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Research Article

Seasonal variation of the ectoparasite infestation levels of *Trachurus picturatus* in Bizerte (Tunisia)

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Abstract: The blue jack mackerel, *Trachurus picturatus*, is a commercially important resource in the Mediterranean Sea and the North-East Atlantic. The main aim of this work was to assess the infection levels and diversity of the ectoparasites of the blue jack mackerel. Over a one-year period, between March 2017 and February 2018, 126 specimens of *T. picturatus* were collected seasonally from the Bizerte coast (Tunisia). The ectoparasite fauna of the examined host was composed of the two monogenean species, *Pseudaxine trachuri* and *Gastrocotyle trachuri* and a copepod species, *Peniculus fistula fistula*. This is the first record of this copepod parasite in Tunisia.

The analysis revealed that the infection levels fluctuated throughout the year. Both monogeneans (*P. trachuri* and *G. trachuri*) had high prevalences during the warm season (P% = 87.1, P% = 32.3, respectively).

Additionally, *P. trachuri* showed some seasonal variations in mean abundance and mean intensity between summer and the other seasons. Furthermore, there was a highly significant variation in the mean abundance of *G. trachuri* between the summer and autumn-winter seasons. The results of the current study may be explained by the seasonal variations in environmental conditions, the life cycles of the hosts and parasites, the feeding and migratory patterns of the hosts, the chemicals released by the hosts, and the interspecific competition between the two monogenean species.

Keywords: *Trachurus picturatus*; Bizerte; ectoparasites; parasitological indices; seasonal variability.

1. Introduction

The blue jack mackerel, *Trachurus picturatus* (Bowdich, 1825), is a highly consumed fish in a number of Mediterranean and Eastern Atlantic countries, especially in the Portuguese mainland and in the archipelagos of the Azores and Madeira (Garcia et al.,2015 ; Vasconcelos et al., 2018 ; Gherram, 2019).

T. picturatus is a pelagic to demersal species, reaching depths of up to 575 m, and is often confined to the neritic zone (Menezes et al., 2006; Gherram, 2019). This migratory fish lives in schools and may overlap in a water column interval with other species of the same genus (*T. trachurus* (Linnaeus, 1758) and *T. mediterraneus* (Steindachner, 1868)) (Gherram, 2019).

The spawning season of the blue jack mackerel begins in December and extends until April-May, with a peak in March (Costa, 2019). It grows faster during the first 3years of life (Vasconcelos et al., 2006). In the Azores, it reaches sexual maturity at 4-5 years (Garcia et al., 2015) while in Madeira and the Canary Islands, maturity is reached earlier (Vasconcelos et al., 2006; Jurado-Ruzafa and Santamaria, 2013). This scad is mainly a plankton feeder but small fishes are also part of its diet (Deudero, 2001; Hirch and Christiansen, 2010).

Metazoan ectoparasites are speculated to be useful bio-indicators of water quality and environmental stability as they are more vulnerable to environmental stress for their close contact with external cues (Santoro et al., 2020).

A number of studies have been carried out in Atlantic waters on the ectoparasite fauna of the blue jack mackerel (Gaevskaya and Kovaleva, 1979, 1985; Hermidaet al., 2016; Costa et al., 2019; Hamdi et al., 2019). The presently work is the first study on the ectoparasite community composition of *T. picturatus*, from the Mediterranean (Tunisian coast). Furthermore, a seasonal investigation was carried out with the aim of assessing the factors that may generate seasonal variation in the infection levels.

1. Materials and Methods

From March 2017 until February 2018, 126 adult specimens of *T. picturatus* (83 females and 43 males) were collected on a seasonal basis “Table 1”, fresh from local fishers from the Bizerte coast “Figure 1”.

The collected fish were transported immediately in iceto the laboratory and analysed for ectoparasites. The skin, mouth, and gill chambers were thoroughly observed. Gills were removed and placed in Petri dishes containing seawater. Each gill arch was separately observed under a stereomicroscope. All parasites were collected and preserved in 70% ethanol.

Table 1.Number and total body length of *T. picturatus*, examined from Bizerte coast. No significant differences were observed between seasons (non-parametric test of Kruskall-Wallis).

