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Aspects of the biology of juvenile Aba, *Gymnarchus niloticus* (Curvier 1829) from Epe Lagoon, Lagos, Nigeria

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Abstract
Gymnarchus niloticus is a commercial and socio-cultural important fish in Nigeria. Nevertheless, its fishery is largely based on the seed catch from the wild. Hitherto, diet preference, feeding strategy, relative gut length, length – weight relationship and Condition Factor (K) of G. niloticus juveniles were investigated. Fish samples (n = 222) were collected monthly between June and November 2017 from artisanal fishermen at Epe Lagoon. Stomach content analysis revealed that juvenile G. niloticus are carnivorous on fish, insects and crustaceans. Juveniles exhibited specialist feeding strategy on insects. Overall relative gut length was 0.65 (<1) re-enforcing carnivorous feeding. Total length and body weight of juveniles were extremely significantly correlated, r = 0.52 (p< 0.001), and showed isometric growth. Mean K was <1 during the study. The predilection for insects by juveniles suggested suitability of insect protein during culture. Poor condition factor indicated vulnerability of the species; hence the need for its conservation.

Keywords: carnivorous, epe lagoon, feeding strategy, juvenile stanzas, gut morphology

1. Introduction

Ample knowledge of the biology on vulnerable early life stages of fishes is central to recruitment and productivity of later stages. Deficient data on the biology of early life stages of fish species especially larval and juveniles may be associated with peak abundance and high mortality rates attributed to these stages in natural population [1, 2]. Consequently, there is a dire need to elucidate the driving factors of pre-juvenile and juvenile mortality in the wild. Adequate data on the biology of these vulnerable early life stages remain indispensable towards comprehending such underlying factors. This may also furnish information on feeding habits besides associated feeding structural traits, for instance gut morphomerty, that are basal requirement for fish survival [3, 4].

Dietary composition and feeding habits of fish often vary with fish species, size, time, season, habitats and other factors all intrinsic links with the environment. At pre-juvenile and juvenile stages, dietary preference is one of the most important factors in the assessment of feeding conditions and their probability of meeting food requirements [5]. To this extent, dietary items of fish are often determined indirectly based on analysis of stomach contents. There is limited information on the diets of fish juveniles in the wild [6, 7, 8]. Such information could form the basis of formulation of artificial diets for such species in culture enclosures. Adequate knowledge on feeding habits of fish species is imperative for culture, rearing and larval control [9].

Relative gut lengths of fish species are increasingly used in conjunction with stomach content analysis for robust data on feeding habits of fishes. It is one of the useful indices for inferring feeding habits of fish species into herbivorous, carnivorous, omnivorous, herbi-omnivorous or carni-omnivorous based on proportion of the gut length with respect to the total length of fish. It has found widespread application in fisheries biology [10, 11] although this trait often changes with life stages during development [11, 12].

The Aba Knife Fish, *Gymnarchus niloticus* is endemic to tropical Africa fresh waters [13]. Other common names include Freshwater Rat-tail, Nile Knife Fish, Aba Aba, Aba Knife Fish, Abba, Frank Fish and Trunkfish.

It is a peculiar fish devoid of anal and pelvic fin but with a modified caudal fin resembling that of a rat [14, 15]. Furthermore, the fin that is involved in locomotion is located on the dorsal side instead of the ventral side like in other Knife Fishes (*Papyroranus afer*, *Xenomystus* nigri). It belongs to Family Gymnarchidae, a mono-specific genus. The fish is not only an economic important fish food but also of great socio-cultural import in Nigeria [14, 16, 17, 18, 19] which endears it as one of the most highly valued freshwater fishes in Nigeria.

Despite its aquaculture potentials including rapid growth, high premium, tasteful, seasonal availability of wild growers [20], the supply of *Gymnarchus niloticus* relies greatly on wild collection which is insufficient for its demands [21]. Tobor [22]classified the species as endangered due to the indiscriminate collection of both young and parent together. Wild collection of the juveniles is also on the increase because of their dark beautiful body colour coupled with their ability to swim in both forward and backward directions makes them ideal ornamental fish.

