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Diversity of digeneans parasitizing *Mullus barbatus* and *Mullus surmuletus* (Teleostean, Mullidae) off the coast of Algerian

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Summary

Mullus barbatus and *Mullus surmuletus* (Perciformes, Mullidae) are a common marine teleost of great commercial importance in many coastal areas. We studied the communities of Digenea species in two congeneric Mullidae hosts collected on the Algerian coast in the southern Mediterranean. Five hundred and seven *M. barbatus* and one hundred and twenty-three *M. surmuletus* were examined. During this work, we collected six species of parasitic Digenea which are related to five different families: Hemiuridae represented by *Lecithocladium excisum*, Fellodistomidae by *Proctoeces maculatus* and which is reported only from *M. surmuletus*, Derogenidae by *Derogenes latus*, Monorchiidae by *Proctotrema bacilliovatum* and finally Opecoelidae represented by two species *Opecoeloides furcatus* and *Poracanthium furcatum*. A critical systematic study revealed an apparent overlap in morphometric data of the six Digenean species from two host fishes. Therefore, the two mullet species are likely to share the same parasite community, and the stenoxenic specificity of Digenean parasites is briefly argued. Prevalence values showed that in the midst of six hundred and thirty Mullidae, one hundred and ninety-six are parasitized (31.11 %). Statistical tests showed that the most parasitized fish hosts are *M. surmuletus* with a high prevalence value (47.15 %), and on the other hand, they proved that small fish are more parasitized than others. Also, the lack of homogeneity between the different parasites is reported. We also note that the use of factorial correspondence analysis (FCA) allowed us, for the first time to highlight the distribution of the parasite species identified in the two mullets according to the seasons.

Keywords: Digenea; Mullidae; *Mullus*; Mediterranean; prevalence

Introduction

The host species (Perciformes: Mullidae Rafinesque, 1815) is one of the oldest known and appreciated fish; it is particularly important in the Mediterranean because it is of great economic and commercial interest (Busalacchi *et al.,* 2010; Mangano *et al.*, 2017; Carbonara *et al.,* 2018). The family Mullidae is one of the largest families, consisting of sixty-two species divided into six genera (Nelson, 2006), of which three genera (*Mullus*, *Upeneus*, *Pseudopeneus*) have been recorded in the Mediterranean Sea (Hureau, 1986; Golani, 1994). The genus *Mullus* Linnaeus, 1758 is represented by two species, *Mullus barbatus* Linnaeus, 1758 and *Mullus surmuletus* Linnaeus, 1758, with a subspecies *Mullus barbatus ponticus* Essipov, 1927 from the Black Sea (Hureau, 1986; Turan, 2006). They are easily recognized by the presence of a pair of long, mobile hyoid barbels on the chin (Randall, 1983;

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Kim, 2002; Nelson, 2006). Their diet is varied, feeding on crustaceans, polychaetes and mollusks, and small fish, fish eggs and echinoderms (Platell & Potter, 2001; Platell *et al.*, 1998; Stergiou & Karpouzi, 2001; Derbal *et al.*, 2010). On the Algerian coast, the red mullet *M. barbatus* and the striped mullet *M. surmuletus* are very abundant and very frequent in commercial catches (Dieuzeide *et al.*, 1955; Djabali *et al.*, 1993; Derbal & Kara, 2001). These species are gregarious, but they do not share the same biotopes (Lombarte *et al.*, 2000) nor the same trophic niches (Labropoulou & Eleftheriou, 1997) because *M. barbatus* is a demersal species, generally frequenting the mud, sand or gravel bottoms of the continental shelf, whereas *M. surmuletus* is a demersal species on the rock and gravel bottoms, but sometimes also on the soft bottoms (Fischer *et al.*, 1987).

Many researchers have been interested in the study of the parasitic biodiversity of the genus *Mullus* because it has a rich parasitic fauna, especially the parasitic Digenea (Gaglio *et al.*, 2011; Carreras-Aubets *et al.*, 2012; Derbel *et al.*, 2012; Hassani *et al.*, 2012; Debenedetti *et al.*, 2013; Bottari *et al.*, 2014; Cinar, 2014; Hassani *et al.*, 2015; Barreiro *et al.,* 2017; Antar *et al.*, 2018; Bottari *et al.*, 2020).Despite all this work, few researchers are interested in epidemiological study using parasitological indices with statistical tests in the Mediterranean area.

This work aims to know the biodiversity of the Digenea parasites of these fishes collected along the Algerian coast and consequently the realization of a complete inventory. In a second step, we will carry out a bioecological approach to the parasites, where we will be particularly interested in the general characteristics of the parasitism, the parasite-host relationships and the parasite-host-environment relation will also be approached because the parasite indices of these two hosts at the same time is not detailed. We also used statistical tests to understand the functioning of parasitism and to compare our data with those available in the Mediterranean.

