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Abstract. One hundred thirty two starry triggerfish, *Abalistes stellatus* (Bloch and Schneider, 1801) (Tetraodontiforms: Balistidae), collected from the fish market of Hodeidah and Luhayah, Yemen coastal water, between 5 October 2009 and 20 April, 2010, were necropsied to study their nematode larvae. 17 (12.9%) were parasitized by nematode larvae of *E. overstreeti* Deardorff & Ko, 1983. The prevalence of parasite infections in fish species in relation to sex of their host was studied. These larvae of this species are reported and described for the first time from waters of Yemen and *Abalistes stellatus* is a new host species for *E. overstreeti*.

Introduction

Nematodes (Phylum Nematoda) are recognized as a natural group, a very special one, comprising a large group of animals. Most are quite small, free-living in mud and soil in freshwater, in the sea and on land, and many are plant parasites. But many are parasites in animals-in invertebrates and vertebrates: Fishes, amphibians, reptiles, birds and mammals- in their digestive tracts, muscles or other tissues, including blood (Berland, 2006). The number of estimated nematode species varies between 500,000 (Hammond, 1992) and one million (May, 1988). The number of nematode species described from vertebrates has also been variably reported as 14,000 (Gardner, 2000) or 8,359 (Hugot *et al.*, 2001). According to the recently proposed system for Nematoda by De
Ley and Blaxter (2002, 2004) largely based on molecular trees, the suborder Spirurina is very large, including 21 super families. About 300 species belonging to four super families (Gnathostomatoidea Railliet, 1895; Habronematoidea Chitwood et Wehr, 1932; Physalopteroidea Railliet, 1893, and Thelazioidea Skryabin, 1915) of the nematode suborder Spirurina are known as the adult parasites of freshwater, brackish-water and marine fishes (Moravec, 2007). Each of the above mentioned spirurine super families with fish parasites comprises a single family in which these fish nematodes are placed: Gnathostomatidae Railliet, 1895 (3 genera, 12 species) in Gnathostomatoidea; Physalopteridae Railliet, 1893 (4 genera, about 37 species) in Physalopteroidea; Cystidicolidae Skryabin, 1946 (23 genera, about 140 species) in Habronematoidea; and Rhabdochonidae Travassos, Artigas et Pereira, 1928 (10 genera, about 114 species) in Thelazioidea.

The life cycles of fish spirurines involve aquatic arthropods (crustaceans or aquatic insects) as obligate intermediate hosts; thus they resemble those of other spirurid nematodes parasitizing terrestrial vertebrates where a variety of arthropods serve as intermediate hosts (Anderson 2000). Fish spirurine nematodes are widely distributed among freshwater, brackish-water and marine fishes, sometimes these nematodes occur in large numbers in their piscine hosts, which suggests that they may affect the health condition of the fish and decrease its resistance against secondary infections. Some of these nematodes were recorded as important pathogens of fishes (Schäperclaus, 1954; Kinkelin et al., 1973; Bauer et al., 1977; Jilek and Crites, 1982; Moravec, 2007).

Some species of adult fish spirurines parasitize a wide range of hosts; others exhibit a relatively narrow host specificity. Within the Gnathostomatidae, the genus Echinocephalus Molin, 1858 includes at present nine valid species that are limited in host distributed species primarily to marine and freshwater stingrays (Hoberg et al., 1998).

Adults of the nematode genus Echinocephalus occur in the stomach and spiral valve of sharks and rays in various regions of the world. Larval stages occur commonly in the gonads or adductor muscles of mollusks as well as in the mesenteries of teleosts (Beveridge, 1987), fishes, serving thus as paratenic hosts for many species parasitic in adulthood in terrestrial vertebrates, mainly birds and mammals but also fishes and an
additional source of infection for the definitive host (Moravec 1994, Anderson 2000).

