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Effect of Biotic and Abiotic Factors on the Epidemiological Index of *Dactylogyrus heteromorphus* El Gharbi, 1994 (Monogenea) Parasitizing the Algerian Barbel *Luciobarbus callensis* (Cyprinidae) Inhabiting Foum-El-Khanga Dam (Souk-Ahras, Algeria)

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Research Article

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Abstract

Examination of 341 individuals of *Luciobarbus callensis* caught in Foum El Khanga Dam during the year 2015, allowed us to collect 2782 specimens of the parasitic species *Dactylogyrus heteromorphus* El Gharbi, 1994. The statistical study of the epidemiological index distribution of *D. heteromorphus* shows that the parasitic infestation varies from one season to another. In contrast, the sex and size of *L. callensis* do not affect parasite infestation. Variations in the epidemiological index of *D. heteromorphus* concerning fifteen physicochemical water parameters were tested statistically. These variations are significant with temperature, salinity, nitrate, nitrite, chloride, phosphate, calcium, sulfate, hardness, turbidity, and electrical conductivity, however, no significant effect of the concentration of magnesium, dissolved oxygen, ammonium, and pH on these indexes according to the Pearson's parametric test.

Keywords: Monogenean**,** *Dactylogyrus heteromorphus, Luciobarbus callensis,* Foum-El-Khanga dam, Epidemiological index

Biyotik ve Abiyotik Faktörlerin Foum-El-Khanga Barajı'nda (Souk-Ahras, Cezayir) Yaşayan Cezayir Barbeli *Luciobarbus callensis* (Cyprinidae) Paraziti *Dactylogyrus heteromorphus* El Gharbi, 1994 (Monogenea) 'nın Epidemiyolojik İndeksi Üzerindeki Etkisi

Özet

2015 yılında Foum El Khanga Barajı'nda yakalanan 341 *Luciobarbus callensis* bireyinin incelenmesi ile *Dactylogyrus heteromorphus* El Gharbi, 1994 parazit türünden 2782 örnek toplandı. *D. heteromorphus*'un epidemiyolojik indeks dağılımının istatistiksel çalışması, parazit istilasının bir mevsimden diğerine değiştiğini gösterdi. Buna karşılık, *L. callensis*'in cinsiyeti ve boyutunun parazit istilasını etkilemediği belirlenmiştir. On beş fizikokimyasal su parametresine ilişkin *D. heteromorphus*'un epidemiyolojik indeksindeki varyasyonlar istatistiksel olarak test edildi. Pearson'ın parametrik testine göre sıcaklık, tuzluluk, nitrat, nitrit, klorür, fosfat, kalsiyum, sülfat, sertlik, bulanıklık ve elektriksel iletkenlik açısından önemli olarak bulunurken magnezyum, çözünmüş oksijen, amonyum ve pH konsantrasyonunun bu indeksler üzerinde önemli bir etkisinin olmadığı belirlenmiştir.

Anahtar Kelimeler: Monojen**,** *Dactylogyrus heteromorphus, Luciobarbus callensis,* Foum-El-Khanga barajı, Epidemiyolojik indeks

INTRODUCTION

Freshwater fish are an important part of biodiversity. They have great economic and social value with nearly 30,000 living species (Moyle and Cech, 2004). Taxonomically, freshwater fish are the most diverse hosts of parasites, with estimates of up to 30,000 species of helminth parasites (Williams and Jones, 1994).

Recently, parasitologists have shown more importance to parasitic ecology, which deals with the influence of environmental conditions on parasitic fauna (Sargsyan, 2013). Seasonal changes in abiotic factors and their influence on the presence of parasites have been the subject of numerous ecological

studies (Rohlenová et al., 2011; Alsarakibi et al., 2012; Singh et al., 2012; Khidr et al., 2012; Karvonen et al., 2013; Majumder et al., 2013; Wali et al., 2016). For example, the prevalence and intensity of parasitic infection have been assessed considering several parameters of water quality (temperature, dissolved oxygen, alkalinity, hardness, clarity) and water pollutants (heavy metals, petrochemicals, effluents, organic pollutants) (Siddall et al. 1997; Yeomans et al., 1997; Faulkner and Lochmiller, 2000; Lefcort et al., 2002; Billiard and Khan, 2003).

