



## Growth and mortality of the rough river prawn *Macrobrachium equidens* Dana, 1852 (Crustacea, Palaemonidae) in Cross River Estuary, Southeast Nigeria

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### Abstract

Population parameters are necessary in order to understand the health of any fishery to determine appropriate management measures. The prawn *Macrobrachium equidens* is an important component of the artisanal *Macrobrachium* fishery of the Cross River Estuary, contributing about 3.8 and 2.9% by number and weight, respectively, to the total catch of the multi-species *Macrobrachium* fishery of the area. Growth and mortality parameters of this prawn *Macrobrachium equidens* was studied from length-frequency data using ELEFAN Programme of FAO-ICLARM Stock Assessment Tools (FiSAT), and the following results were obtained: asymptotic length ( $L_{\infty}$ ) = 107.12 mm, growth constant  $K = 1.25/\text{year}$ , oscillation constant  $C = 1$ , Winter Point  $WP = 0.35$ , total mortality ( $Z$ ) = 4.97/year, natural mortality ( $M$ ) = 2.69/year, fishing mortality ( $F$ ) = 2.28/year and exploitation rate ( $E$ ) = 0.46. The fishery is on the verge of over-exploitation. Regulatory management measure to improve the contributions of this fishery to the overall prawn landing in the area is imperative. The most realizable management option is the closed period, during the reproductive season. This implies periodic closures at two alternate moon phases during the peak of reproductive activities. This option eliminates the contentious closure of the fishery during the most 'lucrative fishing season'. The fisherfolk will easily adopt these short closure periods and cooperate to ensure sustainable management.

**Key words:** Growth, mortality, prawn, *Macrobrachium*, Palaemonidae, management, biodiversity, conservation, estuary, Nigeria.

### Introduction

Studies of the prawn genus *Macrobrachium* in the tropical and subtropical regions of the world range from biology -life history, reproduction and behaviour - to assessment of its fisheries and aquaculture potentials. In the Cross River Estuary and other parts of Nigeria, such studies have been carried out for some species of this genus, e.g., *M. macrobrachion* and *M. vollehovenii*<sup>1-3</sup>. However, population parameters, reproductive biology and fishery of the species *M. equidens* are scanty for this study area. Some aspects of reproductive biology of this species have been studied in Mangalore, India<sup>4</sup>. This species common to the Indo-Pacific region was first reported in Atlantic waters by Powell<sup>5,6</sup>, who also called for further studies, especially population dynamics of the species. No separate fishery currently exists for the species, but it is caught alongside other members of the genus in the area, and contributes about 3.8 and 2.9% by number and weight, respectively, to the total catch of the multi-species *Macrobrachium* fishery of the Cross River Estuary. *Macrobrachium equidens* reproduces year round, but the peak of reproductive activity, which also corresponds to period of highest catch for the fishery, is May to November<sup>7</sup>. The *Macrobrachium* species are cheap but rich protein sources to coastal communities on the range of the Nigerian coastline. Even in metropolitan Calabar and Lagos, the species are sold and consumed fresh as special delicacies. It is considered a cheap protein source because small quantities are sold at affordable prices to locals. The present study is to estimate its population parameters in order to assess the overall state of the species in the fishery, especially as regards management and biodiversity conservation.

### Experimental

Prawn samples for the length-frequency data were obtained from the artisanal commercial prawn fishermen at a landing site on the coast of Calabar (Fig. 1). Samples were collected weekly from February 2003 to June 2004. All weekly samples were later pooled into monthly data prior to length-frequency analysis.

Analysis for the population parameters were carried out using the FAO-ICLARM Stock Assessment Tool (FiSAT) package<sup>8</sup>. This software incorporated the modified form of Von Bertalanffy Growth Function (VBGF)<sup>9-12</sup>, which included the oscillation in growth due to fluctuations in environmental temperature, thus:

$$L_t = L_{\infty} (1 - \exp^{-K \{ (t-t_0) + (CK/2\pi) \sin [2\pi(t-t_0)] \}}) \quad 1)$$

where  $L_t$  is mean length at age (time)  $t$ ,  $L_{\infty}$  is asymptotic length, (i.e., the mean length the fish in a population or stock will achieve if it were to grow indefinitely),  $K$  is the growth constant indicating the rate at which  $L_{\infty}$  is approached,  $t_0$  is "age" at zero length,  $C$  is a constant expressing amplitude of seasonal oscillations in growth, and  $t_s$  is phase of the oscillations, indicating onset of oscillations. The ELEFAN I programme of FiSAT first restructured the length-frequency data by calculating a running average over 5 length classes and peaks are identified as those parts that are above the corresponding running averages. Von Bertalanffy growth curves were then traced through length-frequency samples for any arbitrary seed input of  $K$ ,  $L_{\infty}$ ,  $C$  and Winter Point (WP-the period the fish experiences poorest growth).

