PROXIMATE TISSUE COMPOSITION OF Lates niloticus (L.), Synodontis schall (BROCH AND SCHNEIDER) AND Sarotherodon galilaeus (TREWAVAS) FROM ZARIA DAM.

By

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A thesis submitted to the Postgraduate School, Ahmadu Bello University, Zaria in partial fulfillment of the award of the degree of Master of Science in Fisheries.

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DEDICATION

To humanity.

DECLARATION

I hereby solemnly declare that this thesis is my original work and that it has not been presented in any form for another degree at any other institution. Information derived from the works of others (published and unpublished) has been duly acknowledged in this work.

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CERTIFICATION

This thesis entitled "Proximate tissue composition of *Lates niloticus*, *Synodontis schall* and *Sarotherodon galilaeus* from Zaria dam" by Sadiku, Suleiman Omeiza Eku meets the regulations governing the award of the degree of Masters of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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A B S T R A C T

A total of 272 specimens, comprising 91 Lates niloticus. 95 Synodontis schall and 86 Sarot.herodon galilaeus were biometricaly examined and analysec for muscle proximate composition from February, 19S7 to January, 19SS.

Lengtr--weight relationship study indicates isometric growth pattern in S. schall and S. galilaeus while that of L. niloticus was negatively allometric. Effect of size on composition is not significant in any of the species (P>0.05).

Monthly variation of the proximate constituents was significant (P<0.05) except water. Protein and lipid were higher in the dry season than rains season including periods of high water level in L. niloticus and S. schall, except the protein of S. schall that was lower in the dry season. Protein and lipid composition of S. galilae-s showed discontinuous maxima (Peaks). Monthly variation of ash was not seasonal. The major and minor amino acids arc mineral contents of the three species were higher in the drv season than in the rains season in most cases. These proximate muscle constituents except lipid, and their energy values wiere not significantly different between the species (P>0.05).

There was no significant correlation between water and other constituents (P>0.05) except with lipid of S. schall that was highly significant and inverse, and protein of S. galilaeus t"at was also significant but direct (P<0.05).

TABLE OF CONTENTS

		PAGE
TITLE PAGE	... ...	i
DEDICATION	... ...	ii
DECLARATION	... ...	iii
CERTIFICATION	... ...	iv
ACKNOWLEDGEMENT	... ...	v
ABSTRACT	... ...	vi
TABLE OF CONTENTS	... ...	vii
LIST OF TABLES	... ...	ix
LIST OF FIGURES	... ...	x
LIST OF APPENDICES	... ...	xi
1. INTRODUCTION	... ...	1
2.0 LITERATURE REVIEW	... ...	7
2.1 Fish Composition	... ...	8
2.2 Dynamics of Fish Composition	... ...	10
2.3 Relationship Between Fish Proximate Composition	... ...	14
2.4 Null Hypothesis	... ...	17
3.0 MATERIALS AND METHODS:		
3.1 The Fish Sampling	... ...	18
3.2 Chemical Analysis	... ...	18
3.3 Statistical Analysis	... ...	25
4.0 RESULTS:		
4.1 Length-Weight Relationship of the Fish	...	27
4.2 Relationship Between Size and Proximate Muscle Composition of the Fish	... ...	33
4.3 Seasonal Variation of Proximate Composition	...	43
4.4 Comparison of Proximate Muscle Composition of the Three Species	... ...	51

TABLE OF CONTENTS CONT'D PAGE

4.5 Relationship Between Water and Other Proximate Constituents of Fish Muscle 56

4.6 Seasonal Variation of Amino Acids of the Fish Muscle 61

4.7 Seasonal Variation of Mineral Composition of the Fish Muscle 64

4.8 Comparison of the Energy Content of the Fish Muscle 68

5.0 DISCUSSION 72

6.0 SUMMARY AND CONCLUSION 79

7.0 R E F E R E N C E S 82

8.0 A P P E N D I C E S 90

LIST OF TABLES

TITLE	PAGE
Length-Weight Relationship and Coefficient of Condition	29
Relationship of Weight with Muscle Proximate Composition	37
Proximate Muscle Composition	47
Amino Acid Composition of the Fish in Dry and Rainy Seasons	63
Mineral Composition of the Fish Muscle in Dry and Rainy Seasons	66
Monthly Total Energy Content of the Fish Muscle ...	70

LIST OF FIGURES

TITLE	PAGE
LENGTH-WEIGHT RELATIONSHIP OF:	
Lates niloticus	30
Syndontis schall	31
Sarotherodon galilaeus	32
RELATIONSHIP OF PROXIMATE COMPOSITION WITH SIZE OF:	
Lates niloticus	40
Synodontis schall	41
Sarotherodon galilaeus	42
SEASONAL VARIATION OF PROXIMATE COMPOSITION OF:	
Lates niloticus	45
Synodontis schall	49
Sarotherodon galilaeus	50
SEASONAL VARIATION OF THE SPECIES IN:	
Water	52
Protein	53
Lipid	54
Ash	55
RELATIONSHIP OF WATER WITH OTHER PROXIMATE COMPOSITION IN:	
Lates niloticus	58
Synodontis schall	59
Sarotherodon galilaeus	60
SPECIES VARIATION OF MINERAL ELEMENTS IN THE FISH MUSCLE:	67
SEASONAL COMPARISON OF ENERGY IN THE FISH MUSCLE ...	71

LIST OF APPENDICES

	PAGE
Standard Length, Weight, Condition Factor of the Fish and Proximate Composition of the Fish Muscle ...	90
Variance Analysis of the Proximate Composition of the Fish Muscle	93
Relationship of Water with other Muscle Constituents	95
Amino Acid Concentration of the Fish Muscle	96
Variance Analysis of Amino Acids of the Fish Muscle	99
Mineral Concentration of the Fish Muscle	100
Variance Analysis of the Mineral Contents of the Fish Muscle	103
Energy Content of the Fish Muscle	104
Variance Analysis of the Monthly Total Energy Content of the Fish Muscle	107
Formulae Used	108

CHAPTER ONE

1.0 INTRODUCTION

Nigerians have been speculated to be the greatest consumers of fish and fish products, not only in the sub-saharan portion of Africa, but in the entire continent (Mohammed, 1988). Fish has become a very important source of protein contributing up to 40% of the animal protein as recognised by authors of the fourth National Development Plan (Adesimi and Aderinola, 1983; Dada and Gnanados, 1983).

The per caput consumption of fish per day of Nigerians in the early eighties was about 29.1g, yielding 2.6g of animal protein, representing 35.0% of the livestock products per caput consumption per day and 30.8% of ingested animal protein respectively(Adesimi and Aderinola, 1983). This was a period when fish supply was fairly commensurate with the demand as there was hardly a Nigerian village market without frozen fish in 1980 (Ita, 1986). However, the decline of domestic fish production and restriction on importation of food items in 1984 made her protein supply fell much below demand.

While Nigerian domestic fish production of 563,000 metric tonnes in 1950 was declining, the demand was on a geometric increase and stood at 1.5 million metric tonnes in 1980 (Ita, 1986). Presently, Nigerians are speculated to consume about 3 million metric tonnes of fish per annum. The demand projection by the year 2000 is estimated at 5 million metric

tonnes and only 1 million metric tonnes are expected to come from domestic production (Mohammed, 1988).

In 1975 alone, 120,000 metric tonnes of frozen fish was imported. ₦360 million was spent on the importation of 900,000 metric tonnes of fish in 1980. It was projected that as much as ₦560 million would have been expended on importation of 1.4 million metric tonnes of fish in 1985, but the global economic recession of 1983 never allowed for the execution (Ita, 1986). This unabated and incessant importation of fish can only result in the drain of the foreign exchange earnings of the country. Nigerians must therefore look for domestic means of meeting the insatiable appetite for fish and fish products of teaming Nigerian population.

Ironically, Nigeria is blessed with 12.5 million hectares of inland water mass with annual production capacity of 512,000 metric tonnes (Ita, 1986), and 960 kilometres of coastline. These are underharnessed. In 1980, 1981 and 1982, domestic inland fish production stood at 270,000; 233,000; and 240,000 metric tonnes, presenting harness percentages of 52.7%, 45.5% and 46.9% respectively. This fell to 132,000; 100,000; and 49,000 in 1983, 1984 and 1985 with harness percentages of 25.8%, 19.5% and 9.6% respectively. The bulk of the inland fish production came from capture (artisanal) fishery. A meagre percentage was credited to culture fishery (C.B.N., 1986). The yields of the former are of lower quality than the later. High quality products of aquaculture are therefore not available

to Nigerians. Until recently, very little attention had been paid to this aspect of fish production, hence it has made no significant contribution to our domestic fish production. The offshore domestic fish production also fell drastically through the same period from 293,000 metric tonnes in 1980 to 177,000 metric tonnes in 1985 (C.B.N., 1986). Once these aquatic resources are properly harnessed, the protein-deficient state of Nigeria in the world food balance sheet prepared by experts (F.A.O., 1966; Oyenuga, 1967; N.A.C.D., 1972) will become a history.

This unhealthy food position of Nigeria led to active involvement of the government to solve the nation's nutritional problem and still conserve our foreign exchange earnings. She has over the years considered fishery development a priority alongside the other agricultural subsectors of the economy in her National Development Plans (N.D.P.): The National Accelerated Fish Production Project (N.A.F.P.P.) was charged with bringing the benefits of modern fishing technology to artisanal fishermen; Inshore Fishing Project (I.F.P.) to effect change from small canoes to medium sized inshore fishing vessels and to supply fishing and fish pond construction equipment at 50 per cent subsidy; Fish Seed Multiplication Scheme (F.S.M.S.) to produce high quality fish seeds for distribution to fish farmers, and research projects to boost the harness of industrial fisheries under the care of our water research institutes (Adesimi and Aderinola 1983). The Operation Feed the Nation (O.F.N.) and the "Green Revolution" Programmes were initiated by the government to mobilise the Nigerian populace in her quest for self sufficiency in food

production. This was backed up with Agricultural Credit Guarantee Schemes as well as foreign and world bank participation in providing credit facilities. In January 1987 Nigeria signed an agricultural aid agreement of ₦26.00 million with Japan partly to improve facilities at Nigerian Institute of Oceanography and Marine Research to boost fish production (C.B.N., 1987).

One of the objectives of the Directorate for food, Road and Rural Infrastructure (D.F.R.R.I.) is the development of our fishery resources. About ₦400 million was made available to it in the 1987 budget (C.B.N; 1987) and ₦1.096 billion to agricultural sector including D.F.R.I. in the current budget Adebayo and Sunmonu, 1988). The Homestead Fish Farming Programme (H.F.F.P) under the supervision of D.F.R.R.I. was aimed at producing fish seeds. Towards this goal, the directorate made available ₦4.35 million to research institutes viz; Africa Regional Aquaculture Centre (A.R.A.C), N.I.O.M.R., Kainji Lake Research Institute (K.L.R.I.), Lake Chad Research Institute (L.C.R.I.) and three outstations of the federal department of fisheries (F.D.F) at Panyom, Umma Okigwe and Oyo. They were charged with the responsibilities of producing fingerlings and providing other services needed for aquaculture (Ogunride, 1988).

Despite this enormous contribution by the government, she is yet to realise her objective (Dotun, 1988). One of the reasons is the imbalance between the quantitative and qualitative harnesses of our fishery resource. There are manpower and material provisions for improving fish quantity, while little is done

to improve the qualitative fish production. Fishery science is generally a very young field dated to late 50s in Nigeria as compared to other agricultural subsectors that are as old as modern man. A compiled register of fishery scientists in 1950 had less than two hundred fishery researchers, majority of whom were fishery ecologists and biologists (Sagua, 1983). Government objectives can best be achieved in totality by giving fish nutrition research and development top priorities in the future development plans and projects. These can be in form of researches on the proximate composition of fish. The few existing data on the biochemical composition of fish from tropical Africa (Olatunde, 1980), the present study and subsequent ones will provide background information on the quality of our local fish species. This will help in deciding which of them to breed, timing of breeding and harvest, towards the realisation of high fish quality.

The objectives of this research are therefore to:

1. determine the proximate composition of three local fish species. This will give the nutritional value of the fish. Fish farmers should then be encouraged to direct their effort to production of food fish.
2. establish the seasonal dynamics of these composition. This is towards locating their maxima. It will help in the timing of breeding and harvest to maximise productivity, by synchronising fish reproduction and harvest with high fish quality.

3. correlate these compositions to establish their interrelationships. This will serve as a guide to maximising productivity of the nutrient of interest i.e. protein, and giving evaluation to other compositions once one is known.

CHAPTER TWO

2.0 LITERATURE REVIEW

Fish biochemistry research has been receiving a greater attention in the temperate regions of the world than the tropics (Love, 1970; Olatunde, 1980). The pioneering chemical analysis of fish by Atwater in the temperate dated as far back as 1892. It was not until late 60s that studies of the biochemical composition of freshwater fish from tropical Africa became another focus of fishery science. Prior to this time, very little was known on the biochemical composition of freshwater fish in this region (Watts, 1957; Baruh and Gillard, 1959; Deelstra et al., 1974).

Love (1957) considered the efforts of these early workers in the temperate region wasteful because the number of specimens used were insufficient and biased towards commercial fish. This non-randomised selection resulted in absence of general representativeness and as such made it impossible for logical conclusions from findings (Standsby, 1954; Love, 1957; Hughes et al., 1980 and Vlieg, 1982). They also often undermined the dynamics of fish composition with changes in age, sex, season, tissue, salinity, location, food and feeding habits, environmental temperature etc. (Love, 1957).

Of the few existing data on the proximate composition of fish in Nigerian freshwater (Eyo, 1975; Oni, 1979; Olatunde, 1980), there is perhaps no reference made to the composition of

Lates niloticus and Sarotherodon galilaeus. Oni (1979) investigated the chemical composition of three freshwater fish species including Synodontis schall from Zaria dam. However, this work did not attend to the dynamics of fish body composition and other predicaments that rendered early investigation in the temperate region wasteful.

2.1 FISH COMPOSITION

Fish body composition has been reportedly influenced by several dynamic factors such as diet, ration size, temperature and/body size (Love, 1957; Parker and Vanstone, 1966; Brett et al., 1969; Niimi and Beamish, 1974; Elliot, 1976; Caulton and Bursell, 1977; Weatherley and Gill, 1983b).

Water constitutes about 80 - 85 percent of the body weight (Vinogradov, 1953). The major component of the 15 - 20 percent dry matter is the organic matter, comprising protein, lipid and carbohydrate as the major constituents in a decreasing order of magnitude. The minor component representing 1 - 2 percent of the body wet weight is the inorganic matter (ash), containing mineral elements like potassium, sodium, calcium, magnesium, phosphorus as macro-elements, and iron, copper and zinc, etc as trace elements (Love, 1957).

Nitrogen level measurement has been only a crude estimate of protein in fish, since the protein nitrogen (PN) exists alongside the nonprotein nitrogen (NPN). Protein is the highest organic matter constituent of fish (Standsby, 1962), constituting

a major percentage of the nitrogenous compounds. Other are creatine, free amino acids, trimethylamine oxide (T.M.A.O), anserine, taurine, urea, etc. Eighteen of the twenty-six discovered amino acids have been found present in fish. These have been recorded in an investigation of amino acids content of rainbow trout (Salmo gairdneri), coho salmon (Oncorhynchus kisutch), chery salmon, channel catfish and atlantic salmon (Salmo salar) by Wilson and Cowey (1985). Oni (1979) earlier documented sixteen of the eighteen amino acids of Alestes nurse, Tilapia zillii and Synodontis schall obtained from Zaria dam. They both observed that there is no qualitative difference in the amino acids content of the fish, while amino acids quantity vary from fish to fish. Kanoh et al., (1983) observed quantitative difference in the amino acids content of isolated myosin from requem shark as it had more lysine and glutamic acid content and less aspartic acid and valine than other myosins.

In an investigation of lipid contents of three antartic fish species; Dissostichus mawsoni, Pathogenia borchgevinla and Trematomus bernacchii, Clarke et al. (1984) observed that serum lipid types differ quantitatively from other tissues as sterol esters and triacylglycerol (TAG) lipids were dominant. Nair and Gopakuma (1984) found that phosphatidyl choline lipid was dominant in five lean fish species, namely; silver jaw fish (Johnius argentatus), milk fish (Chanos chanos), pearl spot (Etroplus suratensis), cat fish (Pseudarius jella and Trachysurus species) and three species of shell fish (Peena viridis, Neptunus pelagicus, and Macrobacterium rosenbergii). Many

antartic fish store TAG lipid than wax ester lipid (Reinhardt and Vleet, 1986).

2.2 DYNAMICS OF FISH COMPOSITION

Non-protein nitrogen that usually contaminates protein nitrogen during analysis has been found to differ markedly in the dark and white muscles of fish, hence tissue heterogeneity is a common source of variation in crude protein determination. T.M.A.O and taurine were found to be high in the dark muscle along the lateral line of fish, while histidine, anserine and creatine were in large amount along the white muscle. Little is known about the anatomical distribution of NPN in dark-fleshed fish, although some information is available on white fleshed fish (Sakaguchi and Murata, 1986)— Creatine, trimethylamine oxide in Mackerel (Scomber japonicus) and yellow tail (Seriola quinqueradiata). Epipelagic teleosts, dark fleshed fish which are active swimmers were richer in hemoprotein than white fleshed fish, (Sakaguchi and Murata, 1986). High level of urea was recorded in the muscle and other tissue of reqiuem shark (Watabe et al., 1983).

Seasonal variation was observed in some free amino acids (Jones, 1954) and TMAO in sprats and herring (Ranold and Jacobsen, 1947); Cod and Haddock (Love, 1957). The nine free amino acids, namely; arginine, histidine, isoleucine, leucine, methionine, phenylalamine, threonine, valine and lysine and eight nonessential amino acids; alanine, aspartic acid, cysteine, glutamic acid, glycine, tyrosine, proline, serine of the skeletal

muscle of Ophicephalus punctatus did not differ significantly between seasons, though seasonal variation occurred in the amino acids with peaks in April and November (Siddiqui and Siddiqui, 1977).

Fish in the temperate regions show marked seasonal variation in lipid composition with autum, winter, spring and summer. In winter, there is fat depletion, in the succeeding spring lipid increases and attains high level in the summer. This is maintained in the following autum and is depleted in the winter that follows. This seasonal cycle is superimposed by spawning in reproductivity matured fish. Spring spawning herring fat reserve was lowest immediately after spawning while autumn-spawners were not (Love, 1957). Fat of sardines vary with season with two maxima (Summer and Winter) suggesting two spawning races (Oya et al., 1937). East African reef fish spawn throughout the year with peaks in January - March and September - November, highest in October, corresponding to south eastern monsoon and highest water temperature (Niozka, 1979). Conversely, the caribean reef fish spawn mostly when water temperature is minimal in February, March and April (Munro et al., 1973). Spawning Balsjord cod and baltic cod (Gadus morhua) had negative energy balance from January to spawning as energy stored in lipid reserve in the liver was used, this led to a decrease of liver size. A pre-spawning positive balance was recorded during which liver size increased.

Tissue heterogeneity affects lipid content of fish. Brandes and Dietrich (1953a) showed that fat was highest in the

belly flap of herring fillet, followed by the part anterior to the dorsal fin and decreased steadily towards the tail and less nearer the head. Fat maxima in flesh was attained before the viscera as the latter continued fat accumulation when the former was loaded to capacity (Youdanova, 1939). Lipid of light muscle was highest below the skin and lowest around the spine in New Zealand slender tuna (Allothunus fallai; Vlieg, 1984). Clarke et al. (1984) observed that lipid increased from tail to the most central part of palagic midwater antartic Dissostichus mawsoni. White and red muscles of D. mawsoni and P. borchgrevinla were high in lipid. Subcutaneous tissue level was responsible for the variation in the lipid of jack and blue mackerel (Trachurus declivis and Trachurus novaezelandiae (Vlieg, 1982). In notothenild fish species, lipid was present in the subcutaneous and intermuscular deposit of adipose tissue and connective tissue concentrated close to the most central part of the fish (Clarke et al., 1984). Lipid content of skipjack tuna (Katsuwonus pelamis) from New Zealand and New Caledonian waters was highest immediately below the skin, and dropped steadily to a depth of approximately 10 mm (Vlieg, 1983). Tissue beyond this depth was non oily (Standsby, 1962). Irrespective of the lipid content of the relevant fillet, red muscle of fish was richer in lipid than the white one (Holye et al., 1986).