Most studies on *Gymnarchus niloticus* have been concentrated on the adult. Therefore, this study aimed to report aspects of the biology of the juvenile of a vitally important commercial fish *G. niloticus* inhabiting Epe Lagoon. Five major questions were addressed on its biology: (i) what are the primary diets of the juvenile of *G. niloticus* in Epe Lagoon? (ii) what is the relationship between gut and body lengths of juvenile *G. niloticus* in Epe Lagoon? (iii) what is the relationship between its body length and weight? (iv) what is the feeding strategist of juvenile *G. niloticus* in Epe Lagoon? What is the condition factor of juvenile *G. niloticus* in Epe Lagoon? To address the first questions, stomach contents were identified and analyzed using primary indices (Number, frequency of occurrence and volumetric analysis expressed in percentages; validated by a compound index, Relative Importance Index. The second question was answered by empirical values of relative gut length grounded on ratio of gut length to body length. Regression analysis of length weight supplied the answer to the third question. Amundsen[23] plot revealed the feeding strategies interpreted as either generalist or specialist to answer the fourth question. The fifth question was addressed based on overall calculated average condition factor of the species besides its variations with time (months).

2. Materials and Methods

2.1 Study area

Epe lagoon (Figure 1) lies between longitude N 06° 33.710' E 004° 03'.710' and latitudes N 06° 31.893' E 003° 31.912'. The lagoon is sandwiched between two other lagoons, the Lekki Lagoon (freshwater) in the east and Lagos Lagoon (brackish water) in the west. It has a surface area of 243 km^2 and a maximum depth of 6m. The lagoon opens into the Gulf of Guinea (the sea) via the Lagos Harbor, and the vegetation surrounding the lagoon is of the mangrove swampy type. Epe Lagoon supports a predominantly artisanal fishery activity in Lagos and Ogun States in Nigeria.

2.2 Sample collections

Samples of *Gymnarchus niloticus* juvenile (Figure 2) were collected monthly for six months between June and November, 2017 from local fishermen at Chief market fish landing sites located at Epe Lagoon. The fishermen used cast nets and set net to catch fish samples. Samples were preserved in ice-chest to prevent post- capture digestion, then transported into the laboratory and preserved by deep freezing (Temperature – 4ºC).

2.3 Data collection

Specimens were sorted and identified according to Idodo-Umeh[24] to remove juveniles of other species erroneously collected with the sample. Total lengths of identified individual were measured with a ruler (Precision 0.1 mm) and weighed using a digital weighing balance (Precision 0.1 g).

