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Morphology of the Gonads of *Synodontis eupterus* (Boulenger) from River Rima, North-western Nigeria

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ABSTRACT

This study was carried out to gain knowledge on some aspects of reproduction of *S. eupterus* from River Rima which includes sexual dimorphism, size at first maturity, morphology of the gonads, gonad maturation stages and reproductive cycle. The study was conducted between November 2005 and December 2008. 1,610 samples, comprising of 781 females, 816 males and 13 samples whose sexes could not be identified were examined, giving a female: male ratio of almost 1:1. Means of total length and total weight for females was 10.66±1.61 cm and 18.04±6.39 g, respectively. For males, means of total length and total weight were 10.13±1.29 cm and 13.21±6.02 g, respectively. Sexual dimorphism was observed with the females larger than males and males possessing genital papilla. Size at first maturity for females 7.20 cm total length and 5.70 g total weight and 7.00 cm and 5.10 g in males. Female gonads were larger than those of males. In both sexes, the left gonads were slightly larger than the right ones. Based on macroscopic examination of gonads, six stages of gonad maturation were established in both sexes. Multiple spawning was confirmed for the species, with the peak spawning period between July and September in River Rima.

Key words: *S. eupterus*, size at first maturity, gonad morphology, gonad maturation stages, River Rima

INTRODUCTION

The genus *Synodontis* belonging to the Family Mochokidae is among the most favored edible fish species in northern Nigeria, owing to their tremendous abundance in the artisanal fisheries (Reed *et al*., 1967). It contributes a large proportion of the annual fish landing in the region (Owolabi, 2008). The Genus has 20 species, of which *S. eupterus* (Synonym: *Synodontis macrepipterus,* as reported by Babatunde and Aminu (2004) is a member. It is commonly referred to as the feather fin, squeaker or the upside down catfish. The species is very common in commercial catches and its flesh has excellent flavor which after smoking, has excellent keeping qualities (Reed *et al*., 1967). Holden and Reed (1972) described *S. eupterus* as a small species, with short to medium scaleless body of about 20 cm in length and a bony shield on the head and sides; the colour of the adults of the species is uniformly olive with small round black spots on the body and all the fins and the spots are confluent on the tail and form transverse lines while the juveniles

have the spots arranged in an irregular pattern of tiger like stripes. They further described the species as having a magnificent dorsal fin, with each hard ray extending into long filaments which can vary in different individuals, hence the common name, feather fin; thus, their coloration pattern, grace in movement and extreme toughness make them particularly attractive for aquaria (Reed *et al*., 1967).

This study provides information of the morphology of the gonads and gonad maturation stages of *S. eupterus,* a species of great commercial importance due to its availability the whole year round in the study area, as well as a good candidate in the aquarium industry.

MATERIALS AND METHODS

Study area: The fish samples were collected from River Rima, in Sokoto, northwestern Nigeria. Sokoto lies between longitudes 4°8'E and 6°5'E and latitudes 12°N and 13°58'N (Mamman, 2000). The climate of Sokoto is tropical continental, with much of the rains between June and September while the long dry season is from October and May (Ita *et al*., 1982).

River Rima flows in a south-western direction over 100 km and joins the major River Sokoto to form the Sokoto-Rima river system. The Sokoto-Rima River flows south-westernly in a direction up to Zogirma, where it changes direction and run southwards before emptying into the River Niger. The River is seasonal, usually over flooding its banks during the rainy season in August and September and up to October at times (Mock, 1963).

Fish samples: Samples were collected on a monthly basis for 36 months (November 2005 to December 2008). The samples were examined fresh in the laboratory immediately after collection. On each sample, measurements of total length and standard length (cm) and total weight (g) were taken. Sex was assigned to each sample based on the presence of ovary and testis for female and male, respectively. Possibility of sexual dimorphism, exhibited by most catfishes as a difference in size in the two sexes and also the presence of genital papilla in males (Linder, 2002) was also considered. Gonads were detached and weighed (g). Length and width (cm) of each gonad lobe were measured. Other morphological features of the gonads such as the degree of opacity of the gonads, consistency and vascularization, oocytes or sperm visibility and overall colouration of the gonads were observed. Same features were used to determine the gonad maturity stages (White *et al*., 1998).

