Oecologia Australis
25(4):862–870, 2021
https://doi.org/10.4257/oeco.2021.2504.07

NATURAL HISTORY NOTES ON INTERACTIONS AND ABNORMAL COLORATION IN CARNIVORES IN THE ARAUCARIA FOREST, SOUTHERN BRAZIL

Izar Aximoff[1], Marcelo Hübel[2]**, Antônio Carlos de Freitas[1], Clarissa Rosa[3] & Anthony Caravaggi[4]*

[1] Universidade do Estado do Rio de Janeiro, Instituto de Biologia Roberto Alcantara Gomes, Núcleo de Fotografia Cientifica Ambiental, Laboratório de Radioecologia e Mudanças Globais, Rua São Francisco Xavier, 524, PHLC Subsolo, CEP 20550-900, Maracanã, Rio de Janeiro, RJ, Brazil.

[2] Usina Rio Vermelho de Energia Ltda. Estrada Rio Natal, nº 3710, Rio Natal, CEP 89.290-000, São Bento do Sul, SC, Brazil. **in memoriam

[3] Coordenação de Biodiversidade, Instituto Nacional de Pesquisas da Amazônia. Av. André Araújo, Petrópolis, CEP 69067-375, Manaus, AM, Brasil.

[4] School of Applied Sciences, University of South Wales, 9 Graig Fach, Pontypridd, UK, CF37 4BB.

E-mails: izar.aximoff@gmail.com (*corresponding author); marcelohubel@gmail.com; acafuerj@gmail.com; rosacla.eco@gmail.com; anthony.caravaggi@southwales.ac.uk

Abstract: Carnivores typically exhibit cryptic behavior, which makes it difficult to study the ecology of species in this group. Camera trap bycatch can be a valuable source of important opportunistic records. In this short communication, we present rare records of carnivores in southern Brazil. The first record was of a tayra (Mustelidae) with anomalous coloration known as leucism. Other records were of a possible attempted predation event by two free-ranging dogs on lowland tapir (Perissodactyla, Tapiridae), a threatened species. Our remaining notable records consisted of intra and interspecific interactions of endangered felids (puma, ocelot and southern tiger cat).

Keywords: camera trap; hunting; leucism; mammals; Protected Area.

Carnivores typically exhibit cryptic behavior and low population densities (Regolin *et al.* 2017), which makes it difficult to study the ecology of species in this group. In the last ten years, remote-sensing camera traps have increased in popularity. Further, technological improvements and declining costs have increased their availability and adaptability, thus making it easier to study medium and large mammals in forests than ever before (*e.g.* Wearn *et al.* 2013). Unlike human observers that choose which animals to observe based on criteria defined a priori, camera traps are not subject to selective observation bias. As such, camera trap bycatch (*i.e.* the detection of non-focal species) can be a valuable source of important opportunistic records, such as predation and other inter- and intra-specific interactions (Gnocchi & Srbek-Araujo 2017, Caravaggi *et al.* 2017).

In this short communication, we present opportunistic, rare records of carnivores in the Rio Vermelho Municipal Environmental Protection Area (RVMEPA; 23,000 ha). The RVMEPA is located in the municipality of São Bento do Sul, northeast of Santa Catarina state (coordinates 27°32′48″S 48°26′06″W; Figure 1). The habitat of

