikes and Gannon 2011), and were approved by the Brazilian government (Instituto Chico Mendes de Conservação da Biodiversidade ICMBio/SISBIO license number 14576-2 of 2008-2015) and the Ethics Committees on Animals Using of Universidade Federal de Goiás (process number 086/14) and Universidade Federal de Uberlândia (process number 089/14).

Terrestrial monitoring was performed through conventional telemetry method, with most locations obtained by hoaming (sighting), besides triangulation in the ground without fixed bases (for details see Lemos 2016b). Monitoring were performed daily, alternating day period (morning, afternoon and night) and individuals in order to find the animals at different moments of the day and their home range evenly.

Home ranges analysis – Home ranges analyses comprised location points data from radio tracking, direct observations, and captures recorded between 2008 and 2015. To estimate locations from triangulations we used the software LOAS 4.0 (Ecological

Software Solutions, Inc.) according to the maximum likelihood estimator (Lenth 1981). Magnetic declination, which is used for the correction of azimuths in relation to geographical North, was calculated through the software GeoMag 2.5 for each year of the study. Once obtained the coordinates, home ranges were estimated using the Auto correlated Kernel Density Estimator (Fleming et al. 2015).

Despite the concept, home range is still intensely debated since Burt (1943) (for an interesting discussion on what is a home range see Fieberg and Börger 2012; Powell 2012; Powell and Mitchell 2012) and several estimators have been developed and used since the first studies on how wildlife uses the space (Powell 2012). Among these, Minimum Convex Polygon has always been the most traditional one, despite its failures and limitations, such as to consider areas of little or none use as part of an individual home range, or not consider the intensity of use of internal coordinates (Powell 2000). Nowadays, Minimum Convex Polygon continues to be used for single views of home ranges and comparative purposes between studies on spatial ecology. Aiming on such gaps, another significant step was taken when a probabilistic estimator started to be used for predicting home ranges, the Kernel Density Estimator adapted from Silverman (1986), this non-parametric estimator is calculated through probabilistic functions of density from a random variable, in this case represented by the locations of individuals in the space (Worton 1989).

Although extensively used since then for more detailed spatial analyses, this estimator also may present failures. Besides being an adaptation from a non-parametric statistical method (Powell 2000), it doesn't consider the temporal sequence among localizations (autocorrelation), what may underestimates home range sizes and the degree of importance of certain areas to the individual (White and Garrot 1990; Powell 2012; Fleming et al. 2014). Addressing on the mentioned limitations of estimators cited, Fleming et al. (2015) recently developed the Auto correlated Kernel Density Estimator, a estimator that generates the probability density of an animal occurrence based on the individual's own movement parameters considering the time sequence of the set of locations used. This results in more precise home range estimates and eliminates the bias of autocorrelation between locations generally associated to other traditional methods (Fleming et al. 2015). Although several studies have been using similar methods to estimate and compare home ranges among areas/species, Powell and Mitchell (2012) highlight that difficultly a perfect estimator will be developed, and this will always depend on the question and biological processes of each study.

Considering the gap on hoary fox spatial ecology data for running strong comparisons, except for the first insights provided by Juarez and Marinho-Filho (2002), Dalponte (2003) and Courtenay et al. (2006), we estimated home ranges using the Auto correlated Kernel Density Estimator. Home ranges were generated using the R language (R 3.2.2.), through the specific package *Continuous-Time Movement Modeling* (CTMM; version 0.3.2) (Fleming and Calabrese 2016). For that, we selected individuals of the three species that attended two assumptions: stable variograms and monitoring length. One of the functions of the package (*variogram*) allows to verify the stabilization of home range through the analysis of semi variance of the data, by not only the accumulation of points in the temporal gradient, but also calculating the stochasticity of the movement (though, considering the dependence among coordinates). In other words, a stable variogram means that the home range of the animal in the sampled period reached stability based on independent locations thrpugh the monitoring period. For the second assumption, we considered six months as the minimal monitoring length for an animal to be considered for analyses once this was the shortest length in which variograms of animals stabilized. Also, home ranges were estimated excluding 5% of most external coordinates, as normally done by Kernel Density Estimator (Powell 2012).

Mortality – In order to gather information on the death causes of wild canids at Limoeiro region, radio-collars were equipped with mortality sensors that triggers when the collar is inactive for > 8 hours (what is unexpected for mammals). When detected a signal of mortality we immediately tried to locate and recover the carcass. Once found the carcass, first we searched the region around it for signs (tracks, scratches) of the possible predator or aggressor, and then at the basecamp a detailed examination was carried out to identify the possible death cause.

We grouped causes of mortality in three main classes: *human-related*, *natural* or *unknown*. The class *human-related* were divided into two categories: *indirect causes* (road and railroad kills, and attacks of domestic dogs), which are events where a human doesn't choose to kill the animal, and *direct causes* (poisoning and shooting), which account for events when a person is aware of her act. Among *indirect causes*, an animal was considered road/railroad killed when its carcass was found in the road, roadside, railroad or rail roadside with clear signs of vehicle/train collision (e.g. broken bones, body parts torn apart). Death by domestic dog attack accounted for carcasses found badly damaged by bites but not consumed (as would be expected for a predator). In this case, registers were only considered when we witnessed the persecution and found the carcass of the victim, or a cowboy confirmed his dog had taken the monitored animal. Among *direct causes*, we classified as poisoning when a carcass was found with internal bleeding, blood in the mouth, dead flies and/or other animals (i.e., vultures or conspecifics) nearby, and had no signs of other causes. However, no toxicological exams were carried out to prove it. To determine shooting we searched the carcass for shot marks in the skull and body.

Among *natural causes*, we concluded that a wild canid was predated after a careful search around the place where the carcass was found. Predated animals had canine puncture wounds associated with subcutaneous hemorrhaging, indicating the animals were alive when attacked. We identified the predator species by examining features of carcasses (i.e., size and placement of bite marks) and evidences at kill sites (i.e. tracks and signs, pattern of consumption, vegetation type). We considered an animal probably died by advanced age when familiar old individuals were found close to dens or resting sites without any apparent death cause or previous signs of sickness or apathy. Finally, we classified as *unknown* cause of mortality when carcasses were missing or had none strong evidence of the death cause. Once no advanced disease exams were carried out on monitored animals during the project, unfortunately we didn't quantify the role of diseases for wild canids, although much probably this category is among the most dangerous for anthropized areas as Limoeiro.

Activity period and shelter use – To determine the activity pattern of wild canids at Limoeiro region, all radio-collars used in this study were equipped with an activity sensor, which worked in two modes: inactivity and activity. We recorded activity for each monitored animal while obtaining locations by radio telemetry or during direct observations. For triangulations, we determined the activity status considering the most frequent status during data collection. For example, from the three coordinates taken, if the animal was active in just one and inactive in two, then the animal was considered inactive.

For allowing analyses and comparisons with other studies, day period was divided into 12 time classes of two hours. Although an effort for properly data collection was done, the number of collected coordinates during night periods was greater than during day period, though the total number of records of activity/inactivity were not used to describe the species activity pattern. Once each individual had different records of activity/inactivity in each time class, we calculated the percentage of activity for each individual in each time class. Then we calculated the percentage of activity for all sampled animals at each class. Though, for each time class the percentage represents the proportion of active animals in that time period during the study.

Whenever possible, inactive animals were searched and observed to register if they were using any sort of shelter in their inactivity moments. Once found, we verified if the animal was using any kind of structure that could promote mechanical protection or to other threats (e.g. against climate variations). Thus, animals found inactive, simply sitting or lying on the grass, fully visible, and without any structure resembling a shelter were not considered in this analyzes. Were also removed from the analysis of description and frequency of shelter use every record accompanied by behavioral descriptions of parental care or puppies presence in the structure. In this case the structure would not account for shelter, but instead a den site. In short, we only considered records when the animal was using a shelter for some kind of protection, never for reproduction, even if that same structure (armadillo hole, for example) could be used for both purposes.

Statistical analyses. – Significant deviation from a sex-ratio of 1:1 was evaluated for each species, using chi-square tests for homogeneity. Differences in mean body mass among species and between sexes were tested using analysis of variance and t-tests for independent samples, respectively. Intra and interspecific variation in home-range size was tested using the Kruskal-Wallis non-parametric test. The strength of the linear association between body weight and home range size was measured using the Pearson correlation coefficient. The use of different shelter categories was compared between sexes using chi-square test for independence. Statistical analyses were performed in R 3.0.2 (R Core Team, 2014).

RESULTS

Captures and biometry – After 19 capture campaigns carried at Limoeiro region between 2008 and 2014, a total of 115 wild canids were captured and ear tagged (Lemos 2016b). From these, 40 were hoary foxes (21 males / 19 females), 67 crab-eating foxes (33 males / 34 females), and eight maned wolves (three males / five females). Sex ratio did not differ from 1:1 for the small-sized species (hoary fox: $\chi^2 = 0.025$, df = 1, P = 0.874; crab-eating fox: $\chi^2 = 0.058$, df=1, P = 0.809), indicating that there was an equal probability of capturing either a male or female. This trend seems to apply to maned wolves as well, but once only 3 male wolves have been captured, we could not apply a Chi-squared goodness of fit. The mean (±SE) adult body mass was different among hoary foxes (mean = 3.54 ± 0.35 kg, range: 2.62 – 4.64 kg, *n* = 24), crab-eating foxes (mean = 6.576 ± 0.75 kg, range: 4.90 – 8.18 kg, *n* = 46), and maned wolves (mean = 24.475 ± 2.58 kg, range: 21.0 – 27.0 kg, *n* = 4). However, neither the hoary fox (t = -0.744, df = 22, P= 0.464, *n* = 24) nor the crab-eating fox (t = -1.525, df = 44, P = 0.134, *n* = 46) presented significant differences in body mass among sexes; due the low number of captured maned wolves no intraspecific comparisons were carried..

Monitoring – We radio-collared and monitored 38 hoary foxes (20 males / 18 females), 27 crab-eating foxes (14 males / 13 females), and 8 maned wolves (3 males / 5 females) (*n* = 73 wild canids monitored) (for details see Lemos 2016b). The mean monitoring period per individual was 465 days (± 452) (1 year and three months; range:

03 – 2,286 days), being shorter for hoary foxes (392 days, ± 419), and longer for the other larger species (541 days, ± 512, for crab-eating foxes; and 551 days, ± 378, for maned wolves). From 2,279 coordinates used at this study, 1,662 (72.9%) were obtained byvisualizations, 516 (22.64 %) triangulations, and 101 (4.43 %) captures/recaptures. Number of locations per individual/species ranged from: 01 to 97 (males) and 01 to 111 (females) for hoary foxes; 01 to 82 (males) and 01 to 56 (females) for crab-eating foxes; and 11 to 103 (males) and 28 to 40 (females) for maned wolves.

Mortality – From the 73 canids monitored in Limoeiro region, it was possible to identify eight probable causes of deaths for 30 individuals (65.22% of 46 death events verified) (Figs. 5, 6, and 7). Of 29 hoary foxes, nine (31%) died from indirect-human causes (20.7%, n = 6), such as roadkill (n = 5) and attacked by domestic dogs *Canis lupus familiaris* (n = 1), and direct-human causes (10.3%, n = 3), as conflicts involving the use of poison or shooting (retaliation or prejudice); eight (27.6%) died from natural causes (seven predated by *Puma concolor* [24.1%] and one from advanced age apparently [3.5%]). Death cause of 12 foxes (41.4%) couldn't be identified. For 15 crab-eating foxes, human-related causes accounted for at least 60% of the deaths (n = 9) (indirect causes: 3 railroad kills [20%], 1 road kill and 1 killed by domestic dogs [6.66%, each]; direct causes: (26.68%, n = 4 conflicts with humans). Predation by *P. concolor* and non-identified causes totalized 6 deaths (n = 3[20%] each). We also registered the death of an ear tagged adult male crab-eating fox during a monitoring session. The animal was stampeded by a cattle herd being managed by cowboys, but moments before showed clear signs of apathy, suggesting it was already with some sort of health disability. Only two monitored maned wolves died during the study, one railroad killed and one from non-identified cause.

Home range – Locations of 44 canids (20 hoary foxes, 17 crab-eating foxes, and 4 maned wolves - Figure 8) were analyzed based on their stable variograms and a minimum monitoring length of 6 months (Fig. 9) (Table 2). One male (Rogerio) and two female (Flavia and Constance) hoary foxes totally changed their home ranges during the monitoring period, so their home ranges were analyzed separately for each defined period, providing two different home range sizes. Both fox species presented a wide variation in home range size (Figs. 10 and 11). Home range size of male ($\overline{X}$ = 2.77 km^2, ± 1.51, range: 0.358 – 5.389 km^2, n = 12) and female hoary foxes ($\overline{X}$ = 2.60 km^2, ± 1.96, range: 0.571 – 7.397 km^2, n = 11) using the 95% AKDE were not different (Kruskal-Wallis X^2 = 0.306; d.f. = 1; P = 0,579), (Figs. 12 and 13), as well as male ($\overline{X}$ = 8.864 km^2, ± 8.275, range: 2.080 – 27.829 km^2, n = 8) and female ($\overline{X}$ = 7.611 km^2, ± 5.233, range: 2.259 – 16.253 km^2, n = 9) crab-eating foxes ranges (Kruskal-Wallis X^2 = 0; d.f. = 1; P = 1) (Figs. 14 and 15). Maned wolves mean home range was 66.541 km^2 (± 7.794) and ranged from 56.707 to 75.769 km^2; due to the low number of captures no sexual comparisons were done (Fig.16). We also didn't find correlation among body weight and home range size for the two fox species (hoary fox: r = 0.216, t = 1.016, df = 21, P = 0.321; crab-eating fox: r = 0.175, t = 0.690, df = 15, P = 0.500).

The smallest maned wolf home range were at least two times larger than crab-eating fox range, and seven times larger than the hoary fox range (Fig. 17). Among small canids, crab-eating foxes had significantly larger home ranges than hoary foxes (Kruskal-Wallis X^2 = 11.79; d.f. = 1; P = 0.0005) (Fig. 18).

Activity period – During six years of monitoring we obtained 1,958 activity registers (n = 73 wild canids, from which we analyzed 1,888 (996 from 23 hoary foxes, 628 from 19 crab-eating foxes, and 264 from seven maned wolves). All three species were primarily active during night hours, with highest percentage of active fixes from

19:00 hours to 04:00 hours (Figure 19). Foxes started decreasing activity after 04:00 hours, reached the lowest percentages of activity around 11:00 hours, and didn't resume activity before 16:00 hours. Maned wolves strongly decreased activity at 04:00 hours, however kept higher percentage of active fixes than foxes during the day. Wolves also resumed activity earlier (before 16:00 hours), using day hours with higher percentage than foxes.

Shelter use – During nocturnal observations, most animals registered as "inactive" were in fact resting (sitting or laying) meanwhile other behaviors (e.g. foraging, marking, puppies caring), and in very few occasions were found using any kind of shelter. During the day, when most wild canids at Limoeiro region are really "inactive", the three species were registered using up to 11 types of shelters (n = 417 registers; Figure 20, 21, 22 and 23; Table 3). Hoary foxes used only eight of the 11 categories described, and yellow armadillo (*Euphractus sexcinctus*) holes were visibly the most frequent shelter. Crab-eating foxes and maned wolves had a wider variety of shelters and for both species clumps of tall grass were the most used type.

Female and male hoary foxes used a similar number of types of shelter, however, sexes differed in the use of each category (χ^2 = 19.262, df = NA, P = 0.003). Although armadillo holes were the most used shelter by both sexes, it was apparently much more important for females than for males, which used other shelters in higher and similar frequencies (Figure 24). Female hoary foxes also used shelters in different frequencies among seasons, using much more armadillo holes in the wet season (χ^2 = 13.145, df = NA, P = 0.029; Figure 25); whereas males used shelters in similar frequencies despite the season (χ^2 = 11.85, df = NA, P = 0.081; Figure 26). Different from the hoary fox, the crab-eating fox was the species with larger variety of shelters used (Table 3). Male and females used shelters in similar frequencies (χ^2 = 12.604, df =

NA, P = 0.163), being clumps of tall grass the most used category for both sexes (Figure 27). However, these foxes used shelters in different frequencies among wet and dry season (females: χ^2 = 19,829, df = NA, P = 0.003; males: χ^2 = 14.308, df = NA, P = 0.021), alternating from clump of low grass in the dry season to clump of medium grass in the wet season (Figure 28). Crab-eating foxes were also registered at armadillo holes (most of registers from females) however much less than hoary foxes. Female maned wolves also presented differences regarding shelter use when compared to males (χ^2 = 22.361, df = NA, P = 0.004) (Figure 29). While clumps of medium grass were the main shelter for females, the opposite sex was more registered commonly inside clumps of tall grass (also used by females). Males also used edges of marshes frequently, although females had never been registered in such spots. Both sexes showed no differences in shelter use among seasons (females: χ^2 = 7.321, df = NA, P = 0.425; males: χ^2 = 1.757, df = NA, P = 1; Figure 30).

DISCUSSION

Home ranges and Spatial Dynamics – Our work represents the largest effort conducted to understand the spatial ecology of the hoary fox and part of its relations with the crab-eating fox and the maned wolf at an anthropized landscape of Central Brazil. Based on the monitoring of 38 collared hoary foxes, 27 crab-eating foxes and eight maned wolves, we present reliable data on their spatial dynamics, activity period, shelters used, and death causes for wild canids at a non-protected region.

At Limoeiro region, where pastures comprise most of the landscape, male and female hoary foxes had mean home range of 2.77 Km^2 and 2.60 Km^2, respectively (range: 0.358 – 7.397), male crab-eating foxes 8.86 Km^2 and females 7.61 Km^2 (range: 2.080 – 27.829), and maned wolves, as expected, the largest areas, with 66.54 Km^2

(range: 56.707 – 75.829). While home ranges of other *Lycalopex* have been studied, few individuals of *L. vetulus* were monitored until this study (Juarez and Marinho-Filho 2002; Dalponte 2003; Courtenay et al. 2006). Home ranges are from 23 monitored animals for on average thirteen months (range: 6 – 76) and are within the estimated to hoary fox, thus, may actually represent the mean area used by individuals of the species. While Dalponte (2003) has registered in Nova Xavantina (Mato Grosso state) smaller areas (0.48 km^2), and Courtenay et al. (2006) and Juarez and Marinho-Filho (2002) larger ones in Unaí (Minas Gerais state) and Jaborandi (Bahia state) (4.56 km^2 and 3.85 km^2, respectively), in Limoeiro several individuals had similar home ranges to both extreme values. Thus, although our study demonstrates that hoary foxes home ranges may vary widely (including in the same population), most individuals (> 50%) had home ranges of approximately 2.68 km^2. When compared to other *Lycalopex*, although studies had used different estimators and sampling desings, *L. vetulus* home ranges fit into what have been described to the culpeo fox (*L. culpaeus*), the Darwin's fox (*L. fulvipes*), the pampas fox (*L. gymnocercus*), and the chilla fox (*L. griseus*) (Salvatori et al. 1999; Jiménez 2007; Maffei et al. 2007; Sillero-Zubiri 2009; Luengos Vidal et al. 2012).

Crab-eating foxes are considered common throughout its distribution and their home ranges were estimated at least in six different ecosystems. Unfortunately, very few data is available from Cerrado sites, from few individuals monitored for short time, and variation apparently is high (2.5km^2 – 12.8 km^2) (Juarez and Marinho-Filho 2002; Trovati et al. 2007). At Limoeiro region variation in home range size was also high. The mean home range estimated from 17 individuals at our site (8.23 km^2) is larger than ranges from most studies (Brady 1979; Sunquist et al. 1989; Rocha 2006; Maffei et al. 2007; Campanha 2014), but very similar to the mean home range at Marajó Island (Pará state, 5.32 km^2), where Macdonald and Courtenay (1996) carried a very similar effort (21 foxes monitored during 22 months). Although inserted in the Amazon Biome, Marajó is characterized for having several patches of savanna inserted among gallery forests, woodlands and secondary scrub. Smaller home ranges registered at Marajó may reflect higher food availability at this heterogeneous Amazon landscape. Apparently, home ranges at wetlands such as the *pantanal* and the *llanos* are small (Brady 1979; Sunquist et al. 1989; Rocha 2006; Campanha 2014), while savanna ecosystems seem to hold the largest ranges (Juarez and Marinho-Filho 2002; Trovati et al. 2007; this study).

We were able to estimate the home ranges of four resident adult maned wolves. Other four individuals accounted for young animals whose variograms never stabilized and in fact home ranges didn't stop increasing during the monitoring period. Two of these wolves were known to be the offspring of a monitored couple and were in dispersal process, as probably were the other two. The four adults corresponded to two couples, and due to the small sample size mean home range was calculated for both sexes combined. At Limoeiro, mean home range size for maned wolves was 66.54 km^2, this matches with home ranges registered in other regions with different degrees of landscape conservation and calculated through Kernel and/or MCP estimators (Dietz 1984, 30 km^2; Rodrigues 2002, 56.95 km^2; Melo et al. 2007, 38 km^2; Azevedo 2008, 50.97 km^2; Jácomo et al. 2009, 80.18 km^2; Emmons 2012, 74.9 km^2; Paula 2016, 67.62 km^2). Except for the small areas registered by Dietz (1984) at Serra da Canastra National Park (Minas Gerais state, 30 km^2) and Melo et al. (2007) at Galheiro Reserve (Minas Gerais state, 38 km^2), the rough mean home range calculated for the other studies combined is approximately 66.19 km^2 (Rodrigues 2002; Azevedo 2008; Jácomo et al. 2009; Emmons 2012; Paula 2016), very similar to the wolves at Limoeiro. Although we hadn't evaluated food availability at Limoeiro this region is undoubtedly different, regarding natural habitat availability and conservation degree (Lemos 2016a), from the other studies' areas, which correspond to conservation units of different sizes and their surroundings.

