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Length-weight relationship and condition factor of seven shrimp species in the artisanal shrimp fishery of Iko river estuary, southeastern Nigeria

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Abstract
The Length-Weight Relationship (LWR) and condition factor (K) of seven shrimp species in the artisanal shrimp fishery of Iko River estuary, Southeastern Nigeria were studied between November 2011 and October, 2012. The length-weight relationship had a significant positive correlation (r^2>0.5) for all the species. The intercept (a) showed high heterogeneity among the species. The growth exponent (b) ranged from 2.102 to 3.574 and differed significantly (p= 0.05) from 3 which indicates allometric growth for several species. The regression coefficient of males and females were not significantly different from Isometric growth at *p*>0.05 (F=1.884, p=0.324; t =0.884, df=11, p=0.383).

Keywords: Allometric growth, Length-Weight relationship, Artisanal shrimp fishery, Condition factor.

1. Introduction

Length-weight relationship has a\vital importance in fisheries science. Length-weight relationship helps in establishing mathematical relationship between the two variables, and enable conversion of one variable to another [1]. Length-weight relationship are useful for a wide number of studies, such as estimating growth rates, age structure and other aspects of fish/shrimp population dynamics [2].Variability in the length-weight relationship is a feature that can reflect fluctuations in the uptake and allocation of energy. These morphometric variation can be affected by many factors such as food, stress (overcrowding and disease), or reproductive cycle [3, 4]. Many authors have reported on the length-weight relationship among sexes, species, seasons, and sites for both wild and cultured populations of shrimp. Length – weight relationship of *Nematopalaemon hastatus* in the Cross River estuary, Nigeria was recorded by [5]. The parameters of the length-weight relationship of *Nematopalaemon tenuipes* along the Matharashtra coast, India was recorded by [6]. The length-weight relationship of *P. stylifera* at Calicut was reported by [7]. The length –weight relationship of *P. indicus* in Bagamoyo coastal water, Tanzania was reported by [8]. Length-weight relationship for *P. kerathurus* in the East Ionian Sea (Western Greece) was reported by [9]. The LWR for *Atya gabonensis* from River Benue in Makurdi, Nigeria was recorded by [10]. The LWR for P. *indicus* and *P. monodon* in Buguma creek, Niger Delta Nigeria was recorded by [11]. Length-weight relationship of A. *indicus* in the coastal water of Malaysia was recorded by [12]. The LWR of *M. macrobrachion* in Luubara creek, Nigeria was reported by [13]. The LWR of *P. monodon* cultured in Pichavaram mangroves (Thailand) was reported by [14]. The LWR of *P. atlantica* in the coastal waters of Ondo State was reported by [15]. Fish growth, mean weight at a given body length of fish and the relative wellbeing in fish can be known through this relationship [16]. The condition factor (K) of a fish reflects recent physical and biological circumstances, as it is strongly influenced by biotic and abiotic environmental variables. Condition factor and mean body length indicate the influence of the environment on the biology of fish. It is often assumed that heavier prawns of a given length are in better condition [3]. It shows the well-being of the population during various life cycle stages and assessments of fish condition based on weight at a given length are thought to be reliable indicators of the energetic condition or energy reserve in fish. Condition factor (K) also gives information when comparing two populations living in certain feeding density, climate and other conditions: when determining the period of gonad maturation, and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source [17]. However, studies on the length-weight relationship and condition factor of shrimp populations in Iko River, Nigeria are scarce. Thus, the length-weight relationship and condition factor are needful for the sustainable management of the shrimp resources in the face of the ever changing physico-chemical and edaphic conditions of our aquatic ecosystems.

