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Morphology and condition indices of *Macrobrachium* species in the in the lower Taylor Creek, Niger Delta, Nigeria

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Abstract
The morphometric characteristics and condition indices of *Macrobrachium* species in the Lower Taylor Creek, Niger Delta, Nigeria were studied from June 2008 to May 2010.The largest specimens of *Macrobrachium* species were found among the *Macrobrachium vollenhovenii* with a range of 2.00-13.00 cm and a mean of 6.56±0.12 cm total length. *Macrobrachium felicinum* and *Macrobrachium macrobrachion* had mean total lengths of 4.88±0.25 cm and 5.22±0.19 cm respectively. The relationships between total length and carapace length (TL = a + bCL) of all the species are stated as follows: *M. felicinum* (TL = 1.51 + 2.87CL; r = 0.92, P<0.001), *M. macrobrachion* (TL = 0.67 + 3.98CL; r = 0.92, P<0.001) and *M. vollenhovenii* (TL = 1.18 + 3.21CL; r = 0.98, P<0.001). The mean exponents of the length–weight relationships of *M. felicinum* and *M. vollenhovenii* indicated positive allometric function, while *M. macrobrachion* showed isometric growth. The mean condition factor of *M. felicinum, M. macrobrachion* and *M. vollenhovenii* were 1.23±0.02, 1.26±0.01 and 1.06±0.06, respectively. Seasonally, condition factor was significantly (P<0.001) different between dry and wet seasons in *M. vollenhovenii*.

Keywords: Crustaceans, prawns, morphology, growth, condition factor.

1. Introduction
Shrimps are valued food organisms that are heavily exploited. In West Africa, they are very important export commodity [1, 2]. According to [3], fisheries interest in shrimps in Nigeria has been centred on the marine penaeid species harvested offshore by commercial trawlers while extremely little is known of the local fresh and brackish water species, those supporting the traditional artisanal fisheries and most likely to include suitable candidates for aquaculture. Even the freshwater species that have been studied have mainly been carried out in a brackish water environment: Lagos lagoon [4]; Cross River Estuary [5, 6, 7, 8, 9, 10, 11, 12].

This study was therefore conducted to examine the relative growth of *Macrobrachium species* in the Lower Taylor Creek, Niger Delta, Nigeria, with emphasis on morphometric relationships and condition indices.

2. Materials and Methods
Samples of *Macrobrachium species* were collected biweekly from June 2008 to May 2010 from the Lower Taylor creek (called Gbaraintoru by indigenes), Yenagoa Local Government Area of Bayelsa State. The study area stretched from Koroama to Polaku along the Taylor Creek (a non–tidal fresh water creek). The Lower Taylor creek is situated between 5^0 01^1N; $6^0 17^1$ E and 5^0 02^1 N; 6^0 18^1E (Fig. 1). Samples of shrimps were removed between 0700 hrs and 0900 hrs from basket traps (known locally as 'Ingo') after setting for twenty four hours. Numbers of shrimps from/1biweekly samples of the traps were later pooled to form the monthly and seasonal catches.

2.1 Morphometric measurements
Total length (TL), Carapace length (CL), Chela length (cL), Palm length (PL), Carpus length (CL^1) and Dactyl length (DL) were measured for each animal. Length measurements were made

with a plastic ruler while weight of each shrimp was taken in grams (g) using Ohaus Scout Pro balance model SPU 402. Regression analyses were used to determine the relationships between total length and carapace length for each species

