STUDIES ON THE BIOLOGY OF *Gymnarchus niloticus* IN LAKE CHAD: AGE DETERMINATION AND GROWTH; MERISTIC AND MORPHOMETRIC CHARACTERS

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ABSTRACT

The meristic and morphometric characteristics of *Gymnarchus niloticus* are described and linear regression equations relating various parts of the body to the head length or total length are given.

The age of *Gymnarchus niloticus* in Lake Chad was determined from growth marks on the opercular bones. The mean lengths for age, and mean weights for age obtained for the first five years of life are given. The assymptotic length and the von Betarlanffy growth parameters for the males and females combined were as follows;

L_{∞} = 211.32cm; K = 0.1215; = 2.05224.

INTRODUCTION

Gymnarchus niloticus, "dan sarki" in hausa, meaning "prince", is an electrical fish emitting continuous weak electrical signals generated from an electric organ located in its rat - like tail (Lissman, 1951). It has been shown that *Gymnarchus niloticus* has the ability to locate objects in the water by means of the electric signals it emits (Lissman and Machin, 1958). This fish is of bilogical interest because of its peculiar shape and habits; but it is also economically important in Lake Chad for it is a very much relished edible fish species which during the drought era (1972 to 1984) became the dominant piscivore in the lake.

The body of *Gymnarchus* is elongated, round in section and tapers to end in its rat-like black tail. A long rayed dorsal fin extends from just behind the head to a short distance from the tip of the tail. No pelvic, anal or caudal fins are present. The mouth is large and bears large and sharp incisiform teeth in both jaws. Its colour is blue-grey becoming progressively darker towards the tail. The diet of the adults is alsmost exclusively fish (Sagua, 1983); but the juveniles also feed upon insect larvae and nymphs.

Gymnarchus is common though not abundant in River Nile, River Niger in the riverine areas around the Niger Delta and in some east African lakes such as Lake Turkana. It is however, absent from Lake Victoria.

The breeding habits of *Gymnarchus* were discussed by Budgett (1900) and the origin of its electric tissues determined by Dahlgren (1914). Information on the general biology and growth patterns of *Gymnarchus* is however scanty. The scientist at ORSTOM Laboratory in Lake Chad made only cursory observations on its length-weight relationships (Durrand and Loubens, 1967). Paucity of biological knowledge of this economically important fish could be due to its relative scarcity where it is found.

The study of the detailed biology of *Gymnarchus niloticus* in Lake Chad was initiated in August 1982 and this paper is part of the results of the study.

MATERIALS AND METHODS

Freshly caught specimens of *Gymnarchus niloticus* obtained from hook and line or gill net fishing at Baga and the neerby fishing islands in Lake Chad were used for this study. The underlisted detailed body measurements were made on a standard one-metre measuring board also with the aid of a 3 metre plastic measuring tape graduated in mm. The weight of the whole fish was taken with a top loading salter balance to the nearest gramme. The opercular bones were dissected and cleaned in fresh water from all flesh, and skin. The length of the opercular bones was measured in an antero-posterior plane from its insertion to the free posterior border. The meristic characters recorded included the numbers of gill-rakers; dorsal fin rays; lateral line scales; numbers of teeth in the upper and lower jaws; and numbers of preanal and postanal vertebrae. There was difficulty in enumerating the vertebrae in the tail.

Body Measurement

Total length: The length of the fish from the tip of the snout to the posterior extremity of the tail.

Head length: The distance from the tip of the snout to the posterior border of the operculum.

Eye diameter: The distance from the anterior to the posterior margin of the eye measured across the pupil.

Snouth-Dorsal fin: The direct distance from the snout to the anterior insertion of the dorsal fin.

Length of Dorsal fin: The direct distance from the anterior insertion to the posterior insertion of the dorsal fin measured at its base.

Length of tail: The distance from beginning to the posterior end of the tail.

The age of the fish was determined by examining the opercular bone through incident light in the fresh state. Light passing through the bone reveals alternating bands of opaque and transluscent growth markings and the distance from the anterior insertion of the operculum to each transluscent marking was recorded. The growth band on the edge of the operculum bone was noted as well as the date the fish was caught. Over an annual period tne incidence of occurrence of transluscent and opaque growth markings was determined. The relationships between the length of the operculum bone and the total length of each fish was determined from a linear regression equation.