The composition of the helminth parasites of fish was influenced by the aquatic environmental stress, and the biology of the host. Consequently, they constitute a bio-indicator of the structure and the evolution of the host population. Monogenean species infest gill tissue and are exposed directly to the environment; they are also subject to variations in the abiotic environment in which their host evolves (Zargar et al., 2012).

Dactylogyrus heteromorphus El Gharbi 1994 comes from the class of ectoparasitic monogeneans with a direct life cycle parasitizing exclusively the gills of *Luciobarbus callensis* (Valenciennes, 1842). This host fish is a characteristic species of North Africa where it is very well represented in Algeria, Morocco, and Tunisia (Djemali, 2005). It is an important cyprinid species in the world for aquaculture because of its abundance, availability (year-round), affordability, and economic value (Mimeche et al., 2013).

Algerian continental waters are endowed with an ichthyological fauna that has emerged, especially in recent years, from numerous studies related to its biology, reproduction, and growth (Mimeche et al., 2015; Mouaissia et al., 2017). In contrast, on the parasitological level, it can be considered that any research concerning the freshwater fish hosts is almost non-existent, on *L. callensis*, except those of Boucenna et al (2018), Menasria et al. (2019) in the Oued Charef Dam, and Tolba et al. (2018) in the Beni Haroun Dam.

The objective of this work is to assess the variation in the epidemiological index of *Dactylogyrus heteromorphus* infesting the Algerian barbel *Luciobarbus callensis* inhabiting the Foum El-Khanga Dam (Souk-Ahras, Algeria). It highlights the effect of some biotic (sex and size) and abiotic (season and physicochemical parameters) factors on the distribution of the monogeneans.

MATERIALS and METHODS

Study Area

The Foum El-Khanga dam is located on the Oued-Charef, in the communes of Zouabi and Bir Bouhouche, 20 km south-west of the town of Sedrata (Wilaya of Souk-Ahras). The area of the watershed is 1735 km2 and its current capacity is 80 million cubic meters; the latter is used for upstream irrigation through releases on the perimeter of Guelma and forward illicit irrigation over 200 ha by farmers.

Study Method

During the year 2015 (from January to December), a total of 341 individuals of the Algerian barbel *Luciobarbus callensis* were sampled monthly using gill nets, after specific identification according to the nomenclature and criteria used by Lévêque et al. (1990, 1992). All fish were measured, weighed and the sex was also determined after dissection of the abdominal cavity, the gill arches were examined immediately or preserved with formaldehyde (8-10%) for later study.

The research was carried out by a careful examination of the gills under stereomicroscope (Olympus SZX 10).

The collected parasites were mounted using Magmberg's ammonium picrate glycerol (APG) mixture (Magmberg, 1957), the slide was looted with Canada balsam, and finally observed and measured using a phase-contrast microscope equipped with a photographic system and an ocular micrometer.

Some of our observations were made on fresh material. According to Lambert (1977), the examination of living Dactylogyroidea is the best technique.

The determination of the monogenean species was carried out under the microscope by following the key given by Bykhovskaya-Pavlovskaya et al. (1962), Gusev (1985), and Guegan (1988).

For physicochemical sampling, 15 water quality parameters were measured on the same day of host sampling. These are temperature, pH, dissolved oxygen, electrical conductivity, and salinity, which were measured in situ using a multi-parameter, and turbidity, calcium, magnesium, chlorides, sulfate, phosphate, nitrate, nitrite, ammonia, and total hardness were carried out at the Chemistry Laboratory

of the Algerian Water Institution (Wilaya of Souk-Ahras). Physicochemical characteristics were established according to the standards of Rodier (1984) and AFNOR (1985).

Data Analysis

Prevalence, abundance, and mean intensity were calculated according to Bush et al. (1997).

The Chi-squared test ($\chi 2$) was used to observe the significant effect of the different factors studied: sex, size classes, and seasons on prevalence. In addition, the variation in mean intensity by sex of host was statistically analyzed using the Mann-Whitney test.

The Kruskal-Wallis test was used to see the significance of mean intensity within different host size classes and over the four seasons. Pearson's correlation test was applied to determine the correlations between *D. heteromorphus* infection and the physicochemical parameters of the water. The differences were considered significant at the 5% threshold.

Statistical analysis of the data was performed using Statistica software (StatSoft version 8.0) for Windows.

