Population Dynamics of the Freshwater Clam *Galatea paradoxa* (Donacidae) in the Cross River, Nigeria

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Abstract

The growth of the freshwater clam *Galatea paradoxa* (Born) from the Cross River, Nigeria, was studied based on a count of growth checks on shells, presumed to be laid down annually. Mean lengths at ages 1 to 5 were 4.1 cm, 5.9 cm, 7.4 cm, 8.4 cm and 9.0 cm, respectively; maximum observed size was 11.1 cm. Growth conformed to the von Bertalanffy growth model with the parameters L_∞ = 11.2 cm, K = 0.3 $year^{-1}$ and t_0=-0.5 $year^{-1}$. Total and natural mortalities were estimated at 0.8 and 0.3 $year^{-1}$, respectively; the status of the fishery is briefly discussed.

Introduction

The lower reaches of the Cross River in southeastern Nigeria (Fig. 1) supports a considerable stock of the freshwater clam, *Galatea paradoxa* (Born) (= *Egeria radiata* Lamarck) which sustains a thriving and lucrative artisanal fishery during the dry season (November-March) of each year (Moses 1990a). Moses (1990b) estimated the standing stock of this clam at 2,369 kg ha^{-1} (total wet weight) and remarked that it was being fished at a level of about 83% (328 kg ha^{-1} $year^{-1}$) of maximum sustainable yield, estimated at 398 kg ha^{-1} $year^{-1}$.

A number of proposals have been advanced for the rational exploitation, management and conservation of the Cross River stock of *G. paradoxa* (Moses 1990a, 1990b; King and Udoidiong 1991) in view of the significance of the clam fishery for providing employment and a cheap source of animal protein for many Nigerians.

However, the design and successful implementation of the proposed schemes must incorporate a background knowledge of biology, and especially the growth and mortality patterns of the clam. The present study on the growth and mortality of *G. paradoxa* is a contribution to this end.

The only available previous record of the age and growth pattern of *G. paradoxa* is that of Moses (1990b) which was based on analysis of length-frequency distribution using Pauly's (1983) "integrated method". Moses (1990b), moreover pointed out the need to study the growth of this clam by means of a more direct and reliable aging method. This was attempted in the present study which is based on growth checks on the shells of *G. paradoxa*.

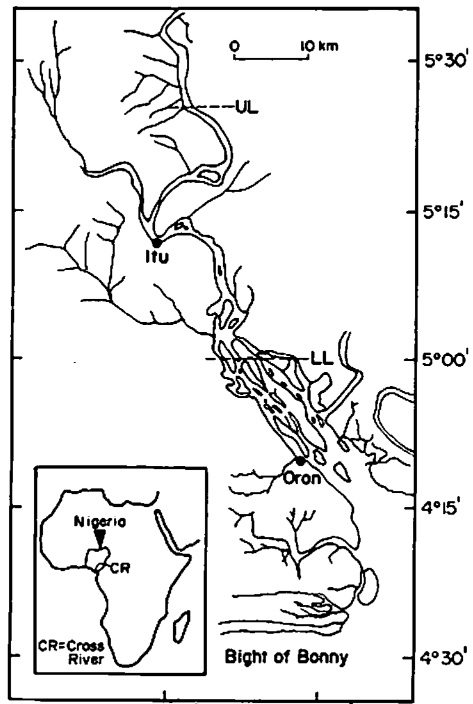

Fig. 1. Map of lower Cross River (Nigeria), showing the sampling station (Itu) and approximate upper and lower limits of occurrence of *G. paradoxa*.

Materials and Methods

A total of 571 randomly selected specimens of *G. paradoxa* were obtained from the clam fishermen at Itu (Fig. 1) from February 1989 to January 1990. The shell length (maximum antero-posterior dimension) of each specimen was measured to the nearest 0.1 cm using Vernier calipers. The concentric growth checks (narrow clear or dark-colored zones on the periostracum) on the shells were counted, and were presumed to be annual, as suggested by the late S.A. Whyte (pers. comm.).