No sexual dimorphism was found among hoary foxes regarding body mass, confirming the reported by Dalponte and Courtenay (2004) and Courtenay et al. (2006). However, we suggest it may be possible for the experienced researcher, eventually, to identify different sexes during direct observations, though it will be interesting if future evaluations consider other body features for sexual dimorphism as Jácomo et al. (2009) did. Among crab-eating foxes no sexual dimorphism was detected neither, reinforcing the registered by Macdonald and Courtenay (1996). Due to small sample size, we couldn't carry sexual comparisons among maned wolves, but sexual dimorphism was described by Jácomo et al. (2009) for five of twelve measurements at Emas National Park (Goiás state, n = 74 adults). No other study presents data on sexual dimorphism for maned wolves.

Body mass and gender had no effect on home range size of hoary and crab-eating foxes; indeed variation was high within each gender of both species, and also for individuals between different moments of its life history. Availability of different types of resources (e.g. food and shelter) play important role on the spatial use (Lucherini et al. 1995; Fisher 2000), but intraspecific social dynamics and interspecific relations much probably play the same or even more intense effect on this aspect of foxes, as other studies have been showing (White and Harris 1994; Tannerfeldt et al. 2002; Kamler et al. 2003a, 2004; Périquet et al. 2015). So, it's necessary to assess other factors in order to understand which may affect home range size in the same population of these small canids. Therefore, the sex ratio of 1:1 registered for both fox species, together with the nonexistence of sexual dimorphism, non-difference in home range size among gender, total overlap of the couple home range, and the first reports on parental behavior (Macdonald and Courtenay 1996; Dalponte and Courtenay 2004; Courtenay et al. 2006; Lemos et al. 2011), strongly reinforce that both small-sized Lupinae species live in monogamic social systems.

Regarding territorial system, apparently the three species had a high degree of site fidelity and kept stable home ranges. Of 20 hoary foxes, only five changed their ranges totally at least once. The female *Constance* used a stable home range between 2011 February and 2013 July, then on July 24th she left the area, just after offspring dispersal and the arrival of a new female who paired with her male. *Constance* settled a new range 13 days later approximately 1.5 km, after pairing with an unmarked male, *Sherlock*, which was later captured and monitored. The couple reared an offspring during the 2014 season. However, *Sherlock* and the puppies died during the first semester of 2015, and on June 4th *Constance* once more shifted her home range. We found her once again in a totally new area approximately 5km from the last one, where she lived for at least 10 months and breed. A second female, *Flavia*, showed similar behavior. During two years (2011-2012) she used the same home range and gave birth in both years. On 2011, her pair died and she apparently maited with her male pup (*Rogerio*) on 2012. On December, *Rogerio* left the area and *Flavia* reared the puppies alone, until their dispersal. On 2013 July 24th, she left the original home range and 15 days later settled a new one approximately 8 km. In less than a month she was found with a monitored male, *Villas-Boas*, with whom she reproduced in 2013 and 2014. *Rogerio* left his natal area on December 2012 to a new range approximately 10 km away from the first one. He was observed with a new female just 22 days after he left his home range and was monitored until his death on 2014 June.

Home ranges analyses combined with direct observations indicate the three canids settled new ranges as soon as they found a new partner and such process took between 13 to 22 days. Except for the young male, the two females in all occasions left their ranges between June-July, which is suggested to be the main period of mating for hoary foxes (Courtenay et al. 2006; Dalponte 2009; Candeias 2014). Besides, new ranges had visibly different sizes from the original ones, suggesting that extrinsic factors may have significant impact on hoary foxes' home range size.

Two young males also provided interesting information about home range dynamics. After monitoring *Gambarini* for three weeks, he left his original area and started using a range that belonged to an adult male, *Grilo*. *Grilo* used the area for 54 months (four years and a half) and shared the area with an adult female (*Rachel*), before was predated by a puma (*Puma concolor*) on 2014 May 6th. *Gambarini* took only 11 days to assume *Grilo*'s range and 38 days to pair with *Rachel*, with whom he reared an offspring during 2014 season. Another young male, *Livingstone*, assumed an adult male home range (*Kerry*). On 2014 October 18th, a puma predated *Kerry*, and his offspring disappeared during the same week. Living in a neighboring area, *Livingstone* took one day to assume the area and 30 days to pair with *Kerry*'s female, *Stacie*.

Although our data suggest that hoary foxes have stable home ranges, but dynamic territorial system, the events described suggest two hypotheses to be tested in future studies: 1) the search for opposite sex partner of and/or offspring dispersal may be strong mechanisms that influence hoary fox spatial dynamics, and 2) the colonization of recently vacated areas and the acquisition of new partners by widowers is apparently a fast process in hoary fox society.

Crab-eating foxes and maned wolves kept their home ranges over all time individuals were monitored. Apparently, in Limoeiro region these species lasts longer in the environment than the hoary fox, though, if search for potential partners really is a major factor on the spatial dynamics of these canids, it would be expected that crab-eating foxes and maned wolves do not change their home ranges frequently.

Activity period and Shelter use – The three wild canids studied appeared to have a generally nocturnal rhythm of activity at Limoeiro region. Based on home range maps and field observations, it was possible to observe that hoary foxes ranges were encompassed by maned wolves ranges in high degree and by crab-eating foxes at some degree. Canids were active primarily during night hours, with most percentage of fixes between 19:00 – 04:00 hours. While hoary and crab-eating foxes had very little activity during the day, especially between the hottest hours (10:00 – 16:00), maned wolves resumed activity earlier, from 14:00 hours onwards. Although different methods have been used to evaluate the activity period of the three species across different studies and habitats, our data are in accordance with the general pattern expected (Brady 1979; Maffei and Taber 2003; Jácomo et al. 2004; Maffei et al. 2007; Emmons 2012).

However, it’s expected that related species of similar size use resources differently to avoid competition (e.g. temporal, spatial, or dietary). Temporal overlapping between the three species is apparently high at our study site, different from Iberá Nature Reserve (Argentina) (Di Bitetti et al. 2009) and Aparados da Serra National Park (Rio Grande do Sul state, Brazil) (Vieira and Port 2007), where crab-eating foxes and pampas foxes seem to alternate activity periods and them reduce temporal overlapping and competition. However, pampas fox are much more similar to crab-eating foxes in terms of body mass and food habits than hoary foxes, and this could explain the difference in overlapping degree among the two studies.

Although overlapping most part of the night, hoary foxes ceased their activity some hours earlier than the other two larger species, as also recorded by Jácomo et al.

(2004) at Emas National Park. The essentially nocturnal behavior of the species could be related to a decrease on the activity of its main prey, termites (Isoptera; Termitidae), which probably diminish its activities during early hours of the morning (Barbosa 1993). A first study on the three canids diet at Limoeiro region points to an insectivorous diet of the hoary fox (Lemos et al. 2011), as already described for other regions (Dalponte 1997; Juarez and Marinho-Filho 2002; Jácomo et al. 2004; Ferreira-Silva and Lima 2006). Hoary foxes prey termites on soil surface licking termite lines or turning dung disks. In these two situations termites are active and outside termite mounds or underground nests. Hoary foxes were never observed breaking termites mounds. This suggests that the species inevitably must be active when termites are out to forage, though being forced to a nocturnal habit. Besides, diurnal high temperatures at Cerrado may represent a limitation to the smaller hoary fox to be active during the day. Crab-eating foxes showed a higher richness of food items consumed, and although fruits comprised for most of them, Arthropods were common on its diet, as in hoary fox. Although other studies report low dietary niche overlap for the hoary fox and the crab-eating fox (Juarez and Marinho-Filho 2002; Jácomo et al. 2004), at Limoeiro these species may compete in some degree.

Despite the apparent high spatial overlap between the three canids, hoary foxes were able to keep exclusive shelters. Armadillo holes accounted for almost 50% of the shelters used by the small hoary fox, and although already reported its use as a shelter hadn't been quantified yet (Dalponte and Courtenay 2004; Courtenay et al. 2006). Although both sexes use armadillo burrows often, females were found more frequently than males in these shelters, and more frequently in the wet season than dry. Females use the holes throughout the year and probably guarantee this resource for the breeding season. Different from other types of shelter (e.g. clumps of grass, with or without thorn), armadillo burrows are adapted during the weeks before the birth of puppies once these will be born inside the modified hole (personal observation), and this activity require energy investment. So, it’s possible that hoary foxes use the shelter along the year as a way to keep it from competitors, until puppies are born mid August (Dalponte and Courtenay 2004; Courtenay et al. 2006; Lemos et al. 2013). Despite the species use up to eight types of shelters, the high frequency use of holes throughout the year (mainly by females), suggests that this type of structure created by yellow armadillos may be a key-resource in hoary fox occurrence in an environment. Future studies should investigate in depth the relationship between the hoary fox and the use of holes, describing the interior of the same and how couples use this resource as reproduction den. Also, it would be of great relevance to evaluate how hoary foxes depend on the presence of dens in their home range and their role on home ranges dynamics.

The larger species were more similar regarding shelters used. Crab-eating fox was the species with the highest number of types of shelters used, reinforcing the generalist character of the species, not only in relation to diet and habitat use as reported by other studies, but also types of shelters used throughout the year. Different from the hoary fox, the main shelters used by these foxes and maned wolves in Limoeiro were clumps of tall grass, followed by edges of marshes for crab-eating foxes and clumps of medium grass for wolves. Armadillo holes were little used by crab-eating foxes and almost exclusively by females, and never by maned wolves as expected. Although maned wolf females do not use edges of marshes, this was the second shelter more used by males and crab-eating foxes. At Limoeiro, this environment is characterized by wetlands associated with small water bodies. These areas keep moisture and are usually fenced to prevent the cattle entry, promoting then a cool shelter of dense vegetation and with little flow of domestic animals.

The three canids were found using shelters mostly during day hours. During the inactive moments of night period, animals were observed resting between foraging intervals, both sitting as lying on the grass or on the top of a termite mound (in the case of hoary foxes), but rarely inside or under shelters. Shelters are an essential resource for several species, and generally are used for protection against predators and weather (Manser and Bell 2004; Kowalczyk and Zalewski 2011; Periquet et al. 2015) or reproducing (Courtenay et al. 2006), and may have significant effect on home ranges settlement (Lucherini et al. 1995; Fisher 2000). Knowing aspects of the natural history of species (e.g. shelters used by carnivores) may help understand their role on ecological networks and even parasites cycles, such as *Trypanosoma cruzi* e *Leishmania* sp., species of high importance for public health (Rocha et al. 2013). These authors suggest that one of the possible causes for hoary fox infection with *T. cruzi* is through Triatomine bugs, which act as vectors also uses armadillo holes as shelter. Very few studies described the shelter use for South American savannas' canids and the role of such structure on animals' ecology. Emmons (2012) suggests that diurnal shelters (which she calls "beds") used by maned wolves at the Bolivian Cerrado Noel Kempff Mercado National Park are used to offer protection against bees and flies, while nocturnal beds for protection against mosquitoes. At Limoeiro, shelters were more used during the day, suggesting it may be useful during this period, when temperatures can reach 40º C degrees. Although pumas frequently predated both foxes and are common at Limoeiro, the species has nocturnal habit and is more registered inside forested areas (Fernanda C. Azevedo, personal observation), habitat not used by hoary foxes. Except for this smaller species, escape from predation does not seem to drive shelter use, at least for the larger species. We believe shelter use at the three canids may be an alternative to escape high temperatures during the day, a common condition at Central

Brazil and Cerrado ecosystem. However, hoary fox apparently also benefit of shelters for rearing puppies, against predation and agonistic behaviors from the two larger canids and domestic dogs (*Canis lupus familiaris*). Twice we registered a hoary fox den, with puppies inside, be verified by a larger canid. On the first occasion, a monitored female maned wolf inspected the den, threading its head and sniffing some times. On the second occasion, a monitored couple of crab-eating foxes did the same, on two different nights and tried to enter the den but gave up after some minutes. As long as we able to observe any puppies were killed or predated on these occasions.

If spatiotemporal overlapping of the three species is really high at Limoeiro, and small foxes may compete for food in some degree, it would be expected high degrees of interspecific competition and killing, as reported to several other sympatric canids (Tannerfeldt et al. 2002; Kamler et al. 2003b, 2012). However, as previous reported by Lemos et al. (2007, 2011), interspecific encounters among the three species, especially agonistic interactions, are probably rare and were not common during observation sessions at Limoeiro. Although hoary foxes have been mentioned in maned wolves scats (Juarez and Marinho-Filho 2002; Jácomo et al. 2004) any hoary or crab-eating foxes was predated or killed by wolves at Limoeiro. Di Bitetti et al. (2009) and Johnson and Franklin (1994) point out that, although species apparently share niches in certain degrees, differences may be on the microhabitat use scale and allow coexistence. We believe such nuances may be especially difficult to detect through conventional radio telemetry, or even Global Positional System (GPS) with very spaced data collection. Though, more studies allying GPS technology with direct observations focusing on the differences of space and microhabitat use are necessary.

Despite the apparently high home range overlap, especially among the smaller species, and same activity period, the three species coexist in Limoeiro region.

According to Juarez and Marinho-Filho (2002) and Jácomo and collaborators (2004), diet overlap between *L. vetulus* and *Cerdocyon thous* is low. Our previous study at the area also showed that diet overlap probably is low, or at least not at a level that would generates competition for food resource. Shelters also do not seem to be the source of competition. However, agonistic events were registered throughout the study, suggesting interspecific territoriality. So what moves this behavior is not yet clear, being necessary future studies that quantify encounters rates and consequences in order to understand which resources trigger the competition and if this reaches the level of interference and displacement.

Mortality – We were able to identify the probable death cause of nearly 70% of the monitored canids. The two smaller species are subject to the same threats, with a large percentage of deaths caused directly or indirectly by man. Also, from the two dead wolves, one at least died due to human cause (railroad killed). More than one third (31%) of hoary foxes and two thirds (60%) of crab-eating foxes deaths were due to causes such as roadkill (6), rail roadkill (4), poisoning or shooting (7), or persecution by domestic dogs (2). Combining results of the three species, from a total of 46 canids, almost half (41.3%, n = 19) were killed by some kind of human action. From 19 deaths, 12 were from involuntary action, as someone or a train doesn't choose to roadkill an animal (although this is highly arguable, once lack of mitigation measurements, and management of security zones and sideways along road and rail roads, over speed, or targeting an animal could be considered voluntary actions). However, the remaining 7 deaths are result of voluntary actions and this means someone choose to fire a gun or put poison in a bait, although killing and persecuting wildlife in Brazil is considered federal crime. Lemos et al. (2011a; b) had already reported on the threats wild canids face at Central Brazil, specially at highly anthropized, non protected areas such as the

Southeastern of Goiás state, and consequently Limoeiro region. Macdonald and Courtenay (1996) also present a high rate of deaths caused by humans at Marajó Island, where hunters killed ten of 12 crab-eating foxes. The hoary fox was considered threatened of extinction recently (Lemos et al. 2013), though, unless the species shows a high birth rate, if we consider that the species is endemic to a biome which greatest part comprises private lands, such as Limoeiro, and that humans are responsible for a significant part of fox's deaths, chances are that the species may really down the slope to an anthropogenic extinction.

The main human-related death causes were road killing and poisoning/shooting. Canids, specially the crab-eating fox followed by the hoary fox, have been described in several studies on road killings as two of the most impacted species (Cunha et al. 2010; Lemos et al. 2011a; Huijser et al. 2013). Regarding poisoning, this practice is common in Brazil, and also at Limoeiro region. During informal talks, people confirm the use of poison to kill predators, blamed for preying on domestic animals. According to Lemos et al. (2011b), no signs of domestic fowl were found in analyzed hoary fox scats at Limoeiro, and appeared in low number in crab-eating foxes. However, prejudice and poor knowledge on wildlife leads farmers and cowboys to kill potential predators, most of the time without a reason or a clear guilty. This practice goes beyond the conflict with canids and extends to other species of Brazilian carnivores such as jaguars (*Panthera onca*) (Conforti and Azevedo 2003; Marchini and Macdonald 2012; Palmeira and Trinca 2012) and pumas (Mazzolli et al. 2002; Verdade and Campos 2003). Although road killings are commonly reported and poisoning frequent, several other threats may have similar effects but end up going undetected, given the difficulty of finding the carcass and further confirmation of death cause. Thus, it is important that more studies quantify the loss of individuals, especially for endangered species as the hoary fox and the maned wolf (Paula et al. 2013).

The main canids natural death at Limoeiro was the predation by pumas, which is the largest predator inhabiting Limoeiro region (Lemos 2016a). Our data represent the first estimative on the impact of a large predator on a Cerrado canid community. At our area, pumas were responsible for at least almost 22% of individuals' removal, with similar impact on both small fox populations (24% of hoary foxes deaths; 20% of crab-eating fox deaths). Intraguild predation is apparently common and expected among carnivores, however very few have been described for South American species (Palomares and Caro 1999; Fedriani et al. 2000; Oliveira and Pereira 2014). Such interaction regulate natural populations and shape community structure (Oliveira and Pereira 2014). Foxes predated were mainly adults and juveniles dispersing, however puppies monitoring in the future may reveal higher rates of this relation, once intraguild predation is one of the main causes of cubs and juvenile mortality in other species (see Ralls and White 1995; Rasmussen 1996; Mills and Mills 2003).

We couldn't identify the death cause of 35% (16) of carcasses found, due lack of clear signs or advanced state of decay. Except for old carcasses, animals with no clear signs of death cause could be associated to several epidemic diseases known to be fatal to wild species (Jorge et al. 2010), so properly quantifying the proportion of animals affected by this type of threat is vital to understand the population dynamics of wild canids at natural and anthropized landscapes.

Conservation and Management Implications – Our data suggest that at least half of the threats to wild canids are related to human activities, especially road kill and conflicts. Once road kills were the leading cause of death in the monitored assemblage and considering that one of the most used shelter by at least two wild canids were clumps of high grass, we strongly suggest that the management of roads' and railroads' security zones have a more frequent maintenance. However, since they are not managed by the government (federal and state) or by concession companies, these areas favor the growing of dense vegetation, high and without the presence of domestic animals, creating ideal habitats for crab-eating foxes and maned wolves, which also reproduce at these areas regularly, and for their prey. It is known that medium and large mammals' vehicle collisions are direct linked to the effect of road attraction caused by increased resource availability (carcasses, seeds), nesting areas or dispersal route (Rosa and Bager 2013). In different years couples of crab-eating foxes birthed and reared puppies in the security zones of the highways and railway that cross the study site. From time to time these areas are burned by farmers illegally without any prior study of the fauna associated to these areas. The most common and efficient maintenance of this type of environment can make it less favorable to be used not only by crab-eating foxes, thus reducing the chances of road killing for different species, not only those evaluated in our study. Although crab-eating foxes are not threatened of extinction (Beisiegel et al. 2013), the species play important role along different ecosystems as a mesopredator carnivore and possible disperser of seeds.

Many canid populations throughout the world are declining due to the expansion of human populations, habitat loss and fragmentation, persecution and illegal poaching, introduction of exotic species and many other reasons (Macdonald and Sillero-Zubiri 2004; Sillero-Zubiri 2009). Several of these were registered as causing foxes' deaths at Limoeiro, on different levels and impact. We hope our data help stakeholders when taking decisions on how to share and apply resources to mitigate such conservation problems. For example, in a region where roadkill is responsible for most of canids' populations' deaths maybe it could be more strategic to invest on the creation of wildlife corridors, wildlife, roadside management, signage, and awareness of drivers. In addition, we strongly suggest to the city hall of Cumari the creation of a program to domestic dogs control on farms and awareness of rural community about the risks of these to wildlife and people when kept in an uncontrolled manner (no reproduction control) and without health care, as annual vaccination. We hope our data contribute to different approaches, helping to learn how the hoary fox shares traits with other Canidae, and to understand how these three sympatric canids coexist and interact under the same conditions.

ACKNOWLEDGMENTS

We thank Centro Nacional para Pesquisa e Conservação de Mamíferos Carnívoros (CENAP/ICMBio) and Fundação Parque Zoológico de São Paulo (FPZSP) for their partnership, and Cleveland Metropark Zoo (Scott Neotropical Fund), Neotropical Grassland Conservancy, Idea Wild, and Smithsonian Conservation Biology Institute for providing the equipment used in the project. We also thank MGO Rodovias for funding the basemap used for spatial analyses. Carlos *Bagual* Fragoso, Hugo Costa, Frederico *Cigano* Souza, Daniel *Gringo* Rocha, and Leandro *Robinho* Abade provided invaluable assistance during fieldwork. We are also grateful to Limoeiro families and landowners for always receiving the team at their places, and Nilson and Ana Luiza Lemos for logistical support.

