

Cockscomb Revisited: Jaguar Diet in the Cockscomb Basin Wildlife Sanctuary, Belize¹

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ABSTRACT

The Cockscomb Basin Wildlife Sanctuary, Belize was established in 1986 following Rabinowitz and Nottingham's 1986 study on jaguar diet and distribution. In 2002, we reexamined jaguar diet following two decades of mitigated human hunting of jaguar prey. We observed high overlap between historical and current jaguar diet constructs. Nine-banded armadillo remained the most frequently consumed prey item. However, collared peccary consumption increased by nearly 20 percent while dietary breadth decreased by 60 percent presumably reflecting increased prey availability following reduced human hunting pressure.

Key words: Belize; *Dasyus novemcinctus*; diet; *Panthera onca*; *Tayassu tajacu*; tropical moist forest.

RABINOWITZ AND NOTTINGHAM'S (1986) INVESTIGATION OF JAGUAR DIET in the then unprotected Cockscomb Basin, Belize, Central America, characterized the local population as opportunistic predators, consuming primary prey items, armadillo (*Dasyus novemcinctus*), and paca (*Agouti paca*), relative to availability. The study incited the Belize government to create what is now the Cockscomb Basin Wildlife Sanctuary (CBWS) effectively prohibiting hunting in the northeast region of the preserve. Local reductions in human hunting may have altered the relative abundance of prey species and diet composition of jaguar. In this exploratory study, we examined jaguar diet in the northeast region of the CBWS during the 2002 wet season (June–December), with the study acting as both an investigation of potential diet change since 1986 and as a pilot for long-term ecological monitoring.

The CBWS occupies 437 km², and is delineated by two mountain ranges: the Cockscomb Mountains to the north and Maya Mountains to the west. Elevation ranges from 50 to 1120 m. On average, the region receives 270 cm of rain annually with the majority falling during the wet season (June–December; Kamstra 1996). Mean annual temperature is 25°C fluctuating an average of 5 degrees between the warmest (April and June) and coldest months (November and January; Kamstra 1996).

We conducted fieldwork in the northeast portion of the CBWS, subsequently referred to as Guam Bank, which encompassed the study area of Rabinowitz and Nottingham (1986). The Guam Bank study region was defined by 35 km of man-made paths regularly surveyed for jaguar scat. Ecotourism was the primary human disturbance in Guam Bank during the study. Patrols conducted by

the Belize Audubon Society (BAS) failed to document evidence of humans hunting jaguar prey in Guam Bank; however, subsistence hunters inhabiting villages on the CBWS periphery established hunting routes and encampments to the south and west of the Guam Bank study area (Weckel 2005).

We constructed jaguar diet from scats collected from 1 June to 24 November 2002. Scats were dusted with a pyrethrum-based insecticide (Reynolds & Aebischer 1991), air-dried, and stored for up to 6 mo in brown paper bags containing silica salts (Wasser *et al.* 1997). Samples were later transferred to a frost-free –20°C freezer for a long-term storage.

Jaguar scats were distinguished from those of the sympatric puma by several methods including the presence of jaguar hair (assumed ingested while grooming), associated pugmarks, identification by indigenous BAS staff, and molecular techniques. Molecular classification of scat origin required extraction of DNA from the scat surface where contact with the colon wall presents the possibility of extracting genetic material from sloughed epithelial cells (Foran *et al.* 1997). We followed a modified protocol (Rusello, American Museum of Natural History, pers. comm.) of the QIAamp DNA Stool Mini Kit (Qiagen, Valencia, CA, USA) for fecal digestion and DNA isolation (Weckel 2005), and targeted the 16S region of the mitochondrial genome for DNA amplification using 16S universal primers (Hoezel & Green 1992). The protocol for DNA amplification and sequencing followed those prescribed by Farrell *et al.* (2000) with minor modifications to reactant concentrations and annealing temperatures (Weckel 2005).