The age-length data were used in determining the parameters of the von Bertalanffy growth function (VBGF), i.e., L_∞, K and t_0. The plot of L_{t+1} against L_t (Ford-Walford plot) was used to estimate L_∞ as detailed in Pauly (1983), while t_0 was estimated by plotting $-\ln(1-(Lt/L_\infty))$ against t (Sparre et al. 1989). Longevity was estimated as from $t_{max} \approx 3/K$ (Pauly 1983). Pauly and Munro's (1984) length growth performance index ϕ' was computed from:

$$\phi' = \log K + 2\log L_\infty \quad ...1)$$

where K and L_∞ are von Bertalanffy growth parameters.

A random sample of 1,161 clams was available for estimation of total mortality; of these, 571 were aged based on checks on their shells. The age of the remaining 590 clams was estimated from the inverse of the VBGF, i.e.,

$$t = -(1/K)\ln(1-L_t/L_\infty)+t_0 \quad ...2)$$

The (natural) log of the number of clams was then plotted against their age and Z estimated as the slope (with sign changed) of the resulting catch curve (Gulland 1969).

Natural mortality (M) is difficult to estimate reliably in bivalve, and we considered two approximate methods, i.e.,

i) the empirical model of Taylor (1958, in Ehrhardt et al. 1983) *viz*

$$M \approx 3/(t_0+(3/K)) \quad ...3)$$

ii) and $M \approx 2K$ (Del Norte 1988).

To estimate the total number of deaths from both fishing and natural sources, total mortality rate (A) was multiplied by the number of clams in the stock (here 83,044 clams ha^{-1}: Moses 1990), with A estimated from

$$A = 1 - e^{-(F+M)} \quad ...4)$$

The catch rate (i.e., deaths from fishing) was estimated from the Baranov catch function:

$$C = N((F/F+M)\ (1-e^{-(F+M)})) \quad ...5)$$

where N is the number of clams in the stock. The number of deaths from natural causes was estimated by subtracting the catch rate from the total mortality rate (Tyler and Gallucci 1980).

Results and Discussion

The maximum size of *G. paradoxa* encountered during this study (L_{max} = 11.1 cm) slightly exceeds the values given by Edmunds (1978; L_{max} = 9.0 cm) and Moses (1990b; L_{max} = 9.6 cm). With regard to growth, Table 1 compares our results with those of Moses (1990); the table also presents growth parameters for *G. paradoxa* estimated by Vakily (1990) from data presented in Kwei (1965) and pertaining to populations in the Lower Volta, Ghana. As might be seen, our values are in general agreement with those of Moses (1990b); this suggests that, contrary to his assertion, the checks on the shell of this clam, which can be counted with unaided eyes, can be used for growth studies.

Another result is that different population of *G. paradoxa* may display strong differences in growth and longevity, as suggested here by the fact that the estimates of K for the Volta River populations are approximately twice as high as those obtained from the Cross River.

Total mortality was estimated as Z = 0.79 $year^{-1}$; our natural mortality estimates range from 0.31 to 0.60 $year^{-1}$, thus suggesting that F (i.e., Z - M) of the order 0.29-0.48 $year^{-1}$, and E(= F/Z) 0.37 to 0.61.

The values of M (and hence F and E) we estimated from Taylor's model are consistent with those of Moses (1990b; Z = 0.82, M = 0.32, F = 0.50 year and E = 0.61) and are hence retained here.

Table 1. Growth and related parameters of *Galatea paxadoxa* on Ghana and Nigeria.

Location	L_{max} (cm)	L_∞ (cm)	K ($year^{-1}$)	t_0 (year)	ϕ'	Source
Akosombo, Ghana	(7.2)*	(7.8)*	0.75	-	-	Vakily (1990), based on Kwei (1965).
Tefle, Ghana	(5.5)*	(5.9)*	0.71	-	-	Vakily (1990), based on Kwei (1965).
Lower Cross River, Nigeria	9.6	9.3	0.36	-0.10	1.52	Moses (1990)
Lower Cross River, Nigeria	11.6	11.2	0.30	-0.54	1.58	this study

*These values are not directly comparable with those below, as they refer to shell *height* rather than shell *length* (hence the ϕ' values, omitted for the Ghana stocks would not be directly comparable, either.)

