UNIVERSIDADE ESTADUAL PAULISTA
"JÚLIO DE MESQUITA FILHO"
Câmpus de São José do Rio Preto

Bárbara Mitsuko Zukeram Fujioka

A área de vida e o uso da vegetação nativa por cães domésticos rurais de vida livre (*Canis familiaris*)

São José do Rio Preto
2024

Bárbara Mitsuko Zukeram Fujioka

A área de vida e o uso da vegetação nativa por cães domésticos rurais de vida livre (*Canis familiaris*)

Dissertação apresentada como parte dos requisitos para obtenção do título de Mestre em Biodiversidade, junto ao Programa de Pós-Graduação Biodiversidade, do Instituto de Biociências, Letras e Ciências Exatas da Universidade Estadual Paulista "Júlio de Mesquita Filho", Câmpus de São José do Rio Preto.

Financiadora: FAPESP – Proc. 2021/02737-7
CAPES – 88887.712974/2022-00, 88887.817884/2023-00

Orientador: Profª. Drª. Rita Bianchi

São José do Rio Preto
2024

F961a

Fujioka, Bárbara Mitsuko Zukeram

A área de vida e o uso da vegetação nativa por cães domésticos rurais de vida livre (Canis familiaris) / Bárbara Mitsuko Zukeram Fujioka. -- São José do Rio Preto, 2024

89 f. : fotos, mapas

Dissertação (mestrado) - Universidade Estadual Paulista (UNESP), Instituto de Biociências Letras e Ciências Exatas, São José do Rio Preto

Orientadora: Rita Bianchi

1. Comportamento animal. 2. Conservação da vida selvagem. 3. Ecologia do movimento. 4. Interação humano-cães. 5. Papel ecológico. I. Título.

Sistema de geração automática de fichas catalográficas da Unesp. Biblioteca da Universidade Estadual Paulista (UNESP), Instituto de Biociências Letras e Ciências Exatas, São José do Rio Preto. Dados fornecidos pelo autor(a).

Essa ficha não pode ser modificada.

Bárbara Mitsuko Zukeram Fujioka

A área de vida e o uso da vegetação nativa por cães domésticos rurais de vida livre (*Canis familiaris*)

Dissertação apresentada como parte dos requisitos para obtenção do título de Mestre em Biodiversidade, junto ao Programa de Pós-Graduação Biodiversidade, do Instituto de Biociências, Letras e Ciências Exatas da Universidade Estadual Paulista "Júlio de Mesquita Filho", Câmpus de São José do Rio Preto.

Financiadora: FAPESP – Proc. 2021/02737-7
CAPES - Procs.
88887.712974/2022-00, 88887.817884/2023-00

Comissão Examinadora

Profª. Drª. Rita Bianchi
UNESP – Câmpus de São José do Rio Preto
Orientadora

Profª. Drª. Natalie Olifiers
UNESP – Câmpus de São José do Rio Preto

Dr. Felipe Martello
University of Oxford - Câmpus de Oxford

São José do Rio Preto
26 de junho de 2024

Nada mais justo do que dedicar esse trabalho para meus
próprios cachorrinhos *Kawaii, Sakura, Kayo* e *Lupi*.

AGRADECIMENTOS

Agradeço a meus pais, a minha irmã, a minha bachan e dichan, a meus avós (*in memorian*), e a minhas tias e tios, pelo apoio incondicional e por sempre colocarem meus estudos como prioridade. Tenho o grande privilégio de pertencer a uma família que valoriza a educação e que apoia o estudo das gerações mais novas.

Agradeço à minha orientadora, Profª. Drª. Rita Bianchi, por ter me aceitado no laboratório e por ter confiado esse trabalho incrível a uma pessoa sem experiência na área. Obrigada por se dedicar tanto aos seus alunos e por contribuir grandemente com a minha formação profissional e meu crescimento como ser humano.

Agradeço também aos professores Georg Heine, Martin Wikelski e Roland Kays, pela parceria na realização desta pesquisa. Em especial ao professor Roland, pela paciência, pelos diversos emails trocados, dúvidas sanadas e ajuda direta nas análises dos dados.

Agradeço as amizades que se fazem presentes mesmo agora que estou distante, as minhas “Gatinhas GP” Bianca, Gabriella, Letícia e Luiz, e a “queridinha” Iael, pelas muitas conversas e momentos divertidos. Assim como a Xodó (Luana) e a Mara, amigas que Jaboticabal me presenteou.

Agradeço aos meus colegas de trabalho e amigos do Laboratório de Ecologia de Mamíferos (LEMA), pelo apoio e pelos incentivos durante a realização deste mestrado. Em especial, agradeço quem esteve diretamente envolvido nesse trabalho: a minha grande amiga Franciele, companheira da ecologia desde a graduação; a Maísa, companheira para todos os momentos; e a Viviane pela dedicação e comprometimento com esse trabalho.

Agradeço ao meu país, o “Instituto de Biociências, Letras e Ciências Exatas” (IBILCE/UNESP), por mais uma vez me proporcionar experiências únicas e inesquecíveis, e a “Faculdade de Ciências Agrárias e Veterinárias” (FCAV/UNESP), com o qual obtive toda a infraestrutura necessária para a realização desta pesquisa.

Agradeço a equipe do Parque Estadual das Furnas do Bom Jesus (PEFBJ), por me hospedarem durante a coleta de campo. E aos tutores dos cães que aceitaram participar da pesquisa e me receberam tão bem nos meses em trabalhamos juntos.

O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001, processos nº 88887.712974/2022-00 e 88887.817884/2023-00, à qual agradeço.

Agradeço à FAPESP pela concessão da bolsa de pesquisa, sob o processo nº 2021/02737-7, Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) *.

E por fim, agradeço aos 105 cachorrinhos que se juntaram a mim nesta aventura da ecologia de movimento. Sem vocês isso não seria possível!

RESUMO

Os cães domésticos são os carnívoros mais comuns no mundo, e alguns são permitidos circular livremente por seus tutores. Esse comportamento aumenta a probabilidade de interações com a vida selvagem, impactando potencialmente os animais nativos por meio da predação, transmissão de doenças, competição e hibridização. Compreender os movimentos desta espécie, incluindo suas áreas de vida e os habitats que utilizam, é essencial para desenvolver e implementar planos de manejo para mitigar esses impactos. O objetivo do primeiro capítulo foi realizar uma revisão da literatura sobre a área de vida e uso de habitat de cães rurais e de vilarejo de vida livre, bem como os fatores que influenciam esses comportamentos. Plataformas de banco de dados foram usadas para buscar artigos sobre os movimentos ecológicos dos cães. Os tamanhos das áreas de vida variaram de 0,0021 ha a 2.706,40 ha. Variáveis que explicam a variação no tamanho da área de vida incluíram idade, castração ou não castração, condições reprodutivas, escore corporal, sazonalidade e comportamento humano. Os cães tendem a usar áreas onde podem obter recursos, como assentamentos humanos e locais ligados às rotinas de seus tutores. Embora infrequentes, os cães utilizam habitats naturais como vegetação nativa e áreas protegidas, e acredita-se que o acesso a essas áreas seja facilitado por mudanças na paisagem causadas por atividades como construção de estradas e desmatamento. O objetivo do segundo capítulo foi analisar a área de vida e o uso de vegetação nativa por cães em uma área protegida e fragmentos do bioma Cerrado, além de testar quais variáveis influenciam o tamanho da área de vida dos cães. O rastreamento por GPS foi usado para monitorar 105 cães durante um período de dois meses. Os tamanhos das áreas de vida foram estimados usando o Estimador de Densidade de Kernel de Autocorrelação 95% (AKDE), e o uso de vegetação nativa foi quantificado com base no número de localizações dentro deste habitat. Os cães exibiram áreas de vida relativamente pequenas, variando de 0,89 ha a 624,75 ha, com uma média de 30,74 ha. Áreas de vida maiores foram correlacionados com fatores como menor escore corporal e acompanhamento dos tutores em atividades diárias. Apenas 3,94% das localizações registradas foram encontradas em vegetação nativa. A proximidade da casa dos tutores a este habitat e um baixo escore corporal foram associadas a um aumento no uso dela. O uso de vegetação nativa é mínimo, e os cães passam a maior parte do tempo ao redor de suas casas dentro da matriz. Os movimentos dos cães são significativamente influenciados pelo cuidado fornecido por seus tutores e sua rotina. Os cães assumem vários papéis na sociedade, e o contexto em que são colocados e o *background* genético influenciam a extensão da sua área de vida e uso de habitat, afetando consequentemente a biodiversidade direta e indiretamente. Dada a distribuição global dos cães e os diversos papéis que desempenham na sociedade, esforços devem ser feitos nas áreas onde os cães estão presentes para investigar seus papéis e impactos potenciais em cada contexto específico.

Palavras–chave: Comportamento animal. Conservação da vida selvagem. Ecologia do movimento. Interação humano-cães. Papel ecológico.

ABSTRACT

Domestic dogs are the most common carnivores worldwide, and some are allowed by their owners to roam freely. This behavior increases the likelihood of interactions with wildlife, potentially impacting native animals through predation, disease transmission, competition, and hybridization. Understanding the movements of this species, including their home ranges and the habitats they utilize, is essential for developing and implementing management plans to mitigate these impacts. The aim of the first chapter was to conduct a literature review on the home range and habitat use of free-ranging rural and village dogs, as well as the drivers of these behaviors. Database platforms were used to search for papers on the ecological movements of dogs. The sizes of home ranges varied from 0.0021 ha to 2,706.40 ha. Variables explaining the variation in home range size included age, neuter status, breeding conditions, body score, season, and human behavior. Dogs tend to use areas where they can obtain resources, such as human settlements and locations tied to their owners' routines. Although infrequent, dogs use natural habitats such as native vegetation and protected areas, and access to these areas is believed to be facilitated by landscape changes caused by activities such as road construction and deforestation. The aim of the second chapter was to analyze the home range and use of native vegetation by dogs in a protected area and fragments of the Cerrado biome, as well as to test which variables influence dogs home range. GPS tracking was used to monitor 105 dogs over a two-month period. Home range sizes were estimated using the 95% Autocorrelation Kernel Density Estimator (AKDE), and native vegetation use was quantified based on the number of locations within this habitat. Dogs exhibited relatively compact home ranges, ranging from 0.89 ha to 624.75 ha, with an average of 30.74 ha. Larger home ranges were correlated with factors such as lower body condition scores and accompanying owners during daily activities. Only 3.94% of recorded locations were found in native vegetation. The proximity of the owners' house to this habitat and low body score were associated with increased use of it. The use of native vegetation is minimal, and dogs spend most of their time around their homes within the matrix. The movements of dogs are significantly influenced by the care provided by their owners and the owners routines. Dogs assume various roles in society, and the context in which they are placed and the genetic background influence the extent of their home range and habitat use, consequently affecting biodiversity both directly and indirectly. Given the global distribution of dogs and the diverse roles they play in society, efforts should be made in areas where dogs are present to investigate their roles and potential impacts within each specific context.

Keywords: Animal behavior. Ecological role. Human-dog interactions. Movement ecology. Wildlife conservation.

LISTA DE ILUSTRAÇÕES

Capítulo 1 - Where are the dogs going? The home range and the use of habitat by free ranging-rural and free-ranging village dogs (*Canis familiaris*)

Capítulo 2 - Where do dogs go? Investigating the movement of free ranging rural dogs (*Canis familiaris*) in Brazil

LISTA DE TABELAS

LISTA DE ABREVIATURAS E SIGLAS

AKDE *Autocorrelation Kernel Density*

BRB *Biased Random Bridge Kernel*

BRBK *Biased Random Bridge Kernel*

CHP *Characteristic Hull Polygon*

CAAE Certificado de Apresentação de Apreciação Ética

ctmm *Continuous Time Movement Models*

CEUA Comissão de Ética de Uso de Animais

GLM *General Linear Model*

GPS *Global Positioning System*

Hdop *Horizontal Dilution of Precision*

IID *Independent Identically Distributed*

KDE *Kernel Density Estimator*

MCP *Maximum Convex Polygon*

MCP *Minimum Convex Polygon*

OU *Ornstein–Uhlenbeck*

OUF *Ornstein–Uhlenbeck foraging process*

PEFBJ Parque Estadual Furnas do Bom Jesus

Std. *Standard*

TCLE Termo de Consentimento Livre e Esclarecido

WSAVA *World Small Animal Veterinarian Association*

LISTA DE SÍMBOLOS

°C Celsius

km Quilômetro

ha Hectare

m Metro

mm Milímetro

\+ Mais

> Maior

< Menor

\+ Mais

% Porcentagem

SUMÁRIO

INTRODUÇÃO GERAL

O cão doméstico (*Canis familiaris*) é considerado o primeiro animal que foi domesticado, há cerca de 20.000 anos (Botigué et al., 2017; da Silva Coelho et al., 2021; Perri et al., 2021), originando-se do lobo cinzento (*Canis lupus*) (Gompper, 2014). Esses animais estão entre os carnívoros mais distribuídos no mundo, com uma população de quase um bilhão de indivíduos, sendo que seu grande número de indivíduos se dá principalmente devido aos subsídios fornecidos pelos seres humanos (Gompper, 2014). Os cães podem ser categorizados de várias maneiras: (1) cães com tutores, que são totalmente dependente de recursos provenientes de seus tutores e seus movimentos são restritos pelos mesmos; (2) cães urbanos de vida livre, que sobrevivem de restos alimentares e não possuem tutores; (3) cães rurais de vida livre, que têm tutores mas se movimentam livremente; (4) cães de vilarejo, que vivem associados a seres humanos e também se movimentam livremente; (5) cães ferais, totalmente independentes de humanos; e (6) cães selvagens, como os dingos, que mantêm independência dos humanos (Gompper, 2014; Vanak; Gompper, 2009). Aproximadamente 75% dos cães globais circulam livremente, com muitos situados em zonas rurais (Hughes & Macdonald, 2013; Gompper, 2014), onde as interações com a vida selvagem são frequentes, particularmente em regiões menos desenvolvidas.

Cães domésticos foram responsáveis pela extinção de 11 espécies de vertebrados e atualmente representam uma ameaça para pelo menos 188 espécies ameaçadas globalmente (Doherty et al., 2017). Os impactos mais comuns incluem predação, além de perturbação, transmissão de doenças, competição e hibridização (Doherty et al., 2017). Nos parques nacionais do Brasil, a predação, competição e transmissão de patógenos por cães têm prejudicado muitas espécies nativas, particularmente mamíferos, como as cutias (*Dasyprocta leporina*), capivaras (*Hydrochoerus hydrochaeris*), antas (*Tapirus terrestris*), quatis (*Nasua nasua*) e tamanduás-bandeira (*Myrmecophaga tridactyla*) (Lessa et al., 2016). O estudo de biologia básica da espécie, como sua área de vida e uso de habitat, é crucial para identificar indivíduos que possivelmente causam impactos, especialmente aqueles que percorrem grandes distâncias.Tais informações são valiosas, por exemplo, para orientar campanhas de vacinação em massa, pois cães com maior mobilidade têm maior probabilidade de transmitir doenças (Hudson et al., 2017).

O comportamento de movimentação dos animais é complexo e é influenciado pela necessidade de buscar recursos, reproduzir, evitar perigos e descobrir novos territórios (Burt, 1963). Compreender como, quando e por que os animais se movimentam é essencial para o desenvolvimento de práticas de gestão dinâmicas que aprimorem e complementem os planos de conservação existentes (Allen; Singh, 2016). A ecologia do movimento, que inclui aspectos como trajetórias, distâncias, tempos, formas e tamanhos das áreas de vida, bem como a seleção de habitats, é crucial para orientar estratégias de manejo da vida selvagem (Allen; Singh, 2016). A área de vida de um animal corresponde à área que o mesmo percorre em suas atividades rotineiras, como alimentação, acasalamento e cuidado com os filhotes, excluindo deslocamentos ocasionais fora dessa área (Burt, 1943). As áreas de vida variam entre diferentes espécies e indivíduos, e podem alterar-se ao longo da vida do animal (Powell; Mitchell, 2012). Um habitat, por sua vez, é definido como uma área que fornece os recursos essenciais para a ocupação, sobrevivência e reprodução de um organismo, proporcionando as condições e recursos específicos necessários para cada espécie (Hall et al., 1997). Portanto, um indivíduo utiliza e se movimenta dentro de um habitat específico conforme a distribuição dos recursos disponíveis nesse local.

Diversos fatores influenciam o comportamento de movimentação de cães rurais de vida livre. Cães mais velhos geralmente têm área de vidas menores devido a menores níveis de atividade (van Bommel; Johnson, 2014). No entanto, em outros casos, cães mais jovens podem apresentar área de vidas menores (Warembourg et al., 2021). Machos castrados podem apresentar menor área de vida que cães não castrados, enquanto o oposto é encontrado em fêmeas (Dürr et al., 2017). Fêmeas em cio ou lactação tendem a se movimentar para áreas mais distantes (Pal, 2003). Durante a estação chuvosa, a necessidade reduzida de buscar recursos e o papel da água como barreira à movimentação dos cães provavelmente causam uma diminuição na sua área de vida (Dürr et al., 2017). Áreas utilizadas pelos cães frequentemente abrangem áreas próximas às atividades humanas, como locais de alimentação e trabalho (Dos Santos et al., 2018; Tiwari et al., 2019; Wilson-Aggarwal et al., 2021; Schüttler et al., 2022). Além disso, cães cujos tutores caçam podem apresentar área de vida maiores que cães cujos tutores não caçam (Wilson-Aggarwal et al., 2021), uma vez que esses animais acompanham os humanos durante essa atividade. Além disso, a alimentação fornecida aos cães pelos humanos limita a necessidade de grandes deslocamentos para busca de recursos, e além disso, evita a formação de grandes matilhas (Tiwari et al., 2019). Isso reduz a área de vida, uma vez que cães bem nutridos tendem a se movimentar menos para encontrar recursos que seus tutores não provêm, e grupos menores de cães necessitam de menos espaço para encontrar os recursos requeridos. No entanto, cães pouco nutridos também podem apresentar menores áreas de vida (Warembourg et al., 2021).

As atitudes humanas em relação aos cães podem impactar significativamente as interações destes com a vida selvagem e funcionar como um estímulo para a invasão de áreas naturais, trazendo várias ameaças (Serpell, 2017). A frequência de cães em áreas protegidas no Brasil é alta, e tanto os impactos decorrentes quanto às motivações para sua presença em ambientes nativos são ainda pouco entendidos (Paschoal et al., 2016). A invasão por esses animais em ambientes de vegetação nativa é vista como uma ameaça extensiva, resultante da alta densidade populacional humana combinada com desmatamento extenso (Ribeiro et al., 2019). O aumento da atividade humana próximo a áreas protegidas facilita o acesso dos cães a essas zonas naturais, pois tais atividades aumentam a heterogeneidade das paisagens e o efeito de borda, intercalando áreas perturbadas com as naturais (Paschoal et al., 2018). Ademais, cães que recebem mais cuidados de seus tutores têm menor tendência a predar animais selvagens e a frequentar vegetação nativa, um fato crucial dado que os ataques desses animais geralmente ocorrem próximos a áreas protegidas (Silva-Rodríguez; Sieving, 2011; Sepúlveda et al., 2014; Nayeri et al., 2022).

O impacto dos cães domésticos sobre a biodiversidade varia enormemente de acordo com o contexto e localização. Estudos específicos são essenciais para determinar se os cães prejudicam a biodiversidade e, se for o caso, entender como isso acontece. Coletar dados biológicos essenciais, como informações sobre os áreas de vidas e uso de habitat dos cães, é crucial para entender a amplitude de sua movimentação, os motivadores desse comportamento e suas preferências de habitat. Embora os impactos já sejam reconhecidos, as razões para a invasão de habitats naturais pelos cães e a totalidade de seus efeitos ainda são mal compreendidos, exigindo investigações adicionais. O primeiro capítulo desta dissertação foca em revisar a literatura existente sobre a área de vida e o uso de habitat por cães rurais e de vilarejo de vida livre O segundo capítulo investiga a área de vida e uso de habitat de cães rurais de vida livre próximos a uma área protegida e fragmentos de vegetação nativa do Cerrado, no estado de São Paulo, Brasil.

REFERÊNCIAS

ALLEN, A. M.; SINGH, N. J. Linking movement ecology with wildlife management and conservation. **Frontiers in Ecology and Evolution**, v. 155, 2016. Disponível em: https://doi.org/10.3389/fevo.2015.00155. Acesso em: 20 maio 2024.

