Length-weight parameters and condition factor of two West African prawns

Udeme I. Enin (1)

Abstract

The length-weight parameters and condition factor of two West African prawns, Nematopalaemon hastatus *Aurivillius, 1898 and* Macrobrachium macrobrachion *Herklots, 1851, from the Cross River estuary, Nigeria, were estimated. Weight growth in* N. hastatus *was found to be isometric, while that in* M. macrobrachion *was positively allometric, indicating that the latter species gets plumber as it grows larger. The implication of these findings with regard to the possibility of applying the conventional fish population dynamics models to the analysis of these shrimp populations, and also to the biological interpretation of the parameters themselves, is discussed.*

Keywords: Length-weight parameters — Condition factor — Shrimps — Nigeria — West Africa.

Résumé

Relations longueur-poids et facteur de condition chez deux crevettes d'Afrique de l'Ouest

Des relations longueur-poids, ainsi que le facteur de condition, ont été estimés chez deux crevettes carides d'Afrique de l'Ouest, Nematopalaemon hastatus *Aurivillius, 1898 et* Macrobrachium macrobrachion *Herklots, 1851, provenant de l'estuaire de la Cross River, Nigeria.*

Il y a isométrie de croissance en poids chez N. hastatus *et allométrie positive chez* M. macrobrachium, *ce qui indique que cette dernière espèce devient plus massive au fur et à mesure de sa croissance. La discussion porte sur l'interprétation de ces indices biologiques eux-mêmes et sur la possibilité d'utiliser, dans le cas de ces deux crevettes, les modèles classiques de dynamique, habituellement appliqués aux populations de poissons.*

Mots clés : Relations longueur-poids — Facteur de condition — Crevettes — Nigeria — Afrique de l'Ouest.

INTRODUCTION

The length-weight relations (LWR) and its parameters are often required in practical assessment of stocks of aquatic species. Pauly (1993) listed several stock-assessment situations when LWR may be needed. These include, (1) the conversion of length of individual fish to weight, (2) estimating the mean weight of the fish of a given length class, (3) conversion of growth equation for length into a growth equation for weight, and (4) morphological comparisons between populations of the same species, or between species.

(1) *Institute of Oceanography, University of Calabar, P.M.B. 1115, Calabar, Nigeria.*

However, in many such situations or when attempting to compare some species, it is usually difficult to find the required LWRs in the literature (PAULY, 1993). This situation is also true for many shrimp species important to the artisanal catch in West Africa. There is therefore the need to estimate and document LWRs for these aquatic species. The estimates may thereafter be incorporated into a database such as Fishbase (FROESE, 1990; PAULY and FROESE, 1991) for easy access, retrieval and use for any assessment work. This report aims at estimating the parameters of LWR and the condition factor for *Nematopalaemon hastatus* and *Macrobrachium macrobrachion* of the Cross River estuary, Nigeria.

The two shrimps selected for this study, the estuarine prawn *(Nematopalaemon hastatus)* and the brackish river prawn *(Macrobrachium macrobrachion)* occur in West Africa from Senegal (20° N) to Angola (16° S) (HOLTHUIS, 1980). *N. hastatus* inhabits the lagoons, estuaries and the coastal waters (SAGUA, 1980), preferring river mouths of salinity upward of 15 ‰ (MARIOGHAE, 1980). *M. macrobrachion* however is a freshwater shrimp, but like most members of the genus *Macrobrachium*, it requires brackish water conditions during the early life-history stages, hence the adults migrate into the estuaries for spawning (NEW and SINGHOLKA, 1985), where they sustain a year-round fishery.

In most of its range of distribution, *N. hastatus* is of considerable importance to the artisanal fishery. In Nigeria, it accounts for more than three-quarters of the landings of the artisanal shrimp fishery in the outer estuaries and near-shore marine waters (SIVALINGAM, 1968; FAO, 1969; ENIN *et al.*, 1991). Similarly, *M. macrobrachion* is an important target species of the artisanal fishery in the inner estuaries and lagoons in Nigeria, constituting on the average 60 % of all prawn landings in the fishery annually, and up to 83 % of the catch during the rainy season (MARIOGHAE, 1982, 1987). Data on the total landings of the different artisanal shrimp fisheries in Nigeria are lacking. However in 1988, the combined total landings of all the artisanal shrimp fisheries in Nigeria was estimated at 48,000 tons (IFAD, 1988).

