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Andean bear diet near to and far from a road

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Abstract: Despite the existence of several regional studies on the diet of the Andean bear (*Tremarctos ornatus*), there is a lack of information about the effects of human disturbances on this species' foraging ecology. Our main goal was to compare Andean bear diet composition between a disturbed area (DA) close to a paved road versus an undisturbed area (UA) far away from it, within the Parque Nacional y Área Natural de Manejo Integrado Cotapata, Bolivia. We collected 120 feces samples between October and November 2014—60 samples from each area. We identified 13 species from the feces collected at UA, whereas we identified only 7 species from the feces at DA. Mean number of identified food items per fecal sample at UA was 2.90 (SD = 0.86) and significantly greater ($t = -4.32$, = 118 df, $P < 0.001$) than DA mean 1.95 (SD = 1.43). Levin's index points to a specialist diet for Andean bears at both areas, but niche breadth at the UA (0.083) was almost twice the value at DA (0.043). Almost half of the items were found at both the UA and the DA (Jaccard's index = 0.538). Simpson's Diversity index ([UA] = 0.310, [DA] = 0.167) shows that Andean bear diet at the UA was also more equitable, as well as less dominated by a single item (Inverse Simpson index N [DA] = 3.229, N [UA] = 5.997). These results suggest that the presence of a road may affect Andean bear foraging ecology.

Key words: Andes, Bolivia, Cotapata National Park, foraging ecology, human disturbances, road ecology, *Tremarctos*, Yungas

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The impacts of roads on wildlife include direct mortality, range displacement, habitat loss and fragmentation, and an increase in the intensity of human activities (Forman et al. 2003, Van Manen et al. 2012). Roads may have long-term effects on biological communities, generally known as the road-zone effect (Forman and Alexander 1998, Spellerberger 1998, Lembrechts et al. 2017), which likely affect wildlife populations in different ways, including behavior. Furthermore, changes in abiotic and biotic conditions near roads lead to differences in resource availability in areas located near roads, resulting in shifts in activity and/or foraging patterns that may promote potential conflicts with human activities (Forman and Alexander 1998, Forman and Deblinger 2000).

The effects of human disturbances on bear behavior have been the focus of several studies, including the differential selection of foraging areas after habitat disturbance (Munro et al. 2006, Johnson et al. 2015) and human activity (Sahlén et al. 2015). Bear behavior likely is affected by roads because habitat accessibility increases mortality risks associated with vehicle collisions and hunting (Roever et al. 2008, Simek et al. 2012). Although bears may not completely avoid foraging near human settlements and roads (Mattson 1990, Mattson and Merrill 2004, Ordiz et al. 2014), it has been reported that they may prefer denning sites far from roads (Reynolds-Hogland et al. 2007) and also generally are affected by road density through habitat loss and road kill risk (McCown et al. 2004).

Although roads have been identified as potentially harmful for Andean bear (*Tremarctos ornatus*) conservation (Kattan et al. 2004), Sánchez-Mercado et al. (2008) only found an indirect effect of road density on the risk of Andean bear poaching in Venezuela. A recent review indicates that Andean bears are not reported by the International Union for Conservation of Nature as highly threatened by roads (Ceia-Hasse et al. 2017).

