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RESEARCH ARTICLE

Endoparasite release in vomit and hairballs mediated by the ingestion of grasses by jaguar in Ecuador

Expulsión de endoparásitos en vómito y bolas de pelo mediada por la ingesta de gramíneas en el jaguar en Ecuador

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Abstract

The intake of plant material by felids is a behavior of interest, since their diet consists almost exclusively of meat. However, there are numerous records of the inclusion of plant material in the diet of various species of felids. During opportunistic observations between October 2021 and March 2022 in Yasuní National Park, Ecuador, we registered the consumption and emesis of itchgrass (*Rottboellia cochinchinensis*) and *Miconia* sp. by jaguars (*Panthera onca*). In addition to itchgrass, vomitus contained various parasites, such as nematodes and tapeworms, and remains of undigested prey including bone fragments, hair balls, and hooves of collared peccary (*Dicotyles tajacu*) and white-lipped peccary (*Tayassu pecari*). These findings highlight the importance of

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plant ingestion by jaguars to reduce intestinal parasite load and relieve their stomachs of materials difficult to digest.

Keywords: Cestoda, emesis, itchgrass, Nematoda, *Panthera onca*, parasites, *Rottboellia cochinchinensis*, Yasuní.

Resumen

El consumo de material vegetal por parte de felinos es un comportamiento que llama la atención, ya que su dieta se compone casi exclusivamente de carne. No obstante, existen registros de la ingesta de material vegetal por diversas especies de felinos. Con base en observaciones oportunistas ocurridas entre octubre de 2021 y marzo de 2022 en el Parque Nacional Yasuní, Ecuador, registramos el consumo y emesis de pasto chino (*Rottboellia cochinchinensis*) y *Miconia* sp. por parte de individuos de jaguar (*Panthera onca*). Además de pasto, en los vómitos encontramos diferentes parásitos, como nematodos y cestodos, y restos de material no digerido, como bolas de pelo, fragmentos de huesos y pezuñas de pecarí de collar (*Dicotyles tajacu*) y pecarí de labio blanco (*Tayassu pecari*). Estos hallazgos resaltan la utilidad del consumo de pasto para el jaguar, que por medio de este comportamiento puede reducir la carga parasitaria intestinal y limpiar su estómago de partículas difíciles de digerir.

Palabras clave: Cestoda, emesis, Nematoda, *Panthera onca*, parásitos, pasto chino, *Rottboellia cochinchinensis*, Yasuní.

INTRODUCTION

Felids are considered strict carnivores, or hypercarnivores, as they feed exclusively on other animals (Sunquist & Sunquist, 2002). However, the ingestion of plants and presence of plant matter in their feces have been observed in several species of wild felids, either in their natural habitat (e.g., Bengal cat, *Priodonailurus bengalensis euptilura*) or in captivity (e.g., snow leopard, *Panthera uncia*), as well as in the domestic cat (Hart, 2008; Sarasola et al., 2016; Yoshimura et al., 2020). It is speculated that felids may ingest plant material for several reasons: a) to expel gastrointestinal parasites (Schaller, 1967), b) to provide themselves with nutrients in the form of vitamins and minerals (Frank & Farid, 2020), c) to stimulate gastric motility and secretion (McLennan & Huffman, 2012), and d) to facilitate the expulsion of ingested hair that occupies the stomach cavity and hinders digestion (Cannon, 2013; Shultz, 2019).

Analysis of feces from wolves (*Canis lupus*) and wild felids reveals that virtually all free-living carnivores have parasites in their gastrointestinal tract (Frank & Farid, 2020; Guberti et al., 1993; Patton et al., 1986; Stahler

et al., 2006). The use of plants to rid themselves of these parasites has been recorded in canids and felids, which commonly ingest plants with little or no nutritional input to their diets, especially herbs (Hart & Hart, 2018). Hardened epidermal striae likely help stimulate the gastrointestinal tract and expel parasites (Lanning & Eleuterius, 1989; Mehra & Sharma, 1965; Trembath-Reichert et al., 2015). Grasses and sedges are especially useful to carnivores, as they are apparently the most sought-after plants for mitigating parasite infections in the gastrointestinal tract (Frank & Farid, 2020).

Little is known about the trophic ecology of felids in the tropics (Rau et al., 1991); in the case of the jaguar (*Panthera onca*) in Ecuador, the knowledge that is available is still scarce (Espinosa et al., 2016; MAE & WCS, 2014), so field observations regarding their feeding habits are valuable.

In this article, we present the results of opportunistic observations of the use of plant species by wild jaguars in Yasuní National Park, Ecuador, highlighting the effect of this behavior to reduce intestinal parasitic load and relieve the stomach of materials that are difficult to digest.

