

First report of *Dactylogyrus fimbriphallus* (El Gharbi, Birgi & Lambert, 1994) infecting *Luciobarbus biscarensis* (Boulenger, 1911) in Oued Tadmit River of Djelfa Governorate (Algeria)

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To cite this article: Djouhina Chabira, Badreddine Attir, Nurten Aydoğdu & Adel Mammeri (07 Apr 2025): First report of *Dactylogyrus fimbriphallus* (El Gharbi, Birgi & Lambert, 1994) infecting *Luciobarbus biscarensis* (Boulenger, 1911) in Oued Tadmit River of Djelfa Governorate (Algeria), African Journal of Aquatic Science, DOI: [10.2989/16085914.2025.2478015](https://doi.org/10.2989/16085914.2025.2478015)

To link to this article: <https://doi.org/10.2989/16085914.2025.2478015>



Published online: 07 Apr 2025.



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First report of *Dactylogyrus fimbriphallus* (El Gharbi, Birgi & Lambert, 1994) infecting *Luciobarbus biscarensis* (Boulenger, 1911) in Oued Tadmit River of Djelfa Governorate (Algeria)

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This study aimed to determine the occurrence of dactylogyrid communities in Sahara barbel, *Luciobarbus biscarensis* (Boulenger, 1911), an endemic species to Algeria, according to season and host factors. A total of 78 samples of *L. biscarensis* were collected seasonally, over four seasons from 2023 to 2024, from Oued Tadmit River in Djelfa Governorate with the help of local fishermen. Thirty-three *L. biscarensis* were infected with one or more individuals of dactylogyrid parasites (42.31%), and a total of 306 individuals were recorded. All monogenean species collected from the gills of the host fish were identified based on the presence of the following morphometric characteristics: two pairs of anchors, dorsal bar, ventral bar, vaginal armament and copulatory tube. Only one *Dactylogyrus* species, *Dactylogyrus fimbriphallus* (El Gharbi, Birgi & Lambert, 1994), was found on the gills. The mean intensity and abundance were 9.27 ± 12.50 parasites per fish and 3.92 ± 9.28 , respectively. The infection levels of *D. fimbriphallus* were also investigated in relation to length and sex of the host fish as well as seasons, and the differences in its prevalence, mean intensity and mean abundance were statistically evaluated. There were significant differences in prevalence, mean intensity and abundance values between seasons. The infestation rate was higher in female hosts than in males. The host fish represents a new host record for *D. fimbriphallus* and new insights into the geographical distribution and host range have been gained. This study highlights the need for further research on helminth parasites, particularly monogeneans, affecting Algerian freshwater fishes, given the limited existing data.

Keywords: endemic fish, host size, monogenean parasites, seasonal effects, sex

Introduction

The freshwater ichthyofauna of Algeria comprises of 48 species belonging to 12 orders, 15 families and 37 genera (Kara 2012). Of these, 27 species are alien, 18 autochthonous and three species are considered endemic to Algeria (Kara 2012). One of the endemic species is Saharan barbel, *Luciobarbus biscarensis* (Boulenger, 1911). It is naturally distributed in the governorate of Illizi; El-Abiod River, Loutaya River and Foun-El-Gherza reservoir in the governorate of Biskra; El-Arab River in the governorate of Khencela; and Ksob River in the governorate of M'sila (Geiger et al. 2014; Brahimi and Belhamra 2016; Brahimi et al. 2017, 2018; Touil et al. 2019).

Only six (native and alien) of the 48 fish species distributed in Algerian inland waters have been studied ichthyo-helminthologically, from which a total of 19 species of helminth parasites have been reported (Allalqua et al. 2015, 2021, 2022; Brahmi et al. 2016; Rouis et al. 2016; Tahri et al. 2016, 2017, 2018; Attir et al. 2017; Djouahra and Arab 2017; Bakaria et al. 2018; Ghazi et al. 2018; Menasria et al. 2020; Arab et al. 2021; Abbaci et al. 2023; Tahri and Bensouilah 2023). Nine of the 19 helminth parasites are species belonging to the class

Monogenea. Six of the nine monogenean species belong to the genus *Dactylogyrus*, including *Dactylogyrus extensus*, *Dactylogyrus cyclocirrus*, *Dactylogyrus arcuatus* and *Dactylogyrus anchoratus* found in *Cyprinus carpio* (Allalqua et al. 2015; Brahmi et al. 2016), as well as *Dactylogyrus onchobdella* hosted by *Aphanius fasciatus* (Ghazi et al. 2018) and *Dactylogyrus heteromorphus* infecting *Luciobarbus callensis* (Allalqua et al. 2021, 2022).

