GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(RESEARCH ARTICLE)

Size structures and length-weight relationships of three freshwater fish, *Brycinus imberi, Labeo coubie, Oreochromis niloticus*, from the Bandama river section located in Haut-Bandama Widlife Reserve (North Central, Côte d'Ivoire)

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GSC Advanced Research and Reviews, 2022, 13(02), 221–226

Publication history: Received on 02 October 2022; revised on 21 November 2022; accepted on 23 November 2022

Article DOI: https://doi.org/10.30574/gscarr.2022.13.2.0305

Abstract

The needs induced by the galloping demography and urbanization in the north-central part of Côte d'Ivoire have provoked strong anthropic pressures on the Bandama River, particularly its section located in the Haut-Bandama Wildlife reserve. This is reflected in the increased invasion of this watercourse by aquatic plants and algae, its enrichment in suspended matter and chemicals of all kinds. This state of the river could have repercussions on the development of biological organisms such as fish. Thus, the study aimed to determine the size structures and length-weight relationships of *Brycinus imberi, Labeo coubie* and *Oreochromis niloticus* from the Bandama River located in the Haut-Bandama wildlife Reserve. It was carried out along the longitudinal gradient (upstream-downstream) of the Bandama River, on 06 stations and during 08 sampling campaigns between January 2018 and February 2019. Fish specimens' lengths measurements were made with an ichthyometer, and with an electronic scale, for the weights. The analysis focused on the size structure and length-weight relationships. Length-weight Relationship (LWR) was described by the equation: W = aLb. *Brycinus imberi* specimens' sizes varied from 5.3 to 13.5 cm SL. At *Labeo coubie*, the specimens have sizes that oscillate between 7.6 and 51.2 cm SL. As for *Oreochromis niloticus*, the sizes were between 8.7 and 17 cm SL. Growth appeared allometric negative with b values of 2.70 for *Brycinus imberi*, 1.08 for *Labeo coubie*, and 2.51 for *Oreochromis niloticus.*

Keywords: Size structure; Length-weight relationships; Haut-Bandama Wildlife Reserve; Bandama River; Côte d'Ivoire

1. Introduction

The galloping demographic growth and urbanization in the north-central part of Côte d'Ivoire have caused strong anthropic pressures on the Bandama River located in the Haut-Bandama Wildlife Reserve. Indeed, the location of agribusiness industries upstream of the Haut-Bandama Wildlife Reserve, intensive agriculture, clandestine fishing using pesticides, and clandestine gold illegal panning have led to the permanent discharge of fertilizers, pesticides, and mining effluents into the Bandama River located in the Haut-Bandama Wildlife Reserve [1, 2]. This situation has caused this watercourse to become more invaded by aquatic plants and algae, which induces its enrichment in suspended matter and chemicals of all kinds [3]. Furthermore, *Brycinus imberi, Labeo coubie* and *Oreochromis niloticus* are the main species encountered in the Bandama River located in the Haut-Bandama Wildlife Reserve. However, the population highly prizes these three (03) species'. Despite the high fecundity of these species, this phenomenon would be likely to influence them negatively through the degradation of their natural habitats [4] and the reduction of the populations of these fishes in the part of the Bandama River [5]. But, like all the other species harvested in this part of the Bandama

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River located in this wildlife reserve, the issue of conservation and sustainable management of these species remains. Faced with this concern, determining the state of biological health and making management decisions necessary to ensure the survival of these species requires knowledge of the biology of fish populations. This knowledge can be achieved by studying these species' population structure and length-weight relationships. Thus, the study aimed to determine these species' size structures and length-weight relationships in the part of the Bandama River located in the Haut-Bandama Wildlife Reserve.

2. Material and methods

2.1. Study site

Created in 1973, the Haut-Bandama wildlife Reserve is located between 8°10'25.3'' and 8°38'25.01'' north latitude and 5° 12'14.1'' and 5°37'55.3'' West longitude, with an area of 123,000 hectares [6].This reserve belongs to the Sudano-Guinean sector, with an average annual rainfall of 1230 mm, daily and annual thermal amplitudes of the order of 26.6°C and a humidity rate of 35 to 79% [7].

