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Food, feeding habits and condition factor of *Pseudotolithus senegalensis* (Cassava croaker) (Sciaenidae) (Valenciennes, 1833) in the cross river estuary, Nigeria

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Abstract
Investigations were conducted on the food, feeding habits and condition factor of cassava croaker, *Pseudotolithus senegalensis* in the Cross River Estuary, Nigeria. The diet components of the croaker consisted of molluscs, shrimps, fish bones, fish scales, shrimps parts, diatoms, polychaete worms, crabs, fish, crab parts, fish egg and plant materials. Detritus, sand grains and mud particles were also isolated from the gut of the fish. Diet components from animal origin was more than those from either plant origin or those classified as 'others'. The study was conducted for three months (August-October, 2019). Diet components from animals origin had numerical abundance of 91 individuals with 68.42% (relative abundance) in August, with 49 (60.49%) in September and 68 (74.73%) in October, while diet components from plant origin had numerical abundance of 24 individuals with a relative abundance of 18.05% in August 13 (16.05%) in September and 7 (7.69%) in October. Diet classified as 'others' had numerical abundance of 18 individuals which formed 13.53% of the total diet in August, with 19 (23.46%) in September and 16 (17.58%) in October. The condition factor of the fish ranged between 0.85-2.78 with a mean of 1.77±1.33 in August, 0.82-1.22 in September and between 0.69-1.58 with a mean of 1.36±1.67 in October. Based on the diet components of the croaker, which mainly consisted of animal origin, the croaker may be classified as a predatory fish with varied condition factor in relation to the month and age of fish. Older fishes had lower condition factor with younger ones having higher condition factor.

Keywords: Food, feeding habits, condition factor, *Pseudotolithus senegalensis*, cross river estuary, Nigeria

Introduction
The study of fish diet is a major topic in the area of fish biology as it forms the basis for establishing the ecological status of a given fish species [1], for determining the direction of flow of energy within the ecosystem [2]. Given the shift in emphasis in fisheries science from single species management to multispecies approaches [3], the study of fish diet provides the most reliable method of determining the nature of biological interactions among species [4, 1, 5].
It may also be demanded that a particular fish species be subjected to aquaculture to boost the supply of cheap protein sources to augment the resources from the wild. In this direction, to enable the composition of suitable feed ingredients for the culture individuals, the diet of the species has to be understood. This is why most studies on diet composition of fish species are usually conducted on individuals harvested from the wild [6, 7].
Pseudotolithus senegalensis (Family; Sciaenidae,) (Cassava Croaker) (Bowdich, 1825) constitutes an abundant and commercially important fish species in the Cross River estuary, Nigeria [8]. The species has an oblique mouth, elongated caudal fin, strong dorsal spine, soft and weak body with size range of between 30 -45cm. Fishing gears include bottom trawls, set net, beach seines and hook-on-line. The species has a wide distribution in brackish waters and estuaries in the Gulf of Guinea (Schneidner, 1990) [8]. This study on *Pseudotolithus senegalensis* is the first on the food, feeding and condition factor of the species in the Cross River estuary, Nigeria and is expected to contribute in building trophic model of the estuary.

Materials and Methods

Description of study Area

The Cross River Estuary Nigeria, (Fig 1) is the study area where the samples for this study were collected. The Estuary takes its rise from the Cameroon mountains and meanders westwards into Nigeria and then southwards through high rainforest formations before discharging into the Atlantic Ocean at the Gulf of Guinea [9].

The climate of the area is characterized by a long-wet season from April to October and a short dry season from November to March [10]. Mean annual rainfall is 2000mm. A short period of drought occurs in the wet season around August/September, which is usually a cold, dry and dusty period between December and January, referred to as the harmattan season. Temperature has been reported in the area to range between 22 °C in the wet season to 33 °C in the dry season, with relative humidity being generally above 60% at all seasons [10].

The Cross River Estuary has a wide diversity of fish species including *Pseudolithus senegalensis* which provides the source of cheap animal protein and source of income for both the riverine and upland population. It provides a nursery ground for both fin and shell fish [11].

