AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Preliminary biodata and growth parameters of *Odaxothrissa mento* in the lower Cross River, southeast Nigeria

[1]James P. Udoh, [1]Imaobong E. Ekpo, [2]Emah E. Essien

[1] Department of Fisheries and Aquatic Environmental Management, University of Uyo, Nigeria; [2] Agricultural Development Programme, Uyo, Akwa Ibom State, Nigeria. Corresponding author:J. P. Udoh, jjamesphilip@gmail.com; jamesudoh@uniuyo.edu.ng

Abstract. The population dynamics of *Odaxothrissa mento* in the lower Cross River, southeast Nigeria, were obtained from a six month length composition data (4.25-14.75 cm TL; mean = 5.91 cm ± 1.02; and 0.71-7.36 g; 1.62 g ± 1.24; n = 1012). The length-weight relationship of the species indicated isometric growth (b = 3.005; r = 0.9623). Three year classes with mean lengths of 7.4 cm, 11.55 cm and 13.3 cm TL, respectively, were identified. The von Bertalanffy exponential growth parameters were estimated as: asymptotic length (L_∞) = 13.7 cm TL, growth curvature (K) = 1.48 $year^{-1}$ and length-at-age zero years, t_0 = - 0.13; L_o = 2.40 cm TL. The estimated growth performance index, φ' = 2.444 based on length and φ = 0.6833, using weight. The computed total mortality, Z = 2.54 $year^{-1}$, natural mortality, M = 1.58 $year^{-1}$ and fishing mortality, F was 0.96 $year^{-1}$. Results indicate the fishery is lightly exploited with current exploitation ratio, E_{cur} = 0.38 < E_{opt} = 0.5; rate of exploitation, μ = 0.3481 $year^{-1}$ < E_{cur}, 35% of the available stock being fished annually; corroborated by Z/K ratio (< 2) and M/K = 2.08, indicating environmental stability. The length-at-first capture L_c = 5.64 cm TL at age 1.7 yr. The fish was yet to complete 50-55% of growth as at the time of capture at L_c, L_{25} and L_{75} compared to L_∞, hence, L_{opt} = 10.1 cm TL, provides least impact on the stock. This finding serves as baseline for management of *O. mento* and clupeids/small-sized fish species in the lower Cross River and tropical environments.
Key Words: fishery policy, length-frequency distribution, mortality, recruitment, potential yield.

Introduction. Clupeids are of great commercial importance in various parts of Africa. Their commercial significance has been high-lighted in the work of various authors: Kainji Lake, Nigeria (Otobo 1979), Lake Rivu Rwanda (Spliethoff et al 1983) and Lake Kariba, Zimbabwe (Marshall 1987). The FAO Working Group for the Assessment of Small Pelagic Fish off Northwest Africa (FAO 2002) emphasis the study of various sardine/clupeid species in order to obtain reliable and consistent age and growth data on the optimum exploitation of the fish species. Fish are limited but renewable resources hence, fish stock assessment allows us to better understand the dynamics of a fish stock, and provide more precise management advice to the fisheries managers on an exploitation level, which in the long run gives the maximum yield in the face of prevailing environmental scenarios. Errors in age determination could have an adverse effect on the quality of the stock assessment and the scientific advice based on that assessment (Sylla et al 2012).

Odaxothrissa mento is among the pelagic, potamodromous, clupeid species widely distributed throughout the Atlantic coast of West Africa, primarily in the neritic and oceanic zones of marine waters from Ghana to Cameroon; and in estuaries from Senegal to Gabon (Fischer et al 1981). It has become adapted to life in tropical brackish and fresh waters, in rivers and streams and in the most riverine parts of some man-made lakes; including Lower Guinea, where it is found from the lower reaches of the River Volta (Ghana), Cross River in the Niger delta, the lower Benue (Nigeria) and to the Wouri (Cameroon), apparently not in Congo system (Entsua-Mensah et al 2010).

In Central and West Africa, it constitutes an important commercial/industrial (Lowenberg & Kunzel 1991) and subsistence/artisanal (Uwe-Bassey 1988) fisheries resource with least vulnerability and no known major threats. Oil spills in the Niger Basin and deforestation and sedimentation in the Volta basin however, threaten the West African populations (Entsua-Mensah et al 2010). It is a predator, hunting macrofauna, feeding mainly on animals like small fishes, including its own juveniles, and on aquatic insects (Whitehead 1985). It possibly migrates upstream to breed.

O. mento locally referred to as "abusim" are caught in large quantities by the fishers using encircling net and Attalla net. The fishers usually fish at night when they can take advantage of the vertical upward movement of the clupeids; clupeids reach the surface shortly before sunset and remain there throughout the night (Otobo 1979). The fish are sold to the local women who process them by smoking or sun-drying into different forms of food for subsequent retailing. The catch contributes a great deal to the protein food intake, health and socio-economic livelihood of coastal and riverine populations of southeast Nigeria.

Despite of this, no serious attempt has yet been made to carryout management-oriented study involving its age, growth, mortality, recruitment, and exploitation. This research therefore seeks to present the preliminary biodata and population dynamics on the growth pattern, mortality, age, recruitment and exploitation of *O. mento* in the Cross River System. Furthermore, the research presents baseline information (as well as reference points) for comparison with population studies of other clupeids/small-sized fish species of tropical environments.

