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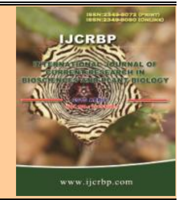


Original Research Article

Aspects of the Population Dynamics of *Nematopalaemon hastatus* (Aurivillius 1898) in River Nun Estuary, Bayelsa State, Niger Delta, Nigeria

S.A. Ngodigha[1], K.J. Alagoa[2]*, J.F. Alfred-Ockiya[3] and J.F.N. Abowei[4]

[1,2]Department of Agricultural Education, Isaac Jasper Boro College of Education, Sagbama, Bayelsa State, Nigeria

[3]Department of Fisheries/Livestock, Niger Delta University, Amassoma, Bayelsa, State. Nigeria

[4]Department of Biological Sciences, Niger Delta University, Amassoma, Bayelsa, State, Nigeria

**Corresponding author.*

A b s t r a c t

Monthly length-frequency data from May 2004 to April 2005 were used to estimate growth, mortalities, recruitment pattern and exploitation rate of *Nematopalaemon hastatus* in the river Nun estuary, Bayelsa State, Niger Delta. Result from the study reveal that Von Bertalanffy growth parameters were estimated as l_∞ = 13.38mm, length, k=1.50 per year, growth parameter index ǿ as 2.43, total mortality (z) was estimated as 3.82 per year and natural mortality (m) 1.01 per year, while fishing mortality was estimated as 2.81 per year. Exploitation rate (e) was estimated as 0.74, indicating heavy fishing pressure on the stock. The recruitment pattern of *Nematopalaemon hastatus* indicates an all year-round recruitment with two peaks. This study therefore concludes that in introducing management strategy for any fishery, it is important to exercise caution because of the uncertainties associated with the analysis of length-frequency data.

K e y w o r d s

Estuary
Exploitation
Growth
Mortality
Nematopalaemon hastatus
Palaemon shrimp

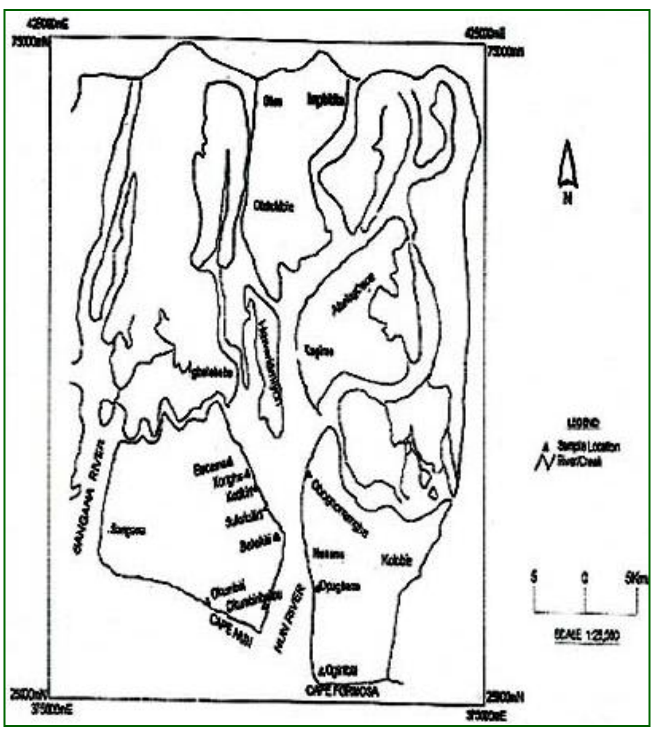
Introduction

Palaemon shrimps and widely distributed in estuarine and coastal waters of the Niger Delta. They are locally known in the Niger Delta as crayfish. They are ranked amongst the important shrimps species because they are harvested for commercial purposes in most areas (Powell, 1982). The distribution of shrimp is greatly affected by the degree of salinity, temperature and availability of nutrients. The presence of Palaemon shrimp in catches depends on the salinity regime, which in turn, is influenced by the quantity and Pattern of discharge from the river. These shrimps are found in water with salinity ranging between 5psu-20psu (Powell, 1980; Waribugo and Alfred-Ockiya, 2000). Temperature in correlation with salinity affects the distribution of some aquatic organisms and as a physiological stimulus signals the onset of migration and spawning activities. Changes in water quality have been observed to have an effect on the biodiversity as well as the period of development and hatching of aquatic organisms. Rainfall is the most important cyclic phenomenon in tropical countries as it brings about important changes in the physical and chemical characteristics of the coastal and estuarine environment. Growth studies are very important tools in fisheries management; providing information for the evaluation of production, stock size, recruitment, mortalities and the status of the shrimp population (Ling,1989; Waribugo, 2005). The growth of individuals determines the amount of stock available in the fishery (King, 1996) and is affected by food supply, competition, parasitism and environmental factors such as rainfall, salinity, presence of dissolved gasses, pollutants, anions and cations.

