Original Research Article

Length-Weight Relations and Condition Factors of Three Freshwater Prawns of River Ethiope, Nigeria

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Received 6th December, 2018; Accepted 26th March, 2019; Corrected 30th March, 2019

Abstract

The investigation of length–weight relations and condition factors of prawns in River Ethiope, is a necessary pre-condition to their successful farming, exploitation and management in the system. The present study captured a total of 241 prawns from three designated study stations; Aghalopke (1), Ovwori (2) and Sapele (3). The prawns were separated into three species: *Macrobrachium dux, M. macrobrachia and Macrobrachium. spp*. Female prawns constituted 50.60 % of the prawn community with length and weight intervals of 4.1-11.1cm and 0.14-20.5g respectively, 15.77% were male; 3.1-10.1cm long, and weighed 0.15-14.62g, while 28.63% were juveniles with length and weight of 2.2-3.5cm and 0.09-1.18g respectively. The tie-up attributes intervals: a (intercept) and b (slope) varied from 0.88-5.12 and 0.43-3.29 respectively, displayed positive allometric growth except *Macrobrachium spp* in station 1. Lengths and weights of the prawns showed no correlation with the physico-chemical parameters which were notably variable. The empirical demonstration of the interauxesis equation and the condition factor forecast good prawn yield, if the system is brought under proper control and management.

Keywords: prawns, River Ethiope, Length-Weight relationship, condition factor

Introduction

River Ethiope is a unique natural water resources endowed with diverse life-sustaining resources that could be fashioned into developing Delta State, Nigeria where it is located, and the nation as a whole (Ikomi and Jessa 2003; Iloba, 2012; Ikomi and Arimoro, 2014; Iloba and Ikomi, 2017). Studies have revealed that it is rich in biological resources, premier in its food sustainability with exploitation, important as a link between primary and secondary energy production (Odum, 1992; Ikomi and Arimoro 2014; Yarra and Magoulick, 2018), and with a remarkable ability at recycling and regeneration of organic compound into nutrient compounds back to the sediment (Yang *et al.*, 2017). Prawns in river Ethiope could be seen as a sustainability trap in our natural resources, provided to help crack poverty, and for health sustenance as food for the populace.

Prawns are important as food because they are rich sources of nutrients. Proximate analysis studies reveal that protein components from prawns are superior to, and of better quality than those from other animal sources such as milk, meat and egg (Asaikkutti *et al*., 2016; Islam *et al*., 2017,). Prawns are therefore alternative means of bridging the gap between animal protein demand and supply (Yang *et al*., 2017). Studies have revealed a noticeable drop in shrimp catch in Nigeria's coastal waters (Okayi *et al*., 2012; FAO, 2016). As such it has become necessary to look for alternative sources of prawns. One source could be River Ethiope where prawns have been reported to be abundant, and to occur all year round (Ikomi and Odum, 1998; Arimoro and Meye 2007). A study of their biology (formational attributes) is a necessary pre-condition for their exploitation and management. By extension, the exploitation of this River for prawns will help enhance our foreign exchange earnings, like the Asian countries with steady supply of over 70-80% of shrimp's global supply (Kunda *et al*., 2008; FAO, 2016, 2018). In view of successful future development of prawn farming in this river, the study investigates the length – weight relationships of the three *Macrobrachium* species in the lower reaches of River Ethiope, in readiness for prawns farming in future due to their affluent existence in this section of the river .

Materials and Methods

Area of Study

River Ethiope is one of River Benin branches, the other being River Jamieson. They are both in the deltaic axis of Nigeria. River Ethiope took its source at Umaja, approximately $5^0$33'N, $16^0$16'E, and flows westward for about 100km where it discharges into River Benin at Sapele. River Benin is boarded by the Atlantic Ocean (Odum, 1992). This river is very clear except at the Sapele end, and has a sandy bottom, and is partially tidal influenced at the Sapele to Aghalokpe end. The average depth of the river is 2 – 7m, and 20m in the deepest part. It is about 1.5 to 90m broad.

River Ethiope is in the deltaic swap forest zone. Consequently, it consists mainly of floating higher aquatic plants such as water aloe *(Striotes), Pistia and Acorus, Azoola afrucaba*, *Nymphala cobus*. Plants totally or partly submerged include *Scripus jacobi, Salvinia nymphellula, Hydrolea glabra, Vossia cuspidata, Pycreus canceolatus and Ludwigia spp*.

Some of the fish species found in River Ethiope include *Tilapia mariiae, Alestia congipinus, Brynomyrans lonmginias, Malopterus electricus* among others. The major human activities associated with River Ethiope include, bathing, washing, commercial sand dredging, fermenting of cassava tubers and lumbering. The level of pollution is very low except in the Sapele are where municipal and home waste are frequently dumped into the river.

