Occurrence and Intensity of Anisakid Nematode Larvae in Some Commercially Important Fish Species in Persian Gulf

*Maryam DADAR ¹, Alireza ALBORZI ², Rahim PEYGHAN ¹, Milad ADEL ³

1. Department of Aquatic Animal Health and Diseases, Faculty of Veterinary Medicine, Shahid Chamran University of Ahvaz, Ahvaz, Iran
2. Department of Parasitology, Faculty of Veterinary Medicine, Shahid Chamran University of Ahvaz, Ahvaz, Iran
3. Department of Aquatic Animal Health and Diseases, Iranian Fisheries Research Center, Tehran, Iran

Abstract

**Background:** Anisakid nematodes are common parasites of fish, mammals, fish-eating birds, and reptiles with a worldwide distribution, causing diseases in human, fish and important economic losses.

**Methods:** A preliminary epidemiological study was carried out on Anisakid nematodes larvae in some commercially important fish species to evaluate the anisakid nematode larvae from greater lizardfish, (*Saurida tumbil*), Japanese thread fin bream (*Nemipterus japonicus*), crocodile longtom (*Tylosurus crocodilus crocodiles*) and longfin trevally (*Carangoides armatus*) from the Persian Gulf of Iran.

**Results:** The collected larvae were identified mainly as the third larval stage (L3) of *Hysterothylacium* larval type A, B and C, *Anisakis* sp., *Raphidascaris* sp., *Pseudoterranova* sp. and *Philometra* sp. (Nematoda: Philometridae). The prevalence of Anisakid larvae infection of examined fishes was 97.2% in *N. japonicus*, 90.3% in *S. tumbil*, 20.5% in crocodile longtom and 5.5% in longfin trevally. *Anisakis* type III for the first time was different from *Anisakis* type I and *Anisakis* type II.

**Discussion:** Zoonotic anisaksids by high prevalence in edible fish could be a health hazard for people. So health practices should be considered in these areas.

Introduction

Zoonotic diseases are important threats in economics value and produce animal protein. These diseases can impair public health and wellbeing (1). Humans suffer from multiple parasitic foodborne zoonoses that many of which are caused by nematodes (2). The behavior of homo sapiens has important role in the
parasitic zoonosis. Human anisakidosis is a recognized zoonosis that is directly connected to the reactions that could lead to inflammatory lesions, allergic response and eosinophilic granulomas (3, 4). Most wild and farmed fish species can be infected by parasites at same stage of their development (5), although literature indicates that only some of them cause disease in human (6). Like pathogenic bacteria, chemical residues, pesticides and heavy metals, parasites are considered as an important risk factor for evaluation fish quality (7).

Nematodes are one of the most common parasites found in aquatic organisms, particularly those belonging to the anisakid family that includes parasites of considerable economic and medical importance (5, 8). These nematodes from the superfamily Ascaridoidea (family Anisakidae with three subfamilies: Anisakinae; Raphidascaridinae and Geozini) are extensive distributed parasites in the Asia (Iran, Korea, Japan), Europe (The Netherlands, France, the United Kingdom, Spain, Germany, Italy), Africa (Egypt), and the Americas (Alaska, Hawaii, Canada). Their life cycles comprise of invertebrates and fish as intermediate hosts, and fish, sea mammals, mammals as well as fish-eating birds being definitive hosts (9). Although these parasites can infect humans after consumption of raw or insufficient cooking fish, there is some evidence suggesting that risk related to not only on the presence of living organisms (10, 11) but it is also connected to the dead parasites that capable of producing proteins and could induce hypersensitivity and allergic reactions (12-14). During infection, other clinical manifestations are important. Some of these signs consist of epigastric pain, as well as systematic or gastrointestinal symptoms, fever, diarrhea, vomiting, gastric and duodenal ulcers (15-17) and intestinal obstruction (18, 19).

While the parasites and their impact on human health have been investigated in many fish species worldwide, there has been a little study of parasites in commercial fish in Persian Gulf. The purpose of this study was to determine how the prevalence and mean intensity of nematode infections varied according to commercially important fish species in Persian Gulf.

