UNIVERSIDADE FEDERAL DE MINAS GERAIS
Instituto de Ciências Biológicas
Programa de Pós-graduação em Ecologia, Conservação e Manejo da Vida Silvestre

Bruna Manuele Campos

Uso de habitat e padrões de atividade da anta (*Tapirus terrestris*) em um dos maiores remanescentes de Mata Atlântica do Brasil

Belo Horizonte
2021

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Dissertação apresentada ao programa de Pós-graduação em Ecologia, Conservação e Manejo da Vida Silvestre da Universidade Federal de Minas Gerais como requisito parcial à obtenção do título de Mestre em Ecologia, Conservação e Manejo da Vida Silvestre.

Orientador: Dr. Fernando Cesar Cascelli de Azevedo

Belo Horizonte
2021

043 Campos, Bruna Manuele.
Uso de habitat e padrões de atividade da anta (Tapirus terrestris) em um dos maiores remanescentes de Mata Atlântica do Brasil [manuscrito] / Bruna Manuele Campos. – 2021.
60 f. : il. ; 29,5 cm.

Orientador: Dr. Fernando Cesar Cascelli de Azevedo.
Dissertação (mestrado) – Universidade Federal de Minas Gerais, Instituto de Ciências Biológicas. Programa de Pós-Graduação em Ecologia, Conservação e Manejo da Vida Silvestre.

1. Ecologia. 2. Habitat. 3. Comportamento Animal. 4. Mamíferos. I. Azevedo, Fernando Cesar Cascelli de. II. Universidade Federal de Minas Gerais. Instituto de Ciências Biológicas. III. Título.

CDU: 502.7

Ficha catalográfica elaborada pela bibliotecária Fabiane C M Reis – CRB 6 – 2680

UNIVERSIDADE FEDERAL DE MINAS GERAIS
INSTITUTO DE CIÊNCIAS BIOLÓGICAS
PROGRAMA DE PÓS-GRADUAÇÃO EM ECOLOGIA, CONSERVAÇÃO E MANEJO DA VIDA SILVESTRE

Ata da Defesa de Dissertação

Nº 414
Entrada: 2019/1

Bruna Manuele Campos

No dia 29 de abril de 2021, às 09:00 horas, por vídeo conferência, teve lugar a defesa de dissertação de mestrado no Programa de Pós-Graduação em Ecologia, Conservação e Manejo da Vida Silvestre, de autoria do(a) mestrando(a) Bruna Manuele Campos, intitulada: **"Uso de habitat e padrões de atividade da anta (Tapirus terrestris) em um dos maiores remanescentes de Mata Atlântica do Brasil"**. Abrindo a sessão, o(a) orientador(a) e Presidente da Comissão, Doutor(a) Fernando Cesar Cascelli de Azevedo, após dar a conhecer aos presentes o teor das normas regulamentares do trabalho final, passou a palavra para o(a) candidato(a) para apresentação de seu trabalho. Estiveram presentes a Banca Examinadora composta pelos Doutores: Cynthia Elisa Widmer de Azevedo (UFSJ), Ana Maria de Oliveira Paschoal (Instituto Serradical) e demais convidados. Seguiu-se a arguição pelos examinadores, com a respectiva defesa do(a) candidato(a). Após a arguição, apenas os senhores examinadores permaneceram no recinto para avaliação e deliberação acerca do resultado final, sendo a decisão da banca pela:

(X) Aprovação da dissertação, com eventuais correções mínimas e entrega de versão final pelo orientador diretamente à Secretaria do Programa, no prazo máximo de 30 dias;

( ) Reavaliação da dissertação com avaliação pelos membros da banca do documento revisado, sem nova defesa, no prazo máximo de 30 dias, sob possibilidade de reprovação;

( ) Reformulação da dissertação com indicação de nova defesa em data estabelecida a critério do Colegiado em observância às Normas Gerais da Pós-graduação na UFMG a ao Regimento do PPG-ECMVS;

( ) Reprovação

Nada mais havendo a tratar, o Presidente da Comissão encerrou a reunião e lavrou a presente ata, que será assinada por todos os membros participantes da Comissão Examinadora.

Belo Horizonte, 29 de abril de 2021.

Assinaturas dos Membros da Banca Examinadora

Documento assinado eletronicamente por **Fernando Cesar Cascelli de Azevedo, Usuário Externo**, em 30/04/2021, às 11:58, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

Documento assinado eletronicamente por **Cynthia Elisa Widmer de Azevedo, Usuário Externo**, em 30/04/2021, às 12:11, conforme horário oficial de Brasília, com fundamento no art. 5º do Decreto nº 10.543, de 13 de novembro de 2020.

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Dedico este trabalho aos meus pais, José Antonio Campos e Silvia Novello Campos, e à minha irmã, Aline Campos, que sempre foram meu porto seguro.

AGRADECIMENTOS

Mais uma etapa de minha jornada acadêmica chega ao fim... e não poderia ter sido mais diferente do que eu havia imaginado. Como poderia prever viver uma pandemia nesse momento? Felizmente, tive muitas pessoas que ajudaram a suportar o caos.

Primeiramente, gostaria de agradecer aos meus pais por terem sentado comigo e me lembrado do quanto eu queria realizar este sonho, independente das circunstâncias. Que me apoiaram a mudar de cidade (de novo!) e aguentaram a distância que já sabíamos que seria grande, mas não imaginávamos que seria imposta tão fortemente... E à minha irmã, que sempre esteve do meu lado. Obrigada por tudo!

Ao meu orientador, Prof. Fernando Azevedo, agradeço primeiramente por ter aceitado me orientar. Quando me graduei eu disse que só faria o mestrado se fosse com ele... Serei sempre muito grata por ter me convidado a tentar a seleção de mestrado novamente. Obrigada pelas aulas inspiradoras, pelo grande aprendizado em campo, e pela exigência que fazem com que eu me dedique cada vez mais. Agradeço pela oportunidade de conhecer o Projeto Carnívoros do Rio Doce e pelo acolhimento que você e a Cynthia me deram em todas às idas a São João del Rei.

Ao Dr. Rodrigo Massara, pela maravilhosa didática em explicar modelagem de uma maneira mais simples e leve, e pela disponibilidade e paciência para lidar com minhas dúvidas. Sou grata por ter acreditado no potencial do primeiro capítulo deste trabalho e ter colaborado para sua execução. Agradeço também ao Prof. Dr. Gabriel Pereira, pela paciência enorme em me ensinar a usar o ArcGIS e SPRING, presencial e remotamente (!), o que se tornou um desafio peculiar com a internet de baixa qualidade em Piracicaba... e mesmo assim manteve o bom humor de sempre.

Juliana, o quanto posso te agradecer? Obrigada pela troca de ideias com os inúmeros e longos áudios, por estar sempre disposta a ajudar mesmo que fosse com um meme para eu rir em um dia difícil. Obrigada por ter liderado o caminho dos modelos de ocupação, teria sido muito mais difícil para mim se não fosse seu empenho.

Gostaria de agradecer também ao Ricardo, ao Álvaro, à Alexandra e aos funcionários e mateiros do Parque Estadual do Rio Doce pelo árduo trabalho em campo que obteve os dados utilizados neste estudo. Este trabalho não teria sido realizado sem vocês!

Não poderia deixar de agradecer aos amigos que me fizeram amar BH e tornaram o isolamento social mais suportável. Em especial, Lorena, Tiago, Paulinho e Ingrid, os poucos e importantes que se tornaram minha família mineira. Eu teria enlouquecido sem vocês! E Lorena, obrigada por me tentar fazer ser uma pessoa menos preocupada e por me alertar sempre de que “Passa rápido demais....” e passou...

Obrigada também ao Jake, que mesmo de tão longe sempre esteve checando se eu estava bem e me motivava a continuar, sempre dizendo que eu ia dar conta. Obrigada por entender meus sonhos e me incentivar a ir mais longe.

Agradeço à UFMG e UFSJ pela estrutura concedida para a realização do mestrado, em especial ao Laboratório de Ecologia de Vertebrados (LEVE) e ao Prof. Dr. Ricardo Solar, por ter cedido o Centro de Síntese Ecológica e Conservação (CSEC) para que eu pudesse vivenciar a atmosfera da pós-graduação. Obrigada aos CSECanos pelo acolhimento! Obrigada a todos os professores e colegas do Programa de Pós-Graduação em Ecologia, Conservação e Manejo da Vida Silvestre. Levo os aprendizados e os momentos compartilhados com muito carinho.

Agradeço às agências financiadoras Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) pelo financiamento do Programa de Pesquisas Ecológicas de Longa Duração (PELD) e pela bolsa de mestrado concedida. Agradeço ao Ministério Público de Minas Gerais pelo financiamento do Projeto Carnívoros do Rio Doce.

Enfim, obrigada a todos os amigos que pacientemente ouviram sobre minhas aventuras em BH e no Parque Estadual do Rio Doce, com direito a vários ‘uai’ porque é impossível não aderir a este sotaque tão bonito!

being the loudest on earth's playground
doesn't make us any more important than
the dirt we crush beneath our feet
we are nothing except air
and fire and water and soil
we are a people
who forget what we are made of
a people who talk about the weather
as if it's mundane and not magic
as if the oceans
are not holy water
as if the sky
is not a vision
as if the animals
are not our siblings
as if nature is not god
and rain is not god's tears
and we are not god's children
as if god is not the earth itself

(Rupi Kaur)

Uso de habitat e padrões de atividade da anta (*Tapirus terrestris*) em um dos maiores remanescentes de Mata Atlântica do Brasil

Fatores ambientais, ecológicos e humanos que compõem a paisagem influenciam a maneira com a qual as espécies utilizam o ambiente. Estudos mostram que mamíferos respondem a heterogeneidade ambiental de acordo com a distribuição espacial e temporal de recursos, como alimento e condições ambientais, ao mesmo tempo em que evitam fatores de risco, como a predação e a caça. A anta (*Tapirus terrestris*) é o maior mamífero herbívoro do Brasil, importante por seu papel na dispersão de sementes e na regeneração das florestas tropicais. O objetivo deste estudo foi avaliar como e quais fatores ambientais, ecológicos e antrópicos influenciam a ocupação, a detecção e o padrão de atividade das antas no Parque Estadual do Rio Doce (PERD), sudeste do Brasil. Nenhuma das variáveis analisadas influenciou a ocupação das antas. No entanto, a detecção da espécie foi fortemente associada com três das variáveis avaliadas: probabilidade de ocupação de potenciais predadores (onça-pintada – *Panthera onca* e onça-parda – *Puma concolor*), construções humanas (incluindo infraestruturas rurais, urbanas e residências dentro e fora dos limites do parque) e áreas de pastagem. Estes resultados indicam que a maior movimentação da anta em locais com maior probabilidade de ocupação de predadores pode estar sendo utilizada como uma estratégia anti-predação. A associação forte e positiva entre a detecção de anta e áreas de pasto provavelmente indica que a espécie utiliza áreas próximas à borda do parque mais frequentemente. Em tais localidades, a altura da vegetação da borda da floresta é menor, podendo estar sendo utilizada como uma das principais áreas para forrageamento, o que explicaria a maior movimentação da espécie em tais localidades. Por outro lado, a associação negativa com construções humanas corrobora estudos anteriores, que demonstram que a espécie evita áreas que são utilizadas mais intensamente por humanos. As análises de padrão de atividade demonstraram que as antas são majoritariamente noturnas e não diferem sua atividade quanto ao sexo, região de localização das cameras-trap no parque (norte e sul) e nem quanto a estação do ano (seca e chuvosa). Nossos resultados indicam que a qualidade de habitat do PERD permite com que a anta use praticamente toda a área protegida. No entanto, estudos populacionais e genéticos precisam ser realizados a fim de avaliar a capacidade de persistência dessa população a longo prazo.

Palavras-chaves: Seleção de Modelos. Comportamento. Mamífero Herbívoro. Armadilhamento fotográfico.

Habitat use and activity patterns of Lowland tapir (*Tapirus terrestris*) in one of the largest Atlantic Forest Remnants in Brazil

Environmental, ecological, and anthropogenic factors that make up the landscape affect the way animals use it. Studies show that mammals are influenced by heterogenic environment according to the spatial and temporal distribution of resources, such as food and mate, at the same time they avoid risk factors, such as predation and hunting. Lowland tapir (*Tapirus terrestris*) is the largest herbivore species in Brazil, which plays an important role in the dispersion and regeneration of tropical forests. Here, we aimed to evaluate how and which of the environmental, ecological and anthropogenic factors affect tapir occupancy, detection and activity patterns in Rio Doce State Park (RDSP), southeast Brazil. None of the variables analysed affected tapir occupancy. However, the tapir detection was strongly associated with three of the covariates evaluated: conditional occupancy of potential predators (jaguar – *Panthera onca* and puma – *Puma concolor*), human settlements (including rural and urban infrastructure, and residences inside and outside of the park) and pasture areas. These results indicate that tapir may have higher movement in areas where predator occupancy probability is higher as an anti-predation strategy. The strong and positive association between tapir detection and pasture areas may indicate that they use areas closer to the forest limits more often. Edge vegetation height is lower, which may be where the main foraging areas are located and would explain more movement of the species in such areas. On the other hand, the negative association between human settlements and tapir detection corroborates previous studies, showing that the species increases its shyness behaviour in areas with more intense human activity. The activity pattern analysis showed that tapirs are mainly nocturnal, and that activity patterns do not differ between sexes, north and south regions of the park, and dry and wet seasons. Our results indicate that tapir use almost the entire protected area, as well as the activities developed in the surrounding areas has not forced tapir to change its behaviour to now. However, demographic parameters should be evaluated to assess the ability of this population to persist in the long-term.

Keywords: Model Selection. Behaviour. Herbivore Mammal. Camera-trapping.

