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GROWTH, MORTALITY AND YIELD OF *PARAILIA PELLUCIDA* (SILURIFORMES: SCHILBEIDAE) IN THE UPPER PORTION OF JEBBA RESERVOIR, NIGERIA

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ABSTRACT

The growth, mortality and yield estimates of the schilbeid catfish, Parailia pellucida (Boulenger), in Jebba Reservoir, Nigeria, were obtained from monthly length frequency data of 12136 specimens collected between November 2003 and October 2004. The von Bertalanfy growth function (VBGF) estimates were: L=129.21 mm forked length; K = 1.810 year^{-1}. The growth performance index was 4.48. The natural mortality rate (M) was 1.71year^{-1}, total mortality rate (Z) 6.54 year^{-1} and the exploitation ratio (E=F/Z) 0.737. Length at first capture L_c was 20 mm FL and maximum length caught was 117 mm FL. Parailia pellucida recruits into the fishery throughout the year with an extended pulse from September to March corresponding to the period of the two flood regimes of the lake. The estimated longevity was 1.65 years. From the Beverton and Holt relative yield per recruit analysis via Knife-edge procedure, were E_{max}= 0.457, $E_{0.1}$=0.357 and $E_{0.5}$= 0.294 while via Selection Ogive were E_{max}= 0.457, $E_{0.1}$=0.407 and $E_{0.5}$= 0.192. The fishery is supported by two sub-stocks, the Lake Kainji stock occurring upstream and those of Jebba Reservoir. The management proposed is that more fishers should exploit the population in the middle and lower portion of the Lake.

***Keywords:** Growth; Mortality; Parailia pellucida; yield; Jebba Reservoir.*

INTRODUCTION

The schilbeid catfishes are important in the component of ichtyofauna of West African fresh waters (Olatunde 1977a; Etim *et al*, 1999). In Lake Kainji, comparative ecology of members of this family namely, *Eutropius niloticus*(Ruppell), *Parailia pellucida* (Boulenger), *Schilbe mystus* (Linnaeus), *S. uranoscopus* (Ruppell) and

Siluranodon auritus (Geoffroy Saint-Hilaire) were studied by Olatunde (1977a & b, 1978a&b, 1979). The analysis of abundance of these fish using gillnet revealed that *Eutropius niloticus* is the most abundant, followed by, in order of importance, *Parailia pellucida, Schilbe mystus, S. uranoscopus* and *Siluranodon auritus* (Olatunde, 1977a). According to Olatunde (1977a), *P. pellucida* were greatly underestimated by the gear used because of its small maximum sizes (120mmTL). *Parailia pellucida* (synonym: *Physailia pellucida*) also known as Glass catfish is a small almost transparent pelagic catfish. The skeleton and airbladder can be clearly seen through the flesh (Reed, et al., 1967). *P. pellucida* (15cmTL) is the biggest and the only commercial species in this genus. Other species are *P. spiniserrata* (6.6cm TL) found in the lower and middle Gambia River, lower Geba River and the Jong Basin (Sierra Leone); *P. somalensis* (6.9cmTL) found in the Ganana River (Somalia) and Tana River (Kenya); *P. occidentalis* (8.5cmTL) found in Ogowe, Congo, Quanza, Luculla and Chiloango Rivers and *P. congica* (10.0 cm TL) found in the Congo Basin.

Even though *P. pellucida* is outnumbered only by the clupeids (*Sierrathrissa leonensis* and *Pellonula leonensis*), they are presently underexploited in Kainji Reservoir because of a lack of appropriate gear to harvest them (Olatunde, 1977). However, in the Jebba Reservoir immediately below the Kainji Dam they presently support a small but important fishery distinct from the clupeids fishery. The fish are usually smoked or sun dried after which they are very tasty and fetch high prices (Reed *et al.*, 1967). Jebba Reservoir unlike Kainji Reservoir has received very little attention since its inception in 1983 besides pre-impoundment and immediate post impoundment studies (Ita *et al*, 1984 & 1985). Systematic data collection from the Lake's fish resources have been lacking. The primary objective of this study is to provide information relevant to the management of the *P. pellucida* fishery in Jebba Reservoir. This paper focuses on the length composition of the catch, growth parameters, mortality and recruitment pattern of *P. pellucida*. The exploitation rate and relative yield per recruit were also computed.

MATERIALS AND METHODS

STUDY AREA

Like the Kainji reservoir upstream, Jebba Reservoir (Figure 1) is a shallow tropical man-made lake created in July 1983 by the damming of river Niger at Jebba, 100km downstream of Kainji dam. It is located in the northwestern part of Nigeria, between 9° 35' N and 9° 50'N and 4° 30'E and 5° 00'E. It has an estimated surface area of 303km^2 and a volume of $3.31 \times 10^9 m^3$. The maximum depth is 105m and a mean depth is between 11m (Ita *et al.*, 1984). Description of the geology and geography of the Niger valley in the area which is now Jebba Reservoir has been described by NEDECO (1959); White (1965); Imevbore (1970). The rocks in the area consist of a Precambrian basement complex and cretaceous sediments, both of which are overlain in some parts by alluvial deposits. The lake can be divided into three different sections. The first extends from the dam to immediately after Moshi River, and consists to the north a deep and steep wide stretch forming about 60% of the total surface area. The second or central part of the lake is a narrow steep sided that only extends a little bigger than the original Niger River course. The third section is like the second parts just immediately after the Kainji dam include the Awuru rapid that has now been submerged. This portion is constantly under the influence of the discharge from Kainji Dam.