Scales were also collected from each fish and examined for growth markings.

RESULTS

Age and Grwoth Rate of Gymnarchus niloticus

The scales of *G. niloticus* were found unsuitable for age determination. There were no clear growth checks on the tiny scales. The opercular bones were therefore, used. Figure 1 shows the relationship between the length of the operculum and total length of *G. nil oicus.*

The linear regression equation relating the two is $LP = 0.0242L + 0.0272$, ($r = 0.947$).

(LP = Length of the operculum in cm and L = Total length of the fish in cm). The highly positive correlation coefficient and the fact that the intercept of the line on the y axis is nearly sero are worthy of note. The operculum grows proportionally with the length of the fish and is thus a valid object for use in direct back calculation for age-length data.

The translucent narrow bands on the operculum were formed from December to January when the lake's water level was highest and the water temperatures were at their lowest (Figure 2).

The mark represents a period of reduced biological activity and reduced growth. The opaque and broader growth band on the opercular bones were found during the remaining months of the year. They represent periods of increased growth and increased biological activity.

A fish which has an opaque band plus one transluscent growth mark was classed as one year old, while those having an additional opaque band, not a second narrow transluscent band was classed one year plus, i.e. aged between one and two years old.

In finding the mean value of the length for each year class, fishes of one year and one year plus were grouped togethr as one year olds etc.

By measuring the distances of the transluscent bands from the point of insertion of the operculum and using the regression equation relating the length of operculum to the total length of the fish, back calculations of the length of the fish at each year mark on the operculum were made.

Table 1 shows the comparison between age-length age-weight data for *Gymnarchus niloticus* obtained by direct observation and from back calculations, which reveals a very close fit in the figures.

Table 1 – Mean age-length, age-weight data for Gymnarchus niloticus from direct observations and back calculations (Males and Females combined)

Age (years)	1	2	3	4	5	6	7
Mean length (cm) (Back calculation (N)	68.94 42	83.88 23	100.12 10	114.17 10	125.61 3	129.04 2	137.31 2
Mean length (cm) (Direct observation (N)	68.88 22	85.50 15	99.25 8	114.42 6	124.00 2	– –	140.00 3
Mean weight (gm) (computed)	1212	2083	3528	5217	6933	7512	9038
Mean Weight (gm) (Direct observation)	1150	2500	3850	5460	7600	–	10420

Table 2 shows the age-length, age-weight data for male and female *G. niloticus* for data directly observed. At each age the males are slightly heavier and longer than the females. The males therefore, have faster growth rate than the females during the first five years.

The Walform growth transformation plot of $Lt+1$ (Ordinate) against Lt (abscissa) gave a linear relationship represented by the equation:–

$$Lt + 1 = 0.886\ Lt + 24.09\ (r = 0.9951).$$

for the combined female and male data from which the asymptotic length (Loo) was found to be 211.32cm. The von Bertalanffy growth parameters were obtained from plotting Ln (Loo – Lt) (ordinate) against t (abscissa)

Table 2 – Mean age-length and mean age-weight for females and and males G. Niloticus from Lake Chad (direct observation)

Age (Year)	1	2	3	4	5	6	7
Females Only							
Mean length (cm)	71.5	83.88	96.14	110.86	–	–	140.5
Annual increment (cm)		12.88	12.26	14.72	–	–	10380
Mean weight (gm)	1320	2050	3550	5080	–	--	10380
Number observed (N)	13	8	5	4			2
Males Only							
Mean length (cm)	72.75	87.36	104.43	121.50	124.00	–	141.00
Annual increment (cm)		14.61	17.07	17.07	2.50	–	
Mean weight (gm)	1140	2470	4170	6230	7600	–	10500
Annual increment (gm)		1330	1700	2060	1370	–	
Number observed	4	7	3	2	2	–	1

the resultant slope (–K) being – 0.1215 and $t_0 = -2.0524$.

By repeating the calculatins using the data for the males only the following results were obtained:–

$L_{t+1} = 34.9009 + 0.7711\ L_t\ (r = 0.9554)$
$L_\infty = 152.4723$ cm
$K = 0.2599$
$t_0 = -1.2298.$

Insufficient data made calculation of the von Bertalanffy growth parameters for the females alone unreliable as there were insuffient points.