	Total	Autumn	Winter	Spring	Summer
Number of examined fish	126	32	30	33	31
Host length (cm) Mean ± SD	21.5 ± 3.3	21.8 ± 3.5	21 ± 3.8	19.8 ± 2.7	23.7 ± 1.4

Figure1. Map showing the locations used to sample *T. picturatus* off Bizerte coast, Tunisia (Yellow rectangle)

The date of sampling, length of the host fish, and microhabitat of the ectoparasite were noted. Subsequently, the collected specimens were processed according to a taxonomic group for examination by stereo and light microscopy. Measurements of parasites were made using an ocular micrometer and with the purpose of identification, drawings were made with the aid of a drawing tube. Parasites were morphologically identified following taxonomic descriptions in the literature (Vidjak et al., 2008; Bouguerche et al., 2020; Bouguerche et al., 2021). In this study, prevalence (P %), mean intensity of infection (MI), and mean abundance (MA) were determined according to Bush et al. (1997). Prevalence (%) is the number of hosts infected with one or more individuals of a particular parasite species divided by the number of hosts examined for that parasite species. The mean intensity is the total number of parasites of a particular species found in a sample divided by the number of hosts infected with that parasite. Mean abundance is the mean of the number of individuals of a particular parasite species per host examined.

Comparisons of the parasitological indices between seasons were assessed by R-Studio software. A Chi-square test was used for prevalence and a Kruskall- Wallis test for mean intensity and mean abundance. All statistical tests were performed at the significance level of 5%.

2. Results and discussion

A total of 294 ectoparasites belonging to three species were found infecting *T. picturatus.*

2.1. Composition of ectoparasite fauna

3.1.1.<u>*Pseudaxine trachuri* Parona & Perugia, 1890</u>

In this study, the monogenean *Pseudaxine trachuri* was collected from the fish gills "Figure 2". This parasite has been frequently reported in European waters (Atlantic Ocean and Mediterranean Sea) and in North Africa from different fishes exclusively of the *Trachurus* genus: *T. picturatus* (Gaevskaya and Kovaleva, 1979, 1985; Costa et al., 2012 Hermida et al., 2016; Hamdi et al., 2019); *T. trachurus*

(Llewellyn, 1962; Neifar, 1995; MacKenzie et al., 2008; Fekiet al., 2016; Shawket et al., 2018) and *T. mediterraneus* (Steindachner, 1868) (Akmirza, 2013).

This species was also collected from a Sparid host, *Boopsboops* (Linnaeus, 1758) (Pérez-del Olmo et al., 2008 ; Bouguerche et al., 2020).

