STUDIES ON THE THE PARASITES OF THE BRANCHIAL CHAMBER AND ALIMENTARY CANAL OF THE FISH FAMILY, MORMYRIDAE,

IN ZARIA DAM, NIGERIA.

BY

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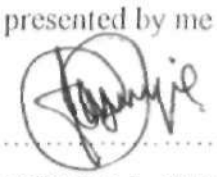
A DISSERTATION SUBMITTED TO THE POSTGRADUATE SCHOOL, AHMADU BELLO UNIVERSITY, ZARIA. IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.d) PARASITOLOGY AND ENTOMOLOGY

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JUNE, 1999

DECLARATION

I hereby declare that this thesis is a record of my own research work. It has not been presented by me or for any previous application for a higher degree.



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14th. SEPT. 1999.

DATE

DEDICATION

To my late father: **Pa *JOSEPH* ADEJORO ONIYE**

and

late **Dr. V. C. OGBOGU**.

CERTIFICATION

This thesis titled: "**A Studies on the parasites of the branchial chamber and alimentary canal of the fish family, Mormyridae, in Zaria Dam, Nigeria**" by **S. J. ONIYE** meets the regulation governing the award of the degree of Doctor of Philosophy (Veterinary Parasitology) of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

Studies on the parasites of the branchial chamber and alimentary canal in relation to length-weight relationships, food and feeding habits, reproductive cycle and fecundity of 2,133 mormyrids, and physicochemical parameters of Zaria Dam were carried out from December 1993 to November, 1995.

The physicochemical parameters of Zaria dam exhibited marked seasonal variations, and significant correlation was demonstrated between rainfall, temperature, turbidity, pH, O_2, NO_3, Cl, Fe and Mn concentrations ($P < 0.05$).

Fish specimens obtained from Zaria Dam included *Hyperopisus bebe occidentalis*, *Mormyrus rume*, *Marcusenius senegalensis*, *Mormyrops deliciosus*, *Hippopotamyrus pictus* and *Petrocephalus bovei*. Length-weight relationships showed that female *M. rume* and *P. bovei* exhibited allometric growth while others grew isometrically. The mormyrids fed on various invertebrates (mainly insects) but adult *M. deliciosus* was piscivorous.

The breeding season of all fish species was June to October, and *M. senegalensis* had highest fecundity while *P. bovei* had the lowest.

The gills of 61.79% of *H.b. occidentalis* were parasitised by *Henneguya* sp., *Clinostomum complanatum*, *glochidia* of mollusc and *Eargasilus sarsi*. The gills of *M. rume* were infected by *Afrolernaea nigeriensis*, *Henneguya* sp., *Tabanus* sp., and *Philometra beninensis*. *A. nigeriensis* had the greatest number of individuals (6, 234) - 90.78% and *P. beninensis* had the lowest (139) - 2.02%.

The gill parasites of *M. senegalensis* were *E. sarsi*, *Dactylogyrus vastator* and *Henneguya* sp. with prevalences of 67.88%, 31.02% and 1.09% respectively. *Lamproglena* sp. (67.08%) and *Hirudo* sp. (32.48%) were found on the gills of *M. deliciosus*, *E. sarsi* on the gills of *H. pictus* and none on *P. bovei*.

Obstruction of the surface of the gills, elongation of tips of gill filaments, heamorrhage and tissue expansion of the inner surface of operculum were lesions associated with infections of *Henneguya* sp. *D. vastator*, *Hirudo* sp. and *P. beninensis* infection respectively.

The gill parasites of the mormyrids showed seasonal occurrence and were affected by temperature, rainfall, turbidity and pH. In *M. rume* and *M. deliciosus* infection by gill parasites was attributed to their feeding behaviour. The gill parasites did not exhibit preference for sex of host except in *M. senegalensis*.

The intestinal parasites of *H.b. occidentalis* were *Rhadinorhynchus horridus* and *Procamallanus laevionchus*, with respective prevalence rates of 99.69% and 0.30% .

The intestinal parasites of some of the examined *M. rume* were *P. laevionchus, Caryophylleus* sp. and *Euclinostomum heterostomum* with respective prevalence rates of 40.69%, 29.30%, and 28.69%. 58 (15.26%) of 380 *M. senegalensis* examined were parasitized by *Caryophylleus sp.* and *P. laevionchus*, with infection rate of 73.03% and 26.96% respectively. The intestine of *M. deliciosus* was parasitised by *Neoechinorhynchus* sp. , *Eucestodaria* sp. and *P. laevionchus* with respective prevalence rates of 48.10%, 36.07% and 15.82%. Of all the intestinal parasites, only *Neoechinorhynchus* sp. in *M. deliciosus* penetrated as far as the stratum compactum of the intestinal wall.

Only *R. horridus* infection of *H.b. occidentalis* did not show marked seasonality of occurrence, all other parasites showed various relationships with physicochemical parameters of Zaria Dam. Increased and decreased incidences of infection in the intestines of various morymyrids were associated with host size and diet. The diets of the mormyrids such as molluscs, gastropods, ostracods and chironomids are suspected as intermediate hosts of parasites found in their intestines.

The sex and gonadal maturation cycle did not appear to influence the incidence of parasites in *H.b. occidentalis*. In contrast, in *M. deliciosus* and *M. rume*, in which females were more susceptible to infection.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Meaning
Temp.	Temperature
pH	A measure of alkalinity or acidity
Fe^{2+}	Iron II ion
Mn	Manganese
NO_3-N	Nitrate nitrogen
Cl^-	Chloride ion
DO/DO_2	Dissolved oxygen
mg/l	Milligram per litre
Log-L	Logarithm of length
Log-W	Logarithm of weight
>	Greater than
<	Less than
%	Percentage
mm	millimetre
cm	Centimetre
mg	Milligram
g	Gram
sp.	Species (singular)
Spp.	Species (plural)
GIT	Gastrointestinal tract

CHAPTER ONE

1.0 INTRODUCTION

At the present rate of growth in population, it is estimated that by the year 2010, the world population will be about 7 billion, and it is therefore imperative that the demand for animal protein, particularly fish, will increase. The present global production level of 90 million tonnes of fish would therefore have to be increased to over 125 million tonnes (Subasinghe, 1995). This will invariably increase the pressure on the already depleting wild stock which some nations are already fighting for (Partit, 1995), thus implying that an upper limit for global fish catches have now been reached (Okunlola,1997).

In Nigeria, fish demand cannot be satisfied by the supply, due to high population growth, increasing cost of meat, decrease in the purchasing power of the currency, the Naira, and withdrawal of input subsidy on fishing equipment (Mabawonku, 1986). Okpanefe(1982) opined that the fish demand in Nigeria by the year 2000AD will be over 2 million metric tonnes while in 1998 the projected demand will be 1.865 metric tonnes.

Although the importance of veterinary practice in animal husbandry was recognized and developed long ago , fish health science was for many years , lagging behind. Subasinghe (1995) stated that fish diseases cause severe financial loss ($1.36 billion in 1990 in Asia alone) and are amongst the greatest factors militating against fish production. In the last three decades, research into diseases of culture and wild fishes in Europe, America, Asia and the far East have developed to a level of sophistication almost equaling that of Veterinary sciences of farm animals, however, the same parallel progress was not achieved in the study of diseases of fish in the tropical and sub tropical waters of Africa (Paperna, 1980).

In natural fish population, a complex dynamic equilibrium exists between fish , and their environment. Environmental factors such as temperature, oxygen and carbon-dioxide concentrations, pH, salinity, and mineral content; influence the number and survival rate of host, intermediate-host and aquatic parasites (Cheng,1973; Subasinghe, 1995).

As with other diseases, parasitic diseases of fish are enhanced by many factors including the host species, age and size of fish (Baldwin et. al.,1967; Bardach, 1972; Paperna, 1980). Other factors include poor environmental conditions, improper pond or hatchery management and

artificial stress condition, such as crowding, imbalanced nutrition, reduced oxygen content of water, increase in organic material as well as changes in water pH and temperature. Diseases may affect both the quality and quantity of fish available. Parasites that cause diseases in fish belong to some important Phyla in the Animal Kingdom. These Phyla are :Protozoa, Platyhelminthes, Nematoda, Acanthocephala, Arthropoda, Annelida and Mollusca. Other Pathogens include viruses, bacteria and fungi.

Heavy infection with protozoan parasites like *Ichthyophthirius multifilis, Badomonas* and *Costia* species on the epithelium of the skin and gills disturbs respiratory and excretory functions of the gills resulting in heavy fish mortality (Hines and Spira, 1973). Infection by the trematodes such as Diplostomulum and Neascus species of gills results in thickening and deformation of the filaments and cataract of the eyes (Cheng, 1973).

The cestode, *Ligula intestinalis* in Cypprinids, causes distension of the abdomen with loss of streamlining, camouflage as well as inhibition of gonadal development with associated pituitary changes.

Larvae and adult of Nematodes such as Eustrongylides, Contracaecum and Ammplicaecum cause decrease in the liver size with concomitant reduction in fat and protein metabolism, gonadal deformation (so called parasitic castration) in cichlids of the genus *Haplochromis* (Markevich, 1951; Paperna, 1980).

Emaciation of fish and heavy obliteration of the intestine by the Acanthocephala worms are not unusual. Amongst the Annelids, Leeches have been reported in five fish species namely, *Bagrus docmac, Barbus altianalis, Barbus tropidolepia, Cyprinis carpio* and *Protopterus aethiopicus*; where infection is heavy, the attachment area is hyperemic and haemorrhagic (Soulsby, 1982; Parperna, 1996).

Amongst the arthropod parasites of fresh water fishes, the dragon fly larvae have been found infesting *Tilapia* and *Clarias* fries (Okaeme, et. al., 1990). Crustacean parasites which include *Argulus, Dolops, Learnae* and *Ergasilus* species, may cause haemorrhage and ulceration at the site of attachment, particularly on the skin and gills of *Bagrus, Clarias, Tilapia and Protopterus* species (Cheng,1973; Onwuliri and Mgbemena, 1987; Okaeme, et.al. 1990). These parasites decrease the aesthetic value, palatability and marketability of fish. For

instance in Asia, fish disease accounted for lost revenue of about US $1.366 billion in 1990 (Subasinghe, 1995). In Africa, particularly in Nigeria, available information on fish parasites, the diseases they produce, and the pathology associated with such diseases is very inadequate and as such, requires due attention. Available information predominantly deals with taxonomic studies of fish parasites based on occasional collections by individuals and from museum material. Dctailed regional surveys of fish parasites were carried out only in a limited number of water systems like the Volta in Ghana, the great Lakes of Eastern and Central Africa , Lake Chad , Rivers Niger and Nile (Ukoli,1969; Onyia, 1970; Paperna, 1980; Onwuhri and Mgbemena, 1987; Ugwuzor, 1987; Okaeme et. al., 1990). All these surveys were not comprehensive, but rather were restricted to one or few species of fish and few taxa of parasitic organisms.

Snieszko (1972) and Valerie, et. al.(1993) have suggested that a clear understanding of diseases of fish must be derived from an appreciation of the environment of the fish (i.e. aquatic environment), the fish itself (the host) and the parasites.

The gills are important organs in the fish because they function as the respiratory and excretory organs. The alimentary tract is equally important as it is involved in the nutrition of the fishes.

Parasites infecting these organs will interfere with the physiological functions, and may ultimately lead to decreased production of these fish species.

In the light of the aforementioned harmful effects of parasites on fish and considering that studies on the parasitic fauna of the fish family Mormyridae in Zaria dam is lacking, and the family is of significant economic importance in Zaria, the present investigation was embarked upon to study:

i. some physicochemical parameters of Zaria dam
ii. some aspects of the biology including diet and reproductive cycle of members of the fish family Mormyridae
iii. the prevalence and epidemiology of the gill and intestinal parasites of the family under natural conditions.
iv. the pathology induced by the parasites with particular reference to the gills and alimentary tract.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. THE FAMILY MORMYRIDAE:

Members of the fish family, Mormyridae are highly aberrant fishes that are peculiar to tropical Africa particularly Zaire and West Africa (Lowe-McConnel, 1975). They inhabit only fresh water environment. The mormyrids have small cycloid scales and their body is covered with thin layer of gelatinous slime. Their common characteristics include upward-pointing pectoral fins, narrow gill openings and an operculum that is hidden under a layer of skin (Reed, et. al.,1967). They are generally bottom-dwellers inhabiting areas where the current is not swift. Taverne (1972), reported that of the endemic families, Mormyridae has the most numerous genera, having sixteen, genera and two hundred species. Twenty-six different species belonging to six genera were reported from Northern Nigeria (Reed et. al., 1967). Lewis (1974) reported eight genera and eighteen species from Lake Kainji. Recently, Ita (1993) reported the existence of seven genera and thirty- three species in major rivers in Nigeria.

2.2 DESCRIPTION OF SOME MEMBERS OF THE FAMILY:

Thistleton (1965), Reed, et.al. (1967) and Lewis(1974) described the following members of the family, Mormyridae, as given below:

2.2.1 *Mormyrus rume* (Cuvier and Valencienne)

This fish has a down-curved, narrow, but elongated snout and features that gives it the common names: "concord fish" and "elephant snout fish". The mouth is small and terminally located at the tip of the snout. The body is golden brown in colour and has no obvious spots or markings (Fig. 1).

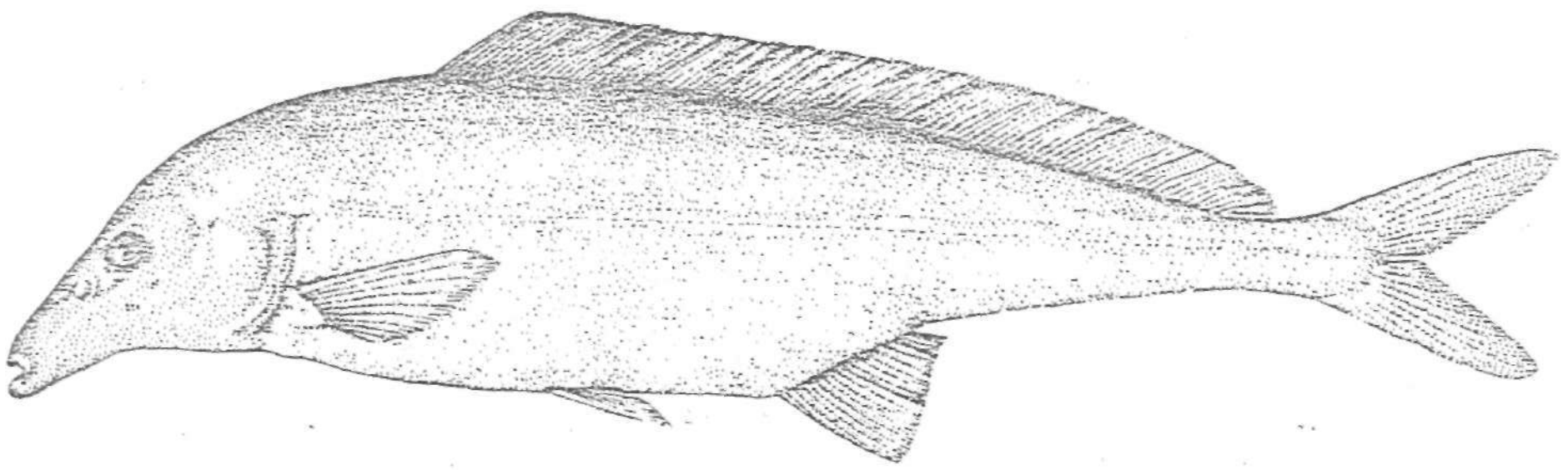


FIG.1 *Mormyrus rume*

2.2.2 *Hyperopisus bebe occidentalis* (Gunther)

The fish with its mouth at the anterior terminal, has a rounded and laterally compressed elongated body and a long anal fin that distinguishes it from other mormyrids. It has a long-rayed anal fin that is about six times the length of the short-rayed dorsal fin situated at the rear of the body. The body colouration is golden brown, with numerous black spots on the head and dorsal surface (Fig. 2).

2.2.3 *Marcusenius senegalensis* (Steindachner)

This is a medium-sized mormyrid, which is laterally compressed. The colour is dark brown (or greyish) with no markings. The caudal peduncle and dorsal profile is straight and slightly concave in front of the dorsal fin (Fig. 3).

2.2.4 *Mormyrops delicious* (Leach)

The body is elongated and almost round in section. The head is small, long and narrow. The body is dark grey with no markings (Fig. 4).

2.2.5 *Petrocephalus bovei* (Cuvier and Valenciennes)

This is a small fish with a deep strong compressed body, large eyes and inferior mouth (Fig. 5). The body colouration is silvery and the fins are nearly colourless apart from the anterior rays of the dorsal fin (sometimes the anal fin). The outer rays of the caudal fin are lightly pigmented.

2.2.6 *Hipopotamyrus pictus* (Marcusen)

This species has inferior mouth and a rounded snout. Body colouration is yellowish-grey and there are usually two or more prominent pale bands on each flank between the dorsal and anal fins. Black bars are present on the dorsal and anal fins, and on the middle rays of each lobe of the caudal fin (Fig. 6).

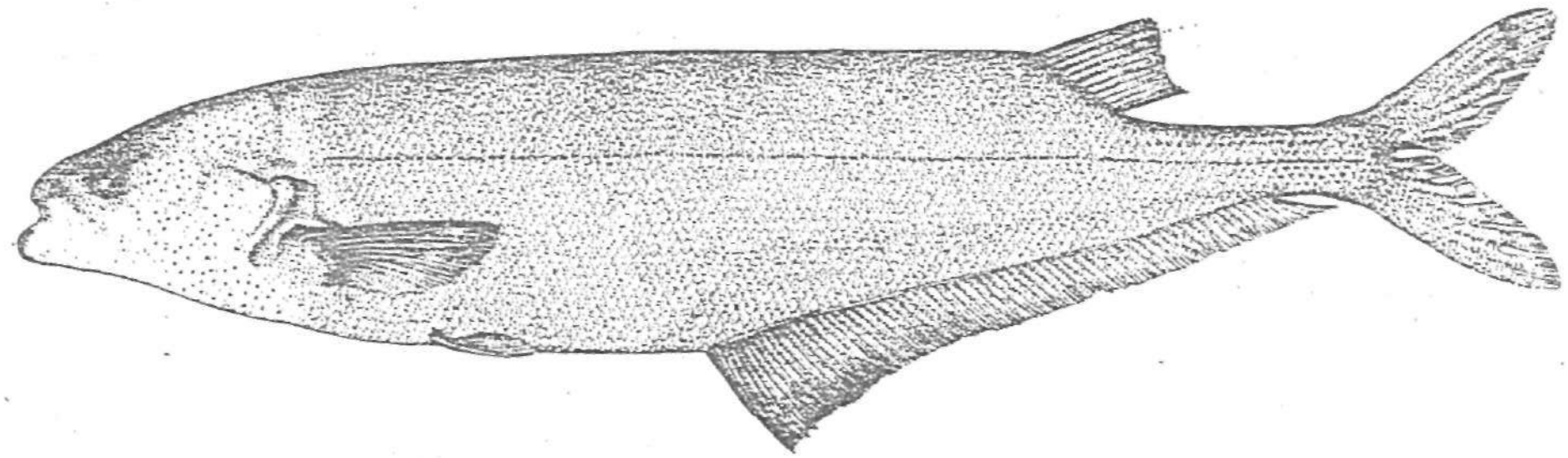


FIG.2 *Hyperopisus bebe occidentalis*

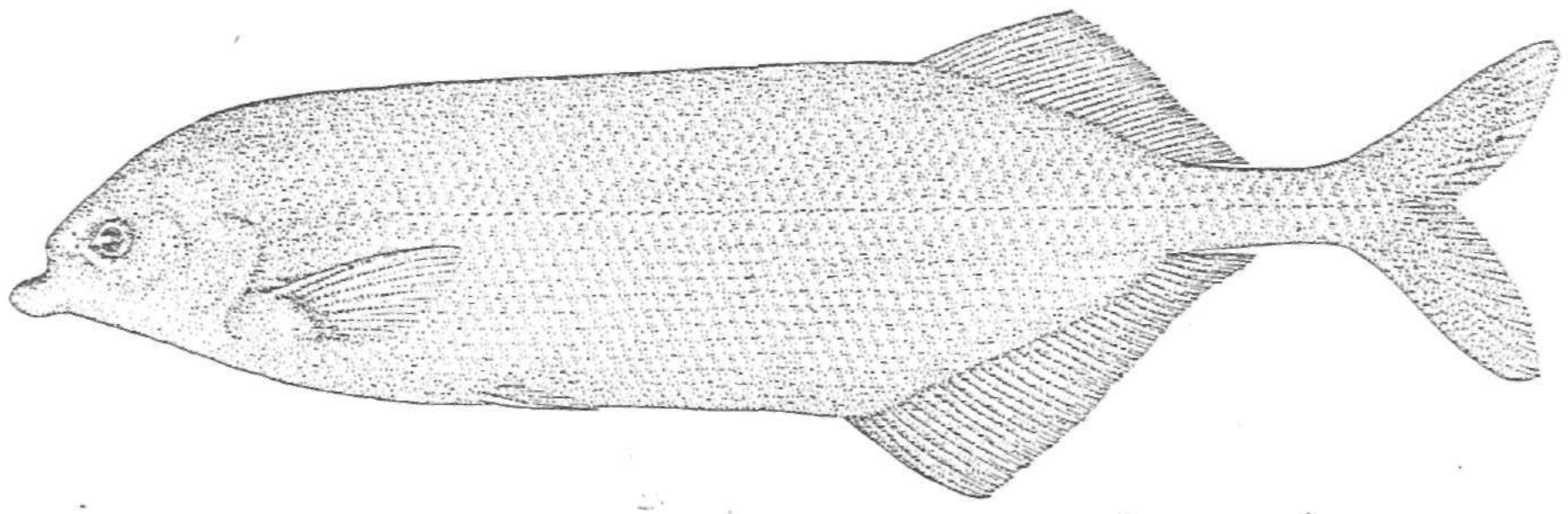


FIG. 3 *Marcusenius senegalensis*

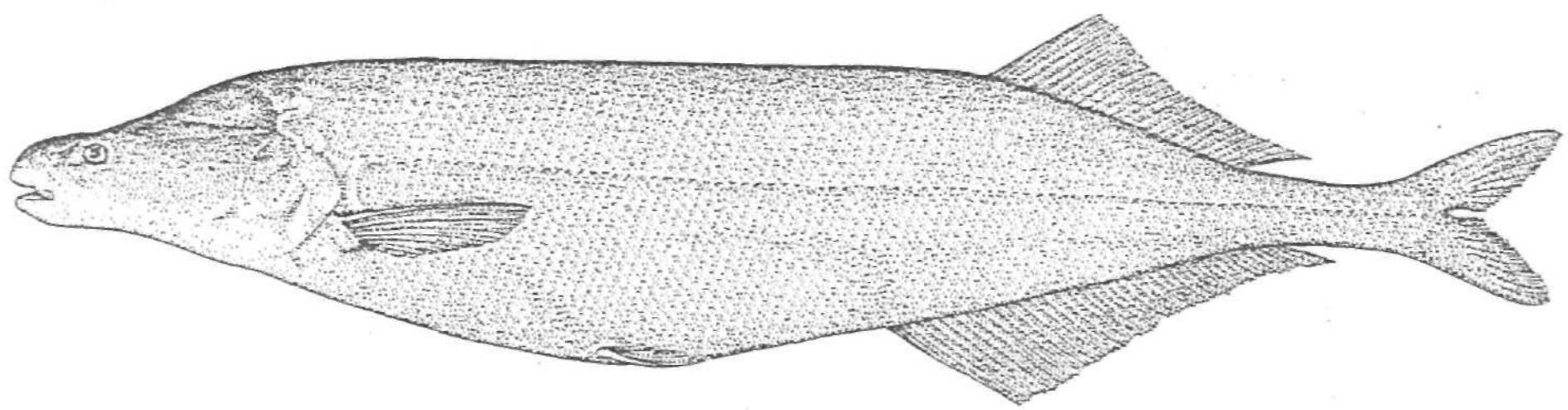


FIG. 4 *Mormyrops deliciosus*

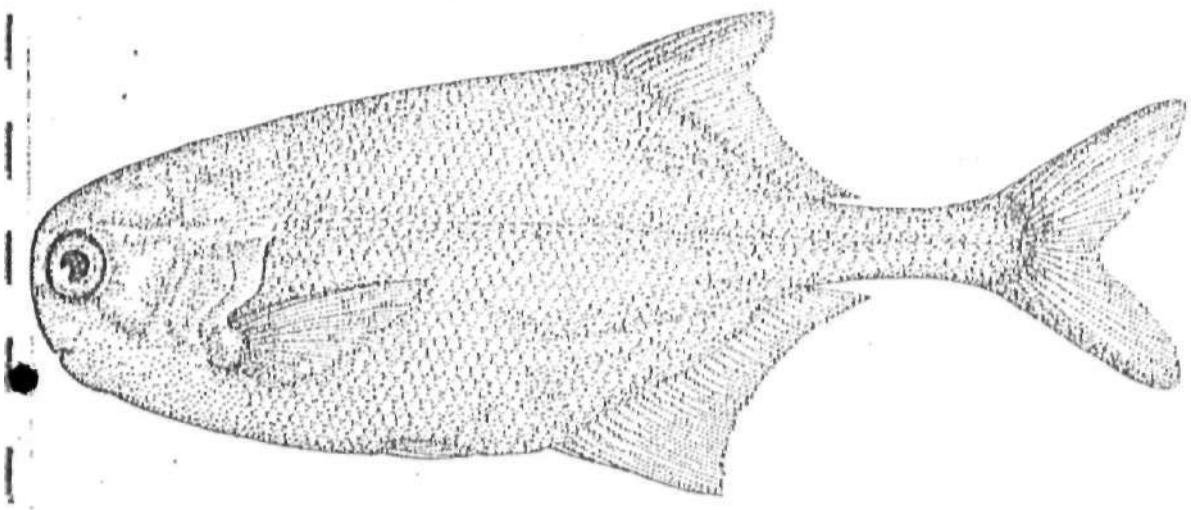


FIG.5 *Petrocephalus bovei*

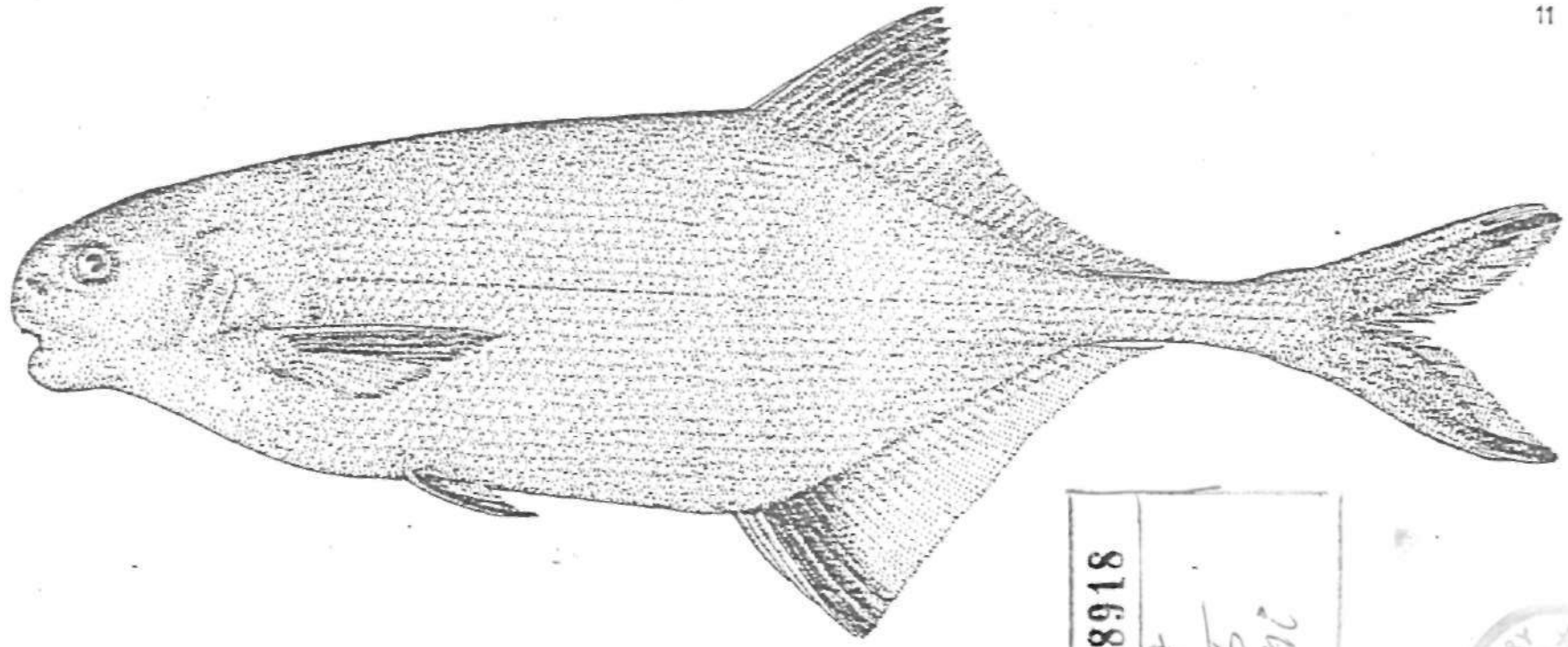


FIG. 6 *Hippopotamyrus pictus*

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2.3 PARASITES OF FISH.