MATERIALS AND METHODS

The samples of *Nematopalaemon hastatus* used in this study were obtained from the catches of the artisanal shrimp fishery at Inua Abasi, one of the major shrimp landing beaches of the *N. hastatus* fishery in the outer estuary (Fig. 1) of the Cross River. The samples were collected in April and October 1988, involving a total of 440 shrimps. Carapace lengths (CL, from eye-socket to the mid-dorsal margin of carapace) were measured to 0.1 mm below, while the weights were taken to 0.01 g. The carapace length-weight relationship of *N. hastatus* was established by least square regression of the logarithmic transformed version of the variables. The fitted equation has the form: $W = a.CL^b$, where W = Weight (g), CL = carapace length (mm), and a and b = parameters.

The carapace length (CL) and total length (TL) relationship was determined using measurements on the 440 specimens of *N. hatatus*. Total lengths (from tip of rostrum to tip of telson) were measured to 1 mm below, while carapace lengths were taken as indicated above. The fitted linear regression was of the form, $TL = a + b.CL$.

Fulton's condition factor (CF) of *N. hastatus* was calculated using the means of carapace length and weight of 440 shrimps obtained above, and the following formula :

$$CF = \frac{\overline{W} \times 100}{\overline{CL}^3}$$

where $\overline{W}$ = mean ungutted weight (g) and $\overline{CL}$ = mean carapace length (mm) of *N. hastatus* (PAULY, 1984; WOOTTON, 1992).

Macrobrachium macrobrachion samples were obtained at Nsidung Beach, Calabar (Fig. 1), from the landings of the artisanal fishermen, who fish in the upper reaches of the estuary, close to Calabar. Samples for the length-weight relationship were collected in July and August 1992. Total length (TL) was measured to 0.1 cm below, while the weight (W) was measured to 0.1 g for a total of 352 specimens of the shrimp. The total length-weight relationship of *M. macrobrachion* was also estimated by transforming both variables logarithmically and fitting a least square regression. The resulting equation was: $W = a.TL^b$, where W = weight (g) and TL = total length (cm), a and b being parameters.

The samples for carapace length (CL) - total length (TL) relationship of *M. macrobrachion* were obtained in August and September 1992. Both total and carapace lengths were measured to 0.1 cm below for a total of 593 specimens of the shrimp. The relationship was established by linear regression of the form, $TL = a + b.CL$. All the correlation coefficients (r) obtained from the various linear regression analyses were tested for significance using the Student's t-Test.

The means of total lenghts and weights of the 352 specimens of *M. macrobrachion* respectively were used to estimate Fulton's condition factor (CF) for the shrimp, using the formula:

