This work aims to provide information about the diversity of parasites associated with *Proceratophrys aridus* Cruz, Nunes & Juncá, 2012 and to describe and compare the helminth fauna of this host to the other inventoried species of the genus. The specimens were manually collected between 2012 and 2016 in ten localities of Northeast Brazil. A total of 37 *P. aridus* were necropsied and analyzed for endoparasites, of which 22 were parasitized with at least one helminth taxon. To verify the similarity between the parasitic communities, a cluster analysis was performed using the Sorensen index. For this analysis, a matrix with presence and absence data for the helminth species related to the Odontophrynidae taxon was built. A total of 867 helminths were recovered, including nematodes, digenetics, and acanthocephalans, presenting a richness of eight species: *Aplectana membranosa* (Schneider, 1866), *Falcaustra mascula* (Rud. 1819), *Rhabdias brevienis* Nascimento, Gonçalves, Melo, Giese, Furtado, & Santos, 2013, *Oswaldocruzia* sp., Cosmocercidae larvae, unidentified trematodes, and cystacanths. The most abundant species with the highest prevalence and mean intensity of infection was *A. membranosa*. This study provides three new records of helminths parasitizing *P. aridus*, in addition to recording trematode and acanthocephalans infections for this host in northeastern Brazil. *Proceratophrys aridus* is the species of the Odontophrynidae family with the highest helminth richness ever recorded.

**Keywords:** Amphibian – Endoparasite – Host – Northeast – Neotropical realm – Semiarid
Parasitological inventories in amphibians from the semiarid region are growing (Campion et al., 2014; Teles et al., 2014, 2015; Araujo-Filho et al., 2015; Teles et al., 2017; Martins-Sobrinho et al., 2017; Lins et al., 2017; Alcantara et al., 2018; Oliveira et al., 2019) and have revealed helminth fauna associated with amphibians is rich and diverse. As the sampling effort grows, with new areas sampled and new host are available, the richness tends to increase considerably (Campion et al., 2014, 2015) and collaborate to elucidate the patterns of composition and richness of helminths associated with amphibian species.

Currently, there are around 49 species of Odontophrynidae in Brazil (Segalla et al., 2019) in this is inserted the genus Proceratophrys Miranda-Ribeiro, 1920 that is currently composed for 40 species widespread along to south America with records in Argentina, Brazil, and Paraguay (Frost, 2019). In Brazil, four species occur exclusively in Caatinga biome, Proceratophrys cristiceps Müller, 1883, Proceratophrys caramaschii Cruz, Nunes & Juncá, 2012, Proceratophrys aridus Cruz, Nunes & Juncá, 2012, and Proceratophrys ararype Mângia, Koroiva, Nunes, Roberto, Ávila, Sant'Anna, Santana & Garda, 2018. These species cited above, only P. aridus has been inventoried for its helminth fauna (Teles et al., 2017; Muller et al., 2018).

Teles et al. (2017) recorded four taxa for P. aridus (Rhabdias sp., Raillietnema spectans Gomes, 1964, Physaloptera sp., and Cosmocercidae larvae), while Muller et al. (2018) researching the phylogeny of Rhabdias in Brazil, identified through the molecular biology Rhabdias breviensis Nascimento, Gonçalves, Melo, Giese, Furtado, & Santos, 2013 associated in a population of P. aridus in South of Ceará State. The aim this work is provided information about the diversity of helminths associated the P. aridus species widespread along to three Northeastern State. Besides, we describe and to compare the helminth fauna associated the P. aridus with other species inventories for the genus in other localities.
MATERIALS AND METHODS

The specimens were collected between 2012 and 2016 in different municipalities from Ceará State: Aiuaba (6°34'25"S, 40°07'25"W), Barro (7°10'36''S, 38°46'54''W), Farias Brito (6°55'50''S, 39°33'56''W), Mauriti (7°23'21"S, 38°46'28"W), Crato (7°13'39"S, 39°25'05"W), Barbalha (7°19'16"S, 39°18'01"W), Missão Velha (7°14'36"S, 39°09'00"W) and Santana do Cariri (7°12'28"S, 39°44'13"W).