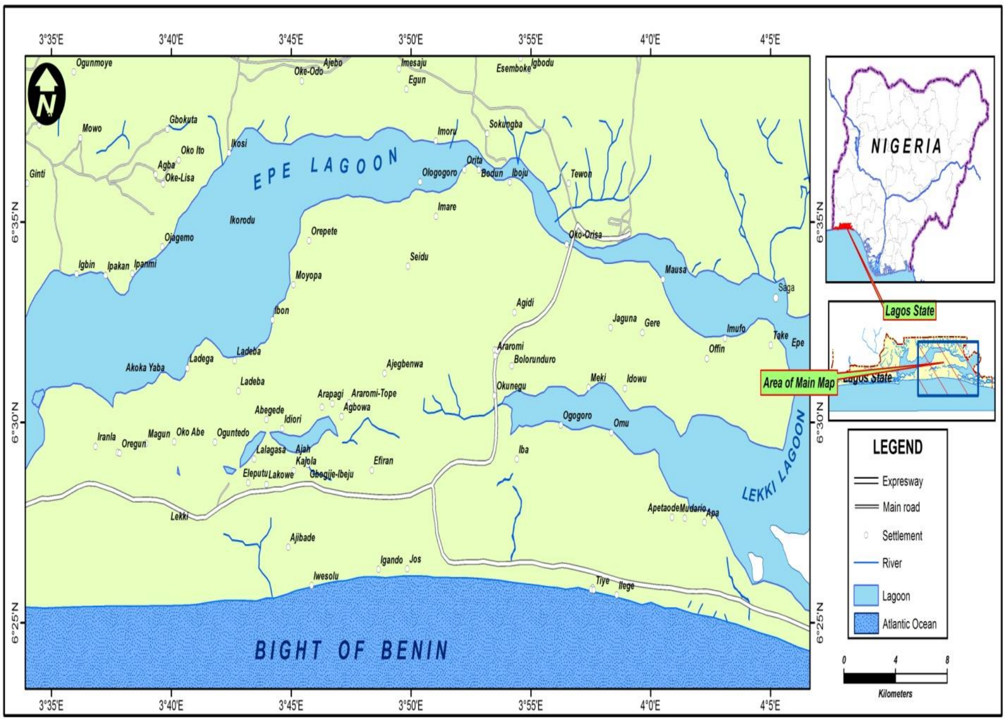

Fig 1: Epe Lagoon

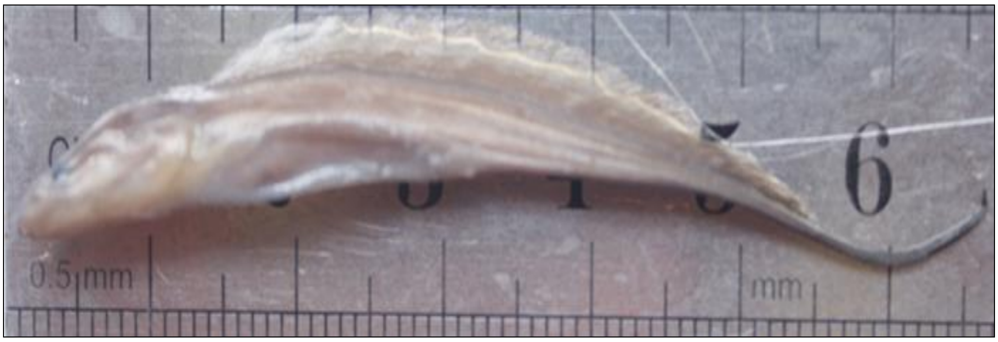

Fig 2: *Gymnarchus niloticus*

The length-weight relationship was described by the formula according to LeCren [25] $W = aL^b$, where W = Total body wet weight, L = Total body length, "a" is a constant and "b" = allometric factor. This equation was logarithmic transformed to Log W = Log a + b Log L; this approximate a straight line when plotted on a graph [26]. Stomach contents were examined after internal dissection of the gut; and analyzed based on the number, volume and frequency of occurrence of each dietary component identified expressed as percentages [27]. Relative Importance Index (RI) was calculated for each prey and group of preys based on the Absolute Importance Index (AI) [28]. Gut lengths of specimen were measured with a rule (precision 0.1 mm) after internal dissection. The Relative Gut Length (RGL) was expressed as the ratio of total length of gut to total body length [29]:

$$RGL = \frac{\text{Total length of gut}}{\text{Total length of fish}}$$

Where fish can be classified as herbivorous (RLG>1), carnivorous (RLG<1) or omnivorous (RLG =, or>, or <1).

The feeding strategy was analyzed according to graphical method of Amundsen [23]; a modification of Costello [30] method. This is based on a two-dimensional depiction, in which each dietary item point pooled as taxonomic category is generated by plotting the frequency of occurrence (In fractions) against prey-specific abundance (P_i). Prey specific abundance is an index of measure of food item based on the bulk (Volume). P_i was calculated using the volume of food categories as follows:

$$P_i = \frac{\sum S_i \times 100}{\sum S_t}$$

Where: P_i = prey specific abundance, S_i = volume of prey i in stomachs, and S_t = total volume of stomach contents in only those individuals with prey i in the stomachs. In order to determine the feeding strategy (specialized or generalized), dietary items encounter in the stomach were grouped as fish, crustaceans, insect, protozoan and rotifera.

An indirect method based on length and weight measurements were used to determine the condition factor of each individual fish according to Anderson and Gutreuter [31]:

$$\text{Condition factor} = \frac{\text{Weight (g)} \times 10^5}{[\text{Length (mm)}]^3}$$

Where w =gutted somatic weight and L = total length

2.4 Statistical analysis

Descriptive statistics (Mean, standard deviation) was used to summarize morph metric parameter of fish data using Microsoft excel. Amundsen plots of feeding strategy was plotted using Microsoft excel spreadsheet coded with Macro command 2007. Correlation and linear regression were performed using Graph Pad Prism Version 5.00 for Windows, Graph Pad Software, San Diego California USA, www.graphpad.com.