RESULTS

Out of a total of 341 *L. callensis* examined, 68.91% were infested by 2782 individuals of *Dactylogyrus heteromorphus* (Figure 1) with parasitic loads of 8 parasites per fish examined (abundance) and 11 parasites per infested fish (mean intensity).

Effect of Biotic Factors

Effect of Sex

The highest rate of infestation was found in female of *L. callensis*, of which 75.70% of the examined population is infested. Moreover, parasite load values were higher in males (MI = 12.79; A = 8.42) compared to females (MI = 10.02; A = 7.59) (Table 1). Statistically, parasitizing by *D. heteromorphus* seems to evolve independently of the sex (prevalence: $\chi 2$= 0.64; p = 0.42; mean intensity: U = 6275; p = 0.93).

Effect of Size Classes

The parasitic index of *D. heteromorphus* in different classes of host size shows that small individuals have the highest infestation rates and parasitic loads (Table 1). The statistical study shows that the size of the host appears to have no influence on the infestation (prevalence: $\chi 2$ = 1.14; p = 0.56; mean intensity: H = 0.01; p = 0.99).

Table 1 Variation in parasite index of *D. heteromorphus* as a function of biotic factors of *Luciobarbus callensis* (sex and size classes)

Biotic parameters		NP	NFE	NIF	P(%)	A	MI
Sex	Male	1970	234	154	65,81	8,42	12,79
	Female	812	107	81	75,70	7,59	10,02
Size classes (in Cm)	[26 - 31[	596	59	44	74,58	10,10	13,55
	[31 - 36[	1885	228	156	68,42	8,27	12,08
	[36 - 41[	301	54	35	64,81	5,57	8,60
Total		2782	341	235	68,91	8,16	11,84

NW : NP : number of parasites ; NFE : number of fish examined ; NIF : number of infested fish

Effect of Abiotic Factors

Seasonal Variation

Parasitic index values of *D. heteromorphus* show fluctuations between seasons. We also note that infestation rate and parasitic loads are the highest during the summer season and the lowest in the winter season (Figure 1).

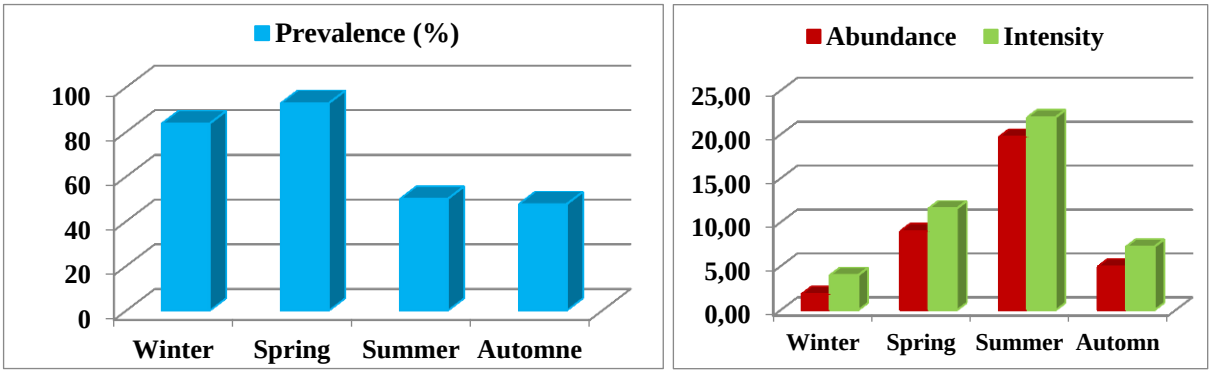

Figure 1. Seasonal variation in the parasite index of *D. heteromorphus* harvested from *Luciobarbus callensis*

The results of the statistical analysis show that the seasons have a very highly significant influence on prevalence ($\chi 2$ = 18.87; p= 0.0003) and mean intensity (H= 18.32; p= 0.0004).

Correlation Between Water Quality and Parasitic Index of D. heteromorphus

Analysis of the Pearson's correlation matrix (Table 2) allowed us to determine some significant relationships between the parasitic index of *D. heteromorphus* and water physicochemical parameters.