The specimens deposited in Herpetological collection from Cariri Regional University regarding two more states from northeastern also were included: Piauí, Santo Antônio de Lisboa municipality (06°58'53" S, 41°14'03" W) and Pernambuco, Exú municipality (07°30'43" S, 39°43'27" W) (Fig. 1). The sample sites are characterized by presents warm semiarid tropical climate and semiarid smooth tropical climate (IPECE, 2016).

A total of 37 specimens of *P. aridus* were collected manually through of active search, euthanized with thiopental sodium injection and necropsied for helminths. The number of individuals collected in each locality sampled has been provided closely with its parasitological descriptors (Table 1). The specimens had the following organs analyzed under stereomicroscopic: liver, lung, heart, stomach, intestines, celomatic cavity, and kidneys. The following parasitological descriptors: prevalence (P), mean intensity of infection (IMI), and mean abundance (AM) has been calculated following Bush *et al.* (1997) using standard error and range.

The helminths were found alive, washed in saline solution (0.9% NaCl), fixed and preserved in 70% ethanol. The nematodes were cleared in lactophenol or lactic acid while the acanthocephalans were removed their cysts, stained in carmim and cleared in creosote. All the endoparasites were observed under stereomicroscopic of light DMLB (Leica) and DM 5000B with interferential phase contrast and identified at the lowest possible level according to the work of Yamaguti (1961), Sprent (1978), Vicente *et al.* (1991), Anderson (2000) and Gibbons (2010). The helminths were deposited under the number CHIBB 8819 – 8838 in the Helminthological Collection of the Institute of Biosciences (CHIBB), São Paulo State University (UNESP), municipality of Botucatu, SP, Brazil.

To verify the similarity between parasites communities was building a matrix of data with variables presence / absent to helminths species related to Odontophrynidae family. The degree of similarity between these communities of helminths was calculated employing Sorensen index (So), with a later clustering analyse using Cluster method utilizing the mean of the unweighted pairs (UPGMA). All analyzed were performed using the software PAST 3.0.

Ethical Approval and/or Informed Consent

All procedures performed in studies involving animals were in accordance with the ethical standards of the institution or practice at which the studies were conducted. The sampling of the anuran specimens was authorized by the Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio (permit 29613-1) and to the ethics committee of the Regional University of Cariri (CEUA/URCA, process nº00260/2016.1).

RESULTS

A total 37 host analyzed, 22 were parasitized at least one helminth taxa (P = 59.5%; IMI = 185.1 ±467.9; AM = 110.1 ±40.5; range 1-190). A total of 867 helminths were collected, included nematodes, digenetics, and acanthocephalans, presenting a richness of eight species: *Aplectana membranosa* (Schneider, 1866), *Falcaustra mascula* (Rudolphi, 1819), *R. breviensis* (Nascimento, Gonçalves, Melo, Giese, Furtado & Santos 2013), *Oswaldocruzi* s.p., *Physaloptera* s.p., Cosmocercidae larvae, trematodes unidentified and cystacanths (Table 2). The most abundant species with the highest prevalence and mean intensity of infection was *A. membranosa* (n = 625; P = 27%; IMI = 65.5 ±107.1).

The similarity between the helminth communities of the five species of Odontophrynidae inventoried was considered low, with *P. aridus* and *Proceratophrys mantiqueira* Mângia, Santana,
Figure 1. Sampled localities of *Proceratophrys aridus* collected in northeast Brazil. Source: QGIS 2.18.

Figure 2. Cluster analysis of species of the Odontophrynidae family for helminth fauna composition, cophenetic correlation coefficient (ccc) = 0.92.
between the other helminths communities of species Proceratophrys genus were P. tupinamba e P. boiei (So = 36.3%), P. tupinamba e P. mantiqueira (So = 16.7%) e P. tupinamba e O. americanus (So = 0), P. boiei e O. americanus (So = 12.5%), P. boiei e P. mantiqueira (So = 22.2%) e O. americanus e P. mantiqueira (So = 0) (Fig. 2).