### Material and Methods

From October 2010 through April 2012 the nematode larvae were examined from four species of fish, including Saurida tumbil (n=31), Nemipterus japonicus (n=37), Tylosurus crocodilus crocodiles (n=34) and Carangoides armatus (n=30). For this purpose fish were examined for the nematode larvae from Choebbed, Boushehr and Dayyer ports from Iran's shores of the Persian Gulf (26.0000° N, 52.0000° E) following the method of Cannon and Deardorff (1, 20). Fish were transported to the central laboratory of Aquatic Animal Health in Chamran University of Ahvaz, Iran and each specimen was individually measured for the total length (cm) and weight (g) (Table 1).

To determine the presence of nematode larvae, each fish were dissected and intestine, stomach, muscles, ovary and body cavity were observed carefully. The collected nematode larvae were washed several times using saline solution and stored in 70% ethanol. They were cleared in glycerine for examination and were identified using stereo- and light microscopy.

### Results

The overall prevalence of anisakids in fish from Persian Gulf was 90.3% in S. tumbil, 97.2% in N. japonicus, 20.5% in T. crocodilus croc-
odile and 5.55 in C. armatus. Of 31 S. tumbil, 37 N. japonicus, examined, 34 T. crocodilus crocodil and 36 C. armatus 28, 36, 7 and 2 were infected by at least one parasite, respectively. Parasite species were identified Anisakis sp., Pseudoterranova, Hysterothylacium type A, Hysterothylacium type B, Hysterothylacium type C, Raphidascaris type PG and Philometra sp. Data on infection parameter are presented in Table 1-2. A total of 646, 206, 18 and 11 nematode were recovered from S. tumbil, N. japonicus, T. crocdiilus crocdil and C. armatus, respectively.

The intensity of infection in each species of fish is shown in Table 1. Larvae were found mainly within abdominal cavity excepted of Philometra sp. that was in ovary. One of our specimens was considered as Anisakis type III, because the larvae were different from Anisakis type I and Anisakis typeII by lacking a mucron on the posterior extremity, possessing an elongated ventriculus, a nerve ring located from the 0.19 mm (0.1-0.29) from the anterior end. The excretory pore was located below the tooth and muscular esophagus was 0.67mm (0.59-0.75) long. The anus was located 0.13 mm (0.09–0.18) from the posterior end. Third-stage larvae were usually found encysted in a coiled, spring-like state on the wall of gonads, intestines and stomach. Total body length and width of the larvae were 5mm-8mm and 0.19mm-0.2mm, respectively.

The 8 larvae collected from 2 species of fish (S. tumbil and T. crocdiilus crocdil) were similar to Pseudoterranova sp. The description of Pseudoterranova sp. was based on measurements of 8 larvae from these fish. Color dark red; length 7 mm (6 – 8) maximum width 0.2 mm (0.1-0.3); 3 lips; possessing boring tooth; excretory pore ventral between subventrallips; nerve ring located from the 0.31mm (0.36-0.45) from anterior end; muscular oesophagus was 1.07 mm (0.9 - 1.3) long followed by a glandular ventriculus 0.38 mm long (0.27-0.49) and 0.16 mm (0.08–0.2) width; intestinal caecum 0.4 mm long (0.31 - 0.43) extending anteriorly slightly further than the anterior margin of the ventriculus; anus 0.2 mm (0.15-0.24) from the posterior end; tail bluntly rounded with small mucron.

Hysterothylacium type A was described according 445 larvae collected from S. tumbil, N. japonicus, T. crocdiilus crocdil and C. armatus. Body was 11mm (8-14) long by 0.2 mm (0.15-0.3) wide at greatest width. Boring tooth projecting anterioreventrad. A nerve ring located from the 0.35 mm (0.27-0.46) from the anterior end. The excretory pore was located below the nerve ring and muscular esophagus was 0.9mm (0.59- 1.3) long followed by a glandular ventriculus 0.13mm long (0.06-0.2) and 0.09 mm (0.08 – 0.1) width. Boring tooth; excretory pore opening just below nerve ring; nerve ring located from the 0.24mm (0.19-0.26) from anterior end; muscular oesophagus was 0.5 mm (0.45 – 0.59) long followed by a glandular ventriculus 0.05mm long (0.04-0.06) and 0.03 mm (0.02 – 0.04) width ; intestinal caecum 0.1 mm long (0.09 - 0.14); anus 0.13 mm (0.12-0.16) from the posterior end and tail conically shaped with a single spine.