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FIGURES

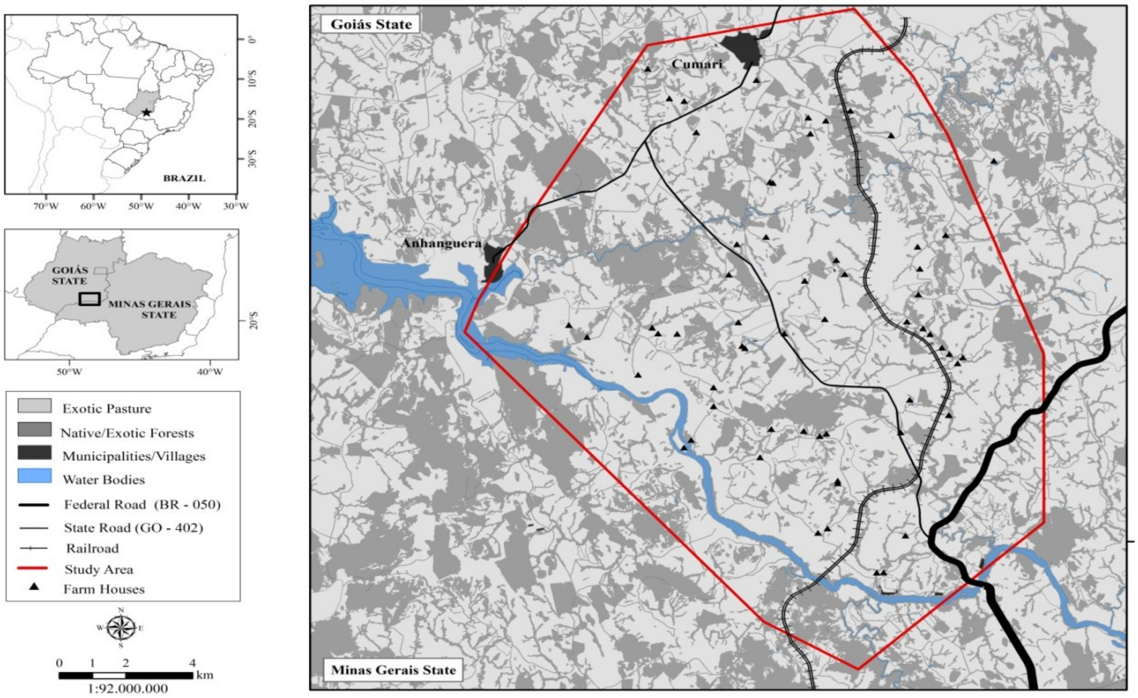

Fig. 1.– Map of the study area showing the land use of altered landscape and highways, railway and farm houses at Limoeiro region, municipality of Cumari, Goiás, Brazil. Red line comprises the main region covered by the project.

Fig. 2. – Limoeiro region, municipality of Cumari, Goiás, Brazil. Natural vegetation represents about 25% of the area and is dispersed in patches (1 – 500 ha) of semideciduous and gallery forest, most along the margins of Paranaíba River.

Fig. 3.– Overlap is intense between wildlife and domestic animals in Limoeiro region, municipality of Cumari, Goiás, Brazil. This picture highlights the proximity among the hoary-fox (*Lycalopex vetulus*) and the cattle (*Bos taurus*) in an exotic pasture.

Fig. 4.– The Limoeiro region, municipality of Cumari, Goiás, Brazil, is crossed by paved and dirt roads that play important role as threat to wildlife. This picture highlights federal highway BR-050 crossing vegetation patches and pastures.

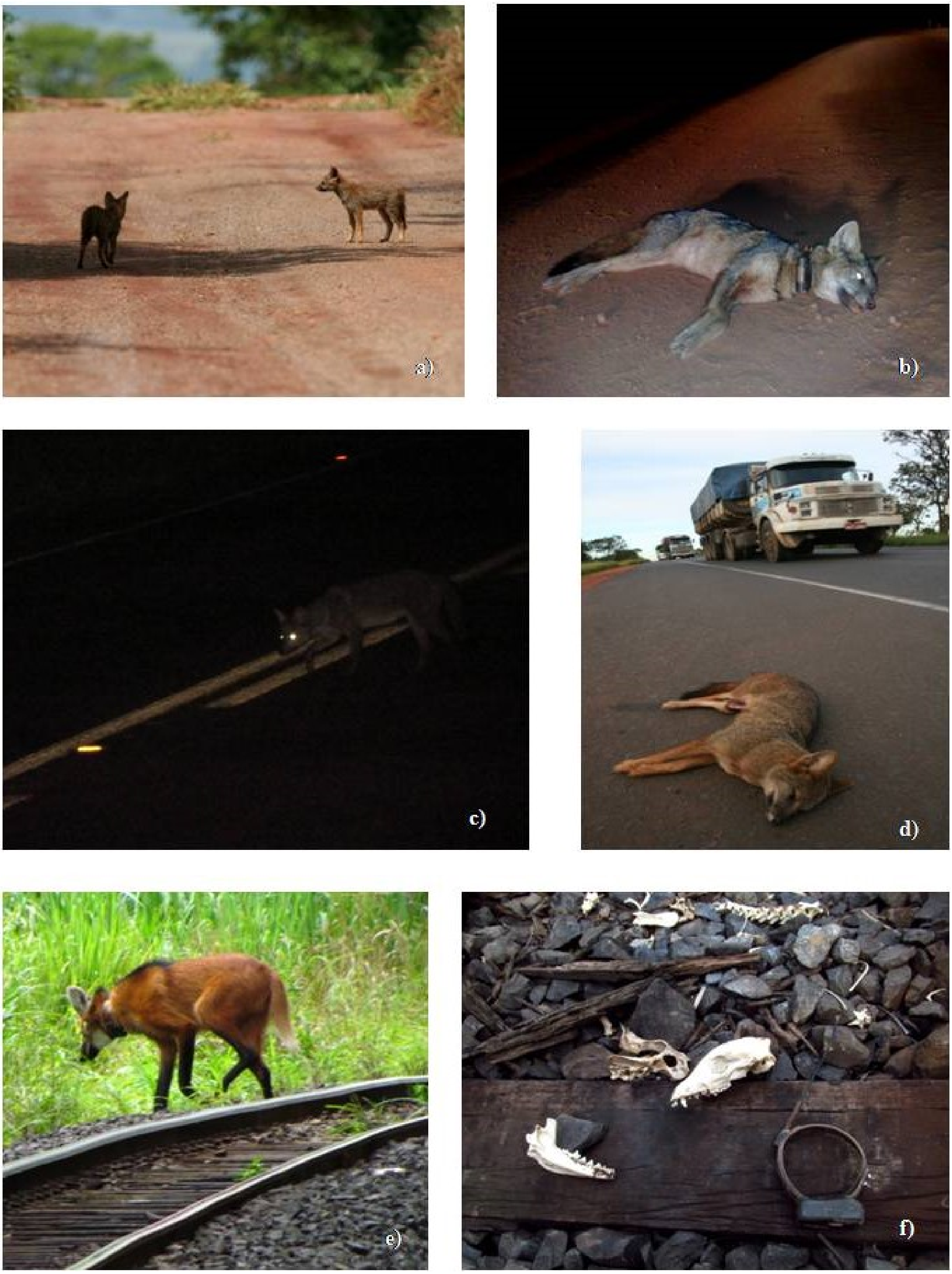

Fig. 5. – Indirect human threats to wild canids monitored between 2008 and 2015 in the anthropized region of Cumari, Goiás state, Brazil. *Lycalopex vetulus* (a, b and d); *Cerdocyon thous* (c and f); and *Chrysocyon brachyurus* (e and f).

Fig. 6. – Apparent and confirmed causes of monitored wild canids death monitored between 2008 and 2015 in the municipality of Cumari, Goiás state, Brazil. a) and b) unidentified causes; c) and d) natural causes such as advanced age; e) and f) predation by *Puma concolor*.

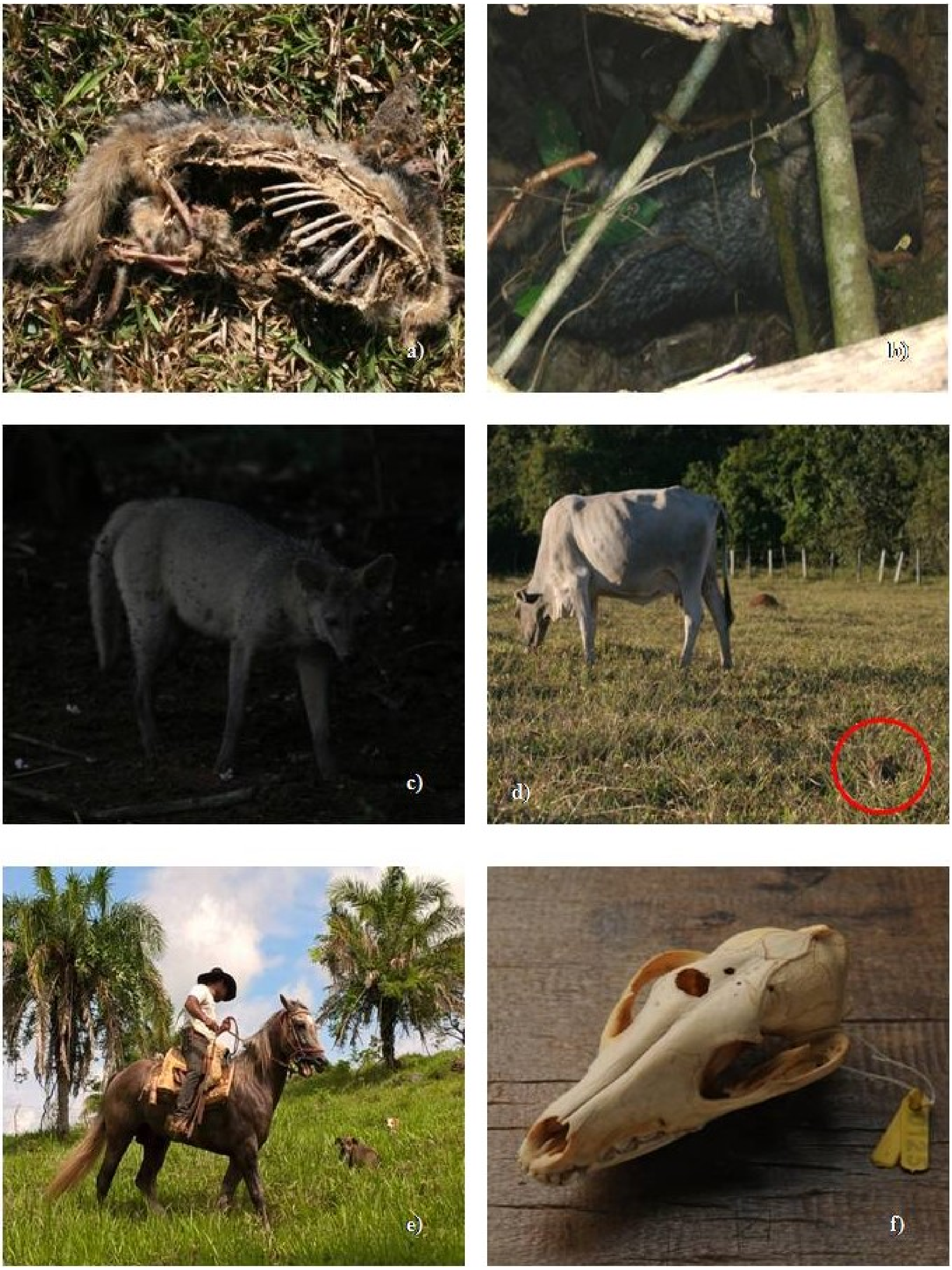

Fig. 7. – Direct and indirect human causes of wild canids death in the anthropized region of Cumari, Goiás state, Brazil. a) and b) purposeful poisoning; c) and d) possible diseases from the close contact with domestic animals such as mange (c); e) and f) attack by domestic dogs (*Canis lupus familiaris*) and shooting. Credits of pictures: c) for Caio F. M. Lima and f) for Adriano Gambarini. The red circle at picture d) highlights a *Lycalopex vetulus* (Hoary fox).

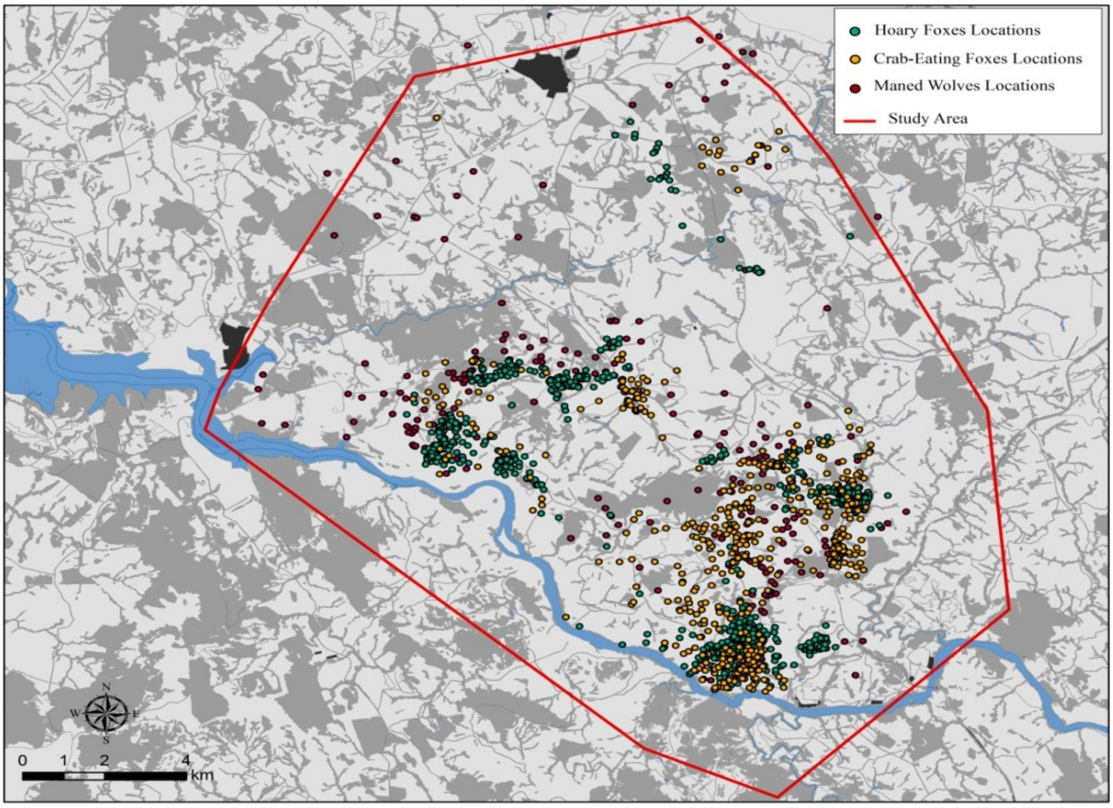

Fig. 8.– Locations of 44 wild canids monitored by VHF radio collars at the municipality of Cumari, Goiás state, Brazil, between 2008 and 2015.

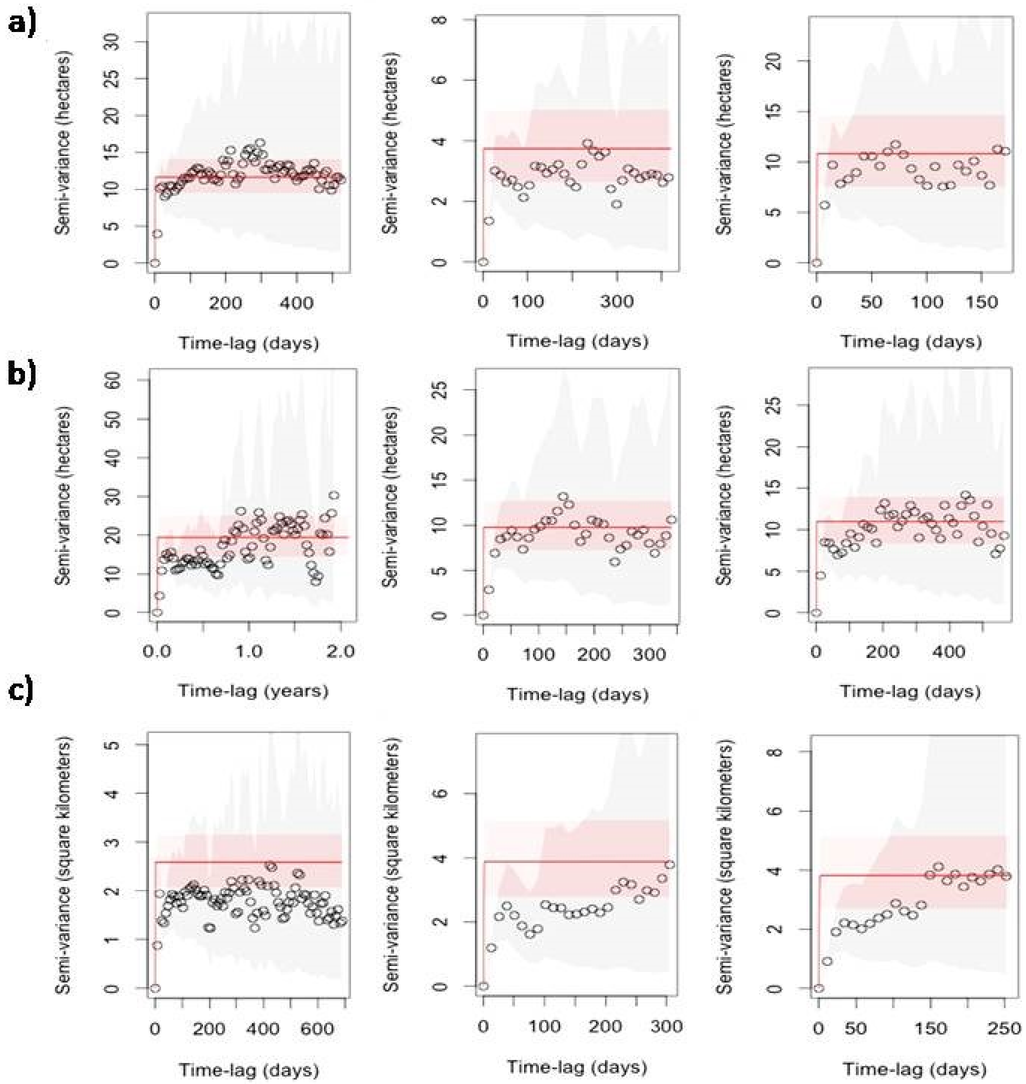

Fig. 9. – Examples of stable variograms from three wild canids monitored at Cumari, Goiás state, Brazil. a) *Lycalopex vetulus* (hoary fox); b) *Cerdocyon thous* (crab-eating fox); c) *Chrysocyon brachyurus* (maned wolf).

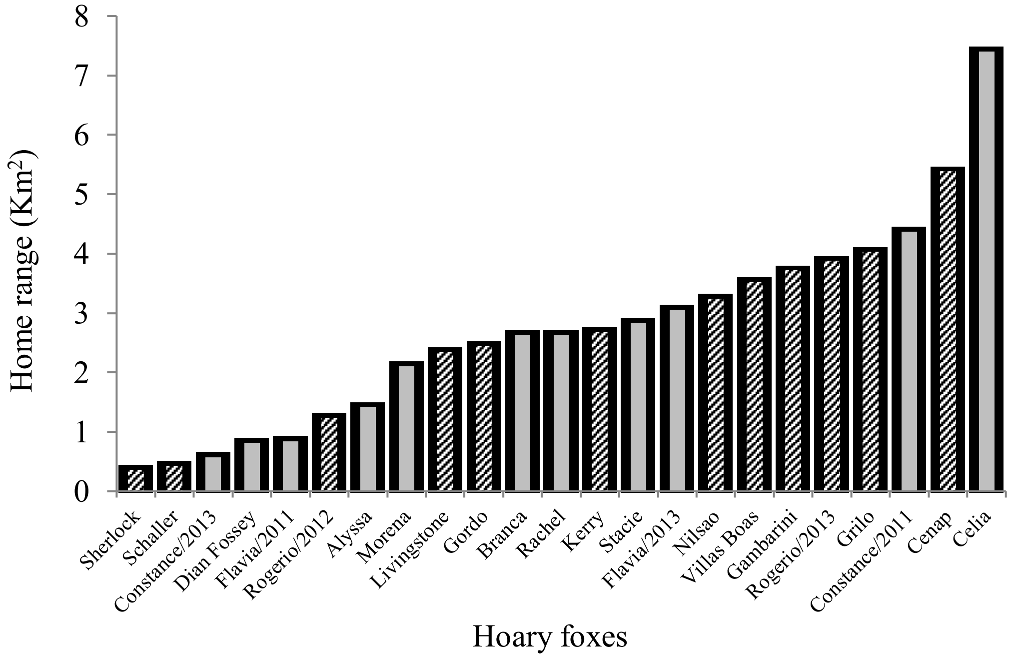

Fig. 10.– Home range size of hoary foxes (*Lycalopex vetulus*) (*n* = 38) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil. Striped columns represent males and gray columns females.