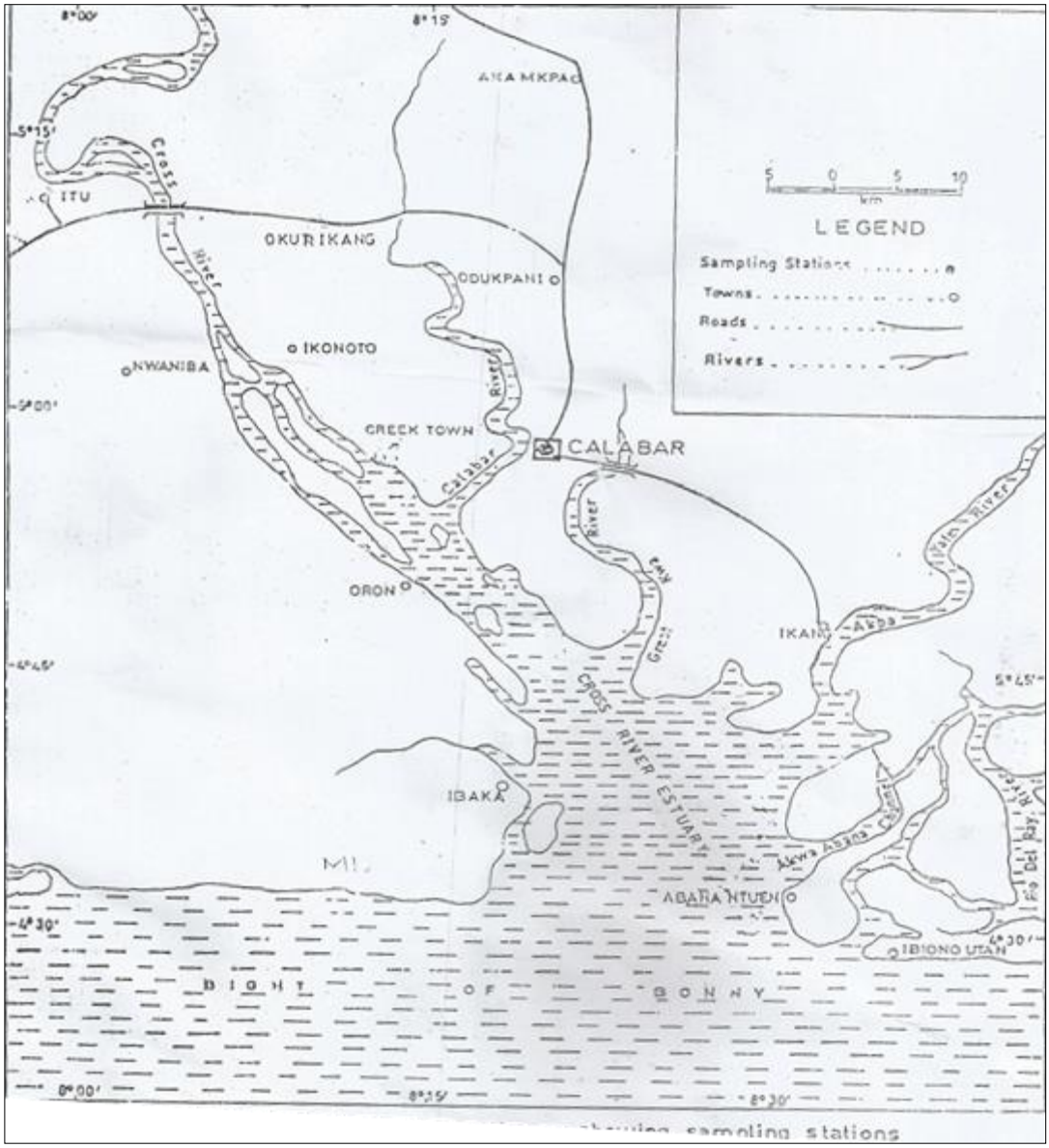

Fig 1: Map of Cross River Estuary, Nigeria, showing (Nsidung Beach)▲ where the fish samples were bought.

