June 2018

Presence and diversity of mammals across microhábitats in San Luis, Monteverde, Costa Rica

Liesel Davis

Presence and diversity of mammals across microhabitats in San Luis, Monteverde, Costa Rica

Liesel Davis
Department of Ecology and Evolutionary Biology
University of California, Los Angeles
EAP Tropical Biology and Conservation Program, Spring 2018
8 June 2018

ABSTRACT

The transformation from natural to human-dominated landscapes is occurring rapidly throughout much of the world. In San Luis, Costa Rica, undisturbed forest land has been converted into farmland, introducing crops for agriculture and free-ranging domestic animals. The aim of this study was to observe how relative local mammal abundance has been impacted by these anthropological factors. I sampled three locations in San Luis: a coffee plantation (Café Bella Tica), a farm containing domestic animals (Marco Marín's farm), and a forest microhabitat. To collect data, I used trail transects, miscellaneous observations, Sherman rodent traps, and camera traps over the course of 14 days. I found a total of seven wild mammal species and 42 wild mammal sightings across the three microhabitats. Four mammal species were found among the coffee plantation (variegated squirrel *Sciurus variegatoides*, olingo *Bassaricyon gabbii*, spiny pocket mouse *Heteromys desmarestianus*, deer mouse *Peromyscus mexicanus*), three were on the farm with domestic mammals (variegated squirrel, agouti *Dasyprocta punctata*, hispid cotton rat *Sigmodon hispidus*), and three were in the forest (white-faced capuchin *Cebus imitator*, agouti, deer mouse). The farm with domestic dogs and cats contained more arboreal wild mammals than terrestrial, which may suggest substantial predatory behavior from the domestic pets. With no significant species richness difference across microhabitats, these results indicate that either human presence is not negatively impacting mammal diversity in San Luis, or that the effect from nearby plantations actually diminished diversity in the studied forest habitat.

Presencia y diversidad de mamíferos entre microhábitats en San Luis de Monteverde, Costa Rica

RESUMEN

La transformación de los paisajes naturales a dominados por actividades humanas está ocurriendo rápidamente en gran parte del mundo. En San Luis Monteverde, Costa Rica, el bosque original se ha convertido en áreas agrícolas, con la introducción de cultivos y animales domésticos. El propósito de este estudio fue observar cómo la abundancia relativa de mamíferos locales se ha visto afectada por estos factores antropológicos. Estudié tres sitios en San Luis: una plantación de café (Café Bella Tica), una finca pequeña con animales domésticos (finca de Marco Marín y Lorena Leitón), y un bosque remanente. Utilicé transectos, trampas para roedores y trampas cámaras durante 14 días. Encontré siete especies de mamíferos silvestres con 42

avistamientos en los tres microhábitats. Cuatro especies de mamíferos en la plantación de café (ardilla *Sciurus variegatoides*, olingo *Bassaricyon gabbii*, ratón espinoso de bolsillos *Heteromys desmarestianus*, y ratón venado *Peromyscus mexicanus*), tres especies en la finca con animales domésticos (ardilla, cherenga *Dasyprocta punctata*, rata de algodón híspida *Sigmodon hispidus*, y ratón venado), y tres especies en el bosque (mono cara blanca *Cebus imitator*, cherenga, ratón venado). La finca con perros y gatos domésticos presentó más mamíferos silvestres arbóreos que terrestres, lo que puede sugerir un comportamiento predatorio sustancial de parte de las mascotas domésticas. Sin diferencia significativa en la riqueza de especies entre microhábitats. Considero que la presencia humana no está impactando negativamente la diversidad de mamíferos en San Luis; podría ser que que el efecto de las plantaciones cercanas ya disminuyó la diversidad en el hábitat boscoso estudiado.