Sampling stations

Three stations were chosen along the course of the river. Station 1 was at Aghalokpe where it is about 83m wide and 14.8m deep. The bottom here is very sandy and the water is very clear. Tidal influence is noticeable. Transparency is very high, and an average of 3.05m was recorded. Water current here is high, and the average velocity of $0.32ms^{-1}$ was obtained. The dominant aquatic plants around this station include *Pistia stratiotes*, *Azolla africana*, *Scirpus jacobii*, *Salvinia nymphellula*, *Hydrolea glabra and Ludwigia sp*. Some of the fish species found in this station include *Alestes longipinnis*, prevalent human activities include bathing, washing, fermenting of cassava and fishing.

Station 2 was situated at about 3.5km from station 1 in a village called Ovwori in Okpe Local Government Area. It is about 54m wide and relatively deep with an average depth of 15.1m. Transparency was also very high especially during the dry season, reaching an average of 2.35m. The current was lower than that of station 1. Average flow velocity recorded was $0.27ms^{-1}$. The dominant plants found around this station were similar to those found in station 1. These were *Pistia stratiotes, Azolla africana, Salvinia nymphellula, Hydrolea glabra* while the fishes seen during this period of sampling included *Alestia longipinnis, Tilapia mariae*, *Brienomyrus sp, Malapterurus electricus* among others. Human activities were the same as seen in station 1.

Station 3 was located in Sapele, about 4.6km from station 2. It is situated in Okirigwre very close to the bridge. This station is about 86m wide and roughly 18.16m deep. Tidal action was much more noticeable in this area. Transparency and current were relatively lower than obtained from other stations. An average velocity of 1.78m and $0.21ms^{-1}$ respectively were recorded. Due to lumbering activities, the vegetation was also low. Some of the plants seen in this area included *Vossia cuspidata, Pycreus lanceolatus, Azolla africana.* Some of the fishes were *Tilapia mariae, Malapterurus electricus and Pelvicachromis teaniatus*. The major human activities include fishing, bathing and washing, dredging of sand and lumbering.

Sampling Procedure

Monthly samples were collected directly from fishermen who caught the shrimps by means of baskets from stations 1 and 2, and by means of the funnel entrance trap from station 3, for six months

The baskets used were of medium size with the length 19.5cm and width of 38.00cm and pore space of 0.4cm. The baskets were used to scoop the grass at the edge of the river and shrimps caught in it were removed and preserved in 10% formaldehyde. At station 3 the traps wwere usually lowered into the water and they were bartered. Baits used included *Menihot esculanta* (cassava), ripe oil palm *(Elaeis guineensis)* fruits, coconut (*Cocos nucifera*) endosperm, fish entrails, decaying fish, soap (sunlight). Baits were sometimes tied up in plastic sheets in order to protect it from other aquatic animals like crabs which could pinch the food from outside the traps. After 24 hours the traps were removed from water, the prawns were removed from the tied end and poured into a basket from which they were stored immediately in 10% formaldehyde. The preserved prawns were conveyed to the laboratory for further examination.

Identification of species and their sexes

The prawn/shrimps were identified using the taxonomic keys of Powell (1982). The main characteristics of identification of this species were the size, shape and the presence or absence of rostrum spines. Other important taxonomic features considered were the presence of spine on the Carapace, the total length of the antenna and the shape and size of the antenna scale (Scaphocerite). The general body colour pattern, the shape and size of the members of the pereopods that end in pincers (chelae) were also considered. In male and female, a tubular appendage, appendix interna is attached to the endopod of the second pleopod. However in males, an additional structure, appendix musculina, which is also a pleopod, was used to differentiate the male from the female (Edokpayi 1990).

Biometric and other Biological Data

Biometric measurements of the prawns were made using a pair of dividers and metric rule. Each prawn was placed on a flat board, stretched out on its ventral surface and measured. Total length (TL) was taken from the apex of the rostrum to the apex of the tail fans (Telson). Lengths as defined by Powell (1982) were measured to the nearest 0.1cm. The weights of the prawn were measured using an OHAUS dial spring scale to the nearest 0.1g.

Length-Weight Relationship

The relationship between the weight and length of the specimen was determined from the relationship.

$$W = a\,L^b$$

Where W = weight in gram; L = length in centimetre, a = regression constant; b = regression coefficient.

The length–weight regression equation was generated by generalized linear regression on log-transformed data performed with PAST Statistical software. The degree of variationbetween the length and weight of the prawns was also estimated by R^2 (coefficient of determination). The regression *ANOVA* was employed to test the isomeric ($b=3$) and allometric ($b\neq3$) nature of the prawns at 0.05 level of significance.

Condition Factors

Data obtained from the length and weight measurements were used to calculate the condition factor (K) from the relationship.

$$K = W/L^3 \times 100$$

Where K = condition factor

L = Total Length

W = Weight in gram.

Physical and Chemical Factors

Water samples were collected monthly in two-liter plastic jerry cans, and taken to the laboratory for analysis. Physical parameters determined included temperature, turbidity, conductivity, dissolved solids, suspended solids, total solids and transparency. The chemical parameters determined were dissolved oxygen, phosphate, pH, alkalinity, salinity, sulphate, potassium, calcium and magnesium as detailed in APHA (1989). The pH of the samples was determined at room temperature using a Jenway digital pH/temperature meter, model 7065. The dissolved oxygen was determined by Winkler's method. Alkalinity was determined by simple titrimetric method with phenolphthalein and methyl orange as end-of-titration pointers. Chloride was measured using simple titration of 50ml of sample with 0.1m silver trioxonitrate (V) solution using three drops of 2% potassium dichromate as indicator. The spectrophotometer was used in determine the presence of sulphate, at an absorbance of 420mm wave length. The titrimetric method was applied to determine the presence of calcium and magnesium in the water samples. The auto–analysis II procedure was used to determine the presence of phosphate.