Jebba Reservoir sources its water mainly from Kainji Lake on River Niger. Other sources include Kotangora, Oli, Wuruma, Moshi, Eku and Awun Rivers. The lake experiences two major floods events per year, namely the 'white' and 'black' floods. The white flood is a result of rain from Nigeria that enters the lake from mid-August with peak flow of 4000 - 6000 m^3s^{-1} from September to October. It is characterized by high turbidity hence the name 'white flood'. The black flood is derived from the rainfall at the upper catchments of River Niger (Guinea, Mali and Burkina Faso), and enters the lake in November with a peak flow of about 2000 m^3s^{-1}. It is characterized by high water transparency. Jebba Reservoir, like Kainji Reservoir, has a high ratio of annual inflow to volume (Mbagwu *et al.*, 2000).

JEBBA RESERVOIR FISHERIES

The fisheries of Jebba Reservoir are mainly artisanal with six fishing villages and 42 fishing camps. According to a frame survey of 2000 (Abiodun *et al.*, 2001; Alamu, 2001) there are 1173 fishermen and 701 fishing canoes, of which 35 have out-board engines. The main types of gears are gillnets (1455). Other gear includes 1165 fishing traps, 971 longlines, 219 cast-nets, 81 Atalla liftnets and 2 beach seine nets. At the time of this study, there are 125 Atalla lift-nets in the lake own by fishers, mainly in Fakun and New Awuru, both villages with a substantial population of Ijaws and Urhobo tribes who are known to use the gear. Of these 125 Atalla, 81 have a 10 mm mesh size used for glass catfish while the rest have a 2 mm mesh size used for clupeids. Women who employed fisherman assistants, in addition to family members for the fishing operations own more than 60% of them. The gear is not used in other parts of the Lake because the kind of current eddies best for its operation are created by discharges from the turbines of the Kainji power station. The fishery is mainly concentrated in the narrow upper portion of the lake 10 km below the Kainji Dam.

LENGTH FREQUENCY

Monthly samples of *Parailia pellucida* were obtained from artisanal fishermen in Fakun and Awuru between November 2003 and October 2004. Samples were collected on every 25^{th} of the month. The fork length of each specimen in a subsample of two kilogram was measured in mm. Fish Stock Assessment Tool (FiSAT) software (Gayanilo *et al.*, 2001) was used to analyze the monthly length-frequency data. Modal progression analyses were performed on the length frequencies using the method of Bhattacharya (1967). The means in each mode were linked and used to generate growth increment data for Gulland and Holt plot and Fabens relative age plot. The ELEFAN procedure in FiSAT was used to sequentially arrange and restructure the monthly length-frequency data from where the preliminary L_{∞} parameter was seeded. The procedure was then used to fit the seasonalized Von Bertalanffy growth function (VBGF) using the equation as modified by Somers (1988).

$$L_t = L\,[1\text{-exp -K(t-}t_o) + (CK/2\pi)\sin(2\pi(t\text{-}t_s)\ (C/K2\pi)\sin 2\pi(t_o\text{-}t_s)]$$

Where L_{oo} = the asymptotic length, K = the von Bertalanfy growth coefficient (year^{-1}), L_t = the length at time t, t_o = the age of fish at zero length, t_s = present length and C = is amplitude of growth oscillations. Here t_s was replaced with WP (wintering point, the time of slowest growth) as WP = t_s + 0.5. The overall growth performance index ? was quantified using Pauly and Munro's model (1982). The length frequency method was used in this study as the use of hard parts of *Parailia pellucida* did give a clear result and this has also been observed by Olatunde (1977), however a few specimens were kept in aquarium for about two months for growth studies. The delicate nature of this fish makes this method also difficult to use as mortality rate was high.

NATURAL MORTALITY

Natural mortality (M) was estimated using Pauly's equation (1980):

$$\text{Log (M)} = -0.0066 - 0.279 \log(L) + 0.6543 \log10(K) \quad + 0.4634 \log10(T)$$

where T = water temperature (°C). The value T = 26.9 °C was entered for both populations.

TOTAL MORTALITY (Z)

Total mortality (Z) of the population was estimated from mean length in the Beverton & Holt (1956) model. The growth performance index phi (?) was quantified using the model of Pauly and Munro (1984);

$$? = 2 \log L + \log K$$

The potential longevity of the catfish was estimated according to Pauly, (1980); $T_{max} = 3/K$

Relative indices of abundance were determined from the length structured virtual population analysis (VPA) of the monthly catch data (Jones 1984). Relative yield per recruit was estimated according to Beverton and Holt (1966) as modified by Pauly and Soriano (1986).

RESULTS

The monthly length frequency data used in the present analysis (Figure 2) consists of 12136 *Parailia pellucida* sampled, ranging from 20 mm to117 mmFL. The minimum length was found in December and February, while the maximum length was found in June. The highest mean fork length was recorded in August (80.98 mmFL) and the lowest in February (51.47 mmFL). Mean length for all data was 62.75 mmFL, median length 55 mmFL and the mode 55 mmFL. Monthly mean lengths were low in the months of high water (September to March) and high during the low water period (April to August). The highest mean length (80.98 mmFL) was recorded in the period of lowest water as shown in Figure 3. The monthly length frequency was unimodal for November and December, 2003 and for January and February, 2004 while two distinctive class groups existed from March to August 2004. The modes are March (55 mm & 85 mm), April (55 mm & 90 mm), May (55 mm & 90 mm), June (60 mm & 87 mm), July (60 mm) and August (60 mm & 90 mm). The Powell-Wetherall plot gave an initial value for L of 129.21 mmFL and a Z/K of 4.171 while was r = 0.808.