Changes in prevalence, mean intensity and abundance values of dactylogyrid parasite infections in fish could be influenced by several factors such as the parasite and its biology, host-parasite interactions, host age, sex, behaviour, immunity and environmental changes, and geographical range, which are important determinants in the host for parasite proliferation and establishment (Tombi and Bilong 2004; Šimková et al. 2005; Khan 2012; Koyun et al. 2015; Sarabev et al. 2019). Prior to this study, there was no prevalence and abundance data recorded for this parasite on any freshwater fish species in Algeria. Furthermore, current literature indicates that no previous helminthological studies have been conducted on *L. biscarensis* ahead of this study. This study aimed to (1)

provide the first data on the dactylogyrid fauna of this host fish, *L. biscarensis*, in the inland waters of Algeria; and (2) determine how the prevalence, abundance and intensity of dactylogyrid infection vary with the seasons, size and sex of the host fish. This information significantly contributes to our understanding of the diversity of the parasites associated with *L. biscarensis*.

Materials and methods

Seventy-eight *L. biscarensis* specimens were collected from the Oued Tadmit River (34°17'21" N; 2°58'50" E), Djelfa Governorate (Figure 1), over four seasons from November

2023 (autumn) to June 2024 (summer), with one sampling campaign conducted every three months, with the help of local fishermen. The species identification of the host fish was performed morphologically using the identification keys of Brahimi et al. (2017). On a seasonal basis, samples of 18–20 *L. biscarensis* individuals with different lengths were collected from the river and examined for the presence of Monogenea communities. The fish were placed in polyethylene containers and immediately transported alive to the laboratory of the Department of Agricultural and Veterinary Sciences, Faculty of Nature and Life Sciences, Ziane Achour University of Djelfa, located 65 km from the site of capture.

