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Metazoan parasites of trachinid fishes (Teleostei: Trachinidae) from Tunisian coasts (Mediterranean Sea)

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A parasitological survey of Trachinus draco *Linnaeus, 1758*; Trachinus araneus *Cuvier, 1829 and* Trachinus radiatus *Cuvier, 1829 collected from Tunisian coasts was performed from January 2014 to January 2015. In total, 18 species of metazoan parasites belonging to 13 genera were found: nine Myxozoa, four Nematoda, one Cestoda, one Digenea, one Monogenea, one Isopoda and one Annelida Hirudinea. Data on morphology, location and infection levels of parasites were provided. The higher species richness was recorded in* Trachinus draco *(18 species), while* Trachinus radiatus *and* Trachinus araneus *harbored 9 and 7 species, respectively. Species richness and diversity according to the host species and the sampling sites based on the Simpson and Shannon-Wiener indices are reported.*

Key words: Trachinidae fish, Metazoan parasites, species richness, Tunisia

INTRODUCTION

Trachinids (Teleostei: Trachinidae) are a family of benthic marine fish living on sandy or muddy bottoms, typically on the continental shelf but also in deeper waters of 150 to 200 m. These fish have a wide distribution through the eastern Atlantic coasts, Mediterranean Sea and Black Sea. In Tunisia, the most commonly known species of trachinids are: the greater weever, (*Trachinus draco*), the spotted weever, (*Trachinus araneus*) and the starry weever (*Trachinus radiatus*). Several studies have been performed on the metazoan parasites of trachinids through the word (DILLON & HARGIS, 1965; ORRECHIA & PAGGI, 1978; GEORGES, 1982; PETTER & MAILLARD, 1988; TRILLES *et al*., 1989; CANNING *et al*., 1999; HORTON, 2000; AKMIRZA, 2004; ÖKTENER & TRILLES, 2004; FARJALLAH *et al*., 2008). Nevertheless, in Tunisia, only two studies have been achieved on trachinid fishes, AZIZI *et al*. (2016) described a new species of myxosporean *Zschokkella trachini* from the gallbladder of *Trachinus draco* and FARJALLAH *et al*. (2008) who reported the nematode *Anisakis pegreffi* parasite of *T. draco*. Parasitic diseases may influence weight, reproduction, growth and survival of the host, inducing significant economic losses in fish production particularly in aquaculture. Therefore, data on biodiversity and ecology of parasites in natural ecosystems, the nature of the host/parasite relationship and the possible use of parasites as biological tags are very important in terms of conservation. In order to expand our knowledge on the biodiversity of trachinids parasites, we have undertaken a parasitological

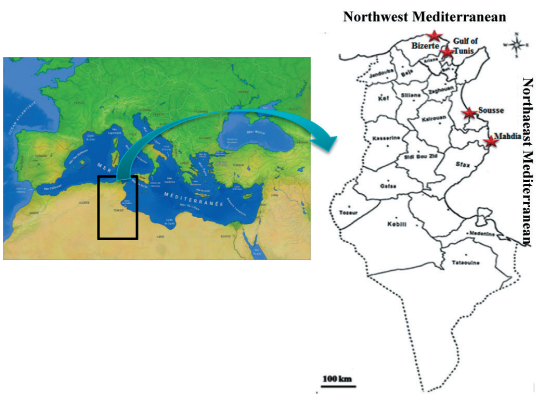

Fig. 1. Map showing the locations of the 4 sampling sites

survey from four different sites along the Tunisian coasts.

MATERIAL AND METHODS

From January 2014 to January 2015, a total of 703 trachinid fishes belonging to *Trachinus draco, Trachinus araneus* and *Trachinus radiatus* were collected monthly from four marine regions in Tunisia, located in the northern coast: Bay of Bizerte (37° 20' N, 9° 53' E) and Gulf of Tunis (36° 49'N, 10° 18' E) and in the eastern coast: Sousse (35° 50' N, 10° 38') and Mahdia (35° 29' N, 11° 3' E). The number of examined specimens and the range of total length (TL) according to the locality are given in the Table 1. In the laboratory fish were examined for the presence of ectoparasites and endoparasites**.** Therefore, skin, fins, gills, eyes body cavity and viscera were examined carefully macroscopically and microscopically. All organs and body fluids were examined as well. Fresh spores of myxosporean isolated from gallbladders were measured according to the guidelines of LOM & ARTHUR (1989). Measurements were based on 30 fresh spores and data were presented as mean ± SD (range). Permanent preparation of monogeneans, digeneans and cestods were made according to JUSTINE *et al.* (2012). Nematodes isolated from the abdominal cavity and intestine were fixed in 70% ethanol, cleared in Amann lactophenol and studied by direct examination between slide and cover slip. Isopods isolated from the body surface and fins were fixed in 70% ethanol. All measurements were carried out using micrometric ocular. Isopods and annelids were photographed under a stereo microscope however the other parasites were photographed with a Canon Power Shot A2500 digital camera mounted on a Nikon E600 microscope using DIC optics. The prevalence, mean intensity and mean abundance were determined according to BUSH *et al.* (1997). Parasite diversity was described on the bases of the Simpson, and Shannon-Wiener indices. These indices were calculated according to MAGURRAN (1988).