Materials and Methods

Between February 2019 and October 2021, a total of 507 specimens of *M. barbatus* and 123 specimens of *M. surmuletus* were collected from fish landings at the fishing harbor in different regions off the Algerian coast that extends from western [Ain Témouchent (35°17'22" N, 1°08'28" W) and Ghazaouet (35°06'0" N, 1°51'0" W)], to central [Cherchell (36º36'31" N, 2º11'50" E), Bouharoune (36°37'24" N, 2°39'17" E), Algiers (36°45'8" N, 3°°2'31" E), La pirouz (36°47'26" N, 3°14'59" E), Cap Djinet (36°52'37" N, 3°43'23" E), Dellys (36°54'48" N, 3°54'51" E) and Béjaïa (36°45'00" N, 5°04'00" E)] and the east [El Kala (36°53'44" N, 8°26'36" W) and Annaba (36°54'27" N, 7°45'26" W)] (Fig. 1). Fishes were kept on ice and transferred immediately to the laboratory (LBEIG, USTHB) shortly after capture. In the laboratory, each specimen was identified with keys (Fischer *et al.*, 1987), weighed (g), measured in full length (cm) and dissected the digestive tract of goatfish were placed in separate Petri dishes containing seawater and observed under a Zeiss microscope for the presence of digenean parasites. The latter were kept in 70 % ethyl, stained with boracic carmine, dehydrated through a graded ethanol series, cleared in clove oil and mounted in Canada balsam as a permanent mount. Drawings were made with an optical microscope equipped with a drawing tube (ZEISS Axioskop) in the laboratory of Parasitology of the Faculty of Biological Sciences of the USTHB (Algeria). Drawings were scanned and redrawn on a computer with Adobe Illustrator (CS5). Parasitological indices first processed the results obtained in this research. Processed the results obtained in this research (Prevalence and abundance) were calculated following Margolis *et al.* (1982). For the statistical study, the Shapiro-Wilk normality test, the Kruskal-Wallis test, the Wilcoxon test, independence and homogeneity tests based on the distribution Chi-square was used, and factorial correspondence analysis (FCA).

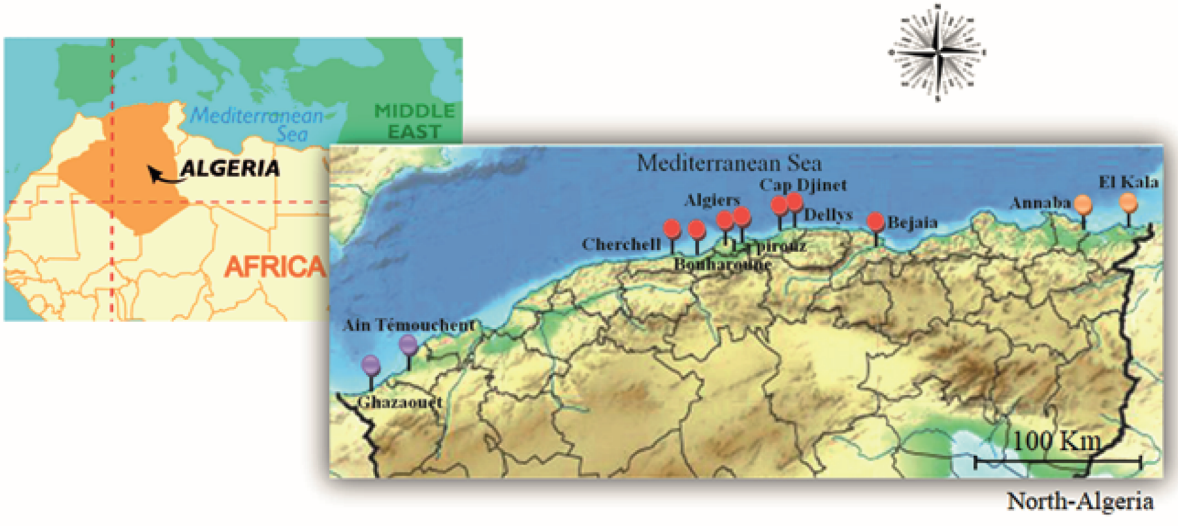


Fig. 1. Map of the Algerian sample collection sites. Main fishing ports along the Algerian coast (modified map).

Table 1. The prevalence and abundance of parasitic infection in two species of red mullet from the Algerian coast.