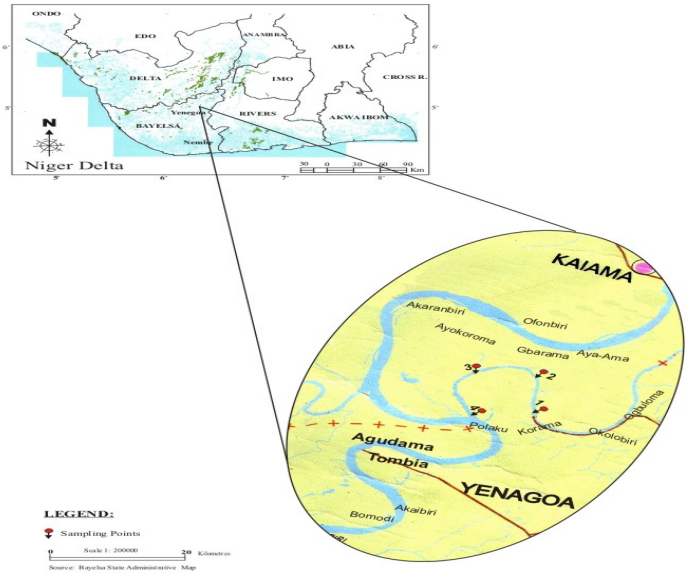

Fig 1: Map of Niger Delta Showing Bayelsa State and Taylor Creek the Study Area

2.2 Length-Weight Relationships

Length–weight relationship was calculated for each sex, for the sexes combined and expressed by the equation:

$$W = aL^b$$ [13]

Where: W= Weight (g); L= Total Length (mm); a= Intercept
b= Slope

The relationship was established by least square regression of the logarithms transformed version of the equation as follows:

$$\text{Log}_{10}\, w = \text{Log}_{10}\, a + b\log_{10} L$$

If b was close to 3 in isometric growth [14], the fitted linear regression analyses was tested for significance. The slope (b) of the length-weight relationship was tested with t-test for departure from isometry (i.e. b=3).

2.3 Condition Factor

Fulton's condition factor (k) was calculated using the formula given by [16] as:

$$K = \frac{100 \times W}{L^3}$$

Where, K= Condition factor
W = Total Weight of Shrimp (g)
L= Total Length of Shrimp (cm)

The mean monthly means was used to determine if monthly, seasonal or yearly variations exist. Also, test (ANOVA) was used to ascertain difference in size classes while t-test was used to test for significant differences between male and female.

3. Results

3.1 Morphometric and meristic characteristics

The morphometric and meristic characteristics of freshwater shrimps in the Lower Taylor Creek are given in Tables 1 to 3. The results revealed that the largest specimens were found among the *M. vollenhovenii* with a size range of 2.00-13.00 cm and mean±S.E of 6.56±0.12 cm. There were significant differences between males and females in the total length and weights of *M. felicinum, M. vollenhovenii* and *M. macrobrachion*. Male *M. vollenhovenii* had significantly longer carapace (P<0.001) than the female, while it was the other way round in *M. macrobrachion*. There was no significant difference (P>0.05) between the male and female in the carapace length of *M. felicinum*. Also, males had significantly longer chelae of *M. vollenhovenii* (P<0.001) and *M. felicinum* (P<0.001) than females while females had longer chelae than males (P<0.05) in *M. macrobrachion*.

There was no difference (P>0.05) between the carpus length of both sexes of *M. vollenhovenii*, while male *M. felicinum* had longer carpus (P<0.001) than the female; but the reverse was the case in *M. macrobrachion* with the female having a longer carpus than the male (P<0.05). The males had longer palm and dactyl lengths than the females both in *M. vollenhovenii* and *M. felicinum* (P<0.001). However, the females in *M. macrobrachion* had longer palm and dactyl lengths than their male counterparts (P<0.05). *M.*

vollenhovenii and *M. felicinum* had significant total dorsal (P<0.05) and post orbital rostral spines (P<0.001) than *M. macrobrachion*. However, there were no significant differences (P>0.005) in both total dorsal and post orbital rostral spines between sexes in all species.

The morphometric ratios of *Macrobrachium* species are shown in Table 4. The total length was about four times the carapace length in *M. felicinum* and *M. vollenhovenii*, while it was four and half times longer than the carapace length in *M. macrobrachion*. The carpus/palm length ratio reveals that they were almost equal in male *M. felicinum*, while in females, the carpus was about fifty percent longer than the palm length. In *M. macrobrachion,* the carpus/palm length ratio was almost 2:1, while the palm was longer than the carpus in *M. vollenhovenii.*

The relationship between total length and carapace length (TL = a + bCL) of *M. felicinum* was positively correlated and very highly significant: TL = 1.51 + 2.87CL (n = 861; r = 0.92; r^2 = 0.85; P<0.001). For *M. macrobrachion*, the relationship was TL = 0.67 + 3.98CL (n = 97; r = 0.92; r^2 = 0.85; P<0.001). Also, the relationship for *M .vollenhovenii* was TL = 1.18 + 3.21CL (n = 341; r = 0.98; r^2 = 0.96; P<0.001).