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CAPÍTULO I

Sumário

INTRODUÇÃO GERAL

Os fatores ambientais, ecológicos e humanos que moldam as paisagens são dinâmicos e influenciam a maneira com a qual as espécies utilizam a paisagem (Schoener 1974). Animais tendem a selecionar locais e horários de atividade que aumentem sua aptidão, favorecendo sua sobrevivência e reprodução (Daan and Aschoff 1982; Manly et al. 1993). Esses padrões de uso de habitat e de tempo são determinados por fatores fisiológicos de cada espécie, por interações inter e intra-específica e pelas interações com o ambiente (Lima and Zollner 1996; Wiegand et al. 1999; Goulart et al. 2009; Naranjo 2009). Dessa forma, locais que fornecem alimento, abrigo, água e oportunidades reprodutivas, ou que protegem contra riscos, como a predação e a caça por seres humanos, tendem a ser selecionados pelas espécies (Downes 2001; Nagy-Reis et al. 2017). Quando não é possível evitar potenciais riscos espacialmente, os animais podem também alterar seu horário de atividade. Por outro lado, eles tendem a ser mais ativos em horários que favoreçam processos fisiológicos, como a dissipação de calor (Schmidt-Nielsen 2005).

Estudos anteriores mostram que grandes herbívoros respondem a heterogeneidade ambiental de acordo com a distribuição espacial e temporal de tais recursos (Anderson et al. 2016; Letnic and Ripple 2017). As antas (Perissodactyla, Tapiridae) compõem um grupo de espécies herbívoras que requerem ações de conservação devido à sua importância ecológica. Elas atuam na dispersão de sementes a longas distâncias, especialmente sementes grandes, as quais animais de menor porte são incapazes de dispersar (O'Farrill et al. 2013). Além disso, quando se movimentam pelas mesmas trilhas repetidamente, seu peso cria depressões no solo, formando locais que podem ser utilizados como tocas ou áreas de banho, como lamaçais, para outros animais de menor porte. Assim, as antas são também classificadas como engenheiras ecológicas (Fragoso 1997; García et al. 2012; O'Farrill et al. 2013; Paolucci et al. 2019). Por conta de tais características, a extinção ou a drástica redução populacional dessas espécies pode levar a um desequilíbrio de processos ecológicos chaves para a manutenção do ecossistema a longo prazo (Foerster & Medici 2002; Medici et al. 2007).

As antas requerem extensas áreas de vida para sobreviver, que podem chegar a 11 km^2 (Herrera et al. 1999; Noss et al. 2003), apresentam um longo ciclo reprodutivo e geram apenas um filhote por gestação (Eisenberg 1997). Além disso, apresentam comportamento solitário, formando pares apenas na época reprodutiva e durante o cuidado parental (Eisenberg 1997). Tais características fazem com que sejam mais susceptíveis às ameaças causadas pelas ações humanas, como a fragmentação de habitats, a caça, o atropelamento e infecções por zoonoses (Medici and Desbiez 2012; Varela et al. 2019).

Uma das espécies deste grupo é nativa do continente asiático (*Tapirus indicus*), e três delas são nativas dos Neotrópicos (*T. bairdii, T. pinchaque* e *T. terrestris*). Atualmente, todas elas se encontram ameaçadas em algum grau, e suas populações dificilmente se recuperam após uma redução extrema, podendo ser rapidamente extintas (Medici 2010; Varela et al. 2019).

A espécie de anta encontrada no Brasil é a *T. terrestris*. Estudos prévios demonstram que fatores ambientais, ecológicos e humanos podem influenciar a maneira como esta espécie usa a paisagem espacial e temporalmente (Medici 2010; Cruz et al. 2014; Ferreguetti et al. 2017). Por conta de seu tamanho corporal, ela precisa selecionar locais adequados ou alterar seu horário de atividade para evitar a perda de água corporal (Schmidt-Nielsen 2005). A espécie também utiliza áreas próximas a recursos hídricos para forragear, descansar, defecar e retirar parasitas (Foerster and Vaughan 2002; Goulart et al. 2009; Naranjo 2009; Medici 2010).

Atividades humanas, como a expansão agrícola e urbana, contribuíram para o aumento no número de rodovias e, consequentemente, do número de acidentes de trânsito envolvendo antas (Forman and Alexander 1998), além de acrescer os casos de contaminação por agrotóxicos (Fernandes-Santos et al. 2018), infecção por doenças contraídas de animais domésticos (Medici and Desbiez 2012), somada à histórica ameaça de caça que estas espécies enfrentam (Varela et al. 2019).

A interação entre presa e predador pode levar a alteração no uso de espaço e no comportamento da presa (Oliveira-Santos et al. 2010; Middleton et al. 2013). Portanto, a presença de potenciais predadores, como a onça-pintada (*Panthera onca*) e a onça-parda (*Puma concolor*), espécies encontradas na Mata Atlântica, pode afetar o uso de habitat e o padrão de atividade da anta, embora ela não seja um dos principais itens alimentares desses felinos (Polisar et al. 2003; Astete et al. 2008; Medici 2010; Azevedo et al. 2016).

Estudos sobre os padrões de atividade da anta *T. terrestris* demostram que ela é primariamente noturna e crepuscular (Padilla and Dowler 1994; Noss et al. 2003; Tobler et al. 2009; Medici 2010; Wallace et al. 2012). No entanto, a espécie é capaz de modificar esses padrões em função de variáveis ambientais e ecológicas, como precipitação, fases da lua e sexo do indivíduo (Foerster and Vaughan 2002; Medici 2010).

Investigar como tais fatores influenciam o uso de habitat e o comportamento dos animais deve ser uma prioridade para conservação (Buchholz & Hanlon, 2012), pois a determinação das características que garantem a persistência de populações de animais considerados engenheiros da paisagem, principalmente em biomas ameaçados como a Mata Atlântica (Myers et al. 2000), podem garantir a integridade do ecossistema (Medici et al. 2012). Assim, o objetivo desse estudo foi avaliar quais fatores ambientais, ecológicos e antrópicos influenciam os padrões de ocupação, detecção, e de atividade da anta *T. terrestris* no Parque Estadual do Rio Doce, Minas Gerais, Brasil.

REFERÊNCIAS

ANDERSON, T. M. ET AL. 2016. The spatial distribution of african savannah herbivores: Species associations and habitat occupancy in a landscape context. Philosophical Transactions of the Royal Society B: Biological Sciences 371.

ASTETE, S., R. SOLLMANN, AND L. SILVEIRA. 2008. Comparative Ecology of Jaguars in Brazil. CAT News:9–14.

AZEVEDO, F. C. C., V. CANUTO, F. SOUZA, AND C. E. WIDMER. 2016. Puma (*Puma concolor*) predation on tapir (*Tapirus terrestris*). Biota Neotropica 16:e20150108.

BUCHHOLZ R. AND E. HANLON. 2012. Ecotourism, wildlife management, and behavioral biologists: changing minds for conservation. pp. 234–249 in B. Wong and U. Candolin, eds. Behavioural Responses to a Changing World: Mechanisms and Consequences. Oxford University Press, Oxford.

CRUZ, P., A. PAVIOLO, R. F. BÓ, J. J. THOMPSON, AND M. S. DI BITETTI. 2014. Daily activity patterns and habitat use of the lowland tapir (Tapirus terrestris) in the Atlantic Forest. Mammalian Biology 79:376–383.

DAAN, S., AND J. ASCHOFF. 1982. Circadian Contributions to Survival. Pp. 305–321 in. Springer, Berlin, Heidelberg.

DOWNES, S. 2001. Trading heat and food for safety: Costs of predator avoidance in a lizard. Ecology 82:2870–2881.

EISENBERG, J.F. 1997. Introduction. In: D.M. Brooks, R.E. Bodmer & S. Matola (Eds). Tapirs: Status Survey and Conservation Action Plan. pp. 5-7. IUCN/SSC Tapir Specialist Group (TSG). IUCN, Gland, Switzerland.

FERNANDES-SANTOS, R. C., E. P. MEDICI, C. TESTA-JOSÉ, AND A. C. CANENA. 2018. Impacto de agrotóxicos e metais pesados na anta brasileira (Tapirus terrestris) no estado do Mato Grosso do Sul, Brasil, e implicações para saúde humana e ambiental.

FERREGUETTI, Á. C., W. M. TOMÁS, AND H. G. BERGALLO. 2017. Density, occupancy, and detectability of lowland tapirs, Tapirus terrestris, in Vale Natural Reserve, southeastern Brazil. Journal of Mammalogy 98:114–123.

FOERSTER, C.R., AND E.P. MEDICI. 2002. The influence of large herbivores on Neotropical forests. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 11(1): 9-10.

FOERSTER, C. R., AND C. VAUGHAN. 2002. Home Range, Habitat Use, and Activity of Baird's Tapir in Costa Rica. Biotropica 34:423–437.

FORMAN, R. T. T., AND L. E. ALEXANDER. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics:207–231.

FRAGOSO, J. M. V. 1997. Tapir-Generated Seed Shadows: Scale-Dependent Patchiness in the Amazon Rain Forest. The Journal of Ecology 85:519.

FREY, S., J. T. FISHER, A. C. BURTON, AND J. P. VOLPE. 2017. Investigating animal activity patterns and temporal niche partitioning using camera-trap data: challenges and opportunities. Wiley-Blackwell. Remote Sensing in Ecology and Conservation.

FRID, A., AND L. DILL. 2002. Human-caused disturbance stimuli as a form of predation risk. Ecology and Society 6.

GARCÍA, M. J., E. P. MEDICI, E. J. NARANJO, W. NOVARINO, AND R. S. LEONARDO. 2012. Distribution, habitat and adaptability of the genus Tapirus. Integrative Zoology 7:346–355.

GOULART, F. V. B., N. C. CÁCERES, M. E. GRAIPEL, M. A. TORTATO, I. R. GUIZONI JR, AND L. G. R. OLIVEIRA-SANTOS. 2009. Habitat selection by large mammals in a southern Brazilian Atlantic Forest. Mammalian Biology 74:182–190.

HERRERA, J. C., A. B. TABER, R. B. WALLACE, AND R. L. E. PAINTER. 1999. Lowland tapir (Tapirus terrestris) behavioral ecology in a southern Amazonian tropical forest. Vida Silvestre Neotropical:31–37.

LETNIC, M., AND W. J. RIPPLE. 2017. Large-scale responses of herbivore prey to canid predators and primary productivity. Global Ecology and Biogeography 26:860–866.

LIMA, S. L., AND P. A. ZOLLNER. 1996. Towards a behavioral ecology of ecological landscapes. World Geomorphological Landscapes 11:131–135.

MANLY, B. F., L. L. MCDONALD, AND D. L. THOMAS. 1993. Resource Selection by Animals: Statistical Design and Analysis for Field Studies.

MEDICI, E. P. 2010. Assessing the Viability of Lowland Tapir Populations in a Fragmented Landscape. Thesis:292.

MEDICI, E. P., AND A. L. J. DESBIEZ. 2012. Population viability analysis: Using a modeling tool to assess the viability of tapir populations in fragmented landscapes. Integrative Zoology 7:356–372.

Medici, E.P., ET AL. 2007. Lowland Tapir (Tapirus terrestris) Population and Habitat Viability Assessment (PHVA): Final Report. IUCN/SSC Tapir Specialist Group (TSG) and IUCN/SSC Conservation Breeding Specialist Group (CBSG), Sorocaba, São Paulo, Brazil.

MEDICI, E. P., K. FLESHER, B. D. M. BEISIEGEL, AND A. KEUROGHLIAN. 2012. Avaliação do risco de extinção de Tapirus terrestris Linnaeus, 1758,. Ano II 1:3–11.

MIDDLETON, A. D. ET AL. 2013. Linking anti-predator behaviour to prey demography reveals limited risk effects of an actively hunting large carnivore. Ecology Letters 16:1023–1030.

MYERS, N., R. A. MITTERMEIER, C. G. MITTERMEIER, G. A. DA FONSECA, AND J. KENT. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853.

NAGY-REIS, M. B., C. A. ESTEVO, E. Z. F. SETZ, M. C. RIBEIRO, A. G. CHIARELLO, AND J. D. NICHOLS. 2017. Relative importance of anthropogenic landscape characteristics for Neotropical frugivores at multiple scales. Animal Conservation 20:520–531.

NARANJO, E. J. 2009. Ecology and Conservation of Baird's Tapir in Mexico. Tropical Conservation Science 2:140–158.

NOSS, A. J. ET AL. 2003. A Camera Trapping and Radio Telemetry Study of Lowland Tapir (Tapirus terrestris) in Bolivian Dry Forests. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 12:24–32.

O'FARRILL, G., M. GALETTI, AND A. CAMPOS-ARCEIZ. 2013. Frugivory and seed dispersal by tapirs: An insight on their ecological role. Integrative Zoology 8:4–17.

OLIVEIRA-SANTOS, L. G. R., L. C. P. MACHADO-FILHO, M. A. TORTATO, AND L. BRUSIUS. 2010. Influence of extrinsic variables on activity and habitat selection of lowland tapirs (Tapirus terrestris) in the coastal sand plain shrub, southern Brazil. Mammalian Biology 75:219–226.

PADILLA, M., AND R. C. DOWLER. 1994. Tapirus terrestris. Pp. 1–8 in Mammalian Species.

PAOLUCCI, L. N. ET AL. 2019. Lowland tapirs facilitate seed dispersal in degraded Amazonian forests. Biotropica 51:245–252.

POLISAR, J., I. MAXIT, D. SCOGNAMILLO, L. FARRELL, M. E. SUNQUIST, AND J. F. EISENBERG. 2003. Jaguars, pumas, their prey base, and cattle ranching: Ecological interpretations of a management problem. Biological Conservation 109:297–310.

SCHMIDT-NIELSEN, K. 2005. Fisiologia Animal: adaptações ao meio ambiente. Santos Editora, São Paulo.

SCHOENER, T. W. 1974. Resource partitioning in ecological communities. Science 185:27–39.

TOBLER, M. W., S. E. CARRILLO-PERCASTEGUI, AND G. POWELL. 2009. Habitat Use, Activity Patterns and Use of Mineral Licks by Five Species of Ungulate in South-Eastern Peru. Source: Journal of Tropical Ecology 25:261–270.

VARELA, D. ET AL. 2019. Tapirus terrestris. *The IUCN Red List of Threatened Species*.

WALLACE, R., G. AYALA, AND M. VISCARRA. 2012. Lowland tapir (Tapirus terrestris) distribution, activity patterns and relative abundance in the Greater Madidi-Tambopata Landscape. Integrative Zoology 7:407–419.

