Do too many ecotourists impact the abundance and activity patterns of wildlife?

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Abstract

The impacts of ecotourism on wildlife are seldom studied, and the popularization of ecotourism may have unintended consequences for wildlife. Using camera trap data from a well-used trail in the Savegre Valley of Costa Rica, I compared the relative abundance and activity patterns of humans and wildlife during time periods of 2019 versus 2020, when international tourism was prohibited due to the global Coronavirus pandemic. Human group size and abundance declined in 2020, and relative abundance of domestic dogs increased. Overall, the abundance and activity of wildlife was little changed in 2020 except for coyote, which changed activity patterns and reduced in group size.

Introduction

Ecotourism is often presented as a way to assist in conservation efforts while allowing visitors to enjoy the local environment. The ecotourism model aims to minimize tourisms impact on the local environment, use funds from tourism to protect local species, and allow an experience that includes education opportunities about the protected flora and fauna (Stronza, 2019). One example of ecotourism done well in Costa Rica is the Savegre Hotel Reserve and Spa, owned by the Chacon family since 1973. Located in the Savegre Valley, the hotel is a destination spot for nature lovers from around the world, especially those wanting to see some of Costa Rica's famous birds. Historically, the Chacon family business has exemplified true ecotourism. However, as more tourists want to support local conservation and ecotourism efforts in the valley, human traffic on nearby trails has increased in recent years. Understanding the impact of human traffic on wildlife is important to inform management and wildlife conservation, and to determine if too much ecotourism has the opposite effect than intended.

Human presence may influence an animal's ability to find prey and change the times that animals are active. Like hunting, the long-term effects of human presence may cause predators to reduce predation on prey species. Due to human traffic, wildlife may leave the area, become more nocturnal or more arboreal, or avoid using trails that humans use frequently (Griffiths, 1993). Additionally, wildlife may be more vigilant while humans are close by, reducing foraging and reproductive success (Ciuti, 2012). In March of 2020, the novel coronavirus pandemic caused a significant reduction in local and international travel around the world. Costa Rica closed its borders to foreigners and non-residents on March 18th to reduce the prevalence of the virus in the country (Zúñiga, 2020). In this study, I compared months from two separate years to study the effect of ecotourism (specifically, hikers) on wildlife. Using camera trapping methods, 107 days from 2019, where there were normal levels of human traffic, were compared with 107 days from 2020, when there was reduced tourism in the Savegre Valley due to the pandemic.

Materials and Methods

Study Area

The Savegre Valley in Costa Rica is home to several native plant and animal species and is a popular ecotourism area in protected montane oak forest. The Robles trail is a well-used hiking trail in the valley and is easily accessed by tourists staying in nearby lodges. Hiking, mountain biking, and domestic dogs are all permitted on the trail. The trail sees high human traffic throughout the year with various group sizes of tourists. Common mammals seen in the valley and on the Robles trail are collared peccary (*Tayassu tajacu*), puma (*Puma concolor*), coyote (*Canis latrans*), spotted paca (*Cuniculus paca*), and white-nosed coati (*Nasua narica*), to name a few.

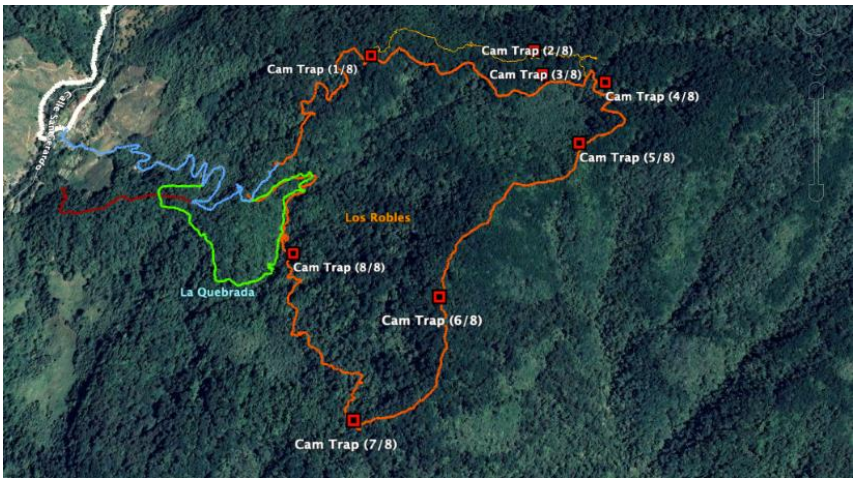

Image 1. The Robles trail, outlined in red, with the locations of the 8 camera stations.

Camera Traps

Camera trapping is a research method that can provide insight into animal behavior, inventory biodiversity, establish species' distributions, and estimate population abundance (Frey et al. 2017). Bushnell Trophy Cam units (Bushnell Corporation, Lenexa, KS, USA) were placed inside steel security boxes (CAMLOCKbox, Green Bay, WI, USA) and were attached to trees with Python 3/8-inch cable locks (Master Lock Company Oak Creek, WI, USA) at about 1 meter from the ground. Each camera was equipped with a passive infrared sensor that triggered the camera when a change in temperature and motion is detected (Welbourne et al. 2016). Cameras were pointed down trail to allow for the animals to be exposed to the camera the longest amount of time. Each camera was loaded with a SanDisk SD memory card ("chip") of 2-8 GB capacity (Western Digital Technologies, Milpitas, CA, USA) and were programmed to take sets of three pictures, each stamped with the date and time taken. Cameras were spaced 1-2 Km apart on the trail and their coordinates and elevation were recorded using Garmin eTrex GPS units (Garmin Ltd., Olathe, KS, USA). For further information on camera trap methodology, see Mooring et al. (2020).

Scent Stations

Each camera trap was accompanied by a scent station constructed out of PVC pipe with an attached sponge sprayed 4-5 times with a scent attractant (*Calvin Klein's 'Obsession for Men'; Calvin Klein Inc., New York, NY, USA*). Scent attractants encourage mammals to stop and investigate, allowing for higher quality photos, especially at night (Viscarra et al., 2011). Scent stations were placed on the edge of the trail in view of the camera and were regularly maintained. For more information on scent station methodology, see Mooring et al. (2020).

Database Creation

Wild. ID is a software program that allows researchers to view, label, and organize images captured by camera traps. Photos from all cameras were loaded into Wild. ID software and labeled with species name and number of individuals seen. Resulting CSV data was analyzed in R Studio and Excel. Only independent observations were included in analysis, defined as sightings of a species at the same camera station that are seen at least 30 minutes apart from another photo of the same species. Photographs of researchers maintaining the cameras and non-mammals (e.g., birds) were excluded from analysis.