2.2. Methodology

This seasonal study was carried out between January 2018 and February 2019, on six (06) sampling stations following the longitudinal gradient of the Bandama River in the RFF-HB. These are stations BTA and BTB in the upper course, stations BSA and BSB in the middle course and stations BYA and BYB in the lower course o (Figure 1).

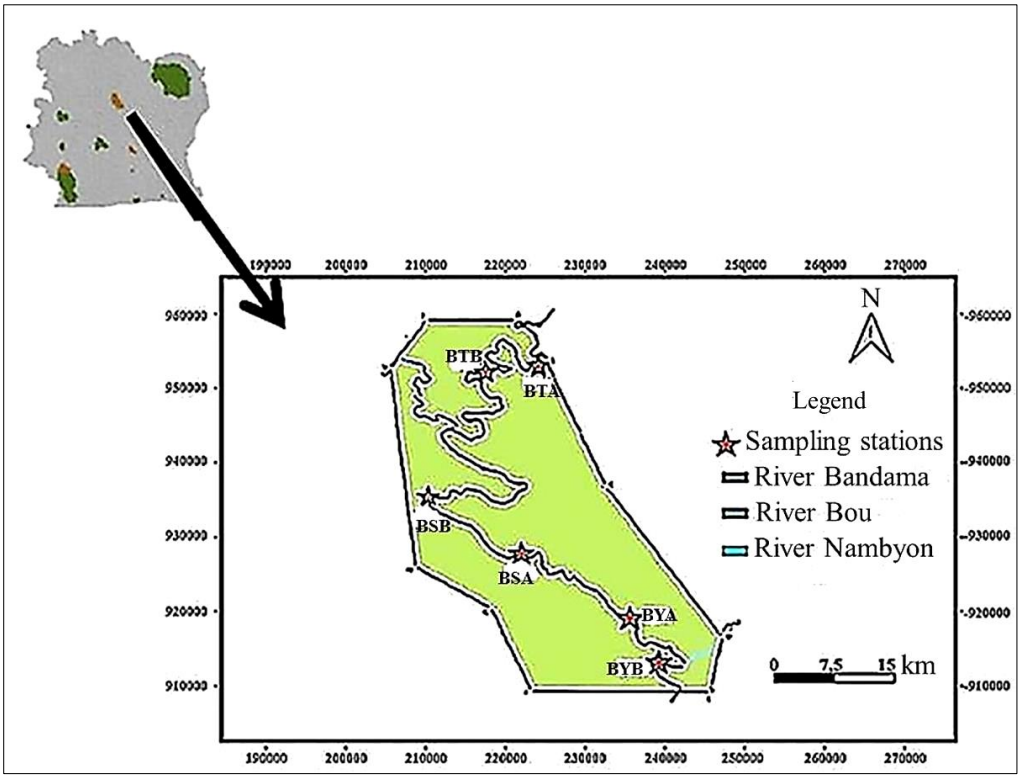


Figure 1 Study sampling stations location on the Bandama River

For ichthyofauna sampling, gillnets (10 to 40 mm square, 30 to 40 m long and 2 to 2.5 m high) and pots baited with pieces of cassava or soap in areas of weak current, were set between 17:00 and 18:00 and visited the next day between 06:00 and 07:00, for night fishing. Then, they were rested between 07:00 and 08:00 and then lifted between 15:00 and 16:00, for the daytime fishing. In addition, the hawk was used to capture the fish with these baits.

Fish specimens' measurements were made with an ichthyometer, for total and standard lengths, and with an electronic scale of precision 0.1 grams, for the weights.

The size frequency distribution was determined globally for the populations of each species collected in the main bed of the Bandama River. Length-weight Relationship (LWR) was described following Le Cren [8] equation, $P = aL^b$ where L, is the standard length of the fish in centimeters and P, the total weight of the fish in grams, the parameters a and b, representing the intercept and the allometry coefficient respectively were deduced by logarithmic linearization. The value of b gives information on the type of growth of the species considered. Growth is said to be isometric if $b= 3$ (growth in weight is equal to growth in height) and allometric if $b \neq 3$ (if $b < 3$ growth is negative allometric i.e. growth in weight is less than growth in height; if $b > 3$ growth is positive allometric or growth in weight is greater than growth in height. To test whether the values of b differ significantly from 3, Student's t test was applied.

