SOME ASPECTS OF THE BIOLOGY OF CLAMS
(Aspatharia Spp) in ZARIA

Thesis submitted to the Ahmadu Bello University, Zaria, in partial fulfillment of the Award of Degree of Master of Science (Animal Biology).

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DECEMBER, 1991

DECLARATION

I hereby declare that this thesis is my own work and has not been submitted in any form in any other Institution or University and all information derived from published and unpublished work of other authors have been acknowledged in this text.

Mrs. Victoria A. Opadeyi

Date

CERTIFICATION

This Thesis entitled:

SOME ASPECTS OF THE BIOLOGY OF CLAMS

(Aspatharia Spp) IN ZARIA

meets the regulations governing the award of the degree of M.Sc. Animal Biology of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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Supervisor

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Head of Department



Date 17/2/99
Dean, Postgraduate School

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DEDICATION

This Thesis is dedicated to the Lord lJesus, Master above Situations and Circumstances who saw me through this work despite all odds.

ABSTRACT

Some physical parameters and nutritive value of clams, Aspatharia species, of the Galma River in Zaria, Kaduna State have been studied. The physical parameters studied include whole weight of the clam, the length, width and depth of the shell which are indices of size and growth of the clams. The mean weight of the Galma clams used in this research was 14,282 grams, mean length, 5.9633 cm; mean width 3.533 cm; and mean depth, 2.4033 cm. There was a high correlation between the clams weight and length (r = 0.9274), width (r = 0.6860), depth (r = 0.73770, volume (r = 0.9475), fresh shell (r = 0.9968), fresh flesh (r = 0.9126). However there was no correlation between the clams weight and 'K' factor and density.

The mean protein value from proximate analysis was 32.7806 percent, mean lipid value was 6.42 per cent, mean value of carbohydrate was 50.31 percent, mean ash value was 7.85 percent. The mean value of organic matter was 97.90 percent while the energy va1ues of the c1am f1esh per each nutrient were 180.93, 60.99 and 217.054 kcal/qm for Protein Lipid and carbohydrate respective1y.

The shell constituted the largest portion of the who1e ca1m with a mean of 70.907 percent.

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CHAPTER I

1.1 INTRODUCTION

Freshwater clams also known as bivalves are molluscs which are characterised by the possession of hard shell, soft body, slippery skin and are generally slow moving. Clams are identified by the outward shell covering of two identical valves. These valves secreted by the body of the animals enclose the soft internal structures. The colouration of these valves vary from dark brown to black, light brown and yellow.

Clams belong to the class Pelecypoda which are characterised by the possession of axe-shaped foot. They could also be referred to as Lamellibranchs because of the presence of leaf-like gills covered by cilia used for feeding and respiration. These clams have modified structures in comparison with all other molluscs. For instance they have lost the head and buccal mass and the radula.

In the advanced countries, clams have been usefully exploited for the benefit of man especially as one of the major sources of protein. They form a good part of the diet in places like Japan, India, Britain and the United States of America. Apart from being food for man, the flesh is also used as baits by the fishermen. According to Pennak (1953), the shell of clams is not less

important either, it has been used as a major source of calcium and phosphorus in animal ration formulation and in countries where clams abound in large quantity, the shell have been used for local road constructions as well as being put into aesthetic uses after polishing. These uses include making of materials such as needlebooks, scent bottle holders, pin cushions, buttons, jewelry and home decorations.

In Nigeria, clams naturally abound in reasonable quantity in the freshwater as well as marine environments. In riverine states such as the coastal parts of Imo, Cross River, Akwa Ibom, Rivers and some parts of Ondo State, the clam flesh is considered a delicacy. The shells are also locally used for measuring stuffs like tobacco snuffs, pepper and fermented locust bean seeds. In the homes, they are used for scrapping burnt pots. There is hope that with much technological developments, clams may be 'farmed' and used widely in Nigeria as we have in other more developed countries.

In view of these already stated importance, it is pertinent that the Biology of clams be fully studied. In this research however, some aspects of the structure such as size (weight, length, width and depth), volume and density will be dealt with while the chemical composition of the clam reflecting its nutritive importance will also be investigated. The chemical composition to be

considered includes the protein, carbohydrate lipids and ash contents.

1.2 JUSTIFICATION OF THIS PROJECT

It is quite obvious in Nigeria today that most families cannot afford the price of the common sources of protein like beef, mutton, chicken and their products such as eggs, milk and others. Most people go daily without meat while an average family takes meat once in a day. Vegetable protein source such as pulses was formerly very affordable by every one but the present high cost has prevented them from being alternatives to animal protein.

In view of this, other sources of protein need to be investigated. These sources should be good alternatives as well as cheap to raise and be readily purchased by all classes of people in the country. Clams fall into this category and experiences of the advanced countries in the farming of clams could be fully utilized to increase protein content of the diet of every Nigerian.

It is also important to mention that economic strains in Nigeria are making a lot of people drop some aspects of our culture which are not particularly necessary especially with reference to some food habits. For example, some wild beans which were used as animal feed before are now being consumed by human beings. It is also a common sight during the rainy season to see women

and children collecting termites in large number. These insects are roasted and sold in large measures in the markets as cheap source of protein and is well acceptable nowadays by many people. The freshwater clams could also become a delicacy in Nigerian homes and whatever bias people have against its consumption could be dropped when they have been well informed about clams nutritive value.

Freshwater clams are found abundantly in many rivers in Nigeria apart from the marine species. They are well adapted to most rivers in the country and so can be raised on large scales. However there is yet a lot to be known about the detailed biology and nutritive value of Nigerian clams. From the experience of those countries that have cultured clams on a large scale, it is relatively easier and cheaper to raise clams than fin fishes. Also, the whole animal is of economic value as the flesh is used as meat for man and the shell can be used for feed formulation for livestock as a source of phosphorus and calcium thus reducing complete dependence on cattle bones. It is expected therefore that a study like this will pave the way for the nationwide recognition of clams and its importance as well as encouraging the government and individuals to incorporate the culture of freshwater bivalves in the fishery programmes of this country especially now that the government is paying greater attention to aquaculture.

CHAPTER 2

LITERATURE REVIEW

Even though much literature is available on clams found in freshwater and marine environments in the advanced and few African countries, there is comparatively little published work on clams in Nigeria. The few attempts made and known to this author were the unpublished B.Sc research works of Ikwuntole (1983) and Ndagi (1984) in the department of Biological Sciences of Ahmadu Bello University, Zaria. Ikwuntole's work was the first major documented research on the freshwater clams in the Zaria area and formed the basis for other works in this area. She did a comparative study of the length weight relationship of clams from two environments in Zaria - the Galma river and the University Lake. The result of this work showed that specimens from Galma rivers were bigger than those from the lake and the latter supported fewer population of clams than the former. Furthermore it was indicated that the relationship between any two of the physical parameters studied namely, length, width, weight, depth and volume, was highly significant.

Ndagi (1984) on the other hand, studied the anatomy of the Zaria Mussels which compared favorably in most aspects with those from Europe and america. Extensive

work has been done on various aspects of the biology of the freshwater clams in countries like United State of America, India, England, Congo and many others. Such aspects include the external form, internal structure, locomotion, habit feeding, excretion, reproduction and others. Some of these aspects will be discussed in this work.

2.1 CLASSIFICATION OF CLAMS

According to Bowden and Happel (1968) quoted by Ellis (1978) clams could be classified as follows:

Plylum	-	Mollusca
Class	-	Pelecypoda
Sub class	-	Palaeocheterodonta
Order	-	Unionaceae
Family	-	Unionidae

Characteristics

Order - Unionaceae

Members of this order are mostly freshwater species and occur buried in mud, silt or sand in rivers, canals, lakes and large ponds. Most of them are relatively large and are subject to environmental variation. They have characteristic oval shape, umbonal sculpture, hinge and muscle with definite scar pattern.

Family - Unionidae

Members are characterised by the presence of complete

gill diaphragm separating the mantle cavity from the exhallant chamber. The external lamella of the outer gill is joined to the mantle at the hind end while the inner gills are separated from the labial palps by a wide gap. There is a supranal opening and there are water tubes. The brood pouch is sometimes formed by all the lamellae or by the outer ones only.

They require moderate amount of calcium in the water.

2.2 IDENTIFICATION OF SPECIMENS IN THIS RESEARCH

The external features of clams used in this research include oval shaped valves attached on the dorsal margin by a hinge as indicated in plate 2.1. The shell valves are similar in shape and size that is they are equivalve. The outer layer of periostracum has dark colouration and the area of erosion normally occurs around the umbo. A small beak or the umbo that points backward is also identified situated near the dorsal edge of the shell as shown in plate 2.2. These descriptions tally with those given by Solem (1978) for the identification of West African Aspatharia Spp which can be classified as follows.

Class - Lamellibrachia

Order - Unionaceae

Family - Mutelidae

It could be therefore accepted that the specimens

being used in this research are Aspatheria Spp whose genus remains to be confirmed.

These clams according to Solem (1978) are similar to the European Anodonta cygea which also belong to the family Unionidae. Their growth is said to be by accretion at their margin which occurs irregularly. The size and shape of the shell valves at the earlier stages in life are indicated by the growth lines caused by some interuption in the growth of the shell at that time as shown in Plate 2.3.

2.3 EXTERNAL STRUCTURE OF CLAMS

The external characteristic feature of the freshwater clam is the shell. It is an oval box, somewhat flattened and composed of two symmetrical concave valves joined by a ligament and locked hinge teeth at the back. The oval outline broadens at the enterior or front end while the posterior or the hind end is narrowed. The dorsal margins of the valves unite on the hinge line while the ventral margins are open and free as recorded by Rogers (1951). A swelling, the umbo or beak is seen as each valves swell forward on the dorsal margin. Furthermore lines of growth, concentric and parallel with the outer free shell margins are seen on the outside. The colour of the shell ranges from white to brown in Sphaeridae and yellow to black in other

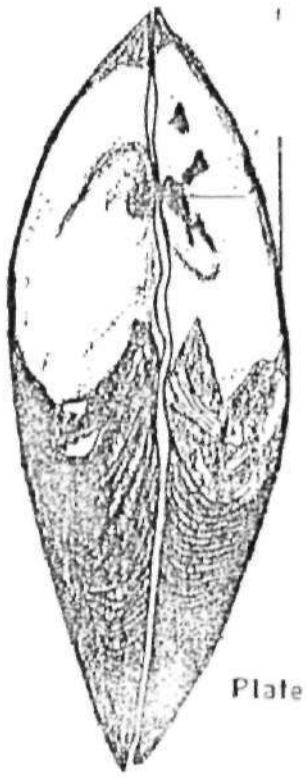
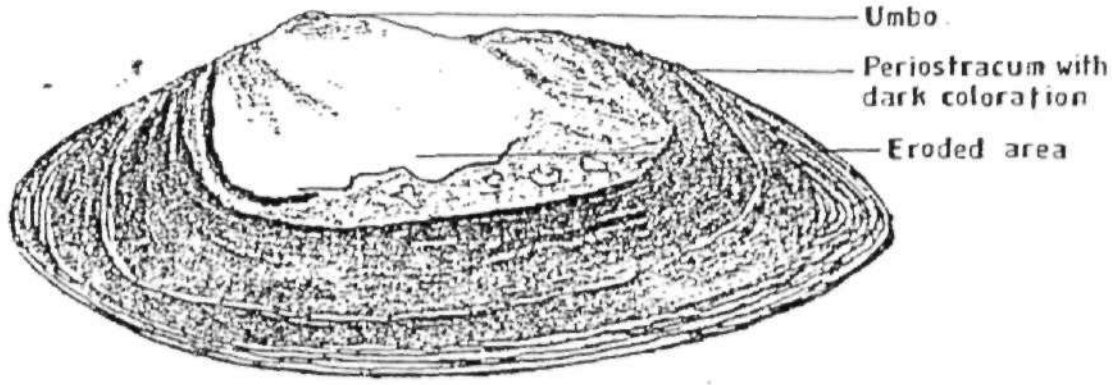
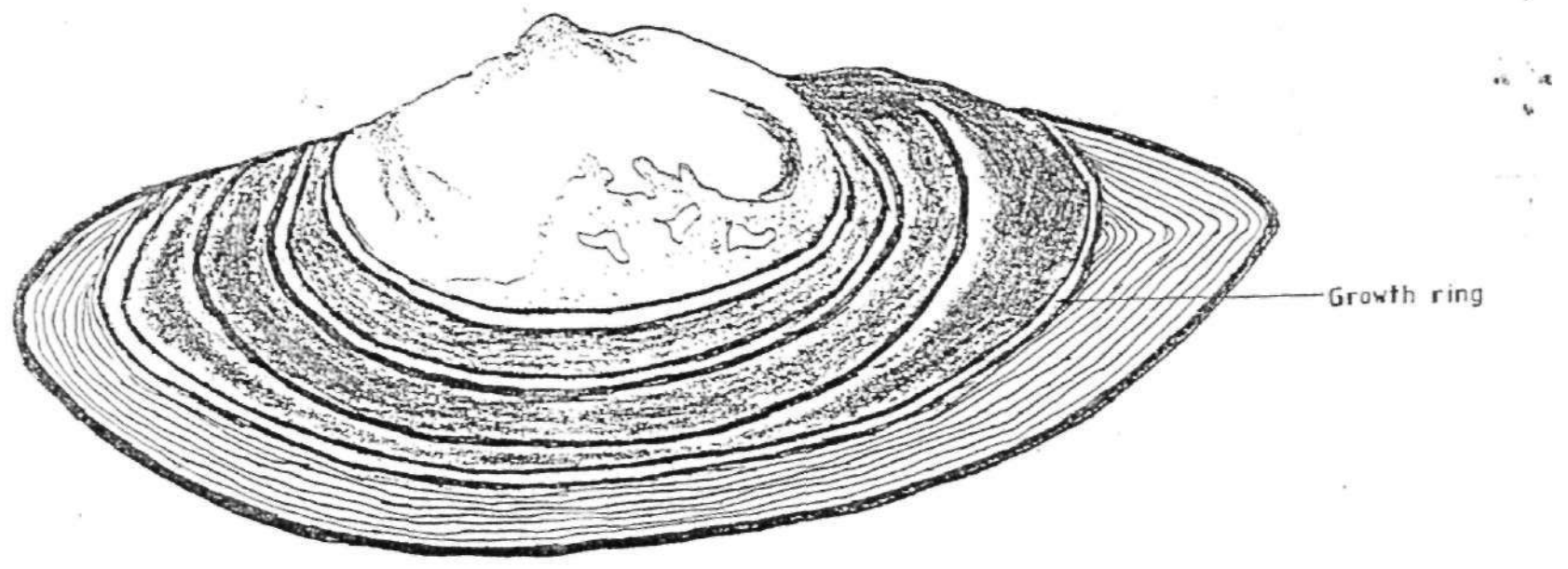


