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Population Parameters of *Macrobrachium vollenhovenii* in the Lagos-Lekki Lagoon System, Nigeria

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Abstract: The population parameters of *Macrobrachium vollenhovenii* (African river prawn) in the Lagos-Lekki lagoon system was estimated using a-24 month (May 2002 to April 2004) length-frequency data. The population parameters of growth; mortality and exploitation rates were, asymptotic length (L_8) = 18.81 cm, growth coefficient (K) = 0.550, goodness of fit (Rn) = 0.195; total mortality (Z) = 2.67 year^{-1}, natural Mortality (M) = 1.35 year^{-1} Fishing mortality (F) = 1.32 year^{-1} and Exploitation rate (E) = 0.49, respectively. Recruitment pulse exhibited two peaks, one major peak and a minor peak which were in September to November and also in February. Length at first capture L_c as obtained from probability of capture analysis of the length-converted catch curve were 3.12 and 3.22 cm by logistic transformation and running average routines. The exploitation of this resource in the Lagos-Lekki lagoon system at the estimated F is almost at optium level as indicated by the E, as such this exploitation level should be maintained for sustainability.

Key words: Population parameters, *Macrobrachium vollenhovenii*, lagoon, Nigeria

INTRODUCTION

The Lagos-Lekki lagoon system is a clearly defined coastal lagoon system in Nigeria comprising of the Lagos, Epe and Lekki lagoons (Fig. 1). It is the largest of the lagoon systems in the West African sub-region and has supported decades of small scale fisheries. *Macrobrachium vollenhovenii* (African river prawn) is an important species in the artisanal shrimp fishery in this coastal lagoon system.

Lagos and its environment has witnessed a high level of development which has resulted in massive sand filling of the lagoons that has impacted greatly on the lagoon resources and the shrimp resource is no exception. The sand filling changes the ecological regimes of the lagoon ecosystem both in terms of the physical structure and physico-chemical parameters, which invariably result in changes in the fishery resources. The domino effect of these large scale developmental activities is borne mainly by the artisanal fisherfolks whose livelihood is hinged on the lagoonal resources. In light of this situation, there is dire need for the resources to be managed sustainably.

Population dynamics of fishes are studied with the major objective of rational management and conservation of the resource (Nassar, 1999). Effective management and conservation of any fishery resource requires considerable knowledge regarding population parameters such as growth, age, recruitment pattern, mortality and exploitation level of the exploited stock. Estimates of these population parameters are lacking for *Macrobrachium vollenhovenii* in the Lagos-Lekki lagoon system. This study was therefore, carried out to provide the requisite parameters for informed scientific basis of managing the Lagos-Lekki lagoon *Macrobrachium vollenhovenii* stock.

MATERIALS AND METHODS

The monthly length-frequency samples analyzed in this study were collected from (18) stations on the Lagos-Lekki lagoon system, longitude 3°22.5’ to 4°13’ E and latitude 6°24’ to 6°38’N (Fig. 1) by the artisanal shrimping gear. The gear consists of a conical shaped cane trap of 44-47 cm in length and a mouth opening of 17-19 cm in diameter. The sampling period was from April 2002 to May 2004. Total Length (TL), from the orbital notch to the tip of the telson, of individual specimen was recorded. These measurements were made to the nearest centimetre (cm).

The analysis of data was done using the routines in FiSAT (Gayanilo *et al*., 1996). Preliminary estimates of the Von Berthalanffy Growth Formula (VBGF) parameters.