Cruz & Feio, 2014 (So = 28.6%) being those with the highest similarity among their parasite populations, followed by P. aridus and Proceratophrys boiei (Wied-Neuwied, 1825) (So = 15.3%), P. aridus and Proceratophrys tupinamba Prado & Pombal, 2008 (So = 12.5%) and P. aridus and Odontophrynus americanus (Duméril & Bibron, 1841) (So = 9.5%). The similarities

Table 1. Parasitological descriptors of helminths associated P. aridus in ten municipalities from Northeastern region, Brazil. Prevalence (%), mean abundance (AM), mean intensity of infection (IMI), standard error (SD), and range.

| Locality            | Host | %  | AM±SD  | IMI±SD  | Range |
|---------------------|------|----|--------|---------|-------|
| Aiuaba, CE          | 17   | 35 | 36.2±16.7 | 102.7±34.4 | 0-190 |
| Barro, CE           | 5    | 80 | 15.6±0.4 | 19.5±70.7 | 0-75  |
| Farias Brito, CE    | 3    | 33.3 | 1±1     | 0.33    | 0-1   |
| Santana do Cariri, CE | 3   | 66.7 | 1.5±1   | 1       | 0-2   |
| Nova Olinda, CE     | 3    | 100 | 1±1     | 1       | 0-1   |
| Crato, CE           | 2    | 100 | 1       | 1       | 0-1   |
| Barbalha, CE        | 1    | 100 | 3       | 3       | 0-3   |
| Mauriti, CE         | 1    | 100 | 24      | 24      | 1-24  |
| Exú, PE             | 1    | 100 | 16      | 16      | 1-16  |
| St. Ant. de Lisboa, PI | 1  | 100 | 1       | 1       | 0-1   |

Table 2. Helminth component community of P. aridus (n=37) from ten municipalities from northeast region, Brazil. Prevalence (%), mean abundance (AM) and mean intensity of infection (IMI) following by standard error (SD), site of infection (SI), and range. (*) new records.

| Echinostoma sp. | %  | AM±SD  | IMI±SD  | SI | Range | Locality |
|-----------------|----|--------|---------|----|-------|----------|
| Nematoda        |    |        |         |    |       |          |
| Aplectana membranosa* | 27 | 16.9±4.32 | 65.5±107.1 | Li, Si | 1-181 | Ba, Ma, No, Bo, Ab |
| Falcaustra mascula* | 2.7 | 0.05±0.16 | 2±2   | Li | 0-2 | Sc |
| Rhabdias breviensis | 13.5 | 0.14±0.24 | 1±0.9 | L | 1-5 | Cr, No, Bo |
| Oswaldocrazi sp. | 2.7 | 0.03±0.08 | 1±1 | Si | 0-1 | No |
| Physaloptera sp. | 5.4 | 0.51±1.95 | 9.5±15.82 | S | 2-19 | Bo, Ab |
| Oswaldocrazi sp. | 10.8 | 5.22±0.16 | 48.25±150.1 | S, Li, Si | 1-170 | Ex, Sc, Ab, Fb |
| Digenea          |    |        |         |    |       |          |
| Trematoda unidentifed* | 2.7 | 0.54±1.62 | 20±20 | Kd | 0.20 | Ab |
| Acanthocephala   |    |        |         |    |       |          |
| Cystacanth       | 5.4 | 0.05   | 1±0.97 | Cc | 1’2 | Sa, Bo |

(Site of infection: Cc = Coelomic cavity; Lung = L; Kidney = Kd; S = Stomach; Li = Large intestine; Si = Small intestine. Locality: Ba – Barbalha, Ma – Mauriti, No – Nova Olinda, Bo – Barro, Ab – Aiuaba, Sc – Santana do Cariri, Cr – Crato, Fb – Farias Brito, Ex – Exú, and Sa – Santo Antônio de Lisboa).
Table 3. List of helminths related to the species of the family Odontophrynidae.