3.2 Length – Weight relationships

The length-weight relationships and related statistics of *Macrobrachium* species are shown in Table 5. The results revealed that the slope values (b) for *M. felicinum* varied from 2.12±0.05 to 3.23±0.09. Generally, *M. felicinum* had positive allometric growth, since the slope value was significantly (t = 86.77; P<0.001) different from "3". However, the female exhibited negative allometry.

Generally, *M. macrobrachion* exhibited isometric growth, since the slope was not significantly (P>0.05) different from "3". This growth pattern was also observed in the female *M. macrobrachion*. However, the male exhibited negative allometry. The "b" values of *M. vollenhovenii* were all greater than "3", indicating that both males and females of this species exhibited positive allometric growth. Figs. 2 to 4 show the plots of the logarithmic transformation of the length-weight relationships for these species.

Table 1: Morphometric and meristic characteristics of *M. felicinum* in the Lower Taylor Creek

Parameter	Male			Female			Combined Sex			
	Min./1	Max.	Mean±S.E	Min.	Max	Mean±S.E	N	Min./1	Max./1	Mean±S.E
Total length (cm)	1.50	7.80	4.78±0.12[b]	1.50	6.70	4.91±0.02[a]	861	1.50	7.80	4.88±0.25
Total weight (g)	0.09	9.93	1.78±0.16[a]	0.04	14.40	1.51±0.03[b]	861	0.04	14.40	1.59±0.44
Carapace length (cm)	0.40	2.30	1.18±0.04[a]	0.30	1.70	1.17±0.01[a]	861	0.30	2.30	1.18±0.01
Chela length (cm)	0.70	4.00	1.73±0.14[b]	0.50	1.60	0.88±0.02[a]	101	0.50	4.00	1.18±0.06
Carpus length (cm)	0.50	2.30	0.96±0.07[b]	0.40	1.10	0.76±0.01[a]	101	0.40	2.30	0.83±0.03
Palm length (cm)	0.40	2.00	0.90±0.07[a]	0.30	0.90	0.48±0.01[b]	101	0.30	2.00	0.63±0.03
Dactyl length (cm)	0.30	2.00	0.83±0.07[a]	0.30	0.70	0.41±0.01[b]	101	0.30	2.00	0.56±0.04
TDR Number	12	15	13.55±0.41[a]	14	15	14.67±0.21[a]	18	12	15	13.94±0.30
POR Number	2	5	4.20±0.33[a]	5	5	5.00±0.00[a]	17	2	5	4.50±0.22

TDR = Total dorsal rostrum; POR = Post orbital rostrum; Min. = Minimum; Max. = Maximum; N = Number; S.E = Standard error

Table 2: Morphometric and meristic characteristics of *M. macrobrachion* in the Lower Taylor Creek

Parameter	Male			Female			Combined Sex			
	Min.	Max	Mean±S.E	Min.	Max.	Mean±S.E	N	Min.	Max	Mean±S.E
Total length (cm)	2.00	7.70	4.33±0.28[b]	2.40	10.00	5.74±0.23[a]	97	2.00	10.00	5.22±0.19
Total weight (g)	0.03	3.89	1.04±0.15[b]	0.25	9.68	2.41±0.28[a]	97	0.03	9.68	1.93±0.20
Carapace length (cm)	0.40	1.50	0.94±0.06[b]	0.50	2.20	1.26±0.06[a]	97	0.40	2.20	1.14±0.04
Chela length (cm)	0.50	1.20	0.80±0.05[b]	0.40	1.70	1.04±0.06[a]	45	0.40	1.70	0.98±0.05
Carpus length (cm)	0.80	1.20	0.92±0.04[b]	0.60	1.80	1.09±0.05[a]	45	0.60	1.80	1.04±0.04
Palm length (cm)	0.30	0.70	0.48±0.03[b]	0.20	1.00	0.61±0.04[a]	45	0.20	1.00	0.57±0.03
Dactyl length (cm)	0.20	0.50	0.33±0.03[b]	0.20	0.80	0.43±0.03[a]	45	0.20	0.80	0.40±0.02
TDR Number	10	10	10.00±0.00[a]	9	11	10.00±1.00[a]	5	9	11	10.00±0.90
POR Number	2	2	2.00±0.00[a]	2	2	2.00±0.00[a]	5	2	2	2.00±0.26