The 114 larvae collected from 2 species of fish (S. tumbil and N. japonicus) were similar to Hysterothylacium type C. The following description is based on measurements of larvae from these fish. Body was 7.3 mm (5.5-9.2) long by 0.13 mm (0.05-0.2) wide at greatest width. Boring tooth projecting anterioreventrad. A nerve ring located from the 0.28 mm (0.26-0.31) from the anterior end. The excretory pore was located below the nerve ring and muscular esophagus was 0.61 mm (0.42- 0.81) long followed by a ventriculus 0.04 mm long (0.03-0.6) and 0.04 mm (0.03 – 0.05) width. Rectal gland was spherical shaped, numbering 4. Tail was 0.15 mm (0.19- 0.21)
long. Type C was very different from other *Hysterobothlacium* in this study by possessing a tuft of 8-10 spinelike projections distally on the tail.

The 3 larvae collected from *S. tumbil* were similar to *Raphidascaris* type A. By possessing a ventricular appendage and no intestinal cecum, this nematode differs from all other larvae collected. Body was 4.5 mm (3.1- 5.2) long by 0.16 mm (0.08-0.2) wide at greatest width. Esophagus was 0.5 mm (0.41-0.61) long. Nerve ring located in anterior. Four of rectal glands were spherical and tail was conically shaped.

*Philometra* sp. with the intensity of 1-5 parasites per fish was isolated from the ovaries of *S. tumbil* and described as *Philometra* sp. The body filiform of the gravid females nematode was yellowish brown to reddish body coloration, cuticle smooth, length about 49.63 mm, maximum width 2.31 mm, with rounded ends; the posterior part of the body is distinctly narrower than the anterior part. The esophagus is narrow, swollen near the mouth to form a distinct bulb 0.13 to 0.17 (0.14) mm long and 0.13 to 0.22 (0.19) mm wide, which is followed by the posterior cylindrical part of the esophagus. The overall length of the esophagus is 1.31 to 1.64 (1.54) mm, the maximum width of its cylindrical part was 0.16 to 0.18 (0.17) mm (Fig. 1).

**Fig. 1**: Various anisakid morphotypes found in the present study. 1, posterior end showing anal glands and tail conically shaped with a single spine of *Hysterobothlacium* type B; 2, posterior end showing 8-10 spinelike projections distally on the tail of *Hysterobothlacium* type C; 3, Tail bluntly rounded with small mucron of *Pseudoterranova* sp.; 4, lacking a mucron on the posterior extremity of *Anisakis* sp.; 5, Four spherical rectal glands and conically shaped tail of *Raphidascaris* type A; 6, Tail with conically shaped and a single spine of *Hysterobothlacium* type A; 7, The relationship between various appendage of the digestive tract of *Hysterobothlacium* type A; 8, *Hysterobothlacium* type B; 9, *Hysterobothlacium* type C; 10, *Pseudoterranova* sp.; 11, *Anisakis* sp.; 12, *Raphidascaris* type A. Scale bars 100 μm in (1–6) and 250 μm in (7) and (9-12).

**Discussion**

The purpose of this study was to determine how the prevalence and mean intensity of nematode infections varied according to commercially important fish species in Persian Gulf. Due to the great potential of Persian Gulf gurnard to be increasingly exploited as a food resource, information on the occurrence and spatial distribution of Anisakid larvae are important (6, 25, 26). In order to illuminate further this aspect, we separately analyzed the Anisakid larvae infection data for *S. tumbil*, *N. japonicus*, *T. crocodilus crocodile* and *C. armatus*. Little is known about the prevalence of zoonotic parasites including anisakids in fish or of anisakiasis in humans in Persian Gulf. Low intensity of *Anisakis* sp. and *Raphidascaris* were collected from long tail tuna fish (*Thunnus tonggol*) caught from north parts of Persian Gulf (27).

*Anisakis* sp. was identified with the frequency of 4% from the intestine and stomach of *Scomberomorus commerson* and the body cavity of *N. japonicus* from Bandar Abbas port, southern of Persian Gulf (28). In similar study, *Anisakis* sp. and *Contracaecum* sp. were reported by Adel et al. on *S. commerson* (29).

