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Population parameters of *Oreochromis leucostictus* from Lake Naivasha, Kenya

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ABSTRACT

Length-frequency data collected from fish landings on Lake Naivasha were used to estimate the growth parameters: total mortality (Z), growth performance index (ø'), exploitation rate and recruitment pattern in *Oreochromis leucostictus*. The asymptotic length (L∞) was 38 cm and K 0.48 yr^{-1}. Z was estimated as 3.5 yr^{-1}, M was 0.19 yr^{-1}, F was 2.6 yr^{-1} and E of 0.74. Recruitment occurs throughout the year, with a peak in January to March, while entry into the fishery occurs at a mean length of 15.9 cm.

Existing restriction on the maximum number of gill nets allowed per fishing licence (10 per boat) and a minimum mesh size (10 cm) in the lake are not adhered to. Poaching using illegal mesh size nets as small as 5 cm and use of more than 10 nets per boat are common in the lake.

INTRODUCTION

Oreochromis leucostictus (Trewavas) is the most commercially important fish in Lake Naivasha after *Micropterus salmoides* (Lacepè) and *Tilapia zillii* (Gervais). The overall species composition in catches since 1987 was *O. leucostictus* 87.4%, *T. zillii* 0.5% and *M. salmoides* 14.8% (MUCHIRI and HICKLEY, 1991). *O. leucostictus* is caught by gill nets of 10 cm mesh size set from wooden or glass-fibre canoes and landed at a single station near Naivasha town. The species was introduced unintentionally in 1956 with a batch of *T. zillii* later flourishing in the early 1960s to dominate the lake fishery. *O. leucostictus* prefers lagoons and littoral areas where accumulation of detritus leads to concentrations of chironomid larvae, its major food source (MUCHIRI and HICKLEY, 1991).

Data collection on L. Naivasha fishery commenced in 1963 but differentiating of the catches into 'basis' and 'tilapia' started only in 1974. Separate recording of *O. leucostictus* and *T. zillii* began in 1987 (MUCHIRI and HICKLEY, 1991). The catch data so far collected were suitable for calculation of catch per unit effort and maximum sustainable yield but not for estimation of population parameters such as growth and mortality rates. This paper utilises the length-frequency data to address this issue.

MATERIALS AND METHODS

Length frequency data on *O. leucostictus* fished by gill nets was collected five days a week for the whole of 1995 from the commercial fishery. The ELEFAN I and II computer programs (PAULY, 1987) were used to estimate population parameters.

The asymptotic (L∞) and the ratio of the total mortality (Z) to the growth constant (K) were estimated using modified Powell-Wetherall method:

$$Li = a + b\,L'i \qquad (1)$$

Where Li = the mean length of fully selected fish computed from L'i (lower class of the first class used in computing Li) upwards. Li is plotted against L'i and a linear regression is carried out to obtain the regression coefficients *a* and *b*.

The growth performance index was computed according to PAULY and MUNRO (1984):

$\emptyset' = \text{Log}_{10} K + 2 \log_{10} L\infty$..............................(2)
Where K is the rate at which length approaches the asymptote and $L\infty$ is the asymptotic length. Total mortality (Z) was estimated using a length-converted catch curve. Natural mortality (M) was estimated from equation of PAULY (1980):

$\text{Log}_{10}(M) = -0.0066 - 0.279 \text{Log}_{10} L\infty + 0.6543 \text{Log}_{10} K + 0.463 \text{Log}_{10} T$............................ (3)
Where $L\infty$ (TL) is expressed in cm, T is water temperature in ˚C (taken as 21 ˚C). The estimation of fishing mortality (F) was obtained by subtraction of M from Z. Exploitation rate (E) is F/Z.

A plot for probability of capture by length was obtained from the backward extrapolation of the right descending arm of a catch - curve, and calculating the number of fish that would have been caught had it not been for selection and incomplete recruitment. Recruitment pattern was obtained by projection onto the time axis of the available length-frequency data.

