Biology of bigmouth sleeper, *Eleotris vittata* (Duméril, 1861) (Pisces: Eleotridae) in the lower Cross River, Nigeria

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Abstract

Between May and December 2014, the abundance, condition factor, length-weight relationship, food and feeding habits of the bigmouth sleeper, *Eleotris vittata* were studied in the lower Cross River, Nigeria. Data generated were subjected to statistical analyses at a 0.05 probability level. A total of 231 specimens were collected and examined. The highest number was recorded in the month of December (79 specimens; 34.20%) while September (2 specimens; 0.87%) had the lowest. The highest monthly condition factor was recorded in June (1.56) while November (1.30) had the lowest. *E. vittata* had total length and total weight ranges of 8.10-110.30cm and 5.07-342.70g respectively. Seasonal variation in abundance of *E. vittata* was higher (121 specimens; 52.38%) during the wet season than the dry season (110 specimens; 47.62%). The results obtained from the length-weight relationship graph showed that the growth pattern of the fish was negatively allometric with b values of 0.16 obtained at P<0.05. There was moderate correlation between the length and weight of the specimens as the correlation coefficient (r) was 0.5586. Feeding intensity was highest in the month of June (88.89 % GRI) and lowest in September (50.00 % GRI). The gut contents revealed that 5 food items were ingested of which three were of primary importance (crustaceans 78.83 %IFD, Pisces 18.88 %IFD and molluscs 10.32 %IFD) while the rest of the items (nematode 4.42 %IFD and macrophytes 3.51 %IFD) were of secondary importance. Hence, *E. vittata* is an invertivore-piscivore.

Keywords: *Eleotris vittata*, feeding habits, size variation, condition factor, lower Cross River

1. Introduction

The family Eleotridae (Perciformes) comprises about 35 genera and 155 species which inhabit tropical and subtropical areas worldwide [1, 2] reported the family Eleotridae as being among the world’s most widely distributed fish. They occurred throughout most of the West African coastline and can be found worldwide in tropical and subtropical regions, but are rarely found in temperate areas [3, 4]. In the Nigerian coastal waters, Eleotrid species comprise *Bostrychus africanus*, *Dormitator lebretonus*, *Eleotris vittata* and *Eleotris danganensis* [5] and they are found in both fresh and brackish waters [6, 7] classified *E. vittata* as a creeklet-dominated species while working in the intertidal fish communities of the Cross River estuary. Data of the functional Length-Weight Relationship (LWR) is important for fish stock assessment [8], estimation of growth rates and age structure [9], calculation of the standing stock biomass [10], condition indices [11, 12] and several other aspects of fish population dynamics [13, 14]. Like any other morphometric characters, the LWR can be used as a character for the differentiation taxonomic units and the relationship changes with the various development events in life such as metamorphosis, growth and onset of maturity [15].

Condition factor, K is an index of the degree of fatness or well-being of a species [16]. The study of condition factor is important to understand the life cycle of fish species, contribute to an adequate management of the species and to maintain the ecosystem equilibrium [17]. This factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the “condition” of that individual fish [18]. Different values in K of a fish indicate the state of sexual maturity, the degree of food sources availability, age and sex of some species [19].

The study of the food and feeding habits of aquatic species is a subject of continuous research because it constitutes the basis for the development of a successful fisheries management programmed on fish capture and culture [20]. Nature offers a great diversity of organisms that are used as food by fish, and these differ in size and taxonomic groups [21, 22] observed that the dietary analysis of organisms in their natural habitat enhances the understanding of the...
growth, abundance, productivity and distribution of these organisms. [23] observed that fish abundance in different habitats is associated with availability and abundance of food and substrate types in a particular habitat. There is paucity of information on the food and feeding habits of *E. vittata* in the lower Cross River. Little attention has been given to some aspects of the ecology of *E. vittata* in the lower Cross River [24]. Thus, this study complements and expands such literatures, but will further provide useful information to fisheries scientists who require these data to make informed research decisions.

