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Tunga penetrans occurrence in Panthera onca crashed in the MT northern region

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Abstract. Tungiasis is a neglected parasitic skin disease, caused by the female sand flea *Tunga penetrans* penetration, that is associated with poverty and occurs in many poor resourced communities in the Caribbean, South America and Africa. Although its effects on humans and domestic animals are well described in the literature, its epidemiology in indigenous populations remains enigmatic and little is known about the tungiasis impact on wild animals, such as jaguars, the only Panthera genus member on the American continent, an important species as an indicator of environmental integrity, which, in Brazil, is on the list of animals threatened with extinction by the Environment Ministry, categorized as vulnerable. The carnivore population decline in Amazon would be accelerated, especially in the eastern and southern border of the Amazonian domain, and it is known that anthropic factors favor the spread of generalist pathogens to new environments and species, representing a greater risk for wild populations. Ectoparasites identification in jaguars is important not only to understand the role of this feline in maintaining the vectors in the wild, but also to know possible agents that can be transmitted by them. The objective of the present work is to report the tungiasis occurrence in five jaguars run over in Sinop, Sorriso and Lucas do Rio Verde, northern MT, between 2018 and 2020; this being the first scientific report found of parasitism by T. penetrans in jaguars in the Amazon biome. The lesions were found on the animals paws, characterizing phases two to five of the Fortaleza classification, and the infestations were evaluated as high, in the youngest animals, to low, suggesting that parasitism degree would be related to the age of the host.
Keywords: tungiasis, jaguars, Amazon

Introduction

Panthera onca is a mammal of the order Carnivora, with wide distribution throughout the Americas (WIDMER, 2009), being the largest carnivore in South America, the third largest living feline in the world and the only representative of the genus Panthera in the American continent (ICMBIO, 2013).

It has a robust, compact and muscular body, weighs between 35 and 130 kg, and measures between 1.7 and 2.4 meters; it is considered opportunistic in relation to its eating habits, and its preferred prey are medium and large animals (FURTADO, 2010).

The jaguar is an important species as an indicator of environmental integrity, due to its position at the top of the food chain, and the removal

of these species can induce structural changes in the ecosystem and loss of diversity, since, for example, in the absence of predators, herbivore populations tend to expand, consequently increasing the consumption of seeds and species in forest regeneration, influencing the forest structure and dynamics (LEITE, 2000).

The area of historical occurrence of jaguars covers from the Southwest of the United States to the South of Argentina, and currently its geographical distribution has been reduced by 55% of the original extension. Approximately 50% of this distribution area is located in Brazilian territory, making Brazil an extremely important country for the long-term conservation of the species (FURTADO, 2010).

In Brazil, it's considered threatened with extinction throughout its territory (IUCN, 2010) and, it is on the list of animals threatened with extinction by the Ministry of the Environment, categorized as vulnerable (VU) (ICMBIO, 2013). Sollmann, Tôrres and Silveira (2008) suggest that more than 50% of the current populations are viable for up to 10 years only, except in the Amazon, which maintains the 193 populations most likely to survive. According to the ICMBio (2013), the population decline in the Amazon would be more accelerated, especially in the "arc of deforestation" region, located on the eastern and southern border of the Amazonian domain, which includes the east and south of Pará, west of Maranhão, northern Mato Grosso and Rondônia, a region of which Sinop and other neighboring cities are part.

It is known that anthropic factors - such as the fragmentation and conversion of natural habitats, the increase in human occupation around natural areas and the consequent increase in contact between domestic and wild animals - favor the spread of etiological agents to new environments and species, being the generalist pathogens, the ones that represent greater risk to the wild populations, thus influencing the occurrence or emergence of diseases (FURTADO, 2010).

In addition to being susceptible to a wide variety of parasites, including viruses, bacteria, protozoa and helminths, among other groups, carnivores are vulnerable to pathogens easily transmitted by domestic species. In this sense, the possibility of contact between jaguars and domestic dogs, culminating in the introduction of new parasites in this wild population, is a real risk and can have extremely serious effects for the conservation of the species (LELES; ARAÚJO, 2015).

Thus, the identification of ectoparasites in jaguars is important not only to understand the role of this feline in maintaining the vectors in the wild, but also to know possible agents that can be transmitted by them (FURTADO, 2010).

Tungiasis is a neglected parasitic skin disease caused by the penetration of the female sand flea Tunga penetrans - which, in Brazil, is popularly called a standing bug, bug flea or pig flea - and it is associated with poverty, according to Heukelbach (2005), and occurs in many resource-poor communities in the Caribbean, South America and Africa.