Results

The study noticed variations in the physico-chemical parameters of water from the river across the three stations. However, it was only two parameters; transparency and calcium that showed statistical difference ($p<0.05$) (Table 1).

Three species of prawn, *Macrobrachium dux, M. macrobrachium and Macrobrachium sp*., were identified in this study. A total of 241 prawns were collected for the period of six months. The number of species varied in difference months. The months of July at station 1 recorded the highest total number of prawns (29) while the lowest number of 7 was recorded in the month of November at station 1. Station 2 recorded highest number in the month of July with 27 prawns, and the least, 7, was recorded in October, while the month of September recorded 20 and 5 in November at station 3 as highest and lowest number of prawns respectively. The monthly abundance of different species is shown in Fig. 1. *M .dux* remained dominant during the entire study period.

Egg-carrying females were more prevalent than the non gravids, constituting over 50.8% of the prawns community. Although *Macrobrachium spp* were sparse and low in number, all *Macrobrachium spp* caught in September were gravid.

The total length variation was from 2.2cm to 11.1cm.

Structural details, condition factor of three Freshwater prawns; *Macrobrachium dux (M. dux), M. macrobrachium(M.m) and Macrbrachium sp(M. sp)* in River Ethiope are represented in Table 2. The length-weight relationships with r close to, or over 0.80 were all statistically significant ($p<0.05$) except *Macrobrachium spp* in Station 1 ($p= 0.32$). The illustration shows that specimen

Table 1: Variation in means of physico-chemical parameters at the three study stations

	Station 1				Station 2				Station 3					
Parameters	Min	Max	X	SE	Min	Max	X	SE	Min	Max	X	SE	F	P
Air Temperature(^{0}C)	25.5	29	27.25	0.53	26	30.1	28.00	0.69	26.8	31.0	28.39	0.85	0.72	0.50
Water Temperature (^{0}C)	26	27	26.3	0.16	26	26.3	26.30	0.15	25.9	26.4	26.15	0.09	0.13	0.88
Transparency (M)	2.5	3.5	3.01	0.14	1.90	2.80	2.36	0.16	1.12	2.20	1.80	0.17	16.16	0.00*
pH	6.28	7.16	6.73	0.15	6.57	7.11	6.81	0.08	4.13	7.08	6.40	0.47	0.58	0.57
Conductivity (µS/cm)	48.00	105.00	80.00	10.42	55.00	110.00	86.78	7.40	60.25	203.0	103.05	22.1	0.65	0.54
Turbidity (NTU)	1.74	4.46	3.19	0.16	2.90	11.02	6.96	0.47	1.16	5.80	3.46	0.27	2.96	0.08
Total Dissolved Solids (mg/L)	17.82	46.10	25.84	4.17	23.19	102.00	50.97	11.99	12.00	53.27	37.41	6.95	2.27	0.14
Total Suspended Solids (mgL^{-1})	6.14	14.33	9.50	1.18	8.50	34.78	18.28	4.07	3.37	20.20	13.78	2.66	2.32	0.13
Dissolved Oxygen (MgL^{-1})	5.8	6.5	6.08	0.11	6.0	7.1	6.4	0.19	6.1	7.2	6.48	0.19	1.67	0.22
Total Alkalinity ($Mg/CaCO_3$)	7.50	22.50	16.25	2.21	10.00	20.00	14.0	1.44	5.0	20.00	14.58	2.69	0.29	0.75
Salinity (MgL^{-1})	17.55	31.59	24.57	2.40	17.55	29.85	22.25	2.11	17.55	29.85	23.70	2.11	0.26	0.78
Sulphate (MgL^{-1})	0.11	0.32	1.85	0.03	0.13	0.28	0.21	0.02	0.10	0.28	0.20	0.03	0.14	0.87
Calcium (MgL^{-1})	1.60	2.40	2.00	0.15	0.80	2.00	1.53	0.19	0.80	1.60	1.33	0.17	4.07	0.04*
Magnesium (Mg/L^{-1})	0.72	1.46	1.09	0.11	0.48	1.46	1.05	0.14	0.36	1.21	0.77	0.14	1.88	0.18
Sodium (MgL^{-1})	3.13	4.51	3.69	0.20	2.81	4.20	3.79	0.20	0.8	3.96	3.05	0.48	1.54	0.25
Potassium (Mg/L^{-1})	1.17	2.02	1.58	0.14	0.97	2.15	1.61	0.19	1.11	1.91	1.43	1.14	0.38	0.69
Phosphate	0.15	0.47	0.31	0.05	0.26	0.59	0.42	0.06	0.19	0.43	0.33	0.04	1.52	0.25

Station. I = Aghalokpe, Station. II = Ovwori, Station. III = Okirigwre.