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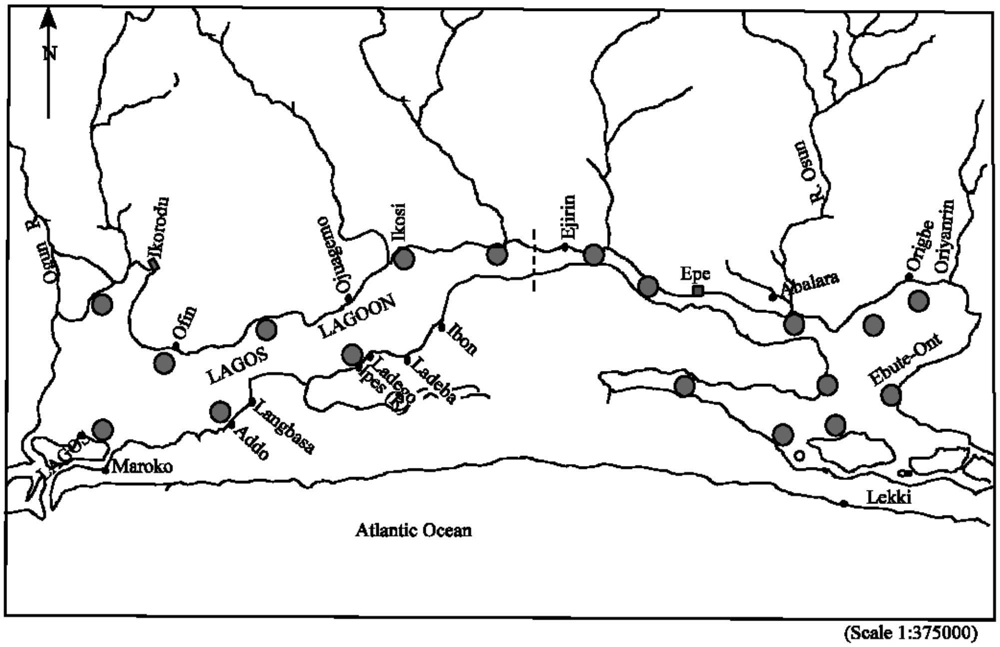

Fig. 1: Study area (Lagos-Lekki lagoon system) with sampling sites

L8 and Z/K were obtained through the Powell-Wetherall Plot (Pauly, 1986; Wetherall, 1986). Final growth estimates were obtained using the ELEFAN I routine (Pauly and David, 1981). Estimates of mortalities were derived from the linearized length-converted catch curve routine. Natural Mortality (M) was derived through the empirical equation of Pauly (1980); mean annual habitat temperature used was 27°C. Estimates of length-at-first-capture (L_c or L_{50}) were derived from probabilities of capture generated from the catch curve analysis. The annual recruitment pattern was produced following Moreau and Cuende (1991), through reserve projection of the restructured data onto the time axis. The Explotation rate (E) was obtained by dividing F by Z (Beverton and Holt, 1956; Pauly, 1984; Pauly and Soriano, 1986).

RESULTS

The monthly length frequency data for 24 months (May 2002-April 2004) of *Macrobrachium vollenhovenii* is presented in Table 1.

Analysis of the length frequency data by the Powell-Wetherall routine gave a value of the VBGF parameter L8 (asymptotic length) to be 18.81 cm total length for *M. vollenhovenii* as shown in Fig. 2a and b. The pseudo-catch curve identifies the age group fully recruited to the fishery and size (age) not affected by gear selection. Black Points to the right were selected for use in fitting the Powell-Wetherall regression plot. The regression equation for the Powell-Wetherall Plot is: Y = 3.33 + (-0.177) * X, r = -0.992, L (mean) is the mean length from L' upwards = 9 cm, L' is the cut off length = 1.72 cm, Estimated L8 = 18.81 cm, Z/K = 4.650.

The original and restructured length frequency data superimposed with estimated growth curve are shown in Fig. 3a and b. The growth coefficient or curvature parameter K obtained by the ELEFAN routine through the Scan of K was 0.570 and L8 of 17.32 cm with a goodness of fit (Rn) of 0.194 by automatic computer generation.

The growth curve starting sample was 11 while the starting length was 8.00 cm. The K value by seeding the Powell-Wetherall L8 of 18.81 cm was 0.550 with a goodness of fit Rn of 0.195. The seeded growth curve starting sample was 6 and starting length 5.50 cm. The seeded values were adopted for subsequent analysis as it has a higher Rn value, since the higher the Rn value the better the fit of the curve. Moreover, the curve starting sample was 6 as against 11 for the automatic computer generated L8. The growth performance index (ø') was also higher with the seeded value compared with the automatic computer generated values.