Collection of samples

The fish samples (*Pseudotolithus senegalensis*) were bought from the artisanal fishermen at Nsidung Beach, one of the landing points of the artisanal fishermen who fish in the Cross River estuary Nigeria. The fish samples consisted mainly of freshly caught individuals. These were stored in an ice-chest and transported to the Biological Oceanography Laboratory for analysis. Storing the samples in an ice-chest reduced the rate of digestion (autolysis and putrefaction) of the diet components prior to analysis as low temperature reduces metabolic rates [12]. Samples were collected for three months (August-October, 2019).

Laboratory studies

Measurement of fish length

In the laboratory, the standard length of each fish was measured using a measuring board calibrated in cm. Standard length was measured as the distance beginning from the tip of the snout to the end of caudal peduncle. Standard length was measured instead of total length as most of specimens were observed to have broken caudal fins due to handling and as

such, may give wrong and biased measurements [13]. Each fish length measured was arranged in tabular forms to enhance the marching of the corresponding weights of the fish. Standard length was measured to the nearest 0.1cm as recommended [14].

Measurement of weight of fish
The weight of the fish was measured individually using UNICON Top loaded balance calibrated in grams to the nearest 0.1g as recommended [14]. The values of the weight of each fish was matched with the corresponding fish length.

Extraction and preservation of fish gut
The gut of each specimen was removed by cutting open the abdomen of the fish from rectum to oesophagus, using a pair of pointed nose dissecting scissors. The two ends of the gut were tied up with three to prevent the discharging of the diet component each gut was preserved separately in 10% formaldehyde solution for 3 days prior to analysis according to the method employed [1].

Analysis of gut content
On the third day of preservation, each gut was cut open and it's content washed with tap water and emptied into a petri-dish. Firstly, the unaided eyes was used to identify the macroscopic food items while a hand lens and a light binocular microscopic food items, respectively at x 40 objectives. The diet components was analyzed using numerical and frequency of occurrence method following [15].

Numerical Occurrence
In this method, the total number of an individual food item in each gut was counted and summed up together for all the guts. This was then expressed as the percentage of the total number of all the food items from all the guts examined [1], using the formula:

$$\% Ra = n/N (100)$$

Where % Ra is the relative occurrence of each diet component n is the number of each diet component N is the total number of all diet component from all guts examined.

Frequency of occurrence
This involved noting the number of guts each diet component is formed (i.e. the number of times a diet component occurs in a gut out of all examined. This was used to determine the total number of guts a particular diet component was observed during the period of study.

Condition factor
Fulton's condition factor (C.F) was estimated for individual fish specimens using the formula [16];

$$C.F = = \frac{w}{L^3} X\ 100$$

Where
C. F. = Condition factor
W = Ungutted weight (g)
L = Standard length (cm) of fish specimen.

Monthly condition factor and mean condition was calculated for the fish during the period of study and used for the plotting in relation to month of study.

Data analysis
Data obtained from the study were analysed empirically using numerical and relative abundance and frequency of occurrence methods.

Presentation of results
Results obtained from this study were presented graphically and by use of charts. The fish species used for the study was photographed and plated (see Plate 1).

Results
Diet component of *P. senegelensis*
The diet composition of *P. senegalensis* consisted of molluscs, shrimps, shrimp parts, fish (whole), fish bones, fish scales, fish eggs, crabs, crab parts, diatoms polychaete worms and plant materials. Other items such as mud particles, sand grains and detritus were also isolated from the gut of the fish (Tables 1a-c).

Monthly variation in the quantity of the diet components consumed by *P. senegalensis*
The number of individual diet items consumed by the fish was observed to vary. In August, 12 molluscs were consumed with no molluscs found in the gut of the fish in September and October. Total number of shrimps consumed in August was 24, with 26 in September and 13 in October (Table 2b). Shrimp parts had 9 individuals in the gut of the fish with none in September while 10 of the shrimp parts were consumed in October. Whole fish had 7 of them consumed in August, with 6 in September and 1 in October. Total of 5 fish eggs were respectively consumed by the fish in September and October. Fish eggs were absent in the diet of the fish in August. However, 8 fish bones were consumed by the fish with 3 and 14 of the fish bones consumed in September and October, respectively. Total of 20, 7 and 23 fish scales were respectively consumed by the fish in August, September and October with 6 crabs consumed by the fish in September and October (Table 2a). Crab parts had 3 of them consumed by the fish in August. However, crab parts were absent in the diet of the fish in September and October, while 2 polychaete worms were respectively consumed by the fish in August, September and October.
Diet components from plant origin which consisted of diatoms and plant materials, had a total of 4 diatoms consumed by the fish in August. Diatoms were absent in the gut of the fish in September and October, with a total of 20, 13 and 7 plant materials respectively consumed in August, September and October (Table 2b).
Diet components classified as other included detritus, mud particles and sand grains. Detritus had 13 and 8 of it consumed in September and October, respectively, with no detritus observed in the gut of the fish in August, with 18 mud particles observed in the gut of the fish in August while 6 and 8 sand particles recorded in the gut of the fish in September and October, respectively (Table 2b). No sand particles were recorded in the gut of the croaker in August.