PLATE 2.1. DORSAL VIEW OF THE GALMA CLAM.



x 2

PLATE 2.2 EXTERNAL STRUCTURE OF THE GALMA CLAM SHOWING THE OVAL SHAPE VALVE.



x 4

PLATE 2.3. THE GALMA CLAM SHOWING ITS SHAPE AND CONCENTRIC GROWTH LINES

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2.3.1 SHELL FORMATION

Morton (1968) described the shell as being formed by deposition of crystals of calcium carbonate in organic matrix of protein substances called concholin. Its structure is highly ordered and falls ideally into 3 zones which he referred to as:

(a) Outer organic layer (Periostracum) which is a quinone tanned protein.

(b) Prismatic or columnar crystalline layer of calcite or aragonite added along the mantle edge.

(c) Inner layer which is nacreaous and is made of the laminate crystalline sheets and produced by the mantle's inner surface.

The calcium supply is obtained essentially from the clam's food in freshwater environment. If the calcium supply is insufficient as is obtained in freshwater, the shells are usually thin. The carbonate content is obtained from carbon dioxide-bicarbonate pool in the mantle or general body tissues.

The shell formation normally occurs in the thin layers of extra pallial fluid between mantle and inner shell surface.

2.4 INTERNAL FORM

The soft body found in the internal part of the clam consists of visceral mass and a muscular foot. The body of the clam is covered with two flesh lobes called

'mantle'. The presence of only two lobes was stated by Ritchie et al (1979) but was contrasted by Morton (1968) who indicated that the mantle edge consists of three lobes namely the outer lobe which secretes the outer calcareaous layer of the shell; the middle lobe which is sensory and the inner lobe or velum which controls the flow of water. Posteriorly the mantle is modified to form a short tubular, dorsal excurrent exhallant siphon, both of which regulate the output and intake of water. Food and oxygen in the water are drawn into the mantle cavity through the ventral, in-current siphon by the action of cillia. Water and wastes go through the excurrent siphon outside.

One lobe of the mantle adheres to the inner surface of each valve and together they form a mantle cavity that encloses the entire body mass. According to Purchon (1968), the mantle cavity, with the organs contained in it contributes more to the bivalves' mode of life than does any other organ complex except perhaps the buccal mass and the radular. It serves primarily for respiration and assumed additional functions including collection and sorting of food, incubation of early development and larval stages and even locomotion. Solem (1978) also agreed with these stated function of the mantle cavity.

The bulk of the body is the foot which is a mass of muscle which a clam could use to

plough slowly along bottom mud. the foot is also used in feeding by raising or lowering the animal in the substrate to a point where food is available.

The digestive system consists of:

(a) the mouth located between two pairs of flesh with ciliated, flap-like labial palps;

(b) a short oesophagus leading to an enlarged stomach which receives the digestive enzymes from the paired liver (digestive gland) surrounding the stomach; and

(c) a coiled intestine followed by a rectum (surrounded by the pericardium) leading into the anus which opens into the mantle cavity near the dorsal excurrent suphon.

As regards Zaria clams investigated by Ndagi (1984) there were no differences in the digestive system as already reported by Kimbal (1978) and Graham (1976).

The circulatory system is an open one consisting of a heart within the pericardial cavity, arteris, sinuses and veins. The heart consists of two auricles and one ventricles. The blood is pumped on anterior sorta to the foot and visceral mass and backward through a posterior gorta to the mantle cavity and rectum.

The respiratory system consists of two pairs of thin gills, one pair on either side of the foot. Each gill is

formed by two platelike lamellae (small plates). Each lamella consists of many vertical filamentous gills bars strengthened by animous rod. Cross partitions between the lamellae divide the gill into numerous vertical tubules. The gill surface has small water pores through which water passes. The gills in addition to being the respiratory organs also act as the pouch in which eggs are collected and fertilized by the sperms brought in through the incurrent siphon. Development of the young clams also begins in the gills and are later released into the water for further development as discovered by Ritchie et al (1979). These descriptions of the gills agreed with the findings of Ndagi 91984).

2.5 NUTRITION

Clams like other bivalves are ciliary feeders on suspension or deposits. Food is collected by the gill and labial palps as there are no radula, buccal cavity or salivary glands.

The oesophagus is short and the intestine is a mere transport tube for faeces (Morton, 1968). The findings of Yonge (1964) and Purchon (1968) have taught much about the working of the stomach in bivalves. The whole action is dominated by the rotation of the crystalline style which is long, flexible rod. The style, apart from being an enzyme store also functions as stirring rod and a

windlass with one or more food strings from the oesophagus wound to it in a tright spirals. The food particles are drawn into the stomach where they are shed partly by contact with the stomach but mainly by the effect of the lowered PH of the stomach contents in reducing the viscousity of the mucus. The free particles are swept acorss the ciliary sorting area. the lightest particles are kept in suspension by the cilia at the crest of the ridges and degree of the efficiency of the otenidum to retain particles is related to the diameter of the particles in suspension. The food particles undergo preliminary extracellular digestion by the style enzymes and the amoebocytes and are finally conveyed to the digestive diverticular where they are phagocytosed and digestion is completed intracellularly. The importance of the otenidia or gills in the fluid mechanic, of suspension in clams has been extensively discussed by Jorgensen (1983).

The contents of mussel food has also been analysed. Tsuchiya (1982) investigated the amount or organic matter caught by a mussel, Mytilus edulis population living in $1m^{2}$ of rocky intertidal shore at Asamuschi, Northern Japan.

Apart from organic matter, sand grains and green algae also serve as food for clams (Purchon, 1968). This view was further supported by Summar et al (1983) who stated

that spat mussels are abundant on the rocky shores of eastern Scotland (UK) in water due to the abundance of the small algae which serve as their food.

2.6 RESPIRATION

Most shore-dwelling prosobranchs are to varying degrees adapted for aerial breathing. In many, the roof of the mantle cavity is thin, vascularized and acts as an additional respiratory surface. all can breathe under water, a respiratory current being maintained mainly by ciliary tracts. Even when exposed to air, the shell valves of many bivalves do not close completely and the free edges of the mantle protude through the shell gape but information is not available to show whether or not cutaneous aerial respiration can play a significant role in respiration. Bivalves such as clams and oysters simply close down completely under conditions of low oxygen and can live without oxygen for about a period of 3 months as indicated by Dodgson (1928). clams like Mya builds up an oxygen debt which is repaid by an increased rate of pumping when the tide returns.

It is assumed that all shore prosobranchs have haemocynin as a respiratory pigment but at best this serves to increase the oxygen carrying capacity of the blood by only about 3 percent (Carter, 1951). Many also have haemoglobin in certain muscles which may act as oxygen

store. it is also certain that the haemocyanin of such animals as have been studied have low loading tensions, that is, they are saturated at low oxygen tension and this can be regarded as an adaptation for life under poor oxygen condition for example, during drought when the animals withdraw into their shells. In order to make up for the low oxygen tension during uncomfortable conditions, the clams like other melluscs become relatively inactive and their oxygen requirement become correspondingly small.

2.7 EXRETION

Needham (1950) has shown that the nature of the end products of nitrogen metabolism of any species is related to the relative toxicity of ammonia concentration, the products of deamination, urea and uric acid and to the ease with which these can be eliminated bearing in mind the availability of water particularly during the *embryonic development*.

Ammonia, the most toxic of the three can be got rid of in the requisite extreme dilution only by aquatic animals. urea which is very soluble must be eliminated along with water but uric acid is almost insoluble and practically innocuous in the concentration in which it can occur dissolved. Moreover, it can be eliminated with practically no water loss. Clams like other aquatic

molluses are said to be ammoniotelic or urotelic that is, they eliminate the products of protein deamination in form of a ammonia or urea dissolved in large volume of water.

2.8 LOCOMOTION

The clam uses the foot actively in locomotion. This is by a series of contractions of the intrinsic muscles fibre of the foot which first elongates and is then thrust forward in the substrate then the distal portion of the foot becomes more or less swollen transversely so that it obtains a purchase and at the same time, the entire foot is shortened as a result the soft portion of the body and its enclosing shell are pulled forward, Pennak (1953) further indicated that repeated muscular contraction results in locomotion which is essentially a series of short hunching movements. Some species are known to move several feet per hour and the resulting long trough like tracts of larger mussels may often be seen on sandy lake where there is little wave action.

2.9. REPRODUCTION

Generally bivalves may be regarded as a group characterised by goniochorism as reported by Coe (1948). Goniochorism refers to sexual dimorphism. Even though in most molluscs, it is difficult to differentiate the male

and the female, the use of size and gaping of the shell may be suitable to determine the sex. This is based on the assumption that the females are bigger and the shell more gaped than in the males.

However some bivalves are hermaphrodite especially in a habitat or ecological situation in which they are confronted by some difficulty in reproductive activity and this difficulty to some extent is eased by the adoption of ambi sexual state. Most of the hermaphrodites as stated by Reisenner (1911) are also those which do not broadcast their eggs but incubate them in the mantle cavity or gill until they have developed as far as larval state or become miniature parents. This later description fits most clams as indicated by Bhushanam et al (1978). He stated that hermaphroditism could be functional or simultaneous that is, the clams produce gametes of the male at one time and female at another time or they produce both male land female types at the same time (simultaneous hermaphroditis). He further described the structure of the testicular follicies as being mostly oval or elongated whereas they ovarian follicle show diversity in shape and size. The seasonal changes in bivalves have been divided into stages namely:

- growing stage which is the post spawning period, with short recovery during which gonadal increases;
- Maturing stages; when the gonads are fully developed;

- Maturity stage; the follicles reach their maximum size and ripe gametes are released;
- Partially spawned stage; where gonads size reduces and ganetes are few.

In species with separate sexes, sperms are released into the water with the male facing down stream and female facing up-stream.

The sperm is pumped into the inhalant siphon and passed into the gills. Eggs released into the water tubes in the female gill and there fertilization takes place. The fertilized eggs are brooded inside the gills until they grow into a stage called glochidium in the Unionaceae. At this point, the larvae are expelled from the exhanlant siphon and dropped to the bottom. If the larve do not come in contact with a suitable host such as fish or salamander or which they could parasitize, they die off. The few lucky larvae clam onto the gills or the body of the host for 10 to 20 days or even up to months. After some times of swimming by the fish, the larva drops and develops into a juvanile which, according to Solem (1978), is about 0.0254 cm long. Enormous numbers of larvae must be produced because of the possibility of only few surviving and developing to adult stage. The juvenile attaches itself to a suitable substratum by means of bysuss or may get itself buried in the sand or mud.

2.10 GROWTH

Yonge (1964) discussed extensively on the growth of molluscs generally. The outstanding features of the growth in molluscs are its variation in rates, developmental stage, age and environmental conditions and chemical reactions which govern body composition and dimensions.

Changes during growth can be represented in two ways namely.

1) Parameter of growth of the whole organism in relation to age.
2) The rate of growth of one part or dimension in relation to another part or to the whole body.

In molluscs generally as in all animals, growth rate may not be uniform with the result that the relative proportions of the body change with increase in size. The difference in growth rate between one part and another considered as a standard is termed allometry of growth. The relationship between a part and the whole body or between two parts of the growing animal can be described by the general equation.