Fish from different vertical and longitudinal locations vary in lipid content. Lipid accumulation appeared to be a function of depth. Benson and Lee (1975) observed that in deep waters, teleosts adapted to cold temperature stored

greater amount of unsaturated lipids than those in shallows or warmer surface waters. In an investigation of the lipid of twenty-two species of antartic zooplankton and fish, mid and deep water dwellers were higher in protein and lipids than those below 900 metres except Parandania boecki, D. mawsoni, a neutrally bouyant pelagic midwater fish had higher lipid than cryopelagic non-neutrally bouyant P. borchgrevinla, while benthic Trematomus bernacchii contained normal lipid level. Fish of southern ocean showed higher wax esters lipid than subtropical species.

Fish body fat relates to the food and feeding habits of the fish. Perches (Perca fluviatilis) fed on fish had higher feed intake, quicker growth rate and also higher lipid and caloric value than those fed with invertebrates (Jezierska, 1974). Largemouth bass (Micropterus salmoides) showed an increase in lipid content with feeding rate and the highest lipid content was recorded at 18^{o}C. In sockeye salmon (Oncorhynchus nerka) and Largemouth bass, lipid increased with meal size (Niimi and Beamish, 1974). Lipid content of wild and cultured 'Ayu' seemed to be affected by sessile algae and commercial diet fed to them (Hirano and Suyama, 1983). Generally, lipid is higher in cultured fish than wild ones (Saeki and Kumagai, 1984). Lipid was stored in the trans-oceanic migrating silver eels (Anguilla anguilla; Boetius and Boetius, 1985). Comparatively, wild fish are long range migrating while cultured fish are short range.

Ogino and Takeda (1976) and Kirchgessner (1986) investigated the influence of food and feeding on the mineral composition of

of the carp (Cyprinus carpio). Increment in the crude protein level in the fish meal increased its calcium and phosphorus. Zinc was the highest micro-element, followed by iron, copper and manganese in that order. In relation to crude ash, there was no difference in mineral retention with different treatment. Level of mineral retention was influenced by a drastically changed mineral supply in the meal.

It was observed that temperature determined the state of lipid Saturated lipid was deposited more as liquid than unsaturated ones at low temperature (Lewis , 1962; Benson and Lee, 1975). Oil content was highest in cold water and decreased as the sea surface temperature rose in skipjack tuna (Vlieg et al., 1983).

Ash was observed to be affected by tissue type as it was high in the pyloric caeca of N. roasii marmorata (Oehlenschlager and Rehbein (1982). Oni (1979) found that the macro-elements of the whole eviscerated body of A. nurse, S. schall and T. zillii were calcium, potassium, sodium and magnesium while iron, zinc and copper were the micro-element in decreasing order of magnitude.

2.3 RELATIONSHIP BETWEEN FISH PROXIMATE COMPOSITION

Fish biometrics and nutritional components of fish were observed to show some relationships. Fish growth, the accretion of protein, lipids, water, carbohydrate, inorganic substances (Gill and Weatherley, 1984) is exponentially expressed by the equation $Y = aX^b$ (Huxley, 1932). Innumerable statistical analyses

by correlation and regression have shown relationship between moisture and oil contents of fish (Jacquot, 1961; Vlieg, 1955).

Generally there is an inverse linear relationship between fat and water content in fattyfish (Brandes and Dietrich, 1953b Tsuchiya et al., 1953; Vlieg, 1984). Inverse relationship was observed between the protein and moisture content of wild and cultured puffers (Saeki and Kumagai, 1984). Similarly, protein and lipid correlated inversely with moisture in brown trout (Salmo trutta),Elliot, 1976).

The proximate composition of American eel correlated linearly and inversely with body weight (Boetius and Boetius, 1955). Protein and moisture decreased with length and wet weight, protein with dry weight in A. rostrata (Gallagher, 1954). Elements like sodium, potassium, phosphorus and magnesium in carp changed correspondingly with growth while calcium rate of change with growth decreased slightly, (Kirchgessner and Schwarz, 1956). The proximate composition of bass was more affected by temperature than weight (Niimi and Beamish, 1973). Bluntnose minnow, (Pimephales notatus) grew faster at 25°C than at 15°C and 30°C Gill and Weatherley, 1954). Age of fish affected the body composition of rainbow drout as body fat and protein increased with age. Water decreased and ash was constant in the first fourteen months of its life. Sex was not identified as a factor in immature stages (Joan and Yousef, 1976).

Starving fishes have been shown to lose protein more rapidly than water, and protein accumulates faster than water in feeding fish (Groves, 1970). Well fed rainbow trout had higher protein and lipid than the starved ones (Weatherley and Gill, 1983). Cultured mullet was richer in protein, lipid and carbohydrate and lower moisture content than wild ones (Perea and De Silver, 1978).

Seasonal effect on composition interrelationship was evident in red cod (Pseudophysis bachis) and hoki (Macruronus novaezelandiae) as there was little seasonal variation in the lipid and protein contents in a year investigation by Vlieg (1982). However, lipid of T. declivis varied widely between seasons while this seasonal difference was little in protein in a similar investigation he conducted. Conversely, no seasonal variation was observed in the moisture, lipid, protein and ash in wild and cultured puffers (Saeki and Kumagai, 1984).

Several tissues of ten fish of prespawning community of antartic N. roasii marmorata showed considerable variation in their protein, lipid, carbohydrate, ash, chloride and phosphorus. Lipid and carbyhydrate were highest in the liver, low lipid was recorded in the stomach, while protein was lowest in the liver and highest in the stomach (Oehlenschlager and Rehbein, 1982).

2.4 NULL HYPOTHESES

Three hypotheses are hereby propounded:

i. There is no difference in the proximate composition of the fish between the seasons.

ii. Similarly, no variation between the proximate composition of the two size groups.

iii. Finally, water correlates with lipids in fatty fish.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 THE FISH SAMPLING

A total of twenty four fish of three species, Lates niloticus, Synodontis schall and Sarotherodon galilaeus, were obtained monthly except August and September with fewer specimens from Sabon Gari market, Zaria, Nigeria. The eight specimens purchased monthly for each species consisted of two size groups of four small and four larger size.

They were taken immediately to the laboratory life when possible, or fresh in rigor mortis. Biometrics (standard length, total length and body weight) were measured using a fish measuring board and electronic mettler balance respectively. The specimens were then descaled except S. schall and eviscerated. The muscle flaps on both sides bounded as follows; below the dorsal fin, above the pelvic fin, after the operculum and before the caudal fin, were removed. The flaps were weighed and then dried. The dry matter was ground to powder, aliquots of which were used for the determination of protein.amino acids, lipid, ash and mineral elements.

3.2 CHEMICAL ANALYSES

3.2.1 Moisture Content Determination

The wet weight of fish muscle removed from every specimen was determined and then it was dried at 60°C to constant weight in an oven (Model OV-440). The weight difference so obtained was

expressed as a percentage of wet weight using the following formula:

$$\% \text{ Moisture} = \frac{(\text{Wet Weight-Dry weight})\ (100)}{\text{wet weight.}}$$

3.2.2 Total Organic Matter (TOM) Determination

After the drying, the total dry matter (TDM) comprises total organic and inorganic matter. 0.5 - 1.0 g of the TDM was incinerated to ash, removing the TOM. The difference in weight after ashing was the TOM. This was expressed as a percentage of TDM (Lighstein and Oginsky, 1965).

$$\% \text{ TOM} = \frac{(\text{TDM} - \text{Ash})\ (100)}{\text{TDM}}$$

3.2.3 Ash Content Determination

0.5 - 1g of dry matter was weighed into a crucible and incinerated in a muffle furnance (Naber Model) at a temperature of 800^{o}C for a period between 24 and 48 hours until ashing was satisfactory. Initial burning off of sooth by gradual increase of temperature to 300^{o}C for 2 hours was done. At the completion of ashing, samples were cooled in a descicator and weighed afterwards to give the total inorganic matter (TIM) otherwise called the ash using the expression below:

$$\% \text{ Ash (TIM)} = \frac{[(\text{Weight of crucible + TIM}) - \text{Weight of Crucible})]\ (100)}{\text{TDM}}$$

3.2.4 Protein Determination

Official methods of food analysis by Association of Official Agricultural Chemists (A.O.A.C., 1980) micro-kjeldahl technique was used with suitable modifications after Markham (1942), King (1978), and Oyeleke (1984).

10 mg of fish powder was digested for 2.5 hours in a micro-kjeldahl digestion flask using 2 cm^3 of nitrogen free concentrated sulphuric acid and 15 - 20 mg of mixed catalyst (1g of selenium, 8g of potassium sulphate and 1g of copper sulphate).

The digest was distilled in a Markham still steam distillation apparatus using excess (10 - 12 cm^3) 40 percent sodium hydroxide to release the ammonia. This was liquified by condensation and trapped in 5 cm^3 of 2 percent boric acid with 2 - 4 drops of a mixed indicator (6 cm^3 of 95 percent alcohol. 12 cm^3 of 0.04 percent bromocresol green and 6 cm^3 of 0.016 percent methylred indicator. 15 cm^3 of the distillate (liquified ammonia and water) was collected, diluted to 50 cm^3 with distilled water and titrated against standardized 0.02M HCl. A blank digested treated the same way showed absence of contamination from reagents.

Percentage total nitrogen (TN) was computed using the formula:

$$\% \text{ TN} = \frac{(\text{Sample titre} - \text{Blank titre})\ (0.02 \times 14.007)\ (100)}{10}$$

Percentage protein nitrogen (PN) was determined by an adjustment. The non protein-nitrogen (NPN) was determined using 15 percent trichloroactetic acid (TCA) to precipitate the protein nitrogen (PN). Their ratio (PN:NPN) was deduced and used as an adjustment factor. The result so obtained was multiplied by 6.25 (Nitrogen to protein conversion factor of fish). Percent protein was expressed as follows:

$$\% \text{ PN} = \frac{\% \text{ TN } (\% \text{ PN})}{\% \text{ TN}}$$

% Pure Protein (PP) = % PN x 6.25 (Niimi and Beamish, 1973).

3.2.5 Amino Acids Determination

Amino Acid Analyzer (TSM - Technicon squential multisample model) was used to determine the sixteen amino acids in acid hydrolysate of sample.

Duplicates of 100 mg sample (defatted fish powder) was treated with 25 cm^3 of 6M HCl. It was warmed for 24 hours in reflux apparatus and 25 cm^3 of distilled water was added. Each sample hydrolysate was diluted to 100 cm^3, and filtered in readiness for analysis.

Catridge of the analyzer was washed with 0.2M NaOH and buffered with a sodium citrate buffer (PH 2.0) until the resin in the catridge equiliberated.

It was then loaded with; 10 ul of internal standard, 10 ul of amino-acid standard (No 15), and 20 ul of the sample

hydrolysate in buffer (PH2.0). Three different buffers were used as follows:

1. Methylcellulose, Thiodiglycol and 30 percent Brij - 35 solution buffer.
2. Thiodiglycol and 30 percent Brij - 35 buffer solution.
3. Thiodiglycol, 30 percent Brij - 35 and sodium chloride buffer.

The amount of each amino acid present in each fish sample was calculated using an accepted formula in Operation manual for TSM as follows:

$$\text{Amount of Amuno acids (g/16gN)} = \frac{Api}{Aun} \times NEsp \times Msp \times Mwtc \times C$$

where,

Api = Area of peak of interest

Aun = Area of peak of norleucine on the same chromatogram

NEsp = (Norleucine equivalent of the corresponding peak from standard chromatogram) = $\frac{\text{Area of norleucine peak}}{\text{Area of each amino acid}}$

Msp = Moles of amino acid in the standard sample

Mwt = Molecular weight of the amino acid

C = $\frac{\text{(Dilution factor for sample) (16)}}{\text{Sample weight (g) x \% Nitrogen in sample x 10 x volume loaded.}}$

Concentration of amino acid is usually expressed as g/16g N according to Fetuga, et al. (1973). This is equivalent to g/100 g amino acids.

3.2.6 Lipid Determination

Solvent extraction (A.O.A.C., 1980) method employing a soxhlet extractor with a 1:1 petroleum spirit (40 - 60°C) and ethanol was used. Duplicates of 0.5g of each sample were put in a filter paper thimble stocked with cotton, weighed (W_1) and put in the extractor. This chamber was filled to overflow into a receiving flask thereby flushing the thimble once. The extractor was then filled to about two-thirds its volume. With the set up in a water bath and water from the tap continuously running through the condenser. Extraction was carried out for a minimum of 10 hours until colour indication of lipid clears out completely from the extractor.

Extracted sample in thimble was removed, ovendried, cooled in a dessicator and weighed again (W_2). Percentage lipid content was calculated as follows:

$$\% \text{ lipid} = \frac{(W_1 - W_2)\ (100)}{0.5}$$

3.2.7 Carbohydrate Determination

The difference method was used for this determination. The amount of protein plus lipid substracted from the total organic matter is assumed to give the value for carbohydrate, since vitamin content is negligible (Watts, 1957).

% Carbohydrate = % TOM - (% Protein + % lipid).

3.2.8 Mineral Element Determination

Four macro-elements; potassium, sodium, calcium, magnesium and two micro-elements; zinc and iron were determined.

Ash from 0.5g of the sample was dissolved in 4 cm^3 of concentrated hydrochloric acid, warmed in a water bath for 30 minutes and four drops of concentrated nitric acid added. Warming continued for additional 30 minutes. The solution was diluted with distilled water and filtered using a vacuum pump. The filterate was diluted to 50 cm^3 for micro-elements determination. A further dilution of 1 in 25 cm^3 was made for macro-elements.

Determination of Potassium, Sodium and Calcium

1.907g potasium chloride, 2.542g sodium chloride were both dissolved in a litre of distilled water. 2.4973g of calcium carbonate was dissolved in appropriate volume of 1M hydrochloric acid and diluted with distilled water to a liter. These were used as standard stock solutions of 1000 parts per million (ppm) each. Appropriate serial dilutions were prepared from each stock solution as standards. They were 'run' in the flame photometer to determine the concentration of the elements in them. Their readings were used to plot standard caliberation curve of each element.

The samples were similarly 'run Their flame photometer readings obtained were used to extrapolate from the caliberation curve the concentration of each element in ppm.

Determination of Magnesium, Zinc and Iron

3.9160g of magnesium chloride hexahydrate was dissolved in a litre of distilled water. 1.2450g of zinc oxide was dissolved in 5 cm^3 distilled water and 25 cm^3 of 5M hydrochloric acid and diluted to a litre with distilled water. 1g of iron grannules was dissolved in 20 cm^3 of 5M hydrochloric acid and 5 cm^3 of concentrated nitric acid, this was diluted to a litre. These were used as standard stock solutions of 1000 ppm each. Appropriate serial dilutions were prepared from each stock solution as standards. They were 'run' in atomic absorption spectrophotometer (A.A.S.-S P Pye unicam model). The A.A.S readings were used to plot standard caliberation curve of each element.

The samples were then 'run'. Their readings were used to extrapolate from the caliberation curve the concentration of each element in ppm.

3.3 STATISTICAL ANALYSES

The following statistics were used: Correlation and linear regression to determine the relationship between length and weight, weight and proximate muscle composition, water and other proximate muscle constituents; and analysis of variance to test significance in the seasonal and species variation of the proximate muscle composition. Others are t-test to test the significance of the difference between the proximate composition of the two size groups and also the conventional seasons, and coefficient of variation to evaluate variation of the proximate composition of individual specimens in a group.

For seasonal statistical analyses, months from December to May and June to November were considered as period of dry and rainy seasons respectively.

CHAPTER FOUR

4.0 R E S U L T S

4.1 LENGHT-WEIGHT RELATIONSHIP AND CONDITION OF THE FISH

Specimens of Lates, niloticus, Syndontis schall and Sarotherodon galilaeus were biometrically examined and analysed. These were in two size groups, belonging to a small and larger size ranges of specimens, sampled monthly for twelve months. A t-test (group) showed that a significant difference exists between the groups. The two groups were therefore recognised for each species in the length-weight relationship study, suming up to 23, 24 and 23 groups of L. niloticus, S. schall and S. galilaeus respectively. Average values of length and weight of individuals of every group were used.

Length and weight are the two routine measurements of size and condition of fish. Mean values (95% confidence limits) and ranges of length and weight of the three species are given in Table 1. In accordance with the exponential growth nature of fish, $Y = a X^b$ (Huxley, 1932), linearised as $\log Y = \log a - b \log X$ (Le Cren 1951). Log weight was regressed on log. standard length. They were further correlated. Figs. 1, 2 and 3 depicts the linear regression and degree of correlation for L. niloticus, S. schall and S. galilaeus respectively. The coefficient of regression 'b' of the length-weight relationship was found to be 3, 3 and 2.6 for S. schall, S. galilaeus and L. niloticus respectively. The 95% confidence limits of the slopes were in a narrow belt with scattering of

points in a wide belt as depicted by the figures. A very strong and direct correlation between length and weight was observed in every species as coefficient of correlation 'r' was very close to + 1.

Condition factor, otherwise called the coefficient of condition or ponderal index denoted as 'K' is the measure of fish condition, degree of fatness, robustness or physical well-being. In these species, it was in a range of 1.75 - 4.34%. S. galilaeus had highest K value while L. niloticus had the minimum, S. schall was intermediate. The range and mean values (95% confidence limits) of K are given in Tables 1. The K evaluation was according to cube law:

$$K = \frac{W\ 100}{L^3}$$

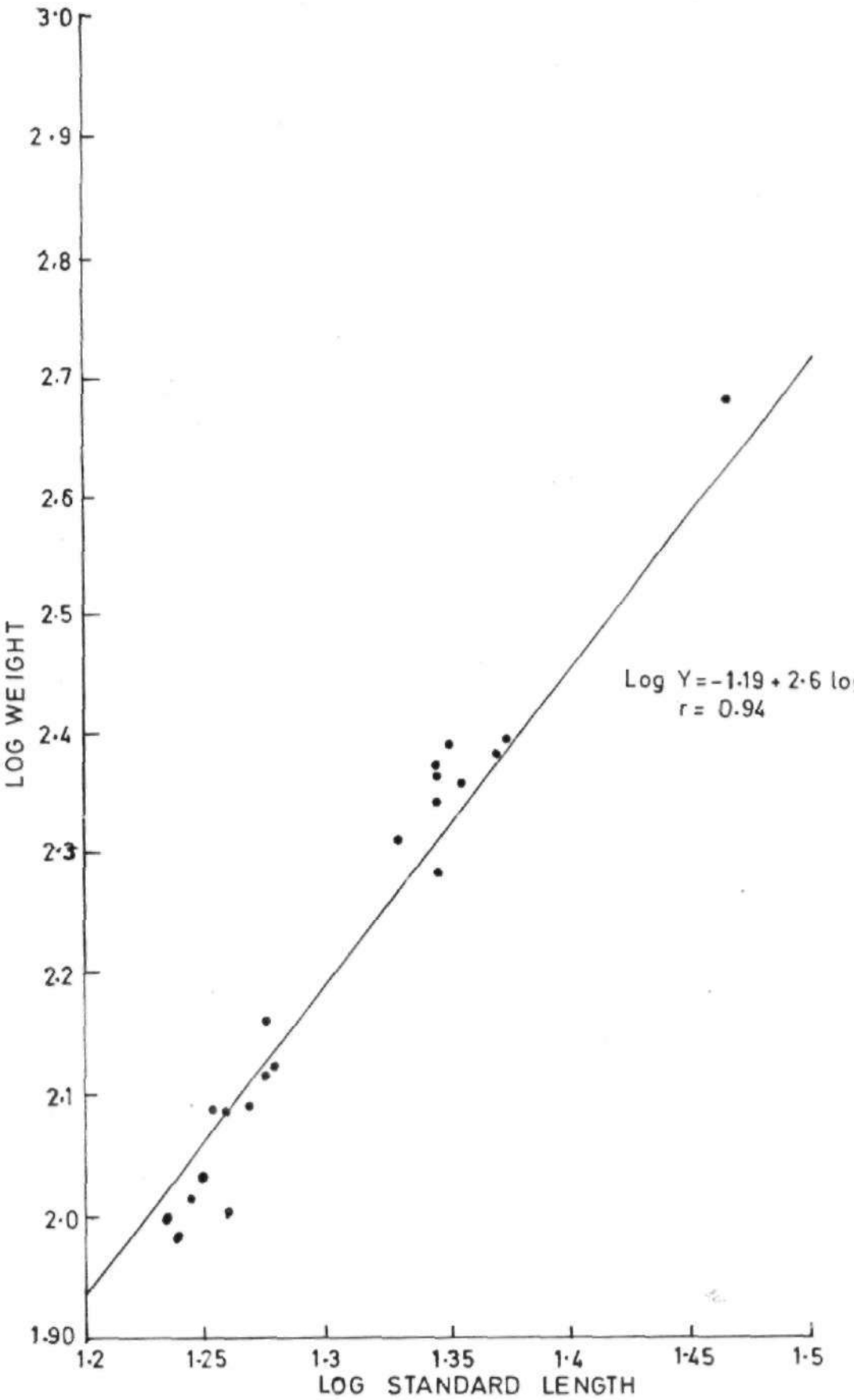
where W = Weight (g)

L = Standard length (cm).

