Field observations of a single male coyote: activity and space use in the rural landscape of Guanacaste Conservation Area, Costa Rica

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Field report

Field observations of a single male coyote: activity and space use in the rural landscape of Guanacaste Conservation Area, Costa Rica

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Abstract

Throughout Central America, the coyote (*Canis latrans*) is considered an invasive mesopredator inhabiting disturbed habitats. However, current knowledge of coyote spatiotemporal behaviour is limited throughout Central America. This study aimed to report preliminary field observations of movements, habitat use, and activity patterns of a collared male coyote within the Guanacaste Conservation Area, Costa Rica. A single male coyote was chemically immobilized and fitted with a satellite telemetry collar in 2019. The device was programmed to track activity and geographic locations, in order to elucidate movement and activity information. We used both a 95% minimum convex polygon and a kernel density estimate to explore space use, as well as the Manly-Chesson selectivity index to determine habitat selection. After 62 tracking days, the collar stopped working. The area used by this coyote varied from 2,394 – 2,425 km^2, depending on the estimation method, and it showed higher selection for disturbed habitats compared to natural areas. Regarding temporal activity patterns, this male coyote was active mostly during the night and showed variable activity levels related to the habitat selected. Hence, we hypothesised that this coyote selected human developed areas during the night in order to maximise foraging success of main prey and to avoid human presence. On the other hand, during the day it selected natural areas in order to avoid the heat of the day and avoid top predators such as the jaguar (*Panthera onca*).

Introduction

Throughout Central America, the coyote (*Canis latrans*, IUCN redlisted as Least Concern; Kays 2018) is considered an opportunistic species that has become invasive by expanding into disturbed areas (Janzen 1983, Gehrt et al. 2009, Poessel et al. 2016, Ripple et al. 2013). Coyote populations thrive under the absence of apex predators within its range e.g., wolves (*Canis lupus*) and pumas (*Puma concolor*; Henke and Bryant 1999, Newsome et al. 2017, Prugh et al. 2009, Ripple et al. 2013). As a result, human resource exploitation and secondary disruption of ecological processes have accelerated the expansion of coyote distribution throughout Central America (Vaughan 1983). However, information on coyotes is limited in Central America, and there is a lack of research on its ecology and spatiotemporal behaviour. Previous evidence suggests that coyote habitat preference varies among individuals and with regard to the ecosystem (Hinton et al. 2015). Therefore, habitat selection of coyotes is an ecological response to the spatial variation of prey and vegetation shaped by the temporal fluctuations in habitats and human disturbances (Vaughan 1983, Arias-Del Razo et al. 2011, Poessel et al. 2016, Boyce 2018).

Regarding the activity patterns of coyotes, the northern distribution of this species shows twilight and nocturnal peaks of activity, and gradually decreasing diurnal activity (Shargo 1988, Quinn 1997, Grinder and Krausman 2001, McClennen et al. 2001, Gese et al. 2012). Coyotes also switch spatial activity near humans, since they become more nocturnal in urban areas and more diurnal in rural areas (Jantz 2011). For such activity in Costa Rica, Wainwright (2007) reported nocturnal and crepuscular temporal activity, however, there is no precise information describing spatiotemporal activity

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of coyotes in tropical habitats. Therefore, we sought to describe spatiotemporal relationships among movement, habitat selection, and daily activity of one male coyote in disturbed and natural areas in the Guanacaste Conservation Area (GCA).

Methods

GCA is located on the Pacific side of Costa Rica (10°53´31"N, 85°35´59"W) and encompasses 340 km^2 of the last remaining tropical dry forests in Central America (Janzen 1988). Annual precipitation averages 1,600 mm, seasonally distributed in a wet season (May to November) and a dry season with almost no rain > 40 mm (December to April; Janzen 1988).

A single, young adult male coyote of approximately 2 – 4 years old was captured using a neck snare trap (Collarum® Live Capture canine device, Coyote Model) and chemically immobilised with a combination of 10 mg/kg of ketamine (10% ketamine, Bremer Pharma GmbH, Warburg, Germany) and 1 mg/kg of xylazine (Procin Equus 10%, Pisa Agropecuaria; West et al. 2014). This individual was fitted with a satellite telemetry collar TGSat-337 / 325CB (Telenax©, Playa del Carmen, Mexico). Once the procedure was performed, the effect of the anaesthetic was reversed using a dose of 0.1 mg/kg yohimbine (2% yohimbine, Richmond Vet Pharma, Vet Up, Buenos Aires, Argentina) 40 minutes after the first anaesthetic dose was applied. Once the coyote recovered, it was returned to its habitat safely. The satellite telemetry collar was programmed to record 12 locations at night (i.e., one per hour) and three during the day (i.e., one every three hours) in order to maximize the habitat selection locations according to the daily activity patterns.