Table 1. Number and range of total length (TL) of the examined hosts according to the locality

Species	**Locality**	**Number**	**Range of TL (mm)**
T. draco	Bay of Bizerte	190	21.5-30.5
	Sousse	110	15.5-28.5
	Mahdia	156	19.5-29.5
	Gulf of Tunis	65	15.5-23.5
T. araneus	Bay of Bizerte	26	19.5-34.5
	Sousse	18	23.5-34.8
	Mahdia	47	21.5-33.9
	Gulf of Tunis	0	-
T. radiatus	Bay of Bizerte	27	19.5-35.9
	Sousse	18	14.5-31.5
	Mahdia	46	14.5-34.5
	Gulf of Tunis	0	-

RESULTS

Composition of the parasite communities

A total of 18 parasite species representing 13 genera were collected from trachinid fishes: Ceratomyxa Thélohan, 1892, Zschokkella Auerbach, 1910, Ortholinea Shulman, 1962, Myxidium Bütschli, 1882, Chloromyxum Mingazzini, 1980, Gnathia Leach, 1814, Helicometra Odhner, 1902, Aspinatrium Yamaguti, 1963, Bothriocephalus Rudolphi, 1808, Stribarobdella Leigh-sharpe, 1925, Anisakis Dujardin, 1845, Hysterothylacium Rudolphi, 1819, and Philometra Costa, 1845. Data on the prevalence, mean intensity, mean abundance, site of infection and locality of parasite species are given in the Table 2.

Myxozoa

Myxosporean was the most diverse group found during the present study, nine species were collected from trachinids (Table 2; Fig. 2). Only two species have been reported in trachinid fishes from different geographical areas: *Myxidium trachinorum* Canning, Curry, Anderson & Okamura, 1999 and *Zschokkella trachini* Azizi, Rangel, Castro, Santos & Bahri, 2016. However, other species belonging to the genera Ceratomyxa, Chloromyxum and Ortholinea were unidentified (Table 3). In the present study, infection by myxosporean species was recorded on fish during summer, winter and spring. The highest infection occurred in summer. Significant differences in the prevalence of infection by myxosporean were found between localities (df= 3, P<0.05).

Cestoda

Bothriocephalus scorpii Müller, 1776 was the only cestod found in the examined fish (Table 2;Fig. 3). This species was found in the intestine of *T. draco, T. radiatus* and *T. araneus* from the Bay of Bizerte, during spring and summer. The maximum prevalence (33%) and the maximum mean intensity (2 ± 4) were noted in