TDR = Total dorsal rostrum; POR = Post orbital rostrum; Min. = Minimum; Max. = Maximum; N = Number; S.E = Standard error

Table 3: Morphometric and meristic characteristics of *M. vollenhovenii* in the Lower Taylor Creek

Parameter	Male			Female			Combined Sex			
	Min.	Max	Mean±S.E	Min.	Max.	Mean±S.E	N	Min.	Max.	Mean±S.E
Total length (cm)	2.00	13.00	6.84±0.13[a]	2.10	11.50	5.82±0.22[b]	341	2.00	13.00	6.56±0.12
Total weight (g)	0.06	36.49	5.61±0.38[a]	0.10	19.77	3.52±0.48[b]	341	0.06	36.49	5.03±0.31
Carapace length (cm)	0.40	3.80	1.76±0.04[a]	0.50	3.00	1.45±0.06[b]	202	0.40	3.80	1.68±0.03
Chela length (cm)	0.70	6.80	2.49±0.08[a]	0.60	4.60	1.88±0.18[b]	202	0.60	6.80	2.36±0.08
Carpus length (cm)	0.40	2.30	1.01±0.03[a]	0.50	1.80	0.98±0.05[a]	202	0.40	2.30	1.01±0.02
Palm length (cm)	0.30	3.70	1.33±0.04[a]	0.30	2.30	1.00±0.09[b]	202	0.30	3.70	1.26±0.41
Dactyl length (cm)	0.30	3.10	1.18±0.04[a]	0.30	2.30	0.88±0.09[b]	202	0.30	3.10	1.11±0.03
TDR Number	13	15	12.88±0.23[a]	12	14	13.33±0.67[a]	55	13	15	12.9±0.27
POR Number	3	6	4.17±0.07[a]	4	5	4.67±0.33[a]	55	3	6	4.20±0.05

TDR = Total dorsal rostrum; POR = Post orbital rostrum; Min. = Minimum; Max. = Maximum; N = Number; S.E = Standard error

Table 4: Morphometric ratios of *Macrobrachium* species in the Lower Taylor Creek

Ratio					
		CL: TL	*PL: *cL	*PL: *CL[1]	*DL: *PL
M. felicinum	M	1:4.01	1:1.92	1:1.07	1:1.08
	F	1:4.20	1:1.83	1:1.58	1:1.17
M. macrobrachium	M	1:4.61	1:1.67	1:1.92	1:1.45
	F	1:4.56	1:1.70	1:1.79	1:1.42
M. vollenhovenii	M	1:3.89	1:1.87	1:0.76	1:1.13
	F	1:4.01	1:1.88	1:0.97	1:1.14

TL = Total length; CL = Carapace length; *cL = Chela length; *PL = Palm length; *CL[1] = Carpus length; *DL = Dactyl length; *Second cheliped

Table 5: Total length–Weight relationships and related statistics of *Macrobrachium* species in the Lower Taylor Creek

Species	Sex	N	a	b ± S.E	r	r^2	Growth Pattern
M. felicinum	M	132	0.009	3.23±0.09	0.96	0.92***	+
	F	726	0.010	2.12±0.05	0.86	0.75***	-
	C	858	0.010	3.15±0.04	0.95	0.90***	+
M. macrobrachion	M	36	0.014	2.71±0.20	0.92	0.84***	-
	F	61	0.011	2.96±0.06	0.99	0.98***	I
	C	97	0.012	2.90±0.09	0.96	0.92***	I
M. vollenhovenii	M	246	0.007	3.29±0.03	0.99	0.98***	+
	F	94	0.007	3.25±0.05	0.99	0.98***	+
	C	340	0.007	3.30±0.03	0.99	0.98***	+

M: Male; F: Female; C: Combined sex; N: sample size; a: intercept; b: slope; r: Coefficient of correlation; r^2: Coefficient of determination; ***P < 0.001; + Positive allometric; - Negative allometric growth; I Isometric growth

