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Reproductive biology of *Synodontis membranaceus* in the Bagoué River (Ivory Coast)

Ms. Kassoum Kouyaté*[1], Touplé Sibiri Koné[2], Zéré Marius Gogbe[3], Valentin N'douba[4]

[1]*Faculty of Sciences and Technologies, Alassane Ouattara University of Bouaké, Ivory Coast*

[2]*Animal Biology and Cytology Laboratories, Faculty of Natural Sciences, Nangui Abrogoua University, Abidjan, Ivory Coast*

[3]*Department of Animal Biology, Faculty of Biological Sciences, Peleforo Gon Coulibaly University, Korhogo, Ivory Coast*

[4]*Laboratory of Natural Environments and Biodiversity Conservation, Department of Biosciences, Félix Houphouët University, Ivory Coast*

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ABSTRACT

This study aims to describe the reproductive parameters of *Synodontis membranaceus* in the Bagoué River basin. Sampling campaigns were carried out every two months from August 2018 to February 2020. The *Synodontis membranaceus* individuals used for the reproduction study were obtained from experimental and commercial fishing. The size at first sexual maturity (L50) for females and males is 110.49 mm and 93.65 mm (standard length), respectively. The average gonadosomatic index (GSI) of *Synodontis membranaceus* females shows two periods: the first from October 2018 to April 2019 and the second from April 2019 to October 2019, with high GSI values (0.14% and 0.39%). In addition, the percentage of mature females during this period is greater than 50%. The gonads therefore reach maturity between February and August. The spawning period takes place from August to February. The estimated absolute fertility of *Synodontis membranaceus* ranges from 2,451 to 15,411 oocytes with an average of 7,157 ± 3,810, and relative fertility is 121 oocytes to 2,342 oocytes per gram of body weight. The average relative fertility is 574 ± 472 oocytes per gram of body weight. In conclusion, the study of reproduction reveals that males reach sexual maturity before females.

***Corresponding author:** Ms. Kassoum Kouyaté ✉ kouyate77kassoum@gmail.com

INTRODUCTION

The high demand for fish protein has led Ivorians to turn to fishing and attracted many foreigners to this sector (Boghué, 2015). This situation has led to an intensification of inland fishing, a sharp decline in stocks, and even their depletion (Vanga, 2004). In addition, the risk of stock collapse is greater when fishing targets young fish that have not yet reached sexual maturity (Myers and Worm, 2005). Given the danger posed by overfishing, it is necessary to monitor the species being exploited. Furthermore, knowledge of the reproductive biology of a fish population is essential for better management of fishery resources. Parameters such as first maturity size, fecundity, and variation in gonadosomatic and hepatosomatic indices better characterize reproduction by indicating the reproductive period, stage of sexual maturation, and spawning strategy (Heins *et al.*, 2004; Stiassny *et al.*, 2011). Furthermore, the protection of fishery resources and their rational use can be planned if habitats and reproductive strategies are known (Dadebo *et al.*, 2003). Unfortunately, there is virtually no data available on the reproductive biology of *Synodontis membranaceus* in the Bagoué River. However, *Synodontis membranaceus*, which is found in this river, is highly prized by consumers and also has a high market value.

Given the current state of knowledge and the interest of the local population in *Synodontis membranaceus*, it is essential to initiate investigations into its reproductive biology. These investigations will provide insight into the various factors that influence the reproduction of *Synodontis membranaceus*, thereby enabling rational management of its stock in the Bagoué River basin. The overall objective of this study is to describe the reproductive strategy of *Synodontis membranaceus* in the Bagoué River in Ivory Coast.

MATERIALS AND METHODS

Study environment and sampling

The Bagoué River, located in northern Côte d'Ivoire between longitudes 5°40' and 7°10' West and latitudes 9°15' and 10°50' North (Adja *et al.,* 2009), originates in the Department of Madinani in Odiénné and flows into Mali (N'da, 2015). It has a catchment area of 10,150 km² (Adja *et al.*, 2009) and flows for a distance of 530 km, 230 km of which are in Ivory Coast (Sanogo *et al.*, 2015). It is subject to a dry tropical transition climate characterized by two seasons: a dry season and a rainy season (Savané and Konaré, 2010). The dry season lasts from mid-November to the end of April, with January and February being very dry. It is often accompanied by hot winds during the day and cool evenings, with significant temperature differences. The rainy season lasts from May to mid-November (Savané and Konaré, 2010). Five sites (Fig. 1) were selected on the river, taking into account their accessibility, environmental characteristics, and, above all, the availability of fishermen and fishing activity.