Countryside biogeography, defined as "the distribution of biological variation over space and time in human-dominated landscapes," is quickly becoming more crucial to understanding the increase in human exploitation of natural resources (Mendenhall 2013). While island biogeography has previously been used to explain habitat fragmentation, countryside biogeography focuses on anthropological impacts (Mendenhall 2014). In 2014, Mendenhall concluded that consequences, either positive or negative, of human-dominated landscapes will ultimately be determined by the "hospitality" of these human-created habitats. Vegetation modification, introduction of other food sources, and predatory domestic pets all have the potential to create a significant impact on local mammal populations.

Coffee, one of Costa Rica's most important agricultural exports, requires alterations to the natural landscape, inevitably impacting local fauna. While shade-grown coffee is advocated to increase diversity of volant species such as birds, bats, and insects, one study revealed that those farms are unable to support comparable numbers of non-volant mammal species (Caudill 2013). Caudill (2013) explains that even though coffee is one of Costa Rica's major exports, the continuous exploitation of forest land is causing detrimental effects to ecosystem health by reducing mammal richness. This will indirectly impact the quality and longevity of coffee farming. However, other research has shown that many mammal species utilize coffee plantations, such as the Mexican deer mouse, *Peromyscus mexicanus.* Deer mice feed on coffee beans, hoarding them in caches to eat later (Reid 1997). I'm interested in understanding if the resources introduced by shade-grown coffee farms can counter more detrimental effects for wild mammals.

Another major disruption humans have introduced to local environments are domestic animals, primarily dogs and cats. Unlike wild predators, domestic animals are not as strongly influenced by the bottom-up influence of food scarcity and have the potential to hunt species to extinction without fear of starvation (Coleman 1997). While wild mammals rely on successful reproduction to maintain their presence in a habitat, domestic pets, specifically cats and dogs, can be introduced to new areas frequently via humans. Loss (2013) stated that domestic cats kill between 6.3-22.3 billion mammals every year, earning them a spot on the "worst invasive species" list. One study revealed dogs to be interference competitors, directly causing the mortality of local foxes (Vanak 2010). Vanak (2010) found that dogs disrupt foxes's spatial distribution, as a result of intraguild competition. Considering all local wild mammal species, a previous study in 2012 by Hammoud found that wild mammal species richness was negatively

correlated with the presence of dogs. However, this study concluded that it was unclear whether this was due to the dog presence or from neighboring human disturbances (Hammoud 2012). By comparing two human-dominated habitats, one with a high prevalence of domestic animals and one without, I hope to clarify this distinction.

While agriculture and domestic mammals can be destructive to surrounding areas, they also have the potential to introduce new resources for local fauna. Mammal diversity among three microhabitats in relatively close proximity can expand upon the data these previous studies gathered. The purpose of this study is to address the question of what mammals are present around a coffee plantation, a farm containing domestic animals, and in a forested area in San Luis, Costa Rica? How does habitat type affect the presence and diversity of wild mammals?

MATERIALS AND METHODS

Study Sites

The three sites in this study were within one kilometer of each other in San Luis, Costa Rica. The first site was a coffee plantation, Café Bella Tica. The house is surrounded by shade grown coffee plants which are in turn surrounded by some forest fragments. The second site was across the street at Marco and Lorena Marín's farm, an organic farm with two free-ranging domestic cats and three free-ranging dogs. The third site was along a forest edge trail, approximately 200 meters from the two farms. The forest this trail bordered is a large plot of undisturbed dense vegetation.

I used four different methods to observe mammal presence: trail transects, miscellaneous sightings, Sherman rodent traps, and camera traps. To identify the mammal species I found, I used Fiona Reid's field guide (Reid 1997).

Trail Transects and Miscellaneous Sightings

I performed ten trail transects in each microhabitat, from 14 May 2018 to 25 May 2018. Each transect was approximately 50 meters, surrounded by trees on either side. I walked each transect for 30 minutes, observing all wild mammals from the trail and recording their behavior while identifying any repeat observations. I walked the transects either in the morning between 5:00AM and 7:00AM or in the evening from 4:00PM to 6:00PM. I completed seven morning transects and three evening transects. I also recorded any other mammal sightings along the sites that were not explicitly seen during trail transects, which were named miscellaneous observations.