The total mortality (Z) was estimated at 2.67 $year^{-1}$, natural Mortality (M) was 1.35 $year^{-1}$, Fishing mortality (F) was 1.32 $year^{-1}$and an exploitation rate E (F/Z) of 0.49 (Fig. 4).

Table 1: Length-frequency data of *M. vollenhovenii* from Lagos-Lekki lagoon system (May 2002-April 2004)

	2002								2003												2004			
ML	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2.5						4													5			3		
3.5					10	8						12						1	8			7	2	
4.5			7		39	20	42	32	19		12	30		5				14		27	3	26	7	
5.5	6	11	16		53	36	66	96	38	12	7	38	77	10	25	8	6	7	20	82	7	30	12	4
6.5	9	27	35	21	64	45	98	193	53	28	30	74	98	96	31	18	44	12	26	104	27	14	21	8
7.5	25	102	84	53	74	85	102	284	78	57	70	92	54	232	75	28	63	29	34	143	39	9	23	26
8.5	7	153	121	122	92	103	130	180	86	77	98	50	37	185	178	87	90	55	47	168	14	4	37	44
9.5	14	94	306	87	76	212	174	82	26	35	61	23	26	111	325	41	48	80	60	99	8		15	23
10.5	5	72	100	41	47	81	116	64	10	19	18	12	19	102	117	21	25	103	111	67	3		2	3
11.5		50	90	22	23	52	73	25	4		5			83	64	14	15	148	38	51	1		1	
12.5		15	49	26	14	35	58					6		37	49	12	10	110	22	36				
13.5			23		8	23	35	7						15	26	9	7	62	19					
14.5					5		12							6	16	7	5	47	13					
15.5		2					7	2			2			3		4	2	9	3					
16.6					3											2	1							
Total	66	526	831	372	508	704	913	965	314	228	301	307	353	880	911	251	316	668	419	777	102	93	120	108

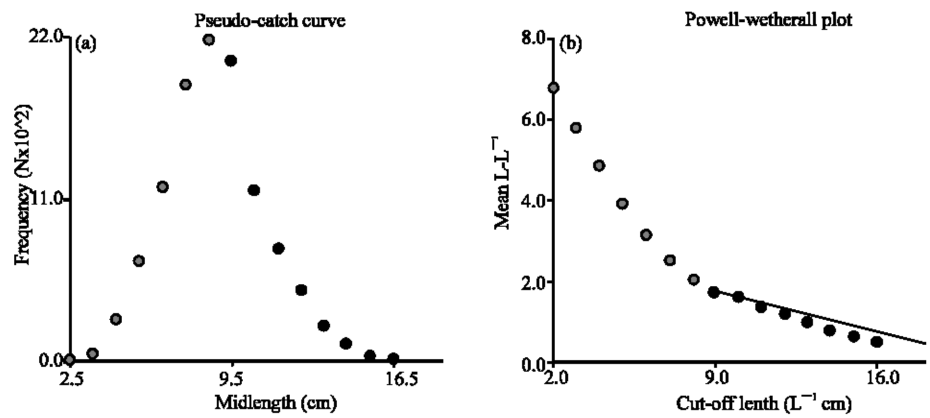

Fig. 2: Pseudo-Catch Curve and Powell-Wetherall Plot Original length frequency data pooled and the frequency plotted against mid-length of class interval