BOTIGUÉ, L. R. et al. Ancient European dog genomes reveal continuity since the Early Neolithic. **Nature Communications**, v. 8, n. 1, p. 16082, 2017. Disponível em: https://doi.org/10.1038/ncomms16082. Acesso em: 20 maio 2024.

BURT, W. H. Territoriality and Home Range Concepts as Applied to Mammals. **Journal of Mammalogy**, v. 24, p. 346–352, 1943.

DA SILVA COELHO, F. A. et al. An early dog from southeast Alaska supports a coastal route for the first dog migration into the Americas. **Proceedings of the Royal Society B**, v. 288, n. 1945, p. 20203103, 2021. Disponível em: https://doi.org/10.1098/rspb.2020.3103. Acesso em: 20 maio 2024.

DOHERTY, T. S. et al. The global impacts of domestic dogs on threatened vertebrates. **Biological Conservation**, v. 210, p. 56–59, 2017. Disponível em: https://doi.org/10.1016/j.biocon.2017.04.007. Acesso em: 20 maio 2024.

DOS SANTOS, C. L. A. et al. Human behaviors determine the direct and indirect impacts of free-ranging dogs on wildlife. **Journal of Mammalogy**, v. 99, n. 5, p. 1261–1269, 2018. Disponível em: https://doi.org/10.1093/jmammal/gyy077. Acesso em: 20 maio 2024.

DÜRR, S. et al. What influences the home range size of free-roaming domestic dogs? **Epidemiology and Infection**, v. 145, n. 7, p. 1339–1350, 2017. Disponível em: https://doi.org/10.1017/S095026881700022X. Acesso em: 20 maio 2024.

GOMPPER, M. E. The dog–human–wildlife interface: assessing the scope of the problem. *In*: GOMPPER, M. E. (Ed.)**. Free-Ranging Dogs and Wildlife Conservation**. Oxford: Oxford University Press, 2014. p. 9–54.

HALL, L. S.; KRAUSMAN, P. R.; MORRISON, M. L. The Habitat Concept and a Plea for Standard Terminology. **Wildlife Society Bulletin**, v. 25, p. 173–182, 1997. Disponível em: https://www.jstor.org/stable/3783301?seq=1&cid=pdf-. Acesso em: 20 maio 2024.

HUDSON, E. G. et al. Domestic dog roaming patterns in remote northern Australian indigenous communities and implications for disease modelling. **Preventive Veterinary Medicine**, v. 146, p. 52–60, 2017. Disponível em: https://doi.org/10.1016/j.prevetmed.2017.07.010. Acesso em: 20 maio 2024.

HUGHES, J.; MACDONALD, D. W. A review of the interactions between free-roaming domestic dogs and wildlife. **Biological Conservation**, v. 157, p. 341–351, 2013. Disponível em: https://doi.org/10.1016/j.biocon.2012.07.005. Acesso em: 20 maio 2024.

LESSA, I. et al. Domestic dogs in protected areas: a threat to Brazilian mammals? **Natureza e Conservação**, v. 14, n. 2, p. 46–56, 2016. Disponível em: https://doi.org/10.1016/j.ncon.2016.05.001. Acesso em: 20 maio 2024.

NAYERI, D. et al. Free-ranging dogs as a potential threat to Iranian mammals. **ORYX**, v. 56, n. 3, p. 383–389, 2022. Disponível em: https://doi.org/10.1017/S0030605321000090 7. Acesso em: 20 maio 2024.

PAL, S. K. Reproductive behavior of free-ranging rural dogs in West Bengal, India. **Acta Theriologica**, v. 48, n. 2, p. 271–281, 2003.

PASCHOAL, A. M. O. et al. Anthropogenic Disturbances Drive Domestic Dog Use of Atlantic Forest Protected Areas. **Tropical Conservation Science**, v. 11, p. 1–14, 2018. Disponível em: https://doi.org/10.1177/1940082918789833. Acesso em: 20 maio 2024.

PASCHOAL, A. M. O. et al. Use of Atlantic Forest protected areas by free-ranging dogs: Estimating abundance and persistence of use. **Ecosphere**, v. 7, n. 10, 2016. Disponível em: https://doi.org/10.1002/ecs2.1480. Acesso em: 20 maio 2024.

PERRI, A. R. et al. Dog domestication and the dual dispersal of people and dogs into the Americas. **Proceedings of the National Academy of Sciences**, v. 118, n. 6, p. e2010083118, 2021. Disponível em: https://doi.org/10.1073/pnas.2010083118. Acesso em: 20 maio 2024.

POWELL, R. A.; MITCHELL, M. S. What is a home range? **Journal of Mammalogy**, v. 93, p. 948–958, 2012. Disponível em: https://doi.org/10.1644/11-MAMM-S-177.1. Acesso em: 20 maio 2024.

RIBEIRO, F. S. et al. Disturbance or propagule pressure? Unraveling the drivers and mapping the intensity of invasion of free-ranging dogs across the Atlantic forest hotspot. **Diversity and Distributions**, v. 25, n. 2, p. 191–204, 2019. Disponível em: https://doi.org/10.1111/ddi.12845. Acesso em: 20 maio 2024.

SCHÜTTLER, E.; SAAVEDRA-ARACENA, L.; JIMÉNEZ, J. E. Spatial and temporal plasticity in free-ranging dogs in sub-Antarctic Chile. **Applied Animal Behaviour** *Science*, v. 250, 2022. Disponível em: https://doi.org/10.1016/j.applanim.2022.105610. Acesso em: 20 maio 2024.

SEPÚLVEDA, M. A. et al. Domestic dogs in rural communities around protected areas: Conservation problem or conflict solution? **PLoS ONE**, v. 9, n. 1, 2014. Disponível em: https://doi.org/10.1371/journal.pone.0086152. Acesso em: 20 maio 2024.

SERPELL, J. From paragon to pariah: Cross-cultural perspectives on attitudes to dogs. *In*: SERPELL, J. (Ed.). **The Domestic Dog: Its Evolution, Behavior, and Interactions with People**. 2. ed. Cambridge: Cambridge University Press, 2017. p. 300–316.

SILVA-RODRÍGUEZ, E. A.; SIEVING, K. E. Influence of Care of Domestic Carnivores on Their Predation on Vertebrates. **Conservation Biology**, v. 25, p. 808–815, 2011. Disponível em: https://doi.org/10.1111/j.1523-1739.2011.01690.x. Acesso em: 20 maio 2024.

TIWARI, H. K. et al. Utilizing group-size and home-range characteristics of free-roaming dogs (FRD) to guide mass vaccination campaigns against rabies in India. **Vaccines**, v. 7, n. 4, 2019. Disponível em: https://doi.org/10.3390/vaccines7040136. Acesso em: 20 maio 2024.

VAN BOMMEL, L.; JOHNSON, C. N. Where do livestock guardian dogs go? Movement patterns of free-ranging Maremma sheepdogs. **PLoS ONE**, v. 9, n. 10, 2014. Disponível em: https://doi.org/10.1371/journal.pone.0111444. Acesso em: 20 maio 2024.

VANAK, A. T.; GOMPPER, M. E. Dogs *Canis familiaris* as carnivores: Their role and function in intraguild competition. **Mammal Review**, v. 39, n. 4, p. 265–283, 2009. Disponível em: https://doi.org/10.1111/j.1365-2907.2009.00148.x. Acesso em: 20 maio 2024.

WAREMBOURG, C. et al. Comparative study of free-roaming domestic dog management and roaming behavior across four countries: Chad, Guatemala, Indonesia, and Uganda. **Frontiers in Veterinary Science**, v. 8, p. 617900, 2021. Disponível em: https://doi.org/10.3389/fvets.2021.617900. Acesso em: 20 maio 2024.

WILSON-AGGARWAL, J. K. et al. Spatial and temporal dynamics of space use by free-ranging domestic dogs *Canis familiaris* in rural Africa. **Ecological Applications**, v. 31, n. 5, 2021. Disponível em: https://doi.org/10.1002/eap.2328. Acesso em: 20 maio 2024.

Este trabalho foi escrito seguindo as normas da revista *Biological Review*

Where are the dogs going? The home range and the use of habitat by free ranging-rural and free-ranging village dogs (*Canis familiaris*)

ABSTRACT

Domestic dogs are the most common carnivores worldwide, and some are permitted by their owners to roam freely. This behaviour increases the likelihood of interactions with wildlife, potentially impacting native animals through predation, disease transmission, competition, and hybridisation. Understanding the movements of this species, including their home ranges and the habitats they utilise, is essential for developing and implementing management plans to mitigate these impacts. Our aim was to conduct a literature review on the home range and habitat use of free-ranging rural and village dogs, as well as the drivers of these behaviours. We conducted a literature survey using database platforms to search for papers on the ecological movements of dogs, focusing on topics such as free-ranging dogs, free-roaming dogs, home range, and habitat use. The sizes of home ranges varied from 0.0021 ha to 2,706.40 ha. Variables explaining the variation in home range size included age, neuter status, breeding conditions, body score, season, and human behaviour. Dogs tend to use areas where they can obtain resources, such as human settlements and locations tied to their owners' routines, including agricultural and livestock areas. Although infrequent, dogs use natural habitats such as native vegetation and protected areas, and access to these areas is believed to be facilitated by landscape changes caused by activities such as road construction and deforestation. The movements of dogs are significantly influenced by the care provided by their owners and the owners' routines. Dogs assume various roles in society, and the context in which they are placed influences the extent of their home range and habitat use,

consequently affecting biodiversity both directly and indirectly. Therefore, management strategies for this species must consider all variables, including context, to ensure successful outcomes.

Key words: animal behaviour, impacts, human-dog interactions, movement ecology, wildlife conservation.

CONTENTS

I. INTRODUCTION

The home range corresponds to the area traversed by an individual during routine activities such as foraging, mating, and nurturing offspring, excluding occasional excursions beyond this area (Burt, 1943). Home ranges vary among different species, individuals within a species, and even change over an individual lifetime (Powell & Mitchell, 2012). Thus, they are not static throughout the life of an individual. For instance, migratory species exhibit different roaming behaviours between seasons, with their migratory paths forming part of their overall home range (Burt, 1943). Despite these variations in home range, all animals use their home ranges to acquire food and other necessary resources, including avoiding predators. Beyond that, the home range is a familiar area for the animals, where they can recognise the locations of resources, escape routes, and potential mates (Powell & Mitchell, 2012).

Understanding an animal home range allows insights into foraging strategies, territoriality, and social interactions. Furthermore, this knowledge is vital for conservation efforts, as it informs habitat management practices and helps identify critical areas that must be protected to ensure the species survival and well-being. Thus, studying home range not only enhances our understanding of an animal life history but also supports the development of effective conservation strategies.

The size of an animal home range is largely determined by its energetic requirements, which are closely tied to its body mass (Tucker et al., 2014). Body mass directly influences energy expenditure rates, thereby dictating the effort required to acquire sufficient food (Mcnab, 1963). Consequently, larger mammals typically have larger home ranges as they need more energy, which in turn necessitates a larger area from which to obtain this energy (Mcnab, 1963). In terrestrial mammals, besides body mass, the diet also contributes to variation in home range size (Tucker et al., 2014). Carnivores tend to have much larger home ranges compared to herbivores of a similar size (Mcnab, 1963; Tucker et al., 2014). Herbivores usually have smaller home ranges because their food sources, such as vegetation, are found more concentratedly (Mcnab, 1963). Conversely, carnivores, especially larger ones, require substantial prey populations to sustain them, necessitating larger home ranges because prey is usually more dispersed. Omnivores occupy an intermediate range, reflecting their flexible feeding habits (Tucker et al., 2014).

Age and sex can be predictors of home range size in animals. In carnivores, subadults often have larger home ranges than their adult counterparts (Lindstedt et al., 1986). This increase can be attributed to their need to disperse or avoid territories controlled by dominant individuals, forcing them to inhabit suboptimal areas temporarily or to seek more nutrients for growth. Males typically have larger home ranges than females, likely as a strategy to enhance their breeding opportunities. Conversely, the energetic demands of lactation and parental care may lead females, especially those with offspring, to occupy larger home ranges than males (Lindstedt et al., 1986).

In herbivores, the influence of individual factors on home range size appears uncertain. In African buffalo (*Syncerus caffer*), vegetation had a stronger influence on space use than individual characteristics such as age and body mass (Naidoo et al., 2011). In moose (*Alces alces*), reproductive status was the most influential individual-level factor explaining variance in home range size, with neither body mass nor age having any effect (van Beest et al., 2011). However, another study on the same species found that the home range size of males was strongly dependent on age, likely because older males use larger areas to ensure access to more females and increased reproductive success (Cederlund & Sand, 1994). The home range of female roe deer (*Capreolus capreolus*) decreased with age and increased in low-quality areas to include more patches of habitat and food resources (Saïd et al., 2009).

Therefore, animal movement is a complex behaviour influenced by the need to find resources, reproduce, avoid threats, and explore new territories (Burt, 1963). Understanding how, when, and why animals move is vital for developing dynamic management practices that can enhance and complement existing conservation plans (Allen & Singh, 2016). Understanding movement ecology, which encompasses characteristics such as pathways, distances, timing, shapes, and sizes of home ranges, as well as habitat selection, is crucial for informing wildlife management strategies (Allen & Singh, 2016). A habitat can be defined as an area that provides essential resources for an individual's occupancy, survival, and reproduction, offering the specific resources and conditions necessary for a particular organism (Hall et al., 1997). Thus, an individual uses and moves within a specific habitat according to the distribution of resources these areas provide. For instance, reintroduced feral cats adjust their spatial use primarily based on the distribution of rabbits, their primary food source (Recio & Seddon, 2013). Roe deer exhibit variations in home range sizes correlating with habitat types: the smallest home ranges are found in set-aside habitats, the largest in herbaceous crops, and intermediate sizes in grasslands and woody vegetation (Börger et al., 2006). Similarly, bears in areas with high densities of supplemental feeding sites tend to frequent areas near these sites while avoiding settlements and agricultural lands, typically foraging less for natural foods than bears relying solely on natural resources (De Angelis et al., 2021).

Understanding the movement and habitat use of domestic dogs (*Canis familiaris*) is crucial for conservation efforts, particularly in areas housing threatened species. Domesticated from the grey wolf (*Canis lupus)* approximately 20,000 years ago (Botigué et al., 2017; da Silva Coelho et al., 2021; Perri et al., 2021), domestic dogs have since achieved nearly global distribution (Doherty et al., 2017). Currently estimated to number around one billion, dog populations continue to grow, partly due to human-provided food subsidies (Gompper, 2014). These dogs can be categorised based on their dependency on humans: (1) feral dogs, which are completely independent; (2) rural free-ranging dogs, which have owners but live freely with some dependence; (3) free-ranging village dogs, which are associated with human settlements in rural areas; and (4) owned dogs, which are fully dependent on their owners and have restricted movements (Vanak & Gompper 2009; Gompper, 2014). Importantly, while all categories can negatively impact biodiversity, feral and rural free-ranging dogs are particularly detrimental to wild animal populations. Given that free-ranging dogs constitute about 75% of the global dog population, their impact on biodiversity is significant and underscores the urgency of studying their behaviour and managing their interactions with wildlife (Hughes & Macdonald, 2013). These interactions highlight a critical gap in conservation research (Sepúlveda et al., 2015).

The impact of domestic dogs on biodiversity varies significantly depending on the context and location. Therefore, targeted studies in each specific situation are crucial to ascertain whether dogs are adversely affecting biodiversity and, if so, to understand the nature of these impacts. Gathering fundamental biological data, such as information on home ranges and habitat use, is essential for comprehending the extent of dog roaming, the drivers behind such behaviours, and their habitat preferences. This knowledge is pivotal for managing dog populations, identifying disease transmission hotspots, and implementing control measures. For example, identifying dogs that roam extensively can aid in targeted mass vaccination campaigns, as these dogs are more likely to spread diseases (Hudson et al., 2017). Furthermore, incidents of dog attacks on wildlife are frequently reported near protected areas, underscoring the need for focused research on the interactions between dogs and wildlife in these regions (Nayeri et al., 2022). Despite the recognised impacts, the reasons dogs invade natural habitats and the full extent of their effects remain poorly understood, necessitating further investigation. This review aims to synthesise existing literature on the home range sizes, behavioural drivers, and habitat use of free-ranging rural and village dogs, as well as to explore the underlying reasons for their specific habitat preferences.

II. METHODS

To achieve our research objectives, we conducted a comprehensive literature survey using platforms such as Google Scholar, Scopus, and Web of Science. We employed keywords including "free-ranging dogs" and "free-roaming dogs," combined with "home range" and "use of habitat." We focused exclusively on academic papers, excluding other document types such as reports and pre-prints. We did not impose any restrictions on the publication period during our searches. The next step involved a thorough review of the selected literature to determine whether it provided detailed information on home range sizes, the factors influencing these ranges, and the habitat use by free-ranging rural and village dogs. Studies lacking this specific information were excluded. In cases where multiple papers used the same dataset, we selected the one most aligned with our research goals. From the final selection of papers, we extracted vital information, including publication year, study area, journal name, tracking methods, and the types of estimators used.

III. RESULTS

This paper aims to review the home range sizes and habitat use of free-ranging rural and village dogs, as well as the drivers of these behaviours. In our research, we identified twenty-three papers on this topic, published between 2003 and 2022. The study areas spanned multiple countries including Australia, Brazil, Chad, Chile, China, Guatemala, India, Indonesia, Kenya, Kyrgyzstan, and Uganda (Fig. 1). Four of these papers investigated both home range and habitat use, thirteen focused solely on home range, and six addressed only habitat use. Among the six papers from Australia, five utilised the same sample, a pattern also observed in two papers from Brazil and two from Chile. Consequently, we selected only one paper from each set of duplicates to meet the objectives of this study. Ultimately, our review included fourteen papers: three covering both home range and habitat use, nine focusing exclusively on home range, and five dedicated solely to habitat use (Table 1).

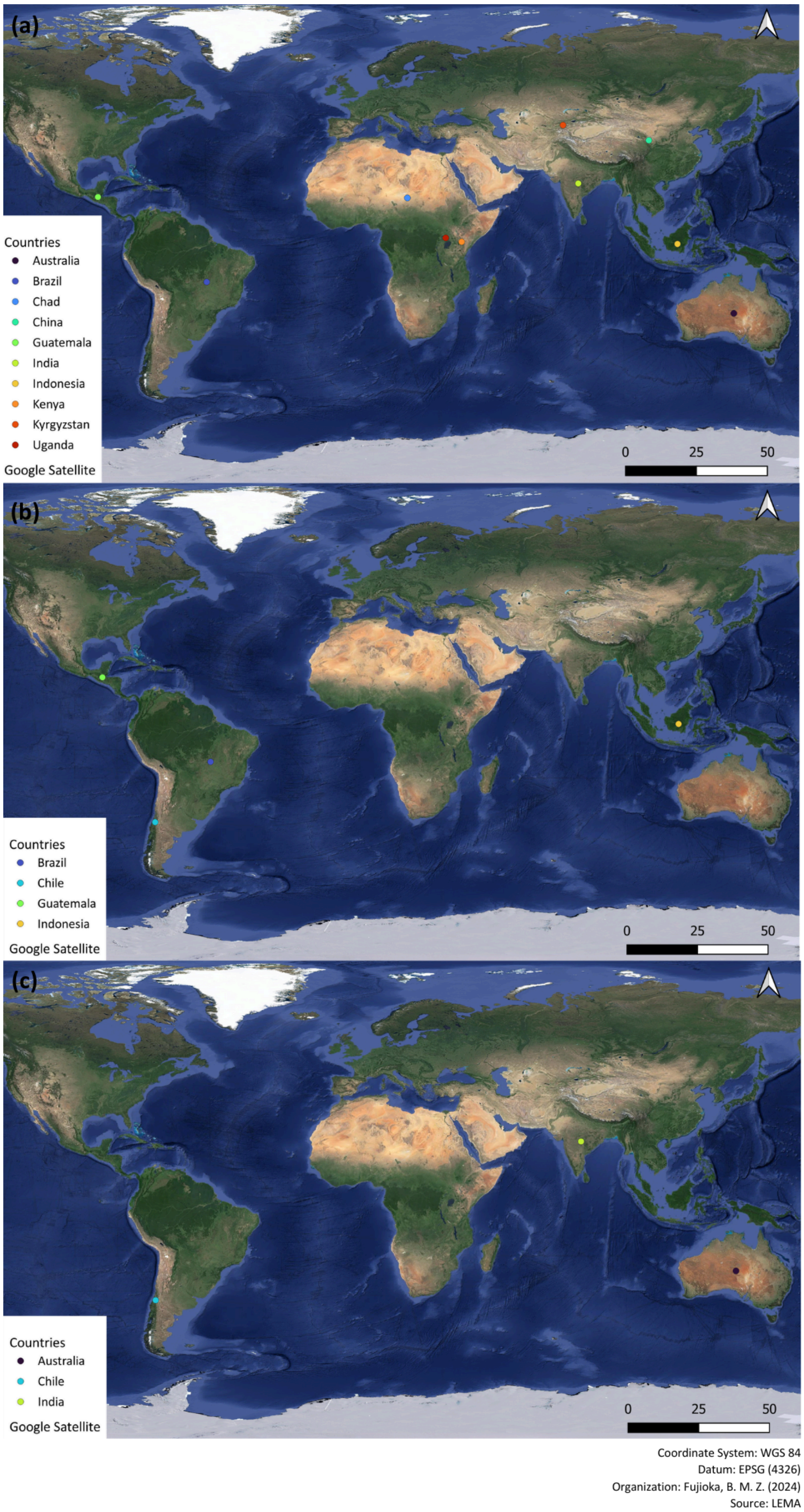

Fig. 1. Study areas of the 23 papers published between 2003 and 2022 on the home range and habitat use of free-ranging rural and village dogs: (a) investigations focusing on home range; (b) investigations focusing on habitat use; (c) investigations addressing both home range and habitat use.