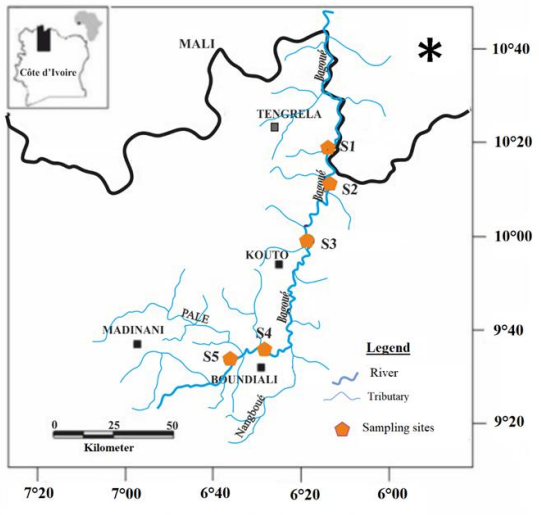

Fig. 1. Bagoué River basin (Ivory Coast) and sampling sites

Data collection

The biological material used in this study consists of specimens of *Synodontis membranaceus* (Geoffroy Saint-Hilaire, 1809) collected from the Bagoué River between August 2018 and February 2020. Gillnets, longlines, and baited artisanal traps were used for experimental and commercial fishing. The identification of the sampled *S. membranaceus* specimens was done using the identification keys of Paugy *et al.* (2003). Gonads were collected using a dissection kit.

A digital jewelry scale KL-50 electronic scale with an accuracy of 0.001 g and a capacity of 50 g was used to weigh the gonads. Five percent formaldehyde and ethanol at different concentrations were used to fix the samples and dehydrate the preparations, respectively. The inclusions were made using a mold and liquid paraffin, while the sections were made using a microtome. The dyes used were hematoxylin and eosin. The sections were viewed using an OLYMPUS CX21 photonic microscope. Sampling campaigns were carried out every two months from August 2018 to February 2020. The campaigns lasted 15 days, with three days spent at each site. For the study of *Synodontis membranaceus* reproduction, fish from experimental and commercial fishing were used. Experimental fishing consisted of setting the nets at 5 p.m. and lifting them the next day at 7 a.m. for night fishing, then setting them again, checking them, and lifting them at noon for daytime fishing. Measurements were taken to the nearest millimeter using a graduated ichthyometer. Weighing was done to the nearest gram using a 0.1g precision scale for fish, and to the nearest milligram for gonads. Sex and stages of sexual maturity were determined and described based on the macroscopic scale used by N'goran (1995) in *Synodontis koensis*. Histological sections were prepared using the classical histology method (Martoja and Martoja-Pierson, 1967; Soro and Fantodji, 2007). In the laboratory, dehydration consists of removing water from the sample. To do this, the samples are placed successively in seven alcohol baths of increasing strength (70%, 75%, 80%, 85%, 90%, 95% and 100%) for one hour each, three toluene baths of 30 mm each, and two paraffin baths at 60°C. The observations and photographs were taken using an *OLYMPUS CX21* photonic microscope connected to a camera and a computer.

Data analysis

The sex ratio (SR), size at first sexual maturity (P), gonadosomatic index (GSI), percentage of mature females (PFM), hepatosomatic index (HSI), absolute fecundity (Fa), relative fecundity (Fr), oocyte diameter (OD), and nucleoplasmic ratio (NPR) were determined using the following mathematical formulas:

$$SR = \frac{\text{Nomber of males}}{\text{Nomber of females}}$$

$$P = \frac{1}{1+e^{-(a+bLS)}} \text{ avec } \text{Standard length}_{50} = \frac{a}{b}$$

$$GSI = \frac{\text{weight of gonads}}{\text{weigth of gutted fish}} \text{x } 100$$

$$PFM = \frac{\text{Nomber of mature females}}{\text{Nomber of female}} \text{x } 100$$

$$HSI = \frac{\text{Liver weight}}{\text{gutted fish weignt}} \text{x } 100$$

$$Fa = \text{Nomber of oocytes x } \frac{\text{Gonad weight}}{\text{weignt of the fraction collected}}$$

$$Fr = \frac{\text{Absolute fertility}}{\text{eviscerated weight}}$$

$$OD = \frac{\sum_1^{\delta o} \text{Average oocyte diameter per female}}{\text{Nomber of oocytes measured per female}}$$

NPR={(Average nuclear diameter per stage of ovarian maturation)/(Average oocyte diameter per stage of ovarian maturation)} × 100

Statistical processing

Spearman's rank correlation test was used to test the correlation between the gonadosomatic index and the hepatosomatic index of females and males. The χ^2 test was used to compare the monthly sex ratio to the theoretical value (1:1) and the size at first sexual maturity of the individuals captured. These tests are significant for a probability value of less than 5%.

