



Anisakidae Skrjabin & Karokhin, 1945 and Raphidascarididae Hartwich, 1954 nematodes in lutjanidae (pisces: perciformes) from the Brazilian Northeast Coast

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Abstract

The present study aimed at describing and evaluating the fauna of Anisakidae and Raphidascarididae nematodes of lutjanid fish (snappers) from the Brazilian northeastern coast unloaded at the city of Aracaju, capital of the State of Sergipe. A total of 186 lutjanids of 5 different species were analyzed including 69 *Lutjanus analis*, 51 *L. vivanus*, 29 *Ocyurus chrysurus*, 23 *L. synagris*, and 14 *L. jocu*. Nematode specimens found in the viscera of these fish were clarified with lactophenol. Illustrations of each of these specimens were prepared to help identify these samples and compose their taxonomic description and classification. At necropsy, 3,183 nematodes belonging to two families were collected from fish viscera which included the following: Anisakidae: *Anisakis*, *Terranova*, *Contraecaecum*, and *Goezia*; Raphidascarididae: *Raphidascaris* (*Ichthyascaris*) and *Hysterothylacium*. A total of six genera of nematodes were found at postmortem examination of which adult worms of only three genera (*Goezia*, *Raphidascaris* and *Hysterothylacium*) were detected in the fish examined. Larvae of *Terranova* sp. were found only in the musculature of *O. chrysurus*. Most of the nematode larvae were present in the mesentery and organs of the fish necropsied. Therefore, the zoonotic potential of these nematodes cannot be ruled out. There was a significant negative correlation between the intensity of parasitism by anisakids and the total body length of *O. chrysurus*; the intensity of parasitism was greater in smaller and shorter fish. There was a significant positive correlation between the abundance of these parasites and the length of *L. synagris*; the presence of these parasites increased according to the fish's body length. To the authors' knowledge, these are the first records of *Raphidascaris* (*Ichthyascaris*) sp. and *Hysterothylacium* sp. in *L. vivanus*, of *Terranova* sp. in *O. chrysurus* and *L. jocu*, and of *Goezia* sp. in *L. analis*. These novel findings add the Brazilian northeast coast and the State of Sergipe in the geographic distribution of these parasites in the country.

Keywords: Anisakis, Goezia, fishes, Terranova.

Nematodas Anisakidae Skrjabin & Karokhin, 1945 e Raphidascarididae Hartwich, 1954 em Lutjanidae (Pisces: Perciformes) do litoral nordeste brasileiro

Resumo

O objetivo deste trabalho é descrever e avaliar a fauna de Anisakidae e Raphidascarididae de peixes lutjanídeos do litoral nordeste do Brasil desembarcados na cidade de Aracaju, capital do estado de Sergipe. Foram analisados 186 lutjanídeos das espécies *Lutjanus analis* 69, *L. vivanus* 51, *Ocyurus chrysurus* 29, *L. synagris* 23 e *L. jocu* 14. Exemplares dos nematodas encontrados nas vísceras foram clarificados em lactofenol e ilustrados para auxiliar na identificação e compor a descrição taxonômica. Foram coletados 3.183 nematodas das vísceras dos peixes, pertencentes a duas famílias: Anisakidae: *Anisakis*, *Terranova*, *Contraecaecum* e *Goezia*; e Raphidascarididae: *Raphidascaris* (*Ichthyascaris*) e *Hysterothylacium*. Totalizando seis gêneros encontrados, apenas nos três últimos gêneros foram encontrados vermes em estágio adulto. Apenas em *O. chrysurus* foram encontradas larvas de *Terranova* sp. na musculatura. A maioria das larvas estava restrita ao mesentério e órgãos dos peixes, e em grande intensidade não podendo se descartar o potencial

zoonótico. Observou-se uma correlação significativa negativa entre a intensidade anisakídeos e o comprimento total de *O. chrysurus*, onde a intensidade dos parasitas é maior em peixes de menor comprimento e uma correlação significativa positiva entre a abundância desses mesmos parasitos com o comprimento de *L. synagris*, onde a presença dos parasitas aumenta conforme o comprimento do peixe. Esse é o primeiro registro de *Raphidascaris (Ichthyascaris)* sp. e *Hysterothylacium* sp. em *L. vivanus*; de *Terranova* sp. em *O. chrysurus* e *L. jocu* e *Goezia* sp. em *L. analis*, adicionando o litoral nordeste do Brasil e o estado de Sergipe na distribuição geográfica desses parasitos.

Palavras chave: Anisakis, Goezia, peixes, Terranova.

1. Introduction

The families Anisakidae Skrjabin & Karokhin, 1945 and Raphidascarididae Hartwich, 1954 are composed of nematodes that carry out their life cycle in aquatic environments using different intermediate or paratenic hosts such as invertebrates, fish, aquatic birds, and mammals. However, both larval and adult stages of species from the genera *Goezia* and *Hysterothylacium* parasitize fish. Anisakids are a major concern to public health issues since they may be accidentally transmitted to humans by the ingestion of raw or undercooked fish infected by L3 larvae (Andrade-Porto et al., 2015; Eiras et al., 2015; Souza et al., 2016). In fish, these larvae may be found in the mesentery, body cavities, musculature, or attached to internal organs (viscera). The presence of these larvae in the fish's skeletal muscle is characteristic of some genera of the family Anisakidae. Anisakid larvae may migrate naturally to fish muscle tissue as a result of postmortem changes that occur in the host or when fish are subjected to freezing (Eiras et al., 2006; Saad and Luque, 2009; Andrade-Porto et al., 2015).

