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Research Article

Reproductive Strategy of *Chrysichthys nigrodigitatus* (Lacepede, 1803) in a Natural Environment in the Nkam River, Littoral Cameroon

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A study on the reproductive strategy of *Chrysichthys nigrodigitatus* was conducted from October 2015 to August 2016, in the Nkam River in Yabassi, Littoral Region of Cameroon. For this purpose, 154 specimens of *C. nigrodigitatus* with total mean weight of 829.96 ± 829.58 g and total mean length of 367 ± 156 mm collected from artisanal fishermen were used. Twenty-nine (29) females at stage V of sexual maturity were selected for the evaluation of the fecundity. It appears that the oogenesis in *C. nigrodigitatus* is of an asynchronous type with multiple laying spread over a long period. The gonadosomatic index (GSI) peaks in June (17.9 ± 7.1 for females and 1.06 ± 0.27 for males). Hepatosomatic index (HSI) was higher in females than in males throughout the year. The mean condition factor K was 1.07 ± 0.09%. The breeding season occurred from April to October during the rainy season. Gonadosomatic and hepatosomatic indices were positively correlated with rainfall, contrary to the K factor, which has been strongly and negatively correlated with this physical parameter. The sex ratio of 1M: 1.5F was in favour of females, thus reflecting an "*r*" type reproductive strategy. Absolute fecundity was estimated at 1374 ± 1022 oocytes for individuals of 107.3 ± 111.9 g mean weight. Mean relative fecundity was 14 ± 3 oocytes/g of body weight. It was recommended that future work focuses on the captivity of this species.

1. Introduction

Fish is an extremely nutritious food, a vital source of protein and essential nutrients, especially for many low-income people around the world [1]. According to FAO [2], world fish supply reached a record of 20 kg per capita, in favour of strong growth in aquaculture, which now provides half of the fish for human consumption. This growth is correlated with the progressive enhancement of native species in certain regions of the world [2].

In Africa, and particularly in Cameroon, as reported by Cacot [3], fish farming has remained focusing on three species of fish: *Clarias gariepinus*, *Oreochromis niloticus*, and *Cyprinus carpio*. At the present state of knowledge, very few of these farmed species have reached a large-scale development potential. This situation would certainly be at the origin of the intensification of research towards new species better adapted to the constraints of African aquaculture. This is particularly the case for studies on some African carp and African catfish: *Labeo senegalensis* by Montchowi et al. [4],

Labeo parvus by Montchowui et al. [5] and Montchowui et al. [6] and *Chrysichthys auratus* [7, 8] in Benin and Egypt, *Labeo coubie* in Nigéria by Ikpi and Okey, and *Labeobarbus batesii* and *Clarias jaensis* in the Mbô Floodplain in West Cameroon by Tiogué et al. [10], Tiogué [11], Tiogue [12], Tomedi et al. [13], Zango et al. [14].

The ichthyological fauna of Cameroon's freshwater is of exceptional interest. Nearly 60 species of fish have recently been identified by Ajonina and Tomedi [15] in the Nkam River, amongst which the most abundant and much appreciated species was *Chrysichthys nigrodigitatus*, locally called "mayèpè." This fish species is the subject of many traditional recipes in households and restaurants, according to Ajonina and Tomedi [15], the consequence of which is the decrease of wild stocks. Therefore, studies on the biology of this species is essential to better develop its breeding captivated. Aspects of the biology of *C. nigrodigitatus* have already been the subject of several studies in West Africa, more particularly in Ivory Coast, where captive breeding trials have been successfully tested by Djéhi [16]. In Cameroon, there is very little information on its reproductive cycle. Hence, the general objective of this study was to evaluate some elements of the reproductive cycle of *C. nigrodigitatus* in view of its domestication, and more specifically, it was to determine in this species the breeding period, sex ratio, and fecundity of this species depending on the endogenous and exogenous factors of the Nkam River.

2. Materials and Methods

2.1. Study Zone. The study was conducted from October 2015 to August 2016, in the Nkam River in Yabassi Township, District of Yabassi, Department of Nkam and Littoral Region of Cameroon (Figure 1). It is located between 9° 50′ and 10° 10′ of LN and between 4° 20′ and 4° 40 LE, with mean altitude of 15 to 20 m [17]. The climate is subequatorial with a tropical tendency of two seasons: a dry season that runs from November to March and a rainy season that runs from April to the end of October. The hottest month is January and the coldest is August. The mean annual rainfall is 2927 mm; the maximum rainfall is between July and August. Monthly temperatures range from 25°C to 35°C and are favourable for aquaculture [18]. The Nkam River results from the merger of two rivers: the "Small Nkam" (Department of Haut-Nkam) and the "Ngoung" (Department of Menoua). It flows from from Nkongsoung (Moungo Department), passing through Yabassi, into the Wouri River at Akwa North (Wouri Department) [19].

2.2. Animal Material. A total of 154 specimens of *Chrysichthys nigrodigitatus* of mean total weight of 829.96 ± 829.58 g and mean total length of 367 ± 156 mm were collected from the local fishermen of Nkam River. Sampling was done monthly and fish samples were hand-harvested using 3- and 4-finger gillnets. After the first 6 months of collection, noting that this capture technique was selective, it was replaced by "bamboo China" structures installed in the various points of the selected station, to have a wide range of the size of the individuals.