Study Periods and Analysis

Study periods of 107 camera days from both 2019 and 2020 were analyzed. The dates analyzed in 2019 were June 12th through September 27th, and the dates analyzed for 2020 were April 1st through July 17th. These 2020 dates were chosen because this is when the least number of humans were expected to be seen on the trail due to Costa Rica enacting lockdown orders in response to the COVID-19 pandemic. Subsets of the first 30 days of both datasets were also analyzed (June 12th-July 12th 2019 and April 1st- May 1st 2020). For all datasets, the daily activity patterns of each species were fitted non-parametrically as kernel density functions, and the coefficient of overlapping (**Δ**) between each (Ridout & Linkie, 2009) was estimated using the package "Overlap" (Meredith and Ridout, 2016) in the R programming language (R Core Team 2018). Only species with more than 10 independent observations were analyzed using Overlap to ensure accuracy of analysis. For all datasets, the relative abundance index (RAI) was used to identify how frequently a species appeared on the cameras. RAI was calculated for each species using the equation:

RAI = [(number of independent records) / (number days camera was active)] * 1000.

For the datasets of 107 days, group sizes of humans were determined and counted. A group was considered small if it contained between 1 and 5 humans, medium if it contained 6 to 10 humans, and large if the group contained 11 or more humans. Like individual observations of animals, an individual group was defined as being sighted 30 minutes apart from another group. For all datasets, activity patterns for 2019 and 2020 were compared for species with 10 individual observations or more. This was done with an adaptation of the package "Overlap" (Meredith and Ridout, 2016) in the R programming language (R Core Team, 2018).

Results

Human Groups

During the 107 days in 2019, a total of 2,781 individual humans were seen on the trail in various group sizes. There were 895 small groups, 57 medium groups, and 27 large groups (Fig.1). The largest group was 27 individuals, and the average group size was 4.6. During the 107 days in 2020, a total of 1,468 individuals humans were seen. There were 601 small groups, 25 medium groups, and 3 large groups (Fig. 1). The largest group was 16 individuals, and the average group size was 3.8. Small groups were defined as groups of 1 to 5 humans, medium 6 to 10, and large 11 or more. There were less humans on the trail in 2020, and group sizes were also smaller in 2020.

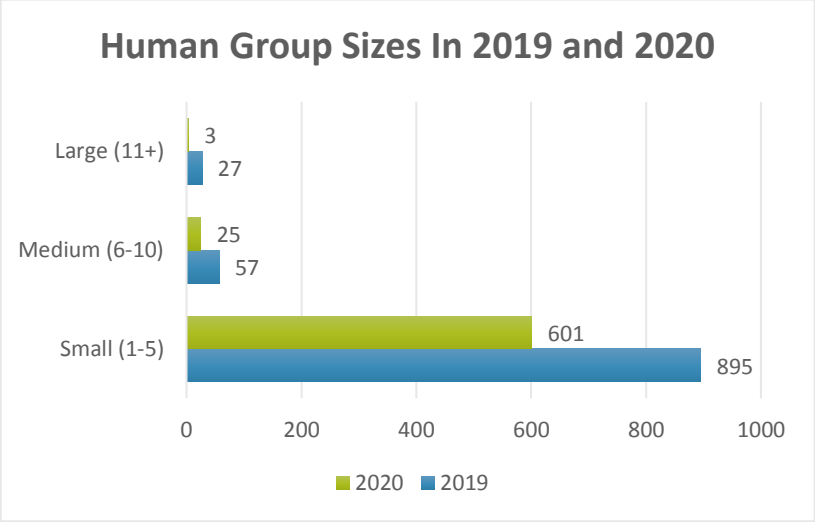

Figure 1. Human group sizes from 2019 (in blue) and 2020 (in green).

Overlap Analysis Full Dataset

For the full 2019 dataset, humans, coyote, collared peccary, and spotted paca had over 10 independent observations and were analyzed using Overlap. See Figure 5 through Figure 7 in the Appendix. For the full 2020 dataset, humans, domesticated dogs, coyotes, spotted paca, collared peccary, and dice's cottontail had over 10 independent observations and were analyzed using Overlap. See Figure 8 through Figure 12 in the Appendix. Except for coyote's, species showed no major change in their activity patterns.

Overlap Analysis 30 Day Dataset

In the first 30 days of the 2019 study period, humans, coyote, spotted paca, and collared peccary had over 10 independent observations and were analyzed with overlap. See Figure 13 through Figure 15 in the Appendix. In the first 30 days of the 2020 study period, when the least number

of humans were expected to be seen, humans, coyote, and spotted paca had over 10 independent observations and were analyzed using overlap. See Figure 16 and Figure 17 in the Appendix. Except for coyote's, species showed no major change in their activity patterns.

RAI Analysis

Relative Abundance was calculated for all wildlife species seen for all study periods. See Figure 18 and 19 in the Appendix for RAI results from the full study periods and the 30 day study periods. A paired, two tailed T-test was run on the full study periods and 30 day study periods to compare 2019 and 2020 RAI results (Table 1). All study periods show no significant change in abundance.

2019 Full Study Period	2020 Full Study Period	2019 30 Day Study Period	2020 30 Day Study Period
Mean = 27.8 SD = 54.9 n = 14	Mean = 26.8 SD = 43.8 n = 14	Mean = 41.6 SD = 61.7 n = 10	Mean = 27.5 SD = 32.4 n = 10
p = 0.914		p = 0.244	

Table 1. T-test results comparing 107 day datasets from 2019 and 2020 and 30 day datasets from 2019 and 2020.

Activity Pattern Analysis for Full Datasets and Subsets

2019 and 2020 activity patterns of human, coyote, collared peccary, and spotted paca were compared for the full study periods. See Figure 20 through Figure 22 in the Appendix. 2019 and 2020 activity patterns of human, coyote, collared peccary, and spotted paca were also compared for the first 30 days of the study periods. See Figures 23 through 25 in the Appendix. All figures show no major change in activity pattern.