Table 2: Structural details and condition factor of the three Freshwater prawns in River Ethiope

		FEMALE		MALE		JUVENILE		POOLED REGRESSION PARAMETERS						
		Length(cm)	Weight(g)	Length(cm)	Weight(g)	Length(cm)	Weight(g)	a	b	r^2	R(Adj)	F	p	K
Station 1	M.dux	3.0 -7.0	0.19- 4.2	3.6-5.9	0.15-2.48	2.2-3.5	0.12-0.31	-2.19	3.18	0.88	0.87	326.14	0.00*	0.29 - 1.31
	N= 48	30		5		13								
	M.m	2.8-5.5	0.17-1.32	3.1-5.0	0.15-1.62	2.2-3.5	0.1-0.3	-1.97	2.65	0.76	0.76	99.32	0.00*	0.38 – 1.30
	N= 33	9		4		20								
	M. sp	2.9 – 3.7	0.19- 0.29	3.7-3.7	0.18-0.18	2.3- 3.2	0.15– 0.26	-0.88	0.43	0.08	0.01	1.06	0.32	0.36 -1.23
	N=14	7		1		6								
Station 2	M.dux	3.0-11.1	0.18-20.5	3.5- 10.1	0.29-14.62	2.4 – 3.2	0.13- 1.18	-5.12	1.58	0.73	0.73	142.73	0.00*	0.49 -5.38
	N=54	26		10		18								
	M.m	2.9- 7.2	0.18 –6.74	6.0-6.1	2.27-2.27	2.2-2.8	0.11-0.19	-2.23	3.29	0.93	0.92	272.00	0.00*	0.49 – 1.81
	N= 24	16		2		6								
	M. sp	2.8- 4.4	0.14-0.31	-	-	2.3-2.7	0.09-0.14	-1.80	2.28	0.82	0.79	31.68	0.01*	0.48– 0.94
	N= 9	7		0		2								
Station 3	M.dux	3.0-11.0	0.24-15.63	4.7-8.0	1.27-6.66	-	-	-2.10	3.16	0.95	0.95	639.7	0.00*	073 -1.33
	N=34	24		10		-	-							
	M.m	4.7-10.15	1.15-13.13	4.7-9.4	1.41-8.6	2.9-3.1	0.2-0.28	-2.07	3.11	0.98	0.98	639.7	0.00*	0.82 -1.36
	N=25	15		6		4								
	M. sp	0	0	0	0	0	0	-	-	-	-	-	-	-

of size range of 2.2cm – 3.7cm were juveniles and most frequent while those that were 3.8cm – 11.1cm were adult and less frequent (Table 2). The females were most abundant (55.60%), followed by the juveniles (28.63%) and then the males (15.77%). The regression equation displayed on the graph gives the relationship between the weight and length of the species identified (Table 2 and Figs. 2 and 3). The slope, *b*, was maximal in *M. macrobrachion* (3.29) and least in *Macrobrachium spp* (0.43), and the intercept, *a*, ranged from -0.88 to -5.12 (Table 2).