Overall numerical and relative abundance of the major diet group of *P. senegalensis*
As presented in Table 3, total of 91 diet components consumed by *P. senegalensis* came from animal in August. This formed 68.42% of the total food consumed by the fish in

August, with 49 (60.49%) in September with 68 (74.73%) in October. The plant origin components of the diet of the fish consisted of 24 individuals which constituted 18.05% of the fish diet in August, with 13 (16.05%) in September and 7 (7.69%) in October, while those classified as others, had 18(13.53%) consumed by the fish in August, with 19 (23.46%) consumed in September and 16(17.58%) consumed in October.

These variations are illustrated in Figure 3. Index of relative importance of the major diet group was higher for diet form animals origin than either plant origin and those classified as "others" (Table 3).

Condition factor (k)

The monthly condition of the fish was observed vary. In August, it ranged of between 0.85-2.78, with a mean of a range of between 0.82-1.68 in September and between 0.69-158 in October, with a mean of 1.77 in August, 1.49 in September and 1.36 in October (Table 4 and Figure 4). The mean condition of the fish was generally observed to reduce with the mouth of study.

Table 1a: Standard length (cm), weight (g), food volume (ml), condition factor (k) and diet component of *Pesudotolithus senegalensis* from the Cross River Estuary, Nigeria August, 2019

S/N	SL (cm)	Wt (g)	Food vol. (ml)	Condition factor (k)	Diet components
1.	23.5	224.6	3.0	1.75	2 Molluscs, 3 Shrimps
2.	20.5	134.0	3.0	1.56	2 Fish Bones, 3 Fish Scales, 1 Shrimp, 4mud Particles
3.	18.0	125.2	2.0	2.15	1 Shrimps, 1 Mollusc, 2 Shrimps Leg (Pieces)
4.	17.0	100.2	1.0	2.04	2 Diatoms, 1 Fish Scales
5.	19.0	100.5	6.0	1.47	4 Fishes, 2 Fish Bones, 6 Fishes Scales,5 Mud Particles
6.	25.5	150.0	4.0	0.90	1 Crab, 3 Crab Parts, 2 Shrimps, 2 Mud Particles
7	26.5	158.3	3.0	0.85	6 Plants Materials, 1 Polychaete Worm, 2 Fish Scales
8	16.0	110.2	2.0	2.69	1 Crab, 2 Fish Scales, 3 Plant Materials
9	16.0	114.0	4.0	2.78	7 Shrimps, 1 Molluses, 4 Shrimp Legs
10	22.5	185.9	6.0	1.63	4 Small Fishes, 2 Crabs, 6 Fish Scales, 4 Fish Bones
11	17.5	98.4	5.0	1.84	3 Fishes, 2 Crabs, 1 Molluscs
12	25.0	158.2	4.0	1.01	2 Molluscs, 3 Shrimps, 2 Diatoms, 2 Mud Particles
13	14.0	60.0	3.0	2.19	6 Plant Materials, 1 Polychaete Worm, 1 Shrimp, Mud Particles
14	17.0	100.0	4.0	2.04	4 Shrimps, 1 Molluscs, 3 Shrimps Parts
15	20.0	135.4	2.0	1.69	2 Shrimps, 5 Plant Materials
				$\bar{k}$ = 1.77	

Table 1b: Standard length (cm), weight (g), food volume (ml), condition factor (k) and diet components of *Pseudotolithus senegalensis* in the Cross River State Estuary, Nigeria (September,2019)

