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Weight-length relationship and condition factor of *Mugil cephalus* (Linnaeus 1758, Mugilidea) in the special wildlife reserve of Gueumbeul (RSFG) in Senegal

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Abstract

The weight-length relationship and the condition factors are fundamental parameters with several uses in biology, fish ecology and fisheries management. Thus, in the Special Wildlife Reserve of Gueumbeul (SWRG) in Senegal, the weight-length relationship and condition factor were established for *Mugil cephalus* (Linnaeus 1758). A total of 311 individuals (97 females and 214 males) of *M. cephalus* were collected by the artisanal fishery using cast nets. The total length and weight ranged from 11.1 to 25 cm and 15.9 to 145.26 g, respectively. The results showed that in the SWRG, both in females (b = 2.60) and males (b = 2.899), *M. cephalus* had negative allometric growth. The analysis of variance showed no significant difference ($p > 0.05$) in the coefficients of determination between females (R = 0.96) and males (R = 0.84). Condition factors (K) were 3.07 and 1.23 for males and females respectively for *M. cephalus* in the reserve.

Keywords: *Mugil cephalus*; Condition factor; Regression; Gueumbeul; Senegal

1. Introduction

The weight-length relationship is one of the most commonly used analyses in fisheries management [1]. This analysis has been widely used in fish biology for several reasons. These include predicting weight from length measurement for yield assessment, estimating weight at age, stock assessment, assessing fish population dynamics and growth, morphometric comparisons between species and populations, and life history comparisons between regions [2, 3, 4, 5, 6, 7]. However, these parameters are therefore of great importance in fisheries assessments, especially for proper exploitation and management of the fish population [3].

As for the condition factor, it is a tool to monitor the evolution of the overweight status of the fish. It is a factor used to compare the condition, fatness or welfare of the fish. It provides information on the state of food abundance and the length of the reproduction period [8]. It is also considered a good tool for comparing the overall physiological condition of a fish or group of fish during a seasonal cycle or between water reservoirs with different ecological conditions [9].

M. cephalus) also known as yellow mullet, is a species of pelagic and gregarious fish living in muddy or sandy bottoms, often at shallow depths. Its life cycle comprises several phases and takes place in different environments. Thus, according to Ameur *et* al. [10], immature and juvenile of *M. cephalus* live in brackish coastal environments (lagoons, estuaries). As adults, they migrate to the sea for maturation and possibly for spawning [10].

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M. cephalus is a popular food fish species in estuarine areas due to its easy fishing and high nutritional value with good amount of protein and minerals [11]. However, this fish species is intensively fished in the estuarine areas of Senegal, of which the Gueumbeul reserve is a prime location for fishing this species.

The stock of *M. cephalus* in the Gueumbeul Reserve has long been poorly known. No studies have been carried out on the Gueumbeul Reserve to try to assess the fish population in general and that of mugilids in particular. The analysis of data on the weight-length relationship and condition factor of a fish stock is an important source of data for rational management purposes as fish growth is unlimited and depends on both environmental and genetic factors [12].

The objective of the present study is to investigate the weight-length relationship and condition factor in the *M. cephalus* population in the basin of the Special Wildlife Reserve of Gueumbeul in order to propose possible measures for sustainable management of fisheries for this species in the SRWG.

2. Material and methods

2.1. Study environment

The Special Wildlife Reserve of Gueumbeul is located in the delta of the Senegal River, more precisely in the department of Saint-Louis (Figure 1). It straddles the rural communities of Ndiébène Gandiole and Gandon. It was created by decree n° 83-550 of May 30, 1983 on a surface area of 720 ha for a perimeter of 12 km, including the Gueumbeul basin and the adjacent zone over a width of 500 m from the edge of the basin. Its geographical coordinates are 15°59 North and 16°28 west.