Table 1. Studies sourced from the literature search that investigated the home range and habitat use of free-ranging rural and village dogs. Studies marked with an asterisk (*) were excluded from the review to avoid duplicate samples.

Ref	Study	Study area	Journal	Type of study
1	Bombara et al., 2017*	Australia	Australia Veterinary Journal	Home range
2	Contardo et al. ,2021	Chile	Biological Invasions	Use of habitat
3	Cunha Silva et al,. 2022	Indonesia/Guatemala	Scientific Reports	Use of habitat
4	Dos Santos et al., 2018	Brazil	Journal of Mammalogy	Home range
5	Dürr & Ward, 2014*	Australia	Preventive Veterinary Medicine	Home range
6	Dürr et al, 2017	Australia	Epidemiology and Infection	Home range
7	Hudson et al., 2017*	Australia	Preventive Veterinary Medicine	Home range
8	Molloy et al., 2017*	Australia	Australia Veterinary Journal	Home range
9	Muinde et al., 2021	Kenya	Ecology and Evolution	Home range
10	Pal, 2003	India	Acta Theriologica	Home range
11	Paschoal et al., 2016*	Brazil	Ecosphere	Use of habitat
12	Paschoal et al., 2018	Brazil	Tropical Conservation Science	Use of habitat
13	Saavedra-Aracena et al., 2021*	Chile	Applied Animal Behaviour Science	Home range/Use of habitat
14	Schüttler et al., 2022	Chile	Applied Animal Behaviour Science	Home range/Use of habitat
15	Sepúlveda et al., 2015	Chile	Mammalian Biology	Use of habitat
16	Silva-Rodríguez et al., 2010	Chile	Austral Ecology	Use of habitat
17	Tiwari et al., 2019	India	Vaccines	Home range
18	van Bommel & Johnson, 2014	Australia	PLoS ONE	Home range/Use of habitat
19	Van Kesteren et al., 2013	Kyrgyzstan	Parasitology	Home range
20	Vanak & Gompper, 2010	India	Journal of Applied Ecology	Home range/Use of habitat
21	Vaniscotte et al., 2011	China	Parasitology	Home range
22	Warembourg et al., 2021	Chad	Frontiers in Veterinary Science	Home range
23	Wilson-Aggarwal et al., 2021	Chad/Indonesia/Guatemala/Uganda	Ecological Applications	Home range

(1) Home range

The home range size of dogs exhibited significant variation across the studies, ranging from 0.17 ha to 252 ha for core home ranges, and from 0.0021 ha to 2706.40 ha for extended home ranges. In terms of tracking methods, GPS was used in most cases (66%) to monitor the dogs, while other methods included direct observations (8%), transects (8%), photographic capture-recapture/sight-resight (8%), and radiotelemetry (8%). Home range estimates were conducted using various methods: Autocorrelation Kernel Density (AKDE) (16.67%), Biased Random Bridge Kernel (BRBK) (8%), Biased Random Bridge (BRB) (25%), Characteristic Hull Polygon (CHP) (8%), Kernel isopleth (8%), Kernel density (8%), Maximum Convex Polygon (MCP) (16.67%), and Minimum Convex Polygon (MCP) (8%) (Table 2).

Of the studies we selected, 75% investigated variables that account for variations in home range size, identifying factors such as age, sex, reproductive status, breeding condition, season, and human behaviour as potential explanations. In some instances, the same variable distinctly influenced the home range, or multiple variables contributed to variations in home range size. Our analysis solely incorporated the size of the dog home ranges, with clear distinctions made between rural and urban dogs. The study by Muinde et al. (2021) examined variables affecting home range; however, this data was excluded from our review because their sample included dogs from urban areas as well. In the study by Warembourg et al. (2021), only the data from Chad was included in our study, as the data from Guatemala, Indonesia, and Uganda also included urban areas (Fig. 2).

Table 2. Papers focusing on the home range of free-ranging rural and village dogs, along with the variables that influence them, selected for this review. References were defined according to Table 1. *Paper excluded from the analysis of home range drivers because their samples included urban dogs. **Maximum Convex Polygon. ***Minimum Convex Polygon.

Ref	Tracking type	Estimator type	Range of home range	Mean of home range	Variables
4	Direct observations	BRBK (50%)	1.40 ± 46.50 ha	20.7 ha	Human behaviour
		BRBK (95%)	6.10 ± 202.20 ha	99.20 ha	
6	GPS	BRB (50%)	0.17 ± 2.33 ha	0.35 ha	Reproductive status/season/sex
		BRB (95%)	0.86 ± 40.46 ha	4.48 ha	
9	GPS	BRB (50%)	-	0.49 ha	-
		BRB (95%)	-	11.38 ha	
10	Transectors	MCP **	3.23 ha ± 0.22 ha (summer)	6.34 ha	Breeding condition/season
			10.13 ha ± 1.00 ha (late monsoon)		
14	GPS	AKDE (95%)	710.40 ± 2706.40 ha (summer)	21 ha	Human behaviour
			292.10 ± 1065.50 ha (autumn)	24.40 ha	
			174.50 ± 617.40 ha (winter)	16.20 ha	
			220.80 ± 882.80 ha (spring)	15.80 ha	
17	Photographic capture-recapture/ sight-resight	MCP **	0.0021 ± 50.48 ha	2.80 ha	Human behaviour
18	GPS	Kernel isopleth (50%)	4.00 ± 252.00 ha	-	Age
		Kernel isopleth (95%)	31.00 ± 1161.00 ha	-	
19	GPS	CHP (95%)	-	2.265 ha	-
20	Radio-telemetry	Kernel density (95%)	-	45.00 ha	-
21	GPS	MCP (95%) ***	0.004 ± 10 ha	-	Sex
22	GPS	BRB (50%)	0.17 ± 0.92 ha	0.30 ha	Sex
		BRB (95%)	1.10 ± 103 ha	7.70 ha	Human behaviour
23	GPS	AKDE (50%)	-	8.00 ha (dry season)	Human behaviour
			-	4.00 ha (wet season)	
		AKDE (95%)	-	54.00 ha (dry season)	
			-	31.00 ha (wet season)	

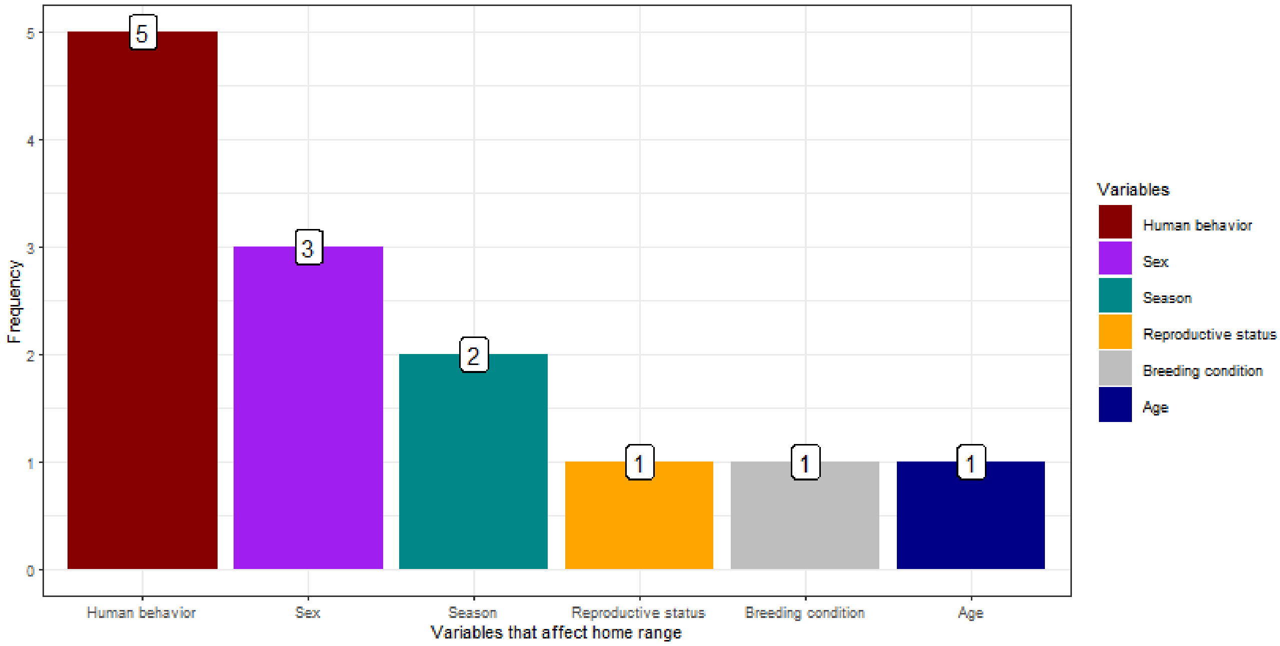

Fig. 2. Frequency of variables identified as predictors of home range in the papers selected for this review.

The influence of age on home range varied across studies. Dürr et al. (2017) suggested that age was not a consistent predictor of home range size. However, van Bommel & Johnson (2014) observed that older dogs exhibited less activity per hour and more tortuous movement, leading to smaller home ranges. In Kyrgyzstan, Van Kesteren et al. (2013) found no significant difference in home range size between males and females, whereas Vaniscotte et al. (2011) and Warembourg et al. (2021) reported that males roamed more extensively than females. Regarding reproductive status, castration generally negatively correlated with home range size in males and positively in females; castrated males travelled less compared to intact males, while the opposite was observed for females (Dürr et al., 2017). Additionally, Pal (2003) noted a significant increase in the home range of females during the late monsoon in India, coinciding with oestrus or lactation periods.

Seasonal variations also impacted home range sizes; in Australia, dogs exhibited larger home ranges during the wet season as water bodies restricted movement and reduced the need to travel for resources, further aided by increased food availability after rains (Dürr et al., 2017). Conversely, the season had minimal impact on the movements of Maremma Livestock Guardian Dogs, likely due to consistent food availability and water throughout the year, and the absence of mating and breeding behaviours due to sterilisation (van Bommel & Johnson, 2014).

Human influence is a key determinant in the movements of this species, as their home ranges are primarily located in areas close to or associated with human activity (Dos Santos et al., 2018; Tiwari et al., 2019; Wilson-Aggarwal et al., 2021; Schüttler et al., 2022). In Brazil, dogs spent only 7% of their total focal time away from their owners, and their home ranges included both the households where they were fed and the agroforests, which serve as workplaces for their owners (Dos Santos et al., 2018). In Chad, these animals tended to be less active in the rainy season and more active during the dry season, coinciding with local hunting activities, likely because they accompanied hunters (Wilson-Aggarwal et al., 2021). The home range of dogs from hunting households was found to be 2.6 times larger than that of dogs from non-hunting households (Wilson-Aggarwal et al., 2021). This pattern was confirmed in another study in Chad, where dogs used for hunting exhibited larger home ranges compared to non-hunting dogs (Warembourg et al., 2021). Human care also impacted the dogs' home range; Tiwari et al. (2019) found that dogs in the study area, despite not having owners, were fed by local people, resulting in smaller home ranges as there was no need to travel long distances for resources. This provision of resources also influenced social behaviour, preventing the formation of groups, with dogs most often sighted alone having smaller home ranges than those frequently seen in groups (Tiwari et al., 2019).

(1) Use of habitat

Among the studies on habitat use by dogs included in our review, the majority employed GPS for monitoring (50%), followed by camera tracking (25%) and radio-telemetry (12.5%). Notably, one study utilised a combination of three sampling methods: fatty acid scent, scat analysis, and radio-telemetry (12.5%). Regarding analytical methods, compositional analysis was the most commonly used estimator (37.5%), followed by regression models (25%), occupancy models (12.5%), probability of use models (12.5%), and the percentage of locations method (12.5%) (Table 3).

To summarise the habitat usage by dogs, we categorised houses, farms, roads, and buildings as "human settlements," while pastures, croplands, and ploughed lands were classified as "agricultural lands." The term "vegetation" was used to include areas referred to as forests, shrublands, and native forests. The use of habitat by dogs appears to be closely linked to human presence, as they predominantly frequent human settlements and areas associated with human activities, such as agricultural and livestock zones. Peatbogs were also noted as a frequently used habitat, alongside vegetation and bare ground. The less commonly used habitats included various forms of vegetation, wetlands, grasslands, and agricultural lands. Sites less frequented also include those with fewer human settlements and agricultural lands (Figs. 3 and 4).

Table 3. Selected papers on habitat use by free ranging rural and village dogs included in this review. References were defined according to Table 1.

Ref	Tracking type	Estimator type
2	Camera-trap	Occupancy model
3	GPS	Regression model
12	Camera-trap	Probability of use model
14	GPS	Compositional analysis (2nd and 3rd order)
15	GPS	Compositional analysis (2nd and 3rd order)
16	Fatty acid scent/scats/radio-telemetry	Compositional analysis (3rd order)
18	GPS	Percentage of locations

20	Radio-telemetry	Regression model

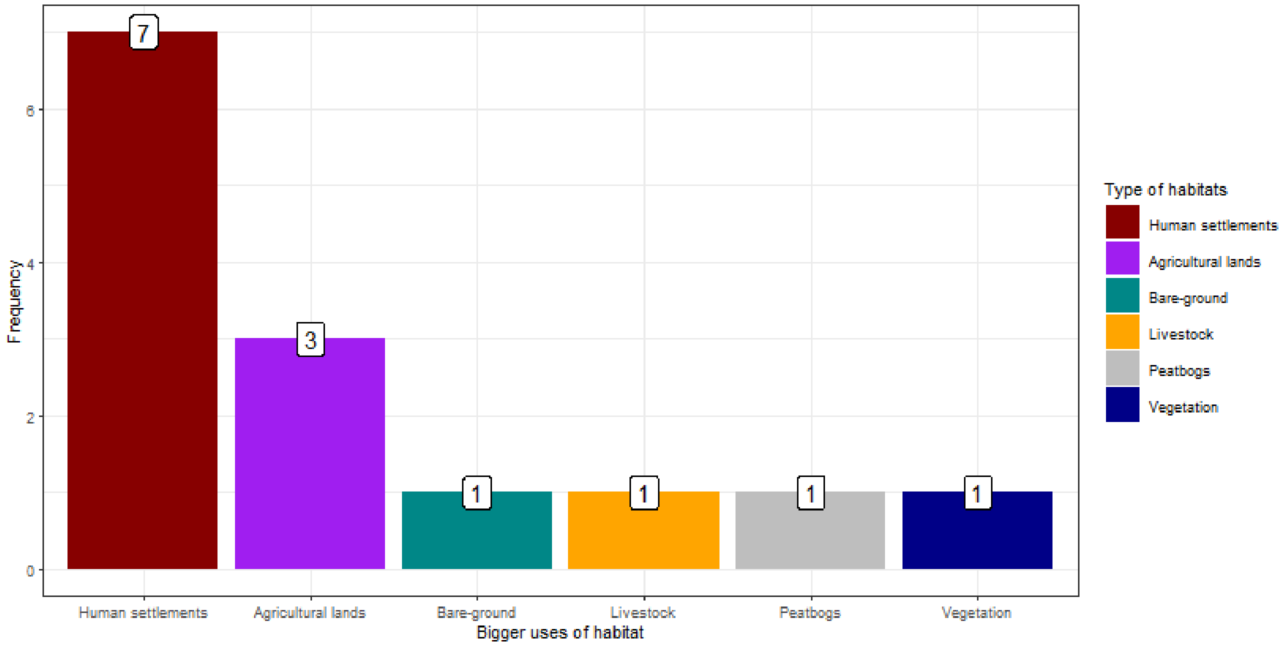

Fig. 3. Frequency of habitats classified as more frequently used in the studies selected for this review.

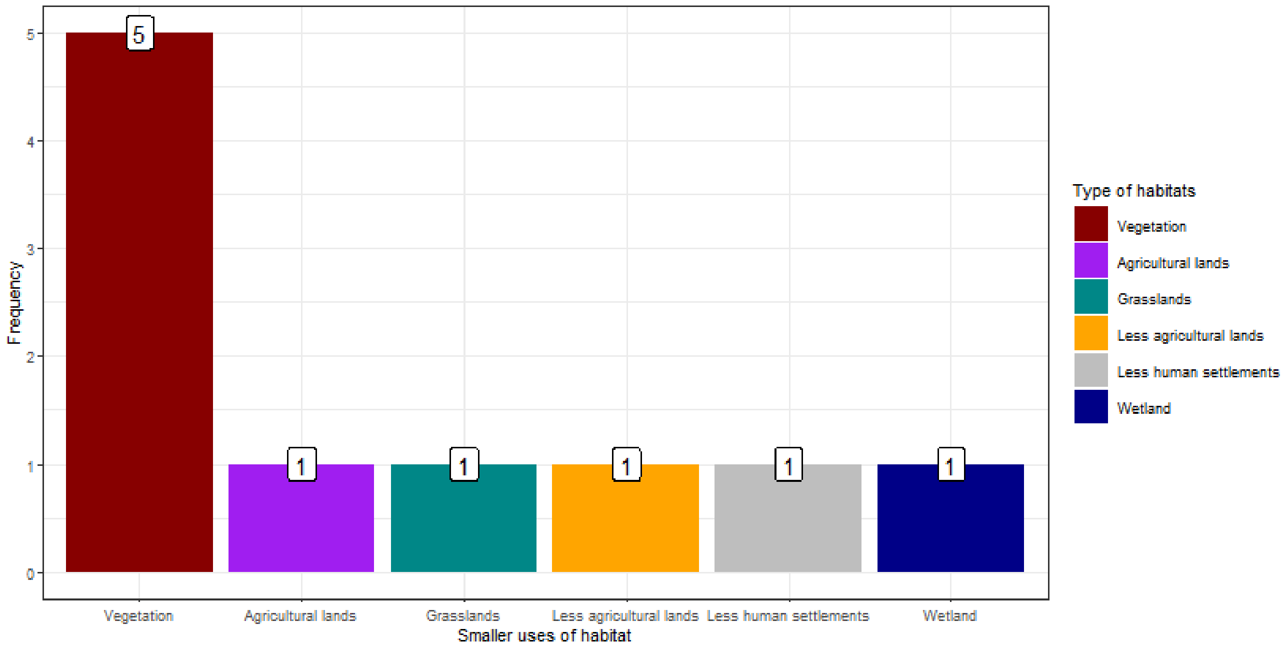

Fig. 4. Frequency of habitats classified as less frequently used in the studies selected for this review.

