*Biodiversity Journal*, 2023,14 (3): 421–429 https://doi.org/10.31396/Biodiv.Jour.2023.14.3.421.429

# Eco-biological study of the Largemouth bass, *Micropterus salmoides* Lacépède, 1802 (Perciformes Centrarchidae), from Keddara Dam (Boumerdes, Algeria)

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**ABSTRACT** The aim of this work is to provide necessary information on the eco-biology of Largemouth bass *Micropterus salmoides* Lacépède, 1802 (Perciformes Centrarchidae) in Keddara Dam Lake, located in northern part of Algeria. A total of 67 specimens (22 females and 45 males) were collected during December 2019 and September 2020. The sex ratio was M:F = 2.33:1 and M:F = 2:1 for December 2019 and September 2020, respectively. The length-weight relationship was estimated for each period, with W = 0.1672xL2.291 for December 2019 and W = 0.0039xL3.405 for September 2020. The condition factor K estimated for December 2019 was K = 15.51±0.49, for September 2020 was K = 13.92±2.22. Macroscopic observation of the gonads showed that the spawning period begins in December. *Micropterus salmoides* feeding activity was high in December 2019, mostly eating fish (60% and 24.56% for fish part for December 2019 and September 2020, respectively, and 10% and 26.31% for full fish for December 2019 and September 2020, respectively). Largemouth bass display biological adaptation and trophic plasticity possibly facilitating its success in Keddara Dam as invasive species.

**KEY WORDS** Feeding; gonads; invasive; length-weight; sex ratio.

Received 27.11.2022; accepted 24.04.2023; published online 10.08.2023

## INTRODUCTION

Nine perch-like freshwater fish were farmed in 30 countries worldwide, with a total production of 0.8 million tonnes, with worth of around US$ 7 billion (Cai et al., 2019), accounting for approximately 0.7% of total tonnage (McLean et al., 2022). Largemouth bass, *Micropterus salmoides* Lacépède, 1802 (Perciformes Centrarchidae, is in the first place in this group, representing for 56 percent of the total production (Cai et al., 2019). China accounts the vast majority of Largemouth bass production (Hussein et al., 2020), which stood at 432.000 tonnes in 2018 (CFS, 2019).

Largemouth bass *Micropterus salmoides*, is an important species in recreational fisheries in North

America since the 1880s and later became the most widely popular and distributed gamefish in the United States since 1975 (Cooke & Philipp, 2009). This species have been introduced in Algeria for the first time in 1956 by the French for the recreational fisheries (Kara, 2012). Beyond some information on spawning and reproduction under controlled conditions (CNRDPA, unpublished data; Zouakh & Meddour, 2017), little is known of the ecology and biology of Largemouth bass in its natural habitat. Lakes and dams may furthermore represent nursery areas for Largemouth bass (CNRDPA, unpublished data), which could yield insights into conditions that affect the recruitment of this species.

*Micropterus salmoides* has become an economically important freshwater aquaculture species in Algeria due to several advantages including good flesh quality, short culture cycle, rapid growth performance, tolerance to handling, and strong adaptability (Bai & Li, 2019).

Determinations of ecological and biological characteristics are fundamental in understanding the adaptation success of Largemouth bass in Algeria biotope, as they allow for assessment of the establishment success of this species, reporting paucity of information on biology and ecology of this species introduced range in Africa (Azuma & Motomura, 1998; Britton et al., 2010; Taylor & Weyl, 2017) and the scarcity of data on its biology and ecology in Algeria.

The present study aimed to provide information and improve the understanding of the adaptation success of Largemouth bass by assessing reproduction, growth, sex ratio, and diet in Micropterus salmoides populations from the Keddara Dam in Northeast Algeria. We report for the first time this species in this lake and, using the results from capture in two different periods (beginning and end of the autumn season), we studied this species in relation to growth, reproduction, and diet and its environment.

## MATERIAL AND METHODS

### *Study area*

The study was carried out in Keddara Dam (36°65'N; 3°43'E), one of the most important dams in Algeria's central region. The reservoir has a total surface area of 5.2 $km^2$ and a maximum depth of 150 m.