TABLE 1: LENGHT-WEIGHT RELATIONSHIP AND COEFFICIENT OF CONDITION (K) OF Lates niloticus, Synodontis schall and Sarotherodon galilaeus.

Species	Variate	Range	Mean values 95% *CL
Lates	Av. std length (cm)	17.22-29.24	20.59 ± 1.29
niloticus	Av. Weight (g)	93.54-483.06	179.85 ± 37.95
	K (%)	1.75-2.20	1.94 ± 0.05
Synodontis	Av. std length (cm)	12.08-16.37	14.35 ± 0.59
schall	Av. weight (g)	39.42-96.38	69.39 ± 8.84
	K (%)	2.09-2.58	2.28 ± 0.05
Sarotherodon	Av. std length (cm)	13.03-20.51	16.42 ± 1.19
galilaeus	Av. weight (g)	65.51-367.28	185.37 ± 40.24
	K (%)	3.39-4.34	3.86 ± 0.13

* CL = Confidence limits.



FIG·1: LENGTH – WEIGHT RELATIONSHIP OF LATES NILOTICUS

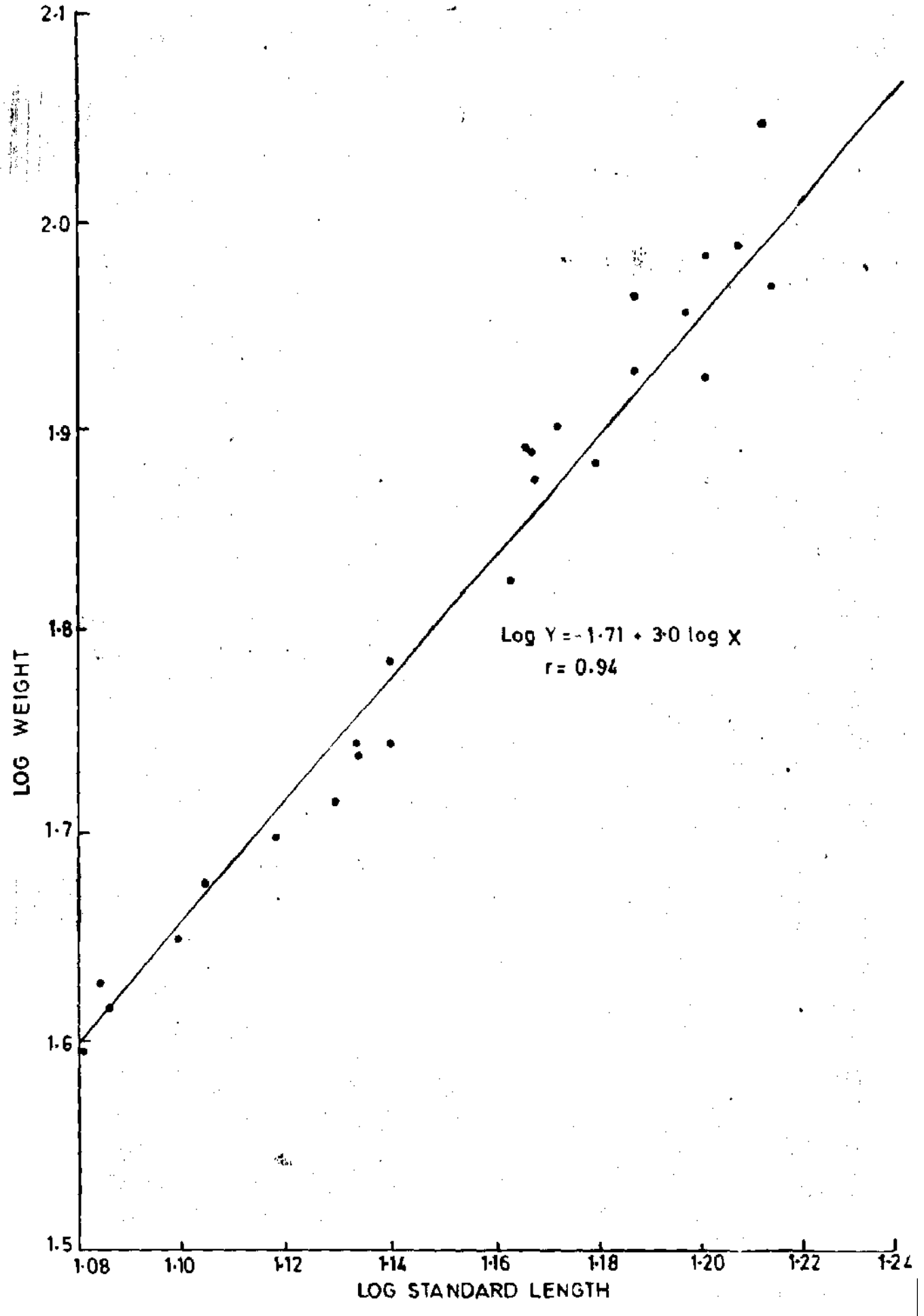


FIG.2:LENGTH WEIGHT RELATIONSHIP OF SYNODONTIS SCHALL

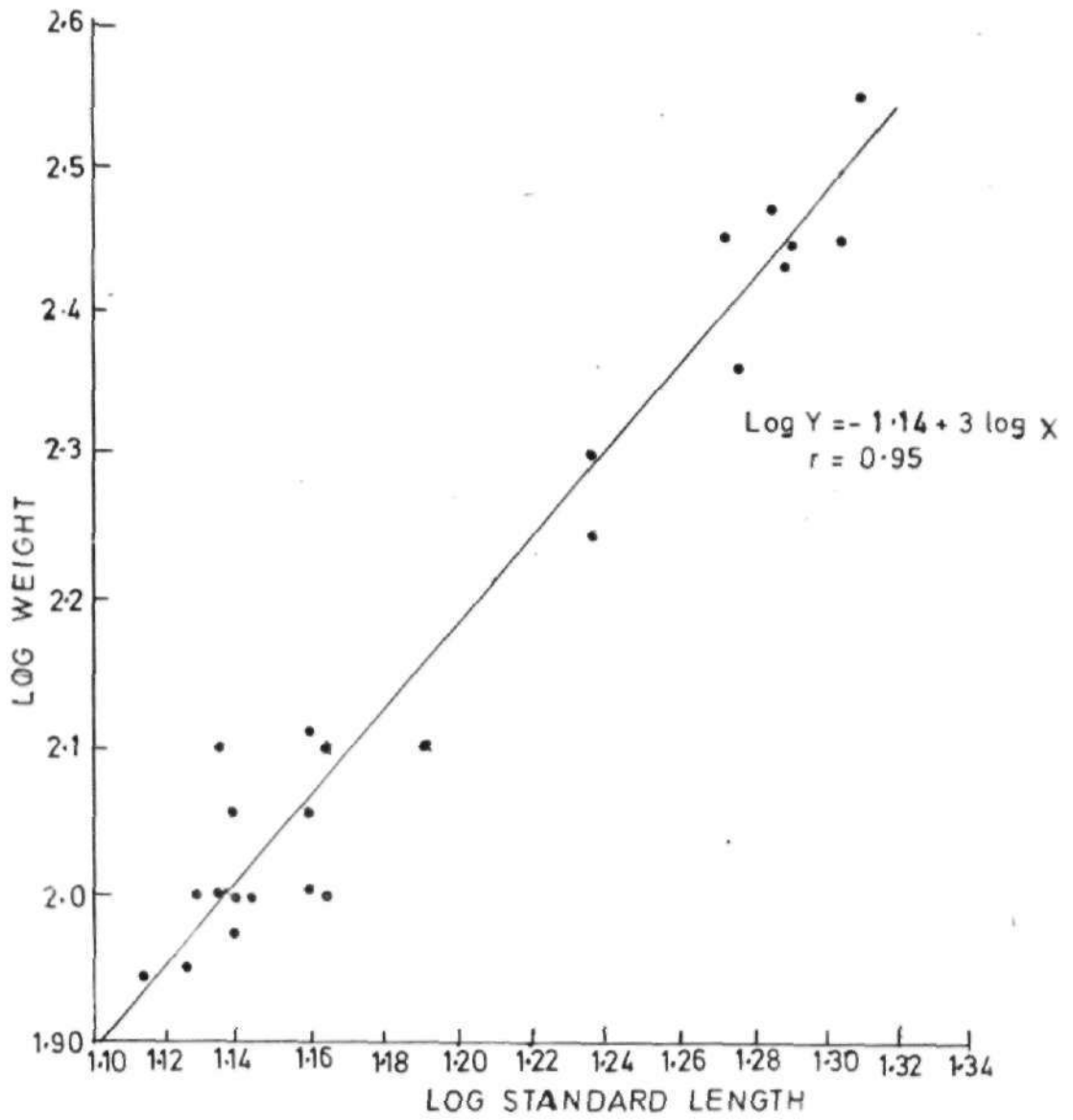


FIG. 3: LENGTH-WEIGHT RELATIONSHIP OF SAROTHERODON GALILAEUS

4.2 RELATIONSHIP BETWEEN SIZE AND PROXIMATE MUSCLE COMPOSITION OF THE FISH

The very strong correlation between length and weight of the three fish species has made it possible for either of them to be related to the proximate composition. For routine purpose weight was used in this study. A t-test has already confirmed the significant difference of the two size groups of the fish viz; Smaller and Larger sizes ($P<0.05$). The groups average weight, ranges and mean values (95% confidence limits) for the three species are given in Table 2A - 2C. However, no significant difference was observed between the proximate composition of the tissue of the two groups in most cases ($P>0.05$), hence pooled. Mean values (95% confidence limits) and ranges of the composition are also indicated in the Tables.

4.2.1 Lates niloticus

No significant difference in the protein and lipid of the two groups ($P>0.05$) was observed. Similar situation was recorded for water and ash except for months of May and Februar for water and February for ash irrespective of size ($P>0.05$). A lo spread of the scattered points about the scope was exhibited b water, protein lipid and ash.

Weights of the two groups correlated inversely and insignificantly with water ($P>0.05$) and represented in a generalised regression $Y = a-bX$ reduced to $Y = a$ Fig. 4 (A).

There is no correlation between the protein content and the weight of the two groups Fig. 4(B). Correlation coefficient was very near zero particularly in the smaller size groups. The regression of protein on weights of the smaller and larger groups can be generalized as $Y = a + bX$ and $Y = a-bX$ respectively, reduced to $Y = a$.

The weight of the smaller group related inversely and insignificantly with lipid ($P>0.05$). The regression of lipid content on weight is expressible as $Y = a-bX$. Conversely, the larger group correlated directly but insignificantly with lipid. This relationship is regressed as $Y = a + bX$. These are reducible to $Y = a$ in the two groups Fig. 4(C).

In the smaller group, the weight correlated directly but insignificantly with ash ($P>0.05$). The regression of the ash content on weight is represented by $Y = a - bX$ reduced to $Y = a$ Fig. 4(D). Conversely, the larger group had an inverse and highly insignificant interrelationship with ash. This is expressed as $Y = a - bX$ also in the figure.

4.2.2 Synodontis schall

Protein and lipid varied insignificantly between the two groups ($P>0.05$). Similar finding was recorded for water and ash except during the months of April and June for water, April, September and November for ash when t-test (group) proved significant irrespective of size ($P<0.05$). Mean values (95% confidence limits) of the coefficient of regression (slope)

indicate that the scattered points were in a wide belt about the slope.

A direct but insignificant correlation exists between the weight and water or protein content of the two groups ($P > 0.05$). The regression of either of the contents on their weights can be generalized as $Y = a + b\lambda$ Fig. 5(A and B).

Conversely, lipid and ash related inversely but insignificantly with the weights of the size groups ($P > 0.05$) hence regressed in a generalisation $Y = a - b\lambda$, reducible to $Y = a$ only in the lipid of the smaller size group Fig. 5(C and D).

4.2.3 Sarotherodon galilaeus

Protein and lipid contents of the two size groups showed significant difference only in December and March respectively, irrespective of size, as t-test (group) for other months proved insignificant ($P > 0.05$). Significant difference of their ash content was in July, April, March and February while water contents of the groups were significantly different in December, August, June and April irrespective of size ($P < 0.05$). Mean values (95% confidence limits) of the slopes show that the scattered points were within a wide belt about the coefficient of regression.

Water content of the smaller size group related directly and insignificantly ($P > 0.05$). Regression of moisture contents on the group weights can be represented as $Y = a + bX$ reducible

to Y = a. Contrary to this was the larger group with moisture content that correlated inversely and insignificantly ($P>0.05$) represented as Y = a - bX Fig. 6(A).

The interrelationship of the weight of the smaller group with protein was direct and insignificant ($P>0.05$) and is represented as Y = a + bX, while the larger group correlated with protein inversely and insignificantly ($P>0.05$) represented as Y = a - bX Fig. 6(B).

There was an inverse and insignificant correlation of lipid content of the smaller group with weight ($P>0.05$), represented in a regression Y = a - bX, reducible to Y = a Fig. 6(C).

Fig. 6(D) indicates the relationship between the group weights and ash content of the fish. Smaller size group related insignificantly and inversely with ash ($P>0.05$). This is represented as Y = a - bX. The weights of the larger size showed a direct but insignificant relationship with ash ($P>0.05$) in a generalised regression Y = a + bX.

TABLE 2A: RELATIONSHIP OF WEIGHT (g) WITH MUSCLE PROXIMATE COMPOSITION (%) OF Lates niloticus

Size Group	Variate	Ranges	Mean values (95% *CL)	95% CL of b Weight vs
Smaller	Weight	95 - 145	115.83 ± 9.77	
Size	Water	78.80-81.20	79.69 ± 0.41	-0.0131 ± 0.0038
	Protein	54.80-66.20	61.43 ± 2.31	0.0763 ± 0.0201
	Lipid	12.00-23.80	16.75 ± 2.09	-0.0519 ± 0.0165
	Ash	4.20-5.50	4.85 ± 0.23	0.0069 ± 0.0021
Larger	Weight	190 - 485	290.45 ± 53.63	
Size	Water	77.50-81.20	79.81 ± 0.81	-0.0094 ± 0.0026
	Protein	54.50-67.60	62.68 ± 2.42	-0.0070 ± 0.0095
	Lipid	12.50-23.30	17.07 ± 2.140	0.0130 ± 0.0082
	Ash	3.90-5.30	4.69 ± 0.29	-0.0057 ± 0.0013

*CL = Confidence limits.

TABLE 2B: RELATIONTIONSHIP OF WEIGHT (g) WITH MUSCLE PROXIMATE COMPOSITION (%) OF Synodontis schall

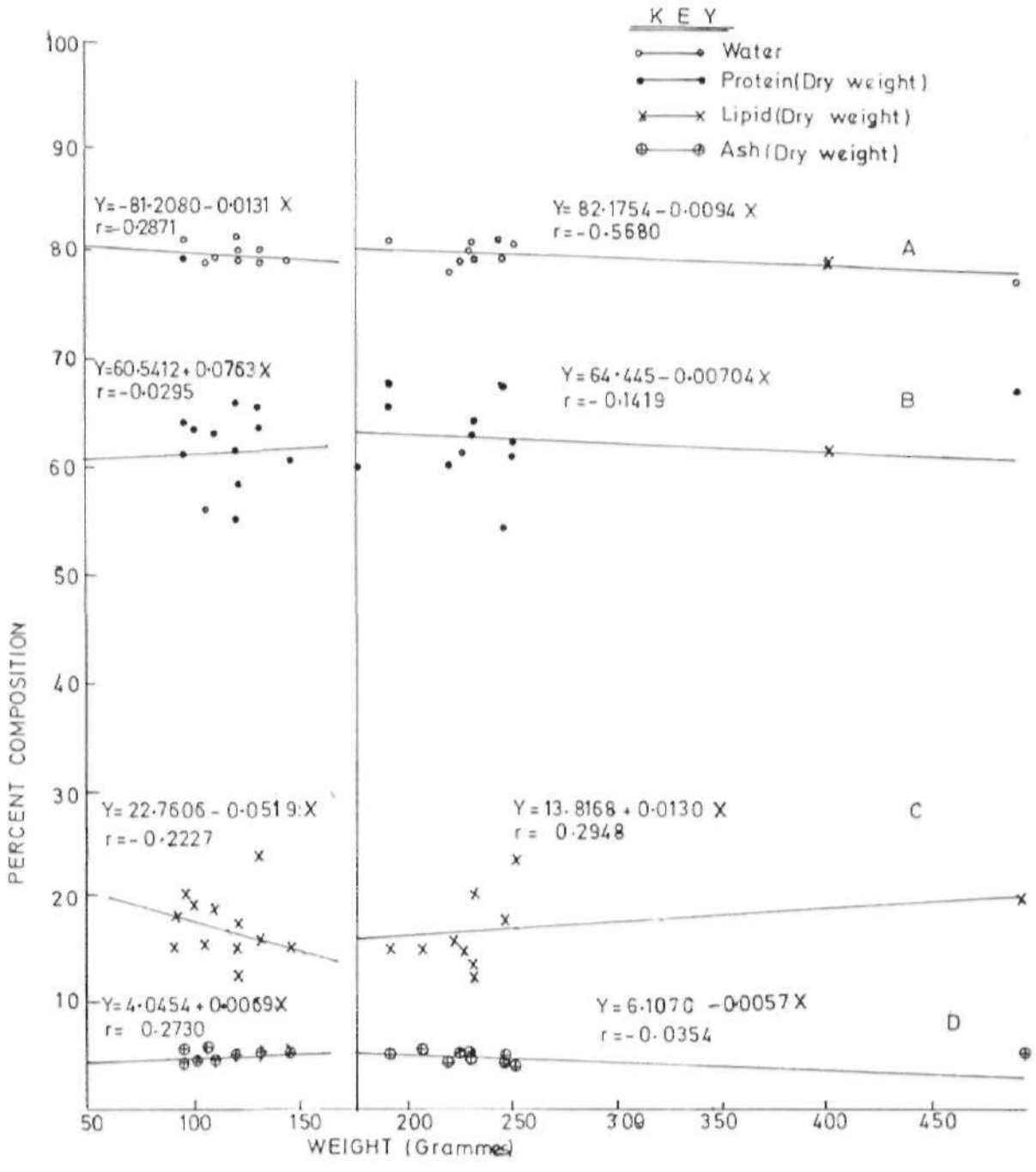
Size Group	Variate	Ranges	Mean values (95% *CL	95% CL of b Weight vs
Smaller	Weight	39.42-75.67	51.71 ± 6.44	
Size	Water	76.30-81.00	79.36 ± 1.02	0.0844 ± 0.0181
	Protein	54.10-65.70	56.28 ± 2.36	0.0472 ± 0.0433
	Lipid	17.10-24.60	21.03 ± 1.56	-0.0359 ± 0.0303
	Ash	4.10-5.45	4.77 ± 0.27	-0.0159 ± 0.0052
Larger	Weight	67.11-111.46	87.07 ± 7.54	
Size	Water	76.50-81.40	79.17 ± 0.86	0.0287 ± 0.0099
	Protein	52.00-60.10	55.57 ± 1.57	0.0519 ± 0.0181
	Lipid	14.70-25.30	20.39 ± 1.91	-0.0977 ± 0.0200
	Ash	3.90-5.70	4.73 ± 0.36	-0.0097 ± 0.0044

*CL = Confidence limit.