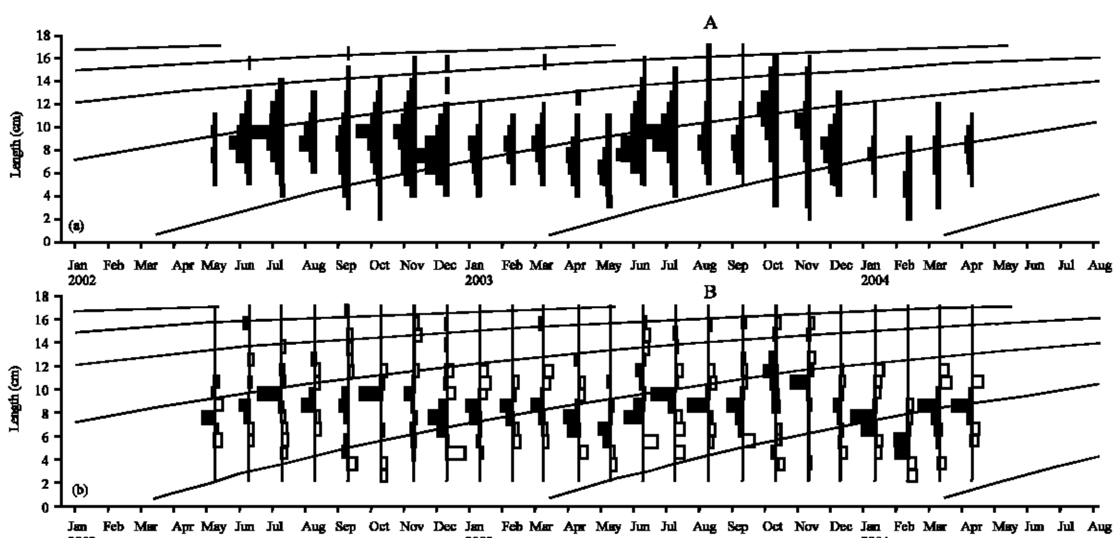

Fig. 3: Length-Frequency for *Macrobrachiumvollenhovenii* with growth curve super imposed (A) Original and (B) Restructured

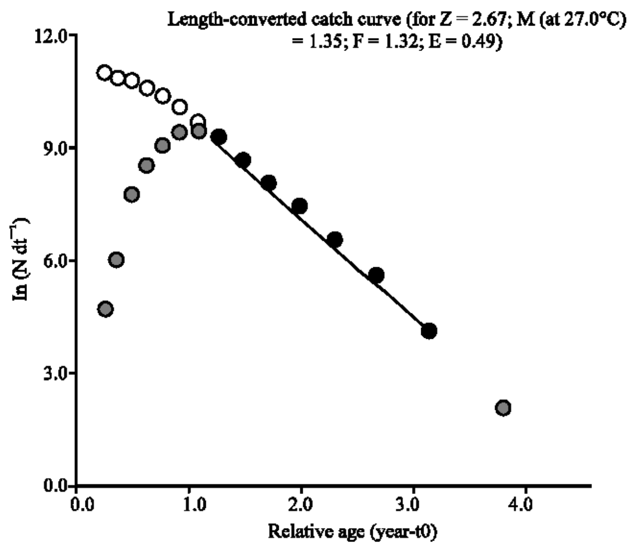

Fig. 4: Length-converted catch curve with extrapolated data points of the right descending side of the catch curve, the shrimp that ought to have been caught (had it not been for the effect of incomplete selection/recruitment) are added to the curve, with the ratio of "expected" numbers to those that are actually caught being used to estimate probabilities of capture. This provides the estimate of mean size at first capture (L_c)