MATERIALS AND METHODS

Between October 2021 and March 2022, we recorded several opportunistic observations and jaguar tracks along the ballasted road of Block 31 hydrocarbon concession, south of the Tiputini River, in Yasuní National Park, Orellana province (Figure 1).

Yasuní National Park is a 1,022,736-ha protected area located in the northeast of the Ecuadorian Amazon, between the Napo and Curaray rivers (MAE, 2011). The park’s elevation ranges between 190 and 400 m a.s.l., and the terrain is segmented by small ridges that rise 25–75 m in height (Bass et al., 2010). The climate in Yasuní is characterized by warm temperatures (average 24–27 °C for all months), high rainfall (around 3200 mm annually), and high relative humidity that averages 80–94 %

throughout the year (MAE, 2011). The road where we conducted our observations is surrounded by mature tropical rainforest.

We obtained six jaguar records, two by direct observation, two by finding hairballs, and two by finding vomit with intertwined parasites (Table 1).

The hairballs and the remains of vomit found were kept in plastic bags for laboratory analysis. We determined the weight of the hairballs with a CAMRY digital scale, model EK5350 (PRECISUR), and classified the animal and plant remains they contained. We measured hooves, hairs, and vegetation with a caliper and provided parasite photographs and samples of plant material to specialists for their identification. We photographed the plant and parasite contents and shared them with specialists for their identification.

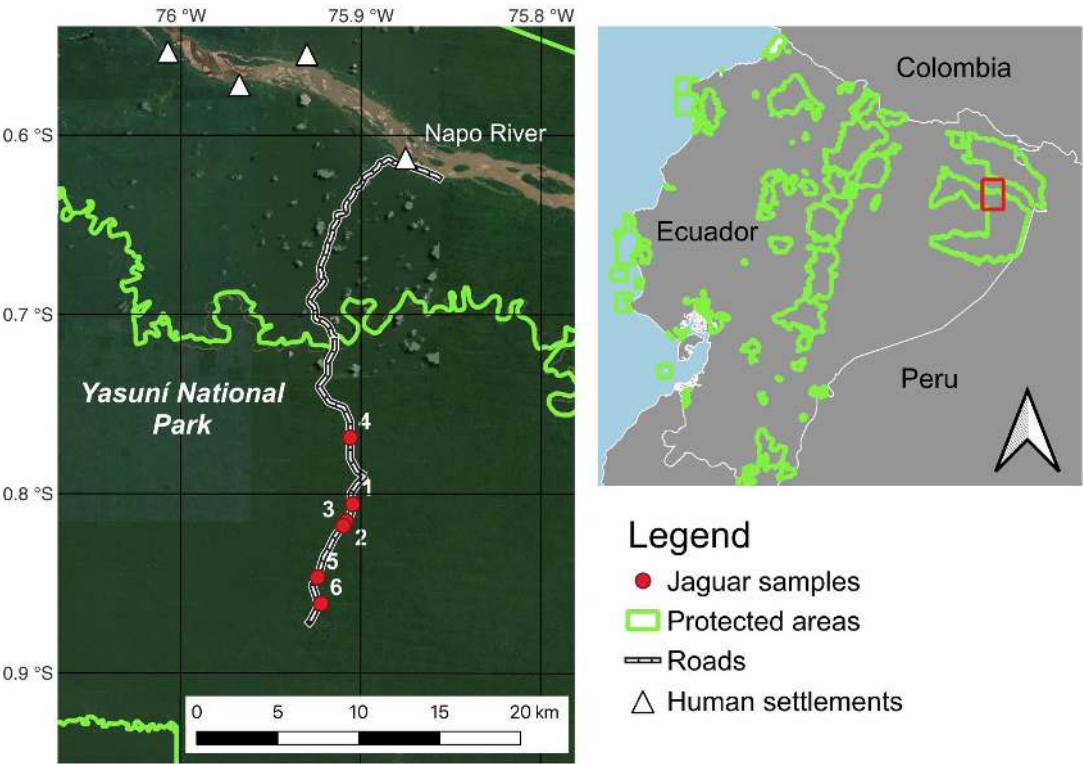


Figure 1. Sites of jaguar sightings or findings of jaguar vomitus in Yasuní National Park, Ecuador. Map prepared by S. Espinosa.

Table 1. Observations and samples taken of jaguar in Block 31, Orellana, Ecuador.