For space use estimations, we used two methods: 95% minimum convex polygon (MCP; Calenge 2006) and 95% kernal density estimate (KDE; Calabrese et al. 2016) using the statistical software R, version 3.6.1 (R Core Team 2019). Additionally, we used the Manly-Chesson selectivity index (MCSI) to elucidate habitat preference comparable to previous carnivore studies (Valeix et al. 2009, Kittle et al. 2016). We estimated daily activity with a triaxial accelerometer sensor inside the satellite collar (standardized activity between 1 = no movement and 100 = constant movement). To test the spatiotemporal habitat selection relationship between natural and human development areas we used a Pearson chi-square test.

Results

A total of 1,010 locations were recorded during 62 continuous days of post-capture monitoring (12 August – 12 October 2019). The estimated area use was 2,394 km^2 for the MCP and 2,425 km^2 (95% CI = 2,399 – 2,441) for the KDE (Figure 1). In addition, the average daily distance traveled was 31.66 km/day (95% CI = 30.57 – 32.76). The coyote utilized 11 different types of vegetation coverage, selecting at highest proportions i) pastures with no specific use (MCSI = 1.59) and ii) cattle pastures (MCSI = 1.21; Table 1). When the vegetation cover was grouped according to natural habitat or human developed, the habitat selection analysis indicated that this male coyote frequently used human developed areas (MCSI = 5.52), significantly more than natural areas (Pearson, $\chi^2 = 36.34$, df = 1, p <0.01).

There was also temporal habitat selection, where the coyote prefered human developed areas at night and natural forested areas during daylight (Pearson, $\chi^2 = 6.41$, df = 1, p = 0.01). Daily activity analysis suggests that this individual coyote was also significantly more active at night, reaching the highest activity peak at 00:00 (Figure 2). During daylight hours, this individual decreased its activity between 07:00 – 16:00 (Figure 2).

Discussion

The area used by this coyote was widespread compared to previous studies in Central America (Ortega et al. 2018). However, due to the short period of data collection of only one individual, our findings are limited. Nevertheless, the long-distance movements observed in this study might support coyote range expansion throughout the region and its plasticity to adapt to new foraging sites. Therefore, its displacement provides an explanation for its adaptability between human developed areas and natural areas, as well as specific preference for human developed areas (Gehrt et al. 2009, Boisjoly et al. 2010, Hinton et al. 2015, Poessel et al. 2016). However, it is important to take into consideration that the ecological processes occurring in the tropics are not comparable to temperate zones in North America (Myers et al. 2013).

Habitat selection depends on several factors, such as the link between natural and human developed areas, and prey availability, which dictate the adaptability for coyotes. Thus, human developed areas seem the most important explanatory variable for coyote presence, as such areas seem essential for their adaptation and survival (Boisjoly et al. 2010, Hinton et al. 2015). Coyotes are a mesopredator and thrive with the extirpation of apex predators, such as the jaguar (*Panthera onca*), around human disturbed areas, therefore, high coyote abundance is a sign of an unbalance ecosystem (Crooks and Soulé 1999, Groom et al. 2005, Prugh et al. 2009, Miller et al. 2012, Ripple et al. 2013). The spatial activity patterns of the coyote in this study were associated with human developed areas; mostly at night with low diurnal activity in natural areas. Thus, we suggest that this behaviour may be associated with the availability of food and risk avoidance shaping its temporal foraging activity (Shargo 1988, Quinn 1997, Kitchen et al. 2000, Grinder and Krausman 2001, McClennen et al. 2001, Jantz 2011, Gese et al. 2012, Poessel et al. 2016). According to their diet in the GCA, their preferred prey is rodents, which thrive around urban areas, and thus these areas provide an excellent habitat of high proportion of opportunistic food availability in addition to protection from larger predators which avoid human presence (Lloyd 2020).

An additional explanation for coyote nocturnal activity might be the overlap of their main prey which are mostly nocturnal, such as rabbits (*Sylvilagus floridanus*), white-tailed deer (*Odecoileus virginianus*), and rodents (Roll et

Figure 1. Home range estimates of a male coyote captured in the Guanacaste Conservation Area, northwest Costa Rica, in 2019 using two different techniques: minimum convex polygon and kernel density estimate.