Digenean species	*Derogenes latus*	*Lecithocladium excisum*	*Opecoeloides furcatus*	*Poracanthium furcatum*	*Proctotrema bacilliovatum*	*Proctoeces maculatus*
Number of positive samples	14	27	155	37	9	8
Prevalence parasites	2.22%	4.29%	24.60%	5.87%	1.43%	1.27%
Number of parasites	19	89	1189	84	147	15
Abundance parasites	0.03	0.14	1.89	0.13	0.23	0.04

Ethical Approval and/or Informed Consent

All applicable institutional, national and international guidelines for the care and use of animals were followed.

Results

The Examination of the digestive tract of 630 teleost hosts of the Mullidae collected along the Algerian coast allowed us to identify 1553 parasitic Digenea divided into sex species, which are attached to 5 families: Hemiuridae Looss, 1899 (*Lecithocladium excisum* (Rudolphi, 1819) Lühe, 1901 (Fig. 2A)), Fellodistomidae Nicoll, 1909 (*Proctoeces maculatus* (Looss, 1901) Odhner, 1911 (Fig. 2B)), Deogenidae Nicoll, 1910 (*Derogenes latus* Janiszewska, 1953 (Fig. 2C)), Monorchiidae Odhner, 1911 (*Proctotrema bacilliovatum* Odhner, 1911 (Fig. 2D)), Opecoelidae Ozaki, 1925 (*Opecoeloides furcatus* (Bremser in Rudolphi, 1819) Odhner, 1928 (Fig. 2E); *Poracanthium furcatum* Dollfus, 1948 (Fig. 2F)).

Our study included a total of 630 individuals, among which 196 were parasitized (31.11 %), including 507 *Mullus barbatus* with 138 parasitized individuals (27.22 %) and 123 *Mullus surmuletus* with 58 parasitized individuals (47.15 %); the Chi-square test (χ^2=18.355) allowed us to detect a highly significant difference ($P < 0.001$) between the prevalence of parasitism according to the host species, that is to say *M. surmuletus* is more parasitized than *M. barbatus* with a higher prevalence. To compare the abundance of the different parasites observed between the two fish species, we first checked the normality with the Shapiro-Wilk test, it turns out that $P < 0.05$ so the abundance values of the parasites do not follow a normal distribution, for that we used the Wilcoxon rond test to compare the different parasite species between the host species, this last one showed us that there is not a significant difference with $P > 0.05$.