3. Results

3.1. Size structures

The size frequency distribution expressed from the standard length (SL) of all specimens of *Labeo coubie, Brycinus imberi* and *Oreochromis niloticus* sampled in this part of the Bandama River located in the Haut-Bandama Wildlife Reserve is presented in Figure 2.

The sizes of *Brycinus imberi* specimens varied from 5.3 to 13.5 cm with a median value of 9.89 cm. For this species, the specimen's size frequencies analysis indicated two modes. The size class [8.02-9.38 cm] was the first modal class and the size class [12.1-13.46 cm] was the second modal class. These two classes were representative of two groups of specimens that can be likened to two cohorts.

Concerning *Labeo coubie*, the collected specimens had sizes that varied between 7.6 and 51.2 cm with a median value of 18.82 cm. The size frequency distribution of this species was unimodal and the sizes most encountered in the captures are between 7.6 and 13.82 cm.

For *Oreochromis niloticus*, the sizes varied between 8.7 and 17 cm with a median value of 12.25 cm. Overall, the population structure of *Oreochromis niloticus* had a bimodal distribution and the collected samples had a greater number of specimens for sizes between 8.7 and 10.08 cm and between 11.46 and 12.84 cm.

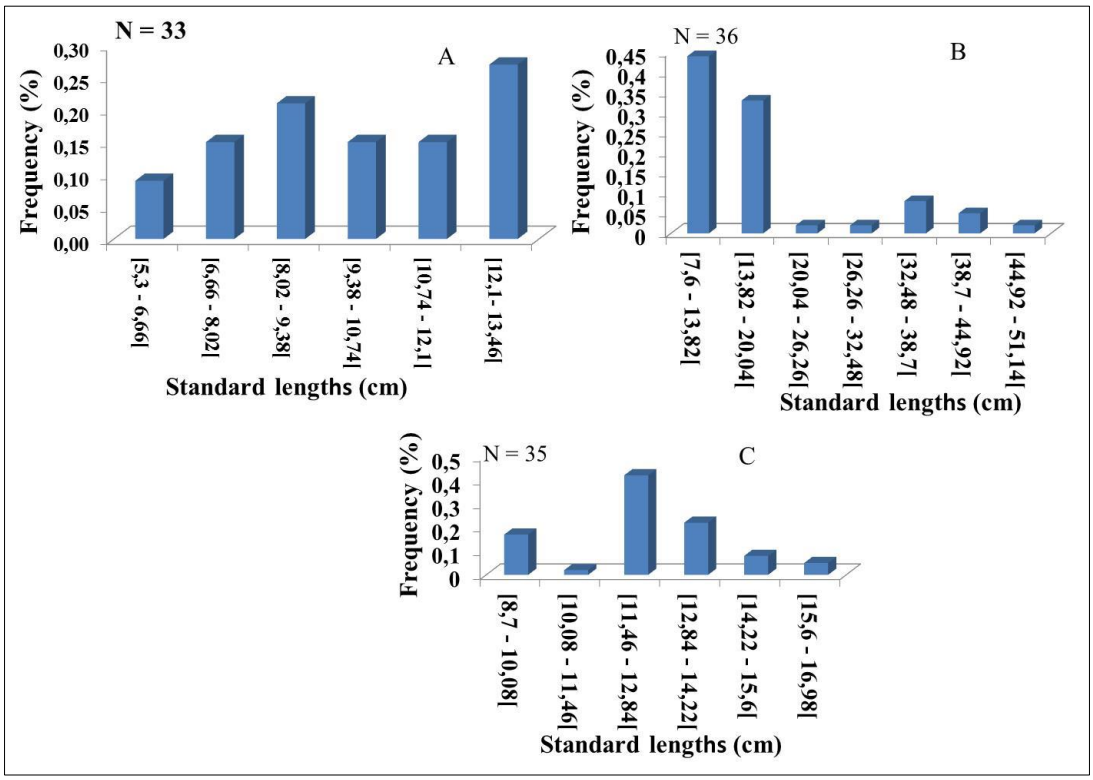
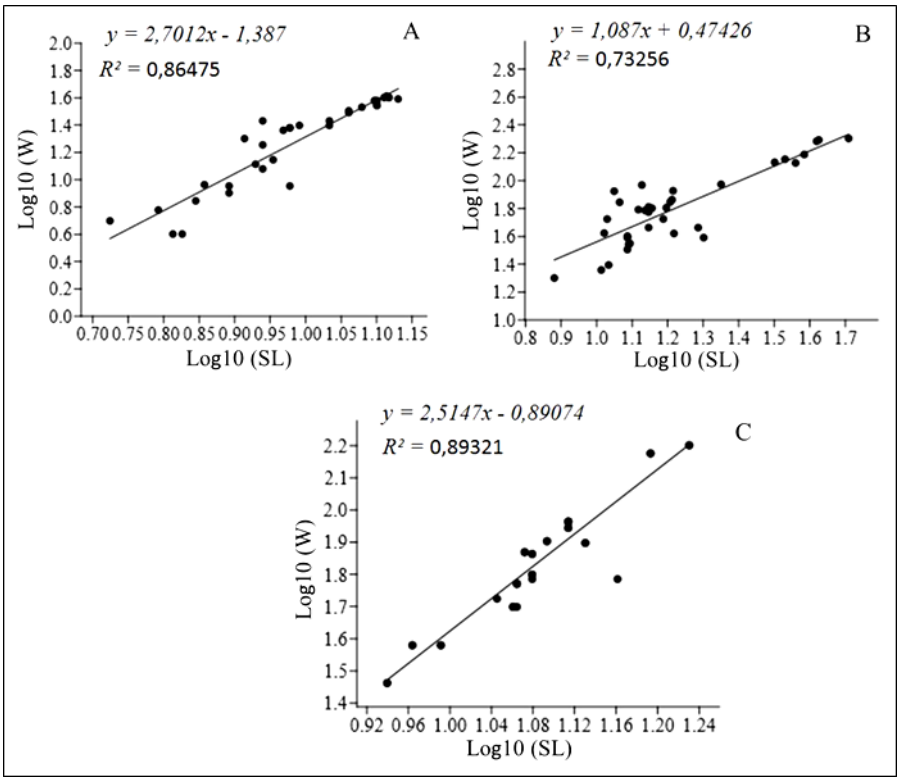