WIEGAND, T., K. A. MOLONEY, J. NAVES, AND F. KNAUER. 1999. Finding the missing link between landscape structure and population dynamics: A spatially explicit perspective. American Naturalist 154:605–627.

CAPÍTULO I

Lowland Tapir (*Tapirus terrestris*) habitat use in one of the largest Brazilian Atlantic Forest remnants

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Abstract

Spatial distribution is one of the main species' ecological patterns that allows the evaluation of how and which of the landscape features affect their habitat use. This understanding helps to establish management actions to conserve the target species and the ecosystem in which it belongs. In Brazil, the lowland tapir (*Tapirus terrestris*) is the largest terrestrial herbivore mammal and plays a key role in forest regeneration. Here, we used camera trap data and an occupancy modelling approach to investigate covariates influencing tapir habitat use in Rio Doce State Park (RDSP), one of the largest Atlantic Forest Protected Area in southeastern Brazil. None of the covariates influenced tapir habitat use, being that the occupancy probability was high throughout the entire park ($\hat{\Psi}$=0.74). Conversely, we found a strong and positive correlation between tapir detection probability and $\Psi_{conditional}$ of predators, which may suggest tapirs move more in such locations to avoid predation. Likewise, the distance to the nearest human settlement correlated positively with the tapir detection probability, suggesting increased avoidance of locations close to urban areas. On the other hand, the distance to the nearest pasture area correlated negatively with the tapir detection probability, indicating the species may be using areas closer to the border of the Park as travel routes and foraging areas, where shorter trees are present for foraging. Our results show that the landscape features inside RDSP present the requirements needed by tapir population. However, given that RDSP is not well connected to other forested areas, studies on population dynamics, health assessment and gene flow are needed to ensure the long-term persistence of tapir population in the Atlantic Forest. On the other hand, tapir's main predator, the jaguar, does not seem to be thriving in the area, which can lead to overpopulation of tapir. The loss of such processes can have severe impacts on ecosystem functions. As RDSP is one of the few last large remnants where species interactions can still be evaluated, the proposal of conservation planning can be designed and applied to other similar Atlantic Forest fragments. Therefore, long-term monitoring programs need to be stablished in RDSP.

Keywords: Biodiversity Hotspot; Ecological Interactions; Imperfect Detection; Large Herbivore; Anthropogenic Threats; Spatial Niche

1. Introduction

Understanding species' ecological patterns of species can help to establish management actions that support the conservation of the target species and, consequently, the ecosystem of which it belongs (González-Maya et al. 2009). Among the ecological patterns, the spatial distribution is important to understand which and how landscape features affect species occupancy, given they do not use the habitat randomly (Nagy-Reis et al. 2017). Most animals select areas that meet their daily requirements while avoiding risky factors, such as predation and anthropogenic threats (Downes 2001; Nagy-Reis et al. 2017).

In theory, protected areas (PAs) are established to be the ideal place for biodiversity conservation. However, it is known that many PAs are located in places that are not optimum for species conservation and, in most cases, these areas are too small and not connected (Caro and Scholte 2007; Gaston et al. 2008). One of the reasons these areas may not effectively conserve biodiversity is the lack of information about the relationship between species and environmental features (Chape et al. 2005). Moreover, many PAs do not have appropriate protection against poaching and other human activities, such as urbanization and agricultural expansion (Caro and Scholte 2007; Gaston et al. 2008; Wittemyer et al. 2008). For large wild species, these effects can be even stronger as they present biological characteristics that make them susceptible to anthropogenic actions, like their low productive rates and their need for large home ranges (Balme et al. 2010), which can force them to leave PAs.

Herbivores are one of the animal groups that require conservation efforts as they are responsible for the maintenance of plant diversity, community structure and forest regeneration (Wright et al. 2000). Consequently, the loss of this key group can lead to strong negative impacts in plant communities (Chape et al. 2005; Galetti and Dirzo 2013). In South America, the lowland tapir (*Tapirus terrestris*) is the largest terrestrial herbivore mammal (Eisenberg and Redford 1999). This species alters the structure of the ecosystem (Sanderson et al. 2002; Coppolillo et al. 2004), helping the regeneration of forests via long-distance seed dispersal (Fragoso et al. 2003; Paolucci et al. 2019). In consequence, the presence of stable lowland tapir populations can help to maintain the ecosystem they inhabit (Medici 2010). However, the species is currently classified as Vulnerable to extinction both globally and nationally, with a decreasing population trend (Livro Vermelho da Fauna Brasileira Ameaçada de Extinção, 2018; Varela et al.

2019). In Minas Gerais state, Brazil, its conservation status is even more worrying, being categorized as Critically Endangered (Machado et al., 1998; Conselho Estadual de Política Ambiental, 2010).

The lowland tapir is usually dependent on water bodies and well-preserved forested areas (Goulart et al. 2009; Naranjo 2009; Medici 2010), although the species has been recorded passing throughout agricultural and silvicultural areas between forest fragments (Salas 1996; Flesher and Gatti 2010; Medici 2010). Further, the tapir requires relatively large home ranges (Herrera et al. 1999; Noss et al. 2003) which usually exceed the borders of the PAs (Brooks et al. 1997; Rowcliffe J.M. et al. 2008), where the species can be impacted by urban growth and the expansion of agricultural areas (Tobler 2002; González-Maya et al. 2009), road killing (Forman and Alexander 1998), agrochemicals (Fernandes-Santos et al. 2018), diseases transmitted by domestic animals (Naveda et al. 2008; Medici and Desbiez 2012) and poaching (Varela et al. 2019). Moreover, in the Atlantic Forest, jaguars (*Panthera onca*) and pumas (*Puma concolor*) have been reported as potential tapir's predators, although tapirs do not make up the main part of the diet of these carnivores (Polisar et al. 2003; Astete et al. 2008; Medici 2010; Azevedo et al. 2016).

One of the challenges to determine factors influencing species occurrence is the fact that detection probability (p) of certain species is not perfect (i.e., $p < 1$; MacKenzie and Kendall 2002; MacKenzie et al. 2005), particularly for elusive species that occur in low population densities, like the tapir (Robinson and Redford 1991; Cullen Jr. et al. 2000; Desbiez 2009). Occupancy modelling is one of the tools that allows accounting for imperfect detection and thus, lead to an unbiased estimate of factors influencing the occupancy probability of species (MacKenzie and Kendall 2002; MacKenzie et al. 2005).

Here, we aimed to evaluate which and how environmental covariates affect the probabilities of occupancy and detection of the lowland tapir in Rio Doce State Park (RDSP), the largest protected Atlantic Forest patch in the state of Minas Gerais, Brazil. Because species detection probability may vary spatially due to habitat features, we interpreted it as a proxy for the frequency (or intensity) of use of locations occupied by tapirs (Massara et al. 2018). We expected that tapir would use more locations with denser forest cover and closer to water resources, as several studies have shown their association with such locations (Cruz et al. 2014; Ferreguetti et al. 2017). Conversely, we hypothesized that human-related habitat features as well as locations with higher occupancy probability of potential predators (i.e., pumas and jaguars) would be avoided and thus, less occupied by tapirs. Specifically, we expected that tapir would use less locations closer to *Eucalyptus* plantations, pastures, croplands, human settlements, and paved and unpaved roads as well as in locations highly occupied by predators.

2. Study Area

This study was conducted in RDSP, which covers ~ 36,000 ha in size. RDSP is located in the eastern region of the state of Minas Gerais (Figure 1), among the municipalities of Marliéria, Dionísio and Timóteo (PELD/CNPq 2007).

The vegetation of the park is classified as semideciduous Atlantic Forest (Mello et al. 1999) and it has one of the largest lacustrine system in Brazil, named as a Ramsar site by UNESCOs Convention on Wetlands. It is composed of 42 natural lakes within its limits (Tundisi and Saijo 1997) and three long streams that cross from the west to the east border of the park: Belém, Turvo and Mombaça. The east border is naturally set by the Doce River while the Piracicaba River comprises the entire northwest boundary (IEF 2001). The surrounding area is composed of extensive *Eucalyptus* plantations, mainly to the east and south, agricultural lands predominantly to the west and urban areas to the north (PELD/CNPq 2007; Oliveira et al. 2019). The climate of the region is characterized by a dry season between April and September and a wet season between October and March (Pereira et al. 2018), with precipitation between 6.5 mm and 278.6 mm (Bezerra-Neto et al. 2019) and medium temperature of 22º C (IEF, 2001).

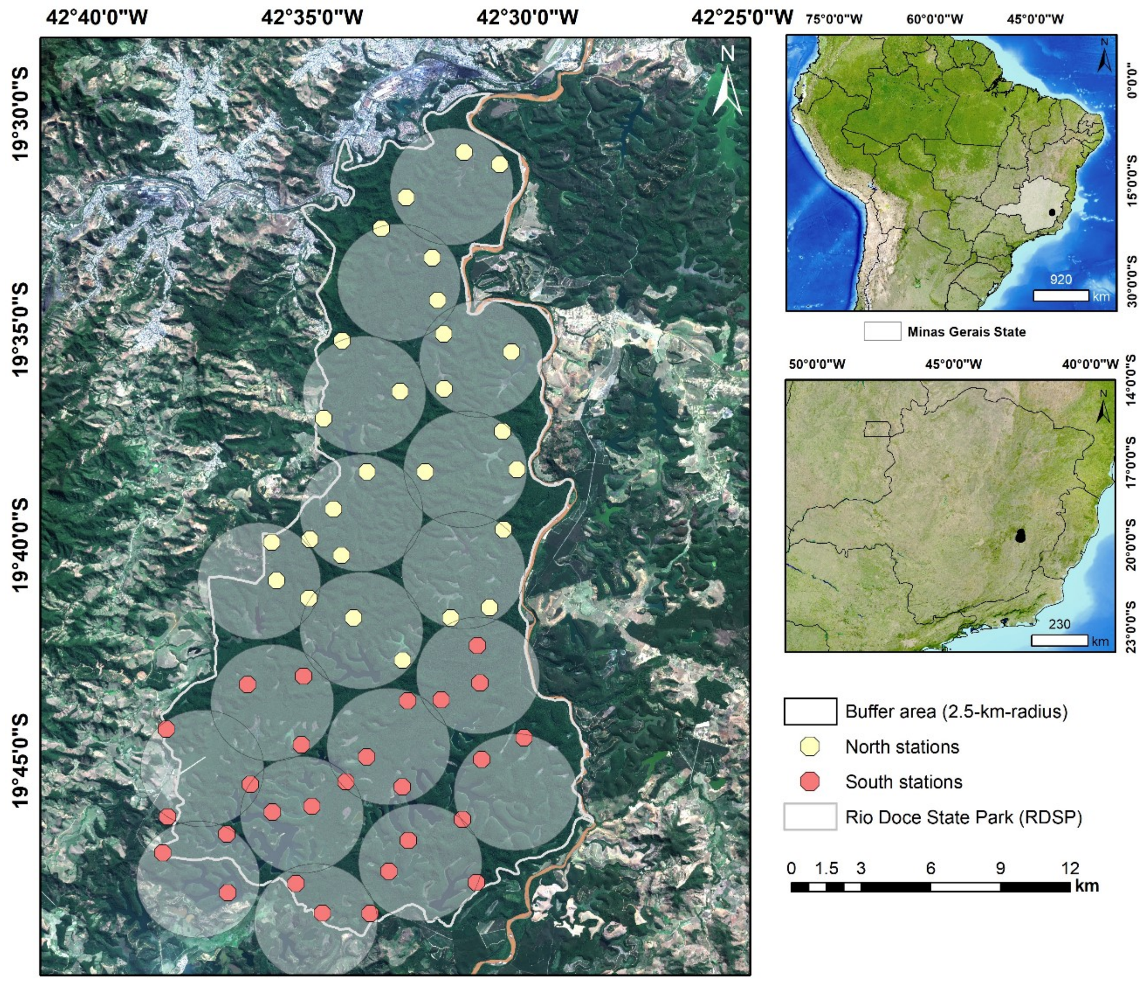

Figure 1 Locations of the camera trap sampling stations within the Rio Doce State Park, state of Minas Gerais, southeastern Brazil, used for sampling tapirs.

3. Methods

3.1. Tapir survey

The sampling design of this study was originally created to survey jaguar population in RDSP by applying capture-recapture models. Thus, 18 buffers of 2.5 km radius were systematically established, which corresponds to the size of the smallest home range size estimated for female jaguars (i.e., 10 km^2) in a tropical forest in Central America (Rabinowitz & Nottingham, 1986). Three random points were deployed within each buffer, defining a total of 54 sampling units located at an average distance of 1.5 km apart. Such procedures were done using the program ArcGIS 10.3 (ESRI 2015). No sampling station was located along roads or trails.

The total survey period lasted for 80 days and the same stations were sampled during the dry (April to August 2016) and wet season (November 2016 to March 2017), totalling 160 days of camera data. Due to the limited number of cameras, the placement occurred in two phases, where they were firstly installed in the north of the park for 40 days, and later in the south, for more 40 days in each season, within a maximum of 120 days of sampling for both sectors in each season, in a total of about 240 days of sampling. However, we only considered camera-trap data when all stations were working at the same time during each season.

In each sampling unit, two camera-traps (of either models: Bushnell Trophy Cam Natureview, Trophy Cam Standard and Trophy Cam Essential – Kansas, USA) were installed, both placed about 40 cm above the ground and set to operate for 24 hours/day to record videos of 10 seconds with 1 minute interval between records. No baits or lures of any kind were used.

Figure 2. Tapir detected at one of the sampling units in Rio Doce State Park, state of Minas Gerais, southeastern Brazil.

3.2 Modeling tapir occupancy and detection in function of environmental covariates

Occupancy probability (*Ψ*) is the probability a site *i* is occupied by the target species (in this case, tapir), while the detection probability (*p*) is the probability of detecting the target species at a site *i* at a specific moment (or sampling occasion) *t*, given it is occupied by the species (MacKenzie et al. 2002). However, here we interpreted detection probabilities as a proxy for the frequency of use of the occupied locations (Massara et al. 2018).