Following molecular classification, scats were broken apart and washed over a series of screens (1.682, 1.000, 0.5, and 0.1 mm mesh). We identified food items to the lowest possible taxon by hair and nail identifications (Putnam 1984). Hair color, length,

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banding, and cuticle patterns were compared to a reference collection compiled from road kills, Belize Zoo, American Museum of Natural History, and University of Florida. Where scale pattern was required to determine prey species, we created enamel impressions of unknown hair following the procedures of Litvaitis *et al.* (1996). Diet was expressed as frequency of occurrence (percent of total scats in which a prey type was found) and compared to the dietary construct of Rabinowitz and Nottingham (1986) using Horn's Similarity Index (SI; Horn 1966), describing the extent of overlap between diet constructs with values varying from 0 (no shared species) to 1 (identical diets).

A total of 34 scats were collected in the Guam Bank study region. Twenty-three scats were identified as jaguar with DNA, pugmarks, ingested hair, and indigenous identification assigning origin to 12, 7, 1, and 14 scats, respectively. Four puma scats were identified by molecular techniques and seven scats were excluded from the analysis as we could not confidently determine their origin.

We observed high overlap (SI = 0.79) between the historical (Rabinowitz & Nottingham, 1986) and current diet constructs, largely reflecting the continued importance of armadillo and paca (Table 1). Despite the continued importance of armadillo, its proportional contribution declined, offset by increased proportions of paca and peccary species (*Tayassu* spp.) since 1986. Collared peccary (*Tayassu tajacu*) was the more important *Tayassu* in 2002, comprising 23 percent of the total diet. Prey species such as northern anteater (*Tamandua mexicana*) and Central American agouti (*Dasyprocta punctata*), comprising 13.6 percent of all prey items in the 1986 jaguar diet, were not discovered among scats collected in 2002. Total dietary breadth decreased from 18 to 7 species from 1986 to 2002, and no evidence of jaguar predation on livestock was observed in the current study.

In the nearly two decades following the creation of the CBWS and the initial study of jaguar, armadillo has persisted as the most consumed prey item, despite declines in overall contribution to the diet. In contrast, collared peccary, a minor prey item during Rabinowitz and Nottingham's study, became the second-most consumed species. Collared peccary has been observed as an important prey species for jaguars across habitat types (Mondolfi & Hoogesteijn 1986, Aranda & Sanchez-Cordero 1996, Chinchilla 1997, Garla *et al.* 2001, Novak 2003, Scognamillo *et al.* 2003) with the geographic distribution of peccaries suggested as a factor limiting the current range of jaguars (Novak 2003).

The observed increase in peccary consumption following the creation of the CBWS potentially stems from decreased hunting pressure in the Guam Bank region. Karanth and Sunquist (1995) suggested that the dominance of small prey in the diet construct of Rabinowitz and Nottingham (1986) might be attributed to human removal of larger prey. The increased importance of peccary and paca, coupled with the absence of northern anteater and agouti support this contention. In the earlier CBWS study, peccary were rarely observed in transect studies (Rabinowitz & Nottingham 1986), while current prey indices generated in the absence of hunting suggest that peccary were a numerically abundant food source (Weckel 2005). However, the relationship between peccary consumption and its availability is equivocal. In protected regions (no

TABLE 1. Jaguar dietary comparison constructed from scats from the Guam Bank study area, Cockscomb Basin Wildlife Sanctuary, Belize, 1986 and 2002.

	2002	1986 ^a
Scats (n)	23	210
Prey items (n)	30	185
Prey items	Frequency occurrence	Frequency occurrence
<i>Dasyppus novemcinctus</i> (Nine-banded armadillo)	33.3	54
<i>Tayassu tajacu</i> (Collared peccary)	23.3	
<i>Tayassu pecari</i> (White-lipped peccary)	3.3	5.4 ^b
<i>Agouti paca</i> (Paca)	23.3	9.3
<i>Mazama americana</i> (Red brocket deer)	6.7	6.5
<i>Nasua narica</i> (White-nosed coatimundi)	3.3	1.0
<i>Potos flavus</i> (Kinkajou)	3.3	0.5
<i>Tamandua mexicana</i> (Northern anteater)	0	9.3
<i>Dasyprocta punctata</i> (Central American agouti)	0	4.3
<i>Didelphis marsupialis</i> (Common opossum)	0	3.2
Reptile (unknown species)	0	1.5
River turtle (unknown species)	0	1.0
Small rodent (unknown species)	0	1.0
<i>Philander opossum</i> (Four-eyed opossum)	0	1.0
<i>Spilogale putorius</i> or <i>Conepatus semistriatus</i> (Skunk)	0	0.5
<i>Gallus gallus</i> (Common rooster; assumed jaguar bait)	0	0.5
Snake (unknown species)	0	0.5
Bird (unknown species)	0	0.5
Mammal (unknown species)	3.3	0

^aDietary construct from Rabinowitz and Nottingham (1986).