Material and Method. Samples of *O. mento* (n = 1012) with varying sizes were randomly purchased bimonthly from artisanal and subsistence fishers at the Itu bridgehead (Figure 1), over a period of six months (July to December 2009). The fishers employed encircling gill net of 11 mm stretched mesh and Attalla lift net measuring 2.9 x 2.9 m, mesh size of 1 mm along the extensive floodplains of the Lower Cross River from the 5°12′26.87′′N, 7°59′51.63′′E area up to and landed at the bridge head (5°10′41.62′′N,8°04′00.60′′E). The entire floodplain is approximately 8000 km^2 and 7 m deep (Moses 1987); with the wet season in April–October and the dry in November-March. Most of the flood areas dry up as the water recedes (Moses 1987). Fish samples were identified (Teugels et al 1992) and measured to the nearest 0.1 cm total length (TL) and 0.1 g total weight (TW) for each specimen and preserved in 10% diluted formaldehyde. Fish condition factor was calculated as:

$$k = 100TW/CL^3.$$

The Bhattacharya (1967) ageing method was employed by analyzing the overall (pooled monthly) length frequency (L-F) distributions; which were first converted to relative frequency and then plotted as histograms (Pauly 1983). Thereafter, the modal lengths of the assumed cohorts were estimated using Bhattacharya's approach and Pauly's (1983) integrated (modal progression) method which assume that the demographic structure of the population does not change and growth patterns repeat themselves from year to year. This further implies that recruitment, mortality and environmental condition (e.g., food availability and abundance) remain constant for a number of years (Pauly 1980 a,b).

The mean lengths were used to obtain estimates of the von Bertalanffy growth function (VBGF) parameters (L_∞ and K) by the Gulland and Holt Plot of ΔTL against the mean length (L_T) (Gulland 1969; Moses 1987; Sparre & Venema 1992) and the Ford–Walford plot of the mean length of fish one year later (L_{T+1}) against the total length (L_T) (Ford 1933; Walford 1946) while t_o (= age of the fish at zero length) was estimated empirically (Pauly 1980 a,b) as:

$$\text{Log}_{10}(-t_0) = -0.3922 - 0.2752\ \text{Log}_{10}L_\infty - 1.038\ \text{Log}_{10}K$$

To establish the length weight relationship, the commonly used relationship $TW = aTL^b$ (Ricker 1975), was applied, where *TW* is the weight (g), *TL* is the total length (cm) and ***a*** and ***b*** are the equation constants.

The length-converted catch curve method (Pauly 1984; Moses 1988, 1990) was used to estimate the instantaneous rate of total mortality (Z). The instantaneous rate of natural mortality (M) was estimated using Taylor's formula (Ehrhardt et al 1975):

$$M = 2.9957/[t_0 + 2.9957/K],$$

where K and t_0 = parameters of VBGF; $2.9957/K = T_{max}$ (Moses 1990) and T_{max} = the maximum age attainable. The length performance index φ' was estimated (Pauly & Munro 1984) as:

$$\varphi' = \text{Log } K + 2 \text{ Log } L_\infty$$
$$\varphi = \text{Log } K + 0.67 \text{ Log } W_\infty$$

where K and L_∞ are parameters of VBGF and W_∞ is the mean weight of very old fish. The optimum length L_{opt} was estimated as:

$$L_{opt} = L_\infty\ [3/(3+M/K],$$

where L_∞ and K are parameters of the von Bertalanffy growth function, and M is the instantaneous rate of natural mortality (Froese 2006).

The fishing mortality (F) was estimated by subtracting the value of natural mortality from the total mortality as $F = Z - M$, while the potential yield and exploitation ratio, $E = F/Z$ and $F = M$ (i.e., E = 0.5). The exploitation rate (μ) was calculated as $\mu = F/Z\ (1\text{-}e^{-z})$, where F = Fishing mortality, Z = Total Mortality and E = 2.7182 (Landau 1979). The lengths at which 25%, 50% and 75% of the catch retain in the net (L_{25}, L_c, L_{75}) were derived by plotting the curve for probability of capture or selectivity ogive, S, of each length class of *O. mento* against the mean total length (Pauly 1984).

Figure 1. Map of a section of the Lower Cross River showing occurrence, fishing area and sampling site of *O. mento* during the study period (Inset: Location of site in southeast Nigeria) (*Source*: Google earth, 2013).

Results and Discussion. *O. mento* is particularly abundant during the rainy seasons from April to October each year in the study area; with marked reduction during the dry season from November and December. The peak of the rainy season appears to be its spawning season. The variations in the size and length-frequency distribution (Figure 2) of *O. mento* (n = 1012) sampled showed that the smallest and largest specimens were 4.25 and 14.75 cm TL, respectively (mean 5.91 cm ± 1.02). Figures 2(A-F) indicate a progression in the modal size groups (% relative population) from 5.0-5.5 cm TL (49.2%) to 5.5-6.0 cm TL (23.3%) in July and August; to 5.0-5.5 cm TL (21.9%, 39.5%, 35.1%, 27.8%) in September to November and 5.5-6.0 cm TL (36.1%) in December, respectively. Figure 2G indicates only one mode with the 5.5-6.0 cm TL size groups numerically dominant and constituting 29.68% of the *O. mento* population in the study area. The weight ranged between 0.71 and 7.36 g (mean 1.62 g ± 1.24). However, Moses (1988) observed L_{max} (largest size in total length) for other clupeids like *Pellonula leonensis* to be 10.0 cm.