2.3. Assay Conduct and Data Collection. The collected fish were kept alive in 20-liter buckets and transported to the Laboratory for Aquaculture and Demography of Fisheries Resources (LADFR) of the Institute of Fisheries and Aquatic Sciences of Yabassi (IFAS), where they were identified according to the identification key of Stiassny et al. [20]. Each individual was then recorded and sexed with the naked eye. The total and standard lengths (tL and sL, respectively) were measured with a 1 mm ichthyometer. The total weight (tW) and the weight after evisceration (evW) were obtained using a Sartorius Competence electronic scale at the 10th of g. After dissection of each fish using the scissors of a dissection kit, the gonads (Figure 2(a)) and the liver were removed with a razor blade, drained, and weighed at 0.01 g on a sensitive electronic scale brand TATINA model 1479V (Figure 3(a)). Based on the sexual maturity scale of the ovaries of *C. nigrodigitatus* established by Otémé [21], only the ovaries of 29 females at stage V of sexual maturity were selected for the estimation of the fecundity: three samples of 1 g of ovary were collected in the rostral, middle, and caudal regions (Figure 2(b)) and weighed. One gram of ovary was put in Gilson's liquid (pure ethanol 98°C (60 ml) + water (920 ml) + acetic acid (9 ml) + mercury chloride (20 g)) to dissociate the oocytes and thus facilitate counting (Figure 3). The oocytes of each sample were counted under a stereoscopic binocular magnifying glass (magnification ×10).

2.4. Collection of Physical Parameters of Water. One station representing the fishing location was selected in the upstream part of the Nkam River. Due to a lack of chemical parameter collection equipment, only the following physical parameters were determined: the transparency, the depth, the temperature, and the rainfall were measured monthly, respectively, using a Secchi disk to within 1 cm, a gallows graduated to the nearest mm, a mercury thermometer, and a rain gauge.

2.5. Studied Parameters

2.5.1. Breeding Period. The breeding period was determined by calculating the following indices as used by Saâdia [22]:

(i) Gonadosomatic index (GSI): GSI (%) = (gW/evW) × 100, where gW = gonads weight and evW = eviscerated weight of fish

(ii) Hepatosomatic index (HSI): HSI (%) = (lW/evW) × 100, where lW = liver weight and evW = eviscerated weight of fish

(iii) K factor has been calculated using the formula of Ricker [23]: $K = (tW/tL^3) \times 100$, where tW and tL are, respectively, the total weight and the total length of the fish

2.5.2. Sex Ratio (S/R). The sex ratio according to Ragheb [8] is translated by the following relation: S/R = number of males/number of females.

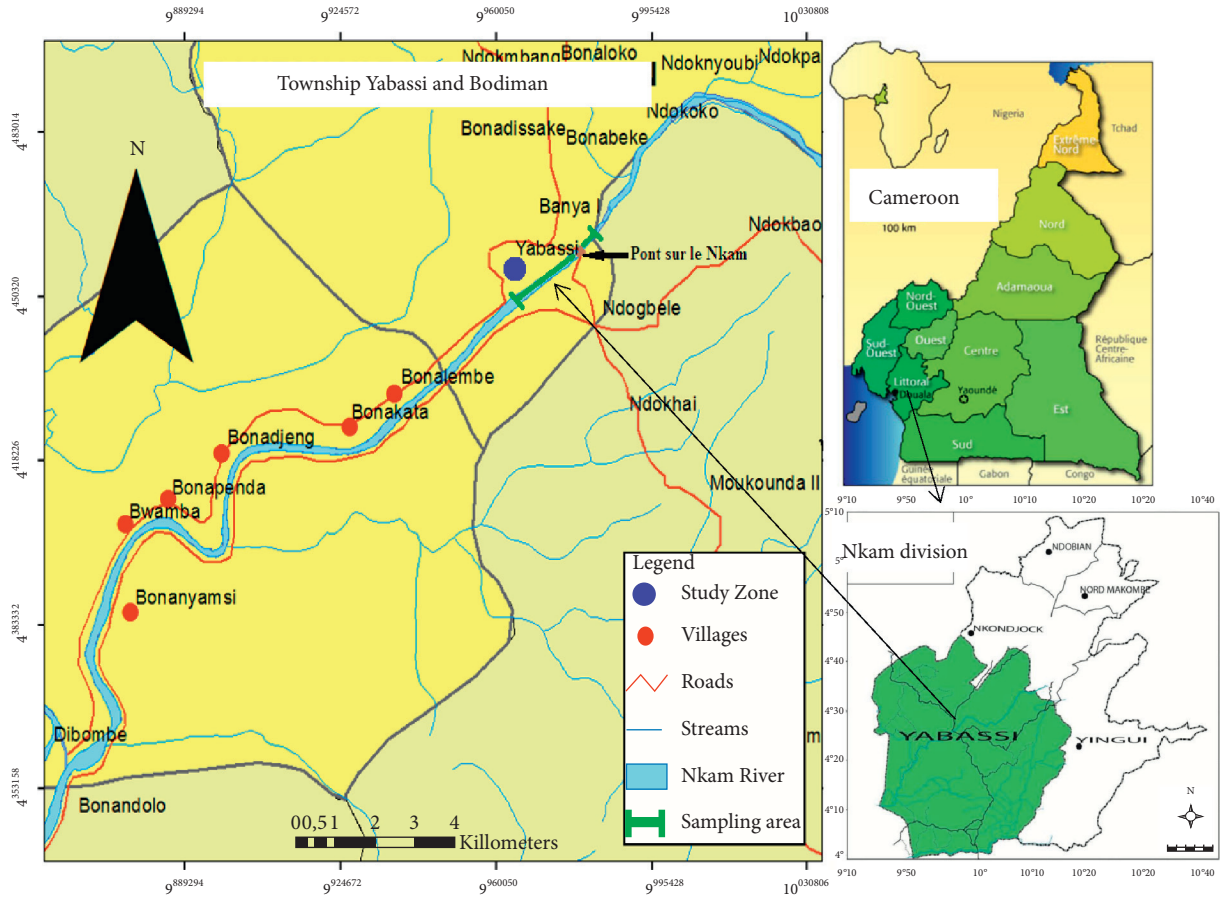
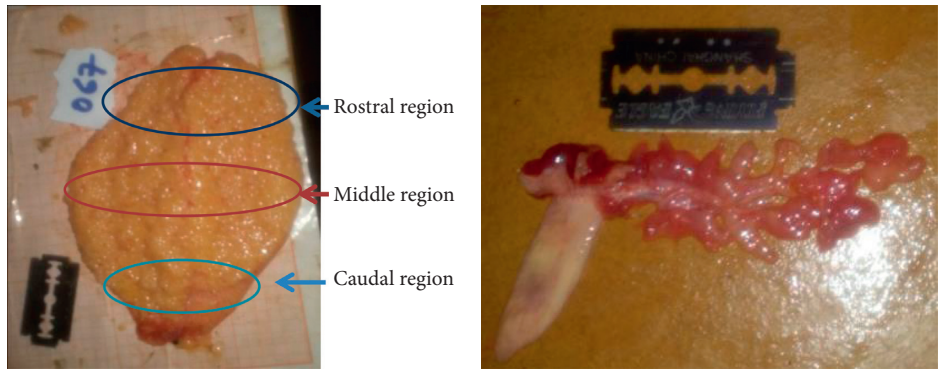