To explore the influence of environmental features on both tapir occupancy and detection probabilities, we generated a land use and land cover (LULC) map for the region encompassing RDSP and its surroundings by interpreting images from the satellite Sentinel-2 (10 m spatial resolution) corresponding to the year of 2016 using the software ArcGIS (ESRI*ArcMap 10.1, Redlands, California—ESRI 2011) and SPRING 5.3 (Câmara et al. 1996). We classified landscape cover into the following categories: forest, lakes, rivers, streams, human settlements, paved and unpaved roads, *Eucalyptus* plantations, pasture, crops and bare soil.

To quantify the area (ha) of native forest we placed a circular buffer of 1.22 km radius around each sampling unit, which corresponds to tapir's average home range in Atlantic Forest (4.7 km^2 – Medici 2010). For the other covariates, we calculated the linear (Euclidean) distance (m) from each sampling unit to the nearest of each of the following land use classes: water body, *Eucalyptus* plantation, pasture, cropland, human settlement, paved and unpaved road.

To explore the influence of predator species on tapir occupancy and detection probabilities, we combined the camera-trap records of jaguars and pumas and estimated the conditional occupancy probability ($\Psi_{\text{conditional}}$; Mackenzie et al., 2006; p.97-98) of predators for each sampling unit using the single-season occupancy model in Program PRESENCE (Hines 2006). The conditional occupancy probability is defined as the probability that predators (jaguars and pumas) were present at a sampling unit given it was sampled but predators were not detected. If predators were detected at a sampling unit, then $\Psi_{\text{conditional}} = 1$ (MacKenzie et al. 2006).

To check for highly correlated covariates ($r \geq 0.6$), we used Spearman's correlation test. The analysis was performed with R 3.5.2 (R Core Team 2018) and only weakly correlated covariates were used to build the final model set (Appendix I). As forest cover had little variation between the stations, we excluded from the analysis. Further, distance to croplands, paved and unpaved roads were highly correlated with distance to human settlements. Thus, we opted to use only human settlement in the final model set (Table 1).

Table 1. Mean and range values of the covariates used to model tapir occupancy (Ψ) and detection (p) probabilities in Rio Doce State Park, state of Minas Gerais, southeastern Brazil.

Covariates	**Mean and range (minimum and maximum)**
Distance to water bodies (m)	867.46 (0.00 - 3313.60)
Distance to human settlement (m)	3679.57 (394.59 - 8255.45)
Distance to pasture (m)	3414.50 (212.13 - 8491.48)
Distance to eucalyptus plantation (m)	2918.63 (127.28 - 6585.39)
$\Psi_{conditional}$ of predators	0.51 (0 - 1.00)

3.3 Analytical Design

3.3.1 Occupancy Modeling

In order to maximize detection probability and reduce variance in the estimated parameters (Mackenzie and Royle 2005; MacKenzie et al. 2006), we combined tapir detections into five-day periods (sampling occasions) to compose detection histories for each unit. Specifically, we recorded whether the camera detected (1) or not (0) a tapir during each sampling occasion.

Firstly, we evaluated for a possible violation of the closed population assumption (i.e., changes in occupancy state between seasons) using our detection histories with 16 occasions (8 occasions for each season – dry and wet season), and applied the multi-season occupancy modelling approach, which allowed us to estimate the parameters of colonization (gamma) and extinction (epsilon) (MacKenzie et al. 2003). We fit two models, where either the colonization and extinction parameters were fixed to 0 (i.e., no changes in the occupancy state between seasons; closed population) or estimated (i.e., changes in the occupancy state between seasons; open population). Using Akaike's Information Criterion adjusted for small sample size (AICc) (Burnham and Anderson 2002), the open population model was best supported (ΔAICc = 34.22 to the closed population model), which indicates change in the tapir occupancy probability between seasons. As we did not aim to evaluate tapir population dynamics between seasons and our survey period comprised only one wet and one dry season, which does not allow to proper verify seasonality changes, we used a single season modelling approach with eight occasions and used 'season' as a categorical covariate (0=dry season and 1=wet season) to model possible changes in occupancy between seasons.

Because we were interested in exploring the most determinant or likely covariates that influenced the probabilities of occupancy and detections of tapirs, we adopted all possible additive combinations of covariates as a model selection strategy (Doherty et al. 2012), as it allowed us to have a balanced model set and thus, to interpret the Akaike cumulative weights (w_+) of each covariate (Burnham and Anderson 2002). We considered covariates with $w_+ \geq 0.50$ as having strong influence on the model parameters (Barbieri and Berger 2004). Importantly, to avoid overparametrized models, we used a maximum of four covariates per model, resulting in a total of 562 models. We used the maximum-likelihood methods incorporated in Program MARK to obtain the model parameter estimates (White and Burnham 1999). To test for lack of independence among sites (i.e., overdispersion), we ran the goodness-of-fit test (MacKenzie and Bailey 2004) in Program PRESENCE (Hines, 2006).

4. Results

The naïve occupancy during the dry season was of 0.76 as tapirs were recorded at 41 (out of 54) sampling units, whereas during the wet season was of 0.69 as tapirs were recorded at 37 (out of 54) sampling units. Our goodness-of-fit test revealed no evidence of overdispersion (χ^2 = 280.13; P = 0.12; ĉ = 1.10). As we obtained more than one model with ΔAICc ≤ 2 (Table 2), we used the model-averaged estimates to calculate the probability of occupancy ($\hat{\Psi}$) and detection ($\hat{p}$) of tapirs, which resulted in $\hat{\Psi}$ = 0.74 (CI95% = 0.64-0.81) and $\hat{p}$ = 0.41 (CI95%= 0.37-0.45).

No evaluated covariate influenced the tapir occupancy probability ($w_+ < 0.50$; Table 3). Conversely, the $\Psi_{conditional}$ of predators showed a strong and positive relationship with tapir detection probability ($w_+ = 0.76$, $\beta = 0.61$; Figure 2A). Likewise, the distance to the nearest human settlement showed a positive correlation with tapir detection probability ($w_+ = 0.67$, $\beta = 1.51\text{x}10^{-4}$; Figure 2B), while pasture showed a negative correlation ($w_+ = 0.63$, $\beta = -1.45\text{x}10^{-4}$; Figure 2C).

Table 2. Model selection results for the top 10 models consisting of the probabilities of occupancy (*Ψ*) and detection (*p*) of lowland tapirs in Rio Doce State Park, state of Minas Gerais, southeastern Brazil. *Ψ* modeled as function of season (season), $\Psi_{conditional}$ of predators (predator), and nearest distance to water body (water), human settlement (human), eucalyptus plantations (eu) and pastures (pasture). p modeled as a function of $\Psi_{conditional}$ of predators (predator), and nearest distance to water body (water), human settlement (human), eucalyptus plantations (eu) and pastures (pasture). The plus (+) signal means an additive effect between two or mode covariates and the dot (.) means only the intercept.

Model	**AICc**	**Δ AICc**	**AICc Weights**	**Likelihood**	**Number of Parameters**	**-2Llog**
Ψ(.), p(predator + water + pasture + human)	965.00	0.00	0.13	1.00	6.00	952.17
Ψ(.), p(predator + pasture + eu + human)	966.44	1.45	0.06	0.49	6.00	953.61
Ψ(.), p(predator + pasture + human)	966.92	1.92	0.05	0.38	5.00	956.33
Ψ(.), p(predator + water + pasture + eu)	966.99	1.99	0.05	0.37	6.00	954.16
Ψ(water), p(predator + pasture +human)	967.79	2.79	0.03	0.25	6.00	954.96
Ψ(eu), p(predator + pasture + human)	968.52	3.52	0.02	0.17	6.00	955.69
Ψ(season), p(predator + pasture + urban)	968.55	3.55	0.02	0.17	6.00	955.72
Ψ(human), p(predator + pasture + human)	968.77	3.77	0.02	0.15	6.00	955.94
Ψ(.), p(water + pasture + human)	968.80	3.80	0.02	0.15	5.00	958.21
Ψ(.), p(water + pasture + eu + human)	968.83	3.83	0.02	0.15	6.00	956.00

Table 3. Cumulative AICc weights (w_+) of the covariates used to model occupancy (Ψ) and detection (p) probabilities of lowland tapirs in Rio Doce State Park, state of Minas Gerais, southeastern Brazil. Ψ modeled as function of season (season), $\Psi_{conditional}$ of predators (predator), and nearest distance to water body (water), human settlement (human), eucalyptus plantations (eu) and pastures (pasture). p modeled as a function of $\Psi_{conditional}$ of predators (predator), and nearest distance to water body (water), human settlement (human), eucalyptus plantations (eu) and pastures (pasture). Estimates of covariate effects (β) are given for the most parsimonious model that included the covariate. Covariates with $w_+ \geq 0.50$ are given in bold.

	Cumulative AICc	**β parameters**		
Covariate	**Weights (*w+*)**	**Estimate**	**Lower 95% CI**	**Upper 95% CI**
Tapir occupancy (Ψ)				
Distance to closest water body	0.17	1.98×10^{-4}	-2.39×10^{-4}	6.37×10^{-4}
Distance to closest human settlement	0.11	8.11×10^{-5}	-1.73×10^{-4}	3.35×10^{-4}
Season	0.11	-0.36	-1.27	0.54
Distance to closest eucalyptus plantation	0.12	-1.05×10^{-4}	-3.65×10^{-4}	1.53×10^{-4}
Distance to closest pasture	0.09	3.90×10^{-5}	-1.98×10^{-4}	2.76×10^{-4}
$\Psi_{conditional}$ of predators	0.08	0.01	-1.22	1.25
Tapir detection (p)				
$\Psi_{conditional}$ of predators	**0.76**	0.61	0.12	1.10
Distance to closest human settlement	**0.67**	1.51×10^{-4}	4.41×10^{-5}	2.58×10^{-4}
Distance to closest pasture	**0.63**	-1.45×10^{-4}	-2.48×10^{-4}	-4.27×10^{-5}
Distance to closest water body	0.49	-0.93×10^{-4}	-1.92×10^{-4}	5×10^{-6}
Distance to closest eucalyptus plantation	0.38	8.43×10^{-5}	-1.60×10^{-5}	1.84×10^{-4}

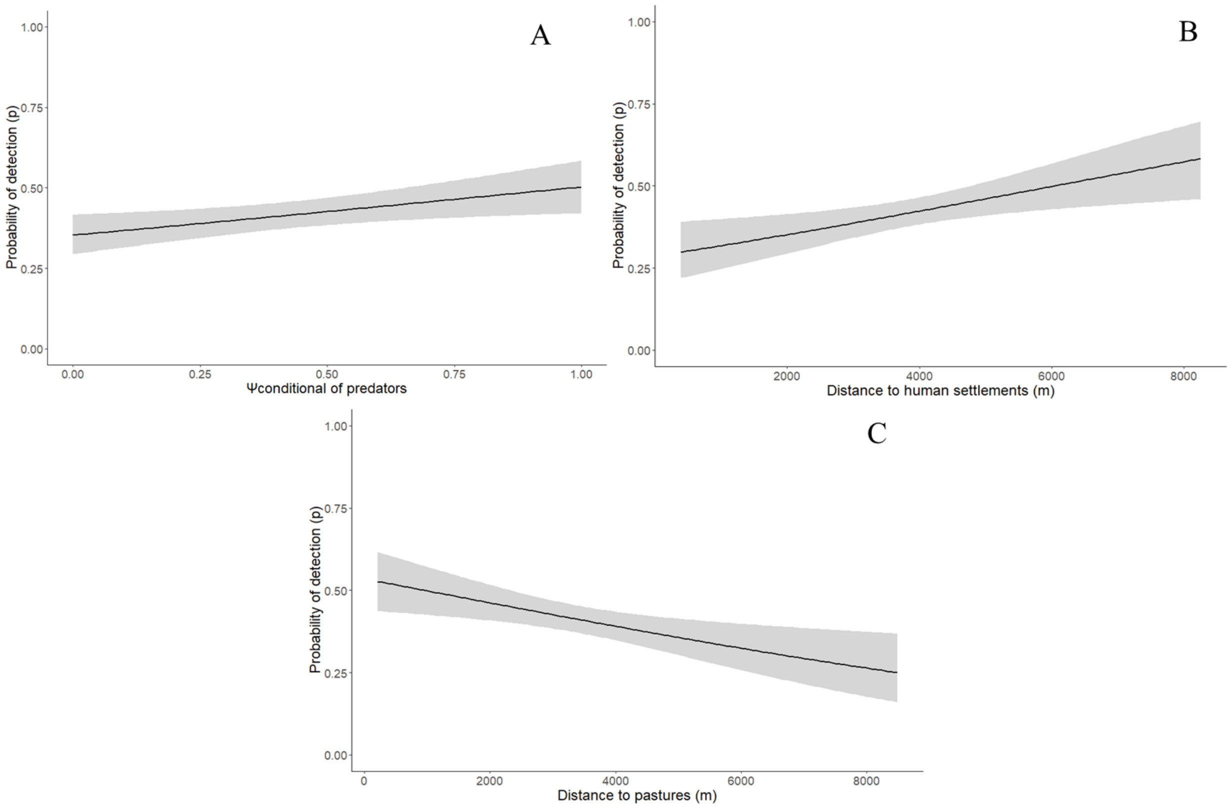

Figure 3. Probability of detection of Lowland tapir (95% CI) in function of conditional occupancy $\Psi_{conditional}$ of predators (A), distance to human settlements (B) and distance to pastures (C). Estimates are from the most parsimonious model that included each covariate.

5. Discussion

The occupancy probability of lowland tapir in RDSP was not influenced by the evaluated covariates, which might indicate that the species use almost the entire park with the same high probability ($\widehat{\Psi}$ = 0.74). RDSP does not present much heterogeneity of natural areas, being mainly composed of well-preserved forest and water bodies. Such composition may have minimized the potential negative effects of anthropogenic activities, such as human settlements, agricultural and silvicultural plantations, on tapir habitat use.

Contrary to what we expected, the tapir detection probability and thus its frequency of use in the occupied locations was strongly and positively related to the conditional occupancy of predators. In small scale, large animals usually limit their space use regarding to food rather than predation (Rettie and Messier 2000; Dupke et al.