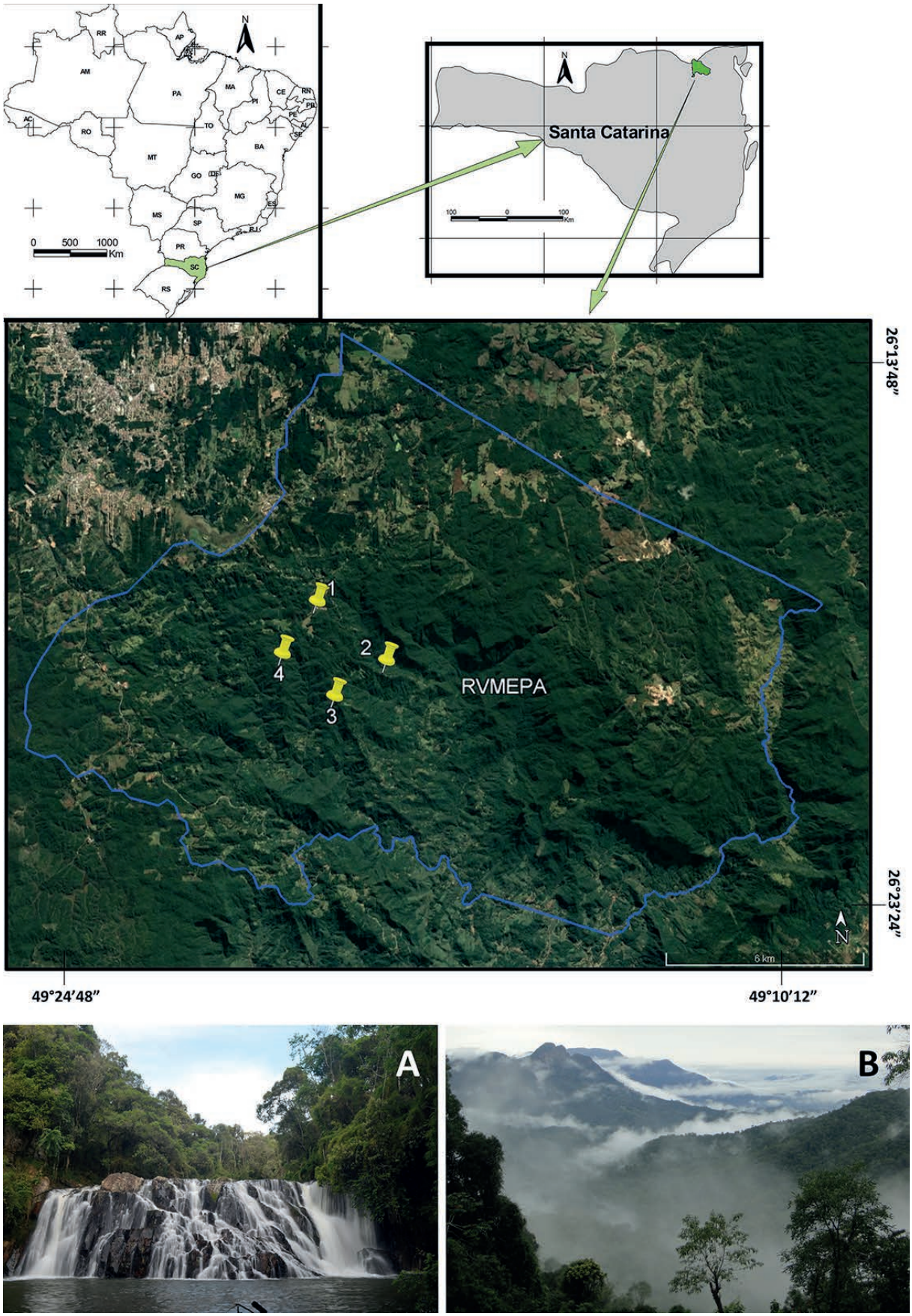

Figure 1. Study area showing the Rio Vermelho Municipal Environmental Protection Area (blue polygon with yellow pins) in the state of Santa Catarina, southern Brazil. Photos: (A) Rio Vermelho, (B) forest environment where the study was carried out.

the RVMEPA largely consists of Araucaria Forest, a mixed ombrophilous forest with a canopy that includes *Ocotea pretiosa*, *O. catharinense*, *Campomanesia xanthocarpa* and *Parapiptadenia rigida*, with *Araucaria angustifolia* emergent. The region has an oceanic temperate climate (Cfb) with a temperate, constantly humid, cool summer, no dry season, and frosts in the winter months. In a long-term camera trap study, we were able to record some relevant history notes that we present here.

We recorded carnivores using four camera traps (Moultrie® and StealthCam®) installed on four trails located in a forest environment (700-800 m altitude), western region of REVMEPA (Figure 1). The data presented herein were obtained from a long-term camera trap survey (January 2014 to December 2019, inclusive) of medium and large terrestrial mammals, totaling 7,300 trap nights (Hübel *et al.* 2020). On each trail, we selected four sampling points, and every three months the trap was repositioned to one of these points. We changed the location of the traps throughout the sampling, maintaining a minimum distance of 2 km between them (maximum distance of 4 km), and avoiding a biased sampling, since throughout the sampling we noticed that many species demarcated the passage path with urine and or left their smell on the trees.

