Research Article

Population parameters and exploitation rate of two dominant fish species in Tovè River (Southern Benin)

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ABSTRACT

Most fisheries in Africa are overexploited or are at the peak of exploitation. A key contributor to this over fishing is poor data on fisheries, inefficient management strategies and unenforced policies. This study deals with growth, mortality parameters and the exploitation rate of Synodontis schall and Shilbe intermedius collected with a range of several fishing gears between October 2015 and September 2016 from Tovè River in Benin to contribute to sustainable management of these fisheries. The von Bertalanffy growth constants for S. schall were TL\(\infty\) = 21.84 cm, K = 0.93 yr\(^{-1}\), and t\(_0\) = -0.49 yr with a derived growth performance index of \(\phi'\) = 2.64. The corresponding estimates for S. intermedius were TL\(\infty\) = 25.20 cm, K = 0.52 yr\(^{-1}\), t\(_0\) = -0.52yr and \(\phi'\) = 2.51. The total mortality rate, Z, for S. schall was estimated as 4.13 yr\(^{-1}\), with the fishing mortality, F, being calculated as 2.31 yr\(^{-1}\). The mortality estimates for S. intermedius were Z = 1.28 yr\(^{-1}\) and F = 0.08 yr\(^{-1}\). The size at first capture was estimated at 5.35 cm and 7.20 cm for S. schall and S. intermedius, respectively. The current exploitation rates for S. schall (0.55) and S. intermedius (0.06) suggest that only the stocks of S. schall was slightly above the assumed optimum value (E\(_{\text{opt}}\) = 0.5). Rational measures must be taken to effectively manage for exploitation of these 2 stocks particularly the one of S. schall.

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INTRODUCTION

Benin water resources are free or open-access resources and have been regarded as unlimited resources that people could exploit without care. This has led to increased exploitation of fish stocks by local people using more sophisticated fishing gears and methods, in turn leading to unsustainable harvesting of some stocks (Hounkpè 1996).

In many aquatic ecosystems in Benin, large-bodied fish have become very scarce in the fisheries (Lacléy et al., 1997). However, few studies have quantified population traits of targeted fish species. In the mean-time in that study they noted that no information is available on the population parameters some aquatic resource in Tovè River which is an affluent of the Ouémé River, the largest river in the region (Benin). This River is located in the lower valley of the Ouémé which is today considered as the second richest valley in the world after the Nile in Egypt. It was chosen as the area of current study considering its importance to the waterside population in terms of fishery and agricultural zones. Nevertheless, the species in Tovè River are usually harvested by local people using gillnets and represents a high-value food source.

Indeed, population parameters such as asymptotic length \(L\infty\) and growth coefficient k, mortality (natural and fishing) rate and exploitation level E were studied with the major objective of rational management and resource conservation (Nasser, 1999; Abowweyere and Falaye, 2008; Sossoukpè et al., 2013). Data on age and growth are especially important to describe the status of a population of fish and to predict the potential output of fishing (Sossoukpè et al., 2016). These two parameters facilitate the evaluation of production, size of stock, recruitment and mortalities (Lowe-McConnel, 1987). Various methods have been developed for assessing the exploitation level and stock status. Among these, the ELEFAN routine implemented in the FiSAT software has been most frequently used for estimating population parameters of finfish and shellfish, primarily because it requires only length-frequency data.
The present work is the first attempt to investigate growth rates, mortality coefficients and the exploitation rate of the main fish species in the Tôvè River using monthly length frequency analyses. The species considered in this study were sampled from the Tôvè ichthyofauna inventory from October 2015 to September 2016 (Djidohokpin et al., 2017a). Sampled fishes were identified at species level, weighted to the nearest 0.01 g and the standard and total lengths were measured to the nearest 0.1 cm. During the ichthyofaunal inventory, two fish species, Synodontis schall (Mochokidae) and Shilbe intermedius (Schilbeidae) were identified as the main species of this fishery.

The present study aims to quantify series of population traits for the two dominant species, S. schall and S. intermedius, of this ichthyofauna including: size at first capture, growth, mortality rates and exploitation, which are essential tools in the management of exploited fish stocks.

MATERIALS AND METHODS

Study area

The Tôvè River is located in the Southern Benin (04°42'47" N, 07°45'2" W). Benin country is located in West Africa at 6°15' and 12°25' North latitude and 0°45' and 04°00' East longitude. It is bounded at the North by Niger and Burkina Faso, at the East by Nigeria, at the West by Togo and South by the Atlantic Ocean. Its surface area is estimated at 114 763 km² (along 700 Km about 125 km wide and 325 km South to North).