Figure 1: Geographical location of Yabassi. (a) Cameroon, (b) Nkam Department, and (c) Yabassi District (source: adapted from [19]).



(a) (b)

Figure 2: (a) Ovaries of *C. nigrodigitatus*, (b) testes of *C. nigrodigitatus*.

2.5.3. Fecundity. Fecundity was evaluated according to Ragheb [8]:

(i) Absolute fecundity (aF) was determined on a sample of 29 females at stage V of sexual maturity. It is defined by the formula: af = total weight of oocytes × number of oocytes in 1 g of ovary

(ii) Relative fecundity (rF) was calculated from the aF. It is translated by: rF = total number of oocytes/weight of the female (Kg)

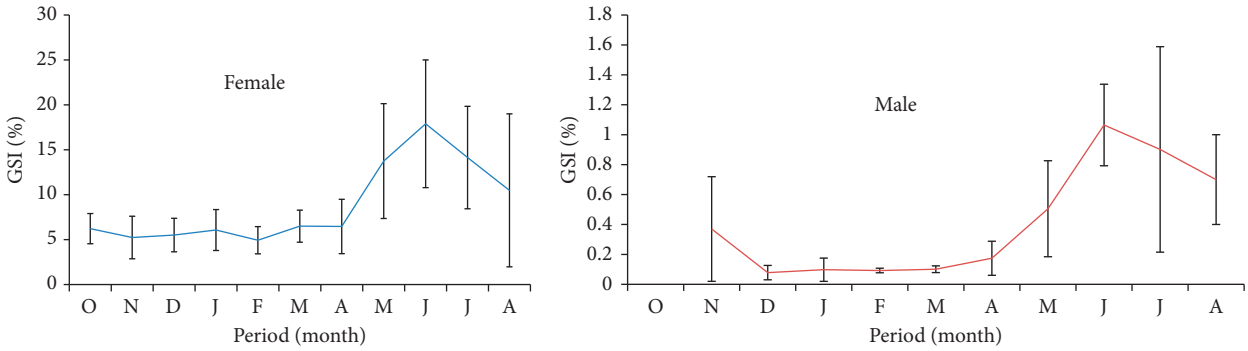
2.6. Statistical Analysis. Descriptive statistics, the $\chi 2$ comparison test, the Pearson correlation test, and the one-way ANOVA test were used to process the data for the parameters studied at 5% level of probability. This was done using the SPSS16.0 statistical software.

3. Results

3.1. Monthly Evolution of Gonadosomatic Index. Figure 4 shows the monthly evolution of the gonadosomatic index

(a) (b)

Figure 3: (a) Electronic scale, (b) oocyte counting device.



(a) (b)

Figure 4: Monthly evolution of GSI by sex of *C. nigrodigitatus* between October 2015 and August 2016 in the Nkam River: (a) female, (b) male.

(GSI) in *C. nigrodigitatus* by sex. It seems that regardless of the sex considered, the GSI has evolved in the same way with values significantly ($P < 0.05$) high from April, and the peak is observed in June.

3.2. Monthly Evolution of the Hepatosomatic Index. Figure 5 portrays the monthly evolution of the hepatosomatic index (HSI) in *C. nigrodigitatus* by sex. In females, three (3) increasing peaks were successively observed: November (1.05 ± 0.21), March (1.24 ± 0.49), and June (1.78 ± 0.56), while in males two (2) decreasing peaks were observed in November (1.41 ± 0.33) and in April (1.01 ± 0.27). The minimum values of HSI were reached in December (0.84 ± 0.32) and in February (0.88 ± 0.15) in females and in March (0.64 ± 0.15) and May (0.48 ± 0.20) in males. In females, the maximum HSI registration period coincided with that of the IGS (June).

3.3. Monthly Evolution of Condition Factor K. Figure 6 illustrates the monthly variation of condition factor K in *C. nigrodigitatus* by sex in the Nkam River. It shows that the mean K factor of *C. nigrodigitatus* recorded between October 2015 and August 2016 in the Nkam River was $1.09 \pm 0.07\%$. Except for the month of December, there was no significant difference between the sexes and the months ($P > 0.05$). However, between May and July, the K factor remained slightly below 1 (0.97 ± 0.01) in females.