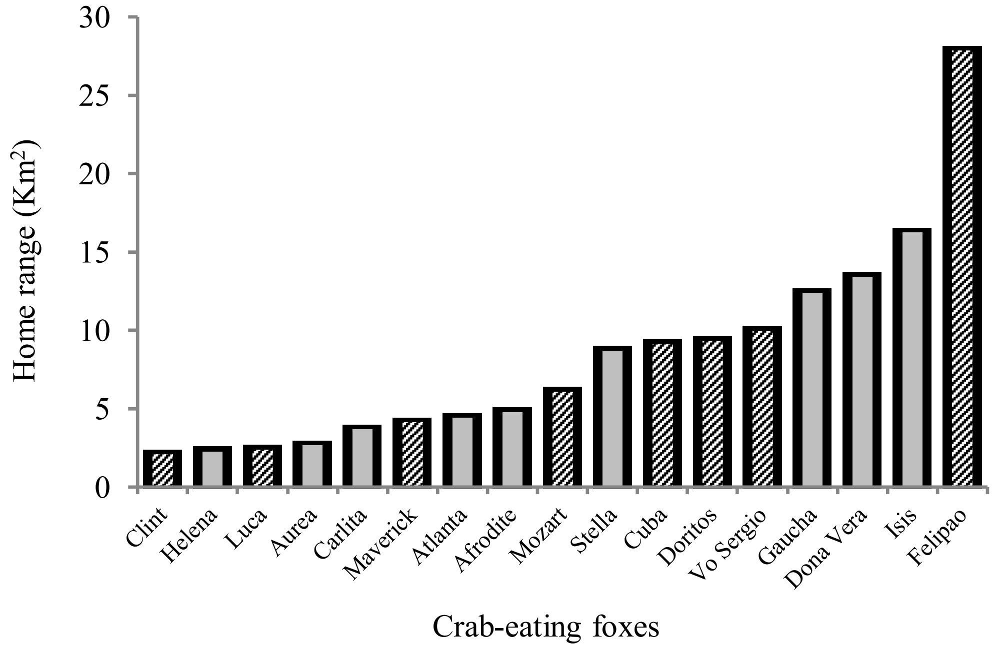

Fig. 11. – Home range size of crab-eating foxes (*Cerdocyon thous*) (*n* = 27) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil. Striped columns represent males and gray columns females.

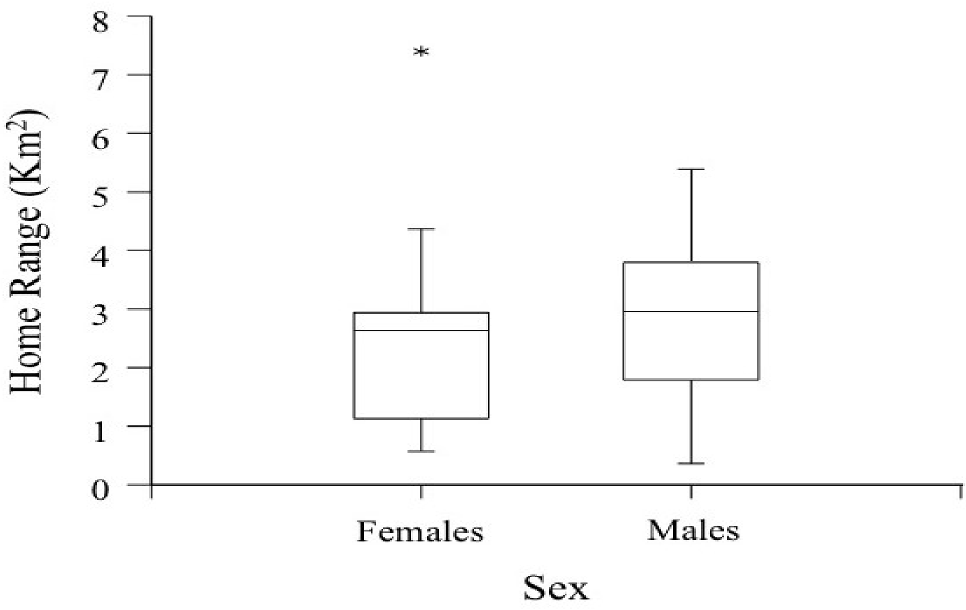

Fig. 12.– Home range size variation of female and male hoary foxes (*Lycalopex vetulus*) (n = 38) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil.

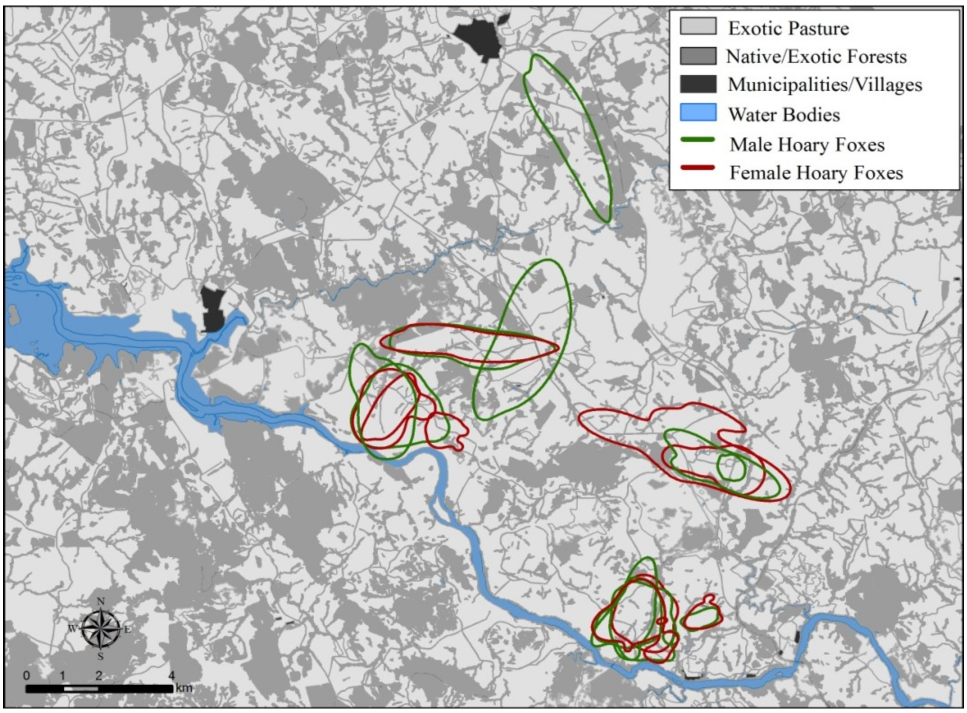

Fig. 13.– Home ranges of hoary foxes (*Lycalopex vetulus*) (n = 38) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil. The green lines represent males and red lines females.

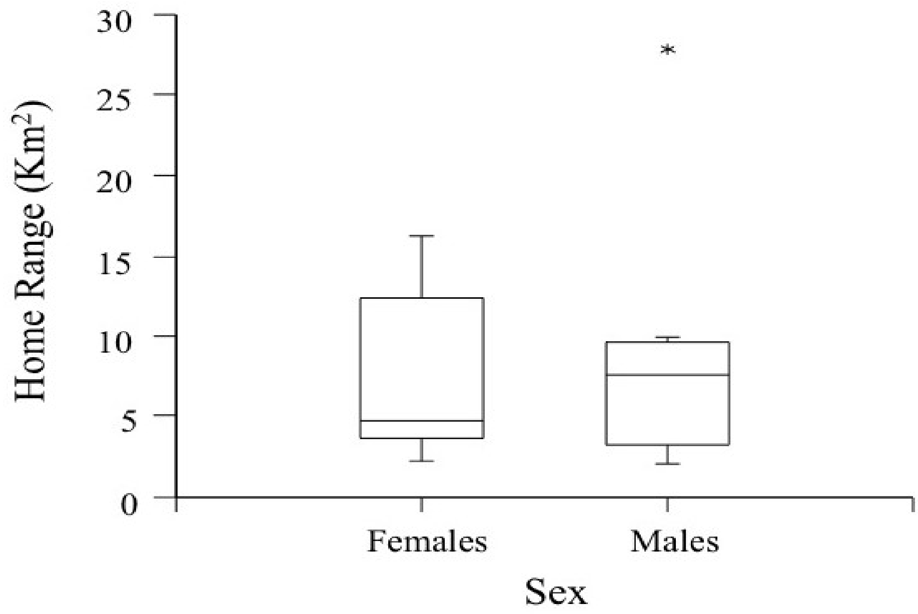

Fig.14.– Home range size variation of female and male crab-eating foxes (*Cerdocyon thous*) (*n* = 27) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil.

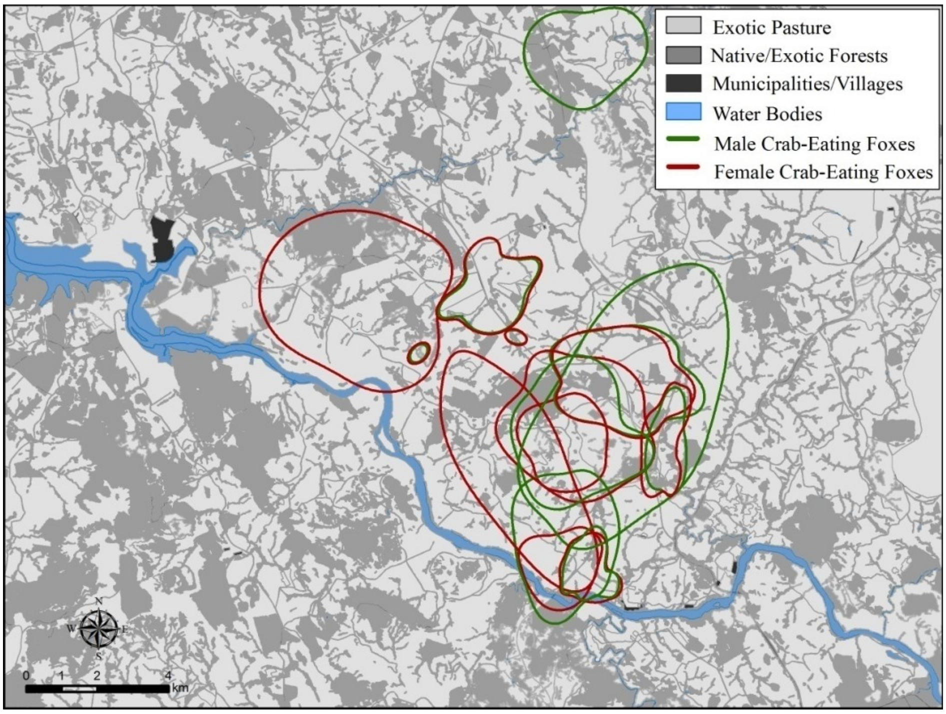

Fig.15.– Home ranges of crab-eating foxes (*Cerdocyon thous*) (*n* = 27) monitored between 2008 and 2015 at Limoeiro Region, municipality of Cumari, Goiás state, Brazil. The green lines represent males and red lines females.

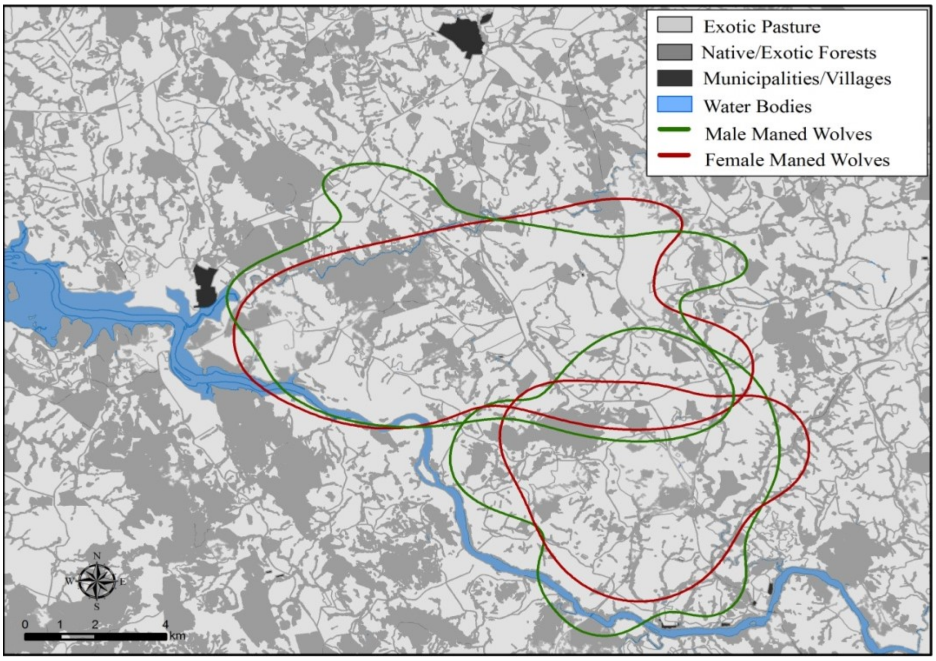

Fig.16.– Home ranges of maned wolves (*Chrysocyon brachyurus*) (*n* = 4) monitored between 2011 and 2015 at Limoeiro Region, Southeast of Goiás state, Brazil.

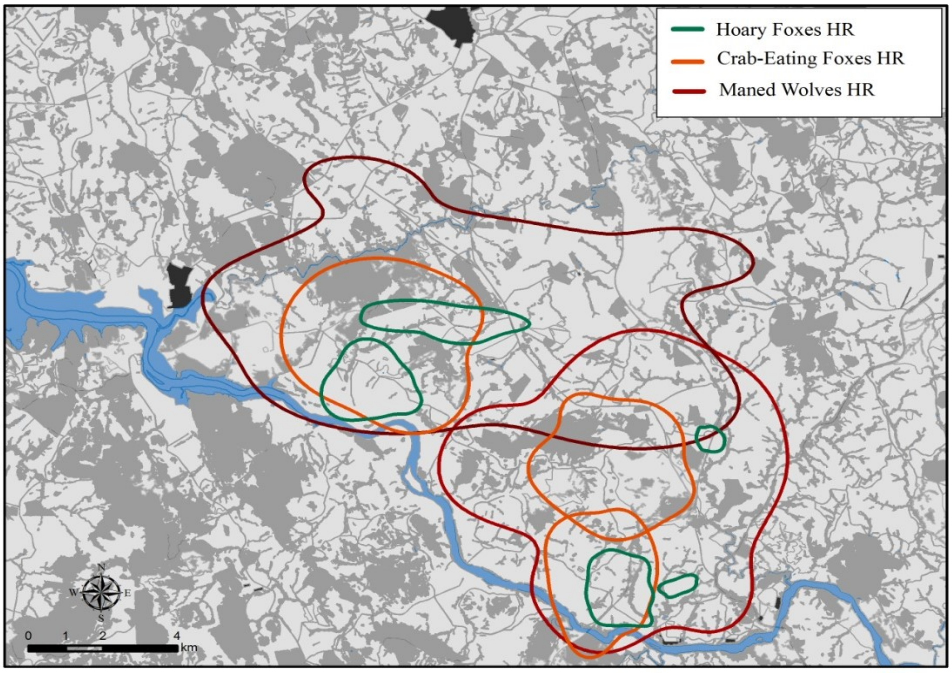

Fig. 17. – Home ranges (HR) of maned wolves (*Chrysocyon brachyurus*), crab-eating foxes (*Cerdocyon thous*) and hoary foxes (*Lycalopex vetulus*) monitored between 2008 and 2015 at Limoeiro Region, Southeast of Goiás state, Brazil, was different in size and presented high overlapping.

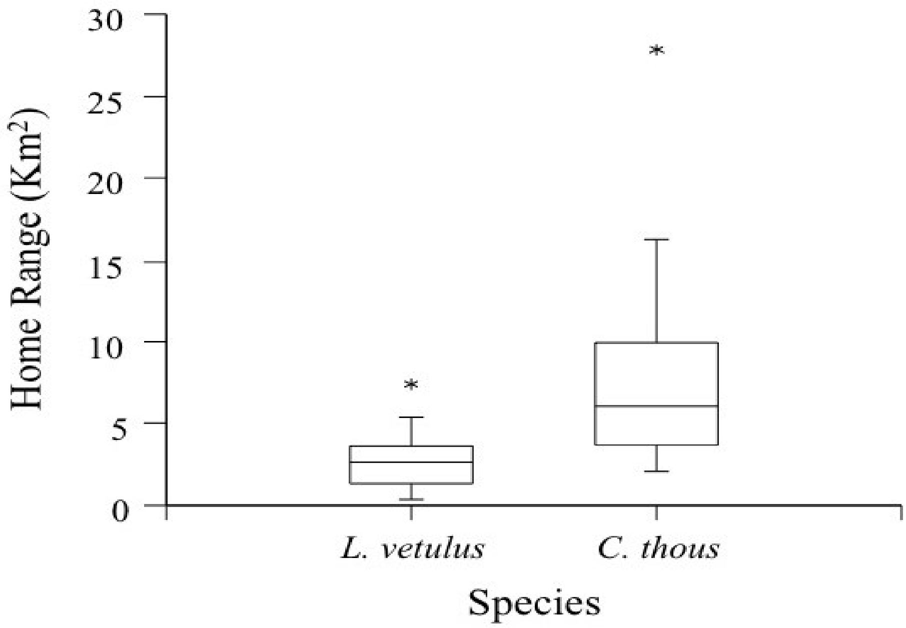

Fig. 18.– Home range size of hoary foxes (*Lycalopex vetulus*) and crab-eating foxes (*Cerdocyon thous*) at Cumari, Goiás state, Brazil. Asterisks represent outlier individuals.

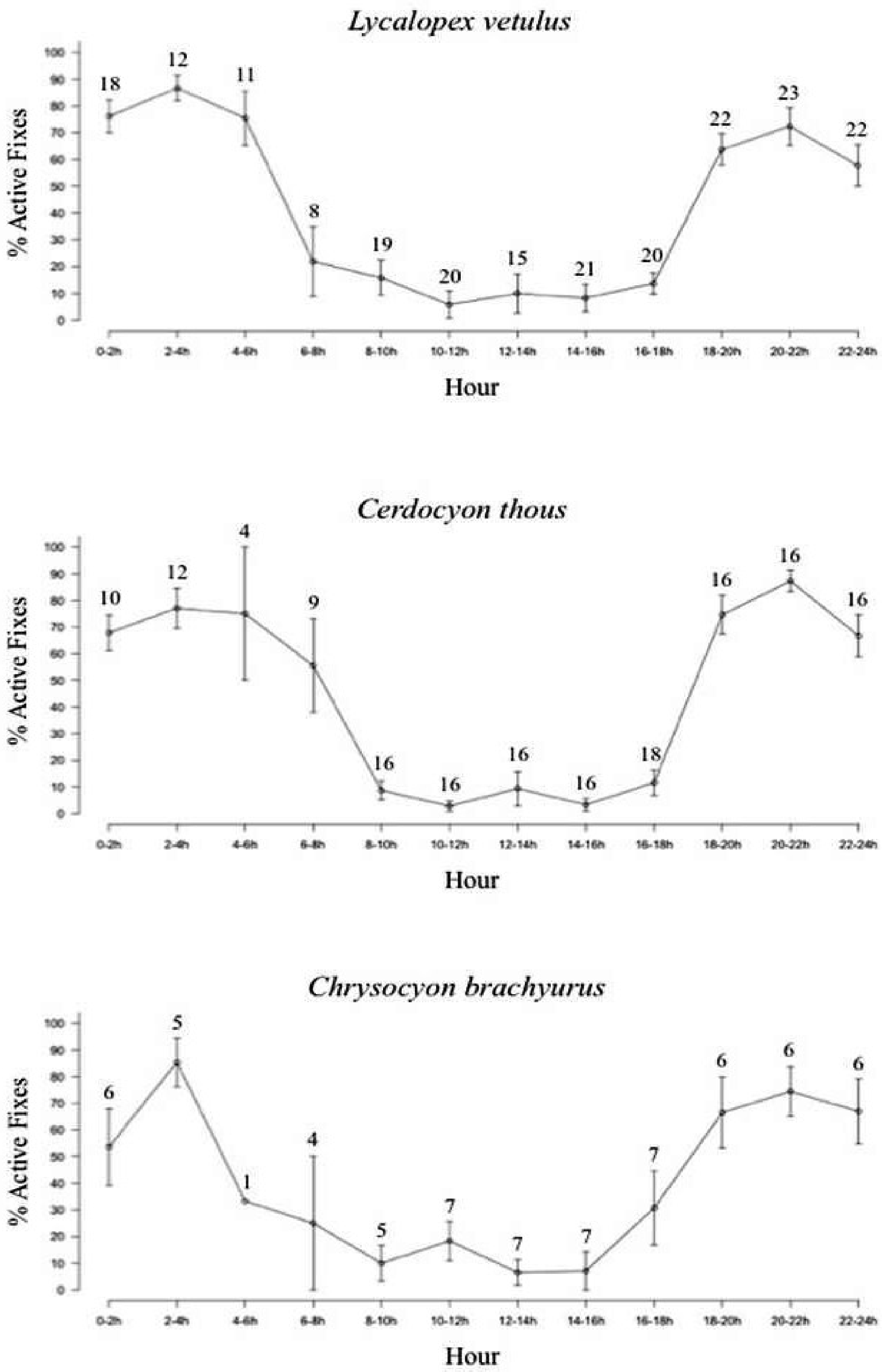

Fig. 19. – Activity patterns of three wild canids in the Limoeiro region, Southeast of Goiás state, Brazil. Percentage of Active fixes is the proportion (± S.E.) of 1,888 radio-fixes when canids were active; day was divided in two hours classes. Numbers on the bars represent the number of individuals sampled at each hour class.