Dogs tend to stay close to their owners' houses or areas associated with human activities. In Chile, the typical habitat use by dogs includes median and mean distances of only 33–42m and 193–602m from their owners' houses, respectively, varying with the season (Schüttler et al., 2022). The rural housing density and the proportion of agricultural lands were positively associated with habitat use by dogs; areas with 50% agriculture and four houses per square kilometre were two to four times more likely to be frequented compared to areas without agriculture or rural housing (Paschoal et al., 2018). Dogs also visit buildings to find food, water, and shelter (Cunha Silva et al., 2022). Studies on the movement of unsupervised Maremma Livestock Guardian Dogs show that they mostly remain around livestock areas, although they occasionally move away, primarily at night (van Bommel & Johnson, 2014). The use of pastures may be influenced by dogs following people or farm animals such as cattle and sheep, and because pastures present little resistance to movement (Sepúlveda et al., 2015). Shrublands, grasslands, savannas, pastures, and peatbogs facilitate movement and orientation, encouraging dogs to explore these areas (Contardo et al., 2021). Similarly, roads also promote access to and exploration of these environments (Cunha Silva et al., 2022). Although dogs predominantly utilise human settlements, they occasionally venture into protected habitats, especially when roads provide access to forested areas (Sepúlveda et al., 2015).

IV. DISCUSSION

In our review of the literature, we observed that dogs exhibit considerable variation in their home range, influenced by various factors, with their association with humans being a particularly significant predictor. The interaction between dogs and humans markedly affects their home range; dogs that exhibit a higher affinity for humans tend to have smaller home ranges (Tiwari et al., 2019). These animals often rely heavily on human-provided food (Dos Santos et al., 2018) or scavenge leftovers from rubbish dumps (Tiwari et al., 2019; Muinde et al., 2021). Indeed, the movement patterns of dogs are influenced by their nutritional state and motivational drives (Powell & Mitchell, 2012). Consequently, dogs typically establish their home ranges in areas where they can access food (Silva-Rodríguez & Sieving, 2011; Dos Santos et al., 2018; Tiwari et al., 2019; Contardo et al., 2021), shelter (Silva-Rodríguez & Sieving 2011; Contardo et al., 2021), and form bonds with humans (Contardo et al., 2021). Intrinsically more active dogs, which may have a lower body condition score, can exhibit larger home ranges due to limited access to food resources at their residences or increased competition for these resources. This necessity to roam further to meet their energy needs may even lead them into natural or protected areas (Molloy et al., 2017).

Home range can also be partly dependent on breeding conditions; studies indicate that females can present larger home ranges when they are lactating (Pal, 2003), as they require more resources during this period. Age appears to be an uncertain predictor of home range size, as it can be positively associated with the distance travelled per day and the size of the extended home range (Muinde et al., 2021; Shüttler et al., 2021), or negatively associated, with older dogs displaying less activity and smaller home ranges (van Bommel & Johnson, 2014). Generally, males exhibit larger home ranges than females, possibly due to increased territorial behaviour (Muinde et al., 2021), and sterilisation seems to affect roaming differently according to sex. Castrated males tend to travel less compared to intact males, and in the case of females, the neutered ones roam more (Dürr et al., 2017; Muinde et al., 2021). Usually entire female dogs were often administered chemical contraceptives, and it is possible this influenced the roaming them, because the effects of chemical sterilisation on the roaming behaviour of dogs are not yet understood (Molloy et al., 2017).

The frequency with which dogs are recorded in native vegetation areas seems to be linked to the activities of their owners, such as hunting (Wilson-Aggarwal et al., 2021) and work (Dos Santos et al., 2018). These observations underscore the need to further explore the relationship between owner activities—including herding, fishing, and agriculture—and dog movements (Wilson-Aggarwal et al., 2021). However, dogs do not necessarily access vegetated areas only when accompanied by their owners; a study found that 98% of monitored dogs ventured into such areas independently (Saavedra-Aracena et al., 2021). In Chile, 50% of rural/village dogs monitored were observed at distances of up to 16.5 km from town, typically in packs of 2–4 individuals (Contardo et al., 2021). Similarly, in Kyrgyzstan, 22 out of 37 dogs (59%) left the village boundary at least once during monitoring (Van Kesteren et al., 2013). Thus, their bond with humans does not confine dogs from exploring more distant locations, and the longer a dog is away from home, the greater the likelihood of it accessing native vegetation (Saavedra-Aracena et al., 2021).

The use of native vegetation and protected areas by dogs is a significant concern among scientists. In Brazil, the frequent presence of dogs in protected areas is well-documented (Paschoal et al., 2016), and it is believed that the intrusion of these carnivores into native vegetation areas represents a considerable additional threat (Ribeiro et al., 2019). This is largely attributed to high human population densities and extensive deforestation (Ribeiro et al., 2019). Human activities around protected areas intensify access for dogs to natural areas, creating a landscape mosaic and increasing the interface between disturbed and natural habitats (Paschoal et al., 2018). The likelihood of dogs spending extended periods in the Atlantic Forest protected areas is greater near human residences, while other factors, such as seasonal changes and mammal richness, appear to have no impact (Paschoal et al., 2016).

Conversely, the avoidance of native forests by dogs may be influenced by the distance of these areas from owner homes, as proximity to houses and roads correlates with higher rates of dog visits (Silva-Rodríguez et al., 2010). Moreover, the use of roads or trails is significant; they not only connect households within communities but also serve as access points to conservation areas and forest habitats (Sepúlveda et al., 2015). Additionally, dogs may utilise shrublands, grasslands, savannas, and peatbogs, as these habitats facilitate movement and might be preferred due to better orientation and easier mobility (Contardo et al., 2021).

Human attitudes towards dogs significantly influence their interactions with wildlife and can drive the invasion of native areas, posing various threats (Serpell, 2017). In Brazilian national parks, dogs impact wildlife through predation, competition, and pathogen transmission, affecting 37 native species, primarily mammals such as agoutis (*Dasyprocta leporina*), capybaras (*Hydrochoerus hydrochaeris*), tapirs (*Tapirus terrestris*), coatis (*Nasua nasua*), and anteaters (*Myrmecophaga tridactyla*) (Lessa et al., 2016). The likelihood of a dog preying on wild animals appears to be influenced by the level of care provided by its owners; well-cared-for animals are less likely to hunt due to reduced hunger (Silva-Rodríguez & Sieving 2011; Sepúlveda et al., 2014). In Chile, inadequately fed dogs were 3.7 times more likely to attack vertebrates compared to those that were adequately fed (Silva-Rodríguez & Sieving, 2011). Consequently, the better the care a dog receives from its owners, the less likely it is to prey on wild animals (Silva-Rodríguez & Sieving 2011; Sepúlveda et al., 2014).

The behaviour of dogs warrants attention due to its implications for the transmission of diseases to wildlife and humans. Dogs and cats share at least 60 parasite species with humans (Macpherson, 2005), and dogs are a significant source of human rabies in Nepal (Acharya et al., 2020). In coastal Australia, predation by dogs on macropods raises health concerns due to the risk of infections from hydatids, *Echinococcus granulosus*, and other parasites (Meek, 1999). In China, the high density of dog faeces in human environments and the prevalence of *Echinococcus multilocularis* within these faeces highlight the role of dogs in environmental contamination in Tibetan villages (Vaniscotte et al., 2011). In Zimbabwe, the potential for large carnivores to contract diseases through predation on dogs is considerable, providing a pathway for the transmission of infectious diseases (Butler et al., 2004). In Chad, dogs that follow their owners into native areas for activities such as hunting may increase the risk of disease transmission (Wilson-Aggarwal et al., 2021). Similarly, in Kenya, dogs presence in water sources, grazing areas, pit latrines, and slaughterhouses suggests their involvement in the spread of diseases, as these sites are crucial from ecological and public health perspectives (Muinde et al., 2021). Dogs that roam more frequently, such as uncastrated males and those from hunting households, are more likely to transmit diseases (Pal, 2003; Wilson-Aggarwal et al., 2021). Therefore, identifying such dogs is vital for guiding management and conservation efforts, including mass vaccination programs (Tiwari et al., 2019) and control strategies (Molloy et al., 2017).

While dogs establish home ranges and use habitats closely related to human presence, their ancestor, the grey wolves, exhibit contrasting behaviours. Wolves are known to define their home ranges primarily to avoid human disturbances (Chavez & Gese, 2006; Oakleaf et al., 2006; Karamanlidis et al., 2017; Ordiz et al., 2020; Kudrenko et al., 2023; van den Bosch et al., 2023). They strategically select habitats to minimise encounters with humans, avoid areas with significant anthropogenic activity (Oakleaf et al., 2006), and steer clear of human-related infrastructure such as roads (Karamanlidis et al., 2017; Ordiz et al., 2020; van den Bosch et al., 2023) and buildings (Ordiz et al., 2020). Wolves prefer areas with substantial natural cover, and their landscape suitability is largely restricted by high human population density and extensive agriculture (van den Bosch et al., 2022). Pastures are typically used only as transit areas rather than foraging sites, as predation on cattle is rare (Chavez & Gese, 2006). However, wolves occasionally approach human settlements (Karamanlidis et al., 2017), dumps (Kittle et al., 2015), and roads (Mancinelli et al., 2018), presumably to scavenge anthropogenic food sources (Karamanlidis et al., 2017).

It is evident that sites associated with human activities, such as roads, trails, pastures, and resource-providing areas, along with the relationship between owners and dogs, influence the habitat usage of free-ranging rural and village dogs. Although only a small percentage of dogs roam far from home, their presence is particularly significant near protected areas (Schüttler et al., 2022). Given their often high population densities (Vanak & Gompper, 2010; Phillips et al., 2012; Ribeiro et al., 2019), even a small number of far-roaming dogs can have substantial impacts on biodiversity conservation efforts (Schüttler et al., 2022). The extreme movements of free-ranging dogs, such as the case of dogs following tourists on trekking trips, in Schüttler et al.'s study (2022), warrant special attention and detailed reporting. This information is crucial for shaping conservation policies, for example, controlling the access of these animals to tourist areas (Schüttler et al., 2022). Therefore, we underscore the importance of considering the diverse contexts in which these adaptable animals are found, as understanding these contexts is essential to comprehending the real roles these dogs play.

V. CONCLUSION

The home range of dogs exhibits significant variability driven by various factors. The effects of these factors vary depending on the context and location in which the animals are situated, potentially causing opposite effects in different areas or, in some instances, no effect at all. Generally, the presence of humans has significantly influenced the roaming behaviours of free-ranging rural and village dogs and their use of habitat. Dogs tend to frequent the same sites as their owners or to stay close to them, but they may also visit places associated with human activity. The routine of the owner, as well as the care provided to their animals, can also be decisive factors in the movement of dogs. Investigating and elucidating the movement ecology of dogs and their bond with humans is vital to manage this species effectively and develop robust public policies. Nevertheless, it is essential to emphasise that other variables can play a role in the movement of dogs, and each case should be studied to fully understand the potential issues and to propose the most appropriate measures for the conservation of biodiversity, when necessary.

REFERENCES

Acharya, K. P., Acharya, N., Phuyal, S., Upadhyaya, M., & Lasee S. (2020). One-health approach: A best possible way to control rabies. *One Health* **10**. https://doi.org/10.1016/j.onehlt.2020.100161

Allen, A. M., & Singh, N. J. (2016). Linking movement ecology with wildlife management and conservation. *Frontiers in Ecology and Evolution*, **155**. https://doi.org/10.3389/fevo.2015.00155

Bombara, C., Dürr, S., Gongora, J., & Ward, M. P. (2017). Roaming of dogs in remote Indigenous communities in northern Australia and potential interaction between community and wild dogs. *Australian Veterinary Journal* **95**, 182-188.https://doi.org/10.1111/avj.12592

Börger, L., Franconi, N., Ferretti, F., Meschi, F., De Michele, G., Gantz, A., & Coulson, T. (2006). An integrated approach to identify spatiotemporal and individual-level determinants of animal home range size. *The American Naturalist* **168**, 471–485. https://doi.org/10.1086/507883

Botigué, L. R., Song, S., Scheu, A., Gopalan, S., Pendleton, A. L., Oetjens, M., ... & Veeramah, K. R. (2017). Ancient European dog genomes reveal continuity since the Early Neolithic. *Nature communications* **8**, 16082. https://doi.org/10.1038/ncomms16082

Burt, W. H. (1943). Territoriality and Home Range Concepts as Applied to Mammals. *Journal of Mammalogy* **24**, 346–352.

Butler, J. R. A., du Toit, J. T., & Bingham, J. (2004). Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: Threats of competition and disease to large wild carnivores. *Biological Conservation* **115**, 369–378. https://doi.org/10.1016/S0006-3207(03)00152-6

Cederlund, G., & Sand, H. (1994). Home-range size in relation to age and sex in moose. *Journal of mammalogy* **75**, 1005-1012.https://doi.org/10.2307/1382483

Chavez, A. S., & Gese, E. M. (2006). Landscape Use and Movements of Wolves in Relation to Livestock in a Wildland-Agriculture Matrix. *Journal of Wildlife Management* **70**, 1079–1086. https://doi.org/10.2193/0022

Contardo, J., Grimm-Seyfarth, A., Cattan, P. E., & Schüttler, E. (2021). Environmental factors regulate occupancy of free-ranging dogs on a sub-Antarctic island, Chile. *Biological Invasions* **23**, 677–691. https://doi.org/10.1007/S10530-020-02394-3/FIGURES/5

Cunha Silva, L., Friker, B., Warembourg, C., Kanankege, K., Wera, E., Berger-González, M., ... & Dürr, S. (2022). Habitat selection by free-roaming domestic dogs in rabies endemic countries in rural and urban settings. *Scientific reports* **12**, 20928.https://doi.org/10.1038/s41598-022-25038-z

da Silva Coelho, F. A., Gill, S., Tomlin, C. M., Heaton, T. H., & Lindqvist, C. (2021). An early dog from southeast Alaska supports a coastal route for the first dog migration into the Americas. *Proceedings of the Royal Society B* **288**, 20203103. https://doi.org/10.1098/rspb.2020.3103.

De Angelis, D., Huber, D., Reljic, S., Ciucci, P., & Kusak, J. (2021). Factors affecting the home range of Dinaric-Pindos brown bears. *Journal of Mammalogy* **102**, 481–493. https://doi.org/10.1093/jmammal/gyab018

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G., Vanak, A. T., & Wirsing, A. J. (2017). The global impacts of domestic dogs on threatened vertebrates. *Biological Conservation* **210**, 56–59. https://doi.org/10.1016/j.biocon.2017.04.007

Dos Santos, C. L. A., Le Pendu, Y., Giné, G. A. F., Dickman, C. R., Newsome, T. M., & Cassano, C. R. (2018). Human behaviors determine the direct and indirect impacts of free-ranging dogs on wildlife. *Journal of Mammalogy* **99**, 1261–1269. https://doi.org/10.1093/jmammal/gyy077

Dürr, S., Dhand, N. K., Bombara, C., Molloy, S., & Ward, M. P. (2017). What influences the home range size of free-roaming domestic dogs? *Epidemiology and Infection* **145**, 1339–1350. https://doi.org/10.1017/S095026881700022X

Dürr, S., & Ward, M. P. (2014). Roaming behaviour and home range estimation of domestic dogs in Aboriginal and Torres Strait Islander communities in northern Australia using four different methods. *Preventive veterinary medicine* **117**, 340-357. https://doi.org/10.1016/j.prevetmed.2014.07.008

Gompper, M. E. (Ed.). (2014). *Free-Ranging Dogs and Wildlife Conservation*. Oxford University Press.

Hall, L. S., Krausman, P. R., & Morrison, M. L. (1997). The Habitat Concept and a Plea for Standard Terminology. *Wildlife Society Bulletin* **25**, 173–182. https://www.jstor.org/stable/3783301?seq=1&cid=pdf-

Hudson, E. G., Brookes, V. J., Dürr, S., & Ward, M. P. (2017). Domestic dog roaming patterns in remote northern Australian indigenous communities and implications for disease modelling. *Preventive Veterinary Medicine* **146**, 52–60. https://doi.org/10.1016/j.prevetmed.2017.07.010

Hughes, J., & Macdonald, D. W. (2013). A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation* **157**, 341–351. https://doi.org/10.1016/j.biocon.2012.07.005

Karamanlidis, A. A., Hernando, M. de G., Georgiadis, L., & Kusak, J. (2017). Activity, movement, home range and habitat use of an adult gray Wolf in a Mediterranean landscape of northern Greece. *Mammalia* **81**, 95–99. https://doi.org/10.1515/mammalia-2015-0091

Kittle, A. M., Anderson, M., Avgar, T., Baker, J. A., Brown, G. S., Hagens, J., Iwachewski, E., Moffatt, S., Mosser, A., Patterson, B. R., Reid, D. E. B., Rodgers, A. R., Shuter, J., Street, G. M., Thompson, I. D., Vander Vennen, L. M., & Fryxell, J. M. (2015). Wolves adapt territory size, not pack size to local habitat quality. *Journal of Animal Ecology* **84**, 1177–1186. https://doi.org/10.1111/1365-2656.12366

Kudrenko, S., Fenchuk, V., Vollering, J., Zedrosser, A., Selva, N., Ostapowicz, K., Beasley, J. C., & Heurich, M. (2023). Walking on the dark side: Anthropogenic factors limit suitable habitat for gray wolf (*Canis lupus*) in a large natural area covering Belarus and Ukraine. *Global Ecology and Conservation* **46**. https://doi.org/10.1016/j.gecco.2023.e02586

Lessa, I., Guimarães, T. C. S., Bergallo, H. de G., Cunha, A., & Vieira, E. M. (2016). Domestic dogs in protected areas: a threat to Brazilian mammals? *Natureza e Conservação* **14**, 46–56. https://doi.org/10.1016/j.ncon.2016.05.001

Lindstedt, S. L., Miller, B. J., & Buskirk, S. W. (1986). Home range, time and body size in mammals. *Ecology* **67**, 413–418

Macpherson, C. N. L. (2005). Human behaviour and the epidemiology of parasitic zoonoses. *International Journal for Parasitology* **35**, 1319–1331. https://doi.org/10.1016/j.ijpara.2005.06.004

Mancinelli, S., Boitani, L., & Ciucci, P. (2018). Determinants of home range size and space use patterns in a protected wolf (*Canis lupus*) population in the central Apennines, Italy. *Canadian Journal of Zoology* **96**, 828–838. www.nrcresearchpress.com

Mcnab, B. K. (1963). Bioenergetics and the determination of home range size. *The American Naturalist* **97**, 133–140. http://www.journals.uchicago.edu/t-and-c

Meek, P. D. (1999). The movement, roaming behaviour and home range of free-roaming domestic dogs, *Canis lupus familiaris*, in coastal New South Wales. *Wildlife Research* **26**, 847–855. https://doi.org/10.1071/WR97101

Milleret, C., Ordiz, A., Chapron, G., Andreassen, H. P., Kindberg, J., Månsson, J., Tallian, A., Wabakken, P., Wikenros, C., Zimmermann, B., Swenson, J. E., & Sand, H. (2018). Habitat segregation between brown bears and gray wolves in a human-dominated landscape. *Ecology and Evolution* **23**, 11450–11466. https://doi.org/10.1002/ece3.4572

Molloy, S., Burleigh, A., Dürr, S., & Ward, M. P. (2017). Roaming behaviour of dogs in four remote Aboriginal communities in the Northern Territory, Australia: preliminary investigations. *Australian Veterinary Journal* **95**, 55–63. https://doi.org/10.1111/AVJ.12562

Muinde, P., Bettridge, J. M., Sousa, F. M., Dürr, S., Dohoo, I. R., Berezowski, J., Mutwiri, T., Odinga, C. O., Fèvre, E. M., & Falzon, L. C. (2021). Who let the dogs out? Exploring the spatial ecology of free-roaming domestic dogs in western Kenya. *Ecology and Evolution* **11**, 4218–4231. https://doi.org/10.1002/ece3.7317

Naidoo, R., Preez, P. D., Stuart-Hill, G., Chris Weaver, L., Jago, M., & Wegmann, M. (2012). Factors affecting intraspecific variation in home range size of a large African herbivore. *Landscape Ecology* **27**, 1523-1534. https://doi.org/10.1007/s10980-012-9807-3

Nayeri, D., Mohammadi, A., Qashqaei, A. T., Vanak, A. T., & Gompper, M. E. (2022). Free-ranging dogs as a potential threat to Iranian mammals. *ORYX* **56**, 383–389. https://doi.org/10.1017/S0030605321000090

Oakleaf, J. K., Murray, D. L., Oakleaf, J. R., Bangs, E. E., Mack, C. M., Smith, D. W., Fontaine, J. A., Jimenez, M. D., Meier, T. J., & Niemeyer, C. C. (2006). Habitat Selection by

Recolonizing Wolves in the Northern Rocky Mountains of the United States. *Journal of Wildlife Management* **70**, 554–563. https://doi.org/10.2193/0022-541x(2006)70[554:hsbrwi]2.0.co;2

Ordiz, A., Uzal, A., Milleret, C., Sanz-Pérez, A., Zimmermann, B., Wikenros, C., Wabakken, P., Kindberg, J., Swenson, J. E., & Sand, H. (2020). Wolf habitat selection when sympatric or allopatric with brown bears in Scandinavia. *Scientific Reports* **10**. https://doi.org/10.1038/s41598-020-66626-1

Pal, S. K. (2003). Reproductive behaviour of free-ranging rural dogs in West Bengal, India. *Acta Theriologica* **48**, 271–281.

