Studies on the biology of two species of catfish *Synodontis schall* and *Synodontis nigrita* (Ostariophysi : Mochokidae) from the Ouémé River, Bénin

Philippe Lalèyè[1], Antoine Chikou[1], Pierre Gnohossou[1], Pierre Vandewalle[2], Jean Claude Philippart[2] and Guy Teugels[3]

[1] **Université d'Abomey Calavi. Faculté des Sciences Agronomiques, Laboratoire d'Hydrobiologie et d'Aquaculture. 01 BP 526 Cotonou. Bénin.**
[2] **Université de Liège, Laboratoire de Morphologie fonctionnelle et évolutive. Institut de Chimie, B6 Sart Tilman. B-4000 Liège et Laboratoire de Démographie des Poissons et d'Aquaculture, 8 Chemin de la Justice. B 4500 Tihange Belgique.**
[3] **Musée Royal de l'Afrique Centrale (MRAC), Laboratoire d'Ichtyologie, B - 3080 Tervuren. Belgique.**
Corresponding address : Philippe Lalèyè, e-mail : laleye@bj.refer.org / laleyeph@yahoo.fr

ABSTRACT. The abundance and distribution, length-weight, condition factor, diet and reproduction of *Synodontis schall* and *S. nigrita* from the Ouémé (Bénin) are described. *S. nigrita* is less abundant than *S. schall* in the river. Both species are euryphagous with their diet containing a wide variety of food items that include various types of plankton, invertebrates and plants. This high diversity of the food composition indicates a wide adaptability to the habitats in which they live. This is an important strategy for survival and an advantage over the fish species competing for a specific food item. Size at maturity differs between species for both males (15 cm TL for *S. schall* and 21 cm TL for *S. nigrita*) and females (16 cm and 22 cm, respectively). Fecundity range is higher for *S. schall* (1841 - 15076 oocytes) compared to that of *S. nigrita* (2647 - 9212). Peak values of GSI for males and females in both species occurred from mid- to late July, indicating one season of major spawning activity per year.

KEY WORDS : *Synodontis schall*, *Synodontis nigrita,* biology, Ouémé river, Bénin

INTRODUCTION

Catfishes support the thriving commercial fisheries in many West African countries (OFORI-DANSON, 1992; OFORI-DANSON et al., 2002). Catfishes of the genus *Synodontis*, are small to medium-sized fish belonging to the family Mochokidae. These are a highly valued food-fish in Benin (BARAS & LALÈYÈ, 2003) and contribute an unquantified but significant proportion to the fishery of the rivers. The genus contains approximately 110 species (POLL, 1971), and hence, have more species than any teleost genus in Africa other than *Barbus* and *Haplochromis* (WILLOUGHBY, 1979). In Bénin, about 11 species of *Synodontis* have been identified and 3 species, *S. schall*, *S. nigrita* and *S. sorex,* are known from the Ouémé River (LALÈYÈ et al., 2004). Previous work on the genus in West Africa has been carried out by DAGET (1954) in Lake Chad, BISHAI & GIDEIRI (1965a, 1965b, 1968) in the Nile River, WILLOUGHBY (1976, 1979) in Lake Kainji, HALIM & GUMA'A (1989) in the White Nile, OFORI–DANSON (1992) in the Kpong Headpond (Ghana), OLOJO et al. (2003) in the Osun River (Nigeria). In Bénin, there is however, no information on many aspects of the genus. This paper investigates the abundance, growth condition, reproduction and diet of *S. schall* and *S. nigrita* in the Ouémé River basin, Bénin.

MATERIEL AND METHODS

Study area and sampling sites

The Ouémé River (Fig. 1) is the largest fluvial basin of Bénin, with a catchments' area of 50000 km², extending to about 510 km in length originating in from the Tanéka mountains (north of the country) (COLOMBANI et al., 1972). Input waters originate from two main tributaries, Okpara (200 km length) and Zou (150 km length). Peak discharge is rapid and occurs in August-September. It crosses many agro-ecological zones draining to the downstream side of the Nokoué Lake and Porto-Novo lagoon complex connected to Atlantic Ocean. It has an average slope of 0.9 m/km, except along the upstream area of the basin where it measures 20 m/km. For the purpose of fish sampling, 4 stations were selected (Fig. 1). The first sampling station is situated on the Okpara tributary river at Kpassa village (09°17'N – 02°43'E). The second sampling station at Atchakpa (08°04'N – 02°22'E) on the Ouémé River is located along a coarse, rocky zone with swift water currents. Toué (07°12'N – 02°17'E) is the third sampling station on the Zou tribrutary. This station marks the transition between the zones of swift water and the delta. The forth station at Agonlin Lowé's village (06°39N – 02°28) is situated in the Ouémé Delta.

The river is influenced by two distinct climates due to its geographic location. The northern basin (near the sources), a tropical tendency of dry and rainy seasons and high varying temperature (10-40°C) are observed throughout the year. From November to March, rains can be rare or turbulent. Furthermore, the harmattan wind, which blows from November to April, accentuates the thermic and hygrometric amplitudes. The rainy season extends from May to September. The southern basin is characterized by a sub-equatorial climate with two rainy and two dry seasons. The great rainy season occurs from April to July with the greatest amount in June. The second rainy season occurs in September. Temperature remains relatively constant varying from 18 to 35°C.

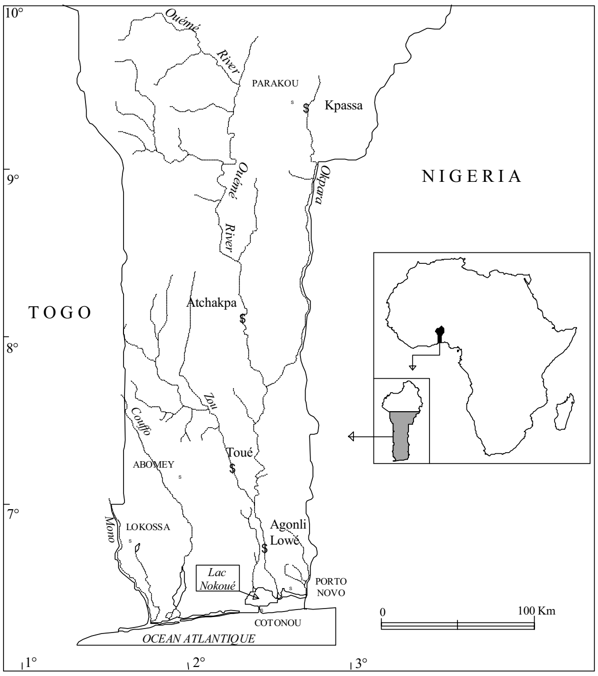

Fig. 1. – Map of the study area showing the location of some towns, villages and the sampling sites

Sampling and analysis

Sampling of both *S. schall* and *S. nigrita* was conducted on a monthly basis from May 1999 to April 2000 by using monofilament gillnets of various mesh sizes (10, 12, 15, 20, 25, 30, 35, 40, 45 mm) per sampling site. Two nets of each mesh size were used. Each net measures 30.0 m length and 2.5 m depth. Floats are used on the head line while lead weights are used on the bottom line. Nets are set in the water and inspected every 3 hours for two days. Total length (TL, to the nearest mm) and body weight (to the nearest 0.1 g) were measured and the sex of fish determined according to Lagler (1971), using macroscopic evaluation.

