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Aspects of Biology and Population Dynamics of *Synodontis Schall* (Bloch and Schneider, 1801) in River Galma, Nigeria

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ABSTRACT

This study investigated the length–weight relationship, condition factor, and population parameters of *Synodontis schall* in River Galma using standard procedures. Samples collected from July to December 2019 had mean standard lengths of 12.33 ± 0.29cm (females) and 11.98 ± 0.30cm (males), with corresponding mean weights of 49.40 ± 3.60g and 45.80 ± 4.00g. Length–weight regressions indicated allometric growth pattern, with b values of 2.4998 (females), 2.0819 (males), and 2.2589 (combined sex). Standard length and weight were positively correlated (r^2). Condition factor (K) values (2.47–2.53) suggested that all individuals were in good physiological condition. The von Bertalanffy growth function produced an asymptotic length ($L\infty$) of 31.50cm. Estimated total mortality (Z), natural mortality (M), and fishing mortality (F) were 2.150, 0.994, and 1.156, respectively. Although males were more numerous, no significant difference in sex ratio ($P > 0.05$) was observed.

Key Words*:* *S. schall*, condition factor, length-weight, sex ratio.

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Introduction

Fish morphometrics have been pivotal to successful ichthyologic studies over the years (Froese and Pauly, 2024). Length-Weight Relationship (LWR) is commonly used to convert length measurement into weight to ascertain the growth characteristics related to these variables. These variables are also used in estimating the well-being (condition) of fish (Bañón *et al.,* 2020; Moutopoulos *et al.,* 2022) and thus required in fisheries assessments. Length weight regressions have been a factor of choice in estimating weight from length since individual measurement of weight is laborious and time consuming (Erondu *et al*., 2021). Condition factor (K), which evaluates the relative robustness or "well-being" of fish, reflects environmental quality, feeding intensity, reproductive status, and habitat suitability (Andrade *et al.,* 2020). A high condition factor typically indicates adequate food availability and favorable ecological conditions, making this metric an important biological index for management and conservation (Gillespie *et al.,* 2021).

Sex ratio can be defined as the number of females to males in a population. It provides information on the proportion of females to males in a given fish population. Such information is required for effective management of a fishery (Kraus and Tomkiewicz, 2023). Mortality refers to fish of all sizes and age groups which die within a defined period in time. Mortality estimates are essential for modeling population dynamics of fish stocks and ecosystems (Prince *et al*., 2020) as they contain information on the biology and ecology of populations under study, thus indicating its renewal, productivity or otherwise (depletion). Relative yield per recruit defines the biomass of individuals recruited into a fishery per unit time while exploitation rate is an index used to describe the extent to which a fishery is utilized. In fisheries stock assessment, these parameters are essential in understanding if a fishery is under fished or overfished as well as the degree of replenishment.

Synodontis schall belongs to the genus *Synodontis* which is the most common out of the three genera (*Mochocus, Synodontis and Chinoglanis*) from the family Mochokidae (Olanrewaju *et al*., 2020). It is among the most favored edible species in Northern Nigeria owing to their abundance in artisanal fisheries and good taste (Akombo *et al.,* 2019). The genus is commercially important in inland waters of West Africa with *S. schall* available all year round.

Materials and Methods

Study Area

River Galma catchment area belongs to the North-Eastern part of Kaduna River basin which borders the Chad basin to the North. It is one of the main tributaries of river Kaduna with its headwaters near the North-Western edge of the Jos plateau and falls near the Magami village into Kaduna plains. River Galma has a tropical wet and dry climate with warm weather year-round, wet season lasting from April to September and dry season from October to March (NIMET, 2021) with mean temperature of 25°C.

Sample Collection, Identification and Morphometric Measurement

Specimens of *S. schall* (n=164) were obtained from fishermen of River Galma (landing sites) during the first week of every month at 7:00-9:00hrs and transported to Fisheries Laboratory, Department of Biology, Ahmadu Bello University, Zaria for analysis. Fish samples were identified using the keys of Olaosebikan and Raji (1998) and Idodo-Umeh (2003). Standard length (SL), total length (TL) and total body weight of individual fish samples were taken according to the method of Akombo *et al*. (2015) and recorded appropriately.