For estimating the size at first maturity, the gonadosomatic index of all the samples collected was compared to their total lengths and weights. The smallest size (length and weight) at which mature gonads of both the sexes were found was taken as the first size at maturity (DeSilva, 1973). Observation of the gonad maturation stages on a monthly basis was carried out to determine the annual pattern of gonadal development of the species.

Statistical analysis: SPSS statistical computer package version 11 was employed for the descriptive statistics of the morphometric features and gonad dimensions while DMRT at 95% was employed to separate the means.

RESULTS

Size distribution of *S. eupterus* samples from River Rima based on sex: A total number of 1,610 samples were analyzed, of which 781 (48.50%) were females while 816 (50.70%) were males. The sex of 13 samples (0.80%) could not be identified. The observed female:male ratio was 0.96:1

which was not significantly ($p<0.05$) different from 1:1 ($X^2 = 1.26^{-4}$). Table 1 shows the values of all the body lengths and weights measured based on sex. The mean total length for females was 10.66±1.61 cm which was significantly ($p<0.05$) higher than that of the males at 10.13±1.29 cm. Females were significantly ($p<0.05$) heavier (18.04±0.39 g), than males (13.21±6.02 g). Females were significantly ($p<0.05$) larger than males as indicated by the mean values of all the other morphometric features (SL, FL, HL, GTH and GW) in the Table 1.

Size at first maturity: The smallest mature female with reproductive activity had a total length of 7.20 cm and a total weight of 5.70 g and was in the mature stage. In males, the smallest mature male had a total length of 7.00 cm and a total weight of 5.10 g. The sizes at different stages of gonad maturation are shown in Table 2.

Morphology of the gonads

Shape: Ovaries of *S. eupterus* were paired, smooth, elongated and joined to each other throughout their length by a connective tissue in the immature stage of maturation. They had prominent blood vessels across them. In the maturing stage, they were fuller and less elongated in shape, still covered with blood vessels and joined by connective tissue which receded posteriorly as they mature. Mature ovaries (Fig. 1) were ovoid or almond shaped and free anteriorly, but connected

Table 1: Means of morphometric features of *S. eupterus* samples from River Rima based on sex

Parameter	Overall (N = 1,610)	Female (N = 781)	Male (N = 816)
Total length (cm)	10.36±1.50	10.66±1.61[a]	10.13±1.29[b]
Fork length (cm)	9.03±1.25	9.25±1.37[a]	8.85±1.06[b]
Standard length (cm)	8.08±1.14	8.30±1.23[a]	7.91±0.09[b]
Head length (cm)	2.37±0.38	2.45±0.41[a]	2.29±0.32[b]
Girth (cm)	1.84±0.39	1.93±0.41[a]	1.76±0.33[b]
Total weight (g)	15.59±8.17	18.04±0.39[a]	13.21±6.02[b]
Gutted weight (g)	12.89±6.45	14.35±7.17[a]	11.63±5.31[b]

Mean values with different letters within a row are significantly different at $p<0.05$

Table 2: Size at different stages of gonad maturity in both sexes of *S. eupterus*

			Total length (cm)		Total weight (g)	
Sex	Gonad maturation stage	No. of samples	From	To	From	To
Female	Immature	118	6.70	15.60	3.37	46.52
	Maturing	94	7.70	17.50	5.22	53.10
	Mature	211	7.20	16.50	5.70	72.20
	Ripe running	285	7.50	14.50	4.30	46.20
	Spent	53	7.20	14.60	4.90	41.50
	Resting	10	10.00	14.50	13.80	39.70
	Sub-total	771	6.70	17.50	3.37	72.20
Male	Immature	94	6.00	17.00	2.19	41.60
	Maturing	171	7.60	13.30	3.80	33.20
	Mature	492	7.00	17.30	5.10	62.40
	Ripe running	44	8.50	14.60	7.20	38.30
	Spent	5	10.00	14.60	12.30	37.10
	Resting	8	11.00	12.60	13.78	22.29
	Sub-total	814	6.00	17.30	2.19	62.40

Fig. 1: Mature ovary of *S. eupterus*. Note: The blood vessels covering the ovaries and the fatty tissues in the visceral cavity; and the olive green colour of the ovaries due to olive green eggs and dots of yellow eggs. The yellow fatty tissues were abundant in the visceral cavity