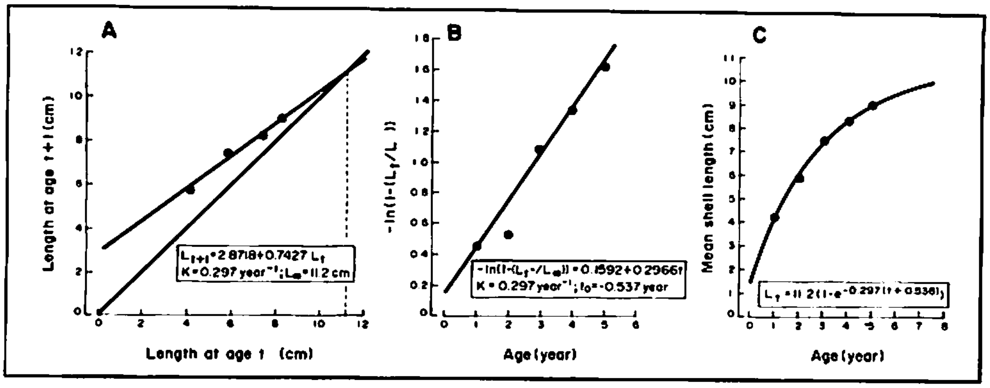

Fig. 2. Growth of *Galatea paradoxa* in the Lower Cross River, Nigeria. A. Ford-Walford Plot for estimating L_∞ and K; B. Plot for estimating t_0 and K, given L_∞; and C. Estimated growth curve.

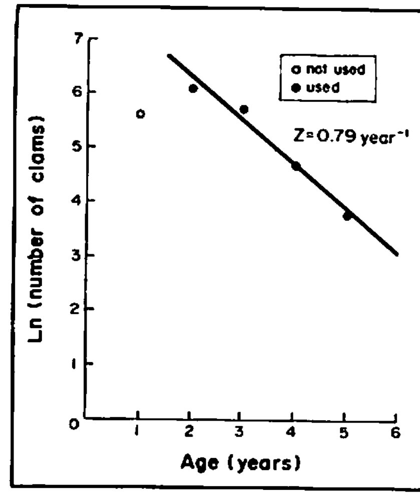

Fig. 3. Age-structured catch curve of *G. paradoxa* in the Lower Cross River, Nigeria (n = 1,161).

Our total death rate estimate was 45,444 clams ha^{-1} $year^{-1}$ while the catch rate C = 27,385 clams ha^{-1} $year^{-1}$. Death rate from natural causes was 18,059 clams ha^{-1} $year^{-1}$. Moses (1990b) estimated the clam catch rate at 327.8 kg·ha^{-1} $year^{-1}$, representing 11,515 clams ha^{-1} $year^{-1}$ (based on the conversion: 2,369 kg ha^{-1} of clams = 83,220 clams ha^{-1}). The present estimate of C is therefore remarkably higher than that of Moses (1990b) which may represent a minimum estimate.

Nevertheless, taken together, both estimates imply a mean of C ≈ 20,000 clams ha^{-1} $year^{-1}$. This seems reasonable in view of the catch per unit effort (catch $fisher^{-1}$ $hour^{-1}$) which is as high as 67-133 clams during the January-February peak fishing season (King and Udoidiong 1991).

An approximation of the state of exploitation of a stock can be obtained from the exploitation rate, based on the premise that optimal yield is attained when F = M (i.e., E_{opt} = 0.5) (Gulland 1971). Accordingly, the value of E for *G. paradoxa* would reflect an exploitation level that is about 20% in excess of E_{opt}. Equation (4) for a fishery that is exploited at its optimum level would take the form:

$$C_{opt} = N(0.5)\,(1-e^{-(F+M)}) \qquad ...6)$$

where C_{opt} = optimal catch rate. From equation (6), C_{opt} = 22,722 clams ha^{-1} $year^{-1}$. The current rate is thus 4,662 clams ha^{-1} $year^{-1}$ in excess of C_{opt}.

This study confirms Moses's (1990b) assertion that the Cross River population of *G. paradoxa* is heavily exploited. Although depletion of the clam stock is not presently apparent throughout its spatial range, there are indications (e.g., increased diving hours per unit catch) of a decline in abundance at some locations, along with a decrease in the sizes of individuals caught and marketed (King and Udoidiong 1991). This study therefore confirms the earlier studies of King et al. (1990), Moses (1990b), and King and Udoidiong (1991) in that measures should be taken to ensure the sustainability of this valuable resource.

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