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THE BREEDING BIOLOGY AND HEMATOLOGICAL PROFILE OF *Gymnarchus niloticus* CUVIER 1829 (OSTEOGLOSSIFORMES: GYMNARCHIDAE) IN SEMI-INTENSIVELY MANAGED PONDS IN THE FLOODPLAIN OF THE RIVER ANAMBRA, NIGERIA

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Abstract- The breeding biology and haematological profile of the commercially important osteoglossid, *Gymnarchus niloticus*,was studied from Ausgust 2011 to December,2012 in semi-intensively managed ponds in the floodplain in the Anambra, river. *Gymnarchus niloticus* matured after the first year when they were 121-189mm in total length. The breeding season lasted from March to September, and recruitment of the osteoglossids into the artisanal fishery began from the latter month. The number of oocytes in both ovaries ranged from 1974-9310. Fecundity-weight relationship was linear and positively correlated = 1451.64+77.19x,r^2 = 0.82. Spawn able oocytes, which constituted over 91% of gonad weight, ranged from 1.05 to 1.75mm in diameter. The haematological characteristics of *Gymnarchus niloticus* (mean weight 140.21±0.21g SD; mean length 114.22 ±0.15cm SD) from the semi-intensively managed ponds of River Anambra were assessed and the values recorded were (mean±SD), Haemoglobin (Hb) 6.44±0.43g dL^{-1}; Haematocrit (Ht) 20.80±0.43%; Leucocrite (Lct), 6.93±0.29%; White Blood Cells (WBC), 29.64±0.67x10^9 cells L^{-1}; Red Blood Cell (RBC) 2.53±0.03x10^{12} cells L^{-1}; Mean Corpuscular Haemoglobin (MCHC), 31.36±0.98g dL^{-1}; Mean Corpuscular Haemoglobin (MCH) 25.60±0.81pg; Mean Corpuscular Volume (MCV) 81.16±1.81fl; Thrombocytes (Thr), 173.93±3.46%, Neutrophils (Neut) 35.81±0.85%; Lymphocytes (Lymp) 46.09±1.01%; Monocytes (Mon) 2.25±0.09%. The highest range of the parameters was recorded in thrombocytes platelets, while the lowest was observed in RBC. Significant differences (P<0.05) between males and females were observed in (Hb), (Ht), (RBC) and thrombocytes, when compared with the values recorded in MCHC, MCH, MCV, WBC, neutrophils, lymphocytes and monocytes.

Keywords- *Gymnarchus niloticus*, breeding, floodplains ponds, Anambra River, environmental factors, early juvenile

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Introduction

The osteoglossid fishery is one of the major fisheries of the semi-intensively managed ponds of Anambra river basin, Nigeria contributing about 9% of the 6000t^{-1} $year^{-1}$ fish yield. In Nigeria, the total fish production per annum stands at about 452146 metric tons [1]. This is far below the actual current demand, which is 216,800 metric tons per annum. This short fall in fish can be remedied through effective management of the various abundant water bodies and the resources there in. Of the osteoglossid species, *Gymnarchus niloticus* is of considerable local commercial importance and is the most abundant especially in the numerous, often semi-intensively managed small floodplain ponds. Apart from the natural fish food organisms, fish in many of these ponds are sometimes fed with by-products from agriculture-based industries, and from food, such cassava and bread fruit proceed directly in the ponds. A feature of tropical flood river systems having a bearing on reproduction and environmental factors and which is prominent in the river Anambra system is the alternation of the flood phase with the dry phase [2,3].

During the flood phase the *Gymnarchus* species occurs mainly in densely neglected swamps where this species of grass, *Echinolao pyramidalis*, about a meter in diameter and at depths of about 1-1.5 m, with a the perimeter builds elliptical floating nests extending several centimeter above the water, except for a small opening through which the fish enters and leaves the nest. The flesh, very oily, has strong rich flavors and is greatly esteemed by most Nigerians. The unique electric organs have been studied extensively [4].

A basic requirement for the management of *Gymnarchus* fishery is an understanding of the reproductive biology of the species, which fisheries managers manipulate to optimize production. While aspects of the biology of other osteoglossid species are beginning to be worked out [5] breeding in *G. niloticus*, including the environmental factors operating and influencing the osteoglossid during spawning and early juvenile migration in the Anambra flood river system has not been investigated. Also the uses of hematological characteristics have been used to diagnose the health status of fish for its management under captive rearing. The knowledge of the

haematological profile of a fish also indicates its dietary sufficiency and physiological response to environmental stress. The hematological profile of a few tropical African fish *spp.* have been reported mainly Cat fishes [6-8] *Heterotics niloticus* [5,9]. These observations on the breeding and haematology of *G. niloticus* focus on gonad maturation, fecundity, spawning and early juvenile migration. It also deals with some environmental parameters influencing these biological attributes, the haematological parameters of the *G. niloticus* and the mean values of the blood parameters as a guide for the management and local production of the fish.

Materials and Methods

The study area was the lower reaches of the river Anambra basin (6° 10' and 70° 20° N: 6° 35' and 7° 40' E) [Fig-1] close to Onitsha where the river Anambra.