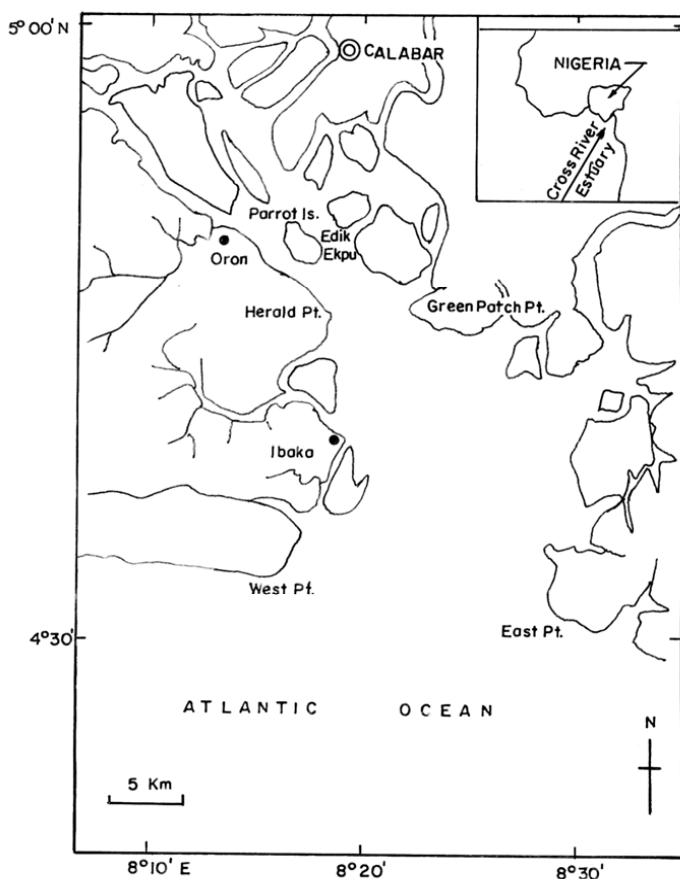


Figure 1. Cross River Estuary, Nigeria, showing the sampling site on the coast of Calabar.

The longevity ( $t_{max}$ ) of the species was then calculated from the relationship by Pauly<sup>13</sup>:

$$t_{max} = 3/K \quad 2)$$

Also, the growth performance index ( $\phi'$ ), the basis for comparison of growth parameters, was computed for this species using the equation<sup>14,15</sup>, thus:

$$\phi' = \log K + 2 \log L_{\infty} \quad 3)$$

The instantaneous rate of total mortality ( $Z$ ) was estimated from the length-converted catch curve analysis method incorporated in FiSAT, with the option accounting for seasonal growth. The catch curves were constructed from the plot of the natural logarithm of the number ( $N$ ) of prawns in various length groups divided by the time needed for an average individual to grow through the length class, against their relative ages ( $t'$ ).

Natural mortality ( $M$ ) was computed from Pauly's empirical formula<sup>16</sup>:

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_{\infty} + 0.6543 \log_{10} K + 0.463 \log_{10} T \quad 4)$$

where  $L_{\infty}$  is asymptotic total length (cm),  $K$  is growth constant,  $M$  is natural mortality and  $T$  is annual mean habitat temperature ( $^{\circ}C$ ) of the water in which the stock lives. In this case, the ambient water temperature of the study area was  $26.7^{\circ}C$ <sup>17</sup>. Then, fishing mortality ( $F$ ) was computed from the relation  $F = Z - M$ , while the exploitation rate ( $E$ ) was obtained from  $E = F/Z$ .