S/N	SL (cm)	Wt (g)	Food vol. (ml)	Condition factor (k)	Diet components
1.	17.5	81.0	4.0	1.51	2 Fish Scales, 1 Shrimp, 4 Plant Materials, Detritus
2.	20.5	135.0	8.0	1.57	6 Small Shrimps, Detritus
3.	14.0	45.0	3.0	1.63	Detritus, 2 Small Shrimps
4.	21.5	159.6	2.0	1.60	2 Small Shrimps, Detritus
5.	16.0	69.0	1.5	1.68	Detritus, 1 Small Shrimp, 2 Fish Eggs
6.	23.0	189.1	4.0	1.55	2 Polychaete Worms, 3 Sand Grains, Detritus
7	15.0	50.1	1.0	1.48	Detritus Only
8	14.0	38.0	5.0	1.38	2 Small Fishes, 3 Fish Bones, Detritus, 2 Small Shrimps
9	28.0	360.0	6.0	1.64	5 Small Shrimps, 2 Small Fish, Detritus
10	32.0	270.2	8.0	0.82	5 Small Shrimps, Detritus
11	15.5	50.0	4.0	1.34	3 Fish Eggs, 5 Fish Scales, Detritus, 1 Small Shrimp
12	28.0	360.2	7.0	1.64	2 Small Fishes, Detritus, 9 Plant Materials, 3 Sand Grains
13	18.0	90.0	2.0	1.54	Detritus
				$\bar{k}$ = 1.49	

Table 1c: Standard length (cm), weight (g), food volume (ml), condition factor (k) and diet components of *Pseudotolithus senegalensis* in the Cross River State Estuary, Nigeria (October, 2019)

S/N	SL (cm)	Wt (g)	Food vol. (ml)	Condition factor (k)	Diet components
1.	16.5	70.0	2.5	1.56	1 Shrimps, 3 Fish Scales, 2 Fish Eggs, Detritus
2.	14.0	38.4	5.0	1.40	2 Polychaete Worms, 5 Fish Scales, 6 Fish Bones, Detritus
3.	28.5	160.0	7.5	0.69	Detritus, 2 Shrimps, 8 Shrimp Parts, 3 Sand Particles
4.	16.5	62.5	3.0	1.39	Mud Particles, (4), 5 Sand Particles, 3 Shrimps
5.	20.5	132.0	10.5	1.53	4 Small Fishes, 3 Shrimps, Detritus
6.	15.5	58.8	3.5	1.58	9 Fish Scales, 4 Fish Bones, 1 Shrimp, Detritus
7	15.5	56.9	4.0	1.53	Detritus, 3 Plant Materials, 2 Shrimps
8	14.5	39.2	4.5	1.29	3 Fish Eggs, 1 Small Fish, Detritus
9	16.0	60.0	3.5	1.46	Detritus, 3 Fish Eggs, 2 Shrimp Parts
10	14.0	38.6	4.0	1.41	1shrimp, 6 Fish Scales, 2 Plant Materials
11	17.5	62.0	6.0	1.16	Detritus, 4 Fish Bones, 1 Small Fish
				$\bar{k}$ = 1.36	

Table 2a: Summary of the diet components of *Pseudotolithus senegalensis* in the Cross River State Estuary, Nigeria (August - October, 2019)

		August		September		October	
S/N	**Diet Component**	**Fo**	**%Fo**	**Fo**	**%Fo**	**Fo**	**%Fo**
1.	Molluscs	12	9.20	-	-	-	-
2	Shrimps	24	18.05	26	32.09	13	14.29
3	Fish bones	8	6.02	3	3.70	14	15.38
4	Fish scales	20	15.04	7	8.64	23	25.27
5	Mud particles	18	13.53	-	-	-	-
6	Shrimps parts	9	6.77	-	-	10	10.99
7	Diatoms	4	3.01	-	-	-	-
8	Polychaete worms	2	1.50	2	2.47	2	2.20
9	Plants materials	20	15.04	13	16.05	7	7.69
10	Crabs	6	4.50	-	-	-	-
11	Detritus	-	-	13	16.05	8	8.79
12	Sand grains	-	-	6	7.41	8	8.79
13	Fish eggs	-	-	5	6.17	5	5.49
14	Whole fish	7	5.26	6	7.41	1	1.10
15	Crab parts	3	2.26	-	-	-	-
	Total (N)	133	120	81	100	91	100