Sherman Rodent Traps

Over five separate nights around 5:00PM, I placed ten Sherman rodent traps along each of the three trail transects. The traps were evenly dispersed throughout the 50 meter transect. Each trap was baited with approximately two tablespoons of a vanilla, oat, and dry rice mixture. I marked nearby trees using colored flagging labeled with their trap number to identify the trap location. The next morning at 7:00AM, I identified any rodents inside the traps using gloves and fabric bags to handle them. I marked each individual to track re-catches by removing a small segment of fur from their back using scissors. The rodents were then released where they were caught.

Camera Traps

To record any other mammals not seen in person, I attached one Bushnell camera trap to trees in each location. The camera traps were placed approximately three feet off the ground and were recording between 16 May to 25 May 2018. Each camera trap was padlocked to a tree to ensure that they would not be moved. The memory cards were checked periodically, and I recorded both domestic and wild mammal sightings.

Data from each method was combined to understand mammal species richness in each microhabitat. I performed two chi squared tests to analyze the significance of domestic and wild mammal distribution across the three microhabitats.

RESULTS

A total of seven wild mammal species were seen across the three microhabitats. I used trail transects, Sherman rodent traps, and camera traps to observe 42 wild mammal sightings overall.

When comparing domestic mammals, the three microhabitats differed significantly in the number of sighted domestic mammals, with Marco Marín's farm being significantly higher (Fig. 1 $\chi^2 = 10.73$, df = 2, $p < 0.001$). At Marco Marín's farm, I observed seven domestic animals using camera traps. One individual cat was observed on the camera trap 12 times (Appendix 1). This was a much higher number of domestic animals compared to the one dog observed passing through the coffee plantation trail. No domestic mammals were sighted in the forest transect (Fig. 1). The camera traps recorded four new domestic dogs and cats on Marín's farm, in addition to the ones that were known to reside there. Therefore, the "farm with domestic animals" indeed had a significantly higher number of dogs and cats than the other microhabitats.

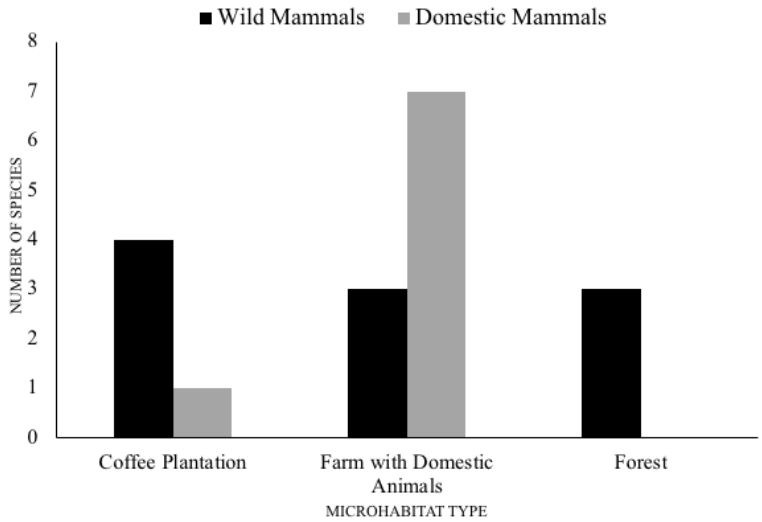


Figure 1: Species richness of wild and domestic mammals in three microhabitats in San Luis, Costa Rica: a coffee plantation, a farm with domestic animals, and a forest habitat.