A total of 3646 specimens of both species were collected. These were dominated by *S. schall* (77%) and data collected were used to length-weight relationships based on the method of Le Cren (1951) and is expressed as follows : Log W = Log a + bLog TL, with W fish weight, TL fish total length and a and b the constants. Relative growth condition factor (Kn, coefficient of condition), which measures physiological well-being of the fish (Wootton, 1994) was estimated using the formula proposed by Tesch (1971) :

$$Kn = \frac{W}{aTL^{b}} \times 100$$

Maturity stages gauged according to the macroscopic evaluation of gonads (Lagler, 1971 and Lalèyè et al., 1995) were recognized for *Synodontis* species as : I – immature (very small sexual organs close under the vertebral column; testes and ovaries colourless; eggs invisible to naked eye); II – developing (Testes and ovearies traslucent; small eggs can be seen with aid of magnifying glass); III – mature (Ovaries orange-reddish; eggs clearly discernible to eye; ovaries occupy about two-thirds of central cavity; anterior testis whitish with short fingerlike processes and those in posterior appear slightly translucent; milt drops from whitish process under slight pressure); IV – ripe (ovaries filing ventral cavity; eggs light green in colour, completely round and fall from ovary with little pressure; eggs oocytes diameter (measured from fresh material) varied from 0.5 mm to 1.0 mm (mean 0.8 mm ± 0.2) in *S. schall* and from 0.8 mm to 1.5 mm (mean 1.1 mm ± 0.3) in *S. nigrita*); V – spent (not yet fully empty; no opaque eggs left in ovaries; ovaries large but flabby; testes thread-like with no granules and are pink-white shrivelled bodies). Average size at first maturity (L_{50}) was defined as the length at which 50% of the females are at an advanced stage of the first sexual cycle (at least in stage III of the maturity scale) as suggested by Tweddle & Turner (1977). This is based on the previously determined reproductive season to avoid bias in classifying resting females as immature (Panfili et al. 2004). The gonado-somatic index (GSI) was calculated based on the formula suggested by Lagler (1971) which is expressed as :

$$GSI = \frac{\text{Gonad weight (g)}}{\text{Total body weight (g)}} \times 100$$

Fecundity was determined from 27 and 26 mature gonads of *S. schall* (13.5 cm - 21.7 cm TL, 30 g - 100 g TW) and *S. nigrita* (14.0 - 23.5 cm TL, 32g-125 g TW), respectively. Absolute fecundity, probable number of oocytes which will be released at the following spawning, was determined by taking two portions of the ovary (500 fresh eggs ± 50) which are then weighed and initially fixed in modified Gilson's fluid (Bagenal & Braum, 1971) for about 2 - 3 weeks until oocytes obtained a free and hard texture. The relationship between fecundity and some morphometric measurements were determined by relating total fecundity (F) data to total length (TL), total weight (TW) using the following formulae :

$$F = a \times TL^{b};\ F = a \times TW^{b}$$

The degree of stomach fullness of the all samples was estimated by the same person by an arbitrary 0-4 points scale defined as follows : 4 points for full, 3 for ¾ full, 2 for ½ full, 1 for ¼ full and 0 for empty stomachs. The fullness index (FI) was considered as the percentage of stomachs completely filled, as well as those considered 75% filled. Stomach contents were sorted into groups and items identified accordingly. Occurrence percentage (F) (Hyslop, 1980) was estimated using the formula :

$$F = \frac{Nei}{Nt} \times 100$$

Where Nei = number of stomachs containing a type of prey i and Nt = total number of full stomachs examined. Schoener's (1970) index was used for establishing diet overlaps between the two species and is calculated as :

$$S = 1–0.5 \left(\sum_{i=1}^{n} Pij – Pik \right)$$

where n = number of food categories, P_{ij} = proportion (% by weight) to food category i in diet of species j and P_{ik} = proportion (by weight) of food category i in diet of species k. This is considered as the most satisfactory method in the absence of any food estimate data. Diet overlaps were considered to be biologically important when S exceeds 0.60 (Wallace, 1981).

RESULTS

Abundance and distribution

The total number, and weight of *Synodontis* caught during the 12-month sampling period is shown in Table 1. *Synodontis* abundance decreases from southern to northern basin. The numbers and weights of the two species in Agonlin Lowé were significantly higher than in other locations (P < 0.05). No *S. nigrita* have been caught in Kpassa by experimental fishing during the study. *S. schall* was observed to be more abundant at all the stations compared to *S. nigrita*. Seasonal variations in numbers and weights are shown in Fig. 2. For both species, peak catches occurred in May and December. In *S. schall*, peak catches also occurred in July and in January-February and in April (2000). Significant yields catches peak were also observed in August for *S. nigrita*. Significant reductions in catch were observed for *S. schall* in August (1999) and in September (2000) for both species.

Size range and population structure

Total lengths of *S. schall* ranged from 6.2 to 34.3 cm. The difference in fish length between males (range 6.6 cm - 31.5 cm TL, mean 15.1 cm ± 4.7 cm TL, N = 1314) and females (6.2 cm - 34.3 cm, mean 15.9 cm ± 5.03, N = 1199) is not significant (P > 0.05) (Fig. 3). In *S. nigrita*, the total length ranged from 6.0 cm to 33.5 cm. No significant (P > 0.05) length differences were observed between males (range 6.0 cm - 31.9 cm TL, mean 16.5 cm 4.1 cm TL, N = 436) and females (range 6.2 cm - 33.5 cm TL, mean 17.0 cm ± 5.3 cm TL, N = 399). Comparing the two species, the difference in fish length is not significant (P > 0.05).