2. Materials and Methods

Sampling Area

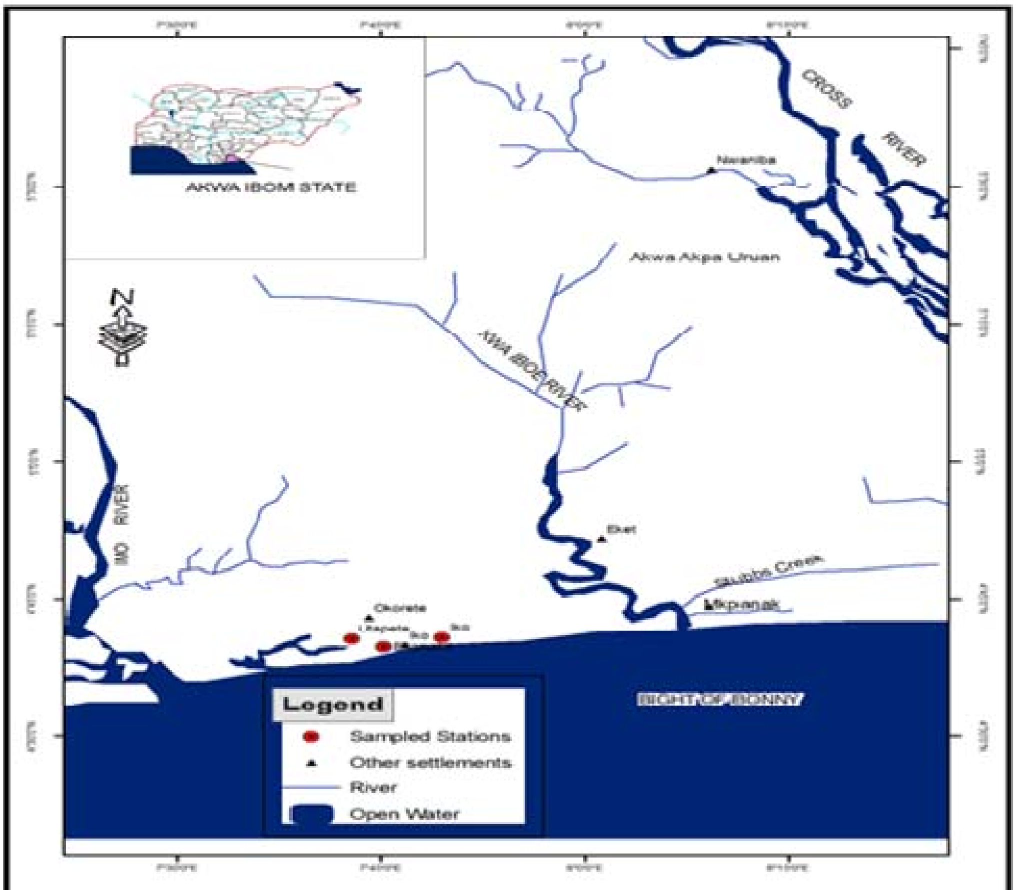

Figure 1: Map of the South Akwa Ibom State Showing the Sampled Stations

Determination of Length-weight

The power equation below was used to determine the length-weight relationship of shrimp species

$$W = aL^b \quad \text{.......... (1)}$$

Whose log linearization, according to method in FiSAT [19] takes the form?

$$LogW = Log\ a + b\ Log\ L \quad \text{.......... (2)}$$

Equation 2 was used in describing the L-W relation of the shrimp

Where W = weight (g); TL = total length (mm), the intercept on the Y-axis and b is exponent or slope indicating isometric growth when b =3 [19]. The weight- length relationship was tested using linear regression model *p*<0.05 significant level and the confidence limit for the regression coefficient was established at 95% confidence interval.

The exponents (b) of the length-weight relationships was tested for departure from isometry (b = 3) i.e. b value differs from 3 significantly, using a t-statistic function given by Pauly [19] as follows:

$$ts = \frac{s.d(x)}{s.d(y)} \cdot \frac{|b-3|}{\sqrt{1-r^2}}\sqrt{n-2} \quad \text{.......... (3)}$$

Where s.d(x) is the standard deviation of the LogL values and s.d(y) is the standard deviation of LogW values, n is the number of shrimps used in the computation, b is the estimated exponent of the LWR and r^2 is the coefficient of determination of the relationship. The value of b is different from 3 if t-calculated is greater than the table value of t for the degree of freedom n – 2 [19]. Additionally, 95% confidence limits of the parameters ‘a’ and ‘b’ and the statistical significance level of r^2 ($P < 0.05$; 0.01) was estimated.

Condition Factor (CF)

Fultons condition factor (CF) of shrimp species was calculated as the body weight expressed as a percentage of the cube of the carapace length.

$$CF = \frac{W}{CL^3} \times 100 \quad \text{.......... (4)}$$

Where W = ungutted weight and CL = carapace length (mm) of *shrimps*. Equation 4 is premised on the assumption that growth is isometric, that is b = 3 [20, 5, 21].