Conductivity (µs/cm), turbidity (NTU), pH, and salinity (PSU) of Keddara Dam were measured in situ using a multi-parameter analyzer (Model WTW multi 340i) and transparency using a Secchi disk.

### *Material*

*Micropterus salmoides* is caught with a trammel net of 50 mm mesh size, 200 m in length, and 3.5 m in width, during December 2019 and September 2020. Immediately after landing, we recorded for each fish total length (cm), standard length (cm), fork length (cm), total weight (g), gutted weight (g), and weights of the liver (g), gonad (g), and stomach (g). Sex was determined by macroscopic examination of the gonads according to stages established by Holden & Raitt (1974) of which we find five stages of sexual maturity for both males and females (stage I: immature; stage II: maturing virgin and recovering spent; stage III: pre-spawning; stage IV: spawning; stage V: spent/post-spawning phase). The Fulton's condition factor, (K= (body weight (g)/ total length $(cm)^3$)*100, were calculated for both sexes. The length-weight relationships of Largemouth bass were also estimated separately for each autumn (2019–2020).

The stomach contents analysis was made after storage at 5% formalin. The identification of the prey was conducted at a higher level of taxonomic rank (subphylum). For the diet analysis, vacuity index (VI), frequency of occurrence (O), numerical abundance (N), and predation intensity (PI), were calculated as (Hynes, 1950):

$$VI = (ES/TES)*100$$
$$O = (SP/TES)*100$$
$$N = (NP/TP)*100$$
$$PI = (TPC/TES)*100$$

Where ES is empty stomach; TES is total examined stomach; SP is number of stomach containing prey; NP is number of each prey item; TP is total number of prey, TPC is total prey category.

### *Data analysis*

All statistics and plots were performed using R version 3.6.1 (R Development Core Team, http://www.R-project.org). The significance level was set at a= 0.05 using the function *t-test*.

## RESULTS

The averages of physicochemical parameters of Keddara waters Dam are presented in Table 1. Conductivity and pH were significantly higher at the end of the autumn season (December 2019) than at the beginning of the autumn season (September 2020). Unlike the turbidity which was significantly lower at the end of the autumn season (December 2019) than at the beginning of the autumn season (September 2020). The lowest values of transparency were recorded in autumn 2019 (end of the season).

Overall, 67 individuals of Largemouth bass were caught during the autumn of 2019 and 2020. The total length (TL) of all the studied Largemouth bass individuals ranged from 14.2 to 35.6 cm (average length 28.6±0.38 cm for December 2019 and 23.3±2.14cm for September 2020). Computation of relationships between biometric parameters (TL, FL, and SL) was represented in Fig. 1. All relationships were highly significant (all $R > 0.9$).

The length-weight relationships of Largemouth bass are presented in Fig. 2 and were estimated separately for each year (beginning and end of the autumn season). The sample size and weight ranged from 27.8 cm to 29.8 cm and from 326.16 g to 392.05 g for the end of the autumn season of 2019 and from 14.2 cm to 35.6 cm and from 32.64 g to 722.07 g for the start of the autumn season 2020, respectively. A significant difference was observed between males and females for the length and weight only for the beginning of the autumn season (September 2020).

The values of $R^2$ and slope b differ from the beginning to the end of the autumn season (December 2019 to September 2020) and all relationships were highly significant, with $R^2$ values being greater than 0.7. The values of b ranged from 2.29 for the beginning of the autumn season (September 2020), to 3.4 for the end of the autumn season (December 2019).

The total sex ratio of males to females was 2.045:1. The lowest male to female ratio (2:1) was recorded at the start of the autumn season (September 2020) and the highest male to female ratio (2.33:1) was recorded at the end of the autumn season (December 2019) (Table 2).

The composition of *Micropterus salmoides* (female and male) maturity stage for the beginning and the end of the autumn period (Fig. 3) shows that the spawning season starts towards the end of the autumn period for this species at Keddara Dam.

