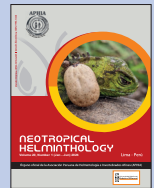




Neotropical Helminthology



ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

PARASITIC INFECTION IN CAPTIVE ANURANS FROM FREE-LIVING ENVIRONMENTS: DIAGNOSIS AND TREATMENT

INFECCIÓN PARASITARIA EN ANUROS EN CAUTIVERIO PROCEDENTE DE AMBIENTES DE VIDA LIBRE: DIAGNÓSTICO Y TRATAMIENTO

INFEÇÃO PARASITÁRIA EM ANUROS EM CATIVEIRO PROVENIENTES DE AMBIENTES DE VIDA LIVRE: DIAGNÓSTICO E TRATAMENTO

Nicole Souza Willers¹, Aline Sombra Santos², Cristiana Ferreira-Silva^{3,*}, Tatiana Feitosa Quirino³, Robson Waldemar Ávila³ & Roberta da Rocha Braga³

¹ Universidade Estadual do Ceará (UECE), Av. Dr. Silas Munguba, 1700, CEP: 60.714-903. Fortaleza, Ceará, Brazil.

² Laboratório de Parasitologia, Programa de Pós Graduação em Patologia, Universidade Federal do Ceará, Faculdade de Medicina, Rua Alexandre Baraúna, 949, Rodolfo Teófilo, CEP: 60430-160. Fortaleza, Ceará, Brazil.

³ Núcleo Regional de Ofiologia, Universidade Federal do Ceará, Centro de Ciências, Campus do Pici, Av. Humberto Monte, s/n, CEP: 60455-760. Fortaleza, Ceará, Brazil.

* Corresponding author: E-mail: cristiannafsilva@gmail.com

Nicole Souza Willers: <https://orcid.org/0009-0008-2188-0496>

Aline Sombra Santos: <https://orcid.org/0000-0002-8811-1877>

Cristiana Ferreira-Silva: <https://orcid.org/0000-0002-3087-2614>

Tatiana Feitosa Quirino: <https://orcid.org/0000-0001-8184-8705>

Robson Waldemar Ávila: <https://orcid.org/0000-0003-3641-8321>

Roberta da Rocha Braga: <https://orcid.org/0000-0002-3646-7951>

ABSTRACT

Free-living amphibians naturally harbor a wide variety of endoparasites, many of which do not cause deleterious effects in healthy individuals. The present study aimed to report the parasites found in coproparasitological examinations of *Odontophrynus carvalhoi* Savage & Cei, 1965 and *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo & Bruschi, 2020, originating from the wild and kept under human care at the Núcleo Regional de Ofiologia (NUROF-UFC), Ceará state, Brazil, as well as the control measures implemented through an antiparasitic program. Direct examination and flotation methods were employed. Protozoa were detected, such as coccidian oocysts and *Nyctotheroides* sp. at various stages, cestode eggs, nematode eggs, and adult nematodes identified as *Aplectana hylambatis* Baylis, 1927. The animals were treated with Fenbendazole (50 mg/kg), and monitoring was performed through fecal examinations following deworming. A reduction in the number of parasite species was observed, thus indicating that the protocol was effective.

Keywords: Anura – Biological Monitoring – Infection Control – Parasitic diseases – Specimen Handling – Wilderness Medicine

Este artículo es publicado por la revista Neotropical Helminthology de la Facultad de Ciencias Naturales y Matemática, Universidad Nacional Federico Villarreal, Lima, Perú auspiciado por la Asociación Peruana de Helminthología e Invertebrados Afines (APHIA). Este es un artículo de acceso abierto, distribuido bajo los términos de la licencia Creative Commons Atribución 4.0 Internacional (CC BY 4.0) [<https://creativecommons.org/licenses/by/4.0/deed.es>] que permite el uso, distribución y reproducción en cualquier medio, siempre que la obra original sea debidamente citada de su fuente original.



DOI: <https://doi.org/10.62429/rnh20262012096>

RESUMEN

Los anfibios de vida libre albergan naturalmente una amplia variedad de endoparásitos, muchos de los cuales no causan efectos deletéreos en individuos sanos. El presente estudio tuvo como objetivo reportar los parásitos encontrados en exámenes coproparasitológicos de *Odontophrynus carvalhoi* Savage & Cei, 1965 y *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo & Bruschi, 2020 provenientes de la naturaleza y mantenidos bajo cuidado humano en el Núcleo Regional de Ofiología (NUROF-UFC), estado de Ceará, Brasil, así como las medidas de control implementadas mediante un programa antiparasitario. Se emplearon los métodos de examen directo y de flotación. Se detectaron protozoarios, como oocistos de coccidios y *Nyctotheroides* sp. en diferentes estadios, huevos de cestodos, huevos de nematodos y nematodos adultos identificados como *Aplectana hylambatis* Baylis, 1927. Los animales fueron tratados con Fenbendazol (50 mg/kg) y y el monitoreo se realizó mediante exámenes coproparasitológicos posteriores a la desparasitación. Se observó una reducción en el número de especies de parásitos, lo que indica que el protocolo fue efectivo.