3. Results

Body size ranges

Total length of juveniles of *Gymnarchus niloticus* (n = 222) collected from Epe Lagoon during the sample period ranged from 49 – 72 mm total length (*M* = 61.48, *SD* = 3.59); weighed 0.9 - 0.31g (*M* 0.52, *SD* = 0.11).

Dietary composition

In the 222 stomachs examined, nearly half (49 %) had empty stomachs. Insect parts were the major food of the juveniles of *Gymnarchus niloticus* (Table 1); it accounted for 24 %, 18 % and 0.6 % by number, occurrence and volume respectively. Fish parts were the next importance food in the diet, accounting for 18 %, 4 % and 0.4 % by number, occurrence and volume respectively. All based on traditional indices (Table 1). Based on the relative importance index (Figure 3), the primary foods of *G. niloticus* juvenile are fish, insect and decapods crustaceans. The most important food category in the diet of *G. niloticus* also based on the relative important index (Figure 4) was insects (36.23 %); followed by fish (31.96%), while rotifera was the least (6.27 %).

Table 1: Summary of stomach contents of *Gymnarchus niloticus* juvenile in Epe Lagoon

Food items		% Number (%N)	% Occurrence Frequency (%FO)	% Volume (%V)	Absolute Importance Index = %N+%FO+%V
Rotifera					
	Trochocera	5.9	5.3	0.19	11.4
	Synchaeta	3.4	3.9	0.09	7.4
Protozoans					
	Paramecium	2.5	1.3	0.07	3.9
	Volvox	7.6	7.9	0.19	15.7
	Polytoma	4.2	6.6	1.40	12.2

	Didinium	3.4	2.6	0.47	6.5
Insecta					
	Insect pupa	5.1	7.9	21.03	34.0
	Chironomid larva	3.4	3.9	9.35	16.7
	Insect parts	20.3	23.7	14.02	58.0
Fish					
	Fish parts	16.9	21.1	28.04	66.0
	Fish scales	15.3	5.3	9.35	29.9
Crustacean					
	Copepod	11.9	10.5	15.89	38.3

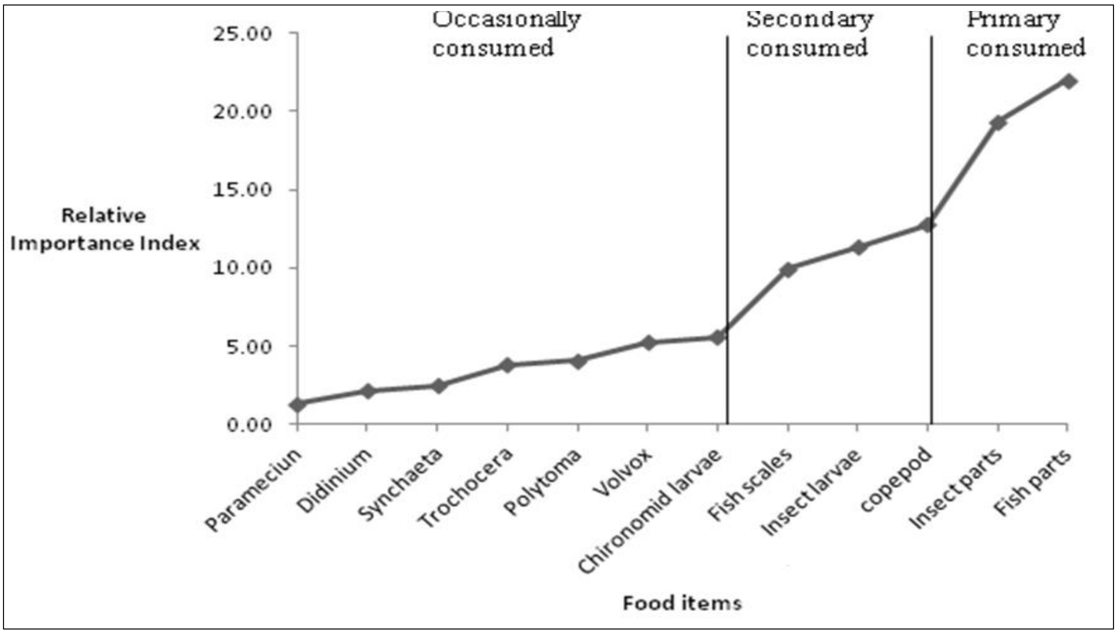

Fig 3: Diet preference of juvenile *Gymnarchurs niloticus* based on relative importance index