RESULTS

Growth

The original-frequency data were restructured using ELEFAN I such that peaks were re-expressed as positive points and conversely for the troughs between peaks. The program then fitted growth curves, the one retained being that which touched peaks while avoiding troughs (Figure 1). Asymptotic length ($L\infty$) was estimated as 38 cm and K was 0.48 yr^{-1}. The growth performance index:
($\emptyset$, = $\text{Log}_{10} K + 2 \log_{10} L\infty$) was thus computed as 2.8.

Mortality

Figure 2 represents the length - converted catch curve, used to estimate Z based on growth parameters estimated by Elefan I and II. The estimates of mortality Z, M and F were 3.5, 0.19 and 2.5 yr^{-1} respectively.

Selection and recruitment pattern

Figure 3 represents the probability of capture (resultant curve) derived from the length-converted catch- curve. This shows that 50% of *O. leucostictus* enters the fishery at 15.9 cm. Recruitment pattern determined through ELEFAN II (Figure 4) shows *O. leucostictus* recruitment to occur throughout the year, with peaks in February and at the end of July.

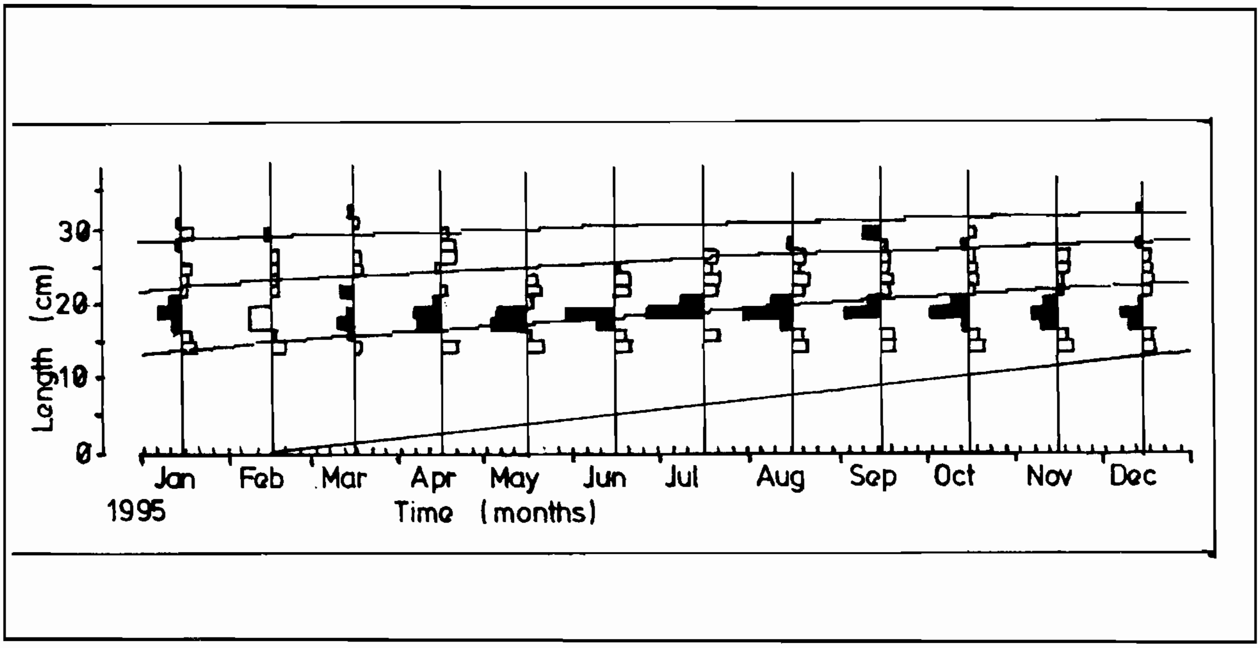

Fig. 1 Restructured length-frequency data of *O. leucostictus* with growth curves fitted using ELEFAN I.

