DISCUSSION

The previous investigations into the growth and reproduction biology of *Synodontis schall* was meant to shed more light onto its biology and dynamics as a means of a more efficient utilization of such an important resource in the Sudan.

*Synodontis schall* is one of the commonest among its twelve, or thirteen relatives in the Sudan (Boulenger, 1909; Sandon, 1950; Bishai and Abu Gideiri, 1967).

Previous investigations into the biology of this species were not numerous (cited in the introduction) and up-dated. *Synodontis schall* is widely distributed in the Nile system, and appears to be a very successful fish.

Investigations into the growth patterns of this species revealed that its lengths (total and standard) could equally well be used for dimensions studies without much variation \( r > 0.80 \). However, in this study the use of standard length was preferred due to
its more constant nature.

One of the most serious problems which face investigations of tropical species of fish is ageing, mainly because of the large number of accessory growth rings which appear between the true ones. Accordingly confirmation of the annuality of the growth rings needs to be done, before any useful deductions can be made. For *S. schall* opercular bones and vertebrae were both efficiently used for its ageing, and confirmed reliable as ageing structures; although the former was slightly inferior. Back-calculation studies for the length at age "1" gave slightly different readings which when compared to the observed data were not significantly different. The values obtained for length at ring "1" confirm the annuality of those growth rings which was substantiated by observations from nature, or 1-year old fish. Unlike cyprinid fish ( A/Rahman, 1978 ) in the frontal bone of this fish, despite the appearance of growth rings on some of its parts, the major part was obscured by very heavy calcification which made it useless for determination of age. Elshai and Abu Gideiri, ( 1965a ) investigated the growth of *S. schall* in White
and Blue Nile as well as the main Nile and reported that no bony structure other than the vertebrae was reliable for age-determination. They reported that opercular bones often showed irregular numbers of rings, which sometimes were more numerous in young than old specimens. This feature was not noticed in the present study. Willoughby (1979) similarly confirmed the reliability of Synodontis vertebrae for age determination.

Bone structures, as tools for ageing tropical fish species have been studied by a great number of workers (e.g. Mishrigi, 1967; Fagade, 1974; Tweddle, 1975; Olatunde, 1979; A/Rahman, 1978; Willoughby and Tweddle, 1978; Gumaz; Hamza and Suliman, 1983; and many others) with a high degree of success.

No fish older than 5 years and younger than 1 year, was caught during this study, and this may partly be attributed to the high selectivity of the gill-nets (Ali and Abu Gideiri, 1977) used, and partly due to the overfishing in that area. S. schall was recorded to live for more than 31 years as observed from aquaria and fish ponds (Flower, 1925; 1935; Brown, 1957).
Growth in parameters such as length and weight correlated well for both sexes of *Synodontis* ( \( r > 0.90 \) ), and despite the relatively narrow range of sizes and ages caught, highly reliable predictive equations could be written (Tables - I and II). Both total and somatic weights were observed to increase exponentially with length, suggesting a faster increase in the latter parameter as the fish grows older (Fig. 2a and b). This increase in weight was well portrayed when it was plotted against age (Fig. 6a and b). The slow down in the length of the fish was also shown by the asymptotic curves obtained for both sexes, where the asymptote was more pronounced for the older specimens. Similar findings were reported for a great number of fish species, both tropical (e.g. A/Rahman, 1978) and temperate (e.g. Le Cren, 1947; Lagler et al. 1962; Bagenan and Tesch, 1968; Gumaa', 1977; and many others). Such a pattern is usually shown for fish which grow isometrically, or nearly so ( \( b \approx 3.0 \) ). In this study the value of the regression coefficients for both sexes, never varied significantly from 3.0 (Table - 1) suggesting isometric growth for that fish.
The difficulty of ageing *Synodontis* lies mainly in the appearance of a large number of accessory growth markings (Plate I and 2); and in the heavy calcification of some bony structures. Nevertheless, results obtained in this study for observed and calculated lengths for age "1" fish agreed; apart from minor variations which were attributed to error in exact localization of the bone focus. This error was more pronounced in opercular bone, but sectioning of vertebral bones made it relatively easy to localize the exact focus.