Palabras clave: Anura – Control de infecciones – Enfermedades parasitarias – Manejo de muestras – Medicina de la Vida Silvestre – Monitoreo biológico

RESUMO

Anfibios de vida livre naturalmente abrigam uma ampla variedade de endoparasitos, muitos dos quais não causam efeitos deletérios em indivíduos saudáveis. O presente estudo teve como objetivo relatar os parasitos encontrados em exames coproparasitológicos de *Odontophrynus carvalhoi* Savage & Cei, 1965 e *Pithecopus gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo & Bruschi, 2020, oriundos da natureza e mantidos sob cuidados humanos no Núcleo Regional de Ofiologia (NUROF-UFC), estado do Ceará, Brasil, bem como as medidas de controle implementadas por meio de um programa antiparasitário. Foram empregados os métodos de exame direto e de flutuação. Foram detectados protozoários, como oocistos de coccídios e *Nyctotheroides* sp. em diferentes estágios, ovos de cestóides, ovos de nematóides e nematóides adultos identificados como *Aplectana hylambatis* Baylis, 1927. Os animais foram tratados com fenbendazol (50 mg/kg), e o monitoramento foi realizado por meio de exames fecais após a vermifugação. Observou-se redução no número de espécies parasitárias, o que indica que o protocolo foi eficaz.

Palavras-chave: Anura – Controle de infecção – Doenças parasitárias – Manejo de espécimes – Medicina da vida silvestre – Monitoramento biológico

INTRODUCTION

In wildlife, parasitic infections are common in anurans and are intrinsically related to environmental conditions and biological aspects of the host, such as behavior, diet, and body size (Campião & Dáttilo, 2020). Parasites can interfere with processes such as migration, predation, dispersal, and speciation, playing a significant ecological role in regulating nature (Vitt & Caldwell, 2009; Matias *et al.*, 2018; Oliveira *et al.*, 2022).

It is observed that many endoparasite species may not cause deleterious effects, whereas others are associated with the occurrence of gastrointestinal diseases and mortality in amphibians (Ellerd *et al.*, 2022). In captivity, stressors can cause immunosuppression, which tends to increase

susceptibility to the development of parasitic diseases (Densmore & Green, 2007). Clinical signs are only noticeable in high-intensity infections, which can cause mechanical obstructions, hemorrhagic ulcers, enteritis, and pneumonia, and may lead to death, depending on the parasite species and the host's overall health (Garner & Jacobson, 2021; Ellerd *et al.*, 2022).

Pithecopus gonzagai Andrade, Haga, Ferreira, Recco-Pimentel, Toledo & Bruschi, 2020 and *Odontophrynus carvalhoi* Savage & Cei, 1965 are species of anuran amphibians distributed in northeastern Brazil and are currently not threatened with extinction, according to the Ceará Threatened Fauna List (SEMA, 2025) and the IUCN Red List (IUCN, 2023).

Pithecopus gonzagai is a small-sized species from the family Phyllomedusidae, belonging to the *Pithecopus hypochondrialis* group, distributed north of the São Francisco River (Andrade *et al.*, 2020). It has an arboreal habit, is predominantly nocturnal, and is mainly associated with lentic environments (Oliveira *et al.*, 2018). In turn, *O. carvalhoi* is a medium-sized frog from the family Odontophrynidae, part of the *Odontophrynus cultripes* group, occurring in areas of the Atlantic Forest, Cerrado, and Caatinga. Individuals of this species have terrestrial habits, often burrow to avoid drying out, and occupy both lotic and lentic environments (Costa *et al.*, 2017).

In this context, the present work aimed to record the occurrence of endoparasites in free-living anurans from the state of Ceará under handling at the facilities of the Núcleo Regional de Ofiologia, Universidade Federal do Ceará (NUROF-UFC), as well as to evaluate parasitic control through the application of an antiparasitic protocol combined with environmental management.

MATERIAL AND METHODS

Seven frogs were collected by manual capture during active searches during scientific expeditions from June to July 2024 and sent to the Núcleo Regional de Ofiologia - NUROF (UFC) in Ceará state, Brazil, for the purpose of studying behavior and adaptation to the *ex situ* environment and for inclusion in environmental education projects.

Four individuals of the species *P. gonzagai* from Uruburetama (-3.648399, -39.472543, WGS 84), which is located in the Morphoclimatic Domain of the Brazilian Caatingas, characterized by the predominance of the semi-arid climate typical of the Caatinga (Ab'saber, 1974; IPECE, 2009), and three *O. carvalhoi* from Mulungu (-4.265315, -38.932152, WGS 84), situated in the Baturité massif, classified as an "highland marshes" a fragment of the Atlantic Forest, a humid tropical forest (Santos-Cavalcante *et al.*, 2024), both areas from the state of Ceará, Northeast of Brazil.

The individuals were kept in glass terrariums specific to each species, with average dimensions of 0.75 x 0.4 x 0.4 m. These environments were enriched with substrates such as moss, soil, leaves, and ornamental plants like anthurium, chlorophytum, and fern, as well as vegetal hideouts. To monitor the environmental conditions, digital thermohygrometers were used, along with spray bottles and humidifiers with dechlorinated water to maintain proper humidity.