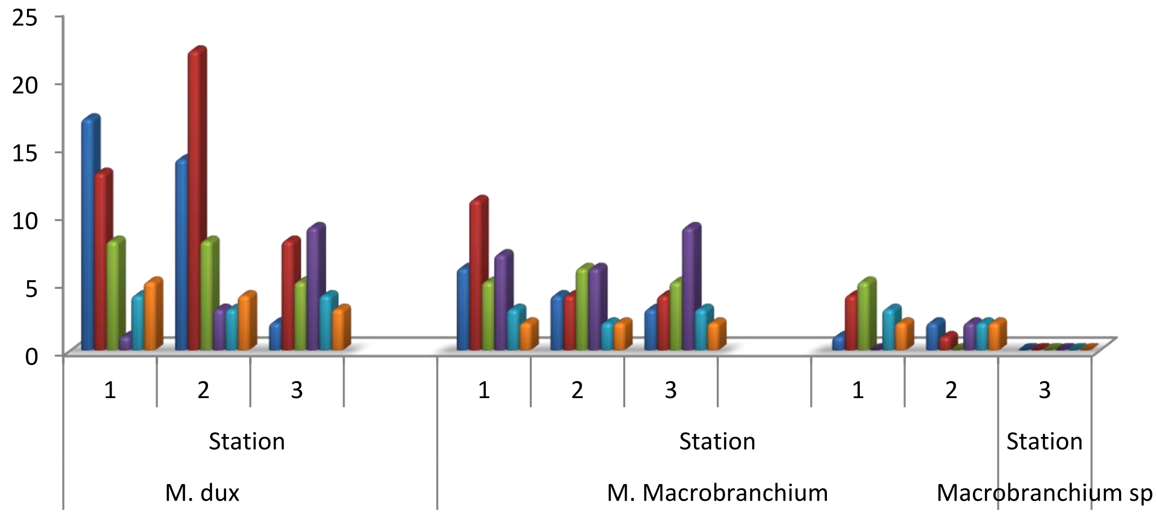
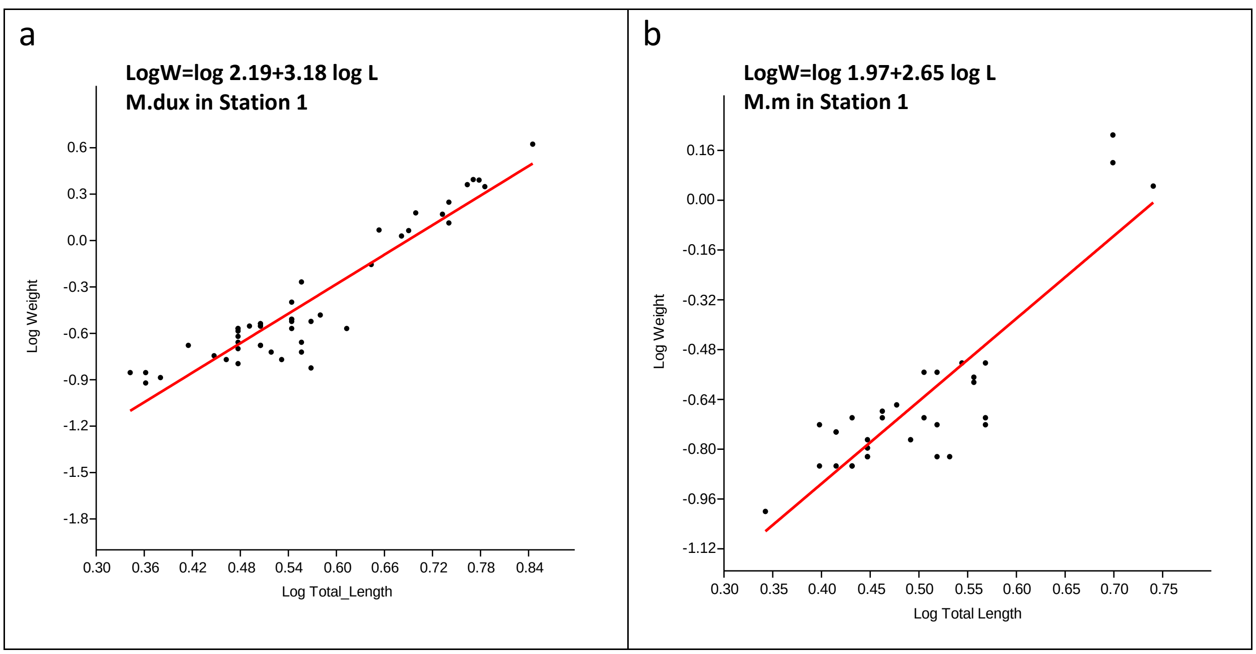