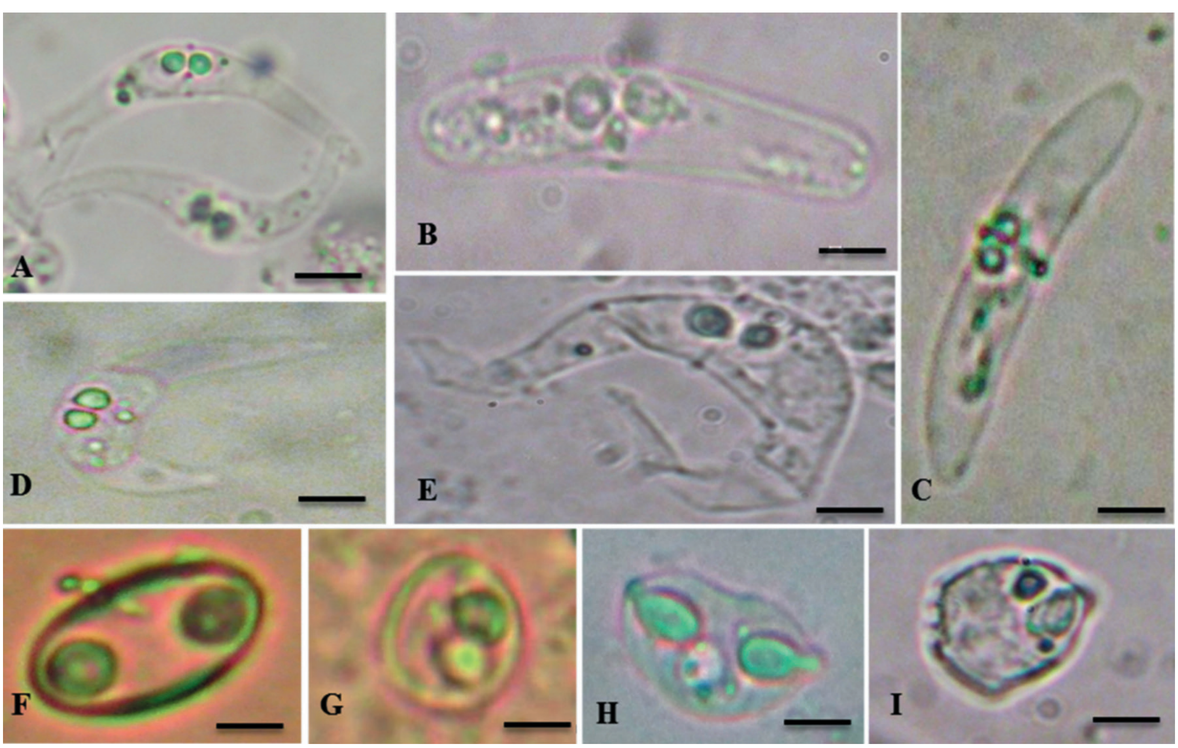

Fig. 2. Mature spores of Myxosporean *species isolated from trachinid fishs from Tunisian coasts. A: Ceratomyxa sp. 1; B:* Ceratomyxa sp. *2; C:* Ceratomyxa sp. *3; D:* Ceratomyxa sp. *4; E:* Ceratomyxa sp. *5; F:* Zschokkella trachini*; G:* Ortholinea sp.*; H:* Myxidium trachinorum*; I:* Chloromyxum sp. *(Scale bars = 8 µm)*

Table 2: List of parasite species found on Trachinidfishes from Tunisian coasts and their infection rates
N.I.F: Number of infected fish; N.P: Total number of parasite specimens; Ac: Abdominal cavity; G: Gill; GB: Gallbladder; B: Body; In: Intestin; Ovary: O

Parasites Species	Host species	Locality	Site of infection	Prevalence (%)	Mean intensity	Mean abundance
Myxozoa						
Ceratomyxa sp. 1	*T. draco*	Bay of Bizerte	GB	49.4	36 ± 24	17.8
		Sousse	GB	46.3	48 ± 31	22.2
		Mahdia	GB	41.5	35 ± 12	14.5
Ceratomyxa sp. 2	*T. draco*	Bay of Bizerte	GB	33.7	62 ± 27	11
		Sousse	GB	27.2	49 ± 9	13.3
		Mahdia	GB	17.8	35 ± 14	11.8
	T. araneus	Bay of Bizerte	GB	24.8	51 ± 22	27.9
		Mahdia	GB	21.3	64 ± 16	26.4
Ceratomyxa sp. 3	*T. draco*	Bay of Bizerte	GB	57.2	36 ± 14	15.9
		Mahdia	GB	44.2	41 ± 32	19.3
	T. araneus	Bay of Bizerte	GB	31.0	46 ± 22	10 .9
		Mahdia	GB	23.8	46 ± 13	14 .2
Ceratomyxa sp. 4	*T. draco*	Bay of Bizerte	GB	26.2	42 ± 16	7.5
	T. araneus	Bay of Bizerte	GB	17.8	39 ± 09	10.2
Ceratomyxa sp. 5	*T. draco*	Bay of Bizerte	GB	46.3	38 ± 19	12.8
		Gulf of Tunis	GB	36.9	31 ± 21	11.6
		Sousse	GB	27.9	39 ± 19	10.9
		Mahdia	GB	33.6	32 ± 27	14.8
Zschokkella trachini Azizi, Rangel, Severino, Santos & Bahri, 2016	*T. draco*	Bay of Bizerte	GB	57.8	74 ± 05	42.8
		Gulf of Tunis	GB	43.0	71 ± 11	30.5
		Sousse	GB	53.8	64 ± 09	34.4
		Mahdia	GB	49.0	62 ± 17	30.4
	T. radiatus	Bay of Bizerte	GB	41.1	68 ± 21	28
		Mahdia	GB	24.4	71 ± 16	17.3
Ortholinea sp.	*T. draco*	Bay of Bizerte	GB	38.1	46 ± 16	9.2
		Mahdia	GB	20	62 ± 12	17.4
	T. radiatus	Bay of Bizerte	GB	39.4	36 ± 26	10.5
		Mahdia	GB	26.6	38 ± 14	10.1
Myxidium trachinorum Canning, Curry, Anderson & Okamura, 1999	*T. draco*	Bay of Bizerte	GB	49.1	42 ± 17	18.3
		Gulf of Tunis	GB	35.3	42 ± 11	28.4
		Sousse	GB	43.6	54 ± 09	23.8
		Mahdia	GB	21.1	38 ± 21	18.6
	T. radiatus	Bay of Bizerte	GB	38.2	54 ± 07	19
		Mahdia	GB	23.3	48 ± 15	16
Chloromyxum sp.	*T. draco*	Bay of Bizerte	GB	0.5	14 ± 07	0.07