. $y = bx^{a}$

where y = linear measurement of shell

b = slope

x = length

a = rate of growth of y

A limitation of allometric method is that it compares only 2 portions of the shell at a time. Growth parameters in Donaz (Latorna cummeatus) was a studied by Nayar (1955) who reported his findings as shown graphically in the following figure (Fig 2.1).

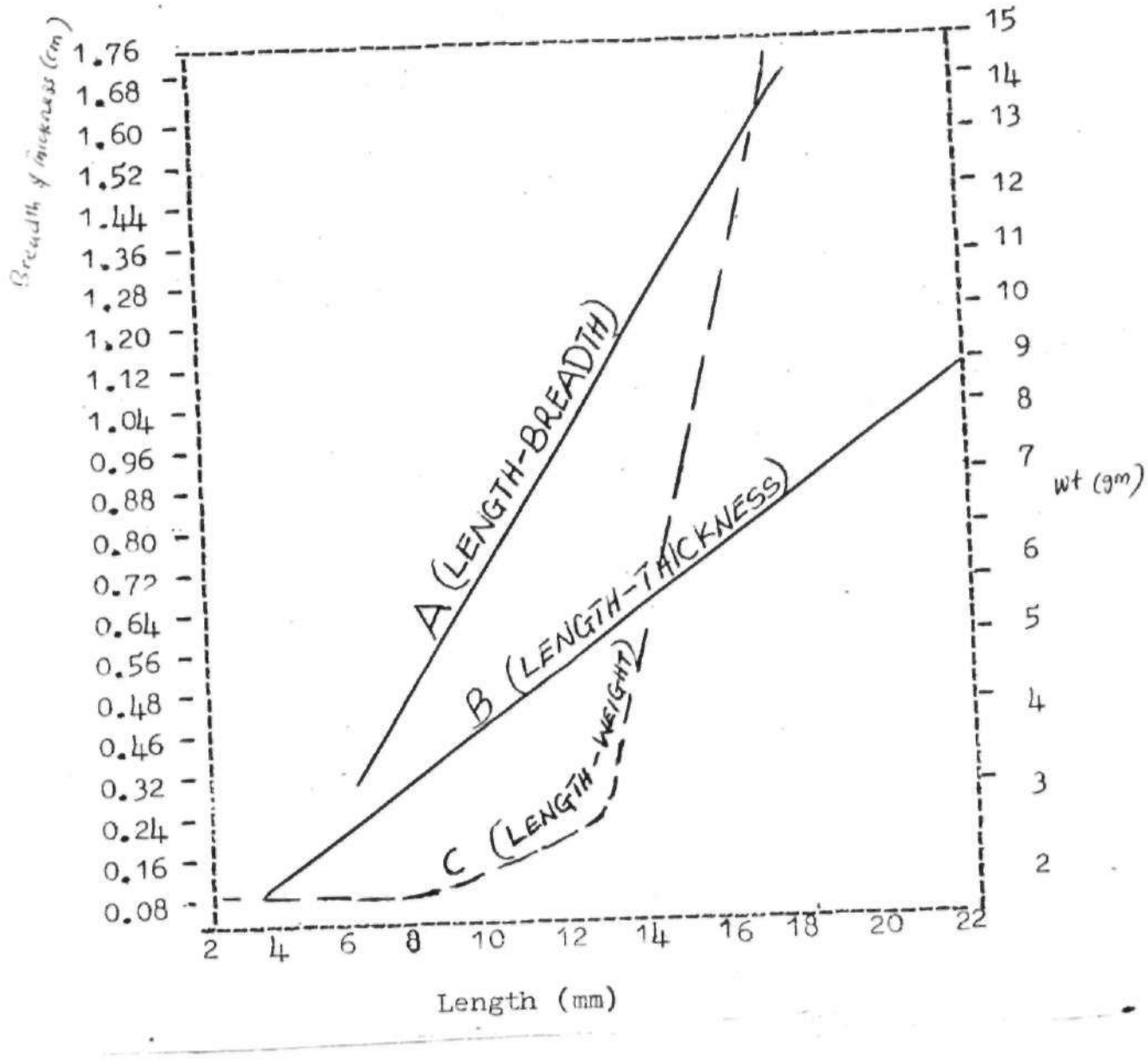
The growth and form of the molluscan shell is frequently considered solely in terms of length, breadth and height but these characteristics alone do not enable shell form *in different genera to be* satisfactorily related. Typically the relationship between the mantle and shell is such that the latter increases in area only by the addition of marginal increment.

2.11 IRRITABILITY

Clams respond to a number of stimulus such as

FIG 2.1

GROWTH PARAMETERS IN DONAX (LATONE)
CUMEATUS AFTER NAYAR (155)



temperature, chemical concentrations (pollutants) and salinity. Tsuchiya (1982) discovered that usually temperature above 40°C will result in the mass mortality of the population of musels Mytilus edulis. As the temperature rose the clams expelled water contained in the shells and 50% of individuals died within one hour from high body temperature rising up to about 40°C. Similary views were expressed on the significance of temperature as a lethal factor for the clams by Colter et al (1982). chemicals such as zinc and other salts also have effect on the clams. Further results from Colter's work indicated that there is a high correlation between high temperature, increased zinc concentration, and high salinity as lethal factors for factors for the clam.

The effect of drought on clams has also been investigated by Metcalf (1983). His findings indicated that there is a high mortality rate during dry months. The clams have been known also to orientate to environmental factors such as light, gravity and kinetics (Yonge, 1964). The larger clams tend to stay in the shallow water because they require a high light intensity before they settle to metamophose. The juveniles have a preference for hard thread like materials for their attachment but after growing for some time, detach themselves to settle in other places as indicated by Wilbur (1964).

2.12 OSMORRGULATION

Clams are poikilosmotic, that is, they are unable to regulate osmosis. It is therefore necessary that some adaptation for, life in the freshwater be made such as the production of urine that is hypotonic to the blood but still about 100 times more concentrated than the medium. This gives high efficiency in osmoregulation and reduces osmotic work as indicated by Morton (1968).

2.13 HABIT OF CLAMS

Clams have the habit of burrowing into the sand. The explulsion of water from mantle cavity has an important role in loosening the sand and making it more penetrable by the shell, with much the same effect as the operation of water-jetting in loosening a pile. The jet is not directed downwards but upwards from pedal gape to assist the passage of the shell as indicated by Purchon (1968).

2.14 ECONOMICS OF CLAMS

According to Macconnaughey (1978), clams commonly occur in great numbers as closely spaced as possible forming mats of beds of clams sometimes covering much of the exposed rock surface between the lower margin of the exposed barnacle zone and the upper edge of the permanent seaweeds zone. These beds themselves provide protection

for many other animals including worms, gastropods, smallcrabs land shrimps. A flourishing bed with the animals attached in dense clusters and nourished by the plant plankton in water that flow over it represents one of the most deanse accumulations of animals life. Yonge (1961) indicated that it has been calculated that an acre of best mussel or clam ground will produce annually 10,0001b or 4530kg of clam meat with a fuel value of 3,000 calories. the calorific value is obtained by using the conversion factors given by Hafez et al (1969) as indicated below:

Protein	-	5.5 kcals/g
Carbohydrate	-	4.1 kcals/g
Lipid	-	9.5kcal/g

It has been said that no known system of cultivation of agricultural land can produce corresponding values in form of animal food. the only major problem presented by the use of clams as human food is the danger of contamination with domestic sewage from the towns rivers where they live.

The factors affecting the attainment of clams to marketable size has also been investigated. These factors according to Kraeuter and Castagna (1985) include seed size, shell bages, crab traps and netting with the seed size at planting affecting the clams more than any other factor. He further indicated that the marketable size is

- 8mm shell height and more than 22mm thickness or precisely 25mm.

Clams are farmed extensively in France, Holland, Spain and Italy. According to Idyll (1978), the yield from raft is astonishing in Spain and this could give up to 5000,000 pounds or 226,800kg of meat per acre.
In the United States, clams especially hard clams (Mercenaria) can be conditioned to spawn in hatcheries while in Rio de Arosa, clam culture is said to be most intensive with approximately 2,000 rafts resulting in one the highest protein yields per unit area on earth as indicated by Tenore (1982).

He further stated that in addition to the high meat yield the faeces of the clams also serve as food to the other species of epifauna which live on or between the densely packed population of clams. another products of economic value obtained from clams are the pearls which are formed when an unwelcome intruder such as a bit of shell or a parasite invade the mantle of the clam. The shellfish then covers the dipict with a layer of nacre and pearls formed are collected from the soft tissue where they are embedded as reported by Summars et al (1983). The most recent work as reported by Fassler (1991) involves the aqua culture of American Pearl by four companies in the United State of America whose products are exported to Japan. These pearls are very

valuable as a recklace of extremely rare round American natural pearls could sell for as much as $100,000.

2.15 PHYSICAL PARAMETERS AND NUTRITIVE VALUE OF CLAMS

Some investigations have been carried out on the physical parameters of clams such as the weight, the length, (thickness) depth (Height). As previously stated, the marketable size for mercanaria (hard clam) is 8mm shell height and 25mm shell thickness Kraecater and Castagna, (1985) reported that the mean length of these clams was 33mm and total densities were 8.00m^{-2}. Also Ikwuntole (1983) research findings on Zaria clams indicated that the maximum length was 6.70cm while the minimum was 3.2cm with a mean of 6.20 (SE 1.6007). The maximum width of the shell was 4.20cm, while the minimum was 2.22cm with a mean of 3.12cm (SE 160.39).
The results further indicated that the maximum depth of the clams was 3.57cm, minimum was 1.31cm while the mean was 1.98 (SE1.003). She further stated that there was a high correlation between the length and weight of the clams used in the research and a positive relationship between any two of the physical parameters such that using the necessary regression equation, any parameter could be deduced from any available data.

The nutritive value of clams in some advanced countries has also been studied. Bardach et al (1972)

stated that the meat of Spanish mussel contain 14 percent protein, 8 percent glycogen and 2.4 percent fat. Furthermore Lutz (1980) also indicated that from researches on mussel meat, it was discovered that it contains 19.70 percent dry matter, 80.30 percent moisture, 97.90 percent organic matter, 12.80 percent protein, 1.40 percent total lipids and 3.40 percent carhobydrates. Lutz further stated that carbohydrate content is higher during summer months as the protein content decreases, this implies that there is a summer boost of carbohydrate during summer. Brook et al (1904) as cited by Lutz (1980) found that the amino acids composition of clams is high indicating high protein content.

CHAPTER 3

3.0 MATERIALS AND METHOD

3.1 SOURCES OF SPECIMENS

The clams used in this project were obtained from the Galma river which is below the Zaria Dam in Zaria Local government Area of Kaduna State. The volume of the water in this river normally reduces very much during the dry months of late November and February, exposing the beds to dry harmattan wind. However between the months of July and September, the river normally overflows its bank. The Galma was chosen as the site of the collection of specimens because it does not dry up completely during the peak of the dry season when most other rivers in this area would have dried up.

3.2 PERIOD OF STUDY

The project was carried out between April and May as well as between October and November (1988). During the months of october and November, the river bank was exposed but still has some considerable amount of moisture for the survival of the clams. Earlier than the month of October, accessibility to the banks as well as collection of specimens were very difficult since the

bank and the surrounding were overflooded. Some attempts were made to get the fishermen with traditional fishing gourds to collect some specimens but could not obtain any since most of them would have settled on the sandy beds of the river.

Towards the end of November some of the clams obtained on the banks were dead due to lack of moisture.

3.3 SAMPLE COLLECTION AND TRANSPORTATION

The method of collection include handpicking of those that were openly found along the bank of the river, shallow digging with a small hoe for those that were buried in the sand, feeling of the shell with the feet and picking for those that were lightly covered by the sand. The samples were kept in transparent plastic bags with the fresh riverwater to provide an environment similar to their natural habitat. The samples were then transported to the laboratory ensuring that there was no wastage of time during transportation. It takes about an average of 35 minutes to drive from the river to the laboratory.

3.4 IDENTIFICATION

The collected specimens were identified by the observation of the outer shell made up of two oval valves if they are similar in shape and size. The shell colouration was also observed. The structure of the beak

situated near the dorsal edge of the shell was also observed. These characteristics helped in the classification of the clams used in this research.

3.4.1 DETERMINATION OF PHYSICAL PARAMETERS

The clams were immediately removed from the water, gently dried with filter paper and their fresh whole weight taken in grams using the top loading Metler balance model (1200). Other physical parameters measured include the length of the bivalve, that is the longest side of one valve, using the vernier caliper with measuring units in millimetres. The width was taken along the equatorial pole of the same valve, while the depth was measured from the centre of one valve to the centre of the other half. These areas of measurements are indicated in the plates 3.1, 3.2 and 3.3.

3.4.2 FRESH WEIGHTS OF THE FLESH AND SHELL

To obtain the fresh weights of the flesh, the valves were carefully opened and a sharp pen knife was used to severe the aductor muscles where they are fixed to the valves. The flesh was gently wiped with filter paper and the fresh weight taken. The weights of the corresponding shells were also recorded.