Paschoal, A. M. O., Massara, R. L., Bailey, L. L., Doherty Jr, P. F., Santos, P. M., Paglia, A. P., Hirsch, A., & Chiarello, A. G. (2018). Anthropogenic Disturbances Drive Domestic Dog Use of Atlantic Forest Protected Areas. *Tropical Conservation Science* **11**, 1–14. https://doi.org/10.1177/1940082918789833

Paschoal, A. M. O., Massara, R. L., Bailey, L. L., Kendall, W. L., Doherty Jr, P. F., Hirsch, A., Chiarello, A. G., & Paglia, A. P. (2016). Use of Atlantic Forest protected areas by free-ranging dogs: Estimating abundance and persistence of use. *Ecosphere*, **10**. https://doi.org/10.1002/ecs2.1480

Perri, A. R., Feuerborn, T. R., Frantz, L. A., Larson, G., Malhi, R. S., Meltzer, D. J., & Witt, K. E. (2021). Dog domestication and the dual dispersal of people and dogs into the Americas. *Proceedings of the National Academy of Sciences* **118**, e2010083118. https://doi.org/10.1073/pnas.2010083118

Phillips, R. B., Wiedenfeld, D. A., & Snell, H. L. (2012). Current status of alien vertebrates in the Galápagos Islands: Invasion history, distribution, and potential impacts. *Biological Invasions* **14**, 461–480. https://doi.org/10.1007/s10530-011-0090-z

Powell, R. A., & Mitchell, M. S. (2012). What is a home range? *Journal of Mammalogy* **93**, 948–958. https://doi.org/10.1644/11-MAMM-S-177.1

Recio, M. R., & Seddon, P. J. (2013). Understanding determinants of home range behaviour of feral cats as introduced apex predators in insular ecosystems: A spatial approach. *Behavioral Ecology and Sociobiology* **67**, 1971–1981. https://doi.org/10.1007/s00265-013-1605-7

Ribeiro, F. S., Nichols, E., Morato, R. G., Metzger, J. P., & Pardini, R. (2019). Disturbance or propagule pressure? Unravelling the drivers and mapping the intensity of invasion of free-ranging dogs across the Atlantic forest hotspot. *Diversity and Distributions* **25**, 191–204. https://doi.org/10.1111/ddi.12845

Saïd, S., Gaillard, J. M., Widmer, O., Débias, F., Bourgoin, G., Delorme, D., & Roux, C. (2009). What shapes intra‐specific variation in home range size? A case study of female roe deer. *Oikos* **118**, 1299-1306. 10.1111/j.1600-0706.2009.17346.x

Saavedra-Aracena, L., Grimm-Seyfarth, A., & Schüttler, E. (2021). Do dog-human bonds influence movements of free-ranging dogs in wilderness? *Applied Animal Behaviour Science* **241**. https://doi.org/10.1016/j.applanim.2021.105358

Schüttler, E., Saavedra-Aracena, L., & Jiménez, J. E. (2022). Spatial and temporal plasticity in free-ranging dogs in sub-Antarctic Chile. *Applied Animal Behaviour Science* **250**. https://doi.org/10.1016/j.applanim.2022.105610

Sepúlveda, M. A., Singer, R. S., Silva-Rodriǵuez, E., Stowhas, P., & Pelican, K. (2014). Domestic dogs in rural communities around protected areas: Conservation problem or conflict solution? *PLoS ONE* **9**. https://doi.org/10.1371/journal.pone.0086152

Sepúlveda, M., Pelican, K., Cross, P., Eguren, A., & Singer, R. (2015). Fine-scale movements of rural free-ranging dogs in conservation areas in the temperate rainforest of the coastal range of southern Chile. *Mammalian Biology* **80**, 290–297. https://doi.org/10.1016/j.mambio.2015.03.001

Serpell, J. (2017). From paragon to pariah: Cross-cultural perspectives on attitudes to dogs. In J. Serpell (Ed.), *The Domestic Dog Its Evolution, Behavior and Interactions with People* (2nd ed., pp. 300–316)

Silva-Rodríguez, E. A., Ortega-Solís, G. R., & Jiménez, J. E. (2010). Conservation and ecological implications of the use of space by chilla foxes and free-ranging dogs in a human-dominated landscape in southern Chile. *Austral Ecology* **35**, 765–777. https://doi.org/10.1111/j.1442-9993.2009.02083.x

Silva-Rodríguez, E. A., & Sieving, K. E. (2011). Influence of Care of Domestic Carnivores on Their Predation on Vertebrates. *Conservation Biology* **25**, 808–815. https://doi.org/10.1111/j.1523-1739.2011.01690.x

Tiwari, H. K., Bruce, M., O'Dea, M., & Robertson, I. D. (2019). Utilising group-size and home-range characteristics of free-roaming dogs (FRD) to guide mass vaccination campaigns against rabies in India. *Vaccines* **7**. https://doi.org/10.3390/vaccines7040136

Tucker, M. A., Ord, T. J., & Rogers, T. L. (2014). Evolutionary predictors of mammalian home range size: Body mass, diet and the environment. *Global Ecology and Biogeography* **23**, 1105–1114. https://doi.org/10.1111/geb.12194

van Beest, F. M., Rivrud, I. M., Loe, L. E., Milner, J. M., & Mysterud, A. (2011). What determines variation in home range size across spatiotemporal scales in a large browsing herbivore?. *Journal of Animal Ecology* **80**, 771-785. https://doi.org/10.1111/j.1365-2656.2011.01829.x

van Bommel, L., & Johnson, C. N. (2014). Where do livestock guardian dogs go? Movement patterns of free-ranging Maremma sheepdogs. *PLoS ONE* **9**. https://doi.org/10.1371/journal.pone.0111444

van den Bosch, M., Beyer Jr, D. E., Erb, J. D., Gantchoff, M. G., Kellner, K. F., MacFarland, D. M., Norton, D. C., Patterson, B. R., Price Tack, J. L., Roell, B. J., & Belant, J. L. (2022). Identifying potential gray wolf habitat and connectivity in the eastern USA. *Biological Conservation* **273**. https://doi.org/10.1016/j.biocon.2022.109708

van den Bosch, M., Kellner, K. F., Gantchoff, M. G., Patterson, B. R., Barber-Meyer, S. M., Beyer, D. E., Erb, J. D., Isaac, E. J., MacFarland, D. M., Moore, S. A., Norton, D. C., Petroelje, T. R., Price Tack, J. L., Roell, B. J., Schrage, M., & Belant, J. L. (2023). Habitat selection of resident and non-resident gray wolves: implications for habitat connectivity. *Scientific Reports* **13**. https://doi.org/10.1038/s41598-023-47815-0

Van Kesteren, F., Mastin, A., Mytynova, B., Ziadinov, I., Boufana, B., Torgerson, P. R., Rogan, M. T., & Craig, P. S. (2013). Dog ownership, dog behaviour and transmission of Echinococcus spp. in the Alay Valley, southern Kyrgyzstan. *Parasitology* **140**, 1674–1684. https://doi.org/10.1017/S0031182013001182

Vanak, A. T., & Gompper, M. E. (2009). Dogs *Canis familiaris* as carnivores: Their role and function in intraguild competition. *Mammal Review* **39**, 265–283. https://doi.org/10.1111/j.1365-2907.2009.00148.x

Vanak, A. T., & Gompper, M. E. (2010). Interference competition at the landscape level: The effect of free-ranging dogs on a native mesocarnivore. *Journal of Applied Ecology* **47**, 1225–1232. https://doi.org/10.1111/j.1365-2664.2010.01870.x

Vaniscotte, A., Raoul, F., Poulle, M. L., Romig, T., Dinkel, A., Takahashi, K., Guislain, M. H., Moss, J., Tiaoying, L., Wang, Q., Qiu, J., Craig, P. S., & Giraudoux, P. (2011). Role of dog behaviour and environmental fecal contamination in transmission of *Echinococcus multilocularis* in Tibetan communities. *Parasitology* **138**, 1316–1329. https://doi.org/10.1017/S0031182011000874

Warembourg, C., Wera, E., Odoch, T., Bulu, P. M., Berger-González, M., Alvarez, D., ... & Dürr, S. (2021). Comparative study of free-roaming domestic dog management and roaming behavior across four countries: Chad, Guatemala, Indonesia, and Uganda. *Frontiers in Veterinary Science* **8**, 617900. https://doi.org/10.3389/fvets.2021.617900

Wilson-Aggarwal, J. K., Goodwin, C. E. D., Moundai, T., Sidouin, M. K., Swan, G. J. F., Léchenne, M., & McDonald, R. A. (2021). Spatial and temporal dynamics of space use by free-ranging domestic dogs *Canis familiaris* in rural Africa. *Ecological Applications* **31**. https://doi.org/10.1002/eap.2328

Este trabalho foi escrito seguindo as normas da revista *Journal of Animal Ecology*

Where do dogs go? Investigating the movement of free ranging rural dogs (*Canis familiaris*) in Brazil

ABSTRACT

1. Free-ranging rural domestic dogs present significant concerns for protected area managers due to their potential negative impacts on native wildlife, including predation, competition, pathogen transmission, and hybridization. The ecological role of dogs varies depending on location and context, emphasizing the need for a comprehensive assessment of their true impact on natural communities.

2. This study aims to analyze the home range and use of native vegetation by dogs in a protected area and fragments of the Cerrado biome, as well as to test which variables influence dogs home range. We also hypothesize that dogs with lower body scores, those accompanying their owners in daily activities, and those residing close to native vegetation are more likely to spend time in it. We employed GPS tracking to monitor 105 dogs over a two-month period. Home range sizes were estimated using the 95% Autocorrelation Kernel Density Estimator (AKDE), and native vegetation use was quantified based on the number of locations within this habitat.

3. Dogs exhibited relatively compact home ranges, ranging from 0.89 ha to 624.75 ha, with an average of 30.74 ha.. Larger home ranges were correlated with factors such as lower body condition scores and accompanying owners during daily activities. Only 3.94% of recorded locations were found in native vegetation, while most were in farming and human settlements. Proximity of the owners house to this habitat and low body score was associated with increased use of it.

4. The use of native vegetation is minimal, and dogs spend most of their time around their homes within the matrix. It is possible that their impact is related to their high density within the matrix, which could cause native species to avoid these areas, thereby reducing connectivity between fragments of native vegetation. The movement of dogs is significantly influenced by the contexts in which they are placed and by their genetic backgrounds. Given the global distribution of dogs and the diverse roles they play in society, efforts should be made in areas where dogs are present to investigate their roles and potential impacts within each specific context.

Keywords: protected areas, conservation management, ecological role, biodiversity conservation, GPS tracking.

RESUMO

1. Cães domésticos rurais de vida livre apresentam preocupações significativas para os gestores de áreas protegidas devido aos seus impactos negativos potenciais sobre a fauna nativa, incluindo predação, competição, transmissão de patógenos e hibridização. O papel ecológico dos cães varia dependendo do local e do contexto, enfatizando a necessidade de uma avaliação abrangente de seu verdadeiro impacto nas comunidades naturais.

2. Este estudo visa analisar a área de vida e o uso de vegetação nativa por cães em uma área protegida e fragmentos do bioma Cerrado, bem como testar quais variáveis influenciam a área de vida dos cães. Também hipotetizamos que cães com menores escores corporais, aqueles que acompanham seus donos em atividades diárias e aqueles que residem próximos à vegetação nativa, têm maior probabilidade de passar tempo nela. Utilizamos rastreamento GPS para monitorar 105 cães durante um período de dois meses. Os tamanhos das áreas de vida foram estimadas usando o Estimador de Densidade Kernel de Autocorrelação (AKDE)

95%, e o uso de vegetação nativa foi quantificado com base no número de localizações dentro deste habitat.

3. Os cães apresentaram áreas de vida relativamente pequenas, variando de 0,89 ha a 624,75 ha, com uma média de 30,74 ha. Maiores áreas de vida foram correlacionados com fatores como menores escores de condição corporal e acompanhamento dos donos durante atividades diárias. Apenas 3,94% das localizações registradas foram encontradas em vegetação nativa, enquanto a maioria estava em áreas agrícolas e assentamentos humanos. A proximidade da casa dos donos a esse habitat e um baixo escore corporal foram associados a um maior uso dele.

4. O uso de vegetação nativa é mínimo, e os cães passam a maior parte do tempo ao redor de suas casas dentro da matriz. É possível que seu impacto esteja relacionado à sua alta densidade dentro da matriz, o que poderia fazer com que espécies nativas evitassem essas áreas, reduzindo assim a conectividade entre fragmentos de vegetação nativa. O movimento dos cães é significativamente influenciado pelos contextos em que estão inseridos e por suas características genéticas. Dada a distribuição global dos cães e os diversos papéis que desempenham na sociedade, esforços devem ser feitos nas áreas onde os cães estão presentes para investigar seus papéis e possíveis impactos dentro de cada contexto específico.

Palavras-chave: áreas protegidas, manejo da conservação, papel ecológico, conservação da biodiversidade, rastreamento por GPS.

1. INTRODUCTION

The domestic dog (*Canis familiaris*) is believed to have been the first animal to be domesticated approximately 20,000 years ago (Botigué et al., 2017; da Silva Coelho et al., 2021; Perri et al., 2021). It belongs to an evolutionary lineage derived from the gray wolf

(*Canis lupus*) (Gompper, 2014). Dogs are considered one of the most widespread carnivores globally, with populations estimated at nearly one billion individuals, largely due to their reliance on human-provided resources (Gompper, 2014). Given their dependence on human resources and their presence across various ecological gradients, Vanak and Gompper (2009) classified dogs into various categories to facilitate communication among researchers (Vanak & Gompper, 2009). These classifications highlight that all dogs can interact with wildlife, often resulting in significant negative impacts on biodiversity (Doherty et al., 2017). Among these categories, feral and free-ranging dogs are particularly responsible for impacting wild animal populations (Gompper, 2014). The wide-ranging ability of dogs in natural habitats increases their potential for competing with sympatric carnivores not only on the outskirts of human settlements but also within native habitats (Vanak et al., 2014).

Domestic dogs have contributed to the extinction of 11 vertebrate species and pose a potential or known threat to at least 188 threatened species worldwide (Doherty et al., 2017). Most of the impacts reported involve predation on mammals, followed by disturbance, disease transmission, competition, and hybridization (Doherty et al., 2017). In Brazilian national parks, predation, competition, and pathogen transmission by dogs have affected numerous native species, particularly mammals such as agoutis (*Dasyprocta leporina*), capybaras (*Hydrochoerus hydrochaeris*), tapirs (*Tapirus terrestris*), coatis (*Nasua nasua*), and giant-anteaters (*Myrmecophaga tridactyla*) (Lessa et al., 2016). In New Zealand, a single dog was responsible for the death of 13 kiwis (*Apteryx mantelli*), accounting for 56.5% of an entire monitored group (Taborsky, 1988). However, in protected areas of the United States of America east, dogs were not considered a threat, despite being the most detected non-human mammals in the region (Parsons et al., 2016). All the three species tested, the white-tailed deer (*Odocoileus virginianus*), the eastern gray squirrel (*Sciurus carolinensis*) and the northern raccoon (*Procyon lotor*) exhibited more temporal avoidance of humans with and without dogs than temporal avoidance of unattended dogs (Parsons et al., 2016). Additionally, results in Brazil showed that native species did not display temporal avoidance of dogs, an introduced predator, to a greater extent than they avoid natural predators puma (*Puma concolor*), maned wolf (*Chrysocyon brachyurus*), and ocelot (*Leopardus pardalis*) (Moretto et al., 2024, unpublished manuscript). Therefore, the impact of dogs on biodiversity varies depending on the environment, emphasizing the importance of context-specific studies.

Around 75% of the global dog population consists of free-ranging dogs, with approximately 60% of them found in rural settings (Hughes & Macdonald, 2013; Gompper, 2014). This places free-ranging rural dogs in a prominent position in terms of biodiversity impacts, underscoring the necessity for further study. Rural environments are where interactions between dogs and wildlife are most likely to occur, especially in less development areas. However, not all rural dogs are alike. The likelihood and types of interactions that may occur between dogs and wildlife depend on the collective space use of the individual dogs (Gompper, 2014). Studies on biological information, such as the home range and habitat use of animals, can be instrumental in identifying roaming dogs, particularly those with higher levels of roaming. This type of information can inform mass vaccination efforts, as these dogs are most likely to transmit diseases (Hudson et al., 2017). Particularly concerning the conservation of areas and habitats of threatened species, understanding the movement and habitat use patterns of free-ranging domestic dogs is crucial in minimizing the risks to wildlife associated with interactions with this species (Sepúlveda et al., 2015).

Several factors can be considered drivers of the roaming behavior of free-ranging rural dogs, and the influence of each of these drivers is diverse. Older dogs tend to exhibit lower activity levels per hour, resulting in smaller home ranges for these animals (van Bommel & Johnson, 2014), nevertheless in other cases the younger dogs could present smaller home ranges (Warembourg et al., 2021). Castration appears to be negatively correlated with the home range size of males and positively correlated with the home range of females, as castrated males tend to travel less compared to intact males, whereas the opposite trend is observed in females (Dürr et al., 2017). Females may also exhibit a noticeable increase in home range when they are in estrus or lactating (Pal, 2003). Dogs may have smaller home ranges during the wet season due to water barriers restricting movement, the abundance of water and increased food availability, reducing their need to travel in search of resources (Dürr et al., 2017). Dog ranges appear to include areas closely associated with human routines or work (Dos Santos et al., 2018; Tiwari et al., 2019; Wilson-Aggarwal et al., 2021; Schüttler et al., 2022). In Brazil, the home range of dogs primarily encompasses the areas where they are fed and agroforests, their owners workplaces (Dos Santos et al., 2018). While dogs whose owners hunt may have a 2.6 times larger home range than dogs whose owners do not hunt (Wilson-Aggarwal et al., 2021), the hunter activity may cause no effect in dogs home ranges (Warembourg et al., 2021). The care provided by humans also affects the home range. Even though dogs do not have owners, people tend to feed them, resulting in smaller home range areas as they do not need to venture long distances to find resources (Tiwari et al., 2019). The provision of resources also prevents these animals from forming groups, as dogs most often sighted in a group tend to have larger home ranges than those mostly sighted alone (Tiwari et al., 2019), because larger groups require larger areas to obtain resources. However, low body score, i.e. lack of food resources, also can be associated with smaller home ranges (Warembourg et al., 2021).

Human attitudes toward dogs can significantly influence their interactions with wildlife (Serpell, 2017) and act as a catalyst for the invasion of native areas, posing numerous threats. In Brazil, the presence of dogs in protected areas is frequently reported (Paschoal et al., 2016), nevertheless, the impacts caused by domestic dogs, as well as the reasons for their invasion of native areas, remain poorly understood. The invasion of these carnivores into native vegetation areas may represent a widespread additional threat, attributed to the combination of high human population density and extensive deforestation (Ribeiro et al., 2019). With the increase in human activities surrounding protected areas, dogs can more easily access natural areas, leading to a mosaic landscape and an increase in habitat edges that juxtapose disturbed and natural habitats (Paschoal et al., 2018). Also, the more care an animal receives from its owners, the less likely it is to prey on wild animals (Silva-Rodríguez & Sieving, 2011; Sepúlveda et al., 2014) and consequently, use native vegetation. This is a importante information considering that dog attacks on mammals can predominantly occur near protected areas (Nayeri et al., 2022).