$$CF = \frac{\overline{W} \times 100}{\overline{TL}^3}$$

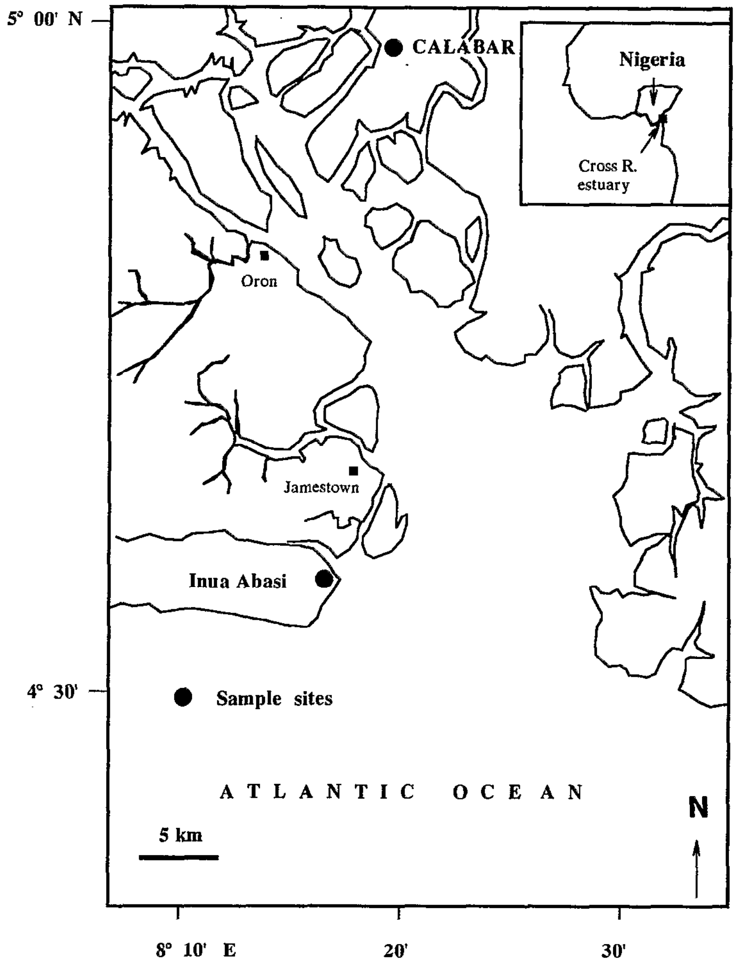

FIG. 1. — The Cross River estuary showing the sampling stations (•) : Inua Abasi Beach and Nsidung Beach (Calabar).
L'estuaire de la Cross River et les stations de prélèvement (•) : Inua Abasi Beach et Nsidung Beach (Calabar).

where $\overline{W}$ = mean ungutted weight (g) and $\overline{TL}$ = mean total length (cm).

The exponents (b) of the two length-weight relationships above were tested for departure from isometry (i.e. b = 3) using a t-statistic function given in SACHS (1974) (see PAULY, 1984, p. 6) as follows :

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

where s.d. (x) is the standard deviation of the Log L values, and s.d. (y) is the standard deviation of Log W 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 $\hat{t}$ calculated is greater than the tabled value of t for the degree of freedom, n — 2 (PAULY, 1984).

RESULTS

The logarithmic plot of weight against carapace length for *N. hastatus* is shown in figure 2. A significant linear relationship was established, with the equation: $W = 0.0011\ CL^{2.92}$ ($r^2 = 0.895$, t-Test, $P < 0.001$, d.f. = 438), and the length-weight parameters estimated as a = 0.0011 and b = 2.92. $\hat{t}$-statistic indicated that the value of b of 2.92 is not sig-

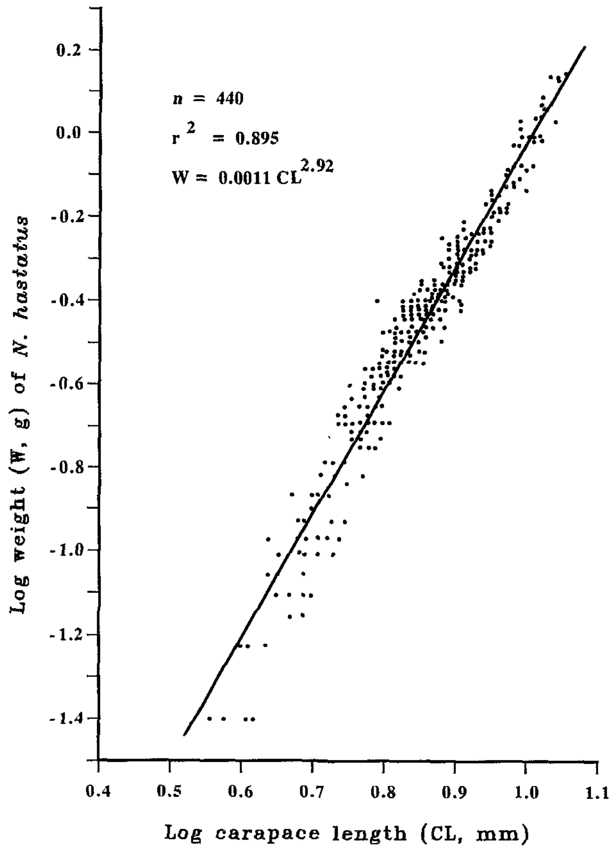

FIG. 2. — Carapace length (CL, mm)-weight (W, g) relationship in *Nematopalaemon hastatus* (n = 440 shrimps).
Relation entre la longueur de la carapace (CL, mm) et le poids (W, g) chez Nematopalaemon hastatus *(n = 440 individus).*