FO = Frequency of Occurrence
% FO = Percentage Frequency of Occurrence

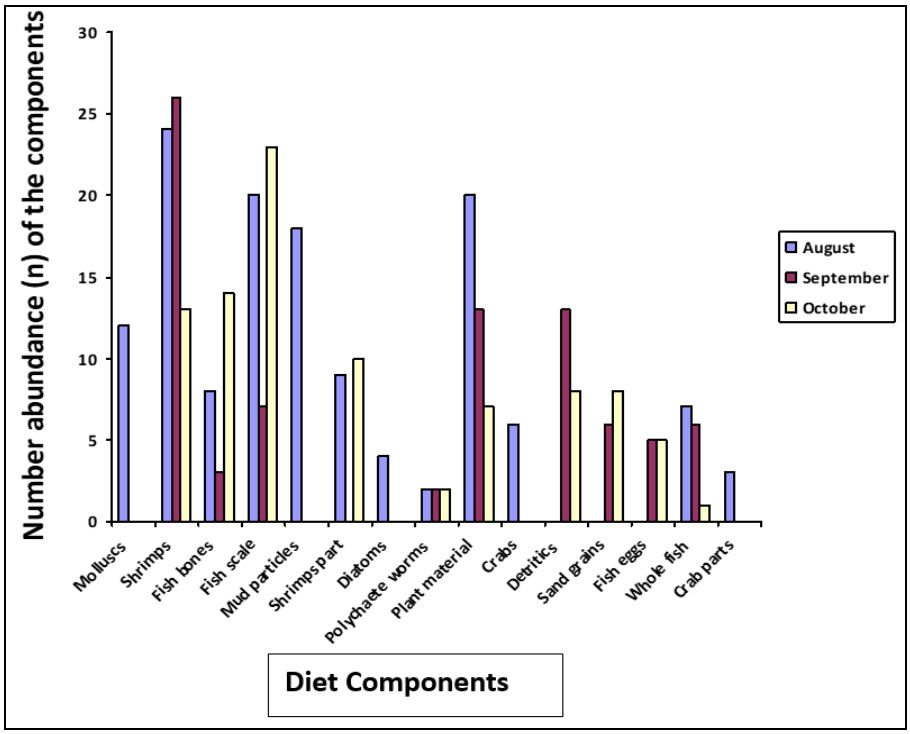

Fig 2: Numerical abundance of the diet component in the gut of *P. senegalensis* in the Cross River Estuary (August – October, 2019) (Derived from Table 4)

Table 2b: Classification of the major diet components of the croaker (*P. senegalensis*)

S/N	Major diet groups	Aug.	Sept.	Oct.	Marginal consumptions
A	**Animal origin**				
1.	Molluscs	12	-	-	12
2	Shrimps	24	26	13	63
3	Shrimp parts	9i	-	10	19
4	Whole fish	7	6	1	14
5	Fish eggs	-	5	5	10
6	Fish bones	8	3	14	25
7	Fish scales	20	7	23	50
8	Crabs	6	-	-	6
9	Crab parts	3	-	-	3
10	Polychaete worms	2	2	2	9
	Total consumed	91	49	68	208
B	**Plant origin**				
1	Diatoms	4	-	-	4
2	Plant materials	20	13	7	40

	Total consumed	24	13	7	44
C	**Others**				
1	Detritus	-	13	8	21
2	Mud particles	18	-	-	18
3	Sand grains	-	6	8	14
	Total consumed	18	19	16	53

Table 2b summaries the major diet groups (from animals and plant origin) of the fish. Items such as detritus, sand grain and mud particles were however classified as "others".

As shown in table 2b, 10 diet components formed the find items from the and items from animals origin the gut *P. senegalensis* namely Molluscs, shrimps, shrimp parts, whole fish, fish eggs, fish bones, fish scales, crabs, crab parts and polychaete worms while 2 diet components (diatoms and plant materials) were from plant origin with detritus, mud particles and sand grains were classified as others.