With an approximately length of 1 km, with an average width of 3 m, the Tôvè River is located in the Ouémé Division, specifically in the Adjohon Sub Division at about 32 Km from Porto-Novo (Capital of Benin Republic). The Sub-Division is limited at the South by the Dan’go Sub Division, at the North by the Bonou Sub-Division, at the East by the Sakété Sub-Division and at the West by the Abomey-Calavi and Zê Sub-Divisions. This river rises in the swamp of Tôvè at Tôvègbamè and flows into the Ouémé River, the largest river of Benin. In order to have exhaustive ichthyofauna inventory of this ecosystem, and its spatial distribution in this river, the river was divided into three main areas A, B and C respectively upstream, middle stream and downstream of the river (Fig. 1).

Fish sampling and data collection

Fishes were collected monthly from October 2015 to September 2016. Fishing was undertaken daily and by night. During the daily fishing sampling, artisanal and experimental fishery techniques were used such as gillnets (mesh size between 10 mm and 100 mm node to node); hoops designed in creels wire mesh; or with local materials, with or without bait, hook in troubled waters with simple and composed lines (long lines); dam nets, enclosure acandas and bamboo traps. For by night fishing, gears are posed at 5 pm and withdrawn by 7 am of the next day. The fish caught are preserved safely in a container with ice and transported to the laboratory where they are identified up to species level and sorted by fishing gear and by areas of investigations. Identification was made using morphometric and meristic characters provided by fish identification keys of Lévêque et al. (1990-1992), (FAO, 1992) and Paugy et al. (2003a, 2003b). Synodontis schall (Bloch and Schneider, 1801) and Shilbe intermedius (Rüppell, 1832) were identified as the most abundant fish species in catches in terms of numbers.
frequency distribution (Pauly, 1984). An index of goodness of fit, (Rn), was determined by automatic computer (Gayanilo et al., 2002). In order to compare the growth rates in this study with those of other authors, the standard growth index (ϕ') was used as a measure of overall growth performance (Pauly and Munro, 1984). The index is defined as:

ϕ' = \log_{10}(K) + 2\log_{10}(L_{\infty})

Longevity was calculated from Pauly’s (1984) equation:

\text{t}_{\text{max}} = \frac{3}{K}

The theoretical age at length zero (t₀) was estimated using Pauly’s (1979) empirical equation:

\log_{10}(t₀) = -0.392 - 0.275 \log_{10}(L_{\infty}) - 1.038 \log_{10}(K)

Assessment of the instantaneous mortality coefficients and related parameters

Once the growth parameters of the von Bertalanffy growth equation were obtained, total mortality Z was estimated by the length converted catch curve method as implemented in ELEFAN. The linearized length-converted catch curve (Pauly, 1984) was constructed using the formula:

\ln\left(\frac{N_i}{\Delta t_i}\right) = a + b t_i

where Ni is the number of individuals in length class i, \Delta t is the time needed for the fish to grow through length class i, t is the relative age (computed with t₀ = 0) corresponding to the midlength of class i. The slope (b) of the curve with its sign changed gives Z.

The regression lines were extrapolated to approximate the probability of capture given natural mortality (M). FiSAT II provides an option to estimate this value using the empirical equation of Pauly (1980) as following:

\log_{10}(M) = -0.0066 - 0.279 \log_{10}(T) + 0.463 \log_{10}(K)

where (T) is the annual mean of habitat temperature (in degrees Celsius). The indicated value is equal here to 27°C (Djidohokpin et al., 2017b). This method of estimating M is widely used throughout the tropics where time series of reliable catch and effort data and several years of Z values are not available (Pauly, 1980). Fishing mortality (F) was obtained by subtracting M from Z and exploitation rate (E) was obtained using this formula E = F / Z. The exploitation rate indicates whether the stock is slightly (E < 0.5) or strongly (E > 0.5) exploited, based on the assumption that fish stock is optimally exploited when F = M or E = 0.5 (Gulland, 1971).

The estimates of length-at-first-capture (Lc or L₅₀) were derived from probabilities of capture generated from the catch curve analysis. The extrapolated points of the length-converted catch curve were used to approximate the probability of capture for each length group using the running average method to estimate the selection parameter L₅₀ through linear interpolation.