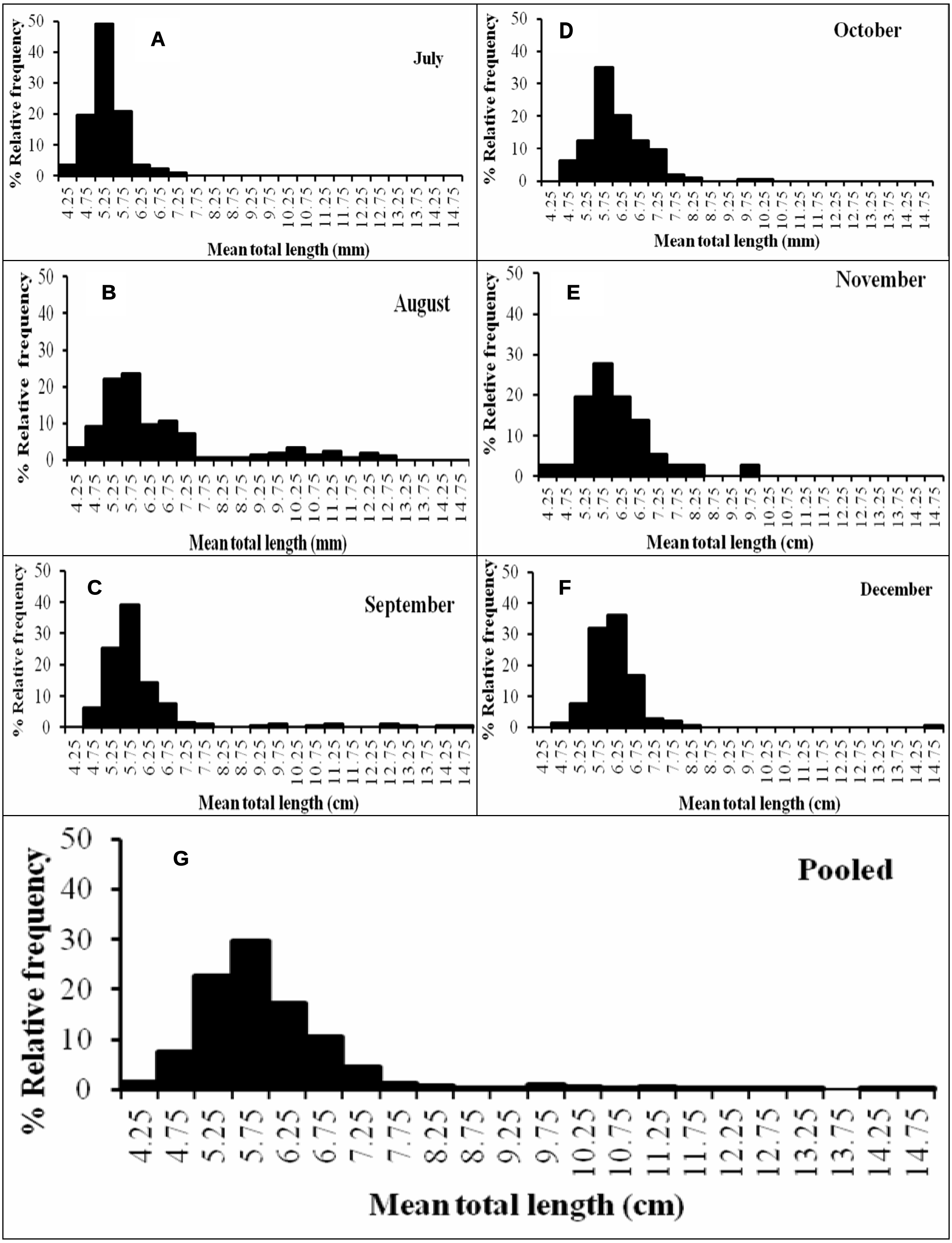

Figure 2. Monthly and pooled length frequency distribution of *O. mento* during the study period.

Length–Frequency of *O. mento* over time (Figure 2) revealed the recruitment season as young fish (4.0-4.5 cm) were caught in the months of July, August and November and absent during the months of October, September and December. According to Moses

(1987) the appearance and disappearance of young fish from estuaries and lagoons appears to be controlled not only by fluctuating salinity, but perhaps also by the spawning periods of the fish.

Analysis using the Gulland & Holt and Ford – Walford methods gave the results of asymptotic length, L_{∞}, as 13.7 cm TL, VBGF growth constant (K) = 1.48 year^{-1} and Z/K = 1.716 (Table 1). Also the growth and weight performance index φ' and φ were 2.444 and 0.6833, respectively. Estimated values for t_o, L_o, and t_{max} were –0.13 year, 2.40 cm TL and 3 years, respectively. From these parameters, Von Bertalanffy length (L_t) and weight (W_t) growth functions were established as:

$$L_t = 13.7\ [1- exp^{-1.48\ (t - (-0.13))}]$$
$$W_t = 5.83\ [1- exp^{-1.48\ (t - (-0.13))}]^{3.005}$$

Result obtained from the length-converted relative age using Bhattacharya (1967) analysis of the length-frequency distribution indicates six modal classes with mean lengths as indicated in Table 1. After isolating the various cohorts, this resolved into mean lengths of 7.4 cm, 11.55 cm and 13.3 cm, corresponding to age groups I, II and III (Figure 3) with age 1^+ dominating the catch (95.7%) followed by ages 2 (2.8%) and 3 (1.2%).

The growth coefficient (K) of clupeids (such as *Sardinella aurita* Valenciennes, 1847) living in tropical waters are highly variable ranging from 1.0 to 1.2 year^{-1} (= 25^{o}C) and 2.4 to 2.9 year^{-1} (= 29^{o}C) (Pauly 1978) whereas Ursin (1984) suggested a mean value of K = 0.72 (26^{o}C). Pauly (1980b) reported L_{∞}, and K for four clupeids in Indo-Pacific waters as 13.0-51.1 cm TL and 0.49-1.65 year^{-1}, respectively. Kunzel & Lowenberg (1990) derived K' = 0.81 and K = 0.96, respectively, from two independent methods for *P. leonensis* in Cross River estuary. K of 1.48 year^{-1} (27.7^{o}C) in this study falls within the above range; and the lowest growth rate occurred around September, that is, during the peak of the rainy season. Payne (1986) noted that at such times tropical rivers show the lowest growth of phytoplankton and low abundance of zooplankton (Kunzel & Lowenberg 1990). This was supported by Otobo (1979) and Marshall (1987) who indicated that clupeids feed mainly on zooplanktons and reduced food supply during the rainy season resulted in growth depression.