Sex Ratio, Length-Weight Relationship (LWR) and Condition factor (K)

Sex determination was based on dissection (Okomoda *et al*., 2018; Ibrahim *et al.,* 2022). Sex ratio was determined following Adeyemo *et al*., (2021). Length-weight relationship was calculated using the equation

$W = aL^b$ (Bagenal, 1978) which was transformed into straight line relationship as Log W = Log a + bLog L (Akombo *et al*, 2015). Condition factor was calculated using $K = 100w/L^b$ (Froese *et al*., 2023; Jatto and Olaoye, 2020).

Condition factor (K) was computed using

$K = 100w/L^b$ (Bagenal, 1978; Andrade *et al*., 2020; Erondu *et al*., 2021).

Growth parameters

Asymptotic length (L∞cm) and growth coefficient (K) were calculated using Fish Key Facts 4 (Froese and Binohlan, 2000). These parameters were fitted into the Von Bertalanffy's model.

Mortality, Relative Yield per recruit (Y/R) and exploitation ratio

Natural mortality (M) was estimated using updated temperature-dependent empirical equations widely applied in tropical inland fisheries (Then *et al.,* 2015; Hordyk *et al.,* 2019). Total mortality (Z) was computed using length-converted catch data in FiSAT II based on the Beverton and Holt (1957) model. Fishing mortality (F) was determined as: F = Z – M. Relative yield-per-recruit (Y/R) and exploitation rate (E) were estimated using FiSAT II routines, following recent modeling approaches for African freshwater stocks (Tsehaye *et al.,* 2022; Gayanilo *et al*., 2020).

Data Analysis

Microsoft excel (2013) was used in computing means, standard errors (ES) and standard deviations (SD) from morphometric data. Length-weight data was subjected to least square regression to ascertain the relationship between these variables. Student t-test was used to test for significant differences between total and standard lengths, weight and condition factor as well as significant difference in sex ratio. All data was tested at 5% level of significance ($P \leq 0.05$).

Results and Discussions

Sex ratio

Sex ratio is an important reproductive index that reflects the demographic structure and breeding potential of fish populations. It is described as the percentage of females to males and is generally considered in the study of reproduction to understand the sexual behavior of fish under consideration at different months of the year (Ahmed *et al*., 2021). Sampling of *S. schall* in River Galma ensured a representative distribution of females and males. The ideal value of sex ratio in fish is 1:1 (Morales-Nin *et al*., 2020). However, the observation from this study slightly differed as more males were observed (Tab. 1). Variation in sex ratio may occur sequel to several factors including year, season, type of gear, month and length group (Attah-Krah *et al.,* 2022; Mollah *et al*., 2019). Geographical location and ecological habitat are among possible factors influencing sex ratio. In this study *S. schall* had 1:1.25 (Table. 1) for females and males indicating that males were numerically higher than females with no significant difference ($P>0.05$). Such patterns are consistent with findings in other tropical freshwater fishes, where sex ratios often fluctuate due to ecological stressors and reproductive strategies (Hassan *et al*., 2021).

Table.1: Sex Ratio of sampled fishes

	Male	Female	Sex Ratio (M:F)	χ^2	P-value
S.schall	91	73	1.25:1	0.0063	0.9

Length-Weight Relationship

The length–weight relationship (LWR) is a fundamental tool for assessing growth patterns and body condition in fish populations. The length-weight regression in this study revealed negative allometric growth pattern with b values below 3 (Figures. 1-3). This shows that, the rate of increase in body length is nonproportionate to the rate of increase in body weight and that, the fish weight increased at a decreasing rate as the fish grew longer. This observation is in agreement with Kumolu-Johnson and Ndimele (2011), Atama *et al.,* (2013) both on *tilapia zilli*. Midhat *et al.,* (2012) also reported b values of 2.2749, 2.2915 and 2.2863 for *S. schall* females, males and combined sex in River Nile at Gizza Egypt. Negative allometry has been widely reported in freshwater catfishes exposed to fluctuating environmental conditions, food availability, or moderate fishing pressure (Yakubu *et al*., 2020; Ibrahim *et al.,* 2022). Recent studies on Synodontis species in African rivers have reported similar growth patterns, attributing variations in the LWR exponent (b) to habitat conditions, hydrological regimes, and ontogenetic changes (Onimisi and Abubakar, 2023; Nwani *et al.,* 2019). Generally, an ideal fish which maintains dimensional equality, the isometric value of b would be 3. A value of b less or greater than 3 indicates allometric growth pattern. A value of b less than 3 indicates negative allometric growth (less proportionate increase in weight as the length increases) while a b value above 3 implies positive allometric growth (fish become heavier as they grow longer). Nwani *et al.,* (2019) reported that b values of most fish species range from 2.0-4.0. The value of correlation coefficient (r^2) was higher than 0.700 which is an indication of strong positive correlation showing positive relationship between fish standard length and body weight.