2. Materials and methods

2.1 Study Area

The present study was conducted in the lower Cross River at Ayadehe in Itu Local Government Area, Akwa Ibom State, Nigeria. It lies between latitude 5° 10’N and longitude 8° 3’E. The area is bounded in the north by Cross River State, west by Ibiono Ibom Local Government Area, east by Uruan Local Government Area, and south by Uyo Local Government Area (Fig. 1). The river rises from the Cameroon mountains and flows south-westwards into the Atlantic Ocean. The lower Cross River lies within a typical tropical humid climate, which is characterized by distinct dry and wet seasons, with peak dry season occurring in December – February [25, 26]. The dry season which lasts from November - March is influenced by the hot north-eastern continental air mass from the Sahara Desert and is characterized by fairly high temperature. Relative humidity is usually high throughout the year. Maximum rainfall occurs during the months of June - September [27]. Its dominant vegetation include trees (*Elaeis guineensis*), Bamboo (*Bambusa africana*), plantain and banana (*Musa spp*), and guinea grass (*Pannicum maximum*). This station is characterized by a sandy erosion and muddy bankroot biotopes made up of silt. The common activities across the entire stretch of the river are fishing and agricultural crop farming on the floodplains especially during the dry season.

2.2 Fish sampling

Samples of *Eleotris vittata* which were the only species of the eleotrid family found in the station (Itu) were collected bi-monthly and randomly for a period of 8 months (May - December 2014) from selected artisanal fishers. The fishing gears used comprised of mainly basket traps and cast nets (with mesh size of 1-25mm) [28].

2.3 Preservation

Fish samples were preserved in 10% formaldehyde solution in well-labelled containers to reduce microbial digestion to the minimum [29, 30]. All preserved samples were removed from the formaldehyde solution, rinsed in clean water and placed slanting with the mouth down to drain out excess fluid for about 5-10 minutes prior to identification and laboratory analysis.

2.4 Measurement and identification

The total length was measured to the nearest 0.1cm using a standard measuring board (1-50cm) as described by [31]. The weight was taken with an electronic weighing balance TDA Series Precision Balance with Model No. TDA: 6002A to the nearest 0.1g. The specimens were dissected and their guts carefully removed. *E. vittata* had no defined stomach, thus, the intestine was used as the gut [32]. Furthermore, the food items in the guts were stored after being carefully removed by the use of forceps in 4% formalin until the contents were analyzed [33].

Fig 1: Map of Itu L. G. A. showing the sampling station at Ayadehe in the lower Cross River, Nigeria (Insert: Map of Nigeria showing the location of Akwa Ibom State).
2.5 Statistical analysis
SPSS (version 19) package was used to determine the means, range, one way ANOVA and Duncan Multiple Range Tests. Microsoft Excel 2010 was used for graphical illustrations of all parameters.

2.6 Length-Weight Relationship (LWR)
The relationship between the length and weight of the fish were established using the parabolic equation [18]:

\[ W = aL^b \]  \hspace{1cm} [1]

Where \( W \) = Weight of fish (g); \( L \) = Length of fish (cm); \( a \) = Constant and \( b \) = an exponential expressing the relationship between length-weight.

The relationship when converted into the logarithmic form gives a straight line relationship graphically thus:

\[ \log w = \log a + b \log L \]  \hspace{1cm} [2]

Where \( b \) = slope of the line; \( a \) = constant

Relative abundance was estimated from the index of preponderance (%IP), which takes account of both number and weight [34, 35];

\[ IP = 100(\%N.\%TW) / \Sigma(\%N.\%TW) \]  \hspace{1cm} [3]

Where

\( \%N \) = percentage number of the species; and \( \%TW \) = percentage weight of all the species sampled during the study.

2.7 Condition Factor (K)
Condition factor (K) which is the degree of fatness or corpulence or well-being of a specimen was calculated using [36]:

\[ K = 100W / L^3 \]  \hspace{1cm} [4]

Where

\( W \) = Weight (g); and \( L \) = Length (cm)

100 is a factor to bring the value of K near unity.