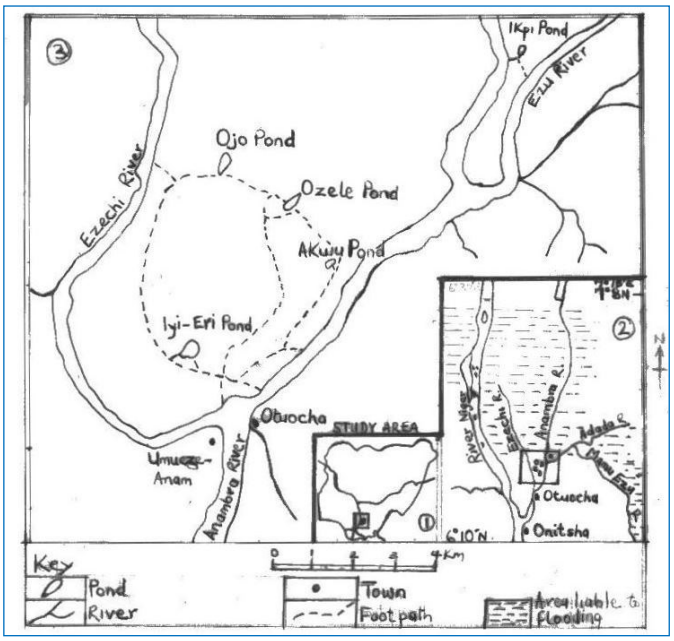

Fig. 1- Map of Anambra River showing the floodplain ponds

This flows in a southwesterly direction throughout its course, discharges into the river Niger. The floodplain in this area is very extensive, about 40 km in some stretches, and has numerous perennial ponds [10,11]. The mean pond and river surface temperatures are 28.90°C (range 25.30-32.40°C) and 27.03°C (range 25.31°C) respectively [5]. The vegetation is derived Guinea savannah; the ponds riparian shrubs are dominated by Rubiaceae and Papillionaceae (= Fabaceae) (e.g. *Pterocarpus spp.* and *Dalbergia spp.*), Cyperaceae and Granmineae (e.g. *Bossia cuspidaa, Paennisetum spp.* and *Cynodon spp*). The latter families and *Ceratophyllium* are abundant in *Gymnarchus* spawning grounds. The climate comprises a rainy season from April to September and a dry season from October to March. These seasons generally correspond to the flood phase and dry phase of the hydrological cycle respectively. During the rainy season, the inundated floodplain is conductive to the reproduction of many fishes [3,12] and the floodplain ponds are naturally, and rarely intentionally, stocked. The total floodplain area of the river Anambra basin is about 165,000 ha and the flow rate in the floodplain ranges from 0.6 to 3 $m.s^{-1}$ [14]. The water in the floodplain begins to discharge from the middle of October. The mean total annual rainfall is 180±30 cm [12]. Many types of food crops are planted and/or harvested during the dry season. Thus enabling establishment of agriculture-based industries which generate by products used as supplementary food in floodplain ponds. In this period also over 75% of fish harvested from floodplain ponds of less than 5000 m^2 are *Gymnarchus* species, and these account for about 70% of fish in the local river port market at Otuocha [10].

Breeding Studies

Samples of *Gymnarchus* were collected from the river systems and floodplain lentic water bodies, particularly from five ponds: Iyi-Eri, Ojo. Ozele, Ikpi and Akwu [Fig-1]. Collections were taken at least once a month from August 2011 to December 2012 using hook and line, baskets and traps with non-return valves. Collections from the Iyi-Eri, Akwu and Ozele spawning grounds were made from April to July 2012. The length (mm total length) and the sex determined. The five ponds were chosen for being representative types of floodplain ponds in the basin and for easy accessibility. Samples from these ponds (which receive various agricultural by-products as supplementary food) and for corresponding months were pooled for gonad maturation studies. Gonads were evaluated macroscopically following recognized six maturity stages (I-immature, II-developing, III-mature, IV-ripe, V-running and VI-spent) in female and four (I-immature, II-developing, III-mature and VI-spent) in male *Gymnarchus* species. Four stages IV and V were indistinguishable from stage III. In males and females, gonad stages III to V represent breeding condition, with oocytes being vitellogenic. Size at maturity was determined as the length at which up to 20% individuals were in gonad stage III. The breeding season was delineated by the presence of gonad stages IV to VI in temporal samples. The gonadosomatic index (GSI) of mature females was calculated using the formula shown in [Eq-1]:

$$GSI = \frac{wet\ gonad\ weight}{wet\ fish\ weight} x100 \qquad (1)$$

All ripe (stage IV) ovaries were preserved in Gil-son's fluid. The separated oocytes were run through seven graded sieves of 0.35 to 2.00 mm aperture size, and the oocyte diameters confirmed using a graduated ocular eye piece micrometer. Fish samples of live fish (mean weight 120 g ± 16.14, mean standard length 35.17 cm ± 2.18) used in the study were acclimatized for two weeks in plastic aquaria, during which they were fed twice daily with artificial commercial feed and ground shrimps obtained locally to avoid the possible effect of starvation on any of the haematological parameters before the commencement of the study. The fish were divided randomly into four groups (1-4) of 16 fishes per ground.