Recruitment patterns

Recruitment patterns were generated from the estimated growth parameters by backward projection of length frequency data, as done in ELEFAN, onto the time axis (Moreau and Cuende, 1991). This type of back-calculation usually allows identification of the number of seasonal pulses of recruitment that have been generated by the represented population in the length frequency data (Gayanilo et al., 2002).

RESULTS AND DISCUSSION

Growth parameters

A summary of the parameters that describe growth in length (K, L₅₀, t₀), derived growth performance index (ϕ') and longevity (tₘₐₓ) is provided in Table 1. The maximum estimate of asymptotic length L₅₀ was observed for Schilbe intermedius (25.20 cm), and the minimum within the Mochokidae for Synodontis schall (21.84 cm). The values for K estimated for the fishes ranged from 0.52/year for S. intermedius to 2.67 for S. schall. The growth estimates as shown in Table 1, indicates that the value of t₀ was given as -0.49 for S. schall and -0.61 for S. intermedius, and the growth performance index (ϕ') was 2.64 for S. schall and 2.51 for S. intermedius. For these estimates, through ELEFAN the goodness of fit (Rn) varied from 0.10, as shown with Schilbe intermedius, to 0.41 for Synodontis schall. Figure 2 showed the growth curves generated from ELEFAN for the 2 fish species during the course of this study.

Table 1: Growth parameters of for Synodontis schall and Schilbe intermedius sampled in the Tovè River from October 2015 to September 2016 in comparison to populations of these species in other Benin localities

<table>
<thead>
<tr>
<th>Parameters</th>
<th>SYNODONTIS SCHALL</th>
<th>SCHILBE INTERMEDUIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Tovè River (Benin)</td>
<td>Tovè River (Benin )</td>
</tr>
<tr>
<td>Localty</td>
<td>21.84 0.93</td>
<td>25.20 0.52</td>
</tr>
<tr>
<td>TL₅₀(cm)</td>
<td>35.00 0.71</td>
<td>32.00 0.32</td>
</tr>
<tr>
<td>K(y⁻¹)</td>
<td>32.00 0.32</td>
<td>26.00 0.70</td>
</tr>
<tr>
<td>t₀(y⁻¹)</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Tₘₐₓ(y⁻¹)</td>
<td>3.22</td>
<td>5.76</td>
</tr>
<tr>
<td>Rn</td>
<td>0.41</td>
<td>0.10</td>
</tr>
<tr>
<td>ϕ'</td>
<td>2.64</td>
<td>2.51</td>
</tr>
<tr>
<td>References</td>
<td>Present study</td>
<td>Montcho (2011)</td>
</tr>
</tbody>
</table>
**Fig. 2:** Length frequency data superimposed on the growth curve of *Synodontis schall* (a) and *Schilbe intermedius* (b) sampled in the Tovè River from October 2015 to September 2016

**Instantaneous mortality coefficients and exploitation rates**

The length converted catch curves are presented in Fig. 3. Instantaneous mortality rates Z, M and F and exploitation rate E are given in Table 2.

**Table 2:** Estimates of mortalities and related parameters obtained for *Synodontis schall* and *Schilbe intermedius* sampled in the Tovè River from October 2015 to September 2016 in comparison to populations of these species in other Benin localities

<table>
<thead>
<tr>
<th>Species</th>
<th>Locality</th>
<th>Parameters</th>
<th>References</th>
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<tr>
<td></td>
<td></td>
<td>Z (y⁻¹)</td>
<td>M (y⁻¹)</td>
</tr>
<tr>
<td><em>Synodontis schall</em></td>
<td>Tovè River (Benin)</td>
<td>4.13</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td>Pendjari River (Benin)</td>
<td>2.72</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>Ouémé River (Benin)</td>
<td>2.01</td>
<td>0.83</td>
</tr>
<tr>
<td><em>Schilbe intermedius</em></td>
<td>Tovè River (Benin)</td>
<td>1.28</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Ouémé River (Benin)</td>
<td>2.56</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Pendjari River (Benin)</td>
<td>1.67</td>
<td>1.01</td>
</tr>
</tbody>
</table>

**Fig. 3:** Length-converted catch curve for *Synodontis schall* (a) and *Schilbe intermedius* (b) sampled in the Tovè River from October 2015 to September 2016