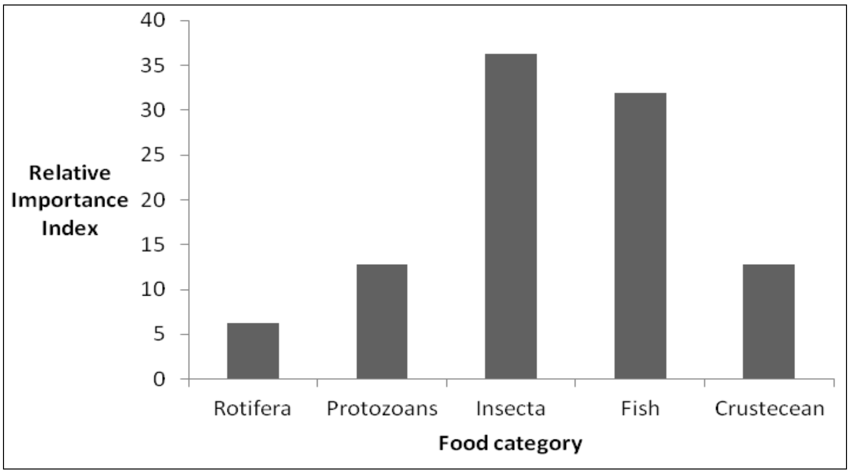

Fig 4: Relative important indices of food categories in the stomach of juvenile *Gymnarchus niloticus* in Epe Lagoon

Feeding strategy

Amundsen's plot (Figure 5) revealed that *Gymnarchus niloticus* juvenile utilize a specialist feeding strategy. Protozoans and rotifers are located in the lower corners indicating abject food items both with low frequencies of occurrence and prey specific abundance. Juvenile of Gymnarchus *niloticus* juvenile is specialist feeders on insects, then fish but seldom on crustacean.

Relative gut length

The estimated relative gut length was 0.65.

Length –weight relationship

Total length and body weight of juvenile *Gynarchus niloticus* were extremely significantly correlated, r (221) = 0.52, p< 0.001). The results of simple linear regression indicated that weight could be predicted from height by the following formula: Y = 3.109x – 3.0476, R^2 = 0.2727. The regression growth coefficient b = 3.0 shows isometric growth.