### Results

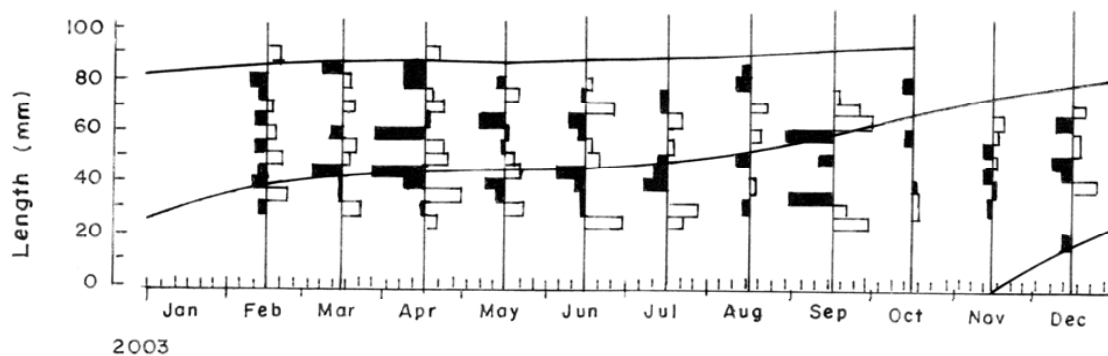
The length-frequency data for this species is presented in Table 1 and the restructured form of the table using ELEFAN I is presented in Fig. 2. The population parameters obtained from the routine analysis are as follows:  $L_{\infty} = 107.12$  mm,  $K = 1.25$ /year,  $C = 1$ ,  $WP = 0.35$  (May). The longevity ( $t_{max}$ ) (Eq. 2) was 28.8 months, while the growth performance index ( $\phi'$ ) was 2.16. The instantaneous rate of total mortality ( $Z$ ) from the catch curve (Fig. 3) was 4.97/year, natural mortality ( $M$ ) was 2.69, fishing mortality ( $F$ ) was 2.28, and the resultant exploitation rate was 0.46. Table 2 is a comparison of the above results with other *Macrobrachium* species from other studies.

### Discussion

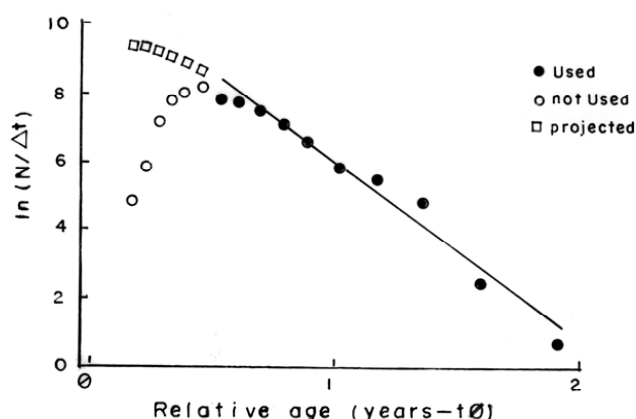
This species, *Macrobrachium equidens* was relatively unknown in Atlantic waters until Powell<sup>5,6</sup> reported its occurrence. The population parameters of the species closely compares with those of *M. macrobrachion*. For instance, Enin<sup>3</sup> obtained  $L_{\infty}$  approximately 13 cm,  $K$  of 1.8/year and  $\phi'$  of 2.48 for *M. macrobrachion*. This compares with  $L_{\infty}$  approximately 11 cm,

Table 1. Length-frequency data for *M. equidens* (constant class interval of 5 mm total length) from the Cross River Estuary, Nigeria.

Mid length	F '03	M	A	M	J	J	A	S	O	N	D	J' 04	F	M	A	M	J
22.5								2			1			1			3
27.5			1		3	2		2				1	2	2	4		18
32.5	2	1	4	8	22	1	12	7	1		1	3	6	4	14	1	44
37.5	1	8	2	26	32	16	13	25	2	5	2	8	10	9	42	9	33
42.5	4	9	12	37	43	30	14	18	4	5	1	12	25	7	20	27	59
47.5	5	15	18	23	58	30	16	20	6	8	6	16	42	5	50	37	48
52.5	3	6	7	33	25	27	18	24	5	6	8	20	15	6	18	14	33
57.5	8	4	7	48	29	14	8	18	7	7	6	17	32	6	26	20	19
62.5	5	6	17	45	23	13	5	26	7	4	6	5	32	6	18	26	11
67.5	10	4	8	70	25	6	3	2	5	2	8	6	14	5	16	17	
72.5	7	2	5	37	5	10	1	3		2	2	3	24	6	8	34	4
77.5	9	2	5	21	9	9		1					6	1	9		3
82.5	8	2	6	26	3		3		1				1	2	2		1
87.5	4	6	5	12			2					1		1			
92.5	1		1												2		1
97.5			1														
Sum	64	65	99	386	277	158	95	148	38	39	41	92	209	61	229	185	277



**Figure 2.** Growth curve of *M. equidens* of the Cross River Estuary ( $L_{\infty} = 107.12$  mm,  $K = 1.25$  year<sup>-1</sup>,  $C = 1$ ,  $WP = 0.35$ ) superimposed on length-frequency data, restructured by ELEFAN I programme.