Cestoda						
Bothriocephalus scorpii Müller, 1776	*T. draco*		In	26,1	2 ± 4	0.1
	T. araneus	Bay of Bizerte	In	33	3± 6	0.8
	T. radiatus		In	26,4	5 ± 4	1.3
Nematoda						
Anisakis sp.	*T. draco*	Bay of Bizerte	In, Ac	85.4	21.1 ± 2.6	9.4
		Gulf of Tunis	In, Ac	75.3	15.1 ± 3.2	11.4
		Sousse	In, Ac	72.7	10.7 ± 0.9	0.7
		Mahdia	In, Ac	47.8	10.2 ± 1.3	8.7
	T. aranaeus	Bay of Bizerte	In, Ac	62	20.2 ± 0.6	10 .1
		Sousse	In, Ac	50	14 ± 2.5	5.4
		Mahdia	In, Ac	38	5.7 ± 0.2	3.5
	T. radiatus	Bay of Bizerte	In, Ac	62.2	3.5 ± 0.4	1.6
		Sousse	In, Ac	56.2	10.4 ± 2.5	5.8
		Mahdia	In, Ac	47	3.7 ± 0.2	2.3
Hysterothylacium sp.	*T. draco*	Bay of Bizerte	In, Ac	50.5	3.1 ± 0.7	1.5
		Gulf of Tunis	In, Ac	36.9	10.8 ± 2.4	4
		Sousse	In, Ac	40.9	4.0 ± 2.8	1.6
		Mahdia	In, Ac	41.0	5.3 ± 1.6	2.2
	T. radiatus	Bay of Bizerte	In, Ac	35.2	5.7 ± 0.9	2
		Sousse	In, Ac	21.1	10.8 ± 1.3	3.3
Hysterothylacium fabri Rudolphi, 1819 (3rd larval stage)	*T. draco*	Bay of Bizerte	In, Ac	75.4	2.9 ± 0.5	1.6
		Sousse	In, Ac	62.3	2.5 ± 1.2	1.5
		Mahdia	In, Ac	54.7	1.9± 2.4	1.4
Hysterothylacium fabri Rudolphi, 1819 (4rd larval stage)	*T .draco*	Bizerte	In, Ac	70.9	6.2 ± 0.7	2.7
		Sousse	In, Ac	61	8.0 ± 2.1	4.8
		Mahdia	In, Ac	44.2	7.8 ± 1.3	5.5
	T. radiatus	Bay of Bizerte	In, Ac	47.0	8.8 ± 0.5	4.1
		Mahdia	In, Ac	28.6	4.4 ± 0.9	2
Philometra sp.	*T. draco*	Bay of Bizerte	Ov	5.7	2 ± 1.4	0.04
Digenea						
Helicometra fasciata Rudolphi, 1819	*T. draco*	Bay of Bizerte	In	4.21	1.6 ± 0 .5	0.06
Monogenea						
Aspiatrium trachini Parona & Perugia, 1889	*T. draco*	Bay of Bizerte	G	16.8	2 ± 1	0.06
	T. radiatus	Bay of Bizerte	G	19.8	3 ± 2	0.6
	T. araneus	Bay of Bizerte	G	18.1	3 ± 2	0.3

Isopoda						
Gnathia sp	*T. draco*	Bay of Bizerte	B	89.0	3 ± 5	2.2
		Gulf of Tunis	G	64.6	3 ± 3	1.9
		Sousse	B	73.6	3 ± 4	1.9
		Mahdia	G	66.8	3.5 ± 2	3.5
	T. radiatus	Bay of Bizerte	G	62.2	4 ± 2	2
		Sousse	G	50	3 ± 1	1.6
		Mahdia	G	56.2	4 ±2	2.4
	T. araneus	Bay of Bizerte	G	65.5	2 ± 2	0.8
		Sousse	G	55.5	3 ± 1	1.6
		Mahdia	G	40.4	3 ± 2	1.9
Hirudinea						
Stibarobdella loricata Schmarda, 1861	*T. draco*	Gulf of Tunis	G	1	1 ± 0	0.01

Table 3. Spores measurements (µm) of myxosporean spp. parasite of trachinid fishes. D: Diameter, L: length, W: width

Species	Spore Length	Spore Width	Size of Polar Capsule
Ceratomyxa sp. 1	9.2 ± 1.4 (8-11)	49.2 ± 1.9 (48–52)	D: 3.5 ± 0.4 (3.2–4)
Ceratomyxa sp. 2	7 ± 2.3 (6-9)	24.8 ± 1.6 (24-28)	D: 3.5 ± 0.2 (3.0-4.0)
Ceratomyxa sp. 3	8	48.7± 1.5 (48-52)	D: 3.6 ± 0.4 (3.2-4)
Ceratomyxa sp. 4	8	39 ± 1 (38- 40)	D: 4
Ceratomyxa sp. 5	10.8 ± 1.8 (8-12)	40.7 ± 1.5 (40-42)	D: 3.6 ± 0.4 (3.2-4)
Ortholinea sp.	10.1± 0.57 (9-11)	12.3 ± 0.64 (12-14)	D: 5
Chloromyxum sp.	13.1 ± 0.6 (13-13.3)	10.3 ± 0.6 (10.2-10.5)	L:3±0.6, W:1.7±0.4

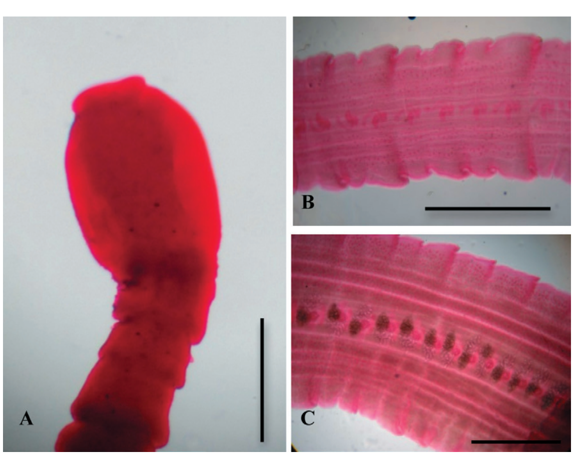

Fig.3. Bothriocephalus scorpii *from the intestin of trachinid fishes. A: Scolex; B: Immature proglottis; C: Mature proglottis*

T. araneus. However, there was no significant difference in the prevalence of infection by *Bothriocephalus scorpii* between host species (df=2, P>0.05).