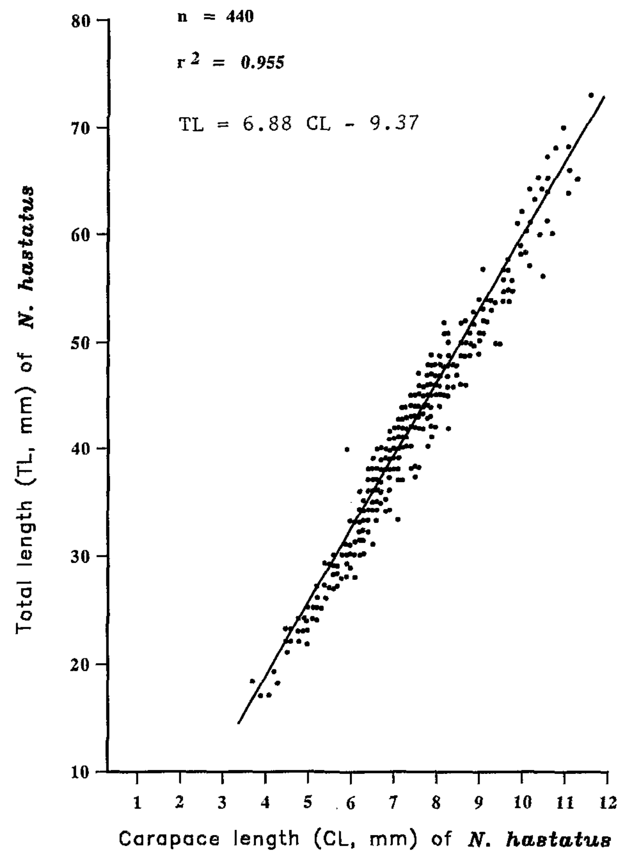

FIG. 3. — Carapace length (CL, mm)-total length (TL, mm) relationship in *N. hastatus* (n = 440 shrimps).
Relation entre la longueur totale (TL, mm) et la longueur de la carapace (CL, mm) chez N. hastatus *(n = 440 individus).*

nificantly different from 3 and hence, the weight growth of *N. hastatus* does not depart significantly from isometric condition.

The means of carapace length and weight in the 440 shrimp specimens used, were 7.39 mm and 0.407 g, respectively. From these, a condition index (CF) of 0.101 was obtained.

The total length-carapace length relationship of *N. hastatus* is depicted in figure 3. The linear regression line was significant ($r^2 = 0.955$, t-Test, $P < 0.001$, d.f. = 438) and had the form, TL = 6.88 CL − 9.37.

Figure 4 gives a graph of the log-transformed values of total length and weight of *M. macrobrachion*. The regression line indicated a significant relationship ($r^2 = 0{,}968$, t-Test, $P < 0.001$, d.f. = 350) with the equation: $W = 0.0058\ TL^{3.28}$. However, the $\hat{t}$ statistic revealed that the value of b = 3.28 is significantly different from 3, indicating that the weight growth of *M. macrobrachion* departs significantly from isometry.

Among the 352 specimens of *M. macrobrachion* used to compute the length-weight relationship, a mean weight of 1.54 g and a mean total length of 5.15 cm were obtained. These resulted in the condition factor (CF) estimate of 1.13.

Figure 5 shows the total length-carapace length relationship in *M. macrobrachion*. The regression analysis indicated a significant correlation ($r^2 = 0.960$, t-Test, $P < 0.001$, d.f. = 591) between the variables, giving the equation : TL = 1.58 + 3.38 CL.

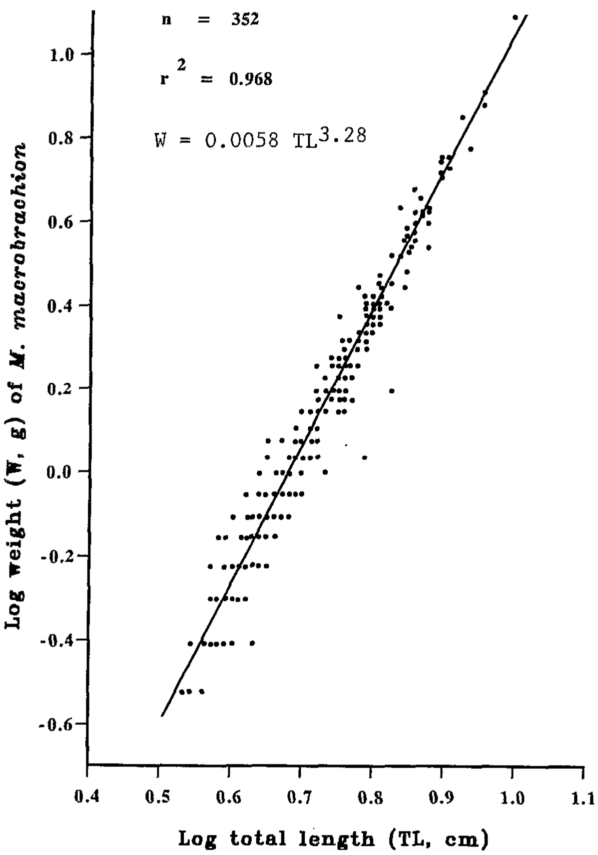

FIG. 4. — Total length (TL, cm)-weight (W, g) relationship in *Macrobrachium macrobrachion* (n = 352 shrimps).
Relation entre la longueur totale (TL, cm) et le poids chez Macrobrachium macrobrachion *(n = 352 individus).*

