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OCELOT DENSITY IN THE CARIBBEAN SLOPE OF THE TALAMANCA REGION, COSTA RICA

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ABSTRACT - Ocelot *Leopardus pardalis* is one of the most widespread species in America. Nevertheless, its ecology, distribution and population status are not well known in several countries, including Costa Rica. Here we present the first published population density estimations in Costa Rica and the first effort for the Caribbean slope of the country. Using camera-trapping, we estimated ocelot density through capture-recapture analysis within the Talamanca-Caribbean Biological Corridor. An abundance of 8 and 5 individuals were estimated by *Mo* and *Mh* models, respectively. Based on previous home-range studies, three Effective Sampling Areas (ESA) were used to estimate absolute density. Density was calculated in 8.95, 10.33 and 11.61individuals (*Mo* model) and 5.59, 6.45 and 7.25 (*Mh* model) individuals × 100 km^{-2} for the maximum, mean and minimum ESA estimates, respectively. Gross extrapolations of the expected population size indicate a low abundance and co-dependence between the corridor and surrounding areas for the long term maintenance of the species in the region.

Key words: Leopardus pardalis, density, camera-trapping, Central America

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Ocelot *Leopardus pardalis* is a secretive and widespread species distributed from the southern United States to NE Argentina and southern Brazil and Uruguay (Caso et al. 2008). Despite its wide distribution, and the fact that it is considered one of the most common cats in Mesoamerica (Caso et al. 2008), there is relatively little information about its ecology and population density in many Neotropical countries. *L. pardalis* plays an important ecological role in Neotropical ecosystems (Oliveira et al. 2010), which is probably more critical in areas where the populations of larger predators, such as jaguar *Panthera onca* and puma *Puma concolor*, have been extirpated (Oliveira et al. 2010). In Costa Rica, the species is distributed throughout the country, however, available information is limited both geographically and ecologically (Navarro-Arquez et al. 2007). Conservation of ocelots is an important issue in Costa Rica due to general loss and reduced available habitat protected (Sánchez-Azofeifa et al. 2001), especially for cats (Rodríguez-Herrera et al. 2002), its potentially important conflict with humans (Caso et al. 2008) and, their significant ecological role and potential as flagship species for landscape-scale conservation planning. Here we present the first estimation of ocelot density in the Caribbean region of Costa Rica.

The Talamanca mountains extent from south-eastern Costa Rica to north-western Panamá. The Talamanca ecoregion is the most important and largest forest patch of Costa Rica and it is the largest unfragmented forested area of southern Mesoamerica (González-Maya et al. 2008a). The complex is mostly under legal protection and special management schemes, including five protected areas, six indigenous territories and some private properties (González-Maya and Mata-Lorenzen 2008). The study area was located on the Caribbean slopes of the mountain range, specifically in the Talamanca-Caribe Biological Corridor (CBTC), a private initiative born to functionally and structurally connect the protected areas of the mountain range (La Amistad NP and Hitoy-Cerere Biological Reserve) to those of the coastal area (Cahuita National Park and Gandoca-Manzanillo Wildlife Refuge). The corridor is located next to the southern border of the country and covers approximately 1055 km^2, between 0 and 500 m a.s.l. The zone is considered as a Tropical Wet Forest (Holdridge 1979), with annual rainfall of 2000-4000 mm and mean annual temperature of 28 °C. The centre of the surveyed area was located in Buena Vista, ca. 9 km west of BriBri (9°39'11.47" N and 82°51'9.21" W).

The survey was carried out by camera-trapping (film camera-traps; PTC Technologies), between February and April 2009. Ten stations, composed by two camera-traps facing each other, were deployed, setting the cameras at approximately 60 cm above ground. Stations were separated approximately by 2.4 km, according to previous studies (Navarro-Arquez et al. 2007; González-Maya et al. 2008b). All stations were checked every 15 days and films and batteries replaced whenever needed. The pictures from paired cameras were considered as from one sampling site for the analyses. Photo-trapped ocelots were identified by their unique spot pattern (Maffei et al. 2005) and a capture matrix was constructed and analysed using capture-recapture analyses for closed populations by CAPTURE. After testing several intervals in order to account for the highest capture probability, as suggested by Trolle and Kéry (2003), twelve five-day long trapping intervals were considered. The size of the sampling area was calculated by the Minimum Convex Polygon method using 100% trapping stations.