Based on obtained results it is obvious that *S. tumbil* has a more diverse fauna of parasites with more intensity than other fish species that this can be attributed to the host body conditions and to the different life patterns. Also, throughout the study, three types of *Hystratylacium* sp. were determinant species with a high prevalence between another nematode. Third-stage larvae from this genus were found in four examined species of fish. Considering the three larval types of *Hystratylacium* collected, type B was most prevalent, followed by
type A and type C. Hystratylacium type B had the highest intensity of infection followed by Anisakis sp, Philometra sp, Pseudoterranova and Raphidascaris type PG. This pattern of intensity was similar to intensity of Hystratylacium larvae in Hawaiian Island (30).

Anisakis type III for the first time was found in this study and it was different from Anisakis type I (15, 21, 31, 32) and Anisakis type II (21, 33-35) by lacking a mucron on the posterior extremity, possessing an elongated ventriculus. By increasing the weight and length of survived fish relative frequencies of anisakid nematode larvae were decreased. This observation was similar to report of Bagherpour et al. that studied correlation between intestine helminthes with sex, season and size in Branchiura orientalis from north of Persian Gulf (36).

In present study, relative frequencies of anisakid nematode larvae were not affected by sex, although this frequency in female fish was higher than male fish. Knudsen suggested that this difference might be related to different feeding habits of both sex of fish (37).

Many of fish species may harbor nematode larva of food hygienic important (38-40). Among of them, nematode larvae of the genus Anisakis and Pseudoterranova (family Anisakidae) found in the muscle tissue and perioral cavity of a wild range of fish species are known to cause anisakiasis and pseudoterranoviasis, respectively (38). Contracaecum and Hysterothyllum, are also considered able to infect man, but rarely (41, 42). Hence, it is vital to recognize epidemiology and ecology of parasites present in infected fish (10, 39).

According to old belief of southern parts of Iran, consuming of raw fish in order to cure the jaundice was useful; therefore, it is necessary that doctors consider Anisakis larvae in patients with signs of abdominal pain and Phleghmonous enteritis (29). The life cycle of Anisakidae consist of small crustaceans as the first intermediate host, fishes and cephalopods as the second host, and marine mammals as the definitive host (42). Kliming and college followed the general nematode life cycle pattern and the adults in the final host (43). The stage L1-L3 are within the eggs and subsequently in intermediate or paratenic host (L3) and as preadult stage (L4) and adults in cetacean final host (whales and seals) (43, 44). Humans are considered as accidental hosts of the parasite following consumption of the secondary hosts. A large number of cephalopod and marine fish species are connected with the transmission of the disease (44, 45). It is important to know that fish of different species can play a vital role in the distribution of anisakids in the environment.

This study investigated some popular fish in the Persian Gulf of Iran and demonstrated considerable infections with potentially zoonotic parasites, including Anisakis type III, Raphidascaris type PG, Philometra sp. and Pseudoterranova sp. and Hystratylacium types A, B and C. These parasitic nematodes are recognized as important pathogens that cause vital problems for human health and foodborne zoonosis (43). Since the 1988, a standardized nomenclature was used for three different terms: 1) anisakidosis caused by any members of the family Anisakidae, 2) anisakiasis caused by members of the genus Anisakis, and 3) pseudoterranovosis caused by members of the genus Pseudoterranova (10, 46). According to this assortment we can recognize anisakidosis, anisakiasis and pseudoterranovosis in this study in Persian Gulf. In addition, we indicate to the zoonotic potential of anisakids to infest humans in costal population in Persian Gulf. Most potential transmission routes are raw, undercooked and lightly marinated seafood according the habit and culture of people in the region (43, 47). Most of these infections induce chronic rather than acute disease with asymptomatic which being diagnosed after the expulsion of the nematodes by coughing, vomiting or defaecation (11). Interestingly, more than 90% of causes are caused by a single larva with peculiar signs (16, 35, 46, 48).

Parasites have also been considered favorable biological tags for discriminating different
stocks or populations of marine fishes, and Anisakis larvae have been reported as a good tool for stock recognition of fishes in Europe and Asia (49-51).

Conclusion

With these studies, we can be optimistic regarding the control of zoonotic nematode infections in the future and use these parasites as biological tags to estimate various aspects of the marine fisheries in Persian Gulf.