Human infections by anisakids are not common in Brazil. However, several authors have reported the presence of these parasites in marine fish, generally in greater prevalences in comparison with other helminths (São Clemente et al., 1994; Luque, 2004; Knoff et al., 2007, 2013; Barros, 2012). Anisakid larvae have been reported by several authors in species of fish of economic importance such as: *Anchoa tricolor*, *Netuma barba*, *Brevoortia aurea*, *Pagrus pagrus*, *Prionotus punctatus*, *Genypterus brasiliensis*, *Aluterus monoceros*, *Paralichthys isoceles*, *Rhamdia quellen*, *Lophius gastrophysus*, *Lutjanus analis*, *Sardinella brasiliensis*, and *Selene setapinnis* (Palm, 1997; São Clemente et al., 1994; Cordeiro and Luque, 2004; Tavares and Luque, 2004; Tavares et al., 2004; Tavares and Luque, 2004; Bicudo et al., 2005; Knoff et al., 2007; Saad and Luque, 2009; Dias et al., 2010; Felizardo et al., 2009; La Rue et al., 2010; Saad et al., 2012; Knoff et al., 2013; Hermida et al., 2014; Moreira et al., 2015; Fontenelle et al., 2015).

Lutjanidae are cosmopolitan fish, live in coral reefs, and are general carnivores, feeding on crustaceans, smaller fish, and molluscs (Allen, 1985; Cavalcanti et al., 2013). In the northeastern region of Brazil, these fish are exploited due to the good quality of their meat, and are considered an important of human food source (Frédou and Ferreira, 2005; Begossi et al., 2011; Cavalcante et al., 2012). Therefore, further research on the nematode fauna that affect this group of fish is needed. The present study aimed

at describing and evaluating the fauna of nematodes from the families Anisakidae and Raphidascarididae in lutjanid fish from the northeastern coast of Brazil unloaded in the city of Aracaju, capital of the State of Sergipe.

2. Materials and Methods

Fish were purchased between March 2015 and July 2016 directly from artisanal fishermen at a fishery unit located in the city of Aracaju, State of Sergipe (SE), northeast Brazil (10 ° 54'17 "S 37 ° 2'56" W) according to supply and availability. These fish originated from the Western Atlantic. They were captured along the Brazilian of northeast coast and unloaded at the fishing unit in Aracaju, SE. Specimens were packed in thermal insulated boxes and shipped to the Laboratory of Tropical Biology at the Institute of Technology and Research. Fish were identified to the species level according to the taxonomic keys published by Allen in 1985. Then each fish was measured - total length (ct) - and weighed - weight (p). Gender was determined by gross examination of the gonads at necropsy. Parasitological evaluation of these specimens was performed according to the guidelines provided by Eiras et al. (2006).

Nematodes that were found in organs and tissues of the digestive system during postmortem examination were fixed in 70% alcohol for further taxonomic classification. Identification of nematodes was based on their morphological characters (ventriculus, intestinal cecum, presence or absence of ventricular appendage), presence/lack of cephalic tooth and cephalic tooth arrangement, and morphology of the caudal region (presence or lack of mucron). Specimens were taxonomically characterized and their morphology compared with previous published reports of nematodes of fish available in the literature. Specimens were clarified with lactophenol. Illustrations were drawn using a light microscope (Coleman Model: N-120) with a light chamber to aid the morphological description and taxonomic identification and classification. Illustrations were prepared and converted to vector images using the software Paint. Net. V4.0.9, Adobe Illustrator cc 2014 and Adobe Photoshop cc (64 bit). Biometry of the specimens was performed using a light microscope (Coleman Model: N-120 Fuse T2A) coupled to a camera (HDCE-X5 model) and to a computer with Scope Image 9.0 (X5) software. Values were expressed in millimeters (mm).

The parasitological indices of prevalence (p%), intensity (I), mean intensity (im), and mean abundance (am) were calculated according to the formulas published

by Bush et al. (1997). Species of the family Anisakidae were grouped into a single group - Anisakidae - in order to carry out the statistical analyses. The Spearman correlation coefficient (rs) was used to assess possible correlations between the intensity and abundance of anisakids and fish body length. In this survey, we used the statistical software Bioestat 5.0, and a level of significance of $p < 0.05$ was considered.

3. Results

A total of 186 lutjanids from 5 different species were analyzed as follows: *Lutjanus analis* (69 specimens), *Lutjanus vivanus* (51 specimens), *Ocyurus chrysurus* (29 specimens), *Lutjanus synagris* (23 specimens), and

Lutjanus jocu (14 specimens). The mean total length and weight for each fish species is shown in Table 1.

A total of 3.183 nematodes belonging to 2 families and 6 species were collected from viscera and musculature of fish: Anisakidae: *Anisakis*, *Terranova*, *Contraecum*, and *Goezia*; Raphidascarididae: *Raphidascaris (Ichthyascaris)* and *Hysterothylacium*. In 4 genera (*Contraecum*, *Goezia*, *Raphidascaris*, and *Hysterothylacium*), the parasitism intensity was low (Table 2). *Anisakis* sp. was the most prevalent genus of nematode in the samples examined. A great parasitism intensity of the genus *Terranova* (1,362 larvae) was found in *O. chrysurus*. Only specimens from the genera *Raphidascaris (Ichthyascaris)*, *Hysterothylacium* and *Goezia* were adults. High prevalence and intensity indices of nematode larval infestation were detected mainly in the intestinal mesentery of fish. Parasites were found in all organs. The site of infection was collectively referred to as "tissues" (Table 2).

