SHORT COMMUNICATIONS

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Occurrence of *Prosthenorchis elegans* in Free-living Primates from the Atlantic Forest of Southern Bahia, Brazil

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ABSTRACT: Parasite prevalence and abundance are important factors affecting species' conservation. During necropsies on a free-living golden-headed lion tamarin (*Leontopithecus chrysomelas*) and two Wied's marmosets (*Callithrix kuhlii*) in the Atlantic Forest of southern Bahia, Brazil, we collected a large number of adult intestinal parasites that we identified as *Prosthenorchis elegans*. This parasite is pathogenic for neotropical primates. *Prosthenorchis* spp. infestation is influenced by diet with increased risk of exposure from ingesting invertebrate intermediate hosts. The biological similarities and sympatric nature of these two nonhuman primates support that they may harbor similar infectious and parasitic agents.

Key words: Acanthocephala, *Callithrix kuhlii*, *Leontopithecus chrysomelas*, neotropical primates, parasitology, thorny-headed worm.

The accelerated process of habitat fragmentation may increase exposure and susceptibility of wildlife to parasites. Characteristics of hosts, such as ranging patterns, population density, intraspecific and interspecific associations, and diet, may influence prevalence and parasite load (Bowman et al. 2006). Habitat fragmentation may alter these characteristics and parasite ecology in many wildlife species (Nunn et al. 2003). Parasites that may infect hosts across taxa are of high conservation concern, particularly when endangered species are infected (Püttker et al. 2008).

The endangered golden-headed lion tamarin (*Leontopithecus chrysomelas*) and the near-threatened Wied's marmoset (*Callithrix kuhlii*; International Union for Conservation of Nature, 2015) are endemic to the Brazilian Atlantic Forest. With only 8–13% of its original cover, the Brazilian Atlantic Forest is one of 34 hotspots of biodiversity (Ribeiro et al. 2009). Wied's marmosets are present in almost all forest fragments and agroforestry systems containing golden-headed lion tamarins, and both species associate frequently (Oliveira et al. 2011; Tisovec et al. 2014). The biologic similarities and sympatric nature of these nonhuman primates suggest they may harbor similar infectious and parasitic agents.

We report the presence of the adult acanthocephalan endoparasite *Prosthenorchis elegans* in free-living *C. kuhlii* and *L. chrysomelas* and discuss potential consequences of these infestations for the conservation of these species. Acanthocephalans share the same fundamental life cycle and developmental stages: a free-living egg (acanthor) requires an arthropod intermediate host for the larval acanthella and cystacanth stages, and the adult utilizes a vertebrate definite host (Machado-Filho 1950).

One dead golden-headed lion tamarin and two dead Wied's marmosets were brought to the Veterinary Hospital, Universidade Estadual de Santa Cruz, in Ilhéus, Bahia, Brazil. The adult male tamarin was collected in the Una Biological Reserve (15°09′S, 39°10′W), an area of lowland Atlantic rainforest characterized by a forest mosaic in different successional stages including patches of old growth. The animal belonged to a group of golden-headed lion tamarins continuously monitored since 2002 for behavioral and ecologic studies (De Vleeschouwer et al. 2011). As part of these studies, this individual was captured on 19 June 2008 to replace its radio collar. During capture, biometric measures were taken and clinical evaluations performed. The animal weighed 646 g and was deemed in good health. We last observed the animal alive on 1 July 2008. We noted it missing from the group on 16 July 2008 and found it dead the following day.

The two marmosets were found dead in a Tomahawk trap (48.3×15.2×15.2 cm) on private land in Camacan, Bahia (15°21′S, 39°33′W), on 11 July 2008. The matrix dominating this landscape consists of an agroforestry system (known locally as cabruca) of cacao shaded by native trees (Oliveira et al. 2011). The trap had been set for a separate study to capture lion tamarins, and unfortunately these two individuals were accidentally captured in one trap and died of lesions from conspecific fighting. These deaths were the first in 10 yr of study, and since 2008 we have changed our protocols and have had no further deaths. The animals were collected and submitted for necropsy.

The tamarin was necropsied within 24 h of collection; the marmosets were immediately frozen and thawed 7 d later for postmortem examination. All procedures were authorized by the Instituto Chico Mendes de Conservação da Biodiversidade and the Brazilian Institute for the Environment and Renewable Natural Resources permits 02001, 006792/05-64, and 113/2007 (L.S.C.), IN 169/2008, and approved by the Animal Welfare Committee of Universidade Estadual de Santa Cruz under permit 004/2008.