Acknowledgments

The author is grateful to the Shahid Chamran University for Applied Education and Training for kindly funding this project. The authors declare that there is no conflict of interests.

References

1. Cannon L. Some ecological relationships of larval ascaridoids from south-eastern Queensland marine fishes. Int J Parasitol. 1977; 7:227-232.
2. Zhu X, Podolska M, Liu J, Yu H, Chen H, Lin Z, Luo C, Song H, Lin R. Identification of anisakid nematodes with zoonotic potential from Europe and China by single-strand conformation polymorphism analysis of nuclear ribosomal DNA. Parasitol Res. 2007; 101:1703-1707.
3. Alvarez-Pellitero P. Fish immunity and parasite infections: From innate immunity to immunoprophylactic prospects. Vet Immunol Immunopathol. 2008; 126:171-198.
4. Buchmann K, Lindenstrom T, Bresciani J. Defence mechanisms against parasites in fish and the prospect for vaccines. Acta Parasit. 2001; 46(2):71-81.
5. Anderson RC. Nematode parasites of vertebrates: Their development and transmission. Cabi; 2000.
6. Olivero Verbel J, Caballero-Gallardo K, Arroyo-Salgado B. Nematode infection in fish from cartagena bay, north of Colombia. Vet Parasitol. 2011; 177(1):119-126.
7. Levens A, Berland B. 18 anisakis species. Fish Parasites: Pathobiology and Protection. Cabi; 2012. p.298-301.
8. Zhang L, Hu M, Shamsi S, Beveridge I, Li H, Xu Z, Li L, Cantacessi C, Gasser RB. The specific identification of anisakid larvae from fishes from the yellow sea, China, using mutation scanning-coupled sequence analysis of nuclear ribosomal DNA. Mol Cell Probes. 2007; 21(5):386-390.
9. Van Thiel P. Anisakis. Parasitology. 1960; 53(16):4.
10. Audicana MT, Kennedy MW. Anisakis simplex: From obscure infectious worm to inducer of immune hypersensitivity. Clin Microbiol Rev. 2008; 21(2):360-379.
11. Baird FJ, Gasser RB, Jabbar A, Lopata AL. Foodborne Anisakiasis and allergy. Mol Cell Probes. 2014; 24(4):167-174.
12. Anadón A, Romarís F, Escalante M, Rodríguez E, Gárate T, Cuéllar C, Ubeira F. The Anisakis simplex ani s 7 major allergen as an indicator of true anisakis infections. Clin Exp Immunol. 2009; 156(3):471-478.
13. Arizono N, Miura T, Yamada M, Tegoshi T, Onishi K. Human infection with Pseudoterranova azarasi roundworm. Emerg Infect Dis. 2011; 17:555-56.
14. Mattiucci S, Fazii P, De Rosa A et al. Anisakiasis and gastroallergic reactions associated with Anisakis pegreffii infection, Italy. Emerg Infect Dis. 2013; 19:496-499.
15. Lee EJ, Kim YC, Jeong HG, Lee OJ. The mucosal changes and influencing factors in upper gastrointestinal anisakiasis: Analysis of 141 cases. Korean J Gastroenterol, Taehan Sohwagi Hakhoe Chi. 2009; 53:90-97.
16. Hwang D, Park SI, Park SC, Lee KS, Choi SK, Kang H, Park CW, Lee S. A case of duodenal anisakiasis with duodenal ulcer. Chonnam Med J. 2012; 48(1):73-75.
17. Cho MH, Lee SJ, Joung HC, Kang JW, Lee KW, Kim YD, Cheon GJ. A case of gastric and colonic submucosal tumors after the removal of 51 Anisakis larvae. Korean J Med. 2012; 82(4):453-458.
18. Kim L-S, Lee Y-H, Kim S, Park H-R, Cho S-Y. A case of anisakiasis causing intestinal obstruction. Kisaengchunghak Chapchi. 1991;29:93-96.