Our paper aimed to investigate the home range and habitat use of free-ranging rural dogs in the vicinity of a protected area and fragments of native vegetation in a Brazilian savannah area located in São Paulo, Brazil. Additionally, we aimed to investigate which variables influence the home range of dogs and to test the hypothesis that dogs with lower body scores, those who follow their owners in daily activities, and those living close to native vegetation are the ones that utilize it the most. This study represents the first application of GPS tracking devices to monitor the movement of free-ranging rural dogs in Brazil. From the GPS data, we gained crucial insights into the ranging behavior and habitat utilization of dogs, as well as potential factors influencing this behavior.

2. MATERIAL AND METHODS

2.2. Study area

The study area was a typical rural landscape located in the northern region of São Paulo state, in the region of the Pedregulho city and encompassing the surroundings of Furnas do Bom Jesus State Park (PEFBJ) with 2,069 ha and Furnas do Rio Grande Special Protected

Area (ASPE do Rio Grande) with 16,742 ha (Fig. 1). Semideciduous seasonal forest formations cover the rugged areas, while the Cerrado biome predominates in higher elevations (Sasaki & Mello-Silva, 2008). Pasturelands and coffee plantations are the main agricultural activities in the region. According to the Köppen classification, the climate is of the Cwb type, defined as highland tropical, with an average annual rainfall of 1.545 mm and mean annual temperatures ranging from 13.7 °C e 26.5 °C (CEPAGRI, 2016 cited in Gouvea, 2020).

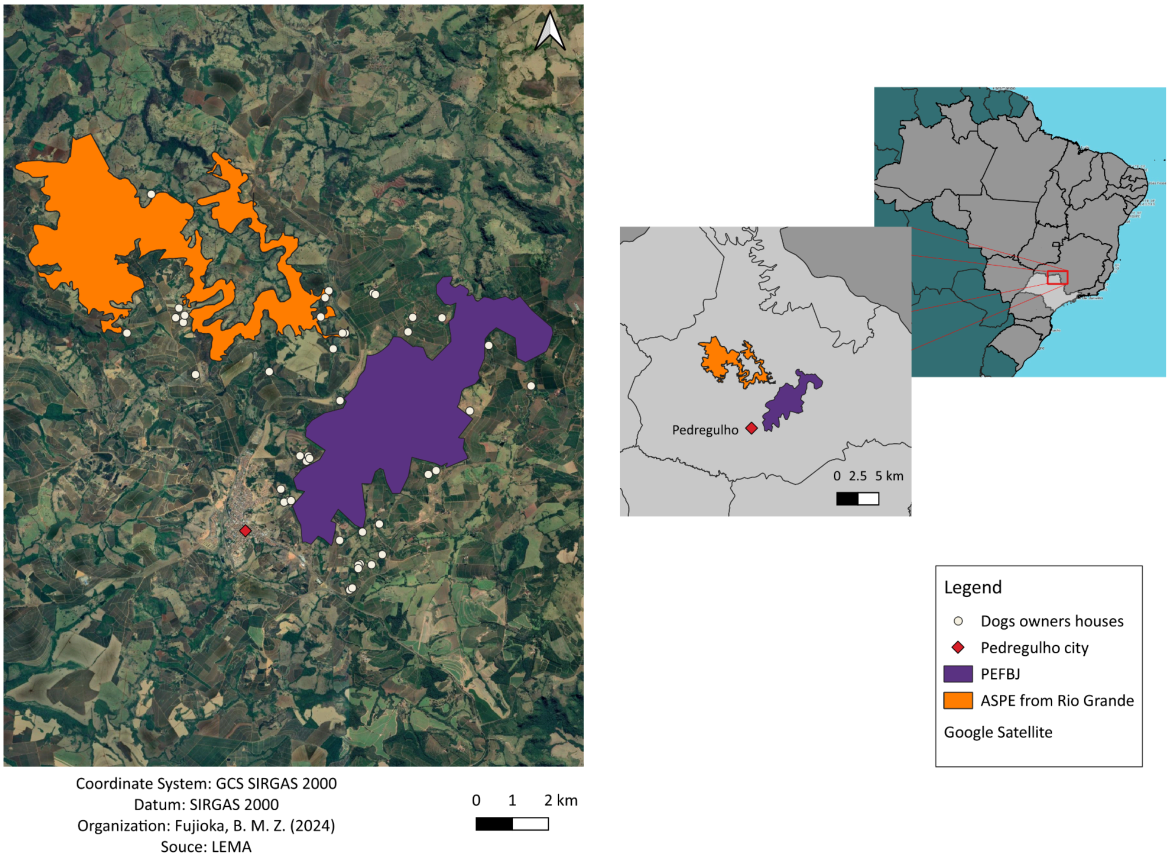

Figure 1. Study area depicting the locations of the homes of dog owners who participated in the study, surrounding the Furnas do Bom Jesus State Park (PEFBJ), part of Furnas do Rio Grande Special Protected Area (ASPE do Rio Grande) and fragments of native vegetation, in the region of Pedregulho city.

2.3. Data sampling

The project involved free-living domestic dogs from different households sampled between August 2022 and January 2024. Owners of each household were invited to participate in the research in person or through messaging/calling, with participation in the study confirmed only upon signing an informed consent form (*Termo de Consentimento Livre e Esclarecido - TCLE*).

The health of the dogs was examined through physical assessment and body score measurement. The body score of dogs was assessed through a physical examination carried out by veterinarians, following a standardized nine-point scale established by The World Small Animal Veterinary Association - WSAVA (Freeman et al., 2011). If the owner did not know the age of their animals, veterinarians estimated this through dentition. Furthermore, as a counterpart for their participation in the study, all participating dogs received V8 and rabies vaccinations. The V8 vaccine (similar to DHPPI+L) protects against eight diseases: distemper, hepatitis (Adenovirus type I), parvovirus, coronavirus, respiratory infections (Adenovirus type 2), parainfluenza and strains of leptospirosis.

The variables we tested were collected in different ways. Through a questionnaire, we obtained information about the dogs, such as sex, age, neuter status, and pack size only of free roaming dogs and whether the dogs accompany the owners during these routine activities. It was measured by a scale ranging from 0 to 2, where 1 corresponds to "does not accompany," 2 to "accompanies 2 to 4 times a week," and 3 to "accompanies every day." The distance from the owner house to the nearest native vegetation area was calculated using QGIS (version 3.30.3).

We monitored dogs using a remote monitoring system developed by the Max Planck Institute of Animal Behavior, adapted in collars (Fig. 2), that captured locations every hour. As per the physical assessment conducted by veterinarians and information collected in the questionnaire, only adult, healthy dogs weighing over five kilograms, and having unrestricted access to outdoor areas were included in the study. Because of these conditions, from the 136 dogs sampled from 55 owners in the study, only 105 from 46 owners could be included in the GPS monitoring stage. Each monitoring period lasted for two months, with battery maintenance and data download conducted every 30 days.

Figure 2. Procedures conducted during sampling. (a) GPS. (b) Vaccination. (c) GPS collar adaptation. (d-e) Dogs wearing GPS, indicated by the red arrow.

All procedures described complied with the ethical standards of the human research committee (*Certificado de Apresentação de Apreciação Ética - CAAE*), granted under the number 54901322.5.0000.9029; and animal use ethics committee (*Comissão de Ética de Uso de Animais - CEUA*), granted under number 69/21.

2.4. Data analysis

We utilized the Cat Lora software, developed by the Max Planck Institute of Animal Behavior, to retrieve the GPS data and transfer them to the Movebank (Kays et al., 2021) database platform. Within Movebank, we implemented three filters to exclude potentially erroneous GPS fixes: speeds >5.56m/s (Wilson-Aggarwal et al., 2021), GPS Horizontal Dilution of Precision (Hdop) >3.3, and Height Above Ellipsoid <650 and >1200 were excluded.

Home range estimation was conducted in Moveapps platform (Kölzsch et al., 2022). Initially, we retrieved the movement tracks from a Movebank study using the Movebank location move1 package (Hirt et al., 2023) and converted the data to a telemetry.list class using the MoveStack package (Scharf, 2023). We generated a variogram (Sciaini & Signer, 2023a) to distinguish range-resident individuals, excluding non-range-resident ones from home range analyses. Movement models were fitted using the continuous-time movement models (ctmm) function (Sciaini & Signer, 2023b), including the Independent Identically Distributed (IID) model, correlated positions but uncorrelated velocities (Ornstein–Uhlenbeck or OU) (Uhlenbeck & Ornstein, 1930), and correlated positions and velocities (Ornstein–Uhlenbeck foraging process or OUF) (Fleming et al., 2014; Noonan et al., 2019). The best model was then employed to estimate home ranges via Autocorrelated Kernel Density Estimation (95% AKDE) (Fleming et al., 2015; Sciaini & Signer, 2023c), while the IID model was utilized to provide the traditional 95% KDE home range estimation (Sciaini & Signer, 2023b). This approach was selected due to evidence indicating that conventional home range measures may underestimate space use (Noonan et al., 2019).

We tested whether the following variables: sex, age, body score, neuter status, pack size, whether the dogs follow their owners in their daily activities, and distance from the house to the nearest native vegetation area influenced the home range size of the dogs. We conducted this analysis using a General Linear Model (GLM) with a Gaussian distribution. Prior to analysis, numeric variables were normalized using the function BoxCox.lambda with MASS (Venables & Ripley, 2002) and fpp (Hyndman, 2013) packages, and normality distribution was confirmed using the Shapiro-Wilk test. All analysis were conducted in the RStudio programming language (version 2023.06.0+421; R Core Team, 2023).

To quantify the percentage of native vegetation in the home ranges, we employed QGIS and the RStudio programming language. We acquired shapefiles for each location of dogs and tilizing packages such as adehabitat (Calenge & Fortmann-Roe, 2023), landscapemetrics (Hesselbarth et al., 2019), raster (Hijmans, 2023), rgdal (Bivand et al., 2023), rgeos (Bivand & Rundel, 2023), and sp (Pebesma & Bivand, 2005; Bivand et al., 2013), we extracted land use and coverage data for each location. Specifically, we accessed the Land Use and Cover Map (pixel of 30m) for the city of Pedregulho provided by Mapbiomas (2022).

We examined whether dogs exhibiting the behavior of accompanying their owners during daily activities utilized native vegetation more than those that did not exhibit the same behavior. The same was made using the body score variable and distance from the owners house to the nearest natural area. This analysis was conducted using the Spearman correlation test within the RStudio environment. Graphical representations were created using the ggplot2 (Wickham, 2016) and ecodados (Paterno et al., 2023) packages.

3. RESULTS

Twenty one dogs monitored were excluded from the study due to GPS or battery malfunctions, GPS loss or damage, or because the dogs did not adapt well to wearing the collar. With the remaining 84 dogs belonging to 35 owners, we collected 35,292 GPS fixes, which were subsequently reduced to 34,030 after excluding 1,262 erroneous fixes using the filters. Thirty three dogs were female (39.29%) and 51 were male (60.71%). Ages ranged from five months to 14 years, with a mean of 3,64 years. Body scores ranged from 2 to 7, with an average of 4.38. Seventy one dogs were not neutered (84.52%), while 13 were neutered (15.48%). The size of free-ranging dog packs ranged from one to nine individuals, with an average of 4.45 individuals per pack. Distance from the owners houses to the closest native vegetation ranged from 9.22 to 1,018.22 meters, with an average of 163.09 m. Thirty one dogs (36.90%) that did not accompany them in daily activities, 7 dogs (8.34%) that accompanied them 2 to 4 times a week, and 46 dogs (54.76%) that accompanied them every day.

3.1. Home range

All the dogs monitored were range residents. Their size of home ranges ranged from 0.89 ha to 624.75 ha, with an average of 30.74 ha. The home range of most of the dogs was very reduced, with sizes until 25.23 ha corresponding to 75% of the values obtained (Fig. 3-4).

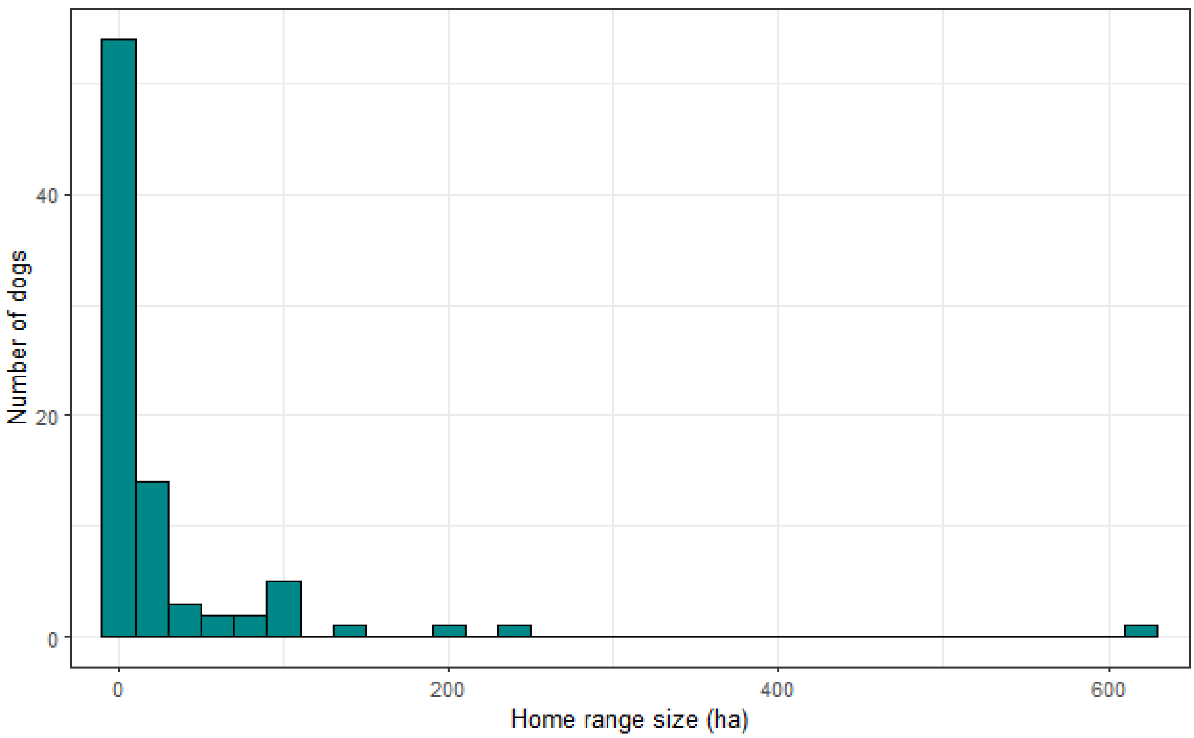

Figure 3. Distribution of home range size of 84 free-ranging domestic dogs, estimated with AKDE (95%).

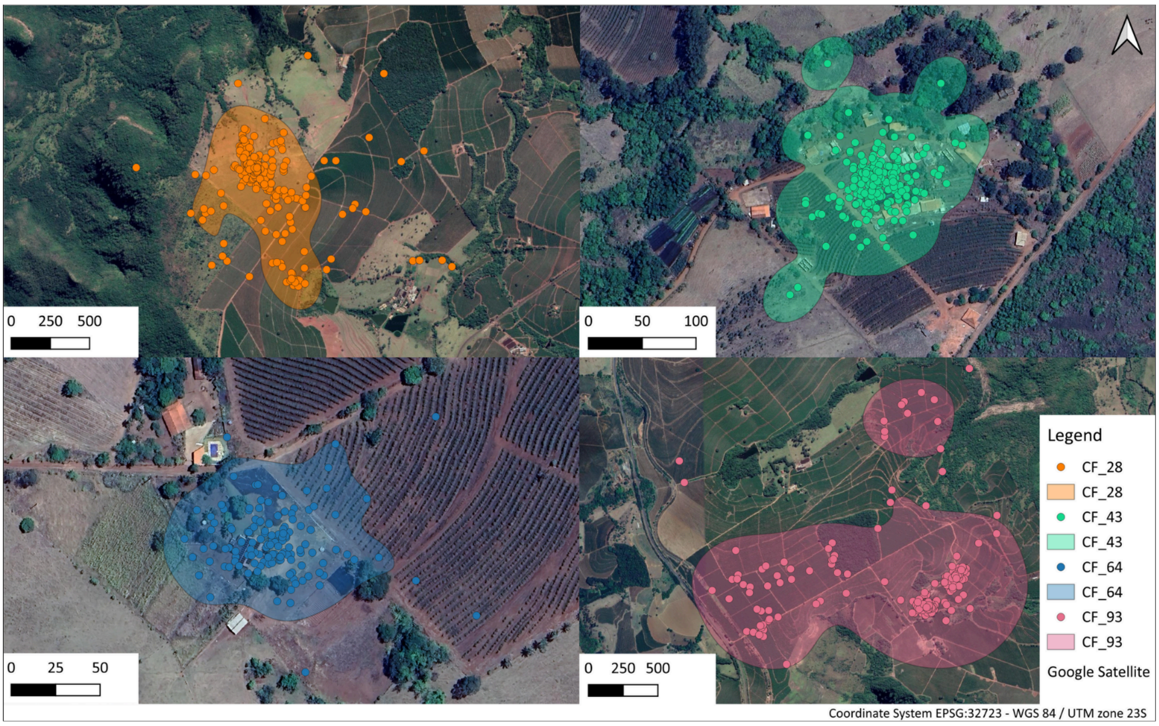

Figure 4. Some home ranges of free-ranging domestic dogs, estimated with AKDE (95%). Each color represents some of the dogs monitored in the study.

The body score of dogs (Body_score) had a significant impact on the size of the home range (t = -2.19, p=0.03), with lower body score values associated with larger home range areas. The frequency with which dogs accompany their owners in daily activities (Owners_following) also showed a significant influence (t = 2.61, p=0.01), with a positive association between frequent accompanying and home range size. The other variables showed no influence in their home ranges (Table 1, Fig. 5).

Table 1. Results of the GLM assessing the drivers of home range sizes for 84 free-ranging rural domestic dogs, obtained with seven variables. **Estimate** = estimate of the variables effect on the response variable, **Std. Error** = the standard error of the coefficient estimate, **t value** = test statistic, **(Pr(>|t|)** = p-value.

	Estimate	Std. Error	t value	Pr(>|t|)

(Intercept)	1.12691	0.51168	2.202	0.0307*
Sex	0.17251	0.17094	1.009	0.3161
Age	0.06972	0.06870	1.015	0.3134
Body score	-0.25637	0.11659	-2.199	0.0309*
Neuter status	0.27213	0.22431	1.213	0.2288
Pack size	0.04634	0.08815	0.526	0.6006
Distance to native vegetation	0.05034	0.03049	1.651	0.1028
Owners following	0.21219	0.08119	2.613	0.0108*

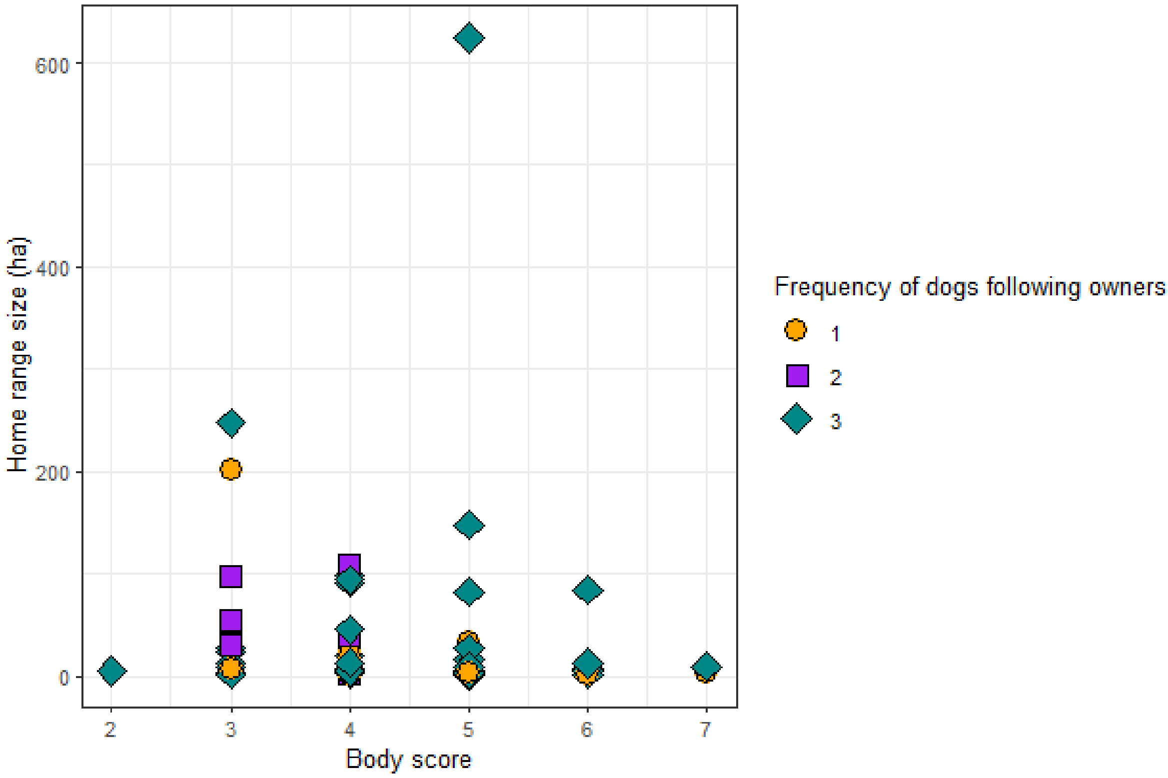

Figure 5. Distribution of home range size in relation to the two variables that influenced the home range of dogs (body score and follow of owners). Orange circles indicate dogs that never follow their owners in daily activities, purple squares indicate dogs that exhibit this behavior 2-4 times per week, and cyan rhombus indicates dogs that follow their owners daily.