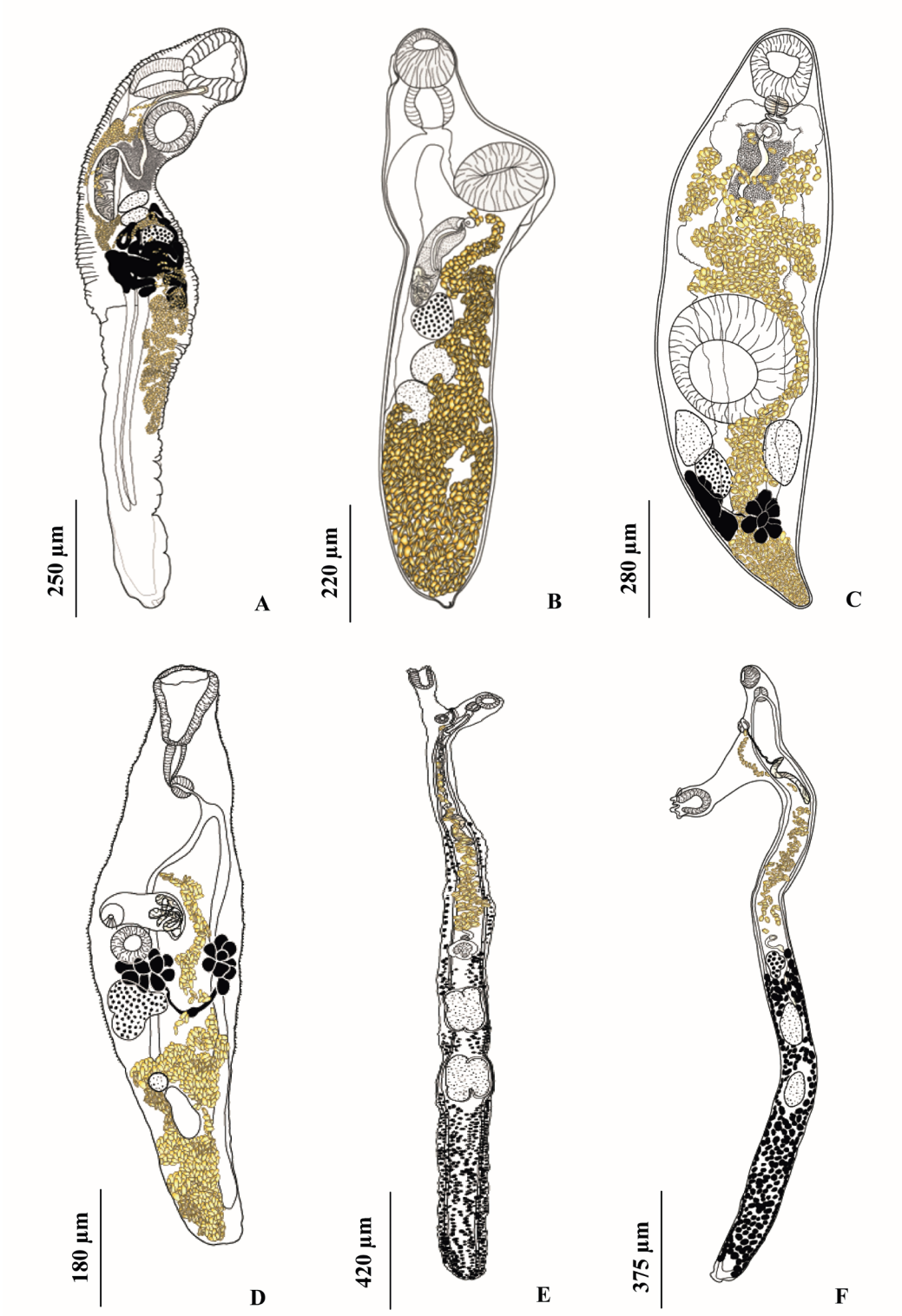
The most diverse parasite fauna was observed in *M. surmuletus* with six species of parasites, contrary to *M. barbatus*, which hosts only five species from which *P. maculatus* is absent. The prevalence values of the parasites according to the host species show a highly significant difference (Table 1); the fauna of these species was dominated by *O. furcatus* (24.60 %), followed by *P. furcatum* (5.87 %) and *L. excisum* (4.29 %) then *D. latus* (2.22 %), while *P. bacilliovatum* and *P. maculatus* had the lowest prevalences (1.43 % and 1.27 % respectively); there is a highly significant difference between the observed prevalences, so the Chi-square test of homogeneity showed the absence of homogeneity between the different parasite species with $P < 0.001$. On the other hand, *O. furcatus* and *P. bacilliovatum* were more abundant than the other parasitic Digenea (A= 1.89; A= 0.23 repectively) in Mullidae species (Table1).

The interpretation of the results in Table 2 shows that the distribution of parasitic Digenea is not the same in the two host species, we noticed that the prevalences and abundances of the latter are higher in *M. surmuletus* than in *M. barbatus*. We also deduced that the distribution of the different parasitic species with a prevalence > 10 % is always high for *O. furcatus* in both species of Mullidae, while *P. furcatum* has a higher prevalence in *M. surmuletus* (14.63 %) than in *M. barbatus* (3.75 %).

The analysis in Table 3 highlights the mean prevalence and abundance of weight and size of the two red mullet species for each parasitic Digenea, the size values show that the highest prevalences and abundances are observed for the species *O. furcatus* (P = 19.44 %; A = 1.33) followed by *P. furcatum* and *L. excisum* (P = 5.30 %; A = 0.09, P = 4.04 %; A= 0.09 respectively) whose size is ≤ 16.5 cm, however fish with a size > to 16.5 cm are dominated by *O. furcatus* (P = 33.33 %; A = 2.83) followed by *P. furcatum* and *L. excisum* (P = 6.84 %; A = 0.21, P = 4.70 %; A= 0.24 respectively). Moreover, the lowest prevalence and abundance were ob-

Table 2. Prevalence (P %) and abundance (A) of parasites found in *Mullus barbatus* and *Mullus surmuletus* in from the Algerian coast.

Digenean species		*Derogenes latus*		*Lecithocladium excisum*		*Opecoeloides furcatus*		*Poracanthium furcatum*		*Proctotrema bacilliovatum*		*Proctoeces maculatus*	
Hosts	**Number of hosts**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**
Mullus barbatus	507	1.97	0.03	3.35	0.05	21.30	1.61	3.75	0.06	0.39	0.00	0.00	0.01
Mullus surmuletus	123	3.25	0.05	8.13	0.50	38.21	3.04	14.63	0.46	5.69	0.20	6.50	1.16



(**A**) *Lecithocladium excisum*, (**B**) *Proctoeces maculatus*, (**C**) *Derogenes latus*, (**D**) *Proctotrema bacilliovatum*, (**E**) *Opecoeloides furcatus*, (**F**) *Poracanthium furcatum*.