Fig. 20. – Types of shelters used by three species of wild canids at Limoeiro region, municipality of Cumari, Goiás State, Brazil. Legend: a) clump of low grass; b) hoary fox (*Lycalopex vetulus* - red circle) resting in a clump of low grass; c) extern side of a clump of medium grass; d) intern side of a clump of medium grass; e) clump of tall grass and f) maned wolf (*Chrysocyon brachyurus*) resting in a clump of tall grass.

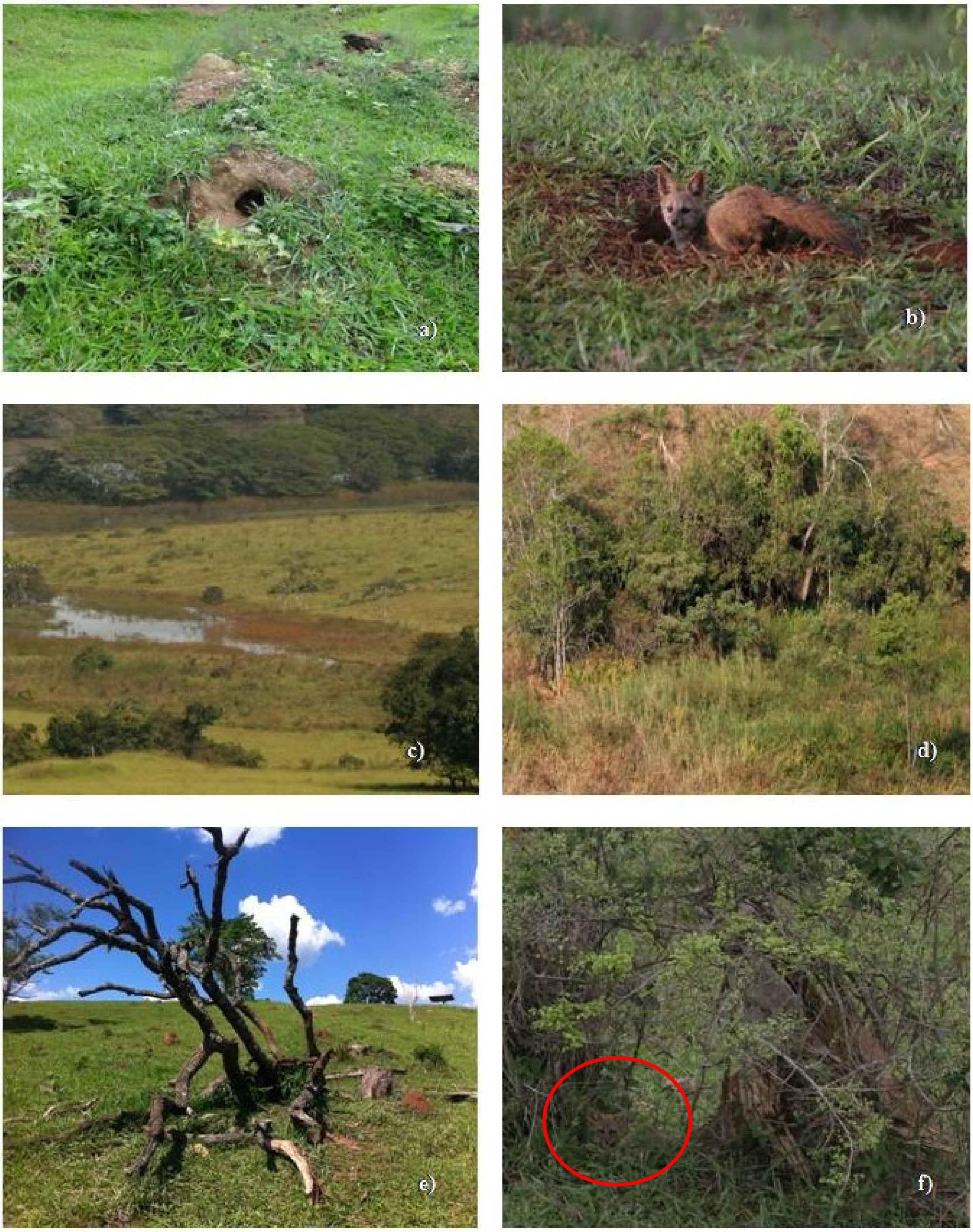

Fig. 21. – Types of shelters used by three species of wild canids at Limoeiro region, municipality of Cumari, Goiás State, Brazil. Legend: a) armadillo hole; b) hoary fox (*Lycalopex vetulus*) in an armadillo hole; c) and d) edge of marsh; e) clump of grass with dead branches and f) hoary fox (*Lycalopex vetulus*- red circle) resting in a clump of grass with dead branches.

Fig. 22.– Types of shelters used by three species of wild canids at Limoeiro region, municipality of Cumari, Goiás State, Brazil. Legend: a) clump of grass with bush; b) hoary fox (*Lycalopex vetulus* - red circle) in a clump of grass with bush; c) clump of grass with thorn bush; d) intern side of a clump of grass with thorn bush; e) bacuri palm (*Platonia insignis*) and f) resting site in the bacuri palm.

Fig.23. – Types of shelters used by three species of wild canids at Limoeiro region, municipality of Cumari, Goiás State, Brazil. Legend: a) clump of grass with *gravatá* (*Bromelia balansae*); b) reed plantation (*Pennisetum purpureum* or *Saccharum* sp.).

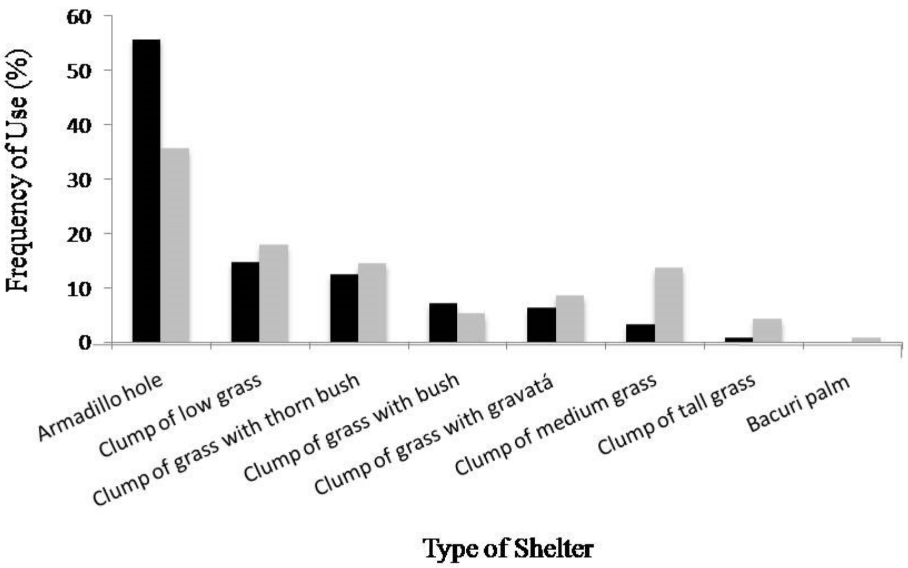

Fig.24. – Types of shelters used by male and female hoary foxes (*Lycalopex vetulus*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are females and grey bars are males. *Gravatá* (*Bromelia balansae*)*;*Bacuri Palm (*Platonia insignis*).

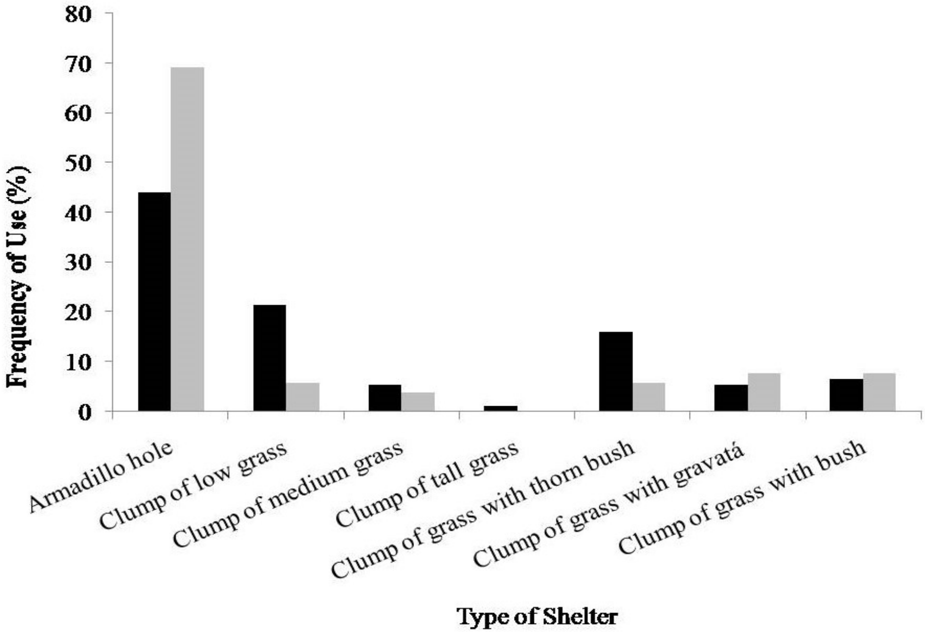

Fig. 25. – Frequency of shelters used in different seasons by female hoary foxes (*Lycalopex vetulus*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are dry season and grey bars are wet season. *Gravatá* (*Bromelia balansae*).

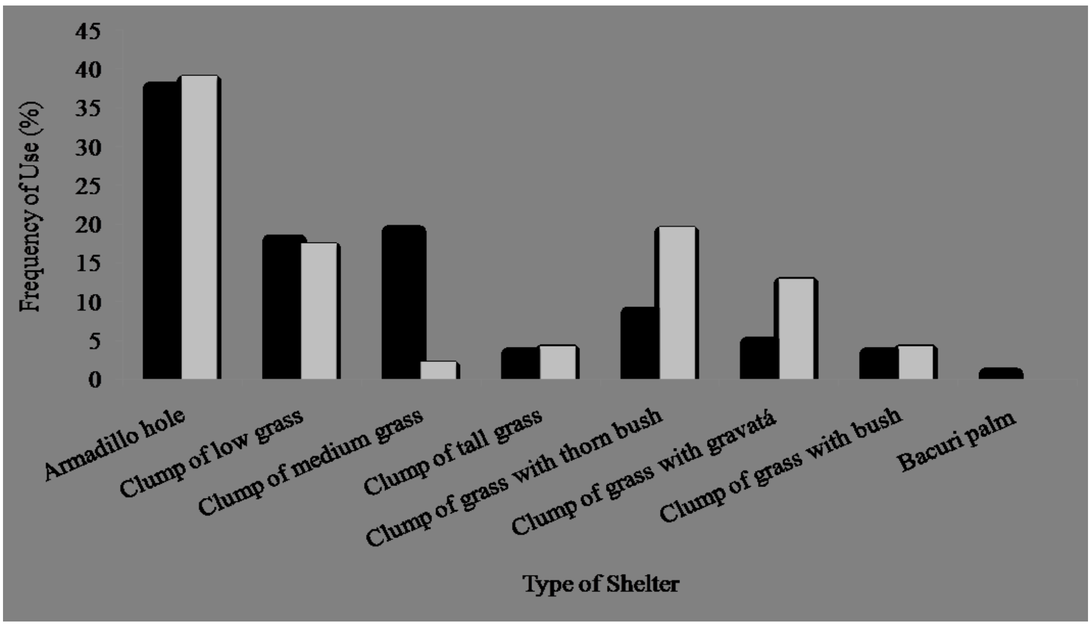

Fig. 26. – Frequency of shelters used in different seasons by male hoary foxes (*Lycalopex vetulus*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are dry season and grey bars are wet season. *Gravatá* (*Bromelia balansae*) and Bacuri Palm (*Platonia insignis*).

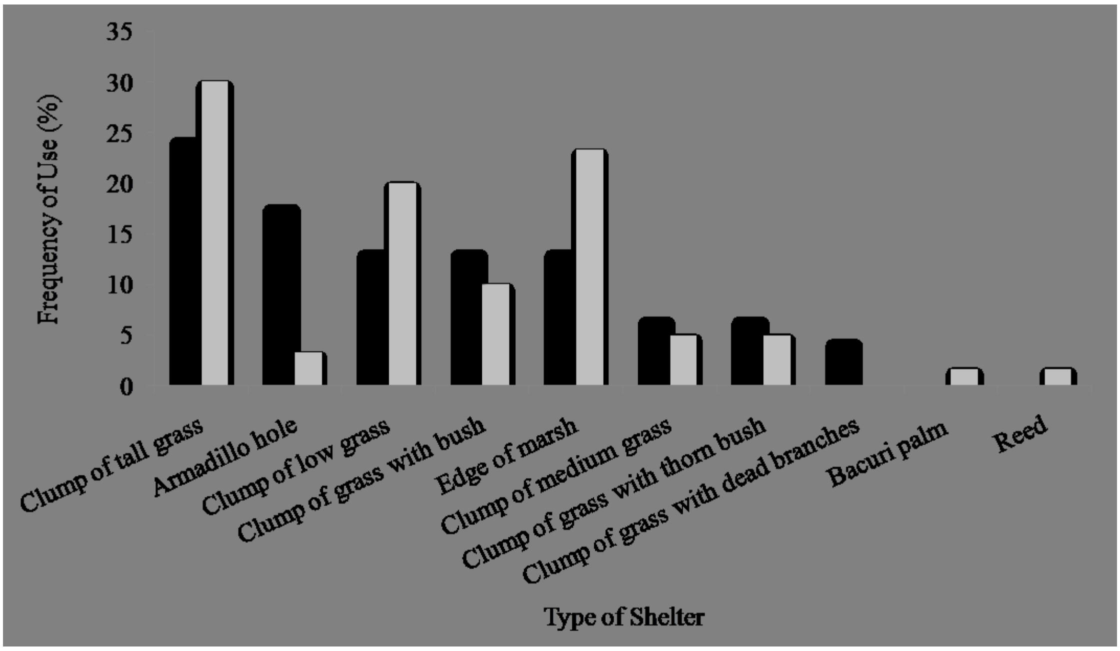

Fig. 27. – Types of shelters used by male and female crab-eating foxes (*Cerdocyon thous*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are females and grey bars are males. Bacuri Palm (*Platonia insignis*) and reed (*Pennisetum purpureum* or *Saccharum* sp.).

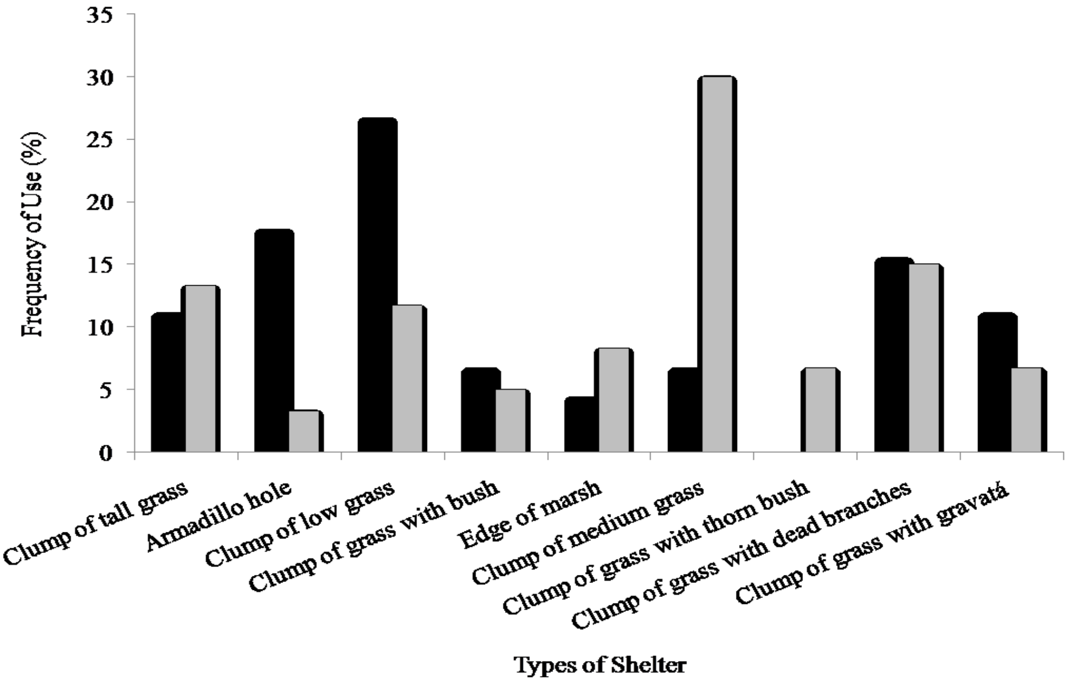

Fig. 28. – Frequency of shelters used in different seasons by male and female crab-eating foxes (*Cerdocyon thous*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are dry season and grey bars are wet season. *Gravatá* (*Bromelia balansae)* and Bacuri Palm (*Platonia insignis*)

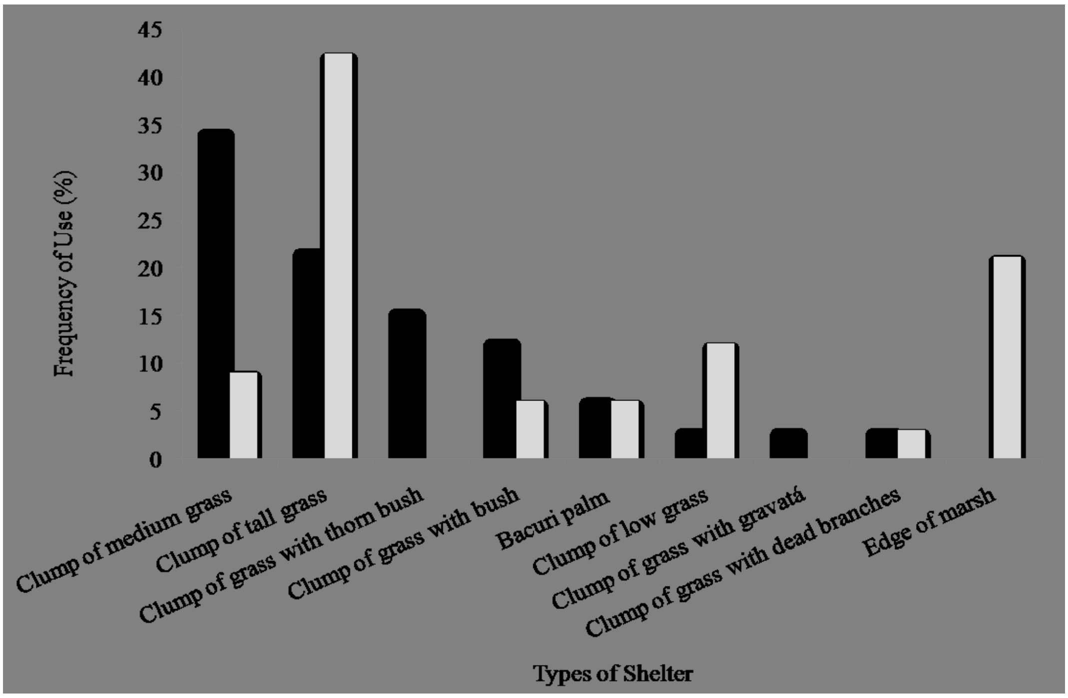

Fig. 29. – Types of shelters used by male and female maned wolves (*Chrysocyon brachyurus*) at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are females and grey bars are males. *Gravatá* (*Bromelia balansae*) and Bacuri Palm (*Platonia insignis*).