Haematological Studies

Six hundred and twenty adult *G. niloticus* (mean weight; 140.12 ± 0.42 g SD; mean length 110.22 ± 0.14 SD) were collected from semi-intensively managed ponds during the low tide and sexed. Eighty four male and female fish were sampled and blood sampled collected from the kidney behind the anal fin. Blood samples were obtained with heparinized plastic syringe, fitted with 21 gauge hypodermic needle and preserve in disodim salt of Ethylene Diamine Tetra Acetic Acid (EDTA) bottles for analysis. Physico-chemical parameters of the waters in the recruitment ponds were taken by using standard methods of APHA [15]. Standard haematological procedures described by Brown [16] were employed in the assessment of the various blood parameters. Haemoglobin (Hb) test was done by the cyanomethaemoglobin method, Packed Cell Volume (PCV) by microhaematocrit method by the Micro-Wintrobe method WBC was determined with the improved Neubauer counter; differential count was done on blood film stained with Grumwald-Giemsa

stain, RBC was estimated using the relationship between Hb and PCV [17]. The following indices: Mean Corpuscular Haemoglobin Concentration (MCHC) and Mean Corpuscular Volume (MCV) were calculated according to Brown [16]. Leucocrit was done according to Wedemeyer, et al [18].

Fecundity, defined as the number of ripening oocytes in the female prior to the next spawning period [19] was determined by direct counting of all ripe oocytes in both ovaries. Regression analyses of fecundity (F) on total length and weight (W) were performed using the least squares method. Communal spawning was inferred using samples of *Gymnarchus* species collected from Iyi-Eri, Akwu, Ojo, Ikpi and Ozelle spawning grounds. Observations on spawning aggregation, migration and actual spawning were made from elevated platforms along the banks of the pond spawning grounds. Data obtained from the experimental fish were subjected to analysis with the General Linear Model (GLM) of ANOVA at 0.05% probability and differences among means were separated with the significant difference using SAS software. To determine the key environmental parameters affecting spawning and early juvenile migration, temperature (°C), current speed (ms^{-1}), conductivity (μScm^{-1}), dissolved oxygen (mg 1^{-1}) and pH, which affect these biological attributes [2,20] were measured, each parameter being replicated in at least three different points in the spawning grounds.

Results

Size and Abundance

G. niloticus in the river system and floodplain ponds ranged from 78 to 295 mm in total length. The length versus frequency distribution of the osteoglossid is shown in [Fig-2]. The 101 to 150 mm total length group was more abundant than the other length groups (p<0.05) [Table-1]. The 251-300 mm and 201-250 mm in total length group was the least abundant but not significantly differently from the groups 151-200 mm and 201-250 mm in the total length. The osteoglossid was more abundant in Akwu pond than in the other ponds (p<0.05) [Table-1]. The osteoglossid fish appeared to be evenly distributed, and frequently occurred in the entire habitat studied. These osteoglossids occur through the year but with the peak from June-August [Table-2].

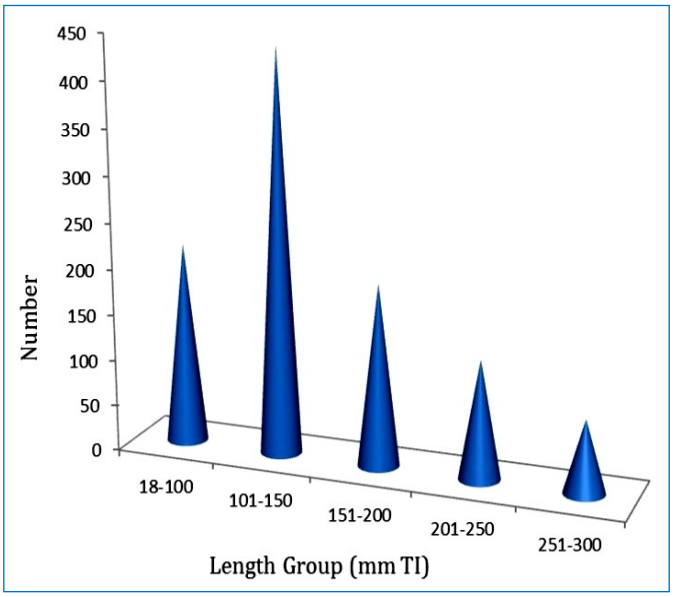

Fig. 2- Length versus frequency distribution of *G. niloticus*, the samples collected for seventeen months

Table 1- The abundance of G. niloticus in relation to length group and ponds. (Figures with the same superscript in the same row or column are not significantly different at p=0.05).