Discussion and Conclusion

As expected, there were fewer humans on the Robles trail in 2020 compared to 2019. In 2019, 2,781 individual humans used the trail compared with 1,468 in 2020. The human group sizes were also smaller in 2020 than in 2019. 2020 had 601 small groups, 25 medium groups, and 3 large groups, while 2019 had 895 large groups, 57 medium groups, and 27 large groups (see Fig. 1). Smaller group sizes of human tourists is likely due to the restriction of international travel to Costa Rica in March due to the coronavirus pandemic. According to the RAI analysis, there were more domestic dogs on the trail in 2020 than in 2019 (see Fig. 18 and 19). This may be because only locals had access to the trail during lockdown months, and locals have the capability to bring their domestic dogs while international tourists may not. The relative abundance of domestic dogs was higher in the first 30 days of the 2020 study period than in the first 30 days of the 2019 study period, indicating that people who lived in or near Savegre Valley were hiking and bringing their dogs along.

The reduction in human activity in 2020 was expected to have a significant impact on local wildlife. A t-test comparing the RAI results of species from the full study periods of both years yielded a p-value of 0.914 (Table 1), meaning there was no significant difference in relative abundance of species in 2020 compared to 2019 during the 107 days. A t-test comparing the RAI results of species from the 30 day study periods yielded a p-value of 0.244 (Table 1), meaning

the first 30 days of both study periods also showed no significant difference in relative abundance. In general, local tourism was more prevalent than expected, and the reduction in human activity may not have been severe enough or long enough to have a significant effect on wildlife. The first 30 days of the 2020 study period (April 1-May1) saw 91 individual observations of humans, the least amount for all time periods analyzed. This result is unsurprising as Costa Rica was experiencing the strictest lockdowns during this time period. Even with this reduction in human activity, there were no significant changes in animal abundance. This may be because wildlife did not have enough time to adjust to the reduction in human activity before more tourists began hiking again in 2020.

The most surprising shift in animal activity was in coyotes. In 2019, coyotes were primarily active close to sunset. However, in 2020, they shifted their activity to closer to sunrise. This is true for both the full study periods and 30-day subsets (see Fig. 3 and 4). Additionally, coyote group size declined from an average size of 2.08 in 2019 to an average group size of 1.64 in 2020. A study examining the impacts of humans and domestic dogs on wildlife in eastern North America found that temporal avoidance of wildlife was higher when humans were accompanied by a domestic dog (Parsons, 2016). Although this study focused on domestic dog's impact on white-tailed deer, eastern grey squirrels, and northern racoons specifically, it is possible that the increase of domestic dogs on the Robles trail in 2020 caused the changes in coyote abundance, group size, and activity. Further research is required to determine why these changes occurred and if they are a result of reduced human activity and/or increased abundance of domestic dogs. Furthermore, to understand tourisms impact on wildlife more fully in the Savegre Valley, longer time periods of reduced human traffic is needed.

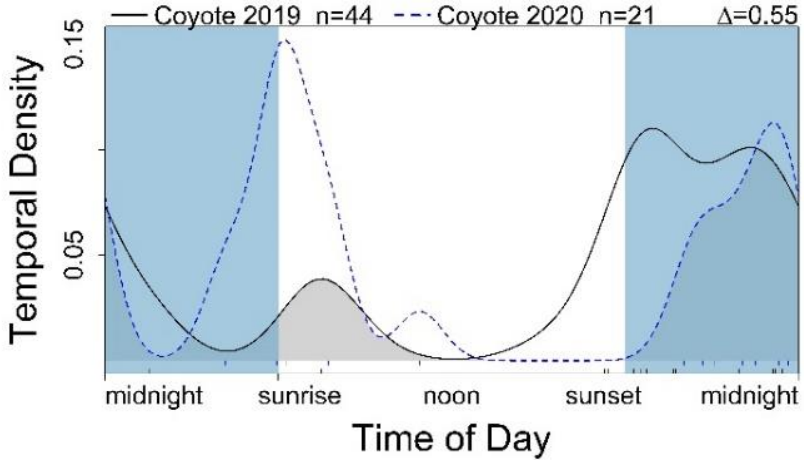

Figure 3. Activity pattern analysis of coyote during the 2019 and 2020 30 day study periods.

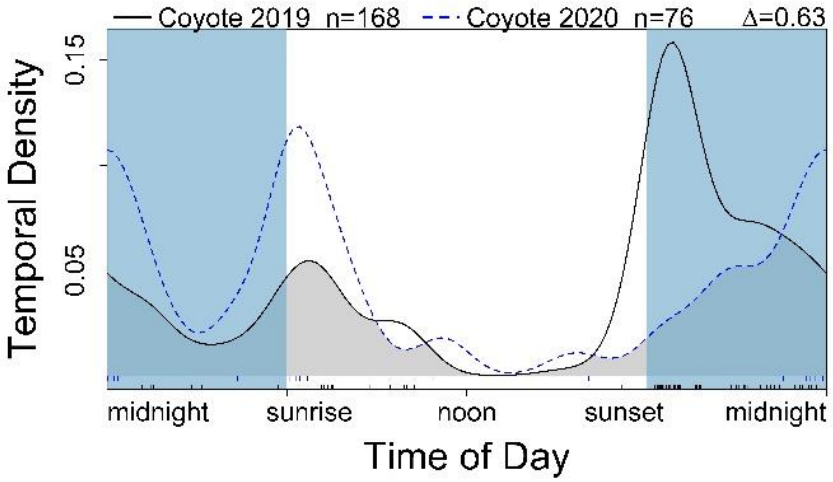

Figure 4. Activity pattern analysis of coyote during the 2019 and 2020 full study periods.

Acknowledgements

I would like to thank Dr. Mike Mooring for his guidance throughout the entirety of this project, Dr. April Cordero and Amy Eppert, who served on my honors committee, and to my peers Abigail Wagner, Steven Blankenship, and Gabby Allen. A heartfelt thank you to Amy, who helped guide me for countless hours through the analysis portion of this study. This research would not have been possible without the continued help of Brendan Blowers DeLeon of QERC. This project is dedicated to the memory of Dr. Ryan Botts. Without his encouragement and expertise, I would have never pursued or completed this project. He is deeply missed.