3.4. Correlation between Reproduction and Physical Parameters. Correlations between reproduction parameters (GSI, his, and condition factor K) and environmental parameters as presented in Table 1 and Figure 7 revealed a positive and significant correlation between rainfall and gonadosomatic index ($r = 0.74$, $P < 0.01$) on the one hand and a negative and significant correlation between this same parameter and the condition factor K ($r = -0.73$, $P < 0.05$) on the other hand. Negative but insignificant correlations were observed between GSI, transparency, and temperature. Only the precipitation correlated positively with HSI, but not significantly ($P > 0.05$).

3.5. Monthly Variation of Sex Ratio. The monthly variation of sex ratio in *C. nigrodigitatus* (Table 2) indicates that the mean sex ratio during the study was in favour of females (1 : 1.5). This sex ratio value was statistically not significantly ($P < 0.05$) different from the theoretical sex ratio (1 : 1). Sex ratio in favour of males was observed only in June. The standard sex ratio (1 : 1) was recorded only in May and December. However, except for November, a sex ratio (1 : 4) significantly ($P < 0.05$) different from the theoretical sex ratio (1: 1) was recorded.

3.6. Fecundity. The absolute fecundity was 1374 ± 1022 oocytes for females with a mean weight of 107.3 ± 111.9 g and a mean total length of 211 ± 52.8 mm and the relative fecundity of 14 ± 3 oocytes/kg for females.

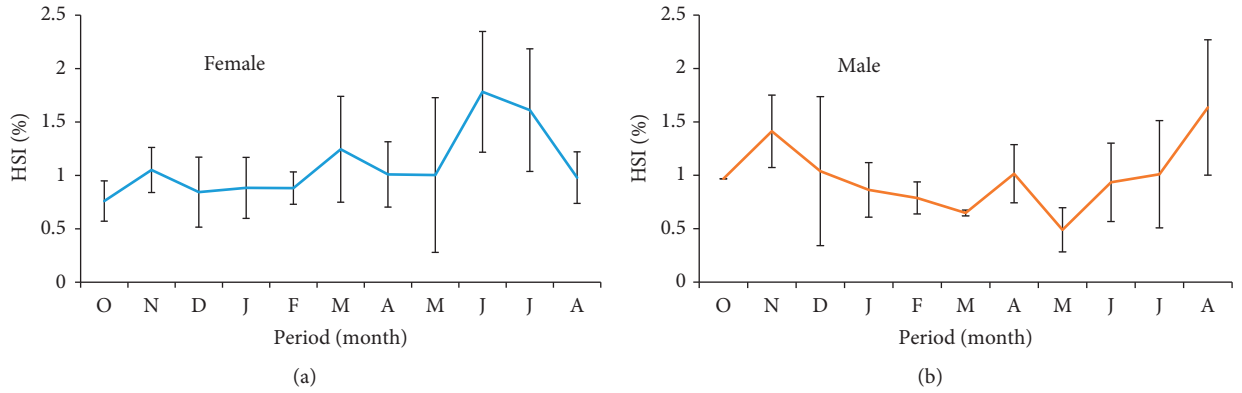


Figure 5: Monthly evolution of HSI by sex of *C. nigrodigitatus* between October 2015 and August 2016 in the Nkam River.

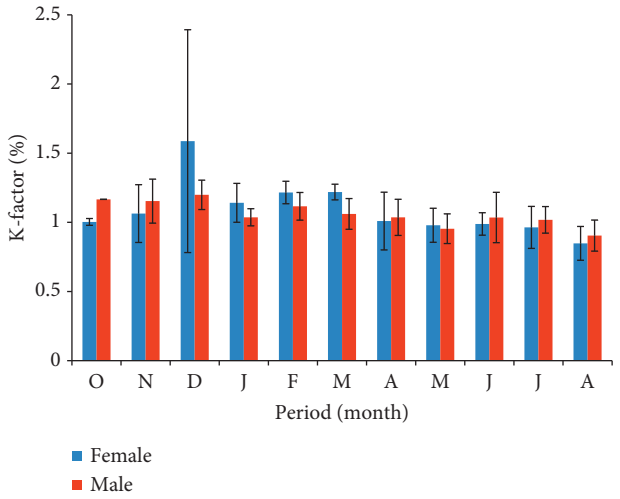


Figure 6: Monthly variation of K factor by sex of *C. nigrodigitatus* between October 2015 and August 2016 in the Nkam River.

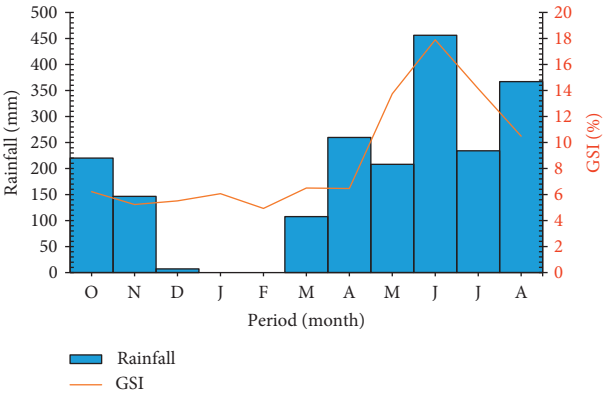


Figure 7: Correlation between the gonadosomatic index of *C. nigrodigitatus* and rainfall in the Nkam River.

Table 1: Correlation between reproduction parameters of *C. nigrodigitatus* and physical parameters of the environment in the Nkam River.

Reproductive parameters	Physical parameters of the environment			
	Depth	Transparency	Temperature	Rainfall
Gonadosomatic index	0.18	−0.53	−0.59	0.74**
Hepatosomatic index	−0.01	−0.41	−0.29	0.57
K condition factor	−0.39	0.59	0.54	−0.73*

*Significantly ($P < 0.05$) correlated, **significantly ($P < 0.01$) correlated.