Total Length (mm)	Ponds					
	Akwu	Ikpi	Ozelle	Ojo	Iy-Eri	Total
78-100	98	52	45	45	12	252[b]
101-150	155	92	98	82	26	453[a]
151-250	61	35	46	38	120	300[bc]
201-250	53	14	13	24	23	127[bc]
251-300	12	12	14	120	25	183[c]
Total	379[a]	205[b]	216[b]	309[b]	206[b]	1315

Also the number of G. niloticus in the various habitats showed no significant difference (p = 0.05)

Table 2- Abundance and percentage of occurrence (%FO) of G. niloticus in the studied habitats

Ponds	Vegetation habitat		Grass habitat		Swampy habitat		Habitat total
	No	%FO	No	%FO	No	%FO	
Akwu	16(0.8)	71	11(0.5)	68	19(1.2)	94	46[a] (2.5)
Ikpi	12(0.5)	93	14(0.7)	80	16(0.8)	77	42[a] (2.0)
Ozelle	18(0.9)	86	19(1.0)	79	12(0.7)	82	49[a] (2.6)
Ojo	14(0.7)	68	16(0.9)	71	15(0.6)	68	45[a] (2.2)
Iyi-Eri	17(0.6)	58	13(0.6)	64	14(0.7)	70	44[a] (1.9)
Hatital Total	77[a]		73[a]		76[a]		
%habitat total	32.6		31.2		33.3		226

%F0 = Percentage Frequency of occurrence, and a = the figures in the same column or row with the same superscript are not significantly different p = 0.05. Abundance and % F.O. in habitants (values in parentheses wt. kg).

Morph Metric Parameters

The LWR analyses of the 12 populations are presented in [Table-3]. The analyses further indicate that the calculated correlations were significant (p<0.05) with coefficient of determination ranging from 48 -98.5%.

Table 3- Length-weight relationships and related statistics in Gymnarcus niloticus (May 2011-March2012)

Month	Total length				Length-weight relationships			
	Mean	SD	Min	Max	a	B	r	N
M	106	0.67	105	108.4	0.0099	2.821	0.946	50
J	106.37	0.73	103.4	106.7	0.0227	2.192	0.735	50
J	106.56	0.56	105.9	108.5	0.0087	2.89	0.992	50
A	106.8	0.46	106.1	108.2	0.0112	2.906	0.977	50
S	105.45	0.59	104.6	107.3	0.01153	2.704	0.972	50
O	106.48	0.65	105.6	108.3	0.0307	2.348	0.949	50
N	106.04	0.43	105.3	107.3	0.0113	2.801	0.933	50
D	104.53	0.51	103.8	106	0.0135	2.612	0.968	50
J	105.7	0.28	105.1	106.3	0.0133	2.564	0.692	50
F	105.78	0.81	104.7	108	0.0116	2.859	0.967	50
M	106.2	0.5	105.4	107.9	0.0317	2.317	0.884	50
Overall	105.99	0.63	103.4	108.4	0.0086	2.939	0.941	550
Rainy season	106.3	0.57	103.4	108.4	0.0081	2.942	0.945	300
Dry season	105.6	0.62	103.8	108.3	0.006	3.169	0.941	250

Size at Maturity

Both sexes of *G. niloticus* matured in the same period. Males matured at a length of 120 mm total length and females at 110 mm total length and over 80% of both sexes attained maturity at ³140 mm total length. The smallest mature male and female *G. niloticus* was detected at 112 mm total length and 100 mm total length respectively [Table-4].

Table 4- The relationship between body weight and total length of the G. niloticus ($W = a\ TL^b$)

Length		Sex	N	A	B	r^2	*p*
Min (mm)	Max (mm)						
109	189	Female	154	$3.9x10^{-3}$	2.978	0.97	<0.001
98	181	Males	148	$1.2x10^{-2}$	3.109	0.869	<0.001
207	370	Both sexes	302	$9.3x10^{-3}$	2.79	0.872	<0.001

Fulton's Conditions Factor (K)

The mean monthly K was 0.78 ± 0.11 and varied from 0.61 ± 0.16 in June to 0.92 ± 0.10 in March [Table-5]. The Osteoglossids were in very good condition in September, October, February and March, whereas the poorest conditions occurred in January, June and July.

Table 5- Mean monthly condition factor, K, of Gymnarchus niloticus from the Anambra River

Month	Mean K ± SD
M	0.72 ± 0.07
J	0.61 ± 0.16
J	0.69 ± 0.06
A	0.77 ± 0.08
S	0.90 ± 0.11
O	0.91 ± 0.09
N	0.79 ± 0.06
D	0.76 ± 0.06
J	0.63 ± 0.07
F	0.91 ± 0.09
M	0.92 ± 0.10
Overall mean	0.78 ± 0.11

Reproductive Biology

The mean monthly gonad somatic index (GSI) of 94 female varied 1.1-33% (mean 2.05 ± 0.72%). There were only slight variations in the mean monthly GSI indicating an all year round reproductive pulse, although three peaks in June, September *G. niloticus* and January were evident [Fig-5]. The monthly dynamics in the percentage male and female at each maturation state [Table-6] showed that immature, mature, ripe and spent gonads were present throughout the year indicating an all year round gonad recrudescence, breeding period and recruitment. There were significantly more females than males in immature stage ($X^2 = 4.4$, df = 1, $p<0.05$) and spent stage ($X^2 = 19.6$, df = 1, $p<0.05$) Males and females did not depart from a 1:1 sex and in mature and ripe *G. niloticus* [Table-6].