Table 1

Mean length-at-age of *O. mento* in the lower Cross River, southeast Nigeria, estimated from length frequency distribution and the exponential model

Age	*Mean TL, cm*		*% Age Composition*
	Catch curve	*Exponential model*	
I	6.1	11.13	65.5
II	7.5*	13.11*	28.7
III	8.6*	13.57*	1.5
IV	10.6*	13.67*	2.0
V	12.5*	13.69*	1.5
VI	14.1*	13.70*	0.8

*Cohorts not separable

Length–weight relationship is used for converting weight data to length and vice-versa. The length exponent "b" of the length-weight relationship is ~ 3.0 (b = 3.005; r = 0.9623; F = 0.289214; n = 35) (Figure 4) indicating an isometric growth:

$$LogTW = 3.005LogTL - 2.223$$

The b value in this study is different from the report of Entsua-Mensah et al (2010) for the same species in Volta River, Ghana (a = 0.0383; b = 2.456; 6.3-11.6 cm SL), but falls within the limits reported, 2.0-3.5 (Carlander 1969), 2.5-3.5 (Carlander 1969) and

2.5-4.0 (Lagler et al 1997) for fish. Froese (2006) reported that in multi-species fisheries $b<>3$ is typical but confirmed the expected range as $2.5 < b < 3.5$, with median b = 3.03 being significantly larger than 3.0, across species, indicating a tendency towards slightly positive-allometric growth (increase in relative body thickness or plumpness) in most fishes. Within-species variance in weight–length relationships and condition factor can be substantial, depending on the time/season, the population, and stomach fullness, developmental state of the gonads or annual differences in environmental conditions. As a result, differences in weight estimated from length can be two-fold or more, depending on which relationship is chosen. The condition factor of the fish sampled was 0.65±0.12 (0.42-1.15). However, growth of fish is isometric at the early age (t_o) and allometric at later age (t_{max}) (Bagenal & Tesch 1978).

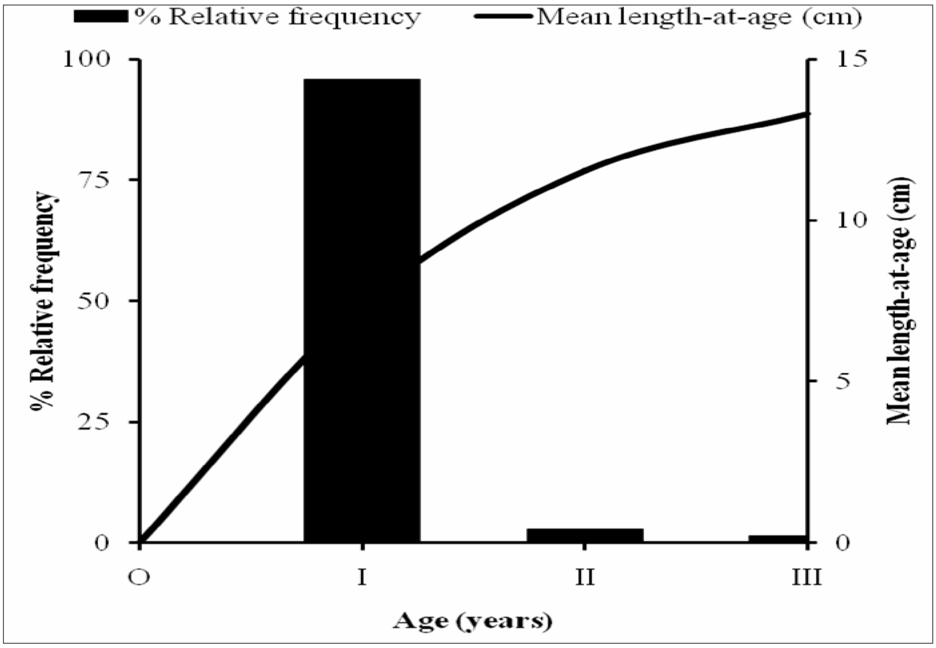

Figure 3. Age composition and growth curve estimated from mean length-at-age data of *O. mento* in the lower Cross River, Nigeria (L_∞ = 13.7 cm TL, K = 1.48 yr^{-1}, t_0 = -0.13, φ' = 2.444).

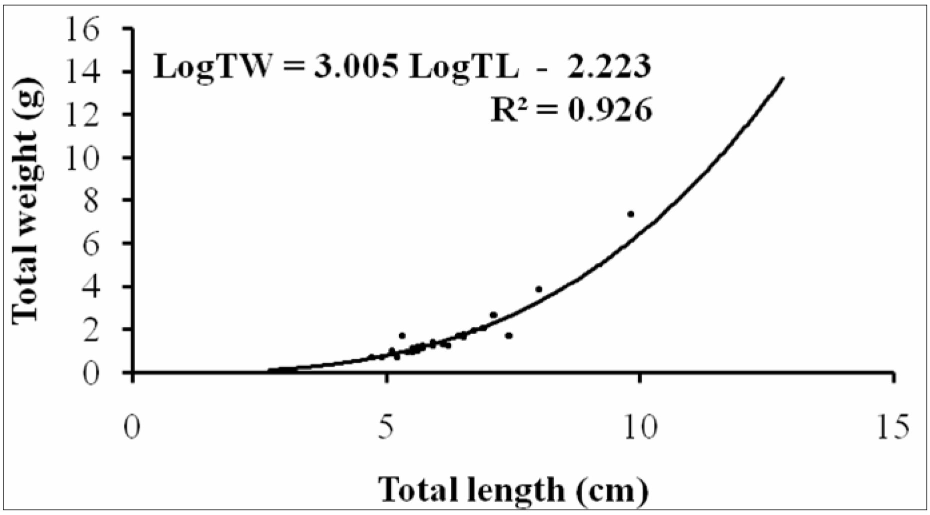

Figure 4. Length–weight relationship of *O. mento*.