2017; Owen-Smith and Traill 2017). This may be the reason for a higher tapir detection, especially due to the apparent low density of predators in the area as most sampling units had low value of $\Psi_{\text{conditional}}$ of predators. Consequently, tapirs may use high quality locations that are better for foraging, even if this means higher chance to encounter predators. Therefore, they may move more intensively as an anti-predation strategy, which increases their chance of being detected by camera-traps.

As predicted, the distance to human settlements was positively correlated with tapirs' detectability, indicating that human infrastructure may induce a behavioural response of increased avoidance by tapirs at these locations. These results agree with other studies showing that they may use with less intensity locations that are more frequented by people (Ferreguetti et al. 2017; Mena et al. 2020).

The tapir detection probability was also higher in locations closer to pastures. Even though pasture areas may increase the risk of disease transmitted from domestic animals, such as cattle (Medici and Desbiez 2012; Fernandes-Santos et al. 2020), and greater chance of being shot by farmers, it has been shown that tapirs can cross such locations (Noss et al. 2003; Medici 2010). In RDSP matrix, these agricultural open locations are near the forest border, where the vegetation presents more accessible heights and young stems are stimulated by higher sunlight, which have been shown to be preferred by tapir as foraging areas (Janzen 1982; Bodmer 1990; Foerster and Vaughan 2002; Tobler 2002).

The presence of *Eucalyptus* plantations around the east and south edges of the park did not influence tapir occupancy and detection probabilities. Although these silviculture areas make up a great part of RDSP matrix, most are located in the eastern border, where the Doce River may be acting as a natural barrier for tapirs' dispersal. Therefore, the pasture locations may be easier to use as travel routes than the *Eucalyptus* plantations, even though previous studies have shown that they are able to use and cross silvicultural areas (Flesher and Gatti 2010).

The distance to the nearest water resource also did not showed a strong influence on tapir occupancy and detection probabilities. Although water has been shown as a determinant factor for the presence and detection of the species (Padilla and Dowler 1994; Foerster and Vaughan 2002; Ferreguetti et al. 2017), this is not a limiting resource inside RDSP. Usually, resources that are abundant and noncyclic have less influence on habitat selection (Keim et al. 2011).

6. Conclusion

RDSP is the largest PA of Atlantic Forest in state of Minas Gerais and our results indicate that the tapir uses almost the entire park area. Despite the evidence that RDSP presents landscape characteristics that are required by tapir population to persist, other demographic parameters need to be evaluated. RDSP is isolated from other forest fragments, surrounded by a matrix of agricultural areas and human settlements (De Oliveira et al. 2020), which probably limit the genetic flow of this population and can lead to extinction in the long term. The loss of large and specialist species can have severe impacts on ecosystems functions (Galetti and Dirzo 2013; Bogoni et al. 2016). In particular, the extinction of large herbivores can promote negative impacts on the structure of plant diversity and community structure as well as cascade effect, which can promote evolutionary changes in the long-term (Medici 2010; Galetti and Dirzo 2013). On the other hand, tapir's main potential predator in the Atlantic Forest, the jaguar, does not seem to occur in large numbers in the park, which can result in tapir overpopulation in the long-term. The effects of such events on ecosystem functions are still unknown. As RDSP is one of the last large remnants where species interactions and functionality can still be evaluated, management actions can be proposed to successfully conserve biodiversity. Such actions can be applied to other similar Atlantic Forest fragments, therefore, long-term monitoring programs need to be stablished in RDSP.

References

ANDERSON, T. M. ET AL. 2016. The spatial distribution of african savannah herbivores: Species associations and habitat occupancy in a landscape context. Philosophical Transactions of the Royal Society B: Biological Sciences 371.

ASTETE, S., R. SOLLMANN, AND L. SILVEIRA. 2008. Comparative Ecology of Jaguars in Brazil. CAT News:9–14.

AZEVEDO, F. C. C., V. CANUTO, F. SOUZA, AND C. E. WIDMER. 2016. Puma (Puma concolor) predation on tapir (Tapirus terrestris). Biota Neotropica 16:e20150108.

BALME, G. A., R. SLOTOW, AND L. T. B. HUNTER. 2010. Edge effects and the impact of non-protected areas in carnivore conservation: Leopards in the Phinda-Mkhuze Complex, South Africa. Animal Conservation 13:315–323.

BARBIERI, M., AND J. BERGER. 2004. Optimal predictive model selection. The Annals of Statistics 32:870–897.

BEZERRA-NETO, J. F., L. M. GAGLIARDI, L. P. M. BRANDÃO, L. S. BRIGHENTI, AND F. A. R. BARBOSA. 2019. Effects of precipitation on summer epilimnion thickness in tropical lakes. Limnologica 74:42–50.

BODMER, R. E. 1990. Fruit patch size and frugivory in the lowland tapir tapirus terrestris. Journal of Zoology 222:121–128.

BOGONI, J. A. ET AL. 2016. Landscape features lead to shifts in communities of medium- to large-bodied mammals in subtropical Atlantic Forest. Journal of Mammalogy 97:713–725.

BROOKS, D. M., R. E. BODMER, AND S. MATOLA. 1997. Tapirs: Status Survey and Conservation Action Plan. IUCN/SSC Tapir Specialist Group (TSG).

BURNHAM, K. P., AND D. R. ANDERSON. 2002. Model Selection and Multimodal Inference. Springer.

CÂMARA, G., R. C. M. SOUZA, U. M. FREITAS, AND J. GARRIDO. 1996. Spring: Integrating remote sensing and gis by object-oriented data modelling. Computers and Graphics (Pergamon) 20:395–403.

CARBAJAL-BORGES, J. P., O. GODÍNEZ-GÓMEZ, AND E. MENDOZA. 2014. Density, Abundance and Activity Patterns of the Endangered Tapirus Bairdii in One of its Last Strongholds in Southern Mexico. Tropical Conservation Science 7:100–114.

CARO, T., AND P. SCHOLTE. 2007. When protection falters. African Journal of Ecology 45:233–235.

CHAPE, S., J. HARRISON, M. SPALDING, AND I. LYSENKO. 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. Philosophical Transactions of the Royal Society B: Biological Sciences 360:443–455.

COPPOLILLO, P., H. GOMEZ, F. MAISELS, AND R. WALLACE. 2004. Selection criteria for suites of landscape species as a basis for site-based conservation. Biological Conservation 115:419–430.

CRUZ, P., A. PAVIOLO, R. F. BÓ, J. J. THOMPSON, AND M. S. DI BITETTI. 2014. Daily activity patterns and habitat use of the lowland tapir (Tapirus terrestris) in the Atlantic Forest. Mammalian Biology 79:376–383.

CULLEN JR., L., R. E. BODMER, AND C. V. PÁDUA. 2000. Effects of hunting in habitat fragments of the Atlantic forests , Brazil. Biological Conservation 95:49–56.

DESBIEZ, A. L. J. 2009. Lowland tapirs in the Nhecolândia Region of the Brazilian Pantanal: Population density, habitat use and threats. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 25:7–12.

DOHERTY, P. F., G. C. WHITE, AND K. P. BURNHAM. 2012. Comparison of model building and selection strategies. Journal of Ornithology 152:317–323.

DOWNES, S. 2001. Trading heat and food for safety: Costs of predator avoidance in a lizard. Ecology 82:2870–2881.

DUPKE, C. ET AL. 2017. Habitat selection by a large herbivore at multiple spatial and temporal scales is primarily governed by food resources. Ecography 40:1014–1027.

EISENBERG, J., AND K. H. REDFORD. 1999. Mammals of the Neotropics. University of Chicago Press, Chicago, Illinois 3:1–624.

FERNANDES-SANTOS, R. C., E. P. MEDICI, C. TESTA-JOSÉ, AND A. C. CANENA. 2018. Impacto de agrotóxicos e metais pesados na anta brasileira (Tapirus terrestris) no estado do Mato Grosso do Sul, Brasil, e implicações para saúde humana e ambiental.

FERNANDES-SANTOS, R. C., E. P. MEDICI, C. TESTA-JOSÉ, AND T. MICHELETTI. 2020. Health Assessment of wild Lowland Tapir (Tapirus terrestris) in the highly threatened Cerrado biome, Brazil. Journal of Wildlife Diseases 56:817–822.

FERREGUETTI, Á. C., W. M. TOMÁS, AND H. G. BERGALLO. 2017. Density, occupancy, and detectability of lowland tapirs, Tapirus terrestris, in Vale Natural Reserve, southeastern Brazil. Journal of Mammalogy 98:114–123.

FLESHER, K. M., AND A. GATTI. 2010. Tapirus terrestris in Espírito Santo, Brasil. Tapir Conservation 19/1:1–40.

FOERSTER, C. R., AND C. VAUGHAN. 2002. Home Range, Habitat Use, and Activity of Baird's Tapir in Costa Rica. Biotropica 34:423–437.

FORMAN, R. T. T., AND L. E. ALEXANDER. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics:207–231.

FRAGOSO, J. M. V., K. M. SILVIUS, AND J. A. CORREA. 2003. Long-distance seed dispersal by tapirs increases seed survival and aggregates tropical trees. Ecology

84:1998–2006.

GALETTI, M., AND R. DIRZO. 2013. Ecological and evolutionary consequences of living in a defaunated world. Biological Conservation 163:1–6.

GASTON, K. J., S. F. JACKSON, L. CANTÚ-SALAZAR, AND G. CRUZ-PIÑÓN. 2008. The Ecological Performance of Protected Areas. Annual Review of Ecology, Evolution, and Systematics 39:93–113.

GONZÁLEZ-MAYA, J. F., J. SCHIPPER, AND K. ROJAS-JIMÉNEZ. 2009. Elevational Distribution and Abundance of Baird's Tapir (Tapirus bairdii) at different Protection Areas in Talamanca Region of Costa Rica. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 18:29–35.

GOULART, F. V. B., N. C. CÁCERES, M. E. GRAIPEL, M. A. TORTATO, I. R. GUIZONI JR, AND L. G. R. OLIVEIRA-SANTOS. 2009. Habitat selection by large mammals in a southern Brazilian Atlantic Forest. Mammalian Biology 74:182–190.

HERRERA, J. C., A. B. TABER, R. B. WALLACE, AND R. L. E. PAINTER. 1999. Lowland tapir (Tapirus terrestris) behavioral ecology in a southern Amazonian tropical forest. Vida Silvestre Neotropical:31–37.

HINES J.E. PRESENCE – Software to estimate patch occupancy and related parameters. USGS-PWRC. 2006. <https://www.mbr-pwrc.usgs.gov/software/presence.html>. Acessed 21 october 2019.

IEF - INSTITUTO ESTADUAL DE FLORESTAS. 2001. Plano de manejo do Parque Estadual do Rio Doce.

JANZEN, D. H. 1982. Seeds in tapir dung in Santa Rosa National Park, Costa Rica. Brenesia 19/20:129135.

KEIM, J. L., P. D. DEWITT, AND S. R. LELE. 2011. Predators choose prey over prey habitats: evidence from a lynx–hare system. Ecological Applications 21:1011–1016.

MACHADO, A.B.M. ET AL. 1998. Livro vermelho das espécies ameaçadas de extinção da fauna de Minas Gerais. Fundação Biodiversitas. 608p

MACKENZIE, D. I., AND L. L. BAILEY. 2004. Assessing the fit of site-occupancy models. Journal of Agricultural, Biological, and Environmental Statistics 9:300–318.

MACKENZIE, D. I., AND W. C. KENDALL. 2002. How should detection probability be incorporated into estimates of relative abundance? Ecology 83:2387–2393.

MACKENZIE, D. I., J. D. NICHOLS, J. E. HINES, M. G. KNUTSON, AND A. B. FRANKLIN. 2003. Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly. Ecology 84:2200–2207.

MACKENZIE, D. I., J. D. NICHOLS, G. B. LACHMAN, S. DROEGE, A. A. ROYLE, AND C. A. LANGTIMM. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248–2255.

MACKENZIE, D. I., J. D. NICHOLS, J. A. ROYLE, K. H. POLLOCK, L. L. BAILEY, AND J. . HINES. 2006. Occupancy Estimation and Modeling. Oxford: Academic Press.

MACKENZIE, D. I., J. D. NICHOLS, N. SUTTON, K. KAWANISHI, AND L. L. BAILEY. 2005. Improving inferences in population studies of rare species that are detected imperfectly. Ecology 86:1101–1113.

MACKENZIE, D. I., AND J. A. ROYLE. 2005. Designing occupancy studies: General advice and allocating survey effort. Journal of Applied Ecology 42:1105–1114.

MASSARA, R. L., A. M. DE O. PASCHOAL, L. L. BAILEY, P. F. DOHERTY, A. HIRSCH, AND A. G. CHIARELLO. 2018. Factors influencing ocelot occupancy in Brazilian Atlantic Forest reserves. Biotropica 50:125–134.

MEDICI, E. P. 2010. Assessing the Viability of Lowland Tapir Populations in a Fragmented Landscape. Thesis:292.

MEDICI, E. P., AND A. L. J. DESBIEZ. 2012. Population viability analysis: Using a modeling tool to assess the viability of tapir populations in fragmented landscapes. Integrative Zoology 7:356–372.

MEDICI, E. P., K. FLESHER, B. D. M. BEISIEGEL, AND A. KEUROGHLIAN. 2012. Avaliação do risco de extinção de Tapirus terrestris Linnaeus, 1758,. Ano II 1:3–11.

MELLO, C. L., C. M. S. METELO, K. K. SUGUIO, AND H. C. KOHLER. 1999. Quaternary sedimentation, neotectonics and the evolution of the Doce River Middle Valley lake system (Southeastern Brazil). Revista do Instituto Geológico 20:29–36.

MENA, J. L., H. YAGUI, F. LA ROSA, P. PASTOR, J. RIVERO, AND R. APPLETON. 2020. Topography and disturbance explain mountain tapir (Tapirus pinchaque) occupancy at its southernmost global range. Mammalian Biology 100:231–239.

MISTLBERGER, R. E., AND D. J. SKENE. 2004. Social influences on mammalian circadian rhythms: Animal and human studies. Biological Reviews of the Cambridge Philosophical Society 79:533–556.