Figure 8 shows the relationship between absolute fecundity and total weight and between this same parameter and the total length of *C. nigrodigitatus* females. It shows that a very strong and significantly positive correlation exists between absolute fecundity and total weight on the one hand ($r = 0.97$, $P < 0.01$) (Figure 8(a)) and between this same parameter and the total length ($r = 0.98$, $P < 0.01$) on the other hand (Figure 8(b)).

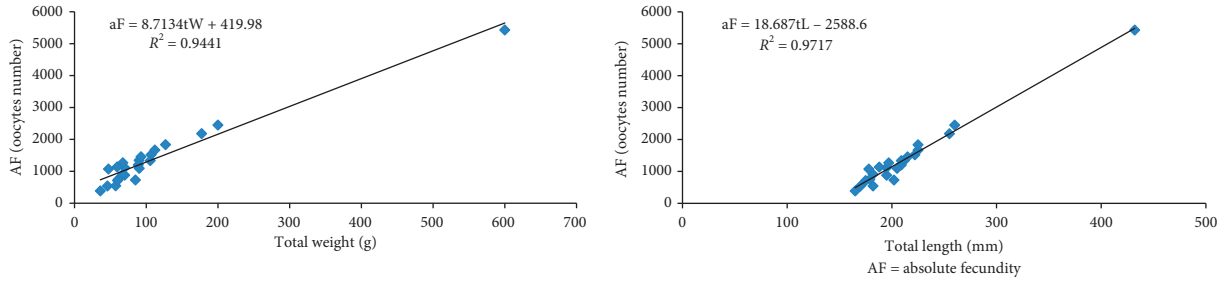
Table 2: Monthly variation of sex ratio in *C. nigrodigitatus* between October 2015 and August 2016 in the Nkam River.

Month	Number		Sex ratio
	Male (*N*)	Female (*N*)	M : F
October	1	2	1 : 2
November	3	12	1 : 4*
December	3	3	1 : 1
January	4	9	1 : 2.3
February	6	8	1 : 1.3
March	2	4	1 : 2
April	9	12	1 : 1.3
May	12	14	1 : 1.2
June	8	6	1 : 0.8
July	8	13	1 : 1.6
August	6	9	1 : 1.5
Total	**62**	**92**	**1 : 1.5**

N = number, M: F = male: female, *significantly ($P < 0.05$) different from the theoretical sex ratio 1 = : 1.

4. Discussion

4.1. Breeding Period. The breeding season of *C. nigrodigitatus* coincides with the continuous rainy season, which lasts approximately six months and is characterized by a single spawning season in June as reported elsewhere [11, 12, 24, 25].



(a) (b)

Figure 8: Relationship between absolute fecundity and total weight (a) and the total length (b) in *C. nigrodigitatus* females in the Nkam River.

The reproduction of *C. nigrodigitatus* is of the asynchronous type as reported elsewhere [11, 12], thus making this species a partial or heterochronous breeder, or fish with multiple spawning or split-spawning. The peak breeding period observed between April and June is similar to that recorded by Ekamen [26] and Offem et al. [27] in the Cross River in Nigeria in the same species and by Dia [28] and Dossou [7], respectively, in Ivory Coast and in Benin. These results, however, are different from those obtained by Otémé [29] and Djéhi [16], who under breeding conditions observed maximum laying in September and October; and those reported by Ragheb [8] which show that the spawning season of *C. auratus* extends from October to June. According to Dia [28], laying occurred between May and July and lasted until November when temperatures had varied between 25°C and 27°C. Hem [30] and Albaret [31] also observed *C. nigrodigitatus* spawning during the rainy season, adding that temperature is a major factor in this phenomenon, associated with salinity and floods. The geographical position, the duration of the rainy season, and the specific characteristics of the water courses may vary the extent and the period of reproduction in *C. nigrodigitatus* as recorded by Ottémé [29]. A positive correlation has been recorded between the gonadosomatic and the hepatosomatic indices, whereas logically these two weight indices vary in opposite directions. Indeed, the fish would draw the reserves of the liver (in particular, the vitellogenin in the females) to manufacture the sexual products as discussed elsewhere [11, 12, 32]. It should probably be due to the fact that some females emit their eggs in a split way; and the partially emptied ovaries do not return to complete rest but continue the vitellogenesis of oocytes that will be emitted later. These results are similar to those of Bouaziz et al. [33] in the Merlu, *Merluccius rnerluccíu* Linnaeus, 1758.

The K condition factor of *C. nigrodigitatus* obtained in this study was higher compared to that obtained by Ezenwa et al. [34] and Dossou [7], respectively, recorded in the Imo River in Nigeria (0.78) and small water body of the Ouémé basin in Benin (0.64), showing that the samples of the Nkam River were of good overweight. These results are close to 0.96, 0.97, and 0.99, respectively, reported in the Bandagry Lagoon in Nigeria by Ezenwa et al. [34] and the river cross in Nigeria by Ekamen [26] and Offem et al. [27] in the same species. As a result, the Nkam River may have very favourable natural conditions for the development of *C. nigrodigitatus*. However, the slight drop in K-factor values (0.94 ± 0.06) noted between May and August may be related to female oviposition weight loss. Indeed, according to Kraïem [35], the fall in values of the relative condition coefficient ($Kr < 1$) indicates the postspawning period qualified by energy expenditure and weight loss.