For wild mammals observed, there was no significant difference between species richness among the three microhabitats (Fig. 1). I observed three wild mammal species on both the forest and farm with domestic animals. I observed four on the coffee plantation. However, the type of species differed among the three sites (Fig. 2). The calculated beta diversity for wild mammals resulted in a value of 2.102. Regarding specific mammal presence, I observed one olingo on the

coffee farm. With transects and camera traps, I saw one agouti on the farm with domestic animals and three individual agoutis in the forest. A troop of white-faced capuchin monkeys was observed twice, and once were accompanied by two agoutis eating fruit the monkeys dropped from the trees (Fig. 2). The first monkey troop observed on 21 May consisted of five individuals and the troop observed on 25 May consisted of eight individuals. Regarding smaller rodent presence, I observed variegated squirrels on both farms but not in the forest habitat. I caught spiny pocket mice and deer mice on the coffee plantation, and of those, two male deer mice were recaptured across several days in the same traps. I observed a hispid cotton rat once on the farm with domestic animals. Referring to number of wild mammal sightings, I observed more arboreal than terrestrial mammals on the farm with domestic animals, largely due to the variegated squirrel presence.

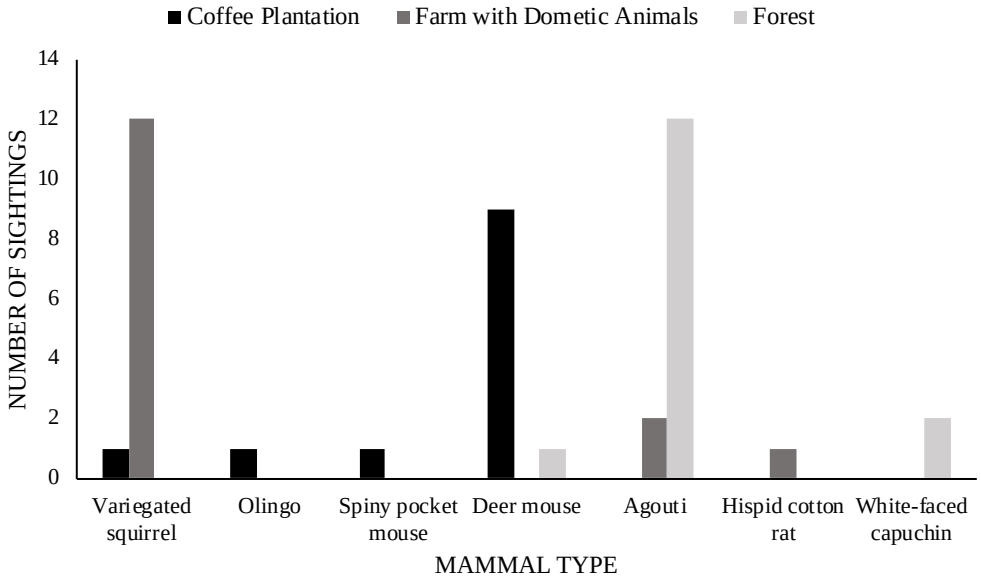


Figure 2: Wild mammal sightings by mammal type in three microhabitats in San Luis, Costa Rica. The three microhabitats used were a coffee plantation, a farm with domestic animals, and a forest trail.

DISCUSSION

This study found no significant difference in mammal species richness among three different microhabitats: a coffee plantation, a farm containing domestic animals, and a section of forest. Surprisingly, the forest habitat did not dominate in species richness, with only three species observed. This may either be because the farm sites were habitable enough to sustain the same species richness as the forest, or because the forest transect utilized was not truly representative of an undisturbed habitat.

Even though the difference was not statistically significant, the coffee plantation contained one more observed species than the other sites- the olingo. This differs from Caudill's findings (2013) of more mammals in undisturbed locations rather than coffee farms. Frequent rodent sightings along the coffee farm I studied suggest that this disrupted environment is still suitable for survival. It provides additional food sources such as coffee beans and insects frequenting the coffee plants, both which deer mice and spiny pocket mice prey on. Daily (2003)

found similar results that "coffee plantations enhance the conservation value of small forest remnants." By enticing smaller mammals like mice, coffee plantations may provide desirable habitats for larger animals such as olingos, who are known to feed on deer mice (Wainwright 2002). Attracting small prey, the coffee plantation may be indirectly providing a suitable hunting location for olingos and other larger mammals.