RESULTS AND DISCUSSION

Sex ratio and size at first sexual maturity

A total of 690 specimens of *Synodontis membranaceus* were captured in the Bagoué River basin. The number of females was 352, or 51.02%, and the number of males was 338, or 48.98%. The overall sex ratio (Table 1) calculated is 1:0.96 (female: male). The overall sex ratio is not different from the theoretical sex ratio of 1:1 (χ^2 = 0.03; $p > 0.05$). The size at first sexual maturity (L_{50}) for females and males is 110.49 mm and 93.65 mm (standard length), respectively (Fig. 2).

Gonadosomatic and hepatosomatic index

Fig. 3 shows the variation in the bimonthly gonadosomatic (GSI) and hepatosomatic (HSI) index for females. The two ratios follow the same trend. However, differences can be observed.

Table 1. Bimonthly and seasonal variations in sex ratio and sex proportion in *Synodontis membranaceus* caught in the Bagoué River between August 2018 and February 2020

Month	Nomber of females	Nomber of males	Total	Sex-ratio	χ^2	*p*-value
August 2018	33	32	65	1 : 0,96	0,03	0,87
October 2018	65	30	95	1 : 0,46	8,77*	0,01
December 2018	16	37	53	1 : 2,31	10,86*	0,01
February 2019	29	32	61	1 : 1,10	0,24	0,62
April 2019	31	36	67	1 : 1,16	0,43	0,51
June 2019	28	33	61	1 : 1,17	0,67	0,41
August 2019	36	33	69	1 : 0,91	0,11	0,74
October 2019	57	34	91	1 : 0,59	4,54*	0,03
December 2019	30	35	65	1 : 1,16	0,43	0,51
February 2020	27	36	63	1 : 1,33	1,35	0,24
Total	352	338	690	1 : 0,96	0,03	0,87
Rainy season	219	162	381	1 : 0,73	1,31	0,25
Dry season	133	176	309	1 : 1,32	1,34	0,25

*significant difference (χ^2 test at the 5% threshold)

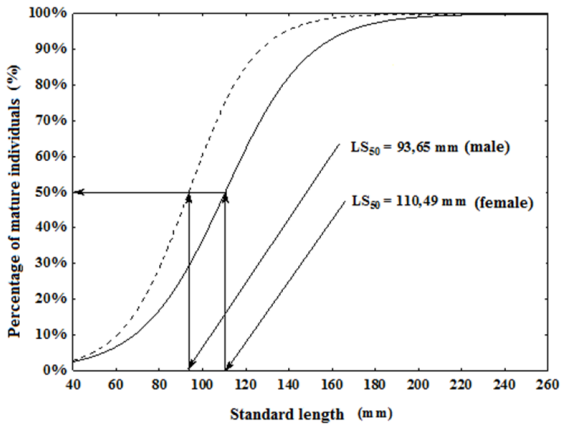

Fig 2. Size at first sexual maturity (L_{50}) in females and males of *Synodontis membranaceus* caught in the Bagoué River from August 2018 to February 2020

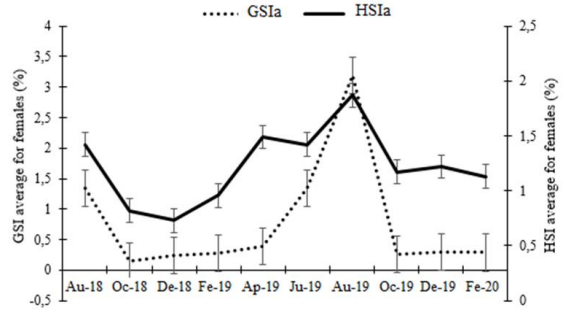

Fig 3. Bimonthly variations in mean gonadosomatic (GSI) and hepatosomatic (HSI) index of female *Synodontis membranaceus* captured in the Bagoué River between August 2018 and February 2020

Au: August; Oc: October; De: December; Fe: February; Ap: April; Ju: June.

The GSR drops sharply from August 2018 to October 2018, from 1.34% to 0.14%, then increases slightly from October 2018 to April 2019 before rising rapidly to reach its peak in August 2019 at 3.19%. The RGS then fell from August 2019 to October 2019. It remained virtually constant from October 2019 to February 2020. The RHS decreased from August 2018 (1.42%) to December 2018 (0.73%) before rising to 1.87% in August 2019. The RHS then declined to 1.13% in February 2020. There is a positive correlation between the RGS and the RHS of females (Spermann test).