Table 6- The dynamics of female and male G. niloticus in maturation stages

Maturation stage	Female	Male	Sex Ratio
Immature	102	73	M : F
Mature	86	93	1.1
Ripe	74	71	1 : 1
Spent	34	6	0.2
Total	296	243	0.8

The size at maturity varied between females and males. The smallest female matured at 104.3 mm TL, whereas in the males it was at 103.4 mm TL. Over 50% of female sexes matured at 104.7 mm TL. Oocyte count of 15 females ranged from 126 to 1580 (mean 896 ± 477 oocytes). The regression equations for the relationships between fecundity and total length and ovary weight ($F = aX^b$, where X stands for either total length or ovary weight) were:

$$F = 21.93TL^{1.82},\ r = 0.37$$

$$F = 847.65\ OW^{0.04},\ r = 0.02$$

The correlations were positive but low; total length had a better predicative value of 0.37 than ovary weight (0.02).

Gonad Maturation and Breeding Season

G. niloticus with immature (Stage I) gonads, absent from May to August [Table-7], appeared to be recruited into the fishery in September. [Table-7] also shows that mature (Stage III) gonads were presents for 8-9 months; gonad recrudescence lasted for about 5 months (October-February) when there was no ripe (Stage IV), running (Stage V) or spent (Stage VI) gonads. Thus, the breeding season seemed to last from March to September with a peak from April to June.

Table 7- Monthly percentage occurrence of males and females of G. niloticus with gonads in different stages of maturity In males, stages III, IV and V are grouped under III.

Month	No of Males Examined	Stages of Gonad Maturity										No of Females Examined
		I	II	III	VI	I	II	III	IV	V	VI	
October	34	36.1	63.9	-	-	50	42.9	7.1	-	-	-	26
November	46	39.6	52.1	8.3	-	28.2	61.5	10.3	-	-	-	37
December	48	38	46	16	-	36.2	42.6	21.3	-	-	-	45
January	31	12.1	24.2	63.6	-	18.8	28.1	53.1	-	-	-	30
February	32	25	20	55	-	24.1	6.9	69	-	-	-	27
March	42	27.3	18.2	54.5	-	30.3	18.2	33.3	18.2	-	-	31
April	16	16.7	22.2	51.1	-	3.2	6.5	51.6	38.7	-	-	29
May	13	-	40	0	-	-	3.1	6.3	53.1	37.5	-	30
June	24	-	11.5	19.2	69.2	-	4	4	56	-	36	23
July	11	-	30.8	-	69.2	-	4.8	-	28.6	14.3	52.4	19
August	39	-	63.4	-	36.6	-	52.6	-	-	-	47.4	36
September	28	13.3	56.7	-	30	2.9	71.4	-	-	-	25.7	33
Total	364											366

The sex ratios of *G. niloticus* are shown on [Table-8]. The monthly sex ratio ranged from 1:0.1 for Ozelle in December to 1:2.0 for Akwu in the month of September, the overall sex ratio of *G. niloticus* in the ponds ranged from 1:0.3 to 1:1.5 with a modal sex ratio of 1:0.7 in favour of the males [Table-8]. The Akwu and Ozelle ponds showed more pronounced sex ratio similarity than the Ojo pond. [Fig-3] Shows cyclic changes in the percentage numbers of non-breeding and breeding male and female individuals. Breeding osteoglossid appeared to be present all the year round with a peak lasting 5-6 months (January to May or June). Breeding males showed more rapid gonad development than females with peaks in March and May respectively. The latter peak coincided with that of mature female gonad somatic index (GSI) [Fig-4]. Non-breeding individuals were dominant for 5 months (August-December).

Table 8- The sex ratio of G. niloticus in the ponds

Month	Akwu		Sex ratio	Ikpi		Sex ratio	Ozelle		Sex ratio	Ojo		Sex ratio	Iyi Eri pond		Sex ratio
	M	F	M : F	M	F	M : F	M	F	M : F	M	F	M : F	M	F	
Jan.	9	24	1 : 0.7	19	11	1 : 0.6	20	12	1 : 0.6	-	-	- : -	11	17	1 : 0.5
Feb.	17	7	1 : 0.3	7	2	1 : 0.3	12	8	1 : 0.5	-	-	- : -	13	6	1 : 0.4
March	7	9	1 : 1.4	-	-	- : -	7	9	1 : 1.4	-	-	- : -	8	10	1 : 0.8
Apr.	36	38	1 : 0.8	12	13	1 : 0.6	11		1 : 0.5	-	-	- : -	32	23	1 : 0.7
May	45	49	1 : 1.1	23	2	1 : 0.9	14	17	1 : 1.2	8	11	1 : 14	44	47	1 : 0.9
June	62	42	1 : 0.7	29	11	1 : 04	13	16	1 : 1.2	20	14	1 : 0.7	62	39	1 : 0.6
July	9	33	1 : 0.6	35	26	1 : 0.7	23	11	1 : 0.5	-	-	- : -	14	34	1 : 0.4
August	46	29	1 : 0.7	24	11	1 : 0.5	18	19	1 : 0.9	-	-	- : -	38	26	1 : 0.7
Sept.	17	38	1 : 2.0	-	-	- : -	21	25	1 : 1.4	8	13	1 : 1.6	15	28	1 : 0.6
Oct.	17	27	1 : 1.5	-	-	- : -	17	27	1 : 1.5	-	-	- : -	19	7	1 : 0.3
Nov.	11	8	1 : 0.7	-	-	- : -	11	7	1 : 0.7	-	-	- : -	48	17	1 : 0.4
Dec.	59	19	1 : 0.3	32	17	1 : 0.5	32	6	1 : 0.1	-	-	- : -	45	25	1 : 0.6
Total	335	323	1 : 0.7	181	93	1 : 0.6	199	157	1 : 0.8	36	38	1 : 1.1	349	279	