| Host          | Parasites                                                      | References                        |
|---------------|----------------------------------------------------------------|-----------------------------------|
|               | Myxidium immersum, Lutz 1889                                   | Cordero (1928)                     |
|               | Oligocanthorhynchus sp.                                        | Smales (2007)                      |
|               | Rhabdias elegans Gutierrez, 1945                               | González & Hamann (2009)           |
|               | Cosmocerca parva Travassos, 1925                               |                                   |
|               | Cosmocerca podicipinus, Baker and Vaucher, 1984                |                                   |
| O. americanus | C. uruguayensis Lent & Freitas 1948                            |                                   |
|               | Travrema aff. stenocotyle Cohn, 1902                           |                                   |
|               | Echinostomatidae gen. sp.                                     |                                   |
|               | Aplectana membranosa (Schneider, 1866) Miranda, 1924           |                                   |
|               | A. meridionalis Lent & Freitas 1948                            |                                   |
|               | Styphlodora sp.                                                |                                   |
|               | Opisthogonimus sp.                                             |                                   |
|               | Falcaustra sanjuanensis González, Sanabria & Quiroga, 2013     | González et al. (2013)             |
| O. cf. barrioi| Aplectana delirae Fabio, 1971                                 |                                   |
|               | Cosmocerca brasiliense Travassos, 1925                         |                                   |
|               | Cosmocerca cruzi Rodrigues & Fabio, 1970                       |                                   |
| P. tupinamba  | Physaloptera sp.                                               | Boquimpani-Freitas et al. (2001)  |
|               | Rhabdias androgyna Kloss 1971                                  |                                   |
|               | Schulzia travassosi Durette-Desset, Baker and Vaucher, 1985    |                                   |
|               | Unidentified Cestoda                                           |                                   |
|               | Aplectana delirae Fabio, 1971                                 |                                   |
| P. boiei      | Cosmocerca parva Travassos, 1925                               | Klaion et al. (2011)              |
|               | Oxyascaris oxyascaris Travassos, 1920                          |                                   |
|               | Physaloptera sp.                                               |                                   |
| P. mantiqueira| Cosmocercidae larvae                                           | Almeida-Santos et al. (2017)      |
|               | Physaloptera sp.                                               |                                   |
|               | Oxyascaris sp.                                                 |                                   |
|               | Oswaldocruzia lopesi Freitas & Lent, 1938                      |                                   |
|               | Rhabdias sp.                                                   |                                   |
| P. aridus     | Rhhabdias brevicensis                                          | Teles et al. (2017)               |
|               | Railietnema spectans                                           | Muller et al. (2018)              |
|               | Physaloptera sp.                                               | Present study                      |
|               | Cosmocercidae larvae                                           |                                   |
|               | Aplectana membranosa                                           |                                   |
|               | Falcaustra mascula                                              |                                   |
|               | Oswaldocruzia sp.                                              |                                   |
|               | Unidentified Trematoda                                         |                                   |
|               | Cystacanth                                                     |                                   |
**DISCUSSION**

*Proceratophrys aridus* is the species of the genus that presented the highest richness of parasites among the others investigated (Cordero, 1928; Boquimpani-Freitas *et al.*, 2001; Smales, 2007; González & Hamann, 2009; Hamann & González, 2009; Klaion, 2011; Almeida-Santos *et al.*, 2017; Teles *et al.*, 2017) (Table 3). This can be explained in the function of the sampled effort, the richness of parasite species is directly influenced by this variable (Campiono *et al.*, 2015). Thus, in this study, the sampled effort was important for growing up the richness of helminths associated *P. aridus* among congeneres.

Brazil is one of the countries of South America that more research helminths of amphibians (Martins-Sobrinho *et al.*, 2017). The present study provides three new records of helminths parasitizing *P. aridus* in the northeast region from Brazil. Regarding other works as Almeida-Santos *et al.* (2017) and Teles *et al.* (2017) we recording besides infection of nematodes, the presence of digenetic trematodes and cystacanths associated in this host, thus totalizing fifteen species of Nematoda, one record of Cestoda, Trematoda, and cystacanth for the genus Proceratophrys.