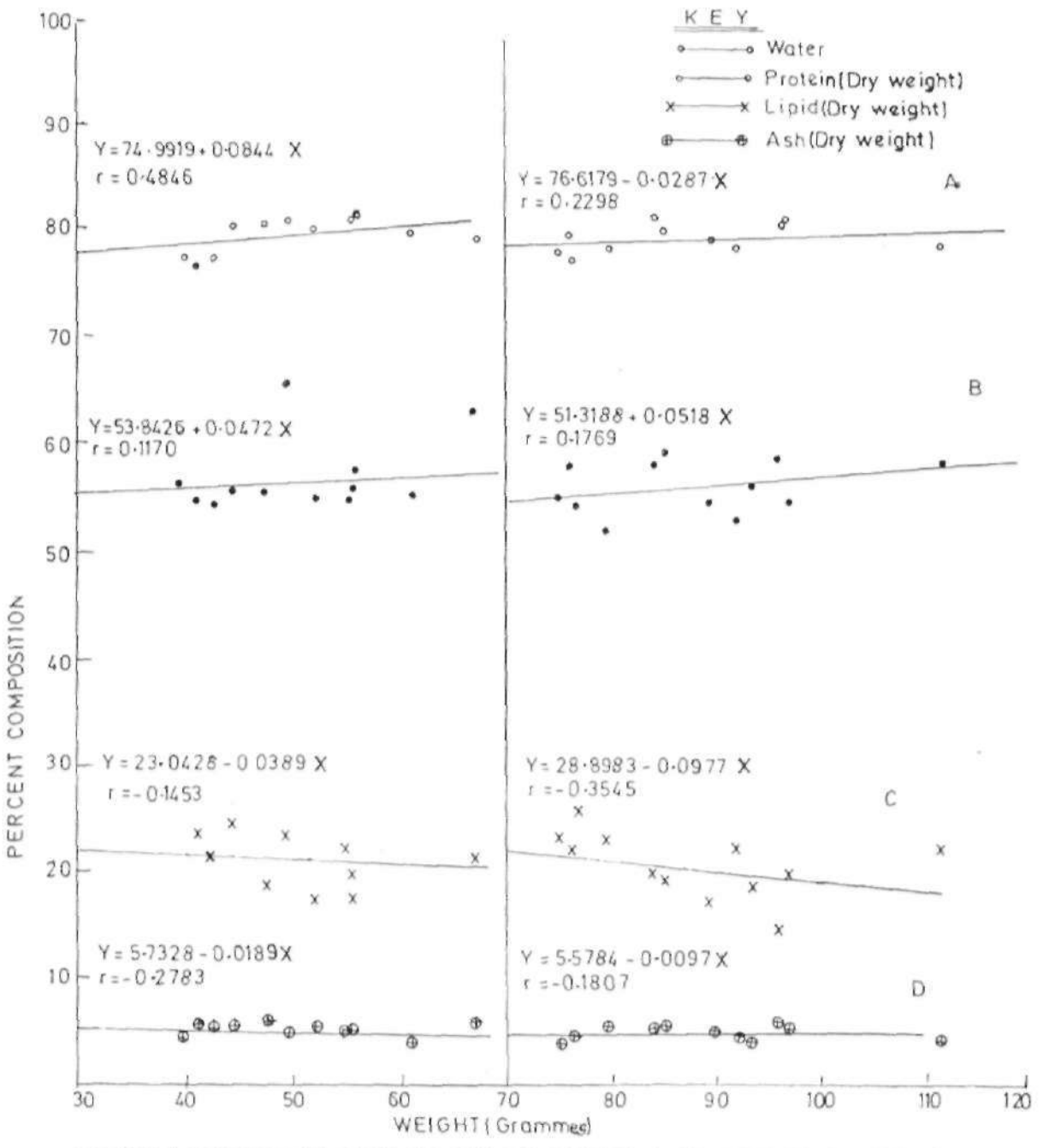
TABLE 2C: RELATIONSHIP OF WEIGHT (g) WITH MUSCLE PROXIMATE COMPOSITION (%) *Sarotherodon galilaeus*

Size Group	Variate	Ranges	Mean values (95% *CL)	95% CL of b Weight vs
Smaller	Weight	85.49-125.50	106.07 ± 9.70	
Size	Water	78.20-82.30	80.20 ± 0.76	0.0175 ± 0.0066
	Protein	55.50-66.70	60.58 ± 2.39	0.0579 ± 0.0224
	Lipid	15.60-24.30	19.98 ± 1.60	-0.0075 ± 0.0156
	Ash	3.60-5.80	5.03 ± 0.42	-0.0118 ± 0.0040
Larger	Weight	176.40-366.96	272.02 ± 36.02	
Size	Water	75.90-82.80	79.75 ± 1.17	-0.0226 ± 0.0051
	Protein	56.20-68.60	61.47 ± 2.49	-0.0257 ± 0.0093
	Lipid	16.30-22.10	15.88 ± 1.16	0.0098 ± 0.0042
	Ash	4.20-6.00	4.95 ± 0.40	0.0024 ± 0.0014

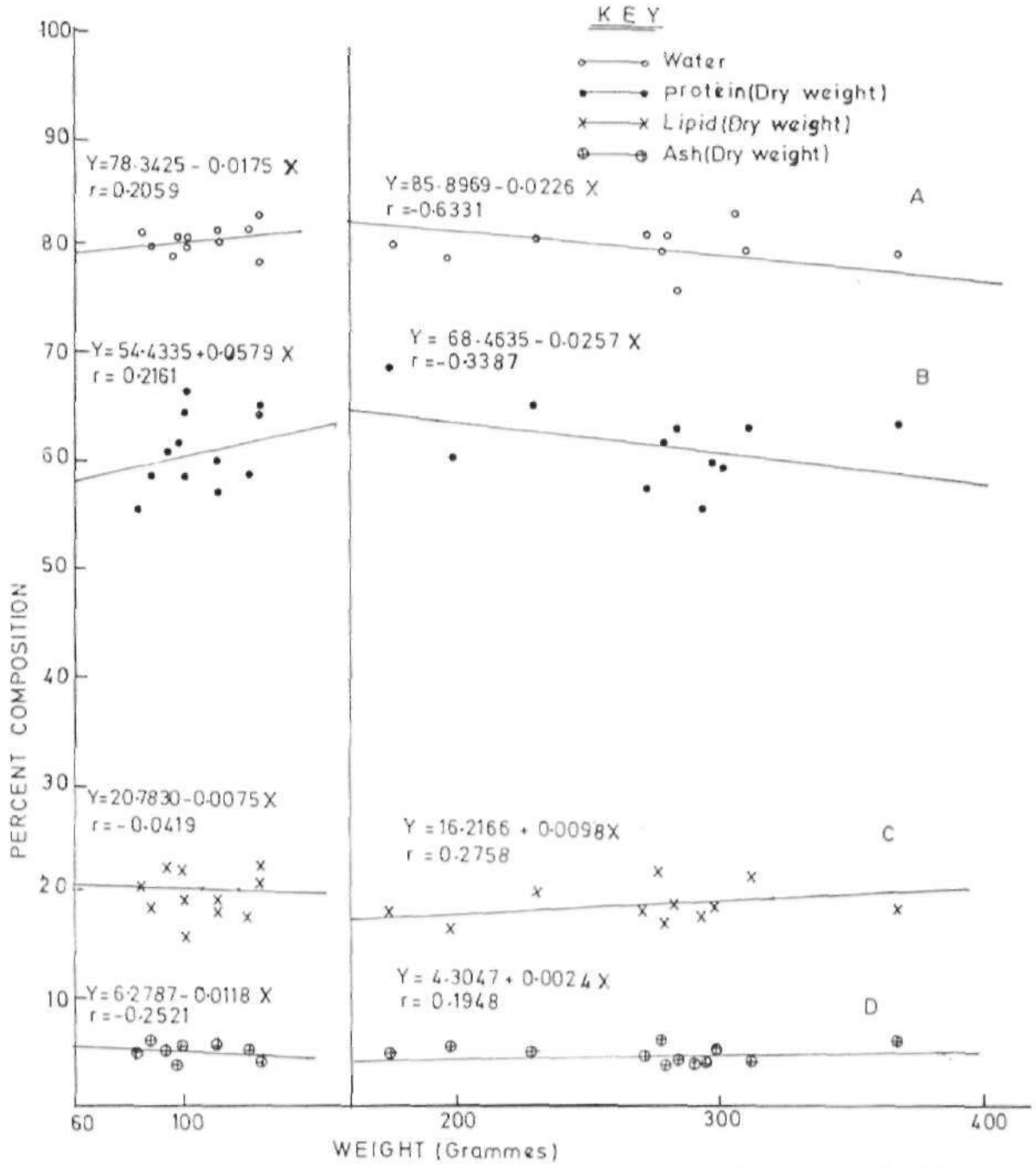
*CL = Confidence limits.



FIG·4: RELATIONSHIP OF PROXIMATE COMPOSITION WITH SIZE OF LATES NILOTICUS



FIG·5: RELATATIONSHIP OF PROXIMATE COMPOSITION WITH SIZE OF SYNODONTIS SCHALL



FIG·6:RELATIONSHIP OF PROXIMATE COMPOSITION WITH SIZE OF SAROTHERODON GALILAEUS

4.3 SEASONAL VARIATION OF PROXIMATE COMPOSITION OF THE FISH MUSCLE

The proximate analyses showed that water was the highest component, followed by protein, lipid and ash in decreasing order of magnitude in the three species. Water constituted a range of 77.1-82% and ash in a range of 4.1-5.8% dry weight (Table 3). The low values of coefficients of variation indicate that the monthly and seasonal variation of water is insignificant. Figs. 7, 8 and 9 depicts the monthly variation. Ash had high coefficients of variation attesting to significant monthly but nonseasonal differences in the three species. Total organic matter amounted to between 94.97 and 95.27% of the dry matter in the three species (Table 3). Protein and lipid monthly variations were significant and seasonal except for S. galilaeus. Their respective mean values (95% confidence limits) are presented in the Table.

4.3.1 Lates niloticus

Fig. 7(A) shows that monthly values of moisture content were within the 95% confidence limits of the mean except for March, September with low values, April and July with high values. Monthly ash content was found to be within the 95% confidence limits except for June and January with high values and April with low value. There occurred a significant and nonseasonal monthly variation, Fig. 7(D).

A direct relationship exists between seasonal variation of protein and lipid. The protein and lipid content of the muscle was high during the dry season, to early part of rainy season. The

protein values for months of May to August and January were high while December and February were low, Fig. 7(B). Others maintained mean values (95% fiducial limits). Lipid content was high in the months of March to May, values for other months were within mean values (95% confidence limits) except August, November and December that were low in lipid, Fig. 7(C).

4.3.2 Synodontis schall

Moisture content of the flesh for the months of March to June (Period of dry season to early rainfall) was low, while moisture in September, November and January (Period of high water level and harmattan respectively) was high. Values for other months were within 95% confidence interval of the mean, Fig. 8(A). Monthly ash content was high in February, March and November, low in June, August and October.Others were within 95% confidence limits of the mean, Fig. 8(D).

Protein and lipid are inversely related, Fig. 8(B and C). The lipid content of the fish muscle for the months of the dry season to early rainfall was high but the protein content was low. Those for the months of high water level were high in protein but low in lipid content. The two components especially lipid tended to rise in the harmattan period. Protein content of fish muscle in months of February to April, June and December which are mostly dry season was low. It was highest in July and within the mean values (95% confidence limits) in other months of mostly period of high water level. Lipid content of fish muscle in the months of March to August, December and

January were within 95% confidence intervals. Others were low in lipid content except in April and May with high values - implying a higher lipid of the fish muscle in the dry than rainy season.

4.3.3 Sarotherodon galilaeus

The muscle had high moisture content in January, February and August and low values were recorded in March and June. Values for other months were within 95% fiducial limits of the mean, with the muscle showing higher water content in the period of high water level and harmattan than hot dry season in most cases, Fig. 9(A). Fig. 9(D) exhibits monthly variation in ash content. The ash content of fish muscle in the months of May, September, and November was high, low in February, April, August, and October; values for other months were within the 95% confidence limits of the mean.

An inverse relationship also was observed between protein and lipid. Their variations were not seasonal. Fig. 9(B) shows some peaks of the variation. High protein values were recorded in the muscle during the months of March, July and August. Low values were recorded from September to January, but November and others were within the 95% fiducial limits of the mean. A major peak occurred in July (rainy season) with minor ones in March and November of dry season and high water level period respectively. In Fig. 9(C), lipid content of fish muscle was high in the months of March to June and August, low in September, November and February, others were within the 95%

fiducial limits of the mean. There were also peaks in lipid seasonal variation. Major peak of lipid was in the dry season month of April with minor ones in high water level periods of August and October.

TABLE 3: PROXIMATE MUSCLE COMPOSITION (%) OF Lates niloticus, Synodontis schall AND Sarotherodon galilaeus

Species	Composition	Range	Mean 95% *CL	Coefficient of variation (%)
Lates schall	Water	78.60-81.00	79.64 ± 0.41	0.88
	Protein	54.60-66.20	62.27 ± 1.93	6.25
	Lipid	12.00-21.90	16.69 ± 1.82	19.29
	Ash	4.10-5.20	4.76 ± 0.16	5.76
Synodontis schall	Water	77.10-81.20	79.24 ± 0.72	1.59
	Protein	53.10-64.30	56.37 ± 1.62	5.07
	Lipid	15.90-25.00	20.70 ± 1.44	12.32
	Ash	4.10-5.50	4.73 ± 0.23	8.57
Sarotherodon galilaeus	Water	78.20-82.00	80.12 ± 0.75	1.6
	Protein	55.80-67.70	60.92 ± 1.99	5.78
	Lipid	15.90-22.80	19.39 ± 1.12	10.21
	Ash	4.70-5.80	5.03 ± 0.25	9.67

*CL = Confidence limits

Level of significance

$P < 0.05$ = Significant

$P > 0.05$ = Insignificant.