2.3.1 Trematodes:

Amongst the monogenetic trematodes, *Dactylogyrus* species has been reported on the gills of Salmonids, where they cause severe damage. *D. vastator* is a real menace to young fish particularly where they are endemic and may cause death within a few days (Parpena,1965). One specimen of *Dactylogyrus* spp. was recovered from the gills of *Lates niloticus* in Lake Chad and they are known to be highly dangerous to warm water fish hatchlings, a few days after hatching and up to weight of 3gm (Onyia, 1970; Sarig,1975). Jegede (1989) discovered *Gyyrodactylus* spp. on the gill surfaces of *Sarotherodon galileaus*. *Proptancylodiscoides chrysichthes* (a monogenea) occurred throughout the year on the gills of *Chrysichthys nigrodigitatus* and the highest parasite burden was recovered in adult fish (Obikezie, *et. al.* 1985)

Balarin (1979) indicated that Digenetic trematodes are considered to be as potentially pathogenic as the monogenea in aquaculture systems. Only the metacercarae stage infect fishes. According to Fryer and Iles (1972), some metacercarial cysts were suspected to infect the young of *Sarotherodon viriabilis* in Lake Victoria and the incidence decreased with the age of the fish.

Okoh (1965) in his preliminary report on the helminth infection of fish from River Niger, observed metacercarae of the following digenetic trematodes, *Clinostomum complaniatum* under the skin of *Synodontis* spp., *Nephrocephalus sessiles* in the viscera of *Heterotis niloticus* and *Euclinostomum heterostomum* in intestine of *Sarotherodon galilaeus* and *Oreochromis niloticus*.

Two species of the genus *Euclinostomum* have been found in Zaria, Nigeria (Shotter,1980), occurring as raised sub-dermal cyst under the skin of *Synodontis schall*. It was also found infecting the pharyngeal and heart region of *Clarias angullaris*. Obikezie *et. al.*(1985) also found two digenetic trematodes, *Siphodera ghaensis* and *Aspidogaster africanus*, occurring occasionally in the intestine of *Crysicthys nigroditatus*. *Alloglossidium* spp.(Digenea) were recovered from the roof of the swim bladder and body musculature of *Sarotherodon galileaus*. Metacercariae of *Clinostomum* spp were recovered from the gills, pharyngeal

region, buccal cavity, operculum, under the scale, body musculature and the liver of the same fish.

Generally, the pathological effect of trematodes results from formation of a fibrous layer around encysted parasite, an event which leads to functional damage of cells. In the gills, pathological lesions results in the loss of the lamellar structure and eventual deformation and even atrophic degeneration of the entire filament. Also metacercariae of trematodes may encyst inside the eye, causing exothalmus, lens cataracts and consequently, blindness (Paperna, 1969 a).

2.3.2. **Cestodes:**

Fish serve as an intermediate host for *Diphylobothrium latum*, a tapeworm of man. The larval form (plerocercoid) of this tapeworm occurs in the fish muscle. This cestode is found in man, in areas such as the far East where fish is consumed raw, improperly cooked or marinaded (Williams and Jones, 1994).

Shotter and Medaiyedu (1971) found *Polynbothrium polyteri*, a cestode, in *Polypterus endlicheri* collected from river Galma in Zaria, Nigeria. The cestode was found in the stomach, intestine and rectum of the fish. Awa, *et al.* (1984) found a cestode that belongs to the family Carypophyllaeidae in the alimentary canal of *Chrysichthys nigrodigitatus* and *Clarias gariepinus* from Badagry Lagoon. Parasites in this same family were found in the intestine of *Chromidotilapia guentheri, C.pulcheri* and *Kenomystus nigri* (Origbo,1987;Iwezue,1988).

Kosheva (1957) discovered mass death of fish caused by the tapeworm ,*Ligula*, in the Kutuluk, basin, USSR. The disease, Ligulosis of Bream, especially in the young, is characterized by sharp decrease in haemoglobin content, deformation and destruction of the liver and the development of the gonads. It also causes a general exhaustion, which affects their weight and plumpness.

Aderounmu and Adeniyi (1972) carried out studies of cestode parasites of some fish from a pond at Ile-Ife, Nigeria. They found that *Clarias lazera* was infected with *Polyonchobothrium* sp., while *Hemichromis fasciatus* and *Oreochromis niloticus* were affected with *Anomotaenia* sp. Amin (1978), recovered three cestodes of the genus *Kawai*

from the midgut and *Polyonchothrium clarias* from the gall bladder and *Bothriocephalus aegyptiacus* from small intestines of some species collected from the Nile River at Giza near Cairo, Egypt. However, Paperna(1980) indicated that cestodes occur almost exclusively in Clariidae and Polypteridae, and only the monozoic (unsegmented) cestodes, the Caryophyllidae, occur in wider range of fish families.

2.3.3. **Nematodes:**

Nematodes have been found to cause necrotic lesions in the dermis, the sub-dermis and the visceral organs of fish. Of importance is the deformation of the gonads by Eustrongylides (Paperna,1980). Goldstain (1970) found *Zeylani cobdela* and *Rhabdodo* spp. in the intestines of *Sarotherodon galilae*. Other Nematodes found in the same fish species include *Procamallanus* sp., *Gendria tilapiae*, *Rhabdochomum* sp., *Eustrongylides* sp., and *Contracaecum* sp. (Fryer and Iles, 1972). Oyetayo, (1988) found *Raphidascraroides africanus*, a nematode, in the fore and midgut regions of *Bostrycus africanus* from Nombe Creek, Port-Harcourt.

Procamallanus sp. were found in the alimentary canals of *Sarotherodon galilaeus*, *Chrysichthys nigrodigitatus*,*Clarias gariepinus*, and *Tilapia guineensis* from Lekki lagoon and Ikoyi fish farm, Lagos. *Histerothylacium* sp. was found encysted on mesenteric tissue in the lower intestine of *Chrysichthys nigrodigitatus* from the Cross River estuary. The same nematode was also found in *Pseudolithus elongatus* (Origbo,1987).

2.3.4. **Annelids:**

Amongst the members of the Phylum Annelida, only the Leeches (Class Hirudinae) were found to parasitize fish. Leeches may be free-living, predaceous, intermittently or permanently ectoparasitic. Infestation with leeches predisposes the fish to secondary bacterial and fungal infections.

Parasitic leeches have been found on skin, gills and oral cavity of fishes where they cause recognizable area of hyperaemia and patechial haemorrhages (Markevich, 1951; Paperna and Zwerner, 1974).

Piscicola geomatra and *Cystobranchus fasciatus* were found on Cyprinids in USSR

In Africa, the leeches have been found attacking wide range of fishes such as the Cichlids, Bagridae, Mormyrids, Synodontidae and Clariidae. Heavy leech infections in eyes and nostrils of cultured Carp in Ghana resulted in mass mortality. (Anon 1965; Paperna and Zwerner, 1974).

2.3.5. **Molluscan Parasites Of Fishes:**

Parasitism of fish by molluscs is uncommon. The larval stages (glocidium) of bivalve molluscs of the super families unionoidea and Muteloidea were found to be temporarily parasitizing fish, especially the gills, fins and sometimes the skin. (Markevich, 1951; Fryer, 1970).

2.3.6. **Acanthocephalan Parasites Of Fishes:**

The insertion of the spiny proboscis of the Acanthocephalan into the intestinal lining destroys the mucosa and connecting tissues. In severe cases, necrosis and tissue changes including ulceration, formation of granuloma or encapsulation (particularly evident in species of *Pomphorhynchus*) occurs. Intestinal perforation with consequent peritonitis could also occur. (Bullock, 1963; Paperna, 1980).

Rhadinorhynchus horridus was found in the intestine of *Hyperopsis bebe occidentalis* from the pre-impoundment of River Niger, at New Bussa (Awachie, 1965). Fryer and Iles (1972) found *Acanthosentia tilapiae* in tilapia. Origbo (1987) also found a specie of Acanthocephala, *Octospinideroides* sp., in the stomach and intestine of some species of fishes including *Hemichromis bimaculatus* and *Chromido-tilapia pulcheri*. *Neoechinorhyncus rutili* was found in some *Tilapia* spp. and *Clarias lazera* (Onwuliri and Mgbemena, 1987) from ponds, streams and rivers in Jos. Paperna (1980) reported that *Acanthogyrus tilapiae* in Cichlids and *Tenuisentis niloticus* in *Heterotis niloticus*, were widely distributed in all African water systems.

2.3.7. **Arthropod Parasites of fish:**

The dragon fly larvae is amongst the arthropod parasites of freshwater fishes reported in Nigeria. The larvae have been found infesting the fry of *Tilapia* and *Clarias* spp. in Lake

Kainji (Okaeme *et al.*, 1990).

The insect, called the water boatman (*Notonecta glauca*), has long rear oar-like legs and a beak with which they can pierce the body of a fish and kill small fishes (Boarder, 1979).

The water scorpion (*Nepa cineria*) can also kill small fishes with its beak. In addition, these arthropods may compete with the fry fishes for food.

Heavy infection of the watermites (Arachnida, Acarina and Hydrachnellae) were found on the gills of *Synodontis membranaceous* in Volta lake (Paperna, 1969 b).

Amongst the crustacean, the copepods , commonly referred to as fish lice, are notable parasites of fishes. Some of these parasites include *Argulus, Dolops, Lernae* and *Ergasilus* spp. These parasites cause haemorrhage and ulceration at the site of attachment. They are mainly found on smooth-skinned fishes such as *Bagrus, Clarias* and *Protopterus* spp., and to a lesser extent, on the Cichlids. The parasites also attack the fins, buccal cavity and the gills.

Clavella uncinata (Muller) is a copepod parasite of the order Lernaeoida that is a common parasite of the gills, buccal cavity and opercular region of many ganoid fish in British waters. It feeds by browsing on the superficial tissues of the whiting, *Odontogadus merlangus merlangus* (L) (Shotter, 1971).

Abandoned attachment sites by *Argulus* sp. are seen as "red circular, crater-like depression" (Paperna 1980). Aken'Ova (1983) found two copepods (*Ergasilus sarsi* and *Lamproglena clariae*) on the gill filaments of *Clarias lazera*. Infection by *Ergasilus lizae* (in *Tilapia aurea*) stimulated marked proliferation of the epithelium of the gill filament which sometimes become completely embedded and fused within the resulting mass of epithelial tissue. Pond mullets heavily infected with *E. lizae* were emaciated, weak, and resulted in 50% loss of stocked fish (Kabata, 1970). *Afrolernae* sp. have been reported in *Mormyrus longirostris* from East African waters (Paperna, 1980).

2.4. FISH AS INTERMEDIATE HOST OF PARASITES OF MEDICAL AND VETERINARY IMPORTANCE.

Various parasites with larval stages in fishes have zoonotic potentials, particularly, when consumed raw, under-cooked or under processed (Lima dos Santos,1994). Some of these parasites infect fish through the fish's food or through the gills or attachment to skin before gaining entrance into the viscera of fish.

The Digenean trematode whose metacercariae occur in fish and are infective to man are members of the families Opistorchidae and Heterophyidae. *Opisthorchis tenuicollis* and *O. sinensis* (*Clonorchis sinensis*) are found in the bile ducts of fish-eating mammals, including cats, dogs, birds and man. The eggs containing fully developed miracidia are passed out of the host faeces, and do not hatch until they are swallowed by snails of the genus *Bithynia*. In the snail the miracidium is liberated and develops into the redia, which in turn, produces free swimming pleurolophocerous cercaria, which then penetrates a suitable fish host and encysts as metacercariae. Man and other animals become infected by eating raw or poorly cooked fish (Komiya,1966; Cheng, 1973). *Heterophyes heterophyes, Metagonimus yokogawai* and *Opisthorchis tenuicollis* infect man and other animals as already described.

The life cycle of the cestode, *Diphyllobothrium latum* involves a copepod as first intermediate host, the fish (such as Pike and Walcye) as second intermediate host. The larval cestode, Plerocercoids, occurs in the fish, while man, the definitive host, which habours the adult tapeworm, *D. latum*, becomes infected by ingestion of improperly cooked fish (Roberts,1978). Other cestodes such as *D. dallie, D. pacificum, Ligula intestinalis* and *Diplogonoporus grandis*, have similar life cycle as *D. latum*, and have been reported in man, piscivorous birds, domestic animals and reptiles (Bear, 1969; Meyer,1970; Sindermann,1970).

The adult form of the nematode, *Dioctophyma renale* occurs in the kidney of wild carnivorous animals and man. The life cycle of the parasite involves an Oligochaete annelid intermediate host which is eaten by fish. The larval nematode then encysts in the fish's viscera and develop into adult in cats, dogs and other animals, and in man when the fish is consumed raw or improperly cooked (Meyer,1970).

Anisakis sp., *Contracaecum* sp., *Angiostrangylus cantonensis* and *Capillaria phillippinensis* have life cycles similar to *Dioctophyma renale*. Their invertebrate intermediate host may be the copepods or molluses (Sindermann,1970; Cross, *et. al*.,1972).Furthermore, embryonated eggs of *C. phillippinensis* that is passed in human faeces can be consumed by fish.

2.5. THE RELATIONSHIP BETWEEN THE AGE, FOOD AND FEEDING HABITS, AND PARASITES OF FISH:

The growth of the host is accompanied by a change in structure, physiology, behaviour and diet; and therefore, a change in parasitic incidence as well as level of infection. Dogiel, (1961) suggested that "the numbers and diversity of parasites increased with age of fish". He also indicated that protozoan parasite were the first set of parasites that infests the young ones of perch and pike.

Ugwuzor (1987) demonstrated a relationship between age of fish and helminth infestation. Of the 340 fishes examined, 180 were juveniles that were not infected by helminth, parasite, while 88 sub-adults and 72 adults were infected by 9 (10.23%) and 17 (23.6%) parasites respectively.

In Dogiel's study of 1961 on parasites of Pike, *Acanthocephalus lucii* infection was independent of host age, but the incidence and level of infection increased with age of host; while there was a decrease with age in the incidence of *Petrocephalus lucii* in the same fish.

Infection of Lake Trout by the monogenean, *Discocotyle sagittata*, takes place when the fish is two years old and when found at the deeper end of lakes. This infection increases steadily until the fish is about five years old. Another monogenean, *Dactylogyrus vastator* is found mainly in young carp, which are surface dwellers; while infection rate is considerably reduced in older carps that are bottom dwellers (Dogiel, 1961; Paling, 1965).

In Whiting (*Odontogadus merlangus* L.), infection rate of the gill by the Monogenean (*Diclidophora merlangi*, Kuhn.) increased from 1.2% in 3-6 months old fish to 58.1% in 6-12 months old fish. Digeneans such as *Hemiurus communis* and *Derogenes varicus* commonly infest the stomach of whiting although

infestation is more in older fish. On the contrary, infestation with the intestinal digeneans, *Stephanostomum pristis* and *Lecithaster gibbosus* decreases with age of the fish. The Nematode, *Contracaecum elevatum*, is prevalent in all age groups although the worm burden is heaviest in younger fish. Infestation with the copepod, *Lernaeocera branchialis* and the acanthocephala, *Echinorhynchus gadi*, also increases with age of fish (Shotter,1972, 1973a and 1973b).

Kennedy (1975) indicated that "the parasite fauna is directly influenced by the feeding behaviour of its host and the level of the latter, and the nature of the predator relationships can therefore serve as a potential index for predicting the structure of the parasite fauna in any given aquatic ecosystem". For example, the adult, *Caryophyllaeus laticeps* in bream (*Abramis brama*) is found as larvae in the tubificid worms on which the breams feed. The numbers of the parasite vary seasonally, and with age of the host, an equilibrium is maintained in the natural environment as a result of over-dispersion of the parasites and a periodicity in immigration of larvae into the adult population due to seasonal feeding pattern of the fish host (Anderson,1974).

The adult cestode (*Polyonchobothrium* spp.) has been reported in *Synodontis* and *Heterotis* fish species in Kainji dam and Lake Chad. As this cestode has the copepods and annelids (Tubifex) as the first intermediate host the fishes would probably have fed upon during their development (Oniye and Annune, 1993).

In acanthocephalan infection, the definitive host (the ducks) are infected by consuming the intermediate host (a crustacean) containing an invasive larvae of the parasite (Petrochenko, 1971). Awachie (1965) indicated that the incidence of *Echinorhynchus truttae* in trout throughout the year is due to the year-round presence of infective larvae as well as the intermediate host *Gammarus pulex*. Infection of fish thus takes place throughout the year. Similar evidences have been reported by Chappell, (1969), Mackenzier and Gibson, (1970) and Boxrucker, (1979).

2.6. SEX AND REPRODUCTIVE CYCLE OF FISH IN RELATION TO PARASITIC INFECTION:

The relationship between the sex of a fish and parasitic infestation have not been properly investigated. In a study of the helminth parasite of fish in Imo river, Ugwuzor (1987) did not clearly show sex preference of parasite to fish species. In a survey of the parasites of cichlids in Zaria area, it was reported that of the 33 *Oreochromis niloticus* studied, 20 males were parasitized by 29 parasites while 11 females had 13 parasites and only 2 fish had no parasites (Maha, 1992). In *Sarotherodon galilae* studied, 25 males had 37 parasites while 9 females had 49 parasites. 24 males of *Tilapia zilli* had 49 parasites while 9 females had a total of 10 parasites. It appeared that the males had higher parasitic burden than the females. Furthermore, it was indicated that metacercariae of *Euclinostomum heterostomum* was present only in the male species of *S.galilae* and *T. zilli* whereas its incidence was highest in females of *O.niloticus*.

Various parasites have been found infecting the gonads of fish. For example,gonadal deformation have been recorded in the cichlids of the genus *Haplochromis*, infested by the nematode of the genera *Eustrongylides, Contracaecum* and *Amplicaecum* (Paperna,1980). Kosheva(1957) associated the decreased gonadal development in the bream to the tapeworm, *Ligula* sp. In addition, *Ligula* causes the hosts 'gonad to regress, thus causing sterility (Paling, 1968). Destruction of the ovaries of *Oreochromis niloticus* by *Myxobolus sarigi* was reported by Obiekezie *et. al.*(1985).

The life cycle of some parasites are often synchronized with that of their host so that infective larvae are only produced or released when the host aggregate (during breeding) or when their progeny appear. For example *Dactylogyrus vastator* (monogenea- trematode) is a parasite of carp which begins to reproduce in spring, its reproduction reaching its peak in summer when the fish congregate for spawning, by which time large number of infectable juveniles are available. Furthermore, *Caryophyllaeus laticeps* reaches its maturation peak in April-May in Dace which breed in March, in May-June in chub which breed in May, and in May-June in Roach which also breed in May (Kennedy,1975). The ciliate protozoans, *Opalina ranarum* and *Nyctotherus cordiformis*,and the monogenean, *Polystomum*

integerrimum are all parasites that have their reproductive cycles synchronized with and physiologically controlled by their host-the frog. It is believed that the host hormones may be involved although maturation of hosts may be related to temperature cycles (El-Mofty and Smyth,1969; Kennedy, 1972 & 1975).

2.7. SEASONALITY OF PARASITIC INFECTION IN FISH:

The incidence of parasitic infection in fish is determined by factors such as the behaviour of the fish, its diet, availability of infective larvae, all of which are directly or indirectly affected by local environmental conditions. Kennedy (1975) suggested that "there is clearly no sharp distinction between seasonal and nonseasonal incidence cycles, and intermediate stages on the cline between them may occur when local conditions restrict infection periods or parasite maturation".

Some parasite produce and infest their host throughout the year while others grow, reproduce and infest their hosts only during certain favourable climatic conditions. Thus, some species do exhibit seasonal cycle. *Proteocephalus filicollis* is a cestode parasite of Stickle-backs which grows and matures in all months of the year in Yorkshire (Chappell, 1969). However this same parasite species exhibited well defined seasonal cycle in Scotland where it matures in late spring and early summer while its growth is inhibited during cold winter temperature (Hopkings, 1959).

Trichodina sp., a protozoan parasite of fish is found in all ages of fish and present throughout the year, the success of its transmission is influenced by the degree of crowding of the fish. In contrast, *Dactylogyrus vastator*, infection of carp increases in spring and summer when temperature for breeding is about 20 - 25 °C and decreases in autumn and winter when the parasites are unable to breed due to fall in temperature. *D. solidus*, however, has a similar cycle to *D.vastator*, but its optimum temperature for reproduction is 15 °C. *Discocotyle sagittata* of char breeds and dies in summer and the new generation infects the fish in Autumn (Dogiel, 1961; Bauer, 1962; Paling, 1965). Similarly, *Proteocephalus fluviatilis*, a cestode, only become gravid in small mouth bass between June and October when water temperature rises above 15 °C, but do not produce eggs when the temperature is low in winter (Kennedy,

1975).

The young ones of *Triaenophrus nodulosus*, a tapeworm of Pike, are said to be present in fish throughout the year but this was also attributed to the availability of the plerocercoid larvae which accumulate and survive in Perch (second intermediate host) until the perch is fed upon by the pike, thereby allowing recruitment to continue throughout the year. Similarly, *Echinorhynchus truttae* infection in trout remains constant throughout the year but the level of infection reaches a peak in July and August. This has been attributed to availability of infective larvae and the intermediate host, *Gammarus pulex*, which is eaten by trout throughout the year, so that infection of fish takes place throughout the year (Awachie, 1965; Cappell,1969).

Peak infection of black bullhead by *Pomphorhynchus bullbocolli*, an acanthocephala, in the summer may be attributed to an increase in host feeding on *Hyalella azteca*, which serves as an intermediate host as well as increase in the availability of infective larvae. An increase in fish feeding occurs with increasing summer temperatures (Boxrucker,1979).

Plerocercoids of *Pomphorhynchus ambloplitis* are found in the viscera of small mouth bass but incidence of intestinal infection is seasonal. Intestinal infection reaches its peak in spring (May and June) and declines in summer and winter when the temperature is respectively higher and lowest. In this respect, temperature prevents the establishment of intestinal infections in summer and winter, and also restricts recruitment thereby creating a seasonality in incidence. Infection of fish by the cestode, *Caryophyllaeus laticeps* in River Avon in UK shows that infection was only possible in the river at the low winter temperature, with no new infections occurring after winter (Hopkins,1959; Fisher,1967; Fisher and Freeman,1969; Kennedy,1969).

2.8. EFFECT OF PARASITE ON NUTRITION OF FISH:

Recent studies on nutritional requirement of parasites have indicated that depletion of host nutrient by parasites results into serious debility especially when parasitic burden is high. Some parasites such as *Ligula intestinalis* may constitute up to 50% of the fish's weight

(Dence, 1958). It is obvious that such parasite divert to their own use a considerable part of the fish's food, leading to retardation of growth and loss of weight of the fish.

Quantitative decrease in muscle lipids have been reported in the fish, *Coregonus laveratus* infected by *Proteocephalus* sp. and *Ergasilus sieboldi*. The lipids are mainly used by the parasites for energy production and development of eggs (Von Brand,1973). For instance, Wanstall, *et. al.* (1982) reported that infection with the acanthocephalan, *Pomphorhynchus laevis* had a significant negative effect on the level of muscle protein in *Neomacheilus barbatulus* and *Salmon gairdneri*. It was suggested that weight loss caused by *P. laevis* infection resulted from a combination of factors such as increased gluconeogenesis of host muscle protein, severe tissue response of the host to infection as well as competition between the host and the parasite for food.

Kadau and Agarwal (1981) reported a decrease in the amino acid profiles of *Clarias batrachus* parasitized by Caryophillid cestodes. Onwuliri *et. al.* (1989), have attributed the decrease in lysine and glutamic acid in *Clarias lazera* to nematodes, cestodes and some trematode parasites.

CHAPTER THREE

3.0. MATERIALS AND METHODS

3.1 THE STUDY AREA:

Zaria is about 645km from the sea and located at an altitude of approximately 2,200 feet (671m) above sea level. It has a tropical continental climate (Hore,1970). The mean daily maximum temperature rises gradually from January (29.8 °C) attaining its highest value (30.2 °C) in April and dropping to its lowest value of (27.2 °C) in August. It rises again to its second peak in October,(Kowal and Knabe, 1972). The mean minimum temperature rises from its lowest value in December/January (13.6 °C/13.7 °C) to its highest value (21.7 °C) in April. There are two main seasons-the wet and dry seasons. The wet season lasts from May to October while the dry season lasts from November to April, although yearly variations may occur.

3.2 THE ZARIA DAM:

Zaria dam lies on longitude 7° 46'E and latitude 11° 07'N(Fig.7). It was constructed on the River Galma and was officially commissioned in 1975. The height of the spillway above the river bed is about 10.67 m and extends up to 25 km in the eastern direction (Omar, 1987). The dam was constructed solely for the supply of drinking water to Zaria and its environs. However, fishing and irrigation are also carried out. It also serve as a recreational centre.

3.3. RAINFALL, TEMPERATURE, pH AND TURBIDITY MEASUREMENT:

Rainfall Data:

Rainfall data for 1993, 1994 and 1995 were obtained from the meteorological unit of the Institute of Agriculture Research (I.A.R) Ahmadu Bello University Zaria.

Temperature:

Surface water temperature of the dam was measured at five designated points with

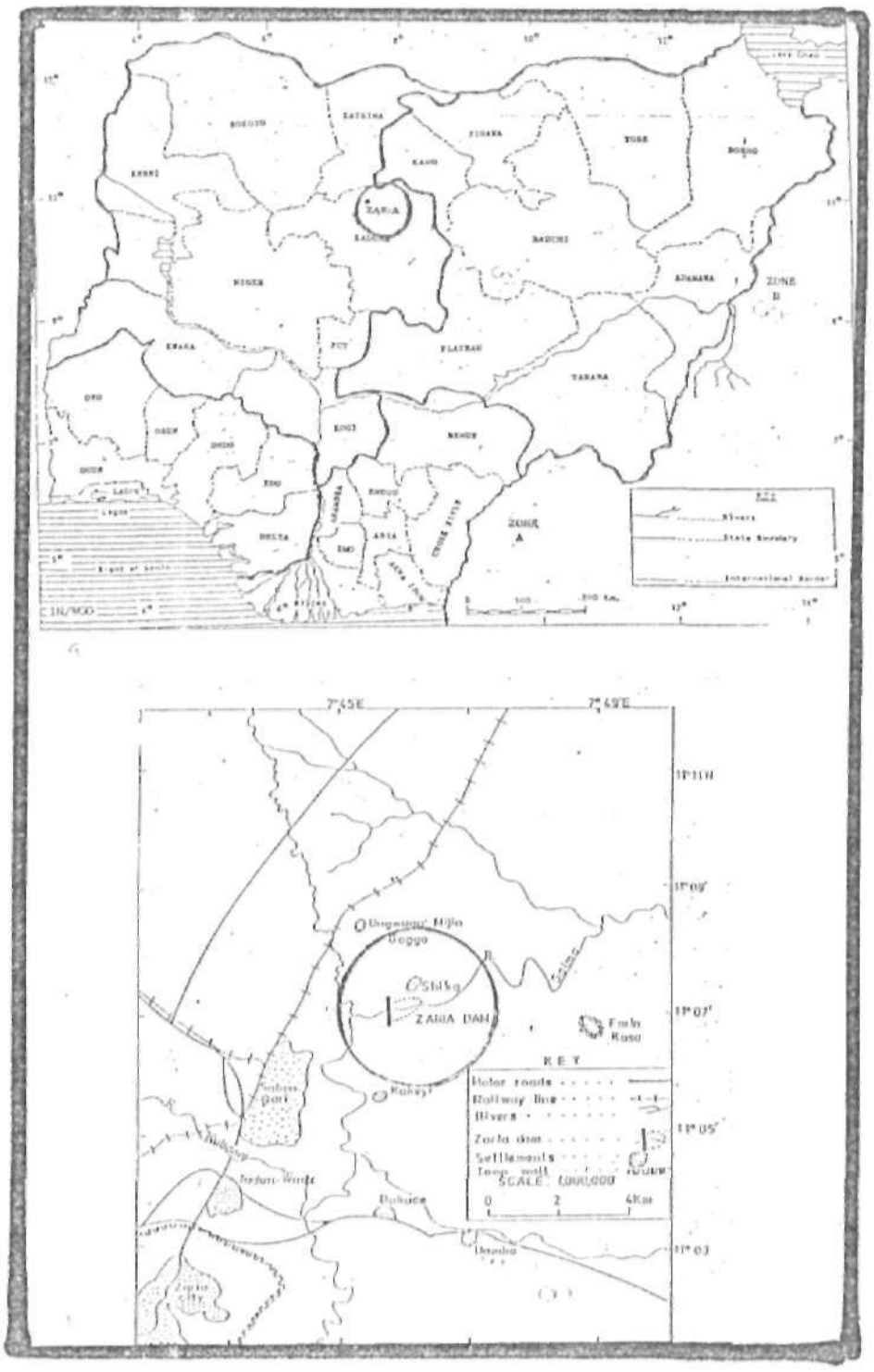


FIG. 7. Location of Zaria in Nigeria (above) and Zaria dam on River Galma (below).

hand-held mercury thermometer and the average temperature was recorded.

pH and Turbidity:

pH was measured at the five points and average reading was recorded. The Horiba field pH meter Model H-7VP was used. The field Turbidimeter Model AL1000 was used to measure the turbidity at the five points and the mean values were recorded in mg/l.