Using L = 129.21 mmFL as seed value analysis with ELEFAN gave the following seasonalized von Bertalanffy Growth coefficients: L = 129.21mm (fork length), K= 1.81year^{-1}, C= 0.50 and WP = 0.25 (Figure 4). The curve was superimposed over the length-frequency histograms using a November as the starting sample and 20mmFL as the starting length (Figure 5). The growth parameter from the Gulland and Holt plot estimate of L was 129.21mmFL and the estimate of K was 2.48year^{-1}. The overall growth performance index, phi prime (?) determined by Pauly and Munro, (1982) was 4.48.

Using the estimated value of the average growth coefficient (K=1.81 year^{-1}), the longevity t_{max} (= 3/K), was calculated as about 1.65 years. The instantaneous total mortality rate (Z) using seasonalized length-converted catch curve was 6.54year^{-1}(Fig. 6). Jones and van Zalinge plot gave an estimated value of 4.988. The instantaneous natural mortality (M) from Pauly's empirical formula (1980) using an average surface temperature of 26.15°C was 1.71year^{-1}. Based on the Z obtained from the seasonalized length-converted catch curve, the instantaneous fishing mortality of 4.82 year^{-1} was computed through the relationship F=Z-M. The current exploitation rate E (=F/Z) was estimated as 0.73 year^{-1}. Virtual population analysis (VPA) output from FiSAT showing catches, survivors and fishing mortality for the various length classes is given in Figure 7.

The recruitment pattern of *P. pellucida* was plotted in relation to the percentage of recruitment versus time (i.e. projecting a set of length-frequency backward onto a 1-year time axis) as shown in Figure 8. The fish recruits into the fishery throughout the year with an extended pulse from September to March corresponding to the period of the two flood regimes of the lake. The probability of capture of *P. pellucida*, which indicates the selectivity pattern of the gear, estimated length at L_{25} as 19.93mmFL, L_{50} as 22.44mmFL and L_{75} was 31.28mmFL with 10mm mesh size net that is used in capturing them.

Relative yield per recruit and relative biomass per recruit were computed using Knife-edge and Selection Ogive procedures. The relative yield per recruit analysis (knife-edge) is shown in Figure 9. The maximum exploitation rate (E_{max}) that gives maximum relative yield per recruit was 0.454. The exploitation rate, which corresponds to 50% of yield per recruit (Y/R), was 0.293 and the exploitation rate at $E_{0.1}$ was 0.360. The selection ogive procedure gave the following estimates: E_{max}= 0.457, $E_{0.1}$= 0.407 and $E_{0.5}$ of 0.192.

DISCUSSIONS

Post impoundments studies showed that the fish fauna of Jebba Reservoir is dominated by cichlids followed by schilbeids. In terms of fish distribution there was a shift from shore (47.9%) in 1983 to surface (42.2%) in 1984 (Ita, 1993). This according to Ita, (1993) is a reflection of increases in the abundance of the family Schilbeidae that have quickly occupied the newly created pelagic zone. Monthly length data samples (raised) were large and considered representative of the glass catfish population in the upper portion of Jebba Reservoir. The length-frequency distribution histograms of glass catfish showed a bimodal pattern between March and August. Except for May and June with smallest sizes of 35 and 45 mmFL respectively, the largest size recorded in this study was 117mmFL while Olatunde (1978) recorded 130 mmSL for female and 120mm for male in Lake Kainji. The maximum length observed for the glass catfish in this study is relatively smaller compared to that of Olatunde (1977). This perhaps is indicative of the population reaching maturity earlier as a result of fishing mortality.

The smallest fish caught was 20 mm and the largest was 117 mm FL while the overall mean length was 62.75mmFL suggesting that the majority of the fish were caught either just before or immediately after reaching maturity. Though no data was obtained for gonadal and maturity state in this study, other works showed that in *P. pellucida*, the males generally attain maturity at a lower length than females. According to Reynolds (1970) and Olatunde, (1978) males become sexually mature at 50-54 mmFL while females become mature at 60mmFL. The length-frequency data for the 12 months did not show a clear modal progression. Rather from September to February there was a single modal class group with little change in average size which may in part be due to migration from upstream in Kainji Reservoir into the Jebba Reservoir. Average modal length in these six months was 57.3mmFL. On the other hand, from March to August two distinctive class groups existed with an overall average modal length of 71.66mmFL. The first period with a single modal class coincides with the annual period of flood in the lake. The fish thus take advantage of this to have an extended breeding season of about six months with the adults moving away from the pelagic zone. This perhaps accounts for the lack of two modal classes between September and February. Where they breed however is not known yet. The present pattern of modal classes agrees with Olatunde (1977) who reported that breeding condition is attained towards the end of the rainy season with spawning commencing in September and continuing throughout the dry season until February in Lake Kainji. A long breeding season has also been reported for the population in Volta Lake in Ghana (Reynolds, 1970). This long breeding period, which involves multiple spawning, tends to compensate for the average fecundity of 3500 eggs recorded by Olatunde (1978). The amount of eggs this fish can produce at a time is limited by their body size. The period between March and July is the period of low water when both the young of the year and the adults are found together thus presenting two modal classes in the population.

