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Eyeworms of wild birds and new record of *Thelazia* (*Thelaziella*) *aquilina* (Nematoda: Spirurida)

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ABSTRACT

The eyeworms of the subgenus *Thelaziella* infect orbital cavities, conjunctival sacs and lachrymal ducts of many wild birds, being able to cause conjunctivitis. In Brazil, at least 10 species of *Thelaziella* have been described. Here we present a brief review of cases of *Thelazia* (*Thelaziella*) *aquilina* and describe the infection of this parasite in *Harpia harpyja*, as a new host record. Two nematodes were collected from the surface of the cornea of an adult female *H. harpyja* in the Amazon region (Brazil) and were morphologically identified as two males of *T.* (*T.*) *aquilina*. This data demonstrated the need for further studies focused on elucidating the transmission, biological cycle, and phylogenetic positioning of *Thelaziella* as subgenus.

1. Introduction

Eyeworms of the genus *Thelazia* (Family Thelaziidae) are transmitted by non-biting flies that feed on ocular secretions of different animal species, including humans (Otranto and Traversa, 2005; Vale et al., 2019). First-stage larvae (L1) ingested with lachrymal secretions undergo through two development stages becoming infective third-stage larvae (L3), eventually being transmitted by the insects while feeding on ocular secretions of a receptive host. Eyeworm infestations can result in different degrees of ocular symptoms (e.g., irritation, redness, tearing, visual disturbances and even corneal ulceration and blindness) according to the parasitic burden as well as to host susceptibility and the occurrence of concomitant bacterial infection (Otranto and Traversa, 2005; Otranto et al., 2021).

The genus *Thelazia* includes subgenera *Thelazia* and *Thelaziella*, which are differentiated based on the presence of the gubernaculum in *Thelaziella* spp. (Chabaud, 1975). Additionally, while nematode species in the subgenus *Thelaziella* (Travassos, 1918) parasitize the orbital cavities, conjunctival sacs, and lachrymal ducts of wild birds (Chabaud 1975; Barus et al., 1978), those in the *Thelazia* infect the eyes and annexed tissues of many domestic and wild mammalian species, including humans (Otranto and Traversa, 2005; Bezerra-Santos et al., 2022a). *Thelazia* spp. primarily develop in the celomatic cavity of muscid flies (Diptera: Muscidae), or of drosophilids of the subfamily Steganinae, in the case of *Thelazia callipaeda* (Otranto et al., 2006; Bezerra-Santos et al., 2022b). Conversely, no information is available about the life cycle of *Thelaziella*. Species of this eyeworm subgenus infect birds throughout many countries, including Japan (Murata and Asakawa 1999), India (Majumdar and Sarkar, 1989), Russia (Daiya, 1968), and mainly Brazil (Pinto et al., 1996; Rodrigues and Rodrigues, 1970). These parasites have been reported in a range of wild bird species (Table 1), within the families Accipitridae, Ciconiidae, Pandionidae, and Falconiiformes (Anderson and Diaz-Ungria, 1959).

Among the wild birds, the Harpy Eagle (*Harpia harpyja*) is one of the world's largest raptors, with a decreasing population in the South America (Brown and Amadon, 1968). The existence of this bird species is threatened by the anthropogenic activities and illegal hunting (Giraldo-Amaya et al., 2021; Birdlife International, 2021). In this study, we

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Table 1
Species of *Thelazia* (*Thelaziella*) spp. reported in wild birds from Brazil.