The correlation between the length of parasitized fish and parasitic indices by anisakids did not show statistical significance, except for *O. chrysurus* and *L. synagris* in which there was a significant negative and positive correlation, respectively (Table 3). Based on these data, we may infer that the number of these parasites does not increase proportionally according to the body size of this host species; the number of parasites is greater in smaller fish. The correlation between fish length and abundance of anisakids was not significant among species, except for *L. synagris* (Table 3) in which there was a significant and positive correlation. This finding shows that for

Table 1. Mean and standard deviation of length and weight of different species of lutjanid fish collected between March 2015 and July 2016 along the coast of Northeast Brazil. ml: mean length; mw: mean weight.

fish species	ml	mw
<i>Lutjanus analis</i>	30.47 (± 6.24)	418.20 (± 297.29)
<i>Lutjanus vivanus</i>	30.36 (± 2.00)	336.74 (± 74.93)
<i>Lutjanus synagris</i>	29.67 (± 9.65)	438.86 (± 446.34)
<i>Lutjanus jocu</i>	41.68 (± 9.72)	1124.57 (± 779.49)
<i>Ocyurus chrysurus</i>	41.09 (± 9.72)	523.65 (± 321.26)

Table 2. Parasitological indices for nematode species of the host species of *Lutjanus vivanus*, *Lutjanus synagris*, *Lutjanus jocu*, *Ocyurus chrysurus*, collected in the period of March 2015 and July 2016 along the Brazilian Northeast coast in which: P% = Prevalence; I = Intensity; MI = Mean Intensity; MA = Mean Abundance.

Host	Number of fish	Parasite	P%	I	MI	MA	Infection site
<i>Ocyurus chrysurus</i>	29	<i>Anisakis</i> sp.	6.80	9	7.00 (± 2.82)	0.48 (± 1.88)	T
		<i>Raphidascaris (Ichthyascaris)</i> sp.	6.80	11	5.5 (± 6.36)	0.37 (± 1.85)	IN
		<i>Terranova</i> sp.	51.72	1328	97.07 (± 131.66)	46.86 (± 102.38)	T
		<i>Terranova</i> sp.	3.44	34	34.00	1.17 (± 6.31)	MUS
<i>Lutjanus vivanus</i>	51	<i>Anisakis</i> sp.	86.27	1227	27.88 (± 25.01)	24.05 (± 25.14)	T
		<i>Raphidascaris (Ichthyascaris)</i> sp.	5.88	3	1.00	0.05 (± 0.23)	IN
		<i>Hysterothylacium</i> sp.	1.96	1	1.00	0.01 (± 0.14)	IN
		<i>Terranova</i> sp.	1.96	2	2.00	0.03 (± 0.19)	MI
<i>Lutjanus synagris</i>	27	<i>Anisakis</i> sp.	17.39	13	3.25 (± 2.87)	0.56 (± 1.64)	T
		<i>Raphidascaris (Ichthyascaris)</i> sp.	4.34	2	2.00	0.08 (± 0.41)	T
<i>Lutjanus analis</i>	69	<i>Anisakis</i> sp.	20.28	214	15.28 (± 36.27)	3.10 (± 17.15)	MI
		<i>Contraecum</i> sp.	1.44	1	1.00	0.01 (± 0.12)	MI
		<i>Goezia</i> sp.	1.44	3	3.00	0.04 (± 0.36)	IN
<i>Lutjanus jocu</i>	20	<i>Anisakis</i> sp.	71.42	308	31.10 (± 29.50)	22.21 (± 28.55)	T
		<i>Terranova</i> sp.	7.14	3	3.00	0.21 (± 0.80)	T

T = Tissues; MUS = Musculature; MI = Intestinal Mesentery, IN = Intestine.

Table 3. Correlation between fish body length of the Lutjanidae family and the intensity and abundance of anisakids, collected from March 2013 to July 2016 along the Brazilian Northeast coast.

Hospedeiro	Intensidade		Abundância	
	rs	P	rs	p
<i>Ocyurus chrysurus</i>	- 0.0664	0.0111*	- 0.0664	0.7320
<i>Lutjanus vivanus</i>	0.2730	0.0666	0.2323	0.1008
<i>Lutjanus synagris</i>	- 0.0401	0.8917	0.4447	0.0334*
<i>Lutjanus jocu</i>	0.6325	0.3675	0.1837	0.1306
<i>Lutjanus analis</i>	- 0.3963	0.2568	- 0.4700	0.0899

*Significant values

this particular species the Anisakidae fauna increases proportionally according to the fish's body size.

All the fish analyzed had at least one Anisakidae larvae (prevalence of 100%) with the greatest intensities of *Anisakis* sp. in *L. analis*, *L. jocu*, *L. synagris*, and *L. vivanus*, and of *Terranova* sp. in *O. chrysurus*. Among all fish specimens evaluated for the presence of anisakids, only *O. chrysurus* presented larvae in the musculature (n = 34) which belonged to the genus *Terranova* (Table 2).

The morphological description of the parasites found is given below:

Superfamily Ascaridoidea Baird, 1853

Family Anisakidae Railliet & Henry, 1912

Subfamily Anisakinae Chabaud, 1965

Genus *Anisakis* Dujardin, 1845

Hosts: *L. analis*, *L. jocu*, *L. synagris*,

L. vivanus, *O. chrysurus*.

Site of infection: viscera (intestinal mesentery).