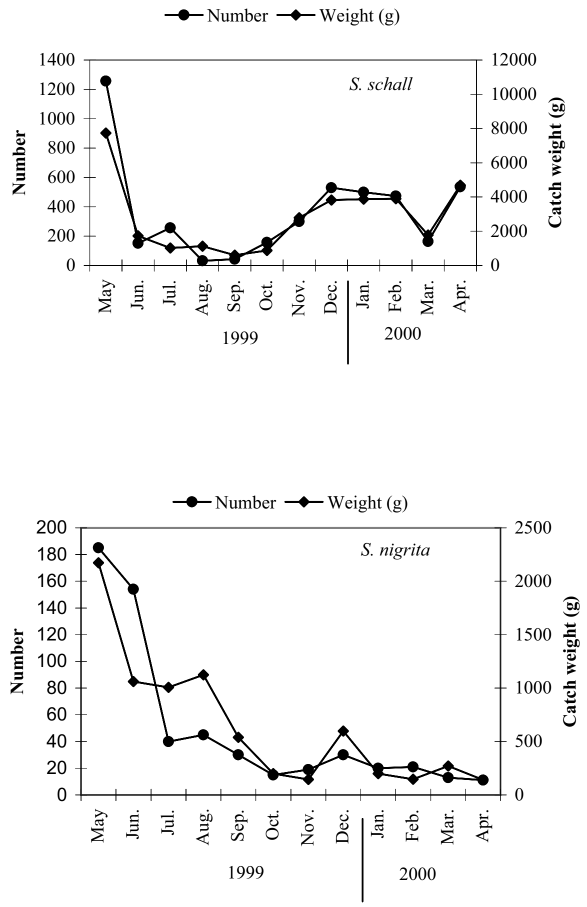

Fig. 2. – Change in seasonal abundance of *S. schall* and *S. nigrita* in Ouémé river basin

TABLE 1

Numbers and weights of *Synodontis* caught at sampling station (May 1999-April 2000)

Sampling stations	*Synodontis nigrita*				*Synodontis schall*			
	Number	% Total no of fish	Total weight (g)	% Total weight of fish	Number	% Total no of fish	Total weight (g)	% Total weight of fish
Kpassa	0	0	0	0	42	0,32	1098	0,64
Atchakpa	9	0,16	1039	0,63	54	0,95	6029	3,68
Toué	165	0,87	2764	0,87	910	4,82	11926	3,76
Agonlin Lowé	715	2,43	8506	2,96	4845	16,44	35670	12,41
Total	889	–	12309	–	5851	–	54723	–

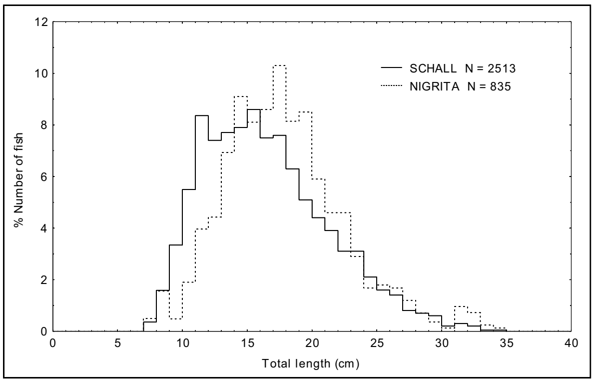

Fig. 3. – Length frequency distribution of *S. schall* and *S. nigrita* in the Ouémé river basin

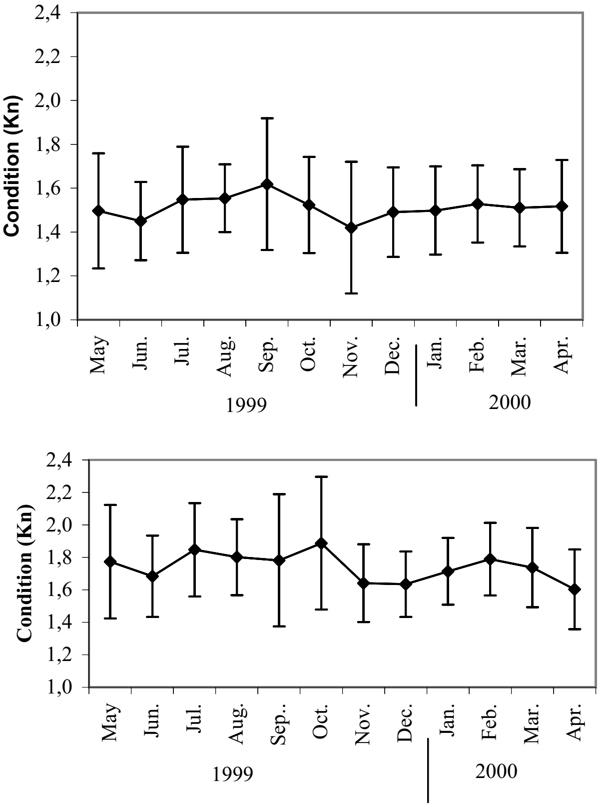

Fig. 4. – The mean monthly relative condition of *S. schall* and *S. nigrita* in the Ouémé river basin (95% confidence limits are indicated)

Length-weight (L-W) relationship

This relationship was described for the two species based on the linear equations :

S. schall : Log TW = - 4.212 + 2.832 Log TL (r = 0.982)

S. nigrita : Log TW = - 4.047 + 2.779 Log TL (r = 0.973)

No significant difference in L-W relationship ($P > 0.05$) was obtained between these two catfish species. In both species, the constant b, which describes the slope of the regression line, is smaller than 3 ($p < 0.01$) : *S. schall*, $t(2511) = 5.78$; *S. nigrita*, $t(831) = 3.459$. This implies that the tendency of the two species is to increase more in size than in mass.

Condition factor (Kn)

The mean monthly relative condition (Kn) value obtained was 1.513 ± 0.005 for *S. schall* while 1.741 ± 0.088 in *S. nigrita* (Fig. 4). Significant difference in average Kn values was observed between species ($P < 0.01$; $F(1,22) = 60.55$). Peak of condition factor occurred during the flooding season which falls in September for *S. schall* and in October for *S. nigrita*. In both species, a relative increase of condition factor has also been observed in July (1999) and from December to February (2000). Lowest value was observed in June and November for both species.

Trophic biology

Of the 2016 stomachs of *S. schall* (3.0 - 34.3 cm TL) examined, about 44% (886) were observed full, 20% (410) were partially filled and 36% (720) were empty. In the case of the 675 *S. nigrita* (3.4 - 33.5 cm TL) stomachs examined, 42% (283) were full, 24% (159) were partially filled and 35% (233) were empty. In general, stomachs of both species were more than half full (Fig. 5). During the year, the mean stomach fullness index estimated as 50.4 ± 9.6 in *S. schall* while 53 ± 16.7 in *S. nigrita*. This indicates a constant level of feeding activity by the two species. Highest index value was observed in June for both species. Lowest values were observed in July and November for *S. schall* and *S. nigrita*, respectively. Similar food items were consumed by both species (Table 2) though varying proportions among preys (Table 3) were observed. Macrophytes and algae were the most frequent food items observed in the stomachs of the two species. Animal prey types are larvae and adults of various insects, crustaceans, rotifers, as well as possible parasitic nematodes. Mud and some unidentified particles were also observed. For *S. schall*, however, molluscs seems to be a preferred prey following macrophytes and algae. The proportion of eggs and fish scales is more important in the stomach contents of *S. schall* (frequence of occurrence, 40.35%) compared to that of *S. nigrita* (1.56%). However, in both species, complete fishes were never found in their stomachs. Diet overlap is biologically important between the two species (S = 0.755).