During the necropsies, the abdominal and thoracic cavities were incised and viscera removed. The digestive tract (stomach and small and large intestines) was examined carefully, separated and opened along its entire length, and frequently rinsed with distilled water to collect all contents. Contents were subsequently screened using a 0.212-mm mesh screen and the remnants sieved and transferred to Petri dishes. All helminths were recorded and fixed with 10% buffered formalin, subsequently cleared in lactophenol, and studied in temporary mounts by light microscope and a magnifying glass. The helminths were identified to species by examining physical structures according to Machado-Filho (1950), Stunkard (1965), and Urquhart et al. (1998). Fecal content removed directly from the intestine was conserved in 10% formalin as preservative and formal-ether sedimentation preparation technique as described by Monteiro et al. (2007).

We discovered worms embedded in the intestinal walls (Fig. 1A) of all three primates, often in nodular lesions. We collected 12 helminths from the golden-headed lion tamarin and six from each of the Wied's marmosets. Ulcers in the intestinal walls, 1–2 mm in diameter, were caused by the embedded worms and extensive tissue reaction around the worms was observed. Based on external morphologic characteristics, including globular proboscides (Fig. 1B) armed with 36 hooks (12 rows of three hooks), we identified three morphologies varying from robust hooks at the top to short hooks at the bottom. The parasites were identified as *P. elegans* based on the taxonomic characteristics of the shape and armature of the proboscis and the size and shape of the body (Machado-Filho 1950).

The temporary mounts treated with lactophenol allowed for visualization of internal morphology of the parasites. The male reproductive system occupied 75% of the total body and was composed of two testicles and the prostatic glands (Fig. 1C). We identified 10 female worms, varying from 1.8 to 3.3 cm, and 14 males of 1.8–2.7 cm long. The method of concentration for the formalin-ether revealed *Prosthenorchis* spp. eggs in the feces (Fig. 1D). We observed parts of other invertebrates, including Coleoptera, in the fecal samples.

There is little information available on the endoparasites of neotropical primates (Monteiro et al. 2007; Sales et al. 2010). However, it is known that most parasites are capable of infecting more than one host species (Freeman et al. 2004). Infestations in New World primates have been reported in zoologic parks