In tropical latitudes, where seasonal changes in temperature and day length are less pronounced, suitable environmental conditions are governed more by the change in rainfall and water level, forming a sequence of wet and dry seasons than by physiological process. Thus many species in equatorial lake breed throughout the year (Welcome, 2001). The estimated longevity of 1.65 years indicates that *P. pellucida* is a short-lived fish; this agrees with Olatunde (1977) who states that they attain 80mm in their first year. However according to Olatunde (1977), females grow faster and also attain bigger maximum size than male in Lake Kainji with males and females reaching 120mmTL and 130mmTL respectively. Baijot and Moreau (1997) estimated that a range of phi prime mean values for some fishes in Africa ranged between 2.65 and 3.32, and considered these as low growth rates. In this study, the values of 4.48 shows that glass catfish exhibit a fast growth rate in Jebba Lake. It is generally agreed that small sized fish grow faster than large sized fish. The total mortality rate of *P. pellucida* (6.54year^{-1}) in Jebba Reservoir is high. This estimate might have been distorted due to influx from the upstream stock. However, the mortality is comparable to 6.30-6.94 year^{-1} obtained for *Stolothrissa tanganicae,* a small pelagic clupeid similar in size and longevity (119mmTL maximum size and longevity of 1.5 years) in Lake Tanganyika (Aro & Mannini, 1995). A problem with estimation of natural mortality are that available methods are empirical equations whose parameters are based on longevity, growth performance, mean temperature and age at sexual maturity which are related to species growth. The natural mortality of *P. pellucida* of 1.71 year^{-1} is high but compares well with that of *S. tanganicae* with 2 year^{-1} (Aro & Mannini, 1995). Most pelagic species open water spawners produce large number of eggs to compensate for the high mortality on eggs and the larvae. In the case of glass catfish, they breed during the flood period when plenty of food and protection is available for the larvae. However, the relatively small size of this fish makes them subject to intense predation. This catfish with almost transparent body have evolves transparency as an adaptation to predation. Transparency has been described as one of the few forms of camouflage possible in pelagic habitat with no surfaces to match or hide behind (Johnsen, 2001). It is also the only form of camouflage, and one of the few adaptations, that involve the entire organism. The Z/K ratio (3.514) for glass catfish, which is >1 in this study indicates a mortality-dominated and a heavily exploited population.

This study shows that *P. pellucida* is a short-lived catfish with rapid growth rate and high natural mortality (r-strategist). It becomes sexually mature early and has a long breeding period extending from September to February. During breeding the adults move away from the pelagic zone of the lake to an unknown breeding ground. The yield per recruit model provided an indication of the actual yield from the fishery in relation to the potential maximum sustainable yield, given a constant rate of recruitment. The current exploitation rate E (F/Z) was estimated as 0.737 year^{-1} is high and is not sustainable except there is a constant replenishment into the fishery from Lake Kainji stock upstream. However in order to maximize the economic gain from the fishery fishers should be encouraged to move to other spots around the reservoir where the conditions are similar to those found below the Kainji Dam. This include places where major and perennial rivers enters the Jebba Reservoir, where current and eddies will enable fishers using the Atalla net to obtain catches comparable to the present fishing ground.