Higher levels of species richness throughout these human-influenced habitats could reflect the Intermediate Disturbance Hypothesis originally suggested by Connell (1978), who argued that only non-equilibrium can maintain higher diversity in tropical ecosystems. Even though human-created microhabitats like agriculture disrupt natural interactions, they also introduce novel vegetation, food sources, and environmental textures- micro-niches that can then be filled by any species capable of enduring disruptions. The three habitats I studied in San Luis represent a microscopic view of this theory. If these anthropologically constructed habitats are still able to maintain functional communities, then they may prove to not be entirely harmful additions. Also pertinent is that both farms were within 200 meters of a larger forest habitat. While corridor effects and mammal home range distance were not explicitly measured in this study, they have the potential to impact habitat choice. Therefore, it is possible that some wild mammals may reside in more isolated locations while choosing to hunt or forage closer to humans. The farms were nonetheless able to attract small animals such deer mice, spiny pocket mice, hispid cotton rats, variegated squirrels, and larger mammals like agoutis and an olingo (Fig. 2).

Another variable heavily prevalent throughout this study was the presence of domestic mammals. Seven domestic mammals were spotted walking the transect of Marco Marín's farm. Wild mammals were also spotted throughout the site, including an agouti, a hispid cotton rat, and variegated squirrels (Fig. 2). Compared to the nine deer mice sightings on the coffee farm and the one sighting in the forest, there were surprisingly zero deer mice caught on the farm with more domestic animals. The frequent appearance of dogs and cats and few mice observations among this transect suggests predation on local mammal and rodent populations. There were no large wild mammal predators spotted on this farm, as compared to the olingo and capuchin monkeys identified in the other two microhabitats. These wild predators were possibly replaced by domestic animals. This is consistent with Hammoud's study in 2012 that found a negative correlation between wild mammal species richness and domestic dogs after observing frequent predatorial chases. Another study in Zimbabwe discovered that domestic dogs were the most common predator within the observed sites (Butler 2004). This monopolization by domestic animals may lower the numbers of smaller terrestrial prey, such as agoutis and mice, while allowing arboreal and less obtainable prey to thrive, such as variegated squirrels (Fig. 2). The true impact of domestic animals, regarding the distance they are willing to traverse in order to hunt, requires further research to fully understand how they influence prey levels.

Edge effects are another possible explanation for the similar mammal species richness found among the three microhabitats. The forest may not have had the most wild mammal species because of negative effects from the nearby farms. The forest transect I used followed a trail along the forest edge. Similar studies on habitat gradients found decreased abundance in animals such as deer mice along forest edges than deeper into the forest (Menzel 1999). This may be due to a combination of factors, including vegetation changes, air temperature, and light intensity differing between the forest edge and interior. In turn, this may have negatively affected how many wild mammals preferred the forest edge. On 22 May, I noticed a pile of motmot feathers along the forest transect trail. While the origin of these feathers cannot be confirmed,

their presence suggests predatory behavior, possibly from a larger mammal present. Therefore, more mammals than the ones observed could have been using this forest edge. However, the lack of sightings throughout may indicate that they do not frequently utilize the edge, possibly as a result of edge effects and negative impacts from neighboring farmland. These human-dominated landscapes may be able to reach and indirectly impact even "undisturbed" forest habitats.

This study documented non-flying wild and domestic mammal presence among three different microhabitats in San Luis. With no significant difference in wild mammal species richness among locations, these findings suggest that while microhabitat does have an effect on what species are present, the number of species is less variable. A possible implication suggests that higher habitat variation in small areas, including forest, agriculture, and domestic mammal presence, increases overall species diversity. As long as these habitats maintain sufficient food and shelter, human and predator presence may increase species richness, allowing different species to take advantage of new niches. Moderate disturbances prevent one species from dominating, allowing multiple species of different trophic levels to thrive. The longevity of this cohabitation requires future studies, while currently suggesting sustainability in habitat variability. The second approach is that the true effects of human-dominated landscapes may stretch past their physical boundaries. Even though humans and their domestic animals may not be frequenting the forest habitat I studied, their impact still has the potential to negatively impact forest-dwelling mammals by encroaching upon forest edges. While the true implications of human-dominated landscapes continue to be discovered, our true ecological impact necessitates reevaluation.