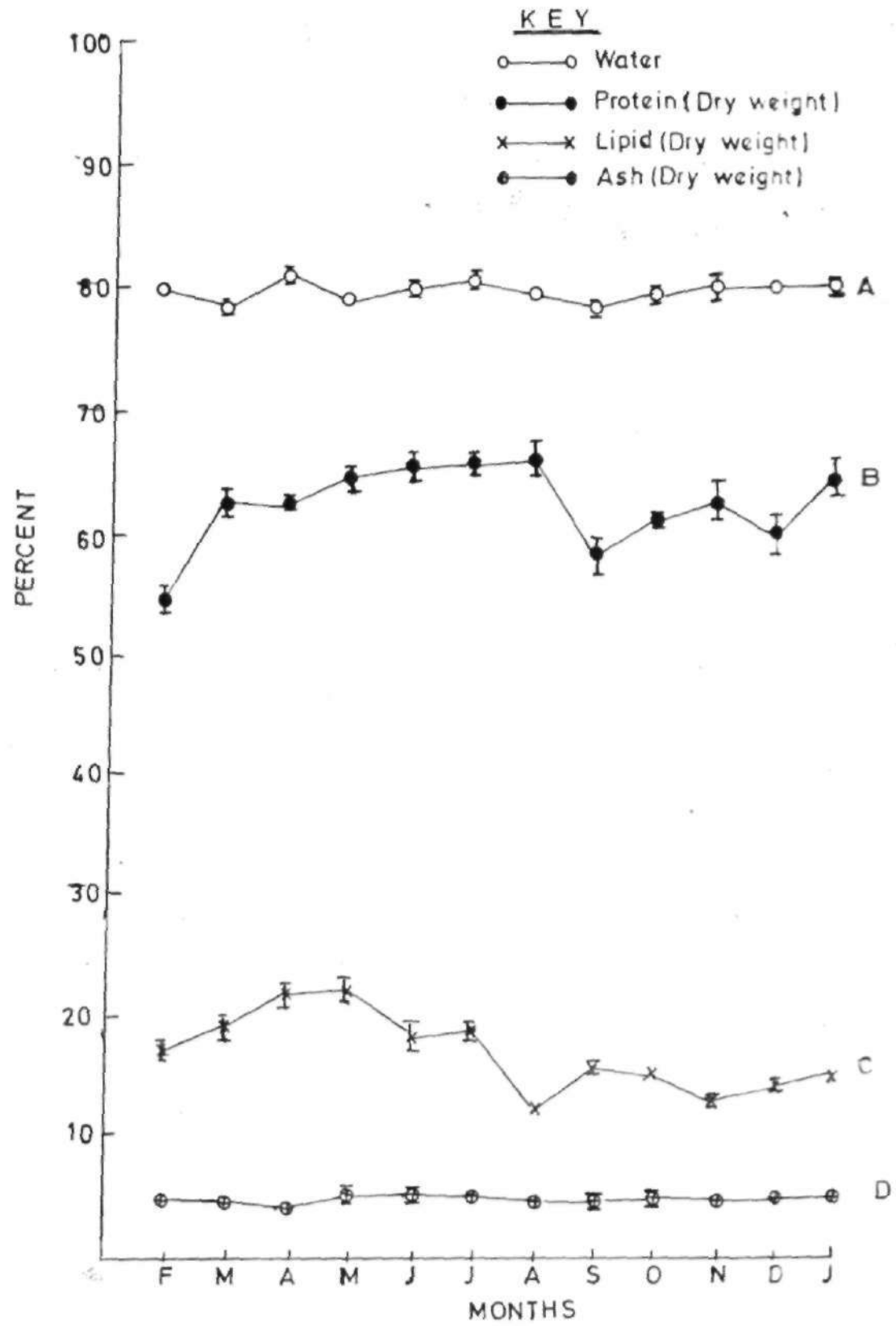


FIG-7: SEASONAL VARIATION IN THE PROXIMATE COMPOSITION OF LATES NILOTICUS

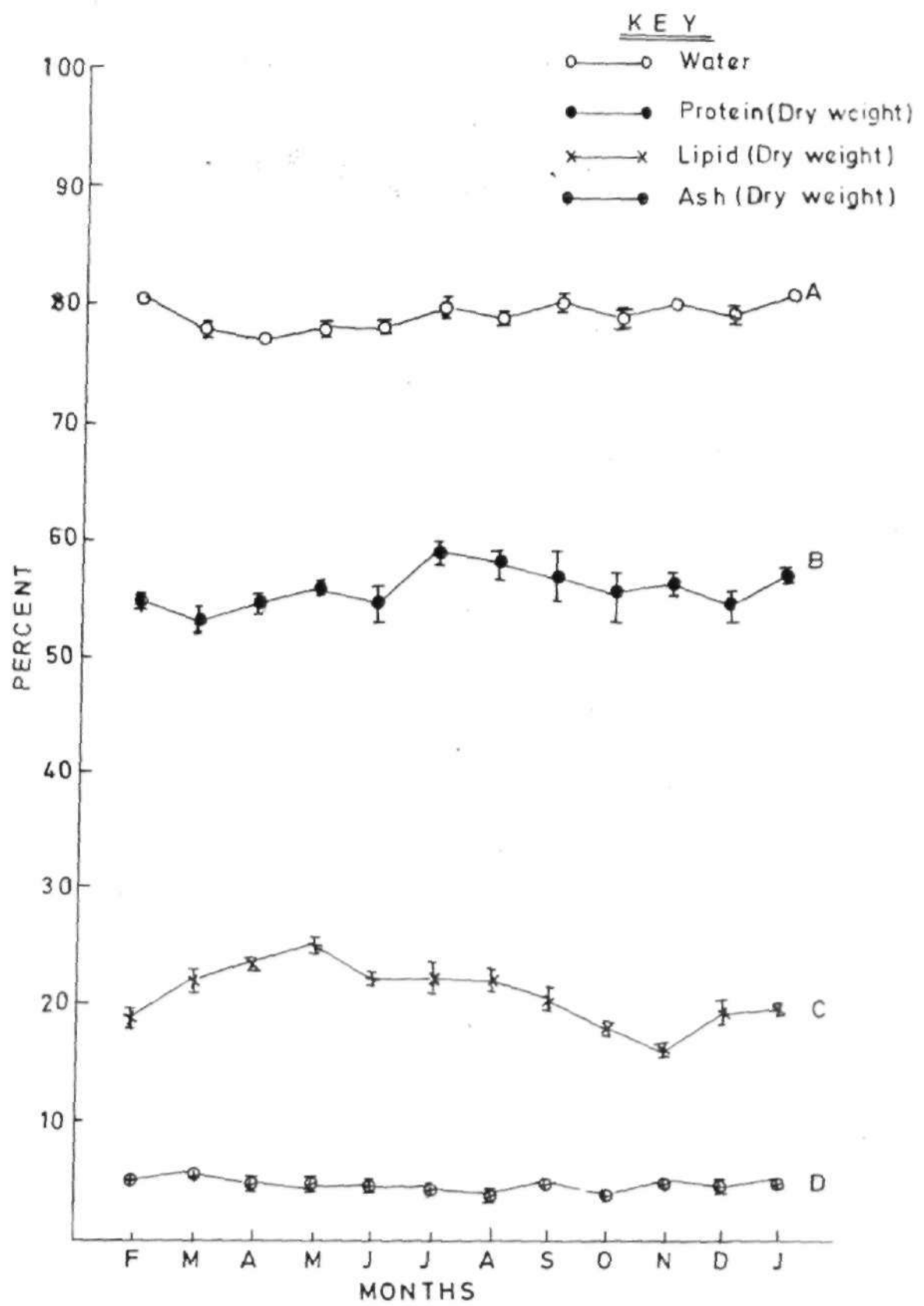


FIG. 8: SEASONAL VARIATION IN THE PROXIMATE COMPOSITION OF SYNODONTIS SCHALL

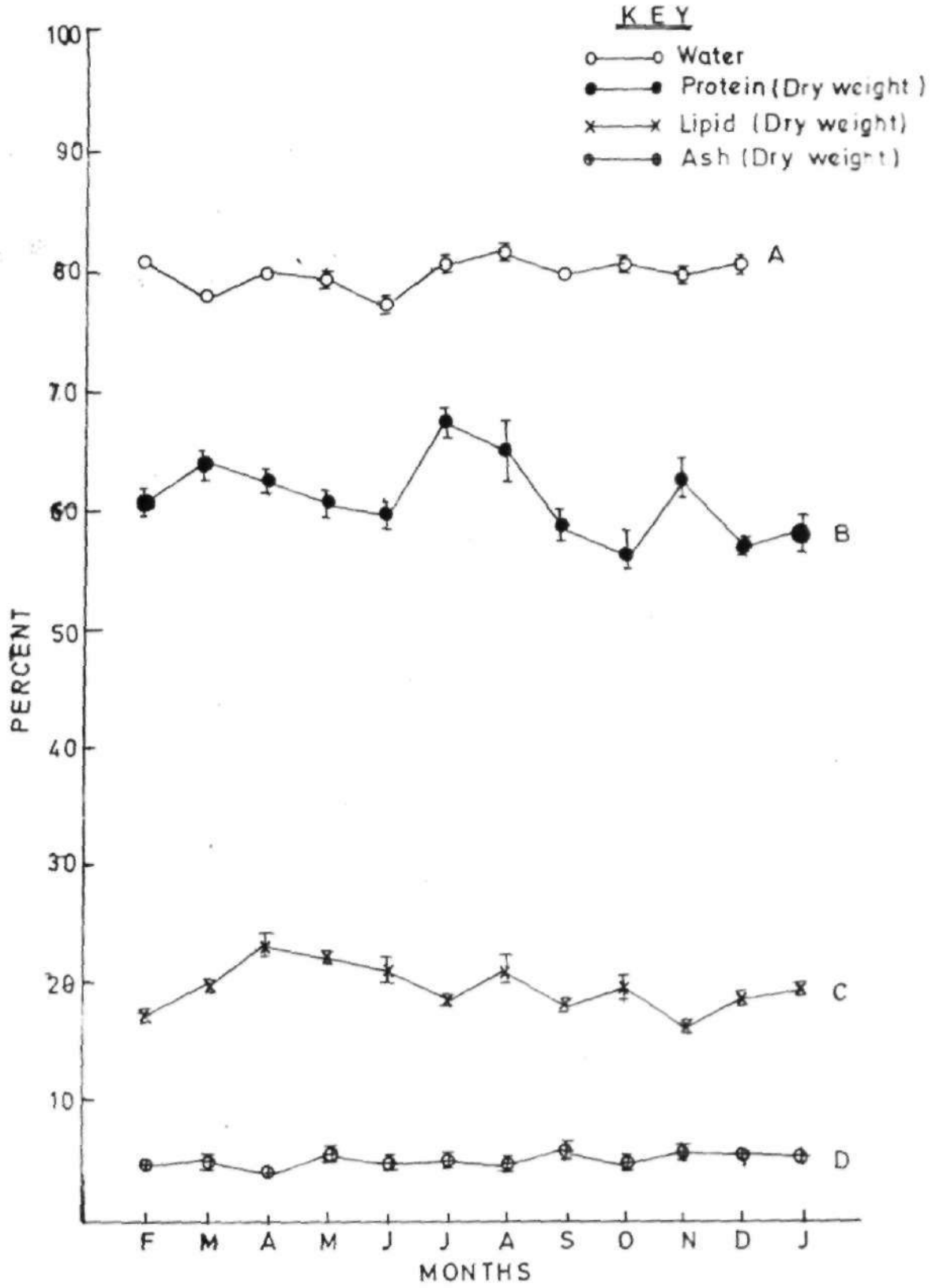


FIG. 9: SEASONAL VARIATION IN PROXIMATE COMPOSITION OF SAROTHERODON GALILAEUS

4.4 COMPARISON OF PROXIMATE MUSCLE COMPOSITION OF THE THREE SPECIES

4.4.1 Water

Analysis of variance in Appendix 4 indicates that the species variation is highly insignificant ($P>0.05$) i.e they are fairly equal in moisture content, this was however seasonal. L. niloticus was highest in the dry season months of March to July while S. galilaeus was highest in the months of August to February of mostly periods of high water level. The three species had equal amount of moisture in November, S. schall and S. galilaeus contained the same amount of moisture in the months of February, March, July and September, similarly L. niloticus and S. schall were equal in March, (Fig. 10).

4.4.2 Protein

The difference in the protein content of the three species was insignificant ($P>0.05$, Appendix 5). This is obvious in Fig. 11. S. schall had the lowest concentration of protein throughout the twelve months and had the same amount with S. galilaeus in October and January. L. niloticus was highest in protein in the months of April to June, August, October and December next to S. galilaeus in February, March, July and September. S. schall and S. galilaeus were equal in October and January, while L. niloticus and S. schall were equal in protein in February.

4.4.3 Lipid

Fig. 12 shows that S. schall was highest in lipid throughout the twelve months except October. It is followed by

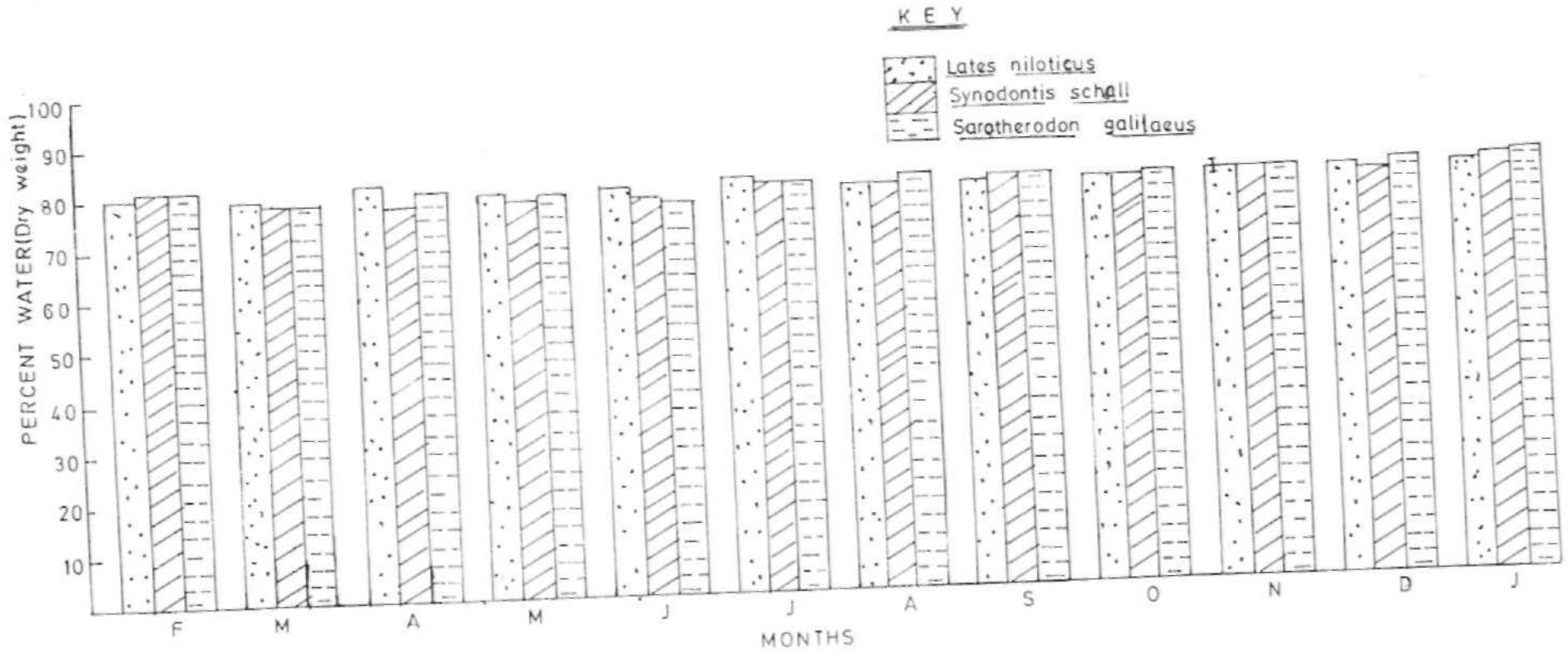


FIG. 10: SEASONAL VARIATION OF WATER IN ; LATES NILOTICUS, SYNODONTIS SCHALL, SAROTHERODON GALILAEUS

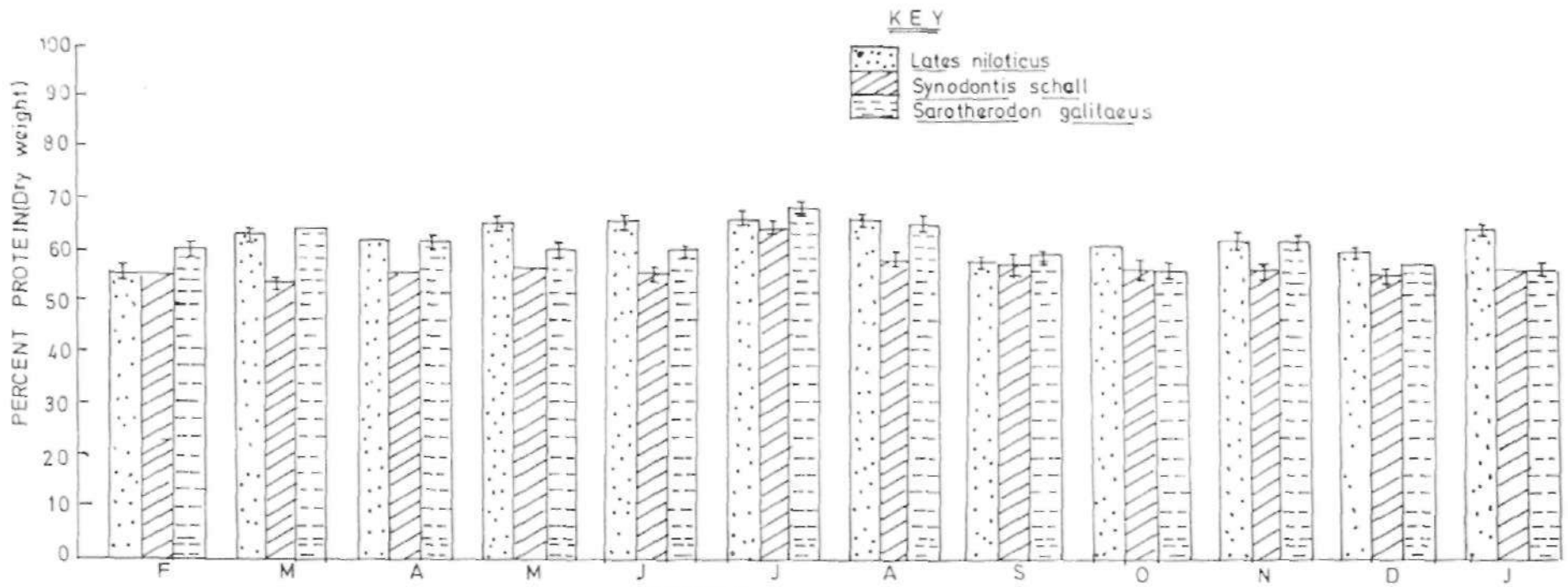


FIG.11;SEASONAL VARIATION OF PROTEIN IN LATES NILOTICUS, SYNODONTIS SCHALL, SAROTHERODON GALILAEUS

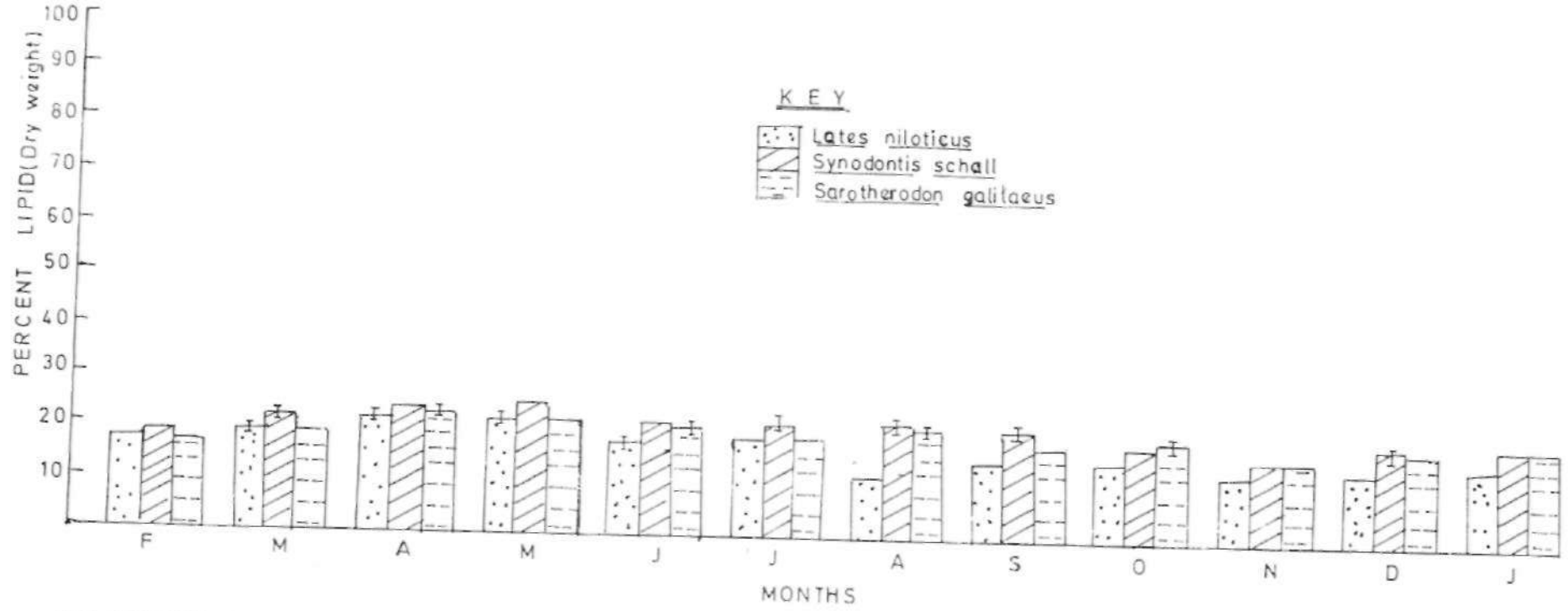


FIG.12: SEASONAL VARIATION LIPID IN LATES NILOTICUS, SYNODONTIS SCHALL, SAROTHERODON GALILAEUS

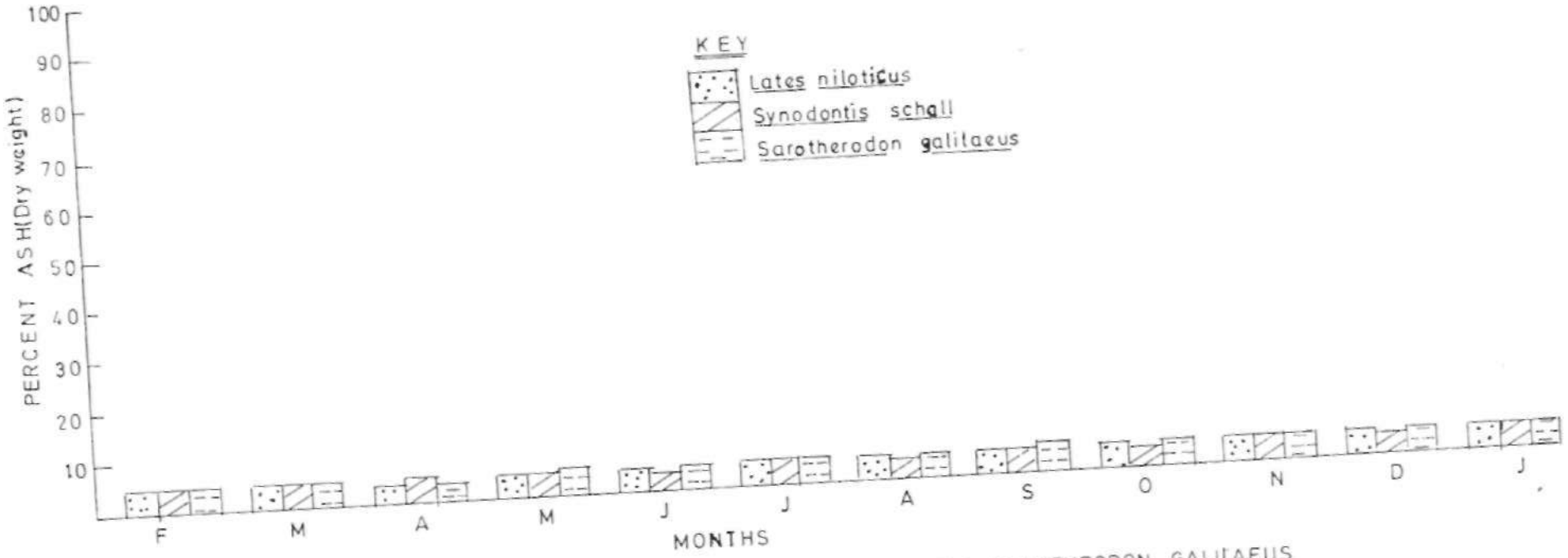


FIG.13:SEASONAL VARIATION OF ASH IN LATES NILOTICUS, SYNODONTIS SCHALL , SAROTHRODON GALILAEUS

S. galilaeus that was highest in October. L. niloticus had least lipid content throughout except February, March and July when it had the same amount as S. galilaeus. Equal lipid content was found between S. schall and S. galilaeus in the months of November and January. Appendix 6 shows significance in this species variation ($P<0.05$).

4.4.4 Ash

An equal quantity of ash was recorded in the three species as variation was highly insignificant similar to water ($P>0.05$ Appendix 7). The highest ash content was recorded in S. galilaeus in May and September, S. schall was highest in April. L. niloticus and S. galilaeus had lowest ash content in April, while S. schall was lowest in July, August, October and December. They were equal in other months (Fig. 13).

4.5 RELATIONSHIP BETWEEN WATER AND OTHER PROXIMATE CONSTITUENTS OF FISH MUSCLE

Regression of the constituents on water showed that 95% confidence limits of the regression coefficients had a wide belt of spread of scattered points about the slope. These limits, regression and correlation coefficients are presented in Appendix 5.