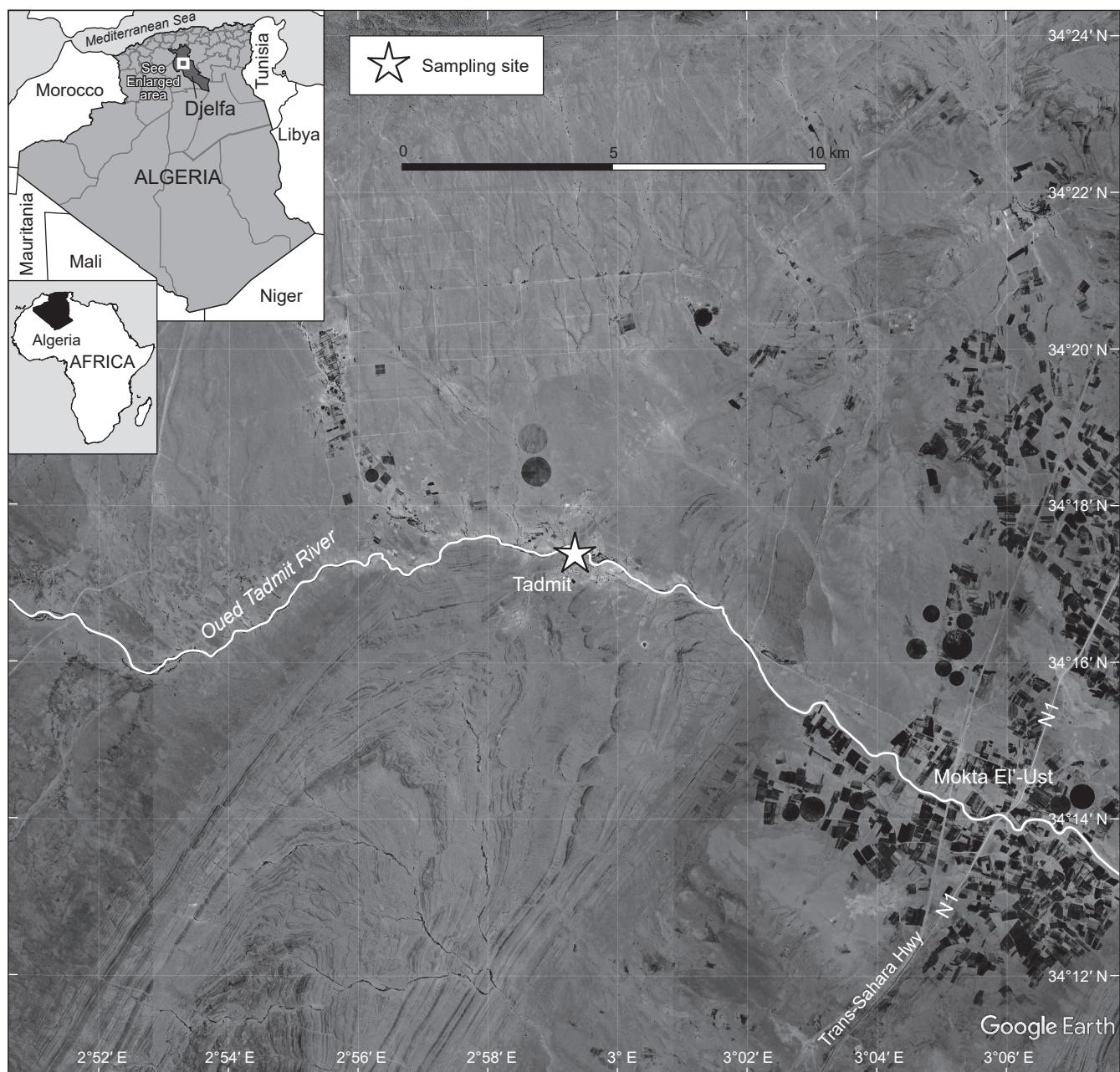


Figure 1: Map of the sampling site of *Luciobarbus biscarensis* in Oued Tadmit River, Djelfa Governorate, Algeria

Fish were held in an aerated aquarium and examined for Monogenea within approximately two to three hours on the same day of capture. Fish were euthanised by severing the spinal cord posterior to the cranium. Prior to parasite examination, the total body length of the fish from the tip of the head to the end of the caudal fin was measured using a measuring board. Similarly, the sex of each *L. biscarensis* individual was determined by observation of the gonads. The opercula were then opened and their arches separated from the sides, kept in a petri dish and examined under an Optika Slx-3 stereomicroscope.

The monogenean specimens found on the gills were collected and prepared for identification either in ammonium picrate solution (Malmberg 1957) under a coverslip or in glycerol jelly (Vasiljkov 1983; Gussev 1985; Stojanovski 1997; Stojanovski et al. 2003). During the study period, the recorded infection data of the dactylogyrid species



Figure 2: *Dactylogyrus fimbriphallus* haptor ($\times 40$)

were classified according to the sampling season and the sex of the host. The identification of dactylogyrid species was carried out using standard taxonomic criteria based on the examination of the hard parts of the haptor and the characteristics of the reproductive organs according to Markevich (1951), Bykhovskaya-Pavlovskaya (1962) and Gussev (1985).

Prevalence, abundance and mean intensity were calculated according to Bush et al. (1997). Standard statistical calculations (standard deviation; SD) were performed using Microsoft Excel (Office 2000). The Kolmogorov–Smirnov test was used to test the normality of the continuous data. The Kruskal–Wallis test was used to assess whether the mean density of parasite species varied significantly between seasons. In contrast to the Kruskal–Wallis test (more than two groups), the Mann–Whitney *U*-test was used to compare two groups. Spearman's correlation test was used to determine correlations between continuous variables based on the distribution of the variable. All statistical analyses were performed using IBM SPSS Statistics v.28 for Windows. A significance level of $\alpha \leq 0.05$ was used.

Results

Luciobarbus biscarensis averaged 8.01 cm (± 1.21 cm, range 5.3–11.6 cm) in total length. Of the 78 *L. biscarensis* individuals examined, the gills of 33 host samples were infected with a dactylogyrid monogenean species. In total, 42.31% of the fish were infected. One monogenean species, *Dactylogyrus fimbriphallus* (El Gharbi, Birgi & Lambert, 1994), was identified based on the hard parts of the haptor and reproductive organs (Figure 2 and Figure 3a, b). In terms of general infection levels, a total of 306 individuals of *D. fimbriphallus* were recorded from 33 individuals of host fish. The mean intensity and abundance were 9.27 ± 12.50 parasites per fish and 3.92 ± 9.28 respectively. Seasonal differences in the infection levels of dactylogyrid species were also observed.