Sample	Record type	Date	Locality	Coordinates	
				Latitude	Longitude
1	Direct observation and sampling (vomit)	10/23/2021	Kilometer 9	00°48'20.5" S	75°54'15.7" W
2	Sampling (hairball)	11/10/2021	Kilometer 8 (Pindoyacu River bridge)	00°48'55.7" S	75°54'28.9" W
3	Sampling (hairball)	2/20/2022	Kilometer 14	00°49'03.7" S	75°54'34.6" W
4	Vomiting with nematodes	2/22/2022	Kilometer 14	00°46'07.0" S	75°54'21.3" W
5	Direct observation and sampling (vomit)	3/22/2022	Kilometer 3	00°50'47.7" S	75°55'26.0" W
6	Vomiting with tapeworms	5/18/2022	Kilometer 2	00°51'40.2" S	75°55'18.6" W

RESULTS

The detail of the six samples we obtained is as follows:

Sample 1 (vomit): We observed from a 20-m distance an adult male jaguar marking some places with its urine. The cat ingested itchgrass *Rottboellia cochinchinensis* (Poaceae; Figure 2a), an exotic species found on some roadsides (Figure 2b). Minutes later, the jaguar traveled a few meters before stopping to vomit (Figure 2c) and then continued walking along the track until it entered the forest at kilometer 12. The sample contained gastric juices, saliva, and the remains of the itchgrass that had been consumed minutes before (Figure 2d).

Sample 2 (hairball): Next to the footprints of a jaguar (Figure 3a), we found an 87 g hairball (Figure 3b) containing hair, hoof remains, and small bone fragments of a collared peccary (*Di-cotyles tajacu*; Figure 3c–d), as well as itchgrass remains and *Miconia* sp. (Melastomataceae; Figure 3e–f).

Sample 3 (hairball): At 300 m from sample 2, we found new jaguar footprints and another 16 g hairball. This sample contained remains of hair, hooves, and bone fragments of a white-lipped

peccary (*Tayassu pecari*), as well as itchgrass remains and what appeared to be the same species of *Miconia*.

Sample 4 (vomit): We observed jaguar tracks (Figure 2e) and fresh vomit (Figure 2f) containing gastric juices with itchgrass remains and a live nematode (*Ancylostoma* sp.; Figure 2g)

Sample 5 (vomit): We sighted a juvenile male jaguar consuming itchgrass. After ingesting the grass, the animal began to retch. Subsequently, it marked its territory with urine and retreated to the side of the road. About 20 m from this sighting, we found a vomit sample with the remains of white-lipped peccary hair, bones, and hooves, as well as itchgrass remains.

Sample 6 (vomit): We found jaguar tracks along with fresh vomit containing remains of gastric juices, itchgrass, and flatworm segments (*Taenia* sp.; Figure 2h).

DISCUSSION

Despite the substantial information available on the biology and ecology of Neotropical felids such as puma (*Puma concolor*) and jaguar, we know little about their parasite loads and infectious diseases in the wild (Patton et al.,

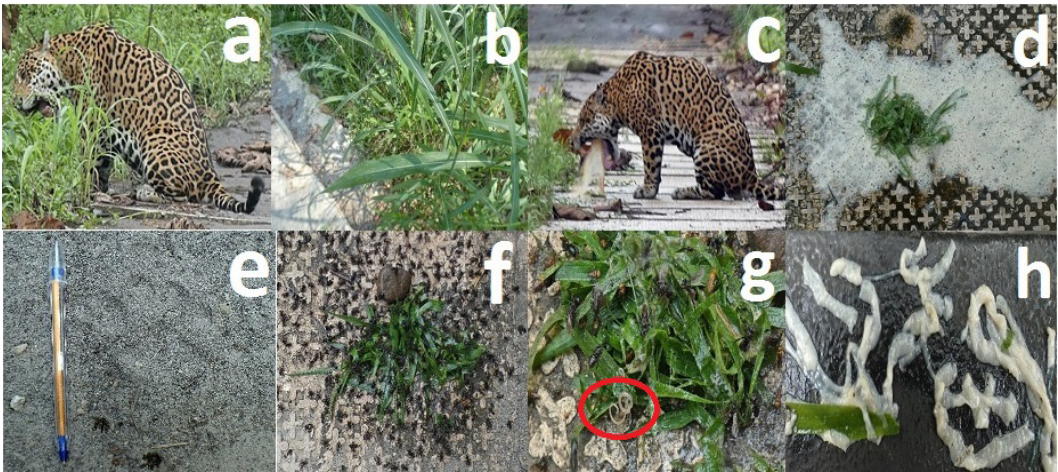


Figure 2. Observation of jaguar while feeding on *Rottboellia cochinchinensis* (a, b) and vomiting (c); fresh vomit (d); jaguar tracks (e); fresh vomit (f), *Ancylostoma* sp. (Nematoda) (g) and *Taenia* sp. (Platyhelminthes) (h). Photographs by G. Maldonado C.