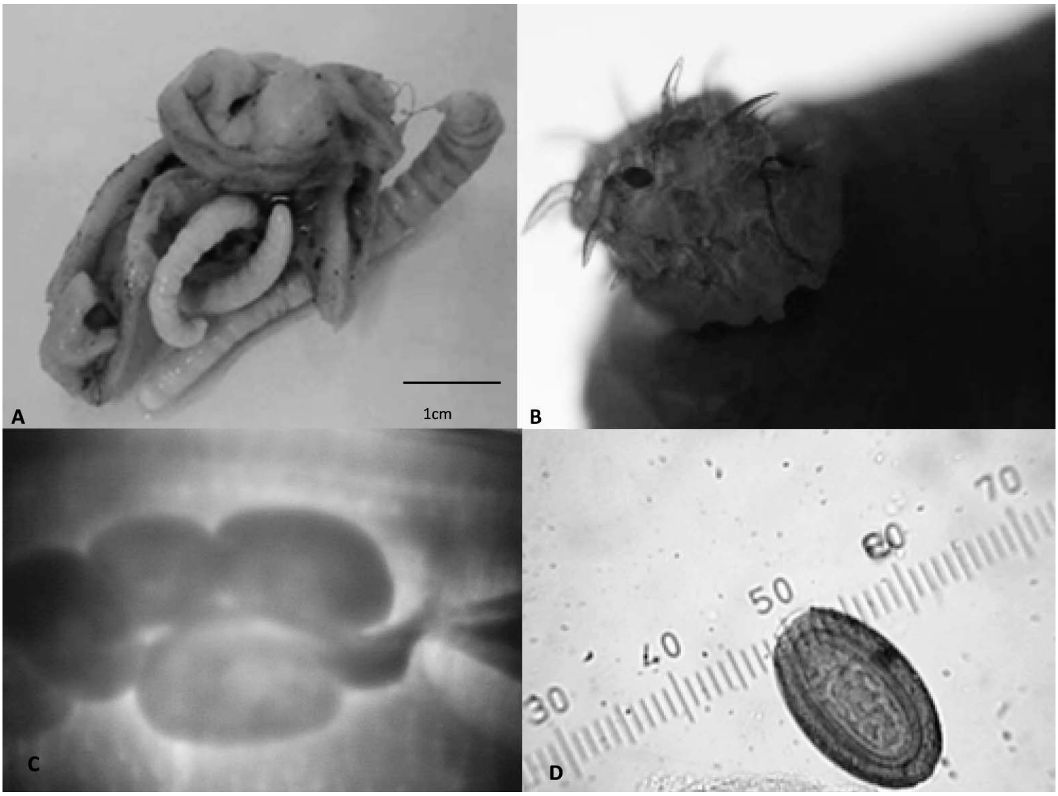

FIGURE 1. Morphologic characteristics of the acanthocephalan endoparasite *Prosthenorchis elegans* from the small intestines of a golden-headed lion tamarin (*Leontopithecus chrysomelas*) and two Wied's marmosets (*Callithrix kuhlii*), in Brazil, 2008. (A) Worms deeply embedded in the intestinal walls; (B) light microscope detail of the proboscis, armed with spines (100×); (C) light microscope detail of male reproductive system, showing cement glands, behind the testes, and the vesiculae seminales (100×); (D) *P. elegans* egg.

intermittently since 1953 (Weber and Junge 2000). Stunkard (1965) described heavy infestations with *Prosthenorchis* spp. in monkeys that died in the London Zoo and 72% of captive lion tamarins dead in Rio de Janeiro Primate Center (Pissinatti et al. 2007). The affected tamarins had diarrhea, loss of appetite, and progressive weakness before dying. In contrast, the animals necropsied in our study were in good overall body condition.

According to Grundman et al. (1976), the degree of injury associated with gastrointestinal parasite infestations is related to the number of worms present. Acanthocephalans are not common in the digestive tract. However, when present, they attach to the digestive tract of a vertebrate host with their proboscis, and the absorption of nutritive liquids occurs by osmosis, exchanging nutrients, gases, and wastes through the host's body wall. They have no mouth or digestive tract. Adult *Prosthenorchis* individuals live embedded and often in nodular lesions, within the lumen of the terminal portion of the ileum, cecum, and colon (Dunn 1963). We believe that the perforations and the nodular lesions observed in the intestinal wall do not represent a paratenic parasitism, because all of the helminths found were adults. We confirmed the mature stage of the parasites by identifying the reproductive tract and by finding parasitic eggs in the hosts' feces.

During its life cycle, the helminth deposits embryonic eggs in the intestine of the final vertebrate host, which are eliminated along with the feces and ingested by the invertebrate, intermediate host. The primates are then (re)infected by eating the intermediate host (e.g., Blattodea and Coleoptera), which contains the larval stages of the parasite (Stunkard 1965; Rey 2001). As both primate species have similar diets, have overlapping territories (Raboy et al. 2004), and share a degraded landscape (Tisovec et al. 2014), infestation by *Prosthenorchis* spp. in the two species may be facilitated.

According to Freeman et al. (2004), anthropogenic habitat destruction may result in important changes in microhabitats, changing both parasite presence and the ecology of Coleoptera. Habitat decline can result in increased contact between groups belonging to the same or different primate species and facilitate transmission of parasites indirectly through contaminated vegetation and soil. An increased population density of Coleoptera within the environment may help maintain the life cycle of the *P. elegans*. Additionally, it has been suggested that stressful conditions (e.g., habitat loss and resource scarcity) may lead to immunosuppression and allow parasite infestations to cause illness and decrease reproductive success, thus impacting the survival of free-living populations (Sales et al. 2010).

Studying parasites provides a valuable resource for investigating ecologic relationships between primates and their environment. Cross-species parasite transmission may be possible in nonhuman primates in the Atlantic forest because of shared habitats and food sources. The loss of habitats may further result in these sympatric species coming into closer proximity or contact. Parasites such as *P. elegans*, which can infect more than one species, may be responsible for clinical disease in endangered species. This study demonstrates the importance of performing necropsies on free-living animals that die so that we may learn about baseline health parameters and possible diseases within populations across the globe (Deem et al. 2005).

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