4.2. Sex Ratio. The sex ratio of 1M: 1.5F observed in this study is statistically close to the theoretical sex ratio (1 : 1). However, it is biologically in favour of females, thus giving this species a reproductive strategy of "*r*" type, thus a polygamous matrimonial regime. These results are similar to the observations made on *C. auratus* (1M: 2F) and on *C. nigrodigitauts* (1M: 4F) by Imerbore and Bakare [36] and on *C. auratus* (1M: 1.18F) by Ragheb [23] in Damietta branch of the River Nile in Egypt. These observations are contrary to those reported in Lake Asejire by Taiwo and Aransiola [37] and Dossou [7] in *C. auratus* (1M: 0.96F) and *C. nigrodigitatus* (1M: 0.93F), respectively. In addition to the spatial and temporal difference, the sex ratio diversification could also be due to the fishing techniques practiced: Indeed, during this study, between May and August, fishermen have replaced the usual gill nets with bamboo from China placed about 3 m on the banks. This fishing gear allows the capture of *C. nigrodigitatus* by couple (sex ratio of 1M: 1F). Dossou [7] also reported the use of this technique in Benin. However, the sex ratio obtained during the breeding season is close to the theoretical sex ratio (1: 1) just like that observed elsewhere [7, 21, 27]. Thus, it seems that the natural approximation of males and females is in relation with the reproduction period.

4.3. Fecundity. The absolute fecundity recorded in this study is very low compared to the 24000 oocytes observed in Kousson on Bandama in Ivoiry Coast by Kouassi [38]. It is also lower than that of 4878 to 87724 oocytes recorded by Otemé [21] in Ebrié Lagoon in individuals weighing from 500 g to 6000 g with an average of 20000 oocytes. However, it is close to 7596 oocytes reported in the South Benin Lagoon Complex by Lalèyè et al. [39]. In the Cross River in Nigeria, Ekamen [26] and Offem et al. [27], respectively, reported a fecundity of 12063 and 25905 oocytes. More recently, in the small water plans of the Ouémé basin in Benin, Dossou [7]

recorded fecundity from 3474 to 28778 with an average of 10783 oocytes in individuals weighing 557.3 g to 2270.1 g. However, these results are nevertheless comparable to those of Fagade and Adébisi [40], which counted 2884 oocytes in Lac Asejire populations. In addition to the fact that fecundity varies from one region to another and from one watercourse to another, it would certainly be linked to environmental factors. It could be strongly related to the weight and length of individuals. According to Otémé [29], the length of *C. nigrodigitatus* allows a better estimate of its fecundity. Offem et al. [27] added that this fecundity increases with the length and weight of *C. nigrodigitauts*.

Unlike absolute fecundity, relative fecundity varies very little from one region to another. The absolute fecundity obtained in this study is comparable to that reported by other authors elsewhere: Dossou [7] reported 15 ± 6 oocytes/g, Otémé [29] 15 oocytes/g, Ekamen [26] 13 oocytes/g, Offem et al. [27] 13 oocytes/g, and Hem [30] 14 oocytes/g in the same species. However, the slight spatial and seasonal variations in the fecundity of *C. nigrodigitatus* are not to be neglected. According to Offem et al. [27], this could be related to the availability of the food. Gorenka et al. [41] add the duration of the spawning season and accumulated reserves. According to Offem et al. [27], an overweight fish is more likely to produce large numbers of oocytes compared to one with poor conditions.

5. Conclusion

C. nigrodigitatus breeds between April and October in the middle of the rainy season. Reproduction in *C. nigrodigitatus* is of the multiple-spike asynchronous type. Gonadosomatic index (GSI) is higher in females throughout the year, and the peak is observed in June in both sexes. The hepatosomatic index (HSI) was higher in females than in males throughout the year. It correlated positively with GSI in females during spawning. Condition factor K was ˃1 indicating that the Nkam River is a favourable environment for the good development of *C. nigrodigitatus*. Condition factor K correlated negatively with the increase in GSI during the reproduction period of *C. nigrodigitatus*. The gonadosomatic and hepatosomatic indices were positively correlated with precipitation, in contrast to the K factor, which was strongly and negatively correlated with this physical parameter of the environment.

The sex ratio was in favour of females for most of the year and is close to the theoretical sex ratio in December, May, and June, reflecting an "*r*" type reproductive strategy.

Absolute and relative fecundity increases with weight and length of *C. nigrodigitatus*, but these parameters seem to be directly influenced by certain environmental factors (food, temperature, salinity, etc.).

In view of these results, *C. nigrodigitatus* is a potential candidate for aquaculture in Cameroon.

Data Availability

All raw and analyzed data of this work are available from the corresponding author (claudine.tiogue@univ-dschang.org/ Claudinetekou@gmail.com) upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] FAO, *La situation mondiale des pêches et de l'aquaculture*, vol. 255, FAO, Rome, Italy.

[2] FAO, *La situation mondiale des pêches et de l'aquaculture 2016. Contribuer à la sécurité alimentaire et à la nutrition de tous*, vol. 224, FAO, Rome, Italy, 2016.

[3] P. Cacot, "Contribution à l'amélioration de la production d'alevins au Cameroun: essais de reproduction et d'élevage de nurserie avec *Clarias gariepinus* et deux autres espèces," *Compte rendu de mission du projet ATP-CIROP. CIRAD*, vol. 64, 2006.

[4] E. Montchowui, P. Lalèyè, P. Poncin, and J.-C. Philippart, "Reproductive strategy of Labeo senegalensis valenciennes 1842 (Teleostei: Cyprinidae) in the Ouémé basin, Benin," *African Journal of Aquatic Science*, vol. 35, no. 1, pp. 81–85, 2010.