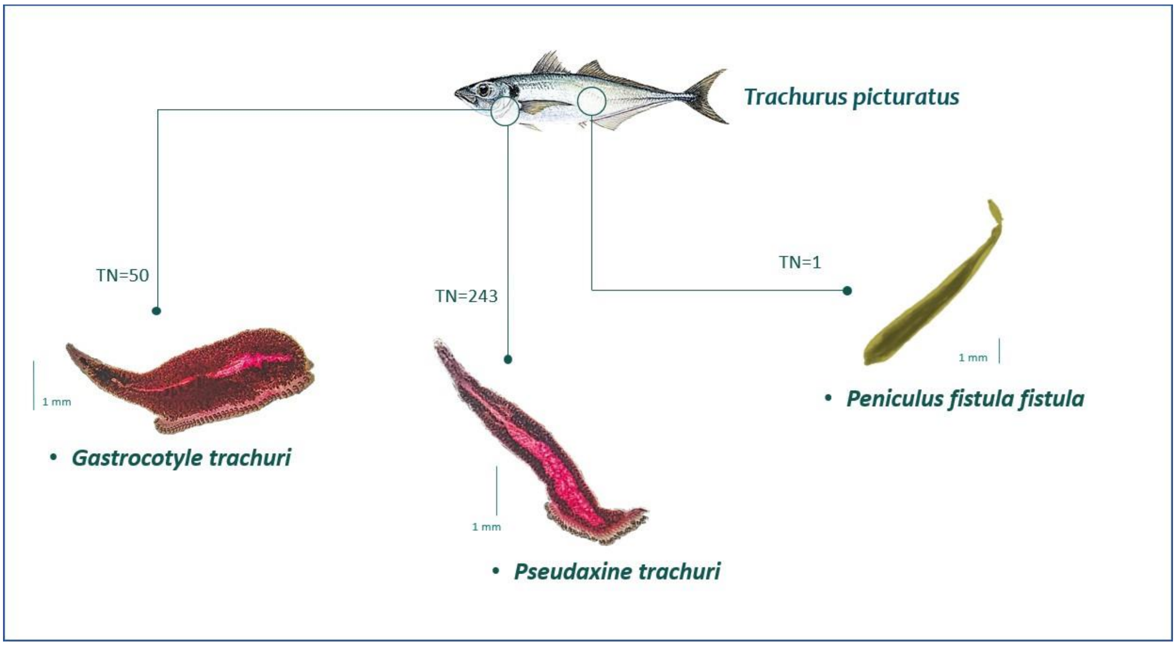

Figure 2. Ectoparasites of *Trachurus picturatus* from Bizerte (Tunisia); TN: Total number of collected ectoparasites

3.1.2 <u>*Gastrocotyle trachuri Van Beneden & Hesse, 1863*</u>

In the present survey, the monogenean species *Gastrocotyle trachuri* was collected from the gills of the blue jack mackerel "Figure 2". This parasite was reported for the first time on *T. trachurus* in Plymouth, British waters (Jones, 1933). It has also been reported from the same host fish off the Atlantic coast of Morocco and along the Tunisian coasts (Llewellyn, 1962; MacKenzie et al., 2008; Neifar, 1995; Feki et al., 2016; Shawket et al., 2018).

This parasite has previously been collected on *T. picturatus* from the coast of the Western Sahara, over seamounts south of the Azores, the Portuguese mainland waters, and from the Tunisian coast (Gaevskaya and Kovaleva, 1979, 1985 ; Hermida et al., 2016; Hamdi et al., 2019).

Moreover, this monogenean has been reported on *T. mediterraneus* from the Mediterranean (South-Eastern of Spain and Algerian coast) (Fernández-Jover et al., 2010; Bouguerche et al., 2021).

G. trachuri has also been reported from five other species of the same genus: *T. lathami* Nichols 1920, *T. novaezelandiae* Richardson 1843, *T. indicus* Nekrasov, 1966, *T. capensis* Castelnau, 1861 et *T. trecae* Cadenat, 1950 (Bouguerche et al., 2021). In addition, it has also been collected from other jackfish species: *Selar crumenophthalmus* (Bloch, 1793), *S. boops* (Cuvier, 1833), *Decapterus russelli* (Rüppell, 1830) and *D. maruadsi* (Temminck & Schlegel, 1843) (Bouguerche et al., 2021).

3.1.3 <u>*Peniculus fistula fistula* Nordmann, 1832</u>

One specimen of the copepod parasite *Peniculus fistula fistula* was collected from the fish body surface (Figure 2). This parasite is widely distributed (Atlantic, Indo-Pacific, Mediterranean Sea, Adriatic Sea, and Marmara Sea) and reported on 49 host species belonging to different families, of which we note *T. picturatus*, *T. trachurus* (Linnaeus, 1758) and *T. symmetricus* (Ayres, 1855) (Öktener and Şirin, 2019). From the 49 host species, only 4 were reported in the Indo-Pacific Ocean, 34 from the Atlantic, and 12 from all, Mediterranean, Adriatic, and Marmara Seas) (Öktener and Şirin, 2019*). P. fistula fistula* seems to be more adapted to the physicochemicals drivers of the Atlantic Ocean. As the only occurrence of this copepod on *T. picturatus* was reported from Portuguese samples (Candeias, 1955), its current presence constitutes a new record for the Tunisian coast and may be related to the horizontal migration of the Atlantic horse mackerel (Moreira et al. 2019).

2.2. Seasonal variability of the parasitological indices

The infection levels of the blue jack mackerel with *P. trachuri* were relatively high during this study with some seasonal differences detected between summer and the other seasons for MI and MA “Table 2” ($p \leq 0.0322$; $p \leq 0.0004$, respectively), and between summer and the autumn-winter period for prevalence ($p \leq 0.0414$).

On the other hand, the infestation with *G. trachuri* was highly significant between the summer and autumn-winter period for MA ($p \leq 0.0417$), and between summer and autumn for prevalence “Table 2” ($p = 0.0156$).