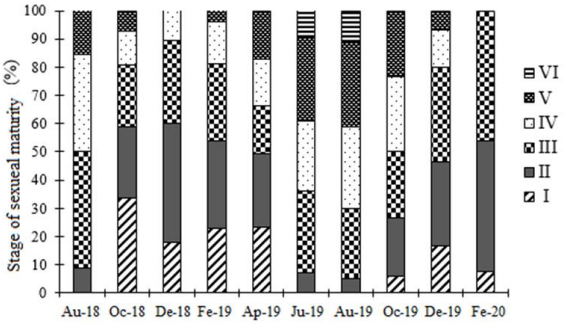

Fig 4. Bimonthly variation in sexual maturity stages in female *Synodontis membranaceus* in the Bagoué River from August 2018 to February 2020

Aug: August; Oct: October; Dec: December; Feb: February; Apr: April; Jun: June.

Reproduction period

Bimonthly variation in stages of sexual maturity

Analysis of the evolution of sexual maturity identified different stages of sexual maturity in females throughout the sampling period (Fig. 4). Females at stage I was observed throughout the study period except for August 2018, June 2019, and August 2019.

Stages II and III appeared in the catches every month. February 2020 was the only month in which individuals at stage IV were absent. Females at stage V were examined over two periods: from August 2018 to October 2018 and from February 2019 to December 2019. Female individuals at stage VI or post-oviposition were observed in catches from June 2019 to August 2019.

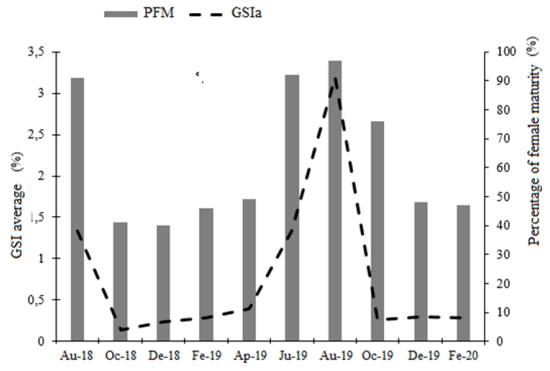

Fig 5. Bimonthly variations in the average gonadosomatic index (GSI) of females and the percentage of mature females of *Synodontis membranaceus* in the Bagoué River between August 2018 and February 2020

Aug: August; Oct: October; Dec: December; Feb: February; Apr: April; Jun: June.

Gonadosomatic index and percentage of mature females, fertility

The coupled evolution of the average gonadosomatic ratio (GSI) and the percentage of mature females (PMF) is shown in Fig. 5. The average GSI of *Synodontis membranaceus* females shows two periods: the first, from October 2018 to April 2019, is characterized by low GSI values between 0.14% and 0.39%. This period coincides with proportions of mature females below 50%. The second period extends from April 2019 to October 2019 with high GSI values.

These fluctuate between 0.39% in April 2019 and 3.19% in August 2019. The percentage of mature females during this period is high (PFM > 50%). In addition, the highest values for GSI and the percentage of mature females were observed during this period. The gonads reach maturity between February and August. The spawning period is from August to February. The estimated absolute fecundity of *Synodontis membranaceus* ranges from 2,451 to 15,411 oocytes, with an average of 7,157 ± 3,810 in females ranging from 68 mm to 224 mm in standard length. Relative fecundity is 121 to 2,342 oocytes per gram of body weight. The average relative fecundity is 574 ± 472 oocytes per gram of body weight.

Microscopic appearance of the gonads

Microscopic examination of the ovaries of *Synodontis membranaceus* reveals six stages of maturation.

Stage I or immature stage (Fig. 6 A): The ovary contains several small oocytes that are more or less polyhedral in shape. Each oocyte occupies a large part of the cell, whose homogeneous cytoplasm is stained purple. The clearly visible nuclear envelope separates the nucleoplasm from the cytoplasm. The size of the oocytes varies between 19.15 µm and 100 µm, with an average of 54.31 ± 18.11 µm. The average nucleoplasmic ratio (NPR) is 81.45%.

Stage II or early maturation (Fig. 6 B): The oocytes, still polyhedral in shape, are larger than those in stage I, with a large nucleus and nucleoli in a peripheral position. The central nucleus becomes chromatic. The oocytes are in primary vitellogenesis. The oocytes have a diameter between 51.20 µm and 372.58 µm, with an average of 130.45 ± 66.50 µm and an average nucleoplasmic ratio of 56.77%.