Rishai and Abu Gideiri (1965a) studied relationships for length and weight of the species, and although their analyses were made on transformed data, they did not describe predictive equations, from which comparisons could be made. A discrepancy, however occur within their data when they reported that a 3-year old fish attained a length of about 28.8 cm in males and 30.5 cm in females (Rishai and Abu Gideiri, 1965b); while in another work (Rishai and Abu Gideiri, 1968) they reported that females maturing at an age of 3-years were of length about 18.0 cm.
The fact that the condition of female
*S. schall* was poorer than that of males, especially
during the breeding season, may be explained in the
light of the food turnover for gonadal maturity.
Oogoniosis probably requires more turnover than sperm-
matogenesis, and as this is not always affected from
the food supply it must be supplemented from the fish
tissues, mainly fat reserves. This was explained for
several temperate water fish species (*Bagenal and
Tesch, 1968; Weatherley, 1972; Davis, 1977*).

In the present study, however, both males
and females were found to mature after completion of
their first year, at length of about 14.0 and 15.0 cm.
(standard length) respectively, which are equivalent
to about 20.0 and 21.0 cm. total lengths. This agrees
more or less with the lengths reported by Bishai and
Abu Gideiri (*1968*), although they greatly vary when
age is considered. Willoughby (*1979*) reported that,
in Lake Kainji (*Nigeria*), male and female *Synodontis
schall* matured at 10.4 and 11.8 cm (standard lengths)
respectively, and commented that those lengths were usually
attained at an age of two years. Early maturation in fish may be due to several physical and biological factors such as temperature, density and food supply, and these may account for the discrepancies between the findings of different authors.

*Syncodontis schall* is a very fecund fish and as was observed from the high figures calculated for its absolute and relative fecundities (Tables - X, XI and XIV). Nevertheless its breeding season (July - August, in this study) was reported as very variable from one locality to other, depending on latitude and altitude. Navar (1959b) reported an identical breeding season for the same species, while Ponedelko and Schulov (1964) reported late summer and autumn for breeding activities in Jebel Aulia reservoir (~ 5 Km south of present sampling locality). Gunna (Pers. Comm.), however, reported an earlier breeding season for the same species, in the southern region of the Sudan (June-July). Bashai and Abu Gideiri (1968) reported July - October as a breeding season for *S. schall* in the White, Blue Niles as well as the main Nile. Willoughby (1979) also reported August as a peak breeding month of *S. schall*.
in Lake Kainji, with some ripe females from May -
November.

Wael (1974) stated that many tropical
species spawn at the beginning of the rainy season,
while Nyang and Gumas (1981) reported that large
number of commercially important species in southern
Sudan, had two breeding seasons one in early April / 
May and the other just prior to the flood. Similar
findings were also reported by Nawar (1957).

One other important point in the reproduction
biology of this species, and which helps in establishing
breeding activity is the gonosomatic index (GSI). The
sudden increase of that index during June, July and Au-
gust (especially for females) (Fig. 12a and b) clearly
suggests activity of the gonads. Despite the wide appli-
cation of this index in ichthyology (Le Cren, 1951; Scott,
1974; Delahunty and De Vlaming, 1980; Hails and Abdullah,
1982) its danger exists when it varies with length. In
the present study, no such variation was noticed, and thus
its use is justified.
The study of sex-ratio was here undertaken with full awareness of gill-net selectivity. Both males and females existed in a more, or less 1:1 ratio, which suggests no segregation throughout the year, except during February / April, when catches were dominated by females (Table - VIII). Mishai and Abu Gideiri (1968), reported that *S. schleier* caught from the White, Blue, or main Nile always showed female predominance (1.5 : 1.0 ratio), while Ponoselko and Schutov (1964) reported a 1.0 : 1.1 males : females ratio for the same species in the White Nile.

In the present investigations, there was a very good correlation between fecundity and morphometric parameters such as length and weight (Table - X), and predictive equations were reliably described. All previous work on the species in Africa, did not describe mathematical relationships for fecundity estimation form different morphological features (e.g. Nawar 1959b, Ponoselko and Schutov, 1964; Mishai and Abu Gideiri, 1968; Willoughby, 1979). The lowest value of about 2,110 eggs was recorded for a 30.4 cm. (total length) fish and the highest value (170,952 eggs) was recorded in a 37.7 cm.
fish. These values differ from those reported by Nawar (1959b) which were 7,340 eggs (37.0 cm) and 138,360 eggs (45.0 cm). Bishai and Abu Sideiri (1968) also gave figures for the lowest and highest fecundities; as 4,785 eggs (26.0 cm) and 141,274 eggs (55.0 cm). These discrepancies, however, may be attributed to the different methods used for fecundity estimation. Another reason may be due to the undefined nature of the ova counted by those workers. In the present study, two types of ova were observed in ripe females, a transparent yellow-brown type and a green-opaque type. The former (less frequent) in this study was considered as immature or atrophying and was not included in the counts. It was also noticed that type of ova decreased greatly in number with onset of breeding.