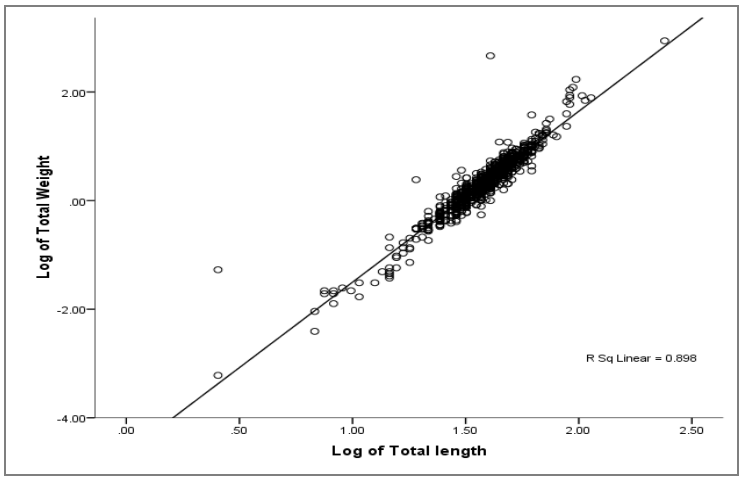

Fig 2: Plot of Length–weight relationship of *M. felicinum* in the Lower Taylor Creek

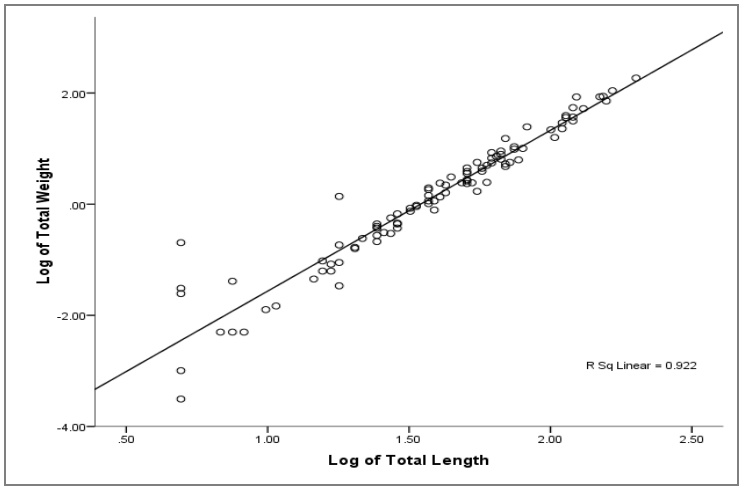

Fig 3: Plot of Length–weight relationship of *M. macrobrachion* in the Lower Taylor Creek

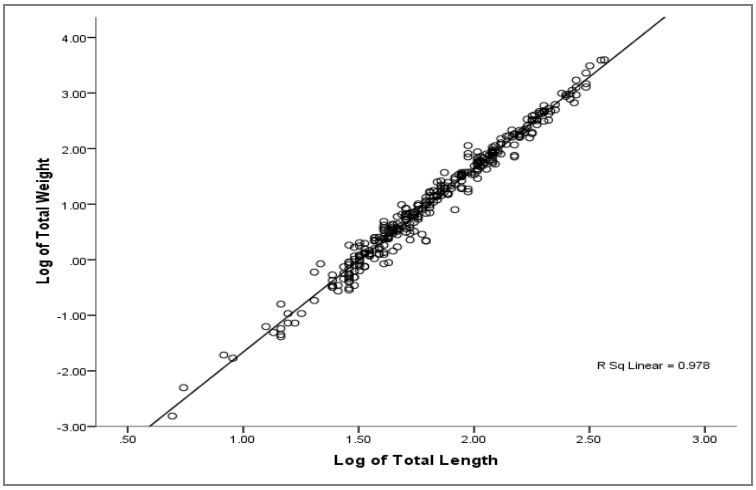

Fig 4: Plot of Length–weight relationship of *M. vollenhovenii* in the Lower Taylor Creek