Species	Wild bird species	Reference
Thelazia* (*Thelaziella*) *anobialata	Hyacinth Macaw (*Anodorhynchus hyacinthinus*), Rusty-margined Guan (*Penelope superciliaris*), Black-necked Araçari (*Pteroglossus aracari*), Red-billed Toucan (*Ramphastos tucanus*), Bare-faced Curassow (*Crax fasciolata*), Chaco Chachalaca (*Ortalis canicollis*)	Skrjabin et al. (1967); Rodrigues and Rodrigues (1970)
Thelazia* (*Thelaziella*) *anadorhynchi	Hyacinth Macaw (*A. hyacinthinus*)	Strachan (1957)
Thelazia* (*Thelaziella*) *aquilina	Bicolored Hawk (*Accipiter bicolor*), Great Black Hawk (*Buteogallus urubitinga*), Yellow-headed Caracara (*Milvago chimachima*), Southern Caracara (*Caracara plancus*), Ornate Hawk-eagle (*Spizaetus ornatus*)	Strachan (1957); Pinto et al. (1994); Rodrigues and Rodrigues (1970, Rodrigues, 1992)
Thelazia* (*Thelaziella*) *buteonis	Blue-throated Piping-guan (*Pipile cumanensis*)	Strachan (1957)
Thelazia* (*Thelaziella*) *campanulata	Roadside Hawk (*Rupornis magnirostris*), Brazilian Tinamou (*Crypturellus strigulosus*)	Molin (1858); Travassos (1918)
Thelazia* (*Thelaziella*) *cholodkowskii	Tropical Screech-owl (*Megascops choliba*)	Strachan (1957)
Thelazia* (*Thelaziella*) *chungkingensis	Alagoas Curassow (*Mitu*)	Strachan (1957)
Thelazia* (*Thelaziella*) *dacelonis	Black-tailed Trogon (*Trogon melanurus*)	Strachan (1957)
Thelazia* (*Thelaziella*) *papillosa	Crane Hawk (*Geranospiza caerulescens*)	Molin (1860)
Thelazia* (*Thelaziella*) *pittae	Black-and-white Hawk-eagle (*Spizastur melanoleucus*)	Strachan (1957)
Thelazia* (*Thelaziella*) *sicki	Owel (*Otus* sp.)	Strachan (1957); Rodrigues (1996)
Thelazia* (*Thelaziella*) *tonkinensis	Amazonian Umbrellabird (*Cephalopterus ornatus*)	Strachan (1957)
***Thelazia* (*Thelaziella*) sp.**	Red-billed Curassow (*Crax blumenbachii*), Toco Toucan (*Ramphastos toco*), Roadside Hawk (*R. magnirostris*), Yellow-headed Caracara (*M. chimachima*), Chaco Chachalaca (*O. canicollis*), Grey-headed Kite (*Leptodon cayanensis*), Grey-lined Hawk (*Buteo nitidus*), and Turquoise-fronted Amazon (*Amazona aestiva*)	Travassos et al. (1939); Travassos (1941, 1942); Pinto et al. (1993)

identify *Thelazia* (*Thelaziella*) *aquilina* in a *H. harpyja*, establishing a new host record. Additionally, we review and discuss the occurrence of these eyeworms in wild birds in Brazil.

2. Materials and methods

An adult female Harpy Eagle was rescued after being shot in the municipality of Rio Branco, Acre State, Brazil, in the Amazon region (Latitude 9° 58′26.49″S Longitude 67°48′35.35″O). During the clinical examination, two nematodes were collected from the corneal surface (Fig. 1; Supplementary Material 1). The nematodes were cleared in lactophenol solution and observed for morphometric examination in optical microscopy (Zeiss Axioscope) with Zen Pro version 3.1 software (Carl Zeiss Microscopy GmH, Germany).

3. Results and discussion

The nematodes were male, whitish with a cylindrical body attenuated at both ends (Fig. 2a and b). The cuticle exhibited transverse striations evenly distributed, forming annulations (Fig. 2c and d). The specimens featured a slightly ventrally curved posterior end with copulatory organs, and spicules that were notably unequal and structurally dissimilar (Fig. 3a and b). The right spicule was thicker and shorter than the left, with the presence of a gubernaculum, which is a peculiar characteristic of the subgenus *Thelaziella* (Fig. 3c). At the caudal end, numerous papillae were located on the ventral side (Fig. 3d), with the posterior end curved ventrally and terminating in a conic tail. Detailed measurements of adults are provided in Table 2 and compared with both male and female specimens of this subgenus.