Figure 3. Jaguar tracks (a); jaguar hairball (b); remains of hooves and bones of *Dicotyles tajacu* (c, d); remains of *Rottboellia cochinchinensis* and *Miconia* sp. (e, f) found in the hairball. Photographs by G. Maldonado C. and G. Barahona.

1986; Srbek-Araujo et al., 2014). Questions remain regarding the impact that diseases and parasites have on the fitness of felids, the main transmission mechanisms of parasites in wild cats, and, as we report in this manuscript, the mechanisms used by felids to decrease their load of endoparasites.

The consumption and emesis of itchgrass observed in at least two male jaguars in Yasuní National Park suggests that the hardened epidermal striae of the grass increases the motility of the feline gastrointestinal tract and aids in the expulsion of endoparasites by inducing vomit (Huffman & Caton, 2001; Lanning & Eleuteri-

us, 1989; Mehra & Sharma, 1965; Trembath-Reichert et al., 2015).

Previous studies have recorded that jaguars harbor a significant number of endoparasite species, such as nematodes (*Ancylostoma* sp.) and tapeworms (such as *Anoplocephala* sp.) found not only in horses but also in collared and white-lipped peccaries (García-Prieto et al., 2012; Patton et al., 1986; Seymour, 1989), both common prey of this big cat in the Neotropics (e.g., Cavalcanti et al., 2010; Miranda et al., 2018; Núñez et al., 2000).

Parasitism is one of the main interactions between free-living felids and their environment, which suggests that it may regulate the populations of the latter (Ceballos et al., 2000). Parasites cause various physiological alterations in their hosts that result in lethargy, weight loss, or metabolic imbalances (Ceballos et al., 2000). These alterations can affect the behavior of parasitized individuals, both interactions between conspecifics (e.g., reproductive, parental, dominance interactions) or with sympatric species, such as prey (Fofana & Hurford, 2022; Grecias et al., 2020; Meyer et al., 2022).

Felids are known to ingest their own hair while grooming, as well as the hair of the prey they eat (Cannon, 2013; Yoshimura et al., 2020). This generates hairballs in their stomachs which interfere with digestion and do not allow the digestive tract to fill completely (Cannon, 2013).

Although felids are strict carnivores (Sunquist & Sunquist, 2002), plant ingestion is a conserved behavioral trait among felid species that has been observed in both captive and free-ranging conditions (Biró et al., 2005; Sarasola et al., 2016). Ingested plants are thought to help excrete hairballs in various felid species, including the domestic cat and free-living cats, such as the Bengal cat (*Prionailurus bengalensis euptilurus*) and the Turkmenistan caracal (*Caracal caracal michaelis*; Cannon, 2013; Shultz, 2019; Yoshimura et al., 2020). The observations we present in this manuscript suggest that, as in other felid species, plant ingestion by jaguars is also related to the expulsion of hairballs, likely to avoid the discomfort they may cause (Cannon, 2013).

These series of observations show that ingestion of grasses seems to be a frequent behavior used by jaguar to maintain a tolerable

parasite load and keep the stomach cavity free of material that is difficult to digest, such as hair, hooves, and bones (Cannon, 2013; Shultz, 2019). Similar cases have been observed in other felids; for example, in tiger (*Panthera tigris*; Schaller, 1967) and puma (*Puma concolor*) droppings, grass has been found intertwined with tapeworms (Taeniidae; Solórzano-García et al., 2017; Toweill & Maser, 1985).

It is notable that to relieve their stomachs of material difficult to digest, the jaguars we observed always consumed itchgrass, an exotic species. These observations likely indicate that the hardened epidermal striae of these plants are highly effective structures in stimulating the gastrointestinal tract to expel material that is difficult to digest along with parasites (Lanning & Eleuterius, 1989; Mehra & Sharma, 1965; Trembath-Reichert et al., 2015). Since we also observed remains of *Miconia* sp. in some cases, we wonder which other native plant species jaguars may use for the purpose of relieving their stomachs of undigestible material and parasites.

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Conflict of interest: The authors declare that we have no conflict of interest with the publication of this article.

Authors' participation: GMC, writing of the manuscript, fieldwork that led to jaguar observations, photographs included in manuscript. SE, contributions to writing and revision of the manuscript, taxonomic identification of tracks, hairball analysis and map development. GB, field observations, hairball collection. JA, field observations, fresh vomit analysis.

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