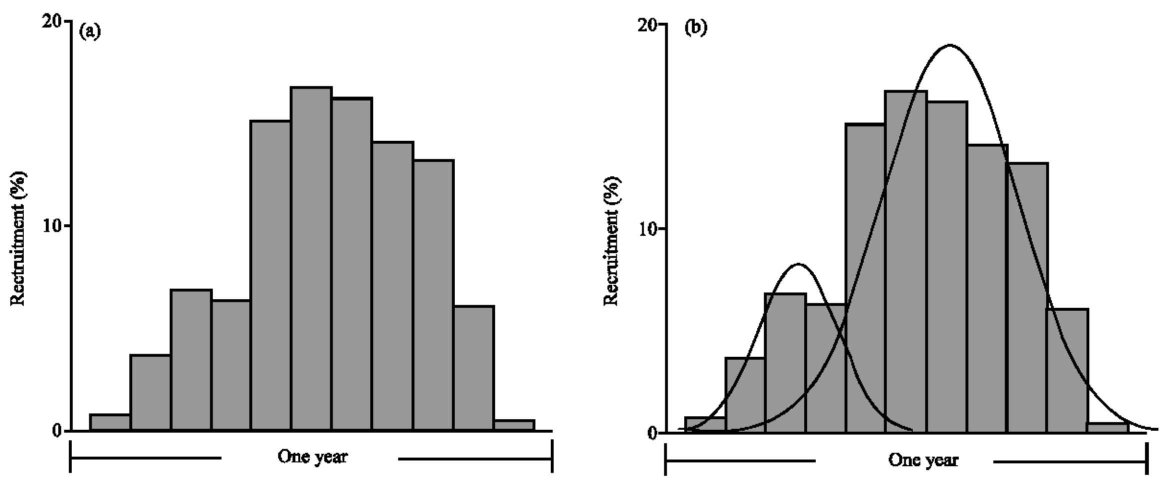

Fig. 5: (A) Backward projection, along a trajectory defined by the VBGF, of the restructured length frequency data onto an arbitrary one-year timescale for *M. vollenhovenii*. The months on the X axis cannot be located exactly (hence the abscissa is an arbitrary year) because of the location parameter (t_0) of the VBGF. (B). Recruitment pattern decomposed into pulses exhibiting two peaks of unequal pulse strength for *M. vollenhovenii*. The pattern was decomposed using NORMSEP and fitted with two Guassian distributions

Table 2: Estimate of length at first capture using both the Logits and Running Average Routines for M. vollenhovenii

Routine	L_{25} (cm)	L_{50} or L_c (cm)	L_{75} (cm)
Logits	1.39	3.12	4.84
Running average	2.08	3.22	5.02

Recruitment pulses were reconstructed from the time series of length frequency data to determine the number of pulses per year and the relative strength of each pulse. Figure 5a show the backward projection, along a trajectory defined by VBGF for *M. vollenhovenii* and Fig. 5b is the recruitment pattern decomposed into pulses. *M. vollenhovenii* from the Lagos lagoon exhibit two peaks of unequal pulse strength.

DISCUSSION

Population dynamics of fishes are studied with the major objective of rational management and conservation of the resource (Nassar, 1999). Effective management and conservation of any fishery resource requires considerable knowledge regarding population parameters such as growth, age, recruitment pattern, mortalities and exploitation level of the stock. Length-frequency data analysis is a reliable way of obtaining shrimp population and fisheries parameters. Reliable growth and other population parameters estimate are dependent on length-frequency data suitability. Pauly (1987) provides on an increasing scale of 0-5, a total sample size of 1,500 and a six-month period as minimum for data suitability. This study met these criteria with a sample size of 11,033 gathered over a period of 24 months.

The VBGF parameter L8 is a major parameter in evaluating the status of the population. L8 for *M. vollenhovenii* for the Lagos-Lekki lagoon system was 18.81 cm and this is very close to 18.0 cm obtained by Etim and Sankare (1998) from Fahe reservoir in Cote d'Ivoire, higher than 16.4 cm obtained by Gabche and Hockey (1995) from Lobe River in Cameroun but lower than 21.36 and 19.90 cm obtained for male and female of the species from Cross River estuary, Nigeria by Nwosu and Wolfi (2006). These differences could be due to the different ecological peculiarities of stocks or population habitat's environment. The growth performance index (ø') however helps to overcome this problem as it allows inter and intra specific comparison of growth performance of fish and shrimp species of different stocks. The ø' for *M. vollenhovenii* was 2.50 which was slightly higher than what was obtained by Etim and Sankare (1998), 2.48 in Fahe reservoir but lower than Nwosu and Wolfi (2006), 2.75 and 2.69 for male and female in the Cross River estuary and Gabche and Hockey (1995), 2.93 from Lobe River. The curvature parameter K value of 0.550 in this study fell within the range estimated for various stocks of penaeid shrimp species of between 0.39 and 1.6 (Pauly *et al*., 1984). The growth curve goodness-of-fit (Rn) of 0.195 in this study is close to the value obtained by Nwosu and Wolfi (2006) Rn = 0.199 for male and 0.183 for female but lower than Etim and Sankare (1998) value of 0.447.