Table 2

Parameters of von Bertalanffy equation of *O. mento* in the lower Cross River system estimated from length frequency distribution compared to *P. leonensis*

Analytical Method/Species	*L_∞, cm TL*	*K, yr^{-1}*	*t_o, yr***	*φ′*
Gulland & Holt*	13.7	1.48	-0.13	2.444
Ford – Walford*	13.7	1.48	-0.13	2.444
P. leonensis Lower Anambra River (Uneke et al 2010)	9.98	1.3	-0.79	2.112
P. leonensis Cross River estuary (Kunzel & Lowenberg 1990)	10.00	0.960	-0.65	2.37

*This study; ** estimated empirically from Pauly (1980 a,b).

Mortality estimates (total, natural and fishing mortality rates) are essential values commonly used in making deductions on potential and maximum sustainable yield for rational exploitation/utilization and optimal management of the fish stock. Wrong estimates of potential yield can result in over exploitation or under exploitation of the fish stock. In this study, we examined the effect of fishing on *O. mento* stock in the lower Cross River. Using the length frequency distribution of Figure 2G to construct the length-converted catch curve (Figure 5), we computed total (*Z*) and natural mortality coefficient (*M*) for *O. mento* (Z = 2.54 $year^{-1}$; M = 1.58 $year^{-1}$) and derived fishing mortality coefficient, *F,* 0.96 $year^{-1}$. The current exploitation ratio, E_{cur} was computed as (F/Z) = 0.37795, indicating that about 38.0% of the total mortality of the available stock was caused by exploitation; while the rate of exploitation, *μ,* gave 0.3481yr^{-1}, indicating that about 35% of the available stock was fished annually (lower than the exploitation ratio, E_{cur} = 0.38). The optimum yield of a fishery is taken when the fishing mortality (*F*) is about equal to the natural mortality (*M*) i.e. $F = M$ or $E = F/Z = 0.5$; hence $E < 0.5$ indicates the *O. mento* of the Cross River system is under exploited (Table 3). The species has a short lifespan of 2-2.5 years and attains up to 50% of the asymptotic length at the first age class (Figure 3).

Table 3

The estimated population parameters of *O. mento* in the lower Cross River system compared with *P. leonensis* (clupeidae) in Southeast Nigeria

Parameters	*Rates*	
	*O. mento (LCR)**	*P. leonensis (LAR)***
Total Mortality Coefficient (*Z*), yr^{-1}	2.54	4.03
Natural Mortality Coefficient (*M*), yr^{-1}	1.58	2.77
Fishing Mortality Coefficient (*F*), yr^{-1}	0.96	1.26
Exploitation Ratio (*E*)	0.38	0.31
Rate of Exploitation (*μ*),yr^{-1}	0.35	0.31
L_c/L_∞	0.423	0.289
L_{25}/L_∞	0.389	0.232
L_{75}/L_∞	0.460	0.347
M/K	2.081	2.131
Z/K	1.716	3.100

L_c/L_∞ = ratio of length at first capture to length at infinity indicating fraction of growth completed by the fish on entry into the exploitation phase; M/K = ratio of natural mortality (M) to intrinsic growth rate (K) indicating entry into the exploitation phase; LCR = Lower Cross River; LAR = Lower Anambra River; *This study; ** Uneke et al 2010.

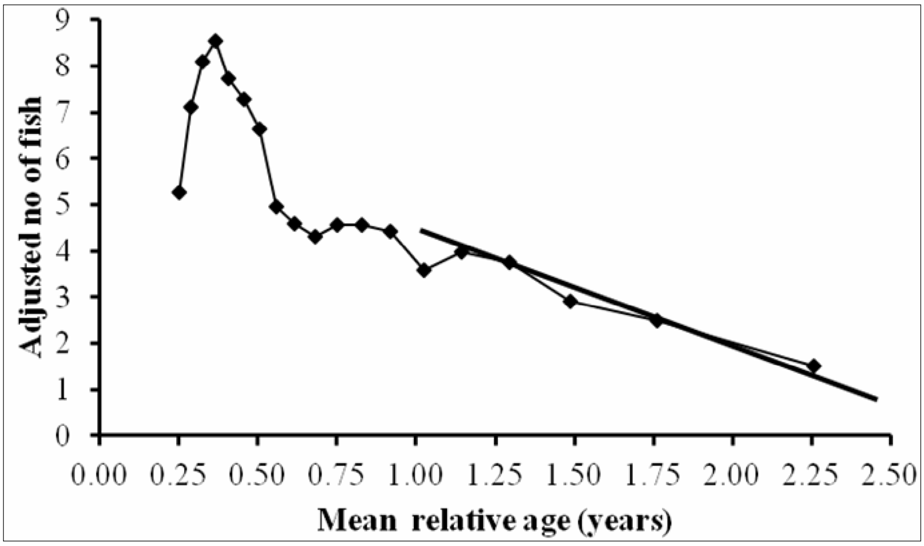

Figure 5. Length-converted catch curve of *O. mento*
($Z = 2.54$ year^{-1}, $M = 1.58$ year^{-1}, $F = 0.96$ year^{-1} and $E = 0.38$).

The instantaneous total mortality coefficient, Z indicates the amount of fish mortality as a result of both natural death (M) and fishing (F). Z, M and F values estimated by this study compare with those reported for other clupeids. The population parameters estimated for *O. mento* (6.0–30.0 cm SL) in lower Anambra flood river system, Nigeria, are similar and comparable to those obtained in this study (Table 3). The VBGF were estimated as $L_\infty = 9.98$ cm TL and $K = 1.3$ year^{-1}; $Z = 4.03$ yr^{-1}, $M = 2.77$ yr^{-1}, $F = 1.26$ yr^{-1} and $E = 0.31$; and the relative yield/biomass per recruit ($E_{max} = 0.641$ and 0.630, respectively) indicate the stock was not overexploited, since $E<E_{max}$. The M value is also a necessary input in the computation of many models in fish population dynamics study. Moses (1990) showed that *Ethmalosa fimbriata* in the Cross River estuary was fully vulnerable at 7.6 cm TL onward. Earlier studies established that the distribution and catch of the small clupeid (*Pellonula*) correlated with water transparency such that high yields are associated with high transparency. Kunzel & Lowenberg (1990) identified January/February as the time of highest spawning near Ikot Okpora, an upstream station with fresh water condition.