Nematoda

Four nematode species were recorded during the sampling period. These species were found along the four seasons with maximum level of infection in summer.

Anisakis sp. (Table 2; Fig. 4) was collected from the intestine and the abdominal cavity of *T. draco* from the Bay of Bizerte, Gulf of Tunis, Sousse and Mahdia, and also from *T. araneus* and *T. radiatus* found in the previous locali-

Fig. 4. Anisakis simplex *from the intestine of trachinid fishes. A: Anterior part of body; B: Lateral view of cephalic end; C: Lateral view of caudal end. (Scale bars: A = 0.5 mm; B,C = 0.2 mm)*

ties except in the Gulf of Tunis where they are absent. The prevalence of infection was relatively higher in all infected fish and varied from 38% to 85.4%. The maximum mean intensity (21.1 ± 2.6) was noted in *T. draco* from the Bay of Bizerte. There was a significant difference in the prevalence of infection between localities (df=2, P< 0.05).

Hysterothylacium sp. (Table 2; Fig. 5) was collected from the abdominal cavity and the intestine of *T. draco* from the Bay of Bizerte, Gulf of Tunis, Sousse and Mahdia, and from the body cavity and the intestine of *T. radiatus* from the Bay of Bizerte and Sousse. Maximum prevalence of this species was noted in *T. draco* from the Bay of Bizerte with 50.5 % and the maximum mean intensity (10.8 ± 2.4) was registered in *T. draco* from the Gulf of Tunis. A significant difference in the prevalence of infection between the localities was noted (df=3, P< 0.05).

Fig. 5. Hysterothylacium sp. *from the intestine of trachinid fishes. A: ventrtal view of body and anterior region; B: Lateral view of cephalic end; C: Lateral view of caudal end. (Scale bars: A = 0.5 mm; B, C = 0.1 mm)*

Hysterothylacium fabri Rudolphi, 1819 (3rd larval stage) (Table 2; Fig. 6) was collected from the abdominal cavity and the intestine of *T. draco* from the Bay of Bizerte, Sousse and Mahdia. However, *Hysterothylacium fabri* Rudolphi, 1819 (4rd larval stage) was collected from the body cavity and the intestine of *T. draco* from the Bay of Bizerte, Sousse and Mahdia, and *T. radiatus* from the Bay of Bizerte and Mahdia. The maximum prevalence of *Hysterothylacium fabri* (third and fourth-stage

Fig .6. Hysterothylacium fabri *from the intestine of trachinid fishes. A: Anterior part of body; B: Lateral view of cephalic end of; C: Lateral view of caudal end of the 3rd larval stage; D: Lateral view of caudal end of the 4 rd larval stage. (Scale bars: 0.5 mm)*

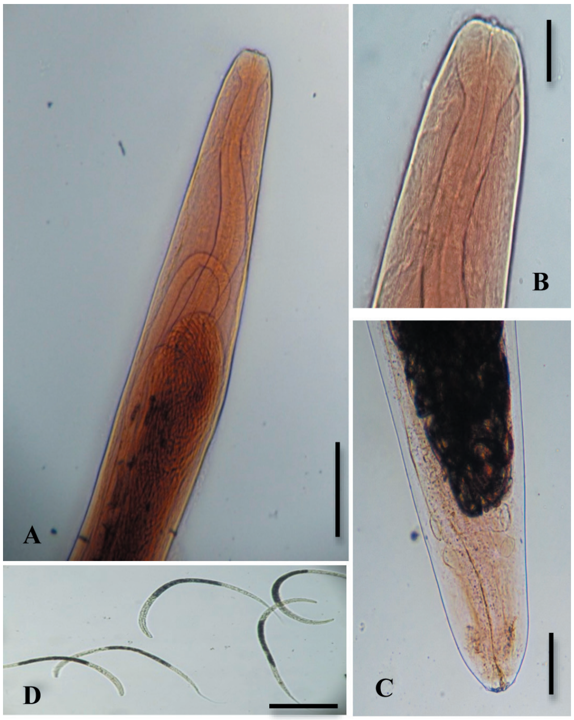

Fig. 7. Philometra sp. *from the ovary of trachinidfishes. A: Anterior part of body; B: Lateral view of cephalic end of; C: Lateral view of caudal end; D: Larva from uterus. (Scale bars: A, B, C = 0.5 mm; D = 0.1 mm)*

Fig. 8. Helicometra fasciata *from the intestine of trachinid fishes. Scale bar: 0.5 mm*

larvae) was observed in *T. draco* from the Bay of Bizerte with respectively 75.4% and 70.9%. The maximum mean intensity was noted for the fourth-stage larvae of *H. fabri* in *T. radiatus* from the Bay of Bizerte with 8.8 ± 0.5. There was significant difference in the prevalence between localities (df= 3, P< 0.05).