To collect fresh feces for direct parasitological examination from *P. gonzagai* a thin layer of water was poured in the bottom of containers to place the individuals (Ministério da saúde, 2012). For *O. carvalhoi*, two methods were used: direct collection of fresh feces from the terrarium and cloacal lavage (Divers & Stahl, 2019), with a 04 urethral catheter and about 0.5 mL of saline solution. The collected material was centrifuged for five minutes at 1200 rpm, and the precipitate was used to prepare slides, sometimes with a drop of Lugol's iodine for better contrast during microscope use. The nematodes were processed using methods outlined in Ferreira-Silva *et al.* (2022). The slides were examined under a light microscope.

The antiparasitic treatment protocol used was Fenbendazole 50 mg/kg, administered orally every 24 hours for 5 days (Walker & Whitaker, 2000; Divers & Stahl, 2019). The drug was diluted and reconstituted on-site, and administered orally using syringes. Follow-up serial parasitological examinations were performed after treatment to assess efficacy at 15, 30, and 60 days. After the last day of treatment, the animals were transferred from their environment to terrariums with new or sterilized substrate and materials that were autoclaved and disinfected.

Ethical aspects

The collections were authorized by the Chico Mendes Institute for Biodiversity Conservation (ICMBio) through the Biodiversity Authorization and Information System (SisBio license Nº. 29613). The procedures for capture, handling, collection, transportation, and *ex situ* management were authorized by the Ethics Committee for Animal Use in Research at the Federal University of Ceará (CEUA-UFC protocol Nº. 6314010321).

RESULTS

The examined individuals showed no noticeable clinical changes, either behavioral or physical. The feces of both species were dark brown, semi-solid, well-formed, and without macroscopic alterations.

The *P. gonzagai* samples collected revealed the presence of protozoa, cestode eggs, and nematode adults and eggs (Table 1). Among the protozoa, unsporulated coccidian oocysts (Fig. 1h), the ciliate *Nyctotheroides* sp. was recorded in the trophozoite (Fig. 1a) and cyst stages (Fig. 1b), with a discarded cyst wall (Fig. 1c). Additionally, rounded-to-oval structures with transparent to translucent contents, suggestive of cysts of *Entamoeba* sp. or *Giardia* sp.,

were visualized. The cestode eggs had a thick, striated shell and were embryonated (Fig. 1f). Embryonated eggs with a thin shell were also recorded (fig. 1d). The adult nematodes were identified as *Aplectana hylambatis* Baylis, 1927 (Cosmocercidae) (Fig. 2a–f). This species is characterized by females being slightly larger than males and by the presence of lateral wings in both sexes. Males have a conical tail, numerous caudal papillae, and heavily chitinized spicules (Fig. 2e), with the posterior end surrounded by a membranous sheath forming an

extension of the spicule (Fig. 2f), as well as a heavily chitinized gubernaculum (Fig. 2e). Females have a post-equatorial vulva with a mamillated cuticular protrusion on the anterior lip of the vulva, a strongly muscular vagina oriented anteriorly (Fig. 2c), prolapsed ovaries (both located anterior to the vulva), and a conical tail (Fig. 2b). Although the direct parasitological examination is qualitative, the findings suggest mild infections with no apparent clinical significance.