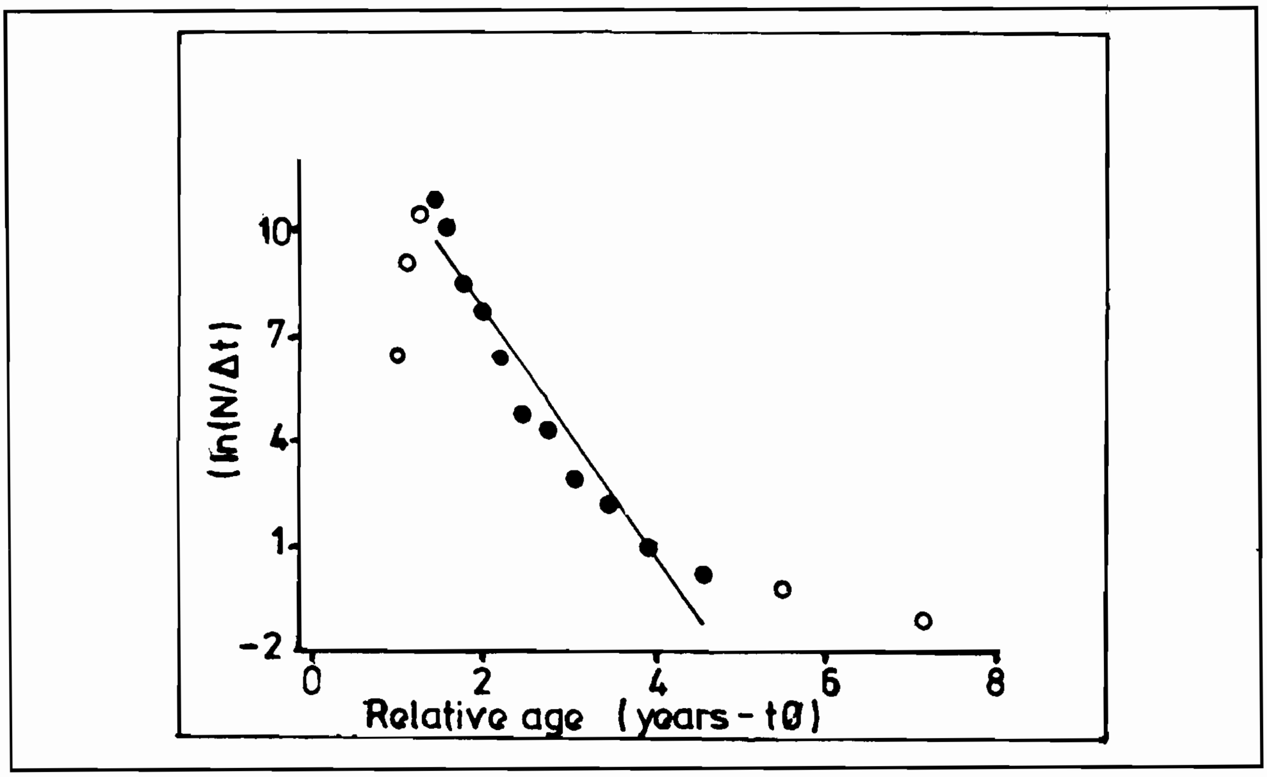

Fig. 2. Length-converted catch curve for *O. leucostictus* from Lake Naivasha (Black dots represented points used in the analysis)