It was found a positive and highly significant correlation between prevalence and water temperature (r=0.79). Nevertheless, the values of this index are inversely proportional to the values of salinity (r=-0.86), nitrate (r=-0.84), nitrite (r=-0.76), chloride (r=-0.73), phosphate (r=-0.68), calcium (r=-0.67), sulfate (r=-0.67), hardness (r=-0.65) and turbidity (r=-0.60). However, parasitic loads are negatively correlated with electrical conductivity where r= -0.68 for abundance and r=-0.67 for mean intensity (significant correlation).

Table 2 Pearson's correlation analysis between water quality and parasitic index of *D. heteromorphus* recorded in *L. callensis* in Foum El-Khanga dam

	r (Prevalence)	***r***	***r (Mean***
pH (/)	0,13^{ns}	-0,06^{ns}	-0,07^{ns}
T(C°)	0,79**	0,33^{ns}	0,28^{ns}
Conductivity	-0,32^{ns}	-0,68*	-0,67*
Total Hardness	-0,65*	-0,39^{ns}	-0,35^{ns}
Ca^{++} (mg/l)	-0,67*	-0,23^{ns}	-0,18^{ns}
Mg^{++} (mg/l)	-0,13^{ns}	0,06^{ns}	0,10^{ns}
SO_4^{3-} (mg/l)	-0,67*	-0,55^{ns}	-0,52^{ns}
Turbidity (UNT)	-0,60*	-0,51^{ns}	-0,46^{ns}
Salinity (S‰)	-0,86***	-0,49^{ns}	-0,45^{ns}
Cl^{-} (mg/l)	-0,73**	-0,31^{ns}	-0,28^{ns}
PO_4^{2-} (mg/l)	-0,68*	-0,36^{ns}	-0,36^{ns}
O_2 (mg/l)	0,57^{ns}	0,44^{ns}	0,39^{ns}
NO_2^{-} (mg/l)	-0,76**	-0,38^{ns}	-0,37^{ns}
NO_3^{-} (mg/l)	-0,84***	-0,54^{ns}	-0,50^{ns}
NH_4 (mg/l)	-0,44^{ns}	-0,22^{ns}	-0,19^{ns}

NW : * ($p \leq 0,05$) ; ** ($p \leq 0,01$) ; *** ($p \leq 0,001$) ; *ns* ($p > 0,05$)

DISCUSSION

The most common measures of the extent of parasite populations in hosts are prevalence, abundance, and mean intensity (Margolis et al., 1982). Calculation of these indexes will make it possible to determine statistically whether communities of monogenean parasites vary according to biotic (sex and host size) and abiotic factors (season and physicochemical parameters of water). For this reason, the ectoparasite *D. heteromorphus* was examined in 341 specimens of *L. callensis* species during the year 2015 from January to December.

Evaluation of parasitic index of *D. heteromorphus* according to host sex does not indicate a significant difference in prevalences and mean intensity between male and female fish. The absence of

influence of fish sex on infestation has already been demonstrated by Allalgua et al. (2015) in *Cyprinus carpio* infested by monogenean parasites in Foum El Khanga dam and by Boucenna et al. (2018) in *L. callensis*.

According to Rohde (1993), only very rare parasite species prefer the sex of the host. However, some studies have found that Monogenean infestation is sometimes correlated with the sex of host fish (Ibrahim, 2012; Chaibi, 2014).

Concerning the distribution of parasitic index by size classes, our results show that the infestation rate and parasitic loads increase with the decrease in total length of *L. callensis*, it is indeed the small specimens that are the most infested by *D. heteromorphus*. Our observations are consistent with those of Fazio et al. (2008) who revealed a negative correlation between individual size and parasite infestation. This can be explained by the fact that young fish are more susceptible to parasite infestation and indeed have a somewhat fragile immune system compared to those of mature (older) fish. Contrary to these results, Ibrahim (2012) reported a significant correlation of prevalence and mean intensity of monogenean infracommunities with the total body length of *Tilapia zillii* collected from Lake Manzalah in Egypt.

According to Luque and Alves (2001), the relationship between host size and epidemiological index of parasites is a widely studied model in marine and freshwater fish. In contrast, Poulin (2000) stated that this model cannot be generalized, because in many systems the host-parasite relationship is positive but weak and not significant. Nevertheless, some quantitative differences and qualitative data are found in size class studies for fish.