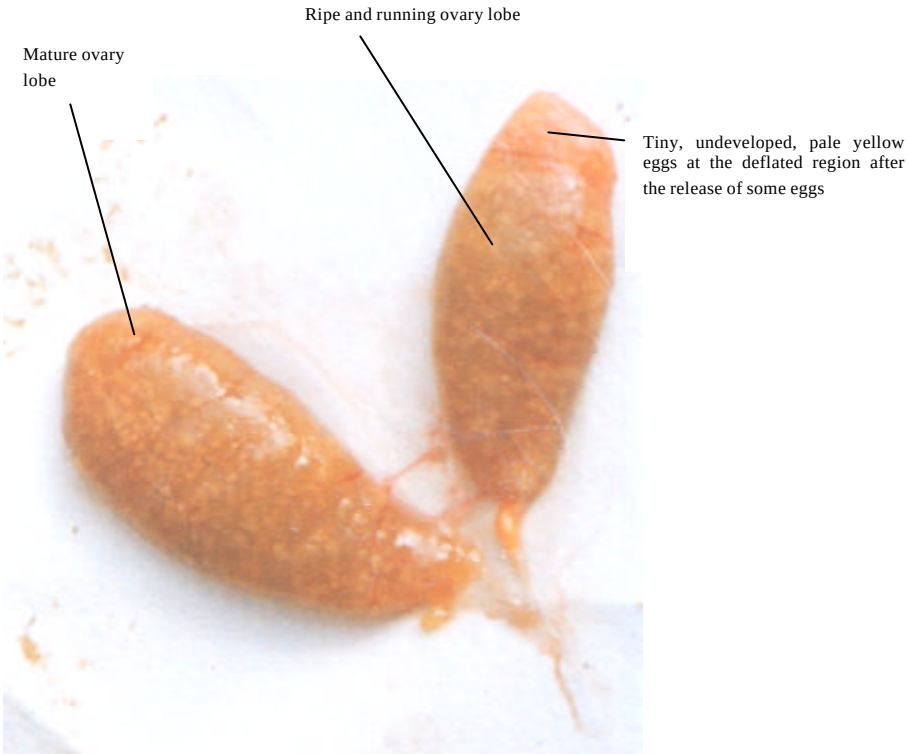

Fig. 2: Ripe and running ovary of *S. eupterus*. Note: Different colours and sizes of eggs showing through the ovarian membrane (yellowish and greenish eggs) in the two lobes. The undeveloped eggs at the tip of the ripe and running lobe may be the ones that may mature later or may be residuals that may not mature at all

only at the posterior, where they opened into the genital aperture. Yellow fatty tissues surround the ovaries. As the ovaries entered ripe and running stage (Fig. 2), they were less oval and became elongated in shape, with the anterior or upper part deflated. Spent ovaries were like deflated sacs

and when stretched, were elongated in shape. Resting ovaries resembled immature ovaries, except for the absence of the connective tissue joining the pair and fewer visible blood vessels.

The testes of *S. eupterus* were paired, elongated, thread like and fused and could not be easily separated in the immature samples. In the maturing stage, they were thicker with rough edges, appearing shorter than the immature ones. Mature testes were flattened, compact structures and leaf-like, striations across them. They were joined along their length by connective tissues. The edges of the testes were rough while the whole testes were covered with prominent blood vessels. Ripe and running testes oozed out milt with the application of pressure on the abdomen and were less firm than mature testes. Spent testes were slimmer, deflated and shrunken and also less leaf-like in appearance. The rough edges were less apparent. Resting testes were slim and thread like and their texture was firmer than the spent testes and more like the immature testes, except that immature testes were also slimmer and firmer, with more visible blood vessels across them than in the resting stage.

Colour: The colour of the ovaries in *S. eupterus* varied with stage of gonad maturation. In the immature stage, the ovaries were pinkish to pale red in colour. The ovaries became darker red, in the maturing stage, containing tiny indiscernible eggs that were reddish in color. Mature ovaries were transparent in colour (Fig. 1), but due to the olive green color of the eggs, they appeared to be olive green in colour. Ripe and running ovaries were also transparent, but as the eggs were released, the ovaries became dark yellow in colour (Fig. 2), reflecting the color of the eggs. Spent ovaries were blood red in colour. As the ovaries entered resting stage, they became pale red, but were still darker than the immature ovaries.

Colour of the testes also varied with stage of gonad maturation. Immature testes were transparent to very pale yellow. Maturing testes were pinkish. In the mature stage, the testes were whitish while in the ripe and running stage they were darker, turning to milky colour. Spent testes were bright red while resting testes were very pale red in colour.