3.4 MEASUREMENT OF CONCENTRATIONS OF CHLORINE, NITRATE, IRON (FE^{++}) AND DISSOLVED OXYGEN:

3.4.1. Chlorine:

The chlorine concentration was measured by collecting the dam water in a dark 100ml bottle, which is then corked immediately stored in an iced box and then transferred to the laboratory. The chlorine concentration(mg/l) was measured using the chloroscope (model PC1), according to the manufacturer's manual.

3.4.2. Nitrate-Nitrogen (NO_3-N)

The Phenoldisulphuric acid method (Mackereth 1963) was used.100mls of the water sample was evaporated, 2 mls of phenoldisulphuric acid was added to the residue which was then allowed to stand for 10 minutes. 15 mls of distilled water was then added followed by 5mls of strong ammonia solution. The resulting yellow mixture was stirred and allowed to cool after which the absorbance was measured at 410nm with spectrophotometer (model S101), distilled water being used as the blank. The NO_3-N concentration (mg/ml) was read from a calibration curve (APHA, 1980).

3.4.3. Manganese and Iron:

150 mls of water sample was preserved by addition of concentrated nitric acid keeping the mixture in a deep freezer before analysis. 40 mls of the preserved water sample was added to 10mls of a 3:1 mixture of concentrated hydrochloric acid and concentrated nitric acid. The resulting solution was placed in a water bath at 90 °C ± 1 °C for 30 minutes, filtered and

analyzed with Atomic Absorption Spectrophotometer Model AAS180-80. The concentration of Manganese and Iron in the water samples were expressed in mg/l., as described by the manufacturer's manual.

3.4.4. **Dissolved Oxygen (DO):**

250 mls of water sample was fixed in the field by adding 2 ml of manganous sulphate followed by 2 ml of alkaline-iodide azide and 2 mls of concentrated sulphuric acid and thereafter transported to the lab in cold ice box. 10 ml of the sample was titrated with 0.0125 N sodium thiosulphate until it turned to pale yellow, and to blue colour on addition of 1ml of starch solution. The titration continued until the blue colour disappeared. The volume of the 0.0125 N sodium thiosulphate titrant used is equivalent to the concentration (mg/l) of the dissolved oxygen ((Lind, 1979; A.P.H.A.,1980).

3.5. FISH SAMPLING

Fish samples were collected from December, 1993 to November 1995, with the aid of artisanal fishers using Cast and gill nets of various mesh sizes, from the study area. The fish samples were transported on ice to the laboratory for subsequent analysis. Fish were identified using texts by Reed *et. al.*, (1967) and Lewis (1974).

Body measurements taken were standard length (cm) and weight (g) as described by Lagler (1970). Length - weight relationships of the different species was established using the formular:

$W = aL^b$ ..... (1) as described by Ricker (1968).

Where: W = weight of fish (g)

L = standard length of fish (cm)

a = constant

b = an exponent

Equation 1 could be transformed to a straight line to permit an evaluation of the constant a and exponent b by taking a log of both sides. This the transforms to:

$\text{Log}_{10} W = \text{Log}_{10} a + b \ \text{Log}_{10} L$ ..... (2)

Thus by regressing $\text{Log}_{10}W$ on $\text{Log}_{10}L$, the intercept would be equal to $\text{Log}_{10}a$ while the

gradient of the regression line would be b.

3.5.1 Assessment of Stomach Fullness and Content:

The abdomen of each fish was opened lengthwise, and the gastrointestinal tract (G.I.T) was removed and placed in a petri dish containing normal saline. The stomach fullness was estimated as described by Olatunde (1978b). The criteria used for this estimation is described in Table 1. For example, if the stomach fullness fall in between the basic scores on the table, points were awarded appropriately. Thereafter the stomach was cut off and its content preserved in 5% formalin until examined.

TABLE 1: Classification of stomach fullness.

STOMACH SIZE	DESCRIPTION	POINTS
Full stomach	The stomach bulges considerably with food	100
¾ full stomach	The stomach is almost full but not bulge	75
½ full stomach	Food occupies about 50% of the stomach volume	50
¼ full stomach	Stomach wall very flabby, sometimes looked as empty	25
Empty stomach	No visible food in the stomach when dissected and examined under the microscope	0

The frequency of occurrence and " points" methods (Hynes, 1950) were employed in the study of the food of the fishes. In the frequency of occurrence method the individual food matter in each stomach were sorted and identified. The number of stomach in which each food item occurred was expressed as a percentage of the total number of stomachs examined. In "points" method, the food items in the opened stomach were broadly grouped into Insecta, Annelida, Crustacea, Mollusca etc. Points were then awarded to the individual food items based on their respective sizes and abundance.

The sum of the points given to the individual dietary items was equal to the points awarded to the stomach size earlier. Points obtained by each food item was summed up and

scaled down to percentages to give percentage relative composition of all the food items.

The description of Ward and Whipple (1959), Needham and Needham (1975), Wetzel (1975), Marshall and Williams (1978) and Pennak (1978) were used to further identify and classify food items.

3.5.2 **Determination of Sex and Gonad Classification:**

Sex was determined by internal examination. The abdomen was opened and gonads were examined to determine sex. Maturity of each gonad was classified based on their maturity scale modified by Kesteven (1960), Nikolsky (1963) and Olatunde (1978). The estimation of gonad maturity is presented in table 2.

3.5.2.1 **Fecundity Estimation:**

Fecundity of the mormyrids were estimated by the "sub-sampling dry gravimetric method" modified after Simpson (1959). Ovaries were preserved in Gilson's fluid for over ninety (90) days after which they were removed. The eggs were then washed gently using distilled water until they were disentangled from the ovarian tissues. The eggs were then poured into a filter paper in a funnel. When the water had drained off, the paper and eggs are spread on blotting paper to remove excess moisture. Clumped eggs were gently separated and air-dried for 24-30 hours at room temperature. Fecundity estimation was obtained by firstly, weighing all the eggs of each fish. Then three samples of 200 eggs from each fish were randomly selected and weighed. The total weight of eggs was divided by the mean weight of the sub- samples and multiplied by 200 to give the fecundity estimate of the fish. Counting and weighing of the eggs were done in the same room to ensure that the moisture and temperature of the eggs were in equilibrium with that of the room air.

TABLE 2: Gonad maturity stages in Mormirids

Maturity stage	Gonad condition	Description of female	gonads male
I	Virgin	ovary very small not discernable	Testis very not easily identifiable
II	Immature or developing	easily discernable, small sized, eggs not distinguishable	clearly visible very thin and translucent
III	Matured / developed	visible, ovary increase in testis size, whitish & swollen.	
IV	Fully matured	about 5% of body wt Eggs not shed even with slight pressure on the abdomen. Ovary have achieved maximum wt.	Changes from transparent to pale rose colour.
V.	Running/spawning	Eggs released on application of slight pressure	No running testis
VI.	Spent/recovering/	Eggs shed, Ovary too flaccid, like empty. sacs. Few ova still present/return to stage II	Testes return stage II/saclike

3.6. EXAMINATION OF FISH FOR PARASITES:

3.6.1. Examination of the Gills:

The two opercula of each fish were removed and their inner sides were examined under the dissecting microscope. Recovered parasites were placed in 0.7% physiological saline. Thereafter, the gills were dissected out and placed in petri dish containing physiological saline and examined with the aid of the dissecting microscope. Each gill arch was numbered 1,2,3 and 4 starting from the outermost gill arch. Parasites found were counted and their positions noted, removed and preserved in 4% formalin and treated as described in 3.6.3. Sites of attachment of the parasites were examined for possible tissue damage.

3.6.2. Examination of the Alimentary Canal:

The gastro-intestinal tract (GIT) was removed from each fish and placed in a petri dish containing physiological saline. The oesophagus, stomach, small intestine and rectum were separated and examined separately for parasites. Inflammation and lesion sites were also noted. Different parasitic group were treated separately as indicated in 3.6.3.

3.6.3. Treatment of Recovered Parasites:

3.6.3.1. Trematodes:

Trematodes in the physiological saline were removed and placed on a slide, drops of formol-acetic-acid(FAA) were added to fix the worm before pressing a cover slip lightly on it to prevent curling of the parasite. This step was used for quick identification prior to mounting on a clean slide in balsam. Prepared specimens were then measured and photographed.

3.6.3.2. Cestodes:

The recovered cestodes were relaxed by placing them in physiological saline and left at 4 °C for about 18hours. Specimens were measured and photographed.

3.6.3.3. Nematodes:

Nematodes recovered were placed in the physiological saline for 40 - 60 minutes. They

were transferred to 70% alcohol for a few minutes, and evaporated in the desiccator. They were mounted in a glycerine medium, identified and photographed.

3.6.3.4. **Acanthocephala:**

Acanthocephalan specimen recovered were left in distilled water for 12hours in the refrigerator to imbibe water and extrude their proboscis. The specimens were treated successively with 30% 50% and 70% alcohol for 10minutes each.When the yellowish colour disappeared, the parasites were mounted in balsam medium, measured and photographed.

3.6.3.5. **Arthropods:**

Isolated arthropods were stored in 10% formalin. Crustaceans that were difficult to disengage from the gills, were preserved in situ in 10% formalin. Some of the crustaceans were drawn in situ or photographed.

3.6.3.6. **Molluscs**:

Gills attacked by the larvae of molluscs (glochidia) were photographed and preserved in 10% formalin.

All specimens were identified by using reference texts by Soulsby(1968), Petrochenko (1971), Paperna(1980) and confirmatory identifications were carried out by experts in the British Museum of Natural History, London.

3.7. **HISTOLOGICAL TECHNIQUE:**

Some freshly dissected gastrointestinal tracts of fish with parasites that penetrated the intestinal wall were fixed in 10% formal-saline. Thereafter, they were treated for 60minutes each in 70%, 80%, 90% and absolute alcohol, followed by a one hour treatment in xylene at 40-50 °C.

The tissues were embedded in paraffin wax. Sectioning was done by using the Rotary microtome (Jung 133-1-20) at 4-6 µm sizes. Tissues on slides were dewaxed by using 3-4 drops of xylene on them,. The slides were later hydrated through descending series of alcohol.

Mounted sections were washed in distilled water and transferred to haematoxylin for

5minutes. They were again washed in water and counter-stained with Eosin for 1 minute.The tissues were then dehydrated through ascending series of alcohol for 3 minutes each. The slides were latter cleared for 2 minutes in xylene, mounted in DPX and photomicrographed.

Sections of the gills that were invaded by parasites were also removed for examination. The parasites were either isolated or removed to study their effects on tissues and later photomicrographed.

3.8. **MICROSCOPIC OBSERVATIONS**:

Slides were viewed with an Olympus microscope. Images were recorded using black and white Mega-Pan and Ilford films. Development and printing of the films were done at the Department of Biological Sciences, Ahmadu Bello University, Zaria.

3.9. **STATISTICAL ANALYSIS**:

Data obtained were subjected to computer analysis at the Institute of Agricultural Research (I. A. R.), A. B. U., Zaria. The computer package SPSS was employed to arrive at the analysis of variance (Duncan's multiple range test of variables) and correlation analysis (Pearson's correlation coefficient).

CHAPTER FOUR

4.0 RESULTS

A total of two thousand, one hundred and thirty-three (2,133) fish specimens belonging to the family Mormyridae were used for this study. They comprised 793 *H.b. occidentalis* (381 males and 412 females), 662 *M. rume* (234 males and 328 females), 380 *M. senegalensis* (225 males and 155 females), 183 *M. deliciosus* (73 males and 110 females), 81 *H. pictus* (34 males,19 females and 28 with undifferentiated sexual character) and 34 *P. bovei* (7 females and 27 others which were sexually undifferentiated).

4.1 RAINFALL, TEMPERATURE, TURBIDITY AND pH

The mean monthly variations in rainfall, temperature, turbidity and pH are presented on Fig. 8. The rainfall data showed two peaks in June and August (231.9 mm and 218.6 mm respectively) while the lowest rainfall (20.4 mm) was in April.

Significant positive correlation was observed between the rainfall and turbidity ($r = 0.985$), and rainfall and pH ($r = 0.647$). There was no correlation between rainfall and other parameters measured (Table 3).

The highest mean monthly variations in water temperatures were in the months of April , May, June and October with temperatures of 29.3 °C, 28.7 °C, 28.2 °C and 29.0 °C respectively, while the lowest water temperature (21.6 °C) was recorded in December.
There was a correlation between water temperature and Nitrate concentration of Zaria dam ($r = 0.791$), but not between water temperature and other parameters measured (Table 3)

The highest mean monthly peaks in turbidity was recorded in June (147.75 cm) and August (111.32 cm),while the lowest record was in January (11.65 cm). Turbidity decreased progressively between August and January, with a yearly mean of 50.36cm. As the rainfall increased the turbidity and pH increased significantly ($P<0.05$) between June and August.

The dam was mostly acidic during the dry season and tended to be alkaline during the rainy season, with pH of 5.5 in March (dry season) and 8.1 in July. Analysis of variance

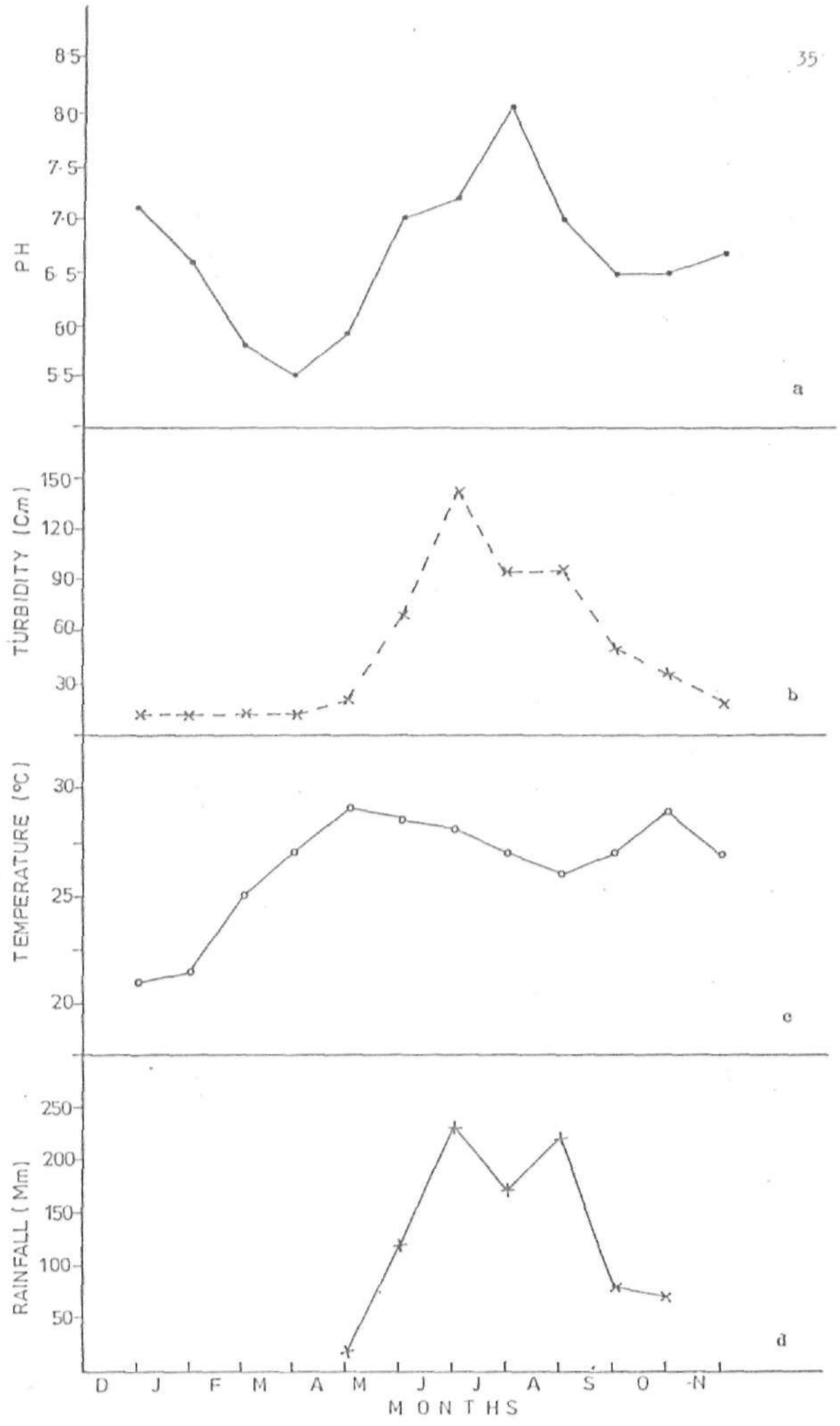


FIG. 8. MEAN MONTHLY VARIATIONS IN P^{H}(a), TURBIDITY(b), TEMPERATURE(c)

TABLE 3. CORRELATION COEFFICIENT BETWEEN THE METROLOGICAL AND PHYSICOCHEMICAL VARIABLES OF ZARIA DAM.

	Turbidity	pH	Water Temp	Fe	Mn	NO_3^-	Cl^-	Rain	Air Temp.
Turbidity	1.0000	0.6798*	0.3523 ns	-0.01761ns	-0.3444	0.3967	-0.2569	0.9847**	0.08174
pH	0.67986*	1.0000	0.1062	-0.0189	-0.5370	-0.1166	-0.5111	0.6426*	-0.3593
Water Temp.	0.3523	-0.1062	1.0000	0.0417	-0.3795	0.7919**	0.0687	0.3875	0.7204**
Fe	-0.0176	-0.0189	0.0417	1.0000	-0.5499	-0.0969	-0.7003*	.07591	-0.38531
Mn	-0.3444	-0.5370	-0.3795	-0.5499	1.0000	-0.0930	0.7132**	0.4012	0.1416
NO_3^-	0.3967	-0.1166	-0.7939**	-0.0964	-0.0930	1.0000	0.0454	0.4027	0.6493*
Cl^-	-0.2569	-0.5111	0.0687	0.7003*	0.7132**	0.0454	1.0000	0.2786	0.5898*
Rain	0.9847**	0.6426*	0.3875	0.0759	-0.4012	0.4027	-0.2766	1.0000	0.12748
Air temp.	0.0817	-0.3593	-0.7204**	-0.3853	0.1416	0.6493*	0.5898*	0.1274	1.0000

* = Significant at 0.05
** = " " 0.01 and 0.05
ns = not significant
when P ≤ 0.05 Significant
" " > 0.05 not significant.

(Table 3) showed significant correlation between pH and turbidity, and pH and rainfall ($P < 0.05$), and no correlation between pH and other parameters measured ($P > 0.05$).

4.2 IRON, MANGANESE, NITRATE, CHLORIDE AND DISSOLVED OXYGEN

The mean monthly variation in the concentrations of iron (Fe), manganese (Mn), nitrate (as NO_3-N), chloride (Cl^-) and dissolved oxygen (DO) are presented in Fig. 9.
The highest concentration of iron (0.57 mg/l) was in August and this decreased progressively during the following eleven months, with the lowest value (0.10 mg/l) in June and July. There was high positive correlation between iron and chloride ($r = 0.70$), and no correlation with NO_3 ($r=0.09$).

Manganese concentration was low throughout the year, with a yearly mean of 0.12mg/l. The lowest concentrations (0.10 mg/l) were recorded from July to November while the other months had fairly higher concentrations (Appendix 1). There was a positive correlation between manganese and chloride concentrations ($r = 0.713$) (Table 3).

The mean monthly concentrations of nitrate-nitrogen showed slightly higher concentrations (0.27mg/l) in May and June, which coincided with the early rainy season, and the lowest concentration, 0.18mg/l, was recorded in January (dry cold season) (Fig..9). There was a positive significant correlation between NO_3^- N and water temperature ($r = 0.791$).

The chloride concentrations were higher during the dry season than the rainy season. The highest concentration (2.78mg/l) was recorded in March and the lowest (2.50 mg/l) in the months of August through November.

Dissolved oxygen concentrations varied between 5.36 and 7.69 mg/l with a yearly mean of 6.19 mg/l. The result showed higher dissolved oxygen between October and March (dry season), with the highest value in January and the lowest in June.

4.3 LENGTH-WEIGHT RELATIONSHIP IN *H.b. occidentalis*

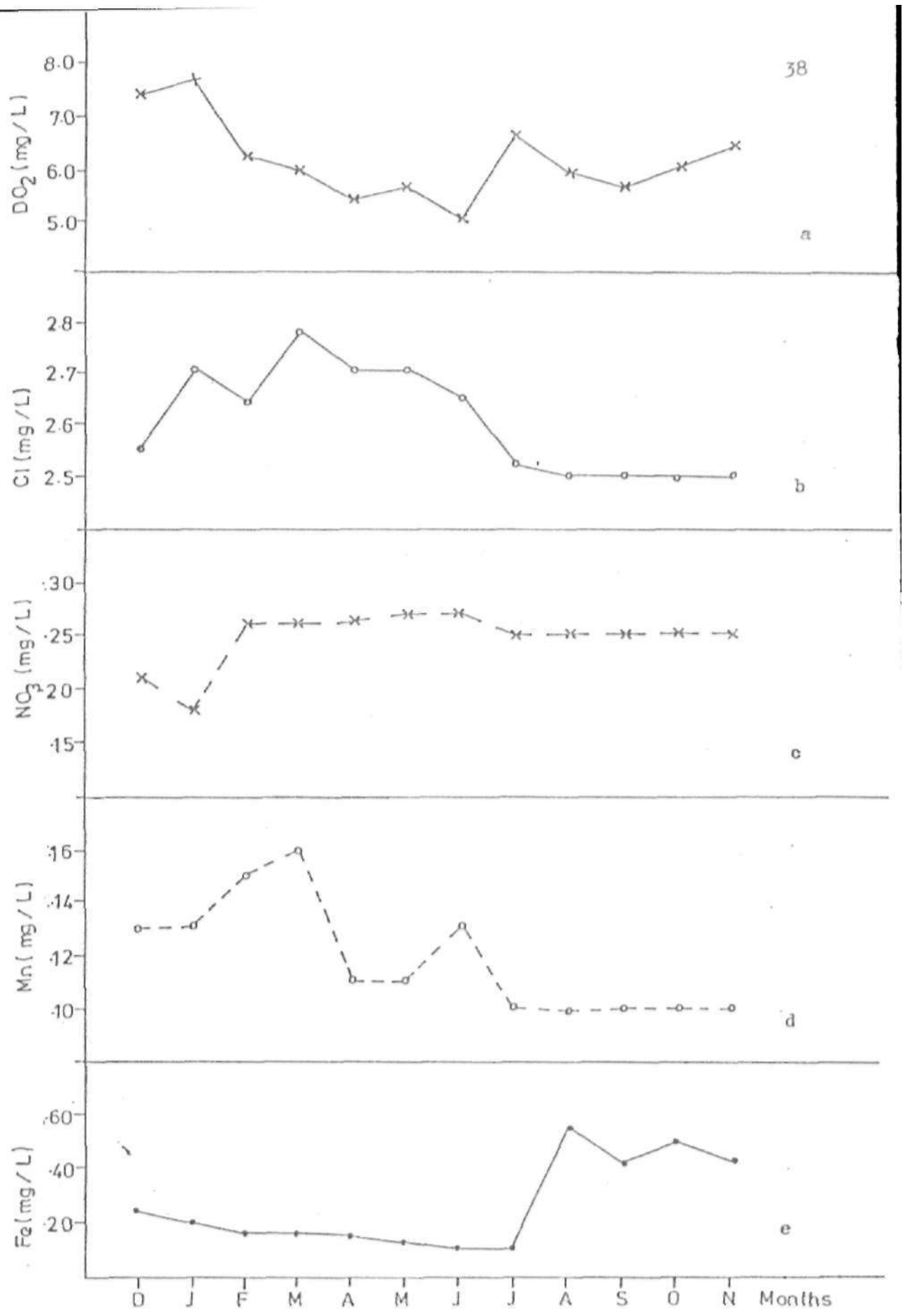


FIG. 9: MEAN MONTHLY VARIATIONS IN DISSOLVED OXYGEN(a), CHLORIDE(b) NITRATE(c), MANGANESE(d) AND IRON(e) OF ZARIA DAM.

There was no significant difference between the lengths and the weights of male and female fish ($P > 0.05$). The relationship between length and weight were significant ($P < 0.05$). The result of the length-weight regression is presented on Figs. 10 and 11. The exponent "b" of male and female of *H.b. occidentalis* were 2.88 and 2.66 respectively.

4.4 FOOD AND FEEDING HABITS OF *H. b. occidentalis*

Table 4 shows the food items that were found in the stomach of *H. b. occidentalis*. The bulk of food items were of plant origin (seeds) with a frequency of occurrence of 64%. The next most abundant were the insects (principally the ephemeropteran nymphs, chironomid larvae and insect remains). The molluscs were mainly lamellibranchs and gastropods while the crustaceans are represented by the ostracods and clam shrimps.

Other food items of minor importance included fish eggs, Hydracarina (Arachnida) and algae. Various quantities of gastropods and ostracods formed part of the fish diet throughout the year whereas the ephemeropteran nymphs were not found during the months of May and June.(Fig.. 12)

Fig. 13 shows that the fish fed throughout the period of investigation. The lowest feeding periods were in December, January and February, whereas the peak feeding month was in July.