The first noteworthy record was of a tayra *Eira barbara* (Linnaeus, 1758) (Carnivora, Mustelidae) with anomalous coloration known as leucism, recorded at 08:01 in June 2015 (Figure 2B). The identification of leucism was confirmed by the local team which registered the pigmentation on the extremities of the limbs and eyes of the individual by direct observation. Anomalies in pelage coloration are due to variation in melanin synthesis which includes the excess (*i.e.* melanism), absence (*i.e.* albinism), or partial (*i.e.* piebaldism) or total deficit over almost the entire body with the exception of the eyes and extremities of limbs (*i.e.* leucism) (Hofreiter & Schöneberg 2010). The tayra lives in the Neotropics and occurs from southern Mexico to northern Argentina (Presley 2000), one of the most common medium size carnivores in the tropical forest (Emmons & Feer 1997). The subspecies that occur in Brazil, *E. barbara barbara*, typically presents a brown body with a gray head and a yellowish spot at the bottom of the throat (Presley 2000) (Figure 2A). In Brazil, some cases of anomalous coloration have been reported in many groups of terrestrial mammals (*e.g.* Abreu *et al.* 2013, Aximoff *et al.* 2020), including recent records of the tayras in the Atlantic forest (Aximoff & Rosa 2016, Talamoni *et al.* 2017). Records of abnormal coloration in wild populations are generally rare as the aberrant individuals are often more susceptible to predation and can be subject to immunological deficiencies (Sazima & Di-Bernardo 1991).

Our second noteworthy record describes one of the first documented case of a possible predation event by two domestic dogs *Canis familiaris* L. 1758 (Carnivora, Canidae) on lowland tapir *Tapirus terrestris* L. 1758 (Perissodactyla, Tapiridae), recorded at 8:47 in July 2015 (Figure 2C-D). Although we have not identified traces of tapir predation by domestic dogs after this event, we no longer obtained tapir records on this trail. This is noteworthy as in this trail we registered more than half (63 %) of the records of the species. Though often considered inefficient hunters, domestic dogs have the potential to impact wildlife via direct predation (Lacerda *et al.* 2009), displacement (Lenth *et al.* 2008), competition (Vanak and Gompper 2010) and disease transmission (Fiorello *et al.* 2006). Indeed, a recent assessment suggested that domestic dogs have attacked at least 80 species in India, including 31 listed as threatened on the IUCN Red List (Home *et al.* 2018). Domestic dogs have directly contributed to the extinction of 11 vertebrate species and have been identified as a threat to at least a further 188 vertebrates, worldwide (Doherty *et al.* 2017).

Feral and free-ranging domestic dogs living in natural environments are an increasing issue in Brazil, especially in areas of Atlantic Forest (Aximoff *et al.* 2015, Mazza *et al.* 2018). Domestic dogs have been recorded attacking tapirs (Gatti *et al.* 2018) and capybara *Hydrochoerus hydrochaeris* (Linnaeus, 1766) (Hendges *et al.* 2015) in the Brazilian Atlantic Forest. Attacks by domestic dogs on tapirs and other wildlife of the RVMEPA are likely to become increasingly common over time. Forest fragments are becoming increasingly isolated and surrounded by farms, from where free-roaming dogs can access the fragments (Fiorello *et al.* 2006). The forest is also frequented by poachers and their dogs (M. Hubel,