Total mortality was estimated to be 4.13 y⁻¹ for *Synodontis schall* and 1.28 y⁻¹ for *Schilbe intermedius* in Tovè River. Most individual mortality was due to natural mortality M, estimated as 1.82 and 1.20 y⁻¹, for *Synodontis schall* and *Schilbe intermedius*, respectively. Fishing mortality F was low in *Schilbe intermedius* (0.08 y⁻¹), but higher for *Synodontis schall* (2.31 y⁻¹) (Fig.3a, b). The exploitation rate E was 0.55 for *Synodontis schall* and 0.06 for *Schilbe intermedius* in Tovè River. Only the E value of *Synodontis schall*, was slightly above the assumed optimum value (E_{opt} = 0.5).

In Tovè River, the curve of relative yield per recruit Y'/R relative to the exploitation ratio E, indicated an optimal exploitation rate (E_{max}) of 0.439 for *Synodontis schall*, a rate relatively similar to the E_{max} estimated for *Schilbe intermedius* (0.421) (Fig.4a, b).
The exploitation rate $E_{0.1}$ (exploitation rate at which the marginal increase of $Y'/R$ is 10% of its entire stock) and $E_{0.5}$ (exploitation rate under which the entire stock is halved) were estimated at 0.369 and 0.286, respectively, for *Synodontis schall*, and 0.355 and 0.278 for *Schilbe intermedius*. Similarly, the model found that 25% and 75% of all the fish of *Synodontis schall* had an estimated length of 3.35 cm and 7.25 cm, respectively, while 25% and 75% of the total caught in *Schilbe intermedius* had an estimated length of 5.35 cm and 9.10 cm respectively.

Recruitment patterns of *Synodontis schall* and *Schilbe intermedius* in Tovè River were not similar (Figs. 6a, b), with a notable bimodal distribution indicating two distinct spawning events (April-May and July-August) for *Schilbe intermedius* and a single distribution where the main recruitment occurred between July-August for *Synodontis schall*.
chemical characteristics of the water (Ofori et al., 2002). A second indication that only the stocks for Synodontis schall are overexploited was obtained by comparing the size at first capture, Lc, i.e. the length at which 50% of the fish measuring that size are vulnerable to capture, with $L_{50}$. Size at first capture was estimated at 5.35 cm in Synodontis schall and 7.20 cm in Schilbe intermedius. According to Aripin and Showers (2000), the exploitation level is already high for virtually all of small sized species like S. schall. This situation is also described by Froese (2004) as recruitment overfishing; other fishes are caught before they can realize their full potential.

The mainly short-lived (3.22 years) Synodontis schall estimated by longevity ($t_{90}$) would be owing to her over exploited. The apparent underexploitation of the populations of Schilbe intermedius could easily switch to overexploitation in the future if sensitization sessions advocating sustainable fishing methods are not organized. Recruitment has been described as a year-round phenomenon for tropical fish and shrimp species (Qasim, 1973; Weber, 1976). The major fish populations studied here exhibited two recruitment peaks, which conforms with Pauly’s (1982) assertion of a double recruitment pulse per year for tropical fish species and for short lived species. The major peak of recruitment for studied species was in the months of the year, which coincides with the rainy season in the South Benin. This was reported by many authors who have investigated the spawning periods for tropical fish populations in Africa (Lowe-McConnell, 1975; Welcomme and De Merona, 1988).

The results reported in this study represent a preliminary demographics parameters data analysis of fish species in Tovè River. However, other aspects such as finding habit and reproduction strategy could be investigated to enrich or extend data base of management and conservation of the fish species of the Tovè River.

**CONCLUSION**

The current study of the population status of S. schall and S. intermedius, based on the samples collected from artisanal catches in Tovè River shows that only S. schall is optimally exploited by the current fishing regime. However,
the higher fishing mortality in Tové River may reflect the increasing use of scoop nets. Therefore it could be recommend the development of a monitoring program to detect shifts in the exploitation rates, indices of overexploitation and changes in life-history traits that may reflect harvest-induced change.

**REFERENCE**


Sossoukpé, E., Nunoo, F.K.E., Ofori-Danson, P.K., Fiogbé, E.D. and Dankwa, H.R. 2013 Growth and mortality parameters of *P. senegalensis* and *P. typus* (Sciaenidae) in nearshore waters of Benin (West Africa) and their implications for management and conservation, *Journal of fisheries research*, 137: 71-80.