Fig. 1: Monthly Abundance of the three freshwater prawns at the Stations



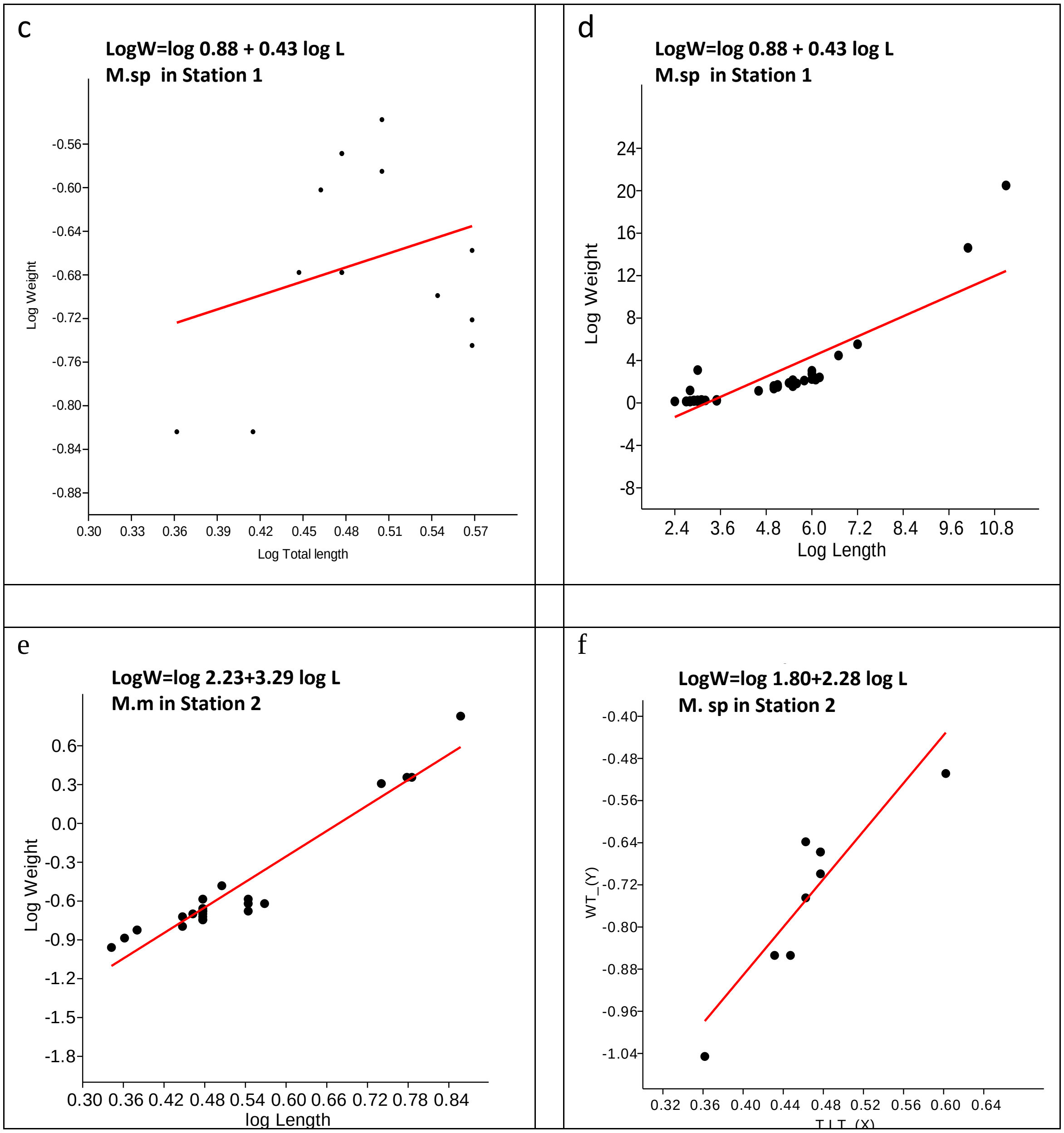


Fig.2 (a, b, c, d, e, f): Length- weight relationship of *Macrobrachium dux, M. macrobranchion and Macrobrachium sp* in Stations 1 and 2

The present study identified variation in condition factor, K, in relation to size and sexes. In male and female groups K value decreased with size of the individual prawn while K increased with the size of the juvenile or immature.

Discussion

The physico-chemical parameters in Table 1 show the fluctuation in salinity, dissolved oxygen, alkalinity, dissolved solids and conductivity. The seasons are typical of the coastal belt of Nigeria which are always steered and determined by the degree and span of rainfall. Higher values of the physico-chemical parameters were generally recorded in the months of August, September, October and November, while the months of June and July recorded the lowest values. This conforms to the work of Imoobe (1997) on water chemistry of Jamieson River, a tributary of Benin River. The river water temperature obtained ranged from 25.9 – 27^0C. These values are similar to those observed in other rivers and creeks in the Niger Delta (Kingdom *et al*., 2013).

The dissolved oxygen values ranged from 5.8 – 7.2 Mg/L^{-1} which is typical with rivers of the Niger Delta. The alkalinity value recorded was very low (5.00ppm) at station 3, while the highest value (22.50ppm) was recorded in station 1 as shown in Table 1.

The pH values recorded were high, and ranged from 4.13 – 7.16. This is similar to the pH values reported at Orogodo River (Arimoro and Meye, 2007). The pH value of Ethiope River was high during the sampling period except in station 3 in the month of July which recorded 4.13. This could be due to influx of decomposing litter from the riparian typical rainforest system sandwiching the river (Iloba, 2012)

The salinity, which ranged from 17.55 – 31.59ppm as presented in this study, is similar to the range given by Balogun *et al.* (2011) at Lagos harbor, a likely reason for the preponderance of prawns in this part of river Ethiope. Nevertheless, no relationship was found between salinity and the biometric parameters. The amounts of sodium, sulphate, phosphate and potassium were similar throughout the sampling period, and ranged from 2.90 – 4.51ppm for sodium, 0.14 – 0.28ppm for sulphate, 0.15 – 0.58ppm for phosphate and 1.11 – 2.15ppm for potassium.

Air temperature was also similar among the stations, and the amount of atmospheric temperature determines the water temperature. The amount of dissolved and suspended solids recorded varied among the stations, and this was probably due to the level of human activities at the various stations during the sampling period. Station 2 recorded the highest value of dissolved solids, while station 3 had the lowest value of dissolved solids. The value of suspended solids recorded is determined by the amount of dissolved solids.

This prawn study confirmed that tropical water systems are highly rich and diverse in prawn species noted for warm waters globally (Khademzadeh and Haghi, 2017). A total of 3 species and 246 individual were recorded. The three species of prawn, namely *Macrobranchium dux, M. macrobranchium and Macrobranchium sp. Macrobranchium,* were encountered in fresh and low

– salinity tidal region of the river, while larger specimen occurred, but not commonly, in the lower non-tidal sections of the river. *Macrobranchium sp.* occurred in the high – salinity mangrove channels or river mouths at the shallow, calmer, vegetated banks and were observed to be poor swimmers. The presence of *Macrobranchium dux, M. macrobranchium and Macrobranchium sp* had been reported by Ikomi (1996), and Odum and Oradiwe (1997) in this system. Edokpayi (1990) and Marioghae (1982) also reported similar abundance of *M. macrobranchium* in Benin River and in Lagos Lagoon respectively, and noted that it was restricted to fresh water zone of large water rivers in the Niger Delta as observed in this study. This confirms its successful culture all year round in non-salty waters. Their survival and growth in non-salty water eliminates the huge amount of money used for the procurement of coastal waters for prawn farming, which was a major challenge in prawn/shrimp culture. The use of our study area, naturally endowed with prawns, will make prawn culture preparation less expensive (Garcia-Guerrero *et al*., 2015).