4.5.1 Lates niloticus

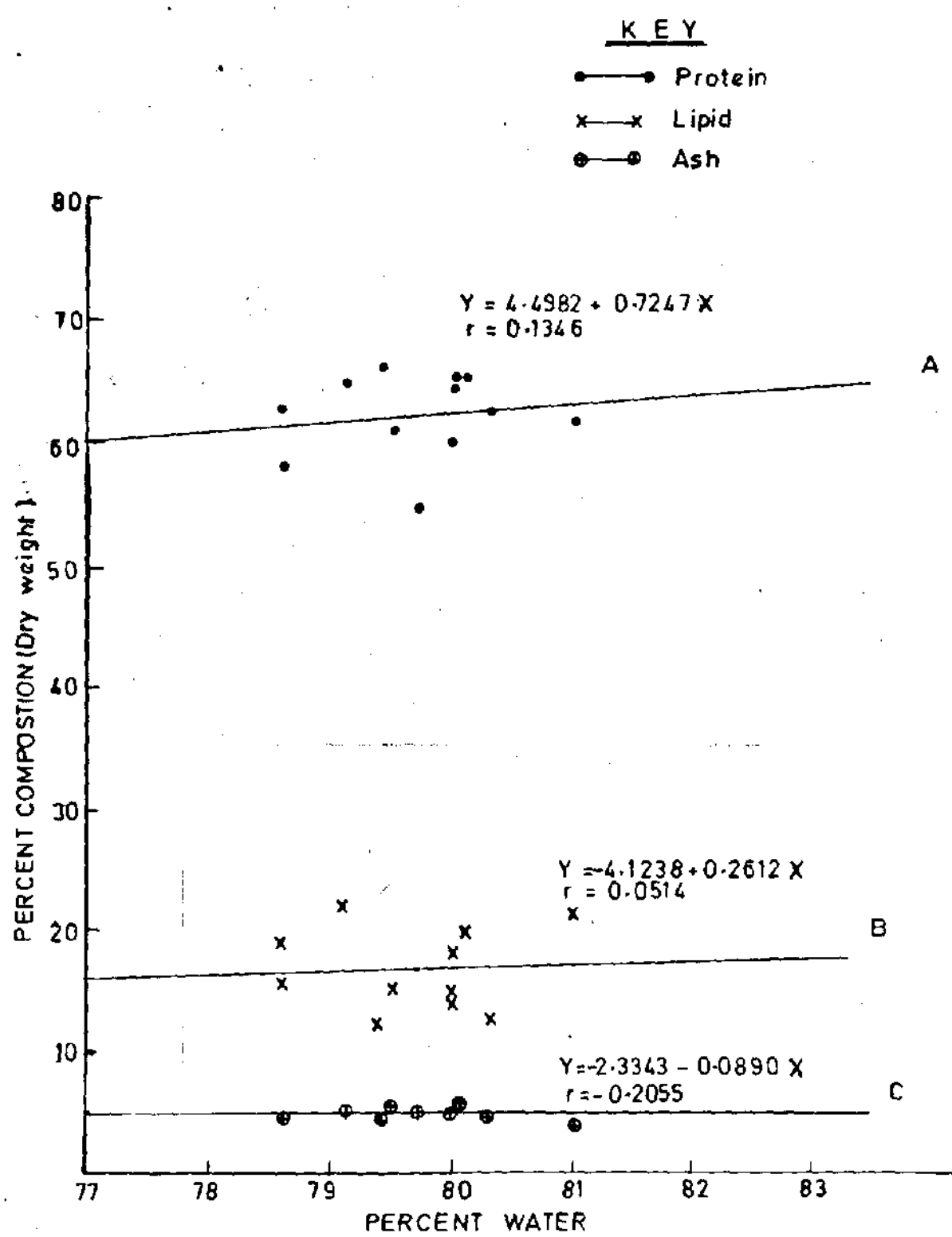
Water had a direct and insignificant correlation with protein ($P>0.05$). A regression of protein on water was best described by the equation $Y = a + bX$, Fig. 14(A). The table

confirms almost complete absence of correlation between lipid and water as coefficient of correlation was near zero. A positive regression exists between them, described as $Y = a + bX$ reduced to $Y = a$, Fig. 14(B). Ash tended to correlate inversely but insignificantly with water ($P > 0.05$). Regression of ash on water had a near zero regression coefficient. However, this relationship could be described as $Y = a - bX$ reduced to $Y = a$, Fig. 14(C).

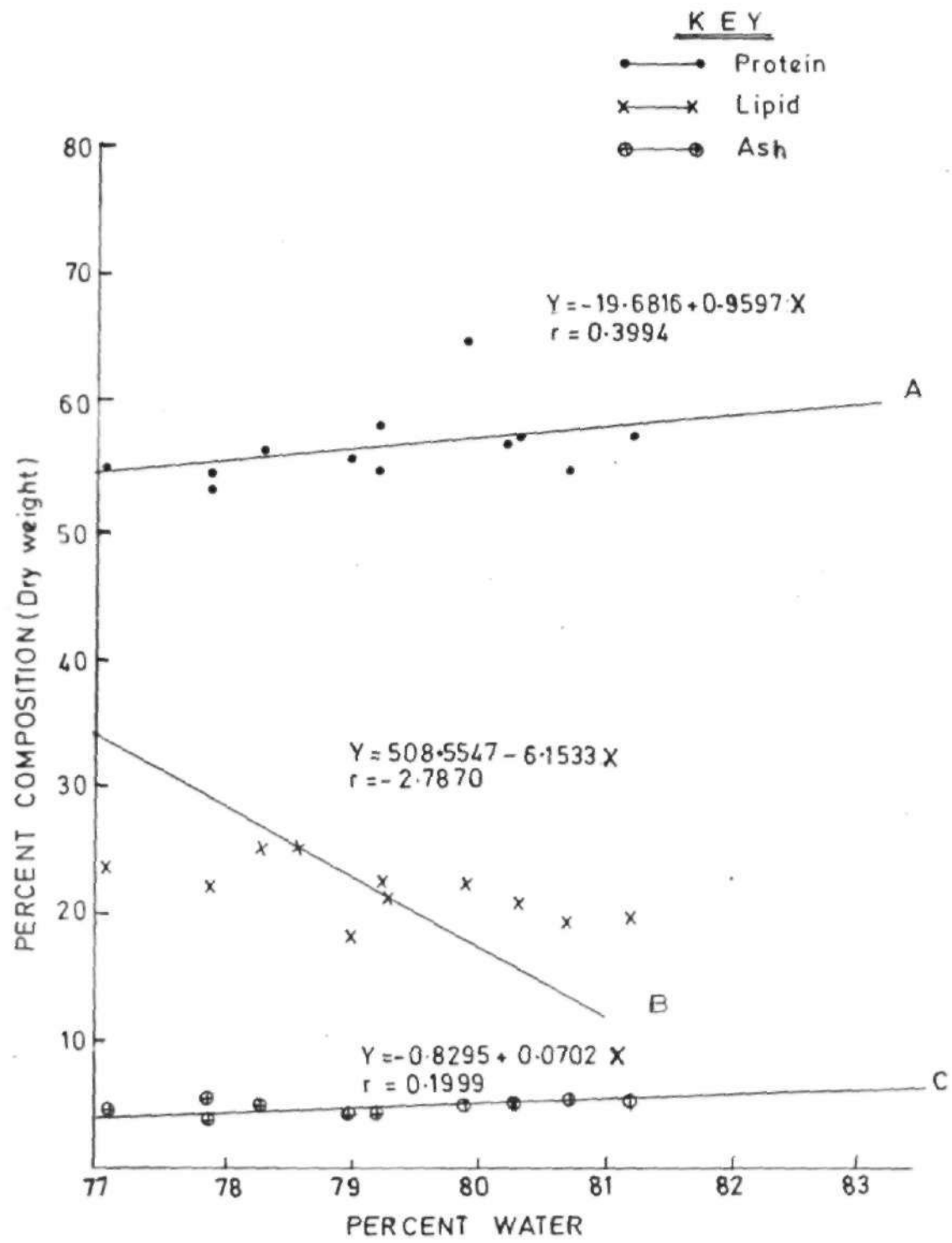
4.5.2 Synodontis schall

A direct but insignificant relationship was evident between water and protein ($P > 0.05$). This was further described in a regression equation $Y = a + bX$, Fig. 15(A). Lipid presented a peculiar situation as it showed a very strong and inverse correlation with water ($P < 0.05$). Coefficients of correlation and regression are very high, such that they are less than the minimum value of -1. This indicates that the regression is more of water on lipid than the reverse as $\tan^{-1}/-2.7570/ = 70.26^{o}$ i.e greater than 45^{o}. Though this relationship was presented as $Y = a - bX$, it is better described as $X = a - bY$, Fig. 15(B).

Ash tended to show an insignificant and direct interrelationship as the coefficient of correlation was not very near zero but the coefficient of regression of ash on water was very near zero. This attests almost complete absence of this relationship described by the regression equation $Y = a + bX$, Fig. 15(C).



FIG·14: RELATIONSHIP OF WATER WITH PROTEIN LIPID AND ASH OF LATES NILOTICUS



FIG·15: RELATIONSHIP OF WATER WITH PROTEIN LIPID AND ASH OF SYNODONTIS SCHALL

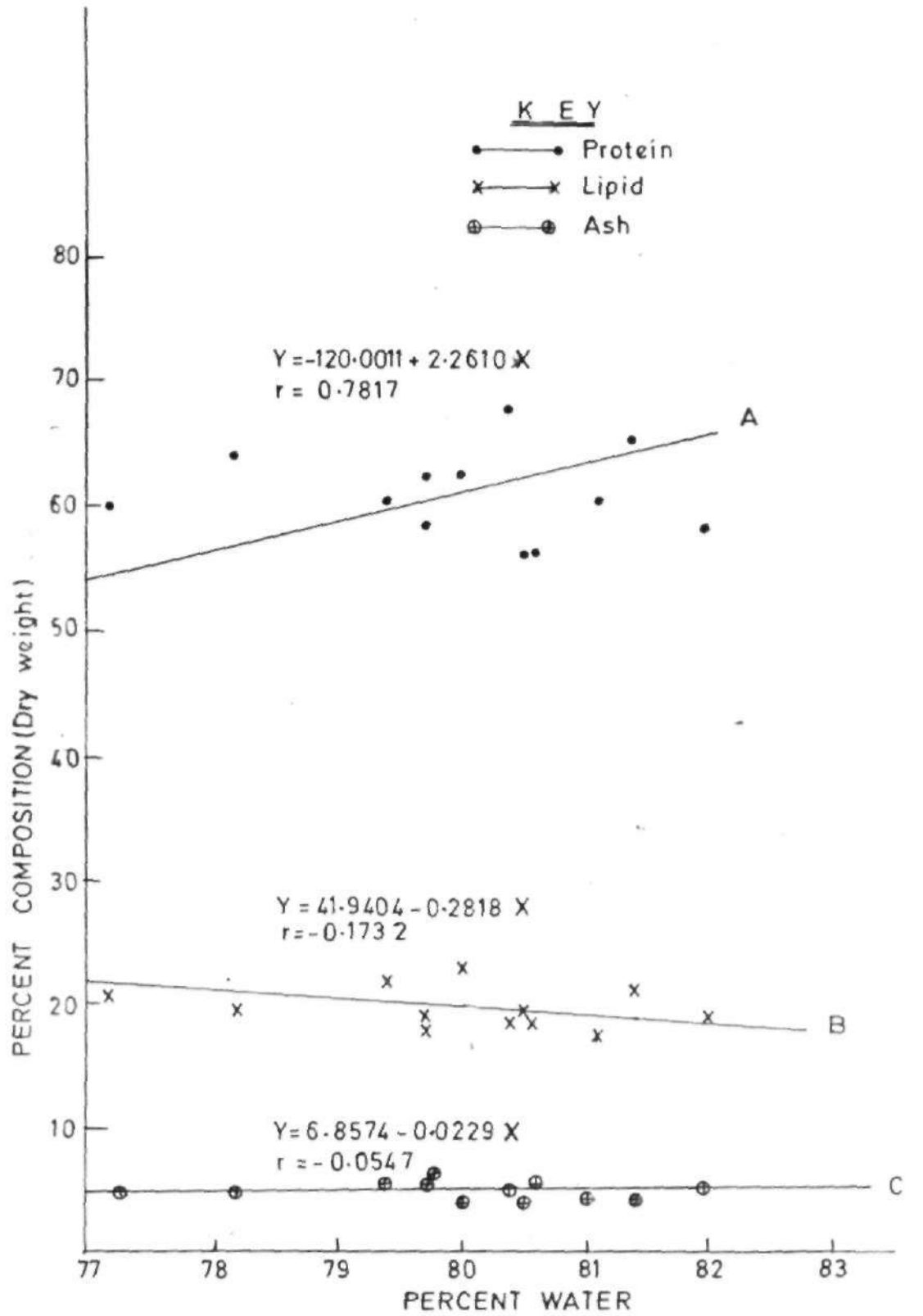


FIG. 16: RELATIONSHIP OF WATER WITH PROTEIN, LIPID AND ASH OF SAROTHERODON GALILAEUS

4.5.3 Sarotherodon galilaeus

Appendix 8 confirms that water correlated significantly and directly with protein ($P < 0.05$). This is peculiar as regression of protein on water had a greater than +1 regression coefficient, i.e. $\tan^{-1} 2.2610 = 66^{o}$, greater than 45^{o}. This implies that the regression is better of water on protein than the reverse. The relationship presented as $Y = a + bX$ could better be described as $X = a + bY$, Fig. 16(A).

Lipid content exhibited an insignificant and inverse relationship with water ($P > 0.05$) described by the regression equation $Y = a - bX$, Fig. 16(B). Ash showed an almost complete absence of relationship with water as both coefficients of correlation and regression were near zero. The regression could be generalised as $Y = a - bX$, Fig. 16(C).

4.6 SEASONAL VARIATION OF AMINO ACIDS OF THE FISH MUSCLE

The sixteen amino-acid present in acid hydrolysates of the muscle of twelve specimens of the three species varied with season. Their mean values (95% confidence limits) in Table 4 indicate that glutamic acid, lysine, aspartic acid and leucine were dominant in decreasing order of concentration and were therefore considered the major amino acids. Others were minor. The major ones were in most cases higher in dry season than rainy season. Minor amino acids were also higher but to a lesser degree in the dry season than the rainy season.

In Lates niloticus, the major amino acids occurred in ranges of 9.29 - 16.72 and 10.31 - 16.47 g/100g amino acids for

dry and rainy seasons respectively. Minor ones were in ranges of 2.20 - 7.12 and 2.40 - 6.67 g/100g amino acids for dry and rainy seasons respectively. Similarly, Synodontis schall had respective dry and rainy seasons ranges of major amino acids of 9.04 - 16.06 and 8.41 - 14.63 g/100g amino acids and minor ones of 2.57 - 6.71 and 2.47 - 6.38 g/100g amino acids respectively. Ranges of 8.72 - 17.88 and 8.11 - 15.78 g/100g amino acids in dry and rainy seasons for the major ones, 2.64 - 6.42 and 2.63 - 6.21 g/100g amino acids in dry and rainy season for the minor ones respectively were recorded in Sarothendon galilaeus.

A t-test of significance of the variation in amino acid concentrations with season in every species proved insignificant ($P>0.05$). Analysis of variance of the amino acids variation between the species had very low calculated f-values ($P>0.05$, Appendix 12) indicating that the amino acids of the different species are similar.

TABLE 4: AMINO ACID COMPOSITION OF Lates nilotious (L.n) Synodontis schall (S.s) and Sarotherodon galilaeus (S.g) IN DRY SEASON (D.S.) AND RAINY SEASON (R.S)

Amino acid g/100 (amino acids)	L.n		S.s		S.g	
	D.S.	R.S	D.S	R.S	D.S	R.S
LYS	11.79	10.63	10.55	10.91	10.60	9.36
ASP	11.08	11.38	13.10	10.78	13.45	9.83
GLU	16.72	16.47	16.06	14.63	17.88	15.78
LEU	9.29	10.31	9.04	8.41	8.72	8.11
HIS	3.62	2.40	3.00	3.54	4.10	3.00
ARG	7.12	6.54	6.19	6.14	6.42	5.88
THR	5.17	4.76	5.39	5.10	5.38	4.96
SER	5.07	4.21	4.66	4.57	4.69	4.11
PRO	5.11	3.52	4.47	4.40	3.85	3.87
GLY	5.29	5.04	5.97	6.18	6.30	6.15
ALA	6.62	6.67	6.71	6.38	6.27	6.21
VA	5.38	5.34	5.52	5.55	5.41	5.00
MET	2.20	2.41	2.57	2.47	2.64	2.63
ILEU	4.70	6.32	4.94	4.91	5.93	4.83
TYR	3.50	5.55	4.11	3.47	3.80	4.58
PHE	3.68	4.75	4.00	4.92	4.07	5.75
t-test	P>0.05		P>0.05		P>0.05	

All values were within 95% confidence limits of the means.

4.7 SEASONAL VARIATION OF MINERAL COMPOSITION OF THE FISH MUSCLE

Twenty four specimens of each species were used for determination of mineral. The six elements analysed, namely; potassium, sodium, calcium, magnessium, zinc and iron exhibited seasonal difference. Their mean values (95% confidence limits) are given in Table 5. Fig. 17 indicates that potassium, sodium, magnesium and calcium were the major mineral constituents of the fish muscle in decreasing order of magnitude. Others were minor. In most cases, concentration of these minerals in the fish were higher in the dry season than rainy season.

In Lates niloticus, the macro-elements were in the ranges of 1213 - 1588, 453 - 1001, 300 - 462 and 73.20 - 109.50 mg/100g; 1025 - 1382, 482 - 693 , 307 - 383 and 76.30 - 115.90 mg/100g for potassium, sodium, magnesium and calcium in the dry and rainy season respectively. Micro-elements occurred in the ranges 2.25 - 4.1 and 7.0 - 21.0; 1.60 - 3.40 and 7.00 - 13.00 mg/100g for zinc and iron in the dry and rainy seasons respectively.

Similarly in Synodontis schall, the macro-elements ranges were 1088 - 1369, 360 - 799, 313 - 432 and 73.20 - 109.50 mg/100g: 1000 - 1176, 367 - 502, 3 07 - 400 and 76.30 - 109.50 mg/100g for potassium, sodium, magnesium and calcium in the dry and rainy seasons respectively. Zinc and iron were again in trace amount in ranges 2.90 - 4.80 and 7.25 - 24.00 mg/100g; 1.80 - 5.20 and 7.50 - 19.50 in the dry and rainy seasons respectively.

Macro-elements of Sarotherodon galilaeus were in ranges of 1038 - 1538, 425 - 1290, 350 - 444 and 76.30 - 109.50 mg/100g; 688 - 1400, 500 - 616, 362 - 494 and 79.30 - 109.50 mg/100g for potassium, sodium, magnesium and calcium in the dry and rainy seasons respectively. Zinc and iron were present in the fish muscle in ranges 2.1 - 6.90 and 6.50 - 15.00 mg/100g; 2.4 - 5.05 and 6.00 - 14.00 mg/100g in the dry and rainy seasons respectively.

In these three species studied, t-test of each with respect to the two seasons attested to the insignificance of the difference in mineral content with season ($P>0.05$). Analysis of variance of the mineral content of the three species given in Appendix 16 with respect to tve species had calculated low F-values ($P> 0.05$, Appendix 17) expressing insignificant variation in the mineral contents of the species.

TABLE 5: MINERAL COMPOSITION OF THE MUSCLE OF Lates niloticus, Synodontis schall and Sarotherodon galilaeus (mg/100g) IN DRY AND RAINY SEASONS.