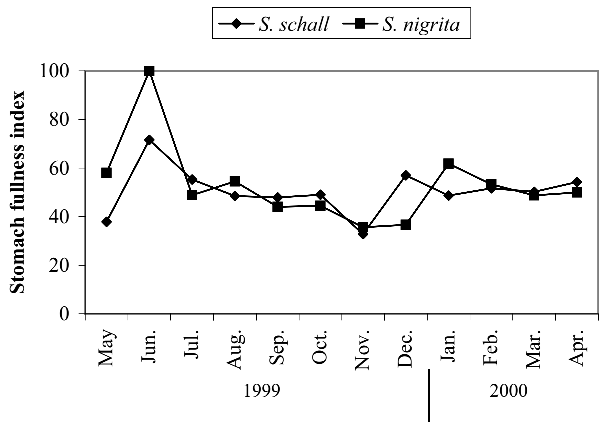

Fig. 5. – The monthly stomach fullness index of stomachs of *S. schall* and *S. nigrita* in the Ouémé river basin

TABLE 2

Plant and animal species identified in the stomachs of either *Synodontis schall* or *S. nigrita*

Food category	Species
Machrophytes	Maize, *Azolla* sp., leaves.
Algae	*Actinocyclus sp, Amphora commutata, Anabaena affinis, Ankistrodesmus fusiformis, Anabaena sp, Calothrix bervissima, Anabaenopsis circularis, Centritractus belonophorus, Anemoeoneis sphaerophora, Closterium aciculaire, Ceratophallus natalensis, Closterium acutum, Ceratophallus sp, Closterium ehrenbergii, Chrococcus limneticus, Closterium leibleinii, Closteriopsis longissima, Closterium monoliferum, Closterium lanceolatum, Ferrisia eburneensis, Closterium parvulum, Closterium lineatum, Closterium pseudolunula, Closterium tumidum, Closterium strigosum, Closterium venus, Cocconeis placentula, Closteropsis sp, Cosmarium brebisonii, Coelomoron pusillum, Cosmarium granatum, Cosmarium connatum, Cosmarium vexatum, Cosmarium contractum, Cyclotella meneghiniana, Cosmarium decoratum, Cymbella silesiaca, Cosmarium lundellii, Diploneis ovalis, Cosmarium pseudodecoratum, Euastrum glaziovii, Cosmarium pseudopyramidatum, Eunotia didyma, Cosmarium quadrum, Eunotia monodon, Cosmarium retusiforme, Eunotia soleirolii, Cymbella caespitosa, Frustulia rhomboides, Euastrum germanicum, Gomphonema granuli, Euastrum pseudopectinatum, Hantzschia amphioxys, Euastrum sphyroides, Merismopedia elegans, Euglena proxima, Micrasteria sp, Fragilaria virescens, Micrasterias orux melitensis, Gomphonema gracile, Microcystis sp, Gomphosphaeria naegiliana, Monoraphidium sp, Gonatozygon monotaenium, Navicula epypto, Lyngbya bourrellyana, Navicula pygmaea, Lyngbya cebennensis, Navicula splendida, Lyngbya contorta, Nitzschia recta, Merismopedia punctata, Nitzschia scalaris, Micrasteria foliacea, Oedogonium globosum, Micrasterias crux-melitensis, Oscillatoria ornata, Micrasterias radians, Pinnularia brauniana, Microcystis aeruginosa, Pinnularia gibba, Microcystis aquatilis, Pinnularia mesolepta, Microcystis delicatissima, Pinnularia neomajor, Microcystis elachstica, Scenedesmus microspina, Microcystis sp, Scenedesmus obliquus, Microcystis weenbergii, Spirogyra sp, Monoraphidium griffihii, Spondylosum planum, Mougeotia sp, Spondylosum secedens, Navicula cebennensis, Spondylosum tetragonum, Navicula cryptocephalla, Staurastrum forficulatum, Navicula cuspidata, Staurastrum polymorphum, Navicula placentula, Stauroneis phoenicenteraon, Navicula pygmaea, Navicula sp, Nitzschia sigma, Nostoc entophytum, Nostoc piscinale, Oscillatoria platensis, Oscillatoria pseudolabyrinthiformis, Oscillatoria sp, Pandorina sp, Pediastrum, Pediastrum duplex, Phacus longicauda, Pinnularia acrosphaeria, Pinnularia borealis, Pinnularia brebissonii, Pinnularia cardinalis, Pleurotaenium cylindricum, Pleurotaenium trabecula, Pseudanabaena catenata, Scenedesmus ecornis, Senedesmus naegelii, Senedesmus quadricauda, Spirulina gigantea, Spirulina linearis, Stauroneis phoenicenteron, Stigeoclonium aestivale, Surirella splendida, Synechocystis aquatilis, Synedra ulna, Tetraedriella gigas, Tetraedron muticum, Ulothrix sp, Ulotrix zonata.*
Rotifera	*Asplanchna girodi, Brachionus platulus, Keratella cochlearis, Lapadella patella, Lecane leontina, Pompholyx sulcata, Proales deaprens, Cepadella*
Insect larvae	Ceratopogonidae larva, Chironomidae larva and pupa, Coleoptera larva, Other Coleoptera, *Euparyphus* larva, Ephemeroptera larva, Heteroptera larva, Hydropsychidae larva, Odonata larva, Culicidae larva and pupa, Lepidoptera larva, Trichoptera pupa, Neotrichia larva, Piralidae larva, Plecoptera larva, Tabanidae larva, Mosquito larva and pupa.
Aquatic insects	Chaoboridae, Chironomidae, Elmidae*, Grillus sp,* Pleidae, Hymenoptera, Heteroptera, Mosquito, Orthoptera, Tabanidae,
Crustacea	Copepoda, Cladocera, Ostracoda, *Macrobrachium*.
Mullusca	*Bellamya unicolor, Bilinus sp, Bulinus jousseaumeis, Bulinus senegalensis, Biomphalaria pfeifferi, Biomphalaria sudanica, Eupera parasitica, Caelatura sp, Cleopatra bulimoides, Gabiella senaariensis, Limnea natalensis*.
Nematoda Miscellaneous	Pisces scales and eggs, Sand particles, Mud, decomposed matter

TABLE 3

Percentage frequency of occurrence of different category in stomachs of *Synodontis schall* and *Synodontis nigrita* caught from the Ouémé River, May 1999-April 2000

Food category	*S. schall* (%)	*S. nigrita* (%)
Macrophytes	59.65	43.70
Algae	35.10	45.63
Insect larvae	17.54	8.40
Aquatic insects	7.02	3.78
Crustacea	5.26	2.94
Rotifera	5.45	0.02
Mollusca	19.30	2.10
Nematoda	12.28	2.52
Fish eggs and scales	40.35	1.56
Unidentified decomposed matter	26.32	2.94
Sand particles	3.51	0.00
Mud	7.02	12.18

Reproduction

Sex-ratio

Sampling of fish from the different stations in the river ensured a representative distribution of males and females species. In general, in both species, males were observed numerically dominant than females ($P < 0.05$). According to the months, the sex ratio is in favour of the males (Table 4, P 0.01, ÷² (1,11) = 29.06 for *S. schall* and 40.50 for *S. nigrita*) except in October for *S. schall* and in June, July, December, January and February for *S. nigrita* where the females were slightly dominant numerically. The same result was obtained in different sizes of the fish.