**Figure 3.** Length – converted catch curve of *M. equidens* of the Cross River Estuary. Estimated  $Z = 4.97$  year<sup>-1</sup>.

of 1.25/year and  $\phi'$  of 2.16 for *M. equidens* in this study, but for a larger species *M. vollenhovenii*, the  $\phi'$  was 2.47,  $L_{\infty} = 18$  cm and  $K = 0.91$ /year<sup>18</sup>. However, the longevity of *M. macrobrachion* (20.1 months) obtained by Enin<sup>3</sup>, differs from 28.8 months for *M. equidens* obtained in this study and 39.6 months obtain for *M. vollenhovenii*<sup>18</sup>. According to Powell<sup>5,6</sup>, previous workers must have confused this species with *M. macrobrachion*, probably due to their close morphological relationship. Also the natural mortality of both *M. equidens* (2.69/year) and *M. macrobrachion* (3.36/year) are both high, indicating that predation and death by other natural processes is high, as against the lower  $M$  (1.97/year) reported for *M. vollenhovenii*<sup>18</sup>. With a temperature difference of 10°C (21°C wet season, 31°C dry season)<sup>17</sup>, the oscillation constant  $C$  obtained in this study indicates strong influence of temperature on the growth of the species<sup>19</sup>. Even a temperature difference of 6°C could result in amplitude of oscillation of 0.6 and 0.9<sup>20</sup>.

**Table 2.** Summary of population parameter obtained for the *Macrobrachium equidens* of the Cross River Estuary, Nigeria and a comparison with other *Macrobrachium* species.

Species	$L_{\infty}$ (TL, mm)	$K$ /year	$C$	WP	$\phi'$	$t_{max}$ (months)	$Z$	$M$	$F$	$E$	Source
<i>M. equidens</i>	107.12	1.25	1.00	0.35 (May)	2.16	28.8	4.97	2.69	2.28	0.46	This study
<i>M. macrobrachion</i>	129.30	1.79	0.50	0.50 (June)	2.48	20.1	10.60	3.36	7.24	0.68	Enin <sup>3</sup>
<i>M. vollenhovenii</i>	180.00	0.91	0.92	0.44 (June)	2.47	39.6	3.69	1.97	1.77	0.47	Etim & Sankara <sup>18</sup>

The Winter Point of 0.35 (May)<sup>21</sup> indicates that growth slows down during this period – corresponding to its peak of reproduction when most of the energy is diverted to gonad development. However, the exploitation rate ( $E = 0.46$ ) indicates that the species is not yet overexploited, unlike the heavily exploited *M. macrobrachion* in the area ( $E = 0.68$ )<sup>3</sup>. Gulland<sup>22</sup> had stated that only exploitation rates greater than 0.5 are indicative of stock overfishing. However, management of the entire fishery, for example, reduction of effort and closure of the fishery at least two weeks during the months of peak reproductive activity, would be necessary to maintain this stock in the biodiversity of the area, as well as help the recovery of the other overfished species. The peak of reproductive activity of this species falls within May and November. Incidentally, this period corresponds to the period of highest catch in the fishery. To achieve successful management, periodic closures during alternate moon phases have been recommended, as against outright seasonal closure, which the fisherfolk deem inimical to their survival.

### Conclusions

This study reveals that this species is not currently overfished, but at the verge of being overfished<sup>22</sup>. The fishery on *Macrobrachium equidens* will be improved with implementation of closed period management options during peak of reproduction. Closure of the fishery periodically is preferred to other options since it could last for shorter periods and will be acceptable to the artisanal fisherfolk who derive livelihood solely on this fishery. In addition, management of this fishery will enhance conservation of the biological diversity of this ecosystem.