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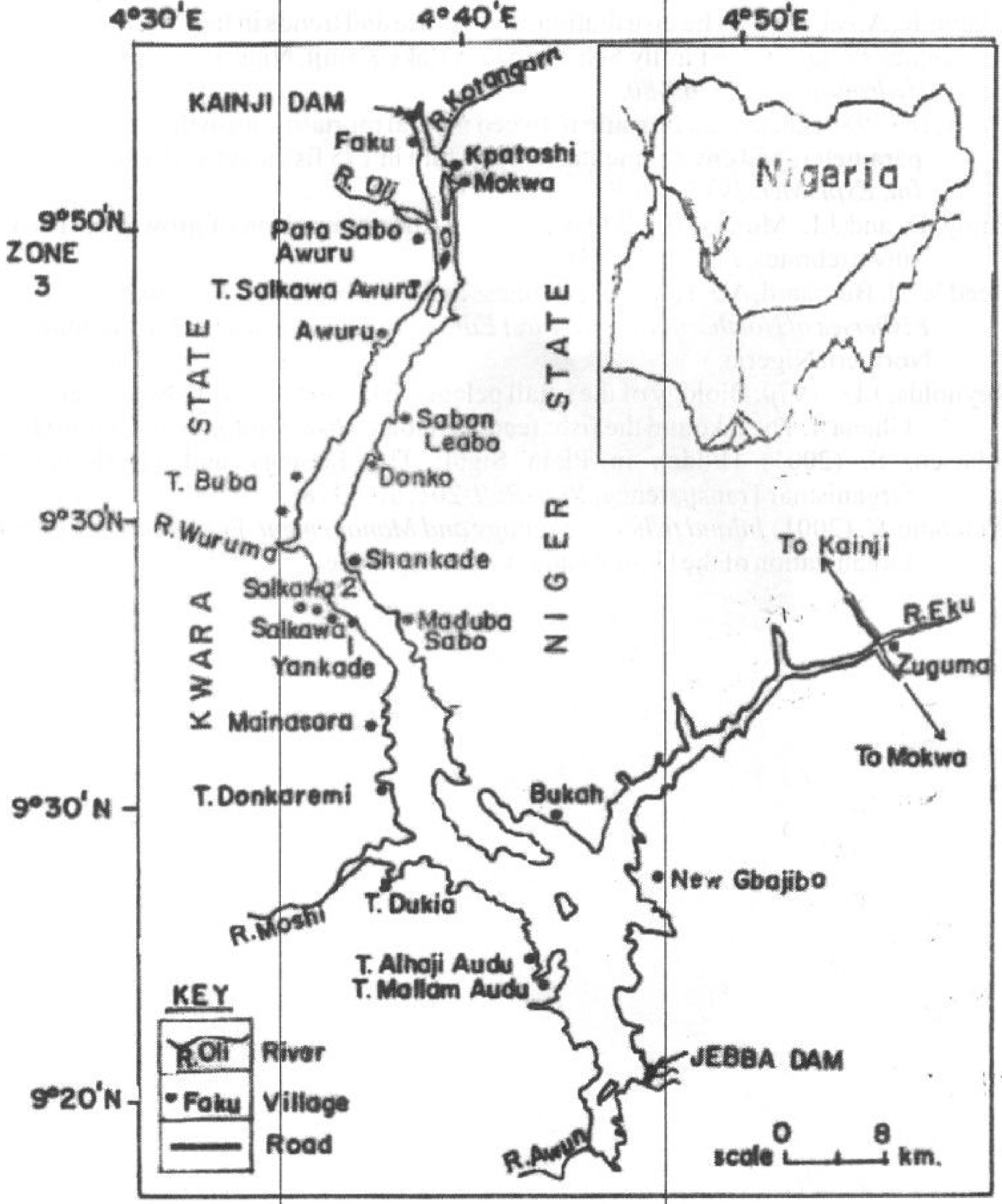
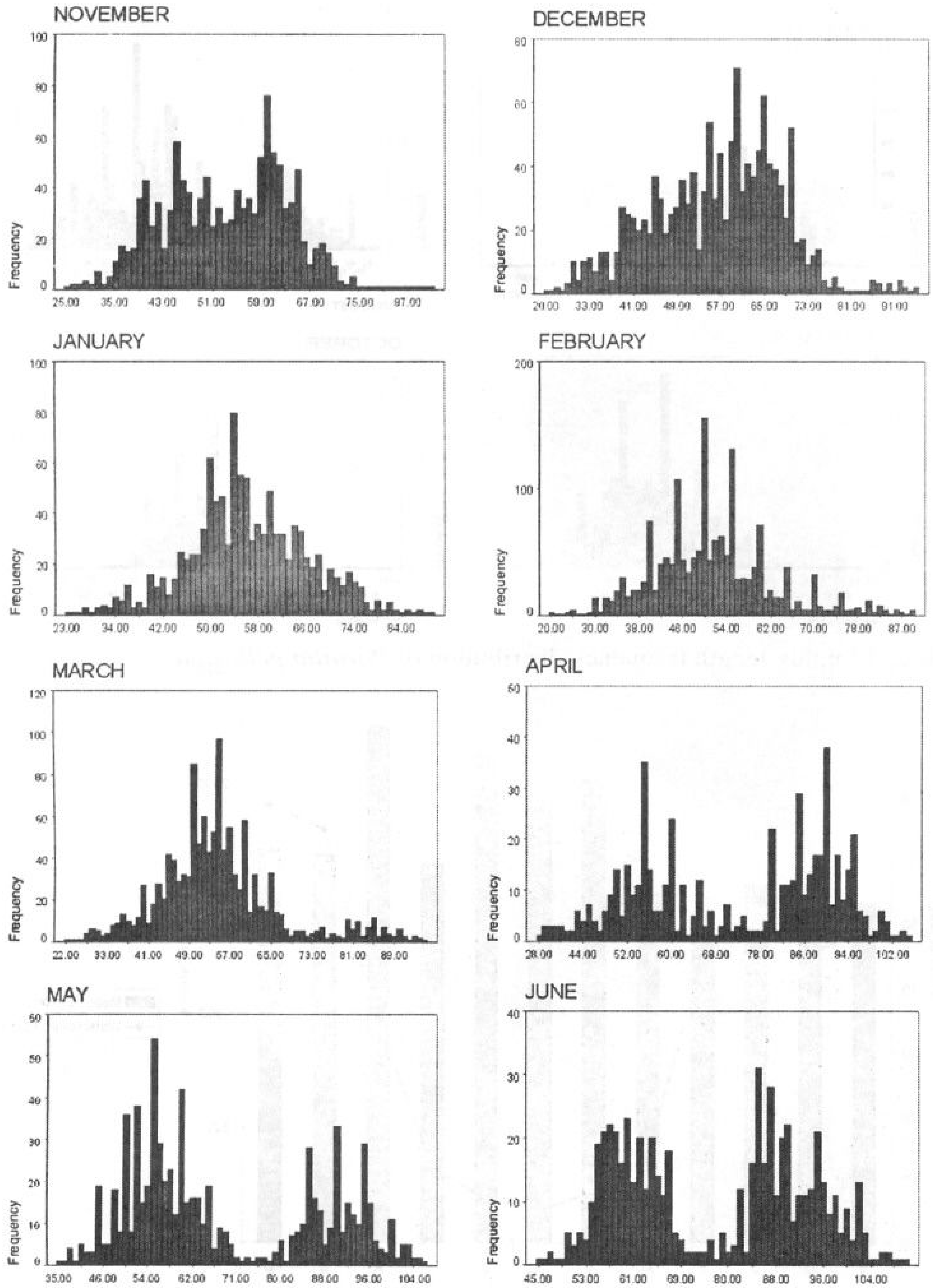