[5] E. Montchowui, M. Ovidio, P. Laleye, C. J. Philippart, and P. Poncin, "Stratégies de reproduction et structure des populations chez *Labeo parvus* Boulenger, 1902 (Cypriniformes: Cyprinidae) dans le bassin du fleuve Ouémé au Benin," *Annales des Sciences Agronomiques*, vol. 15, no. 2, pp. 153–171, 2011.

[6] E. Montchowui, P. Laleye, J. C. Philippart, and P. Poncin, "Reproductive behaviour in captive African carp, Labeo parvus boulenger, 1902 (Pisces: Cyprinidae)," *Journal of Fisheries International*, vol. 6, no. 1, pp. 6–12, 2011.

[7] S. D. H. Dossou, ""Exploitation et biologie comparée de deux espèces de *Chrysichthys* (Poissons, Siluriformes) dans les petits plans d'eaux du bassin de l'Ouémé: cas du village de Késsounou, commune de Dangbo, Bénin," Diplôme d'Etude Approfondie. Faculté des Sciences Agronomique," *Université d'Abomey-Calavi*, vol. 49, 2011.

[8] E. Ragheb, "Reproductive biology of catfish Chrysichthys auratus, Geoffroy Saint-Hilaire, 1809, (Family: bagridae) from Damietta branch of the river Nile, Egypt," *The Egyptian Journal of Aquatic Research*, vol. 42, no. 3, pp. 349–356, 2016.

[9] U. Ikpi and B. I. Okey, "Estimation of dietary composition and fecundity of African carp, *Labeo coubie*, cross river, Nigeria," *Journal of Applied Sciences and Environmental Management*, vol. 14, no. 4, pp. 19–24, 2011.

[10] C. T. Tiogué, M. T. E. Tomedi, D. Nguenga, and J. Tchoumboué, "Caractéristiques de morphologie générale et de croissance du Cyprinidae Africain *Labeobarbus batesii* dans la plaine inondable des Mbô, Cameroun," *International Journal of Biological Sciences*, vol. 4, no. 6, pp. 1988–2000, 2011.

[11] T. C. Tiogué, "Régime alimentaire, caractéristiques de croissance et de reproduction de Labeobarbus batesii, Boulenger, 1903 (Teleostei: Cyprinidae) en milieu naturel dans la plaine inondable des Mbô au Cameroun," Université de Dschang, Dschang, Cameroun, Thèse de Doctorat Ph/D, Faculté d'Agronomie et des Sciences Agricoles Université de Dschang, Dschang, Cameroun, 2012.

[12] C. T. Tiogué, M. T. E. Tomedi, and J. Tchoumboué, "Reproductive strategy of *Labeobarbus batesii* (boulenger, 1903) (Teleostei: Cyprinidae) in the Mbô Floodplain rivers of Cameroon," *International Journal of Zoology*, vol. 2013, Article ID 452329, 8 pages, 2013.

[13] M. T. E. Tomedi, C. T. Tiogué, T. E. Efolé, M. Kenfack, and J. Tchoumboué, "Population structure, condition factor, length - weight and length - age relationships of *Labeobarbus batesii* (boulenger, 1903) in Mbô flood plain in western region of Cameroon," *International Journal of Aquaculture*, vol. 4, no. 19, pp. 113–117, 2014.

[14] P. Zango, M. T. E. Tomedi, T. E. Efole et al., "Performances de reproduction du Poisson chat endogène du Cameroun *Clarias jaensis* (Boulenger, 1909) en milieu contrôlé," *International Journal of Biological and Chemical Sciences*, vol. 10, no. 2, p. 533, 2016.

[15] N. G. Ajonina and M. E. Tomedi, "Aquaforests and aquaforestry: Africa," in *Encyclopedia of Natural Resources: Land*, pp. 16–38, Taylor & Francis, New York, NY, USA, 2014.

[16] B. Y. Djéhi, "Contribution à l'étude des effets de l'âge sur les performances de reproduction du mâchoiron (*Chrysichthys nigrodigitatus*) élevé à la station expérimentale d'aquaculture de Layo en Côte d'Ivoire," Thèse de Doctorat, Dakar, Senegal, p. 72, 2008.

[17] MINEPAT, *Rapport trimestriel d'activité. Délégation Provinciale/MINEPAT*, vol. 69, MINEPAT, Yabassi, Cameroun, 2010.

[18] MINADER, *Rapport trimestriel d'activité. Délégation provinciale/MINADER*, vol. 66, MINADER, Yabassi, Cameroun, 2010.

[19] INC, *Carte du littoral dans le Cameroun, carte de Yabassi dans le Nkam au 1/50000*, Institut National de Cartographie, Yabassi, Cameroon, 2010.

[20] M. L. J. Stiassny, G. G. Teugels, and D. C. Hopkins, "The Fresh and brackish water fishes of lower Guinea, West-Central Africa," in *Faune et Flore Tropicales*, vol. 2, p. 805, Tervureen, MRAC, Paris, France, 2007.

[21] Z. J. Otémé, "Reproduction et fécondité du mâchoiron *Chrysichthys nigrodigitatus* en élevage," *Journal Ivoire Océanologie Limnologie Abidjan*, vol. 2, no. 1, pp. 53–59, 1993.

[22] B. Saâdia, "Bio-Ecologie de *Barbus callensis* (Valencienne 1842) & *Barbus fritschi* (Günther 1874)," Doctorat National Es-ciences. Universite Sidi Mohamed Ben Abdallah, p. 168, Fes, Morocco, 2002.

[23] E. W. Ricker, "Computation and interpretation of biological statistics of fish Populations," *Bulletin of Fisheries Research Board of Canada*, vol. 191, pp. 1–382, 1975.