2.8 Stomach content analysis
There are several indices for expressing the quantitative importance of different food items in the diets of fish as described by [37-39];

2.8.1 Point method (P):
The total point (TP) per food item (based on the point’s volume of the gut fullness) was shared among the gut contents in units proportional to their visually estimated bulk. Each gut was awarded points based on the nature of fullness of the gut (in this case, the intestine). The degree of fullness of each gut was estimated by an arbitrary 0-20 points scale; such that 0, 5, 10, 15 and 20 points were allotted to empty, \( \frac{1}{4} \) full, \( \frac{1}{2} \) full, \( \frac{3}{4} \) full and full guts respectively [40].

The total points (PP) and frequency of occurrence (FO) of each food object were assessed and the index of food (%IFD) estimated. The gut contents of each specimen were later placed on a petri dish and were carefully examined with the unaided eye and a compound microscope. The contents were sorted, identified and the importance of each was assessed by frequency and point methods [39] which were later modified by [41].

Formula for relative importance of food items was given as:

\[ RF = \frac{F_i \times 100}{\Sigma F_i} \]  \hspace{1cm} [5]

Where: \( F_i \) = Frequency of item i; and \( \Sigma F_i \) = Total sum of \( F_i \).

All RF values sum up to 100, thus, the integrated importance of each item was then expressed as an index of food dominance (IFD) by [38] according to the formula:

\[ IFD = \frac{RF \times PP \times 100}{\Sigma (RF \times PP)} \]  \hspace{1cm} [6]

Where: \( RF \) = Relative Frequency of food item; \( PP \) = Point Percentage

This index ranges from 0 to 100%. The use of IFD to establish overall food preponderance is adequate as it incorporates the RF and PP data, thus minimizing the bias characteristic of cases in which results from different analytical methods are independently interpreted.

3. Results
3.1 Monthly abundance and size range
A total of 231 specimens of E. vittata were examined as the only Eleotridae in the lower Cross River. There were statistical differences among the months at 0.05%. The degree of effective contribution (%IP) showed that December (49.38%) had the most significant contribution and was followed by July (19.85%). October and November recorded 12.76% and 10.89% respectively; June and August had (3.34%) while September (0.03%) made the least contribution. The frequency of occurrence (%N) followed the same pattern as %IP with December being the most abundant (79 specimens; 34.20%) while September was the least (2 specimens; 0.87%). Seasonal variation in abundance of E. vittata was higher (121 specimens; 52.38%) during the wet season than the dry season (110 specimens; 47.62%). The fish measured 8.10 - 110.30cm TL range and 17.38cm mean TL while they weighed 5.07 - 342.70g TW range and 74.72g mean TW as shown in Table 1.

3.2 Length-Weight Relationship (L-WR)
The values of the regression coefficients (a and b) and correlation coefficient (r) were shown in Fig. 2. The intercept (a) value of the fish was 1.30 and the corresponding exponent b value was 0.16. The exponent b value of the fish was less than 3 and indicated negative allometric growth pattern while the r which had the value of 0.55 showed a degree of weakly positive correlation. There was no significant (P<0.05) correlation. The regression graph gave a straight line relationship which implied that as the fish increased in length, their weight also increased.
Table 1: Monthly variation in size and abundance of *E. vittata* in the lower Cross River, Nigeria.