3.5 PROXIMATE COMPOSITION OF THE CLAMS

3.5.1 MOISTURE CONTENT DETERMINATION

There are several methods of determining the moisture content of a sample, such as drying the samples

in the oven at 60°C in vacuo, at 70°C, at 96°C in current of dry hydrogen, at 97-102°C, mixed with baked sand, at 110°C and by toluene distillation method. However the

samples in this project were oven dried at 70°C for 24 hours. The flesh and the shells were dried separately and each reweighed at short intervals until a constant weight was obtained. They were later left in the dessicator to cool. The final weight was taken after cooling and the percent moisture was obtained using the formular:

$$\frac{\text{Loss in weight after drying}}{\text{Freshweight}} \times 100$$ as given by (A.O.A.C, 1965)

3.5.2 PROTEIN DETERMINATION

This was determined using the total Nitrogen determination method. The organic matter is oxidised by sulphuric acid in the presence of a suitable catalyst and nitrogen converted to ammonia. The ammonia is liberated by distillation in a Markham steam distillation apparatus in the presence of caustic soda and collected in boric acid. The ammonia is then titrated with standard hydrochloric acid using a mixed indicator. This method is referred to as Microkjedahl method (A.O.A.C,1965). For the sample under consideration, it was discovered after drying, the solid flesh of each clam became minimal thus rendering it inadequate for all further analysis.

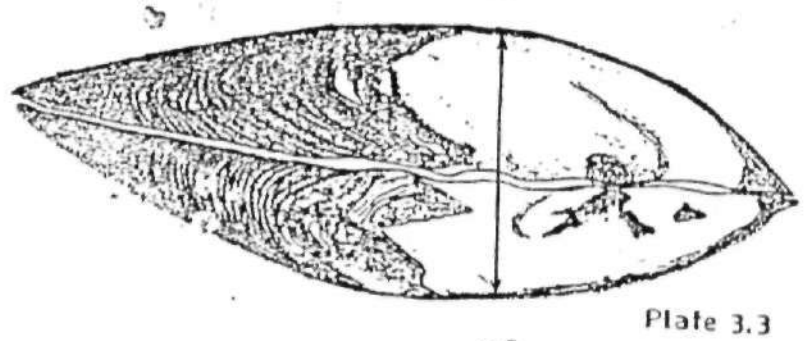


PLATE 3.3. THE GALMA CLAM SHOWING ITS DEPTH .

In view of this, the samples were pooled for analysis. About 0.01 gram from each ground pooled sample was weighed into a small kjedahl flask and the catalyst (a mixture of 1 gram of copper sulphate 8 grams of potassium sulphate and 1 gram of selenium dioxide) on a tip of spatula was added and 1 ml of nitrogen free sulphuric acid was added. The mixture was gently heated on a digestion stand until fumes of sulphuric acid were freely evolved then heated more strongly until the digest was apple green in colour. the digestion was continued for a longer time while the blanks of the reagent were being run at the same time. Adequate care was taken to avoid particles of undigested carbon from sticking to the sides or the tube. A Markham distillation set was used. The digestion flasks were each washed out twice with 1 ml. of distilled water into the steam jacket and ground stopper replaced. 10mls of 40% sodium hydroxide was added through the funnel and when the steam issues freely from the tube at the bottom of the steam jacket, the lower slip was closed. The stopper in the funnel was lifted and the soda allowed to run into the digest. The amonia liberated was distilled into 5mls of 2% Boric acid contained in a 100ml beaker. The tip of the condenser was immersed in the acid until after the first few drops have distilled, then raised above the surface of the Boric acid. The distillate having been collected when the

distillation was complete, the steam jacket was washed out with water in preparation for the next distillation. Two drops of indicator, a mixture of 6ml methyl red (0.16) percent of 95% alcohol); 12mls bromocresol (0.04% in water), mls of 95% alcohol, was added to the distillate and titrated with 0.02n Hydrochloric acid to a faint pink end point. To obtain the amount of Nitrogen available, the following formular was used:

$$\% \text{ Nitrogen} = \frac{(A-B)\ N \times 14.007}{W} \times 100$$

Where A = quantity of HCL used to neutralize test sample

B = quantity of HCL used to neutralized blank

N = Normality of HCL (0.020)

14.007 = Relative atomic mass of Nitrogen in ammonia

W = Weight of sample in mg

To obtain % Protein - % Nitrogen X 6.25, since specific proteins were obtained and analysed and found to contain approximately 16% lnitrogen as indicated by Hafez and Dyer (1969). The advantages of using this Microkedahl method are that a small amount of sample is required especially where total sample weight is very small, and it helps to conserve chemicals.

3.5.3 LIPID DETERMINATION

Fats are insoluble in water and as such organic solvents such as petroleum, ether metanol, n-hexane Chlroroform can be used for extracting fats using soxhlets, continuous extraction chamber (A.O.A.C,1965).

The ethanol ether mixture is effective in splitting the fat from the protein but will dissolve non-fatty substances giving a high result and petroleum dissolves only fat thereby giving low result due to its inability to split the fat-protein linkages. In view of these fats, ethanol-ether mixture with petroleum ether is considered best. Hydrochloric acid can be used to split the fat protein. The extraction was done in duplicate for each pooled sample. 0.5 gram of each dried pooled sample was weighed into a known weighted thimbles and cooled. The thimbless were plugged with fat free cotton wool to stop spillage during the extraction. The extractors were arranged on the heating mantle set at 90°C and about 200mls of solvent was poured into each extractor. As the solvent boiled, the fats were extracted and the extraction continued for about 8 hours after which it was observed that no fat was being extracted any longer. the thimbles were removed and dried at 40°C in the oven for 4 hours and cooled in a dessicator with the cotton wool removed. The thimblers with their fat free contents were reweighed and weights recorded. The percentage lipid was calculated using the formula.

$$\frac{T_1 - T_2}{To} \times 100$$

where To = weight of dried sample

T_1 = weight of dried sample + thimble

T_2 = weight of extracted materials + thimble

3.5.4 DETERMINATION OF ASH

Dry ashing method whereby the test materials is burnt in a murfle furnace at 500-700°C was employed. 1gm of each pooled sample was weighed into clean crucibles of known weights. The crucibles with the samples were serially arranged in a murfle furnace set at 500°C. The ashing was left for more than 30 hours until the content became whitish. Each crucible was then cooled in the dessicator and reweighed.

The percentage ash was obtained from the formula

$$\% \text{ Ash} = \frac{C_3 - C_1}{Co} \times 100$$

Where C3 = weight of ash + crucible

C1 = weight of empty crucible

Co = weight of dried material taken for ashing.

3.5.5 DETERMINATION OF TOTAL ORGANIC MATTER

This was obtained by the difference between 100 and percentage of ash content.

3.5.6 DETERMINATION OF CARBOHYDRATE

Since the total organic matter of the clam flesh is made up of protein, lipid and carhohydrate, the percentage carbohydrate was determined using the formular

% Carhohydrate = % Total Organic matter

(% protein + % lipid)

as indicated by Mc Donald and Edwards et al (1977).

3.5.7 CALORIFIC VALUE

Using the following conversion factors as cited by Hafez

and Ayet (1969)

Protein - 5.5 kcal/g

Carbohydrate - 4.1 kcal/g

Lipid - 9.5 kcal/gm

The calorific values were calculated.

The calorific value implies the gross energy of the nutrients. The average values are estimated as shown above and are regarded as constants.

3.6 STATISTICSL ANALYSIS

The statistical analysis includes finding the minimum, maximum, range, mean and standard error of the weight, length, width, depth, volumes, K constant and density of each clam. The percentage minimum, maximum, range, means and standard error of the fresh flesh moisture were also calculated. From the proximate analysis, the percentage minimum, maximum, range, means land standard error for the protein, lipid, carbohydrate, total organic matter and ash contents were also determined.

Using the conversion factor for each nutrient, the calorific values for protein, lipid and carhohydrate contents of the clams were also calculated. From the data regression equations and correlation coefficients were also obtained. correlation line graphs were drawn to show the relationship between parameters.

CHAPTER 4

4.0 RESULTS

4.1 ABUNDANCE AND DISTRIBUTION

The clams in this study occur naturally in this habitat in scattered form, as observed, the population of the clams along the bank which was the area of collection employed in this research. For every 3 feet movement (approximately 90cm) an average of one clam was collected and within every scoop sand brought up by the hoe, an average of 2 clams was obtained. Only very few clams were hand picked on the surface of the river bank. about an average of 45 clams of various sizes were obtained per collection from which the unsuitable specimens were discarded. The discarded ones included the empty shells, dried or dead clams. The number of specimens randomly selected from the suitable ones was 30 which were the ones used in the subsequent experimentation.

4.2 PHYSICAL PARAMETERS

The physical parameters measured include the whole body weight of the clams, the fresh weight of the shell and flesh separated, the maximum length, width and depth of the clams were also determined.

The volume, density and K factor were also calculated.

TABLE 4.1

PHYSICAL PARAMETERS OF WHOLE BODY

	MINIMUM VALUE	MAXIMUM VALUE	RANGE	MEAN	STANDARD ERROR
FRESH WEIGHT OF CLAM (g) A	9.8	39.8	30.0	14.287	1.0790
MAXIMUM LENGTH (cm) B	5.0	8.0	3.0	5.9633	0.1191
MAXIMUM WIDTH (cm) C	2.5	4.5	2.0	3.3533	0.07155
MAXIMUM DEPTH (cm) D	1.4	2.7	1.3	2.4033	0.117
'k, Factor (A / B^3) (x 10^{-3})	1	9	8	6.3666	0.2774
DENSITY (gm/cm3 (x 10^{-3})	28	51	23	35.8666	1.6019
VOLUME (cm^3)	21.29	97.20	75.91	39.5013	3.0858

TABLE 4.2

SHELL MEASUREMENT

	MINIMUM VALUE	MAXIMUM VALUE	RANGE	MEAN	STANDARD ERROR
FRESH OF TOTAL WEIGHT OF CLAMS	58.34	80.20	21.86	70.6907	0.78949
SOLID SHELL	40.00	77.05	35.05	58.2245	0.4343
MOISTURE CONTENT %	22.95	60.00	37.05	42.7477	0.3337

4.2.1 WHOLE BODY WEIGHT

The minimum whole body weight was 9.8gm while the maximum whole body weight of the clam was 39.8 grams with the mean of 14.287 grams. The standard error was calculated to be ±1.0790 (Table 4.1).

4.2.2 SHELL MEASUREMENT

The fresh shell of the smallest clam weighed 6.1 grams constituting 58.34 percent of the total body weight while the maximum fresh shell weight was 28.7 grams constituting 80.20 percent of the total body weight with a mean of 70.6907 grams (SE ± 0.7894) weight as indicated in Table 4.2.

The minimum solid shell constituted 58.34 percent of the total weight of the organism and a maximum of 80.20 percent with a range of 21.86. The percentage mean was 70.6907 (Se ± 0.7849).

4.2.3 FLESH MEASUREMENTS

The fresh flesh of the clams constituted a minimum of 18.12 percent and a maximum of 41.66 percent of the total body weight.

After drying, the minimum solid flesh made up 3.85 percent while the maximum solid flesh made up 65.63 percent of the total body weight (Table 4.3).

TABLE 4.3

FLESH MEASUREMENT

	MINIMUM VALUE	MAXIMUM VALUE	RANGE	MEAN	STANDARD ERROR
FRESH FLESH % OF WHOLE WEIGHT OF CLAM	18.12	41.66	23.54	29.143	0.1893
SOLID FLESH %	3.85	65.63	61.78	28.2233	0.5757
MOISTURE CONTENT %	34.37	96.15	61.78	71.7833	0.5757

4.2.4 MEASUREMENT OF LENGTH

The minimum length of the clams in this work was 5.0 centimetres while the maximum length was 8.0 centimetres with a mean of 5.9633 (SE ± 0.1191) as indicated in Table 4.1.

4.2.5 MEASUREMENT OF WIDTH

The minimum width of the clams used in this research was 2.5 centimetres while the maximum width was 4.5 centimetres with a mean of 3.353 centimetres (SE ± 0.07155) as indicated in Table 4.1.

4.2.6 MEASUREMENT OF DEPTH

The depth of the clam varied from a minimum of 1.4 centimetres to a maximum of 2.7 centimetres. the mean depth was 2.4033 centimetres (SE ± 0.1177) as shown in Table 4.1.

4.2.7 MEASURE OF K FACTOR, DENSITY AND VOLUME

From the measurement of the length, width and depth of the clams, the 'K' factor that is the proportionally constant was calculated using the formular:

$$\text{'L' factor} = \frac{\text{weight}}{(\text{length})3}$$

The K facor helps us to determine relationship between the weight and the length of the clam, that is the weight is proportional to the cube root of the length of the same clam.

The 'K' factor ranged from 1 to 9 with a mean of 6.3666 (SE ± 0.2774). the volume was obtained by calculation from the product of the values for length, width and depth.