The *Aplectana* genus currently is composed of 28 species distributed in the Neotropical realm (Gomez *et al.*, 2017). In this study, *A. membranosa* was species that present the highest prevalence and intensity of infection. Considered monoxenic cycle life this parasite, the infection occurs through the penetration of the host skin (Anderson, 2000), thus the terrestrial habit and forage behavior of the host can have the exposure it highest risk of infection for this parasite.

In Brazil, occurs nine species of the genus *Aplectana* that infecting amphibians: *A. crossoodactyli* (Vicente & Santos, 1970), *A. crucifer* Travassos, 1925, *A. delirae* Fábio, 1971, *A. lopesi Silva*, 1954, *A. membranosa* (Schneider, 1866), *A. meridionalis* Lent & Freitas, 1948, *A. micropenis* Travassos, 1925, *A. pintoi* Travassos, 1925 and *A. vellardi* Travassos, 1926. In Brazilian Northeast, only *A. membranosa* has records infecting hosts *Leptodactylus labyrinthicus* (Spix, 1824), *L. syphax* Bokermann, 1969 and *Dermatobothrium muelleri* (Boettger, 1885) (Vicente *et al.*, 1991; Lins *et al.*, 2017; Alcantara *et al.*, 2018). This work presents the first record of infection by *A. membranosa* parasitizing a species of *Proceratophrys* genus.

The genus *Falcaustra* Lane, 1915 has 13 species distributed throughout the Neotropical realm (Bursey *et al.*, 2018). In Brazil, there are records of the occurrence of three species parasitizing amphibians, lizards and snakes: *Falcaustra belemensis* Baker and Bain, 1981 (Goldberg *et al.*, 2007), *F. tikashinghi* (Schoenecker, Schmidt & Everard, 1977) Baker & Bain, 1981 (Baker & Bain 1981; González *et al.*, 2013) and *F. mascula* (Rudolphi, 1819; Gomes & Vicente, 1966; Vicente *et al.*, 1991; Goldberg *et al.*, 2007; Teles *et al.*, 2014). Little is known about the life cycle of *F. mascula*, however, some evidence indicates that it has a heteroxenic cycle (Anderson, 2000; González *et al.*, 2013; Teles *et al.*, 2014). *Proceratophrys aridus* represents the second species of the Odontophrynidae family to be recorded infected by the genus *Falcaustra* (González *et al.*, 2013).

To *R. breviensis*, Muller *et al.* (2018) reports the multiple lineages presence of this species in Brazil. One of this lineages has been recorded in the Northeast region (Piaui and South Ceará state) associated *Leptodactylus fuscus* (Schneider, 1799), *Rhinellajimii* (Stevaux, 2002) and *P. aridus*.

This reports confirm the presence of this species outside type locality (Pará, Amazônic Region) expanding their spacial distribution and their hosts, which until then were only Leptodactylidae, evidencing its generalist character. Our reports overlap other records as Muller *et al.* (2018) confirm the presence of this lineage of *R. breviensis* in the Northeast region. The records of Teles *et al.* (2017) and Muller *et al.* (2018) were both from Aiuba locality, Ceará state, thus the records of *Rhabdias* sp. in effect is *R. breviensis*.

The genus *Oswaldocruzia* Travassos, 1917 has 88 species around the world (Svitin & Kuzmin, 2012), 43 reported in Neotropical realm, 14 in a South America, only eight recorded in amphibians and reptiles in Brazil designated to following Bufonidae, Ceratophylinidae, Craugastoridae, Dendrobatidae, Hylidae, Leptodactylidae e Microhylidae taxa (Guerreiro, 2013; Campião et...
al., 2014; Willkens et al., 2016). Almeida-Santos et al. (2017) reported for the first time *O. lopesi* Freitas and Lent, 1938 in *P. mantiqueira* in rain forest in Brazilian southeastern. We present the second records for the family and the first to *P. aridus*, expanding this relation from the Brazilian northeast.