3.2. Use of native vegetation

Between the locations obtained, 30,164 (88.63%) were in agriculture (sugar cane, mixed land uses, coffee, citrus and other perennial crops), 2,502 (7.35%) in pasture, 1.134

(3.94%) in native vegetation (forest formations and savanna), 22 (0.06%) in non-forest natural formations (wetland and grassland) and 13 (0.03%) in urban areas. The number of locations in native vegetation ranged from zero 0 to 509, with an average of 15.78 locations. Most dogs showed limited use of this habitat type, with 75% of them having a maximum of seven locations. All the dogs presented the most use of agriculture. One dog, in particular, showed a prominent use of native vegetation, with 509 locations, 401 more locations than the second bigger use (Fig. 6-7).

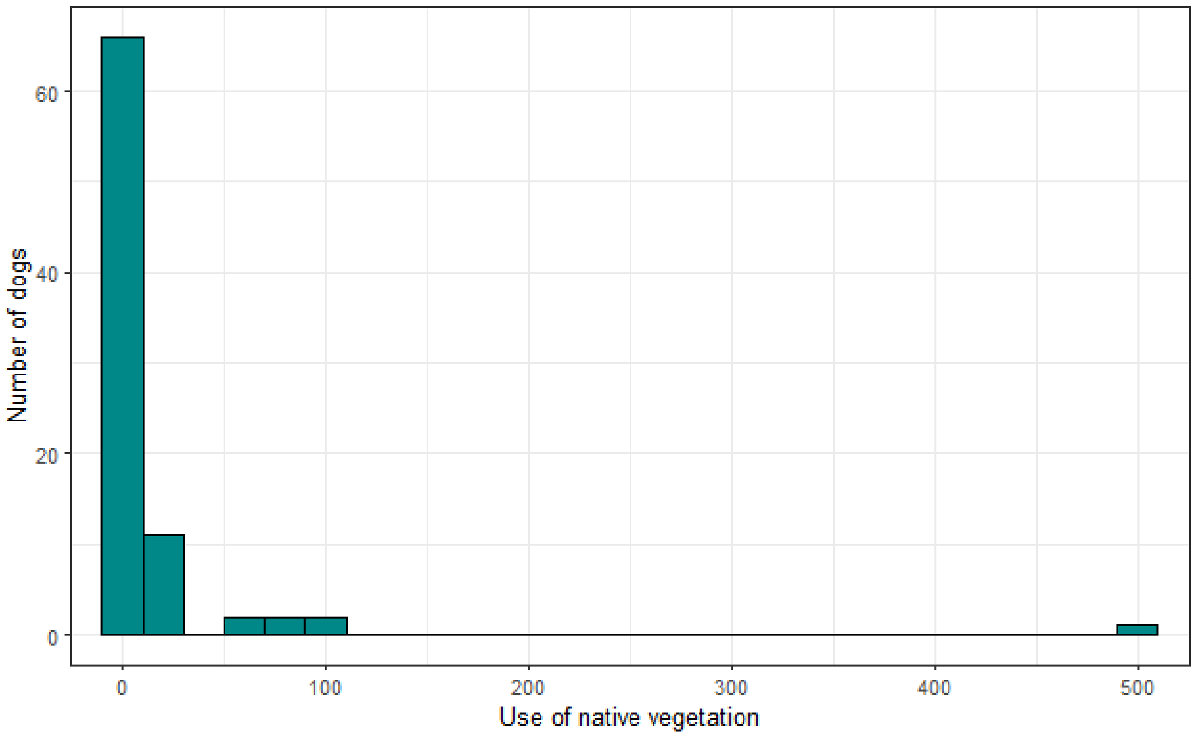

Figure 6. Distribution of the number of locations recorded in native vegetation with 84 free-ranging domestic dogs.

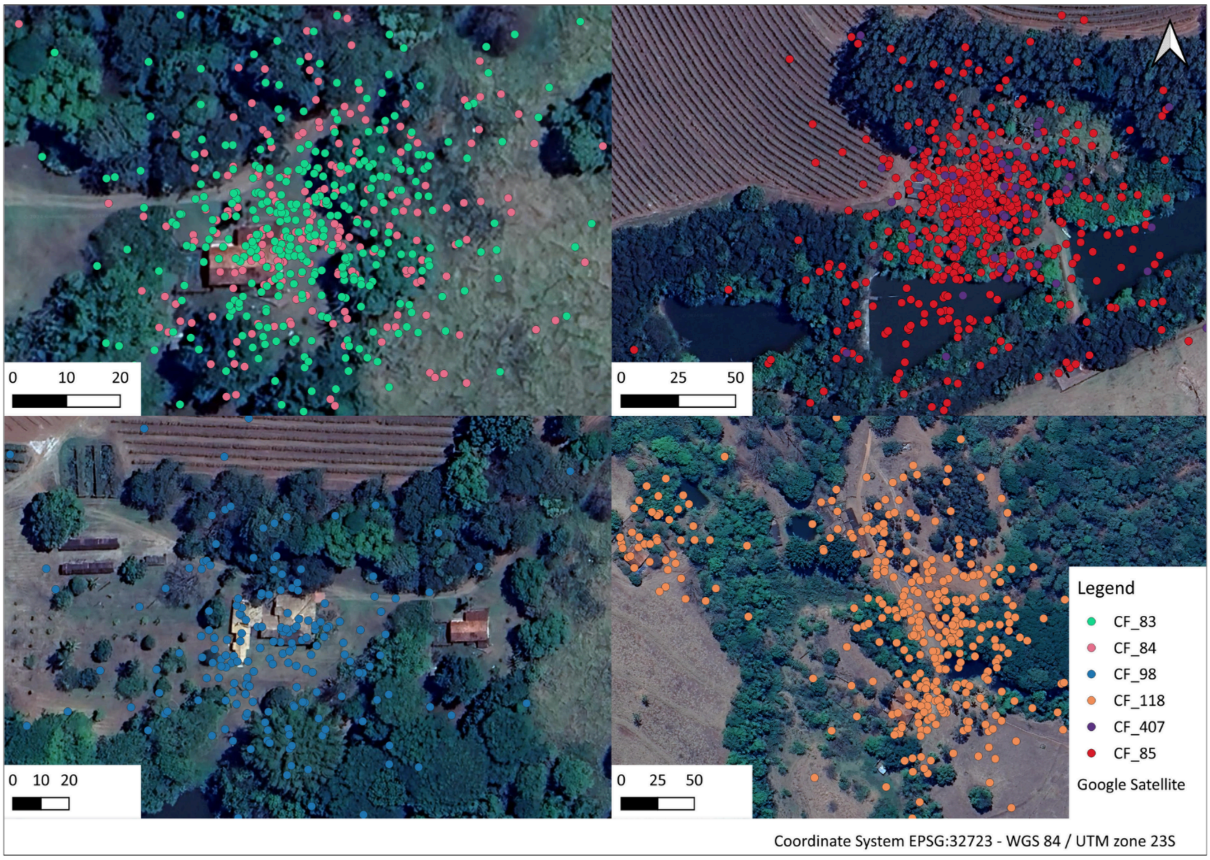

Figure 7. Some locations recorded in native vegetation of free-ranging domestic dogs. Each color represents some of the dogs monitored with more locations in this habitat.

Our results showed a negative correlation between body score and use of native vegetation, (rho=-0.23, p-value=0.03) and the same pattern was found for distance from these areas (rho=-0.27, p-value=0.01). This indicated that dogs with low body scores and that ones living closer to native vegetation tend to use them more. The following of owners by dogs during daily activities resulted in no correlation with the use of these areas (rho=0.02, p-value=0.83) (Fig. 8).

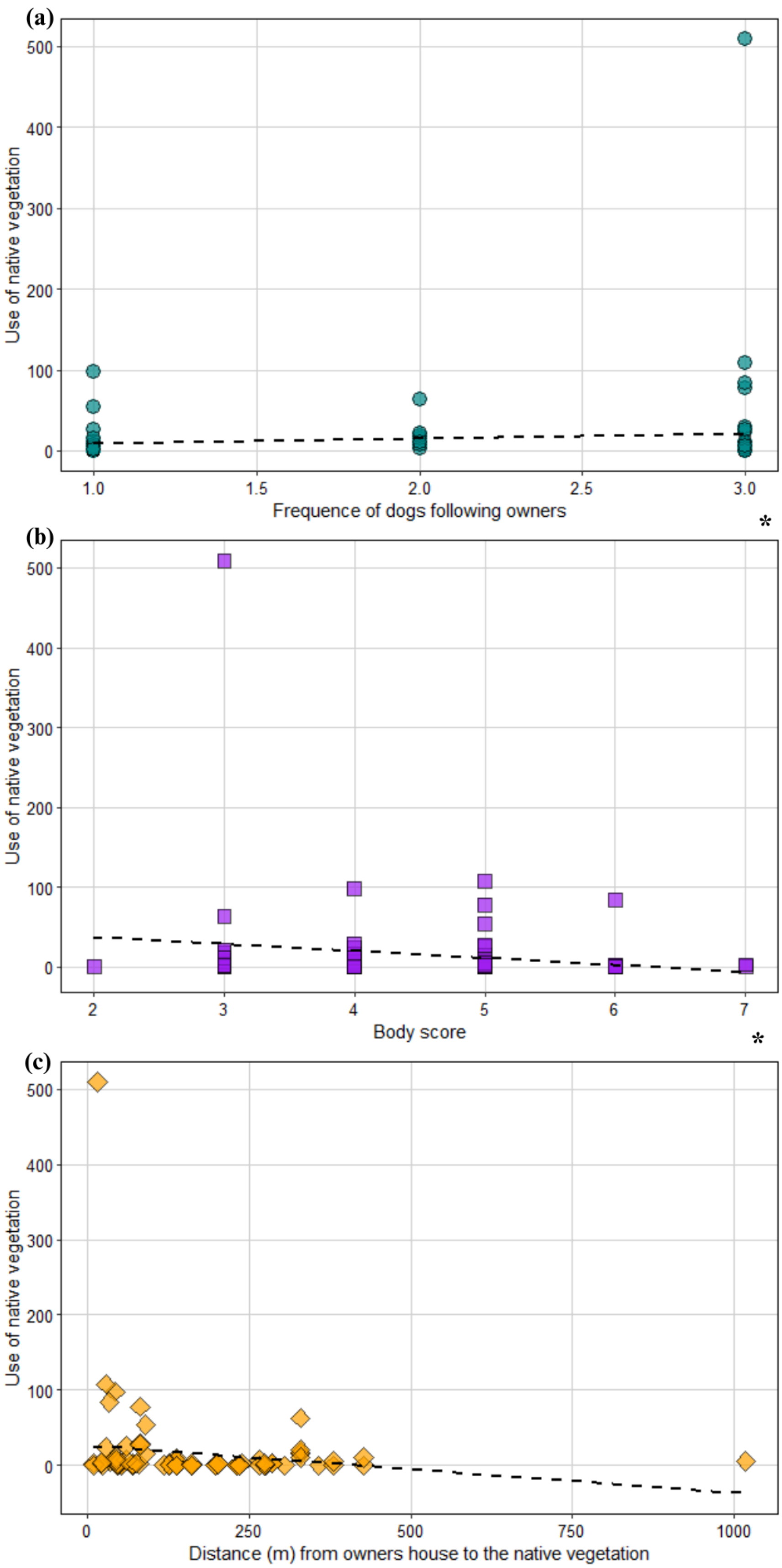

Figure 8. Distribution of the number of locations recorded in native vegetation with 84 free-ranging domestic dogs with the three variables tested (follow of owners, body score and

distance to native vegetation). (a) Correlation between locations in native vegetation and frequency of dogs accompanying their owners in daily activities (1- Does not accompany, 2- Accompanies 2 to 4 times a week, 3 - Accompanies every day). (b) Correlation between locations in native vegetation and dogs body score (1 to 3 - low score, 4 to 6 - optimal score, 7 to 9 - high score). (c) Correlation between location in native vegetation and distance in meters from their owners house to the nearest native vegetation area.
The * indicated significant p-value.

4. DISCUSSION

Free-ranging rural dogs pose a significant threat to biodiversity due to their large populations and easy access to native areas. Investigating the movements of these animals is crucial for understanding the potential impacts they may have on wildlife conservation. Our findings on home range sizes indicate that these dogs do not roam extensively and tend to have smaller home ranges. The primary drivers of this behavior include the frequency with which the dogs accompany their owners during daily activities and the low body scores of these animals. Additionally, our results suggest that dogs spend most of their time around farming and human settlements, and only occasionally in native vegetation. The use of these areas was found to be negatively correlated with the dogs body scores and the proximity of their owners houses to native vegetation.

The size of the home range of dogs can vary greatly, and studies indicate that this variation is distributed between 0.0021 ha to 2,706.40 ha (see Chapter 1 - Fujioka & Bianchi, 2024, unpublished data). Our values of home range size are consistent with those reported in other studies conducted with rural dogs in Brazil (Dos Santos et al., 2018), as well as in Australia (van Bommel & Johnson, 2014; Dürr et al., 2017), Chad (Wilson-Aggarwal et al., 2021), India (Pal, 2003; Vanak & Gompper, 2010; Tiwari et al., 2019), Kenya (Muinde et al., 2021), Guatemala, Indonesia and Uganda (Warembourg et al., 2021). However, dog home range sizes can vary significantly, with much smaller sizes recorded in Tibet (Vaniscotte et al., 2011) and Kyrgyzstan (Van Kesteren et al., 2013), and much larger sizes reported in Chile (Schüttler et al., 2022). Comparing home range sizes across studies can be challenging due to variations in the estimators used to infer home range. Schüttler et al. (2022), who also used AKDE to estimate home ranges, reported sizes ranging from 174.50 ha to 2706.40 ha, which are much larger than those found in our study (Schüttler et al., 2022). Conversely, Wilson-Aggarwal et al. (2021), who also employed the same estimator, reported results more similar to ours, with home range sizes ranging from 4.00 ha to 54.00 ha (Wilson-Aggarwal et al., 2021).

The home range sizes identified in our study align with those found in other investigations, although variations do exist. Comparing home range sizes across different studies can be challenging due to differences in the estimators used. Schüttler et al. (2022), who also utilized AKDE for estimating home ranges, reported significantly larger sizes compared to those in our study. On the other hand, Wilson-Aggarwal et al. (2021), using the same estimator, found results more similar to ours. According to our data, dogs that accompany their owners in daily activities tend to have larger home ranges. These carnivores often establish their home ranges in areas connected to their owners, typically where food and shelter are provided (Silva-Rodríguez & Sieving, 2011; Dos Santos et al., 2018; Tiwari et al., 2019; Contardo et al., 2021). In India, dogs with smaller home ranges were found to have a closer affinity with humans (Tiwari et al., 2019) and a greater reliance on food provided by them (Dos Santos et al., 2018). Our findings also reveal a negative relationship between body score and home range size, suggesting that dogs with lower scores tend to roam more, possibly due to limited food resources provided by their owners or increased competition for these resources, which compels these dogs to roam further to satisfy their energy needs

(Molloy et al., 2017). It is also conceivable that dogs with larger home ranges are inherently more active (Molloy et al., 2017).

The use of native vegetation appears not to be influenced by dogs following their owners in daily activities. This finding contrasts with previous studies, which suggested that dog movements in native vegetation areas are associated with specific owner activities, such as hunting (Wilson-Aggarwal et al., 2021) and agricultural work (Dos Santos et al., 2018). A study conducted in Chile revealed that 98% of monitored dogs accessed natural areas independently of their owners company (Saavedra-Aracena et al., 2021), and these animals were also found at significant distances from where the studies were conducted (Van Kesteren et al., 2013; Contardo et al., 2021). Therefore, the bond between humans and dogs does not necessarily prevent these carnivores from exploring more distant locations, and it is likely that the dogs in our study ventured to these places on their own. In our study area, there is evidence of hunting in the protected areas, and it is possible that the hunters either refused to participate in the study or agreed to participate but removed the GPS devices when they went hunting. Consequently, our results may not fully represent the use of native vegetation by the dogs.

In our study, a low body score appears to be related to the use of native vegetation. This likely occurs because dogs that do not have their nutritional needs fully met by their owners turn to native vegetation to find resources. This situation has significant implications for wildlife, as dogs that are not adequately fed are more inclined to prey on wild animals (Silva-Rodríguez & Sieving, 2011; Sepúlveda et al., 2014; Gompper, 2014), and consequently, they are more likely to utilize native vegetation. The use of these areas by dogs also seems to be influenced by the proximity of their owners houses to them. The likelihood of dogs spending time in protected areas appears to be higher if the density of human residences is greater (Paschoal et al., 2016), while the avoidance of native forests could be associated with the distance of these areas from the owners residences (Silva-Rodríguez et al., 2010). Therefore, dogs that live farther from native vegetation in our study area spend limited time in these habitats, largely because they depend heavily on resources provided by their owners, resulting in minimal time spent away from them. Considering that numerous rural houses are located near areas of native vegetation (Mapbiomas, 2022), in hotspots, the impacts of dogs can be more pronounced due to the high density of dogs (Ribeiro et al., 2019) in developing countries, as well as the high number of species likely to come into contact with these dogs.

Although the dogs in our study generally did not roam extensively and exhibited small home ranges, some exhibited larger ranges. Understanding the movements of these specific individuals is crucial for biodiversity conservation. Identifying dogs that roam more extensively is essential for guiding management and conservation actions, such as mass vaccination (Tiwari et al., 2019) and control programs (Molloy et al., 2017), since these dogs are more likely to transmit diseases (Pal, 2003; Wilson-Aggarwal et al., 2021). For instance, in Chile, significant movement was recorded by a single dog because it followed tourists on a trekking trail (Schüttler et al., 2022). Although this was an isolated incident, it should be carefully documented as it holds important implications for decision-making, especially regarding the control of animal access to tourist areas.

Despite our findings suggesting that dogs utilize little native vegetation, this does not mean they are without impact. Dogs can influence how native species use the matrix, and given the high density of dogs in the matrix of our study area, they may cause native species to avoid that, thereby disrupting connectivity between fragments of native vegetation. Research has shown that matrix development intensity, along with the presence of feral predators like dogs, can profoundly negatively affect species richness (Brady et al., 2011). Open areas may be unsuitable for small marsupials due to the increased risk of predation by dogs or raptors (Forero-Medina & Vieira, 2009). In Brazil, the presence of dogs within protected areas is often considered an edge effect. Maned wolves, for example, seem to avoid areas frequented by dogs, such as those near garbage dumps (Lacerda et al., 2009). Instances of maned wolf persecution by dog packs within protected areas have also been documented, likely contributing to their avoidance of areas populated by dogs (Lacerda et al., 2009).