Table 2b: Summary of the numerical and relative abundance of the major classifications /groups of the diet of *P. senegalensis*

		August		September		October	
	Major diet group	**N**	**%n**	**N**	**%n**	**n**	**%**
1.	Animal origin	91	68.42	49	60.49	68	74.73
2	Plant origin	24	18.05	13	16.05	7	7.69
3	Others	18	13.53	19	23.46	16	17.58
	Overall total	133	100.0	81	100.0	91	100.0

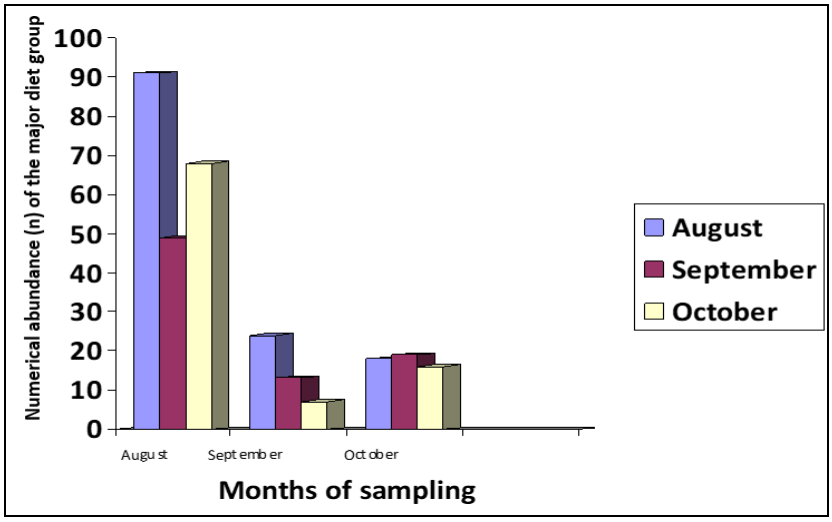

Fig.3: Numerical abundance of the major their groups in the gut of *P. senegalensis* in the Cross River Estuary (August – October, 2019)

Months of study

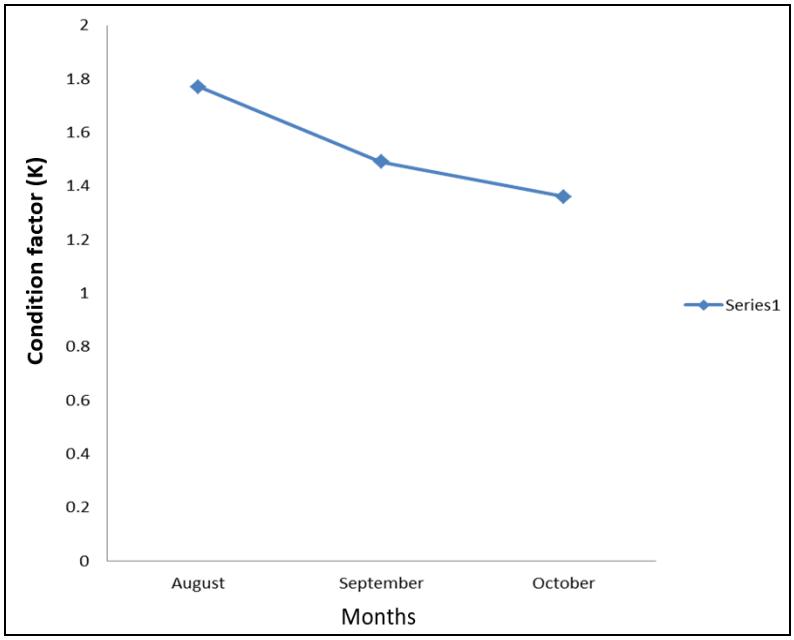

Fig 4: Variations in the mean condition factor (K) of *P. senegalensis* in the Cross River Estuary (August – October, 2019).