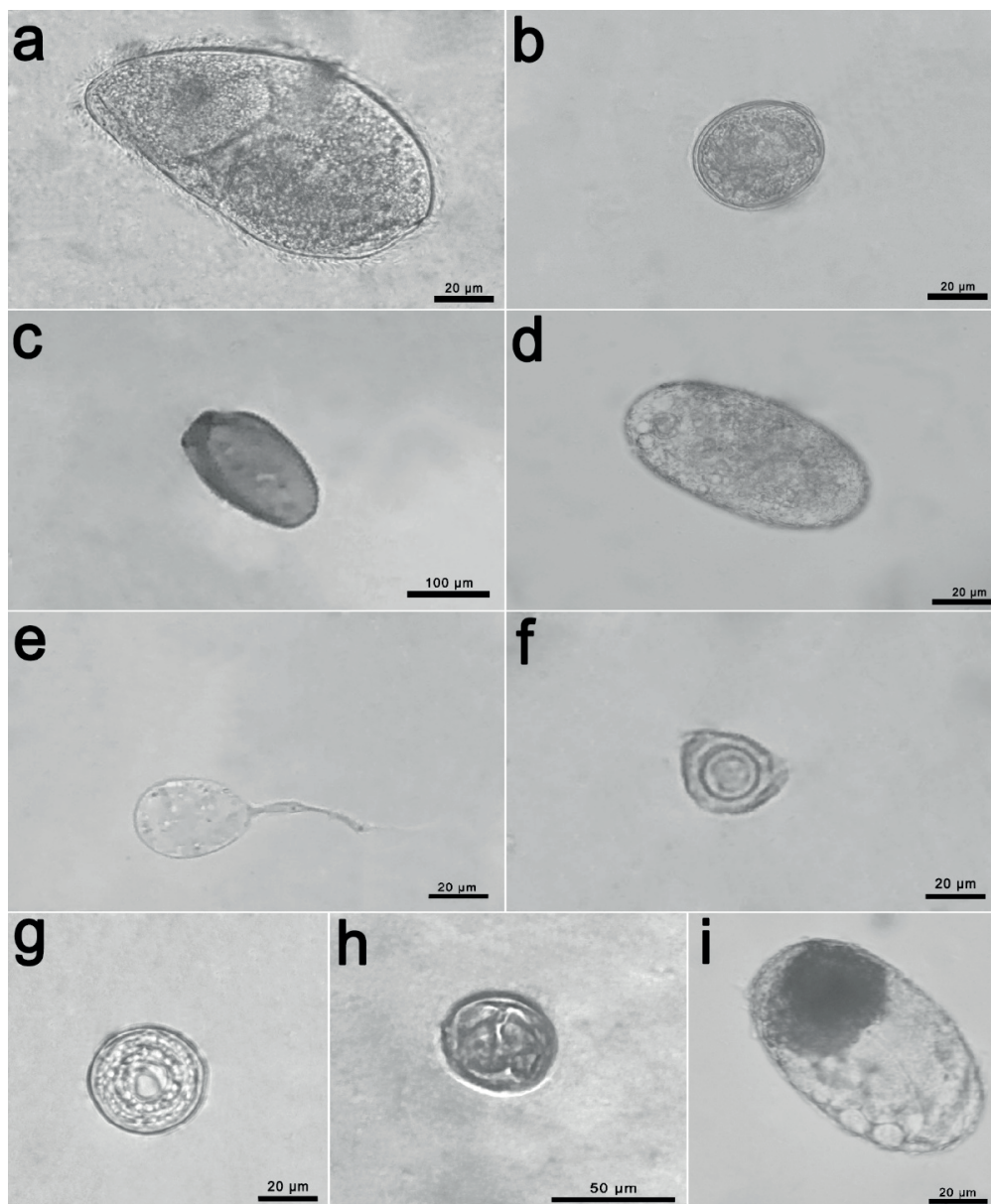


Figure 1: Microscopic findings in the direct parasitological stool exam of *Pithecopus gonzagai* and *Odontophrynus carvalhoi*. **a** - Ciliophora, *Nyctotheroides* sp., trophozoite; **b** - Ciliophora, *Nyctotheroides* sp., cyst with apical operculum; **c** - Ciliophora, *Nyctotheroides* sp., excysted cyst; **d** - Embryonated egg with thin shell; **e** - Uniflagellated protozoan; **f** Embryonated egg cestode; **g** - Rounded larvated egg with thick shell; **h** - Coccidian oocyst; **i** - Embryonated egg with thin, smooth shell, suggestive of trichostrongylids or species with similar morphology

Table 1. Microscopic findings in the direct parasitological stool exam of *Pithecopus gonzagai* and *Odontophrynus carvalhoi*.

Host	Parasite
<i>Pithecopus gonzagai</i>	<p>Protozoa</p> <p><i>Nyctotheroides</i> sp. (Trophozoites and cysts) Cyst of <i>Entamoeba</i> sp. or <i>Giardia</i> sp. Coccidian oocyst</p> <p>Cestoda</p> <p>Embryonated egg</p> <p>Nematoda</p> <p><i>Aplectana hylambatis</i> Embryonated egg, thin shell</p>
<i>Odontophrynus carvalhoi</i>	<p>Protozoa</p> <p><i>Nyctotheroides</i> sp. (Trophozoites and cysts) Uniflagellate protozoan</p> <p>Nematoda</p> <p><i>Aplectana hylambatis</i> Larvated egg</p>

The samples collected from *O. carvalhoi* revealed the presence of trophozoites, and *Nyctotheroides* sp. cysts were again identified, being the cysts rounded, embryonated, with thin, smooth shells, and presenting a polar operculum (Fig. 1a–c). Additionally, moderate numbers of uniflagellated protozoa were observed (Fig. 1e). Also, embryonated eggs with thin, smooth shells, suggestive of trichostrongylids or species with similar morphology (Fig. 1i), were also observed, and a rounded larvated nematode egg with a thick shell (Fig. 1g). Specimens of *A. hylambatis* were observed (Fig. 2a–f), as well as in *P. gonzagai*.

Given these findings, antiparasitic treatment was initiated, and coproparasitological exams were repeated at the end of the protocol. In analyses performed after the end of deworming in *P. gonzagai*, neither nematodes nor cysts of *Entamoeba* sp. or *Giardia* sp. were observed; however, trophozoites of *Nyctotheroides* sp. were still detected in moderate numbers. The coccidian oocysts were observed after deworming, but in smaller quantities.

In subsequent coproparasitological exams of *O. carvalhoi*, a residual presence of embryonated and larvated nematode eggs was observed, with a rounded shape and thick shell, as well as embryonated eggs with a thin, smooth shell, in lower quantities. Also recorded were flagellated protozoa, along with trophozoites and cysts of the ciliated

Nyctotheroides sp. Adult nematodes of *A. hylambatis* were no longer observed after treatment.