Figure 3 shows the graphs relating to the calculations for the growth parameters given above.

Meristic Characters of G. niloticus

The values obtained for the meristic characters investigated are shown in Table 3.

Table 3 – Some meristic characteristics of G. niloticus from Lake Chad

Meristic Character	Number Examined	Means, modes, frequencies, of occurrence
Dorsal fin rays	43	Range 168 to 215. 73% were from 201 to 210. Mean: 205 Std. 8.05
Number of pre-anal vertebrae	5	47 constant in all specimens.
Post-anal vertebrae	5	51–87. Mean number to the end of dorsal fin is 70 vertebrae.
Pre-anal laterall line scales	18	Range: 82 to 100: Mean number 88.
Number of gill rakers on lower limb of 1st gill arch.	51	5–9; mean, 6.75 mode, 7. Frequency 5 (f2); 6 (f18), 7 (f24); 8(5); 9 (f11).
Teeth in lower jaw	48	24–28.24 (f6 26(f21) 28(f21)
Teeth in upper jaw	48	14 constant in all specimens

Morphometric Characters of G. niloticus

Relationships between lengths of parts of the body and the head length or total length were as follows:

Body part as percentage of total length (TL)

Body Part	Arithmetic means, standard deviation
Head length	17.00% TL Std = 1.09, N = 47
Tail length	9.55% TL Std = 1.66, N = 44
Dorsal fin length	74.09% TL Std = 2.50, N = 44
Snout to Anus length	47.46% TL Std = 2.37, N = 45

Body part as percentage of head length (HL)

Body Part	Arithmetic means, standard deviation
(ED) Eye diameter	3.09% HL Std = 0.97, N = 46
(LP) Length of pectoral fin	26.29% HL Std = 2.89, N = 42
(MW) Mouth width	31.65% HL Std = 2.26, N = 15

Linear Regression Equations Relating Lengths of Body Parts to the Total Lengths (TL) or Head Lengths (HL)

(i) Length of Pectoral fin (Lp) and Head Length (HP) Lp = 0.9413 + 0.1919 HL (r = 0.9196) N = 58

(ii) Diameter of eye (ED) and Head Length (HL) ED = 0.3537 + 0.0734 HL (r = 0.2147) N = 58.

(iii) Length of dorsal fin (LDF) and Total length (TL) LDF = –2.2247 + 0.7647 TL (r = 0.99220) N = 56.

(iv) Snout to Anus Length (LSA) and Total Length (TL) LSA = –2.7832 + 0.5048 TL (r = 0.9877) N = 57.

(v) Length of operculum Lop and Total length (TL) Lop = 0.0269 + 0.0242 TL (r = 0 0.9467) N = 60.

(vi) Head Length (HL) and Total Length (TL) HL = 1.2565 + 0.1834 TL (r = 0.9807) N = 58.

(vii) Weight (W) and Total Length (TL) relationship. Log W = 2.978 Log TL – 2.41 (r = 0.9852) N = 58;

It is note-worthy that the positive correlation coefficients obtained for the linear regression lines given above are highly significant for the number of degrees of freedom at 1% level. However, the correlation coefficient (r = 0.2417) obtained for the linear regression of the eye diameter and head length was not significant. The eyes may have a subordinate function in vision in *G. nil otcus* which is able to navigate and locate objects in its environment by use of its electric organ discharge activity.

DISCUSSION

Knowledge of the age composition of a fish population is essential to good resource management. Correct age information is necessary for longevity prediction, establishing growth rate records, the age at maturity and determining the assymptotic length and weight of fishes. Concerning *Gymnarchus niloticus,* there is no previous scientific work known to the author on its age and growth rate in Lake Chad or elsewhere. This study therefore, provides the first attempt at determining the age of this highly prized fish which is also being cultivated in water reservoirs in the southern part of Nigeria. Due to the insufficiency of specimens, it has not been possible. to cross check the age data by the length-frequency technique.