<table>
<thead>
<tr>
<th>MONTH</th>
<th>N</th>
<th>%N</th>
<th>TL (cm) Ranges</th>
<th>TW (g) Ranges</th>
<th>Mean TL (cm)</th>
<th>Mean TW (g)</th>
<th>K</th>
<th>IP (%)</th>
<th>GRI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAY</td>
<td>6</td>
<td>2.60</td>
<td>14.5-21.0</td>
<td>37.99-126.59</td>
<td>17.18</td>
<td>74.47</td>
<td>1.34</td>
<td>0.41</td>
<td>66.69</td>
</tr>
<tr>
<td>JUN</td>
<td>18</td>
<td>7.79</td>
<td>12.3-24.0</td>
<td>28.06-194.45</td>
<td>15.93</td>
<td>67.68</td>
<td>1.56</td>
<td>3.34</td>
<td>88.89</td>
</tr>
<tr>
<td>JUL</td>
<td>48</td>
<td>20.78</td>
<td>10.0-22.0</td>
<td>12.49-163.97</td>
<td>15.85</td>
<td>61.68</td>
<td>1.41</td>
<td>19.85</td>
<td>68.75</td>
</tr>
<tr>
<td>AUG</td>
<td>15</td>
<td>6.49</td>
<td>12.4-27.7</td>
<td>24.71-301.12</td>
<td>18.19</td>
<td>97.45</td>
<td>1.46</td>
<td>3.34</td>
<td>86.67</td>
</tr>
<tr>
<td>SEPT</td>
<td>2</td>
<td>0.87</td>
<td>14.6-16.0</td>
<td>45.8-57.60</td>
<td>17.87</td>
<td>92.37</td>
<td>1.46</td>
<td>0.03</td>
<td>50.00</td>
</tr>
<tr>
<td>OCT</td>
<td>32</td>
<td>13.85</td>
<td>8.80-28.50</td>
<td>8.60-342.70</td>
<td>16.27</td>
<td>71.27</td>
<td>1.48</td>
<td>12.76</td>
<td>56.25</td>
</tr>
<tr>
<td>NOV</td>
<td>31</td>
<td>13.42</td>
<td>8.10-110.3</td>
<td>5.07-210.63</td>
<td>20.22</td>
<td>74.41</td>
<td>1.30</td>
<td>10.89</td>
<td>54.84</td>
</tr>
<tr>
<td>DEC</td>
<td>79</td>
<td>34.20</td>
<td>9.60-110.0</td>
<td>13.4-161.0</td>
<td>17.53</td>
<td>58.43</td>
<td>1.34</td>
<td>49.38</td>
<td>79.75</td>
</tr>
<tr>
<td>TOTAL</td>
<td>231</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3 Condition factor

Monthly variations in condition factor (K) of *Eleotris vittata* revealed that the lowest body condition (K=1.30) was obtained in November, depicting dry season while the highest (K=1.56) was observed in June depicting wet season. The fish body condition was generally high (mean K-value = 1.42) (Table 1).

3.4 Feeding intensity

Table 1 showed that GRI (%) was highest in June (88.89%) and least in September (50.00%). The other monthly GRI (%) in descending order were: 86.67% (August), 79.75% (December), 68.75% (July), 66.69% (May), 56.25% (October) and 54.84% (November). The result from the monthly feeding intensity of *E. vittata* showed that the index of empty guts decreased from September to June while that of full guts decreased from September to November. Stomach fullness recorded in Table 2 was as follows: 0 (66 guts, 28.57%), 5 (51 guts, 22.08%), 10 (16 guts, 6.92%), 15 (23 guts, 9.96%) and 20 (75 guts, 32.47%). The overall feeding intensity of the fish revealed that out of 231 specimens, 66 guts (28.57%) had empty guts while 165 guts (71.43%) had food in their guts, hence, stomachs with food were higher than those without food.

Table 2: Composite feeding intensity of *Eleotris vittata* based on degree of stomach fullness in the lower Cross River, Nigeria.

<table>
<thead>
<tr>
<th>Points</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>66</td>
<td>28.57</td>
</tr>
<tr>
<td>5</td>
<td>51</td>
<td>22.08</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>6.92</td>
</tr>
<tr>
<td>15</td>
<td>23</td>
<td>9.96</td>
</tr>
<tr>
<td>20</td>
<td>75</td>
<td>32.47</td>
</tr>
<tr>
<td>TOTAL</td>
<td>231</td>
<td>100</td>
</tr>
</tbody>
</table>

3.5 Diet composition

The trophic spectrum of *E. vittata* was illustrated in Table 3 and Fig. 3. Five major dietary compositions were identified in the fish stomachs. The dominant food item was crustaceans (74.40%) while the lowest was macrophytes (2.63%). Others were Pisces, molluscs and nematodes having IFD of 18.88%, 7.29% and 4.42% respectively. These dietary comprised of crustaceans (*Callinectes sp* and *Macrobrachium sp*), Pisces (unidentified fish), Mollusca (*Tympanotonus fuscatus* and *Pomacea palludosa*), nematodes and macrophytes (plant roots, seeds and leaves). All the food items were primarily important in the diet of the eleotrids.

Table 3: Overall food composition of *Eleotris vittata* in the lower Cross River, Nigeria.