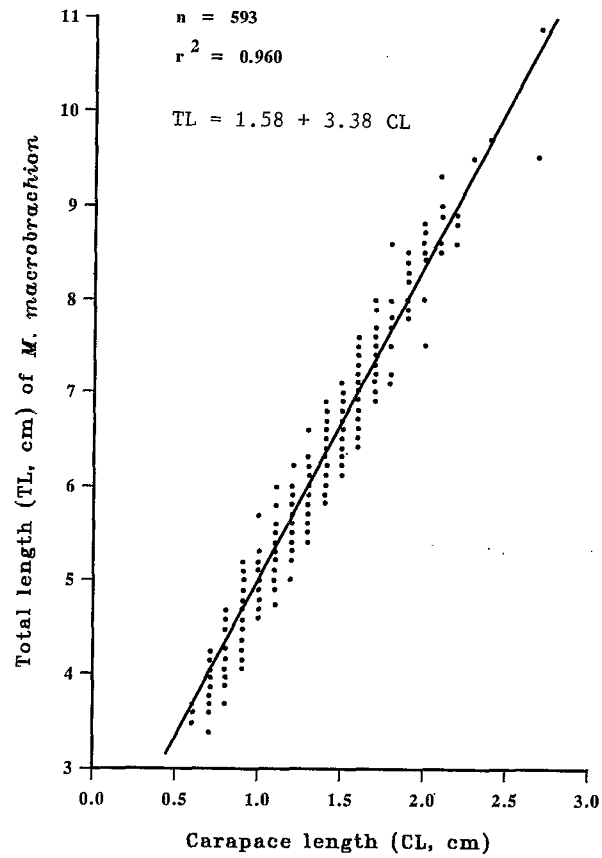

FIG. 5. — Total length (TL, cm)-carapace length (CL, cm) relationship in *M. macrobrachion* (n = 593 shrimps).
Relation entre la longueur totale (TL, cm) et la longueur de la carapace (CL, cm) chez M. macrobrachion *(n = 593 individus).*

DISCUSSION

The exponent (b = 2.92) in the length-weight equation of *Nematopalaemon hastatus* was not significantly different from 3, indicating that *N. hastatus* of the outer Cross River estuary approximates an isometric weight growth (BAGENAL and TESCH, 1978). This condition had already been assumed for the species with regards to growth analysis using von Bertalanffy growth function (VBGF) (ENIN, 1994).

Conversely, the exponent (b = 3.28) of the length-weight relationship of *Macrobrachium macrobrachion* was significantly different from 3, indicating that weight growth of the species is allometric. The implication of this finding is that the dynamics of *M. macrobrachion* populations cannot be analyzed using the conventional fish population dynamics models, most of which assume isometry in fish and invertebrate growth (PAULY, 1984); or at least results from such analyses must be used with caution bearing in mind that the assumption of isometry in the models is violated.

A characteristic of the length-weight relationship in fishes and invertebrates is that the value of the exponent (b) is 3 when growth in weight is isometric (without changing shape). If b value is different from 3, weight growth is said to be allometric (fish changes shape as it grows larger). Allometric growth may be negative (b<3) or positive (b>3). Decrying the general lack of adequate theory to guide research and to formulate testable hypothesis on the LWR of fish and aquatic invertebrates, PAULY (1993) stated that "there is no theory that tells us in which case estimated b values can be expected to be below 3 (negative allometry) or above 3 (positive allometry)" (p. 26).

However, WOOTTON (1992) provides a rough idea on this situation, indicating that allometric growth is negative ($b<3$) if the fish gets relatively thinner as it grows larger, and positive ($b>3$) if it gets plumber as it grows larger. Thus some indication of the condition of fish in a population can be obtained from the length-weight equation. In the particular cases considered here, results indicate that *N. hastatus* does not change shape as it grows larger, while *M. macrobrachion* gets plumber as it grows larger.