Condition Factor (K)

Condition factor reflects the health, physiological state, and ecological fitness of fish. The monthly condition factor of *S. schall* varied from 2.75 in July to 1.83 in September before increasing to a near steady flow from October (2.64) (Figure.4). Condition factor reflects the wellbeing of fish (Edem *et al*., 2021). It reveals information when comparing two populations living in a particular environment with similar conditions to verify if they are making good use of the resource (Shinkafi and Ipinjolu, 2020). Condition factor less than 1.0 shows that fish are not in good condition while K values above 1.0 imply that fish are in good physiological condition. The values of condition factor observed in this study were above 1.0 for females and males. This implies that this species in River Galma is in good condition though males were observed to be in better condition than females (Table. 2). Furthermore, it indicates availability of food resources and suitability of other environmental conditions. The condition factor obtained in this study agrees with Midhat *et al*., (2012) who reported that males of *S. schall* in River Nile at Gizza were in better condition (1.83) than females (1.64). Effiong *et al*., (2022) also reported K values between 2.32 and 2.36 in Idah area of River Niger. The results align with findings that fish inhabiting moderately productive freshwater systems tend to maintain good body conditions even with seasonal fluctuations in water quality (Effiong *et al*., 2022).

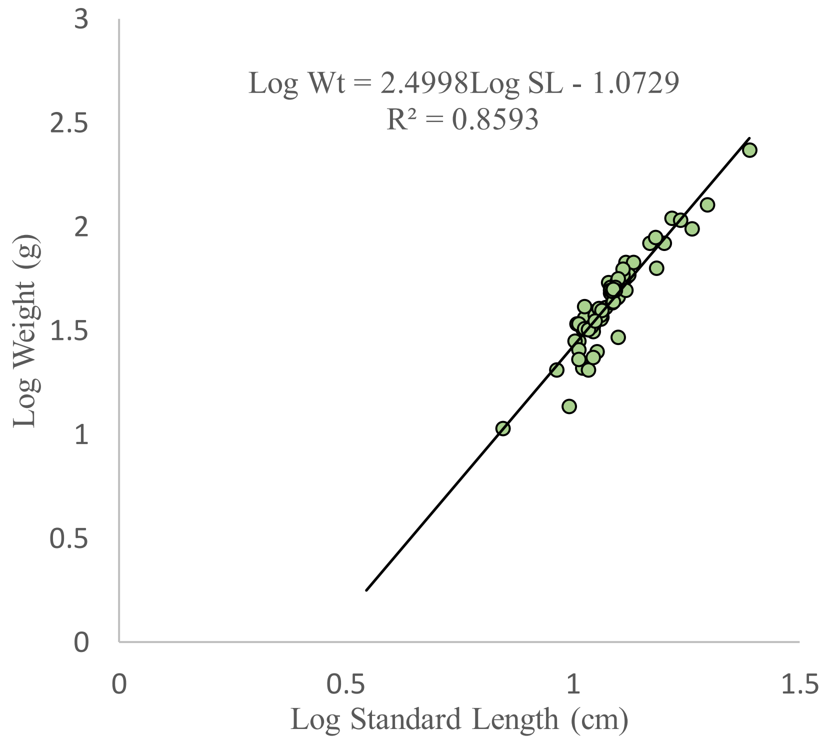

Figure.1: Linear regression relationship between logWT and log SL of *Synodontis schall* females