Fig.1: Jebba Reservoir, Nigeria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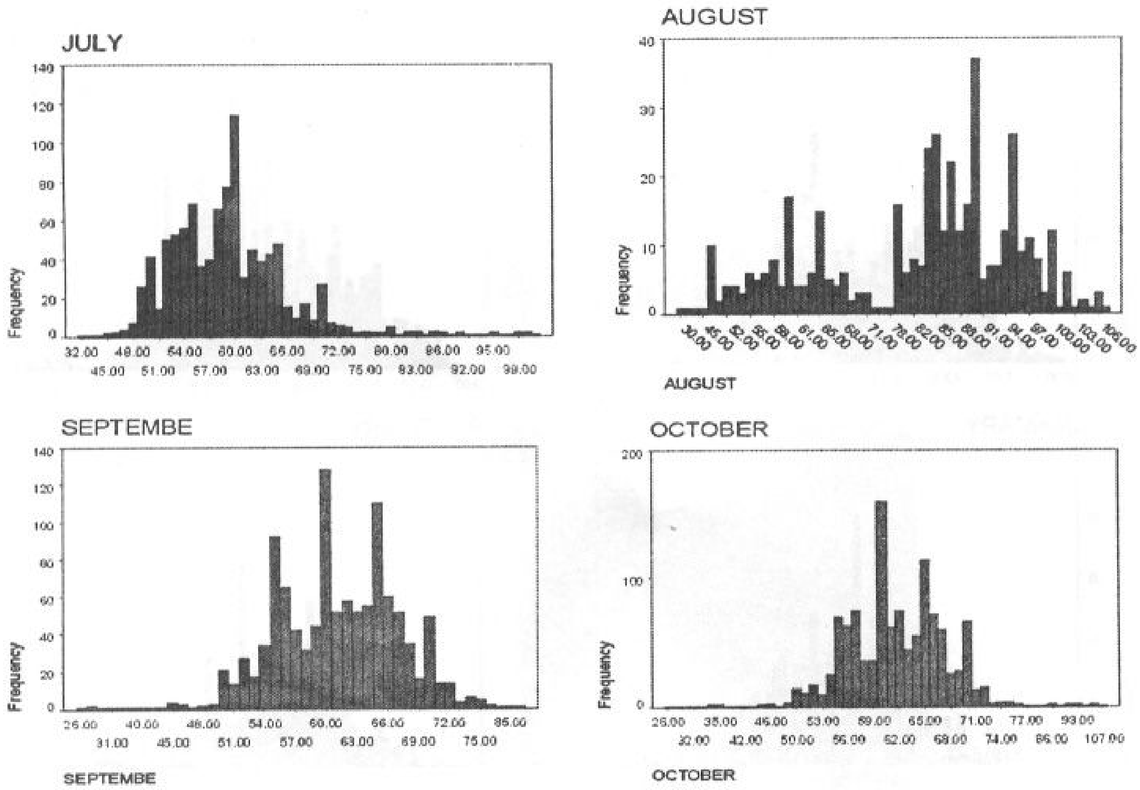