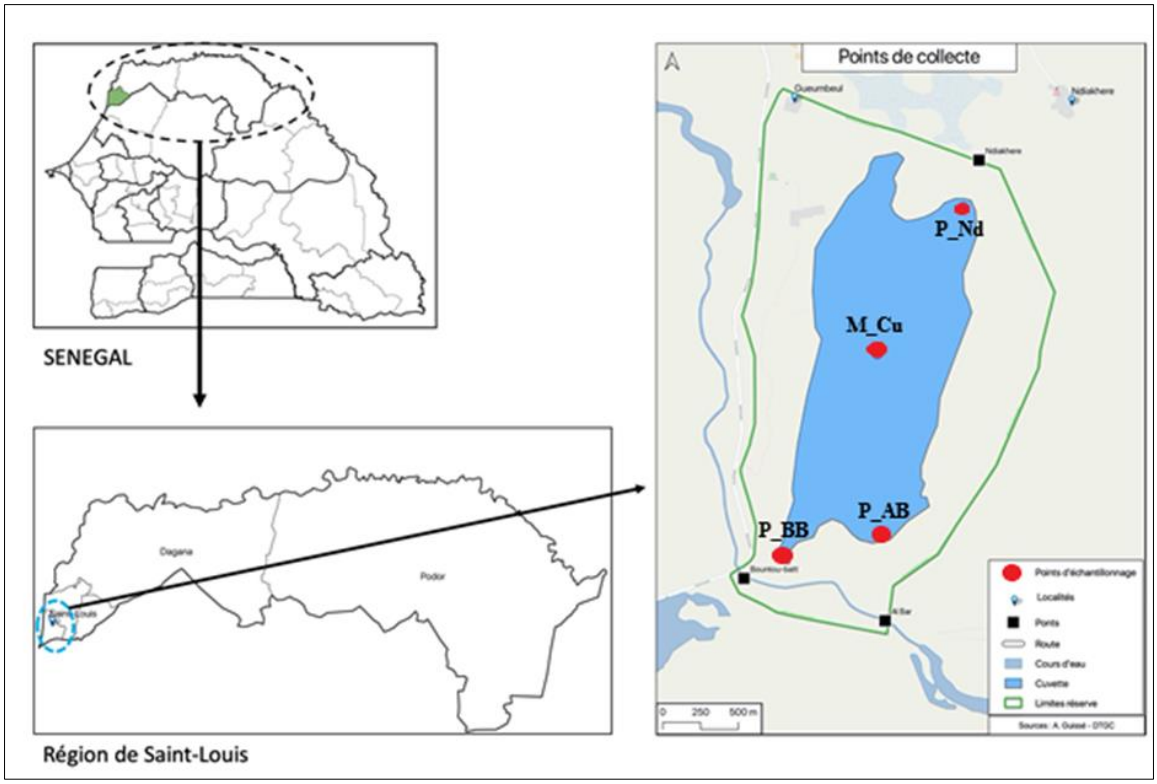

Figure 1 Map of the study area showing the sampling stations (in red) in the Gueumbeul reservoir

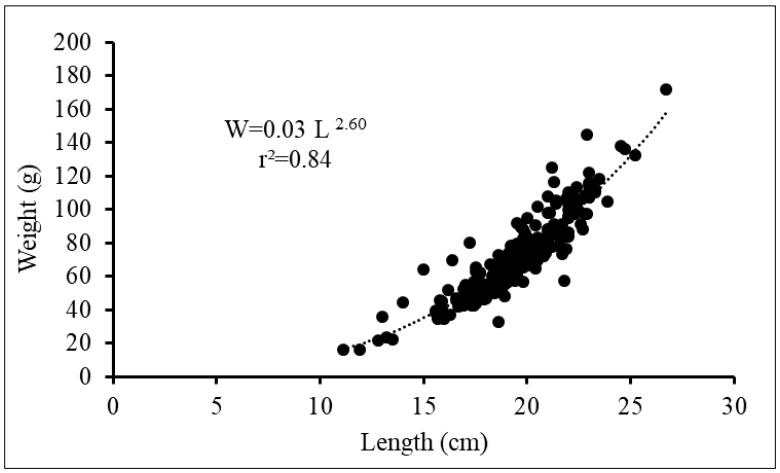

Figure 2 Weight-length relationship of male *Mugil cephalus* from the Gueumbeul reserve