3. Results

The length-weight parameters and the coefficient of correlation (r) estimated for 7 species belonging to 4 genera and 3 families are presented in Table 1. The length-weight relationship had a significant positive coefficient of determination ($r^2>0.5$) for all the species. The intercept (a) showed high heterogeneity among the species. The growth exponent (b) ranged from 2.102–3.574 and differed significantly (p=0.05) from 3 which indicates allometric growth for several species. The regression coefficient of males and females were not significantly different from Isometric growth at $p>0.05$ (F=1.884, p=0.324; t=0.884, df=11, p=0.383). The length –weight graphs for all the shrimp species are presented in Fig. 2(a-g)

Table 1: Length-Weight Parameters of Shrimps from Iko River estuary

Family	Species	N	A	B	Growth Pattern	R	r^2
Penaenidae	*P.atlantica*	2135(F)	0.00000818	2.976	(-)Allometric	0.975485	0.975485
		1523(M)	0.00000121	2.888	(-)Allometric	0.957178	0.916190
		3658(C)	0.00000940	2.945	(-)Allometric	0.969045	0.939047
Penaenidae	*P. kerathurus*	344 (F)	0.00000704	3.005	(I) Isometric	0.970294	0.941470
		283 (M)	0.00000748	2.989	(-)Allometric	0.974405	0.949465
		627 (C)	0.00000722	2.998	(-)Allometric	0.971875	0.944541
Penaenidae	*P. setiferus*	1150 (F)	0.00000357	2.555	(-)Allometric	0.890745	0.793426
		68 (M)	0.00000469	3.055	(I) Isometric	0.968792	0.938558
		1218 (C)	0.00000307	2.592	(-)Allometric	0.898923	0.808062
Penaenidae	*P. scuptilis*	532 (F)	0.00000685	3.008	(I) Isometric	0.981831	0.963993
		266 (M)	0.00000406	3.138	(+)Allometric	0.964606	0.930465
		798 (C)	0.00000708	3.004	(I) Isometric	0.978677	0.957809
Penaenidae	*P. monodon*	5 (F)	0.00000506	3.093	(I) Isometric	0.996758	0.993526
		11 (M)	0.00004352	2.102	(-)Allometric	0.631199	0.398412
		16 (C)	0.00000944	2.597	(-)Allometric	0.824344	0.679537
Palamonidae	*N. hastatus*	63 (F)	0.0000549	2.369	(-)Allometric	0.945237	0.893473
		23 (M)	0.0000131	2.744	(-)Allometric	0.933642	0.871688
		86 (C)	0.00000423	2.436	(-) Allometric	0.944746	0.892546
Penaenidae	*M. rosenbergii*	50 (F)	0.00000950	3.373	(+) Allometric	0.550541	0.303096
		9 (M)	0.00000155	3.574	(+) Allometric	0.971642	0.944088
		59 (C)		3.474	(+) Allometric	0.800618	0.660742

Key: (+) positive allometric growth, (-) = negative allometric growth, (1) = Isometric growth pattern

Analysis of condition factor (K) revealed that K-values for female shrimps are generally higher than that of the male. The K-value ranged between 0.14 (*N. hastatus*) 0.92 (*P. monodon).* The result indicates that heavier shrimps of a given length are in better condition. The study also observed differences in the condition factor of the different sexes of shrimp and a general increase in the K-values of female shrimp compared to that of the males (Table 2). In females *P. atlantica,* the highest condition factor (*K*=0.85) was recorded in January, 2012 while the lowest value (*K*=0.68) was recorded in May, 2013 for males. In *P. kerathurus*, females had the lowest condition factor (*K*=0.62) in April, 2013 and the highest condition factor (*K*=0.89) in November. Generally, there was increase in the condition factor in the dry season in the shrimp species caught in Iko River estuary.