Fig. 2. Biodiversity of Digeneas parasites of two species of mullet of the genus *Mullus* from the Algerian coast.

Table 3. The prevalence and abundance of parasitic infection in two species of red mullet from the Algerian coast in relation to the size and weight of the fish.

Digenean species			*Derogenes latus*		*Lecithocladium excisum*		*Opecoeloides furcatus*		*Poracanthium furcatum*		*Proctotrema bacilliovatum*		*Proctoeces maculatus*	
Hosts	**Mean values**	**Number of hosts**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**
Length (cm)	≤ 16.5	396	1.52	0.02	4.04	0.09	19.44	1.33	5.30	0.09	0.25	0.01	1.01	0.03
	> 16.5	234	3.42	0.05	4.70	0.24	33.33	2.83	6.84	0.21	3.42	0.62	1.71	0.06
Weight (g)	≤ 100	600	1.67	0.02	4.00	0.09	24.33	1.69	5.83	0.13	1.00	0.16	1.17	0.04
	> 100	30	13.33	0.20	10.00	1.27	30.00	5.83	6.67	0.20	10.00	1.70	3.33	0.03

Table 4. Prevalence (P %) and abundance (A) of parasites found in *Mullus barbatus* and *Mullus surmuletus* in the three study areas.

Digenean species			*Derogenes latus*		*Lecithocladium excisum*		*Opecoeloides furcatus*		*Poracanthium furcatum*		*Proctotrema bacilliovatum*		*Proctoeces maculatus*	
Hosts	**Number of hosts**	**Areas**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**
Mullus barbatus	507	Centre	6.82	0.02	12.88	0.06	78.79	1.59	13.64	0.06	1.52	0.00	0.00	0.01
		East	0.00	0.00	0.00	0.00	80.00	3.45	20.00	0.09	0.00	0.00	0.00	0.00
		West	100	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mullus surmuletus	123	Centre	1.96	0.01	15.69	0.52	84.31	3.34	27.45	0.38	7.84	0.23	15.69	0.92
		East	20.00	0.09	40.00	0.55	60.00	1.09	60.00	1.00	40.00	0.00	0.00	1.36
		West	100	1.00	0.00	0.00	50.00	0.25	50.00	1.00	50.00	0.00	0.00	7.25

served in *D. latus*, *P. maculatus* and *P. bacilliovatum* (Table 3); the Chi-square test for prevalence was highly significant ($P < 0.001$), which explains that small fish are more parasitized than large fish. The other values also indicate that the highest prevalences and abundances for each parasite species are observed for *O. furcatus* (P = 24.33 %; A = 1.69) followed by *P. furcatum* and *L. excisum* (P = 5.83 %; A = 0.13, P = 4.00 %; A= 0.09 respectively) whose weight is ≤ 100g, while the second class of fish whose weight is > to 100g are dominated by *O. furcatus* (P = 30.00 %; A = 5.83) followed by *D. latus*, *P. bacilliovatum*, *L. excisum* and *P. furcatum* (P = 13.33 %; A = 0.20, P = 10 %; A= 1.70, P = 10 %; A = 1.27, P = 6.67 %; A = 0.20 respectively), but the lowest prevalence and abundances are still reported for *P. maculatus* (Table 3). The Chi-square test shows a highly significant difference ($P < 0.001$), indicating that small fish are more contaminated than large fish over 100g.

The prevalence and abundance values of the different species of red mullet parasites according to the sampling sites are shown in Table 4. The results show that the species *P. maculatus* infests only the red mullet fish *M. surmuletus* in central Algeria with a high prevalence and abundance rate (P = 15.69 %; A = 0.92), while *O. furcatus* and *P. furcatum* are reported in both species of red mullet in the center and the east, contrary to the west where the latter two are not reported in *M. barbatus*. Furthermore, it is noted that the species *L. excisum* is absent in the west for both species of fish and the east for *M. barbatus* in contrast to *D. latus*, which presents a very high infestation rate in the western fish (P = 100 %; A = 0.13, P = 100 %; A = 1.00) for *M. barbatus* and *M. surmuletus* respectively. Table 4, shows that the western individuals of *M. barbatus* are infested only by *D. latus*. Comparison of the abundance of *M. barbatus* and *M. surmuletus* by region using the Kruskal-Wallis test revealed a non-significant difference with $P > 0.05$.