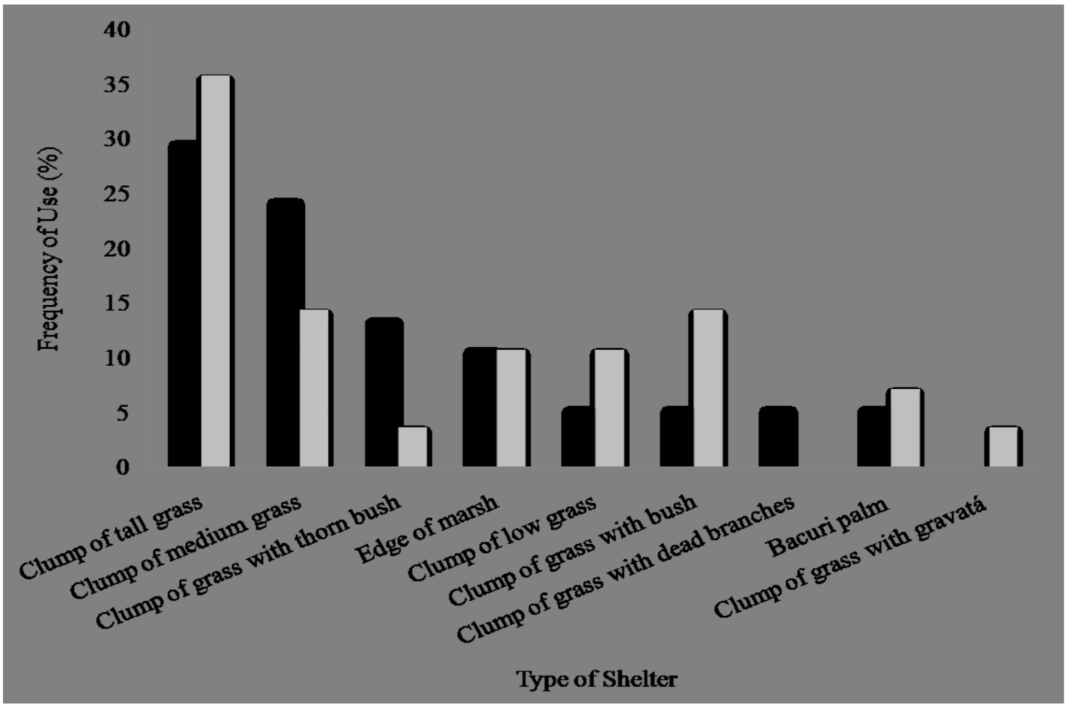

Fig.30.– Frequency of shelters used in different seasons by male and female maned wolves (*Chrysocyon brachyurus* at Limoeiro region, municipality of Cumari, Goiás state, Brazil. Legend: black bars are dry season and grey bars are wet season. *Gravatá* (*Bromelia balansae) a*nd Bacuri Palm (*Platonia insignis*).

CAPÍTULO III

Avaliação do risco de extinção da raposa-do-campo *Lycalopex vetulus* (Lund, 1842) no Brasil

Artigo publicado no periódico *Biodiversidade Brasileira* 21/06/2013

Avaliação do risco de extinção da raposa-do-campo *Lycalopex vetulus* (Lund, 1842) no Brasil

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Citação: Lemos, F.G., Azevedo, F.C., Beisiegel, B.M., Jorge, R.P.S., Paula, R.C., Rodrigues, F.H.G. & Rodrigues, L.A. 2013. Avaliação do risco de extinctão da raposa-do-campo *Lycalopex vetulus* (Lund, 1842) no Brasil. **Biodiversidade Brasileira**, 3(1), pp. 160 – 171.

Justificativa

A raposa-do-campo, *Lycalopex vetulus*, é a única espécie de canídeo brasileiro endêmica do Cerrado, bioma sob alta pressão antrópica e com menos de 20% de sua área original ainda em estado primitivo. Considerando estimativas conservadoras, o Cerrado sofreu um desmatamento de 50% de sua área nos últimos 40 anos; destes, pode-se estimar uma perda de 20% desta área em um período de 15 anos ou três gerações, que deve corresponder a uma perda populacional equivalente para a espécie. Este declínio não cessou. Estima-se que a espécie terá uma perda de hábitat de, pelo menos, 10% nos próximos 15 anos. Considerando que a espécie também sofreu e continua sofrendo perdas importantes não quantificadas decorrentes de atropelamento, predação por cães domésticos, doenças, retaliação à suposta predação de animais domésticos, e alta mortalidade de filhotes/juvenis, o declínio populacional deve, em uma estimativa conservadora, ter sido de pelo menos 30% nos últimos 15 anos e deve atingir o limite de 30% nos próximos 15 anos. Até onde se sabe a espécie só ocorre em território brasileiro, não havendo populações em países vizinhos. Por estas razões, a espécie foi categorizada como Vulnerável (VU) pelos critérios A2+3cd.

Nome popular

Raposa-do-campo, raposinha, raposinha-do-campo (Português), jaguarapitanga (Tupy), waptsã wa (Xavante), hoary fox, hoary *zorro*, small-toothed dog (Inglês), zorro de campo común (Espanhol), renard du Bresil (Francês), kampfuchs (Alemão) (Dalponte & Courtenay 2004).

Notas taxonômicas

Atualmente não são reconhecidas subespécies de *Lycalopex vetulus* (Wozencraft 2005).

Sinonímia

Em alguns trabalhos a espécie é denominada *Dusicyon vetulus*, seguindo Clutton-Brock*et al.* (1976). Apesar de alguns trabalhos utilizarem *Pseudalopex vetulus* a partir de Berta (1987), o mais aceito atualmente é *Lycalopex vetulus*, de acordo com Wozencraft (2005) e Dalponte (2009).

Histórico das avaliações nacionais

A espécie não está incluída na lista brasileira oficial de espécies ameaçadas de extinção (MMA 2003).

Avaliações em outras escalas

A raposa-do-campo é considerada Menos Preocupante (LC – *Least Concern*) pela UICN (Dalponte & Courtenay 2008), mesmo sendo uma espécie endêmica ao Cerrado e sujeita a várias ameaças antrópicas. Esta avaliação baseia-se no fato de a espécie aparentar ser relativamente comum e localmente abundante na área central de sua distribuição, além de exibir certa adaptabilidade a distúrbios antropogênicos (Dalponte & Courtenay 2008). De acordo com os autores, não existiam, até o momento da avaliação, ameaças conhecidas que resultassem ou pudessem resultar em um declínio significantivo da população. Entretanto, os mesmos ressaltam que apesar de suas populações serem consideradas estáveis, ainda são inexistentes estimativas precisas do tamanho e dinâmica populacionais.

No Brasil a raposa-do-campo está presente nas listas vermelhas de espécies ameaçadas de extinção dos estados de São Paulo e Paraná. Em São Paulo é considerada Vulnerável (critério A2c), uma vez que o tamanho da população e sua dinâmica são desconhecidos, além do elevado número de atropelamentos e conflitos com humanos (para detalhes ver Lemos & Azevedo 2009). No Paraná, a raposa-do-campo consta como Dados Insuficientes (DD), devido à falta de informações sobre a real distribuição da espécie no estado (Mikich & Bérnils 2012). O Paraná pode representar o possível limite sul da área de ocorrência da espécie (Mikich & Bérnils 2012), e não o estado de São Paulo, como atualmente reportado na literatura (Dalponte 2009). Entretanto, este aspecto é discutido no tópico seguinte. Em Minas Gerais, apesar de não constar na pesquisa online de espécies ameaçadas do estado (Biodiversitas 2012), Chiarello *et al.* (2008) citam a raposa-do-campo como uma espécie Em Perigo (EN).

Distribuição geográfica

Endêmica do Brasil, a distribuição geográfica da raposa-do-campo originalmente parece estar associada aos limites de extensão do Cerrado (áreas de vegetação savânica) (Dalponte 2009). A espécie pode ainda ser encontrada em zonas de transição, incluindo hábitats abertos no Pantanal (mosaico de campos e vegetação xerofítica), embora ainda existam certos estados e regiões neste bioma onde a espécie não foi registrada até a conclusão deste artigo. É mais comum na região centro-sul do bioma (Dalponte 2009), mas registros recentes têm ampliado consideravelmente sua distribuição para a região norte e nordeste do país. Considerando as novas informações, a área de ocorrência atual da raposa-do-campo estende-se do centro-nordeste e oeste do estado de São Paulo (Dalponte 2003, Dalponte 2009) ao norte do Piauí (Costa & Courtenay 2003) e médio-leste do Maranhão (Lemos & Azevedo, observação pessoal), incluindo os estados do Mato Grosso (centro-sul) e Mato Grosso do Sul (áreas secas e não inundáveis do pantanal), sul de Rondônia (Ribeiro comunicação pessoal) Goiás, Tocantins, Distrito Federal, sudoeste da Bahia, e centro-oeste de Minas Gerais (Dalponte 2003, Dalponte & Courtenay 2008, Dalponte 2009, Lemos & Azevedo observação pessoal) (Figura 1).

Apesar de sua distribuição razoavelmente conhecida, três regiões ainda representam lacunas de conhecimento devido à ausência ou não confirmação de registros. O extremo oeste de sua distribuição, no Mato Grosso do Sul, representa uma destas lacunas. Apesar de sua ocorrência ser sugerida, mas não confirmada, por Anderson (1977) no Cerrado Boliviano, na área da Serranía de Huanchaca, o registro mais a oeste está a cerca de 75 km antes da fronteira boliviana (Dalponte 2009). Outra lacuna é a região nordeste de sua distribuição, na região onde o Cerrado é substituído pelo bioma Caatinga. Apesar de durante a confecção deste artigo os autores terem recebido diversos relatos de outros pesquisadores que afirmam ter registrado a raposa-do-campo no centro e região leste da Caatinga, ao serem analisados, nenhum dos materiais testemunhos (fotos de animais vivos e atropelados, e rastros) confirmou tratar-se da espécie. Por fim, o Paraná representa a terceira lacuna de conhecimento sobre a distribuição da raposa-do-campo. Apesar do estado de São Paulo ser o limite de distribuição conhecido e confirmado por material testemunho (Dalponte 2009), Mikich & Bérnils (2012) incluem a raposa-do-campo na lista vermelha de espécies ameaçadas de extinção do Paraná, baseando-se em três registros na porção leste do estado.

Entretanto até o momento não existem evidências ou registros comprovados que suportem esta ampliação na distribuição.

Uma das maiores dificuldades no conhecimento da real distribuição da raposa-do-campo reside na identificação errônea da espécie por pesquisadores, tradicionalmente baseada na coloração. A raposa-do-campo é facilmente confundida pelo pesquisador não especialista na espécie com outras duas espécies de canídeos brasileiros de mesmo porte: o cachorro-do-mato (*Cerdocyon thous*) e o graxaim-do-campo (*Lycalopex gymnocercus*). O primeiro ocorre simpatricamente ao longo de toda a distribuição de *L. vetulus*. Já o graxaim-do-campo substitui a raposa-do-campo no limite sul de sua distribuição, não sendo conhecida atualmente a distribuição norte da espécie e se a mesma ocorre simpatricamente ou não com a raposa-do-campo. Lemos & Azevedo registraram o graxaim-do-campo no sudoeste do estado de São Paulo, porém é necessário que mais amostragens sejam realizadas na região para melhor conhecer os limites de cada espécie e se as mesmas têm distribuição sobreposta. Ainda, diversos registros no nordeste do país atribuídos à raposa-do-campo, quando analisados mais profundamente, revelam se tratar do cachorro-do-mato, cuja população da região leste de sua distribuição possui indivíduos com pelagem mais clara do que a geralmente encontrada em outras partes do Brasil. Estudos demonstraram que a maior parte dos canídeos diagnosticados com leishmaniose e raiva na região nordeste, identificados como *L. vetulus*, eram na verdade *Cerdocyon thous* (Courtenay *et al.* 1996, Carnieli *et al.* 2008).

Entretanto, vale ressaltar que mesmo havendo sobreposição de coloração da pelagem da raposa-do-campo com as outras espécies de canídeos de pequeno porte do Brasil, a identificação das mesmas deve ser baseada em outras diferenças morfológicas menos variáveis como o tamanho corporal, tamanho e formato da cabeça e focinho em relação ao corpo (sempre maiores e mais robustos no cachorro-do-mato, seguido do graxaim-do-campo), e a presença de uma mancha negra na base da cauda da raposa-do-campo, característica peculiar a todas as espécies deste gênero (*Lycalopex*), além da ponta da cauda negra. Com relação ao graxaim-do-campo, as manchas na cauda podem representar um fator de confusão entre as espécies, mas o graxaim é maior (5 – 8 kg) que a raposa-do-campo (2 – 4 kg), sendo a cabeça, o focinho e o peito mais largos e robustos. Adicionalmente, a realização da identificação das espécies por meio de técnicas moleculares é uma alternativa interessante nos casos em que houver disponibilidade de amostras dos indivíduos, conforme constatado por Carnieli *et al.* (2008).

Portanto, são necessários mais estudos e amostragens que ajudem a eliminar lacunas de conhecimento sobre a distribuição da raposa-do-campo, além da elaboração de material descritivo-fotográfico (artigos, guias e livros) que não só divulgue mais a espécie, mas também auxiliem na formação e qualificação de pesquisadores e leigos interessados na raposa-do-campo e no grupo Canidae.

População

Não existem estudos sistemáticos sobre a densidade populacional de raposa-do-campo ao longo de sua distribuição, exceto o realizado por Rocha *et al.* (2008) em duas áreas no Estado do Mato Grosso, uma de campo sujo e outra de pastagem. Segundo os autores, a estimativa populacional para a área de campo sujo foi de 1,21 indivíduos/km^2 e para a pastagem de 4,28 indivíduos/km^2. Apesar dos autores sugerirem uma possível adaptação da espécie a ambientes antropizados, onde a vegetação natural do Cerrado é substituída por pastagens exóticas, é importante ressaltar que as áreas utilizadas durante o estudo, além de proporcionarem visibilidade diferente, muito maior nas pastagens do que no campo sujo, foram amostradas em momentos diferentes (“campo sujo” em agosto e setembro, “pastagem” em outubro e novembro). Os dois períodos amostrados são momentos diferentes na história de vida da raposa-do-campo. Em agosto os filhotes estão nascendo e as mães passam mais tempo na toca, e os machos fora (Dalponte 2009, Lemos *et al.* 2011a, Lemos & Azevedo observação pessoal), diminuindo a probabilidade de avistamento de indivíduos. Em outubro os filhotes já circulam fora de suas tocas, juntos com seus pais, em pequenos grupos familiares (Dalponte 2009, Lemos *et al.* 2011a, Lemos & Azevedo observação pessoal), aumentando o número de indivíduos que poderiam ser avistados. Portanto, é possível que a diferença de densidade encontrada não reflita a realidade populacional das áreas de estudo, mas seja resultante de um viés amostral. Assim, é imprescindível que futuros estudos de densidade populacional sejam não apenas realizados durante períodos maiores de tempo, que abranjam diferentes épocas do ano, mas que principalmente os transectos sejam feitos em estações/épocas de histórias de vida similares. Isso é extremamente importante dada a falta de outros estudos populacionais, uma vez que a espécie talvez não seja realmente favorecida pela conversão de ambientes naturais de Cerrado em pastagens. Além disto, Lemos e Azevedo (observações pessoais), a partir do acompanhamento de uma população em uma área fragmentada com matriz de pastagens no sudeste de Goiás, município de Cumari, relataram um possível declínio populacional ao registrarem em dois anos consecutivos a morte da maior parte dos filhotes nascidos e também de vários juvenis e adultos. Desta forma, os resultados relatados por Rocha *et al.* (2008) devem ser interpretados com cautela e não podem ser aplicados em toda a distribuição da espécie, dada a inexistência de estudos acerca de densidade e dinâmicas populacionais da raposa-do-campo em outras áreas.

Além disso, a área de distribuição da raposa-do-campo é grande e a espécie não só ocorre em diferentes tipos de ambientes, mas também enfrenta diferentes tipos e níveis de pressão antrópica. De acordo com a UICN a espécie é localmente abundante, mas suas populações são menores que as do cachorro-do-mato, espécie para a qual estimativas populacionais no Brasil também são escassas (Dalponte & Courtenay 2008).

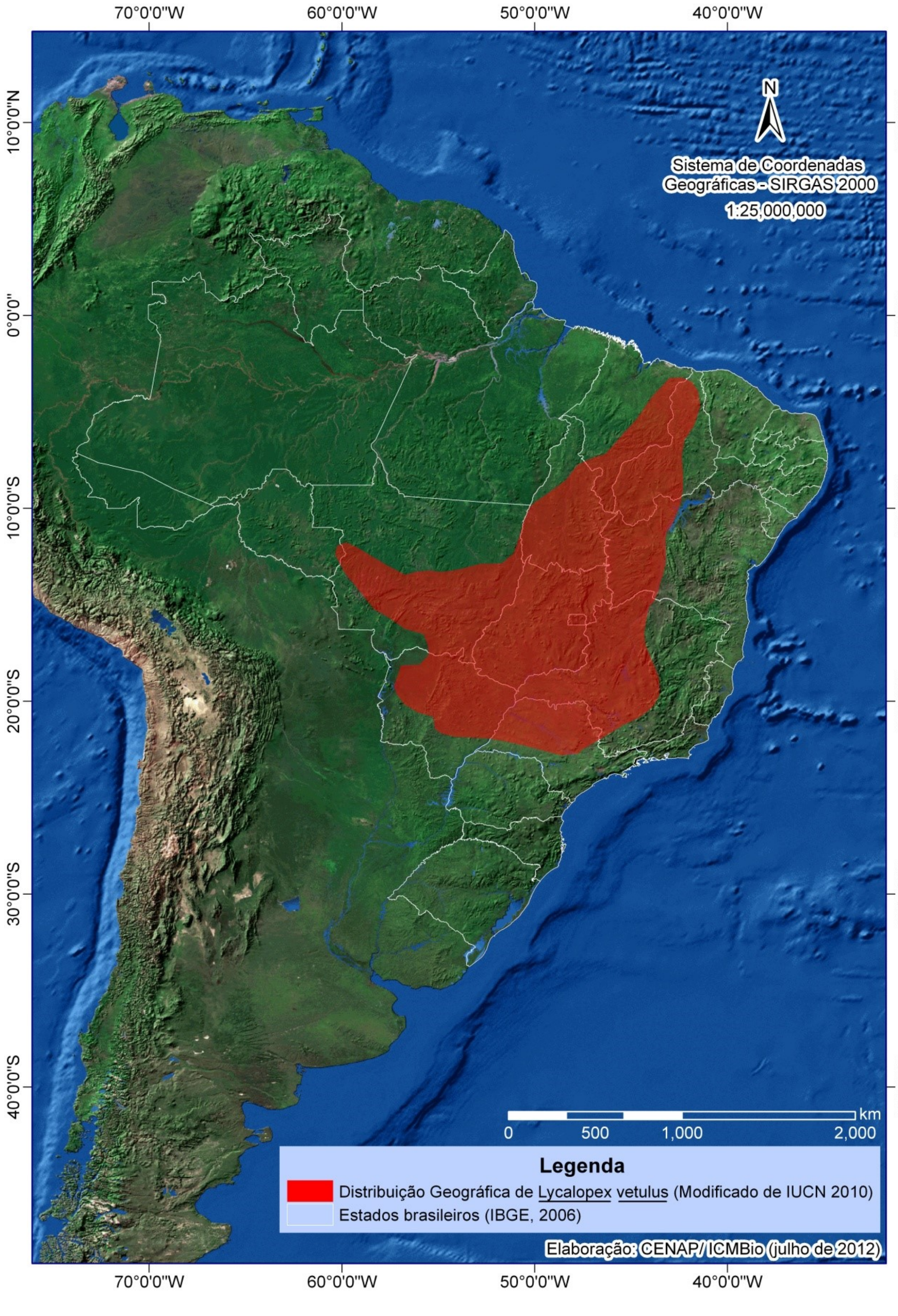

Figura 1 – Distribuição geográfica da Raposa-do-campo *Lycalopex vetulus*.

Consideramos que não se pode afirmar que *L. vetulus* se adapta a áreas antropizadas até que sejam obtidos dados conclusivos sobre as densidades populacionais da espécie em diferentes partes de sua distribuição geográfica. Por esse motivo, as perdas populacionais da espécie foram estimadas com base na perda de hábitat ocorrida em um período de três gerações (15 anos). Segundo Myers *et al.* (2000), o Cerrado possui apenas 20% de área de vegetação primária, sendo que a degradação do Cerrado iniciou-se na década de 1970 (Sano *et al.* 2010). Dados mais conservadores sobre o desmatamento deste bioma apontam para uma perda de cerca de 50% da área de Cerrado (MMA/IBAMA/PNUD 2009). Considerando que esta perda ocorreu em 40 anos, pode-se estimar uma perda de 20% desta área em um período de 15 anos ou três gerações, que deve corresponder a uma perda populacional equivalente para a espécie. As perdas populacionais da espécie não cessaram. Estima-se que a espécie terá uma perda de hábitat de, pelo menos, 10% nos próximos 15 anos. Esta estimativa está embasada em dados de desmatamento do Cerrado no período de 2002 a 2008 (MMA/IBAMA/PNUD 2009). De acordo com este estudo, foram perdidos aproximadamente 14.000 km^2 de Cerrado por ano no período, o que corresponde a 1,34% da área remanescente do bioma (1.063.289 km^2). No entanto, estimamos que, desta taxa anual de desmatamento, aproximadamente 50% se referem à conversão em agricultura e 50% em pastagem e, uma vez que a espécie utiliza pastagens, foi decidido utilizar 0,67% como a perda anual de habitat para a espécie.

Considerando que a espécie também sofreu no passado e ainda sofre perdas importantes não quantificadas decorrentes de atropelamento, predação por cães domésticos, doenças, retaliação à suposta predação de animais domésticos, e alta mortalidade de filhotes/juvenis (ver item *Ameaças e usos*), o declínio populacional nos últimos 15 anos deve ter atingido 30% e o declínio nos próximos 15 anos deve também atingir o limite de 30%, ambos em uma estimativa conservadora, qualificando a espécie à categoria Vulnerável (VU) pelos critérios A2+A3cd.