3.3 Condition factor

Generally, the condition factor of *M. felicinum* ranged from 0.70-11.52, with a mean of 1.23±0.02. The mean condition factor for *M. vollenhovenii* was 1.26±0.01, while it ranged between 0.38 and 6.25 for *M. macrobrachion*, with a mean of 1.06±0.06. The mean monthly K values of *Macrobrachium* species for the two years are shown in Fig. 5. The mean monthly condition factor for *M. felicinum* varied significantly (P<0.05) from 0.97±0.20 (June 2009) to 2.97±0.16 (July 2009), while that of *M. vollenhovenii* ranged from 1.05±0.04 (June 2008) to 1.55±0.08 (October 2009). Condition factor for *M. macrobrachion* ranged from 0.83±0.13 in July 2009 to 2.12±0.10 in August 2008. Seasonally, condition factor was significantly (P<0.001) different between dry and wet seasons in *M. vollenhovenii*. However, there was no seasonal difference (P>0.05) in both *M. felicinum* and *M. macrobrachion* (Fig. 6).

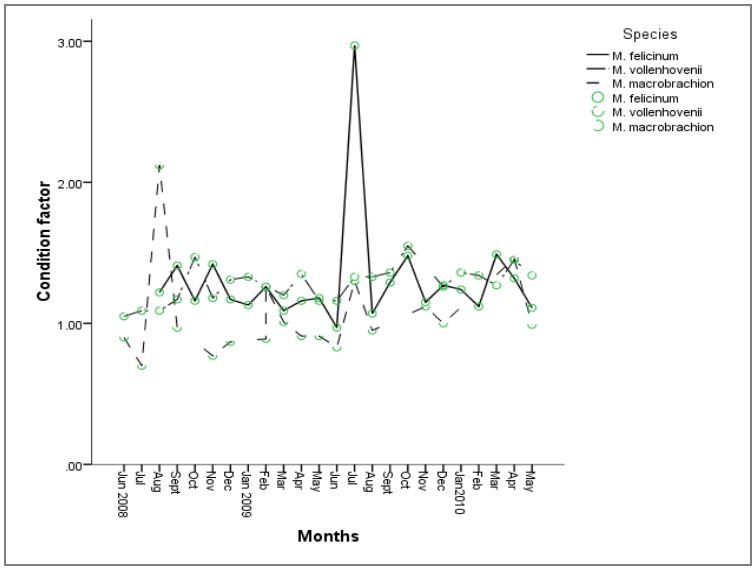

Fig 5: Condition factor of *Macrobrachium* species in the Lower Taylor Creek

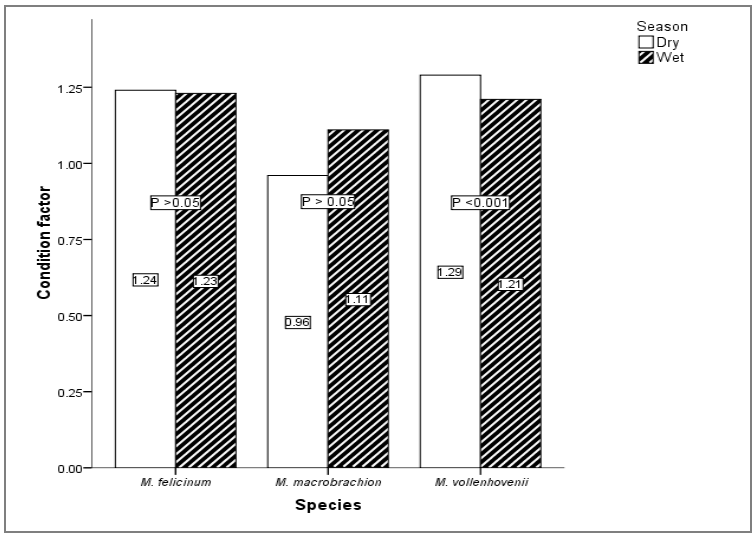

Fig 6: Seasonal Condition factor of *Macrobrachium* species in the Lower Taylor Creek

There were very high significant differences (P<0.001) in the condition factor of the various sizes of the *Macrobrachium* species in the Lower Taylor Creek (Table 6). The smallest size class (1-2 cm) in *M. felicinum* and *M. macrobrachion* had the best conditions while the largest size class (12-13 cm) had the best condition in *M. vollenhovenii*. There was no correlation (r=0.04; P>0.05) between condition factor and total length in *M. felicinum*. However, there was positive correlation (r=0.51;

P<0.001) and negative relationship (r=-0.21; P<0.05) between condition factor and total length for *M. vollenhovenii* and *M. macrobrachion* respectively.