The minimum volume was 21.29 (centimetre)^3 and the maximum was 97.00 (cm)^3 with a mean of 39.5013 (centimetres)^3 (SE ± 3.0858). using the results obtained for the volume, the density was calculated using the formular.

Density = weight per unit volume

The density of the clam on this work varied from a minimum of 28gm/cm^3 to 51 g/cm^3 with a mean of 35.866gm/cm^3 (Se = ± 1.6019) as indicated in Table 4.1.

4.2.8 CORRELATION RELATIONSHIPS

From Table 4.6 it could be observed that there is a high correlation between the physical parameters namely the whole weight of the clam, length, width, depth and volume of the clam. The coefficient of correlation ranges between 0.6860 and 0.94755 when the variable X is the known weight of the clam. However there is a low correlation coefficient between the whole weight of clam, 'K' factor and density as shown in Table 4.6.

The positive correlation between the weight and other physical parameter such as the length, width, depth and

volume of the clams was further shown by the straight line graphs with the points well distributed on the either side of line as shown on figures 4.1 to 4.4. Also there is direct correlation between the whole weight of clam and the fresh shell and flesh of the clams as shown in figures 4.7 and 4.9 respectively. However figure 4.5, 4.6, 4.8 and 4.10 show that there is no correlation between the weight of the clams and the density, K factor dried shell and dried flesh weights respectively.

4.3.1 SOLID CLAM FLESH

After drying the clam flesh, the solid flesh constituted a minimum of 3.85 percent and a maximum of 65.63 percent of the fresh flesh weight. the mean was 1.78 percent (SE ± 0.5755) as recorded in Table 4.3).

4.3.2 MOISTURE CONTENT

The mean moisture content for the clam flesh was 71.7833 (SE ± 0.5757) with the minimum being 34.73 percent and the maximum being 96.15 percent as seen in table 4.3.

4.3.3 ASH CONTENT

The proximate ash composition of the clam shell constitute a minimum of 6.05 percent and a maximum of 12.65 percent of the total solid flesh. The mean was 7.85 percent (SE ± 0.371) as indicated in Table 4.4.

TABLE 4.6: REGRESSION EQUATIONS OF THE WHOLE WEIGHT ON OTHER PARAMETERS

Y	a	b(x)	N	Coefficient of Correlation	P
Y1 aximum jth)	4.606	+ 0.095 (x)	30	0.9274	0.001
Y aximum h	2.7	+ 0.045 (x)	30	0.6860	0.001
Y3 aximum h)	1.236	+ 0.046 (x)	30	0.73778	0.001
Y4 tor=Flesh eight aximum igth)*	0.062.7	+ 1.54470 x 10^{-4}(x)	30	0.0680	0.10
Y5 sity-Fresh eight olume	0.383	+ 7.25 x 10^{-4}(x)	30	0.0685	0.010
Y lume)	0.786	+ 2.7099(x)	30	0.94755	0.001
Y7 esh shell)	0.168	+ 0.722 (x)	30	0.9868	0.001
Y8 y shell)	0.5825	+ 0.3659(x)	30	0.9677	0.001
Y9 esh flesh)	0.173	+ 0.277 (x)	30	0.9216	0.001
Y ry flesh)	0.1699	+ 0.693 (x)	30	0.0960	0.001

here

Y = dependent variables
X = independent variable (weight)
a = Intercept
b = Slope
r = Correlation coefficient between x and Y
P = level of significance

4.3.4 ORGANIC MATTER

The organic matter of the flesh constituted a minimum of 87.35 percent and a maximum of 93.95 percent with a mean of 92.51 (SE ± 0.371) as shown in Table 4.4.

TABLE 4.4

	MINIMUM VALUE	MAXIMUM VALUE	RANGE	MEAN	STANDARD ERROR
OTEIN	20.43	46.106	25.675	32.7806	1.5923
PIDS	3.8	9.2	5.4	6.42	0.297
RBOHYDRATE	39.33	64.28	24.95	50.31	1.780
AL ORGANIC ATTER	87.35	93.95	6.6	92.15	0.371
H	6.05	12.65	6,6	7.85	0.371

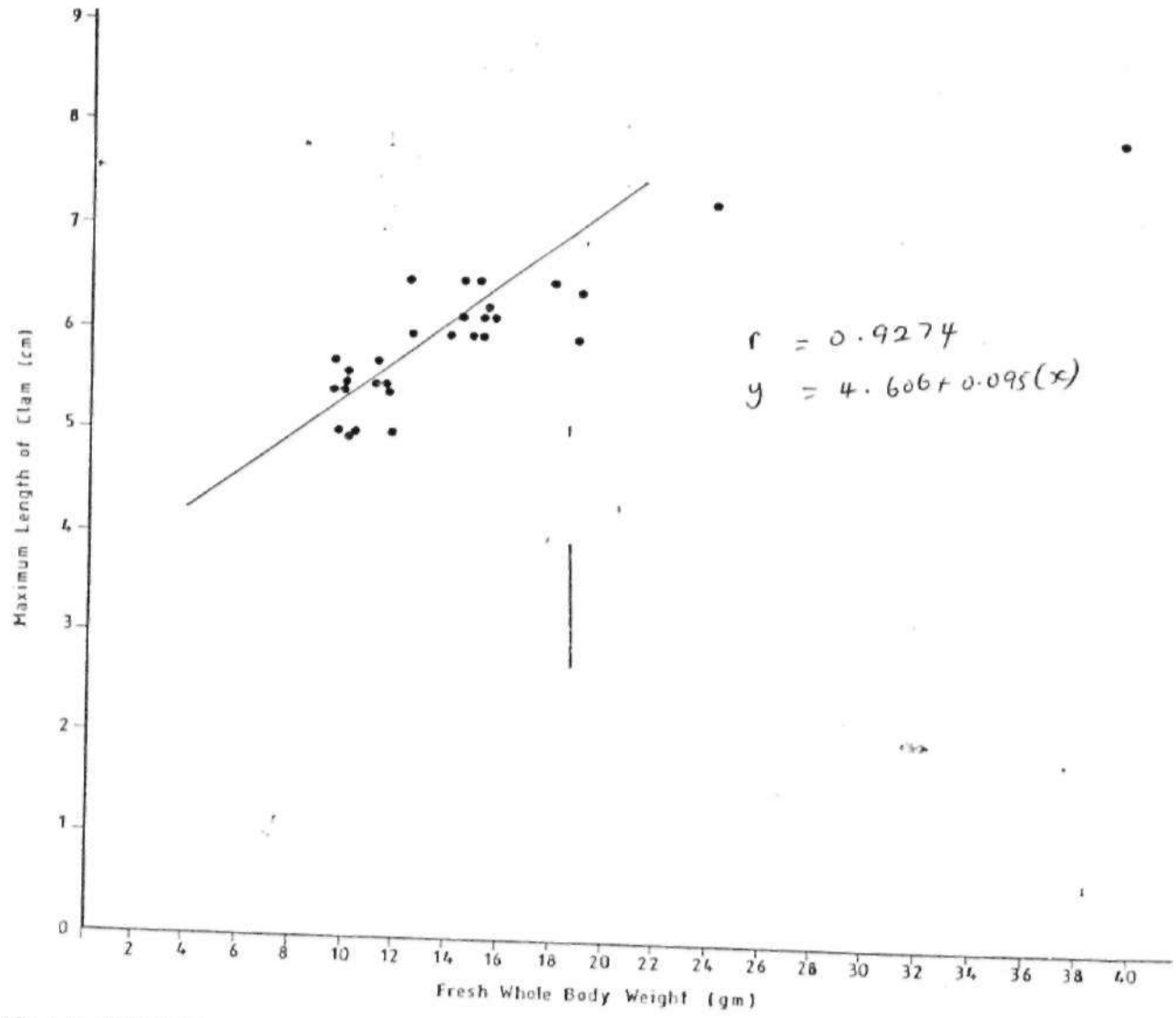


FIG. 4.1. RELATIONSHIP BETWEEN FRESH WATER CLAMS WEIGHT (X) AND MAXIMUM LENGTH (Y_1).

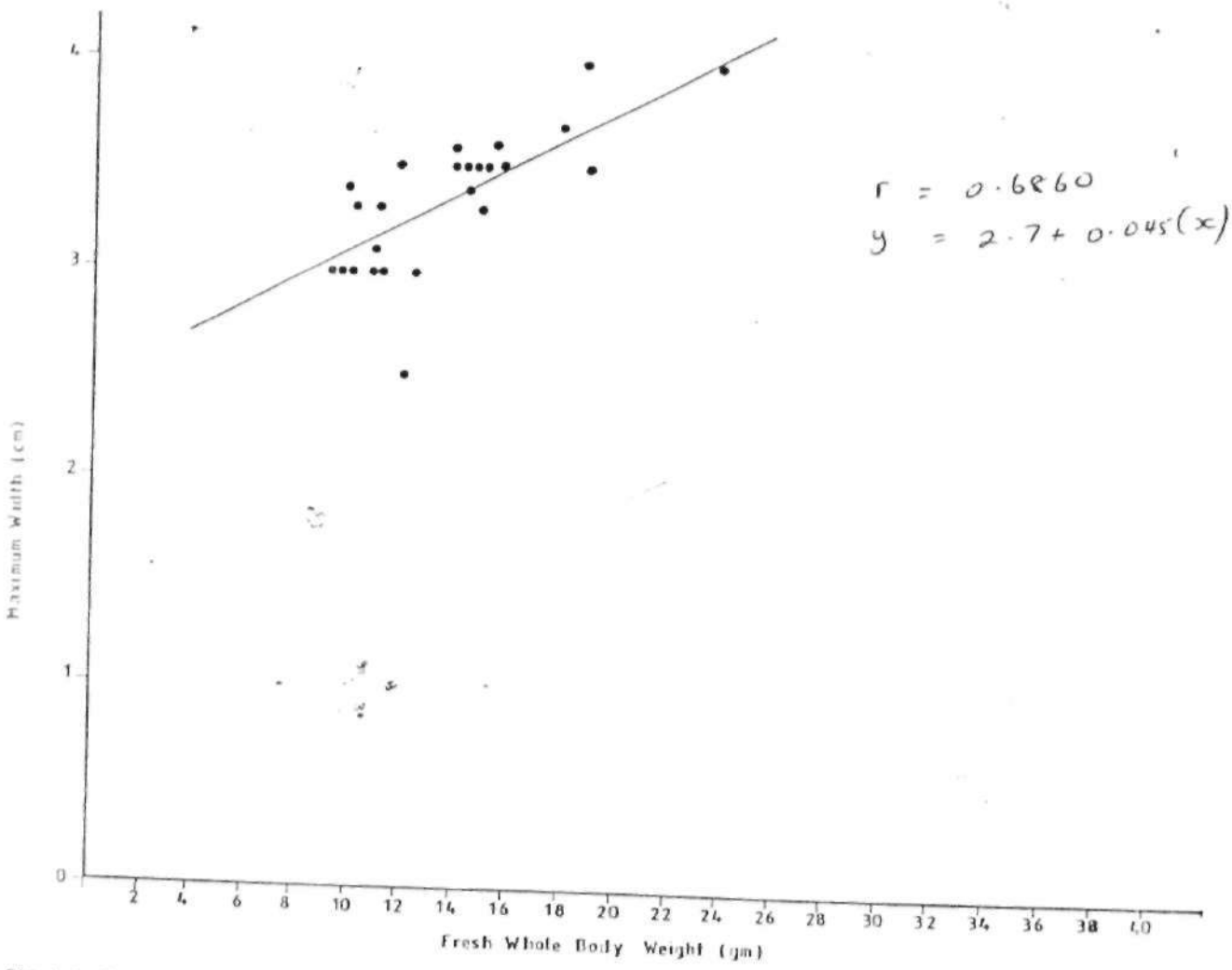


FIG 4.2. RELATIONSHIP BETWEEN FRESH BODY WEIGHT (X) AND MAXIMUM WIDTH (Y) OF FRESH WATER CLAMS.