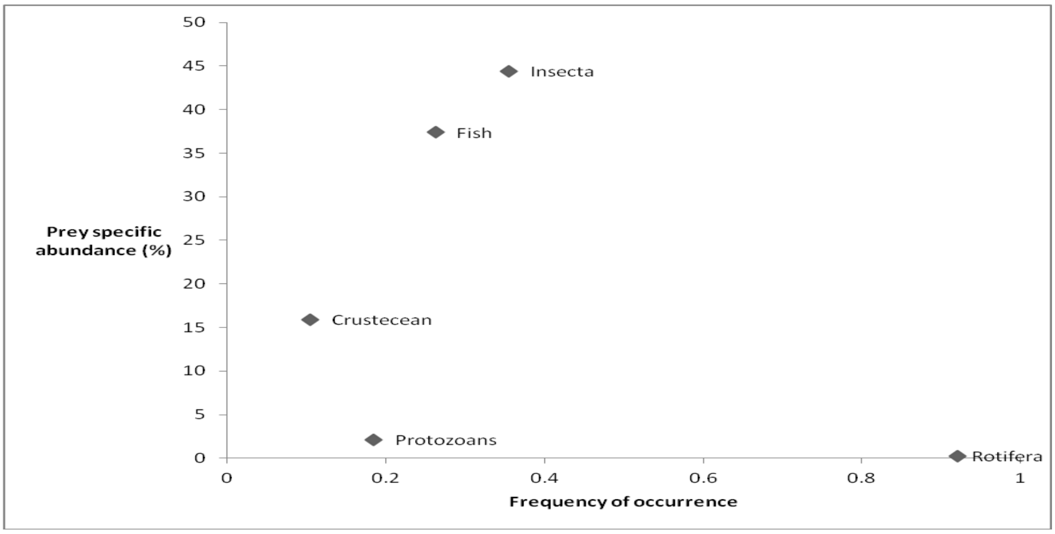

Fig 5: Feeding strategy of juvenile *Gymnarchus niloticus* in Epe Lagoon

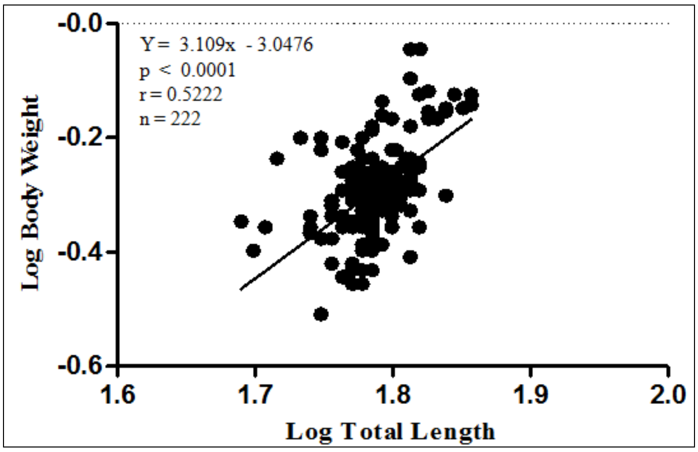

Fig 6: Length-weight relationship of juvenile *Gymnarchus niloticus* from Epe Lagoon

Condition factor

The mean condition factor for the collected juvenile sample of *Gymnarchus niloticus* was 0.23 ± 0.045. Condition factor of juveniles varied with time; monthly mean condition factor was generally less than 1 during the present study. Lowest condition factor was in August 2018 (0.21).

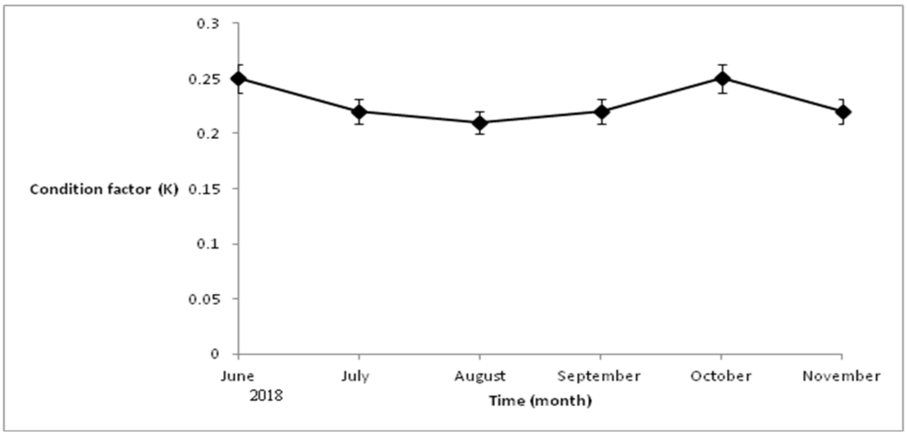

Fig 7: Monthly changes in mean condition factor of juvenile *Gymnarchus niloticus* from Epe Lagoon