Appendix

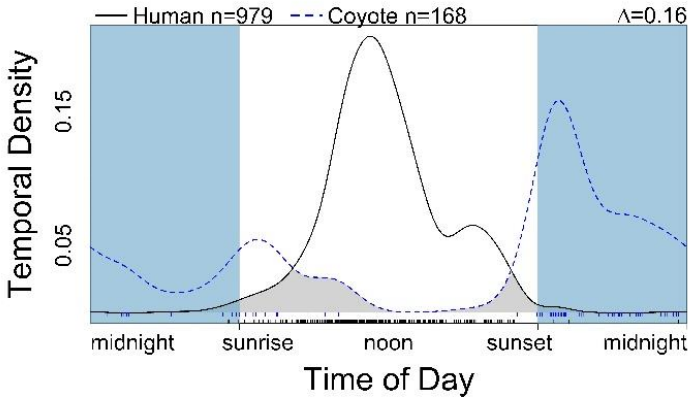

Figure 5. Overlap analysis for humans vs.coyote over 107 days in 2019.

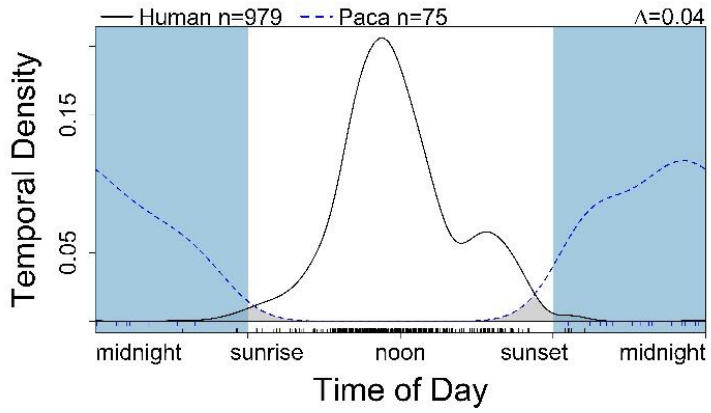

Figure 6. Overlap analysis for humans vs. spotted paca over 107 days in 2019.

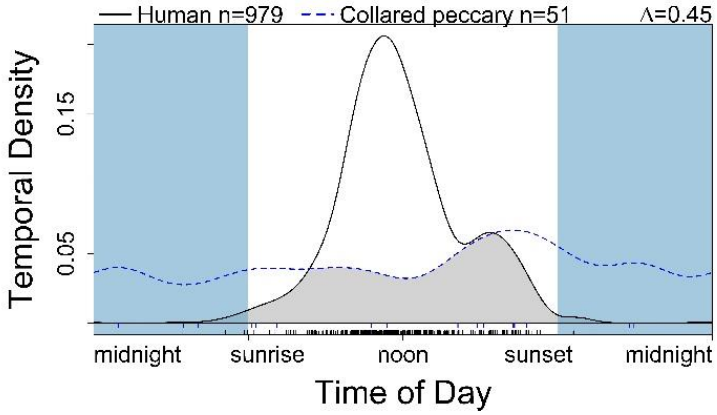

Figure 7. Overlap analysis for human vs. collared peccary over 107 days in 2019.

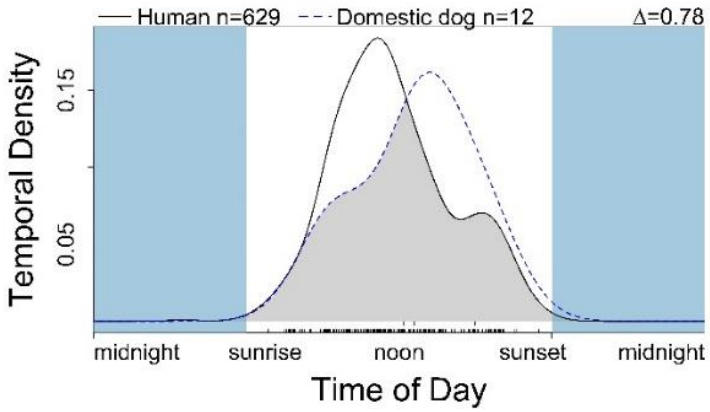

Figure 8. Overlap analysis for humans vs. domestic dogs over 107 days in 2020.

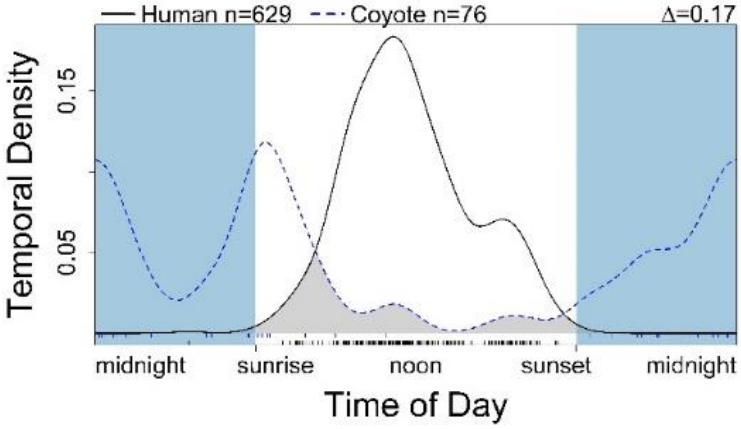

Figure 9. Overlap analysis for Humans vs. Coyote over 107 days in 2020.

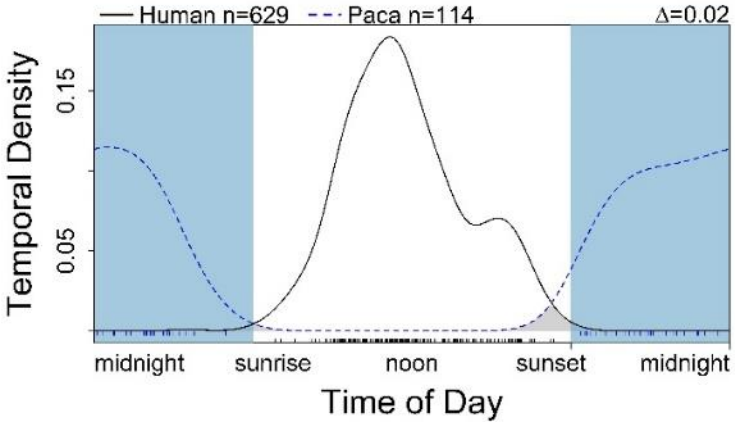

Figure 10. Overlap analysis for humans vs. spotted paca over 107 days in 2020.