TABLE 4

Number of males and females of *Synodontis schall* (a) and *Synodontis nigrita* (b) in the monthly samples

(a) S. schall			
Months	**No. of males**	**No. of females**	**Sex ratio M :F**
May	117	104	1.0 :1.1
June	96	80	1.0 :1.2
July	157	148	1.0 :1.1
August	38	26	1.0 :1.5
September	80	77	1.0 :1.0
October	71	80	1.0 :0.9
November	177	179	1.0 :1.0
December	112	88	1.0 :1.3
January	153	145	1.0 :1.1
February	114	98	1.0 :1.2
March	153	135	1.0 :1.1
April	60	45	1.0 :1.3
Total	1328	1205	1.0 :1.1
(b) S. nigrita			
Months	**No. of males**	**No. of females**	**Sex ratio M :F**
May	22	17	1.0 :1.3
June	21	27	1.0 :0.8
July	23	30	1.0 :0.8
August	55	43	1.0 :1.3
September	66	55	1.0 :1.2
October	63	44	1.0 :1.4
November	91	77	1.0 :1.2
December	29	31	1.0 :0.9
January	19	36	1.0 :0.5
February	1	6	1.0 :0.5
March	44	34	1.0 :0.2
April	5	2	1.0 :1.3
Total	439	402	1.0 :2.5

Size at maturity

For both females and males, the sizes at first maturity is higher for *S. nigrita* (21 - 22 cm) than *S. schall* (15-16 cm). This observation is the same when considering the smallest sizes at maturity for both species : *S. nigrita* at 10 cm (male) and 12.5 cm (female) while 7.8 cm (male) and 8.4 cm (female) for *S. schall*.

Gonado-somatic index (*GSI*) and spawning period

GSI values varied from 0.12% ± 0.1 to 1.854% ± 1.47 and 0.43% ± 0.25 to 9.874% ± 7.38 in *S. schall* males and females, respectively. For *S. nigrita*, values obtained range from 0.29% ± 0.05 to 0.808% ± 0.565 and 0.33% ± 0.01 to 9.88% ± 9.01 in males and females, respectively. GSI values for the two species were found to vary considerably with time, and this variation was at its maximum during July to October (Fig. 6). Peak values for males and females occurred from mid- to late July, indicating one season of major spawning activity per year for both species. Major spawning activity coincided with the high water period (August to October).

Fecundity

The fecundity ranged from 1841 to 15076 eggs in *S. schall* and from 2647 to 9212 eggs in *S. nigrita*. Between species, fish observed with the highest fecundity had a length of 20.8 cm TL and weighed 85 g in *S. schall.* For *S. nigrita,* fecundity is highest in species of 23.5 cm TL in length and 100 g in total weight (TW). The fish with the lowest number of eggs had 13.5 cm TL and 35 g TW in *S. schall* and 14.0 cm and 32 g TW in *S. nigrita*. The relationship between fecundity (F), fish length and weight was investigated and described by the following equations :

$F = 1.978*TL^{2.817}$ ($r = 0.717$) and $= 18.53*TW^{1.425}$ ($r = 0.8088$) for *S. schall*.

$F = 5.951*TL^{2.3008}$ ($r = 0.835$) and $= 190.068*TW^{0.7591}$ ($r = 0.7605$) ($r = 0.7605$) for *S. nigrita*.

High positive exponential fecundity-length and fecundity-weight correlations ($p < 0.001$) were obtained in the two species. No difference were observed between the two species related to each relationship ((t, 45), $P > 0.05$).

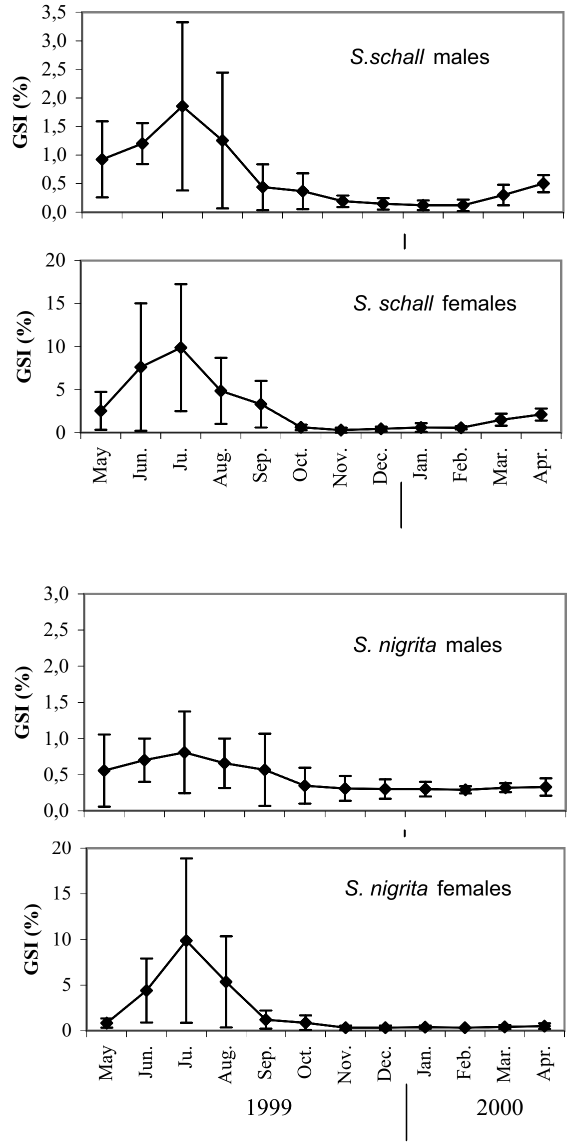

Fig. 6. – Seasonal variation in gonadosomatic index of males and females of *S. schall* and *S. nigrita* (95% confidence limits are indicated).

DISCUSSION

Based on results obtained from experimental and artisanal fishing, *S. nigrita* is less abundant than *S. schall* in the Ouémé River (Table 1). This species was absent in the experimental fishing at Kpassa, but is present in the captures of the fishermen when traps are used.