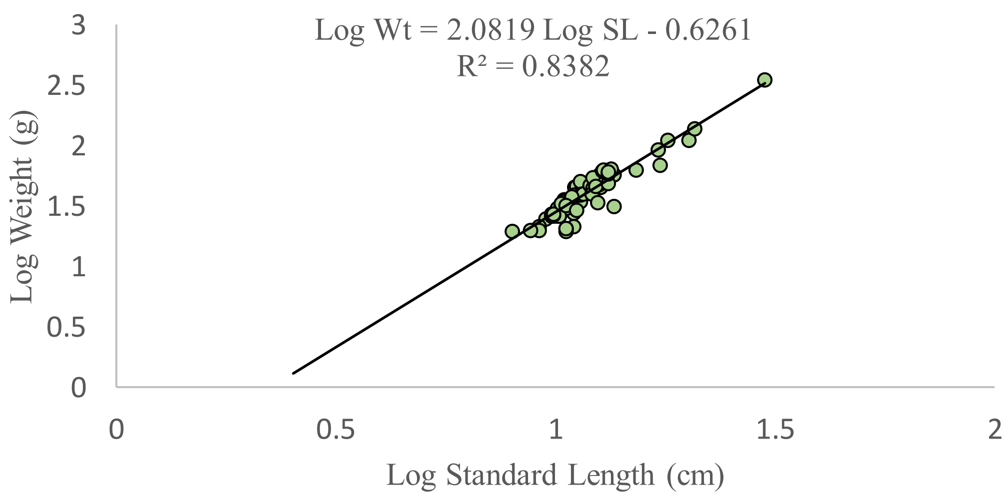

Figure 2: Relationship between logWT and log SL of *Synodontis schall* males collected from River Galma

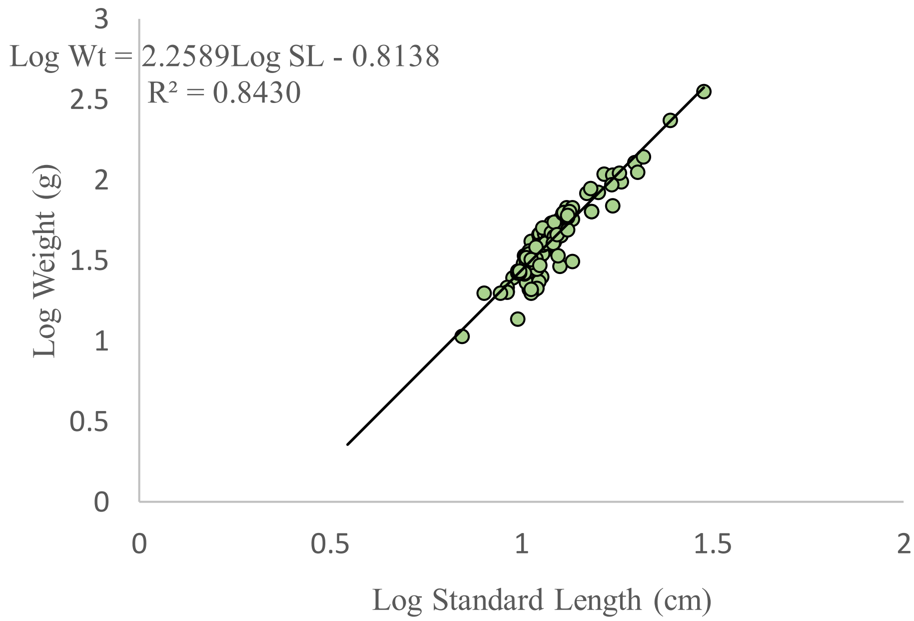

Figure 3: Relationship between logWT and log SL of *Synodontis schall* combined sex collected from River Galma