Evaluation of parasite index indicates that collected *D. heteromorphus* specimens show seasonal variations. Indeed, the highest infestation rates and parasitic loads are noted in the warm season (spring and summer) and the lowest in the cold season (autumn and winter). Several authors have indicated an increase in pest infestation in the warm periods and a decrease in the cold periods (Turgut et al., 2011; Lekeufack-Folefack and Fomena, 2013; Allalgua et al., 2015).

Koyun (2011) also agreed with our results and reported a higher infection of *A. alburnus* by *D. alatus* in summer. In addition, a higher prevalence of *D. marteau* from *B. barbusis* was reported in spring (Kadlec et al., 2003; Stojanovski et al., 2010). Some authors reported no temporal variation in infestation (Genç et al., 2005; Knopf, 2006).

According to Chubb (1970) and Hanzelova and Zitnan (1985), changes in temperature and season have a major influence on the dynamics of *Dactylogyrus* populations, some of which tend to produce more at higher water temperatures, others prefer a cold-water temperature.

Variations in the epidemiological index of *D. heteromorphus* in the fish host *L. callensis* concerning fifteen physicochemical parameters were tested statistically. According to the Pearson's parametric test, the prevalence shows a significantly positive correlation with water temperature. Similar observations were obtained in several studies showing a positive correlation between the increase in water temperature and the oviposition rate of monogeneans (Marchiori et al., 2015; Bayoumy et al., 2015; Gilbert and Avenant-Oldewage, 2016; Ojwala et al., 2018).

Water temperature is the most important factor affecting the life cycle of parasites in the aquatic ecosystem (Karvonen et al., 2013). According to El-Naggar and Khidr (1986) and Zargar et al. (2012), water temperature affects the survival, growth, reproduction, and progression of parasitic helminths.

In contrast, the present study indicates a significantly negative correlation between prevalence and salinity, nitrate, nitrite, chloride, phosphate, calcium, sulfate, hardness, and turbidity. Similar to our results, a study by Khidr (2012) shows a negative correlation between the average intensity of *Microcotyloides* sp and salinity. Numerous works show the impact of salinity and temperature on the longevity of larvae of *A. crassus* (Kennedy and Fitch, 1990; Schippers et al., 1991). These authors report that in freshwater, free-living larvae can live for up to 3 to 4 weeks, but their life span is reduced to 3-4 days if the meeting with the host is not carried out and if the salinity of the environment is high with the absence of temperature increase.

In vitro, Buchmann et al. (1987) and Crespo et al. (1995) also assumed that long-term treatment with sodium chloride reduced the intensity of infestation of European Eel *A. Anguilla* by the *P. anguillae* and *P. bini* monogeneans. These authors found that sodium chloride was very effective in controlling *Cichlidogyrus* infestation.

Ndour's (2007) work on *Sarotherodon melanotheron heudelotti* (Cichlidae) in some dams in Senegal concluded that high salinity could be a preventive measure against parasitic infections since it

affects the biological conditions of both the host and its parasites. The results of Schippers et al. (1991), also point in the same direction, they report that in freshwater, free larvae of *A. crassus* can live for up to 3-4 weeks, but their longevity is reduced to 3-4 days if the encounter with the host is not made and if the salinity of environment is high with no temperature increase.

In our result, Pearson's correlation test revealed an inversely proportional correlation between electric conductivity values and parasitic loads (mean intensity and abundance). In accordance with our results, negative correlations between *P. ichthyoxanthon* infestation intensity and water conductivity were shown by Gilbert and Avenant-Oldewage (2016).

Several studies have shown that there is a close and very sensitive correlation between abiotic factors and parasitism (Alsarakibi et al., 2014; Hagen et al., 2014; Pilecka-Rapacz et al., 2015; Smallbone et al., 2016). According to Esch et al. (1977), environmental factors are important in the recruitment, transmission, colonization, fertility, and survival of adult and larval parasites.

Monogenean parasites are recognized as useful bio-indicators of quality because of their predictable numerical responses to chemical pollution (Pietrock and Marcogliese, 2003; Thomas et al., 2005). They tend to increase in number when exposed to low and medium concentrations of pollutants but disappear at high concentrations (Moles and Wade, 2001; Khan and Payne, 2004).

Conclusively, this study shows that the parasitic index of *D. heteromorphus* is also strongly influenced by variations in abiotic factors (seasons and physicochemical parameters). However, biotic factors (sex and size of *L. callensis*) do not affect the parasite infestation.

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