ACKNOWLEDGEMENTS

I would like to thank everyone who supported this project, either by opening up their land to me or by providing scientific guidance. Special thanks to my teacher, mentor, and friend, Federico Chinchilla, who taught me so much every day. Thank you for patiently and happily accompanied me on site visits, even when it included climbing a hill every morning at 7:00AM to catch rodents. Also, thank you to my wonderful secondary advisor Sofia Flores for introducing me to beautiful San Luis. Thank you to all of the amazing students on this Costa Rica journey with me, including Madi for assisting with the editing process of this paper. A sincere thanks to Marcos and Lorena Marín, and Oldemar and Ersi Salazar for graciously allowing me to use their farms as research sites. Finally, thank you to Bobby, my loyal field assistant who stuck with me throughout my San Luis adventure.

LITERATURE CITED

Butler, J. R. A. and du Toit, J. T. & Bingham, J. 2004. Free-ranging domestic dogs (*Canis familiaris*) as predators and prey in rural Zimbabwe: threats of competition and disease to large wild carnivores. Biological Conservation 115, 369-378.

Caudill, S. A. 2013. Assessment of mammal diversity in coffee-dominated landscapes of India and Costa Rica. University of Rhode Island Digital Commons.

Coleman, J. S. and Temple, S. A. & Craven, S. R. 1997. Cats and wildlife - a conservation dilemma. United States Fish and Wildlife Service.

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. Science, 199(4335), 1302-1310.

Daily, G. G. Ceballos. Pacheco, J. Suzán G. and Sánchez-Azofeifa, A. 2003. Countryside biogeography of neotropical mammals: conservation opportunities in agricultural landscapes of Costa Rica. Conservation Biology, 17(6).

Hammoud, K. 2012. The effect of free-roaming Canis lupus familiaris on wild mammal species richness and abundance in Monteverde, Costa Rica. EAP Tropical Biology and Conservation.

Loss, S. R. and Will, T. & Marra, P. P. 2013. The impacts of free-ranging domestic cats on wildlife of the United States. Nature Communications.

Mendenhall, C. D. Kappel, C. V. and Ehrlich, P. R. 2013. Countryside biogeography. Encyclopedia of Biodiversity, 347-360.

Mendenhall, C. D. Karp, D. S. Meyer, C. F. J. Hadly, E. A. and Daily, G. C. 2014. Predicting biodiversity change and averting collapse in agricultural landscapes. Nature. 213-217.

Menzel, M. A. Ford, W. M. Laerm, J. and Krishon, Diane. 1999. Forest to wildlife opening: habitat gradient analysis among small mammals in the southern Appalachians. Forest Ecology and Management, 114: 227-232.

Reid, F. A. 1997. A field guide to the mammals of Central America and Southeast Mexico. Oxford University Press.

Vanak, A. T. and Gompper, M. E. 2010. Interference competition at the landscape level: the effect of free-ranging dogs on a native mesocarnivore. Journal of Applied Ecology, 47(6), 1225-1232.