DISCUSSION

Before the taxonomic differentiation between *P. gonzagai* and *Phyllomedusa nordestina* Caramaschi, 2006, which occurred in 2020 (Andrade *et al.*, 2020), reports of nematodes from the families Cosmocercidae (*Cosmocerca parva* Travassos, 1925, *Cosmocercella phyllomedusae* Baker and Vaucher, 1983, and *Oxyascaris caudacutus* Freitas, 1958) and Rhabdiasidae (*Rhabdias* sp.) were documented in forest remnants from the states of Pernambuco and Ceará (Sena *et al.*, 2018). Another study conducted in the state of Ceará reports nematodes from the families Cosmocercidae (*Aplectana membranosa* Miranda, 1924 and *Raillietnema spectans* Gomes, 1964) and Molineidae (*Oswaldocruzia mazzai* Travassos, 1935) in specimens of *P. gonzagai* (Sampaio *et al.*, 2022). Therefore, all morphotypes recorded in *P. gonzagai* represent new records for this species.

For *O. carvalhoi*, there are few studies investigating endoparasites of this species, with reports of the occurrence of *A. hylambatis*, *Cosmocerca brasiliense* Travassos, 1925,

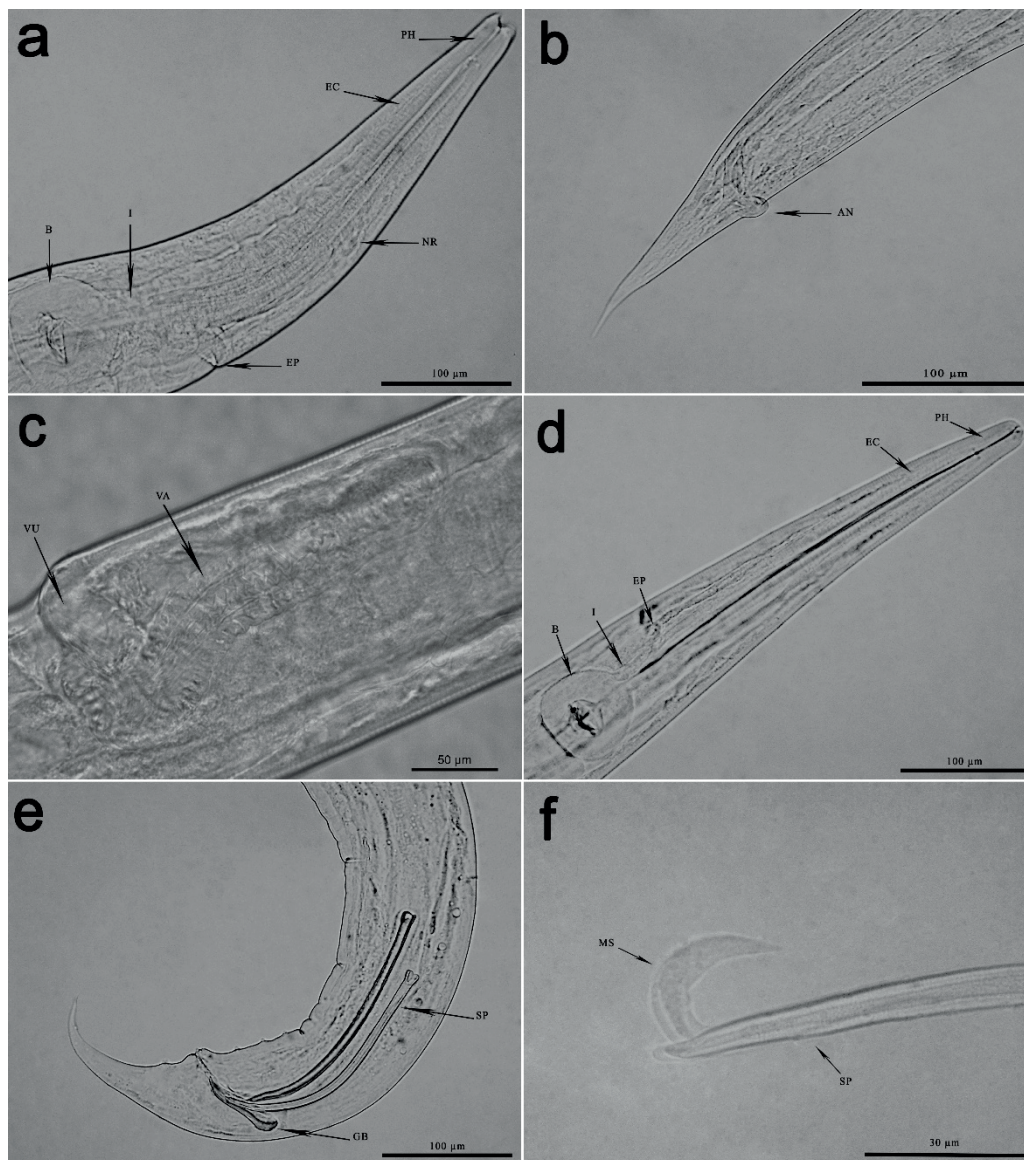


Figure 2. *Aplectana hylambatis* registrada em *Pithecopus gonzagai* e *Odontophrynus carvalhoi*. **a** - Female anterior region, showing pharynx (PH), esophagus corpus (EC), isthmus (I), bulbo (B), nerve ring (NR), and excretory pore (EP), lateral view; **b** - Female tail with the anus (AN) opening in lateral view; **c** - Female with detail of the vulva (VU), muscular vagina (VA), lateroventral view; **d** - Male anterior region, showing pharynx (PH), esophagus corpus (EC), isthmus (I), bulbo (B), and excretory pore (EP), lateral view; **e** - Male tail showing spicules (SP) and gubernaculum (GB), lateral view; **f** - Spicules (SP) with membranous sheath (MS), dissected male for visualization of the membranous sheath.

Gorgoderina parvicava Travassos, 1922, *Ochoterenella* sp., *O. mazzai*, *Oxyascaris* sp., *Parapharyngodon* sp., *Physaloptera* sp., *Raillietnema* sp., *Rhabdias* sp., and *Strongyloides* sp. (Quirino *et al.*, 2023). Therefore, with the exception of *A. hylambatis*, all morphotypes here recorded in *O. carvalhoi* represent new records for this species.

Free-living amphibians commonly to carry a moderate load of protozoans and commensal metazoans in the gastrointestinal tract with no harm to their health

(Densmore & Green, 2007). Interactions and competition among parasites within the host reduce morbidity rates and regulate the risk of developing parasitic diseases (Johnson *et al.*, 2013). The most common parasites of amphibians are *Microsporidia*, *Myxosporea*, and *Coccidia*, which have different impacts on amphibians depending on the species, life stage, and degree of infection.

However, immunosuppressive conditions, often associated with environmental constraints in ex situ settings, may

favor the progression to clinically relevant infections (Densmore & Green 2007). In this context, the *ex situ* management of wild animals requires the implementation of preventive veterinary measures as a fundamental strategy to ensure animal health and welfare (Ossiboff *et al.*, 2020). In the present study, coproparasitological examinations were performed for prophylactic purposes, followed by anthelmintic treatment, considering the potential for fecal contamination within the enclosures, which may promote new infections or reinfections and eventual clinical manifestations (Bais *et al.*, 2017). Although no clinical alterations were observed, high parasite loads of *A. hylambatis* were recorded in *O. carvalhoi*, as well as a significant presence of coccidian oocysts in some individuals of *P. gonzagai*.