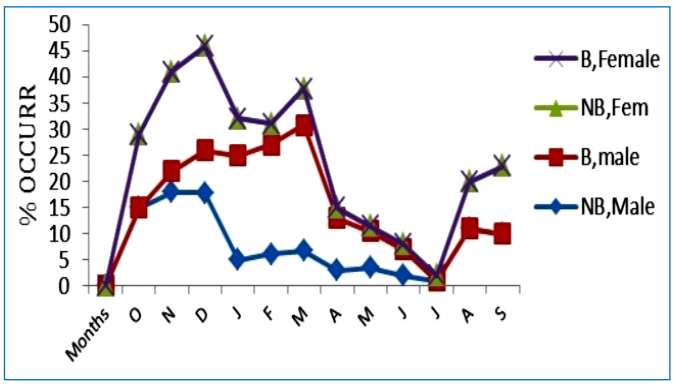

Fig. 3- *G. niloticus* cyclic change in (a) percentages of breeding (B) and non- breeding (NB) males (b) percentages of breeding (B) and non-breeding (NB) females

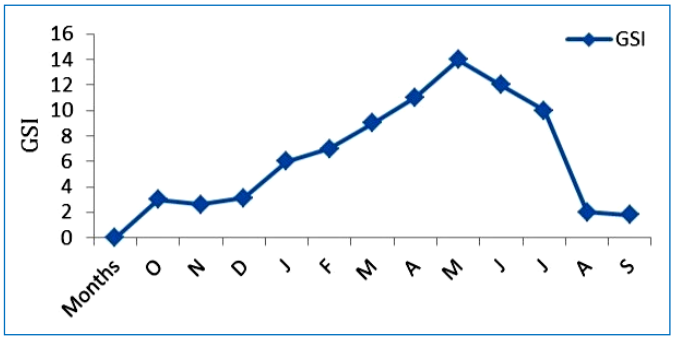

Fig. 4- Mature female gonado somatic index (GSI) with standard deviation

Fecundity

Fecundity ranged from 1974 for an osteoglossids of 100 mm total to 9310 oocytes for individuals of 295 mm in total length. It was related linearly to total length [Fig-5](a) and weight [Fig-5](b). The correlations between them were positive and significant (p<0.001), but body weight had a higher predictive value than total length. The size of oocytes from the ovaries of 46 females *G. niloticus* collected between April and June inclusive, varied from 0.35 to 1.75 mm in diameter with peaks at 0.35 and 1.21 mm [Fig-6]. Oocytes that would have been shed in current breeding season was from 1.05 to 1.75 mm and contributed 91±3% of ovary weight, while non-spawn able oocytes (³1.05) provided only 91±3%. The mean diameter of spawned eggs 8 hrs. after deposition in water was 1.9±0.2 mm (n =.

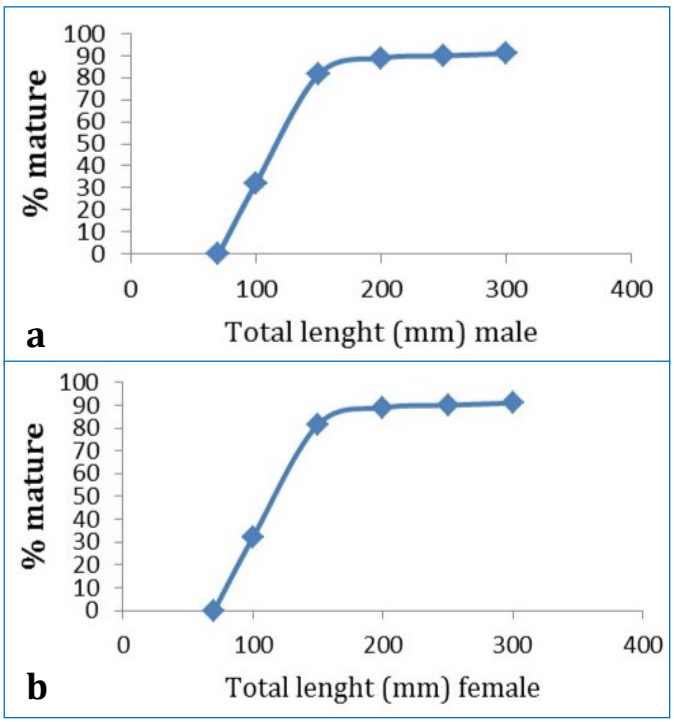

Fig. 5- Percentage of mature male (a) and female (b) *G. niloticus* in relation to total length