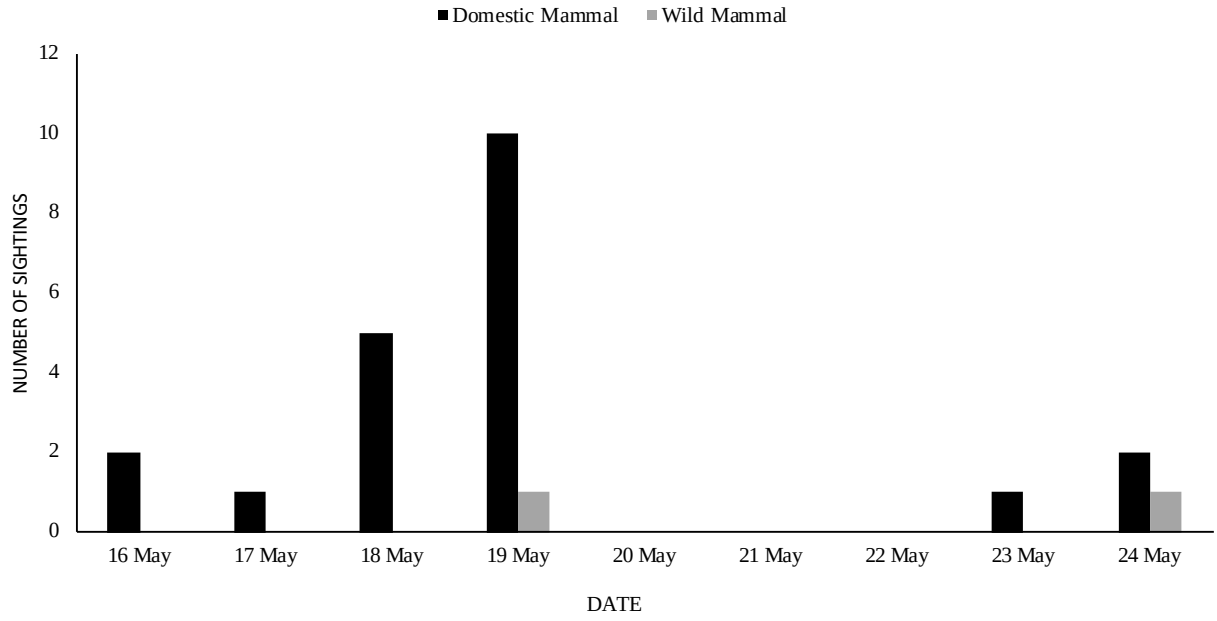
Wainwright, M. 2002. The natural history of Costa Rican mammals. Zona Tropical.

Appendices

Appendix 1: Camera Trap Data for Marco Marín's farm, the farm with domestic animals between 16 May to 25 May. Observations are separated by microhabitat type.

	Coffee Plantation	Farm with Domestic Animals	Forest
Day 4 **16 May 2018** **-All camera traps set-**		2:48AM - unknown cat with cropped tail walking left 8:38PM – unknown gray and white cat walking left	
Day 5 **17 May 2018**		9:15AM - Dixie (domestic cat) walking left	
Day 6 **18 May 2018**	7:54AM - farmer with domestic poodle	8:37AM - German Shepherd dog walking left 8:40AM – Dixie walking left 5:10PM – "Sa-See" (little black dog) walking left 6:54PM – unknown cat with long tail walking left 9:50PM – little black domestic cat walking right	
Day 7 **19 May 2018** -Checked camera traps for 1st time-		1:23AM - Dixie walking right 1:39AM - unknown cat with long tail walking left 9:51AM - Dixie walking left 10:14AM - Dixie walking right 10:59AM - Dixie walking right 11:15AM - Dixie walking left 1:31PM - Dixie walking left 6:51PM - unknown animal, with long tail walking right	No Camera Trap Data from previous days, technical difficulty, fixed camera 4:30PM – agouti walking right (into forest trail)
Day 8 **20 May 2018**		2:46AM - unknown gray and white cat walking left 7:57AM - Dixie walking right 8:23AM - agouti walking left	
Day 9 **21 May 2018** -Checked camera traps for 2nd time-	10:12AM - farmer with domestic poodle		
Day 10 **22 May 2018**			8:46AM - agouti walking out of forest onto path

Day 11 **23 May 2018**		11:52PM - unknown animal with long tail walking right	8:03AM – agouti 8:20AM – agouti 8:58AM – agouti 9:00AM – agouti 9:21AM – agouti 9:29AM – agouti 1:41PM - agouti
Day 12 **24 May 2018**		10:18AM - Dixie walking right 10:36AM - agouti walking right 11:22AM - Dixie walking left	7:35AM - agouti 1:08PM - agouti
Day 13 **25 May 2018** -Checked and removed camera traps-			



Appendix 2: Camera trap data from Marco Marín's farm with domestic animals. The data is separated by number of domestic and wild mammal sightings between 16 May and 24 May.