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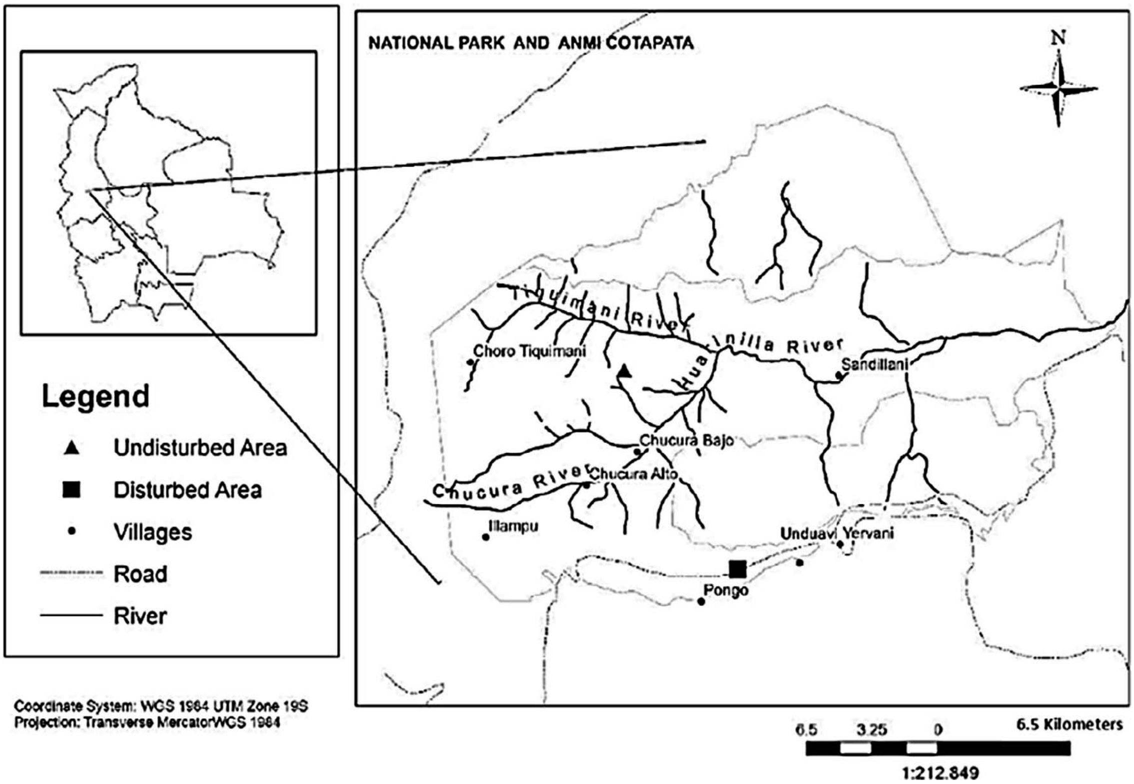

Fig. 1. Map of Cotapata National Park, Bolivia, showing the disturbed and undisturbed areas where we examined food items in Andean bear (*Tremarctos ornatus*) diets from feces collected between October and November 2014. The Pongo village is located 42 km from La Paz city.

This study assesses the effects of a road on Andean bear diet. Long-term qualitative observations from one of us (LFP) in disturbed areas along the road and in other undisturbed Andean bear habitat suggest that areas closer to the road have not yet recovered from road construction impacts. Therefore, we can reasonably hypothesize that availability of food resources for Andean bears should be reduced near the road as a consequence of the road-zone effect (Forman and Alexander 1998). We hypothesize further that Andean bear diet should be less diverse for bears using areas near the road than for bears using areas away from the road's disturbance effect.

Study area

We addressed our study question by comparing Andean bear diet between an area close to a major road and an area far away from the potential effects of the road. We conducted the study at Cotapata National Park and Integrated Management Area (Parque Nacional y Área Natural de Manejo Integrado Cotapata; Cotapata NP; Fig. 1). Cotapata NP is located in the Yungas region of Bolivia, spans approximately 500 km^2, and ranges in elevation between 1,200 and 5,600 m above sea level (asl; Ribera-Arismendi 1995). We chose 2 sampling areas, one near the road that links La Paz city with Coroico Municipality (our disturbance effect) and a second that we considered as removed from the effects of this road. The area subjected to road disturbance (disturbed area = DA) is known as Jinchumuruni, whereas the undisturbed area (UA) is within the Tiquimani River Valley, approximately 30 km walking distance from the DA, and is separated from it by 2 watersheds.

The DA sampling area (67°56′44″W; 16°19′37″S) is between 3,500 and 3,780 m asl and is located approximately 2 km from the road. The road is a 2-lane paved route in operation for 21 years at the time of the study. It was a dirt road long before that time. Cars and trucks travel along the road throughout the day and night, but quantitative data on traffic loads are not available. The nearest human settlement to our DA sampling area is a small (approx. 8 families) community named Pongo (Fig. 1). The main commercial activity at Pongo is restaurant services, offered to people who travel either to Yungas tourism areas or farther away to the Bolivian Amazonian region. People also farm small subsistence crops (mainly potatoes) near the town. The UA (67°59′13″W and 16°12′07″S) is located in the northern portion of the Cotapata NP and is also between 3,600 and 3,800 m asl. The only access to this area is by foot, and human presence is occasional. Bear hunting is known to occur in Cotapata NP as a retaliation measure when livestock is preyed upon, but this illegal practice is uncommon.