Philometra sp. (Table 2; Fig. 7) infecting the ovary of *T. draco* from the Bay of Bizerte was collected with a prevalence of 5.7%, and a mean intensity of 2 ± 1. The main measurements of *Anisakis sp. , Hysterothylacium sp.* and *Philometra* sp. collected from trachinid fishes are reported in table 4.

Monogenea

Aspinatrium trachini Parona & Perugia, 1889 (Table 2; Fig. 9) was collected from the gills of *T. draco*, *T. radiatus* and *T. araneus* from the Bay of Bizerte. The maximum prevalence (19.8%) and mean intensity (22) of *A. trachini* were recorded in *T. radiatus*. No significant difference was found in the prevalence of infection between host species (df=2, P>0.05).

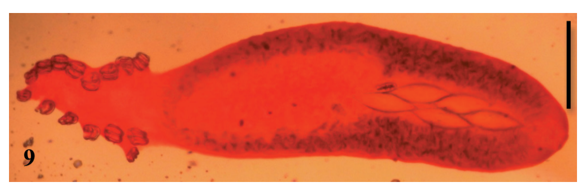

Fig. 9. Aspinatrium trachini *from the gills of trachinidfishes. Scale bar: 2 cm*

Isopoda

Praniza larvae of *Gnathia* sp. (Table 2, Fig. 10) were collected from the gills and the body surface of *T. draco*, *T. radiatus* and *T. araneus* from the Bay of Bizerte, Sousse, Mahdia and Gulf

Table 4. Morphometric measurements (mm) of nematode species parasite of trachinid fishes

Species	Total length	Maximum width	Nerve ring	Oesophagus length	Ventriculus length
Anisakis sp.	18-20.3	0.3-0.4	0.26-0.28	1.56-1.60	0.23-0.25
Hysterothylacium sp.	12.6 – 16.5	0.13 – 0.38	0.14-043	0.25-1.13	0.07-0.15
Philometra sp.	46.3 – 52.3	0.2 – 0.3	-	-	-

Fig. 10. Gnathia sp. *from the gills of trachinid fishes. Scale bar: 1 mm*

of Tunis. This species was found throughout the whole year. Maximum prevalence of *Gnathia* sp. was noted during summer in *T. draco* from the Bay of Bizerte (89%). However, the highest mean intensity (4 ± 2) was noted in *T .radiatus* from the Bay of Bizerte and Sousse. A significant difference was found in the prevalence of infection by *Gnathia sp.* between the host species (df=2, P<0.05).

Hirudinea

Stibarobdella loricata Schmarda, 1861 parasitizing gills of *T. draco* (Table 2, Fig. 11) was collected in spring from the Gulf of Tunis with low prevalence (1%) and mean intensity (1).

Parasite diversity

For the study of parasite diversity of Trachnids from Tunisian coasts, three measures of biodiversity were considered: the species richness (SR), Shannon-Weaver index (H') and Simpson index (D). The different fish species presented component communities with different diversity; each fish-host presented at least seven parasites species. The richest component community was in *T. draco* with 18 parasites species followed by *T. radiatus* (8 species) and *T. araneus* (7 species) (Table 5).

Fig. 11. Stibarobdella loricata *from the gills of trachinid fishes. Scale bar: 0.5 cm*

The Simpson index varied between 0.14 and 0.54. The highest value (0.54) was noted in *T. araneus*. Furthermore, *T. radiatus* and *T. draco* presented different values of the Simpson index: 0.28 and 0.14 respectively (Table 5). The highest value of Shannon-Weaver index of species diversity was observed for the community of *T. draco* (3.11). However, the Shannon-Weaver index was almost the same for *T. radiatus* (2.05) and *T. araneus* (2.1) (Table 5).

The study of parasite diversity according to the sampling site showed that the Bay of Bizerte presented the most important richness species with 17 parasites species followed by Mahdia with 11 species, Sousse with 9 species and the Gulf of Tunis with 7 species (Table 6). The maximum value of the Simpson index was noted in the Gulf of Tunis (0.26), however the minimum value was observed in the Bay of Bizerte

Table 5. The indicators characteristics of the parasite diversity of the T. draco, T. radiatus *and* T. araneus

Index \ Host	*T. draco*	*T. radiatus*	*T. araneus*
Richness species (RS)	19	8	7
Simpson (D)	0.14 ± 0.29	0.28 ±0.12	0.5 4±0.43
Shannon-Weaver (H')	3.11 ±0.12	2.05 ±0.23	2.01 ±0.10

Table 6. The indicators characteristics of the parasite diversity from the different sampling sites

Index \ Localities	Bay of Bizerte	Gulf of Tunis	Mahdia	Sousse
Richness species (RS)	17	7	11	9
Simpson (D)	0.12 ± 0.32	0.26 ±0.22	0.13 ±0.10	0.19 ±0.33
Shannon-Weaver (H')	3.94 ± 0.18	2.87 ±0.20	3.85 ±0.28	3,81 ±0.5

(0.12). The Shannon-Weaver index values were relatively higher in all the sampling sites and varied from 2.87 to 3.94. The maximum value was noted in the Bay of Bizerte (Table 6).