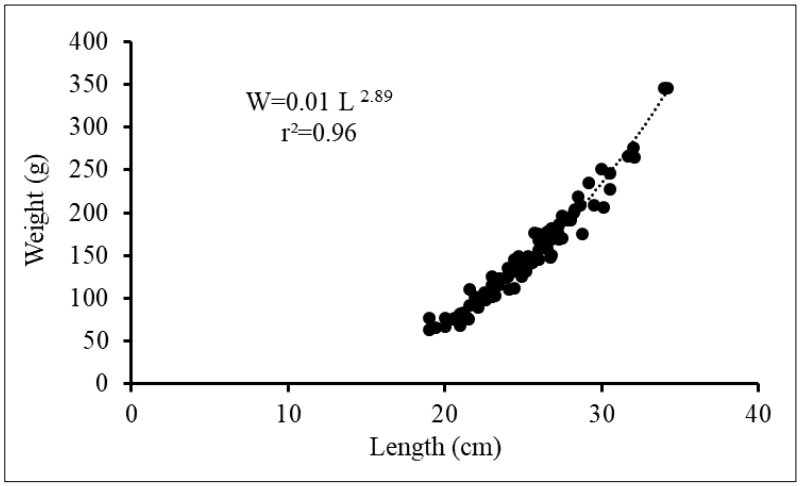

Figure 3 Weight-length relationship of female *Mugil cephalus* from the Gueumbeul reserve

The climate is Sahelo-Sudanian with a rainfall of 200 to 300 mm per year and mild temperatures. It varies between 21°C and 24°C from December to May and between 25°C and 29°C from April to November. The low thermal amplitudes and mild temperatures throughout the year are a consequence of the oceanic influence.

2.2. Selection of stations

The choice of sampling sites was inspired by the water exchange points upstream and downstream of the basin and finally by the frequentation of the riparian population for their various fishing activities in the reserve. Thus, four (04) sampling points were selected and retained. The geographic coordinates of each sampling point are shown in Table 1.

Table 1 Sampling sites upstream and downstream of the Gueumbeul basin

Sampling Sites	Site Code	Latitude	Longitude
Al Bar Bridge	P_AB	15°54'03°N	16°27'43°W
Bountou-Batt Bridge	P_BB	15°54'14°N	16°28'17°W
Ndiakhére Bridge	P_Nd	15°55'47°N	16°27'25°W
Middle Basin	M_Cu	15°55'12°N	16°27'47°W

2.3. Fish sampling and identification

Sampling was conducted over a 12-month period (March 2019 to February 2020) at the four selected sites (Table 1). Fish samples were collected using cast nets by artisanal fishermen. Data were collected twice a month (beginning and end of month) at each site. The fish caught were identified using available identification keys [13, 14, 15, 16], photographed and fixed with 10% formalin for conservation purposes.

2.4. Morphological analyses

After fishing, the fish samples are then sent to the Laboratory of Biological, Agronomic and Food Sciences and Complex Systems Modeling (LABAAM) of the Gaston Berger University of Saint-Louis for measurements and treatment. The individuals are weighed (total weight, eviscerated weight) then measured (total length, standard length) respectively with an electronic scale (Scout Pro) with a capacity of 0.1 g and an ichthyometer calibrated to the nearest cm.

2.5. Relation weight-length and condition factor (K)

The relationship between weight (W) and length (L) of fish was expressed by the equation of [17]. $W = a L^b$, where W = weight (g), L = length (cm), a = constant, b = growth exponent.

The values of a and b were obtained from a linear regression of fish length and weight: $\text{Log } W = \text{Log } a + b \text{ Log } L$. According to [17], the coefficient b is logically close to 3. If $b < 3$, size increases faster than mass and conversely if $b > 3$, it is said that there is positive allometry. If $b = 3$, there is isometry; the shape does not change. This shape index reflects the nutritional status and therefore the trophic environmental conditions and the physiological state of the fish. The correlation R which is the degree of association between length and weight was calculated from the linear regression analysis: $R = r^2$

The condition factor (K) of the fish specimens was estimated from the relationship: $K=100\ W/\ L^b$ [18], where K = condition factor, W = weight of fish (g), L = length of fish (cm). This condition factor is a parameter that provides information on the physical fitness of the fish. This parameter allows monitoring the variations in the metabolic balance of individuals through seasonal changes in overweight due to external and internal factors.