According to Ariza (2009), T. penetrans - Class: Insecta; Order: Siphonaptera; Family: Tungidae; Sub-family: Tunginae; Genre: Tunga; L., 1758) - is the smallest known species of the order Siphonaptera, measuring only one millimeter. Larvae and adults live freely in different types of soil, mainly dry and sandy. While the larvae feed on plant material and other debris, adult male and female fleas need to feed on blood to complete the life cycle.

Linard and Avelar (2014) present adult fleas as mandatory hematophagous ectoparasites that infest humans and animals, both wild and domestic. Ariza (2009) points out that, as T. pentrans is promiscuous in the choice of hosts, it is also found infesting pigs, cattle, goats, horses, rats and wild animals, being considered as a zoonosis.

It is only the female that penetrates the host's epidermis permanently to lay eggs, thus closing its life cycle. After the eggs are expelled, the lesion involution begins (HEUKELBACH, 2005). The entire process, from penetration to remission of the lesion, can last up to six weeks (MUEHLEN et al., 2003) and it is likely that flea eggs, larvae and pupae will survive in the environment for weeks or even months (HEUKELBACH; OLIVEIRA; FELDMEIER, 2003).

In Brazil, eight of the 13 species of Tunga occur (LINARD; AVELAR, 2014), which can be found from the extreme north (State of Roraima) to the extreme south (Rio Grande do Sul) (MUEHLEN et al., 2003), with prevalencerates, in the human species, between 16% and 55% (OLIVEIRA et al., 2014).

Viestel and Silva (2012) affirm that, although it presents a high prevalence in this country, the parasitosis is, many times, unknown to the veterinarians of the great centers for being a zoonosis, who aresuch an important professional for the success in its eradication and control (VIESTEL; SILVA, 2012); and Damazio e Silva (2009), in turn, highlight that, despite its wide distribution, tungiasis is not considered a significant public health issue.

Leles and Araújo (2015) suggest that, in the Amazon context, perhaps the most relevant ectoparasitism is caused by the T. penetrans flea, an age-old condition that is still considered a "plague" among indigenous communities in the Amazon. However, according to Heukelbach (2005), the epidemiology of tungiasis in indigenous populations remains enigmatic and the histopathological mechanisms of the host's inflammatory reaction after infestation are not understood.

Although its effects on humans and domestic animals are well described in the literature, little is known about the impact of tungiasis on wild animals (LINARD; AVELAR, 2014).

In 2012, Widmer and Azevedo carried out a study on tungiasis in jaguars, observed alive in the Pantanal, in good health, and found 100% of the animals observed parasitized by the flea. According to the authors, their trained dogs and three field workers of the project were also infested by T. penetrans during the capture seasons. To date, in Brazil, this is the second study found reporting parasitism by T. penetrans in jaguars, preceded only by Furtado (2010), who found eight parasitized individuals in the Pantanal, of the 31 evaluated.

Thus, the objective of the present study is to report the occurrence of tungiasis in jaguars run over in Sinop, Sorriso and Lucas do Rio Verde, cities in the northern MT, between 2018 and 2020.

Methods

Since 2016, the reception of jaguars that were run over along the BR 161and, as a consequence, died, has been monitored by the Veterinary Hospital of the Health Instiute on the Sinop campus of the Federal University of Mato Grosso (HoVet / ICS / CUS / UFMT). They have been collected by the company Rota do Oeste or by the Federal Highway Police, in the municipalities of northern Mato Grosso.

Upon being received at HoVet, soon a form recording the entry of each animal was filled in, with information provided by the team that accompanied it and with observations made in the physical examination performed.

The corpses were then sent to the Animal Parasitology Laboratory (LADEPAR), for evaluation as to the presence of ectoparasites that could still be attached to them.

Once lesions suggestive of tungiasis were identified, photos were taken, descriptions of the lesions and samples were collected for possible identification of the presence of the female of T. penetrans. The flasks containing the samples fixed in 70% alcohol (CORRÊA et al., 2012) were duly identified with the date of collection, the host animal and the location of the lesions. Subsequently, the samples were observed under a stereoscopic microscope.

The data related to the number of lesions, their appearance, and their location in the animal's body, as well as the identification of the presence of the female of T. penetrans in the lesion, were noted in the form accompanying each corpse.

To determine the degree of infestation, the criteria adopted by Widmer and Azevedo (2012) were used; to classify the lesion caused by the penetration of the female flea in the host, it was used the Fortaleza classification - adopted by Eisele et al. (2003) for animal hosts - and for morphological identification of the neosome, Linard and Avelar (2014) followed.