Size: Of the 816 males of weight analyzed, only the gonads of 806 samples could be measured while gonads of all the 781 females were measured. Table 3 shows the means of gonad weight and the dimension or size of ovaries and testes of the samples based on the six stages of gonad maturation. From the Table 3, ovaries are heavier and larger in size than testes. It was observed that in both sexes, left gonad lobes were larger than the right ones, but the difference in the size of the two lobes are not significant ($p>0.05$). In the two sexes, the largest gonads were those in the mature stage, followed by ripe and running stage while the smallest were those of the immature and resting stages. All the differences in size of the gonads in both sexes based on stages of gonad maturation were highly significant ($p<0.05$).

Monthly occurrence of gonad maturation stages: Monthly occurrence of the different stages of gonad development of female and male samples *S. eupterus* are presented in Tables 5 and 6, respectively. Samples with immature gonads were caught in January to March in both sexes, but in March maturing gonads were also obtained in both sexes, when only one mature female was caught. Same trend was observed in April, where in both females and males, only immature and maturing samples were obtained. The first three stages that is, immature, maturing and mature abound the catches of May and June. In both sexes, the samples were observed to have enhanced body colouration and the colouration patterns were more prominent, thus making them to appear

Table 3: Gonad dimensions of *S. eupterus* based on gonad maturation stages

	Ovary			Testis		
Parameter	No. of samples	Mean	SE	No. of samples	Mean	SE
Gonad weight (g)						
Overall	781	0.893	0.073	807	0.092	0.206
Immature	118	0.106^{b}	0.105	87	0.035^{b}	0.123
Maturing	94	0.373^{b}	0.118	171	0.080^{b}	0.087
Mature	221	2.855^{a}	0.077	494	0.188^{a}	0.051
Ripe and running	285	1.592^{a}	0.068	46	0.137^{a}	0.169
Spent	53	0.297^{b}	0.157	1	0.100	1.444
Resting	10	0.136^{b}	0.362	8	0.014^{b}	0.404
Left gonad length (cm)						
Overall	781	1.828	0.039	807	1.798	0.111
Immature	118	1.245^{d}	0.050	87	1.100^{b}	0.067
Maturing	94	1.790^{b}	0.064	171	1.981^{a}	0.047
Mature	221	2.715^{a}	0.042	494	2.059^{a}	0.028
Ripe and running	285	2.315^{a}	0.037	46	1.463^{a}	0.091
Spent	53	1.592^{c}	0.085	1	3.000	0.681
Resting	10	1.310^{d}	0.195	8	1.187^{b}	0.219
Left gonad width (cm)						
Overall	781	0.519	0.015	807	0.190	0.044
Immature	118	0.216^{d}	0.022	87	0.105^{b}	0.028
Maturing	94	0.459^{c}	0.025	171	0.203^{b}	0.018
Mature	221	0.992^{b}	0.016	494	0.303^{a}	0.011
Ripe and running	285	0.924^{a}	0.014	46	0.228^{a}	0.036
Spent	53	0.336^{c}	0.033	1	0.200	0.240
Resting	10	0.190^{d}	0.076	8	0.100^{b}	0.086
Right gonad length (cm)						
Overall	781	1.810	0.039	807	1.797	0.112
Immature	118	1.253^{d}	0.057	87	1.120^{b}	0.072
Maturing	94	1.755^{b}	0.064	171	1.969^{a}	0.047
Mature	221	2.666^{a}	0.042	494	2.051^{a}	0.028
Ripe and running	285	2.279^{a}	0.037	46	1.457^{a}	0.091
Spent	53	1.594^{c}	0.085	1	3.000	0.620
Resting	10	1.310^{d}	0.196	8	1.188^{b}	0.219
Right gonad width (cm)						
Overall	781	0.508	0.016	807	0.188	0.044
Immature	118	0.210^{d}	0.023	87	0.105^{b}	0.029
Maturing	94	0.472^{c}	0.025	171	0.190^{b}	0.019
Mature	221	0.952^{b}	0.017	494	0.303^{a}	0.011
Ripe and running	285	0.904^{a}	0.015	46	0.228^{a}	0.036
Spent	53	0.328^{c}	0.034	1	0.200	0.246
Resting	10	0.180^{d}	0.078	8	0.100^{b}	0.087