<table>
<thead>
<tr>
<th>Food Items</th>
<th>%RF</th>
<th>%PP</th>
<th>%IFD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crustacea</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Callinectes sp</em></td>
<td>30.73</td>
<td>33.66</td>
<td>73.83</td>
</tr>
<tr>
<td><em>Macrobrachium sp</em></td>
<td>25.49</td>
<td>31.08</td>
<td>7.03</td>
</tr>
<tr>
<td><strong>Total Crustacea</strong></td>
<td>65.22</td>
<td>64.74</td>
<td>80.86</td>
</tr>
<tr>
<td><strong>Macrophytes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>1.33</td>
<td>0.44</td>
<td>0.03</td>
</tr>
<tr>
<td>Seed</td>
<td>2.40</td>
<td>0.70</td>
<td>0.03</td>
</tr>
<tr>
<td>Root</td>
<td>7.84</td>
<td>2.97</td>
<td>0.97</td>
</tr>
<tr>
<td><strong>Total macrophytes</strong></td>
<td>11.57</td>
<td>4.11</td>
<td>1.03</td>
</tr>
<tr>
<td><strong>Molluscs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tympanotonus fuscatus</em></td>
<td>1.85</td>
<td>2.85</td>
<td>5.7</td>
</tr>
<tr>
<td><em>Pomacea palludosa</em></td>
<td>9.83</td>
<td>8.30</td>
<td>2.16</td>
</tr>
<tr>
<td><strong>Total Molluscs</strong></td>
<td>11.68</td>
<td>11.15</td>
<td>7.86</td>
</tr>
<tr>
<td><strong>Nematodes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.72</td>
<td>2.30</td>
<td>3.12</td>
<td></td>
</tr>
<tr>
<td><strong>Pisces</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unidentified fish</td>
<td>12.10</td>
<td>17.69</td>
<td>7.13</td>
</tr>
</tbody>
</table>

Fig 3: Dietary composition of *E. vittata* in the lower Cross River, Nigeria.
3.6 Seasonal variation in diet composition

The composite diet data for the two seasons was higher in the wet season than the dry season (P>0.05) (Fig. 4). The qualitative food compositions portrayed high dissimilarity in proportions between the seasons.

![Fig. 4: Seasonal variations in diet composition of Eleotris vittata in the lower Cross River, Nigeria.](image)

4. Discussion

In the month of September, only 2 specimens were obtained. This varied slightly with the works [42] who reported on the seasonal distribution and richness of fish species that no specimen of *E. vittata* were recorded in September in the Badagry lagoon. Species abundance describes key elements of biodiversity. Indices of abundance reveal how rare a species is, in relation to other species in a given location or community [43].

Seasonal variation in abundance of *E. vittata* was higher during the wet season than the dry season. This agrees with the findings of [44], who reported that 4339 individuals (or 47.01%) accounting for a biomass of 191371.0g were caught in the dry season while rainy season recorded a total of 4890 individual (52.99%) with a total biomass of 224415.6g; thus, significantly higher catch (p<0.05) in the rainy season than dry season. High water season has been considered as the main feeding and growing period for nearly all species in the seasonal flood plain rivers of the tropics [45-49, 44, 50].

*E. vittata* showed high body condition. The mean condition factor ranging from 1.30 – 1.56 obtained in this study conforms to results from other studies. [51] studied the monthly condition factor of *Eleotris lebretonis* procured from a eutrophic creek in southwest Nigeria for one year and got values of between 1.07 and 2.30. The values obtained from this study showed that the samples were in fair condition all through the sampling period. It therefore implies that life in water with all the potential food resources provide a better environmental condition for *E. vittata* to thrive. In fishery science, body wellbeing ≥ 1.0 is considered as good. Certain factors often affect the well-being of a fish: data pulling, sorting into classes, sex, stages of maturity and state of the stomach, sex, stages of maturity, and state of stomach contents [52, 53].