4. Discussion

The stomach contents of juvenile *Gymnarchus niloticus* comprised five food categories namely fish, insect, rotifer, protozoan and crustaceans. This is in agreement with the reports by other workers [23, 32] that *G. niloticus* juvenile feed on insects while the sub-adults feed on a mixed diet of insects and fry of other fish. Through the present study, *Chironomous* larva is a secondary food for this stage of *G. niloticus* in Epe Lagoon. Oladosu and Oladosu [32] reported that the pre-juvenile feed on the larvae of Chironomid; which is in line with observation in this study that chironomid larvae are secondary food for juvenile *G. niloticus*. The midge lay their eggs on the grasses that the parent *G. niloticus* gather around their nest [33], and the eggs hatch in a few days. Chironomids larvae feed normally on organic matter at the bottom of water bodies [34] and are found attached to the submerged grasses around the nest from where the G, *niloticus* larvae and juvenile feed on them. *Gymnarchus niloticus* breeds during the flood period [35]; rainy season in Nigeria. The flood period is often associated with release of nutrients, rapid growth of vegetation, and consequently, an elevated availability of other food sources such as insects, molluscs, seeds, young shoot, leaves [36].

Examination of distribution of points along the diagonal and axes the diagram (Figure 6) of the Amundsen's plots showed clearly a specialist feeding strategy for juvenile *G. niloticus* in Epe Lagoon. This specialist feeding strategy comprises two components: constant or primary food (insect, fish and crustacean) and occasional food (rotifers and protozoan). The dietary preferences in fish rely mainly depend on the nature of food available in the living habitat, environmental conditions, size or sexual stages of fish as well as inter and intra specific competition [37, 38].

Juvenile stages of *Gymnarchus niloticus* are carnivorous as indicated by a Relative Gut Length (RGL) index of 0.6. This is not surprising since diet of the stage consists of strictly materials of animal origins as observed in the present study. In general, gut length varies predictable with diet: carnivores < omnivores < herbivores. This assertion is based on the ratios of alimentary tract length to body length for fishes in diverse dietary categories. Lagler [39] ascertained that shorten intestine in carnivores compare to other feeding group could be attributed to ease of digestion of food from animal origin than vegetable ones. Kramer and Bryant [40] categorized small fishes (50–100 mm SL) by RGL as carnivores (RGL=0.6–0.8), omnivores (0.8–1.0) or as herbivores (2.5–16.4). With respect to feeding, the alimentary tract of fishes displays anatomical and physiological adaptation [41, 42] also reflected in the gut length.

The result shows that the length of the fish increased with body weight. *Gymnarchus niloticus* juvenile exhibit isometric growth (b=3.0). Isometric growth implies all body parts grow at almost the same rate as the fish increases in size. Extremely significant correlation between body length and body weight also support this assertion. Wootton [43] argued that fish exhibiting isometric growth pattern will follow the cube law; retain body shape with constant specific gravity. Hence, b-value must be equal to 3.0. In contrast, negative allometric growth (b<3) [44, 45] were reported for adult *G. niloticus*. This indicates as fish growths it becomes lighter for its length. Differences in growth patter b for juvenile and adult's *G. niloticus* is of course expected. These differences indicate that the species is passing through stages in its life cycle defined by different length – weight relationship. This agreed with Ayoade [44] who reported that the different growth pattern was demonstrated by the size groups of *Schilbe mystus* in Asejire Lake. Juvenile and adult stages of a fish may exhibit differences in the length – weight relationships owing to the changes in the body form with size, feeding habits and factors related to reproduction [46].

There was temporary variation in condition factor of juvenile *Gymnarchus niloticus* inhabiting Epe Lagoon. The fact that the average condition factor was <1 suggested during the present study indicates that juvenile stage *G. niloticus* might be in poor condition at Epe Lagoon. A pollution indicator, *Chironomus* larva, was also a food item indicating possible pollution in the lagoon. High abundance of chironomids is a confirmed phenomenon in polluted water bodies in both temperate and tropical areas [47, 48, 49]. Furthermore, indiscriminate dredging and sand filling activities in the lagoon habitats had likely adversely alter bottom condition over sizeable areas. These could impact negatively on habitat structure and feeding of sensitive and vulnerable juveniles of this species in the lagoon.

5. Conclusion

Poor condition of the juveniles indicated vulnerability of the species, and hence the need for its conservation in Epe Lagoon. Furthermore, the prevailing condition of Epe Lagoon may be unsuitable for the juveniles as indicated by pollution indicator, chironomid, encountered in their stomachs as food items. Insectivorous habits of the juveniles implied that the species may thrive on insect protein diet during culture.

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