In general, nematode larvae are common in most of the teleost fish since they are swallowed when fish eat their prey, which are the intermediary hosts of these worms that are encapsulated in viscera or muscle. The host makes a capsule of connective tissue in order to isolate the parasite. The most important nematode genera found in fish and also those that are important for public health are: *Anisakis, Pseudoterranova; Gnathostoma; Eustrongylides; Contracaecum; Phocascaris* and *Hysterothylacium* (Núñez et al., 2004). Presence of these parasites in various ecosystem and mediums such as water, plants, humans, animals, fishes and other aquatic resources are of great importance and concern (Azmat and Akhter, 2009). Parasitic nematodes are estimated to affect over a billion people world wide, primarily in the third world countries (Nordbring-Hertz, 1988).

Parasitological examinations of 132 specimens of Balistidae, *Abalistes stellatus* of the Yemen coast out in 2009 and 2010 revealed, among other helminthes, Larvae of one gnathostomatid nematode not previously recorded from Yemen coastal waters. The results of detailed study of this parasite is presented herein.

**Materials and Methods**

A total of 120 specimens of *Abalistes stellatus*, (15-45cm length), were collected from the fish market of Hodeidah City-Yemen, during the period from 5 October, 2009 to 20 April, 2010, and examined thoroughly for the presence of nematode larvae in the stomach, intestine, visceral organs and abdominal cavity. Sex was determined in all fishes (The mature fishes and the fish in the spawning season were identified by looking at the color of the gonads, while the immature fishes by microscopic examination of gonads, testes or ovary, smears); there were 59 males and 61 females. Other samples, 12 fish specimens (20-50 cm length) were taken from fish market of Luhayah about 85 km northern of Hodeidah, one male was infected in 2 nematode larvae (Table 1). These markets are all quite different.

Fish were obtained alive or fresh and the larvae were removed from the surrounding host tissue, counted, and the sites of infection noted.
Morphological examinations were carried out with fresh and fixed larvae. After washing in physiological saline, all fresh specimens were examined directly using light microscope. Parasites collected were in excellent condition; the nematodes were fixed alive in hot 70% ethanol. However, larvae of *Echinocephalus overstreeti* Deardorff and Ko,1983 were collected from stomach, body cavity, visceral organs and the intestine. They were cleared with glycerin. Drawings were made with the aid of Panasonic type camera, model No. DMC.TZ2. Japan and Camera Lucida. Nematode specimens were identified to the species level using Moravec and Justine (2006) and on the assistance of Prof. Dr. Luiz Eduardo Roland Tavares, Departamento de Parasitologia Animal, Universidade Federal Rural do Rio de Janeiro, Brazil.

**Results and Discussion**

**1- Observation.**

Frequency of nematode infection in *Abalistes stellatus*:

A total of 132 fish specimens of *Abalistes stellatus* taking from two different fish market were examined. 120 fish individuals from Hodeidah fish market were studied from 5 October 2009 to 20 April 2010. Of these, 16 (13.3%) were infected (Table 1). The percentage infected in each sample ranged from 0-65%. There were 59 males and 61 females, and 11 and 5 were infected, respectively. The second sample consisting of 12 fish individuals from Luhayah fish market, these fish were examined during April and May 2010, the sample of *Abalistes stellatus* from Luhayah market were had lower incidences of infection than those from Hodeidah market (Table 1).

**2-Parasite**

A total of 27 nematode larvae of *Echinocephalus overstreeti* Deardorff and Ko,1983, were collected from 17 specimens of fish, *Abalistes stellatus*, obtained from fish market of Hodeidah and Luhayah, Yemen coastal water. The overall prevalence of infection, 12.9%; intensity, 1-2 larvae per each infected fish, and mean intensity, 1.6.