The computed age, T_c, and length-at-first capture, L_{50} or L_c (age and length at which 50% of the fish entering the gear are retained) was $T_c = 1.7$ year while $L_c = 5.64$ cm TL (Figure 6). The sizes at which 25% and 75% of the catches are retained by the gear were estimated as $L_{25} = 5.19$ cm TL and $L_{75} = 6.14$ cm TL (Figure 6). The relative yield per recruit ($Y`/R$) is a function of different values of exploitation ratio (E) and length at first capture Lc. The present finding indicates the fishery is exploited at age 1.7 yr, $L_c = 5.64$ cm TL and 50-55% of growth is yet to be completed by the fish at the time of captured. This finding serves as a baseline data for further studies in the recruitment of *O. mento* in the lower Cross River system.

Small fish like *O. mento* are abundant and less attractive to rich people, but it is of high value to the poor and under privileged people who constitute the majority and to whom larger fish are unaffordable. They, like sardines, contain vitamins A, D and B groups as well as calcium and phosphorus (Whitehead 1985). The L_c/L_∞ and $L_{25.75}/L_\infty$ values indicate the fraction (0.39–0.46) of growth completed by the fish on entry into the exploitation phase is approximately 40–50%. However, the M/K ratio of 2.08 obtained (Table 3) is similar to 2.13 value derived from Uneke et al (2010) and falls within the range of 1.0 to 2.5 (for fish) indicating a good environmental state (Beverton & Holt 1959). The M/K ratio is an indirect method used by scientists to examine the accuracy of growth parameters and is supposed to be constant for a group of species or closely related families or taxa (Chakraborty 2001).

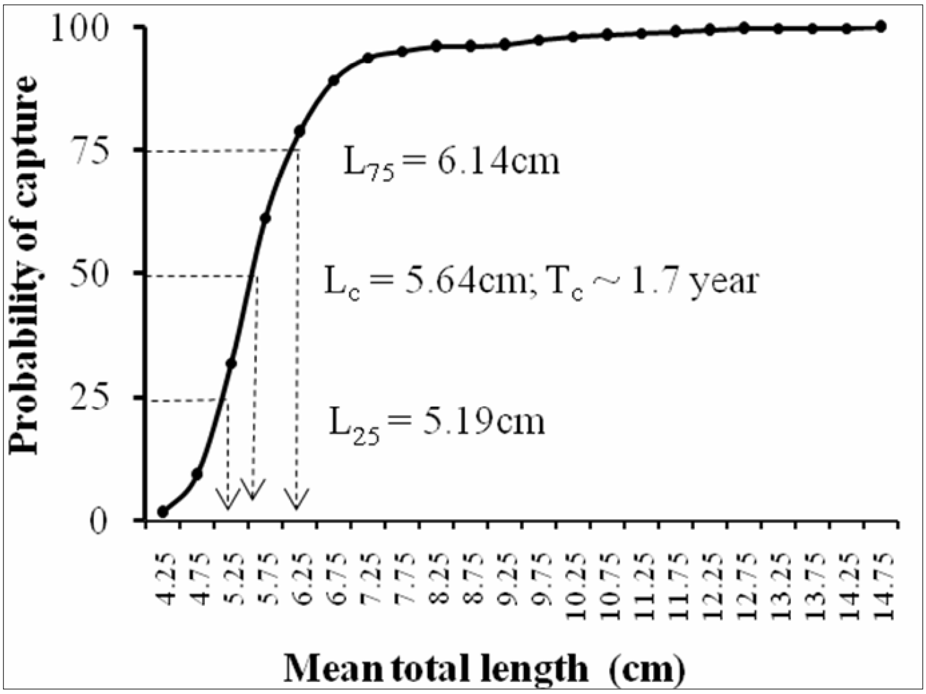

Figure 6. Probabilty of capture of *O. mento* in the lower Cross River indicating the sizes at which 25, 50 and 75% of the catches are retained by the gear.

The size range of 4.25-14.75 cm TL and its preponderance at 5.5-6.0 cm TL, in this study, is a good reflection of its population structure in that the fish grows fast, becomes recruited into the fishery with high fishing and natural mortality (L_c = 5.64cm*TL*). The L_∞ value of 13.7 cm TL in this study (Table 2) is higher than values of $L_\infty \approx 10$ cm TL for *P. leonensis* by Whitehead (1985) and Kunzel & Lowenberg (1990). The reported values for *K* and *φ′* (Uneke et al 2010; Kunzel & Lowenberg 1990) correspond with the values of this study (*K* = 1.48 and *φ′* = 2.444), indicating relatively high growth performance for *O. mento* (Table 2). The annual growth parameters estimated for *S. aurita* in Northwest Africa showed values of *K* (0.405, 0.325 and 0.316), L_∞ (362.5, 393.7 and 389.7 cm TL) with t_0 (-1.458, -1.578 and -1.780), for male, female and all individuals, respectively (Santamaria et al 2012).