Location: Northeastern Coast, Aracaju, SE, Brazil.

Material examined: 56 specimens of L3 larvae

Description (Figure 1): 3rd stage larvae. Thin body (length: 20 ± 2) (Figure 1a). Cuticle with transverse striae, most noticeable in the anterior and posterior extremities, and also evident throughout the body. Anterior end with three slightly defined lips, one dorsal lip with a pair of labial papillae and two subventral lips, each with a single papilla, approximately of the same size (length: 0.06 ± 0.01), with the presence of a ventral cephalic tooth close to the oral aperture (Figure 1b). Thick cuticle; nerve ring located in the anterior region of the esophagus. Long esophagus (length: 1.5 ± 0.1), followed by a long ventriculus (length 0.5 ± 0.07) compressed against the intestine. Absence of ventricular appendix and intestinal cecum. Tail: conical, rounded and tapered with the rectum canal; mucron in the terminal region (Figure 1c).

Genus *Terranova* Leiper & Atkinson, 1914

Hosts: *L. jocu*, *L. vivanus*, *O. chrysurus*.

Infection site: viscera (intestinal mesentery) and musculature.

Location: Northeastern Coast, Aracaju, SE, Brazil.

Material examined: 5 specimens of L3 larvae

Description (Figure 2): Larvae L3, thin body (length: 12 ± 8), cuticle with transverse striae most evident in the anterior and posterior regions (terminal portion of the tail) and some along the body. Anterior end with three

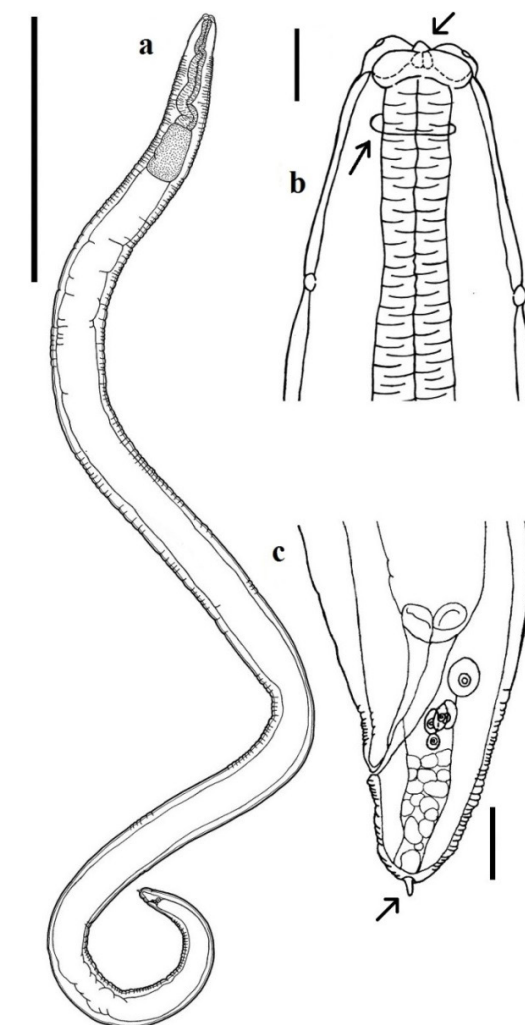


Figure 1. *Anisakis* sp. a - Larva L3 (bar: 5mm). b - Anterior region (bar: 0.06mm), arrows indicate the cephalic tooth and the nerve ring. c - Posterior region (bar: 0.06mm), arrow indicates the mucron.

underdeveloped lips, dorsal lip, and two subventral lips (length 0.07 ± 0.04). Cephalic tooth: pronounced, evident, located near the oral aperture of the larvae which lies between the subventral lips. Opening of the excretory pore near the