**Classification**

Nematoda (Rudolphi,1808) Lankester, 1877  
Class: Secernentea Von Linstow, 1905  
Order: Spirurida Chitwood, 1933
Suborder: Spirurina
Super family: Gnathostomoidea Railliet, 1895
Family: Gnathostomatidae Railliet, 1895
Subfamily: Gnathostomatinae Railliet, 1895
Genus: Echinocephalus Molin, 1858

*Echinocephalus overstreeti* Deardorff and Ko, 1983 (Fig.1)

![Fig. 1. Echinocephalus overstreeti from *Abalistes stellatus*. A-Whole larva. B- posterior end, lateral view. C- Spines of rows 1 to 6. D- Cephalic end. E- Esophageal region.](image)

**Description and Some Measurements (5 Specimens)**

Body covered with fine annular striations, length = 12-20 mm maximum width = 0.350-0.650. Mouth surrounded by two lateral pseudo labia, pseudo labia simple, 0.33-0.40 long, bearing amphids and pairs of cephalic papillae. Cephalic bulb, 0.22-0.40 long by 0.25-0.35 wide, its armed with 6 rows of subulate hooks arranged in semi-circles, composed of about 90-140 hooks each. Larger hooks toward posterior (spines generally increasing in size from 1 to 6 row). Maximum length of spines, 0.034-0.036 (0.035 mm). Oesophagus 2.80-3.00 mm long. Nerve ring 0.450-0.600 mm from anterior extremity. Tail conical, pointed, 0.18-0.29 long.
3-Host

Starry triggerfish, *Abalistes stellatus* (Balistidae), is reef-association; depth range 7-350 meters (Khalaf and Zajonz, 2007); lay demersal eggs that are guarded by one of the parents (Leis and Carson-Ewart, 2000); typically have an extended pelagic juvenile phase. It is the most commonly discarded species in the fishery and comprises 1.1% of the total catch by number (Newman *et al.*, 2001).

Table 1. Incidence of specimens of fish, *Abalistes stellatus* infected with *Echinocephalus overstreeti* larvae.

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of fish</th>
<th>Number (and per cent) infected with <em>E. overstreeti</em> larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>From Fish Market, Hodeidah</td>
</tr>
<tr>
<td>5 Oct.2009</td>
<td>8.0 (3 ♂ + 5 ♀)</td>
<td>2.0 (25.0) = ♂ (66.7)</td>
</tr>
<tr>
<td>24 Oct. 2009</td>
<td>6.0 (4 ♂ + 2 ♀)</td>
<td>0.0 (0.00) = n.inf.</td>
</tr>
<tr>
<td>11 Nov.2009</td>
<td>4.0 (3 ♂ + 1 ♀)</td>
<td>1.0 (25.0) = ♂ (33.3)</td>
</tr>
<tr>
<td>22 Nov. 2009</td>
<td>9.0 (4 ♂ + 5 ♀)</td>
<td>1.0 (11.1) = ♀ (20.0)</td>
</tr>
<tr>
<td>5 Dec. 2009</td>
<td>10 (7 ♂ + 3 ♀)</td>
<td>0.0 (0.00) = n.inf.</td>
</tr>
<tr>
<td>25 Dec. 2009</td>
<td>3.0 (1 ♂ + 2 ♀)</td>
<td>2.0 (66.7) = ♂ (100) + ♀(50.0)</td>
</tr>
<tr>
<td>12 Jan.2010</td>
<td>5.0 (3 ♂ + 2 ♀)</td>
<td>2.0 (40.0) = ♂ (66.7)</td>
</tr>
<tr>
<td>27 Jan. 2010</td>
<td>8.0 (5 ♂ + 3 ♀)</td>
<td>0.0 (0.00) = n.inf.</td>
</tr>
<tr>
<td>5 Feb. 2010</td>
<td>12 (5 ♂ + 7 ♀)</td>
<td>2.0 (16.7) = ♂ (20.0) + ♀(14.3)</td>
</tr>
<tr>
<td>24 Feb. 2010</td>
<td>10 (5 ♂ + 5 ♀)</td>
<td>1.0 (10.0) = ♂ (20.0)</td>
</tr>
<tr>
<td>3 Mar. 2010</td>
<td>12 (4 ♂ + 8 ♀)</td>
<td>0.0 (0.00) = n.inf.</td>
</tr>
<tr>
<td>22 Mar.2010</td>
<td>11 (6 ♂ + 5 ♀)</td>
<td>1.0 (9.10) = ♀(20.0)</td>
</tr>
<tr>
<td>6 Apr. 2010</td>
<td>12 (5 ♂ + 7 ♀)</td>
<td>2.0 (16.7) = ♂ (20.0) + ♀(14.3)</td>
</tr>
<tr>
<td>20 Apr2010</td>
<td>10 (4 ♂ + 6 ♀)</td>
<td>2.0 (20.0) = ♂ (50.0)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>120(59 ♂ + 61 ♀)</strong></td>
<td><strong>16 (13.3) = 11 ♂(18.6) + 5 ♀(8.2)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>From fish Market, Al-Luhayah</td>
</tr>
<tr>
<td>16 Apr.2010</td>
<td>8.0 (7 ♂ + 1 ♀)</td>
<td>0.0 (0.00) = n.inf.</td>
</tr>
<tr>
<td>4 May.2010</td>
<td>4.0 (2 ♂ + 2 ♀)</td>
<td>1.0 (25.0) = ♂ (50.0)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12 (9 ♂ + 3 ♀)</strong></td>
<td><strong>1.0(8.3) = 1 ♂(11.1)</strong></td>
</tr>
</tbody>
</table>