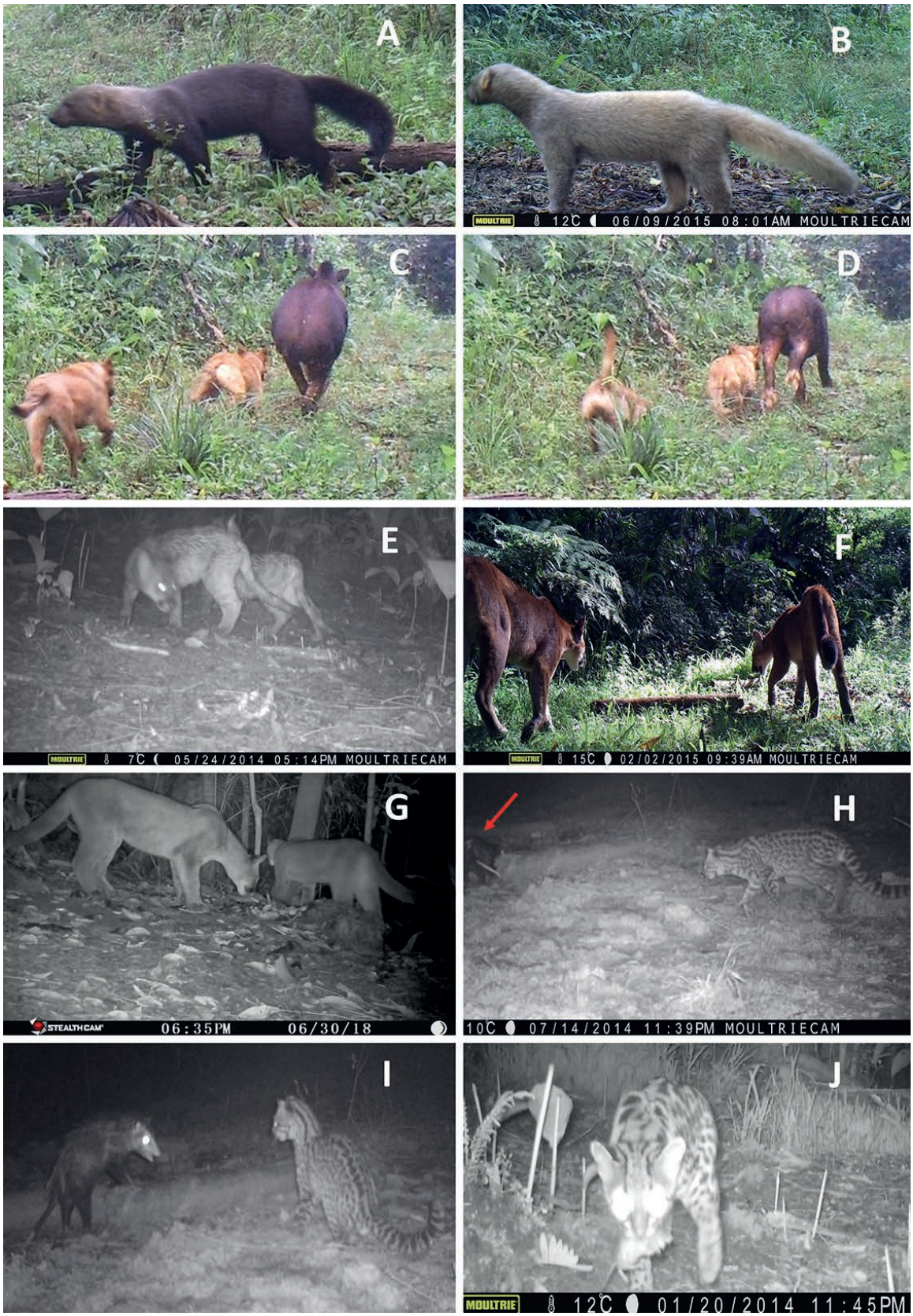

Figure 2. Records of carnivores in Rio Vermelho Municipal Environmental Protection Area, Santa Catarina state, Brazil. Photos: (A) Individual of tayra *Eira barbara* with normal coloration; (B) Leucism in the tayra; (C and D) records of a possible predation event by two free-ranging dogs *Canis familiaris* on lowland tapir *Tapirus terrestris* (Perissodactyla, Tapiridae); (E, F and G) puma cub with their mother; (H and I) records of Southern Tiger Cat *Leopardus guttulus* hunting an opossum and (J) an unidentified rodent.

pers. obs.). In the context of impacts on wildlife, free-ranging domestic dogs are wild domestic dogs are identified as a threat due to predation on threatened species (Doherty *et al*. 2017). Lowland tapir is rare and considered to be endangered in Santa Catarina territory (CONSEMA-SC 2011). This species is also considered vulnerable to extinction in Brazil (ICMBio 2018) and worldwide (IUCN 2018). Predation by domestic dogs, or injury resulting from predation attempts, can magnify the effects of natural predation and other biotic and abiotic factors on the small local tapir population. Lowland tapir has an important role in the forest ecosystem, acting as seed dispersal agents for at least 122 plant species (Tobler *et al*. 2010, Giombini *et al*. 2016), and the dipersion can range up to 3 km away from parent trees (Noss *et al*. 2003).

Our last noteworthy record consisted of intra and interspecific interactions of felids. Felids play an essential role in controlling prey populations (Srbek-Araujo & Kierulff 2016) and are often considered to be umbrella species (*e.g.* Kittle *et al*. 2018, Bou *et al*. 2019). Some species are among the most endangered of Brazilian carnivores (Souza *et al*. 2019). Therefore, data relating to felid ecology should be considered of great importance as they have implications for management and conservation processes.