A total trapping effort of 600 trap-days, over a 7.15 km^2 wide area, allowed us to camera-trap five species of mammals. *L. pardalis* (seven captures) was the most frequently captured species, followed by *Dasyprocta punctata* (four captures), *Pecari tajacu* and *Eira barbara* (two captures each) and *Dasypus novemcinctus* (one capture). From the seven *L. pardalis* pictures, five individuals were positively identified. CAPTURE estimated the Null (Mo=1.0) and Heterogeneity (Mh=0.92) models as the most appropriate ones; we performed the analyses by both probability models and selected *Mh* for extrapolation as it accounted for the highest capture probability. Closure population test (z = 2.456, p = 0.993) indicated that the population was closed during the sampling period. The assessed abundance was eight individuals (SE = 3.9426), with a 95% confidence interval of 6-26 individuals for the null model and five individuals (SE = 2.4085), with a 95% confidence interval of 5-21 individuals for the heterogeneity model. Capture probability was 0.0770 by *Mo* and 0.1167 by *Mh*. Because data did not enable us to calculate the Maximum Distance Moved (Di Bitetti et al. 2006; Trolle and Kéry 2003), we used published estimates of home-range sizes of radio-collared individuals from similar study areas to build

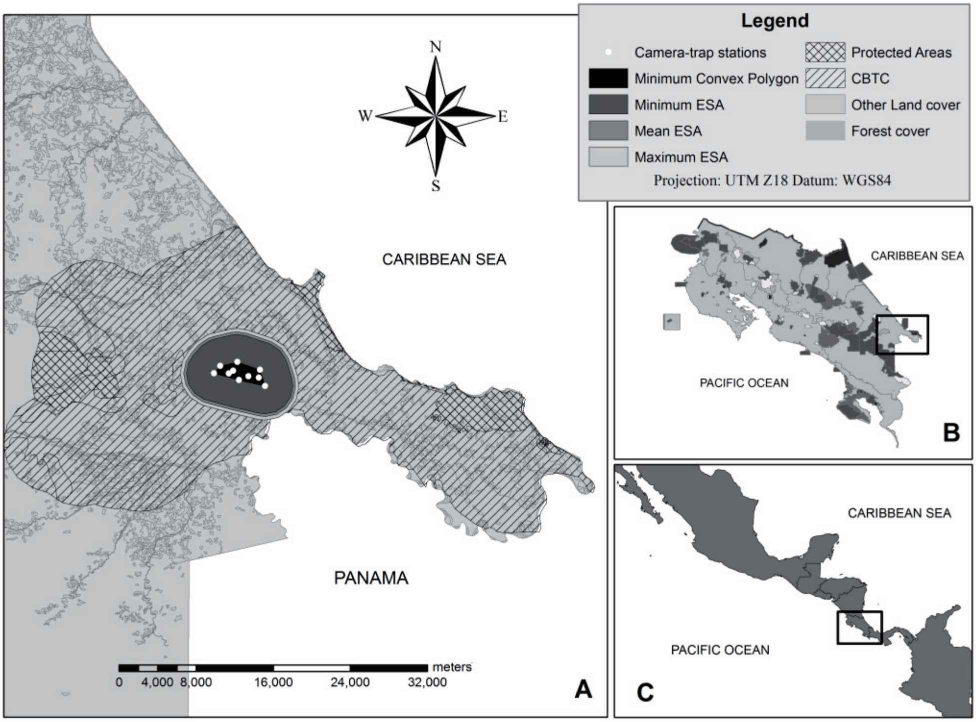

Figure 1 - Map of the study area, showing camera-trap station locations, Minimum Convex Polygon and Effective Sampling Areas within the local, national and regional context. CTBC: Talamanca Caribbean Biological Corridor.

three possible buffer scenarios and therefore three estimated Effective Sampling Areas (ESA). Home range sizes from 14.68 to 38.80 km^2 were obtained from Konecky (1989), Crawshaw and Quigley (1989), Dillon and Kelly (2008) and González-Maya et al. (2008b). Maximum, minimum and mean ranges (31.285 km^2) were then used to calculate ESA (Max=89.33 km^2, Min=68.92 km^2 and Mean=77.45 km^2), computing the radius of such home-ranges and constructing buffer areas around the camera trap stations (*Fig. 1*). Estimated mean densities calculated from the multiple ESA used were 10.29 ± 1.32 individuals × 100 km^{-2} and 6.44 ± 0.83 individuals × 100 km^{-2} for *Mo* and *Mh* models, respectively (*Tab. 1*).