* No infective.

The larval stages of this gnathostomid nematode were found in the stomach, body cavity, intestine and visceral organs of the 17 (12.9%) specimens of *Abalistes stellatus* at various time during the period of study. The intensity of infection was generally low with no more than 2 worms per infected fish. Ko (1976) recovered that the larvae of *Echinocephalus sinensis* in oysters at various time in the year, and she mentioned, infections, however, were only achieved with larvae collected from August to October, suggesting that temperature might be a factor in infectivity. Several factors that arise from 1) the origin of the parasite and
fish, 2) intra- and intraspecific associations between the parasites, 3) the immune functions of the host (Voutilainen, 2009), and 4) both a biotic and biotic factors (MacKenzie et al., 1995) which also influence the prevalence, intensity and abundances of a given parasite species. Moreover, the factors may interact with each other. Although male and female of _Abalistes stellatus_ were almost equal in number (59♂ and 61♀).

In the present study, it is reported that the infection of fish, _Abalistes stellatus_ was more in males than females. Knoff, _et al._ (1997) mentioned that the positive correlation between the sex of the host and the infection was seen in _Mugil platanus_, in which 30% of the components of its parasite community showed differences in their prevalence and abundances relative to host sex. Hemmingsen _et al._ (2000) reported a significantly higher prevalence of the Anisakid nematode _Contracaecum_ sp. in male cod from Balsfjord in northern Norway and suggested potential differences in feeding behavior between sexes. Similar findings have been reported in many freshwater and marine fishes (Al-Zubaidy, 2010), and the main reason for the differences in parasitic load with sex is thought to be physiological. However, endo parasites have been reported to infest the two sexes differentially because male and female fish often have different feeding habits (Rohde, 1993; Aloo _et al._, 2004).

According to Esch _et al._ (1988), host sex can influence parasitism levels due to the behavior and physiological differences between them. Parasites are believed to play a significant role _e.g._, in the evolution of sexual selection and the immune system and in maintaining the genetic diversity of their hosts (Poulin 2007). The influence of host sex, despite its widely citation on the pertinent literature, is usually minimized in papers dealing with communitary analysis (Poulin,1996). Data banks on marine fishes indicates that many parasites did not present quantitative variations caused by host sex (Chaves and Luque, 1999). This is considered to be a reflex of lack of differences in the biology and population dynamics of male hosts (Luque _et al._,1996). Nevertheless, further research is needed in order to visualize the influence of other factors, such as hormonal, immunologic, morphological and behavioral (Bundy, 1988).
Table 2. Comparison between some measurements (in mm) of larvae of *E. overstreeti* from Red Sea fish, *Abalistes stellatus*, Yemen coast with other Localities.