The description of *T.* (*T.*) *aquilina* in the eye of a *H. harpyja* from Brazil represents a new host record for this parasite. Wild birds do not commonly develop ocular lesions, though conjunctivitis was reported in *Ciconia boyciana* (Murata and Asakawa, 1999). Herein, the reported Harpy Eagle did not present any ocular lesion. The taxonomic classification of *Thelaziella* remains unclear. While the Interim Register of Marine and Nonmarine Genera (IRMNG) does not acknowledge it as a subgenus (Register of Marine and Nonmarine Genera- IRMNG, 2021), others have included it in their classification as a subgenus (Hodda, 2022). This situation is worsened by the absence of molecular and

Fig. 1. *Thelazia* (*Thelaziella*) *aquilina* on the cornea of an adult female *Harpia harpyja* in Amazonia region (Brazil).

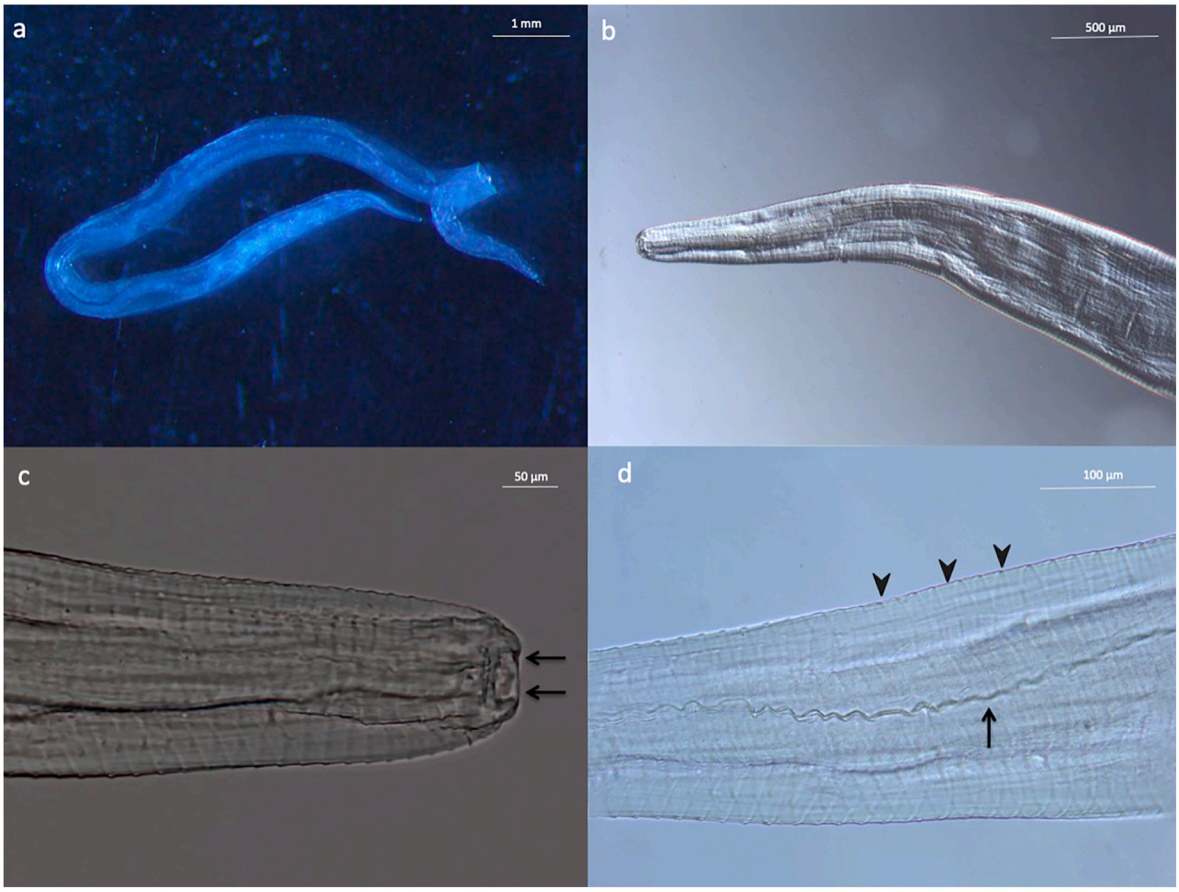

Fig. 2. **a)** Morphology of *Thelazia* (*Thelaziella*) *aquilina* male after extraction from the conjunctival sac; **b)** Anterior part of male; **c)** Cephalic extremity, male, lateral view, buccal cavity hexagonal (arrows); **d)** anterior part in lateral view, portion oesophagus lumen (arrows) and striations (arrowhead) around anterior end.