4.5 REPRODUCTIVE CYCLE AND FECUNDITY ESTIMATE IN *H.b. occidentalis*

Sex ratio showed that more female fish (412) were used compared to the male (381), this is approximately ratio 1:1.08. Fully mature gonads (stage IV) were found mainly from July to October. Fish with spent gonads (Stage VI) were seen in September and October. No fully mature gonad was found in the months of December, January and February. Those with mature gonads (Stage I and II) were mainly found in February to May, with the peak in March in Female fish (Fig.14) while the peak in male was in January in male (Fig.15). The estimated fecundity ranged between 2025 to 4192 (Appendix 3) and the largest individual *(either in weight or length) did not tend to have the greatest fecundity estimate.*

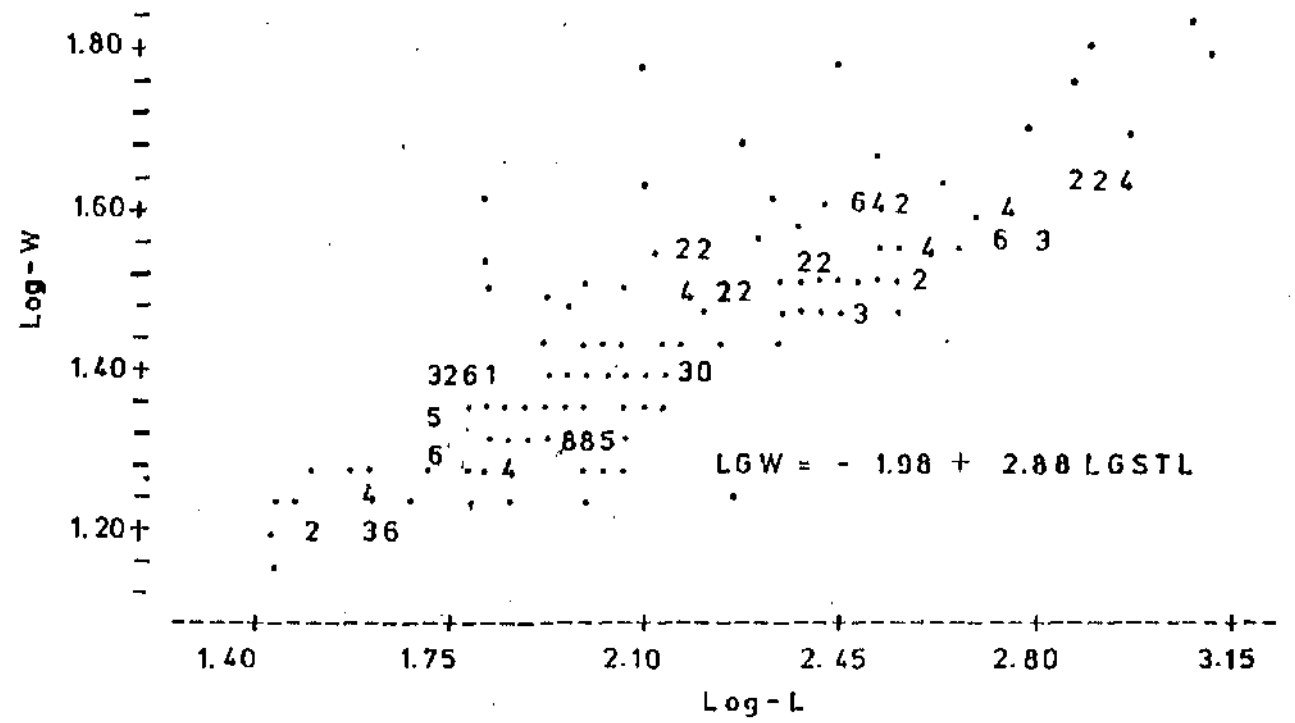


FIG. 10: Length-weight relationship of *H.b. Occidentalis* (male)

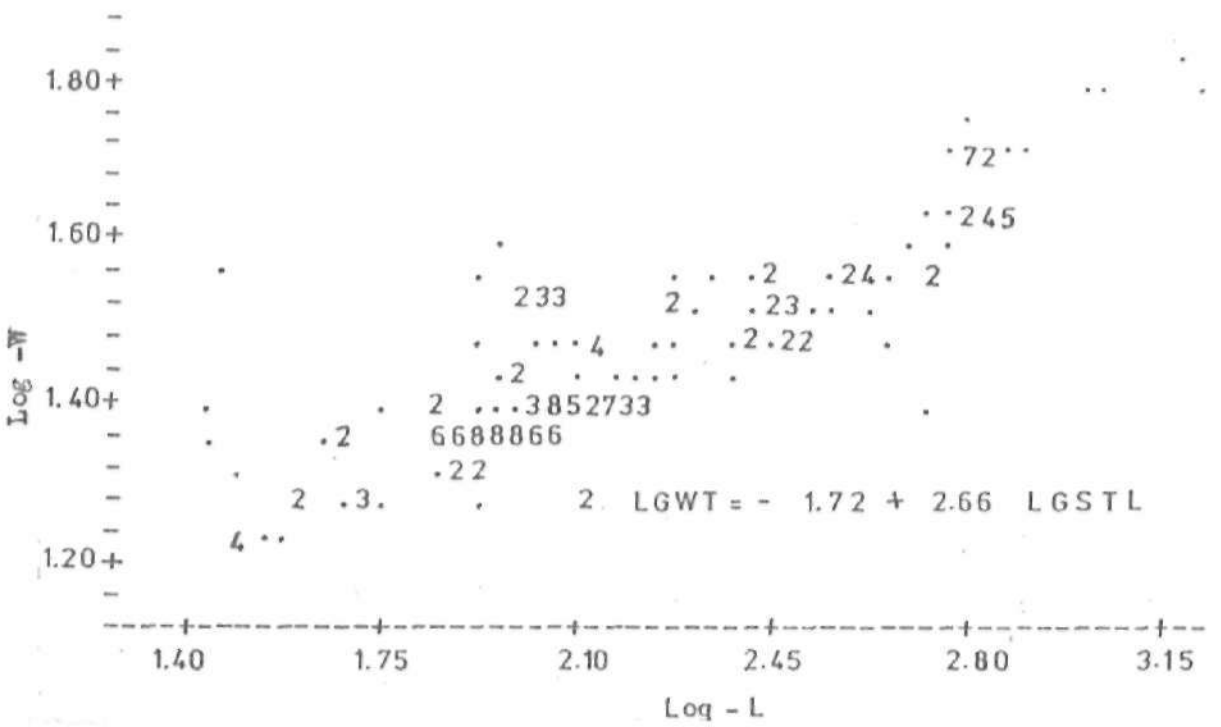


FIG. 11: Length-weight relationship of *H.b. Occidentalis* (female)

Table 4: THE COMPOSITION AND RELATIVE IMPORTANCE OF DIETARY ITEMS IN THE STOMACH OF *H.b. occidentalis*

	Food items	% frequency of occurrence	% total parts
	Insect remains	27.7	5.7
Adult	Hemiptera	1.6	0.9
Insect	Coleoptera	4.9	1.1
	Ephemeroptera Nymph	7.5	2.8
	Trichoptera larvae	6.8	0.5
	Dragonfly Nymph	4.9	0.9
	Megaloptera larvae	3.1	1.1
Immatured	Coleoptera larvae	2.9	0.3
Insects	Lepidoptera larvae	3.9	1.6
	Chironomid larvae	30.1	5.2
	Chaoborus larvae	1.5	1.5
	Heleidae	1.5	0.6
	Fish eggs	10.2	2.7
Crustacean	Ostracods	39.2	9.2
	Clam shrimps	7.8	0.9
Molluscs	Gastropoda	45.8	15.2
	Lamellibranchia	18.1	11.1
Arachnida	Hydracarina	6.5	0.5
	Algae	2.5	0.8
	Seeds	64.5	35.7
	Plant remains	4.9	1.6

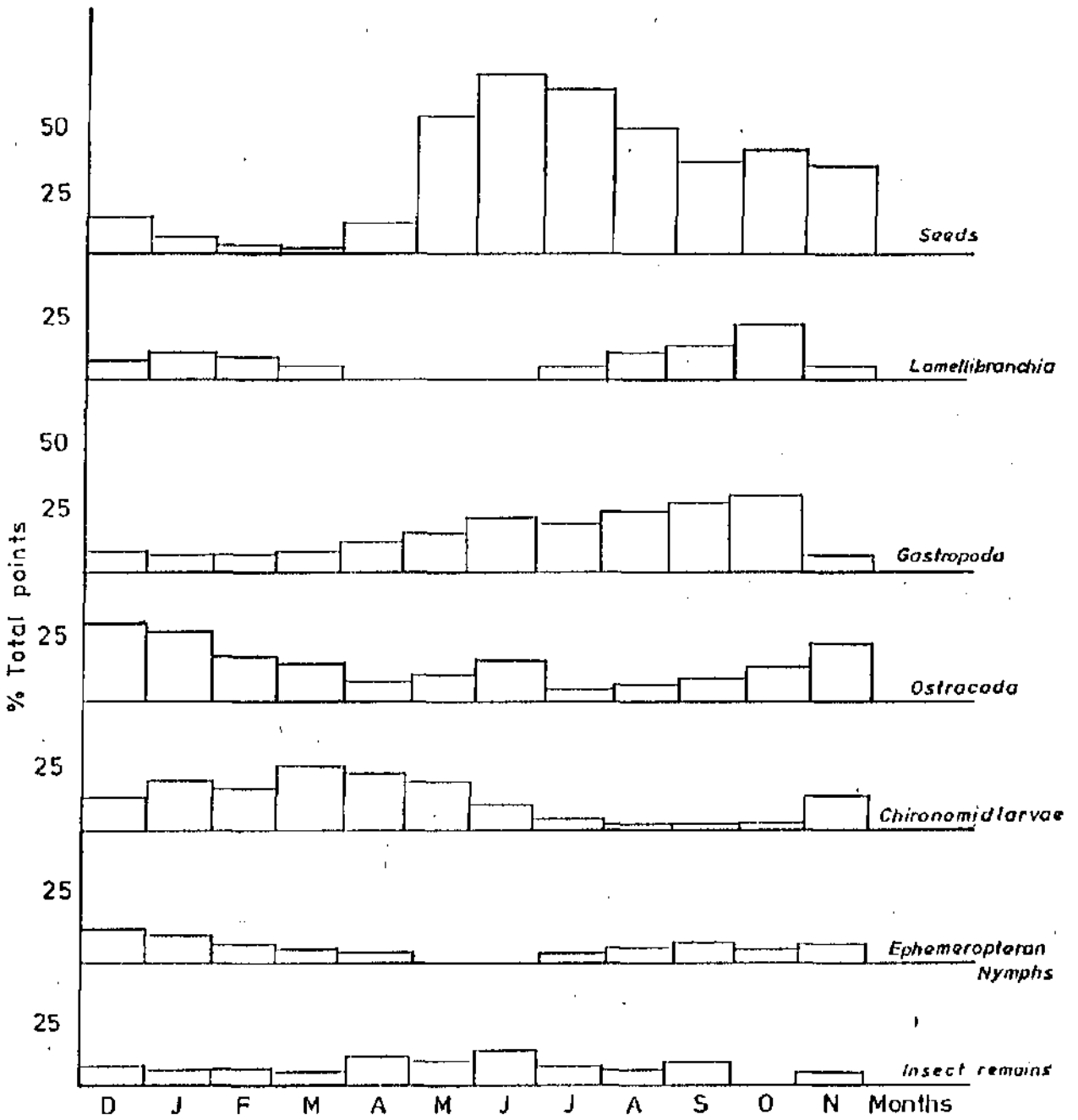


FIG. 12: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH *H.b. Occidentalis*

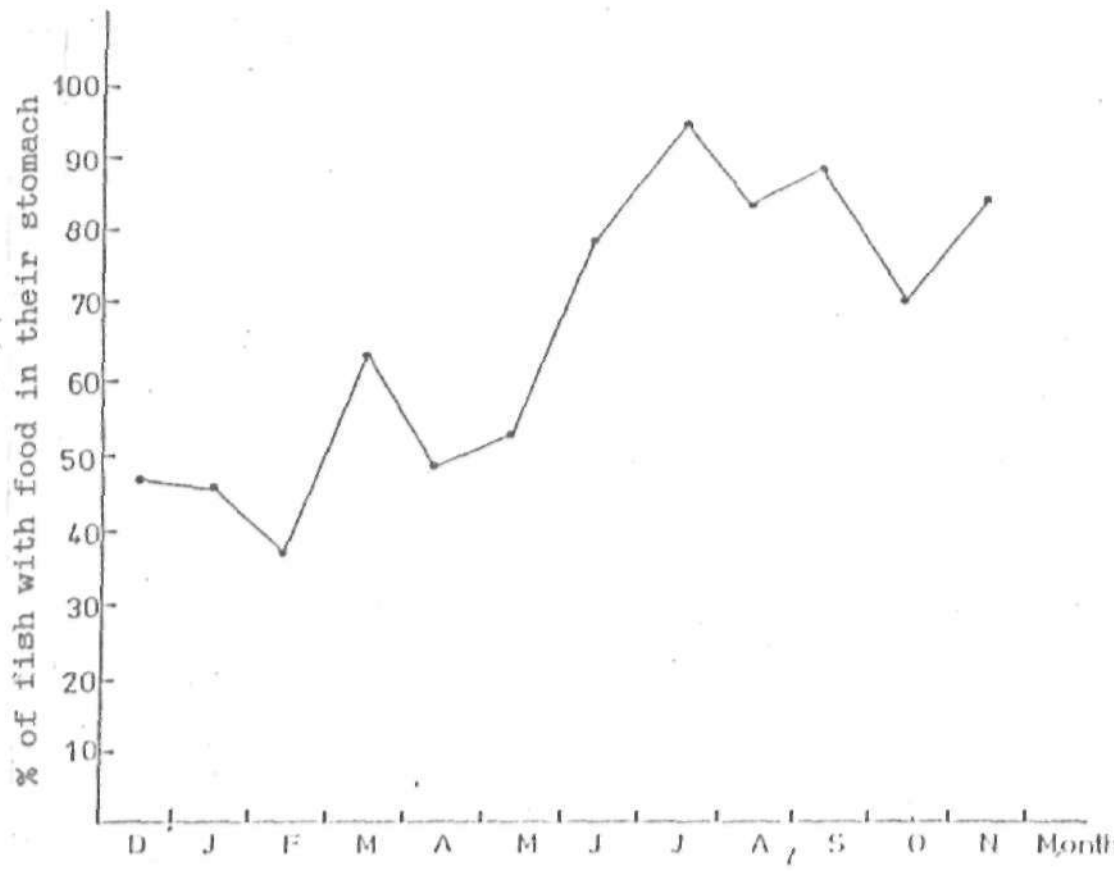


FIG. 13: FEEDING INTENSITY OF *H.b. Occidentalis*

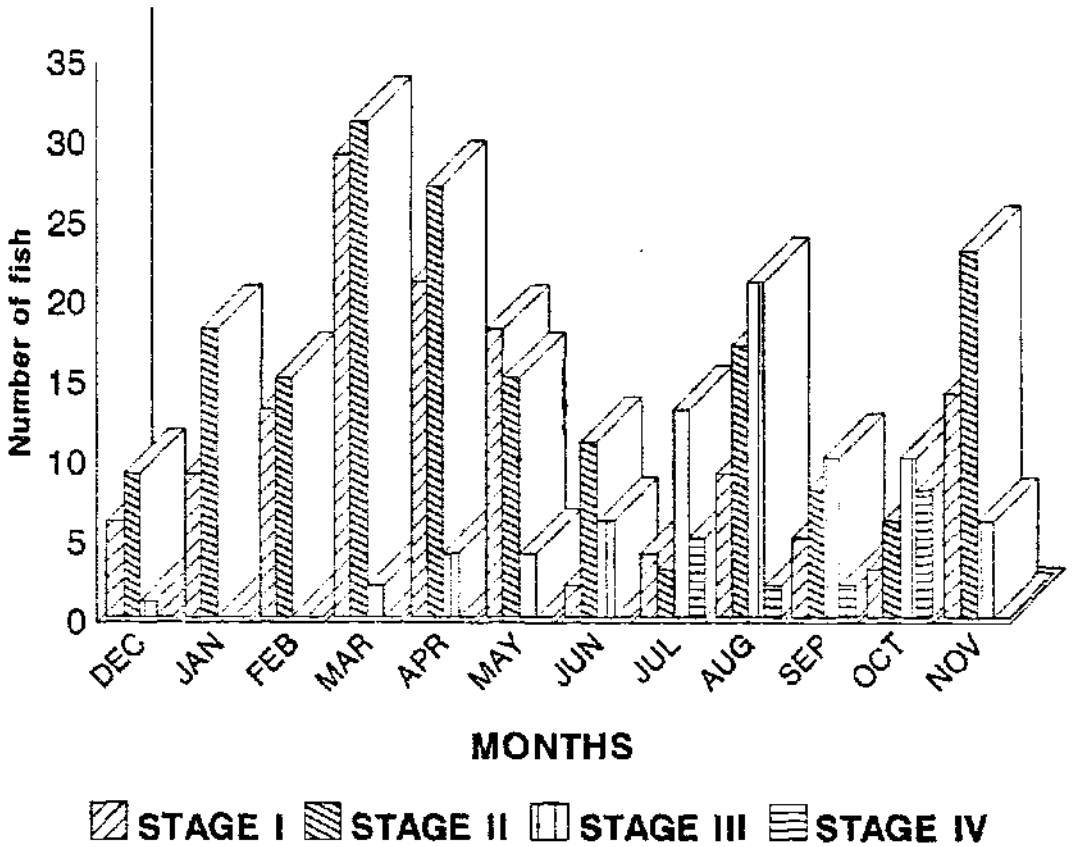


Figure 14: Stages of gonad in female H. b. occidentalis

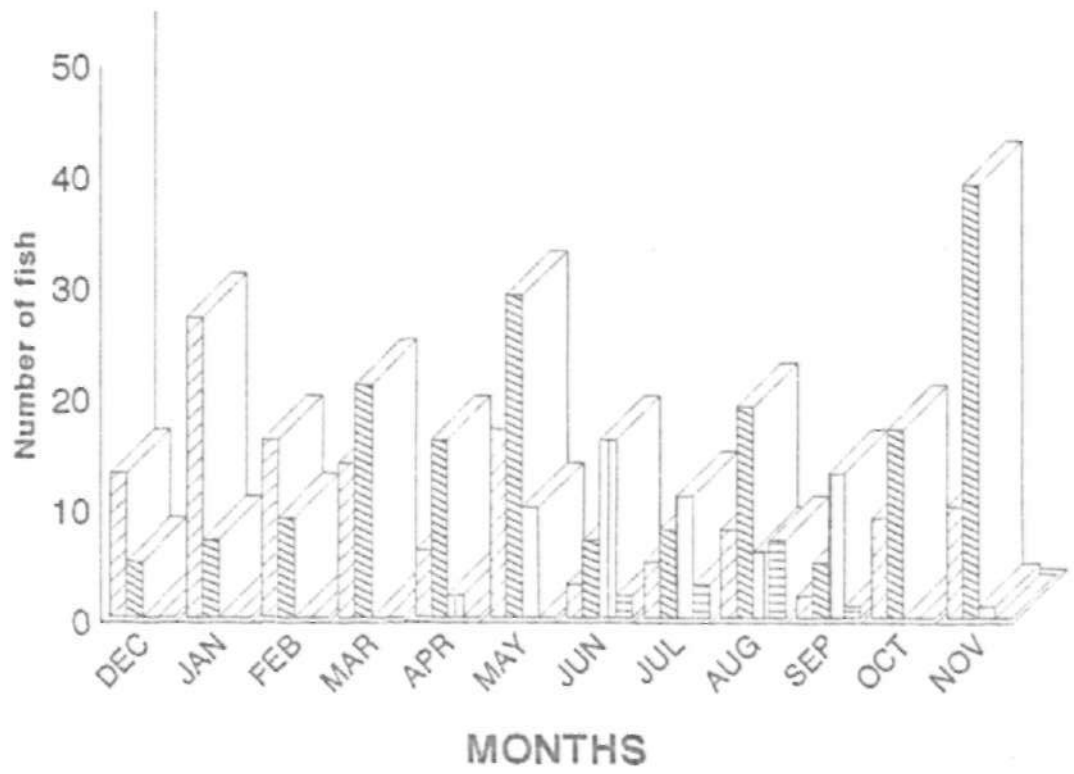


Figure 15: Stages of gonad in male H. b. occidentalis

4.6 PARASITES OF THE BRANCHIAL CHAMBER OF *H. b. occidentalis*

Out of the 793 *H. b. occidentalis* collected, 490 (61.79%) were parasitised by various gill parasites. No parasite was found on the operculum. Parasites found infecting the gills were *Henneguya* sp. *Clinostomum complanatum*, molluscan glochidia, and *Eargasilus sarsi*, which contributed 26.4%, 19.96%, 8.55% and 45.53% of the parasite population respectively. The total of 645 parasites, with infection rate of 67.97% were found on the male fish specimens. The species of parasites recovered from the male fish specimen were *Henneguya* sp., *C. complanatum*, Molluscan glochidia and *E. sarsi*, these representing 21.39%, 24.8%, 10.38% and 43.4% of the total parasite burden respectively. 392 parasite (56.06%) were found on the female fish, with percentage composition of *Henneguya sp.* (28.38%) *C. complanatum* (13.26%), Molluscan glochidia (6.10%) and *E. sarsi* (52.25%).

The monthly occurrence of the respective parasites in the branchial chamber of the male, female and male and female fish combined are presented in appendixes 4a, b and c respectively.

Infection with *Henneguya sp* showed two peaks one in March and October. Infection were not observed in July, August, December and January. The incidence of infection by *E. sarsi* was higher when *Henneguya* was absent. The infection with glochidia (mollusc) was mainly observed during the dry season (November to April).

C. complanatum infection occurred mainly in the months of July to November with peak period in August (Fig.s: 16,17,18).

Analysis of variance of parasitic infection of gills 1,2,3 and 4, showed that there was significant correlation in parasitic infection between gill arches 1 and 2 ($P < 0.05$) and no correlation between gill arches 3 and 4 ($P > 0.05$). In the male and female *H. b. occidentialis*, *E. sarsi* had significantly higher ($P < 0.05$) rate of infection compared to *Henneguya*, *Clinostomum* and glochidia (molluscs). In the male fish, no significant difference existed in infection with *Clinostomum* and *Henneguya* and also between *Henneguya* and Glochidia (Molluscs). However, significant difference was observed between infection with *Clinostomum* and Mollusca. In the female fish species, no significant difference was observed between *Henneguya*, *Clinostomum* and Mollusc infection. The parasite burden

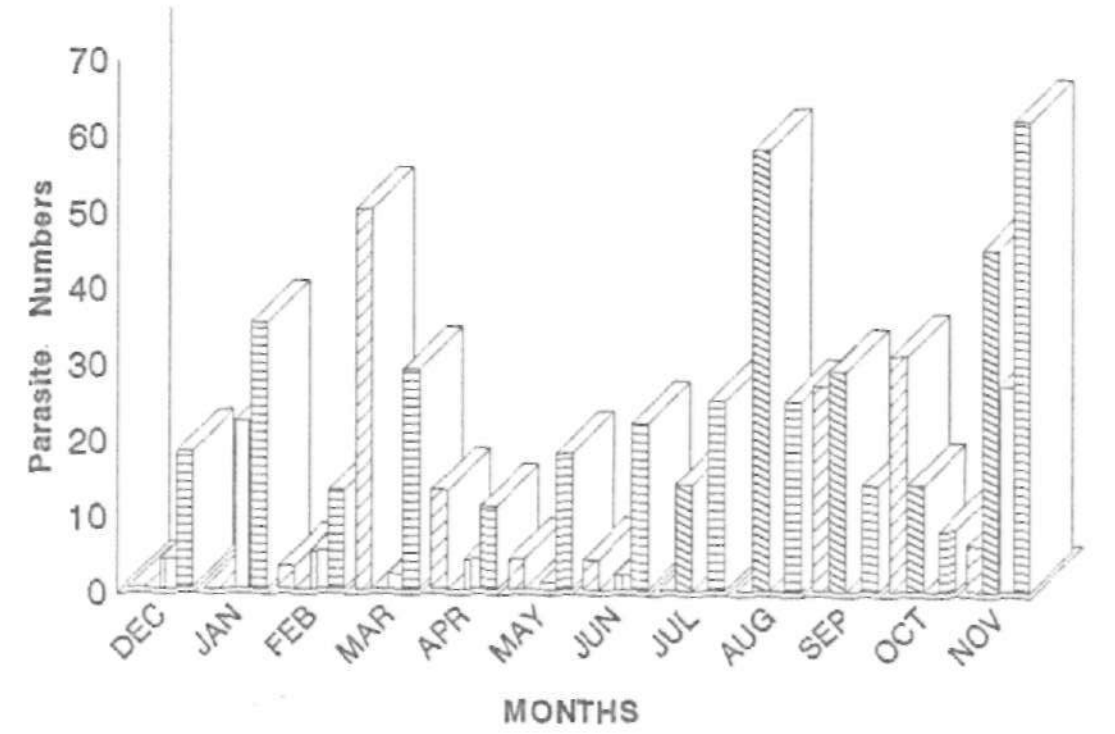


Figure 16: Occurence of parasites in the branchial chamber of male H. b. occidentalis

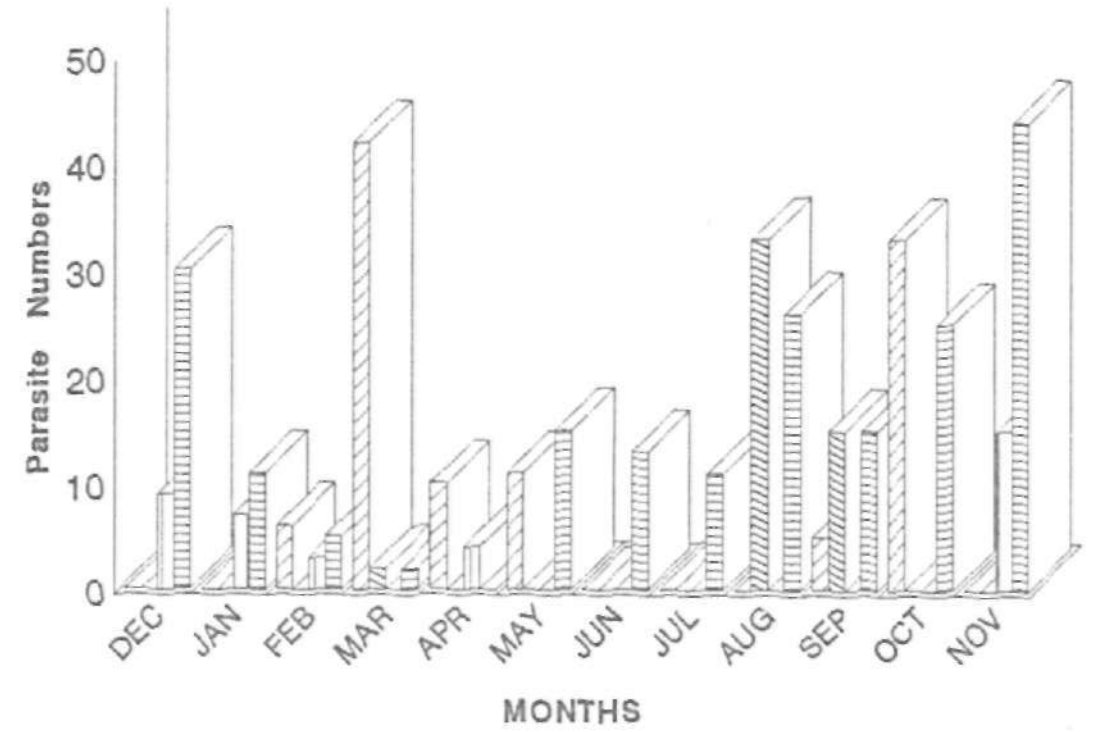


Figure 17: Occurence of parasites in the branchial chamber of female H. b. occidentalis

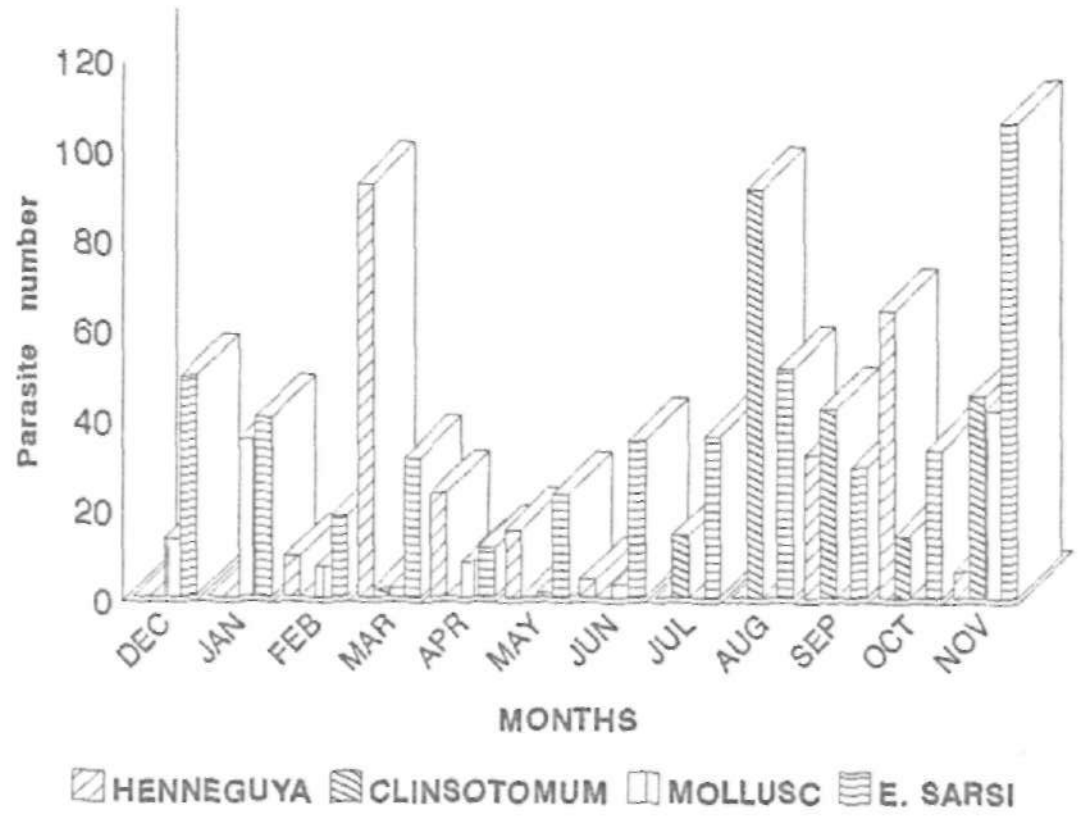


Figure 18: Occurence of parasites in the branchial chamber of male and female H. b. occidentalis (combined)

was higher in gill 1 followed by gill 2, 3 and 4. There was no significant difference in the rate of infection of the male and female fish gills ($P > 0.05$), and the prevalence pattern are similar (Fig..19)

4.7 DESCRIPTION AND PATHOLOGICAL EFFECT OF BRANCHIAL CHAMBER PARASITES OF *H.b. occidentalis*.

4.7.1 **Henneguya cyst**:

The cysts produced by this parasite were whitish or creamish in colour and produced milky discharge when ruptured. They were mostly round or spherical, 0.2-1.0 mm in diameter and attached to various parts of the gill filaments. Sometimes, elongated cysts, 1-4mm in length were found on the fringes of the gill filaments. (Plates I, II and III).