Recruitment has been described as a year round phenomenon for tropical fish and shrimps species (Qasim, 1973; Weber, 1976). The *M. vollenhovenii* stock exhibited two recruitment peaks, which is at variance with the concept of continuous recruitment phenomenon of Qasim (1973) and Weber (1976), however it conforms with Pauly (1982) assertion of double recruitment pulses per year for tropical fish species and for short-lived species. The presence of one major peak and one minor peak (Fig. 5b) probably earlier in the year appears similar to the patterns observed for *Penaeus notialis* off Cote d'Ivoire (Garcia and Le Reste, 1981), *Penaeus duoraum* from Tortugas, Florida (Pauly *et al*., 1984), *Nematopalaemon hastatus* off the Southeast coast of Nigeria (Enin *et al*., 1996) and for *M. vollenhovenii* from Cross River estuary (Nwosu and Wolfi, 2006).

Due to the inability to calculate the parameter t_0 of the von Bertalanffy growth model using length-frequency data alone (Pauly, 1987), the absolute position of the recruitment peak (period of high juvenile-specimens of = 4.5 cm-preponderance) in terms of month of year could not be calculated. However, the position of the peak can be inferred approximately by examining the length frequency data used. The peaks of the smaller sized shrimp for *M. vollenhovenii* were noted in September to November and February. Etim and Sankare (2006) observed this same period (September-November) for this species, however while there was only one peak of recruitment in Fahe reservoir, there was another peak (February) in the Lagos-Lekki lagoon system.

Shrimps are short lived animals and as short lived animals high mortality rates are usually imperative. The Z estimated here, 2.67 $year^{-1}$ falls within the range of 2.46-7.07 $year^{-1}$ estimated by Pauly *et al.* (1984), for several stocks and species of penaeid shrimps. The estimated Z 2.67 $year^{-1}$ in this study is close to 3.69 $year^{-1}$ obtained in Fahe Reservoir, Cote d'Ivoire by Etim and Sankare (1998), 3.41 $year^{-1}$ by Gabche and Hockey (1995) in Lobe River, Cameroun and male (3.93 $year^{-1}$) of the species but far from the female (6.85 $year^{-1}$) by Nwosu and Wolfi (2006) in the Cross River, Nigeria The M obtained by the Pauly's empirical formula was 1.35 $year^{-1}$ while F was 1.32 $year^{-1}$. The M in this study is within the range of 0.77-3.12 estimated for penaeid shrimps (Pauly *et al*., 1984). The F of 1.32 $year^{-1}$ in this study compares well with 0.55-4.68 $year^{-1}$ by Pauly *et al.* (1984), as well as with values of 4.72 $year^{-1}$ by Mathews *et al.* (1987). The E at this estimated fishing mortality was 0.49. Based on the assumption that in an optimally exploited stock, natural mortalities should be equal to fishing mortality and both values or E be equal to 0.5 (Gulland, 1971), the *Macrobrachium vollenhovenii* stock of the Lagos-Lekki lagoon system is not over fished.

Probability of capture analysis by extrapolation of the length-converted catch curve provide reasonable estimates of mean size at first capture L_c (Jensen 1982; Hoydal *et al*., 1982; Anon, 1982). L_c for *M. vollenhovenii* were 3.12 and 3.22 cm using the logistic transformation and the running average methods, respectively. The logistic curve assumes selection is symmetrical or nearly so while the running or moving average smoothen the data sets by interpolating the selection parameters. The L_c obtained in this study was close to 3.5 cm estimated for the male of the species from the Cross River estuary. The L_c is a very vital parameter that should be considered in the management of fisheries resource when used along with length at first maturity as it's an indication of the health status of the resource.

CONCLUSION

Population parameters obtained from length frequency data are very vital tools in the management of a fishery resource. The population parameters obtained from the *M. vollenhovenii* resources of the Lagos-Lekki lagoon system confirmed this fact. The L_c of *M. vollenhovenii* of 3.12 and 3.22cm. The smallest size susceptible to the exploitation method are juvenile.From the management point of view, this is not a health trend for the resource and as such calls for a management strategy that will allow the escape of such sizes from the gear used in the resource exploitation. Recruitment phenomenon on which the biomass of the stock is hinged, exhibited two pluses that peaked in September-November and February. The use of gear precluding immature sizes in this period would ensure sustainabilty. The E is close to the optimum, as such this exploitation level should be maintained for sustainability.

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