Mountain lion *Puma concolor* (Linnaeus, 1771) cubs remain with their mother for up to two years after birth, during which time they learn to hunt (Cimardi 1996). From the six photographic records in our study, it was possible to follow mother-cub associations for four consecutive years, from 2014 to 2018. It was not possible to ascertain whether the same female was detected each year or, indeed, if the same cub was detected on consecutive years (Figure 2E-2F). All records were made in the morning, between 5:00 and 10:00. In each of the four trails, we obtained at least one record, including one at less than 500 m from the hydroelectric plant buildings (Figure 1: arrow 1). On the other hand, three records were taken on the trail furthest from these buildings (Figure 1: arrow 3). Despite the difficulties inherent in identifying individuals of species that do not exhibit distinct markings (*e.g.* Yoshizaki *et al*. 2009, Dorning & Harris 2019), we were able to identify at least three adults and one juvenile mountain lion, based on comparisons of scars, a pattern of fur patches, and body proportions (Di Bitetti *et al*. 2006, Santos *et al*. 2016, Alexander & Gese 2018). Nevertheless, these observations describe the successful breeding of this species in the RVMEPA.

In contrast to *Puma concolor*, southern tiger cat *L. guttulus* (Hensel, 1872) and ocelot *Leopardus pardalis* (Linnaeus, 1758) exhibit distinct, individually-identifiable markings (*e.g.* Maffei *et al*., 2005). We obtained two records of *L. guttulus* hunting presumably an unidentified rodent (Figure 2J) and an opossum (Figure 2H-I). These records were also made on the trail furthest from the buildings. We also were able to identify five individuals, two male and three females, by comparing pelage patterns (Figure 3A). In 2017, we identified two adult ocelots moving together through the forest (Figure 3B). This species was not recorded on the trail closest to the buildings. All five identified individuals, including the two traveling together were identified on the other three trails (Figure 1, arrows 2, 3 and 4). Although felids are among the most commonly detected taxa in camera trap studies, with numerous studies on population parameters, little information about reproductive, parental care, and feeding or diet has been described from photographic records (Santos *et al*. 2016). Despite the search for similar information in other studies that used camera traps, we did not find images or descriptions of multiple ocelots in a single image, nor hunting activities of southern tiger cats. The detections described herein therefore represent potentially important ecological and behavioral data for these species.

Carnivores play a major role in community structure and stability (Srbek-Araujo & Kierulff 2016). Especially small carnivores, native cats are among the most ecologically sensitive species and are particularly susceptible to local extinctions (Regolin *et al*. 2017). With the exception of the puma, the other cats were not identified on the trail near the power plant headquarters, but on the more distant trails in the most central region of RVMEPA. Thus, the current study, while qualitative and comprising a fraction of a much larger dataset, adds to existing evidence regarding the importance of long-term camera trap research in record important natural history