A significant difference was observed ($P<0.05$) for the condition factor K between beginning and end of the autumn season (December 2019 and September 2020). Largemouth bass reached a higher condition in the end of the autumn season (December 2019) ($K= 15.51\pm0.49$) compared to the beginning of the autumn season (September 2020) ($K= 13.92 \pm 2.22$).

For feeding strategy, a total of 60% and 47.4% Largemouth bass contained prey within the stomach for December 2019 and September 2020, respectively, and corresponds to a vacuity index of 20% and 52.6% for the early and late of the autumn season (September 2020 and December 2019), respectively.

Table 3 shows the mean values of diet composition for Largemouth bass. Preys consisted of fish (fish part: 60% and 24.56%) for the beginning and the end of the autumn period (December 2019 and

| | **pH** | **Conductivity (µs/cm)** | **Transparency (m)** | **Turbidity (NTU)** | **Salinity (PSU)** |
|---|---|---|---|---|---|
| **December 2019** | 7.97 ± 0.07 | 1243 ± 17.6 | 1.54 ± 0.15 | 10.01 ± 1.9 | 0.01 |
| **September 2020** | 7.87 ± 0.05 | 1039.33 ± 9.77 | 1.93 ± 0.42 | 35 ± 3.22 | 0.01 |

Table 1. Mean values of the physico-chemical parameters of Keddara waters Dam.