5. CONCLUSION

The home ranges of dogs are small, based on size of animal monitored, and appear to be influenced by their habit of accompanying their owners in daily activities and their low body scores. Although dogs rarely utilize native vegetation, instances where they do tend to involve those living close to these habitats and exhibiting low body scores. Since the use of native vegetation is minimal, and dogs spend most of their time around their homes within the matrix, it is possible that their impact is not directly related to the use of native vegetation. Instead, it may be related to their high density within the matrix, which could cause native species to avoid these areas, thereby reducing connectivity between fragments of native vegetation. Therefore, the impact on native species cannot be entirely dismissed and warrants further investigation. Besides, several animals were recorded inside the protected area by camera traps (Manzo & Bianchi, 2024, unpublished manuscript). Likelly, these animals belong to owners who did not agree to participate in the research because they use the dogs for illegal activities, like poaching. The movement of dogs is significantly influenced by the contexts in which they are placed and by their genetic backgrounds. Given the global distribution of dogs and the diverse roles they play in society, efforts should be made in areas where dogs are present to investigate their roles and potential impacts within each specific context.

REFERENCES

Bivand R., Keitt T., Rowlingson B. (2023). _rgdal: Bindings for the 'Geospatial' Data Abstraction Library_. R package version 1.6-7. https://CRAN.R-project.org/package=rgdal

Bivand R., Pebesma E., Gomez-Rubio V. (2013). Applied spatial data analysis with R, Second edition_. Springer, NY. https://asdar-book.org/

Bivand R. & Rundel C. (2023). _rgeos: Interface to Geometry Engine - Open Source ('GEOS')_. R package version 0.6-3. https://CRAN.R-project.org/package=rgeos

Botigué, L. R., Song, S., Scheu, A., Gopalan, S., Pendleton, A. L., Oetjens, M., ... & Veeramah, K. R. (2017). Ancient European dog genomes reveal continuity since the Early Neolithic. *Nature communications*, *8*(1), 16082. https://doi.org/10.1038/ncomms16082

Brady, M. J., Mcalpine, C. A., Possingham, H. P., Miller, C. J., & Baxter, G. S. (2011). Matrix is important for mammals in landscapes with small amounts of native forest habitat. *Landscape Ecology*, *26*(5), 617–628. https://doi.org/10.1007/s10980-011-9602-6

Calenge C & Fortmann-Roe cfS (2023). _adehabitatHR: Home Range Estimation_.R package version 0.4.21. https://CRAN.R-project.org/package=adehabitatHR.

Contardo, J., Grimm-Seyfarth, A., Cattan, P. E., & Schüttler, E. (2021). Environmental factors regulate occupancy of free-ranging dogs on a sub-Antarctic island, Chile. *Biological Invasions*, *23*(3), 677–691.https://doi.org/10.1007/s10530-020-02394-3.

da Silva Coelho, F. A., Gill, S., Tomlin, C. M., Heaton, T. H., & Lindqvist, C. (2021). An early dog from southeast Alaska supports a coastal route for the first dog migration into the Americas. *Proceedings of the Royal Society B*, *288*(1945), 20203103. https://doi.org/10.1098/rspb.2020.3103.

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G., Vanak, A. T., & Wirsing, A. J. (2017). The global impacts of domestic dogs on threatened vertebrates. *Biological Conservation*, *210*, 56–59. https://doi.org/10.1016/j.biocon.2017.04.007

Dos Santos, C. L. A., Le Pendu, Y., Giné, G. A. F., Dickman, C. R., Newsome, T. M., & Cassano, C. R. (2018). Human behaviors determine the direct and indirect impacts of free-ranging dogs on wildlife. *Journal of Mammalogy*, *99*(5), 1261–1269. https://doi.org/10.1093/jmammal/gyy077

Dürr, S., Dhand, N. K., Bombara, C., Molloy, S., & Ward, M. P. (2017). What influences the home range size of free-roaming domestic dogs? *Epidemiology and Infection*, *145*(7), 1339–1350. https://doi.org/10.1017/S095026881700022X

Fleming, C. H., Calabrese, J. M., Mueller, T., Olson, K. A., Leimgruber, P., & Fagan, W. F. (2014). From Fine-Scale Foraging to Home Ranges: A Semivariance Approach to Identifying Movement Modes across Spatiotemporal Scales. *The American Naturalist*, *183*(5), 154–167. https://doi.org/10.5061/dryad.45157

Fleming, C. H., Fagan, W. F., Mueller, T., Olson, K. A., Leimgruber, P., & Calabrese, J. M. (2015). Rigorous home range estimation with movement data: A new autocorrelated kernel density estimator. *Ecology*, *96*(5), 1182–1188. https://doi.org/10.1890/14-2010.1

Forero-Medina, G., & Vieira, M. V. (2009). Perception of a fragmented landscape by neotropical marsupials: Effects of body mass and environmental variables. *Journal of Tropical Ecology*, *25*(1), 53–62. https://doi.org/10.1017/S0266467408005543

Freeman, L., Becvarova, I., Cave, N., MacKay, C., Nguyen, P., Rama, B., Takashima, G., Tiffin, R., van Beukelen, P., & Yathiraj, S. (2011). 2011 Nutritional Assessment Guidelines. *Journal of the South African Veterinary Association*, *82*, 254–263. http://www.jsava.co.za/index.php/jsava/article/view/84%5Cnhttp://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22616443

Fujioka, B. M. Z. & Bianchi, R. C. 2024. Where are the dogs going? The home range and the use of habitat by free ranging-rural and free-ranging village dogs (*Canis familiaris*). (Unpublished data).

Gompper, M. E. (2014). The dog–human–wildlife interface: assessing the scope of the problem. In M. E. Gompper (Ed.), *Free-Ranging Dogs and Wildlife Conservation* (pp.9–54). Oxford University Press

Gouvea, J. A. (2020). How does the giant anteater *Myrmecophaga tridactyla* use a landscape featuring high human disturbance and free-ranging dogs? (Master 's thesis). Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista "Júlio de Mesquita Filho", São José do Rio Preto, Brazil. Retrieved from https://repositorio.unesp.br/handle/11449/193076

Hesselbarth, M.H.K., Sciaini, M., With, K.A., Wiegand, K., Nowosad, J. 2019. landscapemetrics: an open-source R tool to calculate landscapemetrics. - Ecography 42:1648-1657 (v0.0)

Hijmans R (2023). _raster: Geographic Data Analysis and Modeling_. R package version 3.6-26. https://CRAN.R-project.org/package=raster

Hirt, J., Kölzsch, A., Scharf, A. K. (2023). Movebank Location move1. version v6.5 (22). MoveApps. https://github.com/movestore/movebank-download.git

Hudson, E. G., Brookes, V. J., Dürr, S., & Ward, M. P. (2017). Domestic dog roaming patterns in remote northern Australian indigenous communities and implications for disease modelling. *Preventive Veterinary Medicine*, *146*, 52–60. https://doi.org/10.1016/j.prevetmed.2017.07.010

Hughes, J., & Macdonald, D. W. (2013). A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation*, *157*, 341–351. https://doi.org/10.1016/j.biocon.2012.07.005

Hyndman RJ (2013). _fpp: Data for "Forecasting: principles and practice"_.R package version 0.5. https://CRAN.R-project.org/package=fpp

Lacerda, A. C. R., Tomas, W. M., & Marinho-Filho, J. (2009). Domestic dogs as an edge effect in the Brasília national park, Brazil: Interactions with native mammals. *Animal Conservation*, *12*(5), 477–487. https://doi.org/10.1111/j.1469-1795.2009.00277.x

Lessa, I., Guimarães, T. C. S., Bergallo, H. de G., Cunha, A., & Vieira, E. M. (2016). Domestic dogs in protected areas: a threat to Brazilian mammals? *Natureza e Conservação*, *14*(2), 46–56. https://doi.org/10.1016/j.ncon.2016.05.001

Kays, R., Davidson, S. C., Berger, M., Bohrer, G., Fiedler, W., Flack, A., ... & Wikelski, M. (2022). The Movebank system for studying global animal movement and demography. *Methods in Ecology and Evolution*, *13*(2), 419-431. https://doi.org/10.1111/2041-210X.13767

Kölzsch, A., Davidson, S. C., Gauggel, D., Hahn, C., Hirt, J., Kays, R., ... & Safi, K. (2022). MoveApps: a serverless no-code analysis platform for animal tracking data. *Movement Ecology*, *10*(1), 30. https://doi.org/10.1186/s40462-022-00327-4.

Manzo I. A. & Bianchi, R. C. (2024). The influence of domestic dogs on the spatial and temporal distribution of tayra. (Unpublished manuscript).

Mapbiomas. (2022.). MapBiomas Brazil. Retrieved April 11, 2024, from https://brasil.mapbiomas.org/

Molloy, S., Burleigh, A., Dürr, S., & Ward, M. P. (2017). Roaming behavior of dogs in four remote Aboriginal communities in the Northern Territory, Australia: preliminary investigations. *Australian Veterinary Journal*, *95*(3), 55–63. https://doi.org/10.1111/AVJ.12562

Moretto, L. R., Fujioka, B. M. Z., Da Silva, L. V., Olifiers, N., Riski, L. L., D'Andrea, S. P., Panosso, A. R., Kays, R., Dias, V. B., & Bianchi, R. de C. (2023). Free-ranging dog 's effects on the activity pattern of prey species in areas from Cerrado and Atlantic Forest, Brazil. (Unpublished manuscript). Retrieved from https://doi.org/10.21203/rs.3.rs-3342351/v1

Muinde, P., Bettridge, J. M., Sousa, F. M., Dürr, S., Dohoo, I. R., Berezowski, J., Mutwiri, T., Odinga, C. O., Fèvre, E. M., & Falzon, L. C. (2021). Who let the dogs out? Exploring the spatial ecology of free-roaming domestic dogs in western Kenya. *Ecology and Evolution*, *11*(9), 4218–4231. https://doi.org/10.1002/ece3.7317

Nayeri, D., Mohammadi, A., Qashqaei, A. T., Vanak, A. T., & Gompper, M. E. (2022). Free-ranging dogs as a potential threat to Iranian mammals. *ORYX*, *56*(3), 383–389. https://doi.org/10.1017/S00306053210000907

Noonan, M. J., Tucker, M. A., Fleming, C. H., Akre, T. S., Alberts, S. C., Ali, A. H., Altmann, J., Antunes, P. C., Belant, J. L., Beyer, D., Blaum, N., Böhning-Gaese, K., Cullen, L., de Paula, R. C., Dekker, J., Drescher-Lehman, J., Farwig, N., Fichtel, C., Fischer, C., … Calabrese, J. M. (2019). A comprehensive analysis of autocorrelation and bias in home range estimation. *Ecological Monographs*, *89*(2). https://doi.org/10.1002/ecm.1344

Pal, S. K. (2003). Reproductive behavior of free-ranging rural dogs in West Bengal, India. *Acta Theriologica*, *48*(2), 271–281.

Parsons, A. W., Bland, C., Forrester, T., Baker-Whatton, M. C., Schuttler, S. G., McShea, W. J., Costello, R., & Kays, R. (2016). The ecological impact of humans and dogs on wildlife in protected areas in eastern North America. *Biological Conservation*, *203*, 75–88. https://doi.org/10.1016/j.biocon.2016.09.001

Paschoal, A. M. O., Massara, R. L., Bailey, L. L., Doherty Jr, P. F., Santos, P. M., Paglia, A. P., Hirsch, A., & Chiarello, A. G. (2018). Anthropogenic Disturbances Drive Domestic Dog Use of Atlantic Forest Protected Areas. *Tropical Conservation Science*, *11*, 1–14. https://doi.org/10.1177/1940082918789833

Paschoal, A. M. O., Massara, R. L., Bailey, L. L., Kendall, W. L., Doherty Jr, P. F., Hirsch, A., Chiarello, A. G., & Paglia, A. P. (2016). Use of Atlantic Forest protected areas by free-ranging dogs: Estimating abundance and persistence of use. *Ecosphere*, *7*(10). https://doi.org/10.1002/ecs2.1480

Paterno G, Provete D, Silva F, Gonçalves-Souza T, Vancine M (2023). _ecodados: Base Dados Ecológicos Para o Ensino de Estatística_. R package version 0.0.1.

Pebesma E., Bivand R. (2005). “Classes and methods for spatial data in R.”_R News_, *5*(2), 9-13. https://CRAN.R-project.org/doc/Rnews/

Perri, A. R., Feuerborn, T. R., Frantz, L. A., Larson, G., Malhi, R. S., Meltzer, D. J., & Witt, K. E. (2021). Dog domestication and the dual dispersal of people and dogs into the Americas.

Proceedings of the National Academy of Sciences, *118*(6), e2010083118. https://doi.org/10.1073/pnas.2010083118

Ribeiro, F. S., Nichols, E., Morato, R. G., Metzger, J. P., & Pardini, R. (2019). Disturbance or propagule pressure? Unraveling the drivers and mapping the intensity of invasion of free-ranging dogs across the Atlantic forest hotspot. *Diversity and Distributions*, *25*(2), 191–204. https://doi.org/10.1111/ddi.12845

Saavedra-Aracena, L., Grimm-Seyfarth, A., & Schüttler, E. (2021). Do dog-human bonds influence movements of free-ranging dogs in wilderness? *Applied Animal Behaviour Science*, *241*. https://doi.org/10.1016/j.applanim.2021.105358

Sasaki, D., & Mello-Silva, R. D. (2008). Levantamento florístico no cerrado de Pedregulho, SP, Brasil. *Acta Botanica Brasilica*, 22, 187-202.

Scharf, A. K. (2023). MoveStack to Telemtry.list. version v2.0 (2). MoveApps. https://github.com/movestore/moveStack2telemetry.git

Schüttler, E., Saavedra-Aracena, L., & Jiménez, J. E. (2022). Spatial and temporal plasticity in free-ranging dogs in sub-Antarctic Chile. *Applied Animal Behaviour Science*, *250*. https://doi.org/10.1016/j.applanim.2022.105610

Sciaini, M., Signer, J. (2023a). Variogram. version 0.93 (2). MoveApps. https://github.com/ctmm-initiative/ctmmMoveApp_variogram.git

Sciaini, M., Signer, J. (2023b). Fit a Continuous-Time Movement Model (ctmm). version 0.6 (1). MoveApps. https://github.com/ctmm-initiative/ctmmMoveApp_modelselection.git

Sciaini, M., Signer, J. (2023c). Autocorrelated Kernel Density Estimate (aKDE). version 0.9 (3). MoveApps. https://github.com/ctmm-initiative/ctmmMoveApp_akde.git

Sepúlveda, M., Pelican, K., Cross, P., Eguren, A., & Singer, R. (2015). Fine-scale movements of rural free-ranging dogs in conservation areas in the temperate rainforest of the coastal range of southern Chile. *Mammalian Biology*, *80*(4), 290–297. https://doi.org/10.1016/j.mambio.2015.03.001

Sepúlveda, M. A., Singer, R. S., Silva-Rodríguez, E., Stowhas, P., & Pelican, K. (2014). Domestic dogs in rural communities around protected areas: Conservation problem or conflict solution? *PLoS ONE*, *9*(1). https://doi.org/10.1371/journal.pone.0086152

Serpell, J. (2017). From paragon to pariah: Cross-cultural perspectives on attitudes to dogs. In J. Serpell (Ed.), *The Domestic Dog Its Evolution, Behavior and Interactions with People* (2nd ed., pp. 300–316)

Silva-Rodríguez, E. A., Ortega-Solís, G. R., & Jiménez, J. E. (2010). Conservation and ecological implications of the use of space by chilla foxes and free-ranging dogs in a human-dominated landscape in southern Chile. *Austral Ecology*, *35*(7), 765–777. https://doi.org/10.1111/j.1442-9993.2009.02083.x

Silva-Rodríguez, E. A., & Sieving, K. E. (2011). Influence of Care of Domestic Carnivores on Their Predation on Vertebrates. *Conservation Biology*, *25*(4), 808–815. https://doi.org/10.1111/j.1523-1739.2011.01690.x

Taborsky, M. (1988). Kiwis and dog predation: observations in Waitangi State Forest. *Notornis*, *35*(3), 197–202.

Tiwari, H. K., Bruce, M., O'Dea, M., & Robertson, I. D. (2019). Utilizing group-size and home-range characteristics of free-roaming dogs (FRD) to guide mass vaccination campaigns against rabies in India. *Vaccines*, *7*(4). https://doi.org/10.3390/vaccines7040136

van Bommel, L., & Johnson, C. N. (2014). Where do livestock guardian dogs go? Movement patterns of free-ranging Maremma sheepdogs. *PLoS ONE*, *9*(10). https://doi.org/10.1371/journal.pone.0111444

Van Kesteren, F., Mastin, A., Mytynova, B., Ziadinov, I., Boufana, B., Torgerson, P. R., Rogan, M. T., & Craig, P. S. (2013). Dog ownership, dog behaviour and transmission of Echinococcus spp. in the Alay Valley, southern Kyrgyzstan. *Parasitology*, *140*(13), 1674–1684. https://doi.org/10.1017/S0031182013001182

Vanak, A. T., Dickman, C. R., Silva-Rodriguez, E. A., Butler, J. R., & Ritchie, E. G. (2014). Top-dogs and under-dogs: competition between dogs and sympatric carnivores. In M. E. Gompper (Ed.), *Free-Ranging Dogs and Wildlife Conservation* (pp.69–93). Oxford University Press.

Vanak, A. T., & Gompper, M. E. (2009). Dogs canis familiaris as carnivores: Their role and function in intraguild competition. *Mammal Review*, *39*(4), 265–283. https://doi.org/10.1111/j.1365-2907.2009.00148.x

Vanak, A. T., & Gompper, M. E. (2010). Interference competition at the landscape level: The effect of free-ranging dogs on a native mesocarnivore. *Journal of Applied Ecology*, *47*(6), 1225–1232. https://doi.org/10.1111/j.1365-2664.2010.01870.x

Vaniscotte, A., Raoul, F., Poulle, M. L., Romig, T., Dinkel, A., Takahashi, K., Guislain, M. H., Moss, J., Tiaoying, L., Wang, Q., Qiu, J., Craig, P. S., & Giraudoux, P. (2011). Role of dog behaviour and environmental fecal contamination in transmission of Echinococcus multilocularis in Tibetan communities. *Parasitology*, *138*(10), 1316–1329. https://doi.org/10.1017/S0031182011000874.

Venables, W. N. & Ripley, B. D. (2002). Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0

Warembourg, C., Wera, E., Odoch, T., Bulu, P. M., Berger-González, M., Alvarez, D., ... & Dürr, S. (2021). Comparative study of free-roaming domestic dog management and roaming behavior across four countries: Chad, Guatemala, Indonesia, and Uganda. *Frontiers in Veterinary Science*, *8*, 617900. https://doi.org/10.3389/fvets.2021.617900.

Wickham, H. (2016).ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Wilson-Aggarwal, J. K., Goodwin, C. E. D., Moundai, T., Sidouin, M. K., Swan, G. J. F., Léchenne, M., & McDonald, R. A. (2021). Spatial and temporal dynamics of space use by free-ranging domestic dogs *Canis familiaris* in rural Africa. *Ecological Applications*, *31*(5). https://doi.org/10.1002/eap.2328.

CONCLUSÃO GERAL

De acordo com nossa revisão de literatura, a área de vida dos cães apresenta uma variabilidade significativa, impulsionada por diversos fatores. Os efeitos desses fatores variam conforme o contexto e a localização em que os animais se encontram, podendo causar efeitos opostos em diferentes áreas ou, em alguns casos, nenhum efeito. Em geral, a presença de humanos influencia significativamente os comportamentos de movimento de cães em áreas rurais e vilarejos, bem como seu uso do habitat. Os cães tendem a frequentar os mesmos locais que seus tutores ou a permanecer próximos a eles, além de visitar locais associados à atividade humana. A rotina do tutor e os cuidados oferecidos aos animais também podem ser fatores decisivos na movimentação dos cães.

Na nossa área de estudo, as áreas de vida dos cães são pequenas e parecem ser influenciadas pelo hábito de acompanharem seus tutores em atividades diárias e pelo baixo escore corporal. Embora os cães raramente utilizem a vegetação nativa, nos casos em que o fazem, geralmente vivem próximos a esses habitats e exibem baixo escore corporal. Como o uso de vegetação nativa é mínimo e os cães passam a maior parte do tempo em suas casas dentro da matriz, é possível que espécies nativas evitem essas áreas, reduzindo assim a conectividade entre fragmentos de vegetação nativa.

Dada a distribuição global dos cães e os diversos papéis que desempenham na sociedade, esforços devem ser feitos em áreas onde eles estão presentes para investigar seus papéis e potenciais impactos em cada contexto específico. Por fim, investigar e elucidar a ecologia de movimento dos cães e seu vínculo com os humanos é essencial para gerenciar essa espécie de forma eficaz e desenvolver políticas públicas robustas.