Mortality is function of several factors including growth, intrinsic growth rate (*r*) and growth curvature (*K*), size/weight, longevity as well as temperature (Pauly 1980 b). Mortality creates room for more new recruits; it removes slow-growing fish replacing them with smaller fast-growing fish, resulting in greater rate of recruitment and faster growth. Computed values of *Z, M* and *F* in this study were lower than mortality rates of other clupeids (Table 3). *F*<1, in this study indicates dominance of natural mortality in the *O. mento* stock highlighting the contributions of clupeids as forage species for other piscivores; coupled with cannibalism. The computed L_c of 5.64 cm TL is in close range to the smallest sampled individual of 4.25 cm TL indicating selection/capture is a function of fish length/size class as against the Knife-Edge procedure which assumes that fishes less than L_e are not captured by the gear. As a general rule, when *Z/K* > 1, mortality dominates the stock; if it is equal to 1, then the population is in an equilibrium state where mortality balances growth and if <1, the population is growth-dominated. In a mortality-dominated population, if *Z/K* ratio = 2, then it is a lightly exploited population. In this study, *Z/K* = 1.716, i.e., indicating light exploitation of *O. mento* stock; compared to *Z/K* = 3.100 in Anambra river (Table 3), indicating high levels of exploitation of *P. leonensis* stock in Southeast Nigeria.

The predicted rate of exploitation, *µ,* of 0.3481yr^{-1} is lower than the current exploitation ratio, E_{cur} = 0.38. This means that the stock is lightly exploited, as corroborating the *Z/K* ratio. Hence, the stock could still accommodate higher fishing effort to meet the nutritional needs of the low income populace.

The present situation of *O. mento* stock does not call for management intervention. In spite of the remarkable productivity of the clupeids fishery coupled with cheap and easy construction of gears, the number of fishers is few. Otobo (1979) reported that clupeid fishers could earn more than *Tilapia* and *Citharinus* fishers within the same period. However, considering the multi-species open-access nature of the fishery and to ensure ecosystem-based fisheries management, increasing exploitation rate could increase yield per recruit without causing over-capitalization or overexploitation, growth and recruitment overfishing. However, to ensure ecosystem-based fisheries management, sustainable catches with the least impact on the stocks are best taken at L_{opt} = 10.1 cm TL, where the product of survivors times mean individual weight reaches a maximum and which offers best condition - 2% more weight per specimen than at L_c or L_{75} (Beverton 1992; Froese & Binohlan 2000; Froese 2004).

Conclusions. *O. mento* in the lower Cross river system is lightly exploited; it has a very rapid growth rate (K = 1.48 year^{-1}), small maximum size (L_∞ = 13.7 cm TL), short life span (t_{max} ≈ 3 years) and high natural mortality (M = 1.58 year^{-1}), making the species ecologically an *r*-selected species.

Acknowledgements. The researchers wish to acknowledge the immense contributions of Dr. B. S. Moses in data analyses and report presentation.

References

Bagenal T. B., Tesch F. W., 1978 Age and growth. In: Methods of assessment of fish production in freshwater. Bagenal T. (ed.), HBP Handbook, No. 3, Blackwell Scientific Publication, Oxford, pp. 101–136.

Beverton R. J. H., 1992 Patterns of reproductive strategy parameters in some marine teleost fishes. J Fish Biol 41(Suppl. B):137–160.

Beverton R. J., Holt S. J., 1959 A review of *Limnothrissa modon* in Lake Kariba. Symposium of biology, stock assessment and exploitation of small pelagic fish in the African Great Lakes region. CIFA Occasional Paper, No. 19, pp. 75.

Bhattacharya C. G., 1967 A simple method of resolution of a distribution into Gaussian components. Biometrics 23:115-135.

Carlander K. D., 1969 Handbook of freshwater fishery biology, Vol. 1. The Iowa State University Press, Ames, IA, 397 pp.

Chakraborty S. K., 2001 Growth studies of sciaenids from Mumbai waters using the Bhattacharya method. Naga, ICLARM Quarterly 24(1-2):40-41.

Ehrdardt N. M., Jacquemin P. S., Francisco G. B., German G. D., Juan M. L. B., Juan O. O., Austin S. N., 1975 On the fishery and biology of the giant squid *Dosidicus oioas* in the gulf of California, Mexico. In: Advances in assessment of world cephalopod resource. Caddy J. R. (ed), FAO Fish Acch Pap 231:306-339.

Entsua-Mensah M., Lalèyè P., Moelants T., 2010 *Odaxothrissa mento*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Accessed on 15 December, 2011.

Food and Agriculture Organisation, 2002 Report of the Sardine Otolith Workshop. Kaliningrad, Russian Federation, 28–31 August, 2001. FAO Fisheries Report No. 685, Rome, FAO, 59 pp.

Fischer W., Bianchi G., Scott W. B., 1981 FAO species identification sheets for fisheries area 34, 47. Canada Funds-in-trust, Ottawa and Dept. Fish. Oceans by arrangement with FAO, 47 pp.

Ford E., 1933 An account of the herring investigations conducted at Plymouth during the years from 1924 to 1933. Journal of the Marine Biological Association of the United Kingdom19:305-384.

Froese R., 2004. Keep it simple: three indicators to deal with overfishing. Fish and Fisheries 5:86–91.

Froese R., 2006 Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J Appl Ichthyol 22:241–253.