Both sampling areas are within the Páramo Yungueño (López 1998), so we assume that differences in vegetation structure, if any, are related to the presence of the road at DA. Vegetation cover in the Páramo Yungueño is mainly herbaceous, including grasses of the genera *Stipa* and *Festuca,* dicots such as *Calceolaria* and *Gnaphalium* spp., and scattered shrubs such as *Brachyotum microdon, Satureja (Clinopodium)* sp., *Mutisia, Chuquiraga* and *Baccharis* spp. (López 1998), and *Puya atra,* an endemic Bolivian bromeliad commonly consumed by Andean bears. In addition to Andean bear, common mammals include Andean deer (*Hippocamelus antisensis*), Andean fox (*Lycalopex culpaeus*), and mountain vizcacha (*Lagidium viscacia;* Pacheco et al. 2003). The climate is humid and strongly influenced by ground-level mist for most of the year, as well as mountain range winds. The area frequently is subject to freezing temperatures (Ribera-Arismendi 1995). Annual precipitation ranges between 1,500 and 2,200 mm (Molina-Carpio 2005).

Methods

Sample collection

We compared Andean bear diet between an area close to a road and an area far away from the potential effects of the road. Local knowledge about Andean bear diet and a preliminary field survey in both sampling areas showed that feces were generally grouped near plants of *P. atra.* Following recommendations by Trites and Joy (2005), we set a sample target of 60 at each sampling area as a minimum sample size to adequately describe Andean bear diet.

Between October and November 2014, we collected fresh feces (mostly 2–3 days old, but all <2 weeks), distinguished with the aid of highly experienced park rangers. Fresh samples could be identified by their brown or green color (depending on the quantity of *P. atra*), whereas old samples were dry and either yellow or white. In order to have a reference collection of the local flora, we conducted nonsystematic flora surveys at both sampling areas simultaneously with fecal collection. We stored fecal samples in Ziploc (S. C. Johnson & Son, Inc., Racine, Wisconsin, USA) plastic bags. At the laboratory, we placed feces in a dark spot on newspapers for 2 days at room temperature, adding salt (NaCl) to each sample in order to avoid fungus spread (Ríos-Uzeda et al. 2009). We took collected plants to the Bolivian National Herbarium (Herbario Nacional de Bolivia), where one of us (EG) identified them and made a reference collection of their seeds, fruits, and leaves to make easier the identification of the fecal items.

Fecal analysis followed the protocol of Ríos-Uzeda et al. (2009) with some modifications. We examined the entire sample in order to increase the probability of finding rare items. We did not measure biomass or volume. We separated items in the laboratory by morphotype: seeds, leaves, fruits, fiber, and hair (we did not find any bones), using a precision tweezer and a stereo microscope. We compared plant items with our reference collection and herbarium samples.

We made a reference collection for mammal items using hair samples from several species that we believed might be present at the study sites (Colección Boliviana de Fauna and suggestions from an expert in Cotapata NP small mammals [A. Rico, Instituto de Ecología]). We used both cuticular and medular patterns for the identification of hair samples (Viscarra et al. 2010), using a Motic SMZ 140/143 stereo-microscope (Motic, Hong Kong, China).

Data analysis

We square-root-transformed data on the number of items per sample in order to reach a normal distribution. We compared the diversity (no. of items by fecal sample) between areas using a *t*-test. We compared niche breadth using the Levin's index (Krebs 1989). We assessed similarity in composition with the Jaccard index, which varies between 0 (no overlap) and 1 (complete overlap). We assessed diversity of samples using the Simpson Diversity index, which also varies between 0 (no diversity) and 1 (highest diversity; Krebs 1989). We also compared richness (no. of identified items) between areas using the Inverse Simpson index because this index gives information about the degree of dominance by a single item in the sample. We finally calculated the relative frequency of each item as a means of quantifying its importance (Pacheco et al. 2004).

Table 1. Food items in Andean bear (*Tremarctos ornatus*) diets in undisturbed (away from road) and disturbed areas (near road) within Cotapata National Park, Bolivia, from feces collected between October and November 2014.