In general, abundance and distribution of both *Synodontis* are similar to what was observed earlier on the ichthyofauna of the Ouémé River (LALÈYÈ et al., 2004). According to LALÈYÈ et al. (2004), the stations of Agonlin Lowé and Toué are, by far, the richest in species (Agonlin Lowé, 71 species, = 59.2% of the total ichthyofauna; Toue, 67 species, = 55.8% ichthyofauna). These stations are situated in a vast floodplain whose ecological characteristics favour the colonization by fish. Floodplains present a great variety of habitats of which distribution and dynamics vary according to hydrological seasons (WELCOMME & DE MERONA, 1988).

OFORI-DANSON (1992) reported that *S. schall* contributed about 50% of the biomass of the 5 *Synodontis* spp found in Kpong Headpond (Ghana). ARAOYE (1999) indicated that *S. schall* was caught abundantly in As lake (Nigeria). *S. schall* seems to be an ubiquitous species, being found in all aquatic habitats including headwaters of tributaries, pools in dry sandy river beds, as well as in river and marshes. The high occurrence of *S. schall* within different ecological niches can be attributed to its diverse feeding habits.

The seasonal fluctuations in the numbers and weights of the *Synodontis* spp caught using gillnets suggest four interrelated factors : changes in the behaviour of the fish, fishing activities, rainy season and recruitment. High species yield in catches during April and May corresponds to the beginning of the rainy seasons when food availability is highest due to the flood-introduced nutrients and mixing of water body by rapid currents. Such ecological conditions are favourable to fishes and may allow them to leave their hiding places making them vulnerable for fishing. Increase in fish abundance due to the combination of physico-chemical properties and the presence of food items has already been reported by FAGADE & OLANIYAN (1974) for the Lagos lagoon (Nigeria). In May (1999), the abundance of vulnerable fishes reached its maximum. This situation can justify the importance of catches obtained in this month. The stock of fishes falls down in June due to the intensity of the fishing.

This numerical and ponderal increases of *Synodontis* are then followed by a decrease in June which will increase again during July and August for *S. schall* and *S. nigrita*, respectively. The lowest numerical abundances are registered in August – September for *S. schall* and in October - November for *S. nigrita* when water level is at its highest. The one-month gap noted between the two species could be due to behavioural differences aside from other factors. Decrease in fishing vulnerability may be due to the increased catchments area allowing these species to disperse and hide during spawning. Catch rates increase progressively starting from December when water level and catchments are decreasing. Catch rate for *S. nigrita* starts to decline in January. Decrease in catch of *S. schall*, however, starts only in March.

Decrease in abundance after flooding may be due to the decrease of river margins suitable for feeding and for spawning (HÅKANSON & BOULION, 2002).

Increase in abundance is highly correlated with success recruitment. The viability of these species may be largely enhanced by the reproductive behaviour (guarders), enhancing survival due to decreased predation, of these species (OFORI-DANSON, 1992) complemented by their high reproductive rates.

About size structure of the populations studied, the maximum size for *S. schall* is superior to that indicated by ALBARET (1982) for Ivory Coast (22 cm) while lower to the value indicated by OFORI-DANSON (1992) for *S. schall* (26.7 cm SL, or about 33.5 cm TL) in Kpong Headpond (Ghana). This difference of sizes is even better illustrated by the condition factor for *S. schall* (1.49 ± 0.19), which is lower than that indicated by OFORI-DANSON (1992), 2.54 ± 0.002 for male and 2.91 ± 0.018 for females. Among factors which can explain the difference obtained in the average condition factor (see LE CREN, 1951) of a fish species in two or more habitats, the fact that the fish are in better condition of feeding in a habitat than in the second one can play an important role in this specific case.

Estimated growth factor indices (Kn) for both species, *S. schall* = 1.49 and *S. nigrita* = 1.73, are lower than the estimated range of mean values (2.65 - 3.32) indicated by BAIJOT et al. (1997) for some slow-growing important fishes in Africa.

The food items in the stomach of both *Synodontis* species suggest that they are omnivorous feeders as the diet covers a wide spectrum of food ranging from various types of plankton to invertebrates and plants. This is in agreement with the finding of LAUZANNE (1988) who considers the *Synodontis* genus as eclectic. OLOJO et al. (2003) observed the same food habits in *S. nigrita* from the Osun River (Nigeria). This high diversity of the food composition of both *Synodontis* species indicates a wide adaptability to the habitats in which they live. Many catfishes, such as the *Chrysichthys* spp, are benthic omnivores with a strong tendency to predation (BARAS & LALÈYÈ, 2003). This is an important strategy for survival and an advantage over the fish species competing for a specific food item (PAUGY, 1994; LÉVÊQUE, 1997). A clear morphological explanation for its feeding versatility may be due to the ventral location of the mouth of both *Synodontis* species which encourages a detritivorous mode of feeding while the simple horny structures around the mouth enable it to adapt to filter feeding (OLOJO et al., 2003). These structures also help *Synodontis* to gnaw at any hard plant tissue which form part of its rich diet. WINEMILLER & KELSO-WINEMILLER (1996) stated that *Synodontis leopardinus*, *S. nigromaculatus*, *S. woosnami*, *S. macrostigma*, *S. macrostoma* of the Upper Zambezi River floodplain (Zambia) were omnivores, but interspecific differences were however noted. In Ouémé River, the most frequent food items in the stomachs of both species were macrophytes and algae. The diversity of algae consumed by both species is high (more than 100 species, Table 2). In Kpond Headpond (OFORI-DANSON, 1992), the frequent food item in *S. schall* were chironomids. The insects, fish eggs and scales clearly originated from both the bottom (with organic sediment and pieces of wood often present) and from periphyton of flooded trees, grasses and aquatics plants. These categories of food items were more frequent in *S. schall* stomachs compared to that of *S. nigrita*, suggesting that the habitats used by the two species for their food are not rigorously the same. The presence of sand grains and mud in the stomachs indicates that these species browse on benthic deposits in the river. The presence of nematodes in many stomachs almost in *S. schall* could explain some diseased and parasitized specimens observed during the study. Size-dependent (ontogenic) variation in occurrence of different categories of food in stomachs of the two species is not clear. The overall picture of the diet of *S. schall* and *S. nigrita* that emerges from this study is that of two species which are largely unspecialized in their feeding habits. Unspecialized dietary habits are an optimal strategy for survival in habitats where food sources are subject to fluctuation (Welcomme, 1979; Paugy, 1994; Lévêque, 1997).