*Proceratophrys* genus composes a taxon of diurnal toads, rugged skin that lives in litter leaf. Considering the ecological aspects similarity such as foraging mode and diet of the four species investigated for this genus, we observed that these aspects were not determinant for the helminth assemblage composition. (Boquimpani-Freitas et al., 2001; Almeida-Santos et al., 2017). By the other hand, the geographical distance between the species can be a factor considered (Poulin, 2018). The low similarity between the communities of helminths of *P. aridus* and their congener can be explained by the distribution of these species (Poulin, 2003; Poulin et al., 2011).

*Procetatophrys aridus* has a restricted occurrence in the Brazilian Northeast (Cruz et al., 2012), while *P. tupinamba* and *P. mantiqueira* and *P. boiei* occur mainly in humid forests of southeastern Brazil (Boquimpani-Freitas et al., 2001; Klaion et al., 2011; Almeida-Santos et al., 2017), a factor that justifies higher values of similarity between the helminth communities among these sympatic hosts. Besides, the phylogenetic proximity may also justify the similarities between the species *P. tupinamba* and *P. mantiqueira* (*Proceratophrys appendiculata* group) and *P. boiei* (*Proceratophrys boiei* group) (Prado & Pombal Jr., 2008; Almeida-Santos et al., 2017; Mângia et al., 2018).

All helminths associated with *Procetatophrys* genus can be considered generalists because they occur in several other amphibian taxa (González & Hamann, 2008; Campião et al., 2014; Muller et al., 2018). However, it should be considered that species that compose the community of *P. boiei* parasites such as *Cosmocerca parva* Travassos, 1925 and *Oxyascaris oxyascaris* Travassos, 1920 also have records for the northeastern region (Teles et al., 2015; Silva et al., 2018). The non-occurrence of these species in this study does not imply that they do not parasite *P. aridus* but may be related mainly to the effort employed, corroborating the implications of the sample effort relationship with the richness of parasite species (Campion et al., 2015). Besides, the proximity between the communities of *P. aridus* and *P. mantiqueira* is due more to the number of helminth taxa not determined than the species shared by these hosts.

Parasitic communities provide great models for exploring various subjects related to interspecific associations, community structure, and species richness or diversity determinants (Poulin, 2018). The higher species and localities are inventoried concerning their helminth fauna, the greater the data set that will able to available to trace the distribution, occurrence, and coevolution patterns of endoparasite and their host relationships.

**ACKNOWLEDGMENT**

To the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-CAPES-for research fellowships to D. H. Morais (CAPES/PNPD 22005013001P4) and Fundação para o apoio e a Pesquisa do Estado de São Paulo (FAPESP/12/24945-1). R.W.A. thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing research fellowship (PQ # 303622/2015-6305988/2018-2) and D.H.M (PQ process #313241/2018-0).

**BIBLIOGRAPHIC REFERENCES**

Alcantara, EP, Silva, CF, Silva, LAF, Lins, AGS, Ávila, RW, Morais, DH & Silva, RJ. 2018. *Helminths of Dermatonotus muelleri (Anura: Microhylidae) from Northeastern Brazil*. Journal of Parasitology, vol. 104, pp. 550-556.

Almeida-Santos, M, Siqueira, CC, Anjos, LA, Sluys, MV & Rocha, CFD. 2017. *Ecological aspects of the horned leaf-frog Proceratophrys mantiqueira (Odontophrynidae) in an Atlantic Rainforest area of southeastern Brazil*. Salamandra vol. 53, pp. 413–422.
Anderson, RC (eds). 2000. Nematode parasites of vertebrates, their development and transmission. Cab. International, Wallingford.

Araujo-Filho, JA, Brito, SV, Almeida, WO, Morais, DH & Ávila, RW. 2015. A new species of Parapharyngodon (Nematoda: Pharyngodoniidae) infecting Dermatotus muelleri (Anura: Microhylidae) from Caatinga, Northeastern Brazil. Zootaxa vol. 4012, pp. 386-390.