The cyst were formed within one or two to four gill filaments and tended to occlude the surface of the gills. No gross inflammatory reaction or necrosis was observed at the point of attachment, even when cysts were dislodged or broken.

4.7.2 ***Clinostomum complanatum***:

The parasites were found within the gill cavity and not specifically attached to the gills. The few attached ones did not cause haemorrhage on the gill filaments when detached. The parasite, a digenetic trematode, belonging to the family Clinostomatidae, is dorsoventrally flattened, with length and breadth of 2.84mm to 6.15mm and 1.31 mm to 1.87mm respectively. The oral sucker had diameter of 0.12 mm to 0.30 mm and the ventral sucker 0.34 to 0.66 mm. The excretory vessicle is V-Shaped (Plate IV).

4.7.3 **Glochidia (mollusc)**:

The molluscan larvae, probably that of a lamellibranch, were creamish to brownish in colour. The organism broke with a soft "tick" sound on application of pressure with a pin. There were tiny hooks on the ventral rim of the shell.

They were mainly found adhered to the tip of gill filaments where they were partially

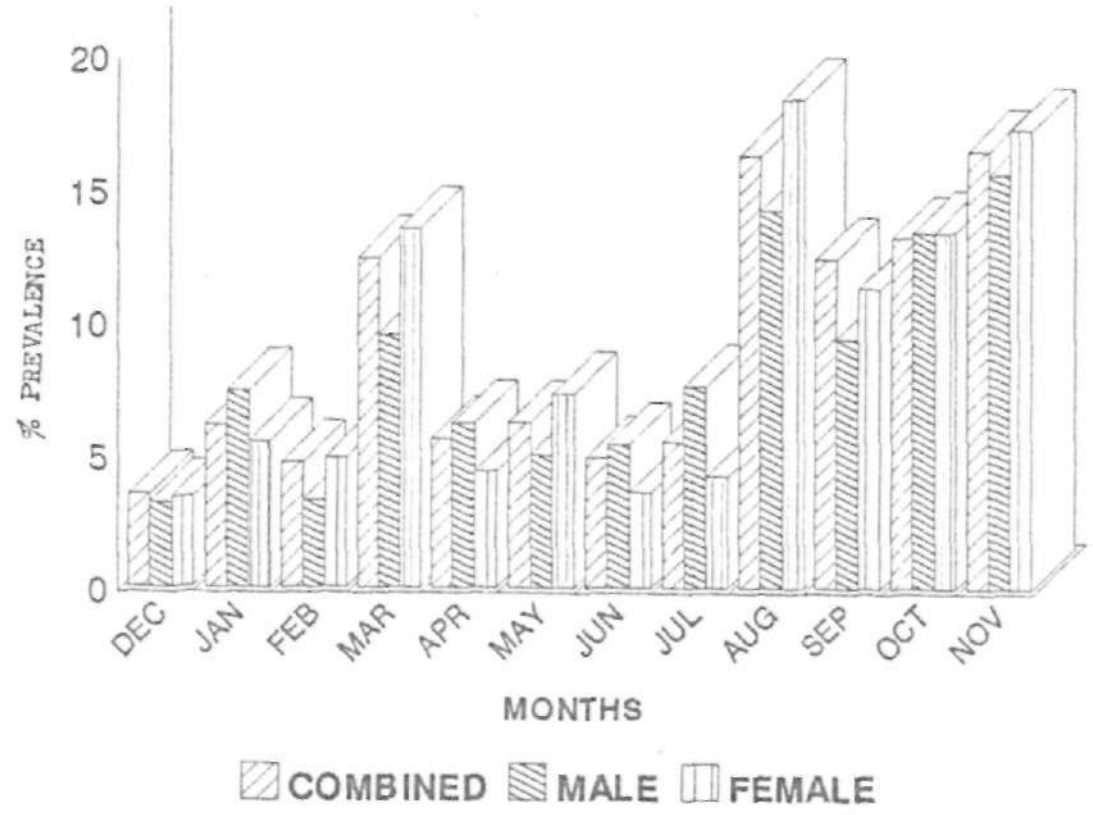


Figure 19: Monthly prevalence of parasites in the branchial chamber of H. b. occidentalis (male, female and combined sexes)



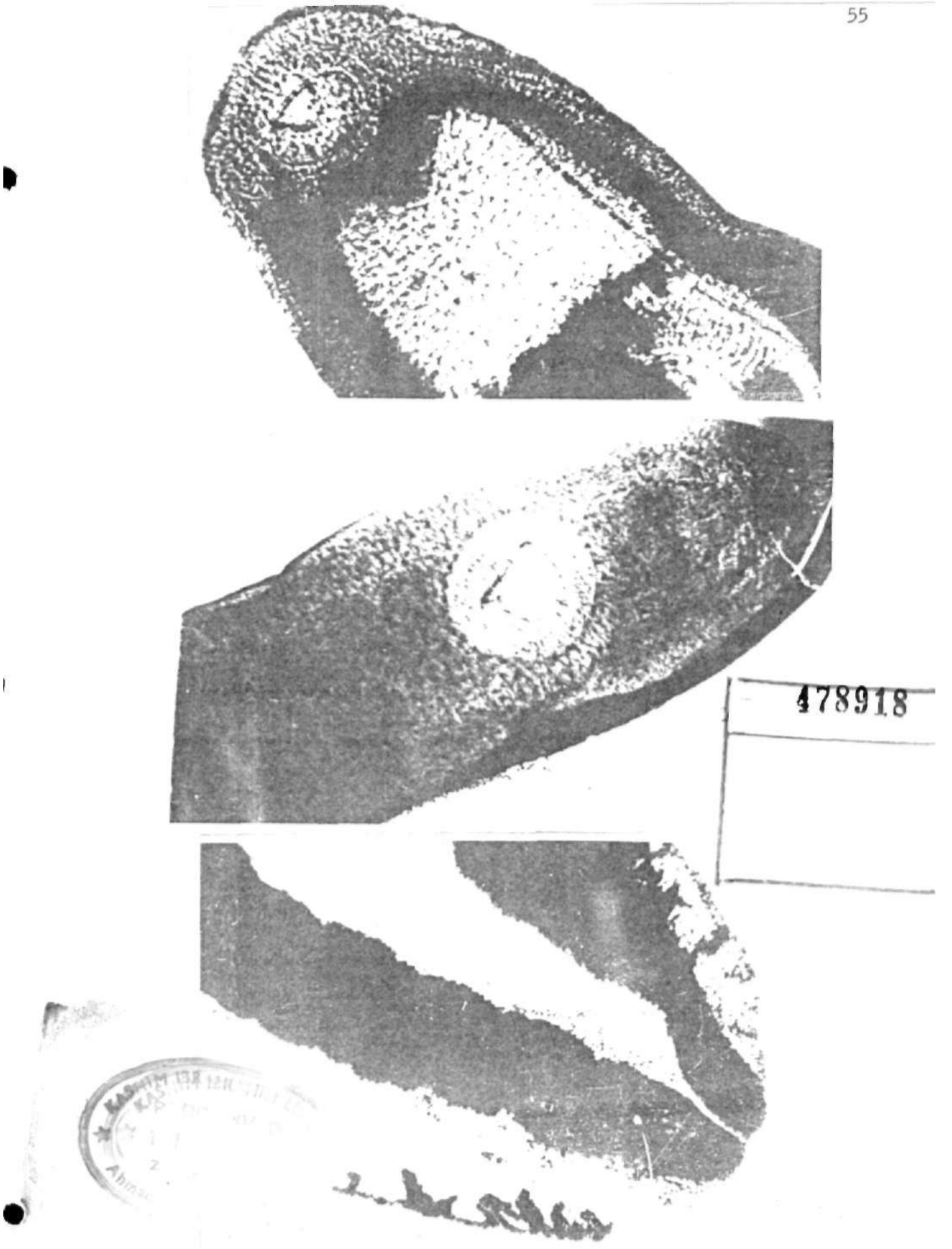
PLATE I: Henneguya cysts at tips of gill filaments of H.b. *Occidentalis* (Mag.X40)



PLATE II: *Henneguya* cyst (arrowed) within gill filaments of *H.b. Occidentalis* (Mag.X40)



PLATE III: *Henneguya* cyst (arrowed) within gill filaments of *H.b. Occidentalis* (Mag.X40)



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PLATE IV: Clinostomum complanatum from gill cavity of *H.b. Occidentalis*

Top=oral sucker
Middle=ventral sucker
Bottom=posterior region(V-shaped)
Magnification X 150

surrounded by the mucous and epithelial tissue of the gill filament and created enlargement (hypertrophy) of the filament (Plates V and VI) and were seen to leave a small round crater when detached from the gill filament.

4.7.4 ***E. sarsi* (females)**:

These are crustaceans that belong to the order Copepoda and family Ergasilidae. All the specimens recovered were females with eggs at different stages of maturation. Body lengths ranged from 0.66 mm to 1.49 mm (Appendix 17). Body is "Cyclop-shaped", the head is fused to the first thoracic segment to form the Cephalothorax, and narrowed towards the posterior tip. There were six thoracic segments, with a pair of egg sacs attached to the sixth. The head had a single reddish median eye towards the anterior end. There were two pairs of segmented antennae, the first is small while the second, used for grasping gill filaments, is large and hook-like.

They were found on various parts of the gills and infection caused hyperplasia of the gill epithelium and the primary filament (Plates VII and VIII).

4.8 PARASITES OF THE GASTROINTESTINAL TRACT OF *H.b. occidentalis*

Out of the 793 *H. b. occidentalis* examined, 642 (60.95%) were parasitised mainly in the intestinal and rectal regions mainly by the acanthocephalan, *Rhadinorhynchus horridus*. A total of 1,205 and 1084 *R. horridus* were found in the GIT of male and female *H. b. Occidentalis* respectively. No significant difference ($P > 0.05$) in parasitic burden within the sexes was observed. Seven specimens of the nematode *Procamallanus laevionchus*, were recovered from the stomach.

The monthly incidence of *R. horridus* in the male fish showed three peaks, November, January and March while the lowest incidence of infection were observed in July and August (Fig. 20). Generally, more *R. horridus* were found in the intestine proper followed by the rectum and the 1st 20mm of the intestine.

In the female fish, the highest mean monthly incidence of *R. horridus* was observed in March, while the lowest was in August (Fig. 21). Generally it appeared that infection rate were higher in the dry season compared to the rainy season. (Fig.21).

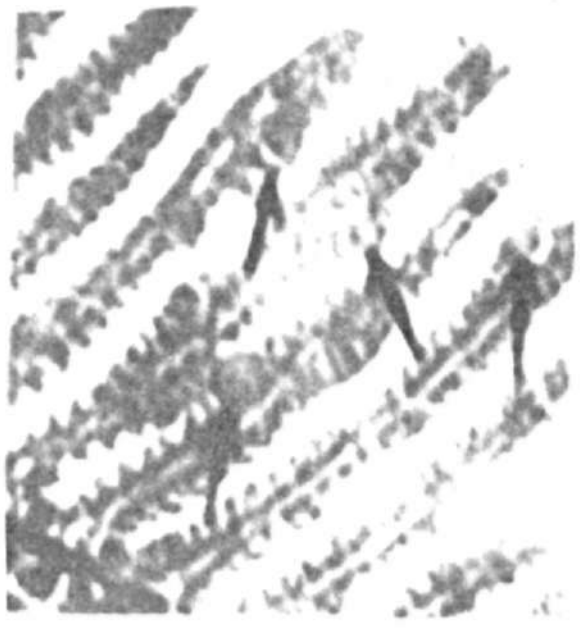


PLATE V: Glochidia of mollusc on gills of *H.b. Occidentalis* (Mag.X40)



PLATE VI: PLATE V: Glochidia of mollusc on gills of *H.b. Occidentalis*, hyperplasia of the gill filament (Mag.X40)

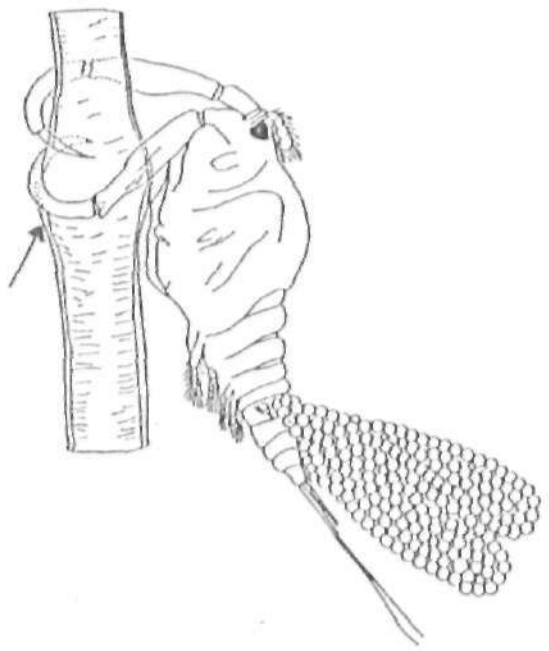


PLATE VII: *E. sarsi* cuasing hyperplasia on a filament
(Mag. x 100)

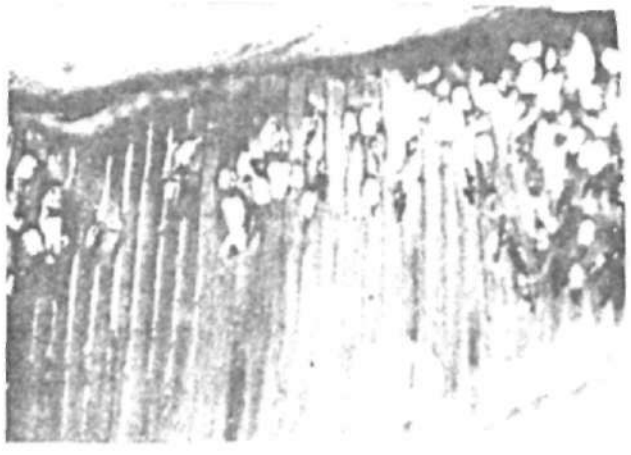


PLATE VIII: *E. sarsi* on gill filaments (Mag:X40)

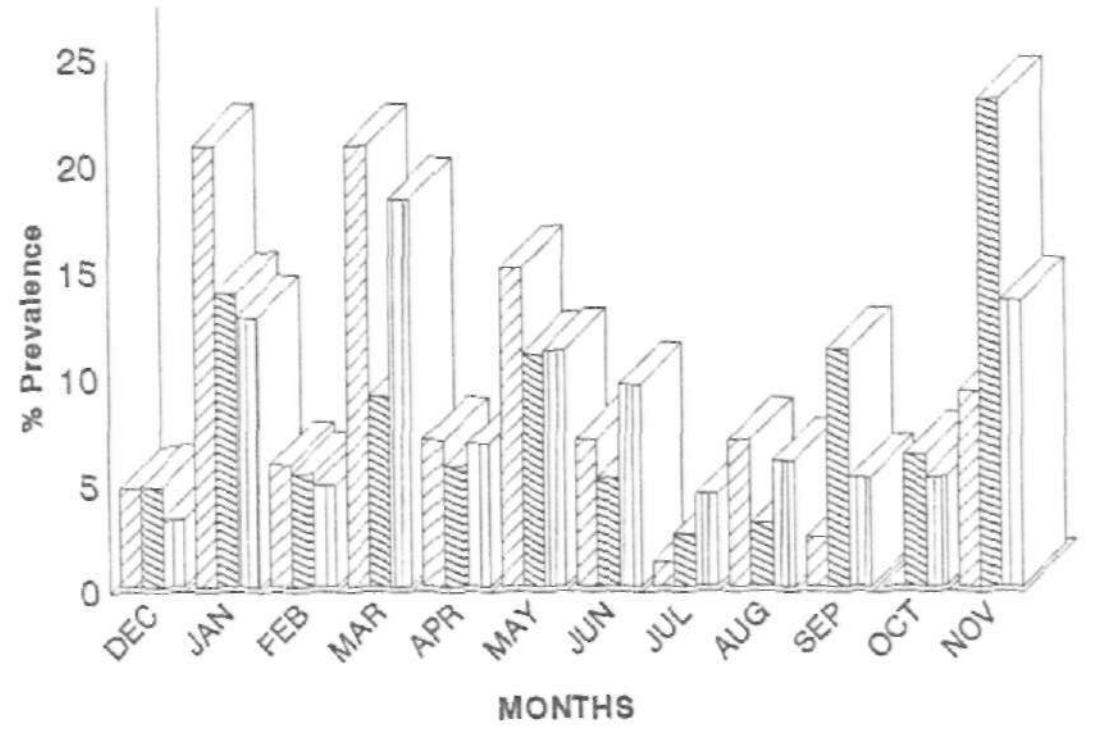


Figure 20: Monthly prevalence of parasites in the GIT of H. b. occidentalis

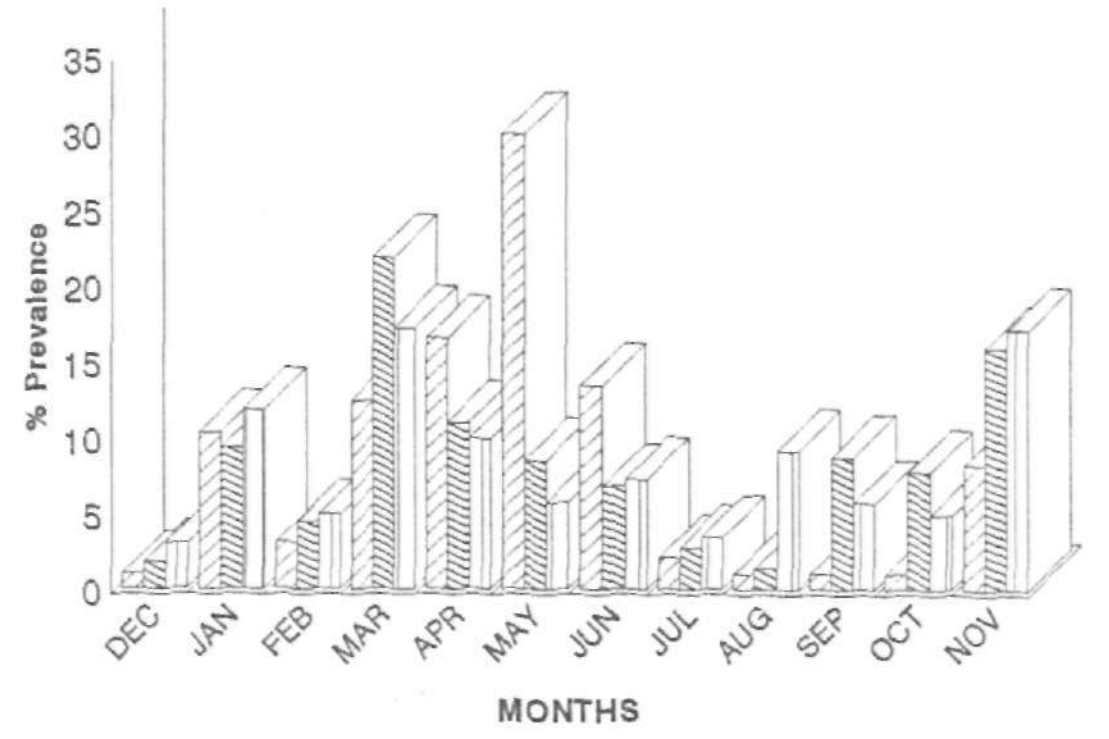


Figure 21. Monthly prevalence of parasites in the GIT female H.b. occidentalis

The overall picture of parasite infection in the GIT of both sexes of *H.b. occidentalis* showed that the mean monthly infection rate was very high (>60%) with the exception of the month of August. The infection rate in different segments of the GIT fluctuated irregularly with the peak of 20% in the first 20mm of the intestine in May (Fig. 22)

Immature acanthocephala were found in the months of March to June, particularly in the 1st 20mm of the intestine; fewer worms occurred in the intestine proper. The mature parasites occurred mainly in the intestine proper and rectum in the months of September to December.

The male to female ratio of adult *R. horridus* in the male as well as in the female fish was 1:4. Generally, the female parasites were more than the male, they featured more in all the segments of the intestine of the fish compared with the male parasites (Figs.23,24 and 25).

There was a positive correlation between the immature and mature acanthocephalla ($P < 0.05$) of the male and female fish. While there was no correlation in monthly infection rate in the male and female fish throughout the year ($r = 0.08$, $P > 0.05$).

4.9 DESCRIPTION AND PATHOLOGICAL EFFECT OF THE INTESTINAL PARASITES OF *H. b. occidentalis*.

4.9.1 *Procamallanus laevionchus*:

The mouth is tiny, slit-like and leads into the esophagus. Length ranged from 5.20 mm to 11.50 mm, while the width ranged from 0.25 mm to 1.15 mm. Larvae were found within the intestinal lumen (not attached to the intestinal wall) (Plate IX).

4.9.2 *Rhadinorhinchus horridus*

The parasite was pale yellow in colour with the length of mature specimen ranging from 9.00 mm to 38.50 mm and width ranged from 0.22 to 1.20 mm. The body is cylindrical, with a proboscis that had 14-16 hooks arranged in longitudinal rows. The hooks at the tip of the proboscis were a bit larger than those within the body (Plate X). Below the proboscis is the neck region which had no hooks or spines, just below the neck region, there are smaller spines and thereafter large spines that differ in sizes (Plates XI,XII and XIII). The male had tapering posterior end while the female had an umbrella shaped

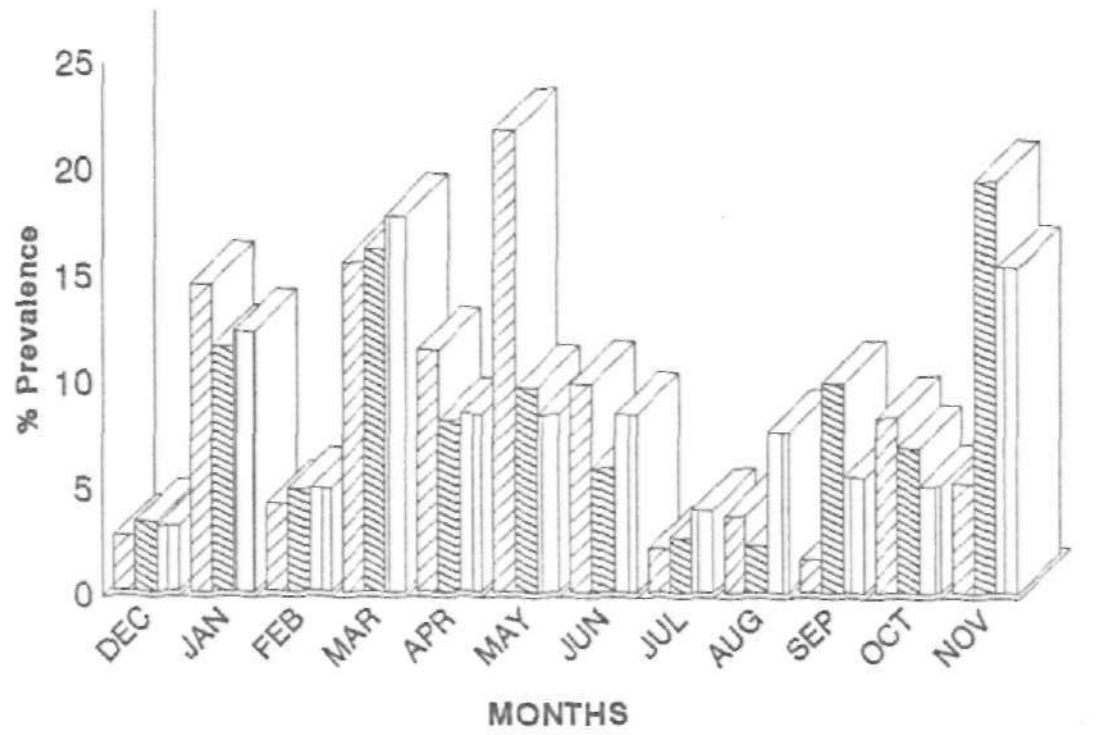


Figure 22: Monthly prevalence of parasites in the GIT of H. b. occidentalis (combined sexes)

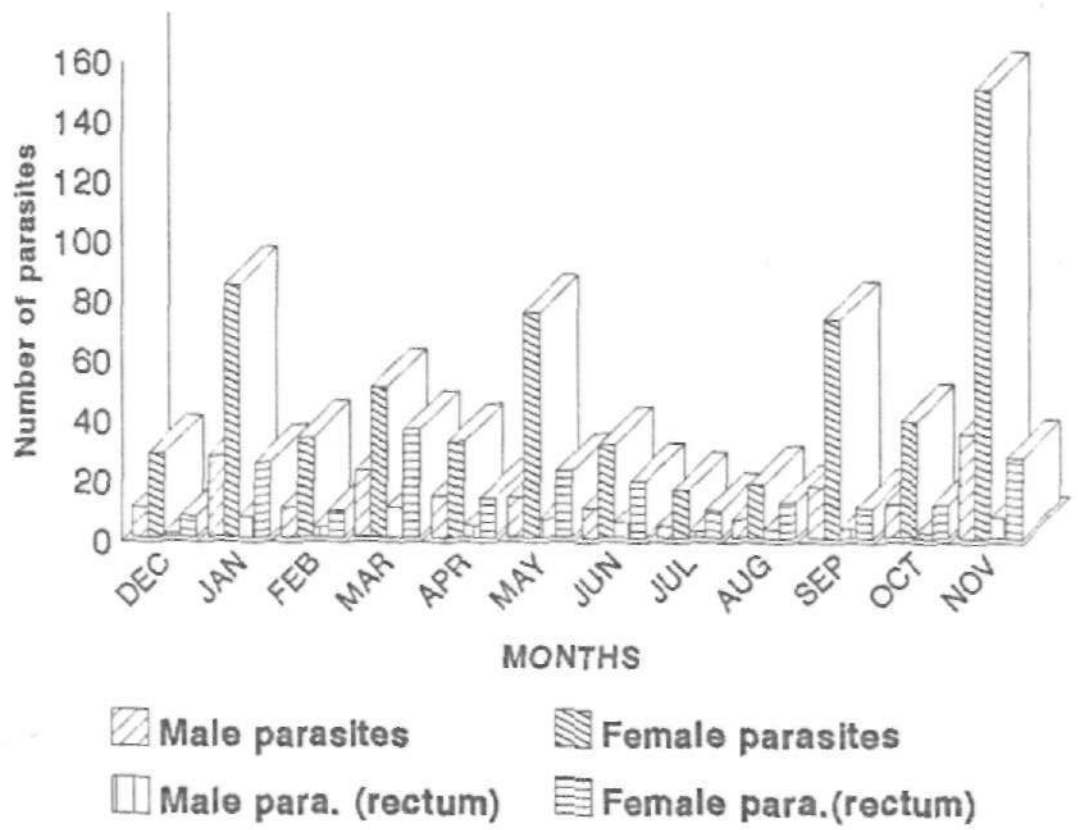


Figure 23: Male and Female Acanthocephalan parasites in the intestine of male H. b. occidentalis