NAGY-REIS, M. B., C. A. ESTEVO, E. Z. F. SETZ, M. C. RIBEIRO, A. G. CHIARELLO, AND J. D. NICHOLS. 2017. Relative importance of anthropogenic landscape characteristics for Neotropical frugivores at multiple scales. Animal Conservation 20:520–531.

NARANJO, E. J. 2009. Ecology and Conservation of Baird's Tapir in Mexico. Tropical Conservation Science 2:140–158.

NAVEDA, A. ET AL. 2008. Tapirus terrestris. *The IUCN Red List of Threatened Species*.

NOSS, A. J. ET AL. 2003. A Camera Trapping and Radio Telemetry Study of Lowland Tapir (Tapirus terrestris) in Bolivian Dry Forests. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 12:24–32.

O'FARRILL, G., M. GALETTI, AND A. CAMPOS-ARCEIZ. 2013. Frugivory and seed dispersal by tapirs: An insight on their ecological role. Integrative Zoology 8:4–17.

OLIVEIRA-SANTOS, L. G. R., L. C. P. MACHADO-FILHO, M. A. TORTATO, AND L. BRUSIUS. 2010. Influence of extrinsic variables on activity and habitat selection of lowland tapirs (Tapirus terrestris) in the coastal sand plain shrub, southern Brazil. Mammalian Biology 75:219–226.

OLIVEIRA, B. R. DE, S. M. CARVALHO-RIBEIRO, AND P. M. MAIA-BARBOSA. 2019. A multiscale analysis of land use dynamics in the buffer zone of Rio Doce State Park, Minas Gerais, Brazil. Journal of Environmental Planning and Management 63:935–957.

DE OLIVEIRA, B. R., E. L. DA COSTA, S. M. CARVALHO-RIBEIRO, AND P. M. MAIA-BARBOSA. 2020. Land use dynamics and future scenarios of the Rio Doce State Park buffer zone, Minas Gerais, Brazil. Environmental Monitoring and Assessment 192.

OWEN-SMITH, N., AND L. W. TRAILL. 2017. Space use patterns of a large mammalian herbivore distinguished by activity state: fear versus food? Journal of Zoology 303:281–290.

PADILLA, M., AND R. C. DOWLER. 1994. *Tapirus terrestris*. Pp. 1–8 in Mammalian Species.

PAOLUCCI, L. N. ET AL. 2019. Lowland tapirs facilitate seed dispersal in degraded Amazonian forests. Biotropica 51:245–252.

PELD/CNPQ – Site 4. 2007. Mata Atlântica e Sistema Lacustre do Médio Rio Doce. Pesquisas Ecológicas de Longa Duração – Sítio No 4(75): 358–362.

PEREIRA, G. ET AL. 2018. Análise Da Variabilidade Da Precipitação Para O Estado De Minas Gerais (1981-2017). Revista Brasileira de Climatologia 1:213–229.

POLISAR, J., I. MAXIT, D. SCOGNAMILLO, L. FARRELL, M. E. SUNQUIST, AND J. F. EISENBERG. 2003. Jaguars, pumas, their prey base, and cattle ranching: Ecological interpretations of a management problem. Biological Conservation 109:297–310.

RABINOWITZ, A. R., AND B. G. Jr. NOTTINGHAM, B. G. 1986. Ecology and behavior of the jaguar (*Panthera onca*) in Belize, Central America. Journal of Zoology 210: 149–159. https://doi.org/10.1111/j.1469-7998.1986. tb03627.x

RETTIE, W. J., AND F. MESSIER. 2000. Hierarchical habitat selection by woodland caribou: its relationship to limiting factors. Ecography 23:466–478.

ROBINSON, J. G., AND K. H. REDFORD. 1991. Sustainable harvest of Neotropical forest mammals. Neotropical Wildlife Use and Conservation (J. G. Robinson & K. H. Redford, eds.). University of Chicago Press, Chicago, Illinois, USA.

ROWCLIFFE J.M., J. FIELD, S. T. TURVEY, AND C. CARBONE. 2008. Estimating animal density using camera traps without the need for individual recognition. Journal of Applied Ecology 45:1228–1236.

SALAS, L. A. 1996. Habitat use by lowland tapirs (Tapirus terrestris L.) in the Tabaro River valley, southern Venezuela. Canadian Journal of Zoology 74:1452–1458.

SANDERSON, E. W., K. H. REDFORD, A. VEDDER, P. B. COPPOLILLO, AND S. E. WARD. 2002. A conceptual model for conservation planning based on landscape species requirements. Landscape and Urban Planning 58:41–56.

TOBLER, M. W. 2002. Habitat Use and Diet of Baird's Tapirs (Tapirus bairdii) in a Montane Cloud Forest of the Cordillera de Talamanca, Costa Rica. Biotropica 34:468–474.

TUNDISI, J. G., AND Y. SAIJO. 1997. Limnological studies on the Rio Doce Valley Lakes, Brazil. São Carlos: Brazilian Academy Sciences, USP-EESC.

VARELA, D. ET AL. 2019. Tapirus terrestris. *The IUCN Red List of Threatened Species*.

WHITE, G. C., AND K. P. BURNHAM. 1999. Program mark: Survival estimation from populations of marked animals. Bird Study 46:S120–S139.

WITTEMYER, G., P. ELSEN, W. T. BEAN, A. C. O. BURTON, AND J. S. BRASHARES. 2008. Accelerated Human Population Growth at Protected Area Edges. Science 321:123–127.

WRIGHT, S. J., H. ZEBALLOS, I. DOMINGUEZ, M. M. GALLARDO, M. C. MORENO, AND R. IBÁÑEZ. 2000. Poachers alter mammal abundance, seed dispersal, and seed predation in a neotropical forest. Conservation Biology 14:227–239.

ANEXOS

CAPÍTULO I

Appendix 1. Spearman's correlation matrix with the covariates measured in the Rio Doce State Park, southeastern Brazil. The forest covariate was measured inside a buffer of 1250 meters in diameter. The other covariables (DistWater, DistPaved, DistUnpaved, DistCrop, DistPasture, DistEu and DistSet) were measured considering the Euclidean distance (linear) between the sampling unit and the nearest land use category. Highly correlated covariates are in bold. * = covariables excluded from the final model set.

	DistWater	DistPaved	DistUnpaved	DistUCrop	DistPasture	DistEu	DistSet	Forest
DistWater	-							
DistPaved*	-0.5							
DistUnpaved*	-0.26	**0.65**						
DistCrop*	-0.45	**0.84**	0.49					
DistPasture	-0.47	**0.67**	0.55	**0.69**				
DistEu	-0.2	0.46	**0.67**	0.15	0.2			
DistSet	-0.18	**0.72**	**0.66**	**0.62**	0.44	0.32		
Forest*	0.55	-0.01	0.22	0.06	0.01	0.18	0.16	-

CAPÍTULO II

Activity Patterns of Lowland Tapir (*Tapirus terrestris)* in the largest Atlantic Forest patch of Minas Gerais

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Abstract

Activity patterns can change according to ecological, environmental, or human-related factors. Depending on the location, the same species may need to adjust their behaviour to acquire their daily energetic needs. Therefore, stablishing the activity patterns of a target species add important behavioural information for both basic ecology and conservation planning. Here, we aimed to evaluate the factors that may influence lowland tapir (*Tapirus terrestris*) activity pattern in one of the largest Atlantic Forest Protected Area in Brazil, the Rio Doce State Park (RDSP). Using camera-trap records, we verified the influence of sex, season (dry and rainy season) and human activity (location of the camera traps close or distant to highly densely populated settlements) on lowland tapir daily activity. The tapir activity pattern was categorized based on the proportion of independent records during night and day times. Tapir showed a predominantly nocturnal behaviour, which corroborates other studies carried out in the Atlantic Forest. There was no significant difference across sexes, seasons, and locations. Our results suggested that the current protection level of the park allows tapirs to maintain their behaviour. Future studies aiming to capture the species in the park should account for their nocturnal behaviour to maximize trapping effort.

Keywords: Daily Activity; Camera-trapping; Behaviour; Rio Doce State Park; Tapir

1. Introduction

As the landscape changes over time, which can happen in the long term or in the course of a 24-hour day, animals may need to adjust their behaviour, including diel activity (Schoener 1974) to meet their daily needs according to the aspects of the area they inhabit (Downes 2001; Nagy-Reis et al. 2017). Therefore, knowledge about species activity pattern is one of the behavioural aspects that add valuable information for both basic ecology and conservation planning (Frey et al. 2017).

One of the main factors regulating animal activity is local sun availability (Halle and Stenseth 2000), being the reason why some species modify their activity time between seasons (Foerster and Vaughan 2002) or according to day temperature (Bennie et al. 2014). However, other factors can affect activity patterns, such as species physical traits (Kronfeld-Schor and Dayan 2003; Roll et al. 2006; Bennie et al. 2014), like body size and shape (Du Toit and Yetman 2005; Kirk 2006), intra and interspecific interactions (Mistlberger and Skene 2004; Foster et al. 2013; Ross et al. 2013; Díaz-Ruiz et al. 2016), as well as human activities (Kilgo et al. 1998; Kitchen et al. 2000; Martin and Réale 2008; Norris et al. 2010).

Overall, species are categorized as cathemeral (use day and night periods), diurnal or nocturnal (Mistlberger and Antle 2011). The detailed patterns of activity of a specific population can help to interpret the relationship between the species and local variables, such as landscape composition, weather conditions, and animal community structure.

The lowland tapir (*Tapirus terrestris*) is listed as Critically Endangered in Minas Gerais state (Machado et al., 1998; Conselho Estadual de Política Ambiental, 2010) and is the largest terrestrial herbivore species in Brazil, playing a key role in plant dispersion and predation (Fragoso et al. 2003; Medici 2010). Throughout its occurrence range, the species has been classified as mostly nocturnal or crepuscular (Padilla and Dowler 1994; J. et al. 2003; Medici 2010; Oliveira-Santos et al. 2010; Wallace et al. 2012; Cruz et al. 2014). However, some environmental and biological factors have already been shown to affect their activity pattern, such as season (Foerster and Vaughan 2002; Medici 2010) and sex (Medici 2010). Thus, the present study aimed to evaluate lowland tapir (*Tapirus terrestris*) activity patterns in Rio Doce State Park (RDSP), the largest Atlantic Forest Protect Area in the state of Minas Gerais, Brazil (Myers et al. 2000), in function of season, sex and locations of the camera traps in the park.

Tapir has a large body size, which make it challenging to dissipate heat. Therefore, they may be more active during cooler times of the day to facilitate such process (Foerster and Vaughan 2002). RDSP presents two defined seasons: a dry season, between April and September, and a rainy season between October and March (IBGE 2002). Therefore, we would expect a seasonal shift in activity patterns in our study area given the variation in mean pluviosity and temperature between seasons.

Tapirs also present a long reproductive cycle (approximately a 400-day gestation period; Barongi 1993) and parental care (Padilla and Dowler 1994). These biological characteristics may require females to stay active longer periods to acquire energy for herself and for the offspring. Therefore, we hypothesized that there would be a difference between the activity patterns related to sex of the individual, being females active for a longer period than males.

RDSP presents different levels of human activity, being the northern region surrounded by extensive urban agglomerates and industrial factories (Oliveira et al. 2019), with lower surveillance against poaching. Studies found that large-bodied species tend to show a strong response to human activity, probably because of their higher probability of being hunted or because of their need for large habitat areas (Gaynor et al. 2018). Given that animals are able to change their behaviour to avoid contact with humans and based on the characteristics of the landscape and anthropogenic pressures surrounding RDSP, we hypothesized that tapirs would be less active in the northern region of the park to avoid contact with humans.

2. Study Area

The present study was conducted in RDSP, which covers ~ 36,000 hectares (ha) and it is located in the eastern region of Minas Gerais state (Figure 1), among the municipalities of Marliéria, Dionísio and Timóteo (PELD/CNPq 2007). RDSP presents a continuum extension of semideciduous Atlantic Forest (Mello et al. 1999) and has 42 lakes within its limits (IEF 2019). The Doce River encompass the entire eastern border, and the northwestern border is set by the Piracicaba River (IEF 2002). The surrounding area of the park is composed of extensive *Eucalyptus* plantations, mainly to the eastern and southern borders, agricultural lands predominantly to the western and urban areas to the northern border (PELD/CNPq 2007; Oliveira et al. 2019).

The climate of the region is classified as semi-humid tropical, with two well defined seasons: dry and rainy season (IBGE 2002), with average precipitation of 1478 mm (Bezerra-Neto et al. 2019) and medium temperature of 22º C (IEF, 2001).