Figure 2 Size frequency distribution (SF) of *B. imberi* (A), *L. coubie* (B) and *O. niloticus* (C) populations collected in the Bandama River located in the Haut-Bandama Wildlife Reserve

3.2. Length-weight relationships

Figure 3 shows the length-weight relationships of the populations of Brycinus imberi, Labeo coubie and Orreochromis niloticus. The regressions were highly significant with correlation coefficients r = 0.92, r = 0.85 and r = 0.94 respectively for these three species. The value of the allometry coefficient (b) was 2.70 for Brycinus imberi, 1.08 for Labeo coubie and 2.51 for Oreochromis niloticus. These values are lower than 3 and significantly different from 3 (threshold value) (Student's t test; $p < 0.05$). The length-weight relationship parameters of these three species were summarized in Table I.



log10 = logarithm to base 10, SL = standard length, W = weight

Figure 3 Regressions between length and weight of *B. imberi (A), L. coubie (B)* and *O.niloticus* (C) populations collected in the Bandama River located in the Haut-Bandama Wildlife Reserve

Table 1 Length-weight relationship parameters of *B. imberi, L. coubie* and *O. niloticus* populations of the Bandama River located in the Haut-Bandama Wildlife Reserve

Species	Nbr	Lengths (LS, cm)			Weights (g)			a	b	ES (b)	r	Cr
		Min	Avg	Max	Min	Avg	Max					
Brycinus imberi	33	5.3	9.89	13.5	4	22.91	41	-1.38	2.70	0.19	0.92	A-
Labeo coubie	36	7.6	19.14	51.2	20	75.84	201	0.47	1.08	0.11	0.85	A-
Oreochromis niloticus	35	8.7	12.1	17	29	74.62	159	-0.89	2.51	0.15	0.94	A-

Nbr = Number of specimens, **Min** = minimum, **Max** = maximum, Av**g** = average, **a** = constancy of proportionality, **b** = Allometry coefficient, **ES** = standard error, **r** = Correlation coefficient, **Cr** = type of growth and **A-** = negative allometry.