Confinement may represent a risk factor for the development of parasitic diseases associated with parasites that have direct life cycles, due to the increased likelihood of continuous exposure to infective stages in the environment (Bartošová-Sojtková *et al.*, 2015; González *et al.*, 2021). Therefore, the importance of systematic health monitoring of anurans maintained *ex situ* is emphasized.

Studies report that nematodes of the genus *Aplectana* sp. are common and considered non-pathogenic in amphibians. Similarly, species of *Nyctotheroides* live in a commensal relationship in the posterior portion of the amphibians' gastrointestinal tract (Şenler, 2000) and are considered to have low pathogenicity. An increase in their numbers in the feces may indicate dysbiosis (Divers & Stahl, 2019).

Treatment with fenbendazole is considered safe and is frequently prescribed, particularly for symptomatic infections (Walker & Whitaker, 2000). Fenbendazole is widely used in veterinary clinics (Carlos *et al.*, 2011). With anti-helminthic and antiprotozoal action, fenbendazole belongs to the benzimidazole group and works by inhibiting the synthesis of adenosine triphosphate (ATP) and the production of cellular microtubules (Lanusse *et al.*, 2009) in parasites (Panarella, 2002). In frogs of the genus *Bufo* sp., the efficacy of fenbendazole was tested and compared with that of other drugs, such as levamisole, with no significant differences in helminth efficacy (Bianchi *et al.*, 2014). Fenbendazole, thiabendazole, and ivermectin are important drugs in the treatment of parasitoses in amphibians (Densmore & Green, 2007).

In this study, the use of the fenbendazole protocol showed promising treatment for mixed parasitic infections in the studied anuran species. However, due to the lack of elimination of the parasitic load in individuals after the

first treatment, maybe booster treatments, fenbendazole dose adjustment, or the use of standardized veterinary preparations could achieve better control of drug absorption and pharmacokinetics. Also, further use of fenbendazole is indicated after monitoring clinical and health signs of the animals, combining information from both parasite load, symptoms, and anamnesis. Since it was not possible to monitor laboratory toxicity in the specimens due to their small body size, and no toxicity signs were observed in this sample, further studies are needed to define an optimal fenbendazole protocol for the species studied. Another issue raised and supported by Li *et al.* (2020) is that infection by *Nyctotheroides* sp. might persist because the insects used as food for the anurans were possibly previously infected, given that these parasites inhabit the gastrointestinal tracts not only of vertebrates but also of invertebrates. In other words, it would not be possible to evaluate the efficacy of fenbendazole against the observed ciliates, as reinfection could be occurring through the diet.