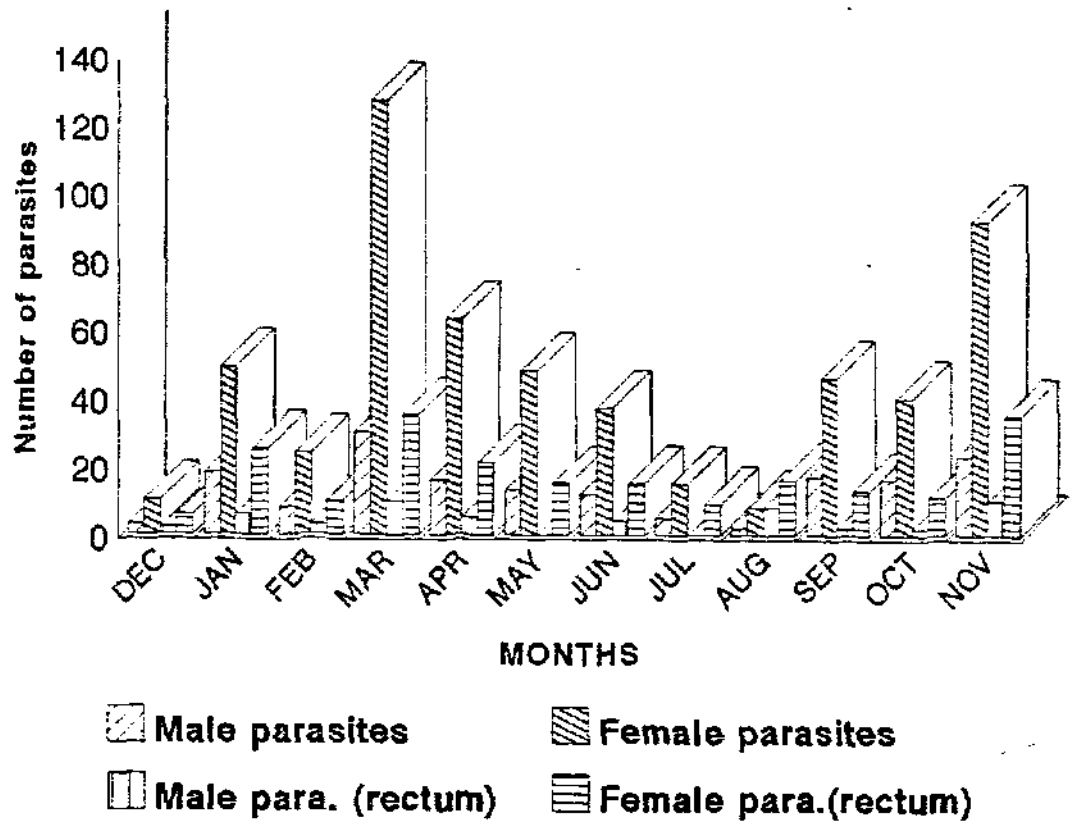


Figure 24: Male and Female Acanthocephalan parasites in the GIT of female H. b. occidentalis

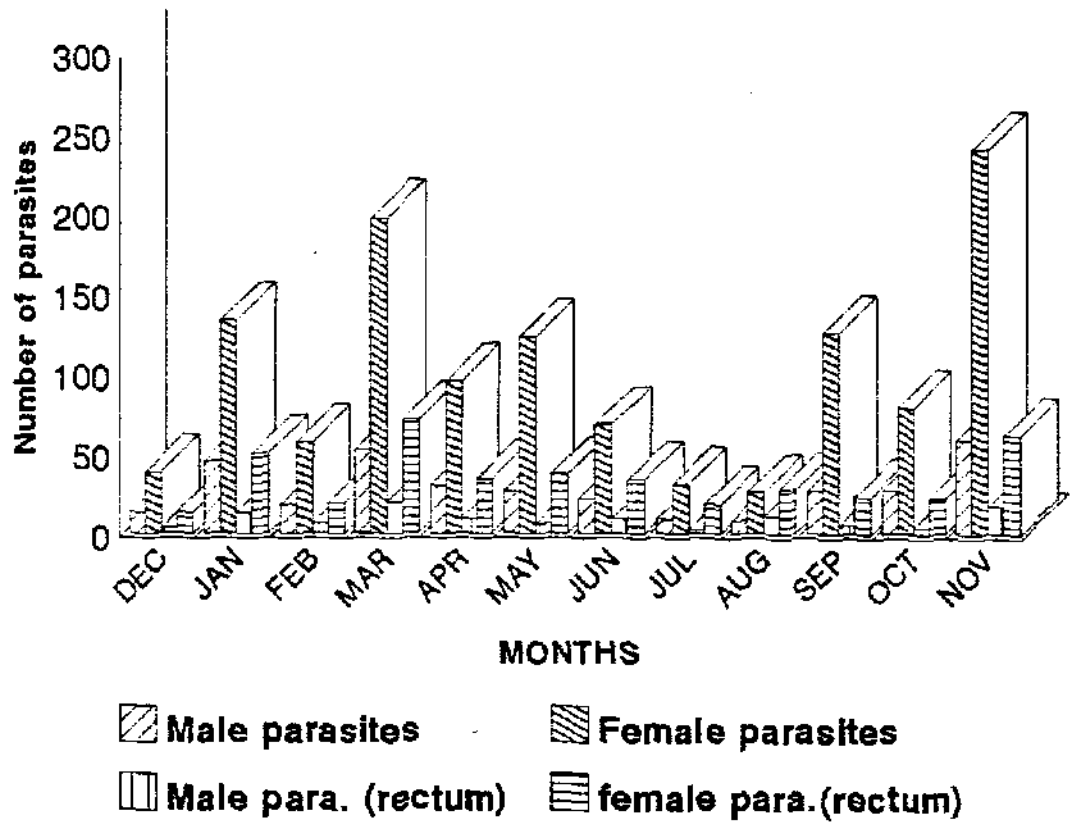


Figure 25: Male and Female Acanthocephan parasites in the intestine of H. b. occidentalis (combined sexes)

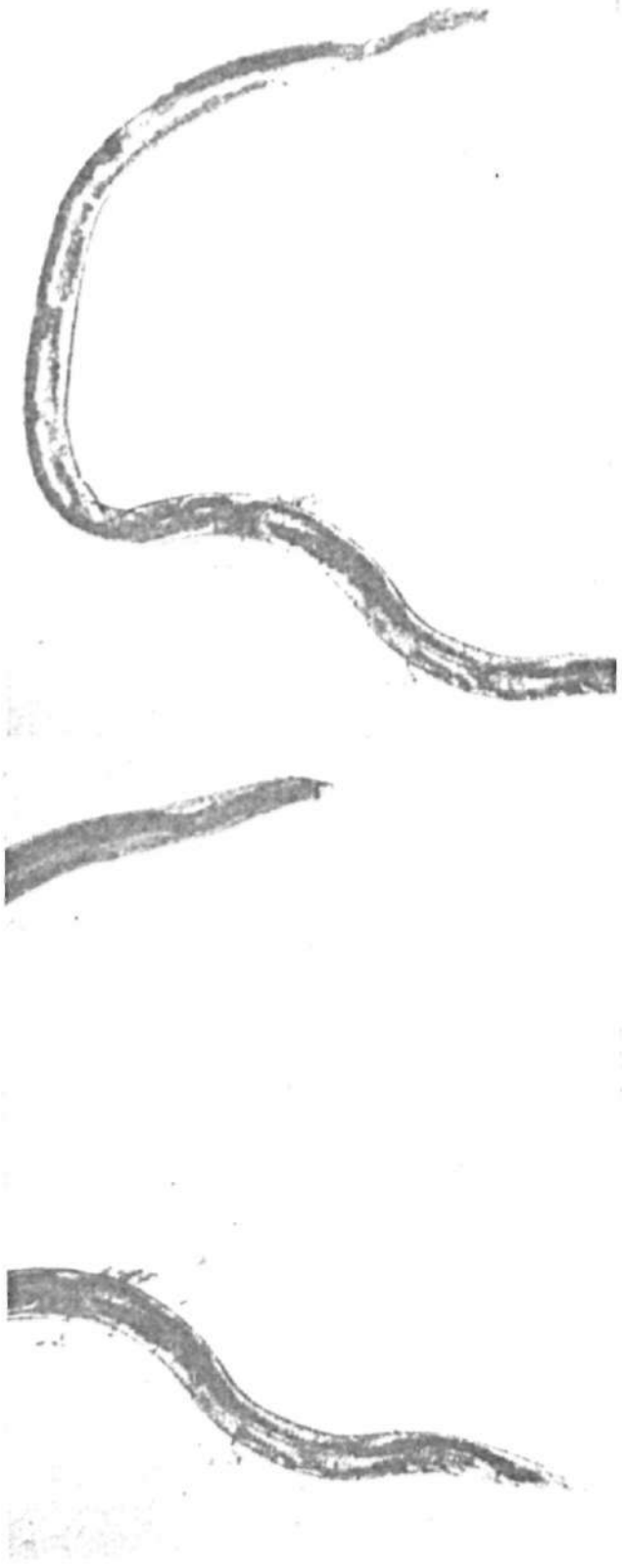


PLATE IX: *Procamallanus laevionchus*-head and tail regions (Mag.X40)



PLATE X: Proboscis of *R.horridus*, showing hooks (Mag.X40)



PLTAE XI: The neck region of *R.horridus*, (arrowed) showing absence of hook between proboscis and lower body (Mag:40)

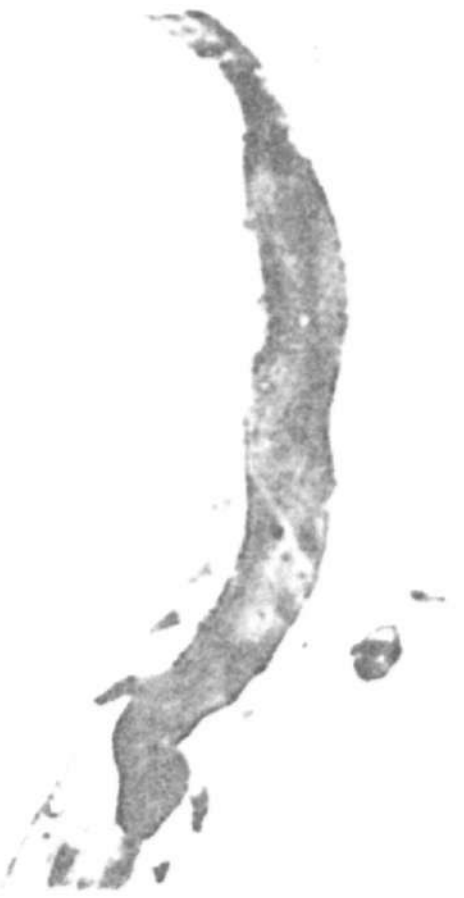


PLATE XII: *R.horridus*(lower part of the body below neck region, with large hooks)(Magnification X 40)

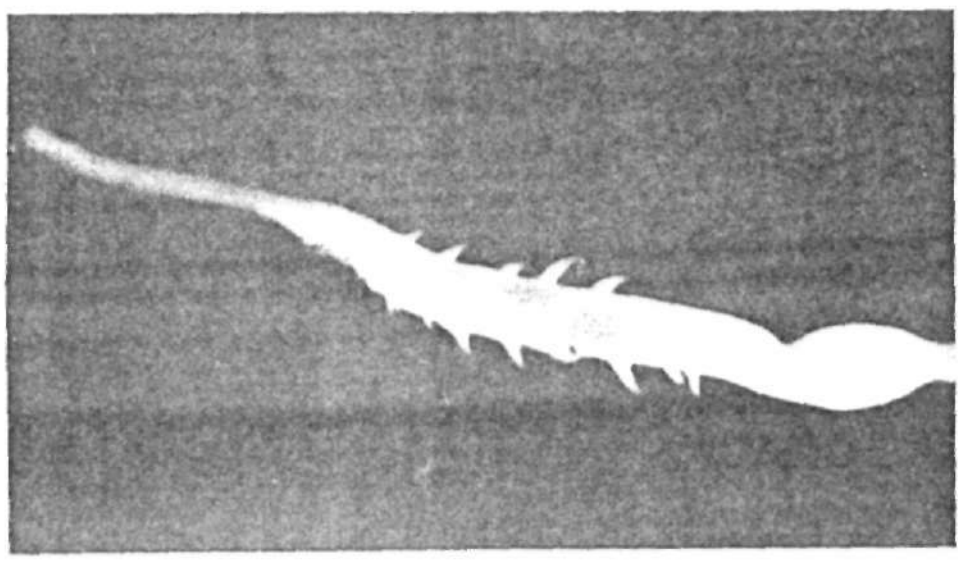


PLATE XIII: *R.horridus*,3/4 part of the body (Magnification X 40)

end. Immature ones had no spines or hooks (Plate XIV) while fairly more mature ones had "Spheroid" structure, just below the body spines, which probably contained the primordia of the internal organs (Plate XV).

Most of the immature parasites were found in the 1st 20mm of the intestine while the mature ones were found mainly lying in the intestine and rectum. In the intestine, some spiny proboscis were inserted into the intestinal wall where destruction of intestinal mucosa and connective tissues were observed (Plates XVI and XVII). Some fish had as many as 37 acanthocaphala in their intestine.

4.10 RELATIONSHIP BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *H.b. occidentalis* AND PHYSICO-CHEMICAL PARAMETERS OF ZARIA DAM

There was a significant relationship between the *Henneguya* sp. and the pH of water in Zaria dam. No significant correlation existed between the parasite and other physicochemical parameters determined (Table 5). For instance, in March when the infection rate of Heneguya was highest, the pH of the Zaria dam was slightly acidic (Lowest) - pH 5.5. In July, the *Henneguya* was not found in the branchial chamber of *H. b. occidentalis* and the pH then was highest (alkaline) i.e. pH 8.1.

In the months of April, May and June when dissolved oxygen was very low *Clinostomum* sp. was absent in the fish.

4.11 RELATIONSHIP BETWEEN THE INTESTINAL PARASITES OF *H. b. occidentialis* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM.

There was no significant relationship between *R. horridus* and Physicochemical parameters of Zaria dam ($P > 0.05$)

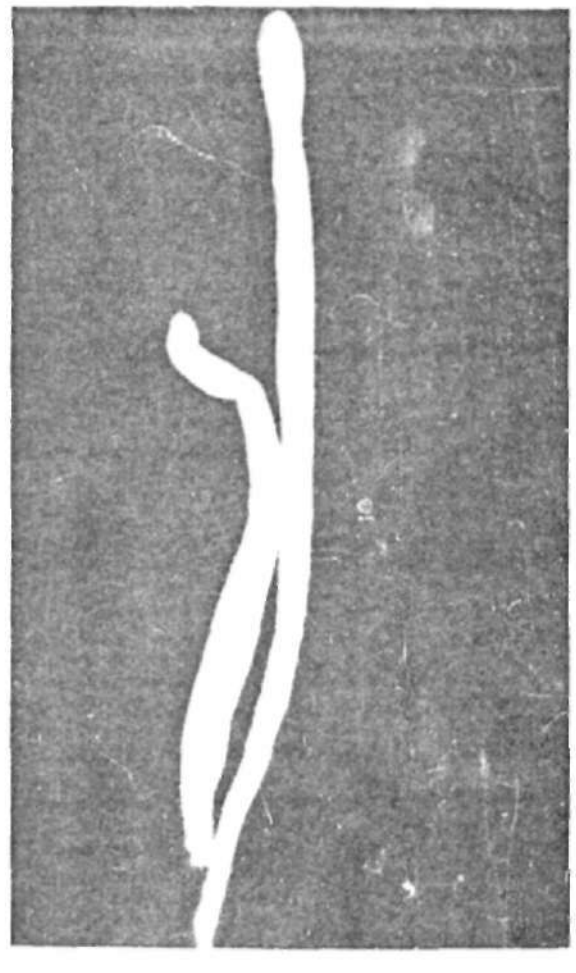


PLATE XIV: Immatured *R.horridus*,(Mag:X40)

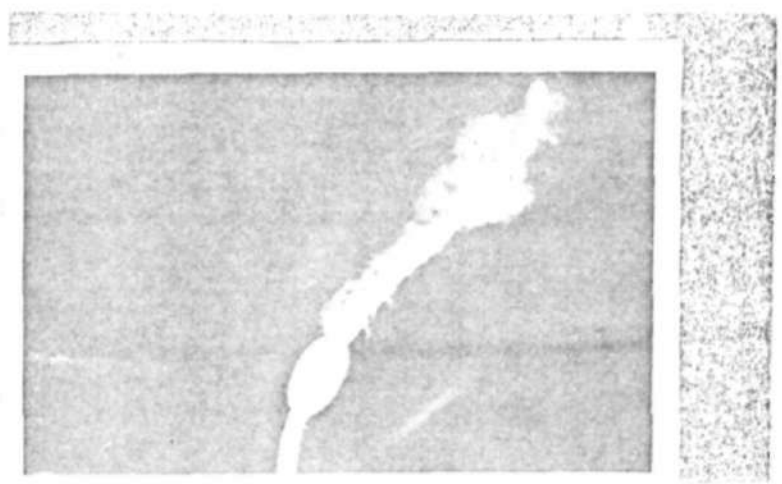


PLATE XV: *R.horridus*, (More matured than in PLATE XIV)
Note: the spheroid structure and FIT Tissue around proboscis (Mag: X40)



PLATE XVI: *R.horridus*, proboscis in the intestinal wall arrowed (Mg.X40)



PLATE XVII: Destroyed intestinal layer by *R.horridus*, (Mucosa, lamina propria and Muscularis layers destroyed) Magnification x 150.

TABLE 5 CORRELATION COEFFICIENT BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *H.b. occidentalis* WITH PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM.

	Physico-chemical Parasites							Climatological	
Parasites	Turbidity	pH	Temp	Fe	Mn	NO_3^-	Cl^-	Rain	Air Temp.
Henneguya	0.3295ns	0.6103*	0.3981ns	0.0984ns	0.2885ns	0.2897ns	0.2997ns	0.2904ns	0.5494ns
Clinostomum	0.3177ns	0.1899ns	0.0686ns	0.8082**	0.5567ns	0.0877ns	0.6463*	-.39144ns	0.2968ns
Mollusc	0.4556ns	0.0625ns	0.4377ns	0.0729ns	0.0164ns	0.5723ns	0.0019ns	0.5309ns	0.5860*
E. sarsi	0.2556ns	0.2674ns	0.2477ns	0.4566ns	0.2918ns	0.2106ns	0.4890ns	0.0881ns	0.6299*

* = Significant at $P < 0.05$
** = " " $P < 0.01$ and 0.05
ns = not significant ($P > 0.05$)
when $P \leq 0.05$ = significant
when $P > 0.05$ = not significant.

4.12 RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *H. b. occidentalis* AND BRANCHIAL CHAMBER PARASITES.

The branchial chamber parasites of the juvenile fish (15.1-22.0 cm) had highest infection rate (75.19%) then the adult (29.1 cm and above) had 68.24%. The least infection rate (54.9%) was observed in the sub-adult (22.1-29 cm) (Appendix 6). The parasite *E. sarsi* appeared in all the age groups. The glochidia were mainly found in the adult fish.

4.13 RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *H. B. occidentalis* AND INTESTINAL PARASITES

The intestinal infection of *H. b. occidentalis* was mainly by *R. horridus*. The percentage infection of the juveniles, sub-adult and adult were 58.91%, 63.22% and 69.57% respectively. There was no significant difference ($P > 0.05$) between the rate of infection amongst the age groups (Appendix 7).

4.14 RELATIONSHIP BETWEEN THE FEEDING HABIT OF *H. b. occidentalis* AND BRANCHIAL CHAMBER PARASITES.

In March, chironomid larvae and ostracods featured prominently in the diet of the fish but the seed component of the diet was very low. However, in October, the commonest food items were the seeds, lamellibranchs, gastropods and ostracods.

The highest infection period of *Clinostomum* sp. was in August. This gradually diminished from September to November. During this period, the most important food items were gastropods, lamelli branchs, ostracods and chironomids. The period also coincided with the highest feeding intensity of the fish.

The glochidia (mollusc) parasites occurred mainly in November to January. During this period, the lamellibranchs and the gastropod food items have started to decrease while the ostracods increased.

E. sarsi occurred throughout the year as gill parasites but its infection rate peaked in November which coincided with the period when ostracods and chironomids were abundant

in the diets of the fish, during this period the feeding intensity of the fish was also fairly higher.

4.15 RELATIONSHIP BETWEEN FOOD AND FEEDING HABIT OF *H. b. occidentalis* AND OCCURRENCE OF INTESTINAL PARASITES

The prevalent parasite in the intestine of the fish was *R. horridus* which occurred throughout the year. The lowest infection rates (61.54% and 44.49%) were observed in July and August respectively, a period which coincided with a decline in the rate of consumption of ostracod and chironomid larvae. This period also coincided with high feeding intensity in the fish. Parasitic invasion of the intestine was highest in March, the chironomid and ostracod consumptions were high, and the feeding intensity of the fish was 62.5%.

4.16. RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *H. b. occidentalis* AND PARASITES OF THE BRANCHIAL CHAMBER

Mature gonads of *H. b. occidentalis* were mainly found in the months of July, August, September and October, during which period the infectivity rate of parasites of the branchial chamber was high. Infection with *Clinostomum* was also highest in August. *Henneguya* sp. and *E. sarsi* constituted a very high percentage of the branchial chamber parasites, they had the highest prevalence in March and November respectively. Stages I and II gonads were observed in November.

4.17 RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE AND PARASITES OF THE INTESTINE OF *H. b. occidentlis*.

The incidence of *R. horridus* in the intestine of *H. b. occidentalis* was higher in the dry season than in the rainy season. The mature gonads were found between July and October, that is, the peak rainy season. Therefore in the dry season when the incidence of the parasite was highest, immature gonads (stages I -III) were prevalent.

4.18. LENGTH-WEIGHT RELATIONSHIP IN *M. rume*.

The length-weight relationships of *M. rume* showed that the exponent 'b' in male and female fish were 2.52 and 0.715 respectively (figs. 26 and 27). The exponent of the female of *M. rume* gave a result indicating negative allometric growth i.e. as they grow larger they tend to become thinner.

Analysis of variance showed a high positive correlation between the length and weight of the male fish ($P < 0.05$), while in the female fish, it was a negative correlation ($P > 0.05$).

4.19 FOOD AND FEEDING HABIT OF *M. rume*

Table 6 shows the food items of the stomach of *M. rume*. Insect formed 82.3% of the food items by the points method. The most important of the insects were the chironomid larvae (31.5%) and the trichopteran larvae (22.5%). Other insects of considerable importance were dragonfly nymph, heleidae larvae and ephemeropteran nymph. Other important items in the stomach included the oligochaetes (4.4%), sandy material (3.4%) and detritus (3.7%).

The monthly variation in the food items are shown in Fig. 28. The chironomid larvae which were the dominant food item in the stomachs examined (Table 6) was present throughout the year but decreased in the diet of the fish between the months of April and July. The peak period during which the trichopteran larvae were consumed (July to November) also coincided with the peak consumption period of dragonfly nymphs, oligochaetes, ephemeropteran nymph and sandy material.

In the months of December to May when the sandy material were absent, the trichopteran larvae and dragonfly nymphs were considerably reduced, however, the chironomid larvae were abundant.

The feeding pattern showed high feeding intensity (> 50%) throughout the year. Generally, the lowest feeding period was in December and January while the highest was in June to November (fig.29).

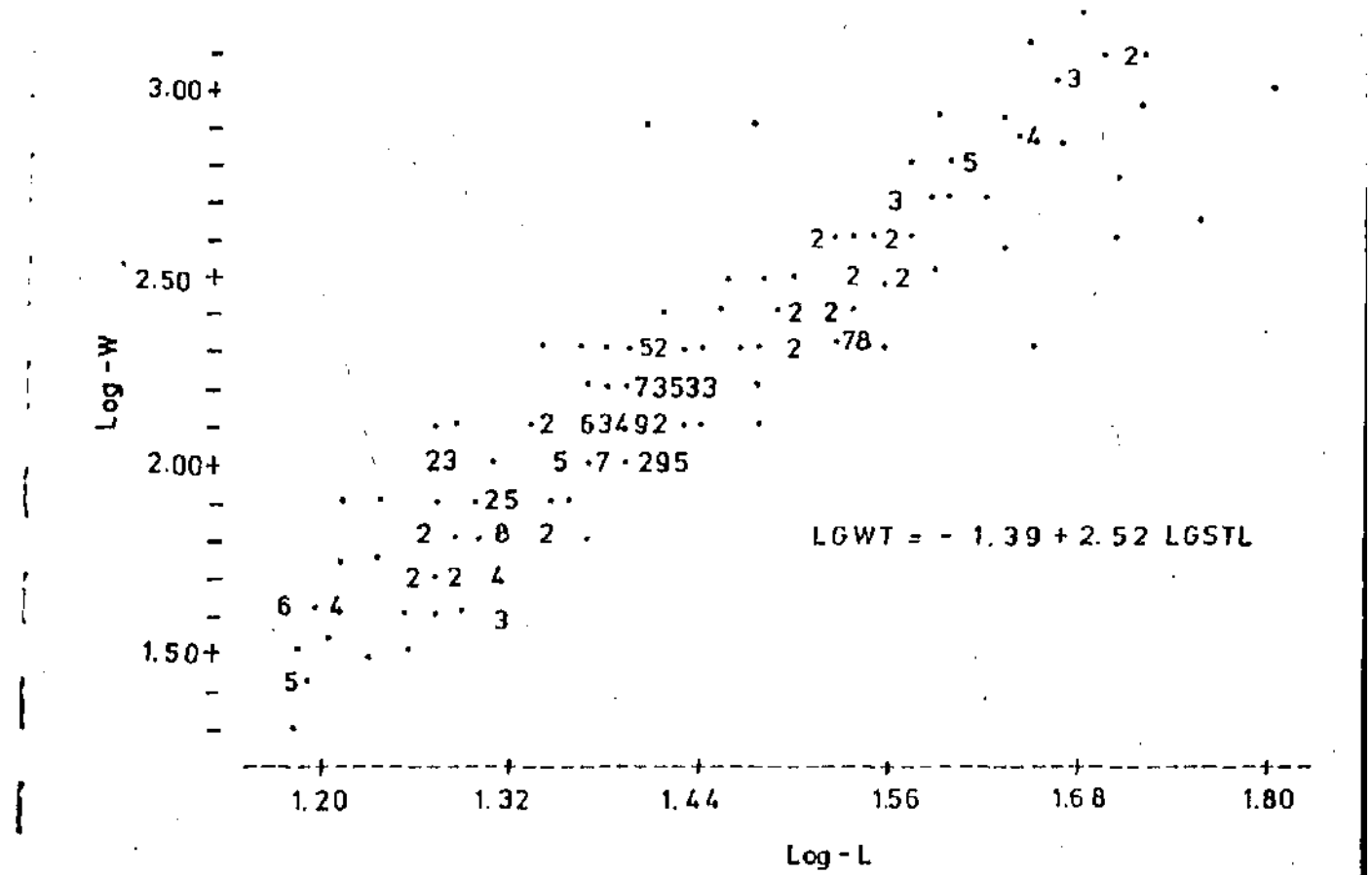


FIG. 26 Length - weight relationship of *M. rume* (male)

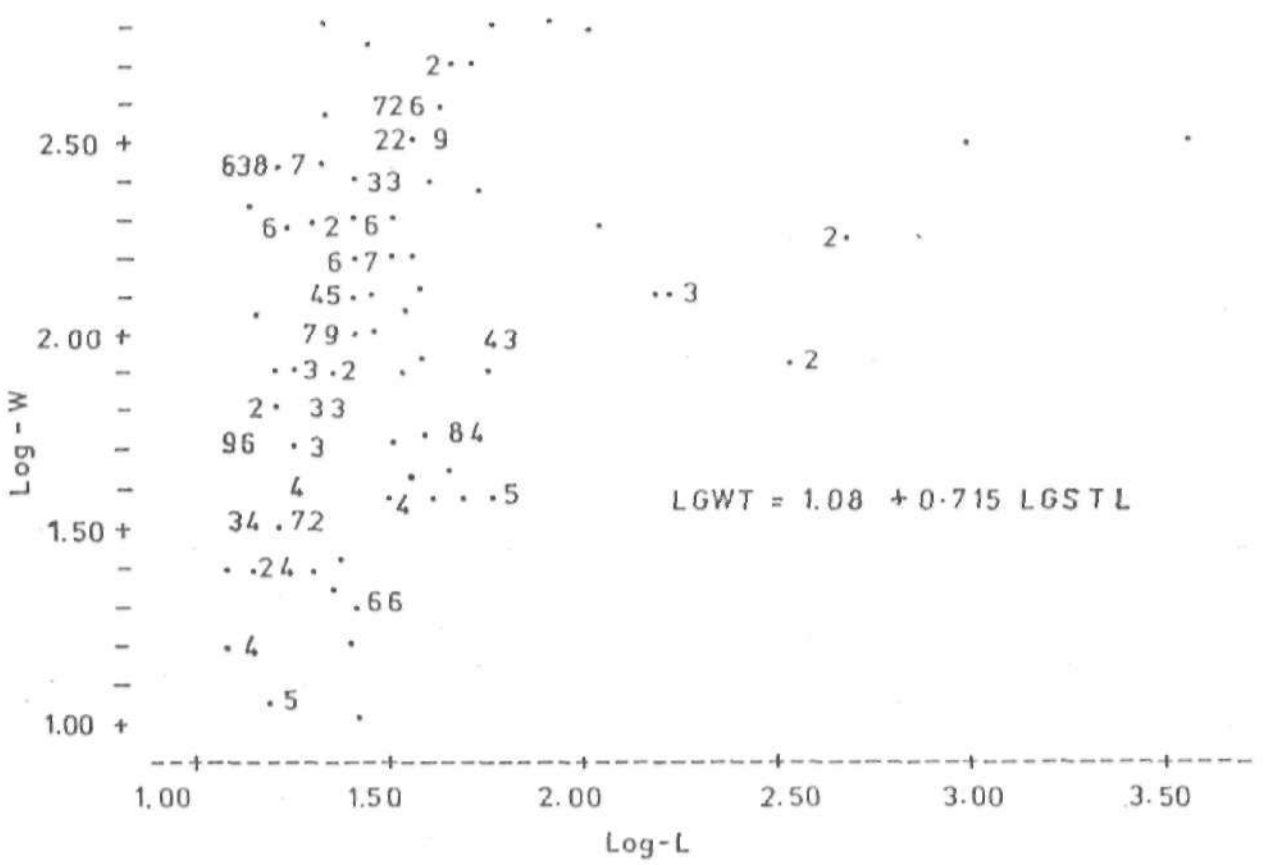


FIG. 27 Length - weight relationship of *M. rubio* (female)