Habitat e ecologia

A raposa-do-campo é uma espécie típica de formações abertas do Cerrado, preferindo as fitofisionomias de campos ou com vegetação mais rala e espaçada como os campos limpos, campos sujos, campos cerrados e cerrado *stricto sensu*, às formações mais densas ou florestais, sejam elas deciduais ou matas de galeria (Cabrera & Yepes 1960, Coimbra-Filho 1966, Dalponte 1997, Dalponte 2003, Silveira 1999, Juarez & Marinho-Filho 2002). Os ambientes preferenciais parecem focar as planícies e chapadões bem drenados do Brasil central, em que o regime de chuvas é bem marcado, apresentando uma estação seca longa onde a chuva é escassa ou inexistente durante pelo menos três meses (Dalponte 2003). Dalponte (2003) estimou que dentre as 53 localidades em que a raposa-do-campo foi observada, 22,6% eram de cerrado *stricto sensu*, 18,8% eram campos úmidos (veredas, campos de murunduns ou campo de vazante), 13% eram campo cerrado, e 11,3% eram campos naturais (campo limpo ou campo sujo).

Apesar de aparentemente evitar regiões pantanosas ou alagadiças, pode também ser encontrada em algumas regiões do Pantanal, onde existem grandes extensões de terrenos secos e abertos durante o período de inundação (Dalponte 2003). Censos realizados nas planícies inundáveis do rio Paraguai não registraram a presença da espécie tanto em áreas baixas e contínuas (Alho *et al.* 1988) quanto em áreas altas e isoladas (Shaller 1983, Dalponte 2003). No nordeste de sua distribuição foi registrada em ambientes de transição entre Cerrado e Caatinga (Barbosa Souza & Olmos 1991, Olmos 1993, Dalponte 1995, Juarez & Marinho-Filho 2002).

Também existem diversos registros da espécie em áreas antropizadas como as de pastagem (Courtenay *et al.* 2006, Dalponte & Courtenay 2008, Rocha *et al.* 2008, Dalponte 2009, Lemos *et al.* 2011a, b), de agricultura (Juarez & Marinho-Filho 2002, Dalponte 2003, Lemos & Azevedo, observação pessoal) e de silviculturas, mais especificamente plantações novas de eucalipto (Courtenay *et al.* 2006) e seringueiras (Lemos & Azevedo observação pessoal). Segundo Dalponte (2003), áreas de pastagem de gado (pastagem manejada e pastagem suja) representaram 24,5% dos pontos onde raposas foram registradas, enquanto campos de cultivo de grãos representaram 7,5% das observações realizadas. Em fazendas de gado no sudeste de Goiás, Lemos *et al.* (2011a) observaram que raposas-do-campo utilizam mais áreas de pasto (preferencialmente pastagem pastada) em detrimento de outros tipos de habitats disponíveis como pastagens abandonadas em algum estágio de sucessão, mata semidecídua e borda de mata, e brejos e borda de brejos, não ocorrendo nenhum registro da espécie em áreas de floresta nem permanentemente alagadas.

A raposa-do-campo é um carnívoro insetívoro-onívoro, que utiliza cupins como a base de sua alimentação (e.g. Dalponte 1995, Dalponte 1997, Juarez & Marinho-Filho 2002, Jácomo *et al.* 2004, Ferreira-Silva & Lima 2006, Trovati *et al.* 2006, Dalponte 2009, Lemos *et al.* 2011a). A espécie consome também, em menores proporções, besouros e gafanhotos e conforme a disponibilidade no ambiente e época do ano frutos silvestres e exóticos, pequenos mamíferos, escamados, anuros e aves (Dalponte 1995, Dalponte 1997, Juarez & Marinho-Filho 2002, Jácomo *et al.* 2004, Ferreira-Silva & Lima 2006, Trovati *et al.* 2006, Dalponte 2009, Lemos *et al.* 2011a). Segundo Dalponte & Lima (1999), *L. vetulus* pode ser considerada uma dispersora potencial de sementes devido à alta diversidade de frutos consumidos e à elevada presença de sementes intactas nas fezes analisadas.

Possui um padrão de atividade crepuscular-noturno, iniciando sua atividade após o por do sol e terminando ao amanhecer (Dalponte 2009). Ocorre em simpatria com outros canídeos brasileiros como o cachorro-do-mato e o lobo-guará (*Chrysocyon brachyurus*), existindo alguma sobreposição entre as dietas dos mesmos (Jácomo *et al.* 2004). Entretanto, aparentemente as adaptações morfológicas que permitem à raposa-do-campo habitar áreas mais secas de campos abertos e sua dieta direcionada primordialmente aos cupins permitem que ela coexista com as outras duas espécies de canídeos (Dalponte 2009). Em algumas regiões foi observado uma sobreposição alimentar moderada entre as duas espécies menores de canídeos brasileiros, *C. thous* e *L. vetulus*, uma vez que apresentaram alguma diferença na preferência por alguns itens alimentares (Silveira 1999, Juarez & Marinho-Filho 2002, Lemos *et al.* 2011a). Jácomo *et al.* (2004) analisaram a sobreposição dos nichos alimentares entre estas três espécies no Parque Nacional das Emas, em Goiás. Segundo os autores, a maior sobreposição observada foi entre o lobo-guará e a raposa-do-campo, no entanto foi verificado que existe diferença no padrão de atividade das espécies, permitindo que habitem o mesmo ambiente em simpatria. Entretanto, na região do Limoeiro (sudeste de Goiás), ambas as espécies têm padrão de atividade similar e ainda assim ocorrem sintopicamente (Lemos & Azevedo observação pessoal).

Com relação ao comportamento, raposas-do-campo são consideradas de hábitos solitários (Lemos & Facure 2011) e monogâmicos, formando pares reprodutivos durante a estação de acasalamento que permanecem juntos durante a criação dos filhotes, sendo o contato entre a fêmea e o macho mais intenso nos quatro primeiros meses de vida da prole (Dalponte 2003, Courtenay et al 2006, Lemos *et al.* 2011a, Lemos & Azevedo observação pessoal). Observações de interações sociais estão restritas às realizadas entre os pares reprodutivos, que podem forragear próximos, mantendo alguma distância de contato, e também entre a mãe e seus filhotes (Dalponte 2003, Dalponte & Courtenay 2004, Courtenay *et al.* 2006, Lemos et al. 2011a).

As fêmeas têm ninhadas de 2 a 5 filhotes que nascem geralmente de julho a agosto, sendo o período de gestação de aproximadamente 50 dias (Dalponte 2003, Dalponte 2009, Lemos *et al.* 2011a, Lemos & Azevedo observação pessoal). No sudeste de Goiás, (Lemos *et al.* 2011a, Lemos & Azevedo observação pessoal) raposas tiveram ninhadas que variaram entre um (N = 1) e 4 filhotes (N = 2), mas ninhadas com três filhotes foram predominantes (N = 5). Normalmente, são usadas as tocas de tatus-peba (*Euphractus sexcinctus*) abandonadas para o nascimento da ninhada (Courtenay *et al.* 2006, Dalponte 2009, Lemos *et al.* 2011a). As fêmeas amamentam os filhotes até os 4 meses de vida, podendo permanecer com eles por 2 a 4 meses (Dalponte, 2009) e eventualmente mais tempo (Lemos & Azevedo observação pessoal). A dispersão dos juvenis ocorre entre nove e 10 meses de idade, quando eles começam a estabelecer seus próprios territórios, podendo ser próximos à área onde passaram seus primeiros meses de vida (Dalponte 2003, Lemos & Azevedo observação pessoal). Registros recentes indicam que o macho e a fêmea participam nos cuidados com a prole (Courtenay *et al.* 2006, Dalponte 2009, Lemos & Azevedo observação pessoal).

Poucos trabalhos foram realizados a respeito do tamanho de área de vida utilizado por raposas-do-campo. Em um estudo realizado na Bahia, Juarez & Marinho-Filho (2002) estimaram a área de vida de uma fêmea adulta em 3,8 km^2 e a de um macho juvenil em 2 km^2. Além disso, conforme registrado pelos autores, a distância percorrida por uma fêmea adulta em uma noite foi de 4,55 km. Courtenay *et al.* (2006) acompanharam um casal e dois filhotes numa área antropizada em Minas Gerais por alguns meses e estimaram em 4,56 km^2 a área de vida compartilhada pelo grupo. No Mato Grosso, três grupos, compostos por um grupo familiar e dois casais foram acompanhados e a média da área de vida encontrada foi de 0,48 km^2 (Dalponte 2009). Tendo em vista o baixo número de animais acompanhados e a curta duração dos trabalhos, faz-se necessário que novos estudos de monitoramento em longo prazo sejam priorizados, para conhecer a área mínima necessária para uma raposa-do-campo atender suas necessidades básicas.

Em relação às interações interespecíficas, existem pouquíssimos relatos publicados sobre encontros entre a raposa-do-campo e outros carnívoros. De 2005 a 2011, no sudeste de Goiás, Lemos e Azevedo (observação pessoal) testemunharam três encontros entre raposas-do-campo e cachorros-do-mato, os quais resultaram em perseguições da espécie maior sobre a menor, o que poderia indicar uma competição interespecífica por uso de habitat (para mais detalhes ver Lemos *et al.* 2007, para uma descrição do primeiro registro). O segundo e terceiro registros consistiram em indivíduos de raposa-do-campo monitoradas por colares VHF (Very High Frequency) sendo afastadas de sua área por cachorros-do-mato também monitorados, sendo que todas as observações foram visuais. Isso contraria o registrado por Courtenay *et al.* (2006), que afirmam que a raposa-do-campo poderia tolerar cachorros-do-mato em suas áreas de forrageio. Fernanda C. Azevedo (observação pessoal) relata um macho de raposa-do-campo em outubro de 2008 com comportamento agressivo afastando um lobo-guará que se aproximou muito de uma toca de filhotes (Lemos *et al.* 2011a).

Com relação aos carnívoros de grande porte, como onças-pardas (*Puma concolor*) e lobos-guarás, apesar de Jácomo *et al.* (2004) registrarem pelos de raposa-do-campo em fezes de lobos-guarás, não existem registros que indiquem se a mesma foi ativamente predada ou consumida como carcaça encontrada, embora de Paula (comunicação pessoal) tenha registrado um lobo-guará perseguindo uma raposa-do-campo, mas sem alcançá-la, no Parque nacional da Serra da Canastra.

Ameaças e usos

As maiores ameaças à conservação da raposa-do-campo parecem ser a destruição de seu hábitat e outros efeitos negativos diretos e indiretos causados pelo homem (Lemos *et al.* 2011b). Uma vez que a espécie só ocorre nos domínios do Cerrado, e este se encontra entre os 25 ecossistemas mais ameaçados do planeta (Myers et al.; 2000), as ações antrópicas aparentemente representam a maior fonte de mortalidade da espécie (Lemos *et al.* 2011b). Por serem consideradas terras improdutivas", nas últimas duas décadas o governo federal incentivou o desbravamento e "desenvolvimento" das fronteiras comerciais e industriais no Cerrado. São diversas as ameaças resultantes de tais ações, sendo a expansão da fronteira agropastoril a principal fonte de fragmentação e supressão de hábitats adequados à sobrevivência da espécie. Áreas de Cerrado nos estados de São Paulo e Minas Gerais ocorrem em manchas isoladas e atualmente encontram-se separadas da porção mais contínua e central do bioma.

Como resultados do avanço desordenado das atividades humanas estão o crescimento (em tamanho e número) dos centros urbanos, a crescente exploração da madeira para fornecimento de carvão e a expansão da malha viária e ferroviária (Dalponte 2003, Lemos & Azevedo 2009, Lemos *et al.* 2011b). Atropelamentos (tanto em rodovias quanto em ferrovias) contribuem com um número relativamente elevado de retirada de indivíduos das populações de raposas-do-campo (Dalponte 2003, Dalponte & Courtenay 2004, Lemos & Azevedo, 2009, Lemos *et al.* 2011b). Outras ameaças são os ataques por cães domésticos, que perseguem tanto adultos quanto filhotes, e a perseguição direta pelo homem em virtude da percepção errônea de ataques a animais domésticos (Dalponte 2003, Lemos & Azevedo 2009, Lemos *et al.* 2011b), apesar de aves domésticas serem pouco frequentes ou ausentes na dieta da espécie (Lemos *et al.* 2011a).

Além disso, a proximidade da espécie com animais domésticos possibilita a transmissão de patógenos, principalmente em áreas periurbanas e sedes de fazenda (Silveira 1999, Dalponte & Courtenay 2008, Lemos e Azevedo 2009, Megid *et al.* 2010, Lemos *et al.* 2011b). Apesar de no passado raposas-do-campo terem sido identificadas como reservatório de *Leishmania chagasi* (Deane & Deane 1954), Courtenay *et al.* (1996) realizaram um trabalho comparativo de crânios e demonstraram que os indivíduos infectados tratavam-se na verdade de cachorros-do-mato identificados erroneamente como raposas-do-campo. Dados confirmados de animais infectados incluem um indivíduo atropelado cujos exames confirmaram o diagnóstico de cinomose (Megid *et al.* 2010), dois indivíduos positivos para o vírus da parvovirose canina (Curi 2005), e um caso de mortalidade por sarna reportado no Brasil central (Marinho-Filho comunicação pessoal). Assim, é urgente que sejam realizados estudos em longo prazo que ajudem a conhecer melhor a susceptibilidade de raposas-do-campo a doenças em geral e a entender melhor o papel destas na sobrevivência de populações em diferentes partes de sua distribuição, tanto em áreas protegidas quanto antropizadas.

Ações de conservação

Não existem ações de conservação específicas para esta espécie em curso ou planejadas por parte de instituições governamentais. Ações necessárias incluem medidas que priorizem a proteção dos habitats adequados à sobrevivência da raposa-do-campo, que são específicos do bioma Cerrado, já que esta espécie é endêmica deste ecossistema. Em segundo lugar, mas não menos importante, está a realização de um Plano de Ação Nacional (PAN) para a conservação da raposa-do-campo, com o objetivo de reunir especialistas e informações que possam discutir as melhores estratégias para aumentar o conhecimento da espécie e garantir sua sobrevivência em longo prazo.

Projetos e iniciativas, governamentais e privadas, que visem reduzir os impactos humanos causados no Cerrado, como ações voltadas para a produção e desenvolvimento sustentável, e a manutenção da biodiversidade em agro-ecossistemas nas políticas de desenvolvimento agro-pastoril (Dalponte 2003) podem contribuir de forma efetiva para a conservação da raposa-do-campo em áreas antropizadas.

Programas pontuais ou de menor escala devem complementar as ações acima sugeridas, permeando os temas abaixo:

- Estudos sobre densidade, abundância relativa e tendências populacionais da raposa-do-campo, que comparem áreas protegidas com áreas sob diferentes níveis de perturbação antrópica;
- Atualização da distribuição da espécie;
- Papel de doenças na regulação populacional da raposa-do-campo;
- Programas de informação e educação para a conservação da biodiversidade que desestimulem a captura e caça de animais silvestres e que divulguem a espécie;
- Programas de implementação de técnicas para a mitigação do impacto de empreendimentos lineares nas populações de raposas-do-campo;
- Programas de vacinação, castração e posse responsável de cães domésticos nas áreas de ocorrência da raposa-do-campo, principalmente no entorno de unidades de conservação.

Pesquisas realizadas

O Programa de Conservação Mamíferos do Cerrado (PCMC), sob coordenação de Frederico Gemesio Lemos e Fernanda Cavalcanti de Azevedo e com a participação de outros colaboradores, vem estudando a espécie desde 2002 na região do sudeste de Goiás, município de Cumari, Goiás, e no Triângulo Mineiro. O grupo vem estudando os aspectos básicos da história natural da raposa-do-campo (ecologia espacial, uso de habitat, dieta, dispersão de filhotes e taxas de sobrevivência e mortalidade), sua relação com canídeos sintópicos, como o cachorro-do-mato e o lobo-guará (sobreposição espacial, temporal e alimentar, além de interações diretas), seu perfil sanitário na região e as causas de mortalidade em um ambiente antropizado. Inserido no PCMC, o Projeto Raposa-do-campo tem atividades previstas para pelo menos até 2015.

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CONCLUSÕES GERAIS

Nas últimas décadas, o crescente interesse pela manutenção de espécies em ambientes fragmentados levou ao surgimento de novas abordagens e ao delineamento de ações globais relacionadas à conservação da biodiversidade. Neste contexto, são cada vez mais necessários estudos que avaliem como a fauna vem respondendo aos diferentes graus de modificação nos ecossistemas promovidos por ações humanas. A porção sudeste do estado de Goiás representa boa parte deste cenário, uma vez que está situado no centro do bioma Cerrado e, como em muitas outras regiões deste ecossistema, sua fauna e flora vêm sofrendo forte influência antrópica.

O trabalho de acompanhamento de três espécies de canídeos silvestres em uma área modificada como a região do Limoeiro e sem qualquer proteção oficial permitiu entender um pouco mais como esses organismos tem sobrevivido nesse ambiente e as ameaças com que convivem diariamente. Ainda, mais especificamente, conhecer a biologia da raposa-do-campo vai além de entender suas relações ecológicas, pois pode contribuir para entendermos melhor a história evolutiva da família Canidae na América do Sul e como se deu a irradiação de canídeos deste grupo pelo continente sul-americano. Raposas-do-campo e cachorros-do-mato também representam um ótimo modelo de como se comportam canídeos de pequeno porte do grupo Lupinae. Resultados obtidos durante este trabalho nos permite chegar às seguintes conclusões:

1. Pouquíssimos trabalhos comparando esforços de amostragem, e métodos e sucesso de captura com canídeos silvestres foram realizados no Brasil, sendo que muito pouca informação sobre este aspecto encontra-se disponível na literatura;

2. Armadilhas tipo caixa de médio e grande porte iscadas com sardinhas em óleo são muito eficientes para capturar e monitorar (através de eventos de captura/recaptura) canídeos silvestres; ainda, tomadas as devidas precauções, e sempre com a presença de um médico veterinário, mostraram ser um método seguro;

3. Apesar de ter a segunda maior taxa de captura, a raposa-do-campo (*Lycalopex vetulus*) teve a maior taxa de recaptura e pode ser um ótimo modelo para estudos de dinâmica populacional;

4. O formato da mancha na base do rabo presente em canídeos do gênero *Lycalopex* pode ser usado para identificar indivíduos de maneira não-invasiva; estudos populacionais com armadilhamento fotográfico e/ou observação direta podem se utilizar desta característica morfológica;

5. Raposas-do-campo apresentaram área de vida média de 2,68 km^2, embora áreas possam ser sete vezes menores ou três vezes maiores; ainda, áreas de vida não variam com o sexo nem massa corpórea dos indivíduos;

6. Cachorros-do-mato (*Cerdocyon thous*) tiveram áreas de vida média de 8,23 km^2. Áreas não variaram com sexo nem massa corpórea dos indivíduos, podendo ser quatro vezes menores ou três vezes maiores que a média;

7. Assim como em outras áreas sob diferentes graus de conservação, lobos-guará (*Chrysocyon brachyurus*) tiveram áreas de vida média de 66,54 km^2;

8. As três espécies de canídeos silvestres demonstraram ter alta sobreposição espacial e temporal, e mesmo utilizando abrigos em diferentes frequências, ainda são necessários mais estudos que permitam entender como as três espécies coexistem sem estabelecer altos níveis de competição direta ou por interferência;

9. Apesar de estarem sujeitas a causas de morte naturais, as principais ameaças à sobrevivência de canídeos silvestres no Limoeiro são oriundas de ações humanas,

fazendo-se urgente a criação e implementação de medidas de mitigação que envolvam as comunidades rurais, as quais convivem com estas espécies diariamente;

10. Devido à condição de endemia, as taxas atuais de desmatamento e substituição de ambientes naturais onde a raposa-do-campo ocorre, altas taxas de mortalidade de filhotes, e outros fatores de ameaça relatados neste trabalho e compilados na literatura nacional e internacional, a raposa-do-campo é classificada como uma espécie vulnerável à extinção.

ANEXOS

Anexo A: Ata de defesa de tese defendida na Universidade Federal de Uberlândia, em 02 de setembro de 2016.