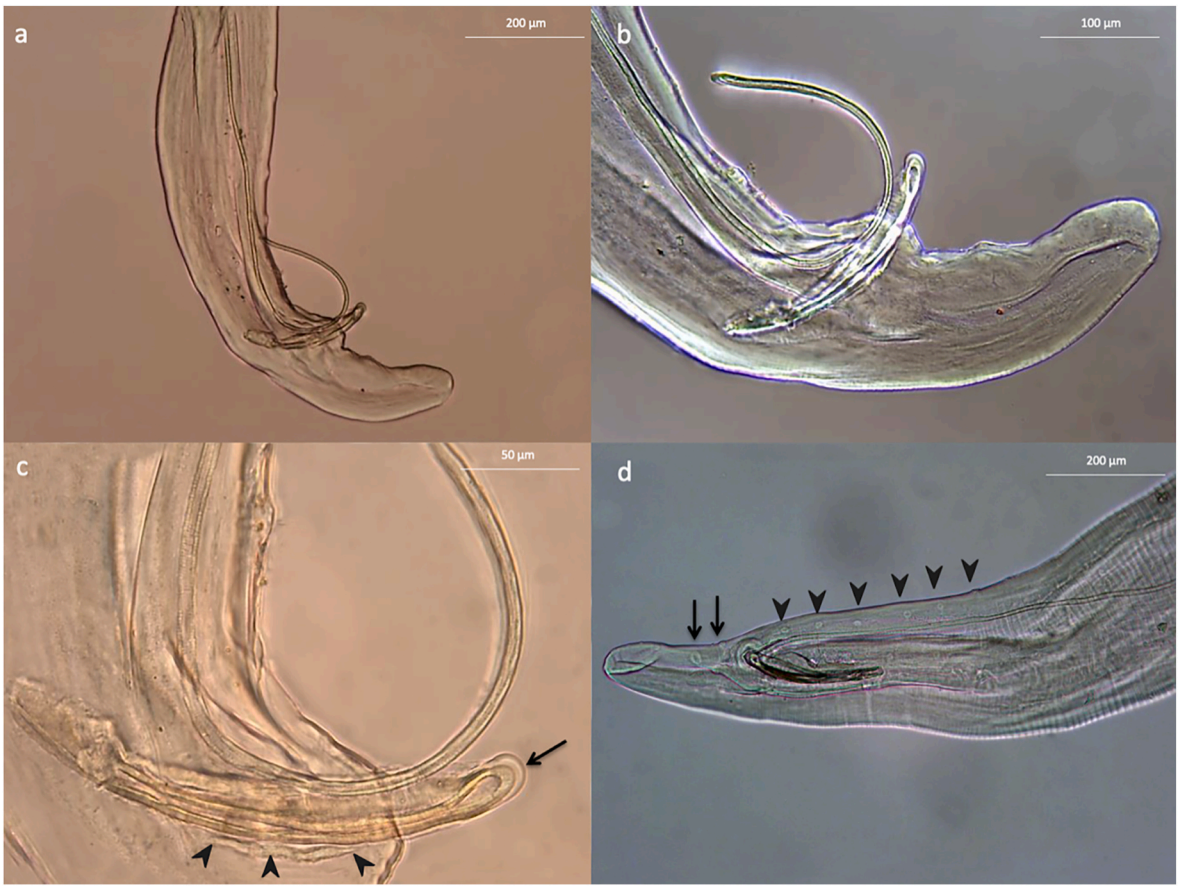

Fig. 3. Morphology of *Thelazia* (*Thelaziella*) *aquilina* male: **a)** Posterior end, male, lateral view, spicules; **b)** Posterior end, right spicule and distal portion of the left spicule; **c)** Right spicule and gubernaculum (arrowhead); Distal portion of the right spicule, bulbar expansion with transparent hyaline membrane (arrows); **d)** Posterior end, male, ventral view, spicules and papillae pre (arrowhead) and post-cloacal (arrows).

Table 2
Morphological descriptions of male and female specimens of *Thelazia* (*Thelaziella*) *aquilina* specimens in wild birds.

Thelazia (*Thelaziella*) *aquilina*										
Host	*Harpia harpyja*		*Spizaetus ornatus*		*Aquila audax*, *Haliaeetus leucogaster*, and *Hieracidea berigora*		*Ciconia boyciana*		Ciconiiformes	
Locality	Brazil		Brazil		Australia		Japan		NA	
Reference	Present study[a]		Strachan (1957)		Baylis (1934)		Murata and Asakawa (1999)		Barus et al. (1978)	
Gender	Male 1	Male 2	Male	Female	Male	Female	Male	Female	Male	Female
Body length (mm)	13.04	18.63	14–14.5	19.5	12.0–18.0	18.0–19.0	18.1–20.1	20.1–24.8	13.5–18	19.0–20.0
Body width (µm)	406.4	250.5	333–570	500	390–430	300–370	391–429	489–652	440–470	430–470
Buccal capsule depth (µm)	18.2	18.0	–	–	16–20	20–24	29–31	29–44	39–39	39
Buccal capsule width (µm)	34.3	35.2	39–43	47	25–30	34–36	39–47	42–54	20–40	29–40
Nerve-ring from anterior extremity (µm)	412.3	401.4	310–390	300	310–410	–	382–484	406–490	340	340–360
Oesophagus length (mm)	0.90	1.160	0.90–1.20	1.20	0.72–1.20	0.94–1.2	0.84–1.00	0.87–1.11	0.93–0.95	0.88–1.11