<table>
<thead>
<tr>
<th>organs</th>
<th><em>E. overstreeti</em></th>
<th><em>E. overstreeti</em></th>
<th><em>E. overstreeti</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Body L:</td>
<td>14.59- 26.90</td>
<td>12.9- 14.3(13.7)</td>
<td>12- 20</td>
</tr>
<tr>
<td>W:</td>
<td>0.408- 0.789</td>
<td>0.28- 0.35(0.31)</td>
<td>0.350- 0.650</td>
</tr>
<tr>
<td>Pseudo labia</td>
<td>0.40- 0.42</td>
<td>-</td>
<td>0.33- 0.40</td>
</tr>
<tr>
<td>Cephalic bulb L:</td>
<td>0.272- 0.422</td>
<td>0.25- 0.40 (0.33)</td>
<td>0.22- 0.40</td>
</tr>
<tr>
<td>W:</td>
<td>0.340- 0.422</td>
<td>0.30- 0.36 (0.33)</td>
<td>0.25- 0.35</td>
</tr>
<tr>
<td>Spine length</td>
<td>0.24-0.57</td>
<td>0.020-0.025(0.023)</td>
<td>0.34-0.036(0.035)</td>
</tr>
<tr>
<td>Oesophagus</td>
<td>3.26- 3.29</td>
<td>2.2- 4.4(3.3)</td>
<td>2.80 - 3.0</td>
</tr>
<tr>
<td>Located of nerve</td>
<td>0.476-0.625</td>
<td>-</td>
<td>0.450-0.600 from anterior extremity</td>
</tr>
<tr>
<td>Host <em>Taeniura meyen</em></td>
<td>Scallops (Mollusca):Chlamys bifrons, and Pecten albus</td>
<td><em>Abalistes stellatus</em></td>
<td></td>
</tr>
<tr>
<td>Site of infection.</td>
<td>Stomach</td>
<td>Gonads and muscles</td>
<td>Body cavity, visceral organs, and intestine</td>
</tr>
<tr>
<td>Locality</td>
<td>South Pacific Ocean off Noumea, New Caledonia</td>
<td>Northaven- South Australia</td>
<td>Red Sea, Yemen coastal water</td>
</tr>
</tbody>
</table>

Larvae of *Echinocephalus* are frequently found in a variety of teleosts and mollusks, serving apparently as paratenic hosts, but their species identification is problematic. Moravec and Justine (2006) pointed out that the numbers and arrangement of minute spines in the anterior dorsal and ventral groups on the cephalic bulb may be a rather reliable taxonomic criterion for their identification. The present larvae were identified as *E. overstreeti* Deardorff and Ko, 1983 based on the characters of the head bulb (Moravec and Justine, 2006), the cephalic papillae and pseudo labia, and on the assistance of Prof. Dr. Luiz Eduardo Roland Tavares. The morphology and measurements of specimens of the present material correspond, more or less, to the descriptions of the larvae of this species from others localities (See Fig. 1 and Table 2).
Adult specimens of *Echinocephalus overstreeti* was originally described by Deardorff and Ko (1983) from the ray *Taeniura melanospilos* Bleeker (syn. of *T. meyeni*) from off the Marquesas Islands, Australian waters. Later adult specimens were recovered from 2 of 2 (100%) and 13 of 15 (87%) *Dasyatis sephen* (Forsskal); from 1 of 2 (8%) *Myliobatis australis* Macleay; from 1 of 1 (100%) *Urogymnus asperrimus* (Bloch and Schneider); from 2 of 2 (100%) *Taeniura melanospilos* (type-host), and 2 of 4 (50%) and 1 of 1 (100%) from the shark, *Heterodontus portusjacksoni* (Meyer) (Beveridge, 1987, 1991; Brooks and Deardorff, 1988; Moravec and Justine, 2006).

The present finding represents a new locality record for this nematode which previously was unknown from the Red Sea, Yemen coasts, and *Abalistes stellatus* is a new host species for *E. overstreeti*. In addition, our findings also extend the geographic range of the larvae of this species, which is known from Australian and Caledonia coastal waters (Beveridge, 1987; Moravec and Justine, 2006). The present report also considerably extends the host range of *E. overstreeti*, which is known from rays; sharks and Mollusca belonging to different families (Deardorff and Ko, 1983; Beveridge, 1987; Moravec and Justine, 2006).