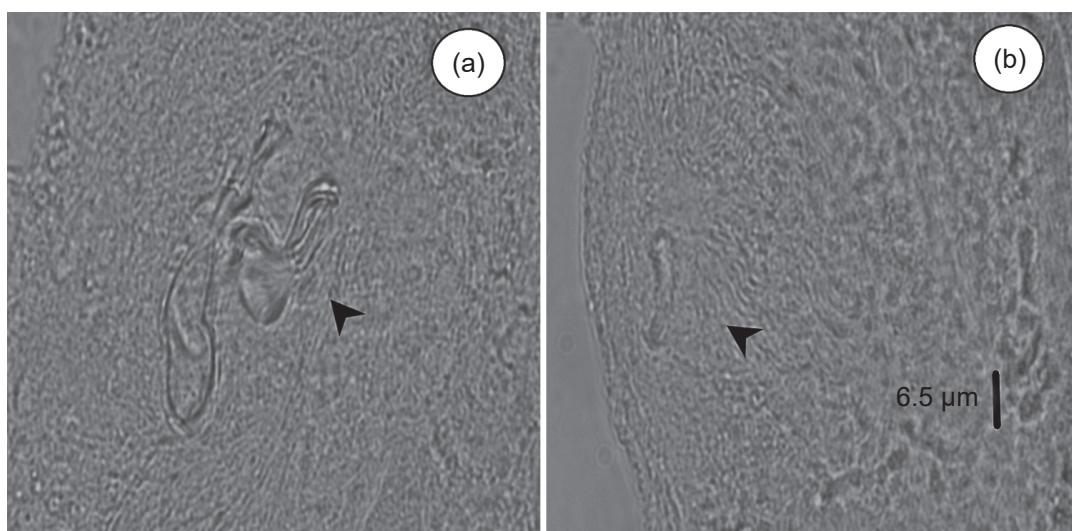


Figure 3: *Dactylogyrus fimbriphallus*. a) copulatory organ ($\times 100$); b) vaginal tube ($\times 100$)

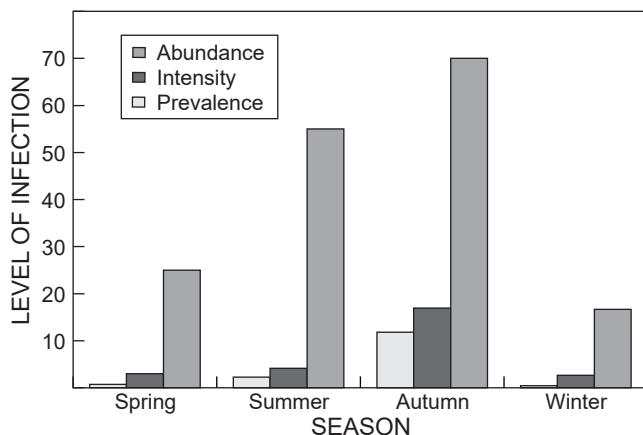


Figure 4: Distribution of *Dactylogyurus fimbriphallus* infection values in *Luciobarbus biscarensis* from Oued Tadmit River, Djelfa Governorate, according to seasons

In autumn 2023, 20 fish were dissected, of which 14 were parasitised by dactylogyrid, showing a 70% prevalence of infection (Figure 4) with a mean intensity of 16.93 ± 16.24 parasites per fish and abundance of 11.85 ± 15.61 . In winter, out of 18 samples examined, three were parasitised by *D. fimbriphallus*. The prevalence of parasitism was 16.67%, which was the lowest infection rate during the present study, while the mean intensity and abundance were 2.67 ± 0.58 parasites per fish and 0.44 ± 1.04 , respectively (Figure 4). In the spring of 2024, a total of 20 hosts were examined, of which five specimens showed infection with a prevalence of 25%. The mean intensity was 3 ± 2.35 parasites per fish and the abundance was 0.75 ± 1.71 (Figure 4). During the summer of this year (2024), a total of 20 specimens were examined for helminthological investigation, of which 11 hosts were found to be infected with dactylogyrid parasites. The overall prevalence of infection for the season was 55%, with mean intensity and abundance of 4.18 ± 3.40 and 2.30 ± 3.26 , respectively (Figure 4). The significance of the difference per season was calculated using the Mann–Whitney *U*-test; it showed that there was a significant difference between infection in summer and winter ($p = 0.014$, $U = 107.500$), between spring and summer ($p = 0.039$, $U = 132.500$) and when comparing spring and autumn ($p < 0.001$, $U = 76.000$).