The use of bony parts in the determination of the age of Nigerian fishes has, however, been done by Bayagbona (1968) using the Otoliths of croakers; Fagade (1974) using opercular bones of *Tilapia melanotheron;* Ezenwa and Ikusemiju (1981) using the first dorsal spine of *Chrisichthys nigrodigitatus* and Willoughby (1979) using veterbae for Lake Kainji's *Synodontic* species. In Lake Chad, Hopson (1972) used scales of *Lates niloticus,* on which he found "winter rings" formed during the coldest months of January and February to determine age.

The problem usually encountered in determining the ages of tropical fishes by use of growth marks or checks formed seasonally on skeletal parts,.arises from little environmental changes, especially of temperature This is particularly true of low latitudes. But the further one goes (north or south) from the equator or the higher one goes in latitude, the greater the seasonal temperature changes. Lake Chad located in a semi-arid area between latitudes 12o 30'N and 14o 30'N experiences well marked seasonal changes in water temperature with a drop of about 10oC between the warmest months (May/June 28oC) and the coldest months, (December/January, 17.08oC). The cold period also coincides with high water level. This seasonal drop in temperature has also been associated with reduction in feeding intensity (Sagua, 1983) and hence results in a reduced growth rate reflected on the operculum as transluscent band. The validity of the transluscent growth band for age determination arises from its formation only once in a year. Fagade (1974) has shown that other seasonal changes such as salinity could also cause formation of growth marks on operculum of *Tilapia mealnotheron* in Lagos Lagoon.

The biggest specimen of G. niloticus seen during this study in Lake Chad was a female of 157 cm TL weighing 14.25kg. Durand and Loubens (1969) found, as their largest specimen in Lake Chad, a fish of 151 cm TL, weighing 15.50 kg but its sex was not stated.

The observed largest size is 74.4% of the calculated assymptotic length (211 cm) for the combined data for females and males. This value appears a good estimate since the high fishing pressure in Lake Chad makes larger and older fishes to be rare.

The value of Loo (152 cm) obtained for the males would, therefore, appear to be an under estimate. This is, however, the best information that is obtainable from the observed data.

A certain amount of variability in the meristic and morphometric characters will be expected in G. niloticus over its wide geographic distribution range in Africa in which the species is endemic. The results in this paper for Lake Chad, should therefore, form basis for useful comparison with those of workers in other parts of the continent and the water bodies in Nigeria.

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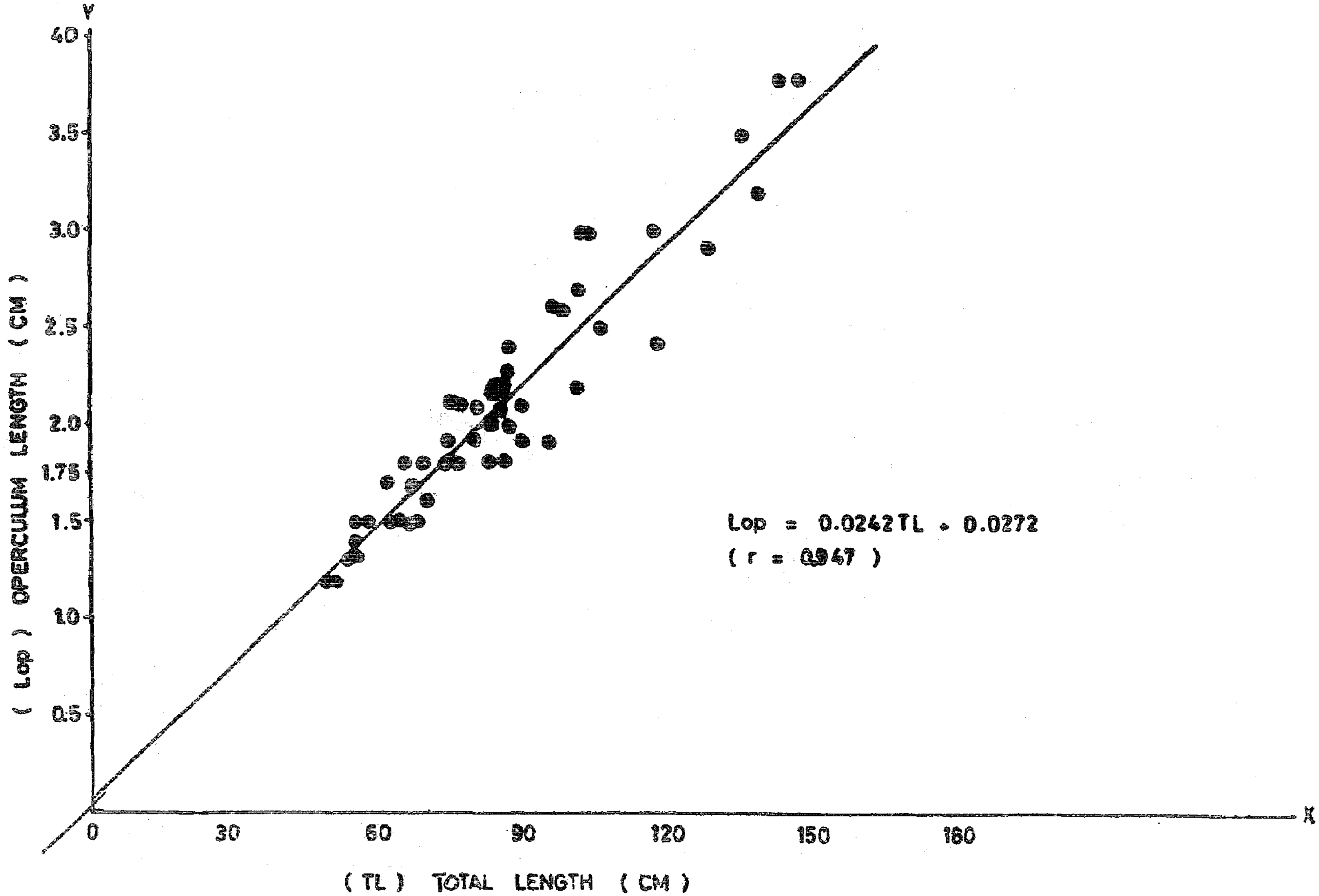