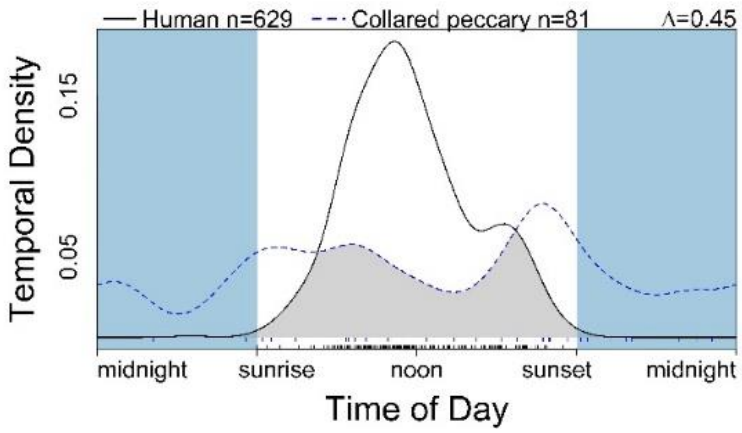

Figure 11. Overlap analysis for humans vs. collared peccary over 107 days in 2020.

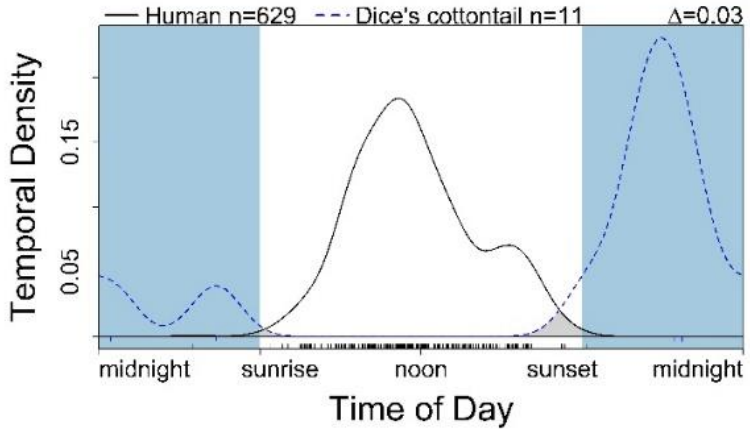

Figure 12. Overlap analysis for humans vs. dices cottontail over 107 days in 2020.

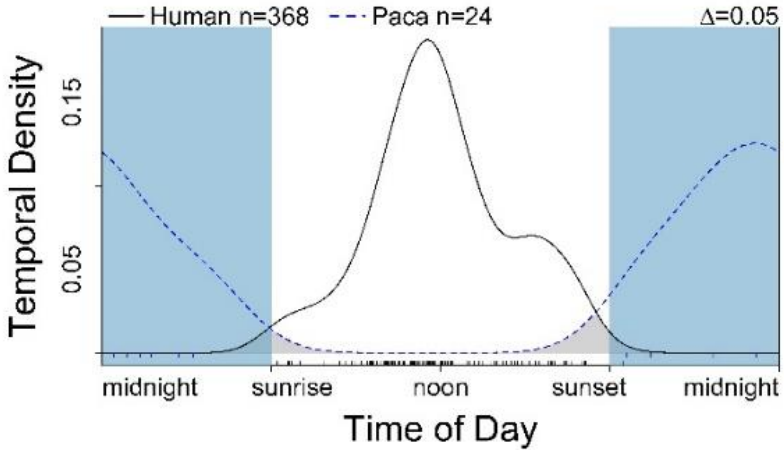

Figure 13. Overlap analysis for human vs. spotted paca over 30 days in 2019.

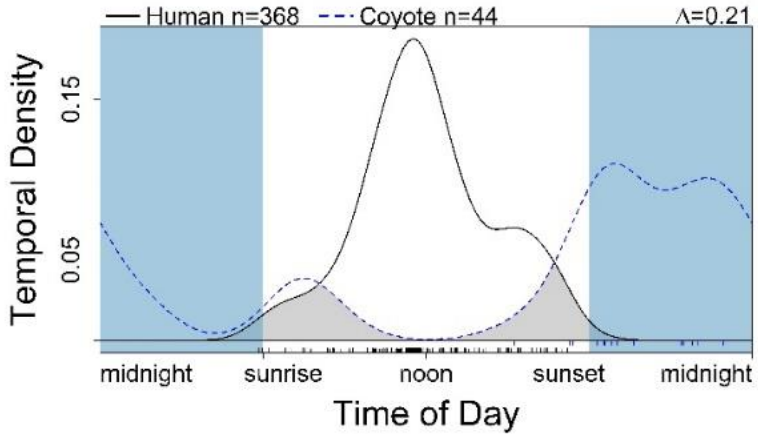

Figure 14. Overlap analysis for human vs. coyote over 30 days in 2019.

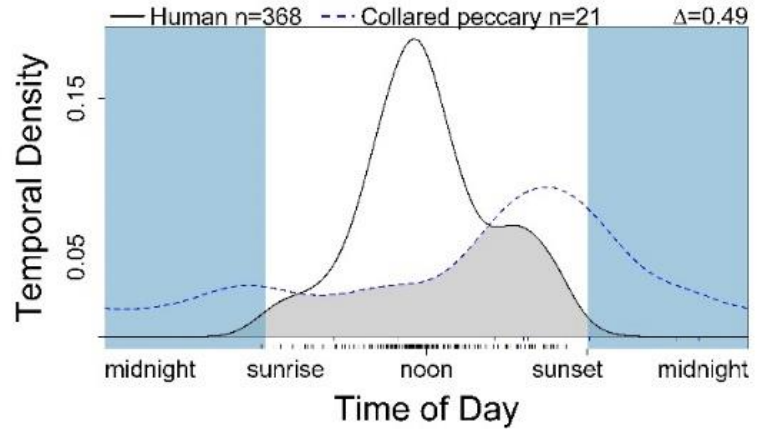

Figure 15. Overlap analysis for human vs. collared peccary over 30 days in 2019.

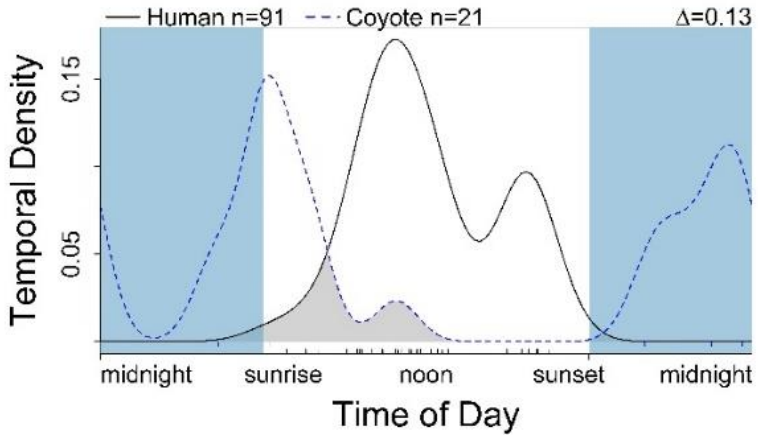

Figure 16. Overlap analysis for humans and coyote over 30 days in 2020.