There is an important difference in reproductive biology between the two species of *Synodontis*. Size at maturity was observed higher for *S. schall* compared to that of *S. nigrita.* In Lagoon Ébrié (Ivory Coast), Albaret (1982) obtained 15.5 cm of size at maturity for *S. schall*. Halim & Guma'a (1989) observed different values (14.0 - 15.0 cm SL) for *S. schall* in White Nile (Sudan). In Lake Kainji (Nigeria), Willoughby (1979) reported smaller sizes at maturity for *S. schall*, 10.4 and 11.8 cm for male and female, respectively. The highest values (20.0 cm) were obtained by Ofori-Danson (1992) for female of *S. schall* in the Kpong Headpond (Ghana). Maturation of fish may be affected by several physical and biological factors, and these may account for the discrepancies observed between the findings of different authors. The influence of varying environmental conditions on maturity and reproductive traits have been shown in studies by Laë (1997), Lévêque (1997), Duponchelle et al. (1998), Duponchelle & Legendre (2001) and Panfili et al. (2004) in other West African aquatic systems.

It is clear from the drop in monthly G.S.I that spawning of *S. schall* and *S. nigrita* in the Ouémé River occurs from August to October which coincides with the flooding period of the river. This, however, is not in agreement with other observations on fish reproduction ecology in other floodplain environments. Welcomme (1979) and Baras & Lalèyè (2003) indicated that the majority of floodplain fish species initiate spawning after horizontal flooding has begun, i.e. well into the rainy season. In Lake Chad, the spawning activity for *S. schall* occurs from mid-July through September (Blache, 1964). The different environmental and climatic conditions in the habitats could explain the discrepancies observed. As conditions change during the year with the change in season, the suitability of the environment for the vulnerable early life-history stages will vary. A fish should reproduce at that time of year that will tend to maximize its lifetime production of offspring. The larval fish must hatch into a world that can provide appropriate food, protection from predators and benign abiotic conditions (Wootton, 1994).

The two species have different fecundities. Though, *S. nigrita* produces more oocytes compared to *S. schall,* when comparing the smallest sizes at maturity, egg production by *S. schall* out-numbers that of *S. nigrita* after reaching the size of 20 cm TL. These values varied greatly from counts given for *S. schall* by Ofori-Danson (1992) from Kpong-Headpond (14000-165000 eggs), Nawar (1959) from the Nile River (7000-130000 eggs), Halim & Guma'a (1989) from the White Nile River (10000-90000 eggs), Olatunde (1989) from Zaria (Nigeria) (2014 - 13262). The great variations in the number of eggs produced by the individual of a certain species were demonstrated for a large number of other tropical fishes (Nawar, 1959; Awachie & Ezenwaji, 1981; Lalèyè et al., 1995; Baras & Lalèyè, 2003 and many others). Apart from the environmental factors, the differences observed may be, in part, attributed to the methods used for fecundity estimation.

Eggs diameters at ripe stage were greater (0.8 mm-1.5 mm) in *S. nigrita* than in *S. schall* (0.5 mm-1.00 mm). For *S. schall*, Halim & Guma'a (1989) reported a range of 0.6 mm to 0.9 mm from White Nile in Khartoom. The greatest estimation (1.15 mm to 1.20 mm) was given by Albaret (1982) for *S. schall* from Ivory Coast. Such variations in the eggs diameters were similarly reported for other tropical fishes (i.e. Awachie & Ezenwaji, 1981).

CONCLUSION

The feeding versatility of *S. schall* and *S. nigrita* coupled with the high fecundity enables these species to overcome perturbations, natural or human induced, in the Ouémé River. Life-history of species is influenced by varying ecological conditions and highly tolerant species, such as the catfishes, are promising candidates for commercial exploitations.

ACKNOWLEDGEMENTS

This research has been financially supported by the Belgium Development Cooperation (DGCD, Biodiversity and Aquaculture of Catfishes in Benin' Project). Our gratitude goes to all the fishermen for their cooperation and assistance. We are also grateful to the anonymous referees for their constructive reviews of this manuscript.

REFERENCES

Albaret, J.J. (1982). Reproduction et fécondité des poissons d'eau douce de Côte d'Ivoire. *Revue d'Hydrobiologie Tropicale*, 15 (4) : 347-371.

Awachie, J.B.E. & H.M.G. Ezenwaji. (1981). The importance of *Clarias* spp in the fisheries developpement of the Anambra river basin, Nigeria. *CIFA Technical Paper*, 8 : 212-224.

Araoye, P.A. (1999). Spatio-temporal distribution of the fish *Synodontis schall* (Teleostei : Mochokidae) in Asa lake, Ilorin, Nigeria. *Revista de Biologia Tropical*, 47 : 1061-1066.

Bagenal, T.B. & E. Braum (1971). Eggs and early life history. In : Ricker W.E. (ed), *Methods for assessment of fish production in freshwaters* (2nd ed.). International Biological Programme, 3. Oxford and Edinbourgh. pp 166-198.

Baijot E., J. Moreau & S. Bouda (eds) (1997). Hydrobiological aspects of fisheries in small reservoirs in the Sahel region. C.T.A. Publ. 252 p.

Baras, E. & P. Lalèyè (2003). Ecology and Behaviour of Catfishes. In : Arratia G., B.G. Kapoor, M. Chardon & R. Diogo (eds), *Catfishes*. Vol. 2, Science Publishers, Inc. USA. pp 525-579.

Bishai, H..M. & Y.B.A. Gideiri (1965a). Studies on the biology of the genus *Synodontis* at Khartoum. 1. Age and growth. *Hydrobiologia*, 26 : 85-97.

BISHAI, H.M. & Y.B.A. GIDEIRI (1965b.) Studies on the biology of the genus *Synodontis* at Khartoum. 2. Food and feeding habits. *Hydrobiologia*, 6 : 98-113.

BISHAI, H.M. & Y.B.A. GIDEIRI (1968). Studies on the biology of the genus *Synodontis* at Khartoum. III. Reproduction. *Hydrobiologia*, 31 : 193-202.

BLACHE, J. (1964). Les poissons du bassin du Tchad et du bassin adjacent du May Kebbi. Etude systématique et biologique. Paris. *Cahiers Mémoires ORSTOM* 4 (2) : 1-485.

COLOMBANI J., J. SIRCOULON, F. MONOD & J. RODIER (1972). Monographie du delta de l'Ouémé (tome 1). Rapport O.R.S.T.O.M., Hydrol., France, Bondy, 200p. (Ronéo).

DAGET, J. (1954). Les poissons du Niger supérieur. Dakar. *Mémoires I.F.A.N*, 36 : 1-391.

DAGNELIE, P. 1973. Théorie et méthodes statistiques. *Press. Agron. de Gembloux*, 1, 378 p.

DUPONCHELLE, F., L. POUYAUD & M. LEGENDRE (1998). Evidence effects on reproductive characteristics of Nile tilapia (*Oreochromis niloticus*) populations from man-made lakes of Ivory Coast. *Aquatic Living of Resources* 11 (3) : 137-144.