The length distribution showed variations in each month which could not be attributed to inconsistent, random, far-flung length range observed monthly in the present study. The occurrence of juveniles and gravid females throughout the study could be an indication of multiple spawning (Odum and Oradiwe 1997). The abundance of gravid females depicts reproductive activity in the river. Condition factor was highest in the juveniles indicating how well the environment favours their growth. Ogidiaka *et al*. (2018) also noted similar condition factor for prawn juveniles in Forcados River Estuary. The condition factors for female prawns were comparably higher than those of males, responsible for their preponderance in this system. The observed condition factor in the present study was relatively higher than that reported by Okayi *et al*. (2012) in lower Benue and Niger Rivers, and similar to the records of Arimoro and Meye, (2007) in Orogodo River. Length - weight relationship exhibited in the present study showed the expected increase in length and weight. The growth in length and the gain in weight were highly significantly correlated ($p<0.05$).

This study confirmed that the prawns in this system fell within the volumetric, three dimensional growth hypothesis (Gautam *et al*., 2014; Ferdaushy and Alam, 2015). However, the negative allometric growth noted in *M.dux*, capable of attaining greater sizes than those recorded in this study, could be attributed to human disturbance along the entire course of the river (Iloba, 2012).

The sex ration recorded was 1 male to 3.8 female (1:3.8). In all the cases the females were significantly more than the male, indicating good, conducive environment. Edokpayi (1990) reported male:female ratios of 1:4 and 1:2 for *Macrobranchium* species. The preponderance of juveniles confirms steady recruitment intensity required for successful fishery.

The non-detection of significant environmental impact may not be an absolute declaration of their non-influence on their growth in the system but probably suggests other intrinsic attributes in the system (Oguguah *et al*., 2011; Kingdom *et al*., 2013). Environmental impacts of prawns/shrimps have been widely reported by researchers (Khademzadeh and Haghi, 2017)

Conclusion and Recommendation

The physico-chemical parameters obtained in this study reveal that the Ethiope River shows fresh condition. This area is good for prawn culture, and will provide means of livelihood to people of Sapele and its environ in the near future, if properly managed. There is therefore the need for government to monitor human activities in this river. This will sustain and boost production of prawn, a good sustainable source of human protein for today and future generation.

References

American Water Association and Water Pollution Control Federation (APHA) (1989) *Standard Methods for the examination of water and waste waters.* 15th Ed. Washington, DC.

Arimoro, F.O. and Meye, J.A. (2007). Some Aspects of the biology of *Macrobrachium dux* (Lenz, 1910) (Crustacea: Decapoda: Natantia) in River Orogodo, Niger Delta, Nigeria. *Acta Biologica Colombia* 12(1): 111-122.

Asaikkutti, A., Bhavan, P.S., Vimla, K., Karthik, M., Cheruparambath, P. and Rajkumar, G. (2016). Comparative Studies of the proximate composition of three body parts of wild, cultured and frozen prawn (Macrobrachium rosenbergh)(DeMan, 1879). *International Journal of Pure and Applied Zoology* 4(1): 85-91.

Balogun, K.J., Ladigbolu, I.A. and Olaji, E.D. (2011) Hydrochemistry of a tropical jarbor: Influence of Industrial and Municipal input. *Journal of Applied Science and Environmental Management* 15(4): 575-581.

Edokpayi, C.A. (1990) Ecology of prawn (Crustacea: Decapod, Natantia) in the Benin River at Koko, Delta State. University of Benin, Nigeria 222pp

FAO (2016). *The State of World Fisheries and Aquaculture. Contributing to food security and nutrition for all*. Food and Agriculture Organization of the United Nations, Rome, Italy. Rome. 200pp.

FAO (2018). *Globefish Highlights FIAM*. 2nd Issue, 2018. Food and Agriculture Organization of the United Nations, Rome, Italy. 80pp.

Ferdaushy, M.H. and Alam, M.M. (2015). Length – weight relationships and condition factor of nine freshwater fish species of Nageshwari, Banglasdesh. *International Journal of Aquatic Biology* 3(3): 149-154.

Garcia- Guerrero, M., Romero, R.S., Vega- Villasante, F. and CostesJacinto, E. (2015). Conservation and aquaculture of native freshwater prawns: the case of the Canque river prawn, *Macrobrachium americanum* (Bate, 1868). *Latin American Journal of Aquatic Research*. 43(5): doi: 10.3856/vol43-issue5-fulltext-x.

Gautam, K., Nazar, A.R., Ganesh, E.A., Mahendran, S. and Mahadevan, G. (2014). Study of length and weight relationship of *Litopenaeus vannamei* (Boone, 1931) from East Coast of India. *International Journal of Science Inventions Today* 3(4): 365-376.