Another characteristic of LWR is that where weight growth is isometric ($b = 3$), the parameter (a) can be interpreted as the condition factor of the fish by multiplying it by hundred (i.e. CF = a.100), but if b is not equal to 3, the value of (a) ceases to be an index of condition (PAULY, 1984) and cannot be interpreted biologically. In the present analysis, $\hat{t}$-statistic has confirmed that the estimated b value of 2.92 for *N. hastatus* did not depart significantly from 3. It is little wonder therefore that the use of parameter (a) as an index of condition for *N. hastatus* (i.e. CF = 0.0011 × 100) gives a value of condition (0.11) which is quite similar to the estimated value of Fulton's condition factor (CF = 0.101) obtained from mean length and mean weight in sample.

In the case of *M. macrobrachion*, positive allometric growth was indicated such that the parameter (a) when multiplied by hundred (i.e. 0.0058 × 100) gives a value (0.58) which is quite different from the estimated value of Fulton's condition index (CF = 1.13) obtained from mean length and mean weight in sample. Thus the value of the parameter (a) cannot be an index of condition for *M. macrobrachion* and cannot be interpreted in biological terms.

The high and significant correlation between carapace length and total length in the two species of shrimp indicates that either of the variables is suitable for establishing length-weight relationship for both species.

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REFERENCES

BAGENAL (T. B.) and TESCH (F. W.), 1978. — «Age and growth». *In* BAGENAL (T.), ed. : *Methods of assessment of fish production in freshwaters. IBP Handbook No. 3.* Blackwell, Oxford : 101-136.

ENIN (U. I.), 1994. — *The artisanal shrimp fishery of the outer Cross River estuary, Nigeria.* Ph. D. Thesis, University of Calabar, Nigeria, 204 p.

ENIN (U. I.), LOWENBERG (U.) and KUNZEL (T.), 1991. — The *Nematopalaemon hastatus* (estuarine prawn) fishery in the outer estuarine region of the Cross River, Nigeria. *Arch. Fisch Wiss.* 41 (1) : 67-88.

FAO, 1969. — *Fisheries survey in the Western and Mid-Western Regions, Nigeria.* Final Report, FAO-UNDP/SF 74/NIR/6, 142 p.

FROESE (R.), 1990. — FISHBASE : an information system to support fisheries and aquaculture research. *Fishbyte* 8 (3) : 21-24.

HOLTHUIS (L. B.), 1980. — *Shrimps and prawns of the world : an annotated catalogue of species of interest to fisheries.* FAO Fish. Synop. 125, 271 p.

IFAD, 1988. — *Nigeria : artisanal fisheries development project. Appraisal report.* International Fund for Agricultural Development, 61 p.

MARIOGHAE (I. E.), 1980. — *The ecology and commercial fishery of* Palaemon (Nematopalaemon) hastatus *Aurivillius 1898.* M. Sc. Thesis, University of Port-Harcourt, Nigeria, 70 p.

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. afr.*, 96 : 493-508.

MARIOGHAE (I. E.), 1987. — *An appraisal of the cultivability of Nigerian palaemonid prawns.* ARAC/87/WP/4. UNDP/ FAO/NIOMR, Lagos, 12 p.

NEW (M. B.) and SINGHOLKA (S.), 1985. — Freshwater prawn farming : a manual for the culture of *Macrobrachium rosenbergii. FAO Fish. Tech. Pap.* 221, 118 p.

PAULY (D.), 1984. — *Fish population dynamics in tropical waters : a manual for use with programmable calculators.* ICLARM, Studies and Reviews 8, 325 p.

PAULY (D.), 1993. — Editorial : Fishbyte Section. *NAGA, The ICLARM Quarterly* 16 (2-3) : 26.

PAULY (D.) and FROESE (R.), 1991. — FISHBASE: assembling information on fish. *NAGA, The ICLARM Quarterly* 14 (4) : 10-11.

SACHS (L.), 1974. — *Angewandte Statistik.* Springer Verlag, Berlin.

SAGUA (V. O.), 1980. — Observations on the ecology and some aspects of reproduction biology of the small white shrimp *Palaemon hastatus* Aurivillius (Crustacea: Palaemonidae) in the Lagos area of Nigeria. *Bull. IFAN*, Sér. A, 42 (2) : 279-295.

SIVALINGAM (S.), 1968. — *Present status and possible development of eastern Nigeria fisheres 1966.* Min. of Information Printing Division, Lagos, 57 p.

WOOTTON (R. J.), 1992. — *Fish ecology : tertiary level biology.* Blackie, London, 212 p.