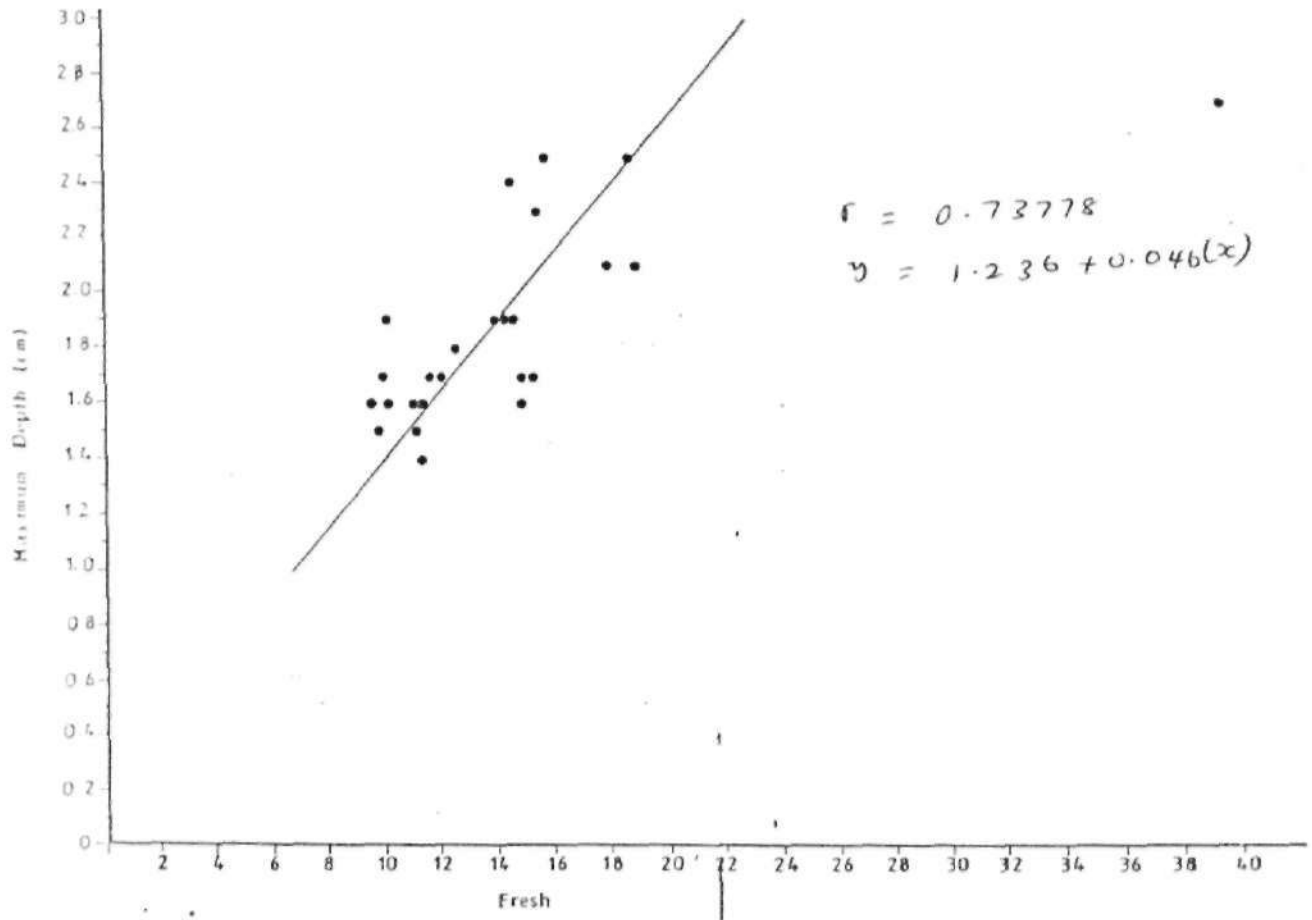


FIG. 4.3. RELATIONSHIP BETWEEN WHOLE BODY WEIGHT AND DEPTH OF FRESH WATER CLAM.

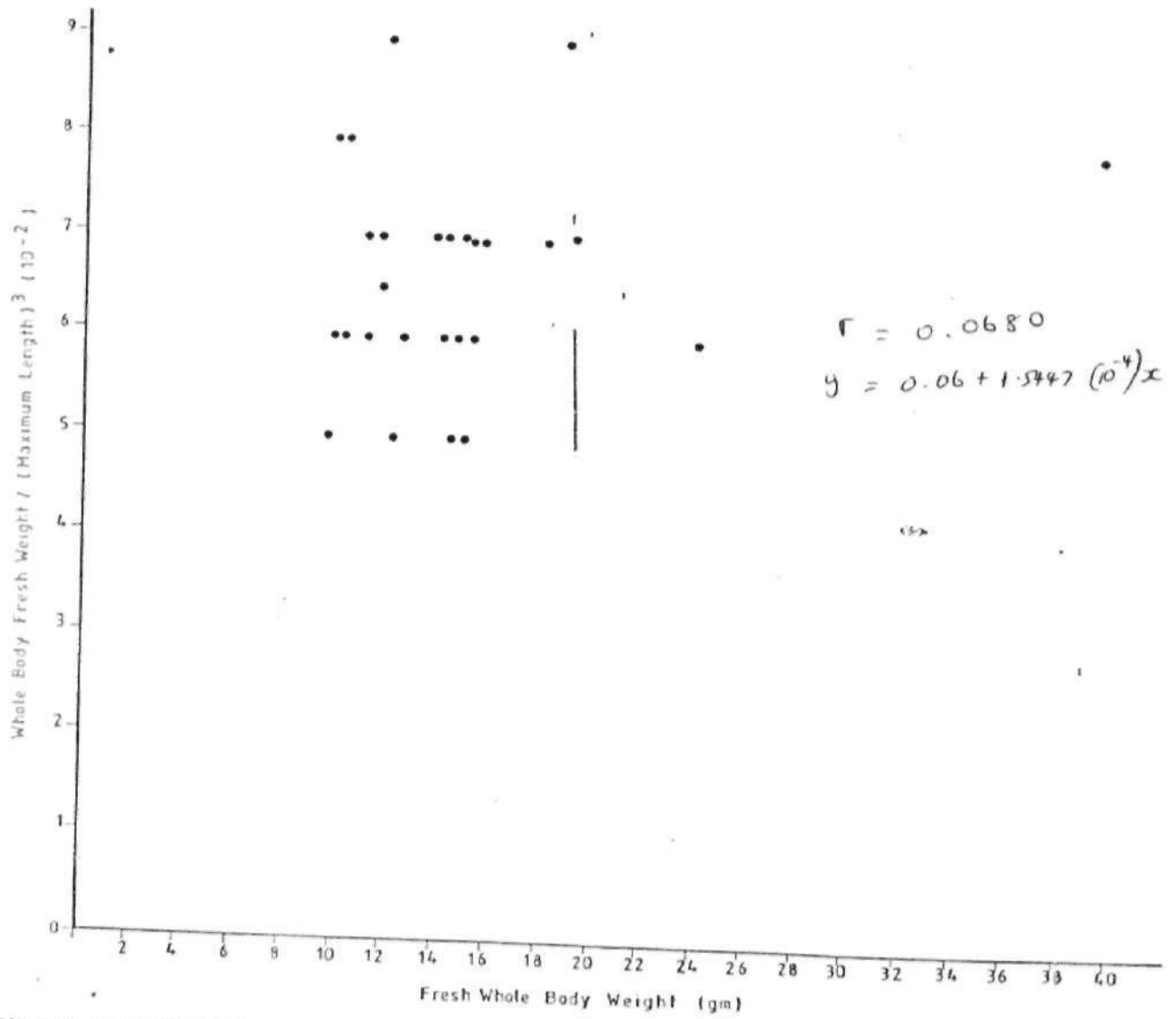


FIG 4.4 RELATIONSHIP BETWEEN THE WEIGHTS AND 'K FACTOR $\left(\frac{\text{(Fresh Body Wt)}}{\text{(Maximum Length)}^3}\right)$ OF CLAMS.

$r = 0.0685$

$y = 0.383 + 7.25(10^{-4})x$

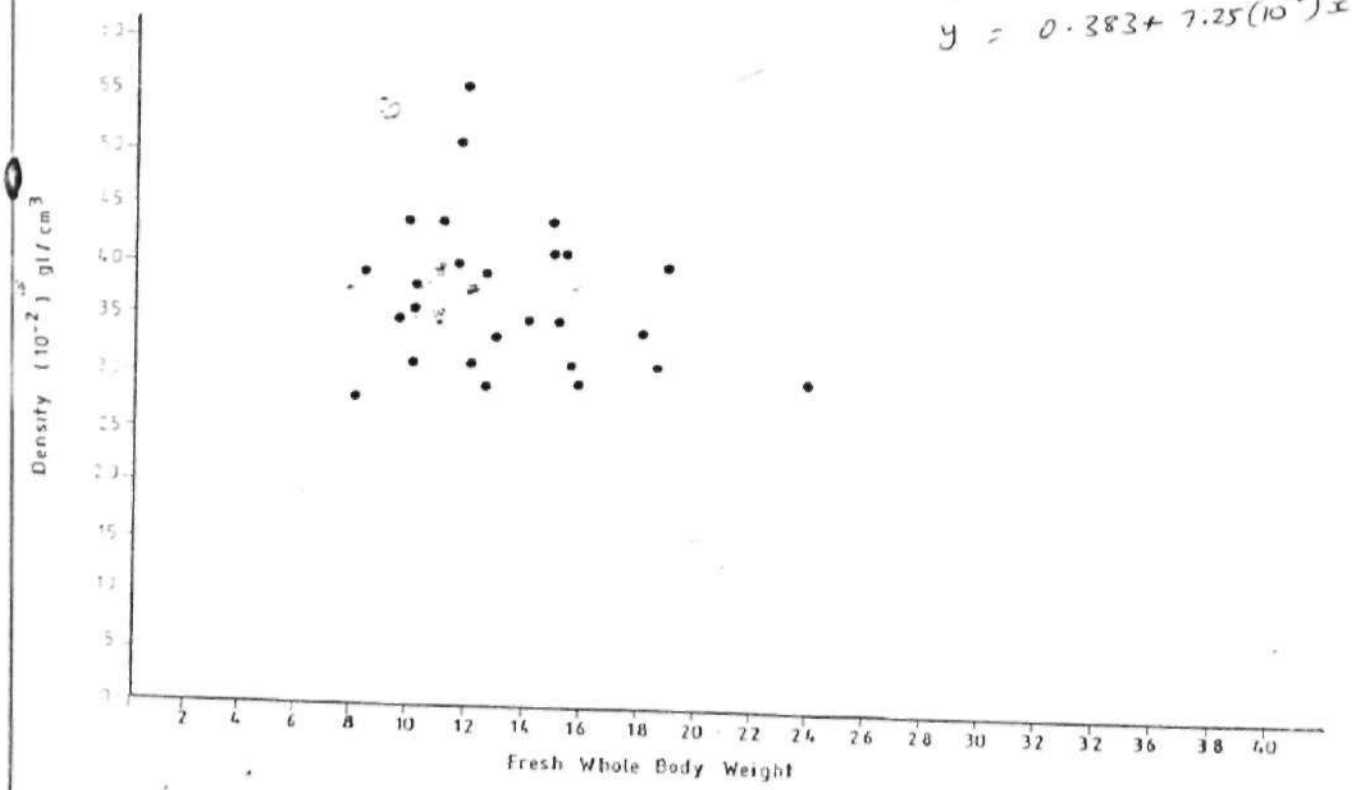


FIG 4.5. RELATIONSHIP BETWEEN FRESH WHOLE BODY WEIGHT AND DENSITY OF CLAMS.

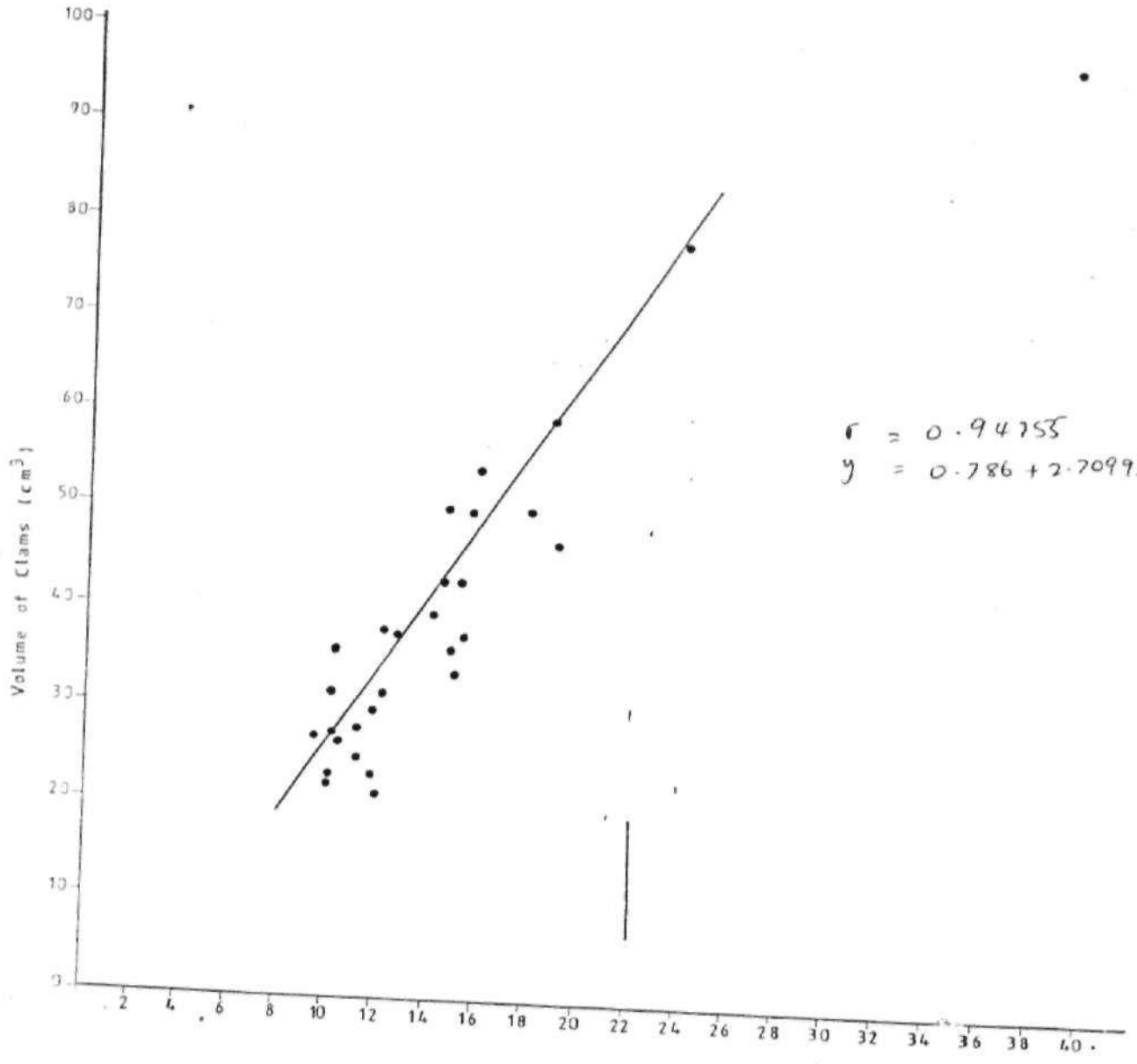


FIG. 4.6. RELATIONSHIP BETWEEN WEIGHT AND VOLUMES OF FRESH WATER CLAM.