Table 2: Mean length, weight and condition factor (K) for the shrimp species in Iko River estuary

		Female				**Male**				**Combined Sex**		
Family/ Species	N	MTL,cm X± SE Min - Max	MTW,(g) X± SE Min - Max	K	N	MTL,cm X±SE Min - Max	MTW, (g) X±SE Min-Max	K	N	MTL,cm X±SE Min - Max	MTW,(g) X±SE Min-Max	K
Penaenidae *P.atlantica*	2135	87.22±0.36 (37.2-143.25)	5.47±0.06 (0.38-23.18) 11682.66	0.82	1523	84.40±0.36 (31.85-128.30)	4.81±0.05 (0.22-13.82) 7339.99	0.80	3659	86.02±0.26 (31.85-143.25)	5.20±0.04 (0.22-23.16) 19022.65	0.82
Penaenidae *P.kerathurus*	344	74.32±0.67 (44.35-116.2)	3.23±0.09 (0.63-12.44) 1113.51	0.78	283	74.57±0.65 (48.55-113.95)	3.18±0.09 (0.81-11.99) 902.39	0.76	627	74.43±0.47 (44.35-116.2)	3.21±0.06 (0.63-12.44) 2015.9	0.77
Penaenidae *P.setiferus*	1150	64.58±0.29 (31.2-120.55)	1.62±0.02 (0.13-14.23) 1866.25	0.61	68	57.87±1.32 (36.35-100.45)	1.33±0.16 (0.32-8.45) 91.13	0.68	1218	64.20±0.28 (31.2- 120.55)	1.60±0.02 (0.13-14.23) 1957.25	0.60
Penaenidae *P.scuptilis*	532	90.22±0.79 (40.7-140.3)	5.92±0.14 (0.57-22.85) 3152.53	0.81	266	78.96±0.70 (46.5-104.6)	3.96±0.11 (0.73-11.62) 1054.78	0.80	798	86.46±0.60 (40.7-140.3)	5.27±0.11 (0.57-22.85) 4207.31	0.82
Penaenidae *P.monodon*	5	195.22±24.78 (121.35-251.15)	73.69±23.23 (13.18-128.76) 368.48	0.99	11	190.67±10.09 (113.25-222.05)	61.62±6.49 (27.0-90.73) 677.88	0.88	16	192.09±9.90 (113.25-251.15)	65.39±8.15 (13.18-128.76) 1046.36	0.92
Palamonidae *N. hastatus*	63	49.76±0.98 (27.45- 62.35)	0.60±0.03 (0.17-1.25) 38.27	0.48	23	45.15±1.20 (36.25- 59.4)	0.47±0.03 (0.21-0.79) 10.9	0.51	86	48.53±0.81 (27.45-62.35)	0.57±0.02 (0.17- 1.25) 49.17	0.49
Palamonidae *M. roseenbergii*	50	65.10±2.35 (19.5-120.3)	4.04±0.77 (0.25-32.6) 202.11	0.15	9	60.25±4.07 (42.2-74.90)	2.81±0.66 (0.71-6.63) 25.36	0.13	59	64.36±2.09 (19.5-120.3)	3.85±0.66 (0.25-32.6) 227.47	0.14
Total	4279 (62.2%)				2183 (37.80%)				5763			