Froese R., Binohlan C., 2000 Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. J Fish Biol 56:758–773.
Gulland J. A., 1969 Manual of methods for fish stock assessment. Part 1. Fish Population Analysis. FAO Manual in Fisheries Science No. 4, Rome, 154 pp.
Kunzel T., Lowenberg U., 1990 Studies on the population dynamics of *Pellonula leonensis* (clupeidae) in Cross River, Nigeria. Fishbyte 8:8-13.
Lagler K. F., Bardach J. E., Miller R. R., Passino D. R. M., 1997 Ichthyology. John Wiley and Sons Inc, USA, 506 pp.
Laudau R., 1979 Growth and population studies of *Tilapia galilaea* in Lake Kenneret. Freshwater Biology 9:23-32.
Lowenberg U., Kunzel T., 1991 Investigation on the trawl fishery of the Cross River Estuary, Nigeria. J Appl Ichthyol 7:44-53.
Marshal B. E., 1987 Growth and mortality of the introduced Lake Tanganyika clupeid *Limnothrissa miodon* in Lake Kariba. J Fish Biol 31:603-615.
Moses B. S., 1987 The influence of flood regime on fish catch and fish communities of the Cross River floodplain ecosystem, Nigeria. Envir Biol Fish 18:51-65.
Moses B. S., 1988 Growth, mortality and potential yield of bonga, *Ethmalosa fimbriata* (Bowdich, 1825) of Nigerian inshore waters. Fish Res 6:233-247.
Moses B. S., 1990 Growth, biomass, mortality, production and potential yield of the West African clam *Egeria radiata* (Lamark) (Lamellibranchia, Donacidae) in the Cross River system, Nigeria. Hydrobiologia 196:1-15.
Otobo F. O., 1979 The fish fauna changes and the place of clupeids in Lake Kainji, Nigeria. Hydrobiologia 64(2):99–103.
Pauly D., 1978 A preliminary compilation of fish length growth parameters. Ber Inst Meereskd. Christian-Albrechts Univ Kiel, No. 55, 200 pp.
Pauly D., 1980a A new methodology for rapidly acquiring basic information on tropical fish stocks: growth, mortality and stock-recruitment relationships. In: Stock assessment for tropical small-scale fisheries. Saila S. B., Roedel P. M. (eds.), Int. Center for Marine Resource Dev., Univ. Rhode Island, pp. 154-172.
Pauly D., 1980b A selection of simple methods for the assessment of tropical fish stocks. FAO Fish. Circ., No 729, FAO, Rome, 54 pp.
Pauly D., 1983 Some simple methods for assessment of tropical fish stocks. FAO Fish. Tech. Pap. No. 234, FAO, Rome, 52 pp.
Pauly D., 1984 Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Studies and Reviews No. 8, Manila, Philippines, 325 pp.
Pauly D., Munro J. L., 1984 Once more on the comparison of growth in fish and invertebrates. Fishbyte 2(1):21.
Payne A. I., 1986 The ecology of tropical lakes and rivers. John Willey and Sons, Chichester, 301 pp.
Ricker W. E., 1975 Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 119, 382 pp.
Santamaria M. T. G., Hernández E., Pascual-Alayón P., Balguerías E., Sancho A., Duque V., Quintero M. E., 2012 Age determination and preliminary growth parameters of round sardinella (*Sardinella aurita* Valenciennes, 1847) off Northwest Africa. In: Science and management of small pelagics. Garcia S., Tandstad M., Caramelo, A. M. (eds), Symposium on Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, 11–14 March 2008, Casablanca, Morocco. FAO Fisheries and Aquaculture Proceedings. No. 18. Rome, FAO, pp. 431–433.
Sparre P., Venema S. C., 1992 Introduction to tropical fish stock assessment. Part 1. Manual FAO Fish Tech Pap No. 306(1), FAO, Rome, 376 pp.
Spliethoff P. C., de Iongh H. H., Frank V. G., 1983 Success of the introduction of the fresh water clupeid *Limnothrissa miodon* (Boulanger) in Lake Kivu. Fish Mngl 14(1):17–31.

Sylla M., Wagué A., El Youssoufi A., Mendy A., Diagne A., Amenzoui K., Darboe F., Santamaria M. T. G., Timoshenko N., Morgado C., Caramelo A. M., Tandstad M., 2012 Age estimation of sardine (*Sardina pilchardus*) and round sardinella (*Sardinella aurita*) in Northwest Africa. In: Science and management of small pelagics. Garcia S., Tandstad M., Caramelo, A. M. (eds), Symposium on Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, 11–14 March 2008, Casablanca, Morocco. FAO Fisheries and Aquaculture Proceedings. No. 18. Rome, FAO, pp. 425–430.

Teugels G. G., Reid G. M., King R. P., 1992 Fishes of the Cross River basin (Cameroun-Nigeria): taxonomy, zoogeography, ecology and conservation. Annales du Musée royal d'Afrique centrale (Sciences Zoologiques) 266, 132 pp.

Uneke B. I., Nwani C. D., Okogwu O., Okoh F., 2010 Growth, mortality, recruitment and yield of *Pellonula leonensis* Boulenger, 1917 (Osteichthyes: Clupeidae) in a tropical flood river system. Journal of Fisheries International 5(1):19-26.

Ursin E., 1984 The tropical, the temperate and the arctic seas as media for fish production. Dana 3:43–60.

Uwe-Bassey B. U., 1988 The catch structure of the artisanal gillnet fishery of the lower Cross River. M. Sc. Thesis, University of Calabar, Nigeria, 105 pp.

Walford L. A., 1946 A new graphic method of describing the growth of animals. Biol Bull 90:141-147.

Whitehead P. J. P., 1985 FAO Species Catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. FAO Fish. Synop. Rome, FAO, 125(7/1):1-303.

*** Google earth, 2013.

Received: 04 September 2013. Accepted: 25 October 2013. Published online: ... November 2013.

Authors:
James P. Udoh, Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo-52001, Nigeria, e-mail: jjamesphilip@gmail.com; jamesudoh@uniuyo.edu.ng
Imaobong E. Ekpo, Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo-52001, Nigeria, e-mail: imaobongekpo14@yahoo.com
Emah E. Essien, Akwa Ibom Agricultural Development Programme (AKADEP), Mbiabong-Etoi, Uyo, Akwa Ibom State, Nigeria, e-mail: essienemah@yahoo.com

How to cite this article:
Udoh J. P., Ekpo I. E., Essien E. E., 2013 Preliminary biodata and growth parameters of *Odaxothrissa mento* in the lower Cross River, southeast Nigeria. AACL Bioflux 6(6):599-610.