Condition factor was very highly significantly (P<0.001) different between male and female in *M. vollenhovenii*, but no difference (P>0.05) was observed between the sexes in *M. felicinum* and *M. macrobrachion* (Fig. 7).

Table 6: Mean Condition factor (±S.E) of various size classes of *Macrobrachium* species in the Lower Taylor Creek

Class size (cm)				Species		
	N	*M. felicinum*	N	*M. macrobrachion*	N	*M. vollenhovenii*
1 – 2	2	4.74 ± 3.56[a]	6	3.13 ± 0.13[a]	-	-
2 – 3	12	1.00 ± 0.12[c]	9	0.96 ± 0.12[b]	5	1.01 ± 0.08[e]
3 – 4	77	1.19 ± 0.06[c]	20	0.93 ± 0.08[b]	17	0.99 ± 0.05[e]
4 – 5	446	1.19 ± 0.05[c]	20	0.96 ± 0.07[b]	75	1.12 ± 0.03[de]
5 – 6	287	1.25 ± 0.06[c]	2	0.96 ± 0.07[b]	69	1.17 ± 0.03[cd]
6 – 7	27	1.31 ± 0.09[c]	13	1.00 ± 0.09[b]	51	1.30 ± 0.03[bc]
7 – 8	9	1.94 ± 0.15[b]	17	0.96 ± 0.10[b]	50	1.36 ± 0.03[bc]
8 – 9	-	-	5	1.05 ± 0.13[b]	25	1.32 ± 0.04[bc]
9 – 10	-	-	5	0.98 ± 0.20[b]	27	1.40 ± 0.04[b]
10 – 11	-	-	-	-	9	1.37 ± 0.06[b]
11 – 12	-	-	-	-	10	1.39 ± 0.06[b]
12 – 13	-	-	-	-	3	1.75±0.11[a]

Different letters in the same columns indicate significant differences at P < 0.05; N = Number of specimens used for analysis; S.E = Standard error

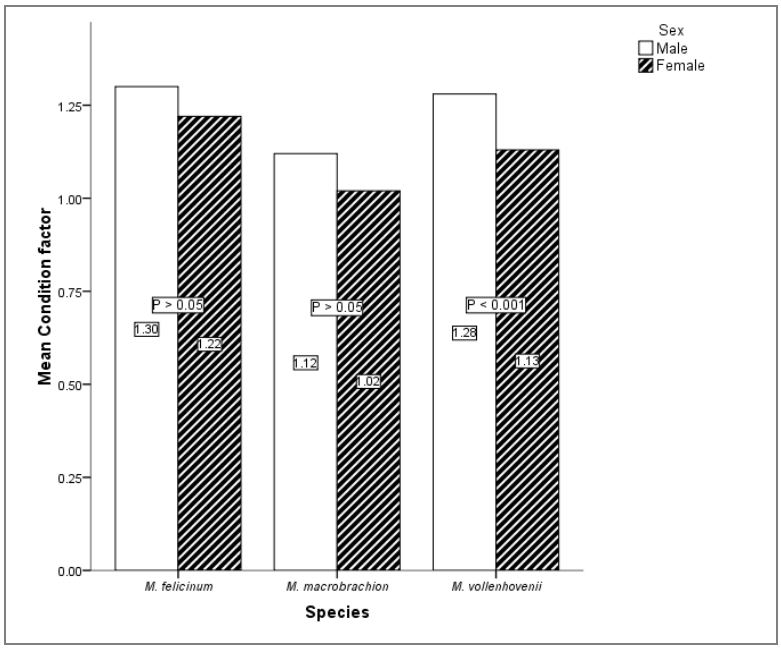

Fig 7: Condition factor of Male and female *Macrobrachium* species in the Lower Taylor Creek

4. Discussion

4.1 Morphometric and meristic characteristics

The largest specimen of *M. felicinum* seen was 7.80 cm. [3] had reported that it rarely exceeded 80 mm, although, [16] had reported a maximum size of 9.20 cm from Lagos and Ondo States' waters. However, the mean length and weight of *M. felicinum* in this study is far lower than what [16] reported. There was sexual dimorphism in the weights, as the females were significantly (P < 0.01) heavier than the males.