If infected hosts invade a new locale and their parasites become established, these invasive parasites may impact native species if they can recruit to novel hosts, e.g., the swim bladder nematode, *Anguillicola crassus*, native to Asia, *A. crassus* has been introduced to Europe and North America where it now infects native eels in both natural and cultured conditions. *Anguillicola crassus* can reach high prevalences in native eel populations and it can cause severe pathology in European and North American eels (Barse and Secor, 1999).

The rhizocephalan barnacle, *Heterosaccus dollfusi*, followed its portunid host crab, *Charybdis longicollis*, from the Red Sea through the Suez Canal to the Mediterranean Sea. However, while *C. longicollis* invaded the Mediterranean before 1954 and is now well established, its parasite has only recently arrived (Galil and Innocenti, 1999).

Larval stages of the nematode genus *Echinocephalus* have been found in the gonads or adductor muscles of mollusks *Amusium balloti* Bernardi, 1861; *Katylesia scalarina* (Lamarck, 1818), and *Polinices conicus* (Lamarck, 1822) (Johnston and Mawson 1945a; Lester et al., 1980). *Echinocephalus pseudouncinatus* was originally described from...
numerous juvenile specimens found in the foot of pink abalones *Haliotus corrugata* from San Clemente Island off Southern California (Millemann, 1951). Juveniles of another species of *Echinocephalus*, *E. uncinatus*, are known to infect Sea urchins and mollusks elsewhere (Baylis and Lane, 1920), as well as in the mesenteries of the some teleosts species *Chrysophrys auratus*, *Platycephalus arenarius* and *Sillaginodes punctatus* (Johnston and Mawson 1945 b; Hooper 1983; Beveridge, 1987).

Because life cycles for species of *Echinocephalus* involve mollusks, as intermediate hosts (Ko, 1975), the possibility of accidental infection in humans is apparent. In this regard, the larval stages of *E. sinensis* Ko, 1975, have been shown to be capable of penetrating the gastrointestinal tract and undergoing random visceral migrations in a variety of mammals (Ko *et al.*, 1975; Ko, 1976). This species, therefore, may represent a human health risk to consumers of the raw oyster, where the worm's life cycle is known to exist. Thus, like other gnathostomatids such as *Gnathostoma spinigerum* Owen, 1836, can pose a health risk for humans (Hoberg *et al.*, 1998).

Acknowledgment

I would like to express my deep gratitude to Prof. Dr. Luiz Eduardo Roland Tavares, *Departamento de Parasitologia Animal, Universidade Federal Rural do Rio de Janeiro*, Brazil for his assistance in identification of the parasitic infestation.

References


يرقات إيكينوسيفاليس أوفرستريتي ديردورف
وكر، 1983 (نيماتودا: جناثوستوماتيدا) في أسماك البحر الأحمر، أباليستس ستيلاتس (بالبيستيدي)، المياه الساحلية اليمنية
على يناوي الزبيدي
قسم الأحياء البحرية والمصائد، كلية علوم البحار والبيئة، جامعة الحديدة، اليمن

أماלה المستخلص. تم جمع 132 نموذج من السمكة
(تعزف محليا بالسمكة الخنزيرية أو حجوم) العائدة إلى رتبة
Balistidae وعائلة Tetraodontiformes
في كل من مدينتي الحديدة واللحبية، المياه الساحلية اليمنية، خلال
السماك بين 5 أكتوبر 2009 و20 إبريل 2010م. فحصت الأسماك
بحثا عن يرقات الديدان الخيطية، وكانت النتائج: إصابة 17 سمكة
(12.9%) بيرقات الطور الثالث للديدان الخيطية إيكينوسيفاليس
أوفرستريتي إذ تم تشخيصها ووصفها لأول مرة من المياه البحرية
اليمنية، كما تم تسجيل سمكة Abalistes stellatus
السماك. وكذلك تمت دراسة نسبة وشدة الإصابة طبقا لجنس العائل
السمكي.