Means in column with same superscript are not significantly different ($p>0.05$)

more attractive from June up to September. By July, the number of immature and maturing samples had declined and there were larger numbers of mature samples with few ripe, running and spent gonads in the two sexes. In August, no immature female was caught, but two samples with maturing gonads were caught and mature and ripe and running gonads dominated the catches. In males, very few samples with immature and maturing gonads were obtained in August but

Table 4: Macroscopic description of gonad maturation stages of females and males of *S. eupterus* from River Rima, Nigeria

Maturity stage	Female	Male
Immature (I)	Ovaries very small, elongated and colourless with smooth edges. Ovaries appeared like a single structure. GSI ranged from 0.06-2.23% with a mean of 0.74±0.49 SD.	Testes very tiny, colorless and thread like. Not easily discernible with naked eyes. GSI ranged from 0.03-2.75% with a mean of 0.30±0.43SD.
Maturing (II)	Ovaries larger rounder and pink in colour, with very tiny discernible eggs. The left ovary lobe slightly larger than the right, with few blood vessels covering them. Ovaries joined by connective tissue throughout their length. GSI range from 0.57 to 10.80%, with a mean of 2.67±1.64 SD.	Testes were longer, threadlike, milky with rough edges. GSI ranging from 0.11 to 9.98%, with a mean of 0.71±0.85 SD.
Mature (III)	Paired ovaries oval with transparent membrane and free. Ovaries covered with prominent blood vessels, the two lobe of a single ovary of slightly nnequal size. GSI ranged from 0.53 to 28.40% with a mean of 12.44±5.81 SD. Eggs of different sizes and colour with majority olive green (Fig. 1). Mean egg size was 0.71±0.11 SD.	Testes flattened, compact with striations, appearing leaf-like in structure, white in colour and translucent. The left lobe slightly larger than the right and are so close, but not joined together and can easily be separated. GSI ranged from 0.07 to 11.94%, with a mean of 1.31±1.35 SD.
Ripe and running (IV)	Posterior end of ovaries reddish with tiny yellow eggs while the anterior is filled with yellowish and green eggs. Ripe and running ovaries are lighter in colour than mature ovaries, with eggs appearing to be released in batches (Fig. 2). GSI range from 0.79-36.72% with a mean of 8.78±4.65 SD. Mean egg size is 0.68+0.01 SD.	Testes less translucent and milky in colour, but still with the same shape. The testes less distended and with a gentle pressure on the abdomen, milt oozes out. GSI ranged from 0.05-9.25% with a mean of 1.02±1.30 SD.
Spent (V)	Ovaries opaque and blood red, appearing like empty deflated sacs. Few bloody eggs still fonnd in the sacs. Blood vessels not prominent. GSI ranged from 0.51 to 14.12%, with a mean of 1.98±2.33 SD.	Testes appeared thinner, flabby, deflated and milky in colour. GSI was 0.27% (only one sample was fonnd in spent stage).
Resting (VI)	Ovaries smaller, firmer and pale red in colour. Blood vessels not visible. GSI ranged from 0.08 to 1.45% with a mean of 0.52±39 SD.	Testes pale red, very thin and threadlike, but firmer than in spent stage. GSI ranged from 0.05-0.10%, with a mean of 0.07±0.02 SD.

Table 5: Monthly occurrence of gonad maturation stages in females of *S. eupterus* from River Rima, Nigeria

	Gonad maturation stage						
Month	I	II	III	IV	V	VI	Total No. examined
January	13						13
February	18						18
March	6						06
April	1	1	1				03
May	2	8					10
June	12	32	1				45
Jnly	18	50	123	97			288
August		3	90	157	7		257
September			6	31	44		81
October					1	7	8
November					1	3	28
December	24						24
Total MS	118	94	221	285	53	10	781
(%) MS	15.11	13.09	28.30	36.49	6.79	1.28	100

Table 6: Monthly occurrence of gonad maturation stages in males of *S. eupterus* from River Rima, Nigeria

	Gonad maturation stage						
Month	I	II	III	IV	V	VI	Total No. examined
January	11						11
February	13						13
March	10	1					11
April	2		4				06
May	03	17					20
June	05	29	1				35
July	29	119	228	1			377
August		5	208	5			218
September		1	51	38	4		93
October					1	5	06
November	10					3	13
December	11						11
Total MS	94	171	492	44	5	8	814
(%) MS	11.18	21.01	60.44	5.41	0.61	0.98	100

mature females dominated the catches, with few ripe and running and spent samples. The catches of September were dominated by spent samples in both sexes with very few mature and ripe and running samples in females, but immature stages were completely absent. In males, a single immature sample was caught and very few mature and ripe and running samples. Resting ovaries dominated the catches of October in females while in males few resting testes were observed. Immature and spent gonads were also caught in October, but maturing, mature and ripe and running gonads were absent. Catches of November were dominated by immature gonads in both sexes while in females, spent and resting stages were also observed. In the males, only resting individuals apart from immature samples were observed while immature, mature, ripe and running and spent stages were absent.