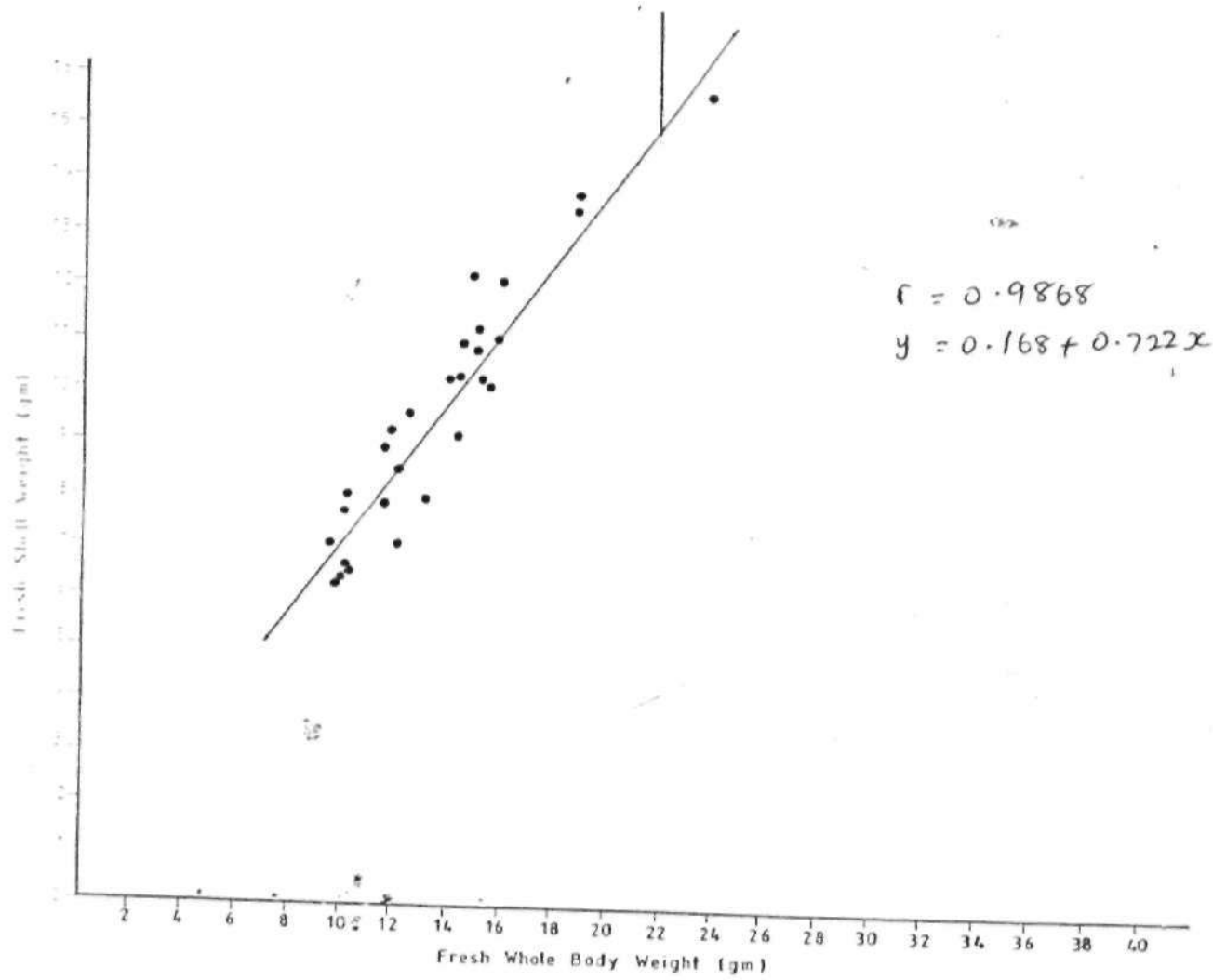


FIG - 7. RELATIONSHIP BETWEEN WHOLE BODY WEIGHT AND FRESH SHELL WEIGHT OF CLAMS.

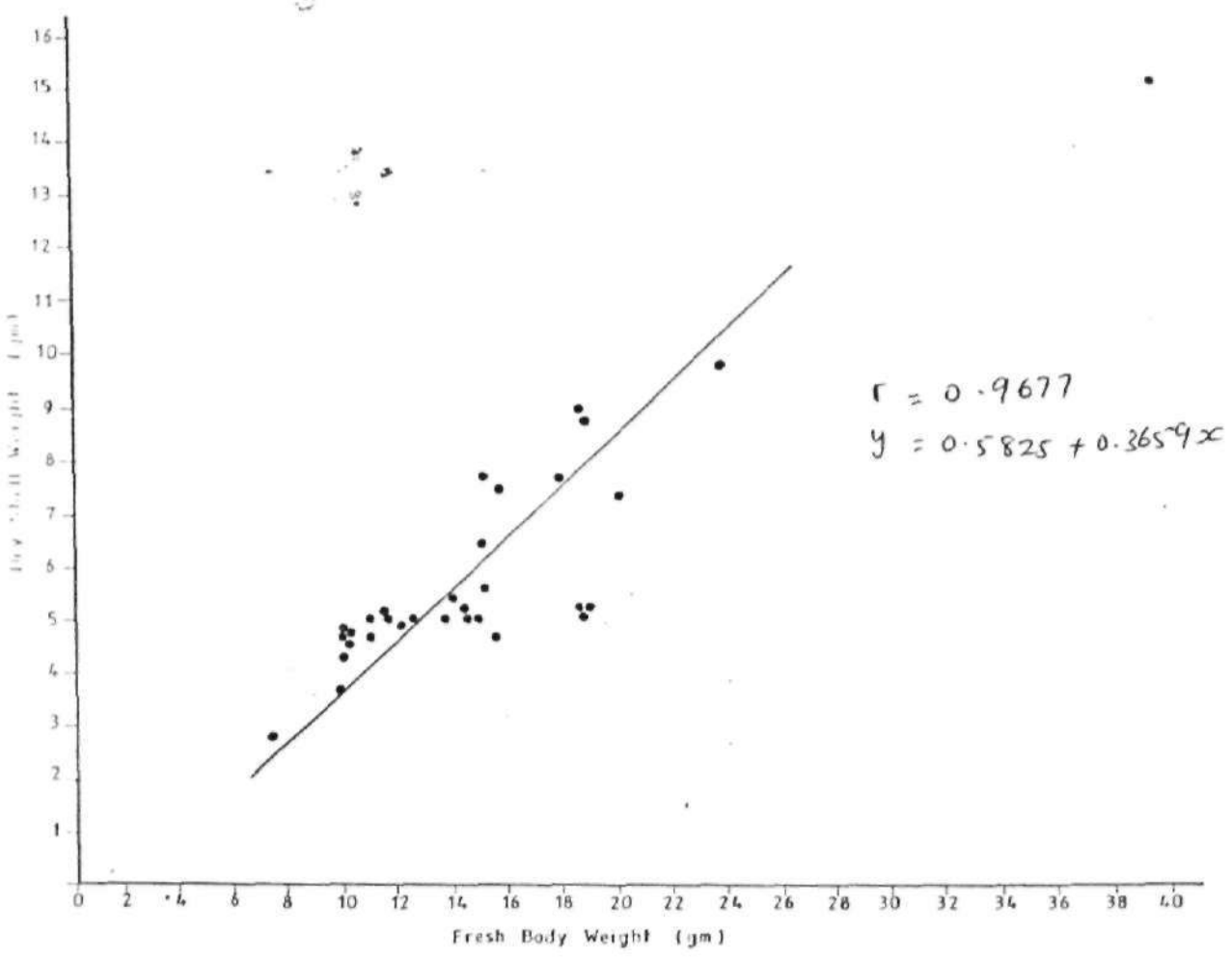


FIG 48. RELATIONSHIP BETWEEN FRESH WHOLE BODY WEIGHT AND DRIED SHELL.

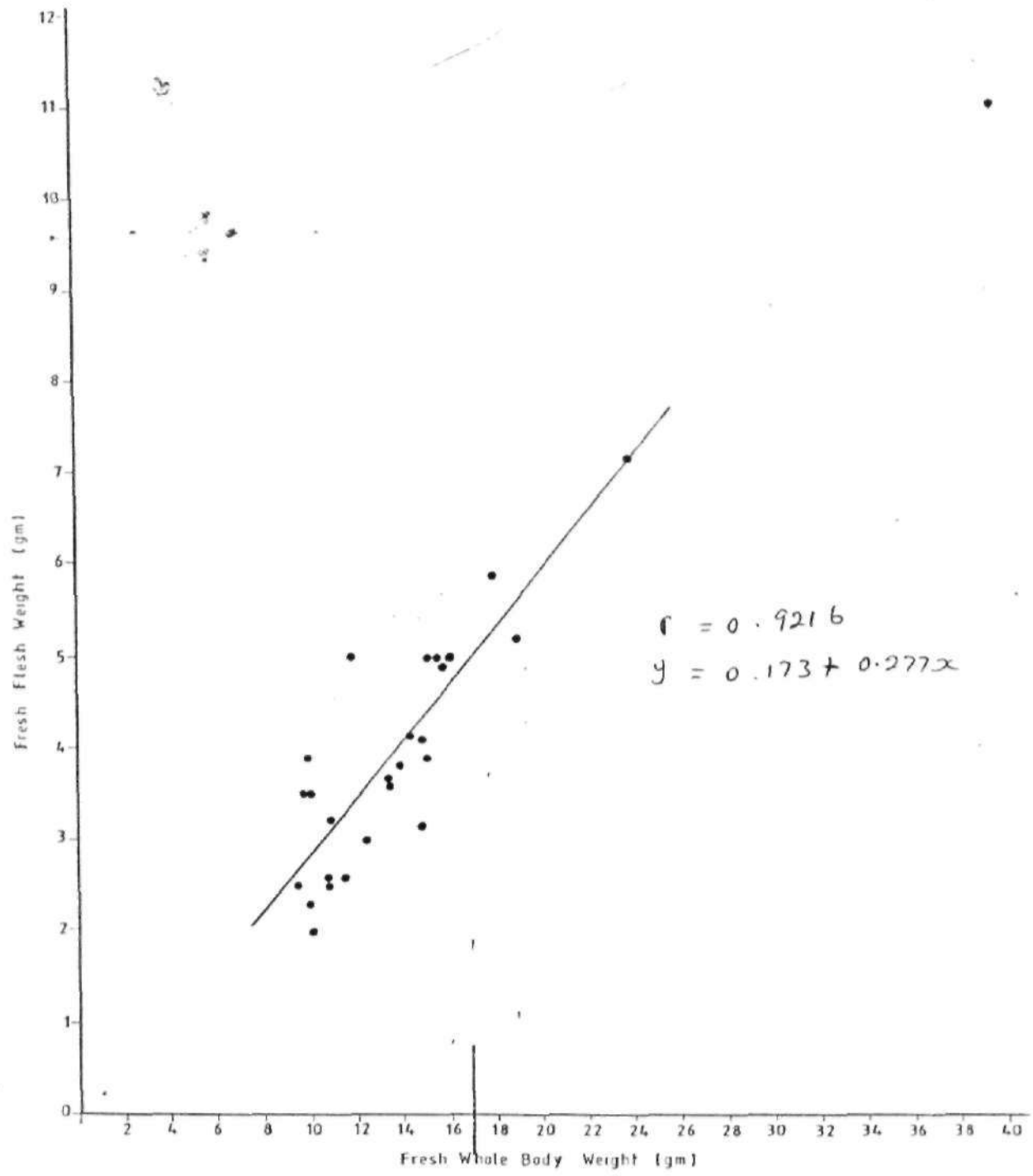


FIG 4.9 RELATIONSHIP BETWEEW FRESH FLESH WEIGHT AND WHOLE BODY WEIGHT.