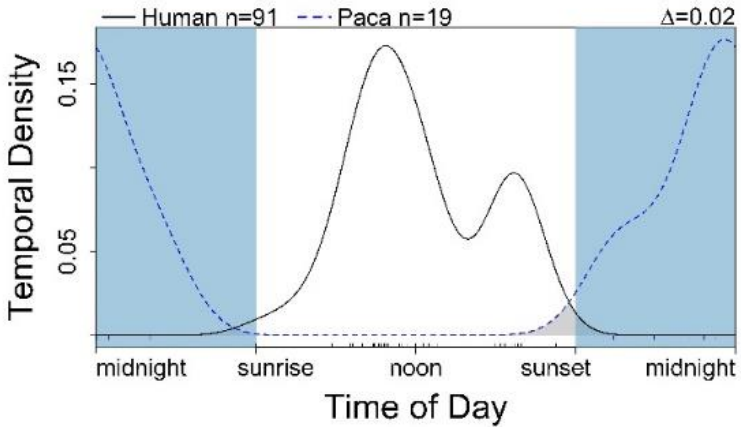

Figure 17. Overlap analysis for humans vs. spotted paca over 30 days in

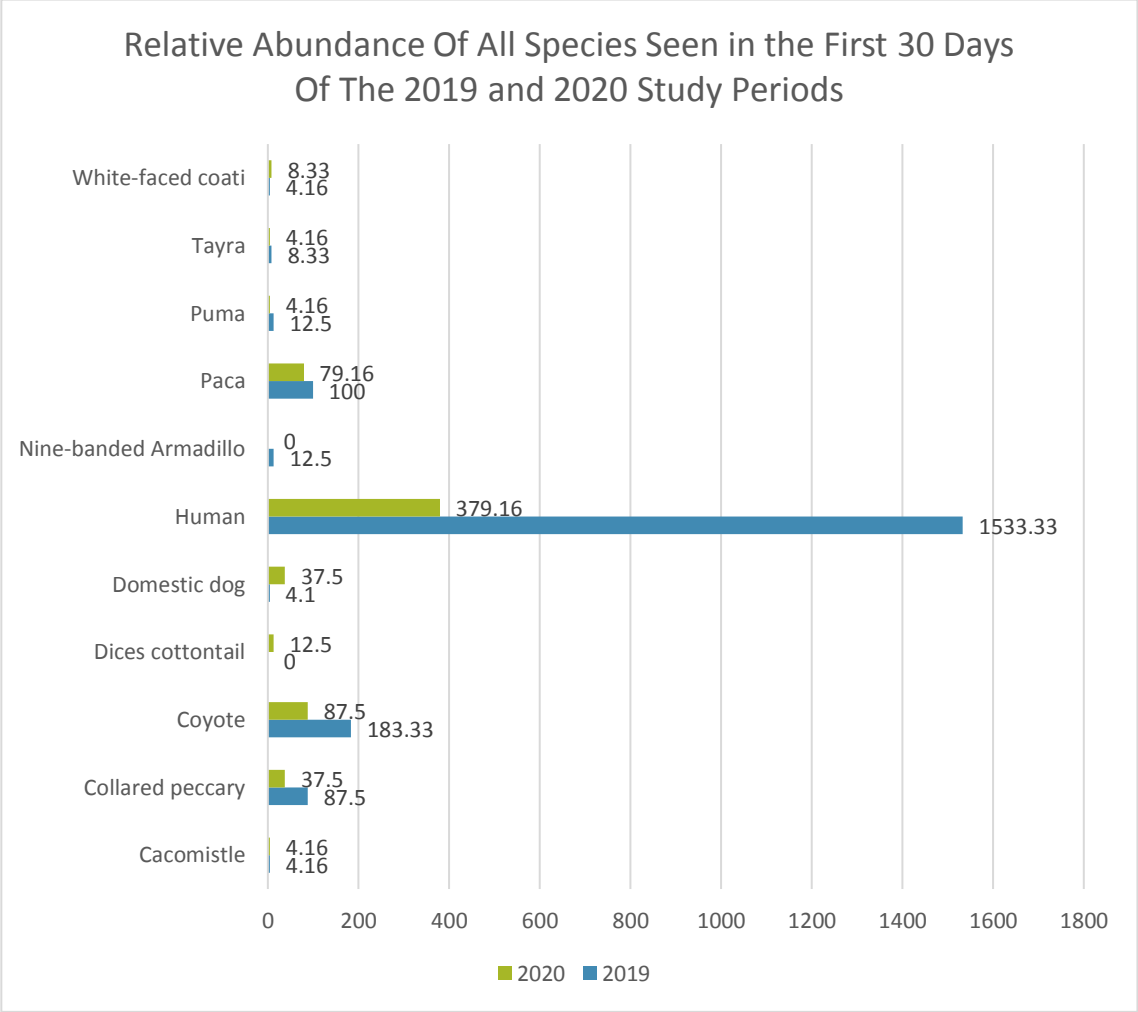

Figure 18. Relative Abundance for all species seen in the first 30 days of the 2019 (in blue) and 2020 (in green) study periods. RAI is calculated with the equation: [(number of independent records) / (number days camera was active)] * 1000.