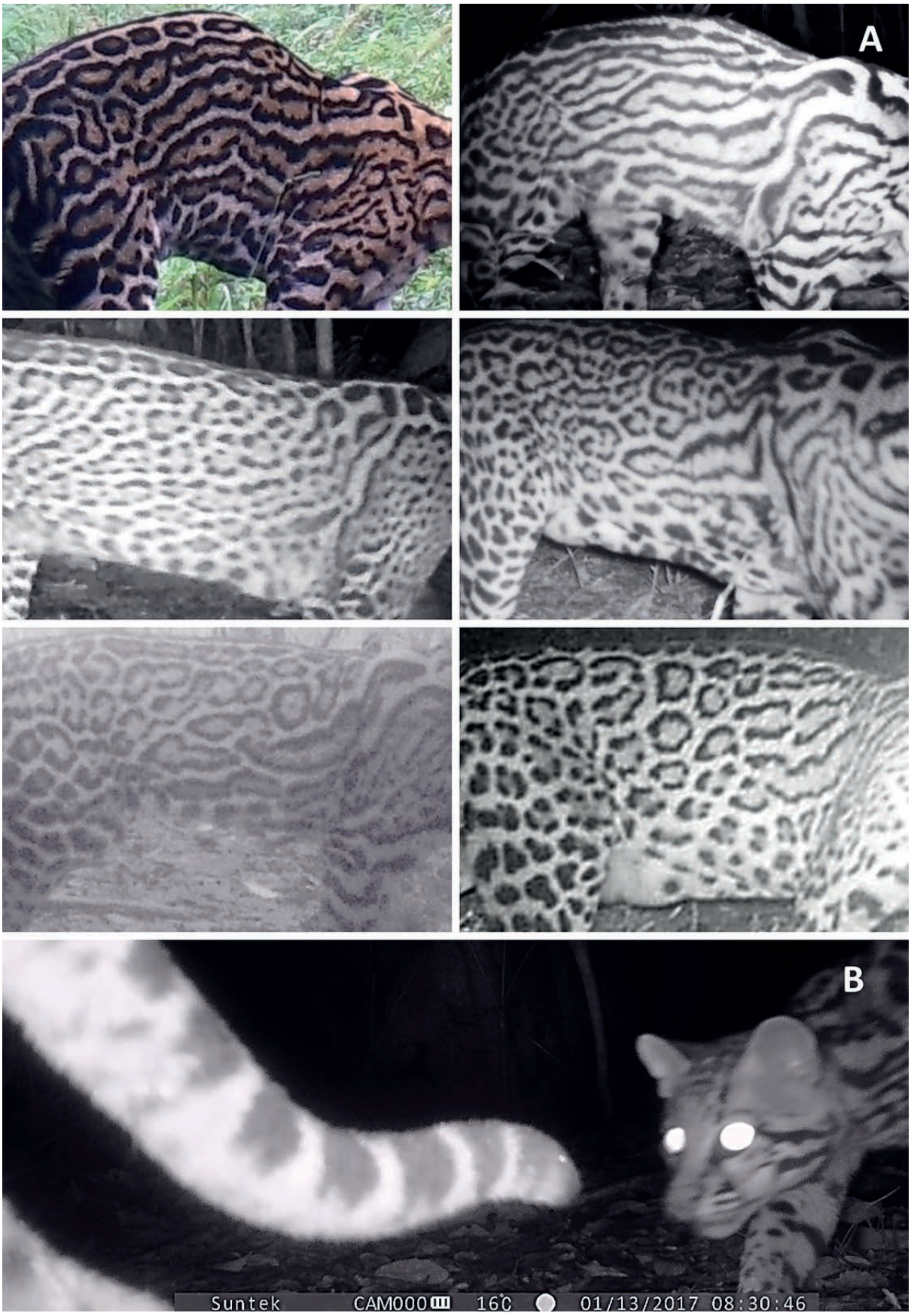

Figure 3. Records of carnivores in Rio Vermelho Municipal Environmental Protection Area, Santa Catarina state, Brazil. (A) Comparison of spot patterns in five individuals of ocelot *Leopardus pardalis*; (B) two adult ocelot individuals moving together.

notes that could help to understand interactions between species and individual characteristics within and across carnivore guilds.

ACKNOWLEDGEMENTS

We thank the Innovation Department - InovUERJ, for the granting (Qualitec Superior) to first author, and we also thank the editors and anonymous reviewers for the important contributions.

REFERENCES

Abreu, M. S. L., Machado, R., Barbieri, F., Freitas, N. S. & Oliveira, L. R. 2013. Anomalous colour in Neotropical mammals: a review with new records for *Didelphis sp.* (Didelphidae, Didelphimorphia) and *Arctocephalus australis* (Otariidae, Carnivora). Brazilian Journal of Biology. 73,185–194.

Alexander, P. D. & Gese, E. M. 2018. Identifying individual cougars (*Puma concolor*) in remote camera images–implications for population estimates. Wildlife Research, 45, 274–281.

Aximoff, I. A. & Rosa, C. A. 2016. First records of albinism in greyheaded tayra (Carnivora, Mustelidae) and occurrence in high-altitude grassland in Brazil. Oecologia Australis. 20, 526–531.

Aximoff, I., Zaluar, M. T., Pissinatti, A., Bastos, P. A., De Assis Morais, T., Rosa, C. A. & Vale, M. M. 2020. Anomalous pigmentation in invasive and native marmosets, *Callithrix jacchus*, *Callithrix penicillata* (Primates, Callitrichidae), and Their Hybrids in Brazil. Folia Primatologica, 91, 149–158.

Aximoff, I., Cronemberger, C. & Pereira, F. 2015. Amostragem de longa duração por armadilhas fotográficas dos mamíferos terrestres em dois parques nacionais no estado do Rio de Janeiro. Oecologia Australis, 19, 215–231. DOI: 10.4257/oeco.2015.1901.14

Bou, N., Cuyckens, G. A. E., González, E. M. & Meneghel, M. 2019. Conservation planning in Uruguay based on small felids (*Leopardus spp.*) as umbrella species. Studies on Neotropical Fauna and Environment, 54, 169–180.