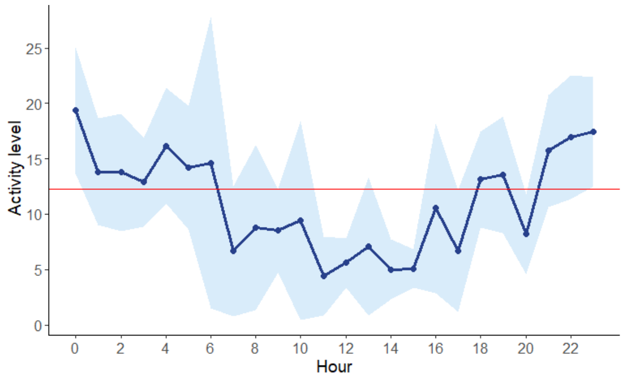

Figure 2. Average daily activity of a male coyote captured in the northwest of Costa Rica in the Guanacaste Conservation Area in 2019, with the total average activity level shown in red and the 95% confidence intervals for each hour.

Table 1. Manly-Chesson selectivity index for 11 types of vegetation cover available and the habitat use of the localizations obtained from a male coyote individual in the Guanacaste Conservation Area, Costa Rica, 2019.

Habitat type	Area (km)	Number of GPS points	Available habitat (%)	Coyote habitat use (%)	Manly-Chesson selectivity index	Standardized index (%)
Natural habitat	203.88	422	51.44	41.78	2.91	34.53
Dry forest	*181.85*	*364*	*45.88*	*36.04*	*0.79*	*9.32*
Open dry forest	*20.65*	*57*	*5.21*	*5.64*	*1.08*	*12.85*
Water	*0.67*	*0*	*0.17*	*0.00*	*0.00*	*0.00*
Wetland	*0.38*	*1*	*0.10*	*0.10*	*1.04*	*12.36*
Mangrove forest	*0.33*	*0*	*0.08*	*0.00*	*0.00*	*0.00*
Human development	192.53	588	48.57	58.22	5.51	65.48
Cattle pasture	*109.36*	*337*	*27.59*	*33.37*	*1.21*	*14.34*
Pasture	*40.49*	*164*	*10.22*	*16.24*	*1.59*	*18.85*
Sugar cane	*23.72*	*57*	*5.98*	*5.64*	*0.94*	*11.19*
Agriculture	*9.63*	*18*	*2.43*	*1.78*	*0.73*	*8.70*
Rice field	*5.05*	*4*	*1.27*	*0.40*	*0.31*	*3.69*
Urban	*4.28*	*8*	*1.08*	*0.79*	*0.73*	*8.71*
Total	**396.41**	**1,010**	**100**	**100**	**8.42**	**100**

al. 2006, Arias-Del Razo et al. 2011, Hernández-Saintmartín et al. 2013). Our results of the daily activity can be explained by the preference, during the daytime in natural areas, for avoiding the heat of the day and peak human activity in urban areas. Temperatures can rise above 37 °C in the GCA. In addition, preference for natural areas during the day can be explained by the avoidance of larger predators, such as jaguars, which decrease their daily activity during the day in natural areas (Montalvo et al. 2012, Hernández-Saintmartín et al. 2013, Herrera et al. al. 2016).

During the past century, the geographic distribution of coyotes has undergone rapid expansion from northwestern Costa Rica into Panama due to accelerated deforestation and habitat loss during the 1940 – 1960s, and is expected to expand into South America promptly (Vaughan 1983, Hody and Kays 2018, Hody et al. 2019, Monroy-Vilchis et al. 2020). The loss of habitat has expanded human developed areas, which are the ideal habitat for coyotes as it provides opportunistic food and allows them to avoid larger predators.

In summary, our field results indicated that this male coyote selected human-developed areas near to human settlements and, in those same areas, increased its activity at night. The satellite telemetry collar failed after 62 tracking days; nevertheless, these findings show important insights related to large movements and behavioural insights of an expanding species that is rapidly expanding its range towards South America (Vaughan 1983, Hody and Keys 2018, Monrey-Vilchis et al. 2020). We highly recommend long term movement studies on coyotes in order to elucidated space use and how the recovery of apex predators and competitors might mitigate and supress coyote populations in seasonal ecosystems such as GCA for conservation purposes.

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