Results and discussion

Five cadavers, 3 males and two females, had lesions suggestive of tungiasis in the metacarpal, metatarsal and digital cushions, according to Chart 1. The location of the lesions in the animal's body follow the same pattern as found by Widmer and Azevedo (2012).

According to Linard and Avelar (2014), these are regions that come into regular contact with the ground, such as the feet in humans and the hands and feet of domestic and wild animals, or the ventral abdominal region in domestic and wild mammals; according to the authors, the impact of these fleas on the host will depend on the attachment site.

Table 1. Data collected on jaguars positive for tungiasis.

ID	Receipt date	City	Genre	Age	Lesions location	Injury stage[1]	Infestion level [2]
1	04/20/2018	Lucas do Rio Verde	Male	Adult	Both metacarpal cushions; both metatarsical ones.	4	Low
2	06/07/2020	Sorriso	Male	Young adult	Both metacarpal and metatarsal cushions; digital cushions from both hands and feet.	2 - 5	High
3	0706/2020	Sorriso	Female	Adult	Left metacarpal cushion. Both metatarsical cushions.	2 2 - 4	Low
4	07/12/2020	Sinop	Female	Cub	Both metacarpal and metatarsal cushions; digital cushions from both hands and feet.	2 – 5	High
5	08/12/2020	Sorriso	Male	Young adult	Both metacarpal and metatarsal cushions; digital cushions from both hands and feet.	2 - 5	High

[1] Based on Fortaleza classification, proposed by Eisele et al. (2003); [2] Based on the classification proposed by Widmer & Azevedo (2012).

Figure 1. High infestation by different stages of development of T. penetrans in a jaguar´s left hand.

Ariza (2009) points out that the majority of lesions occur on the legs and the animals may have severe infestation so that they have difficulty on walking and may die, presumably, due to possible bacterial superinfection and consequent septicemia. Oliveira et al. (2014) list among the infectious bacteria, Clostridium tetani, etiological agent of tetanus, and Damazio e Silva (2009),Clostridium perfingens, which causes gangrene and can lead to amputation of the appendix. However, in the present study, lesions suggestive of secondary infection were not found and the animals had good body condition.

Corrêa et al. (2012) state that the dogs examined had typical tungiasis behavior, such as restlessness, frequent licking of the limbs and limited mobility and Silva et al. (2001) point out that the condition can lead to the mutilation of affected limbs (in more severe cases) and when it affects the ceilings of cows, sows and the hooves of cattle, among others, it can lead to a drop in production due to stress. There were no mutilations in the felines examined at LADEPAR, even in those in which the infestation was considered high and which had parasites in different stages in the Fortaleza Classification.

Despite these assessments in domestic and human animals, Widmer and Azevedo (2012) observed that T. penetrans infestation, even accompanied by a secondary infection, does not seem to affect the movement and predation pattern of jaguars, even though point out that further studies are needed to elucidate the possible consequences of tungiasis injuries in jaguars, especially in relation to possible interferences in the ability to capture prey and / or patrol their territories.

Given the number of injuries per appendix, the infestation was considered low (1 to 20 injuries) in three animals and high (more than 20 injuries) (Figure 1) in two others. The degree of infestation found in these animals follows the same pattern as those found by Widmer and Azevedo (2012), who observed from low to high infestation rates and suggest that heavy infestations occurred in younger jaguars, with lighter legs, probably formed with less keratin. This consideration seems to find support in the present study, since the three cadavers that had high infestations were from the youngest animals.

When observed in the corpse, the lesions maintained morphological aspects compatible with phases 2, 3, 4 and 5 (Chart 1) (Photo 1), and the animals were in good physical condition - the same condition found by Widmer and Azevedo in 2012 in jaguars in Pantanal do MS – being the injuries resulting from being run over the only ones responsible for their deaths.

Heukelbach (2005), when describing the lesion in humans, recalled that the infestation by T. penetrans is a dynamic process, with lesions that continuously alter its morphological aspect and, Ariza et al. (2007) evaluate that, in contrast to scabies and pediculosis ectoparasitoses, tungiasis is self-limiting for four to six weeks, but that in endemic areas, however, constant reinfestation is the rule, and affected individuals may present some dozens of parasites at different stages of development, which is aggravated by the precarious living conditions, generating sequelae and potentially avoidable outcomes.