The relationship between the infestation parameters and the four seasons of the year are presented in Table 5. The results show that both *O. furcatus* and *P. furcatum* are present all the year round

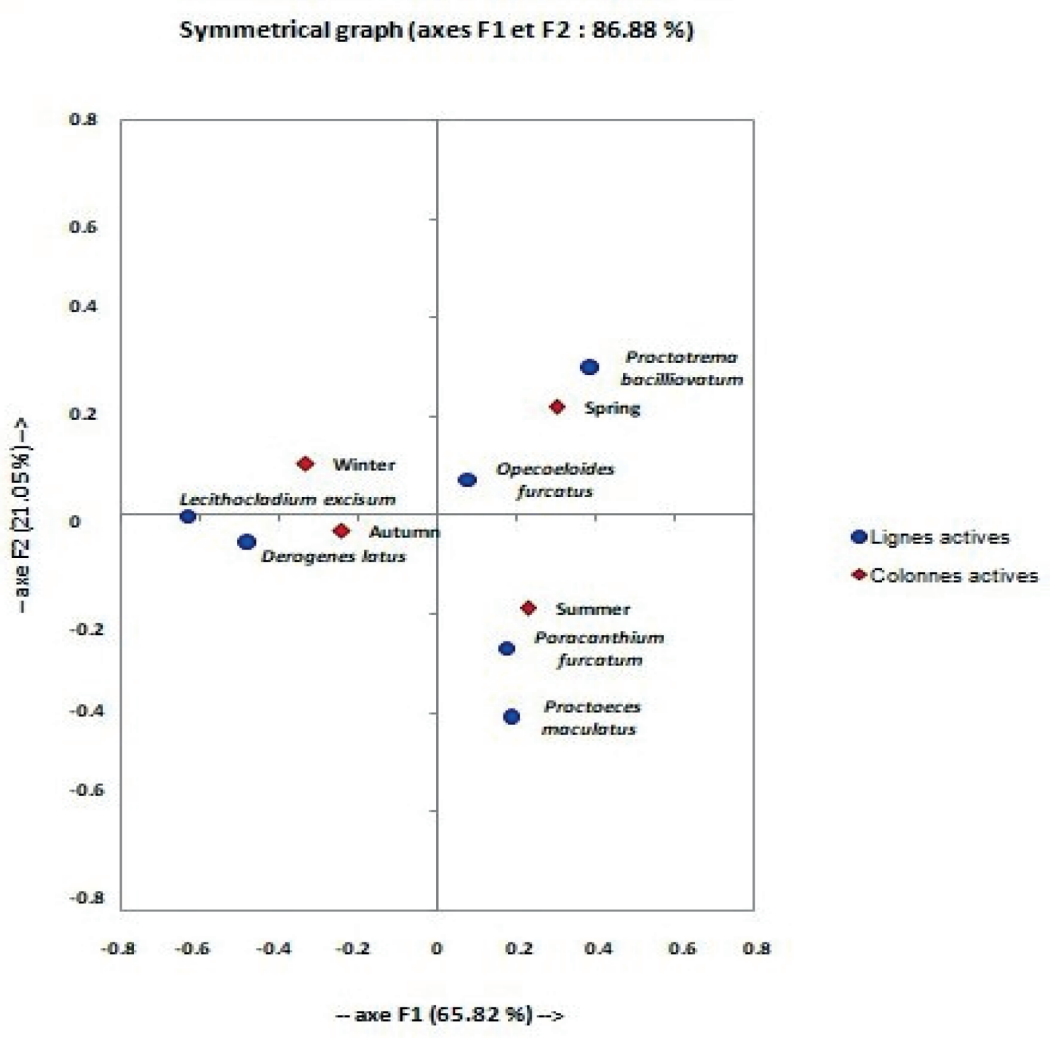


Fig. 3. Correspondence Factorial Analysis (AFC) of parasitic Digenea according to the seasons of two red mullet species.

Table 5. The seasonal variation in the prevalence (P %) and abundance (A) of Digeneas parasites found in *Mullus barbatus* and *Mullus surmuletus*.

Digenean species			*Derogenes latus*		*Lecithocladium excisum*		*Opecoeloides furcatus*		*Poracanthium furcatum*		*Proctotrema bacilliovatum*		*Proctoeces maculatus*	
Hosts	**Number of hosts**	**Seasons**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**	**P (%)**	**A**
Mullus barbatus	507	Autumn	5.66	0.02	24.53	0.11	71.70	0.98	15.09	0.07	0.00	0.00	0.00	0.00
		Winter	12.50	0.06	12.50	0.08	79.17	1.16	4.17	0.01	0.00	0.00	0.00	0.00
		Spring	3.03	0.01	3.03	0.01	78.79	1.57	18.18	0.06	3.03	0.00	0.00	0.02
		Summer	10.71	0.06	0.00	0.00	89.29	3.83	14.29	0.06	3.57	0.00	0.00	0.01
Mullus surmuletus	123	Autumn	21.43	0.13	21.43	0.42	57.14	0.76	35.71	0.34	21.43	0.13	14.29	1.16
		Winter	16.67	0.07	50.00	2.73	83.33	2.53	16.67	0.53	0.00	0.07	16.67	0.00
		Spring	0.00	0.00	5.56	0.05	83.33	3.49	5.56	0.26	16.67	0.03	5.56	2.51
		Summer	0.00	0.00	15.00	0.10	95.00	5.52	55.00	0.81	5.00	0.58	20.00	0.03