Food item	Undisturbed area	Disturbed area
Plants		
Ericaceae		
Gaultheria hapalotricha	+	+
Pernettya prostrata	+	+
Cavendishia bracteata	+	−
Vaccinium floribundum	+	+
Bromeliaceae		
Puya atra	+	+
Rosaceae		
Hesperomeles obtusifolia	+	−
Hesperomeles cuneata	+	+
Escalloniaceae		
Escallonia myrtilloides	+	−
Animals		
Rodentia		
Oligorizomys sp.	+	+
Akodon mimus	+	−
Artiodactyla		
Vicugna vicugna	+	−
Didelphimorphia		
Gracilinanus aceramarcae	+	+
Lagomorpha		
Unidentified	+	−

Results

We collected 120 fecal samples, 60 at each area. We identified 13 species in Andean bear diet at Cotapata NP—8 plant species and 5 animal species. All 13 species were present in fecal samples from UA, but we identified only 7 at DA (Table 1). Additionally, the mean number of species per fecal sample at UA (2.90, SD = 0.86) was significantly greater than at DA (mean = 1.95, SD = 1.43; $t = -4.32$, 118 df, $P < 0.001$). It is important to note that our study reported 3 new animal species for Andean bear diet: *Gracilinanus aceramarcae* (Didelphimorphia), and 2 rodents *Oligoryzomys* sp. and *Akodon mimus.*

Puya atra was the most frequently consumed food item at both sites, but it was considerably more common in the samples from the DA than in those from the UA (46% vs. 33% of samples, respectively, $\chi^2 = 41.38$, 1 df, $P < 0.05$). Another important difference was the presence of vicuña hair (*Vicugna vicugna*) at the UA (Fig. 2). We did not find garbage items in our fecal samples.

Although the Levin's index points to a specialist diet for Andean bears at both areas, niche breadth at the UA (0.083) was almost double the DA value (0.043). The Jaccard's index (0.538) showed that almost half of the items were shared between UA and DA. Finally, Andean bear diet at the UA also was more equally distributed (Simpson's Diversity index [UA] = 0.310, [DA] = 0.167) and less dominated by a single item (Inverse Simpson index [DA] = 3.229, [UA] = 5.997; Table 2).

Discussion

The diet of Andean bear was more diverse in the undisturbed area away from the road, which supported our prediction. Vehicle transit, human noise, hunters, and possibly the presence of cattle and cattle ranchers might be factors that influence bear behavior near roads (Spellerberger 1998, Coffin 2007). Reports about Andean bears using areas near roads, or human-disturbed areas (Goldstein 2006, Albarracín 2010), suggest that this species may habituate to some changes in their environment. This habituation is likely to include a change in their diet, as we detected in our study.

Although our study design had some shortcomings, such as a lack of replicated sites and an absence of a direct assessment of resource availability, we believe that our results correctly reflect the situation. The fact that both study areas were located within Páramo Yungueño allows us to assume that any differences in Andean bear diet are the result of distinct resource availability between UA and DA.

An important finding is the presence of vicuña in the diet at the UA. According to local people and park rangers, vicuñas were considered extirpated at Cotapata NP ≥30 years ago. Andean bears may have preyed upon vicuñas in other areas before returning to defecate, but the potential recovery of vicuña populations within the park is an important topic that needs further study.

Patches of *P. atra* that were located very close (<200 m) to the road at the DA did not show any signs of foraging (leaves spread around) or presence of feces near the plant. Andean bears usually defecate near predated *P. atra* individuals (park rangers, personal communications). This anecdotal information matches the understanding by local residents that Andean bears tend to avoid human disturbance very close to the road, which may even preclude bears from using highly palatable resources.

The diet of the Andean bear across its range includes 78 plant species from 34 families, and 12 animal species from 9 orders (Brown and Rumiz 1989, Eulert 1995, Azurduy 2000, Goldstein 2000, Vargas and Azurduy 2006, Gonzales et al. 2016). The number of species in the diet of Andean bears at Cotapata NP matches the average number of species per study site (13.32; SD = 2.63)