Available at: http://ijpa.tums.ac.ir
19. Takabe K, Ohki S, Kunihoro O et al. Anisakidosis: A cause of intestinal obstruction from eating sushi. Am J Gastroenterol. 1998; 93(7):1172-1173.
20. Deardorff TL, Overstreet RM. Seafood-transmitted zoonoses in the united states: The fishes, the dishes, and the worms. Microbiology of marine food products. Springer; 1991. p.211-265.
21. Berland B. Nematodes from some norwegian marine fishes. Sarsia. 1961; 15(2):1-50.
22. Petter A, Cabaret J, Tcheprakoff R. Ascaridoid nematodes of teleostean fishes from the eastern north atlantic and seas of the north of Europe. Parasite. 1995; 2(2):217-230.
23. Petter AJ, Maillard C. Larves d’ascarides parasites de poissons en méditerranée occidentale. Bull Mus Natl Hist Nat. Section A, Zoologie, biologie et écologie animales. 1988;10(2):347-369.
24. Bush AO, Lafferty KD, Lotz JM, Shostak AW. Parasitology meets ecology on its own terms: Margolis et al. Revisited. J Parasitol. 1997:575-583.
25. Suzuki J, Murata R, Hosaka M, Araki J. Risk factors for human anisakis infection and association between the geographic origins of Scomber japonicus and anisakid nematodes. Int J Food Microbiol. 2010;137:88-93.
26. Verbel JO, Caballero-Gallardo K, Arroyo-Salgado B. Nematode infection in fish from cartagena bay, north of Colombia. Vet Parasitol. 2011; 177(1):119-126.
27. Eslami A, Sabokroo H, Ranjbar-Bahadori S. Infection of anisakis larvae in long tail tuna (Thunnus tonggol) in north persian gulf. Iran J Parasitol. 2011; 6(3):96-100.
28. Soofiani NM, Keivany Y, Shooshtari AM. Contribution to the biology of the lizardfish, Saurida tumbil (teleostei: Aulopiformes), from the Persian Gulf. Zool Middle East. 2006; 38(1):49-56.
29. Adel M, Azizi HR, Nematalohi A. Scomberomorus commerson, a new paratenic host of Contracaecum sp. And Anisakis sp.(nematoda: Anisakidae) from Persian Gulf. World. 2013; 5(3):310-314.
30. Deardorff TL, Kliks MM, Rosenfeld ME, Rychlinski RA, Desowitz RS. Larval ascaridoid nematodes from fishes near the Hawaiian islands, with comments on pathgenicity experiments. 1982; http://hdl.handle.net/10125/419.
31. Cannon L. Some larval ascaridoids from south-eastern Queensland marine fishes. Int J Parasitol. 1977; 7(3):233-243.
32. Oshima T. Anisakiasis is the sushi bar guilty? Parasitol Today. 1987; 3(2):44-48.
33. Weerasooriya MV, Fujino T, Ishii Y, Kagé N. The value of external morphology in the identification of larval anisakid nematodes: A scanning electron microscope study. Z Parasitenk. 1986; 72(6):765-778.
34. Smith JW. Anisakis simplex (rudolphi, 1809, det. Krabbe, 1878)(nematoda: Ascaridoidea): Morphology and morphometry of larvae from euphausiids and fish, and a review of the life-history and ecology. J Helminthol. 1983; 57(3):205-224.
35. Kagé N, Sano M, Takahashi Y, Tamura Y, Sakamoto M. A case of acute abdominal syndrome caused by Anisakis type-ii larva. Jpn J Parasitol. 1978;27:427-431.
36. Bagherpour A, Afsharnasab M, Mobedi I, Jalali B, Mesbah M. Prevalence and intensity of anisakid nematodes from the northern gulf of Iran. Iran J Fish Sci. 2011; 10(4):570-584.
37. Knudsen R, Curtis MA, Kristoffersen R. Aggregation of helminths: The role of feeding behavior of fish hosts. J Parasitol. 2004; 90(1):1-7.
38. Chai J-Y, Darwin Murrell K, Lymbery AJ. Fish-borne parasitic zoonoses: Status and issues. Int J Parasitol. 2005; 35(11):1233-1254.
39. Conlan JV, Sripa B,Attrwood S, Newton PN. A review of parasitic zoonoses in a changing southeast Asia. Vet Parasitol. 2011; 182(1):22-40.
40. Llarena-Reino M, Abollo E, Regueira M, Rodríguez H, Pascual S. Horizon scanning for management of emerging parasitic infections in fishery products. Food Control. 2015; 49:49-58.
41. Deardorff TL, Overstreet RM. Review of Hysterothylacium and Ichthyostrongylus (both previously Thyrnascaris) (nematoda: Anisakidae) from the northern gulf of Mexico. Proc Biol Soc Wash. 1980; 93:1035-1079.
42. Lima dos Santos CA, Howgate P. Fishborne zoonotic parasites and aquaculture: A review. Aquaculture. 2011; 318(3):253-261.
43. Klimpel S, Palm HW. Anisakid nematode (ascaridoidea) life cycles and distribution: Increasing zoonotic potential in the time of climate change? In: Progress in parasitology. Springer Berlin Heidelberg, 2011. p.201-222.