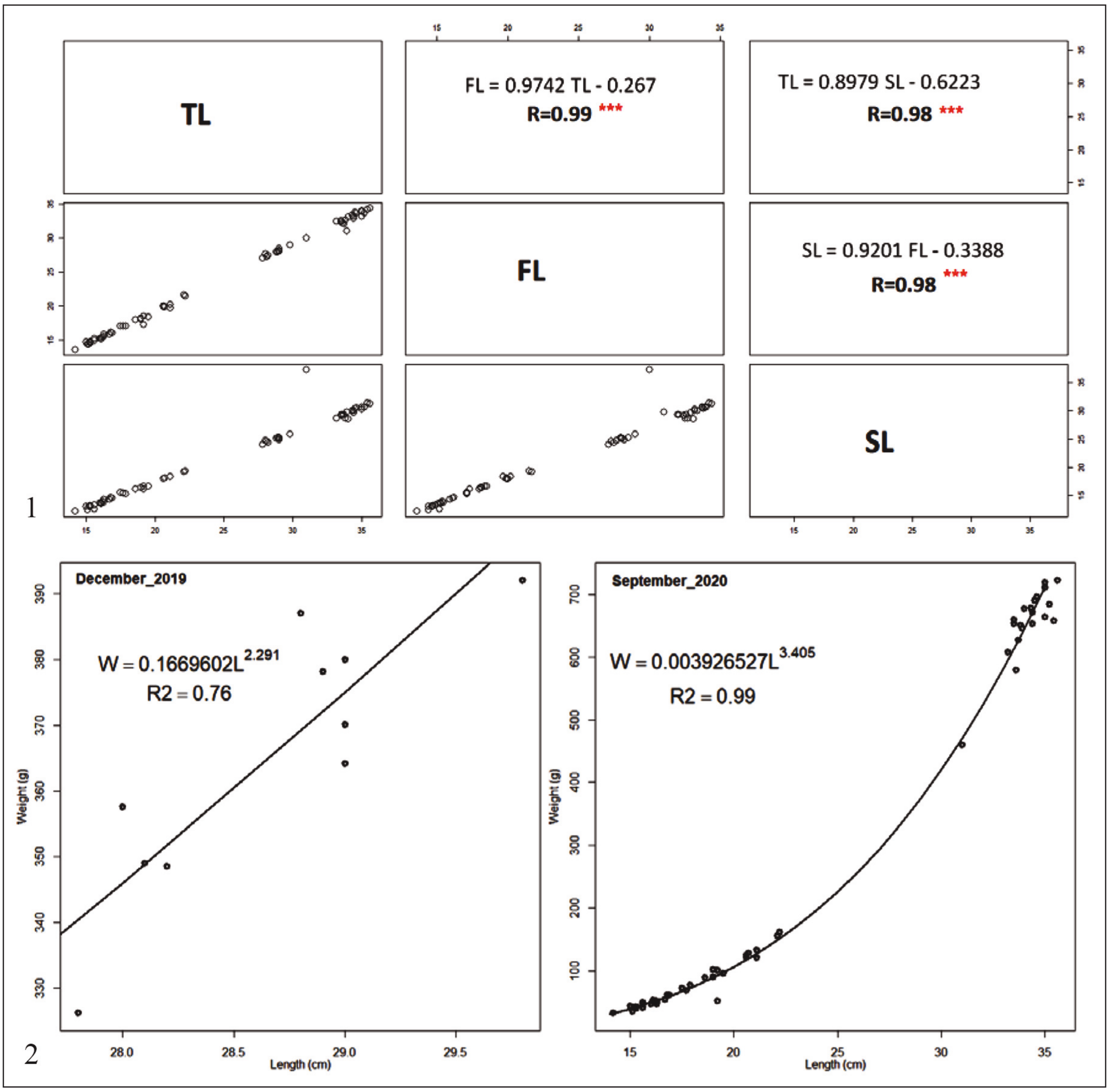


Figure 1. Morphometric relationships between standard, fork, and total length for Black bass caught in Keddara Dam (Algeria). Figure 2. The length-weight relationships for Black bass caught in Keddara Dam (Algeria).

| | Male | Female | Total | Ratio |
|---|---|---|---|---|
| **December 2019** | 7 | 3 | 10 | 2.33:1 |
| **September 2020** | 38 | 19 | 57 | 2:1 |
| **Total** | 45 | 22 | 67 | 2.045:1 |

Table 2. The sex ratio for male and female *Micropterus salmoides* sampled in Keddara Dam (Algeria).

September 2020), respectively; Full fish: 10% and 26.31% for the beginning and the end of the autumn period (December 2019 and September 2020), respectively), Prawn (10 % and 1.75% for December 2019 and September 2020, respectively), Oligochaeta (Full or Oligochaeta part: 10% and 1.75 % for December 2019 and September 2020, respectively), Insecta (0% and 1.75% for December 2019 and September 2020, respectively). Fish parts constitute the most significant frequently observed prey.

Fish part was more significantly abundant prey in December 2019 than in September 2020 and full fish was the most significantly abundant prey in September 2020 than in December 2019. Largemouth bass exhibits significant predation intensity in December 2019 than in September 2020 for full fish.

## DISCUSSION

This research provides information on the biology, presence and ecology of *Micropterus salmoides* in Keddara Dam. Moreover, works on Largemouth bass are few or rare in Algeria despite

| Diet | Fish part | Full fish | Prawn | Full Oligochaeta | Oligochaeta part | Insecta |
|---|---|---|---|---|---|---|
| **O2019** | 60* | 10 | 10 | 10 | 10 | 0 |
| **O2020** | 24.56* | 26.31 | 1.75 | 1.75 | 1.75 | 1.75 |
| **N2019** | 55* | 5* | 10 | 3.33 | 6.66 | 0 |
| **N2020** | 21.66* | 22.2* | 0.35 | 0.58 | 1.17 | 1.4 |
| **PI2019** | 90 | 10* | 10 | 10 | 20 | 0 |
| **PI2020** | 54.4 | 47.37* | 1.75 | 1.75 | 3.51 | 7.02 |

Table 3. Diet composition means of Largemouth bass, *Micropterus salmoides* (O: frequency of occurrence (%), N: numerical abundance (%); PI: predation intensity (%), N=10 for December 2019 and N=57 for September 2020; *: significant difference).