Materials and methods

Samples used in this study were collected from artisanal shrimpers operating along the river Nun estuary. The shrimping area extends from Akassa at the river mouth to about 12.5km north and lies between longitudes 5^{o}55, and latitude 4^0 20,. It is one of the many rivers that discharge into the Atlantic Ocean through the Niger delta on the bight of Benin and Bonny (Fig. 1).

Fig. 1: Map of the study area – River Nun Estuary.



Samples were sorted out into different species, and identified according to Holthuis (1980) and FAO, (1980). Carapace length for 2,400 specimens was determined to the nearest 1.0mm.The length-frequency data was analyzed using Elefan 1 package (Gayanilo et al., 1989). The procedure taken to extract growth parameters using Elefan 1 from length-frequency data are describe by Powell, 1980; Pauly, 1987 and Brey et al. (1988). The growth model used in the analyses was the seasonally oscillating version of the von Bertalanffy growth function as proposed by Pauly and Gaschutz (1979). The model has the form:

$$L_t=l_\infty(1-e^{-[k(t-to)+ck/2\prod[\sin 2\prod(t-ts)]})$$

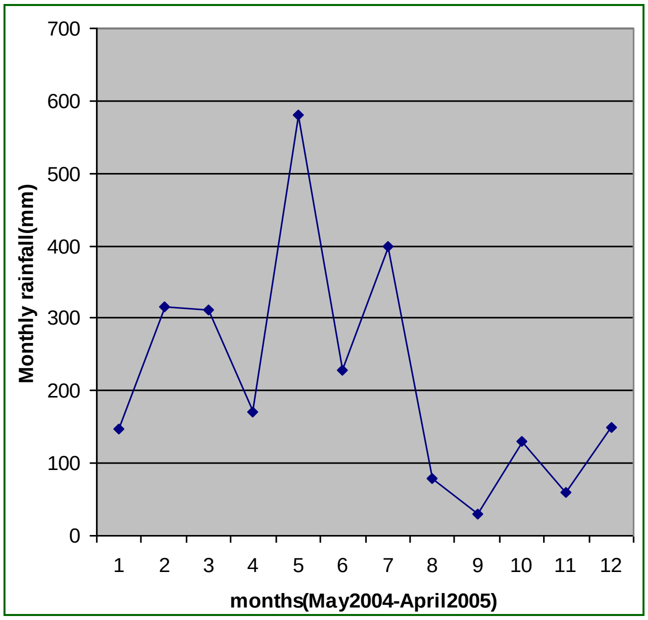
Where L_t is predicted length at age t, l_∞ is asymptotic length, and k is growth coefficient, c is the amplitude of seasonal growth oscillation, t_o is the hypothetical age at zero length, t_s is the age at the beginning of growth oscillation-winter point, ($wp=t_s+0.5$) is the time of year when growth is slowest (Pauly, 1987) . Modified Wetherill plot (Pauly, 1986) was used to obtain an initial estimate of asymptotic length (l_∞).this method is based on the right- descending part of the length-frequency curve and calculates the regression equation

$$L - l' = a + bl'$$

Where L' is the cut-off length for each size class, l is the mean length from l′ upward. Growth parameters were estimated as $l_\infty=al-b$,z/k=(1+*b*)*l*-*b*.the estimate of l_∞ was then seeded in Elefan 1 to optimize the estimates of the growth parameters, l_∞ and k. Since the maximum-recorded carapace, length lmaxof *N. hastatus* in Nigeria is 15mm (Sagua, 1981) and 16.7mm in the southeast coast of Nigeria (Enin et al., 1996). Seeded l_∞ values used ranged between 10mm to 18mm and seeded k values ranged from 0.3 to 2.0 per year. Elefan 1 identifies the peak in the length-frequency samples and searches for the best combination of growth parameters (l_∞, k, c, wp) using a goodness-of-fit index (r_n) (Pauly, 1987). The final estimates of l_∞ and k were used to calculate an index of growth performance :(ϕ)=$\log_{10}$ k+2 $\log_{10}$ l_∞ (Pauly and Munro, 1984; Morea et al, 1986), total mortality was estimated by the length-frequency catch curve procedure ,where percentage of samples in length groups were pooled to stimulate a steady-state population. Natural mortality (m) was estimated by

Pauly (1980) empirical formula: $\log_{10}m = 0.0066 - 0.279\log_{10} l_\infty + 0.6543 \log_{10}k + 0.4634 \log_{10} t$ using a mean annual temperature of 28°c for the inner continental shelf of Nigeria (Willams, 1968).