44. Klimpel S, Palm HW, Rückert S, Piatkowski U. The life cycle of Anisakis simplex in the norwegian deep (northern north sea). Parasitol Res. 2004; 94(1):1-9.

45. Smith JW, Wootten R. Anisakis and anisakiasis. Adv Parasitol. 1978; 16:93-163.

46. Audicana MaT, Ansotegui IJ, de Corres LF, Kennedy MW. Anisakis simplex: Dangerous—dead and alive? Trends Parasitol. 2002; 18(1):20-25.

47. Farahnak A, I Mobedi, Tabibi R. Fish anisakidae helminthes in Khuzestan province, south west of Iran. Iran J Public Health. 2002; 31:129-132.

48. Daschner A, Pascual C-Y. Anisakis simplex: Sensitization and clinical allergy. Curr Opin Allergy Clin Immunol. 2005; 5(3):281-285.

49. MacKenzie K. Parasites as biological tags in population studies of marine organisms: An update. Parasitology. 2002; 124 Suppl:S153-63.

50. Quiazon KMA, Yoshinaga T, Ogawa K. Distribution of Anisakis species larvae from fishes of the japanese waters. Parasitol Int. 2011; 60(2):223-226.

51. Mattiucci S, Nascetti G. Advances and trends in the molecular systematics of anisakid nematodes, with implications for their evolutionary ecology and host parasite co-evolutionary processes. Adv Parasitol. 2008; 66:47-148.

Table 1: Fish species from which anisakid larvae were collected in the present study

| Fish species | N | Mean length (cm) | Mean weight (gr) | Prevalence (%) | MI±SD (Range) | MA±SD |
|--------------|---|-----------------|------------------|----------------|----------------|--------|
| Saurida tumbil (Lizardfish) | 31 | 38.7±6.8 | 477.1±260.8 | 90.3 | 23.07±21.3 (3-74) | 20.83±15.6 |
| Nemipterus japonicas (Japanese threadfin-bream) | 37 | 25.4±7.2 | 236.4±353.2 | 97.2 | 4.72±3.4 (1-45) | 5.6±4.7 |
| Tylosurus crocodilus crocodile (Crocodile needlefish) | 34 | 74.4±5.3 | 357.1±320.3 | 20.5 | 1.57±2.02 (1-6) | 0.32±5.9 |
| Carangoides armatus (Longfin trevally) | 36 | 20.7±6.2 | 90.5±20.7 | 5.55 | 4.5±1.09 (2-4) | 0.25±0.6 |

N is the number of fish sampled, prevalence is the % of infected fish and (MI) is the mean number of larvae in the infected fish host ±SD, (MA) is the mean abundance.

Table 2: L3 larvae of the Anisakidae family detected in fish of Persian Gulf

| Host | N | Infected organ/s | Anisakis sp. | Pseudoterranova sp. | Hysterothylacium type A | Hysterothylacium type B | Hysterothylacium type C | Raphidias caris type PG | Philometra sp. |
|------|---|-----------------|-------------|--------------------|------------------------|------------------------|------------------------|-----------------------|---------------|
| Saurida tumbil | 28 | Body cavity/ovary | 17 | 7 | 161 | 332 | 113 | 3 | 13 |
| Nemipterus japonicus | 36 | Body cavity | 2 | 0 | 64 | 103 | 1 | 0 | 0 |
| Tylosurus crocodilus crocodile | 7 | Body cavity | 3 | 1 | 1 | 6 | 0 | 0 | 0 |
| Carangoides armatus | 2 | Body cavity | 2 | 0 | 3 | 4 | 0 | 0 | 0 |

N is number of fish with Anisakid larvae