Table 6: FOOD ITEMS IN THE STOMACH OF *M. rume*

	Food items	% frequency of Occurrence	% total point
Adult Insect	Insect remains	48.5	11.9
	Coleoptera	3.7	.8
	Coleoptera larvae	7.4	1.3
	Ephemeroptera Nymph	12.1	6.6
	Dragonfly Nymph	15.4	4.0
	Trichoptera larvae	49.1	22.5
Immature Insect	Chironmid larvae	75.5	31.5
	Chironomid pupae	10.8	1.7
	Chaoborus pupae	2.8	0.3
	Heleidae Larvae	15.1	2.6
Crustacean	Ostracods	1.2	0.1
	Clam shrimps	3.1	0.7
Arachnida	water Spider	1.4	0.2
Mollusc	Gastropod	2.9	0.2
Annelids	Oligochaetes and Tubifex	10.2	4.4
	Sandy Material	13.2	3.4
	Detritus	12.8	3.7
	Plant remains	9.8	0.6
	seeds	18.6	2.5

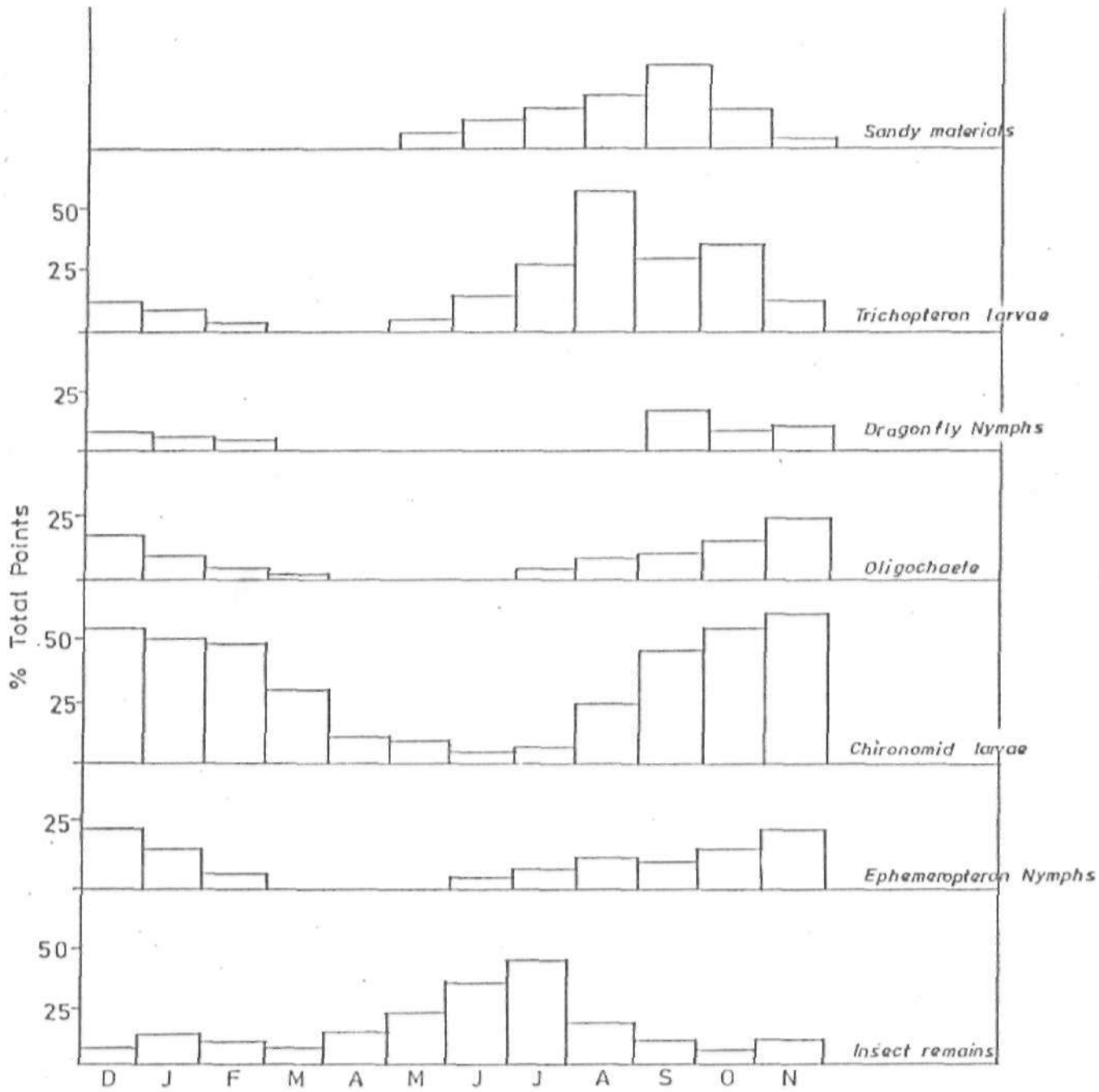


FIG. 28: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH OF *M. rume*.

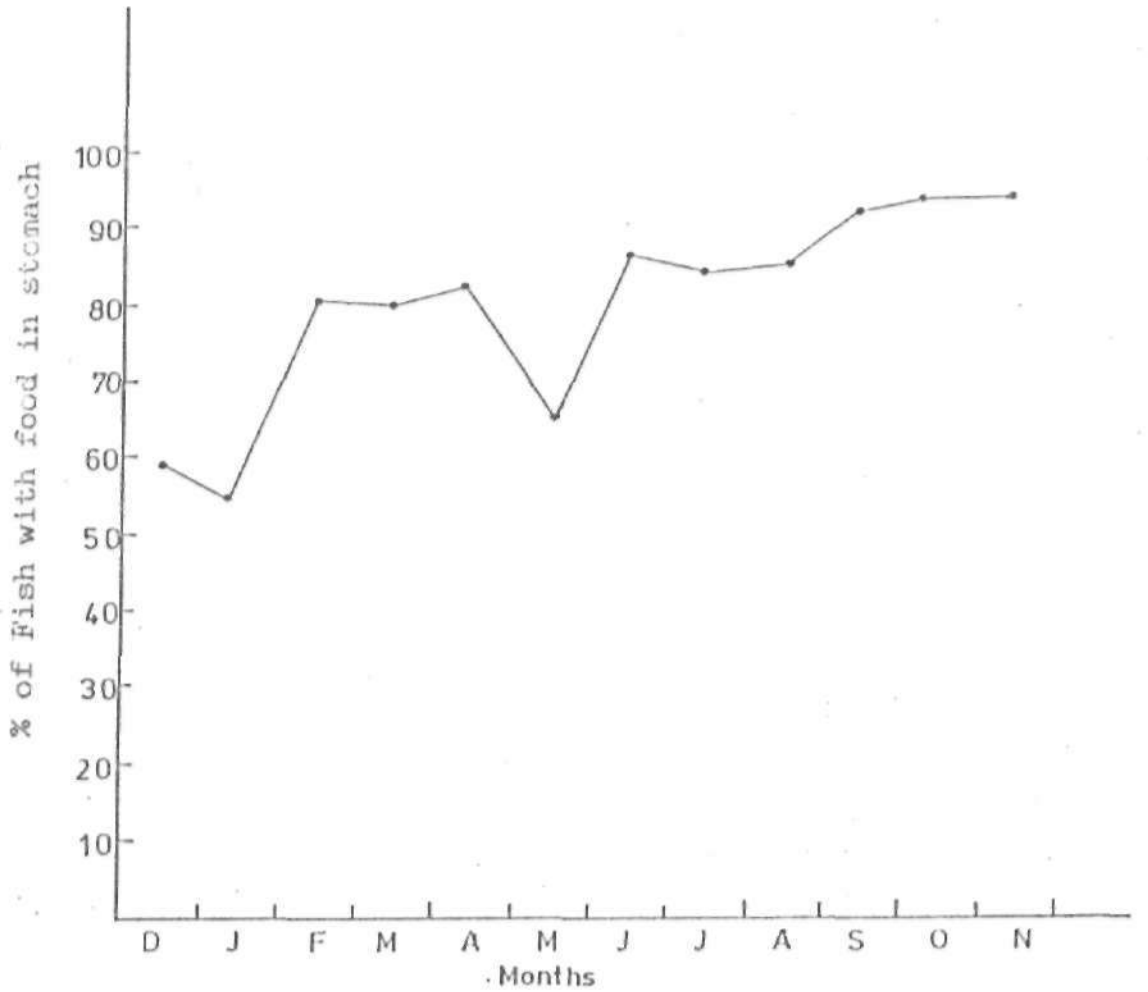


FIG. 29: FEEDING INTENSITY OF *M. rume*.

4.20 REPRODUCTIVE CYCLE AND FECUNDITY ESTIMATE IN *M. rume*

Figs. 30 and 31 shows the stages of gonad maturity in *M. rume*. Mature gonads stage IV of *M. rume* were found in July, August, September and October in the male and female and only two were found in October. The spent gonads (stage VI) were mainly found in September and October in the female fish. The stages I and II gonads (virgin and immature) were found throughout the year, (prominent in November to March in the male, October to May in the female).

The fecundity estimate of *M. rume* (appendix 3b) showed that it ranged between 1073 to 2899 eggs in mature fish. Fish with the longest length did not have the highest fecundity estimate.

4.21 PARASITES OF THE BRANCHIAL CHAMBER OF *M. rume*

662 *M. rume* comprising 284 males and 378 females were examined in this study. A total of 4,377 parasites with 92.96% incidence of infection were found in the branchial chamber of 264 male fish, and 2,490 parasites with 91.80%, were found in 347 female fish (Appendix 9a,b and c). The level of infection of male fish was significantly higher ($P<0.05$) than their female counterparts.

Afrolernaea nigeriensis, larvae of *Tabanus* sp. and *Hemeguya* sp. were found on the gills, whilst *Philometra beninensis* were found in the inner surface of the operculum.

In male fish the infection rate of the first gill arch was significantly different from those of the 2nd, 3rd,and 4th ($P < 0.05$). But the rate of infection between the 3rd and 4th gill arches were not significantly different ($P > 0.05$). In female fish, there were significant differences between the 1st gill arch and the others ($P< 0.05$), but no significant differences in the rate of infection of the 2nd, 3rd and 4th gill arches.

The monthly occurrence of *A. nigeriensis* in the male and female fish showed that highest infection of the gills was observed in June and July respectively, and which increased gradually until October when the peak infection was noticed in male fish. Peak infection occurred in November in the female fish. High infection rates in both sexes continued until March after which period a drastic decline was observed. Lowest infection period in male

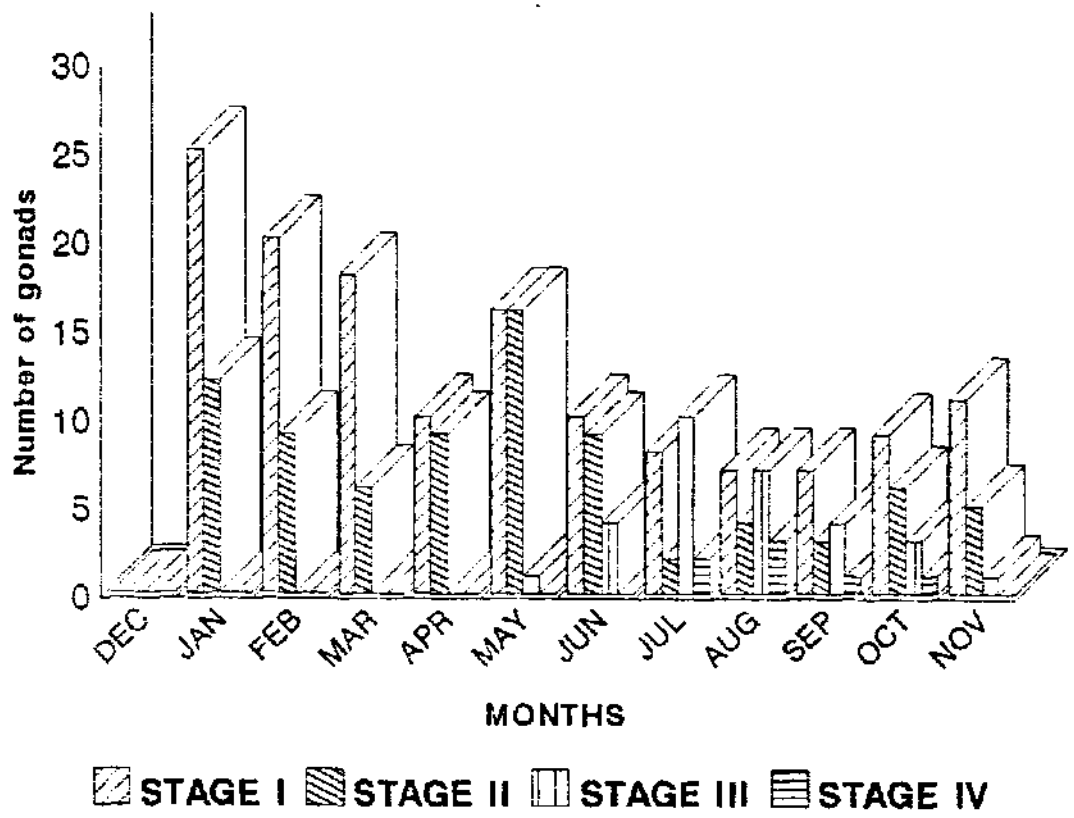


Figure 30: Stages of gonad in male M. rume
M. rume (male)

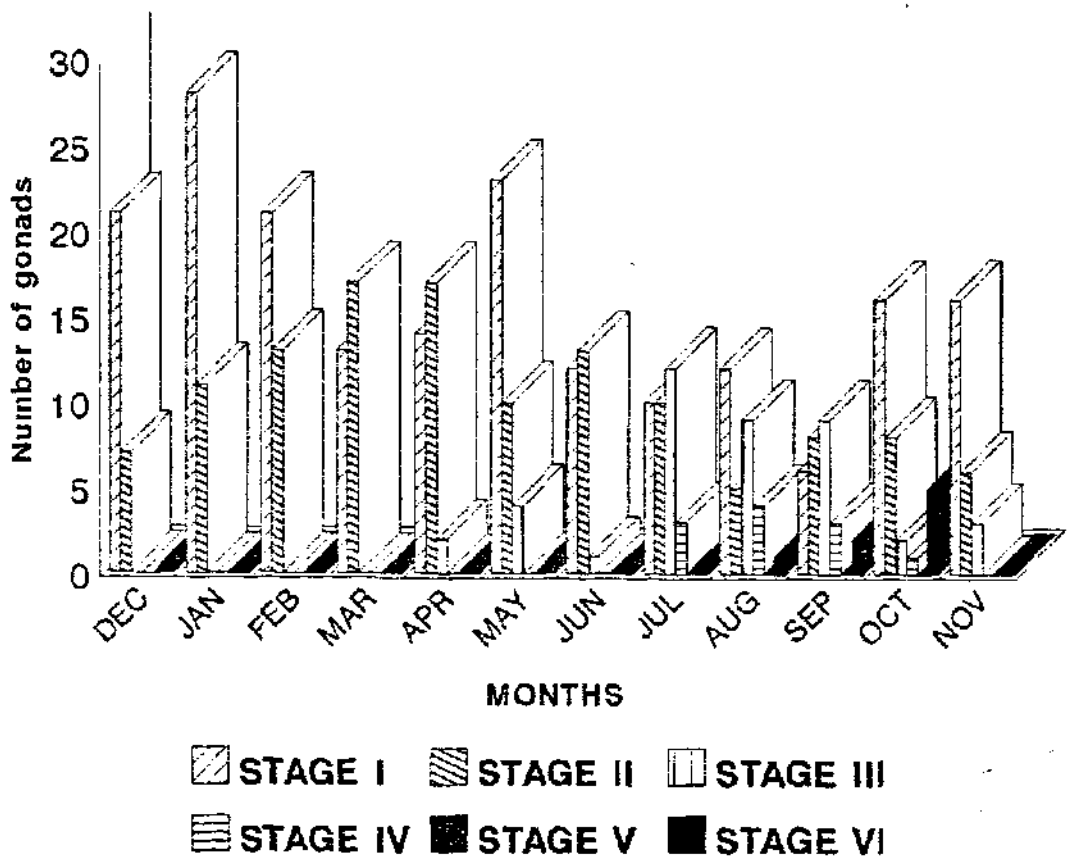


Figure 31: Stages of gonad in female M. rume

fish occurred between April and June, and in March in female fish (Figs. 32, 33 and 34).

The infection period of *Tabanus* sp. larvae was in September and October in male fish and November to January in female fish.

Henneguya sp. was generally present throughout the year on the gills of *M. rume* with parasite load levels highest in April after which they decreased from July to September (fig. 34), a period which coincided with the rainy season.

Monthly infection rate of the parasites (Fig. 35) showed that the fish had higher parasitic load in the months of December to March with a peak in January. The highest number of parasites recovered (6,234) was *Afrolernaea nigeriensis*, followed by *Henneguya* sp. (310), then *Tabanus* sp. (184) and lastly, *Philometra* sp. (139).

4.22 DESCRIPTION AND PATHOLOGICAL EFFECT OF BRANCHIAL CHAMBER PARASITES OF *M. rume*

4.22a. ***Henneguya* sp.:-** The pathology inflicted in *M. rume* by this parasite was similar to that in *H. b. occidentlis*, in 4.7.1.

4.22b ***Philometra beninensis*** (Obiekezie, 1986)

This nematode parasite (Dracunculoidea) was found as coiled parasites beneath the integument of the inner surface of the operculum. Motile larvae of the parasite were found within the whole length of the adult parasite.

The length of the parasite ranged from 12.50 mm to 33.70 mm while the width ranged from 4.00mm - 11.5 mm. The mean length of the larvae was 0.22mm (Plates XVIII, XIX and XX).

The parasite caused expansion of the thin epithelial tissue of the inner surface of the operculum.

4.22c: ***Tabanus* sp. larvae**

Eighteen *Tabanus sp.* larvae were found, mainly on the filament of the 1st gill arches attached to basal region of the gill filaments. Others were found just on the gill filaments

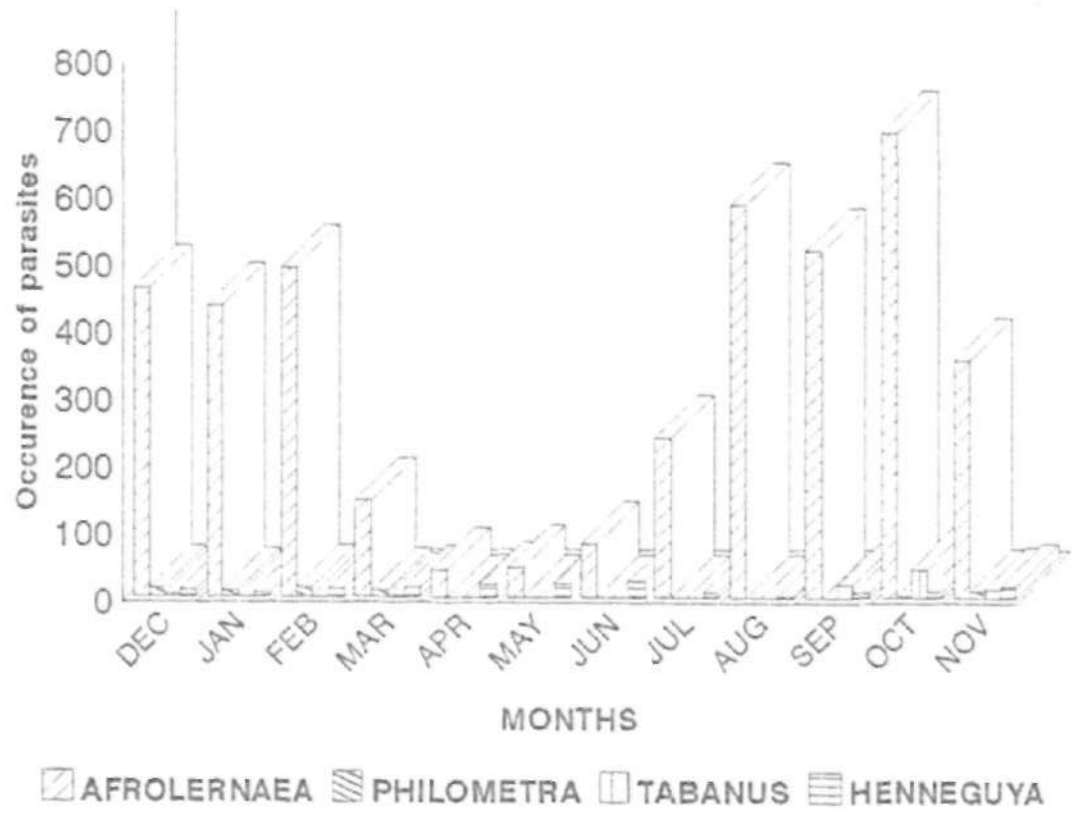


Figure 32: Monthly occurence of parasites in the branchial chamber of male M. rume

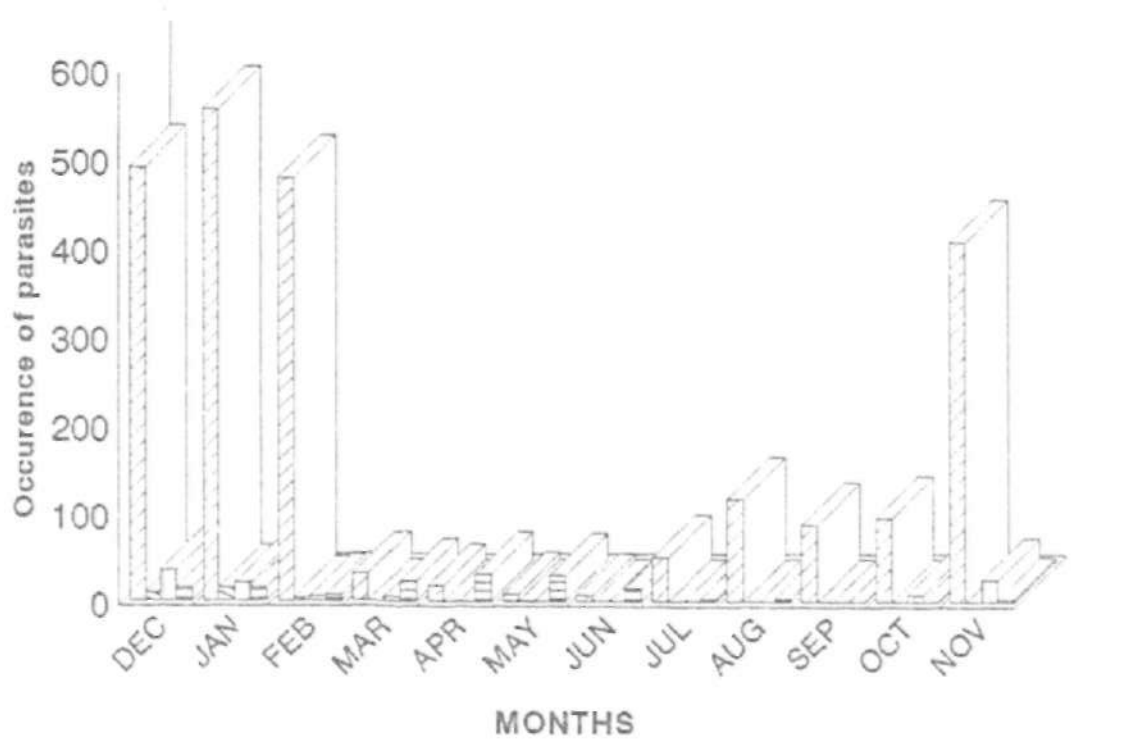


Figure 33: Monthly occurence of parasites in the branchial chamber of female M. rume

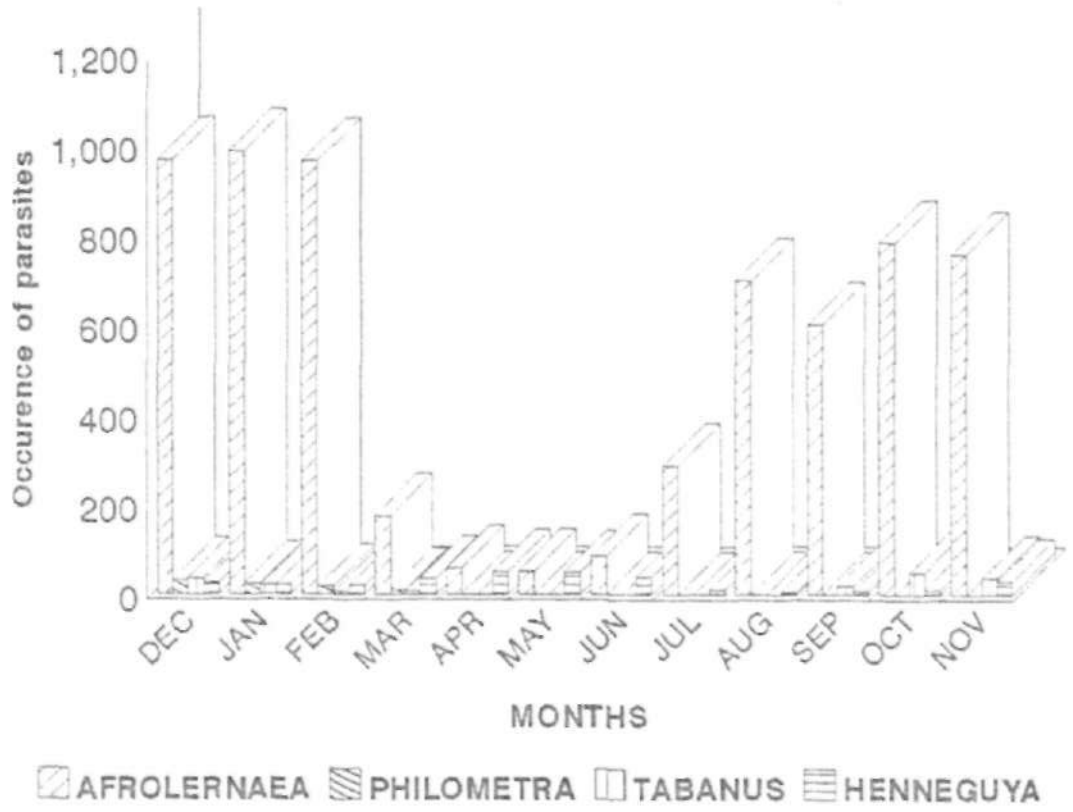


Figure 34: Monthly occurence ofparasites in the branchial chamber of M. rume (combined sexes)