Of the total number of *L. biscarensis* examined in the study, 45 were males. Of these, 17 were positive for dactylogyrid parasites with prevalence and mean intensity of 37.78% and 7.88 ± 10.22 , respectively. The rest of the hosts were females (33), of which 16 were infected, giving a prevalence of infection of 48.48% and a mean intensity of 10.75 ± 14.74 (Figure 5). There was no statistically significant difference in the number of *D. fimbriphallus* depending on the sex of the host (Mann–Whitney *U*-test = 655.500, $p = 0.327$).

For *L. biscarensis*, the maximum number of dactylogyrid parasites was found in fish with a body length of 11 cm (53 individuals in autumn). The total parasite burden (Figure 6) increased as a function of fork length with a significant but weak correlation ($r = 0.287$, $p = 0.011$).

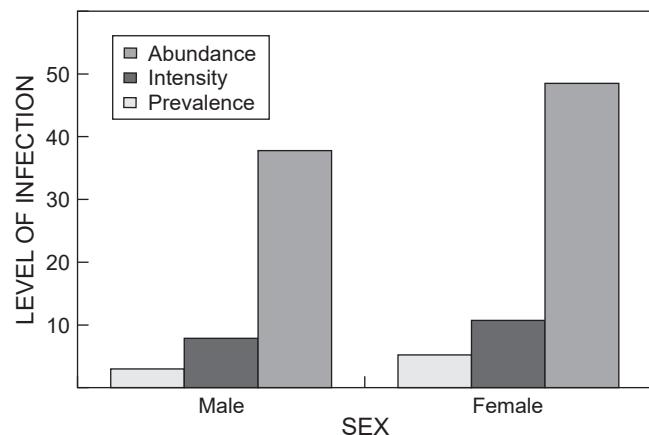


Figure 5: Distribution of *Dactylogyurus fimbriphallus* infection values in *Luciobarbus biscarensis* from Oued Tadmit River, Djelfa Governorate, according to sex

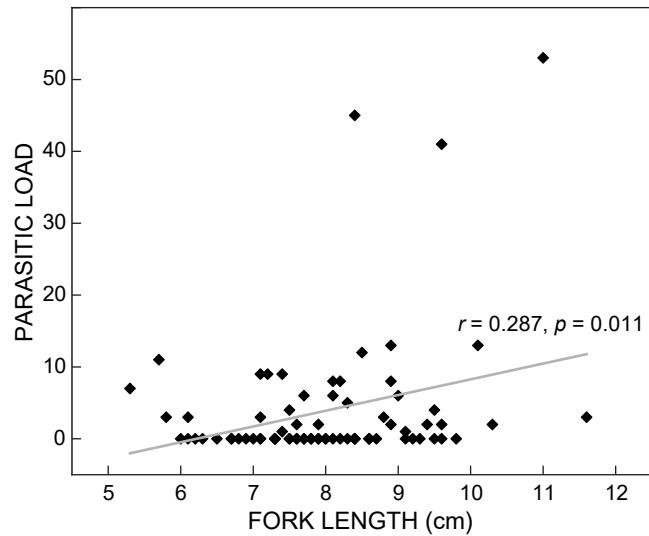


Figure 6: Relationship between the fork length of *Luciobarbus biscarensis* from Oued Tadmit River, Djelfa Governorate and *Dactylogyurus fimbriphallus* load

Discussion

This study was conducted to identify the prevalence, mean intensity and mean abundance of the dactylogyrid parasites on *L. biscarensis*. One dactylogyrid monogenean species, i.e. *D. fimbriphallus*, was identified on the gills of *L. biscarensis* (El Gharbi et al. 1994) (Figure 2 and Figure 3a, b). Species identification was based on the comparative morphology of the chitinoid structures, parts of the haptor and reproductive organs (e.g. vaginal armament ends, male copulatory organs and vaginal tube). *Dactylogyurus fimbriphallus* is common in *Luciobarbus* spp. (Pugachev et al. 2010) and has been previously reported from *Luciobarbus figuigensis* (Pellegrin, 1913), *Luciobarbus moulouyensis* (Pellegrin, 1924), *Luciobarbus issenensis* (Pellegrin, 1922), *Luciobarbus lepiney*