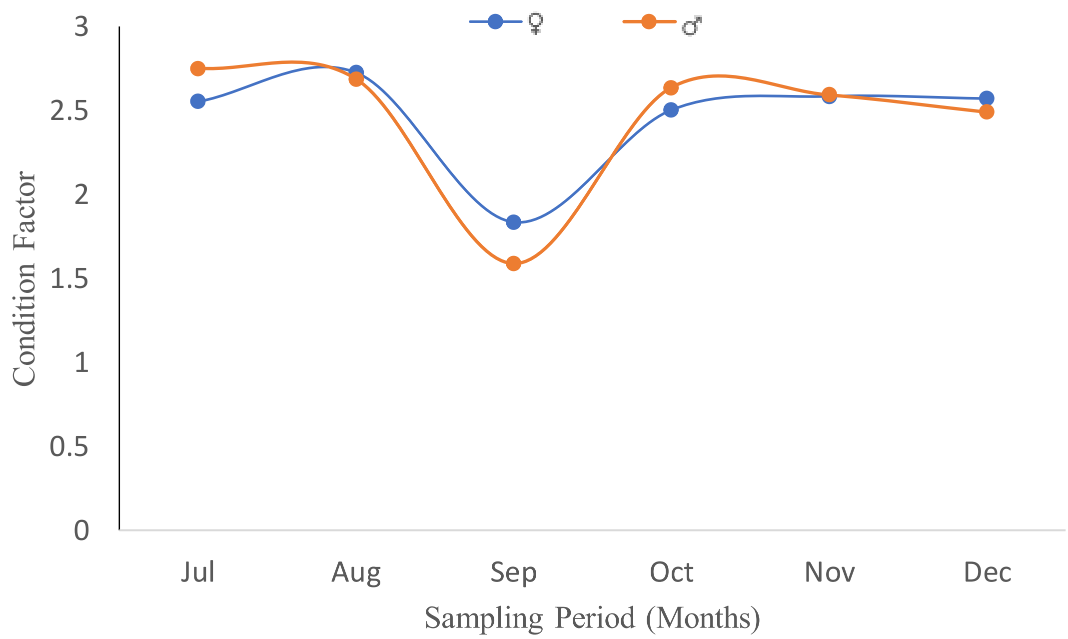

Figure.4: Monthly Variation of Condition Factor of *S. schall*

Table.2: Variation of Morphometric Measurements of *Synodontis schall*

Parameter	**Sex**		**df**	**T-Value**	**P-Value**
	Female	**Male**			
Total Length (cm)	15.83±0.55	16.70±1.30	122	0.61	0.54
Standard Length (cm)	12.33±0.29	11.98±0.30	160	0.86	0.39
Weight (g)	49.40±3.60	45.80±4.00	161	0.66	0.51
Condition Factor	2.47±0.05	2.53±0.05	160	0.80	0.42

Growth parameters

Length-frequency analysis revealed an asymptotic length (L∞) of 31.50 cm and a growth coefficient (K) of 0.520 under Von Bertalanffy Growth Function (VBGF) (Figure. 5). These values indicate moderate growth typical of African catfish species in inland waters. Variations in asymptotic length among populations of *S. schall* have been attributed to genetic diversity, habitat characteristics, prey abundance, and population density (Chukwu *et al.,* 2021; Daniel *et al*., 2023).

The L∞ recorded in this study is smaller than values reported for populations in larger or less disturbed water bodies. This suggests that local environmental conditions in River Galma such as hydrological fluctuations or fishing pressure may influence maximum attainable size. Fish growth has been shown to be location-specific, with environmental stressors contributing to geographic variability in growth traits (Gbedemah *et al*., 2020).