Stage III or maturation (Fig. 6 C): At this stage, the ovaries are characterized by oocytes undergoing secondary vitellogenesis. A ring of lipid inclusions appears at the periphery of the cytoplasm. The large nucleus becomes increasingly chromatic and contains numerous vitelline grains. The zona pellucida forms around the oocyte, whose diameter ranges from 77.41 µm to 387.47 µm, with an average diameter of 203 ± 74.19 µm. The nucleoplasmic ratio is 33.93%.

Stage IV or pre-ovulation (Fig 6 D): The oocytes are large and rounded in shape. The nucleus is small and diffuse.

The amount of vitellus is homogeneous and occupies almost the entire volume of the cytoplasm. The lipid inclusions merge and increase in volume. The diameter fluctuates between 152.80 µm and 847 µm (472.99 ±187.40 µm). The average nucleoplasmic ratio is 24.35%.

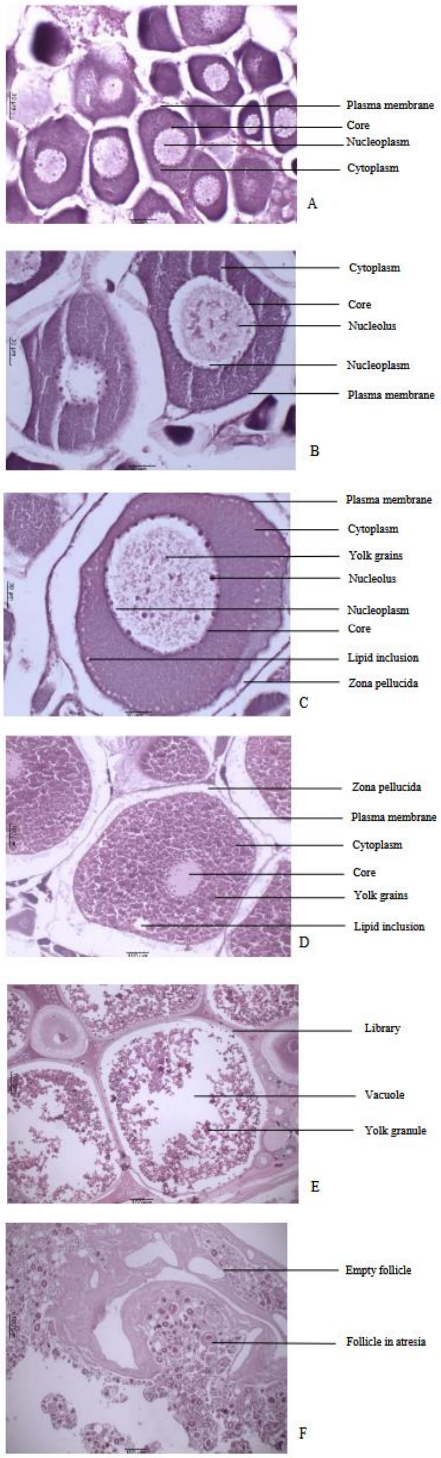

Fig 6. Cross-section of an ovary of *Synodontis membranaceus* caught in the Bagoué River between August 2018 and February 2020
A = stage I of sexual maturity; B = stage II of sexual maturity; C = stage III of sexual maturity. D = stage IV of sexual maturity; E = stage V of sexual maturity; F = post-spawning stage. Hematoxylin-eosin staining; magnification x 200.

Stage V or laying stage (Fig 6 E): The rounded oocytes have reached their maximum size, which varies from 215.43 µm to 895.64 µm. The average size is 540.06 ± 150.25 µm. The theca is clearly visible. The vitelline inclusions, having lost their consistency, fuse to form a large vacuole. The increase in cytoplasmic volume makes the nucleus invisible.

Stage VI or post-ovulation stage (Fig 6 F): After ovulation, the ovary appears disorganized. It consists of empty follicles that have released the second oocyte and oocytes in stages I and II. There are remnants of mature oocytes showing signs of atresia.