^bPrey item was not identified to the species level.

human removal of prey) of the Maya Biosphere Reserve (MBR) in Guatemala, collared peccary was underrepresented in jaguar diet relative to local availability (Novak 2003). Collared peccary represented a greater fraction of jaguar diet in unprotected regions of the MBR, despite concomitant lower collared peccary densities (Novak 2003). Furthermore, similar to our findings, armadillo was the most frequently consumed prey item in both protected and unprotected areas (Novak 2003), suggesting a regional importance of armadillo to jaguar diet regardless of the availability of other prey types.

Jaguars consumed fewer prey species in 2002 than in 1986, further supporting the contention that reduced human hunting has altered jaguar prey use. Dietary breadth is believed to be indicative of resource availability, with niche contraction related to increases in prey abundance (Emlen 1966). However, minor prey items in the 1986 diet construct may still have been consumed by jaguars in 2002, but not observed due to the small sample size (Reynolds and Aebischer 1991). Nuñez *et al.* (2000) required 35 scats to accurately depict the diet of dry forest jaguars, while warning that the minimal sample size would be much higher for cats of humid forests where the prey base is more diverse.

Speculation on the impact of mitigated human hunting is further limited by the aggregation of peccary species in the previous study. Rabinowitz and Nottingham (1986) did not distinguish between collared and white-lipped peccary (*Tayassu pecari*) either in jaguar scat or in an index of relative prey availability, ignoring ecological disparities that obscure historical comparisons. In 2002, both peccary species were equally abundant, although jaguars selected for collared peccary while consuming white-lipped peccary relative to its abundance (Weckel 2005). The greater importance of collared peccary may reflect greater variability in the distribution of white-lipped peccary. Herds of white-lipped peccary are believed to expand their range seasonally, migrate between home ranges, or travel in a nomadic fashion (Kiltie & Terborgh 1983, Sowls 1984, Bodmer 1990, Hernandez *et al.* 1995, Fragoso 1998), increasing their vulnerability to hunting. In Guam Bank, white-lipped peccaries are observed primarily during the wet season, traveling beyond the protection of Guam Bank during the dry season (E. Saqui, BAS, pers. comm.). In contrast, collared peccaries are territorial (Sowls 1984), year-round inhabitants of the CBWS, using home ranges varying from 0.5 to 1.29 km² (Donkin 1985). Guam Bank can support several herds of collared peccary, providing a food source believed to be free from hunting pressures. Localized prey populations, such as the collared peccary, may have had the opportunity to grow in number and stabilize following the creation of the CBWS, providing a consistently abundant prey source.

Traveling in smaller herds than white-lipped peccary, collared peccary may also present a lower foraging risk (Roosevelt 1920, Kiltie & Terborgh 1983, Mayer & Wetzel 1987). However, such evidence is ambiguous. Jaguars consumed white-lipped peccary more frequently than collared peccary in both Costa Rica (E. Carrillo, Wildlife Conservation Society, pers. comm.) and Brazil (Garla *et al.* 2001), suggesting that the relative importance of peccary species is site specific, likely reflecting many factors including abundance, seasonal availability, foraging risk, and prey distribution.

Although the overall diet of Guam Bank jaguars changed relatively little with the creation of the Cockscomb Basin Wildlife Sanctuary, the increase in collared peccary consumption does suggest that previously unregulated human activity may have limited jaguar consumption of this regionally important jaguar food source. In the future, as natural habitats become both scarcer and smaller, jaguar conservation will need to become increasingly focused on managing for important jaguar prey items. Historical dietary comparisons, essential for evaluating the success of conservation strategies such as the creation of protected areas, can provide better-informed management decisions.

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