Fig.2: Monthly length frequency distribution of *Parailia pellucida*

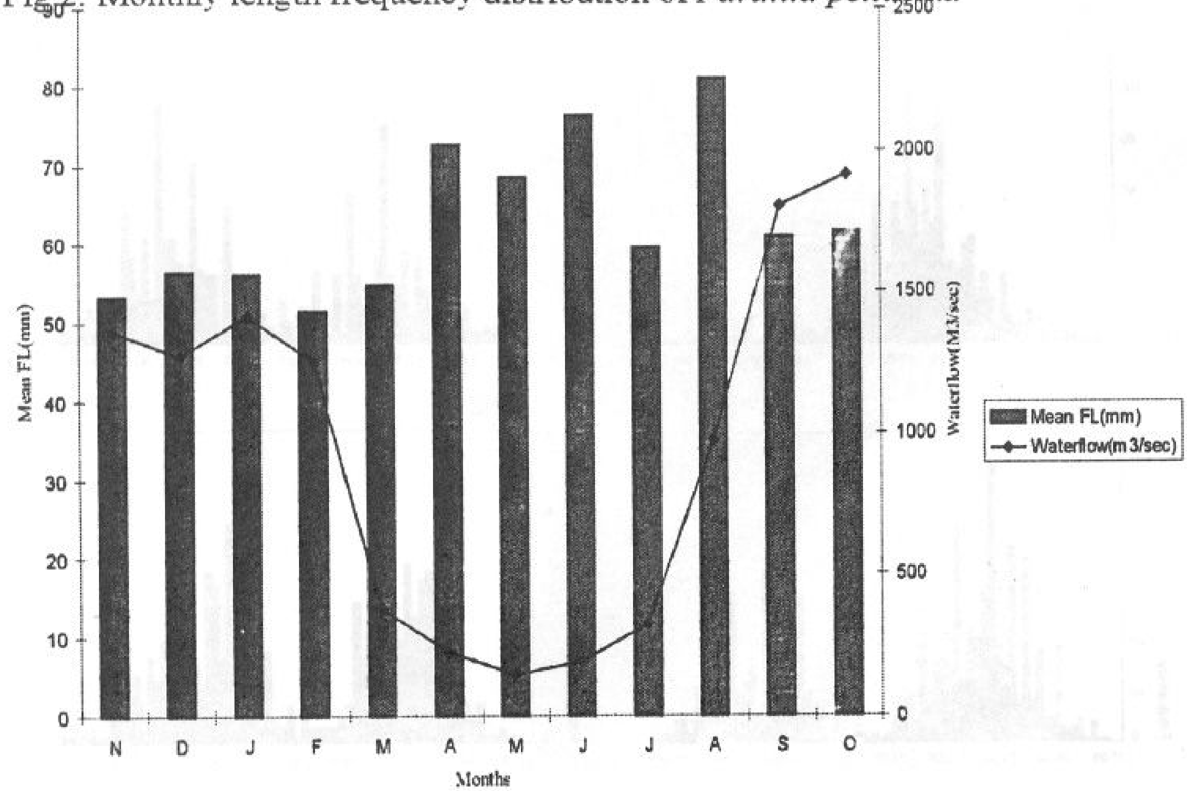

Fig 3: Monthly mean length of *P. pellucida* and waterflow in Jebba Reservior

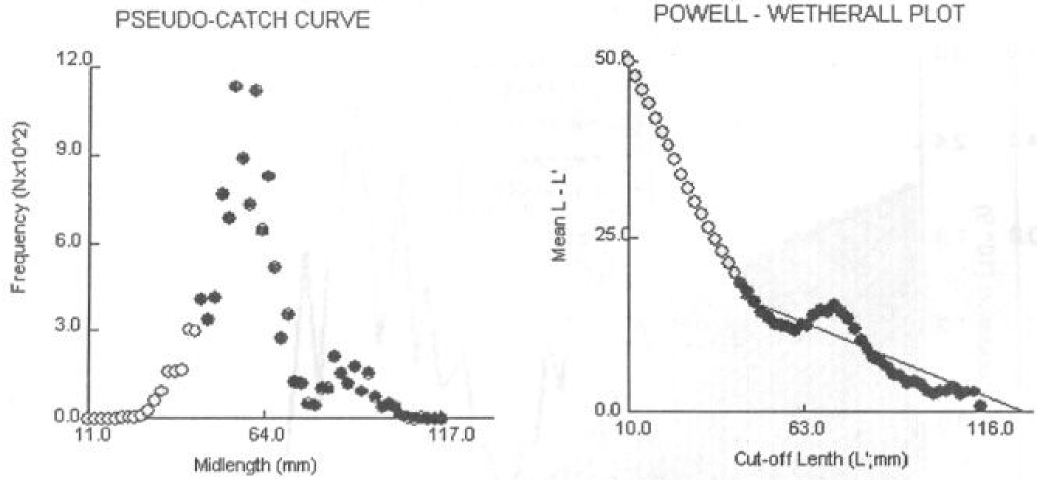

Fig. 4: (a) Pseudo-catch curve of *Parailia pellucida.* (b) Powell-Wetherall regression the regression equation is $Y= 24.99 + (-0.193)*$, $r= -0.808$.

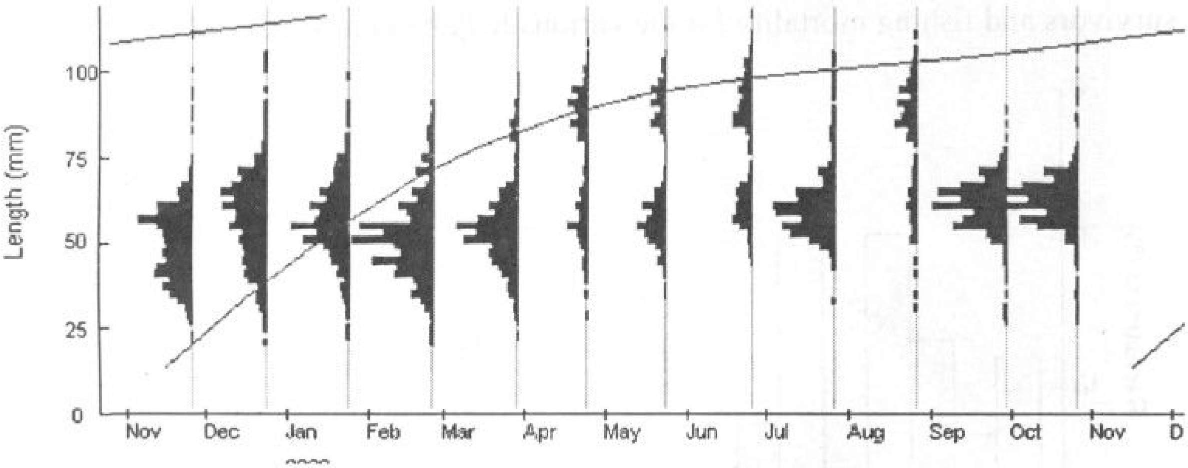

Fig. 5: Length frequency distribution output from FiSAT for *Parailia pellucida* caught in 2003 and 2004 with a superimposed growth curve.

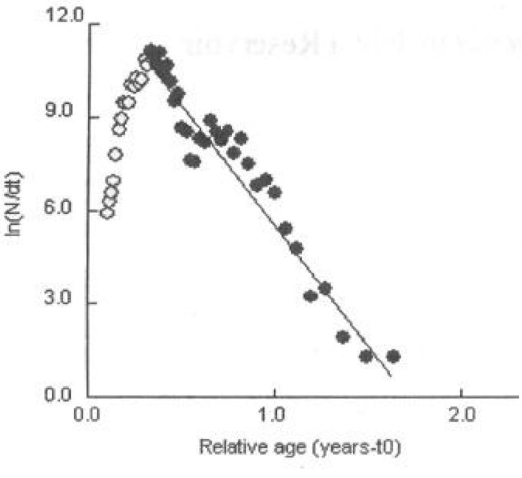

Fig. 6: Seasonalized length-converted catch curves for *Parailia pellucida* for the estimation of Z (total instantaneous mortality).