N/B: The highlighted figures are total weight of each species

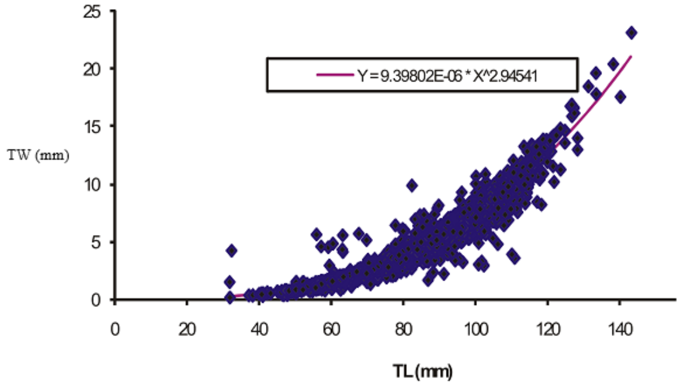

Fig 2a: Length-Weight Relationship graph for combined sex of *P. atlantica*

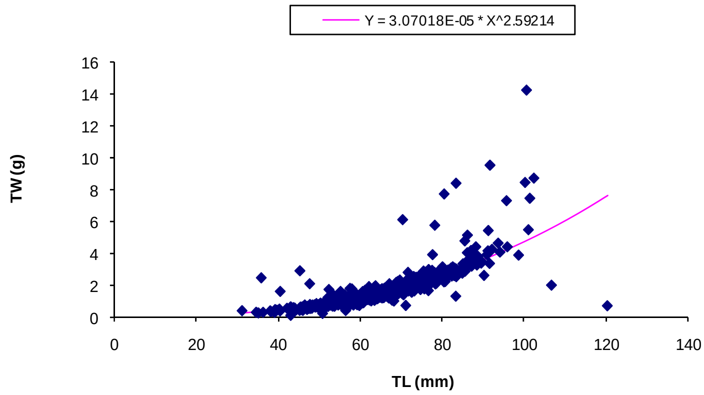

Fig 2c: Length-Weight Relationship graph for combined sex of *P. setiferus*

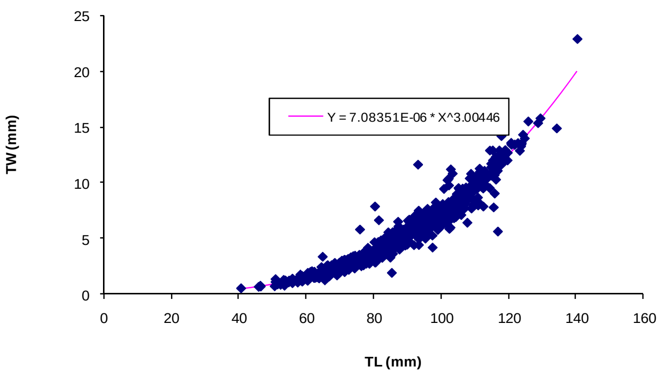

Fig 2d: Length-Weight Relationship graph for combined sex of *P. scuptilis*

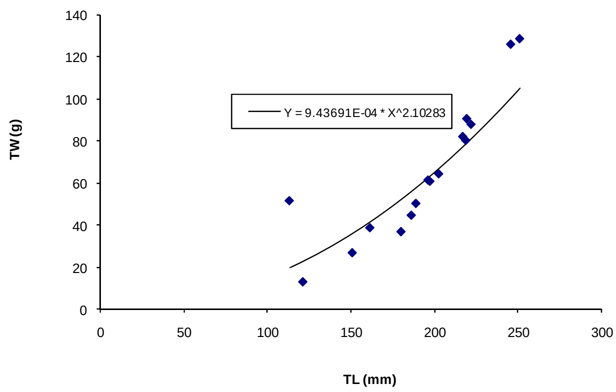

Fig 2e: Length-weight Relationship graph for combined of sex *P. monodon*

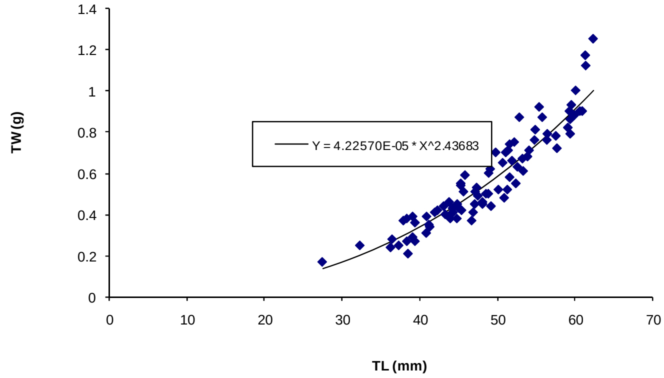

Fig 2f: Length-Weight Relationship graph for combined of sex *N. hastatus*

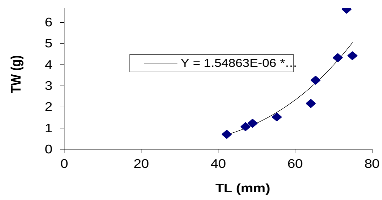

Fig 2g: Length-Weight Relationship graph for combined sex of *M. rosenbergii*

4. Discussion

The values obtained from the length/weight relationship (LWR) of shrimps in Iko River estuary showed that there was a high and significant correlation between the total length and weight of shrimp (r=0.550541-0.996758). This means that the length and weight of shrimp increase in the same proportion. Coefficient of determination r^2>0.5 obtained for the species indicated the fitness of the model used in this analysis. Dimensional inequality recorded for shrimps in Iko River could be used to explain the slenderness or stoutness of the shrimp. The shrimp becomes slender as it increases in length, indicating negative allometric growth and becomes plumber as the shrimp increases in length, indicating positive allometric growth.