DUPONCHELLE, F. & M. LEGENDRE (2001). Rapid phenotypic changes of reproductive traits in response to experimental modifications of spatial structure in Nile tilapia (*Oreochromis niloticus*). *Aquatic Living of Resources*, 14 : 145-152.

FAGADE, S.O. & C.I.O. OLANIYAN (1974). Seasonal distribution of the fish fauna of the Lagos lagoon. *Bulletin de l'I.F.A.N.* Tome I Série A : 45-67.

HÅKANSON, L. & V.V. BOULION (2002). The lake foodweb : modelling predation and abiotic/biotic interactions. Backhuys Publishers, Leiden, 344 p.

HALIM, A.I.A. & S.A. GUMA'A (1989). Some aspects of the reproductive biology of *Synodontis schall* (Bloch-Schneider, 1801) from the White near Khartoum. *Hydrobiologia* 178 : 243-251.

HYSLOP, E.J. (1980). Stomach contents analysis- a review of methods and thier application. *J. of Fish Biol.*, 17 : 411-429.

LAË R. (1997). Effect of climatic changes and development on continental fishing in West Africa : the examples of the Central delta of the Niger in Mali and coastal lagoons in Togo. In : REMANE K. (ed), *African Inland fisheries, aquaculture and environment*. FAO, Italy. pp 66-86.

LAGLER, K.F. (1971). Capture, sampling and examination of fishes. In : RICKER W.E. (ed), *Methods for assessment of fish production in freshwaters* (2nd ed.). International Biological Programme, 3. Oxford and Edinbourgh : 7-44.

LALÈYÈ, P., J.C. PHILIPPART & P. PONCIN (1995). Biologie de la reproduction de deux espèces de *Chrysichthys* (Siluriformes, Bagridae) du lac Nokoue et de la lagune de Porto-Novo au Bénin. *Journal of African Zoology*, Vol. 109(3) : 213-224.

LALÈYÈ, P., A. CHIKOU, J.C. PHILIPPART, G. TEUGEULS & P. VANDEWALLE (2004). Etude de la diversité ichtyologique du bassin du fleuve Ouémé au Bénin (Afrique de l'Ouest). *Cybium*, 28 : 329-339.

LAUZANNE, L. (1988). Les habitudes alimentaires des poissons d'eau douce africains. In : LÉVÊQUE C., M.N. BRUTON & G.W. SSENTONGO (eds), *Biologie et écologie des poissons d'eau douce africain*s. ORSTOM, Paris : 221-242.

LE CREN, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch, *Perca fluviatillis*. *J. of Animal Ecol.*, 20 : 201-219.

LÉVÊQUE, C. (1997). Biodiversity dynamics and conservation : the freshwater fish of tropical Africa. Cambridge University Press, United Kindom, 438p.

NAWAR, G. (1959). On the fecundity of the Nile catfish, *Synodontis schall* (Bloch-Schneider, 1801). *Sudan Notes and Records*, 40 : 139-140.

OFORI-DANSON, P.K. (1992). Ecology of some species of catfish *Synodontis* (Pisces : Mochocidae) in the Kpong Headpond in Ghana. *Environnemental Biology of Fishes*, 35 : 49-61.

OFORI-DANSON, P.K., G.J. DE GRAAF & C. VANDERPUYE (2002). Population parameter estimates for *Chrysichthys auratus* and *C. nigrodigitatus* (Pisces : Cloroteidae) in Lake Volta, Ghana. *Fisheries Research*, 54 : 267-277.

OLATUNDE, A.A. (1989). Some aspects of the biology of *Synodontis schall* (Block-Schneider). *Journal of Aquatic Science, :* 49-54.

OLOJO, E.A.A., K.B. OLURIN & O.J. OSIKOYA (2003). Food and feeding habits of *Synodontis nigrita* from the Osun River, SW Nigeria. *Naga, WoldFish Center Quaterly*, 26 (4) : 21-24.

PANFILI, J., A. MBOW, J.-D. DURAND, K. DIOP, K. DIOUF, D. THIOR, P. NDIAYE & R. LAË (2004). Influence on the life-history traits of the West African black-chinned tilapia (*Sarotherodon melanotheron*) : Comparison between the Gambia and the Saloum estuaries. *Aquatic Living Resources*, 17 : 65-74.

PAUGY, D. (1994). Ecologie des poissons tropicaux d'un cours d'eau temporaire (Baoulé, haut basin du Sénégal au Mali) : adaptation au milieu et plasticité du régime alimentaire. *Revue Hydrobiologie Tropicale*, 27 : 157-172.

POLL, M. (1971). Révision des *Synodontis* africains. *Annales des Sciences zoologiques du Musée royal de l'Afrique centrale*, Tervuren, 191 : 497.

SCHOENER, T. W. (1970). Non-synchromous spatial overlap of lizards in patchy habitats. *Ecology*, 52 : 408-418.

TESCH, W. (1971). Age and growth. In : RICKER W.E. (ed), *Methods for assessment of fish production in fresh waters* (2nd ed.). International Biological Programme. Oxford and Edinbourgh. 97-130.

TWEDDLE, D. & J.L. TURNER (1977). Age, growth and natural mortality rates of some cichlid fishes of lake Malawi. *Journal of Fish Biology*, 10 : 385-398.

WALLACE, J. (1981). An assessment of diet-overlap indexes. *Transaction of American Fisheries Society*. 110 : 72-76

WELCOMME, R.L. (1979). Fisheries Ecology of Floodplain Rivers. Longman. 317p.

WELCOMME, R.L. & B. DE MERONA (1988). Fish communities of rivers. In : LÉVÊQUE, C. M.N. BRUTON, G.W. SSENTONGO (eds), *Biologie et écologie des poissons d'eau douce africains*. ORSTOM : 251-276.

WILLOUGHBY, N.G. (1976). The buoyancy and orientation of the upsidedown catfishes of the genus *Synodontis* (Pisces : Siluroidei). *Journal of Zoology*, 180 : 291-314.

WILLOUGHBY, N.G. (1979). Some aspects of the ecology of *Synodontis* (Pisces Siluroidei) in Lake Kainji during its early years. In : *Proceedings of the International Conference on Kainji Lake and River Basins Development in Africa*, Vol. 2. Kainji Lake Research Institute, Ibadan : 376-386.

WINEMILLER, K.O. & L.C. KELSO-WINEMILLER (1996). Comparative ecology of catfishes of the Upper Zambezi River. *Journal of Fish Biology*. 49 : 1043-1061.

WOOTTON, J.R. 1994. Ecology of Teleost Fishes. In : CHAPMAN & HALL (ed). *Fish and Fisheries Series 1*. (4th ed). 404 p.

Received: April 14, 2005
Accepted: June 30, 2006