The months of October and November had the largest fish: 8.10-110.3cm and 8.60-342.70g respectively. The larger sizes of *E. vittata* sampled in these two months could be attributed probably to their faster growth rates and intense feeding habits as observed by [54, 55]. This is a transition phase between the wet and dry seasons; the water level by this time is reducing through the sampling period. It therefore implies that life in water with all the potential food resources provide a better environmental condition for *E. vittata* to thrive. In fishery science, body wellbeing ≥ 1.0 is considered as good. Certain factors often affect the well-being of a fish: data pulling, sorting into classes, sex, stages of maturity and state of the stomach, sex, stages of maturity, and state of stomach contents [52, 53].

The b value in this study could be considered to be very low. But, it may be important to note that similar observations have been reported for other fishes fish species such as *S. schall* [56], *Clarias gariepinus* and *Risha africana* [61]. Differences in a and b values have been attributed to the age, sex, fecundity of the fishes, sampling methods and sample size as well as the prevailing ecological conditions in the different water bodies [13].

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Seasonal variation in abundance of *E. vittata* was higher during the wet season than the dry season. This agrees with the findings of [44], who reported that 4339 individuals (or 47.01%) accounting for a biomass of 191371.0g were caught in the dry season while rainy season recorded a total of 4890 individual (52.99%) with a total biomass of 224415.6g; thus, significantly higher catch (p<0.05) in the rainy season than dry season. High water season has been considered as the main feeding and growing period for nearly all species in the seasonal flood plain rivers of the tropics [45-49, 44, 50].

*E. vittata* showed high body condition. The mean condition factor ranging from 1.30 – 1.56 obtained in this study conforms to results from other studies. [51] studied the monthly condition factor of *Eleotris lebretonis* procured from a eutrophic creek in southwest Nigeria for one year and got values of between 1.07 and 2.30. The values obtained from this study showed that the samples were in fair condition all through the sampling period. It therefore implies that life in water with all the potential food resources provide a better environmental condition for *E. vittata* to thrive. In fishery science, body wellbeing ≥ 1.0 is considered as good. Certain factors often affect the well-being of a fish: data pulling, sorting into classes, sex, stages of maturity and state of the stomach, sex, stages of maturity, and state of stomach contents [52, 53].

The months of October and November had the largest fish: 8.10-110.3cm and 8.60-342.70g respectively. The larger sizes of *E. vittata* sampled in these two months could be attributed probably to their faster growth rates and intense feeding habits as observed by [54, 55]. This is a transition phase between the wet and dry seasons; the water level by this time is reducing through the sampling period. It therefore implies that life in water with all the potential food resources provide a better environmental condition for *E. vittata* to thrive. In fishery science, body wellbeing ≥ 1.0 is considered as good. Certain factors often affect the well-being of a fish: data pulling, sorting into classes, sex, stages of maturity and state of the stomach, sex, stages of maturity, and state of stomach contents [52, 53].

The b value in this study could be considered to be very low. But, it may be important to note that similar observations have been reported for other fishes fish species such as *S. schall* [56], *Clarias gariepinus* and *Risha africana* [61]. Differences in a and b values have been attributed to the age, sex, fecundity of the fishes, sampling methods and sample size as well as the prevailing ecological conditions in the different water bodies [13].
productivity and distribution of organisms \[22\]. The knowledge of the diet of a species in nature is important for the establishment of its nutritional needs and of its interaction with other organisms \[22\] and the presence of various food types (plants, animal, detritus and sediments) in their stomachs is an indication of their feeding habits. Feeding intensity of fish can be determined based on degree of fullness of stomach. Fish can also be further classified into categories based on their predominant feeding habits \[46\]. Thus, \textit{E. vittata} can be considered as an invertivore-piscivore. This is in agreement with the findings of \[66, 67\].

5. Conclusion
The present theory of the few occurrence or fish disappearance during the month of September in the different geographical terrain is not clear but should evoke further investigation on \textit{E. vittata}. The fish fed on wide range of food items mostly of animal origin and can therefore be said to be invertivore-piscivore. This study provides new information on the length-weight relationship, condition factor, food and feeding habits of \textit{E. vittata} and has greatly contributed to the knowledge of sustainable fishery resources in the lower Cross River. More qualitative investigations should be carried out in areas of reproduction and in relation to water quality to update this benchmark information.

6. References
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