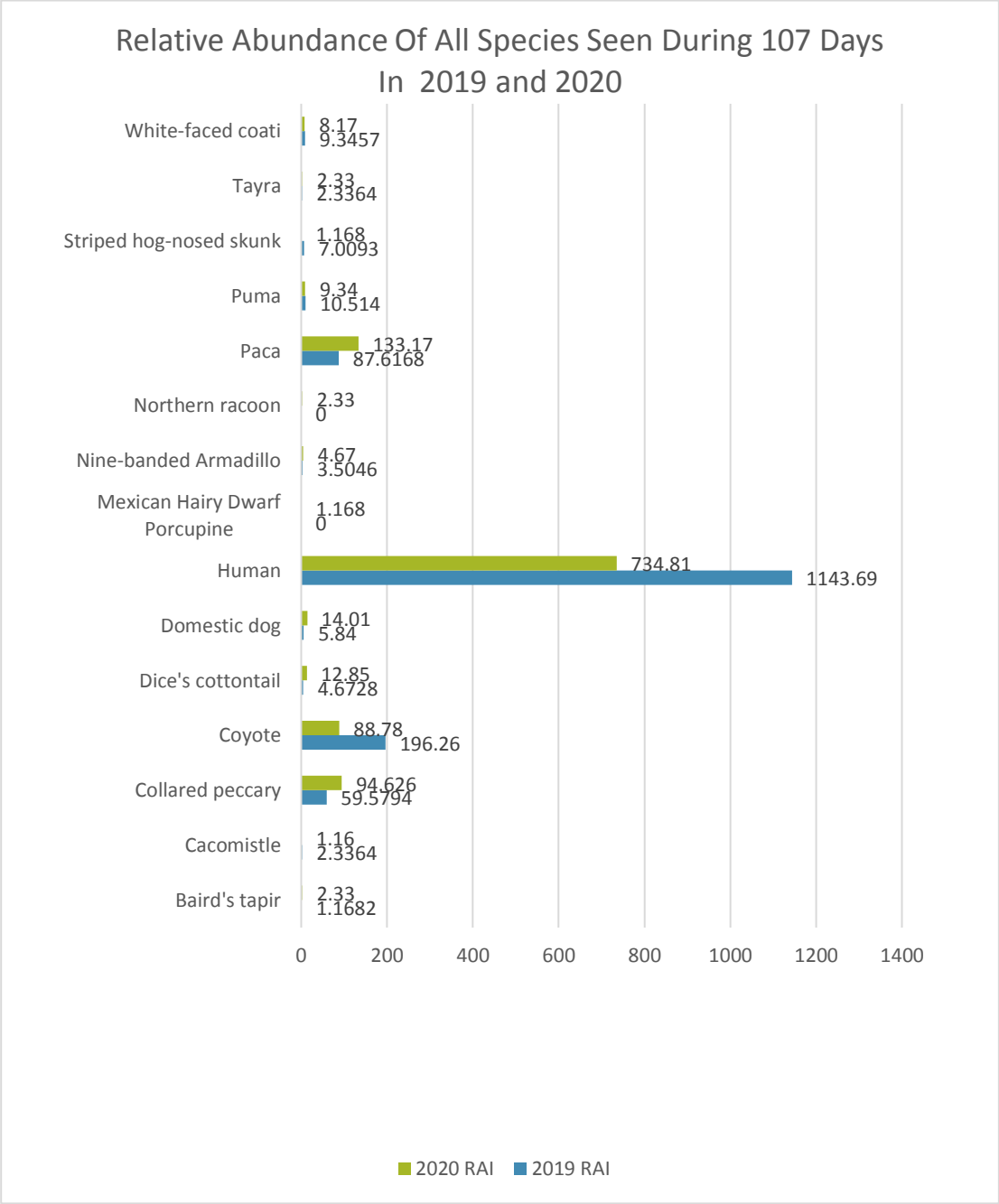

Figure 19. Relative Abundance of all species seen over 107 days in 2019 (in blue) and 2020 (in green). RAI is calculated with the equation: [(number of independent records) / (number days camera was active)] * 1000.

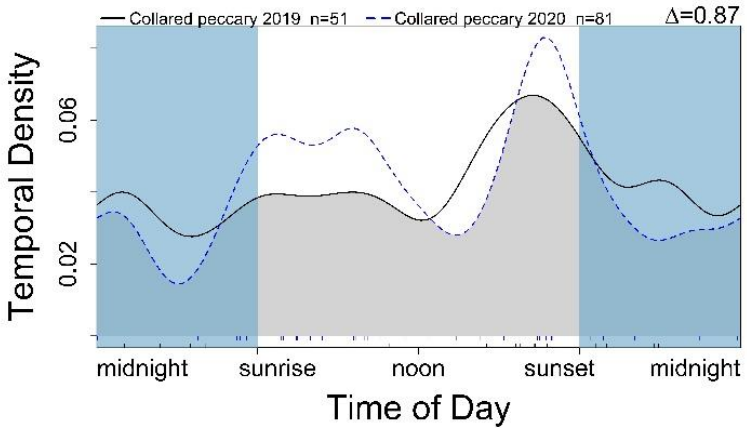

Figure 20. Activity pattern analysis of collared peccary over 107 days in 2019 and 2020.

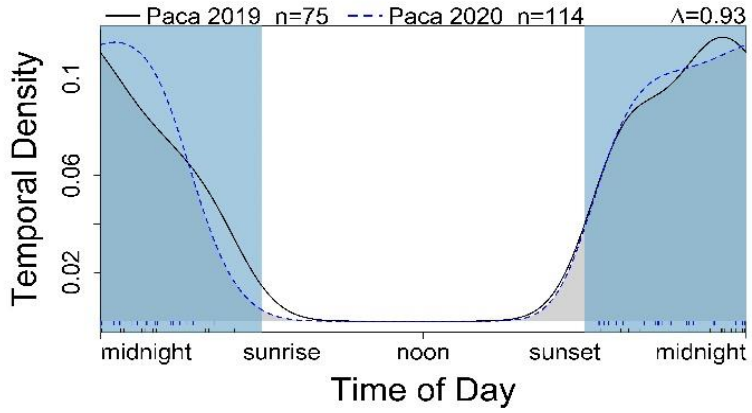

Figure 21. Activity pattern analysis of spotted paca over 107 days in 2019 and 2020.

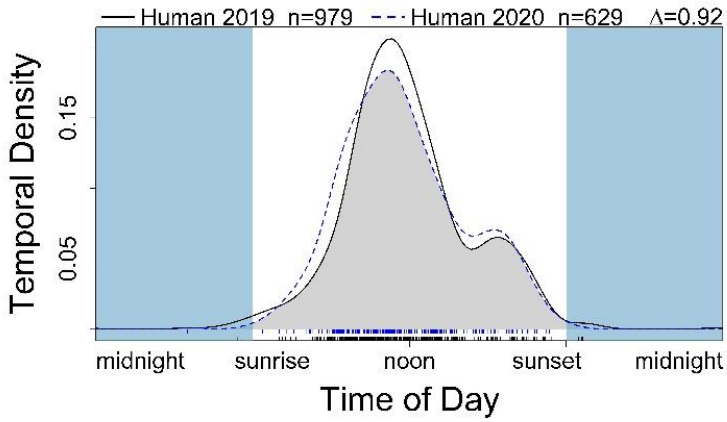

Figure 22. Activity pattern analysis of humans over 107 days in 2019 and 2020.