[24] L. V. De Vlaming, "Oocytes development patterns and hormonal involvements among Teleosts," in *Control Process in Fish Physiology*, J. C. Ranchin, T. J. Petcher, and R. Duggan, Eds., vol. 176–199, Croom Helm, London, UK, 1983.

[25] J. Nuñez-Rodriguez, Z. Otémé, and S. Hem, "Comparative study of vitellogenesis of two African catfish species *Chrysichthys nigrodigitatus* (Claroteidae) and *Heterobranchus longifilis* (Clariidae)," *Aquatic Living Resources*, vol. 8, no. 4, pp. 291–296, 1995.

[26] B. S. Ekanem, "Some reproductive aspects of *Chrysichthys nigrodigitatus* (Lacepede) from cross river Nigeria," *Naga, ICLARM*, vol. 2, no. 2, 2000.

[27] O. B. Offem, Y. S. Akegbejo, and T. I. Omoniyi, "Diet, size and reproductive biology of the silver catfish, *Chrysichthys nigrodigitatus* (Siluriformes; Bagridae) in the cross river, Nigeria," *Review Biology in Tropics*, vol. 56, no. 4, pp. 1785–1799, 2008.

[28] K. A. Dia, *Détermination de l'âge des Mâchoiron Chrysichthys nigrodigitatus: Premières Estimations de la Croissance*, Document Scientifique Centre de Recherches Océanologiques, vol. 6, no. 2, , pp. 139–151, Abidjan, Côte d'Ivoire, 1975.

[29] J. Z. Otémé, "Cycle sexuel et fécondité du mâchoiron *Chrysichthys nigrodigitatus* en lagune Ebrié (Côte d'Ivoire)," *Journal Ivoire Océanologie Limnologie Abidjan*, vol. 2, no. 1, pp. 61–67, 1993.

[30] S. Hem, "Premiers résultats sur la reproduction contrôlée de *Chrysichthys nigrodigitatus* en milieu d'élevage," in *Aquaculture Research in the African Region. Proc. African Seminar on Aquaculture*, E. A. Huisman, Ed., pp. 189–205, PUDOC, Wageningen, Netherlands, 1986.

[31] J. J. Albaret, "Les Poissons: biologic et peuplement," in *Environnement et ressources aquatiques de Cote d'Ivoire," Tome II. Les milieux lagunaires*, J. R. Durand, P. Dufour, D. Guiral, and S. G. F. Zabi, Eds., pp. 239–279, Editions de l'ORSTOM, Paris, France, 1994.

[32] R. Fehri-Bedoui, H. Gharbi, and A. EL Abed, "Période de reproduction et maturité sexuelle de *Liza aurata* des côtes Est et Sud de la Tunisie," *Bulletin Institutionnel Natl Science Technique Mer Salamm-Bô*, vol. 29, pp. 11–15, 2002.

[33] A. Bouaziz, A. Bennoui, F. Djabali, and C. Maurin, "Reproduction du merlu *Merluccius merluccius* (Linnaeus, 1758) dans la région de Bou-lsmaıl," *CIHEAM-Options Méditerranéennes*, vol. 35, pp. 109–117, 1998.

[34] L. B. Ezenwa, L. Ikusemiju, and O. I. C. Olaniyan, "Comparative studies of the Catfish, *Chrysichthys nigrodigitatus* (Lacepede) in three isolated geographical areas in Nigeria for breeding purposes," in *Aquacult. Res. In the African Region*, E. A. Huisman, Ed., Wageningen Academic Publishers, Wageningen, Gelderland, The Netherlands, 1986.

[35] M. M. Kraïem, "Systématique, biogeographie et bio-écologie de Barbus callensis Valenciennes, 1842 (poisson, Cyprinidés) de Tunisie," Thèese de doctorat, p. 227, University of Tunis, Tunis, Tunisie, 1994.

[36] A. M. A. Imevbore and O. Bakare, "The food and feeding habits of non-cichlid fishes of the River Niger in the Kainji reservoir area," in *Kainji: a Nigerian man-made lake. Kainji Lake studies*, S. A. Visser, Ed., vol. 1. Ecology, pp. 49–64, Nigerian Institute of Social and Economic, Research, Ibadan, Nigeria, 1970.

[37] O. I. Taiwo and M. O. Aransiola, "Length–weight relationship, condition factors and fecundity of *Chrysichthys nigrodigitatus* and *Chrysichthys walker* in Asejire Lake," in *Proceedings of the 3rd Annual Conference of the Fisheries Society of Nigeria (FISON)*, p. 227, Lagos, Nigeria, 2001.

[38] J. N. Kouassi, "Notes sur la biologie de *Chrysichthys nigrodigitatus* et de *Chrysichthys velifer*. Développement de la pêche du lac de Kossou," Projet PNUD/FAO," *IVC*, vol. 526, no. 8, 1973.

[39] A. P. Lalèyè, C. J. Philippart, and P. Poncin, "Biologie de la reproduction de deux espèces de *Chrysichthys* (Siluriformes ; Bagridae) au lac Nokoué et à la lagune de Porto-Novo au Bénin," *Journal Africain de Zoologie*, vol. 109, no. 3, pp. 213–224, 1995.

[40] O. S. Fagade and A. A. Adebisi, "On the fecundity of *Chrysichthys nigrodigitatus* (Lacepede) of Asedjire dam, Oyo state Nigeria," *Nigerian Journal of Science*, vol. 1, pp. 127–131, 1979.

[41] S. Gorenka, K. C. Vanja, and Z. Barbara, "Population structure, size at maturity and condition of sardine, *Sardina pilchardus* (Walb, 1792), in the nursery ground of the eastern Adriatic sea (Krka river Estuary, Crotia) Estuarine," *Coastal and Shelf Sciences*, vol. 76, pp. 739–744, 2008.