Baker, MR & Bain, O. 1981. Falcaustra belemensis n. sp. (Nematoda, Kathlaniidae) from the lizard Neusticurus bicarinatus L. (Teiidae) of Brazil. Bulletin du Muséum National D’Histoire Naturelle, vol. 4, pp. 117–121.

Boquimpani-Freitas, L, Vrcibradic, D, Vicente, JJ, Bursey, CR, Rocha, CFD, & Sluys, MV. 2001. Helminths of the horned leaf frog, Proceratophrys appendiculata from southeastern Brazil. Journal of Helminthology, vol. 75, pp. 233-236.

Bursey, CR, Goldberg, SR & Grismer, LL. 2018. New species of Bakeria (Nematoda; Strongylidea; Molineidae), new species of Falcaustra (Nematoda; Ascaridida; Kathlaniidae) and other helminths in Cnemaspis mcguirei (Sauria; Gekkonidae) from Peninsular Malaysia. Acta Parasitologica, vol. 59, pp. 643–652.

Gibbons, L (eds). 2010. Keys to the nematode parasites of vertebrates, Supplementary Volume. CABI International, U.K., Wallingford.

Goldberg, SR, Bursey, CR, Caldwell, JP, Vitt, LJ & Costa, GC. 2007. Gastrointestinal Helminths from Six Species of Frogs and Three Species of Lizards, Sympatric in Pará State, Brazil. Comparative Parasitology, vol. 74, pp. 327–342.

Hamann, MI & González, CE. 2009. Larval digenetic trematodes in tadpoles of six amphibian species from Northeastern Argentina. Journal of Parasitology, vol. 95,
pp. 623–628.

IPECE (Instituto de Pesquisa e Estratégia Econômica do Ceará). 2016. [Institute of Research and Economic Strategy of Ceará]. In: Perfil Básico Municipal do Município de Aiubaba. Retrieved June 05, 2018 from http://www.ipece.ce.gov.br/perfil_basico_municipal/2016/Aiubaba.pdf (In Portuguese)

Klaion, F, Almeida-Gomes, M, Tavares, LER, Rocha, CFD & Sluys, MV. 2011. Diet and nematode infection in Proceratophrys boiei (Anura: Cycloramphidae) from two Atlantic rainforest remnants in Southeastern Brazil. Anais da Academia Brasileira de Ciências, vol. 83, pp. 1303-1312.

Lins, AGS, Aguiar, A, Morais, DH, Silva, LAF, Ávila, RW & Silva, RJ. 2017. Helminth fauna of Leptodactylus syphax (Anura: Leptodactylidae) from Caatinga biome northeastern Brazil. Revista Brasileira de Parasitologia Veterinária, vol. 26, pp. 74-80.

Mângia, S, Koroiva, R, Nunes, PMS, Roberto, IJ, Ávila, RW, Sant'anna, AC, Santana, DJ & Garra, AA. 2018. A new species of Proceratophrys (Amphibia: Anura: Odontophrynidae) from the Araripe Plateau, Ceará State, Northeastern Brazil. Herpetologica, vol. 74, pp. 255–268.

Martins-Sobrinho, PM, Silva, WGO, Santos, EG, Moura, GJB & Oliveira, JB. 2017. Helminths of some tree frogs of the families Hylidae and Phyllomedusidae in an Atlantic rainforest fragment, Brazil. Journal of Natural History, vol. 51, pp. 1639–1648.

Muller, MI, Morais, DH, Costa-Silva, GJ, Aguiar, A, Ávila, RW & Silva, RJ. 2018. Diversity in the genus Rhabdias (Nematoda, Rhabdiasidae): Evidence for cryptic speciation. Zoologica Scripta, vol. 47, pp. 595-607.

Oliveira, CR, Ávila, RW & Morais, DH. 2019. Helminths Associated with Three Physalaemus Species (Anura: Leptodactylidae) from Caatinga Biome, Brazil. Acta Parasitologica, vol. 64, pp. 205-212.