DISCUSSION

In this study, we provided for the first time a data on metazoan parasites of trachinid fishes from Tunisian coasts and their infection indices. Endoparasites collected from trachinids were most dominant than ectoparasites. Indeed, myxosporeans represent the most species-rich group (nine parasites species). Diversity of myxosporean species can be related to the diversity of actinospores parasitizing the invertebrate hosts (polychaetes) present in the sampling sites. These invertebrate hosts living in the sediment were in direct contact with trachnids, so they can easily be exposed to the myxospores released from these fish.

According to literature, this is the first record of *Ceratomyxa spp.* in Trachinidae from easterm Mediterranean waters. *Ceratomyxa reticularis* Thélohan, 1895 was previously reported from the gallbladder of *Trachinus draco* from Mediterranean coasts off France (EIRAS, 2006). However, this species differs greatly, in dimensions and shape, from the *Ceratomyxa* species of the present study. Among the 300 *Ceratomyxa* species previously described from different geographical areas (EIRAS, 2006; GUNTER & ADLORD, 2010; ROCHA *et al.,* 2015; THABET *et al.,* 2015; MANSOUR *et al.,* 2016), no one was morphologically similar to the specimens found.

Zschokkella trachini Azizi, Rangel, Castro, Santos & Bahri, 2016 was already described in *Trachinus draco* from the Bay of Bizerte (AZIZI *et al.,* 2016). In the present work, this species was found in *T. radiatus* from three localities along the Tunisian coasts (Gulf of Tunis, Sousse and Mahdia).

In this study we report for the first time the presence of *Ortholinea sp.* in trachinid fishes. *Ortholinea sp.* parasitizing *T. draco* and *T. radiatus* from the Bay of Bizerte and Mahdia was morphologically different from the 23 species of the genus *Ortholinea* available in the literature (LOM & DYKOVÀ, 2006; ABDEL-GHAFFAR *et al.,* 2008; KARLSBAKK & KØIE, 2011; RANGEL *et al.,* 2014; ABDEL-BAKI *et al.,* 2015; RANGEL *et al.,* 2016).

Myxidium trachinorum previously collected from the gallbladder of lesser weever *Echiichthys vipera* off England (CANNING *et al.,* 1999) was reported for the first time from the gallbladders of *T. draco* and *T. radiatus* living in Tunisian waters and in the Mediterranean Sea.

In this study we report for the first time the presence of *Chloromyxum* sp. in Trachinids. Among the 140 species of *Chloromyxum* described worldwide (EIRAS *et al.,* 2012), only *Chloromyxum tanakai* Fujita, 1936 collected from *Oncorhynchus keta* from Japan (EIRAS *et al.,* 2012) is relatively similar to the present one but differs greatly in dimensions. *Chloromyxum* sp. has been found only in *Trachinus draco* from the Bay of Bizerte with a very low prevalence (0.5%).

In the present work, the prevalence of myxosporeans infection varies in relation to the host species and the sampling site. Indeed, we have noted gradual decreases of prevalence from the north to the center coasst and in the most cases, the maximum values of prevalence were recorded in the Bay of Bizerte. These variations were generally associated to the environmental conditions, specially water temperature that have an important effect on the development of myxosporeans in fish and invertebrate hosts (MCGEORGE *et al.,* 1996; KENT *et al.,* 2001; YOKOYAMA, 2003; CANNING & OKAMURA, 2004). In fact, during the sampling period we have noted that the high water temperatures were recorded in the Bay of Bizerte (14,1 −31,1°C), followed by the Gulf of Tunis (8 − 28°C) then Sousse and Mahdia (11.8°− 27°C). These observations showed that the high water temperatures favored the release of actinospores from invertebrate hosts and the development of myxospores within the fish hosts. Other authors (YOKOYAMA *et al.*, 2012; FONTES *et al.*, 2015) reported this finding.

Concerning the nematodes infections, we report for the first time the presence of Philometra sp. in *T. draco* from Tunisian coasts. In fact, two species of the genus Philometra Costa, 1845 have been previously reported from trachinid fishes: *Philometra filiformis* Stossich, 1896 infecting the gonads of *T. draco* from the Adriatic Sea and Italy (STOSSICH, 1896; ORECCHIA & PAGGI, 1978) and *Philometra globiceps* Rudolphi, 1819 parasitizing the body cavity of *T. draco* from the Black Sea (MORAVEC, 2006). Nevertheless, *Philometra* sp. was morphologically different from these two species of *Philometra*.

In this study, *Anisakis* sp. was detected in trachinid fishes from Tunisian coasts. According to our knowledge, only the work of FARJALLAH *et al.* (2008) reported the presence of *Anisakis pegreffi* (CAMPANA-ROUGET & BIOCCA, 1955) from *T. draco* collected from Mahdia. Moreover, we report for the first time the presence of two species of *Hysterothylacium* in trachinid fishes from the Tunisian coasts.

Prevalence, mean intensity and mean abundance of nematodes in trachinid fishes were variable depending on the host species and the sampling site. *Anisakis sp.* was the most abundant species, followed by *Hysterotylacium fabri*, *Hysterothylacium sp.* and *Philometra sp.* We noted a gradual decrease of the prevalence rate from the north to the central coasts. It seems that infected intermediate hosts of nematodes are more abundant in the north coasts. The variations of the prevalence and the abundance of nematodes were probably related to the type and quantity of food consumed by hosts (BAGHERPOUR *et al.,* 2011; OLASUNMIBO OLUMUYIWA & OLATUNDE, 2014).