Species	Season	K	Na	Ca	Mg	Zn	Fe
Lates	Dry Season	1349.17	714.50	98.53	373.40	3.35	12.04
niloticus	(DEC-MAY)	±144.40	±274.65	±13.61	±73.63	±0.97	±5.66
	Rainy season	1184.17	600.33	93.12	352.25	2.53	9.67
	(JUN-NOV)	±123.41	±132.93	±14.64	±51.20	±0.82	±2.28
Synodontis	Dry season	1256.25	586.33	92.98	312.90	4.07	15.54
schall		±218.54	±201.27	±16.09	±54.70	±0.93	±5.66
	Rainy season	1110.60	458.60	92.48	360.60	3.51	11.88
		±90.52	±66.05	±13.72	±47.03	±1.30	±4.78
Sarotherodon	Dry season	1194.17	828.20	90.44	406.25	4.23	12.75
galilaeus		±207.55	±505.36	±12.47	±63.50	±1.91	±3.43
	Rainy season	1117.00	565.33	96.53	403.80	3.52	9.21
		±267.69	±41.80	±12.35	±64.91	±0.97	±3.10

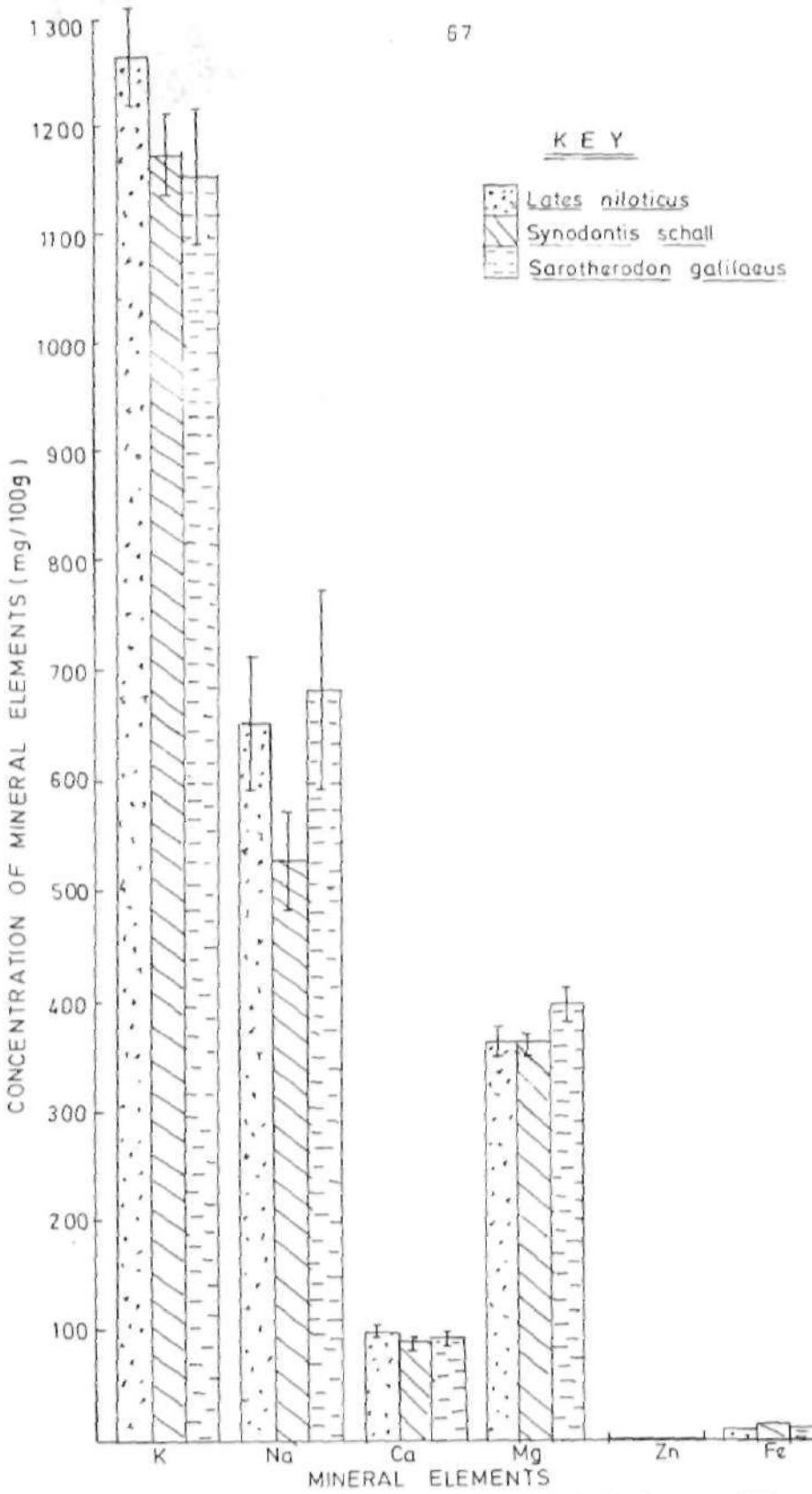


FIG.17: SPECIES VARIATION OF MINERAL ELEMENTS IN LATES NILOTICUS, SYNODONTIS SCHALL, SAROTHERODON GALILAEUS.

4.8 COMPARISON OF THE ENERGY CONTENT OF THE MUSCLE OF FISH

Assuming the calorific values of 9.5, 5.7 and 4.0 $calg^{-1}$ for fat, protein and carbohydrate respectively, (Klieber, 1975), energy content of the muscle of L. niloticus, S. schall and S. galilaeus was evaluated for the twelve months of studies. Percentage carbohydrate was obtained by difference method.

The three species had energy content in ranges of 302.67 - 385.89 $calg^{-1}$, 114.00 - 237.50 $calg^{-1}$ and 34.40 - 93.20 $calg^{-1}$ for protein, lipid and carbohydrate respectively. The mean values (95% confidence limits) of the three species energy contents are presented in Table 6. There was significant variation in the energy values of every component of the species. This was attested to by the significant coefficients of variation of carbohydrate, lipid and protein calorific values in decreasing order. In Fig. 15, L. niloticus and S. galilaeus protein and lipid energy contents maxima were in the months of dry season when carbohydrate energy was low, and conversely for the months of high water level. S. schall had high protein in the period of high water level, low lipid and high carbohydrate. Significant difference in the caloric content of protein, lipid and carbohydrate was obvious.

Fig. 15 shows the monthly total energy content of the species, ranging between 556.26 and 615.48 $Calg^{-1}$. Mean values (95% confidence limits) of total energy are found in the Tables. Coefficient of variation of each species was insignificant,

expressing absence of significant monthly difference. Months of March to August were higher in total energy content in S. galilaeus; March to September in S. schall and March to July in L. niloticus. Calculated low F-values ($P>0.05$, Appendix 22) confirmed the absence of significant difference in the monthly total caloric content of the three species. Their ranges and 95% confidence limits of the monthly total energy content are given in Appendix 21.

TABLE 6: MONTHLY ENERGY CONTENT OF THE MUSCLE OF Lates niloticus, Synodontis schall AND Sarotherodon galilaeus

Species	Energy component	Range($Calg^{-1}$)	Mean values 95% *CL	Coefficient of Variation(%)
Lates	Protein	311.22-377.34	354.92±11.01	5.4
niloticus	Lipid	114.00-208.05	158.57±17.30	19.28
	Carbohydrate	34.40-93.20	65.13±11.01	29.87
Synodontis	Protein	302.67-366.51	321.29±9.21	5.07
schall	Lipid	151.05-237.50	196.73±13.70	12.31
	Carbohydrate	36.00-90.80	72.77±8.74	21.22
Sarotherodon	Protein	318.06-385.89	347.23±11.35	5.70
galilaeus	Lipid	151.05-216.60	184.22±10.64	10.21
	Carbohydrate	34.40-80.40	58.67±9.25	27.87

* CL = Confidence limits

P>0.05 = Insignificant

P<0.05 = Significant.

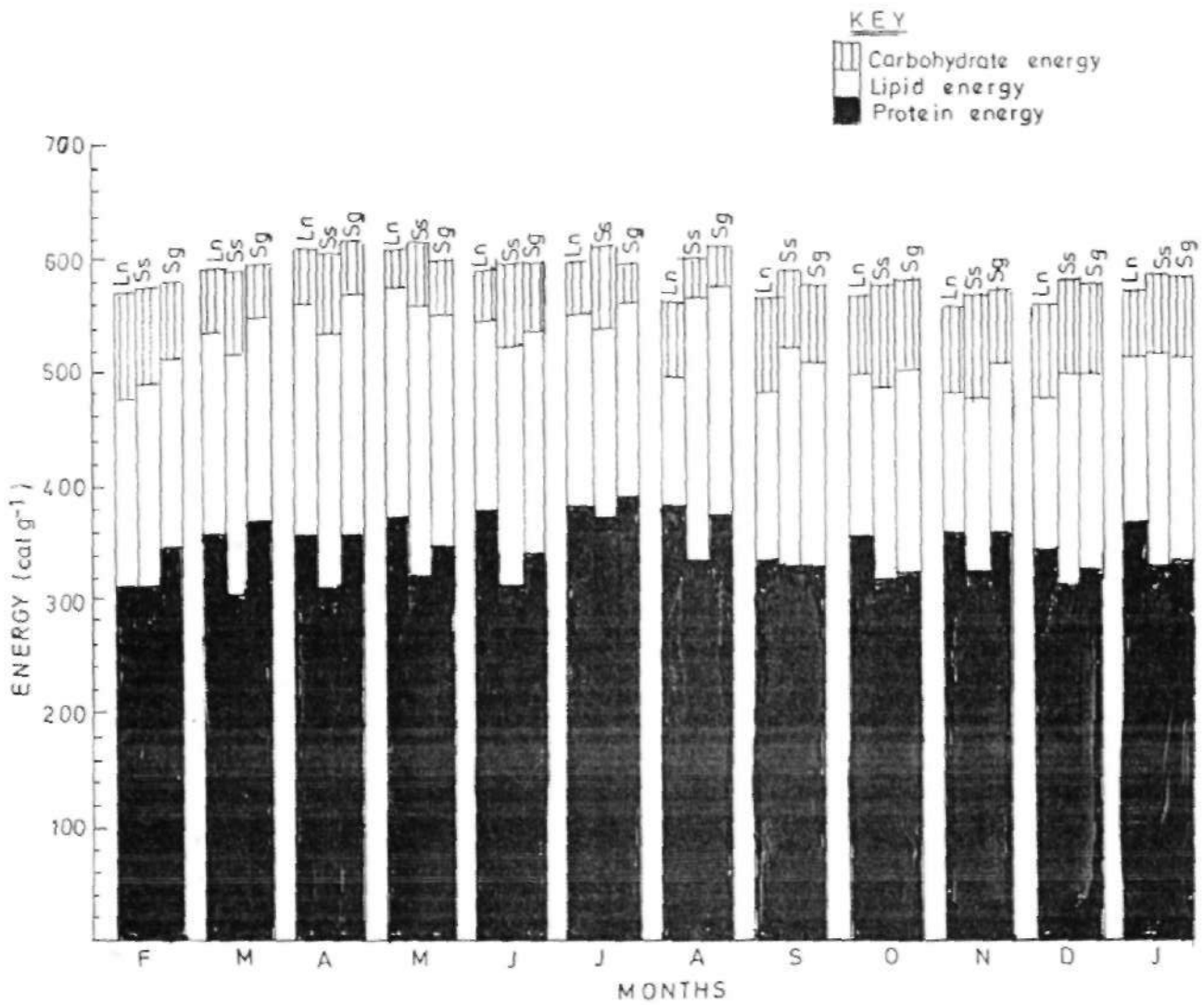


FIG.18: SEASONAL COMPARISON OF ENERGY CONTENT IN L. NILOTICUS (Ln), S. SCHALL (Ss), S. GALILAEUS (Sg)

CHAPTER FIVE

5.0 DISCUSSION

A routine preamble to fishery investigation is the biometric examination of fish specimens. Analysis of data from this has been very useful in growth studies and the estimation of the physiological state of the fish. According to Lagler (1956), linear regression of standard length and weight gave very useful coefficient of regression, 'b' in determining growth pattern. It was noted that 'b' value of 3 indicates isometric growth. Below this, growth is negatively allometric and above, it is positively allometric.

In this study, isometric growth was observed in Synodontis schall and Sarotherodon galilaeus, and negative allometric growth in Lates niloticus. 'b' values were within the conventional limits of 2 and 4(Ricker, 1970). Isometric growth patterns have earlier been documented in Schilbe mystus, Physailia pellucida and Eutropius niloticus (Olatunde, 1977). Three fish species, Alestes nurse, Synodontis schall and Tilapia zillii have been documented to exhibit negatively allometric growth pattern except T. zillii - a related species to S. galilaeus, that was isometric (Oni et al., 1983). In the present study, the observed growth pattern for S. schall is however isometric. S. schall has been described as a short bodied fish with cephalonuchal shield, (Reed et al., 1967). This factor could possibly be responsible for the isometry.

Condition factor (K), otherwise called ponderal index is not a constant for individuals, species and population (Lagler, 1956). Despite this, it is still a useful measure of relative robustness. It further explains differences in fish population in relation to species, age, growth rate, sexual maturity and locality, in addition to estimating the physiological state of the fish (Oni et al., 1983). K values as low as 1.080, 1.700 and 1.006 have been documented for E. niloticus, S. mystus and P. pellucida respectively (Olatunde, 1977) and as high as 3.998 for T. zillii (Adegboye in press) in earlier investigations. Similar investigation on Alestes sp, Synodontis sp and Tilapia sp gave K values of 1.743, 2.480, and 3.158 respectively (Oni et al., 1983). This present investigation identified S. schall and S. galilaeus as robust fish in increasing order of robustness while L. niloticus was least robust with K values of 2.28, 3.86 and 1.94 respectively. This indicates that robustness is directly related to growth pattern.

Immense volume of data exist on the biochemical composition of temperate fish (Love, 1970) as against the indequate information on the tropical African fish particularly with respect to changes in season (Olatunde, 1980). Conventionally, there are two seasons in the tropics, viz; rainy and dry seasons. In the locality of this study, the cold harmattan wind of December to February has divided the dry season into cold and warm dry seasons. Similar climatic condition was recorded by Morgan (1979) in Jos area, Nigeria. Seasonal effect on the fish proximate composition was in accordance with these seasons.

Water was the major proximate composition of the muscle of L. niloticus, S. schall and S. galilaeus constituting more than 75% wet weight. Past investigations of moisture content of fish have shown a maxima of 80 - 85% in water rich tissues of the fish (Vinogradov, 1953)especially the muscle. Per dry weight, protein constituted more than 50%, followed by lipid of more than 10%. Less than 10% of the muscle dry weight was ash. The same order of magnitude was recorded in brown trout (Elliot, 1976); A. nurse, S. schall and I. zillii (Oni, 1979); E. niloticus, S. mystus and P. pellucida (Olatunde, 1980). Percentage composition per wet weight of constituents in Salmo trutta has shown that water and protein were dominant while lipid and ash constituted less than 5% (Elliot, 1976).

The mineral determination revealed the presence of two classes of elements according to their magnitude, viz; macro-elements comprising potassium; sodium, magnesium and calcium; and micro-elements comprising iron and zinc in decreasing order of magnitude. These classes have been recognised by earlier researchers. Data from the works of Oni (1979), Olatunde (1980), and Kirchgessner and Schwarz (1986) recorded calcium as the highest macro-element. This was due to differences in the tissue used. Bony tissues (carcasses) used in these earlier investigations raised the calcium level. A reversal of this present order of magnitude of the micro-element was the finding of Olatunde (1980) as zinc was higher than iron. Oni (1979) recorded the same order with the present investigation.

The concentrations of amino acids recorded in the present study are similar to those of Oni (1979). Of the sixteen amino acids found present, Aspartic acid, glutamic acid, leucine and lysine were dominant, others were minor in both sets of data. The data of Oni (1979) has lower concentrations of the amino acids than that of this investigation. The use of the whole eviscerated body tissue of lower protein content in the former is probably responsible for this concentration. Wilson and Cowey (1985) data on amino acids of rainbow trout, atlantic salmon, cherry salmon, coho salmon and channel catfish carcasses were closer to the former due to their similarity in the tissue analysed.

Energy contents of the muscle of L. niloticus, S. schall and S. galilaeus have shown that the bulk of the stored energy of the fish was attributed to protein, lipid and carbohydrate in decreasing order. These fish can therefore be tagged protein fish. P. pellucida, S. mystus belonging to the fatty fish family, Schilbeidae, store much of their energy as lipid (Olatunde, 1980). Energy store of A. nurse, S. schall and I. zillii was more of protein than lipid (Oni, 1979).

Proximate composition of the fish was not dependent on size. This cannot be unconnected with the similarity in the physiology of the two size groups as they are both developing sub-adults. Adults of S. schall are usually at least 40 cm in length, L. niloticus adults are greater than 60 cm while those of S. galilaeus are 30 - 40 cm (Reed et al, 1967). Major and/or lasting energy storing

and depleting physiological activities like gonadal development and spawning were absent. Total protein has been found to be unaffected by size (Tsuchiya et al., 1953; Love, 1957). Generally as fish grows bigger, percentage composition of many constituents increases. Crude ash in the bones (Tsuchiya et al., 1953) and fat (Lovern, 1935; Tsuchiya et al., 1953) have been shown to follow this pattern.

In L. niloticus, higher protein and lipid levels were observed in the dry season than rainy season including period of high water level. Protein in S. schall was similarly higher in the dry season. The period of high protein coincides with the period of high aquatic productivity. Dry season has been found to be a period of high primary aquatic productivity with maxima in June and July (Kemdirim, 1981). This period is the equivalent of temperate summer. The situation in S. schall could probably be due to the advanced stage of maturity of specimens and spawning period or the observed highly significant inverse relationship of lipid with water and protein. The maxima of fat content of muscle and viscera do not usually coincide, the former precedes the latter as observed in herring by Youdanova (1939), hence high record of lipid in the fish muscle in months earlier than September when eggs were noticed in some of the specimens. S. galilaeus exhibited no marked seasonal variation, though peaks of annual protein and lipid content were evident. Though, this has been found to be characteristic of multiple spawners as peaks of protein and lipid composition depicts spawning races (Love, 1957). What is unclear is whether protein and lipid content

could be influenced by spawning in non-spawning sub-adults specimens of S. galilaeus. In the temperate, high lipid and protein contents of fish during the food abundant summer and their low contents during the food deficient winter are well documented (Love, 1957).

Amino acids and mineral contents of L. niloticus, S. schall and S. galilaeus varied with seasons. Values of these contents were higher in the dry season than rainy season. Similar finding has been observed for the free amino acids in sprats and herring (Ranold and Jacobsen, 1947); and cod and haddock (Love, 1957). However, the nine free amino acids and eight non essential amino acids of Ophicephalus punctatus differed insignificantly with season (Siddiqui and Siddiqui, 1977).

There was no significant variation in components of the three species except lipid (Appendices 4, 5, 6, 7, 12 and 17). The three species are likely to belong to the same nutritional protein class of food fish. Studies of the nutritional component of three species of the family Schilbeidae showed similar and moderately high values of protein and very high lipid; this earned them the food fish class (Olatunde, 1980). Industrial fish are usually of very low nutritive value i.e low lipid and protein. No significant difference was observed in a comparison of the amino acids of the three species hereby studied. That of rainbow trout, atlantic salmon, coho salmon, cherry salmon and channel cat fish (Wilson and Cowery, 1985); A. nurse, S. schall and I. zillii (Oni, 1979) is also insignificant respectively.

Figs. 4, 5 and 6 show insignificant correlation between size and composition. Vlieg (1984) observed no correlation between the oil contents and length of I. declivis in contrast to his earlier findings. Growth had no effect on the moisture, protein, lipid and ash of puffers (Saeki and Kumagai, 1984). However, Anguilla rostrata increased in protein and moisture with length and wet weight (Gallagher, 1984). This controversy might be that existence of correlation with size could probably be a coincidence of physiological transition of the components and the size in question.

Water showed no correlation with protein, lipid and ash in the three species examined during this study except the very strong and inverse correlation with lipid in S. schall and that of protein which was direct in S. galilaeus (Figs. 14, 15 and 16). This suggests that S. schall is a fatty fish and S. galilaeus a protein-rich fish, hence they have higher K values than L. niloticus. Brandes and Dietrich (1958) showed that a strong correlation exists between moisture and oil levels in whole fish fillets and parts of the fillet of fatty fish, and that this is usually inverse (Elliot, 1976). Elliot in addition observed an inverse correlation between water and protein.

CHAPTER SIX

SUMMARY AND CONCLUSION

Proximate analysis of the fish samples was according to A.O.A.C. official methods of Food Analysis with suitable modifications where necessary. Except water, all other constituents were analysed per dry weight.

Null hypotheses were propounded to test the existing popular hypotheses in literature: that size and season have effect on the promimate composition of fish muscle Love (1957); and that there exists a relationship between water and lipid content of fatty fish (Brandes and Dietrich, 1953b).

The results of this investigation on subject to statistical analysis showed that except for water, there was significant monthly variation in the constituents ($P<0.05$). Seasonal variation exists in the protein and lipid contents of the fish except S. galilaeus. Protein and lipid were higher in the dry season than rainy season in L. niloticus and S. schall except the protein of S. schall that was lower in the dry season. Protein and lipid content variation of S. galilaeus was discontinuous. Variation in ash was not seasonal. It was observed that seasonal variation in the amino acids and mineral contents of the fish muscle exists but insignificant ($P>0.05$). Species difference was not significant ($P>0.05$) in water, protein, mineral, amino acids and energy contents of the fish muscle. Correlation was insignificant

between water and other constituents of the fish muscle ($P > 0.05$) except the significant inverse relationship between water and lipid in S. schall and also the significant but direct relationship between water and protein in S. galilaeus ($P < 0.05$).

Since it has been observed that season is a factor controlling fish quality. The propounded hypothesis of no seasonal effect is hereby rejected. The alternate hypothesis is therefore that, the fish muscle proximate composition in the two seasons differ. This periodicity should be given due consideration in the formulation of policies of fishery management. On careful study of the seasonal abundance of fish and quality. Harvest of fish should be encouraged only in periods of direct positive relationship between quality and quantity of fish in our waters.

Size is not always a factor of fish quality. This study has shown that the proximate constituents of the small and larger size group were not significantly different. Based on this alone, we accept the propounded hypothesis about the absence of size effect. Probably the effect of size could be evident only when the fish are sampled at physiologically distinct stages of life. A knowledge of fish size becomes helpful when the size attained by fish at every physiological state is well documented. With this, we can by ordinary observation of fish size predict its physiology and decide whether it is of good quality and therefore ripe to serve as food or not.

Finally, for correlation study, the hypothesis propounded on moisture-lipid relationship is hereby accepted as S. schall is a fatty fish. The high level of fat in S. galilaeus is also responsible for inverse correlation of the water-lipid though insignificunt. L. niloticus was low in fat, hence showed absence of this correlation. S. schall and S. galilaeus are of higher nutritional quality than L. niloticus. The nutritional class of fish - a manifestation of its physiology, if known will help to predict this correlation.