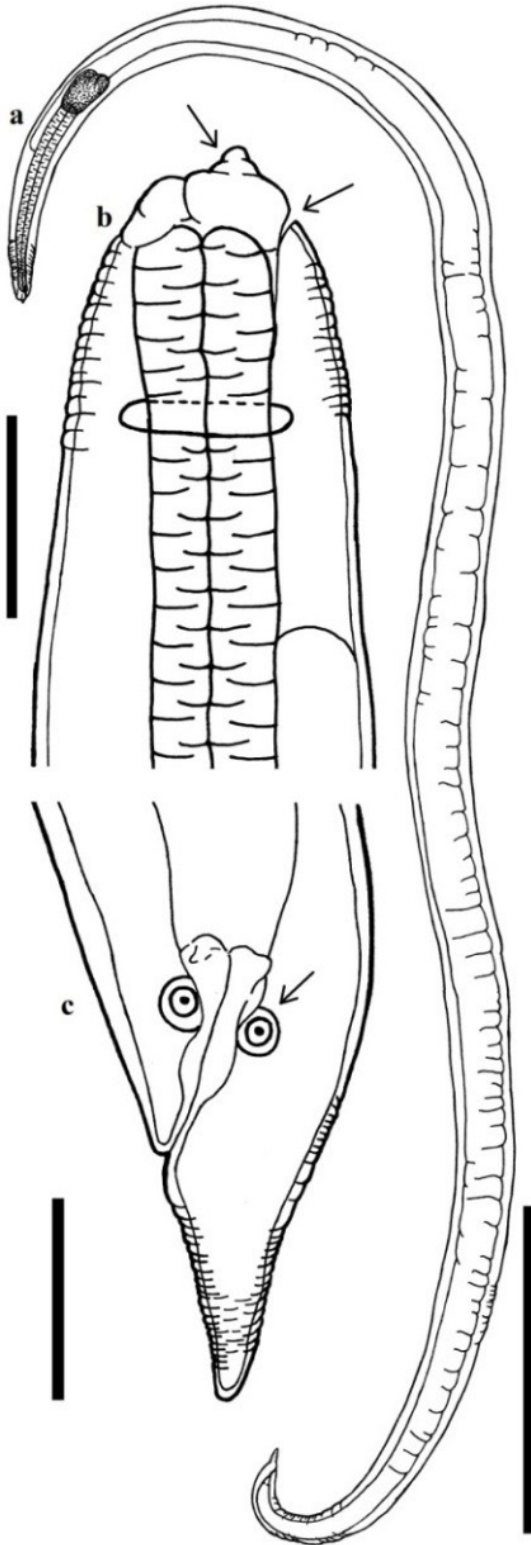


Figure 2. *Terranova* sp.; a - Larva L3 (bar: 3mm) collected from *Lutjanus vivanus* and *Lutjanus jocu*; b - Anterior region (bar: 0.04 mm); arrows indicate the cephalic tooth and opening of the excretory pore; c - Posterior region (bar: 0.04mm); arrow indicates the rectal glands.

ventro-lateral lips. Nervous ring at the anterior end of the esophagus (Figure 2b). Esophagus (length: 1.3 ± 0.5) and short ventriculus (length: 0.3 ± 0.1) without ventricular appendage. The intestinal cecum extends over the ventriculus, exceeding half of the esophagus. The posterior region has a robust, conical and transversely striated tail; mucron absent; two spherical rectal glands present (Figure 2c).

Superfamily Ascaridoidea Baird, 1853

Family Raphidascarididae Hartwich, 1954

Subfamily Raphidascaridinae Hartwich, 1954

Genus *Hysterothylacium* Ward and Magath, 1917

Host: *L. vivanus*.

Infection Site: Intestine

Location: Northeastern Coast, Aracaju, SE, Brazil.

Material examined: 1 pregnant female.

Description (Figure 3): Elongated body (length: 21), which becomes thinner in the anterior end (Figure 3a). The cuticle that lines the body is transversely striated. Whitish body. Lips: well developed; interlabium absent. It has three rounded lips with elliptical labial papillae and anterior lobes (Figure 3b). Subventral lips of the same size (length: 0.2) and slightly smaller dorsal lip (length: 0.1). Long esophagus (Length: 3) occupies 14% of body length. Oval and short ventriculus (Length: 0.2), present; short ventricular appendix (Length: 0.5). Intestinal cecum inverted and slightly longer than the ventriculus. The uterus extends

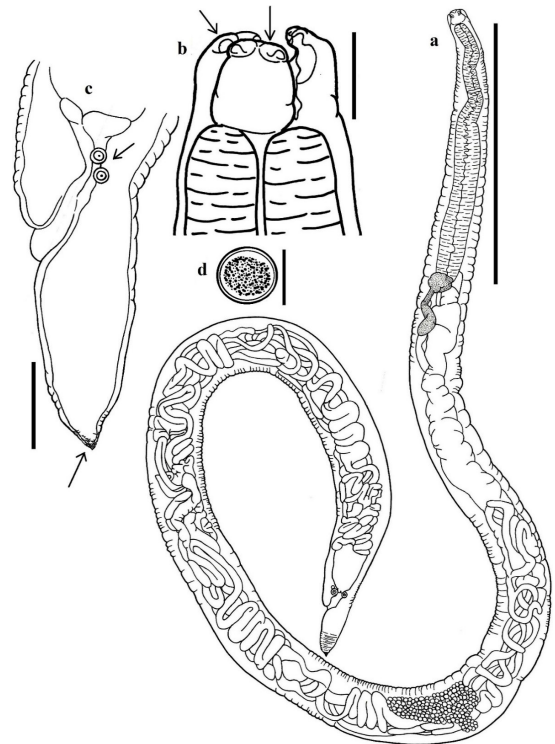


Figure 3. *Hysterothylacium* sp. a - Adult female (esophagus scale: 3mm). b - Anterior region and detail of the lips (scale: 0.2mm); arrows indicate anterior lobes; c - Caudal region; arrows indicate the rectal glands and cuticular spines at the end of the tail; d - Egg (scale: 0.01mm).

posteriorly to the level of the rectum. Numerous elliptical eggs with delicate and thin membranes (Figure 3d). Mucron absent. Conical and tapered tail, with evident transverse striations, with numerous cuticular protrusions, similar to nodules in the terminal portion of the tail (Figure 3c). Caudal region has three spherical rectal glands.

Super family Ascaridoidea Baird, 1853

Family Raphidascarididae Hartwich, 1954

Subfamily Raphidascaridinae Hartwich, 1954

Genus *Raphidascaris* Railliet & Henry, 1915

Species *Raphidascaris (Ichthyascaris)* sp.

Host: *L. vivanus*.

Infection Site: Intestine

Location: Northeastern Coast, Aracaju, SE, Brazil.

Material examined: 4 specimens (3 pregnant females and 1 male).

Description (Figure 4): Female (Figure 4 a2): Elongated body (length: 10; width: 0.67).