DISCUSSION

The sex ratio observed in all *Synodontis membranaceus* catches in the Bagoué River does not indicate any significant difference, even though there is a slight predominance of females over males. This dominance of females would be an advantage for the survival of the species because, according to Araoye (2001), a large number of females would reduce the competition that could exist between males for reproduction. This result is consistent with the work of Akombo *et al.* (2011) on *S. membranaceus* and *Synodontis schall* in the lower reaches of the Benue River in Makurdi, Nigeria. Contrary results were obtained for other species of the genus *Synodontis* by Midhat *et al.* (2012) in *S. schall* in the Nile in Egypt. Indeed, the difference in sex ratio in different populations could be explained by fishing techniques, mortality rates, and differences in growth between the sexes recorded in the environments considered (Chikou, 2006). This variation could also be explained by the movement of females to specific habitats at the time of spawning (Atsé *et al.,* 2009; Konan *et al.,* 2013). The size at first sexual maturity in *S. membranaceus* in the Bagoué River indicates

that males (93.65 mm LS) reach maturity faster than females (110.49 mm LS). This observed difference can be explained by the fact that the size at sexual maturity of individuals depends on biological and/or ecological factors in the environment, as noted by Wague and M'Bodj (2002) in their work on round sardinella along the Mauritanian coast. The results of this work contradict those of Kouassi *et al.* (2018) in Lake Buyo and Koffi *et al.* (2018) in the Taabo dam. These authors showed that females of *S. koensis* and *S. punctifer* reach sexual maturity before males. However, the work of Chikou *et al.* (2011) on *S. nigrita* in the Ouémé Delta in Benin showed that males and females reach sexual maturity at the same size. Variations in the size at first maturity depending on the basin are thought to be due to the fact that fish develop strategies according to their environment in order to adapt and take advantage of their ecosystem (Lévêque and Paugy, 2006). According to Dadebo *et al.* (2003), determining the size at first sexual maturity is essential for fisheries management. It is therefore important that catches of this species be limited to fish larger than 111 mm in standard length.

The cumulative points of the gonadosomatic index and hepatosomatic index of females coincide. This result confirms that *S. membranaceus* is a fatty fish. It stores energy reserves mainly in the muscles, in the peri-visceral mesentery, and under the skin (Koné, 2000). These reserves are then transferred to the liver and gonads to meet energy requirements during the breeding season.

Regarding the breeding season of *S. membranaceus* in the Bagoué River, higher proportions of mature females were observed during the rainy season. These observations provide important information for determining the breeding season of this species, which is between April and October. In addition, this species lays its eggs during the same period. Similar results in other species of the genus *Synodontis* corroborate our findings. Layèlè *et al.* (2006) showed that *S. schall* and *S. nigrita* spawn between August and October in the Ouémé River in Benin. According to Koffi *et al.* (2019), *S. punctifer* reproduces from August to September in the Taabo dam lake.

In *S. ocellifer* and *S. schall* sampled from the Baoulé River in Mali, spawning occurs between June and August (Paugy, 2002). All these authors agree that most fish have breeding periods that coincide with the rainy season. The absolute fecundity (7157 ± 3810) of *S. membranaceus*, obtained in the Bagoué River, falls within the range given by Layèlè *et al.* (2006) for *S. schall* and *S. nigrita* in the Ouémé River in Benin. *Synodontis membranaceus* belongs to the category of fish with high fertility and small eggs. The fertility observed in this study may be a strategy for this species to maximize the survival of its offspring (Sylla *et al.*, 2009). These results are consistent with the work of Kouassi *et al.,* 2018 on *S. koensis* in the Buyo dam lake. Histological examination of the ovaries and determination of the proportions of oocytes at different stages of the ovarian cycle allow the spawning strategy of a species to be described (Lefler *et al.,* 2008).

Oogenesis can be described by several criteria (Konan, 2010). Each stage can be characterized by the size of the oocytes, the homogeneity of their structure, the quantity and distribution of lipid inclusions, and their state of hydration (Bouhali *et al.,* 2015). *Synodontis membranaceus* has six stages of microscopic ovarian development. Rapid growth of the oocytes was observed from stage II of ovarian maturation with the establishment of the vitellus and lipid reserves. From this stage onwards, the oocytes increase in volume through the accumulation of vitelline reserves until stage IV. The distribution of oocyte frequencies shows that only one batch from the stock progresses to spawning. This observation indicates that *S. membranaceus* is a species that spawns once and only once.

CONCLUSION

The study of reproductive biology in *Synodontis membranaceus* in the Bagoué River reveals that males reach sexual maturity before females. The evolution of the RGS, coupled with variations in maturation stages and macroscopic and microscopic observations of the gonads, places the reproductive

period between April and October (rainy season). The average absolute fecundity of females is 7157 ± 3810 oocytes, and relative fecundity is positively correlated with standard length and total mass.