Discussion

The food items recorded in the gut of *Pseudotolithus senegalensis,* suggest that the species is euryphagous (i.e feeding on a wide range of food items although higher percentage of the diet components came from animal origin forming between 60.49 -74-73% of the food consumed by the croaker, with 7.69-18.05% food components from plant origin and 13.53- 23.46% classified as others consumed by the fish. The presence of diet components such shrimps, fish and fish parts and crabs/ crab parts in varying percentage of occurrences shrimps (14.29-32-09%), shrimp parts (6.77-10.99%), whole fish (1.10-7.41%), crabs (4.50%) and crab parts (2.26%) are an indication that *P. senegalensis* feeds voraciously. Voracious animals are known to exhibit carnivorous feeding habit [17]. Similar voracious feeding strategy was reported of *P. senegalensis* [18] in Cameroon waters, in West African coastal waters [19] and in near shore waters off Benin, West African [20].

The diet composition of *Pseudotolithus senegalensis* suggests that *P. senegalensis* in the Cross River estuary, Nigeria, is a predator. Feeding characteristics of fishes can be divided into 3 basic groups namely; Plant feeders (Which consume phytoplankton, algae, and detritus), Zoophagus (Which include zooplanktophagus, benethophagus and predators) and Omnivores (Which consume both plants and animals) [21].

The stomach contents analysis of *P. senegalensis* in the Cross River estuary though showed the presence of different feeding types, which may not be unconnected with change in body size, did not allow the classification of the fish as an omnivore as the present of food items was more of animal origin. Several authors [21, 1, 13, 20] reported diet change (ontogenicity) in skates (*Bathyraja aleutica, B. interrupta, B. panniferea, B. virolacea, B. matsubarai, B. maculate* and *B. minispinosa*) in the Northern Island of Kano chatka the sliver catfish (*Chrysichthys nigrodigitatus*) from the Cross River, Nigeria; the silver catfish (*Chrysizhthys nigrodigitatus*) from the Cross River estuary, Nigeria, *Pseudotolithus* specie from west African coastal waters. The existence of diet shift in *P. senegalensis* used in the present study agrees with the report of previous workers as noted above.

In the estuarine ecosystem, diverse groups of organisms are present and/ are available as food for different fish sizes and groups [22] and as an individual fish grows, the tendency to exhibit a change in diet is always the outcome [1, 21, 6, 24, 25]. A fish species feeds mainly on food items that can fit into its mouth and what its stomach can digest, and that as a fish grows, its stomach becomes longer and its digestive system becomes more developed. It has been noted that as feeding rates relative to body weight decreases, absolute rate of food consumed increases [26]. As a fish grows, it has the capacity to pursue preys than smaller individuals [13] and as such, more food items from animals' origin are found in the gut of sub-adult individuals than juveniles [24]. This might have been the premise for the individuals of the *P. senegalensis* studied which consisted mainly of sub-adults, had more of food items from animals' origin.

Considering the ranges of the monthly mean condition factor 1.77 (for August), 1.49 (for September) and 1.36 (for October), a trend which was reducing in relation to month of sampling, portrays a reducing fish health as it grows to adult size. Most authors have reported that older fishes feed generally for maintenance [13, 24, 25], while younger individuals feed for growth and the development of reproductive organs to enable them reproduce and their young ones to be recruited into the standing stock, which according to some authors provides the premise for the usual ontogenetic shift in the food and feeding habits of fishes in their respective niches in the aquatic ecosystem [27, 28, 29].

Conclusion & Recommendations

Total of 15 different diet components were identified during the period of study and were classified as diets from animals/plants and others. Diet from animal origin formed between 60.49-74.73% of the total food consumed by the fish, while those from plant origin formed between 7.69-18.05% of the total food consumed and those classified as 'others' formed between 13.53-23.46% of the total diet consumed by the croaker. Based on the diet composition of the fish, it could be classified as an active predator. Mean condition factor of the *P. senegalensis* ranged between 1.36-1.77 and was observed to reduce with the month of study with a value of 1.77 in August, 1.49 in September and 1.36 in October, an indication of reduced feeding intensity with fish age, which permits older individuals to feed for maintenance and younger ones to feed for growth and reproduction.

Due to the sparse information on the biology of the species (*P. senegalensis*) inhabiting the Cross River estuary, Nigeria, further studies are recommended on aspects such as morphometric, Age, spawning and fecundity and parasitology studies on the species.

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