The cuticle of the body is also transversely striated. Relatively opaque/not very transparent body. It has three well-developed lips (length: 0.06; width: 0.07). In each lip there are anterior lobes and elliptic labial papillae, a pair of papillae in the dorsal lobe and a papilla in each subventral lobe, and also presents narrow lateral wings that join in one side of the body near the base of the lips (Figure 4b). Short esophagus (length: 1; width: 0.2) occupying 11% of the body. Flat, oval and short ventriculus (length: 0.1; width: 0.2); ventricular appendage present (length: 0.5; width: 0.1). The vulva opens shortly before the terminal region of the ventricular appendage. Uterus extends posterior to the level of the rectum. Numerous eggs occupy a large area in the central region of the body; these eggs are elliptical, and have delicate and thin membranes (Figure 4d). Conical and tapered tail, with transverse striations evident; there are small lumps similar to nodules in the terminal portion. Mucron: absent. The caudal region has three spherical rectal glands (Figure 4 c1).

Male (Figure 4 a1): Elongated body, same length and width of female (length: 10; width: 0.6). It also has three well-developed lips of approximately the same size. Lips with anterior lobes and elliptical labial papillae, a pair of papillae on the dorsalis and a papilla in each subventral. Short esophagus, of equal length to the female (length: 1mm; width: 0.2). Flat, oval and short ventriculus, as well as in female (length: 0.1; width: 0.2); ventricular appendage present, slightly larger than that of female (length: 0.6). Conical and tapered tail; mucron absent. The caudal region has three spherical rectal glands (Fig 4 c2). Ventrally curved posterior region with 36 pairs of subventral papillae. Spikes equal in length (Length: 0.3), pointed and without ornamentation, corresponding to 3% of the body length (Figure 4e).

Superfamily Ascaridoidea Baird, 1853

Family Anisakidae Skrjabin & Karokhin, 1945

Genus *Goezia* Zeder, 1800

Host: *L. analis*.

Infection Site: Intestine

Location: Northeastern coast, Aracaju, SE, Brazil

Material examined: 3 specimens.

Description (Figure 5): Medium-sized nematodes, Elongated body, male smaller (length: 7.5; width: 0.7) than female (length: 9.7mm; width: 0.7) with very thick cuticle, transversely striated body with several transverse rows of posteriorly oriented spines around the body (Figure 5a, b). The rows of thorns begin just after the lips. The lines gradually become more separate, becoming less spaced as they approach the tail. Lips nearly identical morphologically; inner part of each lip with two distinct lobes oriented towards the oral aperture (Figure 5c). Dorsal lip with two double papillae; ventro-lateral lips each with a single papilla and a double papilla. Interlabium absent. Triangular oral aperture. Esophagus occupies 9.2% of body length in females (Length: 0.9; width: 0.1) and 10.6% in males (length: 0.8; width: 0.1). Elliptical and

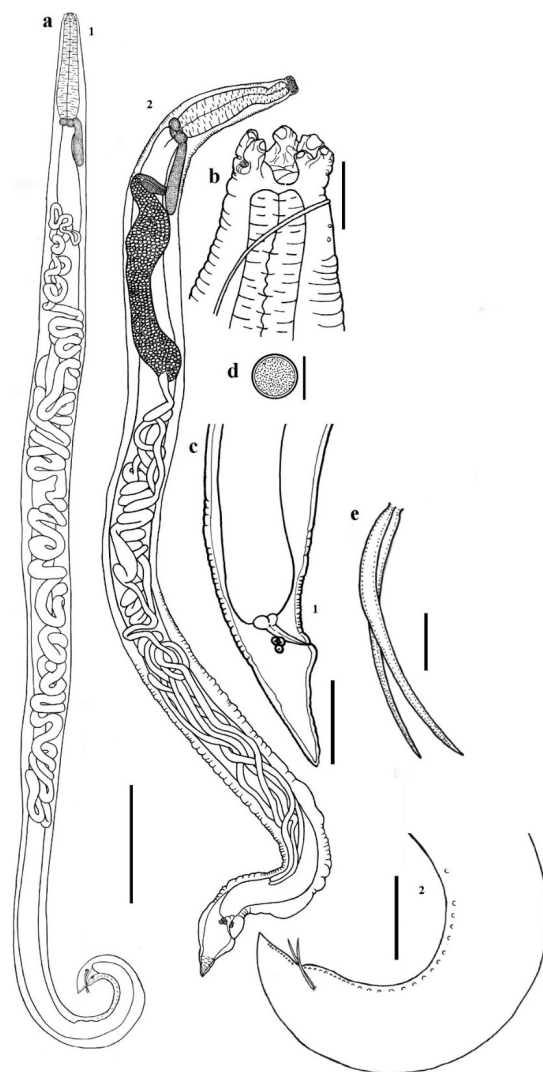


Figure 4. a1 and a2 - Female and male of *Raphidascaris (Ichthyascaris)* sp. (bar: 1mm); b - Anterior region (bar: 0.5mm); c1 and c2 - Posterior of female and male (bar: 0.5mm); d - Egg (0.01mm); e - Spikes of the core (bar: 0.1mm).

small ventriculus (Length: 0.04; width: 0.1). Ventricular appendage of the female (length: 1.4; width: 0.05) is larger than the ventricular appendage of the male (length: 0.4; width: 0.04). Intestinal cecum inverted, reaching part of the esophagus (Figure 5f). Conical tail with the digitiform process (Figure 5d). In the terminal portion of the male tail, there are cuticular spines and a pair of similar spicules (length: 0.8) (Figure 5e). In the female, there is a mucron with 20 small spines. Spherical eggs with thin, smooth shell, and non-cleaved contents (Figure 5g).