4. Discussion

The maximum sizes recorded in this study for *Brycinus imberi* (13.5 cm), *Labeo coubie* (51.2 cm) and *Oreochromis niloticus* (17 cm) were much smaller than the maximum sizes reported by Tal *et al*. [9], for *Brycinus imberi* (15 cm) and for *Oreochromis niloticus* (27.5 cm) in Ayame I reservoir and in Buyo reservoir (33 cm), but better than the maximum sizes reported for *Labeo coubie* (50 cm) in Buyo reservoir by these authors. However, these values recorded in this part of the Bandama River are largely lower than the maximum sizes recorded in other African waters indicated in the

literature for these fish species, which are 19.8 cm for *B. imberi* [10] ; 75 cm for *L. coubie* [11], and 60 cm for *O. niloticus* [12].These size differences would be a consequence of the disparities in ecological factors of the study environments. In fact, the section of the Bandama River located in the Haut-Bandama Wildlife Reserve was said to be suffering from a degradation of its ecological integrity linked to anthropic activities dominated by gold panning. This section of the Bandama River would therefore present ecological conditions that were not very favorable for fish growth. Boussou [13], in his work on the Banco, Comoé, Bia and Tanoé basins, noted that due to spatial disparities, for the taxa inhabiting these hydrosystems, the growth and maximum size observed may be different. In this area, clandestine fishing was one of the activities that clandestine fishers engage in to supply the local markets around the Haut-Bandama Wildlife Reserve with fish [1].

The calculated value of the allometric coefficient b (2.51) was less than 3, suggesting that *O. niloticus* had negative allometric growth in this section of Bandama River. Our results were consistent with those obtained by Froese & Pauly [14] who noted a negative allometry for this species (2.97), but were different from those of Sirima *et al*. [15] who noted a positive allometry (b > 3) for *O. niloticus* in the Comoé River basin in Burkina Faso. Concerning the genus *Brycinus*, the index of allometry coefficient recorded was less than 3 for *B. imberi* (b = 2.70), indicating a negative allometric growth. This result corroborates those of Sirima *et a*l. [15] for this genus in the Comoé basin in Burkina Faso where b was less than 3, reflecting negative allometric growth. Our data were also similar to the values recorded in the literature by Froese & Pauly [14] who indicated a negative growth allometry (b = 2.97) for the genus *Brycinus*. In all species considered in this analysis, the slope of the equation relating weight and length revealed values of b less than 3. This reflecting that these fish had grown more in size than in weight throughout the main bed of the Bandama River section located in the Haut-Bandama Wildlife Reserve. The low values (b < 2.5) observed in *Labeo coubie* could be related to the narrowness of the size classes and the number of individuals. The negative growth allometry found in this study would confirm the impact of anthropogenic pressures on these species [16, 17]: These species seem to be under enormous pressure and would be in difficult living conditions in the Haut-Bandama Wildlife Reserve [18].

5. Conclusion

This study determined the size structures and length-weight relationships of *Brycinus imberi, Labeo coubie* and *Oreochromis niloticus* populations from the Bandama River located in the Haut-Bandama Wildlife Reserve. On the whole, these species specimens' were smaller than those reported in the literature. In general, these species shown a negative allometric growth. These results constitute preliminary data for the study of this fish species in the Bandama River located in this Wildlife Reserve, which should help develop strategies for conservation and sustainable management of the resources of this reserve.

Compliance with ethical standards

Acknowledgments

The authors would like to thank all the institutions that made this study possible, in particular the OIPR (Ivorian Office of Parks and Reserves) and the University Jean Lorougnon Guédé of Daloa.

Disclosure of conflict of interest

No conflict of interest.

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