in both host species, with an infestation rate that is high for *O. furcatus* in summer for *M. barbatus* and *M. surmuletus* (P = 89.29 %; A = 3.83, P = 95.00 %; A = 5.52 respectively) and we also noticed that *L. excisum* is absent in summer for *M. barbatus* but in the second *M. surmuletus* it is present throughout the year with a high infestation rate in winter (P = 50.00 %; A = 2.73), furthermore *D. latus* species is absent in *M. surmuletus* in spring and summer but has a high infestation rate in autumn (P = 21.43 %; A = 0.13), while the prevalence and abundance values of *P. bacilliovatum* according to the seasons show that the latter is absent in winter in both host species, in addition it is an uncommon parasite as it is not abundant in *M. barbatus* (Table 5) and for *P. maculatus* we noted that this species is only reported in *M. surmuletus* during the four seasons with a high prevalence rate in summer (20 %), but it is very abundant in autumn and spring (A = 1.16, A = 2.51 respectively).

Comparison of the abundance of *M. barbatus* and *M. surmuletus* by season using the Kruskal-Wallis test revealed a non-significant difference with $P > 0.05$, so there is no seasonal difference.

Correspondence factor analysis (CFA) (Fig. 3) was applied to reveal the distribution of parasitic species found in the two red mullet species according to season. The contribution of the parasitic Digenea found in the two red mullet species to the total inertia is 65.82 % for axis 1 and 21.05 % for axis 2. The sum of these two rates is equal to 86.88 %. All the information is contained in the plane of axes 1 – 2. The participation of the seasons in the formation of axes 1 and 2 is as follows: for axis 1, it is autumn with 28.12 % and spring with 28.41 % that are most involved in the construction of axis 1, while for axis 2, it is spring with 47.03 % and summer with 44.46 % that are most involved in the development of axis 2. While the participation of the parasitic Digenea in the formation of the two axes is as follows: The species that intervene most in the formation of axis 1 has a rate equal to 60.89 %; it is *L. excisum*. It is followed by *D. latus*, which participates with 18.04 %, then *P. bacilliovatum* and *P. furcatum* with 7.65 % and 6.32 %, respectively. The other species participate at lower rates. On the other hand, *P. furcatum* is the species that contribute most to the elaboration of axis 2, with a percentage that equals 46.95 %. Followed by *P. maculatus* with a percentage equal to 23.66 %. In contrast, *O. furcatus* and *P. bacilliovatum* come in the third position with 14.67 % and 13.95 %, respectively. The other species occur at lower rates. The distribution of the parasites by season is as follows: each quadrant represents a season; winter is in the first quadrant, spring in the second quadrant, summer in the third quadrant and autumn in the fourth quadrant, which indicates that the parasites are found throughout the different seasons. The scatter plot shows that *O. furcatus* is represented throughout the year, so it is an omnipresent species. On the other hand, it shows that *L. excisum* is a species that predominates in autumn and winter, unlike *P. furcatum* and *P. maculatus*, which are predominant in summer. In particular, we note that spring is a season represented only by *P. bacilliovatum* and autumn by *D. latus*, that is to say, where the infestation is high.

Discussion

Studies of the parasitic fauna of the Digenea parasites of the two species of red mullet *M. barbatus* and *M. surmuletus* with their bioecological analyses along the Algerian coast are rare and fragmentary.

Of the 1553 parasites collected, we found six species of Digenea parasites in *M. surmuletus* and five species in *M. barbatus* that belong to different families. Concerning *M. surmuletus*, our results are similar to those of Brahim Tazi *et al.* (2009). While in western Algeria, Haddad *et al.* (2013) and Hassani *et al.* (2015) reported the same species of Digenea parasite except for *P. maculatus*. In the Mediterranean, many works have shown that the parasitic fauna of this species of mullet is almost the same with an infestation rate that varies from one region to another, such as Bartoli *et al.* (1991), Bartoli *et al.* (2005), Martinez-Vicaria *et al.* (2000), Derbel *et al.* (2012), Anter *et al.* (2018) and Bottari *et al.* (2020) In the Mediterranean *M. barbatus* harbors a very limited number of parasites unlike the first species, our results are different from the works of Janiszewska (1953), Martinez-Vicaria *et al.* (2000), Derbel *et al.* (2012) and Bottari *et al.* (2020) and therefore we report the presence of *D. latus* for the first time in Algeria in *M. barbatus*, as well as *L. excisum*.