Overall, this study contributes to the knowledge that coproparasitological examination has been effective in monitoring the health of captive amphibians. Treatment with fenbendazole eliminated the adult nematodes of *A. hylambatis* and reduced the protozoa in the feces of *P. gonzagai* and *O. carvalhoi*, warranting monitoring via coproparasitological exams and subsequent booster doses to assess parasitic load.

ACKNOWLEDGMENTS

We sincerely thank the team of professors, technicians, and students members of the Núcleo Regional de Ofiologia (NUROF-UFC), Ceará state, Brazil, for their dedicated study and scientific management of the reptiles and amphibians received and housed at the facilities. Special thanks go to those who occasionally joined and handled fieldwork on sporadic assistance. CFS thanks the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the postdoctoral fellowship (#154469/2025-4). RWA thanks Fundação Cearense de Apoio ao Desenvolvimento Científico e Tecnológico – FUNCAP for partial financial support [UNI-0210-00556.01.00/23; FC3-0198-00006.01.00/22], and Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq for a research grant [PQ 307722/2021-0]. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001, through a PhD fellowship awarded to ASS.

Author contributions: CRediT (Contributor Roles Taxonomy)

NSW = Nicole Souza Willers

ASS = Aline Sombra Santos

CFS = Cristiana Ferreira-Silva

TFQ = Tatiana Feitosa Quirino

RWA = Robson Waldemar Ávila

RRB = Roberta da Rocha Braga

Conceptualization: NSW, ASS, RRB**Data curation:** NSW**Formal Analysis:** NSW, ASS, CFS**Funding acquisition:** RRB, RWA**Investigation:** NSW, ASS**Methodology:** NSW, RRB, CFS**Project administration:** NSW, RRB, RWA**Resources:** RRB, RWA**Software:** NSW, CFS**Supervision:** RRB, RWA**Validation:** RRB, CFS, TFQ, ASS, RWA**Visualization:** NSW, CFS, TFQ, ASS, RWA, RRB**Writing – original draft:** NSW**Writing – review & editing:** CFS, TFQ, ASS, RWA, RRB**BIBLIOGRAPHIC REFERENCES**

- Ab'Saber, A.N. (1974). O domínio morfoclimático semi-árido das caatingas brasileiras. *Geomorfologia*, 43, 1–39.
- Andrade, F.S., Haga, I.A., Ferreira J.S., Recco-Pimentel S.M., Toledo L.F., & Bruschi D.P. (2020). A new cryptic species of *Pithecopus* (Anura, Phyllomedusidae) in north-eastern Brazil. *European Journal of Taxonomy*, 723, 108–134.
- Bais, B., Tak, L., & Mahla, S. (2017). Study of Preventive Health Measures for Wildlife in Captivity: a review of management approaches. *International Journal of Avian & Wildlife Biology*, 2, 73–75.
- Bartoľová-Sojková, P., Oppenheim, R.D., Soldati-Favre, D., & Lukeš, J. (2015). Epicellular Apicomplexans: parasites “on the way in”. *Plos Pathogens*, 11, 1–9.
- Bianchi, C.M., Johnson, C.B., Howard, L.L., & Crump, P. (2014). Efficacy of fenbendazole and levamisole treatments in captive houston toads (*Bufo* [anaxyrus] *houstonensis*). *Journal of Zoo and Wildlife Medicine*, 45, 564–568.
- Campiã, K.M., & Dáttilo, W. (2020). Biological drivers of individual-based anuran–parasite networks under contrasting environmental conditions. *Journal of Helminthology*, 94, 1–7.
- Carlos, C.Z., Nunes, P.F., Silva, T., & Silva, A.R.C. (2011). Mentha crisper e fembendazol no tratamento de parasitoses: um estudo clínico. *Pubvet*, 5, 1–18.
- Costa, E.F., Nascimento, F.A.C., Junior, M.M., & Santos, E.M. (2017). Aspectos de vida de *Odontophrynus carvalhoi* Savage & Cei, 1965 (Amphibia, Anura, Odontophrynidae) em um brejo de altitude no Nordeste brasileiro. *Boletim do Museu de Biologia Mello Leitão*, 39, 95–115.
- Densmore, C.L., & Green, D.E. (2007). Disease of amphibians. *ILAR Journal*, 48, 235–254.
- Divers, S.J., & Stahl, S.J. (2019). *Mader's Reptile and Amphibian Medicine and Surgery* (3th ed.). Elsevier.
- Ellerd, R., Saleh, M.N., Luksovsky, J.L., & Verocai, G.G. (2022). Endoparasites of pet reptiles and amphibians from exotic pet shows in Texas, United States. *Veterinary Parasitology: Regional Studies and Reports*, 27, 100671.
- Ferreira-Silva, C., Alcantara, E.P., Ávila, R.W., & Silva, R.J. (2022). First record of *Cosmocerca podicipinus* (Nematoda: Cosmocercidae) parasitizing *Leptodeira annulata* (Serpentes: Dipsadidae) in northeastern Brazil. *Brazilian Journal of Biology*, 82, e265583.
- Garner, M.M., & Jacobson, E.R. (2020). *Infectious diseases and pathology of reptiles, color atlas and text*. (2th ed.). CRC Press: Taylor and Francis Group.
- González, C.E., Hamann, M.I., & Duré, M.I. (2021). Nematodes of Amphibians from the South American Chaco: distribution, host specificity and ecological aspects. *Diversity*, 13, 1–24.