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REFERENCES

Adja MG, Jourda JPR, Ta MY, Kouamé K, Kouamé KJ, Kouamé KF, Saley MB, Djé KB, Biemi J. 2009. Mid-dry season diagnosis of the water status of the Bagoé watershed (Sudano-Sahelian environment of Côte d'Ivoire) using Landsat ETM+ images. Sécheresse **20**(3), 253–261.

Akombo PM, Atile JI, Adikwu IA, Araoye PA. 2011. Morphometric measurements and growth patterns of four species of the genus *Synodontis* (Cuvier, 1816) from Lower Benue River, Makurdi, Nigeria. International Journal of Fisheries and Aquaculture **3**(15), 263–270.
https://doi.org/10.5897/IJFA11.111

Araoye PA. 2001. Morphology of the gonads in the reproductive cycle of *Synodontis schall* (Pisces: Mochokidae) in Asa Lake Ilorin, Nigeria. Journal of Aquatic Science **16**(2), 105–110.
https://doi.org/10.4314/jas.v16i2.20014

Atsé BC, Konan KJ, Kouassi NJ. 2009. Reproductive biology of the cichlid *Tylochromis jentinki* in the Ebrié lagoon (Ivory Coast). Cybium **33**(1), 11–19.

Boguhé GFDH. 2015. Reproductive biology and exploitation of two shrimp species of the genus *Macrobrachium*: *M. macrobrachion* (Herklots, 1851) and *M. vollenhovenii* (Herklots, 1857) from the Bandama River (Ivory Coast). Doctoral thesis, Félix Houphouët-Boigny University, Abidjan, Ivory Coast, 206 p.

Bouhali ZF, Lechekhab S, Ladaimia S, Bedairia A, Amara R, Djebar AB. 2015. Reproduction and gonadal maturation of *Sardina pilchardus* in the Gulf of Annaba (northeastern Algeria). Cybium **39**(2), 143–153.
https://doi.org/10.3368/cybium.2015.029

Chikou A, Laléyé PA, Bonou CA, Vandewalle P, Philippart JC. 2011. First maturity and capture sizes of six catfish species in the Ouémé Delta, Benin (West Africa). International Journal of Biological and Chemical Sciences **5**(4), 1527–1537.
https://doi.org/10.4314/ijbcs.v5i4.55

Chikou A. 2006. Study of the demography and fishing exploitation of six species of catfish (Teleostei, Siluriformes) in the Ouémé Delta in Benin. Doctoral thesis, University of Liège, Belgium, pp. 349–390.

Dadebo E, Ahlgren G, Ahlgren I. 2003. Aspects of reproductive biology of *Labeo horie* Heckel (Pisces: Cyprinidae) in Lake Chamo, Ethiopia. African Journal of Ecology **41**(1), 31–38.
https://doi.org/10.1046/j.1365-2028.2003.00404.x

Heins DC, Baker JA, Guill JM. 2004. Seasonal and interannual components of intrapopulation variation in clutch size and egg size of a darter. Ecology of Freshwater Fish **13**(4), 258–265.
https://doi.org/10.1111/j.1600-0633.2004.00064.x

Koffi OH, Diaha NC, Soro Y, N'da K. 2018. Fishing and morphological characteristics of an endemic catfish *Synodontis punctifer* (Daget, 1964) in the Taabo hydroelectric dam (Ivory Coast). European Scientific Journal **14**(15), 101–116.
https://doi.org/10.19044/esj.2018.v14n15p101

Koffi OH, Soro Y, Diaha NC, N'guessan Y, N'da K. 2019. Comparative study of the reproduction of *Synodontis punctifer* (Daget, 1964) upstream and downstream of the Taabo hydroelectric dam, Ivory Coast. Journal of Environmental Science, Computer Science and Engineering & Technology **8**(1), 001–013. https://doi.org/10.24214/jetet.A.8.1.00113

Konan KJ. 2010. Study of population parameters, reproductive biology, and feeding strategies of the cichlid *Tylochromis jentinki* (Steindachner, 1895) in Ebrié Lagoon (Ivory Coast). Doctoral thesis, University of Cocody, Abidjan, Ivory Coast, 176 p.

Konan YA, Ouattara S, Koné T, Bamba M, Koné I. 2013. Reproductive characteristics of *Thysochromis ansorgii* (Pisces, Cichlidae) in the Tanoé-Ehy swamp forest (Ivory Coast). Journal of Applied Biosciences **71**, 5715–5727. https://doi.org/10.4314/jab.v71i1.98815

Koné T. 2000. Diet and reproduction of a lagoon tilapia (*Sarotherodon melanotheron* Rüppell, 1852) in the Bia River and Ayamé Dam Lake (Ivory Coast). Doctoral thesis, Katholieke Universiteit Leuven, Belgium, 253 p.