In the present survey, the presence of nematodes of the family Anisakidae was high in the fish samples examined. The non-significant correlation between the fish body length and the parasite intensity of 4 of the 5 fish species of this study allows us to infer that the parasitism by anisakids is neither determined nor influenced by the length of the host, and that fish of varying sizes may be infected and have zoonotic potential. *O. chrysurus* was the only species that presented negative and significant correlation between host's body length and intensity of anisakids. The same was observed between the abundance of *Anisakis* sp. and the body length of *L. synagris*.

Infection by these parasites involves aquatic invertebrates and fish as intermediary hosts through the food chain, which explains how fish acquire these parasites. On the other hand, the fish could play a role as paratenic hosts helping

to disseminate and spread the parasites until reaching a definitive host (Bicudo et al., 2005; Saad et al., 2012).

The larvae of anisakids showed high prevalence and intensity rates in fish tissues, in particular in the intestinal mesentery, with the highest indexes represented by *Anisakis* sp. However, larvae of *Contracaecum* sp. and *Terranova* sp. were found at lower intensities. According to Azevedo et al. (2007), the presence of these larvae in the mesentery represents a low zoonotic potential. However, due to the high intensity of anisakids collected, the zoonotic risk cannot be ruled out since these parasites may migrate to the musculature of barely live or freshly caught fish. Evidence indicates that the presence of anisakid larvae in tissues of economically important fish negatively affects fish industrialization in addition to its implications for public health (Knoff et al., 2013).

Montoya-Mendoza et al. (2014) demonstrated that *O. chrysurus* shared a rich parasitic community. The authors found larvae of the genus *Contracaecum* in the viscera of fish. In the present study, larvae of *Terranova* were found were found in *O. chrysurus* with high prevalences (more than 50%), and different from the authors regarding the site of infection (the musculature), demonstrating that larvae ability to migrate and the possibility of zoonotic transmission. To the authors' knowledge, this is the first report of *Terranova* sp. in *O. chrysurus* and *L. jocu*. Larvae of *Terranova* have been previously reported in other fish by other authors including Cordeiro and Luque (2004), Tavares and Luque (2004), Tavares et al. (2005) and Luque et al. (2008) in *Selene setapinnis*, *Netuma barba*, *Anchoa tricolor* (Spix & Agassiz, 1829), *Pseudopercis numida* Miranda-Ribeiro, 1903, and *P. semifasciata* Cuvier, 1829, respectively.

Cortes et al. (2009) reported the genera *Contracaecum* sp. and *Raphidascaris* sp. in *L. analis* and *L. synagris* in which *Raphidascaris* sp. presented the highest prevalence for both species of fish. However, the findings published of the authors may not be accurate. These authors described adults of *Contracaecum* sp. in *L. analis*. These parasites reach the adult stage only in the digestive tract of piscivorous birds and mammals which are their definitive hosts (Saad et al., 2012). The present survey also documented the occurrence of the genus *Contracaecum* and the species *L. analis* with a low intensity (n = 1 larva) which was considered an incidental finding.

Hermida et al. (2014) analyzed specimens of *L. analis*, and recorded the presence of nematodes of the genus *Hysterothylacium* (P= 3,3%; IM= 3,00±2,83; AM= 0,10±0,66), different from the present study which reported the presence of *Anisakis* sp. with higher prevalence, intensity, and abundance indices (P= 20,28%; IM= 15,28±36,27; AM= 3,10±17,15). The morphological analysis of *Anisakis* larvae in relation to the tail does not match the one described by Bicudo et al. (2005) in Rio de Janeiro, southeast Brazil, being less sharp and more rounded and conical, with mucron and transverse striations evident in the terminal region, having the morphology and length similar to those described by Felizardo et al. (2009)

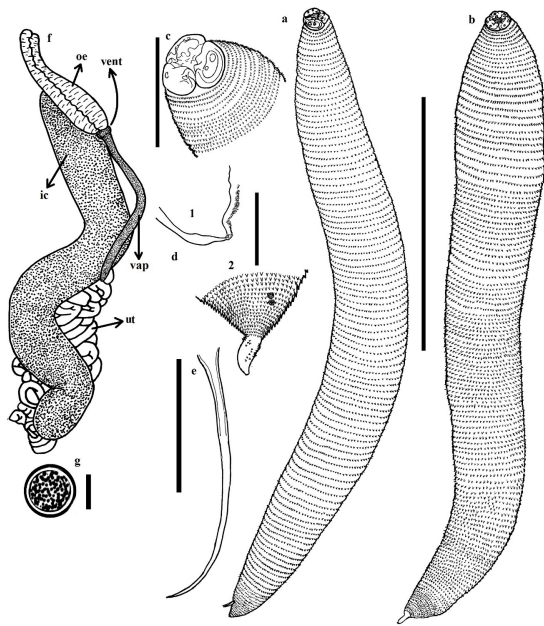


Figure 5. a and b - Male and female adults of *Goezia* sp. (bar: 1mm); c - Anterior region, with prominence of the lips (bar: 0.5mm); d- Posterior Region: 1 - terminal portion of the male; 2 - terminal portion of the female (bar: 0.5mm); e - Spicule of the male (bar: 0.6mm); f - arrangement of internal organs: esoph - esophagus vent - ventriculus; apv - ventricular appendage; inc - intestinal cecum; ut - coiled uterus g - Egg (bar: 0.01).

and Saad et al. (2012). Larvae of *Terranova* were larger in relation to other larvae of *Terranova* spp. reported by other authors; the excretory pore located near the ventrolateral base of the lips and the short intestinal cecum were morphological characters that corroborated with previous findings published by Tavares et al. (2007), Saad et al. (2012), and Fonseca et al. (2016).