Based on these figures, gross potential maximum abundance estimates for the entire corridor, based on the *Mh* model, would be 67.89 ± 8.74 individuals, up to 321.46 individuals when the confidence intervals range are used.

The relatively small area covered by camera-traps, the lack of Mean Maximum Distance Moved estimations derived from spatial re-captures specific for the study and the low number of trap stations can influence density estimations due to constraints related with capture probabilities. However, our estimation reached the capture probability threshold previously proposed as the lower limit for meaningful abundance estimates, and the Minimum Convex Polygon covered was similar to previous studies (Trolle and Kéry 2003).

Table 1 - Density estimations for the two models selected and their respective 95% confidence intervals according to Effective Sampling Areas (ESA) estimated from literature.

Model	Abundance estimation			Density (ind. × 100 km^{-2})
Mo	Model estimation	8	Mean	10.3
			Min	9.0
			Max	11.6
	Lower confidence interval estimation	6	Mean	7.7
			Min	6.7
			Max	8.7
	Upper confidence interval estimation	26	Mean	33.6
			Min	29.1
			Max	37.7
Mh	Model estimation	5	Mean	6.5
			Min	5.6
			Max	7.3
	Upper confidence interval estimation	21	Mean	27.1
			Min	23.5
			Max	30.5

Although these estimates need to be reviewed and validated, they provide a gross view of potential total abundance (Maffei et al. 2005). Previous studies on ocelot density reported higher densities in areas with large patches of pristine habitat, but comparable estimations for ecosystems similar to those found in Costa Rica. Estimated mean densities for Brazil (Trolle and Kery 2003) and Bolivia (Maffei et al. 2005), using similar methods, were significantly higher than those reported here (from 30 to 56 individuals × 100 km^{-2}). In Argentina (Di Bitteti et al. 2006) and Belize (Dillon and Kelly 2008), ocelot densities ranged from 12 to 13 individuals × 100 km^{-2}, whereas recent estimations for Colombia (Díaz-Pulido and Payán 2011) showed mean density of 5.5 individuals × 100 km^{-2}. The only previous estimation for the Talamanca region, on the Pacific slopes, reported a density coincident with our model estimation (mean density 7.34 individuals × 100 km^{-2}; Navarro-Arquez et al. 2007; González-Maya et al. 2008b).

Despite the potential bias related to sample size, the alarmingly low potential number of individuals for the entire corridor represents a call for action in order to extensively explore the relative importance of the study area for the conservation of the species within the Talamanca ecoregion. The densities estimated for the area suggest that its ocelot population is potentially playing a critical role in the maintenance of species across the Caribbean piedmont and lowlands of the cordillera, since it is the only actively managed and preserved site for conservation purposes (Schipper, 2009). Also, the similar densities from the Pacific slopes indicate that the figures herein reported are consistent and probably are related to similar ecological traits for the species in the region, although ocelots have strong sympatric relationships with jaguar on the pacific slope (González-Maya et al., 2010). The presence of similar populations on both sides of the cordillera could represent potentially a meta-population dynamic and may represent an opportunity to favor the species presence in the area on the long term, in spite of the fact that previous studies considered the highest elevations of the cordillera (above 2,500 m) as an effective barrier for the dispersal of lowland mammals (González-Maya et al. 2008a; Schipper 2009). As previously mentioned, the long term persistence and conservation of ocelot in the region depends on most of the Caribbean lowlands, and CBTC, to maintain minimum viable populations (Díaz-Pulido and Payán 2011). Other studies have shown the importance of the active protection of this corridor for the functional connectivity across the elevation gradient and the maintenance of lowland mammal populations (Schipper, 2009).

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