Caravaggi, A., Banks, P. B., Burton, A. C., Finlay, C. M., Haswell, P. M., Hayward, M. W. Rowcliffe, J. M. & Wood, M. D. 2017. A review of camera trapping for conservation behaviour research. Remote Sensing in Ecology and Conservation, 3, 109–122.

Cimardi, A. V. 1996. Mamíferos de Santa Catarina. Fundação do Meio Ambiente. p. 302.

CONSEMA – SC. 2011. Reconhece a Lista Oficial de Espécies da Fauna Ameaçadas de Extinção no Estado de Santa Catarina e dá outras providências. Resolução Conselho Estadual do Meio Ambiente n° 002. Secretaria de Estado do Desenvolvimento Econômico Sustentável. Florianópolis. (https://tinyurl.com/wvys8pp8).

Di Bitetti, M. S., Paviolo, A. & De Angelo, C. 2006. Density, habitat use and activity patterns of ocelots (*Leopardus pardalis*) in the Atlantic Forest of Misiones, Argentina. Journal of Zoology 270, 153163. https://doi: 10.1111/j.1469-7998.2006.00102.x

Doherty, T. S., Dickman, C. R., Glen, A. S., Newsome, T. M., Nimmo, D. G., Ritchie, E. G., Vanak, A. T. & Wirsing, A. J. 2017. The global impacts of domestic dogs on threatened vertebrates. Biological conservation, 210, 56–59.

Dorning, J. & Harris, S. 2019. The challenges of recognizing individuals with few distinguishing features: Identifying red foxes *Vulpes vulpes* from camera-trap photos. PloS one, 14, p.e0216531.

Emmons, L.H. & F. Feer. 1997. Neotropical rainforest mammals: a field guide. The University of Chicago Press. 2, 396.

Fiorello, C.V., Noss, A. J. & Deem, S. L. 2006. Demography, hunting ecology, and pathogen exposure of domestic dogs in the Isoso of Bolivia. Conservation Biology 20, 762–771.

Gatti, A., Seibert, J. B. & Moreira, D. D. 2018. A predation event by free–ranging dogs on the lowland tapir in the Brazilian Atlantic Forest. Animal Biodiversity and Conservation, 41, 311–314.

Giombini, M., Bravo, S. & Tosto, D. 2016. The key role of the largest extant Neotropical frugivore (*Tapirus terrestris*) in promoting admixture of plant genotypes across the landscape. Biotropica, 48, 499–508.

Gnocchi, A. P. & Srbek-Araujo, A. C. 2017. Common vampire bat (*Desmodus rotundus*) feeding on lowland Tapir (*Tapirus terrestris*) in an Atlantic Forest remnant in southeastern Brazil. Biota Neotropica, 17: e20170326 https://doi.

org/10.1590/1676-0611-bn-2017-0326

Hendges, C., Salvador, C. & Nichele, M. A. 2015. Mamíferos de médio e grande porte de remanescentes de Floresta Estacional Decidual no Parque Estadual Fritz Plaumann e em áreas adjacentes, Sul do Brasil. Biotemas, 28, 121–134.

Hofreiter, M. & T. Schöneberg. 2010. The genetic and evolutionary basis of colour variation in vertebrates. Cellular and Molecular Life Sciences, 67, 2591–2603.

Home, C., Bhatnagar, Y. V. & Vanak. A. T. 2018. Canine Conundrum: domestic dogs as an invasive species and their impacts on wildlife in India. Animal Conservation, 21, 275–282.

Hübel, M., Aximoff, I., Freitas, A.C., Rosa C. Mamíferos de médio e grande porte na Área de Proteção Ambiental Municipal do Rio Vermelho em Santa Catarina, sul do Brasil. Oecologia Australis. Ahead of print (https://revistas.ufrj.br/index.php/oa/issue/view/1109/showToc)

ICMBio. 2018. Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume II – Mamíferos. ICMBio/MMA, Brasília.

IUCN. 2018. The IUCN Red List of Threatened Species. Version 2018-2. Retrieved on January 5th, 2019, from http://www.iucnredlist.org.

Kittle, A. M., Watson, A. C., Cushman, S. A. & Macdonald, D. W. 2018. Forest cover and level of protection influence the island-wide distribution of an apex carnivore and umbrella species, the Sri Lankan leopard (*Panthera pardus kotiya*). Biodiversity and Conservation, 27, 235–263.