The genus *Goezia* is known for presenting general morphological characters such as three radial lips and thick striated cuticle with several crowns of spines projected from the back of each segment. Its life cycle is not yet fully known and warrants further research (Deardorff and Overstreet, 1980). *Goezia* species have been reported in several species of fish including *Rhaphiodon vulpinus*, *Serrasalmus marginatus*, *Ageneiosus valenciennes*, *Hoplosternum littorale*, *Arapaima gigas*, *Hemisorubim platyrhynchos*, *Mylossoma orbignyanus*, *Parauchenipterus galeatus*, *Pimelodus maculatus*, *Leporinus friderici*, *Ageneiosus militaris*, *Trachelyopterus galeatus*, *Brycon orbignyanus*, *Piacactus mesopotamicus*, *Oxydoras knerii*, *Iheringichthys labrosus*, and *Macrodon ancylodon*, (Moravec et al., 1993; Vicente and Pinto, 1999; Abdallah et al., 2006; Santos and Moravec, 2009; Azevedo et al., 2010; Eiras et al., 2010; Kohn et al., 2011; Fujimoto et al., 2012).

The majority of the studies on *Goezia* include freshwater fish. Studies of this genus of nematode in marine fish, especially in Lutjanidae, are scarce. In the present study, *Goezia* sp. was found in the intestinal lumen of the gut at low intensity. These were adult specimens/pregnant females which suggests that *Lutjanus analis* was playing the role of the definitive host for this parasite. Records of this parasitic group in lutjanids are rare. There are only one other case published by Rizwana et al. (2000) describing *Goezia argentimaculati* in *Lutjanus argentimaculatus*. All species of *Goezia* are parasites of freshwater fish. Thus, parasitic infestations of *L. analis* by nematodes may be explained by the estuarine behavior of fish which may have acquired the parasites through the trophic chain. The presence of adult specimens of *Goezia* sp. in the intestine in *L. analis* is considered a novel finding.

Raphidascaris and *Hysterothylacium* are parasites that have teleost fish as intermediate, paratenic, or definitive hosts. These were the only genera found as adults in *L. vivanus* (*Raphidascaris* (*Ichthyascaris*)) as follows: 3 pregnant females and 1 male; *Hysterothylacium*: 1 pregnant female) being considered as new occurrences of these parasites in this species of fish and demonstrating that this species of fish is playing a role as the definitive hosts in the life cycle of these parasites, unlike other studies published elsewhere that reported only larvae of this group of nematodes parasitizing fish. *Raphidascaris* (*Ichthyascaris*) sp. presented lower body and esophagus length and esophagus size in relation to the larger body when compared to the parameters described for *R. (I.) etelidis* in *Etelis coruscans* (Lutjanidae) by Moravec and Justine (2012) (10mm, 1mm and 11% x 26.63mm, 2.30, 8.1%, respectively). Two other species of the same subgenus, one in New Caledonia (Moravec and Justine, 2005) and

one in China (Xu et al., 2012) have also been described. The number of subventral papillae and the size of the spicules in relation to the body were within the average of the parameters of species such as *R. (I.) nemipteri* Moravec and Justine (2005); *R. (I.) arii* Yooyen et al. (2011); *R. (I.) longispicula* L, Li et al. (2012), and *R. (I.) lophii* (Wu, 1949).

The genus *Hysterothylacium* was initially included in the family Anisakidae, but was then moved into the family Raphidascarididae (Eiras et al., 2015) composing the family together with *Raphidascaris*. In the present study, the specimen of *Hysterothylacium* sp. found in *L. vivanus* was an adult female with eggs. It had a long esophagus and an inverted intestinal cecum slightly longer than the ventriculum which is a morphological feature shared by three other species: *H. longilabrum* Li, Liu & Zhang, 2012; *H. anguillae* Moravec et al. (2012), and *H. gibsoni* Xu et al. (2014). However, the second species was found in rivers whereas the others occur in marine environments. In Brazil, the genus has been reported in several marine and freshwater fish (Eiras et al., 2015). We believe that this is the first record of *Hysterothylacium* sp. in *L. vivanus*.

Anisakids reach adulthood in the digestive tract of birds and marine mammals which are definitive hosts of these nematodes, and have aquatic invertebrates and fish as intermediary or paratenic hosts during their larval stages (L1, L2, L3, and L4) (Eiras et al., 2015). Therefore, identification at the species level is only possible using molecular tools. For *Raphidascaris* (*Ichthyascaris*) sp., only one male specimen was found, which made it difficult to accurately identify the species. Only one gravid female of *Hysterothylacium* was detected.

Azevedo et al. (2007) states that due to the complexity of marine environments, life cycle adaptations of parasites may occur. This may explain the occurrence of *Hysterothylacium* sp, *Raphidascaris* (*Ichthyascaris*) sp. and *Goezia* sp. in adult stage in lutjanids.

In conclusion, this is the first records of *Raphidascaris* (*Ichthyascaris*) sp. and *Hysterothylacium* sp. in *L. vivanus*, of *Terranova* sp. in *O. chrysurus*, and of *L. jocu* and *Goezia* sp. in *L. analis*. Based on the findings of the present survey, the Brazilian northeast coast and the state of Sergipe are now included in the geographic distribution of these nematodes of fish in the country. Significant correlations between host body length and parasitic fauna for *Ocyurus chrysurus* and *Lutjanus synagris* are new data for these species.

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