In the present study, both species of mullet have a high infestation with a significant difference between their prevalences. According to our results, *O. furcatus* is the most frequent and abundant species in both host fishes, which is similar to many works in the Mediterranean Sea; according to Derbel *et al.* (2012), Martinez-Vicaria *et al.* (2000), Bottari *et al.* (2020), several authors have reported the presence of the latter in different points of the Mediterranean, on the other hand, the latter is followed by *P. furcatum*, these results are in agreement with those obtained by Martinez-Vicaria *et al.* (2000) in Spain. On the other hand, Derbel *et al.* in 2012 and Bottari *et al.* in 2020 reported the same parasites except for *P. furcatum* in *M. barbatus*. In western Algeria, we found in *M. surmuletus* four species of parasites *D. latus*, *O. furcatus*, *P. furcatum* and *P. bacilliovatum*. These results are similar to the work of Brahim Tazi *et al.* (2009), Haddad *et al.* (2013) and Hassani *et al.* (2015); moreover, in our case, the infestation rate of *D. latus* is very high (P = 100 %, A = 1.00) in contrast to previous works (P = 4 %, A = 0.07; P = 1 %, A = 0.04; P = 8 %, A= 0.11 respectively), this may be due to either the availability of the intermediate host or the feeding regime.

It is also noted that the infestation rate of *O. furcatus* and *P. furcatum* is higher in *M. surmuletus* than in *M. barbatus*, which is similar to the work of Martinez-Vicaria *et al.* (2000) in Spain. On the other hand, the species *O. furcatus* is still dominant in *M. surmuletus* in the Mediterranean as Derbel *et al.* (2012), Hassani *et al.* (2015) and Bottari *et al.* (2020) contrary to the work of Bartoli *et al.* (2005) and Anter *et al.* (2018) where they reported that *P. furcatum* and *P. bacilliovatum*, respectively, have a high rate of infestation in comparison to the other parasite species.

This study also shows that the prevalence rate of parasites as a function of host size is always high in large fish compared to small fish in both host species; these results are similar to those of Martinez-Vicaria *et al.* (2000) where it was observed that the infestation rate of *O. furcatus* and *P. furcatum* is high in both large mullidae species. On the other hand, Martinez-Vicaria *et al.* (2000) indicate that there is no significant difference between parasitism and the size of the fishes, contrary to our data which show a highly significant difference between the infestation rate, the size and the weight of the hosts. Our results show that small fish are more parasitized than the big ones; this can be due to the immune system which is weak. Concerning parasitism, according to the seasons, we notice a significant difference contrary to Martinez-Vicaria *et al.* (2000). However, it is noted that *O. furcatus* is always more abundant throughout the year than *P. furcatum* which is similar to the work of Martinez-Vicaria *et al*. (2000) in Spain, according to Bartoli and Gibson (1991) the latter species has a lower prevalence and a more restricted distribution compared to *O. furcatus*, Moreover, it was deduced that in Algeria these two species of parasites are present during the four seasons in the two host species with a high infestation rate, unlike the species *O. furcatus*, which exists in Spain and has a low rate in autumn, on the other hand we note that the infestation rate of *P. furcatum* in Algeria in *M. barbatus* is low in winter and high in spring in *M. surmuletus* which differs from the work of Martinez-Vicaria *et al.* (2000) in Spain where the infestation rate is low in autumn in *M.barbatus* while it is high all year round in *M. surmuletus* This may be due to the variation in the diet of mullidae throughout the year (Derbal *et al*., 2010; El Bakali, 2010) or their feeding habits (Arculeo *et al.,* 1997), although both fish species dig the substrate when feeding and use barbels to detect their prey but *M. barbatus* digs deeper in search of its prey than *M. surmuletus*. According to Derbal *et al.* (2010) the diet of the latter shows heterogeneity in spring and autumn and they considered that *M. surmuletus* is a voracious predatory species that feeds throughout the year, including during the period of gonad maturation which extends from February to June on the Algerian east coast.

It should be noted that the Correspondence Factorial Analysis (CFA) allowed us to link parasitism to seasons (Dajoz, 1982); it showed us that each parasite species has a high parasite specificity at a given period, unlike other digenean parasites, which are present all year round. However, unfortunately, we could not compare our data with other works because this test was done for the first time.

Conflict of Interest

The authors declare that they have no conflict of interest.

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