The seasonal variation of infestation of *T. picturatus* with the two monogeneans and the high infection levels during the summer months could be related to the feeding habits of the host, which vary according to its life cycle. During his study on the infestation of *T. trachurus* with the two monogeneans *P. trachuri* and *G. trachuri*, Llewellyn (1962) concluded that the reproductive activity of these parasites is orchestrated by the seasonal change of the host eating habits and migration habits from coastal waters to the sea bottom. In fact, the first vertical migration of the young scads to the bottom coincides with the maximum occurrence of the monogenean larvae deposited in the bottom by the adult parasite. Thereafter, while the young infested scads migrated to coastal waters and became plankton feeders, the reproductive activity of the adult monogeneans was suspended temporarily, or a state of diapause occurred. After some months, these parasites lay their eggs, which will reach the sea bottom waters in anticipation of the return to the bottom of potential hosts such as adult scads after the spawning period in coastal waters and other young scads that hatched during the previous year (Llewellyn, 1962).

During this work, the infection levels of *T. picturatus* with *P. trachuri* (P = 67.5% ; MI= 2.9 ± 2.1 ; MA= 1.90 ± 2.20) were found to be higher than those with *G. trachuri* (P = 15.9% ; MI= 2.5 ± 2.0 ; MA= 0.39 ± 1.20). This could be related to an interspecific competition between the two monogenean species. Furthermore, the large size of the species *G. trachuri* may influence the success of infection. Poulin (1999) has demonstrated a negative correlation between the monogeneans size and mean intensity of fish infection.

Table 2 Prevalence P(%), mean intensity (MI ± SD) and mean abundance (MA ± SD) of ectoparasites in *Trachurus picturatus*from coast of Bizerte (Tunisia) during the seasons

Parasites		**P% (IF/EF)**		**MI**		**MA**	
Monogenea							
Pseudaxine trachuri	**Autumn**	65.6 * (21/32)	-Su	2.4 ± 2.4	-Su	1.47 ± 2.18	-Su
	Winter	50 * (15/30)	-Su	2.5 ± 1.5	-Su	1.23 ± 1.63	-Su
	Spring	66.7 (22/33)		2.1 ± 1.3	-Su	1.42 ± 1.48	-Su
	Summer	87.1 * (27/31)	-Au -Wi	4.0 ± 2.4 *	-Au -Wi -Su	3.52 ± 2.63 *	-Au -Wi -Su
Gastrocotyle trachuri	**Autumn**	6.3 * (2/32)	-Su	3.0 ± 2.8		0.18 ± 0.87 *	-Su
	Winter	10 (3/30)		2.3 ± 1.2		0.23 ± 0.77 *	-Su
	Spring	15.2 (5/33)		2.0 ± 1.2		0.30 ± 0.85	
	Summer	32.3 * (10/31)	-Au	2.7 ± 2.8		0.87 ± 1.89 *	-Au -Wi
Copepoda							
Peniculus fistula fistula	**Autumn**	0.0 (0/32)		-		0.00	
	Winter	3.3 (1/30)		1.0 ± 0.0		0.33 ± 0.09	
	Spring	0.0 (0/33)		-		0.00	
	Summer	0.0 (0/31)		-		0.00	

IF: infested fish; **EF**: examined fish; **Au**: Autumn; **Wi**: Winter; **Sp**: spring; **Su**: Summer (corresponding season with which there is a significant difference); * indicate significant differences at p<0.05 between seasons)

The low level of infection during the winter with only one specimen of the euryxenous copepod species *P. fistula fistula* is in accordance with the analyses of Öktener and Şirin (2019) who reported that the infection rate of the benthopelagic host species with this parasite is about 21% of 49 host species.

3. Conclusion

Studies on fish parasites are important at different levels such as fish health monitoring in aquaculture, ecosystem health survey, and fish stock identification. The results of the current survey confirm the direct relation between the ectoparasite infestation levels and several biotic and abiotic drivers. The variation of the infection levels during the year of the blue jack mackerel from off Bizerte (Tunisia) with the two monogenean species *P. trachuri* and *G. trachuri*, as well as the high values of the parasitological indices during the warm period, may be related to the changes in the environmental factors throughout the seasons, host and parasite life cycles, host feeding and migrating habits, and host-generated chemicals that could stimulate the eggs hatching process. Interspecific competition between the two monogenean species and the large size of *G. trachuri* could explain its lower values of the parasitological indices. This study is the first record of the copepod *P. fistula fistula* in Tunisia.

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