Oesophagus width (µm)	65.8	83.3	–	–	–	–	–	–	–	–
Left spicule length (mm)	2.257	2.447	2.40–2.50	–	1.7–2.3	–	1.90–2.90	–	2.18–2.28	–
Left spicule width (µm)	6.7	7.1	–	–	–	–	–	–	–	–
Right spicule length (µm)	210.2	214.4	142–150	–	170–240	–	160–230	–	210	–
Gubernaculum length (µm)	75.7	77.1	–	–	36–68	–	75–114	–	Present	–
Pairs of pre-cloacal papillae	8	8	8		6–10	–	8–9	–	9	–
Pairs of post-cloacal papillae	4	–	4		4–5	–	3–4	–	5	–
Tail length (µm)	231.7	220.3	280–300	260	130–220	150–170	201.0	312–429	199–203	–

[a] Female specimens not collected in the present study.

phylogenetic data on these nematodes (Liu et al., 2013), which is, in this case, caused by the preservation in formalin. This emphasizes the necessity of proper preservation in ethanol for nematodes. In addition, the biological cycle and transmission of *Thelaziella* is completely unknown, differently from data available for *Thelazia* spp. (Otranto et al., 2003).

The findings reported here demonstrate the presence of *T.* (*T.*) *aquilina* in Brazilian wild birds, even three decades since the last report (Pinto et al., 1994), with *H. harpyja* identified as a new host for this eyeworm. Additional comprehensive studies are clearly warranted to elucidate the transmission, biological cycle, and phylogenetic

relationship of *Thelaziella* species, as well as to clarify its subgenus classification.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijppaw.2024.100910.

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