Poulin, R. 2003. The decay of similarity with geographical distance in parasite communities of vertebrate hosts. Journal of Biogeography, vol. 30, pp. 1609–1615.

Poulin, R, Blanar, CA, Thieltges, DW & Marcogliese, DJ. 2011. The biogeography of parasitism in sticklebacks: distance, habitat differences and the similarity in parasite occurrence and abundance. Ecography, vol. 34, pp. 540–551.

Poulin, R. 2018. Best practice guidelines for studies of parasite community ecology. Journal of Helminthology, vol. 93, pp. 8-11.

Prado, GM & Pombal Jr, JP. 2008. Espécies de Proceratophrys Miranda-ribeiro, 1920 com apêndices palpebrais (Anura; Cycloramphidae). Arquivos de Zoolgia, vol. 39, pp. 1-85.

Rudolphi, C. 1819. Entozaarum Synopsis cui Accedunt mantissa duplex et indices locupletissimi. August Rucker, Berlin, Germany.

Segalla, MV, Caramaschi, U, Cruz, CAG, Grant, T, Haddad, CFB, Garcia, CFB, Berneck, PCA & Langone, JA. 2016. Brazilian Amphibians: List of Species. Herpetologia Brasileira, vol. 8, pp. 35-46.

Silva, CS, Ávila, RW & Morais, DH. 2018. Helminth community dynamics in a population of Pseudopaludicola pocoto (Leptodactylidae: Leiuperinae) from Northeast-Brazilian. Helminthologia, vol. 55, pp. 292–305.

Smales, LR. 2007. Acanthocephala in amphibians (Anura) and reptiles (Squamata) from Brazil and Paraguay with description of a new species. Journal of Parasitology, vol. 93, pp. 392–398.

Sprent, JFA. 1978. Ascaridoid nematodes of amphibians and reptiles (Squamata): Gedoelstascaris n.g. and Ortleppascaris n.g. Journal of Helminthology, vol. 52, pp. 261-282.

Svitin, R & Kuzmin, Y. 2012. Oswaldocruzia duboisii (Nematoda, Moliniaeidae): morphology, hosts and distribution in Ukraine. Vestnik Zoologii, vol. 46, pp. 195–203.

Teles, DA, Cabral, MES, Araujo-Filho, JA, Dias, DQ, Ávila, RW & Almeida, WO. 2014. Helminths of Leptodactylus vastus (Anura: Leptodactylidae) in an area of the Caatinga, Brazil. Herpetological Notes, vol. 7, pp. 355-356.

Teles, DA, Sousa, JGG, Teixeira, AAM, Silva, MC, Oliveira, RH, Silva, MRM & Ávila, RW. 2015. Helminths of the frog Pleurodema diplolister (Anura, Leiuperidae) from the
Caatinga in Pernambuco State, Northeast Brazil. Brazilian Journal of Biology, vol. 75, pp. 251-253.

Teles, DA, Brito, SV, Araújo-Filho, JA, Teixeira, AAM, Ribeiro, SC, Mesquita, DO & Almeida, WO. 2017. Nematode parasites of Proceratophrys aridus (Anura: Odontophrynidae), an endemic frog of the Caatinga domain of the Neotropical region in Brazil. Herpetological Notes, vol. 10, pp. 525-527.

Willkens, Y, Maldonado Jr, A, Santos, JN, Maschio, GF & Melo, FTV. 2016. Redescription of Oswaldocruzia chambrieri (Strongylida: Molineidae) from Rhinella margaritifera (Anura: Bufonidae) in Caxiuana National Forest, Brazil. Acta Parasitologica, vol. 61, pp. 567–575.

Yamaguti, S. 1961. Systema Helminthum – Nematodes, Interscience Publishers, London.

Vicente, JJ, Rodrigues, HO, Gomes, DC & Pinto, RM. 1991. Nematóides do Brasil. Parte II: Nematóides de anfíbios. Revista Brasileira de Zoologia, vol. 7, pp. 549-626.