(Pellegrin, 1939), *Luciobarbus massaensis* (Pellegrin, 1922) and *Luciobarbus pallaryi* (Pellegrin, 1919) from the Sebou, Oum Er-Rbia and Moulouya rivers and from the Guir, Draa, Souss, Noun and Massa basins in Morocco (El Gharbi et al. 1994; Benovics et al. 2020; Dlapka 2020; Rahmouni et al. 2020). Our findings represent the first confirmed occurrence of this parasite outside of Morocco and only the second reported instance globally, expanding its known geographic distribution.

In this study, *Dactylogyrus fimbriphallus* was recorded from *L. biscarensis* with an overall prevalence of 42.31%, a mean intensity of 9.27 ± 12.50 parasites per fish and an abundance of 3.92 ± 9.28 . While there exist no known records of *D. fimbriphallus* infesting *L. biscarensis* in Algeria, the comparative prevalence and mean intensity of infection of this parasite species in *Luciobarbus massaensis* in Morocco are 91% and 2.1 ± 1.5 , respectively (Dlapka 2020). However, the mean intensity value in the present study was similar to the mean intensity of 2.1 ± 1.5 recorded from *L. massaensis* in Morocco (Dlapka 2020).

Prevalence, mean density and abundance of the *Dactylogyrus* parasite varied considerably across seasons with *L. biscarensis* as host, with the highest infection levels in autumn and the lowest in winter (Figure 4). Indeed, several studies have demonstrated significant seasonal variations in the infection levels of *Dactylogyrus* spp. among various fish hosts. Some studies have found higher rates of dactylogyrid infection in spring and summer when these parasites proliferate (Koskivaara et al. 1991; Stojanovski et al. 2004; Mhaisen and Abdullah 2006; Abdullah 2007; Koyun and Altunel 2011; Koyun 2012; Öztürk 2014; Aydoğdu et al. 2015; Abdullah and Nasraddin 2020; Elbay and Öztürk 2021). In contrast, and in agreement with the present study, some investigations have reported high dactylogyrid infection levels during autumn in similar climates (Raissy et al. 2013; Aydoğdu and Kubilay 2017; Tunç and Koyun 2018).

Seasonal variations in *Dactylogyrus* spp. infections affected by host life cycles and environmental conditions have previously been demonstrated (Raissy et al. 2013; Aydoğdu and Kubilay 2017; Tunç and Koyun 2018). These studies suggest that the successful reproduction of the parasite relies on the release of eggs in favourable aquatic conditions for hatching and the subsequent development of oncomiracidia, the free-swimming larval stage of *Dactylogyrus*, which do not reach sexual maturity in the seasons when the water characteristics are most suitable for hatching and migrating. Autumn, thus, represents the optimal season for the reproduction of *D. fimbriphallus*. However, a comparative analysis could not be carried out as there were no reports on seasonal variations in prevalence, mean density and abundance of this parasite species.

The present study also aimed to determine the relationship between the infection parameters (prevalence, mean intensity and abundance) of *D. fimbriphallus* parasitism and the length of *L. biscarensis* as the host fish, as many studies have shown a relationship between parasite prevalence and the length of the fish. In our study, the number of *D. fimbriphallus* parasites increased with increasing length of *L. biscarensis* with a significant

but weak correlation ($r = 0.287$, $p = 0.011$) (Figure 5). Similarly, there are previous reports indicating that the number of *Dactylogyrus* spp. increased with the length of the host fish in a wide range of freshwater fish species in different countries, suggesting a direct relationship between the number of *D. fimbriphallus* parasites and the length of *L. biscarensis* (Aydoğdu et al. 2003, 2015; Šimková et al. 2005; Ibrahim 2012; Abdullah and Nasraddin 2020). The increase in monogenean parasite infection levels with host length was attributed to larger-sized host fish having larger gills to filter a greater volume of oncomiracidium-carrying water and more surface area for parasite attachment (Nie and Kennedy 1991; Aydoğdu et al. 2003; Özer and Öztürk 2005; Mladineo et al. 2010; Amos et al. 2018; Nabi et al. 2020). Furthermore, fish with increased length had greater longevity and had been exposed to the environment for longer periods of time and, therefore, accumulated dactylogyrid parasite larvae on their larger gill surface area year-on-year.