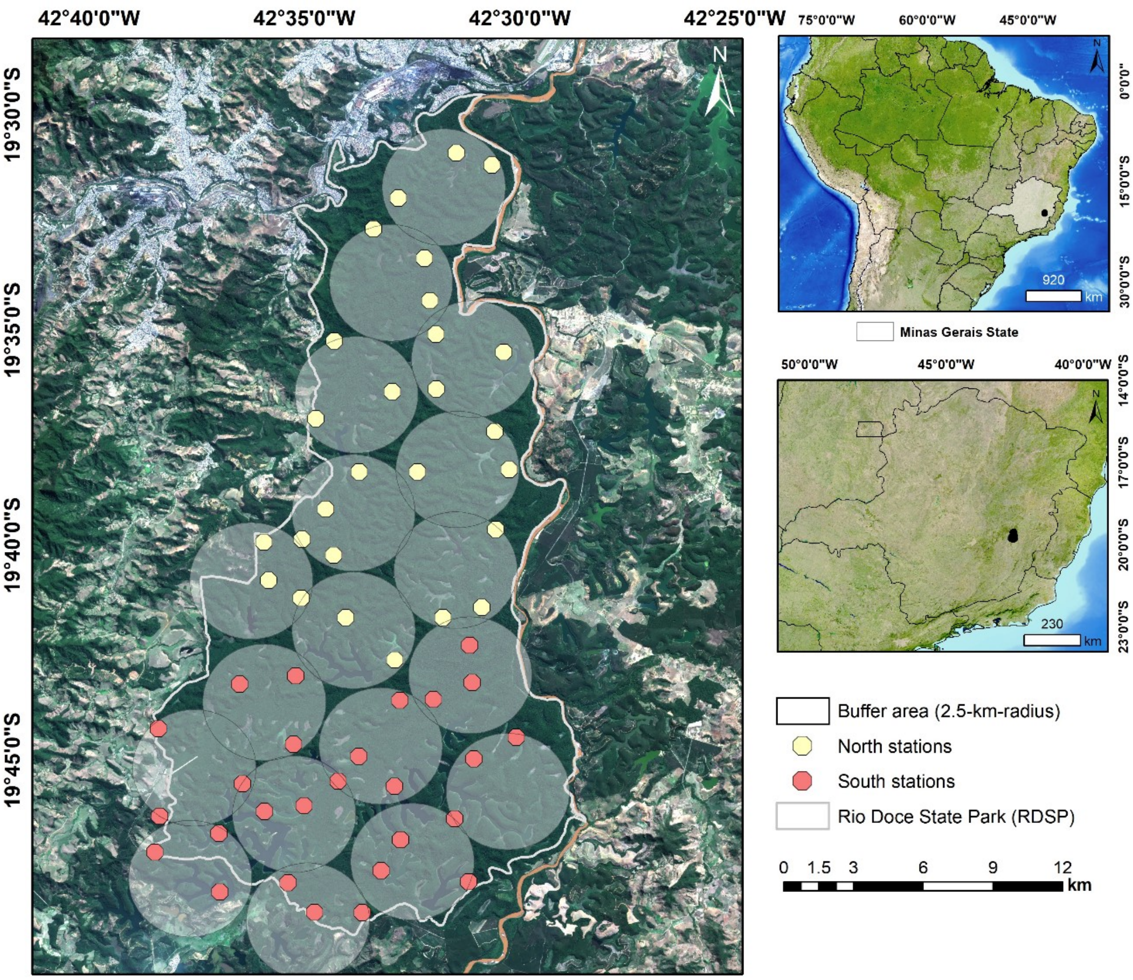

Figure 1. Map of the Rio Doce State Park, state of Minas Gerais, Brazil, with the camera-trap sampling stations, used to assess tapir activity patterns.

3. Methods

3.1. Camera-trapping

The camera trapping design was part of the Project Carnívoros do Rio Doce, whose primary goal was to evaluate jaguar population status. To cover the entire park, a total of 54 sampling units were randomly established at an average distance of 1.5 km between each other (Figure 1). Due to logistical restrictions, the cameras were firstly set up in the north of the park and then in the south, covering both seasons: dry season -

April to August 2016 – and rainy season - November 2016 to March 2017. The sampling period was of 40 days each season and in each region (north and south).

At each sampling unit, two camera-traps (of the following models: Bushnell Trophy Cam Natureview, Trophy Cam Standard and Trophy Cam Essential – Kansas, USA) were installed about 40 cm above the ground. The settings of all cameras were standardised to work 24 h to record videos of 10 s length and 1 min recording interval. The records were analysed to register species, date, time and location. To avoid autocorrelation, we only used records with at least 1 hour between them or when we could unambiguously identify individuals (Carbajal-Borges et al. 2014). Considering this same interval, multiple individuals of the same species were considered as one single record of the species (Azevedo et al. 2018).

3.2. Data analysis

Lowland tapir activity pattern was determined according to the proportion of independent records, as described by van Schaik & Griffiths (1996). The classification was determined following Gómez (2005): diurnal, if less than 10% of records at night; nocturnal, if more than 90% of records at night; mostly diurnal, if 10% to 29% of records at night; mostly nocturnal, if 70% to 89% of records at night; or cathemeral, if 30% to 69% of records at night.

To analyse the data, we first adjusted all records to the sunrise or sunset hour of each specific day to account for sun's position changes according to season (Nouvellet et al. 2012). Afterwards, we transformed the sunset and sunrise hours in radians. To determine lowland tapir daily activity pattern and to check for overlap between sexes, north and south records, and rainy and dry season records, we followed the method described by Ridout & Linkie (2009).

We ran a non-parametric circular kernel-density function to assess tapir daily activity patterns. To assess how similar were the activity patterns between sexes, seasons, and locations of the camera traps inside the park, we estimated the coefficient of overlapping (Δ-hat), which is the common area under both density curves, ranging from 0 (no overlap) to 1 (complete overlap) (Ridout and Linkie 2009). Therefore, we expected low Δ-hat value if the species have different activity pattern across sexes, seasons and locations within the park. As we have a large sample size (>75 camera records), we used Δ_4 estimator as recommended by Meredith & Ridout (2020). To assess the precision of this estimator, we calculated the 95% confidence intervals of each overlap index using smoothed bootstrap with 10,000 resamples (Meredith and Ridout 2020). Statistical analyses were implemented in the software R 3.5.2 (R Core Team 2018) using the *overlap* R-package (Meredith and Ridout 2020) with a smoothing parameter of 1.0. To assess if the differences in activity patterns between sex, season and location were statistically significant ($p < 0.05$), we used chi-square independence test also performed in Program R 3.5.2 (R Core Team 2018).

4. Results

Out of a total sampling effort of 7,447 trap/nights, we obtained 1889 tapir records. Of these, 892 were considered as independent detections, and 306 (34.3%) records were identified as females, 255 (28.6%) males and 331 (37.1%) were unidentified.

Tapirs were mostly nocturnal ($t = 4.7739$, $df = 47.842$, $p < 0.01$), with 695 (77.9%) night records and 197 (22.1%) records during daytime. The species becomes more active after sunset to sunrise (Figure 2). The main periods of activity occurred from 18:00-4:00 h, with two main peaks: one between 18:00 h and 19:00 h, and a second and longer one between 01:00 h and 04:00 h (Figure 2). Tapirs were mostly inactive from 07:00-13:00 h (Figure 2 and 3).

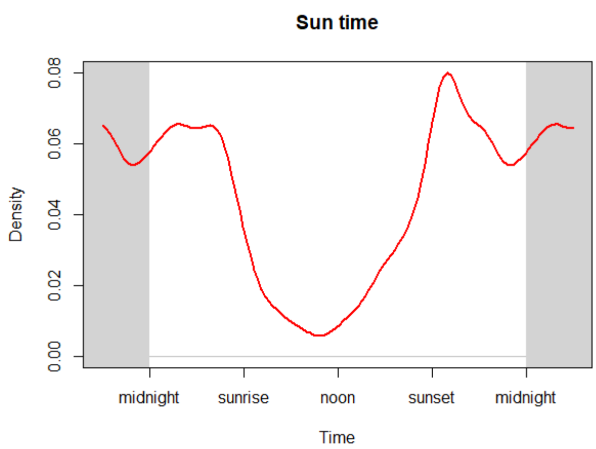

Figure 2. Lowland tapir (*Tapirus terrestris*) activity pattern

according to sun time based on camera-trap surveys
(from 2016 to 2017) in Rio Doce State Park, Minas Gerais
state, Brazil.

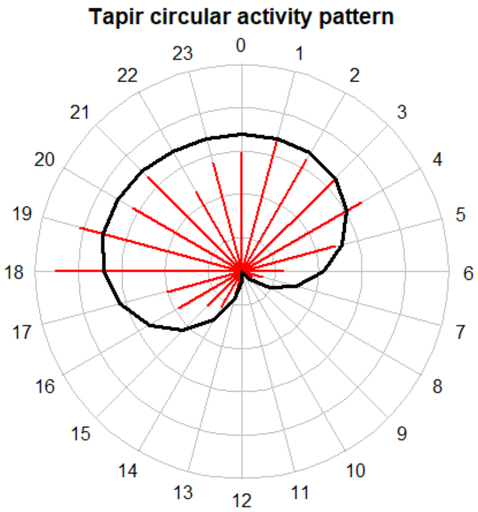

Figure 3. Circular activity pattern of lowland tapir (*Tapirus terrestris*) based on camera-trap surveys (from 2016 to 2017) in Rio Doce State Park, Minas Gerais state, Brazil.

Male and female tapirs did not show significant differences in their activity patterns ($\chi^2_{1,\ N=\ 561}$= 1.44, *P*=0.23), with a high overlap between them (Δ = 0.91, 95% CI = 0.86 – 0.96; Figure 4). However, females were constantly active between 01:00-04:00h, while males had peaks at 01:00 h, 03:00 h and 05:00 h (Figure 4). Further, while females had a peak of activity between 18:00-19:00 h, males were mostly active at 19:00 h (Figure 5). Moreover, male tapirs were not completely inactive during day hours (Figure 5).

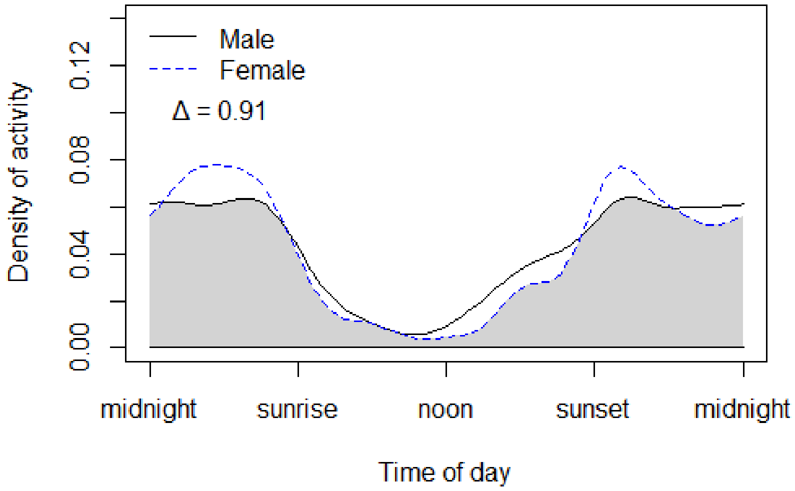

Figure 4. Activity pattern of male (n = 255) and female (n = 306) lowland tapir (*Tapirus terrestris*) based on camera-trap surveys (from 2016 to 2017) in Rio Doce State Park, Minas Gerais state, Brazil. The coefficient of overlapping is represented by the shaded area.

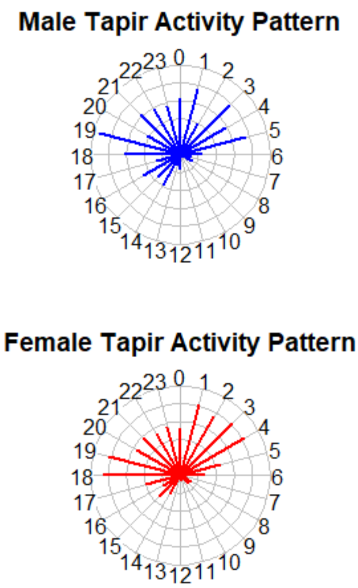

Figure 5. Circular activity pattern of male and female lowland tapir (*Tapirus terrestris*) based on camera-trap surveys (from 2016 to 2017) in Rio Doce State Park, Minas Gerais state, Brazil.

Tapir activity patterns between dry and rainy season were similar ($\chi^2_{1,N=892}$= 1.35, *P* =0.24), with high overlap (Δ-hat = 0.94, 95% CI = 0.90 – 0.97; Figure 6). One slightly difference is that the species presented higher peaks of activity just before sunrise and after sunset during the dry season. Records from the northern and southern portions of the park also did not show significant differences ($\chi^2_{1,N=892}$= 1.89, P =0.17), and presented high degree of overlap (Δ-hat = 0.87, 95% CI = 0.82 – 0.91; Figure 7). However, it was possible to notice that tapirs at the northern portion of the park were recorded during day hours more often than at the southern portion. Records from the southern portion had two peaks of activity, one between 02:00-03:00 h and a second one at sunset, while tapirs at the northern portion had a peak of activity between 04:00-05:00 h and a second one after sunset (Figure 7).

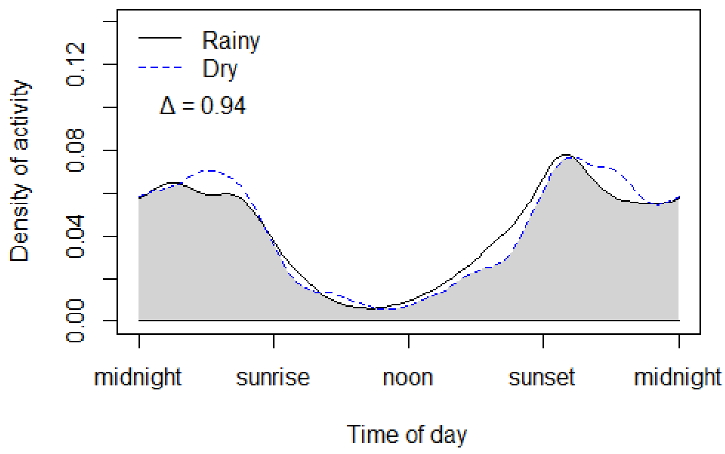

Figure 6. Lowland tapir (*Tapirus terrestris*) activity pattern during the rainy and dry season based on camera-trap surveys (from 2016 to 2017) in Rio Doce State Park, Minas Gerais state, Brazil. The coefficient of overlapping is represented by the shaded area.

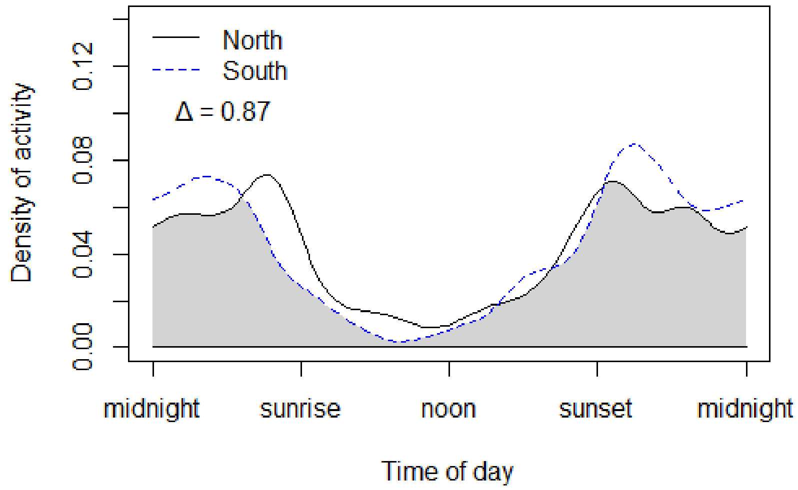

Figure 7. Activity pattern of south and north camera-trap records (from 2016 to 2017) of lowland tapir (*Tapirus terrestris*) in Rio Doce State Park, Minas Gerais state, Brazil. The coefficient of overlapping is represented by the shaded area.