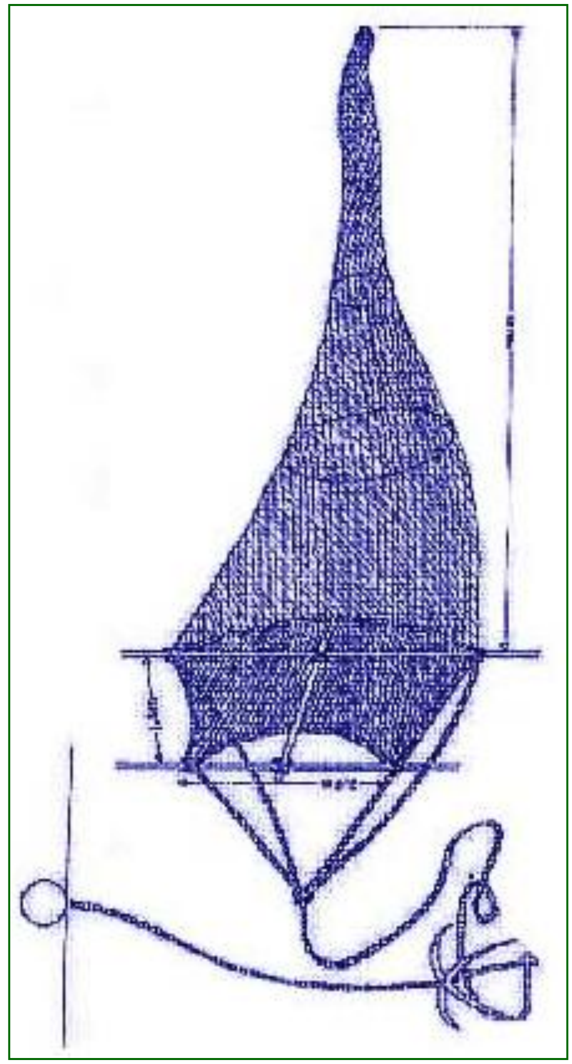
Fig. 2: Mean monthly rainfall during study period.



Fishing mortality (f) was estimated from the relationship f=z−m. The fraction of total mortality (z) due to fishing mortality (f) or exploitation rate was estimated from e=f/z. The recruitment pattern was estimated by projecting the length-frequency data backward onto the time axis down to zero length, using the von Bertalanffy growth equation and the estimated growth parameters (Pauly, 1982).

Rainfall pattern was collected from the Meteorological department of Port- Harcourt international Airport (Fig 2). Dug–out canoes measuring between 8-10m and powered by 8HP were employed in the coastal fishery, while the dugout canoes employed in the estuary were powered manually and measure between 4-7m.It takes an average of 90minutes for coastal shrimpers to get to their fishing ground, while estuarine shrimpers spend 10 minutes to get to the fishing ground. The bag-net is the gear employed in the fishery. It is a conical nylon bag net measuring between 4 and 5m (Fig 3). The mouth of the net is about 2.5m wide and 2m high and oriented to filter the on-coming currents.

Fig. 3: Stow net.



Results

The monthly mean rainfall is shown in Fig. 2. The rainfall was highest in September and lowest in January. During the rainy season, rainfall was highest in September and lowest in May. Rainfall was highest in November and lowest in January during the dry season. From the length-frequency data used in the analyses of growth parameters of *N. hastatus* (Table 1), the best estimates of growth parameters from Elefan 1 are l_∞ = 13.38mm carapace length, k=1.50,c=0.5, wp=0.5. Reconstructed length-frequency data (Fig. 4) superimposed on the estimated growth curve gave the growth parameter index ǿ as 2.43. The length-converted catch curve (Fig. 5) estimated total mortality (z) at 3.82 per year and natural mortality (m) at 1.01 per year. By subtraction, fishing mortality was estimated as 2.81 per year. Exploitation rate (e) was estimated as 0.74.

The recruitment pattern of *N. hastatus* as shown in Fig. 6 indicates a year-round recruitment with two peaks.