Fig. 1. RELATIONSHIP OF TOTAL LENGTH AND OPERCULUM LENGTH IN G. NILOTICUS

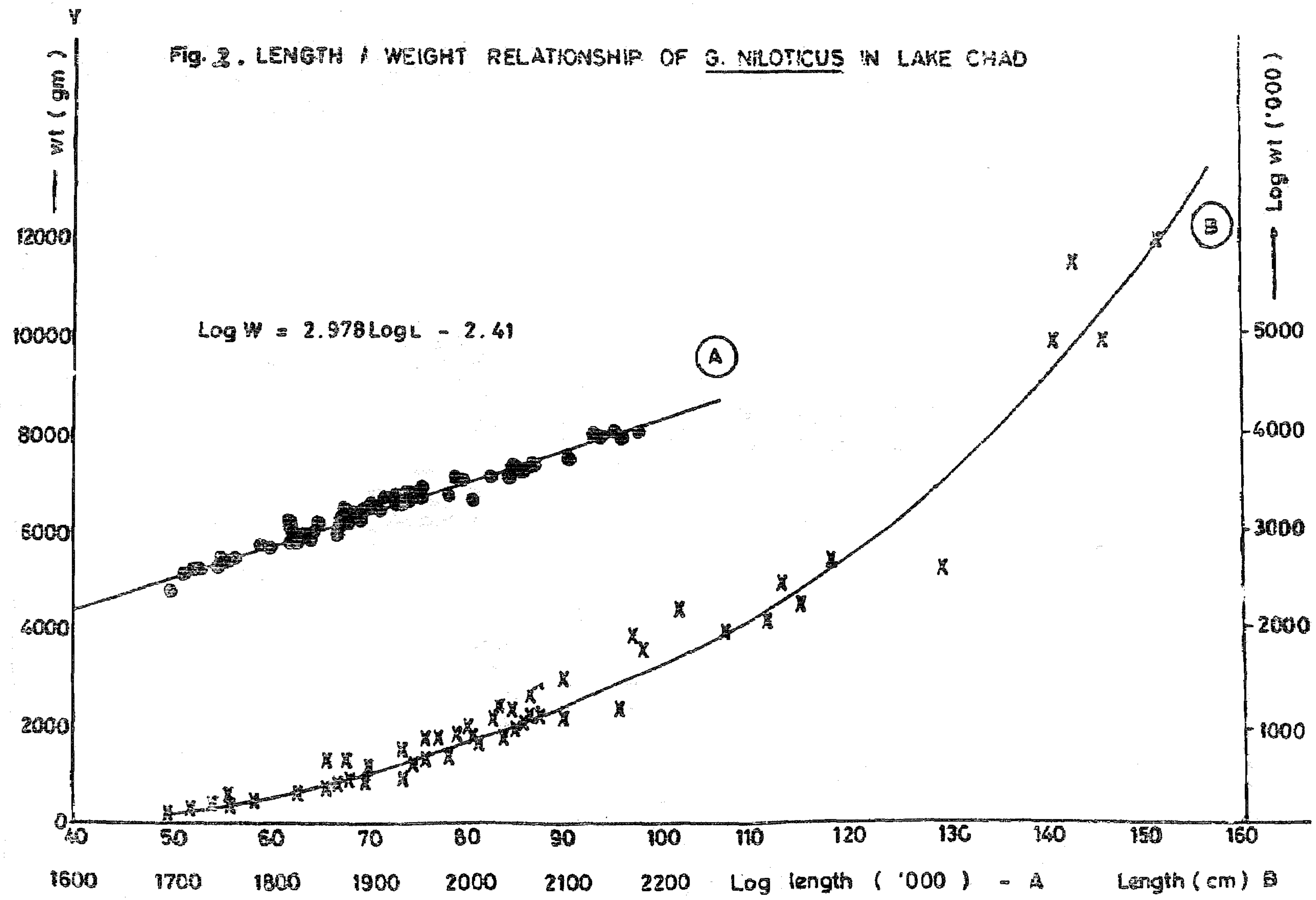

Fig. 2. LENGTH / WEIGHT RELATIONSHIP OF G. NILOTICUS IN LAKE CHAD