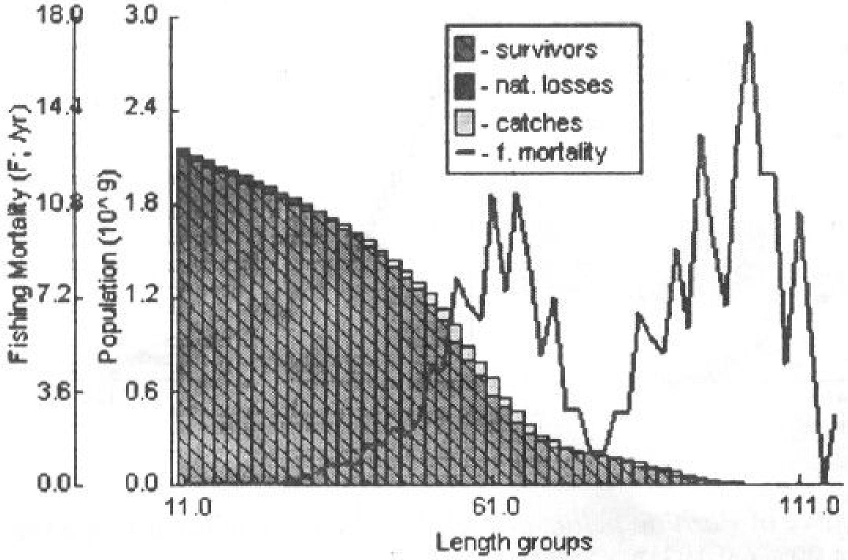

Fig. 7: VPA graph output from FISAT showing catches, survivors and fishing mortality for the various length classes.

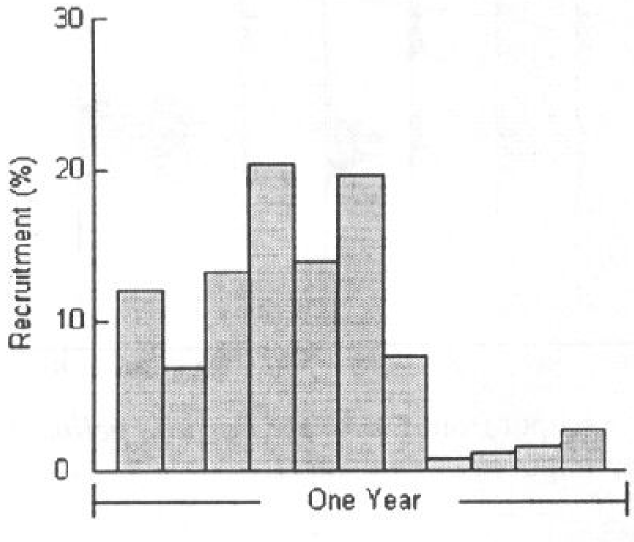

Fig. 8: Recruitment pattern of *Parailia pellucida* in Jebba Reservoir

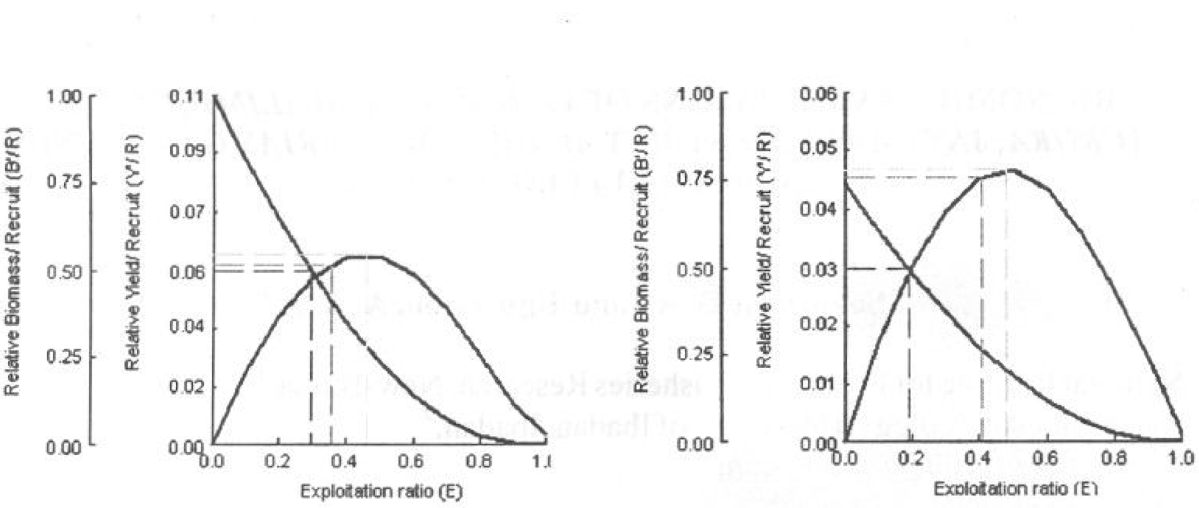

Fig. 9: (a) Yield per recruit and biomass per recruit curve for *P. pellucida* using Knife-edge procedure. E_{max}= 0.457, $E_{0.1}$=0.357 and $E_{0.5}$= 0.294 (b) Yield per recruit and biomass per recruit curve for *P. pellucida* using Selection ogive procedure. E_{max}= 0.457, $E_{0.1}$=0.407 and $E_{0.5}$= 0.192