In December, only immature gonads were encountered in both sexes while all the other five gonad maturation stages were absent. From the gonad maturation stages recorded, spawning of *S. eupterus* has its peak in July and August and up to September when it begins to decline. Spent gonads started appearing from July and increased through September. Spawning was over by October and gonads entered resting condition. By November, immature gonads started appearing through February and from then on, maturing gonads were observed which would mature by May to June. Description of all the maturation stages has been given in Table 4.

DISCUSSION

In *S. eupterus*, the sex ratio of 1:0.96 of female to male was not significantly ($p<0.05$) different from 1:1, even though the number of males exceeded that of females. This difference in number may be due to disparity to differential survival over certain environmental conditions. Abayomi and Arawomo, 1996 reported higher sex ratio in favour of males of *Clarias gariepinus* in Opa reservoir.

In addition to the presence of genital papilla in adult male samples which is a characteristic of most catfishes (Holden and Reed, 1972) female samples were significantly ($p<0.05$) larger and heavier than the males. Thus, indicating the presence of sexual dimorphism in the species. Linder,

2002 also reported sexual dimorphism in several families of catfishes. Larger size in females than in males of *Synodontis* was reported for *S. clarias* in River Rima (Shinkafi *et al*., 2002) and *S. schall* and *S. nigrita* in Oueme River (Laleye *et al*., 2006). Larger size of females at first maturity which is a characteristic of most catfishes was reported by Oymak *et al*. (2001), Laleye *et al*. (2006) and Offem *et al*. (2008a, b).

Morphological examination of the gonads revealed disparity in size of the two lobes of each pair of the gonads and that generally, the left lobes were larger than the right ones in both sexes. Similar finding was reported by Ratty *et al*. (1990) and Omotosho (1993). Observation of the ovary in ripe and running stage showed that during spawning, not all of the eggs in one lobe of ovary were released at once, but there was a pattern of releasing on the ripe eggs at a time and probably later, more of the eggs ripen and will be released later. It is not clear whether the two lobes release the eggs alternately, or the one lobe finish releasing all of its eggs before the other. However, no sample was found with an empty lobe. A further study is required to find out the full pattern of spawning and egg release in the species.

Six stages of gonad maturation were established for *S. eupterus* in this study. Based on macroscopic examination of the gonads, visible morphological changes during development in colour, shape, vascularization and size occurred during the maturation process and these follow the same pattern in most oviparous fishes (Barr, 1968). The sizes of the gonads increased from immature to the maturing and it was largest at the mature stages. Thereafter, they declined from ripe and running stage to spent, finally up to resting stages and back to immature. According to Omotosho (1993), the increase in weight and volume of gonads from one stage to another as they advance in maturity before spawning is as a result of accumulation of trophic substances in the reproductive cells while the decrease in the thickness of the walls of the ovaries is due to maximal distension of the walls due to due to increase in number and size of oocytes.

The sequential year round development of the various stages of gonad maturation as recorded through the monthly survey of the gonads confirmed the annual reproductive cycle of the species while the peak spawning period was during the high flood period which in this case was from July to September. This is in accordance with the reports of Reed *et al*. (1967), Imevbore (1970) and Olatunde (1989). The Authors reported the spawning period of most fish species to be during the flood season and that the flood among other things provides expanded habitat and abundant food. So as to ensure the survival of the huge number of young fish produced, as well as reproductive niche and shelter for juveniles, consequently enhancing reproductive success (Ikomi and Odum, 1998).

CONCLUSION

In this study, sexual dimorphism was confirmed for *S. eupterus* and females mature at a slightly larger size than males. Asymmetry of the two lobes of a single gonad was observed. Six stages of gonad maturation were established for this species and its peak spawning season is from July to September. The species was also found to be a multiple spawner in River Rima.

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