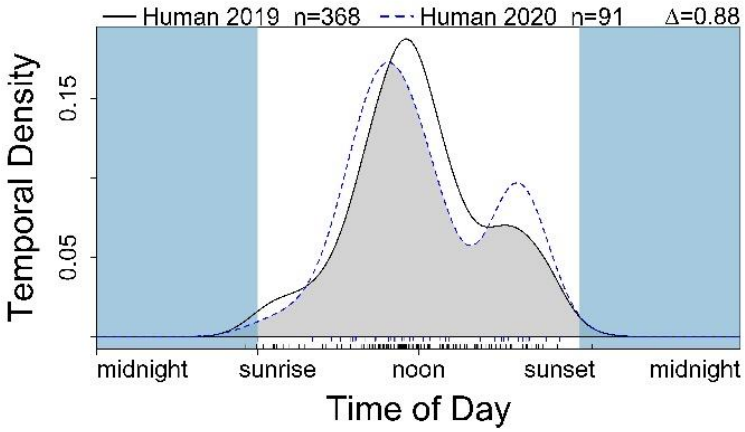

Figure 23. Activity pattern analysis of humans over 30 days in 2019 and 2020.

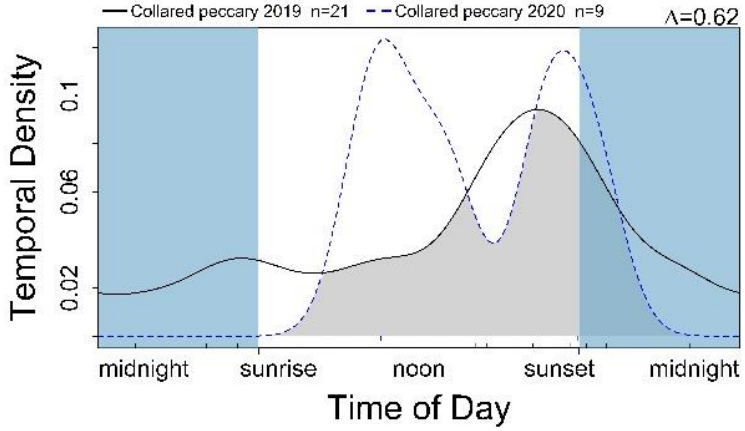

Figure 24. Activity pattern analysis of collared peccary over 30 days in 2019 and 2020.

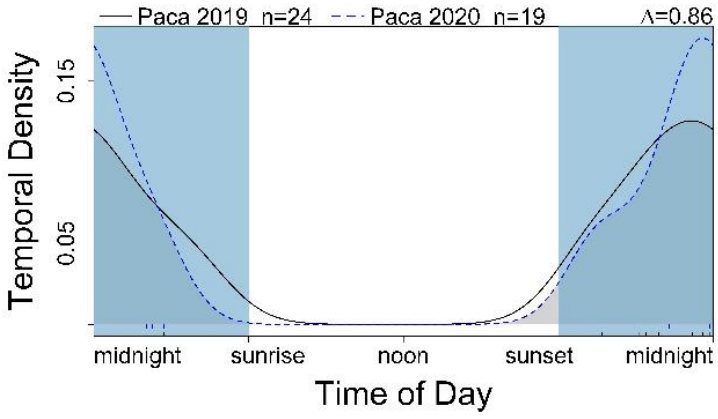

Figure 25. Activity pattern analysis of spotted paca over 30 days in 2019 and 2020.

References

CIUTI, S., NORTHRUP, J. M., MUHLY, T. B., SIMI, S., MUSIANI, M., PITT, J. A., & BOYCE, M. S. (2012). Effects of Humans on Behaviour of Wildlife Exceed Those of Natural Predators in a Landscape of Fear. *PLoS ONE*, *7*(11). https://doi.org/10.1371/journal.pone.0050611

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. Remote Sensing in Ecology and Conservation 3:123–132.

GRIFFITHS, M., & SCHAIK, C. P. (1993). The Impact of Human Traffic on the Abundance and Activity Periods of Sumatran Rain Forest Wildlife. *Conservation Biology*, *7*(3), 623–626. https://doi.org/10.1046/j.1523-1739.1993.07030623.x

KARANTH, K. U., J. D. NICHOLS, AND N. S. KUMAR. 2004. Photographic sampling of elusive mammals in tropical forests. Pp. 229-247 in Sampling Rare or Elusive Species: Concepts, Designs, and Techniques for Estimating Population Parameters (Thompson, W. L., ed.). Island Press. Washington D.C.

MOORING, M. S. A. A. EPPERT, AND R. T. BOTTS. 2020. Natural selection of melanism in Costa Rican jaguar and oncilla: A test of Gloger's Rule and the temporal segregation hypothesis. Tropical Conservation Science 13:1–15. https://doi.org/10.1177/1940082920910364

R CORE TEAM. 2018. R: a language and environment for statistical computing. R Foundation for 1022 Statistical Computing. Vienna, Austria. https://www.R-project.org/.

RIDOUT, M. S., AND M. LINKIE. 2009. Estimating overlap of daily activity patterns from camera 1019 trap data. Journal of Agricultural, Biological, and Environmental Statistics 14:322–337.

Stronza, A. L., Hunt, C. A., & Fitzgerald, L. A. (2019). Ecotourism for Conservation? *Annual Review of Environment and Resources*, *44*(1), 229–253. https://doi.org/10.1146/annurev-environ-101718-033046

VISCARRA, M. E., G. AYALA, R. WALLACE, AND R. NALLAR. 2011. The use of commercial perfumes for studying jaguars. CAT News 54:30-31.

ZÚÑIGA, A. 2020. Costa Rica declares state of emergency due to CORONAVIRUS; will close borders to foreigners and Non-residents. https://ticotimes.net/2020/03/16/costa-rica-declares-state-of-emergency-due-to-coronavirus-will-close-borders-to-foreigners-and-non-residents

PARSONS, A. et al. 2016. The ecological impact of humans and dogs on wildlife in protected areas in eastern North America, Biological Conservation, Volume 203, Pages 75-88.