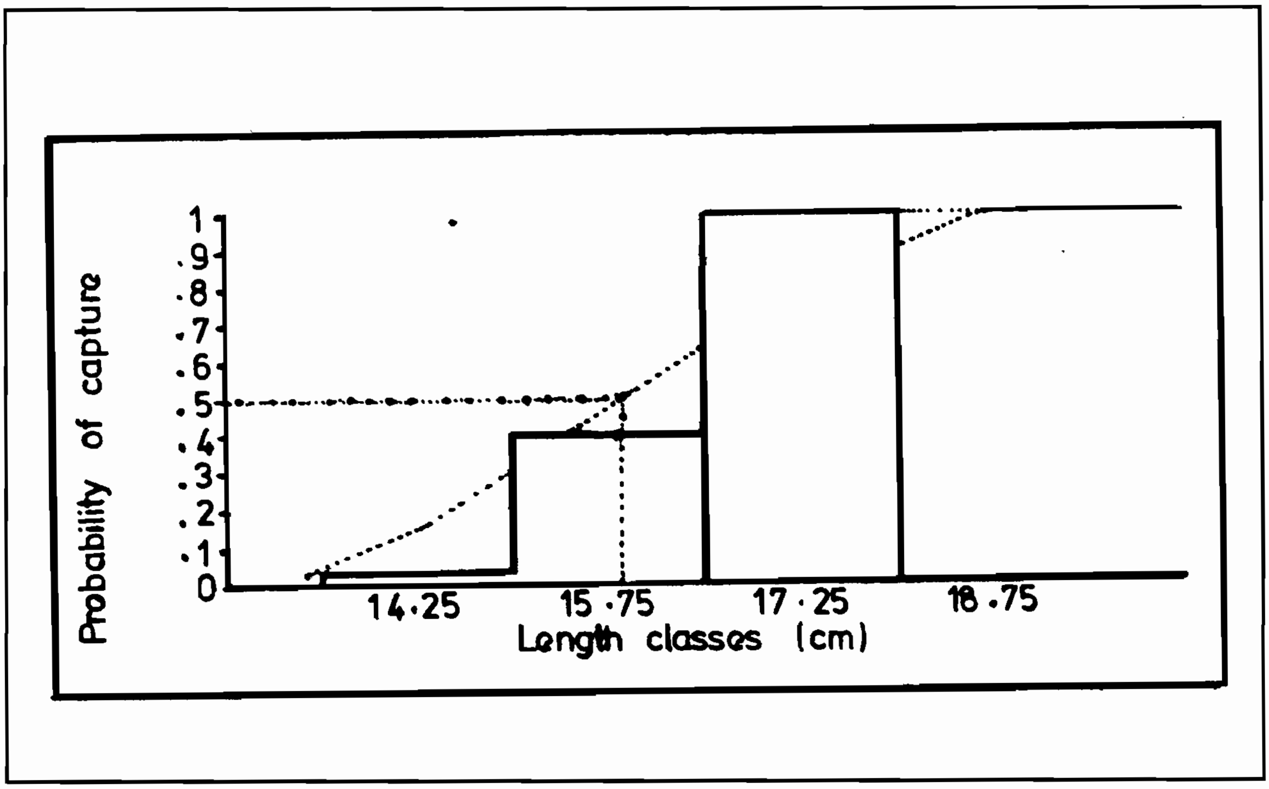

Fig. 3. Selection pattern of *O. leucostictus* from Lake Naivasha. Where estimates of L_{25} = 14.7 cm, L_{50} = 15.9 cm