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## References

- <sup>1</sup>Marioghae, I. E. 1982. Notes on the biology and distribution of *Macrobrachium vollenhovenii* and *Macrobrachium macrobrachion* in the Lagos lagoon (Crustacea, Decapoda, Palaemonidae). Rev. Zool. Afri. **96**(3):493-508.
- <sup>2</sup>Marioghae, I. E. 1990. Studies on Fishing Methods, Gear and Marketing of *Macrobrachium* in the Lagos area. NIOMR Tech. Pap. 53, 20 p.
- <sup>3</sup>Enin, U. I. 1995. First estimates of growth, mortality and recruitment parameters of *Macrobrachium macrobrachion* Herklots, 1851 in the Cross River Estuary, Nigeria. Dana **11**(1):29-38.
- <sup>4</sup>Murthy, D.K., Rajagopal, K.V., Varghese, T.J. and Udupa, K.S. 1987. Reproductive biology of the freshwater prawn *Macrobrachium equidens* (Dana). Indian Journal of Animal Sciences (India) **57**(9):1026-1034.
- <sup>5</sup>Powell, C. B. 1983. Fresh and brackish water shrimps of economic importance in the Niger Delta. Proceedings of Second Annual Conference of the Fisheries Society of Nigeria, Calabar, pp. 254-285.
- <sup>6</sup>Powell, C. B. 1987. Occurrence of the Indo-Pacific prawn *Macrobrachium equidens* in West Africa (Crustacea, Decapoda, Palaemonidae). Rev. Hydrobiol. Trop. **19**(2):75-79.
- <sup>7</sup>Nwosu, F. M. 2000. Studies on the Biology, Ecology and Fishery Impact on the *Macrobrachium* Species of the Cross River Estuary, Nigeria. PhD thesis, University of Calabar, Nigeria, 224 p.
- <sup>8</sup>Gayaniilo, F. C. Jr. and Pauly, D. (eds) 1997. FAO-ICLARM Stock Assessment Tools (FiSAT). Reference Manual. FAO Computerized Information Series (Fisheries), No. 8, FAO, Rome, 262 p.
- <sup>9</sup>Bertalanffy, L. von 1938. A quantitative theory of organic growth (inquiries in growth laws II). Human Biology **10**:181-213.
- <sup>10</sup>Bertalanffy, L. von 1957. Quantitative laws of metabolism and growth. Quantitative Review Biology **32**:217-231.
- <sup>11</sup>Pauly, D. and Gaschiitz, G. 1979. A simple method for fitting oscillating length growth data, with a program for pocket calculators. ICES Demersal Fish Comm. 1979/G24, 26 p.
- <sup>12</sup>Somers, I. F. 1988. On seasonally growth function. Fishbyte **6**(20):13-14.
- <sup>13</sup>Pauly, D. 1980. A Selection of Simple Methods for the Assessment of Tropical Fish Stocks. FAO Fish. Cir. No. 729, 54 p.
- <sup>14</sup>Munro, J. L. and Pauly, D. 1983. A simple method for comparing the growth of fishes and invertebrates. Fishbyte **1**(1):5-6.
- <sup>15</sup>Pauly, D. and Munro, J. L. 1984. Once more on the comparison of growth in fish and invertebrates. Fishbyte **2**(1):21.
- <sup>16</sup>Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. Int. Expl. Mer. **39**(3):175-192.
- <sup>17</sup>Akpan, E. R. and Offem, J. O. 1993. Seasonal variation in water quality of the Cross River, Nigeria. Rev. Hydrobiol. Trop. **26**(2):95-103.
- <sup>18</sup>Etim, L. and Sankara, Y. 1998. Growth and mortality, recruitment and yield of the freshwater shrimp, *Macrobrachium vollenhovenii* Herklots, 1857 (Crustacea, Palaemonidae) in Fahe Reservoir, Côte d'Ivoire, West Africa. Fish. Res. **38**:211-223.
- <sup>19</sup>Longhurst, A. R. and Pauly, D. 1987. Ecology of Tropical Oceans. Academic Press, San Diego, Calif., 407 p.
- <sup>20</sup>Pauly, D. 1984. Fish Population Dynamics in Tropical Waters: A Manual for Programmable Calculators. ICLARM Study Review No. 8, 325 p.
- <sup>21</sup>Sparre, P. and Venema, S. C. 1992. Introduction to Tropical Fish Stock Assessment. Part I. Manual. FAO Fish. Tech. Pap. No. 306.1, Rev. 1. Rome, 376 p.
- <sup>22</sup>Gulland, J. A. 1971. The Fish Resources of the Ocean. West Byfleet, Surrey, Fishing News Books Ltd., FAO, 255 p.