Table 1. Length-frequency data of *Nematopalaemon hastatus* of the River Nun Estuary, Bayelsa State, Niger Delta (May 2004−April 2005).

Length (mm)	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
3.0	2						30	6			20	17
4.0	3	7	2				29	7			21	17
5.0	53	8	12	9	2	3	33				31	39
6.0	38	12	10	11	6	1	26	25	13	10	28	36
7.0	36	25	21	20	4	25	20	26	48	52	24	23
8.0	33	42	25	23	12	39	16	18	27	26	24	24
9.0	25	57	40	27	55	53	21	43	47	52		24
10.0	16	44	90	38	90	83	18	72	67	74	21	13
11.0	16	25	20	76	58	14	15	18	20	18	10	12
12.0	8	8	10	10	19	29	13	26	17	17	15	17
13.0	7	4	7	21	5				12	8		
14.0	3	3	1					5	3	4	2	2
Total	240	232	240	236	251	247	221	243	254	261	218	224

Fig. 4: Growth parameters of *N. hastatus* in River Nun Estuary, Bayelsa State, Niger Delta.

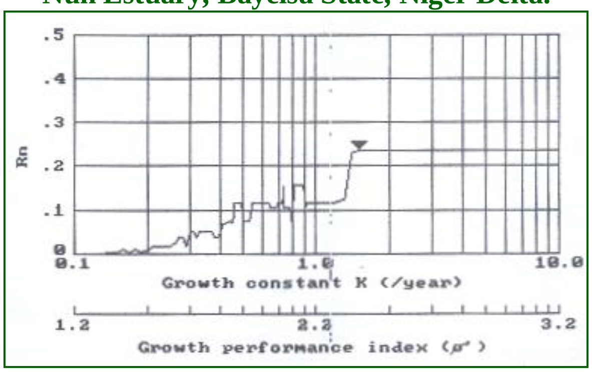


Fig. 5: Carapace length-converted catch curve of *N. hastatus* of the River Nun Estuary, Bayelsa State, Niger Delta. Estimated Z=3.82.

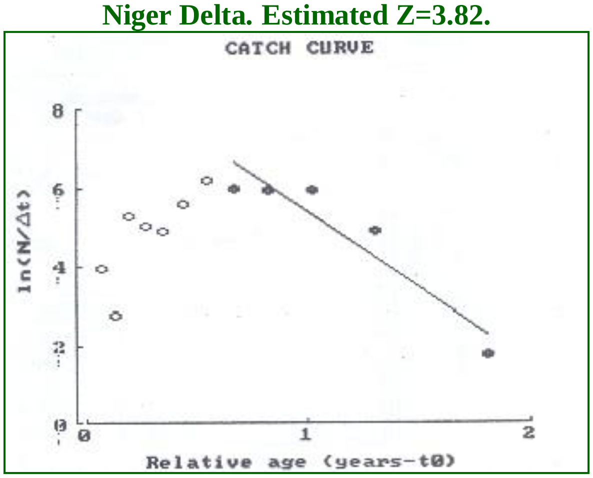
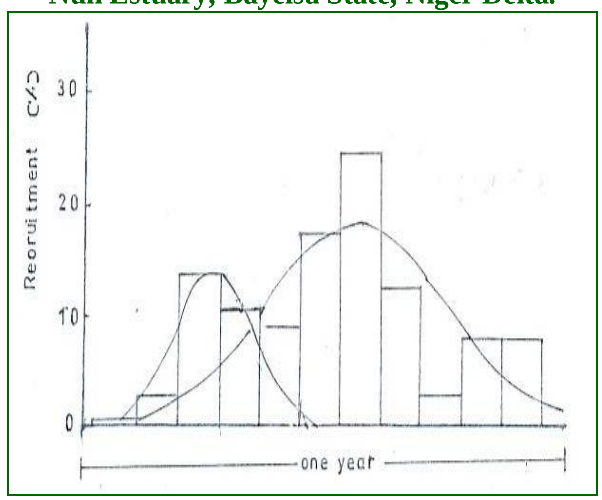


Fig. 6: Recruitment pattern of *N. hastatus* in River Nun Estuary, Bayelsa State, Niger Delta.