Kouassi KHD, Kamelan TM, Berté S, Kouamelan EP. 2018. Reproductive parameters of *Synodontis koensis* Pellegrin, 1933 (Siluriformes, Mochokidae) in Lake Buyo (Côte d'Ivoire). Journal of Applied Biosciences **132**, 13461–13474.

Lalèyè P, Chikou A, Gnohossou P, Vandewalle P, Philippart JC, Teugels GG. 2006. Studies on the biology of two species of catfish *Synodontis schall* and *Synodontis nigrita* (Ostariophysi: Mochokidae) from the Ouémé River, Bénin. Belgian Journal of Zoology **136**(2), 193–201.

Lefler KK, Hegyi A, Baska F, Gal J, Horvath A, Urbanyi B, Szabo T. 2008. Comparison of ovarian cycles of Hungarian riverine fish species representing different spawning strategies. Journal of Animal Sciences **53**(10), 441–452.

Lévêque C, Paugy D. 2006. General characterizations of ichthyological fauna. In: Fish of African continental waters: Diversity, ecology, human use (Lévêque C, Paugy D, eds). Editions IRD, Paris, 45–57.

Martoja R, Martoja-Pierson M. 1967. Introduction to animal histology techniques. Masson et Cie, Paris, France, 345 p.

Midhat AEK, Mohammed MNA, Seham AI. 2012. Environmental studies on *Synodontis schall* (Bloch and Schneider, 1801) (Pisces: Mochokidae) in the River Nile at Gizza sector, Egypt: Biological aspects of population dynamics. Journal of Fisheries and Aquatic **7**, 104–133.

Myers RA, Worm B. 2005. Extinction, survival or recovery of large predatory fishes. Philosophical Transactions of the Royal Society B: Biological Sciences **360**, 13–20. https://doi.org/10.1098/rstb.2004.1573

N'da AS. 2015. Biodiversity, fish community structure, and trophic relationships in a basin in northern Ivory Coast: The case of the Bagoué River. Doctoral thesis, University of Cocody-Abidjan, Ivory Coast, 220 p.

N'goran YN. 1995. Biology, ecology, and fishing of the ethmalose: *Ethmalosa fimbriata* (Bowdich, 1825) in the Aby lagoon (Ivory Coast). Doctoral thesis, University of Western Brittany, France, 195 p.

Paugy D, Lévêque C, Teugels GG. 2003. Fauna of freshwater and brackish water fish of West Africa, Volume 2. Tropical Fauna Collection 40. Institute of Research for Development (IRD), Paris; MRAC and MHN, 815 p.

Paugy D. 2002. Reproductive strategies of fishes in a tropical temporary stream of the Upper Senegal basin: Baoule River in Mali. Aquatic Living Resources **15**, 25–35. https://doi.org/10.1051/alr:2002015

Sanogo Y, Samaké F, Koné A, Traoré D. 2015. Diversity of fish populations in the Bagoé River (Niger Basin, Mali). Agronomie Africaine **27**(1), 47–56. https://doi.org/10.4314/aga.v27i1

Savané I, Konaré A. 2010. Climate. In: Atlas of West African biodiversity, Volume III: Côte d'Ivoire (Konaté S, Kampmann D, eds). Abidjan & Frankfurt/Main, 124–125.

Soro D, Fantodji A. 2007. Organization and evolution of male gonads in farmed grass rats (*Thryonomys swinderianus*) during sexual maturity: Histological study. Revue Française d'Histotechnologie **20**(1), 71–81.

Stiassny MLJ, Brummett RE, Harrison IJ, Monsembula R, Mamonekene V. 2011. The status and distribution of freshwater fishes in central Africa. In: Brooks EGE, Allen DJ, Darwall WRT (eds). The status and distribution of freshwater biodiversity in central Africa. IUCN, Gland, Switzerland and Cambridge, UK, 27–44.
https://doi.org/10.5555/iucn.book.106604

Sylla S, Atsé BC, Kouassi NJ. 2009. Reproductive strategy of the Carangidae *Trachinotus teraia* Cuvier, 1832 in the Ebrié lagoon (Ivory Coast). Sciences & Nature **6**(1), 83–94.
https://doi.org/10.4314/scinat.v6i1.48662

Wague A, M'Bodj OB. 2002. Study of certain aspects of reproduction in round sardinella *Sardinella aurita* (Valenciennes, 1847) caught along the Mauritanian coast. Scientific Bulletin of the Mauritanian Institute of Oceanographic Research and Fisheries **29**, 13–18.