Since host sex has been reported to be an important biotic factor in determining the host-parasite relationship, we investigated the influence of *L. biscarensis* sex on the prevalence and abundance levels of infection of *D. fimbriphallus* (Pickering and Christie 1980; Ibiwoye et al. 2004; Boungou et al. 2008; Singhal and Gupta 2009; Allumma and Idowu 2011; Vankara et al. 2011; Akoll et al. 2012; Gupta et al. 2012; Öztürk 2014; Kundu and Al-Bhuiyan 2016; Elbay and Öztürk 2021). We found a higher prevalence and mean intensity of *D. fimbriphallus* in female individuals of the *L. biscarensis* than in males demonstrating that *L. biscarensis* females are more susceptible to *D. fimbriphallus* infection compared to males. However, there was no statistically significant difference in the number of *D. fimbriphallus* depending on the sex of the host (Mann–Whitney U -test = 655.500, $p = 0.327$). The higher prevalence and abundance of parasite on female hosts compared to males observed in our study are consistent with literature (Thomas 1964; Ramadan 1991; Kurupinar and Öztürk 2009; Açıkel and Öztürk 2012; Ibrahim 2012; Santoro et al. 2014; Yazmen and Öztürk 2014; Aydoğdu and Kubilay 2017; Attir et al. 2017; Amos et al. 2018; Kestek 2018; Tunç and Koyun 2018). Male and female fish hosts have different responses to parasitism owing to the physiological, morphological, biological and behavioural differences between the two sexes, therefore different infestation levels can occur as one sex may be more susceptible to infection than the other (Thomas 1964; Ramadan 1991; Kurupinar and Öztürk 2009; Açıkel and Öztürk 2012; Ibrahim 2012; Santoro et al. 2014; Yazmen and Öztürk 2014; Attir et al. 2017; Aydoğdu and Kubilay 2017; Amos et al. 2018; Kestek 2018; Tunç and Koyun 2018). Female fish are known to be more susceptible to helminth parasites than males because they provide more reproductive material, eat less food and expend more energy during spawning (Thomas 1964; Ibrahim 2012; Santoro et al. 2014). Additionally, aggressive behaviour of males during spawning season stresses females, and this stress may reduce the resistance of female hosts to parasite infection, thereby increasing parasite load in female fish (Thomas 1964; Ibrahim 2012; Santoro et al. 2014; Amos et al. 2018).

Conclusions

One species of ectohelminth, monogenean parasite was found and identified on the gills of *L. biscarensis* in Oued Tadmit river, Algeria: *Dactylogyurus fimbriphallus*. This is the first report of *D. fimbriphallus* in the Oued Tadmit River and in Algeria, and signifies a new locality for *D. fimbriphallus* and *L. biscarensis* as a new host. We suggest that the different levels of infection in this species may be related to season, size and/or sex of the host fish. *Dactylogyurus fimbriphallus* had greater prevalence, mean intensity and mean abundance on female *L. biscarensis* of longer length in autumn. This study highlights the need for further research on parasites of Algerian freshwater fish, particularly monogenean parasites, to address the current knowledge deficit.

Acknowledgements — The authors would like to thank Prof. Ziane Laiadi, former director of the LGBVB laboratory at the University of Biskra, for his invaluable support. Also, Dr. Guendouz Abdelaziz, former Dean of the Faculty of Natural and Life Sciences at the University of Djelfa, for giving us access to the laboratory. Authors also thank Mr. Messaoud Abdellali and Mr. Guersis Mohamed for their help in catching and transporting the fish. We would like to thank the administration of the University of Biskra for allowing us to attend a practical training course in freshwater fish parasitology in Turkey. The authors are grateful to Dr. Ali Aydoğdu for helping with monogenean identification and the provision of laboratory facilities of the Department of Aquatic Animal Diseases, Faculty of Veterinary Medicine, Bursa, Uludag University used in this study.

Data availability statement — The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethical standards and permit requirements — No ethical approval was required, as this study did not involve clinical trials or experimental procedures. During the study, no treatment/experiment was implemented on live animals. No permit was required for sampling fish in an open body of water. All sampling and laboratory techniques on fish have complied with the ethical standards of the relevant national and institutional guides for the care and use of animals.

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