Bothriocephalus scorpii was the only species of cestods collected from trachinids and reported for the first time in the intestine of the three Trachinus species from the Tunisian coasts. Otherwise, this species was also reported in *Trachinus draco* from Turkey (AKMIRZA, 2004).

Digenean parasites collected in this study were limited to the species *Helicometra fasciata* infecting the intestine of *Trachinus draco* from the Bay of Bizerte, with a low prevalence of 4.21%. This species was previously reported in *Trachinus draco* from Turkey (AKMIRZA, 2004).

Aspinatrium trachini was recorded for the first time from trachinid fishes in tunisian waters. According to the literature data, this monegenean species has been reported in *T. draco* from Spain (LOPEZ-ROMAN & GUEVARA-POZO, 1973), in *T. radiatus* from Greece (PAPOUTSOGLOU, 1976), and in *T. araneus* from Montenegro (RADUJKOVIĆ & EUZET, 1989). Infection caused by *A. trachini* was observed only in the Bay of Bizerte. It seems that the environmental conditions in particular water temperature stimulate the development of *A. trachini.* Indeed, the higher temperatures were recorded in the Bay of Bizerte, which can influence the parasite abundance and the egg production in monogenean life cycle. The present results are supported by other studies where the highest mean intensity and abundance were found in spring and summer (RAWSON & ROGERS, 1973; KADLEC *et al.* 2003; OZTURK & ALTUNEL, 2006; MARTINS *et al*. 2014).

The Gnathiid isopods are the most common ectoparasites infecting a wide host range of fish worldwide. The present study report the presence of praniza larvae from trachinids in different sampling sites. These larvae belong to the genus *Gnathia.* According to literature, parniza larvae of *Gnathia sp.* have been previously reported in *T. draco*, *T. radiatus* and *T. araneus* from North African Mediterranean coasts (RAMDANE *et al.* 2009).

The Leeches are parasites of various fish species, little is known about the distribution of these parasites in Tunisia. In the present study *Stibarobdilla loricata* was reported for the first time from *Trachinus draco* from Tunisian coasts with a very low prevalence (1%). However, this species was previously reported in *Trachinus draco* from Turkey by AKMIRZA (2004).

In the present study, the species richness (SR) of trachnids was relatively important. Indeed, each fish host presented at least seven parasites species. The highest SR was recorded in *T. draco.* According to Simpson index, *T. draco* carried the highest parasite diversity. This result was confirmed by Shannon index, thus, the maximal value was observed in *T. draco*. However, the Shannon-Weaver index was the same for *T. araneus* and *T. radiatus*.

The important SR and diversity of parasitic species found in *T. draco,* could be explained by the higher number of the examined fish

(519) compared to the other fish host species. Moreover, *T. draco* may be more susceptible to the infection by parasites, compared to the other trachinid fishes.

Concerning diversity of the parasite metacommunities according to the sampling sites, the Bay of Bizerte presented the richest community followed by Mahdia. The two other sites, Gulf of Tunis and Sousse showed a less important species richness. The values of the Shannon-Wiener and Simpson's index show the richest diversity of parasite species in the Bay of Bizerte. Parasite diversity in relation to the locality can be affected by the seasons; in fact the sampling period was different in the fourth sampling sites. On the other hand, each sampling site was characterized by specific environmental conditions such as temperature and salinity, which may influence the development of the different parasites species. In addition to the presence of appropriate environmental conditions for the parasite, abundance of appropriate intermediate hosts can affect the parasite diversity.

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Metazoični nametnici kod paukovki (Teleostei: Trachinidae) sa obala Tunisa (Sredozemno more)

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SAŽETAK

U ovom radu se iznose istraživanja nametnika kod predstavnika porodice Trachinidae: *Trachinus draco* Linnea, 1758; *Trachinus araneus* Cuvier, 1829. i *Trachinus radiatus* Cuvier, 1829, koji su prikupljeni sa obala Tunisa. Istraživanje je trajalo od siječnja 2014. do siječnja 2015. godine. Ukupno je utvrđeno 18 vrsta metazoičnih nametnika iz 13 rodova: devet iz Myxozoa, četiri iz Nematoda, jedna iz Cestoda, jedna iz Digenea, jedna iz Monogenea, jedna iz Isopoda i jedna iz Annelida Hirudinea. Tijekom znanstvenog istraživanja istraživani su podaci o morfologiji, lokaciji i razini infekcije parazita.

Veće bogatstvo vrsta zabilježeno je kod *Trachinus draco* (18 vrsta), dok su *Trachinus radiatus* i *Trachinus araneus* imali 9 i 7 vrsta. Navodi se bogatstvo i raznolikost vrsta prema vrstama domaćina i lokacijama uzorkovanja na temelju Simpson i Shannon-Wiener indeksa.

Ključne riječi: Trachinidae, metazoični nametnici, raznolikost vrsta, Tunis