There was sexual dimorphism in the sizes of both *M. vollenhovenii* and *M. macrobrachion.* In *M vollenhovenii*, males were longer while females were larger in *M. macrobrachion*. According to [17], *M. vollenhovenii* attains a maximum total length of 182 mm. But in this study, the maximum size observed was 13 cm in a male specimen. The mean length was 6.56±0.12 cm; lower than those reported by [16, 17, 19].

The sizes of *M. macrobrachion* observed in this study were also lower than those reported by [20] in Badagry Creek and [18] in the Lagos Lagoon. [21] had reported that *M. macrobrachion* rarely exceed 120 mm, although a prawn of 138mm had been caught in Lagos Lagoon.

The 12–15 dorsal rostral spines and 3–5 postorbital spines counted for *M. felicinum* are close to the 14–17 and 3–5 respectively reported by [3] in the rostral formula for it. The total number of dorsal spines (9–11) observed for *M. macrobrachion* is similar to the 7–11 observed for the morphotype II of *M. macrobrachion* in the Badagry Creek [20]. The two postorbital teeth observed also agree with the diagnosis of the *M. macrobrachion* by [3] in his monumental compendium on shrimp of economic importance in the Niger Delta. [22] had used the presence of dissimilar chelae in separating sexes of *M. felicinum*. However, in this study, both sexes were observed to exhibit dissimilar chelae in several specimens, even in berried shrimps. The possibility of sequential (or protandric) harmaphroditism may not be ruled out in *M. felicinum.* Protandric hermaphroditism is phenomenon found in the Pandalid shrimp; they reproduce first as males and later change into females and spawn as such for the rest of their lives [23].

The high and significant correlations between total length and carapace length in all the species indicate that either of the variables is suitable for establishing Length–Weight relationships (LWR).

4.2 Length – Weight relationship

The positive allometric growth observed for *M. felicinum* here is different from the isometric growth reported by [24] in the Mu River, Makurdi and the negative allometric growth observed by [25] in the Badagry Creek, Lagos. The implication is that *M. felicinum* gets plumper as it grows larger [26]. The isometric growth observed in this study for *M. macrobrachion* is contrary to the positive allometry reported by [5] in the Cross River estuary and [27] in Luubara Creek and the negative allometric growth observed in the Badagry Creek, Lagos [25] for the species. The results here therefore show that *M. macrobrachion* does not change shape as it grows larger.

The "b" values observed for *M. vollenhovenii* in this study were higher than that reported by [28] in the Lagos–Lekki Lagoon system. Although, a negative allometric growth had been reported for male *M. vollenhovenii* [28] and pooled specimens of *M. vollenhovenii* [19], a positive allometric growth pattern was observed in this study, similar to the growth reported for female *M. vollenhovenii* in Lagos–Lekki system [29] and the Badagry Creek [25] indicating that *M. vollenhovenii* gets plumper as it grows larger.

4.3 Condition factor

The condition factor of *M. felicinum* in this study was lower than 2.031 reported for the same species in Mu River, Makurdi [24]. The condition factor of 1.06 for *M. macrobrachion* is close to the 1.13 reported for it in the Cross River Estuary [5], but far higher than those (<0.001) reported by [27] in Luubara Creek in Ogoni and the Badagry Creek in Lagos [25]. Among the three species studied, *M. macrobrachion* had the least condition factor, while *M. vollenhovenii* had the best condition throughout the study period. The differences in condition factors of the species may be attributed to the fact that *M. felicinum* and *M. vollenhovenii* are more important in non–tidal freshwater zones of white water than *M. macrobrachion* and would thrive better than *M. macrobrachion* in this environment. White water has described by [3] as river waters that have high conductivity values (above 40 micro Siemens per centimeter). *M. macrobrachion* is found more in the brackish water environment.

5. Conclusion

There was sexual dimorphism in the sizes of *M. vollenhovenii* and *M. macrobrachion* in the Lower Taylor Creek. The length–weight shows *M. felicinum* and *M. vollenhovenii* get plumper as they grow longer while *M. macrobrachion* does not change shape as it grows. *M. vollenhovenii* had the best condition throughout the study period.

6. Refresnces

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