Fig. 3a GRAPH OF ln (L∞ - Lt) AGAINST t (YEARS) FOR <u>G. NILOTICUS</u> FROM LAKE CHAD (Maies and Females)

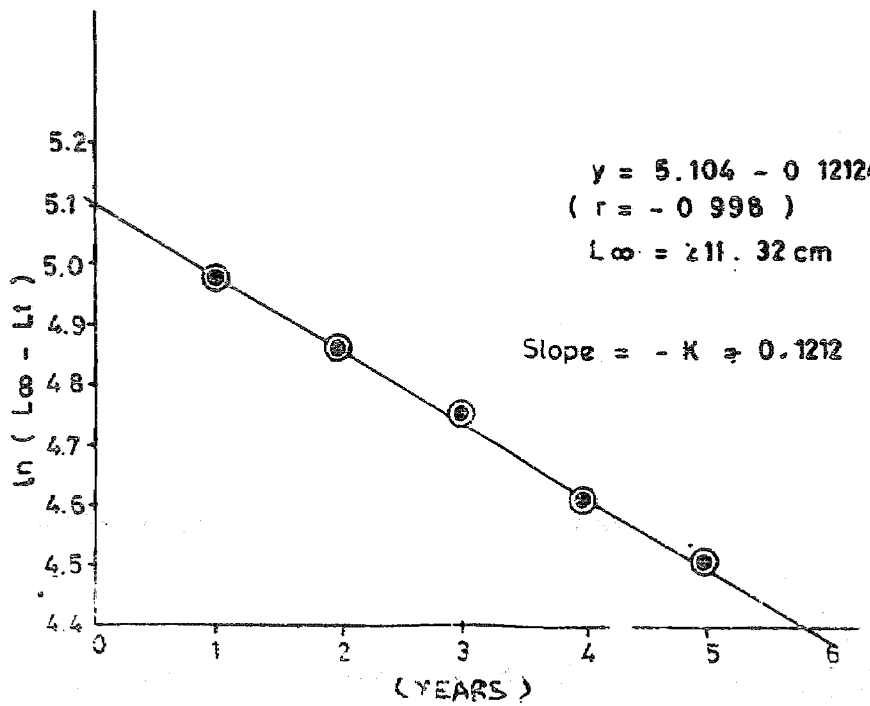

Fig. 3(b) THE WALFORD PLOT OF Lt + 1 AGAINST Lt FOR *G. NILOTICUS* FROM LAKE CHAD