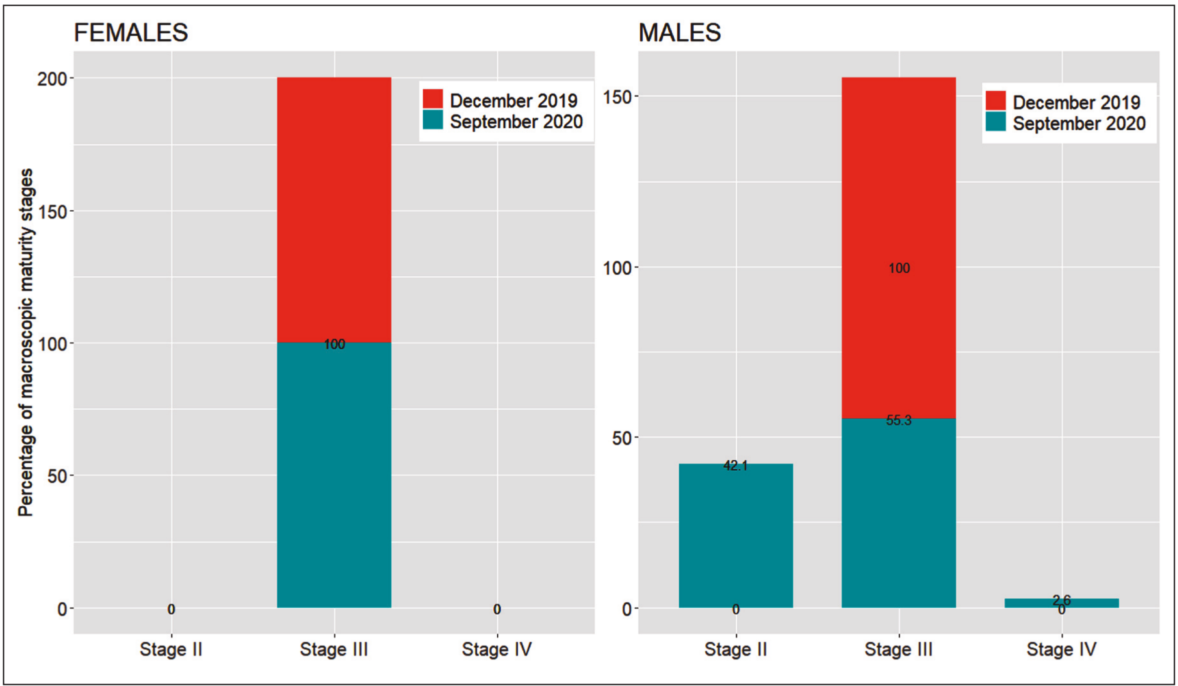


Figure 3. Percentages of macroscopic maturity stages in females and males of *Micropterus salmoides*, over the autumn of 2019 and 2020.

its importance in terms of aquaculture and economics. Based on the present results, we can outline an evident adaptation of *Micropterus salmoides* in Keddara Dam that presents excellent possibilities for Largemouth bass growth and reproduction, with favorable environmental conditions.

In fact, it is known that ability of visually feeding piscivorous fish to forage is accepted to be affected by turbidity (Hecht & van der Lingen, 1992). Reid et al. (1999) noted no significant reduction in the diet frequency of Largemouth bass at intermediate levels of turbidity between 18 and 50 NTU, although changes in the prey size selectivity did occur.

Largemouth bass inhabits freshwater environments and sometimes must tolerate sudden fluctuations in salinity. *Micropterus salmoides* appear to have adapted to low-salinity environments by developing osmoregulatory mechanisms, reducing active ion transport, and tolerating higher plasma levels (Meador & Kelso, 1990).

Stroud (1967) reported range of 6.5–8.5 for the optimal pH and Stuber et al., 1982 noted that spawning of Largemouth bass is affected at pH less than 5.0 (no reproduction) and pH above 9.6 (no eggs survival).

In aquatic communities, light is an important factor that influences predator-prey interactions (McMahon & Holanov, 1995). Baker et al. (1993) reported that Largemouth bass seek protection from light and prefer shaded areas during all stages of life. McMahon & Holanov (1995) indicated that water clarities less than 0.5 m Secchi depth reduce Largemouth bass foraging success to 67 and 75% less than at 2 m Secchi depth and high water clarities (4 m Secchi depth).

Regarding conductivity, Glover et al. (2012, 2013) and Huntsman et al. (2021) reported water quality conditions within Largemouth bass physiological limits of conductivity < 8600 µs·cm−1.