Discussion

The best estimate of l_∞ =13.83 mm carapace length for *Nematopalaemon hastatus* was lower than that given by Sagua (1981) and Enin et al. (1996). This is acceptable since l_∞ is supposed to be the mean value (Ricker, 1975). Sagua (1981) estimated l_∞ carapace length of 15mm in Lagos area of Nigeria, while Enin et al. (1996) gave l_∞ carapace length of 16.7mm in the southeast coast of Nigeria. The l_∞ value estimated here compares well with those recorded. K value of 1.5 per year for *N. hastatus* estimated falls within the range of values (0.39 and 1.6 per year) given by Pauly et al. (1984) for various stocks of Penaeid shrimps. The winter point (wp, the period of the year with the slowest growth) of 0.5 indicates that growth was slowest between June and July of the year. This may be due to reproductive activity of the shrimp, whereby energy is converted into reproductive material. This phenomenon may have accounted for the estimated amplitude of seasonal growth oscillation of 0.5. Growth performance index (ǿ) of 2.43 estimated for *N. hastatus* in this study compares well with that (2.24) estimated by Enin et al. (1996) for *N. hastatus.* A number of criteria exist for considering the suitability of length-frequency data used for the estimation of growth parameters of shrimp species (Wolff, 1989).

The presence of modal groups should be discernible from the raw data, with apparent shift in the model length overtone. Rutherford (1971) developed a system for assessing length data for growth studies, based on the need to obtain a sufficient number of measurements, well distributed over time. Pauly's rule-of-thumb provides on an increasing scale of 0-5, the total sample size and the number of months over which sample is accumulated. A total sample size of 1500, and above accumulated over a period of six months and above is regarded as excellent for such analysis. The sample used in this study is above this criterion. Studies have shown that growth parameters estimated from Elefan 1 are usually biased due to individual variability in growth parameters, seasonal oscillation in growth, size-dependent selection, variable recruitment period and large length-class intervals used in grouping length data (Isaac, 1990). It was found to be the principal source error in k,. The double recruitment peaks per year conforms to the assertion of Pauly (1982) that the double recruitment pulse per year is nearly a general feature of tropical fish species. It also appears similar to the pattern observed by Enin et al. (1996) for *N. hastatus* in the southeast coast of Nigeria. The result in this study disagrees with the concept of continuous recruitment, believed to be the rule among tropical species (Qasim, 1973; Weber, 1976).

Owing to the fact that t_o of the von Bertalanffy growth model could not be estimated from the length-frequency data alone, the month of the year corresponding to the peak of recruitment cannot be calculated. However, the peaks of the small size shrimp could be used. The highest was observed in November and a second peak was between March and April. This corresponds to the larger spawning peak between July and September, then a smaller peak between March and April. The instantaneous rate of total mortality (z) estimated (3.82 per year) in this study falls within the range of values (2.46-7.07) given by Pauly et al. (1984) for species of Penaeid shrimps and several stocks; while in the southeast coast of Nigeria values up to 5.61 per year have been obtained for *n=N. hastatus* (Enin, 1991).

Natural mortality (m) estimated here (1.01 per year) also falls within the range 0.77-3.12 estimated by Pauly et al. (1984) for species of Penaeid shrimps, and compares well with the value (2.92 per year) estimated by Enin et al. (1996) in the southeast coast of Nigeria. The estimated fishing mortality (2.81 per year) in this study falls within the range of values (0.55-4.68) by Pauly et al. (1984), as well as with the values (2.68 per year) obtained by Enin et al. (1996). Mortalities estimated in this study could be bias upward due the migratory behaviour of the shrimp. Pauly (1987) reported that estimates of total mortality (z) from length-converted catch may be biased due to sampling gear and by the behavior of the animal. *N. hastatus* were scare during the heavy rains (July-September) because they migrate from the estuary and coastal waters into the deeper continental shelf (Marioghae, 1980; Marioghae, 1981; Sagua, 1981; Enin et al., 1991). Such behavior in animals is known to affect the representativeness of the length-frequency data obtained from such samples and leads to bias fishery parameters estimate (Pauly, 1987). Exploitation rate (e) of 0.74 estimated here indicates that the fishery might be experiencing high fishing pressure. This is bases on the assumption that in an optimal exploited stock, natural and fishing mortalities should be equal or e=f/z=0.5 (Gullard, 1971). Analysis of exploitation rate (e) based on mortalities estimates, indicates that the fishery is subjected to high fishing intensity. This is based on the assumption that a stock is optimally exploited when fishing mortality (f) equal natural mortality or e=f/z=0.5 (Gullard, 1971). As reported by Waribugo (2005), *P. maculatus* are found with *N. hastatus* in most places in Nigeria and restriction of the shrimp to the lower estuaries could be due to the fact that shrimps are essentially pelagic and have oxygen demand. The findings in this report examine growth, mortalities and recruitment patterns of this shrimp as well as exploitation rate of the shrimp stock.

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