(L∞): 31.50
(K): 0.520

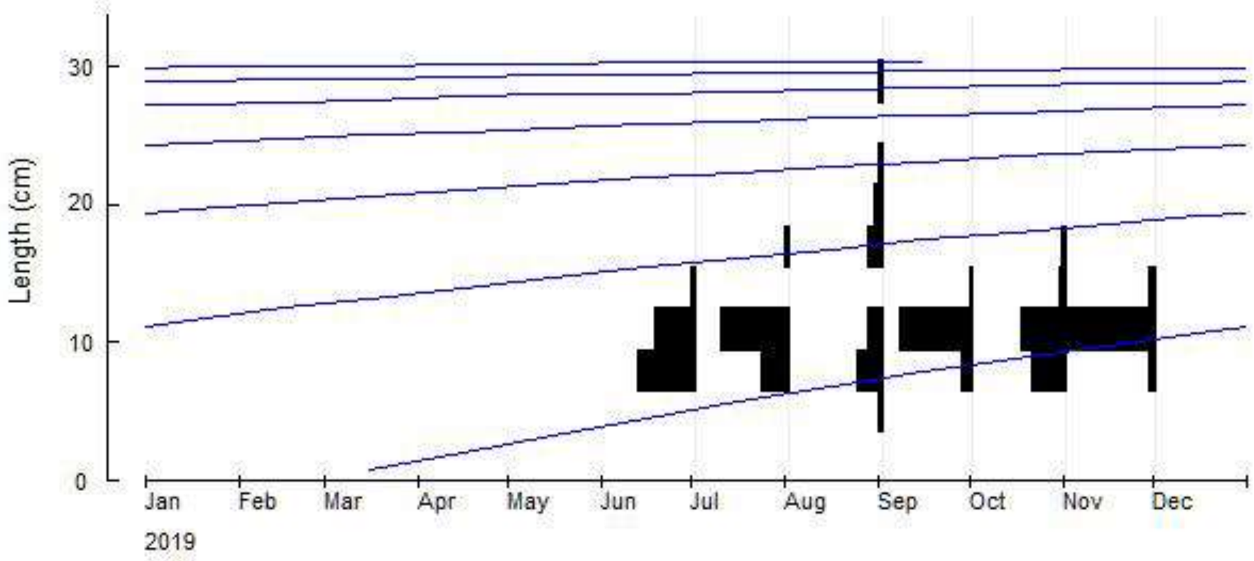

Figure.5: Von Batterlanffy growth function for *S. schall*

Mortality

Natural mortality (M = 0.994) was lower than total mortality (Z = 2.150), with fishing mortality (F) estimated at 1.156 (Table. 3). A relatively low natural mortality rate suggests that *S. schall* is a hardy species capable of withstanding environmental stress. Similar patterns have been reported in other Synodontis species across West African rivers, where resilience and opportunistic feeding contribute to lower natural mortality (Adewumi *et al.,* 2021). However, the higher fishing mortality indicates moderate fishing pressure that could influence stock sustainability if unmanaged. This suggests the need for community-based co-management strategies to prevent overexploitation of freshwater fish resources (Obi *et al.,* 2023).

Table.3: Mortality parameters for *S. schall* collected from River Galma

Fish species	Mortality parameter		
	Natural (M)	Fishing (F)	Total (Z)
S. schall	0.994	1.156	2.150

Exploitation rate (E)

Exploitation rate operates with the assumption that the optimal value (E) equals 0.5. Thus, the use of E or 0.5 as optimal value for exploitation rate is based on the assumption that maximum sustainable yield is obtained when fishing mortality equals natural mortality (F=M) (FAO, 2022). In this study, the E_{max} obtained was 0.370, $E_{0.5}$ was 0.241 while the $E_{0.1}$ was 0.304. The estimation of the exploitation rate for *S. schall* shows that, the species is not overfished based on the optimum value of E (E_{max}= 0.370) (Figure.6). The relatively low exploitation values may be due to low fishing intensity, gear type selectivity, or habitat features that limit accessibility to fishers. Recent studies have similarly documented low exploitation levels in inland Nigerian water bodies where artisanal fisheries dominate (Ojo *et al.,* 2020; Bankole *et al*., 2023).

Lc/Loo: 0.050
M/K 1.9115
E-max: 0.370
E-10: 0.304
E-50: 0.241

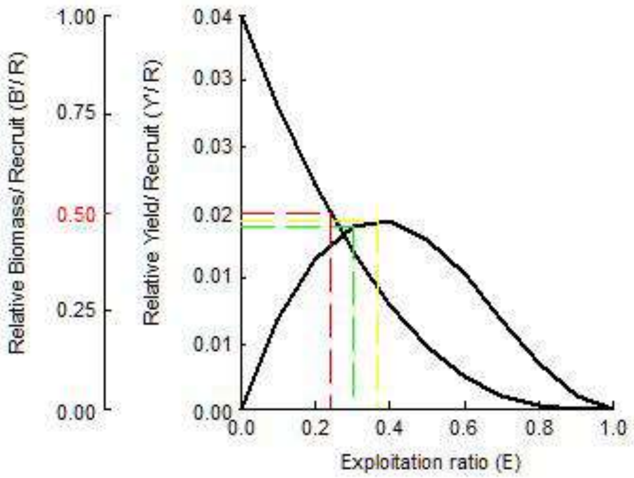

Figure.6: Relative yield per recruit for *S. schall*

Conclusion

S. schall in River Galma exhibited negative allometric growth pattern. Fish body weight positively correlated standard length ($r^2 > 0.85$). The physiological wellbeing of fish expressed by condition factor (K) showed that this species is in good condition (K = 2.47±0.05, 2.53±0.05). Males outnumbered females (1.25:1). *S. schall* had lesser natural mortality (0.994) than fishing mortality (1.156) indicating the influence of fishing pressure on fish population.

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