2.6. Data Analysis

A regression analysis was performed to determine the relationship between the weight and length of *Mugil cephalus*. For each sex, the slopes of the weight-length regressions were compared to 3 using Student's t-test [19] to determine whether the species grew isometrically.

3. Results

A total of 311 fish (97 females and 214 males) were measured. The size ranges recorded and used to determine the weight-length relationship are 11.1 to 19.46 cm for males and 19 to 25 cm for females. The weights ranged from 15.9 to 71.89 g for males and 62.6 to 145.26 g for females. The relationships found for male and female individuals are shown in Figure. 1 and 2. There is a significant correlation between height and weight for males (R=0.84) and females (R=0.96). The weight-length relationship and growth parameters are shown in Table 2. The values of b obtained are less than 3 ($b < 3$), showing that in the Gueumbeul *M. cephalus* basin there is negative allometric growth regardless of sex. Regarding the condition factor (K), a significant difference is noted between male (3.07) and female individuals (1.23).

Table 2 Equations and growth parameters of male and female *Mugil cephalus* in the Gueumbeul basin

Species	Sex	Equations	a	b	K	r^2
M. cephalus	Male	W=0.03 L 2,60	0.03	2.60	3.07	0.84
	Female	W=0.01 L 2,89	0.01	2.89	1.23	0.96

4. Discussion

Data on the morphometric parameters of a fish are very important for taxonomic and characterization studies because morphometric measurements vary according to the species, sex, habitat and size of the fish [20, 21, 22]. The "a" represents the body shape coefficient while "b" is an exponent with a value between 2.5 and 3.5 [23] indicating an

interpretation of relative fish well-being or normal growth dimensions [24]. The coefficient *b* of male and female *Mugil cephalus* from the Gueumbeul reserve was 2.60 and 2.89 respectively. These values of the allometric coefficient ($b < 3$), show that *M. cephalus* sampled from the Gueumbeul basin has negative allometry; suggesting that size increases more than weight in both males and females. This recorded negative allometry could be due to the lack of food resources and the advanced state of degradation of the bowl. This finding is confirmed by Yakubu *et al.* [25] who noted that the allometry coefficient is related to the quality of the aquatic environment and the availability of natural production.

These results are similar to those of Sarr *et al.* [26] and Kurma & Ramesh [27] who obtained allometric coefficients of 2.76 and 2.69 for male and female *M. cephalus* in the Senegal River estuary and 2.66 and 2.74 for male and female *M. cephalus* in the east coast of Andhra Pradesh in India, respectively. According to Kara & Bayhan [28] and Victor *et al.* [29], fish growth parameters, as well as weight-length relationships, are affected not by one, but by several sets of factors such as season, habitat, temperature, salinity, diet, health and food availability. Concerning the R values, they are 0.84 and 0.96 for males and females of *M. cephalus* respectively. These R values very close to 1 show a strong relationship between height and weight in *M. cephalus.* This means that there is a proportionality between weight and length in *M. cephalus* in the Gueumbeul reserve. Similar results (0.96 and 0.94) were obtained by Khayyami *et al.* [30] respectively at the port of Bandar Abbas and Qeshm Island in the northeastern Persian Gulf. Similarly, studies by Sarr *et al.* [26] (R=0.92 for males and 0.93 for females) corroborate the results obtained. However, there is a significant difference between the value of the condition factor K (3.07 and 1.23) of *M. cephalus* for males and females respectively. This difference may be due to the fact that females are less representative in the *M. cephalus* population studied. According to King [24], variations in K in fish may be indicative of food abundance, adaptation to the environment, gonad development, sample size, habitat quality, growth increment, water temperature and salinity, fishing activities, individual metabolism, age and maturity. According to the results of the condition factor K obtained, the basin of the Gueumbeul reserve is a nutrient-rich environment with favourable living conditions.

5. Conclusion

The results obtained in the present study constitute the first data base on the biology and growth parameters of *Mugil cephalus* (Linnaeus 1758) in the Gueumbeul basin and will serve as a tool for ecologists and managers of the reserve to take adequate management measures for the conservation of the ichthyological biodiversity in general and the stock of *M. cephalus* in particular, which is very important for the local fishery.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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