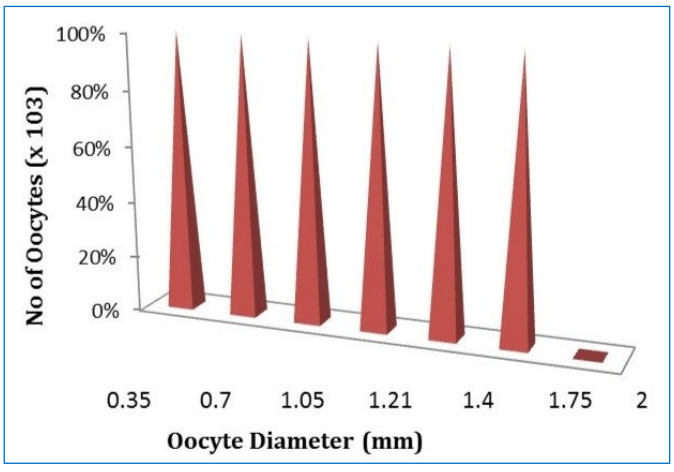

Fig. 6- The Diameter versus frequency distribution of the oocytes of 57 *G. niloticus* for nine months

Spawning and Juvenile Migration

Spawning takes place after inundation by local rainfall in areas adjacent to the ponds, the eggs being deposited mainly on submerged leaves of grasses, sedges and *Ceratophyllum.* Of the environmental parameters [Table-9], only conductivity was statistically different during spawning, while the current speed and dissolved oxygen were higher during early juvenile migration than during other periods. In fact, no migrating juveniles were caught at any seasonal channel with a current speed of less than 0.08 ms^{-1}. Since the speed of the current affected the dissolved oxygen [Table-9], the former was considered more critical in triggering juvenile migration, which took place only at night and in groups.

Table 9: Environmental variables and Gymnarchus niloticus at Iyi-Eni pond iv spawning ground (17 May, during spawning (a); 18 May, 28 hours after spawning (b); and 14 September 2012, during juvenile migration, 120 days after spawning (c)). Mean figures in the same column with the same superscript are not statistically different, p = 0.05.*

Current m/s	pH	Conductivity (µ s cm^{-1})	Dissolved Oxygen (mg l^{-1})	Temperature (^{0}C)	Salinity	Ammonium nitrogen	Ammoniun nitrite
0.02±0.004^b	7.54±0.03^a	40±0.08^b	5.5±0.08^b	29±1.6^a	11.81±0.9^a	0.46±0.31^a	0.0043±0.01^a
0.02±0.006^b	7.4±0.08^b	45±1.6^b	5.4±0.08^b	29±0.8^b	13.1±0.5^b	0.45±0.29^a	0.0044±0.03^b
0.1±0.008^a	7.50±0.08^a	46±0.8^a	5.9±0.08^a	28±1.6^a	12±0.7^a	0.47±0.31^a	0.0041±0.02^c

The juveniles were probably swept by water current from the distributor water channels to the river or sometimes to the ponds. Spawners and juveniles were heavily fished by local fishermen using especially traps and baskets. In the Iyi-Eri and Ozele spawning grounds, the latter fishing gear was used in February 2012 to scoop up standard *Gymnarchus* larvae resulting from a minor spawning in January 2012 after the first few heavy rains. The mean physic-chemical characteristics of the water in the ponds were temperature, 28.14±0.26°C; pH 6.6±0.13; ammonia nitrogen, 0.47.47±0.01 mgL^{-1}; ammonium nitrite, 0.0042±0.01 mgL^{-1}; dissolved oxygen, 4.26±0.33 mgL^{-1}; and salinity, 12.34±0.16%.

The haematology profiles of *G. niloticus* male and female [Table-10] indicated that the platelets values (78-220x10^0 cells L^{-1}) observed in males was higher than (112-210x10^6 cells L^{-1}) recorded in female, RBC (1.90-2.80x10^{12} cells L^{-1}) value observed in male was lower than (1.90-2.90x10^{12} cells L^{-1}) recorded in female. The mean values of pooled data [Table-10] for male and female fish indicated that in most of the parameters, the values for the female were higher than that of the male.Significant differences (p<0.05) between males and females were observed in (Hb), (Ht), (RBC) and thrombocytes, when compared with the values recorded in MCHC, MCH, MCV, WBC, neutrophils, lymphocytes and monocytes.

Table 10- Haematological profile of male and female G. niloticus from the semi-intensively managed ponds in the flood plain of River Anambra

Parameter	Male			Female		
	*Mean ± SD	Minimum	Maximum	*Mean ± SD	Minimum	Maximum
Hb	5.99±0.28^b	1	7.6	6.94±0.27^a	1.6	8.2
PCV	19.91±0.37^b	16.2	23.4	21.80±0.78^a	10.1	27.3
Lct	7.05±0.41^a	3.6	12.6	6.8±0.44^b	3.2	11.7
WBC	29.57±0.81^a	22.6	40	29.73±1.11^a	17	38
RBC	2.46±0.04^b	1.9	2.8	2.60±0.05^a	1.9	2.9
MCHC	30.50±1.46^a	4.67	41.46	32.36±1.27^a	15.84	44.31
MCH	24.62±1.18^a	4.54	34	26.69±1.08^a	8.42	34.16
MCV	81.20±1.83^a	65.6	103	81.12±3.28^a	38.33	100.83
Thromb	176.32±5.13^a	78	220	171.24±4.60^b	112	210
Neut	34.90±1.12^a	20.4	41.3	36.83±1.31^b	21.4	48.6
Lymp	45.79±1.41^a	32.7	60.2	46.21±1.49^b	33.7	59.60.20
Monocyte	2.23±0.11a	1.2	3.6	2.28±0.16^b	1.1	3.7