Although in wild life the occurrence and impact of this disease remain uncertain (WIDMER; AZEVEDO, 2012), it can be said that reinfestation occurred in the individuals evaluated with high

infestation and in one of them with low infestation, since they had lesions compatible with the phases from the neosome hypertrophy (Phase 2) to the formation of scar fibrosis by tissue repair mechanisms (Phase 5).

Regarding the identification of the species from the observation of the neosomes in the stereoscopic microscope, it was identified that the etiological agent of observed tungiasis, in the five evaluated animals, was T. penetrans, a species that, according to Furtado (2010), is endemic in Brazil and domestic and wild animals can act as your reservoir; however, the role of jaguars in maintaining this ectoparasite in nature is not known.

No free-living fleas were caught on the jaguar's body. Linard and Avelar (2014) state that fleas leave hosts trapped for a long time, and abandon the carcass completely after the hosts' death, that is, the authors suggest, the data would be more accurate if obtained as soon as possible after the capture or death of the hosts. However, the same authors point out that this situation does not apply to sand fleas in which pregnant females remain attached to their hosts even after death.

The studied jaguars were run over in Sinop, Sorriso and Lucas do Rio Verde, which seems to be the first scientific report of this occurrence in these locations. It is worth noting, however, that, unfortunately, unofficial reports of running over wild animals are common in the region that ICMBio (2013) called the “arc of deforestation”, and which covers such municipalities.

The jaguar has high ecological requirements: large areas with good habitat quality and abundance of prey, being sensitive to environmental disturbances of anthropic origin; thus, the presence of the jaguar in a given area indicates its good conservation status (FURTADO, 2010). However, the loss and extensive fragmentation of habitats, plus hunting have caused great damage to jaguar populations in all Brazilian biomes (ICMBIO, 2013), which vary in risk classification, according to the biome evaluated. While for IUCN (2010), the jaguar is considered threatened with extinction throughout its territory, for ICMBio (2013), in the Amazon, the classification of the jaguar is almost threatened since: it is the most important area for conservation long-term jaguar; this biome has the most extensive area of suitable and non-fragmented habitat for this feline; it covers approximately 70% of the current area of occurrence of the species and still connects the populations of other important ecosystems; approximately 65% of the Amazon is in Brazilian territory; and that Brazil, in this way, is home to the largest jaguar population in the world (ICMBIO, 2013).

However, this condition can deteriorate early if no policies are in place to encourage the preservation of this biome, especially when one thinks that, as stated by Furtado (2010), population declines in wild cats due to diseases have already been reported, but little is known about the potential role of pathogens in jaguar populations.

Due to the presence of a variety of domestic and wild animals, possibly serving as reservoirs, tungiasis control is difficult to achieve, especially since many people in endemic areas consider tungiasis to be a nuisance rather than a disease and therefore tend to neglect this ectoparasitosis (HEUKELBACH, 2005).

In this context, programs that prioritize the control of ectoparasites do not exist in terms of public health in the country. As a result of high contagiousness, inadequate handling, neglect by both the population and health professionals and / or the presence of animal reservoirs, in addition to complex life cycles, effective control of ectoparasitoses is a challenge for public health (HEUKELBACH, OLIVEIRA, FELDMEIER,2003).

Finally, this appears to be the third scientific report of T. penetrans parasitizing jaguars in Brazil, and the first in the Amazon biome. Both previous reports were made by Furtado (2010) and Widmer and Azevedo (2012), who observed free jaguars in the Pantanal biome.

It is suggested, therefore, that further studies on tungiasis be encouraged and supported, given: the fact that it is a zoonosis widely distributed in Brazil (LINARD; AVELAR, 2014) and still constitute a public health problem in poor communities Latin America, the Caribbean and Africa (ARIZA, 2009); that even affects indigenous peoples of different ethnicities and geographic distribution (HEUKELBACH, 2005; ARIZA, 2009; GURGEL, 2009; RODRIGUES et al., 2010; LELES; ARAÚJO, 2015; BRASIL, 2019); and that, with the limitation of the natural habitat of wild animals, their growing proximity to humans and domestic animals peridomicillides, wild animals may have a prominent epidemiological role, as disseminators of this ectoparasitosis. This last factor is of even greater concern with regard specifically to the jaguar, as it has high ecological requirements.

Conclusion

T. penetrans parasites the jaguar in the Amazon biome, occurring in Lucas do Rio Verde, Sorriso and Sinop, in northern MT. New studies on this parasitosis should be conducted in this biome, evaluating its occurrence in the host species, the pathogenesis of female flea penetration in jaguars, the impact on the parasitized individual and its survival, as well as the epidemiological importance of this felid in maintaining the etiological agent in nature and its potential for dissemination.

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