Serviço Público Federal - Ministério da Educação - Universidade Federal de Uberlândia
Programa de Pós-Graduação em Ecologia e Conservação de Recursos Naturais
Campus Umuarama – Bloco 2D – Sala 26 – Uberlândia (MG) – CEP: 38400-902
(034) 3225-8641 http://www.ppgeco.ib.ufu.br/ ecologia@umuarama.ufu.br

ATA DA SESSÃO PÚBLICA DE DEFESA DA 43ª TESE DE DOUTORADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA E CONSERVAÇÃO DE RECURSOS NATURAIS (PPGECRN) DA UNIVERSIDADE FEDERAL DE UBERLÂNDIA (UFU)

Defesa de Tese de Doutorado, Nº. **43**, PPGECRN
Data: **02 de setembro de 2016**
Discente: **Frederico Gemesio Lemos** Matrícula: **11213ECR005**
Título do Trabalho: **"Ecologia e conservação da raposa-do-campo (*Lycalopex vetulus*) e suas interações com canídeos simpátricos em áreas antropizadas de Cerrado do Brasil Central."**
Área de concentração: **Ecologia.**
Linha de pesquisa: **Ecologia Animal**
Projeto de Pesquisa de vinculação: **Ecologia Animal e Interações Ecológicas**

No dia **02** de **setembro** do ano de **2016** na sala 2D14, Campus Umuarama da UFU reuniu-se a Banca Examinadora designada pelo Colegiado do PPGECRN composta pelos seguintes Professores Doutores: **Julio Cesar Dalponte** – Instituto Pró-Carnívoros, **Rogerio Cunha de Paula** - ICMBio, **Ronaldo Gonçalves Morato** – Instituto Chico Mendes, **Natália Mundim Torres** - INBIO/UFU e **Kátia Gomes Facure Giaretta** - INBIO/UFU, presidente da banca e orientador do(a) candidato(a). O(a) Presidente declarou aberta a sessão às **13h00min**, saudou a todos e apresentou os membros da Banca Examinadora e, em seguida, passou a palavra ao(à) candidato(a) para que expusesse sua tese. A duração da apresentação do(a) discente e o tempo de argüição e resposta foram conforme as normas do Programa. A seguir o presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a argüir o(a) candidato(a). Terminada a argüição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu os conceitos finais. Em face do resultado obtido, a Banca Examinadora considerou o(a) candidato(a) **APROVADO(A).** Esta defesa de Tese de Doutorado é parte dos requisitos necessários para a obtenção do título de "Doutor(a) em Ecologia e Conservação de Recursos Naturais". O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas do Programa, a legislação pertinente e a regulamentação interna da UFU. O(a) Presidente(a) agradeceu aos membros da Banca Examinadora e a todos que contribuíram para o êxito do processo que concluía às **18h15min** e declarou encerrada a sessão, cujos trabalhos são objeto desta Ata que será assinada pelo candidato(a) avaliado(a) e os membros da Banca Examinadora. Uberlândia (MG), 02 de setembro de 2016

Dr. Frederico Gemesio Lemos...

Prof. Dr. Julio Cesar Dalponte...

Prof. Dr. Rogerio Cunha de Paula ....

Prof. Dr. Ronaldo Gonçalves Morato ....

Profa. Dra. Natália Mundim Torres ....

Profa. Dra. Kátia Gomes Facure Giaretta .... [1]

[1] 1 cópia do aluno, 2 cópias PROPP, 1 cópia secretaria

Anexo B: Parecer de aprovação do projeto na Comissão de Ética no Uso de Animais (CEUA) da Universidade Federal de Goiás.

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE GOIÁS
PRÓ-REITORIA DE PESQUISA E INOVAÇÃO
COMISSÃO DE ÉTICA NO USO DE ANIMAIS/CEUA

UFG

Goiânia, 10 de novembro de 2014.

PARECER CONSUBSTANCIADO REFERENTE AO PROJETO DE PESQUISA DO PROTOCOLO N. 086/14

I - Finalidade do projeto de pesquisa: Outros – projeto isolado

II - Identificação:

- **Título do projeto:** Projeto ecologia e conservação da raposa-do-campo (*Lycalopexvetulus*) em áreas antropizadas de Cerrado no Brasil Central
- **Pesquisador Responsável/ Unidade:** Frederico Gemesio Lemos/ Regional Catalão
- **Pesquisadores Participantes:** Frederico Gemesio Lemos, Fernanda C. de Azevedo, Ricardo Corasa Arrais, Mozart Caetano de Freitas Júnior
- **Unidade onde será realizado:** Regional Catalão
- **Data de apresentação a CEUA:** 19/09/14

III - Objetivos e justificativa do projeto: Aumentar o conhecimento sobre a ecologia da espécie e conhecer sua relação com outros carnívoros sintópicos em fazendas de gado no município de Cumari, Goiás, Brasil. Os objetivos específicos do projeto são: 1) descrever a área de vida, o uso de habitat, o padrão de atividade e o comportamento social da raposa-do-campo em um ambiente alterado com matriz de pastagens antrópicas e fragmentos de cerrado; 2) descrever o cuidado do casal à prole, a dieta, idade da dispersão dos filhotes e o sexo que dispersa; e 3) descrever a sobreposição de nicho espacial e as interações da espécie com outros canídeos sintópicos.

IV - Sumário do projeto:

- **Discussão sobre a possibilidade de métodos alternativos e necessidade do número de animais:** O projeto propõe a investigação dos processos ecológicos de canídeos silvestres. Estas questões permeiam o acompanhamento de indivíduos de vida livre, através da captura e instalação de coleira radiotransmissora, para obtenção de dados ecológicos e comportamentais dificilmente obtidos utilizando-se de outra metodologia. O número de animais a serem empregados na pesquisa foi estabelecido baseado em um projeto piloto realizado na área de estudo utilizando focagem noturna e 30 armadilhas fotográficas (que possuem sensores de calor e movimento que disparam automaticamente) entre os anos de 2013 e 2014.
- **Descrição do animal utilizado (número, espécie, linhagem, sexo, peso, etc):** Serão utilizadas 3 diferentes espécies, a saber: *Lycalopex vetulus* (raposa-do-campo) com peso de 2.5kg - 4.2kg, *Cerdocyon thous* (cachorro-do-mato) com peso de 6 kg – 8 kg, *Chrysocyon brachyurus* (lobo-guará) com peso de 20kg - 30kg. Todos da linhagem Canidae, todos adultos e subadultos, entre machos e fêmeas.
- **Espécie e número total de animais utilizados:** Serão utilizadas: 30 *Lycalopex vetulus*, sendo 15 fêmeas e 15 machos; 30 *Cerdocyon thous*, sendo 15 fêmeas e 15 machos; 08 *Chrysocyon brachyurus*, sendo 04 fêmeas e 04 machos.
- **Descrição das instalações utilizadas e número de animais/área/qualidade do ambiente (ar, temperatura, umidade), alimentação/hidratação:** Serão capturados canídeos de vida vidra livre na área de

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE GOIÁS
PRÓ-REITORIA DE PESQUISA E INOVAÇÃO
COMISSÃO DE ÉTICA NO USO DE ANIMAIS/CEUA

estudo, localizada na Região do Limoeiro, município de Cumari, Goiás, Brasil. Os animais serão observados em seu habitat natural.

- **Utilização de agente infeccioso/gravidade da infecção a ser observada e análise dos riscos aos pesquisadores/alunos:** Não se aplica. Por se tratar da captura de carnívoros silvestre em área natural, toda a equipe deve estar preparada para eventuais riscos. Para que todo o procedimento anestésico e a coleta de dados, incluindo a vistoria presencial das armadilhas, os integrantes deste projeto de pesquisa possuem cursos e especializações no manejo de fauna silvestre. Será utilizada pela equipe durante toda execução das atividades equipamentos de proteção física como roupas resistentes, perneiras, luvas de couro, chapéus ou bonés, botas antiderrapantes e resistentes à água. A equipe também dispõe de cambão com cabo de 1,80 m, puçá de aro grande, arma anestésica reserva (pistola e zarabatana), lanternas potentes, equipamento de telemetria e sistema de rádio comunicação. Obrigatoriamente todos os membros da equipe executora estão devidamente protegidos contra a raiva (carteira de vacinação e sorologia atualizados), febre amarela e tétano.
- **Adequação da metodologia e considerações sobre o sofrimento imposto aos animais:** Vide pág. 18 a 21 do projeto de pesquisa.
- **Método de eutanásia:** Não se aplica.
- **Destino do animal:** Permanecerá em seu ambiente natural.

IV – Comentários do relator frente às orientações da CEUA:

- **Quanto a documentos:** A documentação está de acordo com o exigido pela CEUA/UFG.
- **Quanto aos cuidados e manejo dos animais e riscos aos pesquisadores:** As informações constantes no projeto e ficha protocolo quanto aos cuidados e manejo dos animais e riscos aos pesquisadores estão de acordo com princípios éticos indicados pelo CONCEA.

V - Parecer da CEUA:

De acordo com a documentação apresentada à CEUA, consideramos o projeto **APROVADO**.

Reiteramos a importância deste parecer Consubstanciado, e lembramos que o(a) pesquisador(a) responsável deverá encaminhar à CEUA-PRPI-UFG o Relatório Final baseado na conclusão do estudo e na incidência de publicações decorrentes deste, de acordo com o disposto na Lei nº. 11.794 de 08/10/2008, e Resolução Normativa nº. 01, de 09/07/2010 do Conselho Nacional de Controle de Experimentação Animal-CONCEA. O prazo para entrega do Relatório é de até 30 dias após o encerramento da pesquisa.

VI - Data da reunião: 10/11/14

Assinado de forma digital por RENATA MAZARO:12343522812
Dados: 2014.11.14 13:12:52 -02'00'

Dra. Renata Mazaro e Costa
Coordenadora da CEUA/PRPI/UFG

Anexo C: Parecer de aprovação do projeto na Comissão de Ética no Uso de Animais (CEUA) da Universidade Federal de Uberlândia.

Universidade Federal de Uberlândia
Pró-Reitoria de Pesquisa e Pós-Graduação
Comissão de Ética na Utilização de Animais (CEUA)
Rua Ceará, S/N - Bloco 2T, sala 113 – CEP 38405-315
Campus Umuarama – Uberlândia/MG – Ramal (VoIP) 3423;
e-mail:ceua@propp.ufu.br; www.comissoes.propp.ufu.br

ANÁLISE FINAL Nº 166/14 DA COMISSÃO DE ÉTICA NA UTILIZAÇÃO DE ANIMAIS PARA O PROTOCOLO REGISTRO CEUA/UFU 089/14

Projeto Pesquisa: "Ecologia e comportamento da raposa-do-campo (*Lycalopex vetulus*), do cachorro-do-mato (*Cerdocyon thous*) e do lobo-guará (*Chrysocyon brachyurus*) em áreas antropizadas de Cerrado no Brasil Central"

Pesquisador Responsável: Frederico Gemesio Lemos.

O protocolo não apresenta problemas de ética nas condutas de pesquisa com animais nos limites da redação e da metodologia apresentadas. Ao final da pesquisa deverá encaminhar para a CEUA um relatório final.

SITUAÇÃO: PROTOCOLO DE PESQUISA APROVADO.

OBS: O CEUA/UFU LEMBRA QUE QUALQUER MUDANÇA NO PROTOCOLO DEVE SER INFORMADA IMEDIATAMENTE AO CEUA PARA FINS DE ANÁLISE E APROVAÇÃO DA MESMA.

Uberlândia, 28 de outubro de 2014

Prof. Dr. César Augusto Garcia
Coordenador da CEUA/UFU

Anexo D: Autorização para execução do projeto concedida pelo Instituto Brasileiro do Meio Ambiente e do Recursos Naturais (IBAMA) e Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), Brasil.

Ministério do Meio Ambiente - MMA
Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - IBAMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

Número: 14576-1	Data da Emissão: 31/03/2008 16:05	Data de Validade: 31/03/2009

Dados do titular

Registro no Ibama: 1827988	Nome: Frederico Gemesio Lemos	CPF: 014.293.776-23
Título do Projeto: ECOLOGIA E CONSERVAÇÃO DA RAPOSA-DO-CAMPO LYCALOPEX VETULUS EM ÁREAS DE CERRADO NO SUL DE GOIÁS, BRASIL		
Nome da Instituição : UNIVERSIDADE FEDERAL DE GOIAS		CNPJ: 01.567.601/0001-43

Observações, ressalvas e condicionantes

1	A participação de pesquisador(a) estrangeiro(a) nas atividades previstas nesta autorização depende de autorização expedida pelo Ministério de Ciência e Tecnologia (CNPq/MCT).
2	Esta autorização não exime o titular e a sua equipe da necessidade de obter as anuências previstas em outros instrumentos legais, bem como do consentimento do responsável pela área, pública ou privada, onde será realizada a atividade.
3	Esta autorização não poderá ser utilizada para fins comerciais, industriais, esportivos ou para realização de atividades inerentes ao processo de licenciamento ambiental de empreendimentos. O material biológico coletado deverá ser utilizado para atividades científicas ou didáticas no âmbito do ensino superior.
4	A autorização para envio ao exterior de material biológico não consignado deverá ser requerida por meio do endereço eletrônico www.ibama.gov.br/cites. Em caso de material consignado, consulte www.ibama.gov.br/sisbio - menu Exportação.
5	O titular de licença ou autorização e os membros da sua equipe deverão optar por métodos de coleta e instrumentos de captura direcionados, sempre que possível, ao grupo taxonômico de interesse, evitando a morte ou dano significativo a outros grupos; e empregar esforço de coleta ou captura que não comprometa a viabilidade de populações do grupo taxonômico de interesse em condição in situ.
6	Este documento não dispensa o cumprimento da legislação que dispõe sobre acesso a componente do patrimônio genético existente no território nacional, na plataforma continental e na zona econômica exclusiva, ou ao conhecimento tradicional associado ao patrimônio genético, para fins de pesquisa científica, bioprospecção e desenvolvimento tecnológico.
7	Em caso de pesquisa em Unidade de Conservação Federal, o pesquisador titular deverá contactar a administração dessa unidade a fim de CONFIRMAR AS DATAS das expedições, as condições para realização das coletas e de uso da infra-estrutura da unidade.
8	As atividades contempladas nesta autorização NÃO abrangem espécies brasileiras constante de listas oficiais (de abrangência nacional, estadual ou municipal) de espécies ameaçadas de extinção, sobreexplotadas ou ameaçadas de sobreexplotação.

Equipe

#	Nome	Função	CPF	Doc. Identidade	Nacionalidade
1	Joares Adenilson May Júnior	Veterinário	910.011.889-34	2539609 ssp-SC	Brasileira
2	Kátia Gomes Facure	Pesquisadora	102.097.368-44	19270500 SSP-SP	Brasileira
3	Fernanda Cavalcanti Azevedo	Bióloga de campo e coordenadora	032.310.099-60	6262453/1 ssp-PR	Brasileira
4	Hugo Cardoso de Moura Costa	Biólogo de campo	069.416.176-40	13084336 ssp-MG	Brasileira

Locais onde as atividades de campo serão executadas

#	Município	UF	Descrição do local	Tipo
1	CUMARI	GO	Sul de Goiás	Fora de UC
2	CALDAS NOVAS	GO	Parque Estadual da Serra de Caldas Novas - PESCAN	UC Estadual

Atividades X Táxons

#	Atividade	Táxons
1	Captura de animais silvestres in situ	Pseudalopex vetulus, Cerdocyon thous
2	Coleta/transporte de amostras biológicas in situ	Cerdocyon thous, Pseudalopex vetulus
3	Marcação de animais silvestres in situ	Cerdocyon thous, Pseudalopex vetulus

Material e métodos

1	Amostras biológicas (Carnívoros)	Animal morto ou partes (carcaça)/osso/pele, Sangue, Regurgitação/conteúdo estomacal, Pêlo, Fragmento de tecido/órgão, Fezes, Ectoparasita, Urina, Ecdise
2	Método de captura/coleta (Carnívoros)	Armadilha tipo gaiola com atração por iscas ("Box Trap/Tomahawk/Sherman")

Este documento (Autorização para atividades com finalidade científica) foi expedido com base na Instrução Normativa Ibama nº154/2007. Através do código de autenticação abaixo, qualquer cidadão poderá verificar a autenticidade ou regularidade deste documento, por meio da página do Ibama/Sisbio na internet (www.ibama.gov.br/sisbio).

Código de autenticação: 38868557

Ministério do Meio Ambiente - MMA
Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio
Sistema de Autorização e Informação em Biodiversidade - SISBIO

Autorização para atividades com finalidade científica

Número: 14576-6	Data da Emissão: 03/08/2015 22:56	Data para Revalidação*: 01/09/2016

* De acordo com o art. 28 da IN 03/2014, esta autorização tem prazo de validade equivalente ao previsto no cronograma de atividades do projeto, mas deverá ser revalidada anualmente mediante a apresentação do relatório de atividades a ser enviado por meio do Sisbio no prazo de até 30 dias a contar da data do aniversário de sua emissão.

Dados do titular

Nome: FREDERICO GEMESIO LEMOS	CPF: 014.293.776-23
Título do Projeto: Ecologia e Conservação da Raposa-do-campo (Lycalopex vetulus) em áreas antropizadas de Cerrado no Brasil Central	
Nome da Instituição : UNIVERSIDADE FEDERAL DE GOIAS	CNPJ: 01.567.601/0001-43

Cronograma de atividades

#	Descrição da atividade	Início (mês/ano)	Fim (mês/ano)
1	Execução do projeto (captura dos animais, monitoramento dos animais, coleta e análise de dados)	01/2013	12/2016

Observações e ressalvas

1	As atividades de campo exercidas por pessoa natural ou jurídica estrangeira, em todo o território nacional, que impliquem o deslocamento de recursos humanos e materiais, tendo por objeto coletar dados, materiais, espécimes biológicos e minerais, peças integrantes da cultura nativa e cultura popular, presente e passada, obtidos por meio de recursos e técnicas que se destinem ao estudo, à difusão ou à pesquisa, estão sujeitas a autorização do Ministério de Ciência e Tecnologia.
2	Esta autorização NÃO exime o pesquisador titular e os membros de sua equipe da necessidade de obter as anuências previstas em outros instrumentos legais, bem como do consentimento do responsável pela área, pública ou privada, onde será realizada a atividade, inclusive do órgão gestor de terra indígena (FUNAI), da unidade de conservação estadual, distrital ou municipal, ou do proprietário, arrendatário, posseiro ou morador de área dentro dos limites de unidade de conservação federal cujo processo de regularização fundiária encontra-se em curso.
3	Este documento somente poderá ser utilizado para os fins previstos na Instrução Normativa ICMBio n° 03/2014 ou na Instrução Normativa ICMBio n° 10/2010, no que especifica esta Autorização, não podendo ser utilizado para fins comerciais, industriais ou esportivos. O material biológico coletado deverá ser utilizado para atividades científicas ou didáticas no âmbito do ensino superior.
4	A autorização para envio ao exterior de material biológico não consignado deverá ser requerida por meio do endereço eletrônico www.ibama.gov.br (Serviços on-line - Licença para importação ou exportação de flora e fauna - CITES e não CITES).
5	O titular de licença ou autorização e os membros da sua equipe deverão optar por métodos de coleta e instrumentos de captura direcionados, sempre que possível, ao grupo taxonômico de interesse, evitando a morte ou dano significativo a outros grupos; e empregar esforço de coleta ou captura que não comprometa a viabilidade de populações do grupo taxonômico de interesse em condição in situ.
6	O titular de autorização ou de licença permanente, assim como os membros de sua equipe, quando da violação da legislação vigente, ou quando da inadequação, omissão ou falsa descrição de informações relevantes que subsidiaram a expedição do ato, poderá, mediante decisão motivada, ter a autorização ou licença suspensa ou revogada pelo ICMBio, nos termos da legislação brasileira em vigor.
7	Este documento não dispensa o cumprimento da legislação que dispõe sobre acesso a componente do patrimônio genético existente no território nacional, na plataforma continental e na zona econômica exclusiva, ou ao conhecimento tradicional associado ao patrimônio genético, para fins de pesquisa científica, bioprospecção e desenvolvimento tecnológico. Veja maiores informações em www.mma.gov.br/cgen.
8	Em caso de pesquisa em UNIDADE DE CONSERVAÇÃO, o pesquisador titular desta autorização deverá contactar a administração da unidade a fim de CONFIRMAR AS DATAS das expedições, as condições para realização das coletas e de uso da infra-estrutura da unidade.
9	As atividades contempladas nesta autorização NÃO abrangem espécies brasileiras constante de listas oficiais (de abrangência nacional, estadual ou municipal) de espécies ameaçadas de extinção, sobreexplotadas ou ameaçadas de sobreexplotação.

Outras ressalvas

1	A pesquisadora estrangeira Stacie Marie Castelda informou que deu entrada em processo CNPq - Expedição Científica e só estará contemplada por esta Autorização Sisbio mediante a emissão de autorização do MCT, concedida por meio de Portaria ministerial.

Equipe

#	Nome	Função	CPF	Doc. Identidade	Nacionalidade
1	JOARES ADENILSON MAY JUNIOR	Veterinário	910.011.889-34	2539609 SSP-SC	Brasileira
2	Fernanda Cavalcanti Azevedo	Coordenadora e Bióloga de campo	032.310.099-60	6262453/1 SSP-PR	Brasileira
3	RICARDO CORASSA ARRAISRI	Coordenador Veterinário	311.495.088-41	284103603 SSP-SP	Brasileira
4	RONALDO GONCALVES MORATO	Colaborador e Consultor técnico	074.413.198-70	15931144 SSP-SP	Brasileira
5	ROGERIO CUNHA DE PAULA	Colaborador e Consultor técnico	166.165.498-36	201852718 SSP-SP	Brasileira
6	Adriano Gambarini	Fotógrafo	153.635.128-82	17677156 ssp/sp-SP	Brasileira

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