- IPECE. (2009). Perfil Básico Municipal: Uruburetama. *Instituto de Pesquisa e Estratégia Econômica do Ceará, Governo do Estado do Ceará*.
- IUCN. (2023). *The IUCN Red List of Threatened Species 2023*. Amphibian Specialist Group & Instituto Boitatá de Etnobiologia e Conservação da Fauna.
- Johnson, P.T., Preston, D.L., Hoverman, J.T., & LaFonte, B.E. (2013). Host and parasite diversity jointly control disease risk in complex communities. *The Proceedings of the National Academy of Sciences*, 110, 16916–16921.
- Lanusse, C.E., Alvarez, L.I., Sallovitz, J.M., Mottier, M.L., & Bruni, S.F.S. (2009). Antinematodal Drugs. In: Reinemeyer, J.E., & Papich, M.G., (eds.), 10th ed. *Veterinary Pharmacology and Therapy*, pp.1035–1080.
- Li, M., Hu, G., Li, C., Zhao, W., Zou, H., Li, W., Wu, S., Wang, G., & Ponce-Gordo, F. (2020). Morphological and molecular characterization of a new ciliate *Nyctotheroides grimi* n. sp. (Armophorea, Clevelandellida) from Chinese frogs, *Acta Tropica*, 208, 1–12.
- Matias, C.S.L, Ferreira-Silva, C., Sousa, J.G.G., & Ávila R.W. (2018). Helminths infecting the black false boa *Pseudoboa nigra* (Squamata: Dipsadidae) in northeastern Brazil. *Acta Herpetologica*, 13, 171–175.
- Ministério da Saúde. (2012). Manual de diagnóstico laboratorial da infecção por agentes oportunistas: parasitos intestinais e *Pneumocystis jirovecii*. *Ministério da Saúde, Brasil*.
- Oliveira, C.R., Mascarenhas, W., Batista-Oliveira, D., Araújo, K.A., Ávila, R.W., & Borges-Nojosa, D.M. (2022). Endoparasite community of anurans from an altitudinal rainforest enclave in a Brazilian semiarid area. *Journal Helminthology*, 96. e62.
- Oliveira, R.M., Schilling, A.C., & Solé, M. (2018). Trophic ecology of two *Pithecopus* species (Anura: Phyllomedusidae) living in syntopy in southern Bahia, Brazil. *Studies on Neotropical Fauna and Environment*, 54, 1–12.
- Ossiboff, R.J., Origgi, F., Stacy, N.I. (2020). Editorial: health and disease in free-ranging and captive wildlife. *Frontiers In Veterinary Science*, 7, 1–6.
- Panarella, M. (2002). Fenbendazole. *Pharm Profile*, S40, 24.
- Quirino, T.F., Batista-Oliveira, D., Saldanha, M.C., & Waldemar-Ávila, R. (2023). Helminths que infectan el escuerzo de Carvalho *Odontophrynus carvalhoi* del estado brasileño de Ceará. *Neotropical Helminthology*, 17, 247–258.
- Sampaio, N.K.S., Teixeira, A.A.M., Nascimento, J.M., Ribeiro, S.C., Almeida, W.O., & Brito, S.V. (2022). Endoparasite community structure of an anuran assemblage in the Caatinga, Northeastern Neotropical Region. *Journal of Helminthology*, 96, 1–8.
- Santos-Cavalcante, N., Fernandes-Ferreira, H., & Garbino, G.S.T. (2024). Range extension of *Chiroderma doriae doriae* (Chiroptera: Phyllostomidae) to a forest enclave in the Caatinga. *Brazilian Journal of Mammalogy*, 93, e932024136.
- SEMA. (2025). *Lista Vermelha de Espécies Ameaçadas da Fauna do Ceará*. 2ª edição. Secretaria do Meio Ambiente e Mudança do Clima, Governo do Ceará.
- Sena, P.A., Conceição, B.M., Silva, P.F., Silva, W.G.O., Ferreira, W.B., Junior, V.A.J, Moura, G.J.B., & Oliveira J.B. (2018). Helminth communities of *Pithecopus nordestinus* (Anura: Phyllomedusidae) in forest remnants. *Herpetology Notes*, 11, 565–572.
- Şenler, N.G., & Yildiz, S. (2000). The Ciliate Fauna in the Digestive System of *Rana ridibunda* (Amphibia: Anura) - II *Nyctotherus* (Nyctotheridae: Heterotrichida). *Turkish Journal of Zoology*, 24, 245–252.
- Vitt, L.J., & Caldwell, J.P. (2013). *Herpetology: an introductory biology of amphibians and reptiles* (4th ed.). *Elsevier*.
- Walker, I.D.F. & Whitaker, B.R. (2000). Amphibian Therapeutics. *Veterinary Clinics of North America: Exotic Animal Practice*, 2, 239–255.

Received January 24, 2026.

Accepted March 11, 2026.