Absolute fecundity of S. schall, however, was observed to be between 10,000 and 90,000 eggs for most specimens examined and these are inkeeping with Nawar (1959b) findings of 7,000 to 130,000. The great variation in the number of eggs produced by the individuals of certain species was demonstrated for large number of other tropical fishes (Nawar, 1959a, Nawar and Yoakim, 1962;
The present study on the relative fecundity as the number of eggs per gram body weight, showed great variation. The highest value (310 eggs) (Table - XV) was obtained during the onset of spawning season (August). In general a range of 20 to 90 eggs for most individuals was noted. This great variation may be related to differences in the diameter and size of mature ova and to the different proportions of small to large ova in different ovaries.

The number of eggs per gram ovary weight in this study (Table - XVII) ranged between 1,211 and 5,442 eggs. The mean numbers for small individuals (15.0 - 17.0 cm standard length) was 2628 eggs and for larger individuals (31.0 - 33.0 cm. standard length) was 3390 eggs. Willoughby (1979) reported a range of 1,300 to 2,500 eggs per gram ovary weight for the genus from lake Kainji (Nigeria).

Nikolsky (1963) reported that fecundity usually increased with length until a state of senility is
approached when it starts to decrease. Ludwig and Lange (1975) also pointed out the effect of the interaction of age and length upon fecundity, and concluded that females of equal lengths, but different ages, produce a different number of eggs. This effect, however, was not felt in the present study as the range of ages studied was not great, and thus no 'senile' fish was caught.

Another factor that might significantly affect estimation of absolute fecundity in fish is the ovarian tissue, which accounts for a considerable proportion of the ovary weight and is often the cause of discrepancies between different authors' findings.

Egg-diameter was observed to vary from one specimen to the other and even within the same ovary (0.33 - 1.59 mm), this variation was not very great (C.v. < 13.0%). Both Nawar (1959b) and Bishai and Abu Sideiri (1968) reported a range of 0.33 - 1.00 mm for the egg-diameter of S. schall; while Ponedelko and Schutov (1964), reported a range of 0.55 - 1.55 mm for the genus. Such variation in egg-diameter were similarly reported for other tropical fishes by several workers (e.g.}
SUMMARY

1) A total of 631 specimens (311 females and 320 males) of *Synodontis schall* were investigated for their growth patterns and reproduction biology.

2) The growth of this species was nearly isometric \( b = 3.0 \) for both sexes.

3) The age studied ranged from 1+ to 5 years.

4) Vertebrae and opercular bones were successfully used as ageing structures for this species.

5) Growth rings were confirmed, through back-calculation, as being laid annually.

6) Back-calculated lengths at the completion of the first growth ring differed slightly from observed lengths.

7) Parameters such as length, weight and age were all highly correlated and predictive equations were described.
8) Weight increased exponentially with length, while length increased asymptotically with age.

9) Futhon's condition factor 'K' calculated during this study.

10) *Synodontis schall* mature after completion of their first year of life at lengths of about 14.0 and 15.0 cm standard length for males and females respectively.

11) Absolute fecundity for the size-ranges examined ranged between 2,110 and 170,952 eggs.

12) Spawning takes place once a year, between July and August, and it is during that time that highest values of the gonosomatic index (GSI) were recorded.

13) A "vague" reciprocal relationship was observed between gonadal dry weight and ash (%). This relationship was more pronounced in females.

14) Variation in egg-diameter were not significant (especially at the onset of spawning).
15) The absolute fecundity of *S. schall* increased exponentially to length and weight.

16) Ovarian sac and tissue constituted a significant proportion of the gonad weight.

17) Relative fecundity was highest during August (the spawning season), but decreased with time as the breeding seasons approaches its end.

18) Absolute fecundity increased exponentially with age and the effect of senility was not felt.
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