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APPENDIX 1

STANDARD LENGTH WEIGHT AND PROXIMATE COMPOSITION OF *Lates niloticus*

Months	Mean Standard Length (cm)	Mean Weight (g)	Monthly Means (%) Moisture	Protein	Lipid (dry weight)	Ash	K
FEB	18,66	120	80.1	54.8	16.8	5.2	1.89
	22.34	245	79.3	54.5	17.7	4.5	2.20
MAR	17.50	110	79.6	63.0	18.3	4.4	1.90
	29.24	485	77.5	62.2	19.6	4.8	1.93
APR	17.22	95	81.2	61.2	19.8	4.2	1.83
	23.77	250	80.9	61.10	23.3	3.9	1.85
MAY	19.10	130	78.8	65.4	23.8	5.0	1.92
	23.12	230	79.3	63.9	20.1	4.8	1.87
JUN	17.38	95	79.1	63.7	18.2	5.0	1.88
	23.44	245	81.1	67.3	17.6	4.9	1.86
JUL	17.56	100	79.9	63.5	18.8	4.7	1.75
	22.03	190	81.2	67.6	18.2	5.1	1.77
AUG	18.62	120	79.4	66.2	12.0	4.6	1.90
	-	-	-	-	-	-	-
SEP	17.74	105	79.1	55.7	15.4	5.5	1.92
	22.23	220	78.2	60.8	15.3	4.0	2.00
OCT	18.79	145	79.3	60.7	15.0	5.0	2.17
	22.80	225	79.6	61.5	15.2	4.9	1.92
NOV	17.99	120	79.7	61.6	12.5	4.7	2.08
	22.96	230	80.9	63.0	12.5	4.5	1.91
DEC	18.24	120	80.2	57.8	14.9	4.8	1.99
	22.23	230	79.8	62.2	13.5	4.9	2.08
JAN	18.92	130	79.9	63.5	15.5	5.1	1.89
	21.33	205	80.1	65.4	14.8	5.3	2.10

APPENDIX 2

STANDARD LENGTH, WEIGHT AND PROXIMATE COMPOSITION OF *Synodontis shall*

Months	Mean Standard length (cm)	Mean Weight (g)	Moisture	Monthly means (%)			Coefficient of Condition
				Protein (dry weight)	Lipid	Ash	
FEB	12.74	47.35	80.4	55.1	18.5	5.45	2.29
	16.11	95.21	81.00	54.4	19.4	4.90	2.28
MAR	12.13	42.45	77.10	54.20	21.30	5.30	2.38
	14.86	79.49	78.30	52.00	23.00	5.70	2.42
APRI	12.19	41.29	76.30	54.40	23.60	5.20	2.28
	14.69	75.05	77.80	54.80	23.70	4.20	2.37
MAY	12.59	44.76	79.80	55.60	24.60	5.00	2.24
	15.14	76.44	76.80	54.10	25.30	4.50	2.20
JUN	12.08	39.45	77.10	56.20	21.70	4.40	2.24
	15.38	91.92	78.70	53.10	22.20	4.50	2.52
JUL	13.15	49.95	80.70	65.70	23.20	4.50	2.20
	14.55	67.11	79.20	62.90	20.80	5.00	2.18
AUG	14.66	75.87	79.70	57.90	22.10	4.30	2.41
	16.29	111.46	78.70	57.80	21.80	3.90	2.58
SEP	13.61	55.26	80.70	54.10	22.10	4.40	2.19
	15.38	84.83	80.00	60.10	18.90	5.30	2.33
OCT	13.80	55.73	79.80	55.30	17.20	4.30	2.12
	16.37	93.37	78.20	55.80	18.50	4.10	2.13
NOV	13.49	52.16	80.10	54.50	17.10	4.80	2.12
	15.89	96.28	80.40	58.30	14.70	5.30	2.40
DEC	13.96	60.90	79.60	55.10	21.60	4.10	2.24
	15.74	89.75	78.90	54.30	17.00	4.90	2.30
JAN	13.61	55.38	81.00	57.30	19.40	4.80	2.20
	15.89	83.89	81.40	57.80	19.40	5.10	2.09

APPENDIX 3

STANDARD LENGTH, WEIGHT AND PROXIMATE COMPOSITION OF
Sarotherodon galilaeus

Months	Mean Standard (cm)	Mean Weight (g)	Moisture	Monthly means (%) Protein (dry weight)	Lipid	Ash	Coefficient of condition
FEB	14.59	125.29	81.30	58.60	17.60	5.10	4.03
	18.88	280.00	80.80	62.20	16.90	4.20	4.16
MAR	14.49	128.15	78.20	64.30	20.30	4.10	4.21
	20.51	366.96	78.20	63.40	18.60	6.00	4.26
APR	13.43	98.36	80.40	61.50	24.30	3.60	4.06
	20.09	313.64	79.60	63.30	21.40	4.30	3.86
MAY	13.61	100.93	79.30	58.60	21.80	5.30	4.00
	19.63	278.41	79.40	62.20	22.10	5.80	3.68
JUN	13.84	93.99	78.50	61.10	22.70	5.05	3.54
	19.54	285.09	75.90	58.00	18.80	4.50	3.82
JULY	13.74	98.52	80.80	66.70	19.10	5.60	3.80
	17.26	176.40	80.00	68.60	18.10	4.60	3.39
AUG	15.56	128.50	82.30	64.90	22.50	4.60	3.41
	18.84	229.50	80.60	65.30	20.00	4.80	3.43
SEP	13.40	87.90	79.70	58.60	18.10	5.80	3.65
	-	-	-	-	-	-	-
OCT	13.03	85.49	80.90	55.50	20.60	4.80	3.87
	19.23	294.80	80.10	56.20	18.10	4.60	4.15
NOV	13.96	99.12	79.90	64.10	15.60	5.50	3.64
	17.22	197.63	79.40	60.60	16.30	5.40	3.87
DEC	14.49	113.44	79.90	55.90	18.00	5.50	3.73
	19.41	271.80	81.30	57.40	18.60	5.20	3.71
JAN	13.77	113.18	81.20	57.10	19.20	5.40	4.34
	19.19	297.94	82.80	59.00	18.30	5.10	4.21

APPENDIX 4

VARIANCE ANALYSIS OF WATER CONTENT OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	NH
Between the species (S) S = 3	2	3.7222	1.8611	2.0472	Accepted
Between the months (M) M = 12	11	24.5556	2.2323	2.4555	Accepted
Residual	22	20.0002	0.9091		
Total	35	47.5478	1.3585		

APPENDIX 5

VARIANCE ANALYSIS OF PROTEIN CONTENT OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	NH
Between the species(S) S = 5	2	222.1666	111.0833	19.1177	Accepted
Between the months(M) M = 12	11	218.7500	19.8864	3.4225	Accepted
Residual	22	127.8300	5.8105		
Total	35	568.7466	66.2499		

APPENDIX 6

VARIANCE ANALYSIS OF THE LIPID CONTENT OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	N H
Between the species(S) S = 3	2	98.7222	49.3611	21.4567	Rejected
Between the month(M) M = 12	11	190.5556	17.3232	7.5302	Accepted
Residual	22	50.6110	2.3005		
Total	35	339.8889	9.7111		

APPENDIX 7

VARIANCE ANALYSIS OF THE ASH CONTENT OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	INH
Between the species(S) S = 3	2	1.0556	0.5278	3.2163	Accepted
Between the months(M) M = 12	11	2.8889	0.2626	1.6002	Accepted
Residual	22	3.6111	0.1641		
Total	35	7.5556	0.2159		

APPENDIX 8

RELATIONSHIP OF WATER WITH OTHER MUSCLE CONSTITUENTS OF Lates niloticus, Synodontis schall AND Sarotherodon galilaeus.

Species	Water related to:	b	95% *CL of b	r
Lates	Protein	0.7249	0.7249±0.0270	0.1346
niloticus	Lipid	0.2612	0.2612±0.0257	0.0514
	Ash	-0.0890	-0.0890±0.0023	-0.2055
Synodontis	Protein	0.9597	0.9597±0.0206	0.3994
schall	Lipid	-6.1553	-6.1553±0.0522	-2.7870
	Ash	0.0702	0.0702±0.0032	0.1999
Sarotherodon	Protein	2.2610	2.2610±0.0671	0.7617
galilaeus	Lipid	-0.2818	-0.2818±0.0154	-0.1732
	Ash	-0.0229	-0.0229±0.0059	-0.0547

*CL = Confidence limits.

APPENDIX 9

AMINO ACID CONCENTRATION OF Lates niloticus MUSCLE IN g/100g

AMINO ACID	MAR	MAY	JUL	AUG
LYS	12.94	10.63	9.96	11.29
HIS	4.32	2.91	2.16	2.64
ARG	7.81	6.42	6.77	6.30
ASP	11.52	10.64	9.71	13.04
THR	6.14	4.19	4.20	5.32
SER	5.55	4.58	3.77	4.64
GLU	16.45	16.99	16.21	16.73
PRO	4.20	6.01	3.90	3.13
GLY	5.91	4.66	5.09	4.99
ALA	6.92	6.31	7.36	5.98
VAL	5.01	5.75	5.97	4.73
MET	2.42	1.97	2.34	2.47
ILEU	5.00	4.40	7.89	4.74
LEU	8.58	9.99	11.16	9.43
TYR	3.76	8.23	6.18	4.92
PHE	4.18	3.18	5.56	3.93

APPENDIX 10

AMINO ACID CONCENTRATION OF *Synodontis schall*

MUSCLE IN g/100g

AMINO ACID	APR	MAY	JUN	JUL
LYS	10.52	10.63	10.62	11.19
HIS	3.48	2.52	3.84	3.24
ARG	6.52	5.86	6.63	5.64
ASP	12.43	13.77	11.55	10.00
THR	5.43	5.34	5.30	4.89
SER	4.41	4.90	4.58	4.56
GLU	15.59	16.52	15.76	13.50
PRO	4.50	4.43	4.07	4.73
GLY	5.67	6.24	6.30	6.05
ALA	6.50	6.91	6.19	6.57
VAL	5.17	5.86	5.83	5.27
MEY	2.16	2.98	2.18	2.75
ILEU	4.44	5.23	4.65	5.16
LEU	8.52	9.55	8.49	8.33
TUR	4.70	3.51	3.86	3.08
PHE	3.68	4.31	4.97	4.87

APPENDIX II

AMINO ACID CONCENTRATION OF *Sarotherodon galilaeus* MUSCLE IN g/100g

AMINO ACID	MAR	APR	JUN	AUG
LYS	10.47	10.72	8.88	9.84
HIS	3.64	4.56	2.87	3.13
ARG	5.90	6.84	6.13	5.63
ASP	16.09	10.81	9.38	10.28
THR	5.23	5.53	5.13	4.78
SER	4.82	4.56	3.85	4.36
GLU	16.59	19.16	15.23	16.33
PRO	3.89	3.80	3.88	3.84
GLY	6.43	6.17	4.94	7.36
ALA	6.10	6.44	5.49	6.92
VAL	5.53	5.28	4.57	5.43
MET	2.89	2.39	2.22	3.04
ILEU	5.34	6.51	4.41	5.25
LEU	8.23	9.20	8.90	7.32
TYR	4.16	3.44	3.73	5.42
PHE	4.63	3.50	4.35	7.14

APPENDIX 12

VARIANCE ANALYSIS OF AMINO ACIDS OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	NH
Between the species	2	0.14	0.07	0.0053	Accepted
Within the species	45	589.49	13.10		
Total	47	589.63	12.55		

APPENDIX 13

MINERAL CONCENTRATION OF Lates niloticus mg/100g TISSUES

Months	K	Na	Ca	Mg	Zn	Fe
DEC	1,419	480	103.70	388	3.7	7.0
JAN	1,588	453	109.50	367	4.1	8.75
FEB	1,213	502	103.50	462	2.9	13.50
MAR	1,255	1,001	97.60	350	-	14.50
APR	1,276	964	73.20	-	3.95	21.00
MAY	1,344	887	103.70	300	2.25	7.50
JUN	1,382	578	109.50	357	1.60	7.75
JUL	1,216	482	115.90	307	1.80	9.75
AUG	1,176	501	97.60	353	2.25	7.0
SEP	1,182	693	97.60	362	3.40	9.50
OCT	1,124	809	76.30	-	2.75	13.00
NOV	1,025	539	91.50	-	3.40	11.00

APPENDIX 14

MINERAL CONCENTRATION OF *Synodontis schall* mg/100g TISSUES

Months	K	Na	Ca	Mg	Zn	Fe
DEC	1,368	360	103.70	363	4.80	7.25
JAN	1,369	425	103 .70	313	4.35	15.00
FEB	1,200	462	109.50	432	3.80	17.00
MAR	-	799	91.50	-	-	14.00
APR	1,088	761	76.25	394	4.50	24.00
MAY	-	711	73.20	362	2.90	16.00
JUN	1,163	462	103.70	394	1.80	14.50
JUL	1,176	482	109.50	307	3.30	19.50
AUG	1,138	367	85.40	400	2.60	7.50
SEPT	1,076	502	82.40	351	3.70	12.00
OCT	-	-	76.30	344	5.20	9.75
NOV	1,000	480	97.60	-	4.50	8.00

APPENDIX 15

MINERAL CONCENTRATION OF Sarotherodon galilaeus mg/100g TISSUES

Months	K	Na	Ca	Mg	Zn	Fe
DEC	1,538	510	109.50	419	6.90	6.50
JAN	1,100	425	91.50	350	3.95	15.00
FEB	1.050	684	76.30	444	2.90	15.50
MAR	1,326	1,290	91.50	-	5.90	13.00
APR	1,038	-	79.30	-	3.65	14.00
MAY	1,113	1,232	94.55	412	2.10	12.50
JUN	1,213	578	103.70	375	2.40	14.00
JUL	1,250	500	109.50	362	2.90	7.00
AUG	951	541	85.40	394	3.45	11.00
SEP	688	578	79.30	-	3.30	7.75
OCT	1,200	616	97.60	394	5.05	9.50
NOV	1,400	579	103.70	494	4.00	6.00

APPENDIX 16

MINERAL COMPOSITION OF THE MUSCLE OF THE FISH

Species	K	Na	Ca	Mg	Zn	Fe
Lates	1266.67	657.42	98.33	364.00	2.92	10.85
niloticus	±95.10	±130.45	±8.18	±36.67	±0.58	±2.62
Synodontis	1175.33	528.27	92.73	366.00	3.77	13.71
schall	±96.26	±104.12	±8.65	±28.03	±0.70	±3.26
Sarotherodon	1155.58	684.8 2	93.49	404.89	3.87	10.89
galilaeus	±140.98	±196.87	±7.46	±34.11	±0.91	±2.23

APPENDIX 17

VARIANCE ANALYSIS OF THE MINERAL CONTENTS OFTHE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	NH
Between the species	2	4496.78	2245.39	0.01	Accepted
Within the species	15	3284000.30	218933.35		
Total	17	3288497.10	19344 1.01		

APPENDIX 18

ENERGY CONTENT OF THE MUSCLE OF *Lates niloticus*

Monthly Average Energy values ($Calg^{-1}$)

Months	Protein	Lipid	Carbohydrate	Total
FEB	311.22	164.35	93.20	568.77
MAR	356.82	179.55	55.60	591.97
APR	354.54	205.20	48.40	608.14
MAY	368.22	208.05	34.40	610.67
JUN	373.35	170.05	46.40	589.80
JUL	373.35	175.75	44.40	593.50
AUG	377.34	114.00	68.80	560.14
SEPT	331.74	145.35	87.20	564.29
OCT	348.27	143.45	75.60	567.32
NOV	355.11	118.75	82.40	556.26
DEC	342.00	134.90	84.00	560.90
JAN	367.08	143.45	61.20	571.73

APPENDIX 19

ENERGY CONTENT OF THE MUSCLE OF *Synodontis schall*

Monthly Average Energy values ($Calg^{-1}$)

Months	Protein	Lipid	Carbohydrate	Total
FEB	311.79	179.55	84.80	576.14
MAR	302.67	209.95	77.20	589.82
APR	311.22	224.20	68.40	603.82
MAY	318.63	237.50	57.60	613.73
JUN	311.79	208.05	76.00	595.84
JUL	366.51	209.00	36.00	611.51
AUG	329.46	209.00	64.40	602.86
SEPT	325.47	194.75	70.40	590.62
OCT	316.92	170.05	89.20	576.17
NOV	321.48	151.0 5	90.80	563.33
DEC	311.79	183.35	86.00	581.14
JAN	327.75	184.30	72.40	584.45

APPENDIX 20

ENERGY CONTENT OF THE MUSCLE OF *Sarotherodon galilaeus*

Monthly Average Energy values ($Calg^{-1}$)

Months	Protein	Lipid	Carbohydrate	Total
FEB	344.28	164.35	70.40	579.03
MAR	363.66	185.25	46.80	595.71
APR	355.68	216.60	43.20	615.48
MAY	344,85	208.05	48.00	600.90
JUN	339.72	196.65	59.60	595.97
JUL	385.89	176.70	34.40	596.99
AUG	371.07	201.40	36.00	608.47
SEPT	334.02	171.95	70.00	575.97
OCT	318.06	184.30	80.40	582.76
NOV	355.68	151.05	62.20	571.93
DEC	323.19	173.85	78.80	575.84
JAN	330.60	180.50	71.20	582.30

APPENDIX 21

MONTHLY TOTAL ENERGY CONTENT OF THE FISH MUSCLE

Species	Ranges	Mean values 95% CL	Coefficient of Variation
Lates niloticus	556.26-610.67	578.62±10.87	3.32
Synodontis schall	563.33-613.73	590.79±8.72	2.61
Sarotherodon galilaeus	571.93-615.48	590.11±7.97	2.30
	P>0.05		

APPENDIX 22

VARIANCE ANALYSIS OF THE MONTHLY TOTAL ENERGY CONTENT OF THE FISH MUSCLE

Sources of Variation	df	SS	MSS	F(0.05)	NH
Between the species	2	31.19	15.60	0.0008	Accepted
Within the species	6	116502.68	19417.11		
Total	8	116533.87	14566.73		

APPENDIX 23

FORMULAE USED

Mean values (95% confidence limits)

1. $= M \pm t_{0.05}$ S.E; where m = mean, S.E. = standard error

   $t_{0.05}$ = t - distribution table value at 95% probability of acceptance.

2. Coefficient of Variation

$= \frac{S}{M} \times \frac{100}{1}$ where S = standard deviation

3. Coefficient of regression (b)

$$= \frac{\frac{\Sigma XY}{n} - \left(\frac{\Sigma X}{n}\right)\left(\frac{\Sigma Y}{n}\right)}{\frac{\Sigma X^2}{n} - \left(\frac{\Sigma X}{n}\right)^2}$$

4. Coefficient of correlation (rxy)

$$= \frac{\frac{\Sigma XY}{n} - \left(\frac{\Sigma X}{n}\right)\left(\frac{\Sigma Y}{n}\right)}{\left[\sqrt{\frac{\Sigma X^2}{n} - \left(\frac{\Sigma X}{n}\right)^2}\right]\left[\sqrt{\frac{\Sigma Y^2}{n} - \left(\frac{\Sigma Y}{n}\right)^2}\right]}$$

5. t – test (group)

$$t = \frac{|M1 - M2|}{S\sqrt{\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

6. t – test (Paired)

$$t = \frac{\overline{X1 - X2}}{S/\sqrt{n}} \text{ or } \frac{\text{mean of difference}}{\text{standard error of difference}}$$

where X and Y are variates analysed, n the number of every variate.

7. Anova (Analysis of Variance) One Way

$$\text{Variance ratio} = \frac{\text{Between species mean sum of squares}}{\text{Within Species mean sum of squares}}$$

8. Anova (Two Way)

Between species variation for the 12 months. $= \frac{\text{Between the species mean sum of squares}}{\text{Residual mean sum of squares}}$

Between the months variation in the three species. $= \frac{\text{Between the months mean sum of Squares}}{\text{Residual mean sum of squares.}}$

9. Calculation of areas of norleucine and amino acid peaks

The area under a peak is known to be proportional to the product of the height of the peak and the width of the peak at half the height. The measurement was carried out in this order:

a) The net height (hn) of the peak was measured using a metric scale.

b) The half - height on the chart was then measured by dividing the net height by two ($\frac{1}{2}h$)

c) The width of the peak at half height was measured (W)

d) The net - height results were multiplied by the width

Area of a triangle ($\frac{1}{2}bh$).