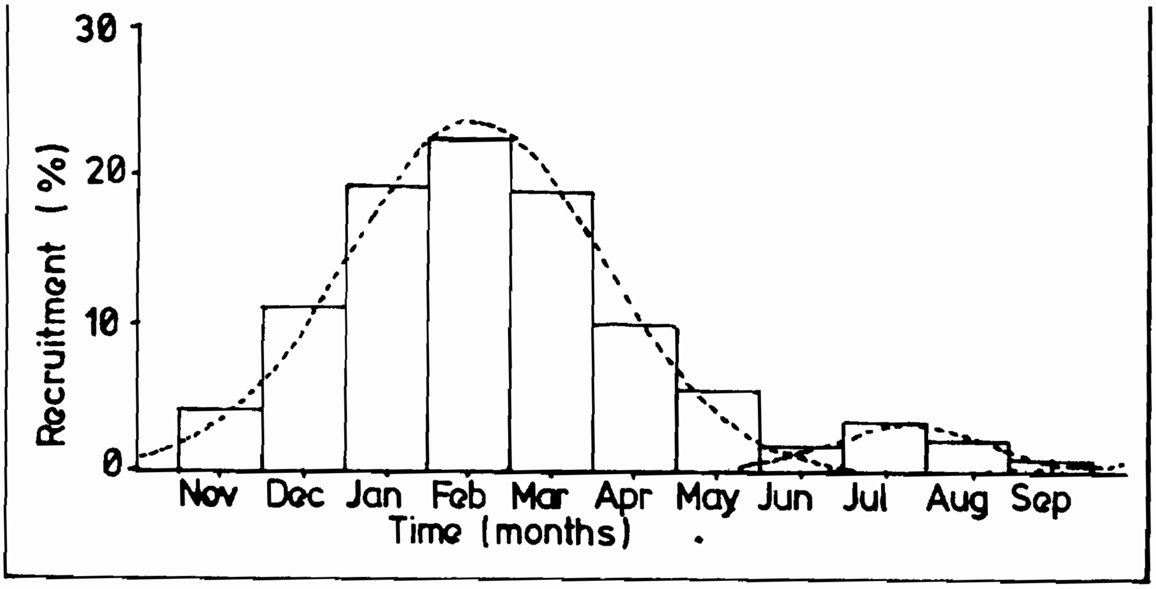

Fig. 4. Recruitment pattern of *O. leucostictus* from L. Naivasha. Fitting of the graph was done using ELEFAN II.

DISCUSSION

The asymptotic length in this study of 38 cm is higher than the estimate of 32 cm reported by SIDDIQUI (1979). Available records show that *O. leucostictus* in L. Naivasha start maturing at 16 cm (TL) (female) and 18 cm (male) (TREWAVAS, 1983). From this study the largest group of fish lies between 17-20 cm (TL). The growth parameter K of 0.48 yr^{-1} shows that *O. leucostictus* in L. Naivasha grows moderately. MOREAU *et al.*, (1986) records a K of 1.16 yr^{-1} for *O. leucostictus* from L.Victoria and 1.62 for *O. aureus* from L. mariut. This study shows that *O. leucostictus* in the lake is now caught at a much longer length than in the 1970s. But most fish entering the fishery are not given a chance to grow further (L_{50} = 15.9 cm).

The growth performance index (ø') of *O. leucostictus* in L. Naivasha of 2.8 is high. Genetic makeup, fishing regime and diet type may determine growth potential of a species (SSENTONGO and WELCOME, 1985). Over-fishing results in reduction of the average size of fish and a faster growth rate. Increase in K results in high ø'. Over-fishing of *O. leucostictus* is confirmed by high exploitation rate (E = 0.74). Ingestion of detritus is suitable for optimum growth and is nutritionally adequate for tilapias (BOWEN, 1982). *O. leucostictus* feeds of detritus and chironomid larvae which could be contributing to this high ø'.

Most tropical fish stock recruitment continues all year round with seasonal oscillations corresponding to the rainy seasons (RUFLI and VAN LISSA, 1982). This study shows *O. leucostictus* recruits to the fishery throughout the year with peak corresponding to rainy season in the watershed area (November-December and April- May).

The total mortality rate Z of 3.5 yr^{-1} is quite high. This high Z could be due to intense fishing in L. Naivasha (E = 0.74) and use of illegal mesh sized gill nets. The key assumption of catch curve analysis, that the relative abundance of the different size groups in the catches reflect their abundance in the population, was probably not met because of the sampling gear used.

Although there are restrictions on the maximum number of gill nets allowed per fishing licence (10 per boat) and a minimum mesh size (10 cm), these regulations are not adhered to (MUCHIRI and HICKLEY, 1991). Poaching using illegal mesh size nets and use of more than 10 nets per boat is common in the lake. A survey carried out in 1996 showed that nets with stretched mesh down to 5 cm are commonly used in the lake. Continual use of smaller mesh sizes would lead to further reduction of *O. leucostictus* size/length at first capture and consequently the fishers would in turn reduce their mesh sizes to target the smaller fish. This will decrease long term catches of the species. BEVERTON (1959) had predicted a similar trend due to use of smaller mesh gill nets to capture the dwindling stocks of *O. esculentus*, *Bagrus docmac*, and *Barbus altianalis,* once traditional species in L. Victoria.

When this problem of small mesh sizes is compounded with poaching it could spell doom to *O. leucostictus* and the entire L. Naivasha fishery. The collapse of *O. leucostictus* would not only be disastrous to L. Naivasha ecosystem, but also to the economy of the people depending on the lake. Relevant government departments which are empowered with authority should seek immediate solution.

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