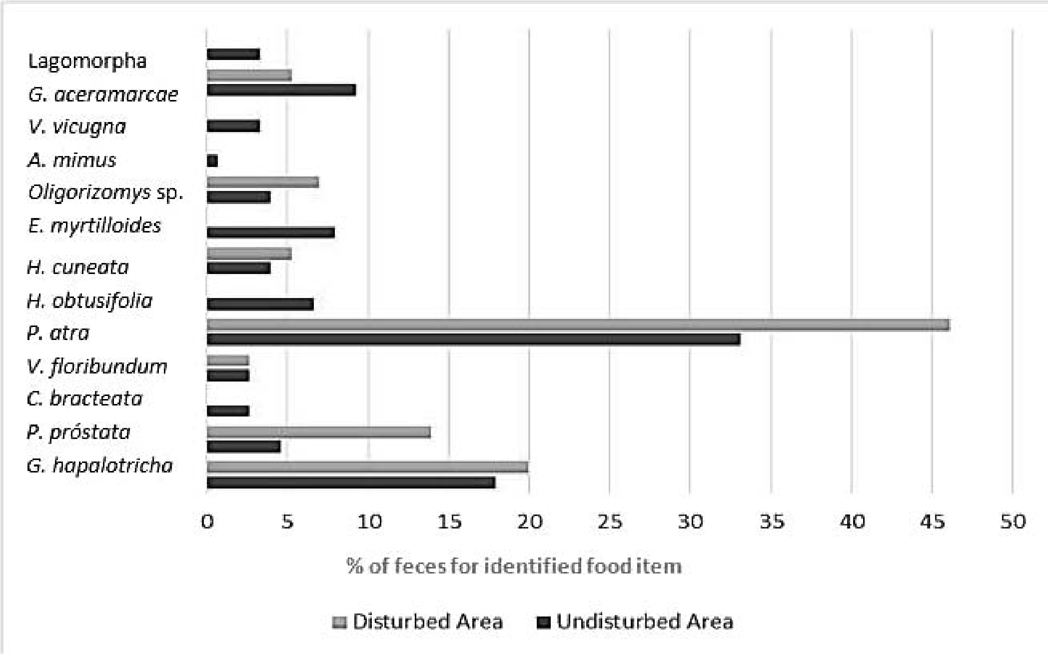

Fig. 2. Percentage of Andean bear (*Tremarctos ornatus*) fecal samples with different food items (collected within Cotapata National Park, Bolivia, between Oct and Nov 2014) from a Disturbed Area (near road) and an Undisturbed Area (away from road). Data were square-root-transformed for analysis.

for the 30 studies carried out across its distribution range (Figueroa 2013). It is important to mention that none of the previous studies considered sampling at disturbed areas.

Considering only those studies carried out in areas of Páramo Yungueño, in Bolivia (Rivadeneira-Canedo 2008, Ríos-Uzeda et al. 2009), it is clear that Ericaceae and *Puya* spp. are the main plant food items in this habitat. The Ericaceae *Vaccinium floribundum, Gaultheria hapalotricha, Pernettya prostrata,* and *Cavendishia bracteata* are creeping and erect shrubs that grow mostly on open places near trails inside the forest. These plants are tolerant of trampling and light exposure, which are common conditions in disturbed places. The same studies report only 4 animal items: *Bos taurus, Equus caballus, Equus* sp., and an unidentified small mammal. This finding is quite different from what we found in Cotapata NP and we believe this is likely a result of different livestock availability at our study site, where only cattle are present (only at DA) but not very common.

Table 2. Summary of indices used for comparing Andean bear (*Tremarctos ornatus*) diet (from data collected between Oct and Nov 2014 in within Cotapata National Park, Bolivia) between the disturbed area (DA, near road) and undisturbed area (UA, distant from road).

Index	DA	UA
Levin's index	0.043	0.083
Simpson's index	0.167	0.310
Inverted Simpson's index	3.229	5.997
Jaccard's index	0.538	

There are 34 animal species (both domestic and wildlife, insects, worms, etc.) reported in the diet of Andean bears at the regional level, but only 1–7 were found in the bear's diet at any site (Figueroa 2013). The number of animal species (5) reported in the diet of Andean bear in Cotapata NP fits within this range. However, our results are amongst the highest reported frequency (10%) of feces with animal remains for Andean bears to date (Peyton 1980, Azurduy 2000, Rivadeneira-Canedo 2008, Ríos-Uzeda et al. 2009), with the possible exception of the study by Gonzales et al. (2016), who reported animal remains in all of their 6 fecal samples. Our diet assessment also reports the highest frequency of occurrence of small rodents in the Andean bear diets. Given the small size of these animals, we hypothesize that bears do not actively search for them, but find and capture these rodents as they forage for other food resources. The presence of vicuña in Andean bear diets was previously reported only for Peru, while Lagomorpha (only *Sylvilagus* spp.) was reported for Colombia, Venezuela and Ecuador (Figueroa 2013).

Our results reinforce the notion that Andean bears have an omnivorous diet. Given the already discussed limitations of our study, we can only preliminarily conclude that the road may affect Andean bear foraging ecology, resulting in a lower diversity of foraging species in diet. If Andean bear foraging ecology is affected by the presence of a road, this should be considered for long-term population monitoring of the species and also for the design of conservation strategies, as well as for road planning.

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