5. Discussion

Our results show that lowland tapirs are mainly nocturnal, corroborating other results of tapir´s activities reported in the Atlantic Forest (Medici 2010; Oliveira-Santos et al. 2010; Cruz et al. 2014) and in the Amazon Forest (Tobler et al. 2009; Wallace et al. 2012). This may be explained by tapir's difficult to dissipate heat due to their massive body size, forcing the species to obtain most of their daily energy needs at night, when temperatures are lower at these biomes (Speakman and Król 2010).

The general pattern of tapir activity at both rainy and dry seasons, males and females, as well as northern and southern records were quite similar. They showed two main peaks of activity: one just after sunset and other between midnight and sunrise. However, there were some slight variations.

The highest overlap of tapir's activity pattern was between the rainy and dry season meaning they did not change their behaviour across seasons in the park. This is probably related to the small difference in the mean pluviosity and temperature across seasons during our survey period (INMET 2017; Lima and Cupolillo 2018). However, there is a slightly increase in daily activity during rainier months, a pattern that was also observed in studies conducted in other areas of the Atlantic Forest (Medici 2010). This pattern can be a consequence of a decrease in daily temperature during the rainier months, allowing tapirs to be active longer during day hours.

Despite of no significant differences found in male and female activity patterns, male tapirs were slightly more active during daytime than females. A study carried out in an area of Atlantic Forest showed that male tapirs are lighter weighted than females (Medici 2010). Therefore, they may be able to stay slightly more active during daytime, not impacting much their heat dissipation process. However, as tapirs from RDSP were not captured and measured, future studies should test this hypothesis.

Tapir records during daytime hours were more often in the northern than in the southern portion of the park, although the difference was subtle. RDSP is known as a well-protected area from lethal human activities, such as poaching (Massara et al. 2018). Although the northern portion of the park is closer to highly human-dense cities, the Piracicaba river sets up the border of the park, separating the forest continuum from the city, which appears to be acting as an effective barrier, decreasing edge effects associated with proximity to human-populated areas. On the other hand, the southern portion of the park is an area more accessible to visitors and researchers, with more human infrastructure inside this portion of the park. Therefore, human activity during daytime hours may be higher inside this portion than in the north of the park, where the access is more difficult. Consequently, the slightly higher number of records from the southern portion at night is possibly due to human avoidance behaviour. Some studies show that even non-lethal activities can have an impact in animal diel activity (Frid and Dill 2002; Gaynor et al. 2018). Therefore, we encourage future studies to compare areas where human activities are higher with RDSP to evaluate if tapirs change their diel activity due to higher anthropic influences.

6. Final Remarks

Our results indicate that tapirs inhabiting RDSP presents similar activity patterns compared to other Brazilian biomes. We hope that this study serves as a baseline to compare the tapir behaviour with other regions, specially evaluating the impact of higher human activities in the behaviour of an endangered species. Further, the information on tapir activity patterns in RDSP can be taken into consideration to evaluate, choose and customize field methods and designing future research efforts in the area.

References

AZEVEDO, F. C., F. G. LEMOS, M. C. FREITAS-JUNIOR, D. G. ROCHA, AND F. C. C. AZEVEDO. 2018. Puma activity patterns and temporal overlap with prey in a human-modified landscape at Southeastern Brazil. Journal of Zoology 305:246–255.

BENNIE, J. J., J. P. DUFFY, R. INGER, AND K. J. GASTON. 2014. Biogeography of time partitioning in mammals. Proceedings of the National Academy of Sciences of the United States of America 111:13727–13732.

BEZERRA-NETO, J. F., L. M. GAGLIARDI, L. P. M. BRANDÃO, L. S. BRIGHENTI, AND F. A. R. BARBOSA. 2019. Effects of precipitation on summer epilimnion thickness in tropical lakes. Limnologica 74:42–50.

CARBAJAL-BORGES, J. P., O. GODÍNEZ-GÓMEZ, AND E. MENDOZA. 2014. Density, Abundance and Activity Patterns of the Endangered Tapirus Bairdii in One of its Last Strongholds in Southern Mexico. Tropical Conservation Science 7:100–114.

CRUZ, P., A. PAVIOLO, R. F. BÓ, J. J. THOMPSON, AND M. S. DI BITETTI. 2014. Daily activity patterns and habitat use of the lowland tapir (Tapirus terrestris) in the Atlantic Forest. Mammalian Biology 79:376–383.

DÍAZ-RUIZ, F., J. CARO, M. DELIBES-MATEOS, B. ARROYO, AND P. FERRERAS. 2016. Drivers of red fox (*Vulpes vulpes*) daily activity: prey availability, human disturbance or habitat structure? Journal of Zoology 298:128–138.

DOWNES, S. 2001. Trading heat and food for safety: Costs of predator avoidance in a lizard. Ecology 82:2870–2881.

FOERSTER, C. R., AND C. VAUGHAN. 2002. Home Range, Habitat Use, and Activity of Baird's Tapir in Costa Rica. Biotropica 34:423–437.

FOSTER, V. C. ET AL. 2013. Jaguar and Puma activity patterns and predator-prey interactions in four brazilian biomes. Biotropica 45:373–379.

FRAGOSO, J. M. V., K. M. SILVIUS, AND J. A. CORREA. 2003. Long-distance seed dispersal by tapirs increases seed survival and aggregates tropical trees. Ecology 84:1998–2006.

FREY, S., J. T. FISHER, A. C. BURTON, AND J. P. VOLPE. 2017. Investigating animal activity patterns and temporal niche partitioning using camera-trap data: challenges and opportunities. Wiley-Blackwell. Remote Sensing in Ecology and Conservation.

FRID, A., AND L. DILL. 2002. Human-caused disturbance stimuli as a form of predation risk. Ecology and Society 6.

GAYNOR, K. M., C. E. HOJNOWSKI, N. H. CARTER, AND J. S. BRASHARES. 2018. The influence of human disturbance on wildlife nocturnality. Science 360:1232–1235.

HALLE, S., AND N. C. STENSETH. 2000. Activity Patterns in Small Mammals: An

Ecological Approach. Springer, Berlin, Heidelberg.

IBGE. Instituto Brasileiro de Geografia e Estatística. Mapa de Clima do Brasil. 2002. <ftp://geoftp.ibge.gov.br/informacoes_ambientais/climatologia/mapas/brasil/Map_BR_clima_2002.pdf>. Acessed 21 september 2018.

IEF - INSTITUTO ESTADUAL DE FLORESTAS. 2001. Plano de manejo do Parque Estadual do Rio Doce.

IEF. Instituto Estadual de Florestas. Parque Estadual do Rio Doce; 2019**.** < http://www.ief.mg.gov.br/component/content/195?task=view> Accessed 26 September 2019.

INMET. Instituto Nacional de Meteorologia. 2018. Sistema de Suporte à Decisão na Agropecuária, Balanço Hídrico Sequencial. <http://sisdagro.inmet.gov.br/sisdagro/app/monitoramento/bhs>. Acessed 23 December 2020.

KILGO, J. C., R. F. LABISKY, AND D. E. FRITZEN. 1998. Influences of hunting on the behavior of white-tailed deer: Implications for conservation of the Florida panther. Conservation Biology 12:1359–1364.

KIRK, E. C. 2006. Eye Morphology in Cathemeral Lemurids and Other Mammals. Folia Primatologica 77:27–49.

KITCHEN, A. M., E. M. GESE, AND E. R. SCHAUSTER. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. Canadian Journal of Zoology 78:853–857.

KRONFELD-SCHOR, N., AND T. DAYAN. 2003. Partitioning of time as an ecological resource. Annual Review of Ecology, Evolution, and Systematics 34:153–181.

LIMA, J. M., AND F. CUPOLILLO. 2018. Análise espaço-temporal das chuvas persistentes na região do Parque Estadual Do Rio Doce–PERD, sob influências das zcas e zcou (out/2015 a dez/2016). Revista Brasileira de Climatologia 1.

MARTIN, J. G. A., AND D. RÉALE. 2008. Animal temperament and human disturbance: Implications for the response of wildlife to tourism. Behavioural Processes 77:66–72.

MEDICI, E. P. 2010. Assessing the Viability of Lowland Tapir Populations in a Fragmented Landscape. Thesis:292.

MELLO, C. L., C. M. S. METELO, K. K. SUGUIO, AND H. C. KOHLER. 1999. Quaternary sedimentation, neotectonics and the evolution of the Doce River Middle Valley lake system (Southeastern Brazil). Revista do Instituto Geológico 20:29–36.

MEREDITH, M., AND M. RIDOUT. 2020. Overview of the overlap package.

MISTLBERGER, R. E., AND M. C. ANTLE. 2011. Entrainment of circadian clocks in mammals by arousal and food. Essays in Biochemistry 49:119–136.

MISTLBERGER, R. E., AND D. J. SKENE. 2004. Social influences on mammalian circadian rhythms: Animal and human studies. Biological Reviews of the Cambridge Philosophical Society 79:533–556.

MYERS, N., R. A. MITTERMEIER, C. G. MITTERMEIER, G. A. DA FONSECA, AND J. KENT. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853.

NAGY-REIS, M. B., C. A. ESTEVO, E. Z. F. SETZ, M. C. RIBEIRO, A. G. CHIARELLO, AND J. D. NICHOLS. 2017. Relative importance of anthropogenic landscape characteristics for Neotropical frugivores at multiple scales. Animal Conservation 20:520–531.

NORRIS, D., F. MICHALSKI, AND C. A. PERES. 2010. Habitat patch size modulates terrestrial mammal activity patterns in Amazonian forest fragments. Journal of Mammalogy 91:551–560.

NOSS, A. J. ET AL. 2003. A Camera Trapping and Radio Telemetry Study of Lowland Tapir (Tapirus terrestris) in Bolivian Dry Forests. Tapir Conservation: The Newsletter of the IUCN/SSC Tapir Specialist Group (TSG) 12:24–32.

NOUVELLET, P., G. S. A. RASMUSSEN, D. W. MACDONALD, AND F. COURCHAMP. 2012. Noisy clocks and silent sunrises: measurement methods of daily activity pattern. Journal of Zoology 286:179–184.

OLIVEIRA-SANTOS, L. G. R., L. C. P. MACHADO-FILHO, M. A. TORTATO, AND L. BRUSIUS. 2010. Influence of extrinsic variables on activity and habitat selection of lowland tapirs (Tapirus terrestris) in the coastal sand plain shrub, southern Brazil. Mammalian Biology 75:219–226.

OLIVEIRA, B. R. DE, S. M. CARVALHO-RIBEIRO, AND P. M. MAIA-BARBOSA. 2019. A multiscale analysis of land use dynamics in the buffer zone of Rio Doce State Park, Minas Gerais, Brazil. Journal of Environmental Planning and Management 63:935–957.

PADILLA, M., AND R. C. DOWLER. 1994. Tapirus terrestris. Pp. 1–8 in Mammalian Species.

PELD/CNPQ – Site 4. 2007. Mata Atlântica e Sistema Lacustre do Médio Rio Doce. Pesquisas Ecológicas de Longa Duração – Sítio No 4.(75): 358 – 362.

RIDOUT, M. S., AND M. LINKIE. 2009. Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological, and Environmental Statistics 14:322–337.

ROLL, U., T. DAYAN, AND N. KRONFELD-SCHOR. 2006. On the role of phylogeny in determining activity patterns of rodents. Evolutionary Ecology 20:479–490.

ROSS, J., A. J. HEARN, P. J. JOHNSON, AND D. W. MACDONALD. 2013. Activity patterns and temporal avoidance by prey in response to Sunda clouded leopard predation risk. Journal of Zoology 290:96–106.

SCHOENER, T. W. 1974. Resource partitioning in ecological communities. Science 185:27–39.

SPEAKMAN, J. R., AND E. KRÓL. 2010. The heat dissipation limit theory and evolution of life histories in endotherms-time to dispose of the disposable soma theory? Pp. 793–807 in Integrative and Comparative Biology. Oxford Academic.

TOBLER, M. W., S. E. CARRILLO-PERCASTEGUI, AND G. POWELL. 2009. Habitat Use, Activity Patterns and Use of Mineral Licks by Five Species of Ungulate in South-Eastern Peru. Source: Journal of Tropical Ecology 25:261–270.

DU TOIT, J. T., AND C. A. YETMAN. 2005. Effects of body size on the diurnal activity budgets of African browsing ruminants. Oecologia 143:317–325.

WALLACE, R., G. AYALA, AND M. VISCARRA. 2012. Lowland tapir (Tapirus terrestris) distribution, activity patterns and relative abundance in the Greater Madidi-Tambopata Landscape. Integrative Zoology 7:407–419.

CONCLUSÃO GERAL

O PERD é a maior área de Mata Atlântica de Minas Gerais, portanto é uma das poucas áreas de proteção que oferecem disponibilidade de habitat adequado para a anta e sua presença faz do parque uma importante área fonte de espécies vegetais para recuperação e restauração das áreas de seu entorno.

No entanto, outros parâmetros populacionais precisam ser avaliados. O PERD é isolado de outros fragmentos florestais e está circundado por uma matriz de uso humano, o que provavelmente está limitando o fluxo gênico da anta e pode levar ao seu declínio populacional ao longo prazo. A perda de espécies de grande porte que desempenham importantes papeis ecológicos, como a dispersão de sementes a longa distâncias, pode ter impactos severos nas funções ecossistêmicas, o que é particularmente agravante em biomas ameaçados como a Mata Atlântica. Como o PERD é um dos últimos grandes fragmentos do bioma onde interações entre espécies e funcionalidades podem ser avaliadas, ele deve estabelecer programas de monitoramento a longo prazo que possam propor ações de manejo para a conservação da biodiversidade que possam ser aplicadas em outros fragmentos de Mata Atlântica.