4.3.5 PROTEIN CONTENT

Analysis showed that the minimum protein content of the pooled sample was 20.431 percent and the maximum was 46.106 percent with a mean of 32.7806 percent (SE ± 1.592) as shown in Table 4.4.

4.3.6 LIPID CONTENT

The lipid content of the solid flesh was 3.8 percent (minimum) and 9.2 percent (maximum) and a mean of 6.42 percent (SE ± 0.297) as shown in table 4.4.

4.3.7 CARBOHYDRATE CONTENT

The carbohydrate content of the solid flesh was computed by difference method and the minimum content was 39.33 percent while the maximum was 64.28 percent. The mean content was 50.31 percent (SE ± 1.780) as shown in Table 4.4.

4.3.8 CALORIFIC VALUE

using the conversion factor 5.5 for protein the mean calorific value was calculated to be 32.7806 kcal/gm.

For lipids with the conversion factor of 9.5 the mean calorific value was 6.42 kcal/gm while the total value was 60.99. For carbohydrate having a conversion factor of 4.1 the mean calorific value was calculated to be 52-94 kcal/gm while the total value was 217.054 kcal/gm as indicated in table 4.5.

TABLE 4.5

CALORIFIC VALUE

	MEAN	CONVERSION FACTOR	CALORIFIC VALUE KCal/gm
PROTEIN	32.7806	5.5	180.293
LIPIDS	6.42	9.5	60.99
CARBOHYDRATE	52.94	4.1	217.054

CHAPTER 5

5.0 DISCUSSION

5.1 DISTRIBUTION AND ABUNDANCE

From the observation made on the distribution and abundance of the clams used in the research in their natural habitat, it could be said that the population is fairly sparse. This could be accounted for however by the fact that the collection was done mainly along the banks of the Galma river. The population could be much higher, using the method in commercial clam harvesting such as dredging which has the advantage of reaching the bed of the river. The sparse population could further be explained by the fishing business going on in this river. Investigation revealed that the clam flesh is being used by fishermen as baits. It could also be assumed that some birds on the bank are preys of the clam. This suggestion agrees with Bardech et al (1972) who stated that whelks are common predators of clam and they constitute one of the problems associated with clam farming. However the Galma River in comparison with the University lake in Zaria supports a higher population of clams than the later and the clams are more tolerant to adverse environmental conditions than those from the University lake as indicated by Ikwutole (1983). This could imply that some of the country's rivers will be suitable for

commercial production of clams. It will however be necessary for such commercial production to employ dredging as a means of harvesting as well as making precautions against predators such as the big birds.

5.2 BODY SIZE

From Table 4.1, the mean weight of the clams from river Galma used on this research was 14.287 grams, the maximum weight being 39.8 gms and minimum, 9.8 gms. These clams in comparison with those used by Ikwuntole (1983) in her research work could be considered to be smaller in size. Her results indicated that the mean, maximum and minimum weights were 23.061, 47-03 and 7.26 gms respectively. The differences in weight could be due to differences in the points and periods of collection. From these results, it could be assumed that these clams have the capacity to grow larger than their sizes during the time of this research especially with improved management when cultured on a large scale. Other parameters considered included the length, width and height of the clams. The study of this parameters was considered necessary because they are indices of growth. The mean length of the clams in Zaria was 5.9633 cm, the mean width being 3.533 cm and mean depth was 2.4033 cm. Ikwuntoles results on clams in Zaria on the hand showed that the mean length was 6.20 cm, the mean width being

3.12 cm and the mean depth of 2.22cm.

However, the result obtained by Krauchter and Castagna (1985) showed that the marketable size for hard clams (Mercenaria mercenaria) is 8mm, shell height is 25mm. It could therefore be inferred from these results that the River Galma clams are well suitable in size for market in comparison with the hard clams.

Correlation studies were also carried out on the Galma clams and results showed that some physical parameters which are also indices of the growth and physical robustness of the clams, are positively correlated. The body weight of the clam is highly correlated with the length (coefficient of correlation is 0.9274), width (coefficient of correlation is 0.7377), volume (coefficient of correlations is 0.9475), fresh shell (coefficient of correlation 0.9868), fresh flesh (coefficient of correlation 0.9126) as shown in table 4.6. From these findings it could be implied that with the knowledge of one of the parameters the other parameters can be computed using the regression equations obtained as shown in Table 4.6 and figures 4.1 - 4.4, 4.7 and 4.9. For example if clams are collected during an investigational study from a river far away from any laboratory, the weight of the clams can be calculated using the relevant regression equation and the weight

could be used to also determine the amount of fresh flesh that would be available as well as the dry flesh that could also be obtained and the results would help to determine the quantity of meat obtainable from the clams when produced on a large scale.

The positive correlational relationships obtained in this research tallies with the work of Ikwuntole (1983) and Yonge and Barret (1964). However Yonge et al indicated that there is a limitation to this method since only two portions of the shell can be compared at one time.

Other parameters such as the K' factor, density showed no correction with the weight of the clams as shown in Table 4.6 where the correlation coefficient are much lower than those of already 4.5,4.6, 4.8 and 4.10. This implies that their values are not dependent on the weight of the clams. These findings also agree with those of Ikwuntole (1983).

5.3 NUTRITIVE VALUE OF THE CLAM FLESH

. The main product of nutritional value in clams is the flesh. The results in the research showed that the flesh constituted a mean percentage of 29.143, maximum percentage being 41.86 and the minimum percentage being 18.12 of the fresh body weight as indicated in Table 4.3.

The mean percentage of the solid flesh was found to be 28.2233 while the maximum value was 65.63 percentage and the minimum value of 3.85 percentage of the fresh flesh weight. the corresponding differences make up the moisture content. Even though the percentage of the flesh of the single clam appears fairly low, this will become insignificant when produced on a large scale as supported by the view of Yonge et al (1964) who indicated that an acre of best clam ground will produce annually 10,000 lbs (4,536 kg) of meat with a fuel value of 3,000 calories, Tenore et al (1983) also agreed with this view in his report on the intensive clam culture in Rio de Arosa where approximately 2,000 rafts of clams are cultured giving one of the highest protein yields per unit area on earth, Idyll (1978) further supported this viewing by indicating that the yield from raft in Spain could be as astonishingly high as 500,000 lbs (226,800 kg) of meat per acre. Furthermore from proximate analysis of the clam flesh, results showed that the mean protein value was 32.7806 percentage (maximum and minimum values being 46.106 and 20.431 percentages respectively). the protein value of the flesh of the Galma clams could be considered much higher than that given by Bardach et al (1972) for Spanish mussels that have percentage of protein and those worked on by Lutz (1980) whose protein value was 12.80 percentage. The higher protein value could probably be

due to the pooling effect of the samples used in this research. it could also be due to their diet which is likely to have high nitrogen content obtained from fertilizer run off from the farms around the river. In view of the fact that the major nutrient being sought for in clams is protein, it could be inferred that the Galma clams are very suitable for human consumption as a major source of animal proteins. This should also encourage culturing of clams commercially. The mean lipid content of the Galma clams was 6.42 percent while the maximum value of 9.2 percent and a minimum of 3.8 percent. The mean value obtained in this research is higher than those given by Bardach (1972) as 2.4 percent and lutz (1980) as 1.40 percent. Apart from the pooling effect stated earlier, the higher value of lipid content of the Galma clams could be also due to their diet. However, in comparison with the protein content the lipid value is very low. These clams like all other molluses are very suitable for patients requiring diets with low lipid content.

. The carbohydrate content of the Galma clams was found to be high as indicated in the results in which the mean value was 50.31 percent obtained through the difference method. The minimum content was 39.33 percent while the maximum value was 64.28 percent. This result is

high when compared with the value obtained for glycogen content by Bardach (1972) which was 8 percent. Apart from the previously explained pooling effect, the other reason that could be forwarded for the high value of carbohydrate is that a lot of agricultural activities involving the use of fertilizer is carried on around the valleys of the Galma river resulting in large run-off of fertilizer into the river during heavy rains. The fertilizer provide a lot of nutrients for the small algae resulting in alaalbloom which in turn serve as carhohydrate source for clams in this environment. Lutz (1980) also reported that carbohydrates content of clam flesh increases during the summer months with a relative decrease in protein content. The total organic matter of the Galma clams is also very high as indicated by the mean value of 93.95 percent. This result compares favorably with that obtained by Lutz (1980) in which the value was 97.90 percent. The flesh also contained some minerals as shown by the values of ash contents. The mean value was 7.85 percent with minimum and maximum values of 6.05 and 12.65 percent respectively. The low ash content implies low mineral supply, hence when using clams as food, the mineral supply must be supplemented with other food, rich in them. The low ash content however could obviously be explained by the fact that a lot would have been used up in the formation of the clam shell

especially essential minerals such as calcuim and phosphorus.

The energy value of the flesh of the Galma clams could be considered high too as shown by the calorific values of 180,293, 60.99 and 217.054 kcal/gm for protein, lipid and carbohydrate respectively. This finding agrees with Yonge et al (1961) who stated that it has been calculated that an acre of best mussel ground will give annually 4530 kg meat with a fuel value of 3000 calories. With these high fuel value as well as high protein content, it will be advantageous for the country to pick up shell fishery as part of her aquaculture programmes in Nigeria.

5.4 SHELL VALUE

The shell is a very important component of the clams and its usefulness in animal feed composition, pearl collection and other uses have been stated already. From measurements taken, the shell constituted a mean of 70.907 percent of the total clam body weight with a maximum of 80.20 percent and a minimum of 58.34 percent. From this result it could be seen that the shell constitutes the largest part of the whole clam. Since clams are much easier to raise than other aquatic animals, the abundant shells that would be obtained from its commercial production could serve as a cheap and

alternative source of calcium and phosphorus for animal feed. This will help to reduce the amount being spent on cattle bones hitherto being used for feed composition.

CHAPTER 6

6.0 CONCLUSION

In this study, some aspects of the biology of clams Aspatharia species of the Galma River in Zaria, Kaduna State have been studied as a part of the investigations of the fishery potentials of Nigerian freshwater clams. These aspects include some of the physical parameters and chemical composition of these clams. The physical measurements considered include the weight of the clams, the length, width and depth of the clams, which are indicators of the size and growth of the clams. These listed factors are significantly highly related to each other as indicated by the high values of the correlation coefficient. This implies that with the knowledge of one of these measurement, the other parameters can be determined. These clams can be considered to have the capacity to grow larger than their present size since a previous work done on the same site revealed that the clams used in that research were bigger in size than the present ones. It is very probable that factors such as availability of food, location of collection and sampling method were responsible for the differences in size. However the clams in this research could be considered to compare favorably with their counterparts in the developed countries such as Japan, United States of America and britain where clam culture is carried out

very extensively. it could therefore be implied that the freshwater clams in Nigeria could be produced on a very large scale when adequate study on some other areas have been carried out.

The other physical parameters studied includes the volume, density, factor which are indicators of the physical robustness of the clams; and the weight of fresh and dry components of the clams namely the shell and the flesh were also determined.

The proximate composition of the clam flesh was also determined with the aim of finding out the nutritional importance of these clams. From the results obtained the clams' flesh has high protein content, high carbohydrate value but low fat content. Since one of the major aims of studying the biology of the clams in this project is to investigate the value of the protein, it could be safely said that clams are very cheap but rich sources of protein for human beings when compared with other sources such as higher animals and vegetables. Also from the research findings, the clams flesh has high carhobydrate content when collection is done between the months of April and May and October and early November.

The low lipid content of these calms like all other molluscs also make them highly recommendable for people who require low fat content in their diet and also for the general populace nowadays when the emphasis is placed

on reducing the cholesterol content of our food. Apart from the usual protein and lipid, some ash content consisting essentially the minerals or bioelements is also compatible with those from advanced countries where clam culture is commercially practised.

From these research findings, it could be implied that the Nigerian clams have high potentials and can compare very favorably with those of the advanced countries where much advantage has been taken of this cheap source of protein.

RECOMMENDATION

As stated earlier in this work, there is not much known about the biology and fishery potentials of Nigerian clams. Ikwuntole's work was the first major documented research on the freshwater clams in Zaria area. The second work was that of ndagi. There are so many other areas that need be investigated such as growth patterns, reproduction, effects of environmental factors such as weather elements, physical, chemical and biological factors, the economics of production, techniques of production and other areas. Since this work form part of the preliminary investigations, one would recommend that the department of biology should involve other students in other areas mentioned above in order to have a complete work which will serve as a guide or basis

to commercial production of clams as cheap and alternative source of protein for human consumption in Nigeria.

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