In this study, the observed differences in length-weight relationships can be related to reproduction or feeding activities (Weatherley & Gill, 1987; Wootton, 1990; Moutopoulos & Stergiou, 2002), and the differences in b-values can be attributed to the combination of one or more factors such as differences in the number of individual examined, differences in the observed length ranges of the fish caught and season effect (Moutopoulos & Stergiou, 2002, Chabet dis et al., 2022).

Because of the size-selective properties of the trammel net used, the samples do not include the small-sized individuals for Largemouth bass caught. Consequently, the use of the length-weight relationships in the present study should be limited to the observed length ranges (Petrakis & Stergiou, 1995; Goncalves et al., 1996; Chabet dis et al., 2022).

The sexual dimorphism in the size of *Micropterus salmoides* was reported in the first studies published by Heidinger (1976). Also, larger females were observed by Alessio (1984) only occasionally. However, Rodríguez-Sánchez et al. (2009) noted no significant differences between sexes in Primera de Palos' lake (Huelva, Spain). In Keddara Dam, no significant differences were detected between males and females at the end of the autumn season (December 2019) unlike at the start of the autumn season (September 2020) when a significant difference was observed between males and females for the length and weight. These results support the results of other researchers and can be explained by reproductive activity (Beamish et al., 2005; Granado-Lorencio, 2000).

The sex ratio of males to females of *Micropterus salmoides* from Keddara Dam was 2.33 males: 1 female for December 2019 and 2.33 males: 1 female for September 2020. This result seems close to the result of Beamish et al. (2005) in Lake Manyame, Zimbabwe (2.05 males: 1 female), and different from the values found by Taylor & Weyl (2017) in Wriggleswade (1 male: 1.13 females) and in Mankazana (1 male:1.14 females) in the Eastern Cape Province of South Africa. A number of hypotheses may explain these subsequent changes in this value, like differences in habitat preference according to the sex or season, selective mortality, sampling errors, reproductive stress suffered by female and males (Fernandez & Rossomanno, 1997; Granado-Lorencio, 2000; Beamish et al., 2005)

Regarding the diet of Largemouth bass *Micropterus salmoides* in the Algerian freshwaters, there is very scarce data. The present finding showed that Largemouth bass is not exclusively piscivorous, feeds also on prawns, Oligochaeta, and insects that live in Keddara Dam. Marinelli et al., (2007) mentioned that decapod *Palaemonetes antennarius* is the major food items *Micropterus salmoides* in Lake Bracciano (Italy). Alessio (1984), Rodriguez-Jimenez (1989), Godinho & Ferreira (1994), Nicola et al. (1996), Godinho et al. (1997) and Godinho & Ferreira (1998) indicated that Largemouth bass ingest fish (the predominant food item) and crustaceans and insects (also frequently eaten).

The number of prey was lower in our study when compared with other studies (Rodriguez-Jimenez, 1989; Godinho & Ferreira, 1994; Godinho et al., 1997; Godinho & Ferreira, 1998; Marinelli et al., 2007). He et al. (1994), Hickley et al. (1994), Godinho et al. (1997) and Olson et al. (1998) reported that Black bass is an opportunistic predator with an alimentary range depending on the feeding resources and on the environment.

The current study showed a significant difference related to the stomach content of fish (fish part or full). Many factors could have affected the amount and type of food found in the stomach content of Black bass like the water temperature and the reduction of the foraging activity during the reproductive period (Alessio, 1984; Rosemblum et al., 1994).

The feeding and spawning strategy in Keddara Dam is likely an adaptation for Largemouth bass that helps ensure reproductive and life success where the biotope is frequently subjected to disturbances out of control, like water level fluctuations, noting that these waters are intended for drinking water. However, in freshwater environments, biological invasions are an important factor for biodiversity loss (Almeida et al., 2012) and have a variety of negative impacts on habitats and native species, such as habitat degradation (García-Berthou, 2001), competition (Keller & Brown, 2008), food web alteration (Almeida et al., 2009), and predation (Schilling et al., 2009).

In conclusion, the present study provides some basic ecologic and biologic information on the reproduction and feeding habits of *Micropterus salmoides* in Algeria, reporting for the first time the presence of this species in a favourable environment as Keddara Dam.

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