Thus, an evaluation of length-weight relationship provides an essential tool for stock and yields potential assessment of shrimp population. The growth coefficient for both sexes of *N. hastatus* indicated negative allometric growth showing that the rate of increase in body length is not proportional to the rate of increase in body weight. This also implies that the species become thinner as they grow older. Negative allometric growth was also recorded for *N. hastatus* by [5] (b =2.92) from the Cross River estuary Nigeria; for *N. tenuipes* by [6] (b=2.83M and b=2.925F) along the Maharashtra coast, India; for the same species from the same location [22] (b = 2.8F) and (b=2.7M); for *N. hastatus* from Ayetoro, Ondo State [15]. The positive allometric growth recorded for Peneaid shrimps in Iko River estuary is also similar to the report of [7] who recorded b=2.978 (M) and 2.958 (F) for *P. stylifera* from Calicut. Positive allometric growth b=3.0 (M) and b= 3.0 (F) for *P. indicus* from Bagamoyo Coastal waters, Tanzania was recorded by [8]. Positive allometric growth was equally recorded for *P. notialis* from Bugama Creek, Niger Delta, Nigeria [11], while positive allometric growth (b=3.3) for *P. atlantica* in River, Ondo State was reported by [15]. However, b=2.99 from combined sex of *P. sculptilis* from Penang water was recorded by [23], b=2.6 for combined sex [24], b=2.5 from Selangor Water [25], a=2.9 (M), b=3.0 (F) in Australian water [26]; b =2.8 combined sex from the coastal waters of Perak, Peninsular Malaysia [27]. Furthermore, b=2.3 for females and b=2.4 for males of *P. kerathurus*, in the Amvrakikos gulf, India was recorded by [7, 28], while b=2.0 for *P. kerathurus* from

East Ionian Sea (Western Greece) was recorded by [9]. Similarly, negative allometric growth (b=2.97) in *P.monodon* from Buguma Creek in the Niger Delta, Nigeria was recorded by [11]. In Pichavaran Mangroves (Thailand), negative allometric growth for male b=2.4 and females, b=2.6 was reported by [14]. In Coastal Waters of Ondo State, South West, Nigeria, [15] recorded b=2.5 for *P. monodon.* The differences could be due to geographic condition and growth condition of the shrimps in different localities. The slight variation in the values of b and r is understandable because length-weight relationship of a species could vary according to locality and season [29, 30].

Differential morphological characteristics presented in Table 2 showed conspicuously differences between the sexes of shrimps in Iko River estuary. Such changes have been identified in several crustaceans [31, 25, 2]. The pattern of sexual dimorphism where females are larger than the males is the same pattern of sexual dimorphism appeared in number of species of commercially important penaeid shrimps [32, 33, 34] Reported that females had a greater carapace length and body weight than males of the same total length and this difference became more pronounced in larger size groups. Bigger female sizes might be due to greater weight, increase per molt cycle leading to faster growth in rate.

Condition factor (CF) is useful in expressing the wellbeing or fatness of the shrimp. It varies with sex, stage of maturity, and time of the year. The differences in the condition factor between males and females could be due to the presence of gravid females or due to higher weight of the female's gonads, which are lacking in their male counterparts. The use of condition factor as an index of growth and feeding intensity was reported by [35], which can be inferred that the higher k value for *P. monodon* recorded in this study can be explained with the fact that this species grow bigger and faster than other Penaeid shrimps. The lower k value for *N. hastatus* could be a result of feeding rate, severe exploitation and environmental factors of Iko River. The condition factor is an indicator of the changes in food reserves as stated by [15]. Heavier fish of a given length are in better condition as opined by [36]. The differences in weight for all the shrimp species may be due to the individual condition factor as it relates to the well-being and fatness of the organisms.

The condition factors K = 0.49 (*N. hastatus*), *K* = 0.82 (*P. atlantica*), *K* = 0.74 (*M. rosenbergi*) were different from the record in the coastal waters of Ondo state by [15]. These differences could be due to pollution status and oil reserves at Iko River which could affect the biotic integrity of the shrimp species. Pollution was also seen to affect the condition factors in Shanawan drainage canal in Egypt [31]. The differences in length-weight relationship and condition factor of shrimp may be due to sex, maturity, season and environmental conditions (e.g, pollution) [15].

5. Conclusion

Analysis of condition factor (K) revealed that K-values for female shrimps are generally higher than that of the male. The K-value ranged between 0.14 (*N. hastatus*) to 0.92 (*P. monodon).* The result indicates that heavier shrimps of a given length are in better condition.

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