Hb: Haemoglobin (g dL-1), Ht: Haematocrit (%), Lct: Leucocrite (%) Mcv: Mean Corpuscular Volume (fl) WBC: White blood count (cellsx109 cells L-1); RBC- Red blood cells (cellsx1012 1-1). MCH: Mean Corpuscular Haemoglobin (pg). MCHC: Mean Corpuscular Haemoglobin Concentration (g dL-1), Plt (platelets x109 L-1) Neut: Neutrophils (%) Lymp: Lymphocytes (%), Mono: Moncytes

Discussion

The presence of gonads (Stages III-V) in breeding condition all the year round the cyclic and rapid gonad development and the bimodal peak in ooctye distribution indicate that multiple spawning could occur under natural and favorable environmental conditions [21-23]. This means that even when the endogenous conditions are favorable, spawning does not take place until it is triggered off by the right environmental factors. Thus, the minor and major spawning in *G. niloticus* in the River Anambra basin in January and March to September 2012 when gonads were in the breeding condition were only possible because the exogenous factors of rainfall. Flooding [2,24] and conductivity were adequate. Based on age inferred from lengths versus frequently analysis, *Gymnarchus nilotucs* is interpreted to mature and spawn between first and second year of life at 101-150 mm in total length. During this period the breeding grounds have adequate quantity and quality of larval fish food organisms, vertebrate fish predators are virtually absent and the physic-chemical parameters are optimum thus enhancing the survival of Gymnarchus larvae. The speed of the current during receding water appears to be a critical environmental factor in triggering early juvenile migration to the ponds or river. The flow rate determines the direction of migration depending on the seasonal water channel into which the juveniles were swept. The threshold current speed in the floodplain spawning grounds appears to be about 0.08 ms^{-1} as no migrating juveniles were caught below this value. It does seem that grass, sedges and other aquatic macro-phytes, abundant in these areas, are responsible for the reduction of the speed of the current to this threshold value recorded at the beginning of receding water towards the end of the rainy season. In receding channels where inundated and emergent vegetation are minimal, the current speed was higher. Migration occurs during the night in *Gymnarchus niloticus* as in many tropical and temperate fish species [2,20,25,26]. The nocturnal of *Gymnarchus niloticus* early juveniles appears, like in the adult communal spawners to ensure their protection from fish predators, such as *Gymnarchus niliticus* (personal observation), thus enabling them to enhance their survival. Generally, large numbers of wild *Gymnarchus juveniles* are produced and harvested for food and for stocking ponds all over southeastern Nigeria. However, the indiscriminate exploitation of spawners and juveniles constitutes a major impediment to the full realization of the potential yield of *Gymnarchus niloticus* in the river Anambra basin.

The haematological characteristics of a number of cultural fish species have been studied with the aim of establishing normal values ranges with respect to sex, age, and size, environmental and physi-

ological conditions [6,24,28]. According to Sowunmi [29] sex of a fish is a fundamental factor in establishment of its haematological profiles. The significant differences (p<0.05) between male and female observed in the values of Hb, Ht, RBC and platelets agrees with the findings on *Clarias gariepinus* [29-31] *Clarias isheriensis* [6] *Clarias buthupogon* [32] *Oreochromis niloticus* [33] and *Tilapia guineensis* [28]. The females had higher values of Hb, Ht, Let, RBC, MCH, neutrophils, lymphocytes and monocytes than the males, corroborating that reports by Etim, et al [34] in *Chrysichthys nigrodigitatus* and *Chrysichtys furcatus*; Gabriel, et al [31] in *Clarias gariepinus* and Ibiwoye, et al [35] in *C. angler's*. The females having higher values of blood parameters associate with oxygen transport, suggest that under adverse environmental conditions, that impact negatively on available oxygen, the females may be better equipped to handles such stressors than the males. Besides, in case of injury or diseases the female with high number of lymphocytes, neutrophils and monocytes involved boy defense may be less vulnerable monocytes than the male. Variations were recorded in the values of the various blood parameters within the same sex. Similar observations have been made in other fish species and were attributed to intrinsic factors [24,34].

Conclusion

The conclusion may be reached, therefore, that the plasticity and resilience of breeding attributes of *Gymnarchus niloticus* enable it to survive and thrive in both remote sahalian and coastal environments. Early sexual maturity, rapid growth and recruitment compensate the mortality of species resulting from predation and fishing. Thus the high abundance in Anambra river is sustained. There is a fundamental difference in some of the blood characteristics of male and female *G. niloticus* and within the same sex. This should be taken into consideration when using changes in blood characteristics as indices of health status in the culture of the species.

Conflict of Interest: None declared.

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