Hammer, Ø., Harper, D.A.T. and Ryan, P.D. (2001). PAST: Paleontological Statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Ikomi, R.B. (1996). The biology of the African leaf fish *Polycentropsis abbreviate,* Boulenger, 1901 in the River Ethiope, Nigeria. *Acta Ichthyologica et Piscatorial*. Vol. xxvi, Fasc. 1.

Ikomi, R.B., and Arimoro, F.O. (2014). Effects of recreational activities on the littoral macroinvertebrates of Ethiope River, Niger Delta, Nigeria. *Journal of Aquatic Sciences* 29(1): 155–170.

Ikomi, R.B. and Jessa, H. (2003). Studies on aspect of the biology of *Tilapia mariae* (Boulenger, 1899) (Osteichthyes Cichlidae) in Ethiope River, Niger Delta, Nigeria. *African Zoology* 38(2): 255-264.

Ikomi, R.B and Odum,O.(1998). Studies on aspects of the ecology of the catfish Chrysichthys auratus Geoffrey St. Hilaire(Osteichthyes; Bagridae) in the River Benin(Niger Delta, Nigeria), *Fisheries Research* 35: 209-218.

Iloba, K.I. (2012). The Physico-chemical Characteristics and Plankton of Ethiope River, Nigeria. Ph.D Thesis, Delta State University Abraka, Delta State, 446pp.

Iloba, K.I and Ikomi, R.B. (2017). Phytoplankton Diversity as index of water quality in the Umuaja Watershed, Delta State, Nigeria. *International Journal of Applied Biological Research* 9(1): 93 – 206.

Imoobe, T.O.T. (1997). Crustacea of Jamieson River, Nigeria. PhD Thesis. University of Benin, Benin-City, Nigeria. 155pp

Islam, A., Mondal, S., Bhowmik, S., Islam, S. and Bejum, M. (2017). A comparative analysis of the proximate composition of wild and cultured prawn (*Macrobrachium rosenbergii*) and shrimp (*Penaeus monodon*) *International Journal of Fisheries and Aquatic Studies* 5(4):59-62.

Khademzadeh, O. and Haghi, M. (2017). Length –weight relationship and condition factor of white leg shrimps *Litopenaeus vannamei* (Boone, 1931) in culture systems of Choebdeh, West- South of Iran. *International Journal of Fisheries and Aquatic Studies* 5(1): 298-301.

Kingdom, T., Hart, A.I. and Erondu, E.S. (2013). Effects of environmental factors on the abundance of shrimps, *Macrobrachium* species, in the lower Taylor Creek, Niger Delta, Nigeria. *African Journal of Pollution and Health* 10: 71-79.

Kunda, M., Dewan, S., Uddin, M.J., Karim,M., Kabir, S. and Uddin, M.S. (2008). *Asian Fisheries of Science* 21:451-456.

Marioghae, I.E. (1982). Notes on the biology and distribution of *Macrobrachium vollehoveni* and Macrobrachion in Lagos lagoon. *Revue de Zoologie Africaine* 93(3):493-508

Odum, O. (1992). The Eccology and Biology of the fishes of the Ethiope River, Nigeria. Ph.D Thesis, University of Benin, Benin-City 222pp.

Odum, O. and Oradiwe, U. (1997). Some aspect of the biology of *Macrobranchium macrobrachion* (Herklots, 1851) (Crustacea: Decapod: Palaemonidae) in the Ethiope River, Nigeria. *Journal of African Zoology* 109: XXX – XLVI.

Okayi, R.G., Ataguba, G.A., and Mbata, F.U. (2012) Stock assessment of shrimps and prawns of the Benue and Niger River, Nigeria. *E3 Journal of Agricultural Research and Development* 2(4):92-95.

Ogidiaka (2018). Comparative Studies of the Growth Characteristics of *Macrobrachium macrobrachion* and *Macrobrachium vollenhovenii* in Forcados River estuary, Niger Delta, Nigeria. International *Journal of Scientific Research in Multidisplinary Studies* 4(9): 31-33.

Oguguah, N.M., Nwadukwe, F.O., Atama, C.I., Chidobem, J.I., and Eyo, J.E. (2011). Growth performance of hybrid catfish (*Heterobranchus bidorsalis* (male) x *Clarias gariepinue* (female) at various stocking densities in varied culture tanks. *Animal Research International* 8(3): 1419-1430

Powell, C.E. (1982) Freshwater and brackish water shrimps of economic importance in the Niger Delta. In: Proceeding of 2nd Conference Fishery Society of Nigeria, Calabar, Nigeria. January 1982, pp 254-288.

Yang, P., Lai, D.Y.F., Jin, B., Bastviken, D., Tan, L. and Tong, C. (2017). Dynamics of dissolved nutrients in the aquaculture shrimps ponds of the Min River estuary, China: Concentration, fluxes and environmental loads. *Science of the Total Environment* 603-604:256-267.

Yarra, A.N. and Magoulick, D.D. (2018) Modelling effects of invasive species and drought on crayfish extinction risk and population dynamics. *Aquatic Conservation: Marine and Freshwater Ecosystems* 29:1-11