Lacerda, A. C. R., Tomas, W. M. & Marinho-Filho, J. 2009. Domestic dogs as an edge effect in the Brasília National Park: interactions with native mammals. Animal Conservation, 12, 477–487.

Lenth, B. E., Knight, R. L. & Brennan, M. E. 2008. The effects of dogs on wildlife communities. Natural Areas Journal. 28, 218–227.

Maffei, L., A.J. Noss, E. Cuéllar, & D.I. Rumiz. 2005. Ocelot (*Felis pardalis*) population densities, activity, and ranging behaviour in the dry forests of eastern Bolivia: data from camera trapping. Journal of Tropical Ecology, 21(3), 349–353.

Mazza, I., da Rosa, C. A., De Souza, A. C., Aximoff, I., & Passamani, M. 2018. Mamíferos de médio e grande porte registrados em florestas dominadas por Araucaria angustifolia na RPPN Alto-Montana, Serra da Mantiqueira. Oecologia Australis, 22(1), 74–88.

Noss, A. J., Cuéllar, R. L., Barrientos, J., Maffei, L., Cuéllar, E., Arispe, R., Rúmiz, D. & Rivero, K. 2003. A camera trapping and radio telemetry study of lowland tapir (*Tapirus terrestris*) in Bolivian dry forests. Plant Diversity, 229, 44–45.

Presley, S. J. 2000. *Eira barbara*. Mammalian species. 636, 1–6.

Regolin, A., Cherem, J., Graipel, M., Bogoni, J., Ribeiro, J., Vancine, M. & Castilho, P. 2017. Forest cover influences occurrence of mammalian carnivores within Brazilian Atlantic Forest. Journal of Mammalogy, 98, 1721–1731.

Santos, K., Pacheco, G. & Passamani, M. 2016. Medium-sized and large mammals from Quedas do Rio Bonito Ecological Park, Minas Gerais, Brazil. Check List, 12(1), 1830.

Sazima, I. & Di-Bernardo, M. 1991. Albinismo em serpentes neotropicais. Memórias do Instituto Butantan, 53, 167–173.

Srbek-Araujo, A. & Kierulff, M. 2016. Mamíferos de médio e grande porte das florestas de Tabuleiro do norte do Espírito Santo: grupos funcionais e principais ameaças. Floresta Atlântica de Tabuleiro: Diversidade e endemismos na Reserva Natural Vale, 469–480.

Souza, Y., Gonçalves, F., Lautenschlager, L., Akkawi, P., Mendes, C., Carvalho, M. M., Bovendorp, R. S., Ferreira, H., Rosa, C., Graipel, M. E., Peroni, N., Cherem, J. J., Bogoni, J. A., Brocardo, C. R., Miranda, J., Silva, L. Z., Melo, G., Cáceres, N., Sponchiado, J., Ribeiro, M. C. & Galetti, M. 2019. Atlantic mammals: a dataset of assemblages of medium and large-sized mammals of the Atlantic Forest of South America. Ecology, 100(10), e02785.

Talamoni, S., Viana, P. I. M., Costa, C. G., Palú, L., Oliveira, R. B. & Pessôa, L. M. 2017. Occurrence of leucism in *Eira barbara* (Carnivora, Mustelidae) in Brazil. Biota Neotropica. 17: e20170328. http://dx.doi. org/10.1590/1676-0611-bn-2017-0328.

Tobler, M.W., Janovec, J. P. & Cornejo, F. 2010. Frugivory and seed dispersal by the lowland tapir *Tapirus terrestris* in the Peruvian Amazon. Biotropica, 42, 215–222.

Vanak, A. T. & Gompper, M. E. 2010. Interference competition at the landscape level: the effect of

free-ranging dogs on a native mesocarnivore. Journal of Applied Ecology 47: 1225 – 1232.

Wearn, O.R., Rowcliffe, J. M., Carbone, C., Bernard, H. & Ewers, R. M. 2013. Assessing the status of wild felids in a highly-disturbed commercial forest reserve in Borneo and the implications for camera trap survey design. PLoS One, 8: e77598.

Yoshizaki J., Pollock, K. H., Brownie, C. & Webster, R. A. 2009. Modeling misidentification errors in capture-recapture studies using photographic identification of evolving marks. Ecology. 90: 3–9. https://doi.org/10.1890/08-0304.1 pmid:19294906

Submitted: 23 November 2020
Accepted: 3 March 2021
Published on line: 05 April 2021
Associate Editor: João Pedro Souza-Alves