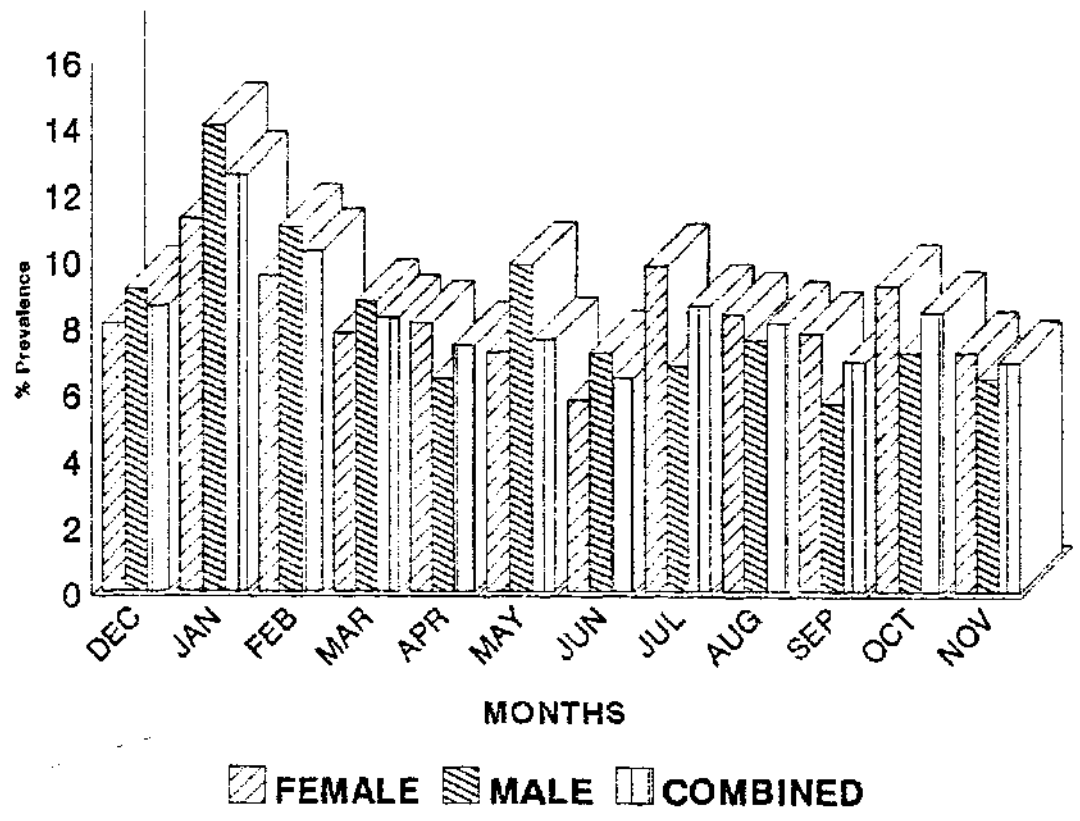


Figure 35: Mean monthly infection rate of parasites in the branchial chamber M. rume (Male, female and Combined sexes)

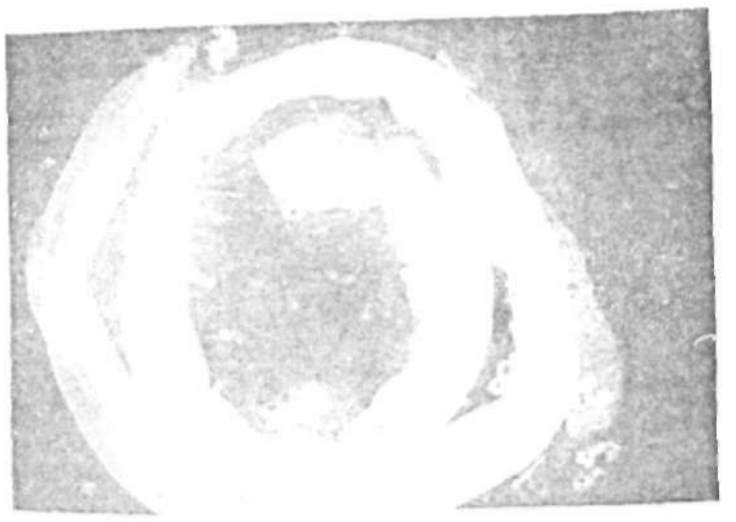


PLATE XVIII: *Philometra beninensis* as seen under the epithelial tissues of operculum of *M. rume* (Mg. x 60)

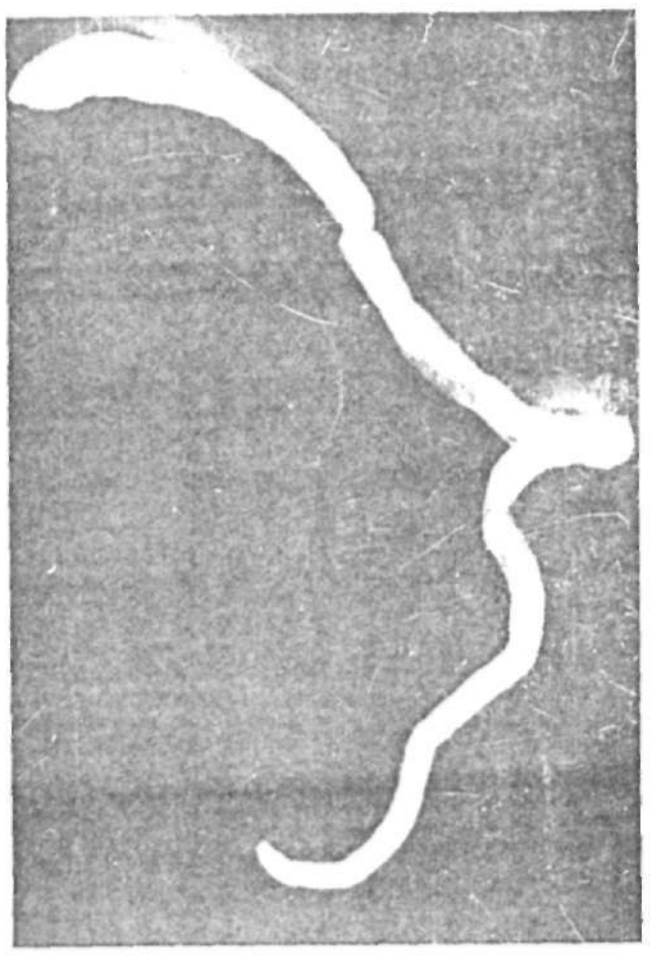


PLATE XIX: *P. beninensis* uncoiled (Mg. x 40)



PLATE XX: coma shaped larvae in *P. beninensis* (Mg. x 150)



(not attached). The larvae were vermiform and comprised of 11 segments and a head (Plate XX1). The larvae were 4.00mm - 7.00 mm long and 1.5 mm to 2.5 mm wide (the widest segments were measured). "Pin head spots" lesions were observed within the epithelial tissue, at the point of attachment in host.

4.22d: ***Afrolernaea nigeriensis* (Dollfus)**

The head of this parasite had short attachment structures, long neck and thickened trunk from where two bead-like strands, each containing 26 - 30 singly arranged eggs were found. Total length vary from 7.55 to 15.50 mm. Length of egg sack range from 1.60 mm to 3.80 mm. (Plate XXII).

4.23 Parasites of the Gastrointestinal Tract of *M. rume*

Out of the 284 male fish examined, 97 (34.15%) were parasitised by 180 parasites. 378 female fish were examined, of which 132 (34.92%) were parasitised by 250 parasites (Appendix 10a, b and c). *Procamallanus* sp., a nematode, was mostly found in the stomach and intestine, while *Caryophyllaeus* sp. (caestode) and *Euclinostomum sp* (a trematode) were found exclusively in the intestine. There were significant differences ($P< 0.05$) in the total and monthly parasitic infection of the male and female gastrointestinal tract, and also between each type of parasite in the male and female GIT (Figs. 36 and 37). The monthly parasitic infection in both sexes showed that the months of March and April witnessed the highest incidence of infection (62.96% and 65.38% respectively), *Caryophyllaeus* and *Euclinostomum sp.* being the only parasites encountered then (Fig..38). The lowest infection rate occurred in the months of September (13.95%), June (16.33%) and August (17.31%) (Fig.39).

Procamallanus sp. were mainly found in the dry months of October to March, with November as the peak infection month.

The most abundant parasite in the sampled fish population was *Procamallanus sp.* (175) then *Caryophyllaeus sp.* (126) and *Euclinostomum sp.*(121). Statistical analysis showed that *Procamallanus* infection had no correlation ($r = 0.03$) with the other two parasites while there was correlation ($r = 0.65$) between the monthly incidence patterns of *Caryophyllaeus* and *Euclinostomum spp.*

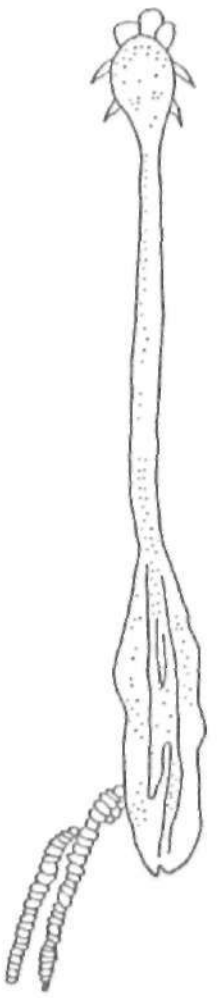


PLATE : XXII . Afrolernae nigeriensis

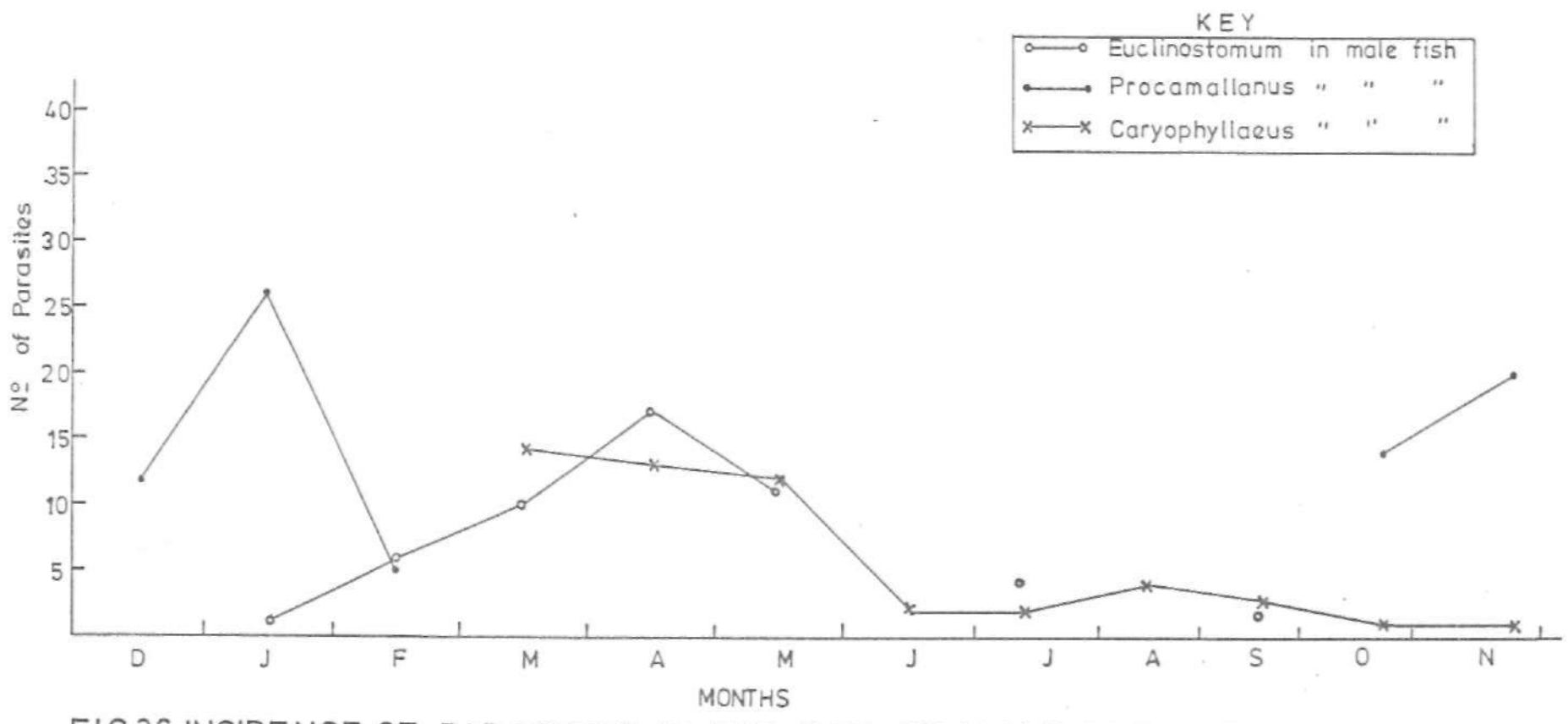


FIG.36 INCIDENCE OF PARASITES IN THE G.I.T. OF MALE M. RUME

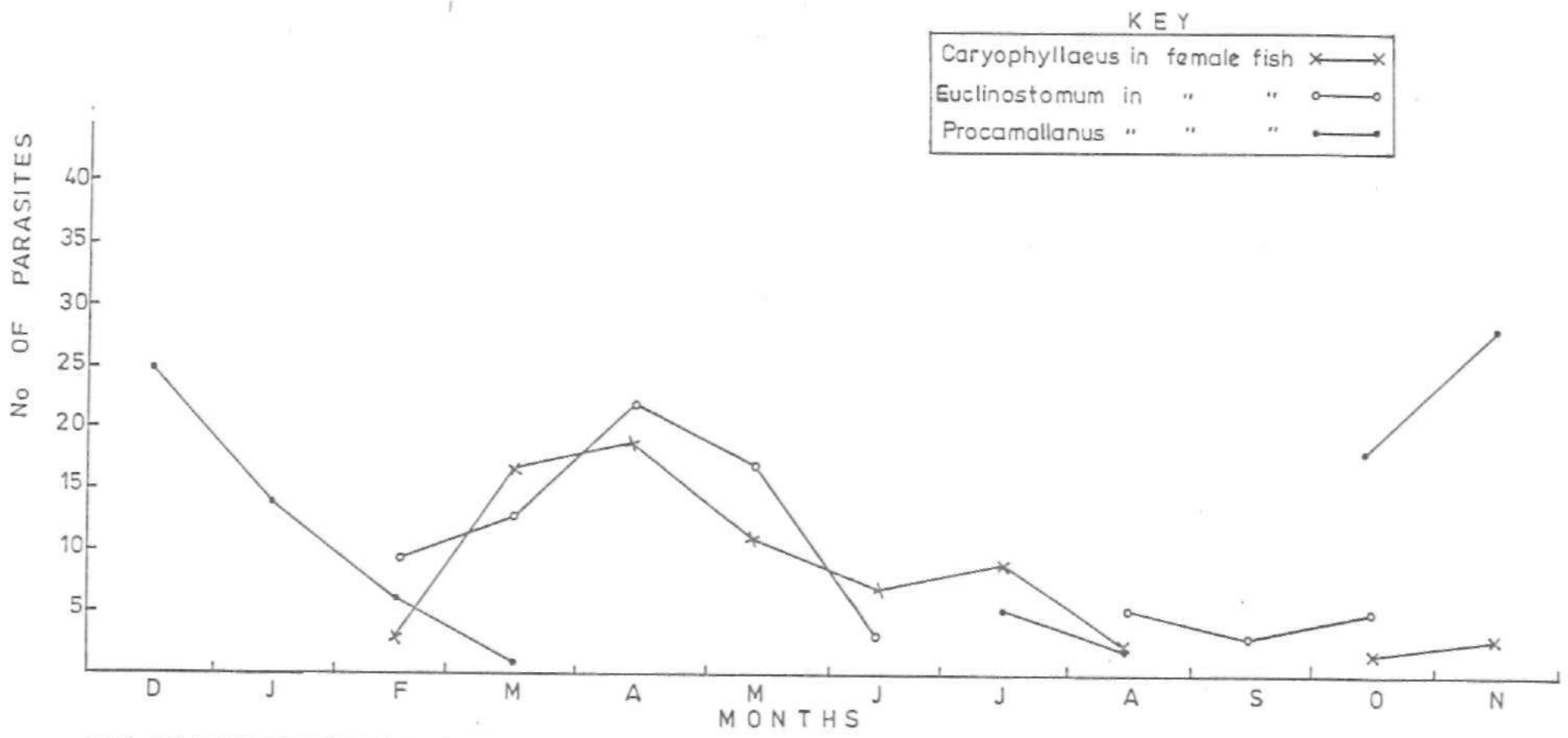


FIG. 37 INCIDENCE OF PARASITES IN THE G.I.T OF FEMALE M. RUME

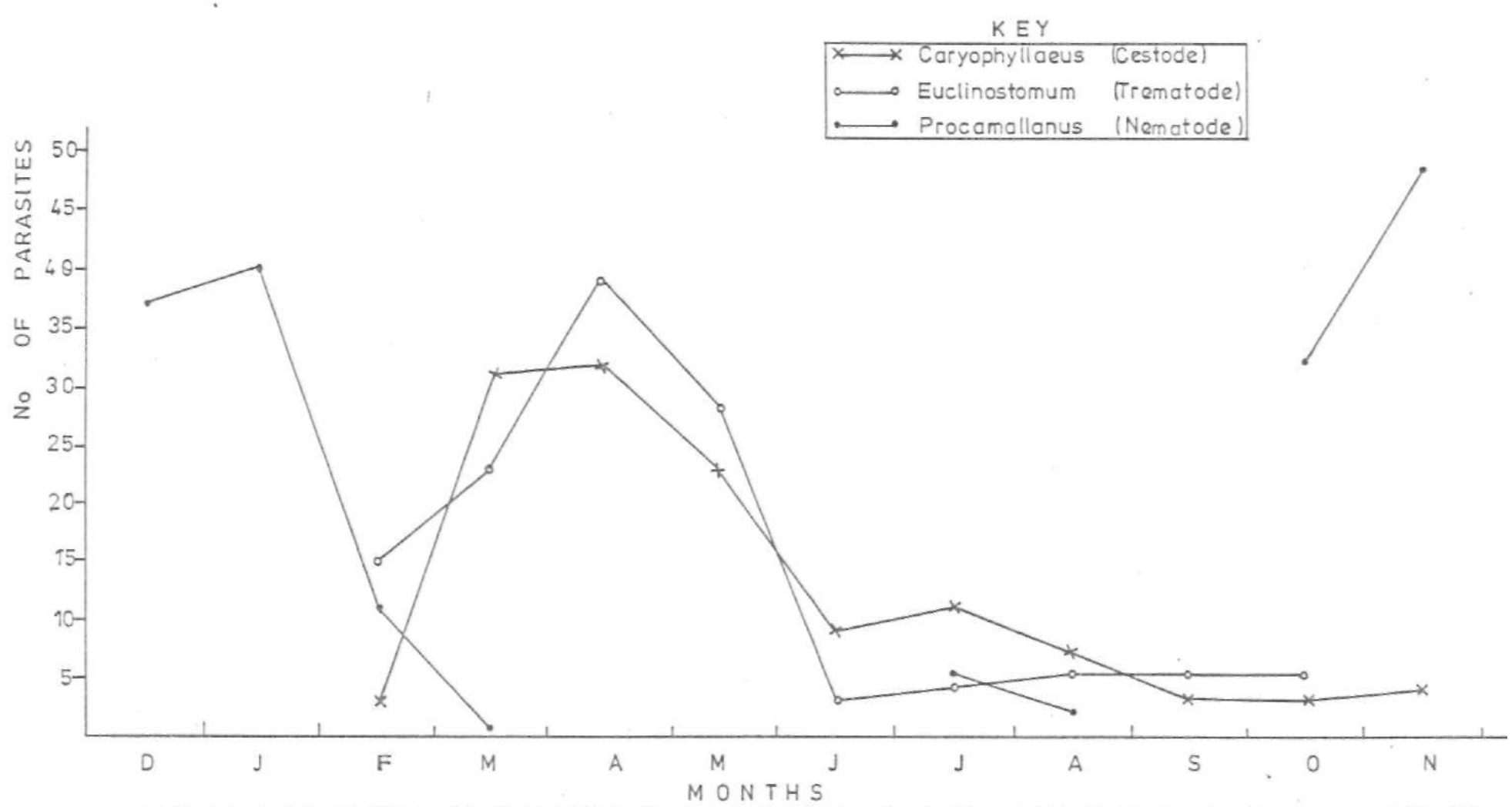


FIG. 38 INCIDENCE OF PARASITES IN THE MALE AND FEMALE OF M. RUME (COMBINE

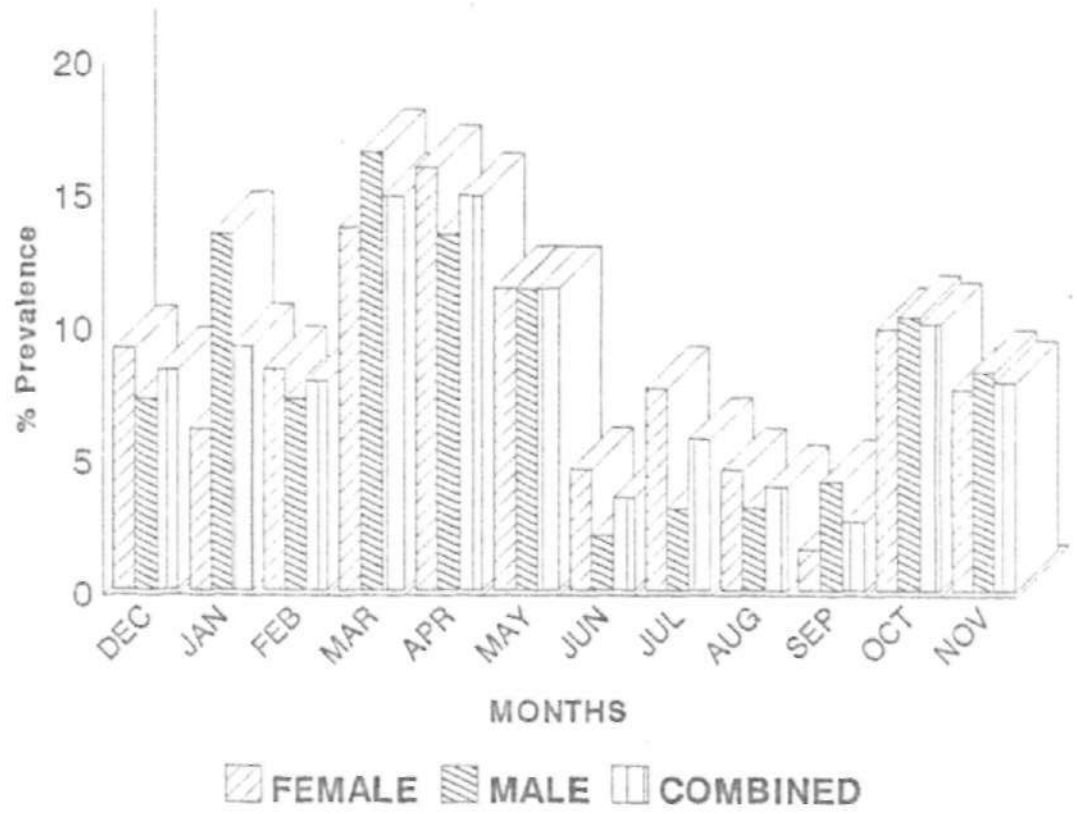


Figure 39: Monthly prevalence of parasites in the GIT of M. rume (combined, MALE, FEMALE).

4.24 DESCRIPTION AND PATHOLOGICAL EFFECT OF THE GASTROINTESTINAL PARASITES OF *M. rume*

4.24a **Procamallanus laevionchus**: The pathology inflicted by this parasite in *M. rume* was similar to that of *H. b. occidentalis* in 4.9a

4.24b ***Euclinostomum heterostomum***.

The pathology inflicted in *M. rume* by this parasite was similar to that of *H. b. occidentalis* in 4.7b except that *E. heterostomum* had roundish ventral sucker and curly intestine, and were found within the intestinal lumen from which they were scrapped off (Plate XXIII). No lesion was observed at the site of attachment.

4.24c ***Caryophyllaeus Sp***.

The parasite has a definite anterior region that is "spatulate" (Plate XXIV) and a neck that is highly retroactive. The length from 7.5 to 11.0 mm and the width from 1.5 mm and 3.2 mm. The parasite retrieved from the intestinal lumen inflicted no pathological effect on the host.

4.25 RELATIONSHIP BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *M. rume* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

In the male of *M. rume*, infection by *A. nigeriensis* was positively correlated with Fe^{++} and Cl^- concentrations at $P < 0.005$ (Table 7). In the months of August to February, when *A. nigeriensis* infection was high, the Fe^{++} concentration in the dam was also high. From June to December, when *A. nigeriensis* infestation was high, the chloride concentration was low.

The relationship between *A. nigeriensis* in female fish and temperature and NO_3^- of Zaria dam were highly significant ($P < 0.05$). Between March and June, the incidence of *A. nigeriensis* on the gills were at their lowest and the period coincided with the hottest period of the year with water temperature > 27 °C. The NO_3^- concentration was also highest during the aforementioned period (> 0.25mg/l).

Philometra beninensis infection in male of *M. rume* had significant relationship with aquatic turbidity, temperature and Mn ($P < 0.005$). *Philometra* was prevalent in the dry



PLATE XXIII: *Euclinostomum heterostomum* from intestine of *M. rume*
(Mg.x 40)

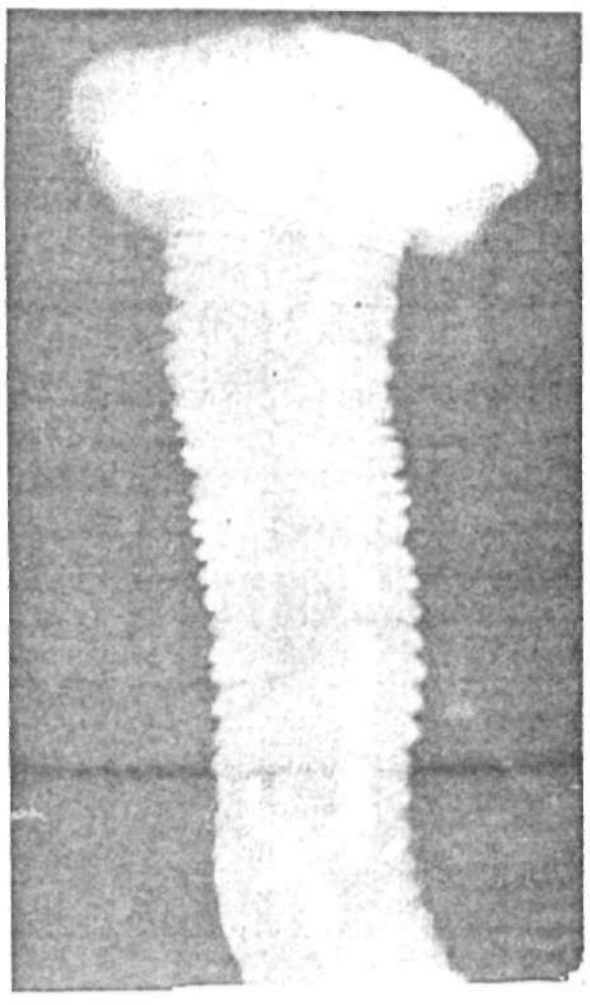


PLATE XXIV: Caryophyllidean cestode from intestine of *M. rumo*
(Mg. x 60)

TABLE 7 CORRELATION COEFFICIENT BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *M. RUME* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM.

Parasites	Turbidity	pH	Temp.	Fe	Mn	NO_3^-	Cl^-	Rain	Air Temp.
A. nigeriensis			0.0086*c	0.0043		0.0045c	0.0174		
			0.0004			0.0008*			
Philometra	0.0123		0.0001c		0.0326c	0.0067c			
			-0.0134		0,0260	0.0004*			
Tabanus				0.0267		0.0111*			
				0.0083*					
Henneguya				0.0386c			0.0073c		
							0.0008*		

*Values above are significant at $P < 0.05$.
for female fish.
• values are significant at $P < 0.05$ for male fish
c values are significant at $P < 0.05$ for when both sexes were analysed together.

season (November to March) when dissolved oxygen was greater than 6.4 mg/l and completely absent in April to September (wet season) when dissolved oxygen concentration was below 6.0 mg/l (except for July). In the dry season, the turbidity was lowest, water temperature was fairly lower then than other months and Mn concentration was very low in November and rose gradually in December, January, February and to the highest value (0.16mg/L) in March. Whereas in the wet season, temperature and turbidity were high and *Philometra sp.* was absent.

The occurrence of *Philometra* in female fish had no correlation with water turbidity, temperature and Mn but had a high correlation with NO_3^- concentration ($P < 0.05$) which was high in the dry season months when the prevalence of *Philometra* was also high.

The *Tabanus sp* in male and female fish had a significant relationship with Fe^{++} concentration. *Tabanus* were found mainly from September to December during which the Fe^{++} concentration was highest. There was a significant relationship between the NO_3^- concentration and *Tabanus* parasite ($P < 0.05$) in female fish. When the NO_3^- concentration was at the highest peak (March to June) *Tabanus* was completely absent. As *Hemeguya* sp. decreased gradually in the female fish in the months of June to December, the Cl^- ion concentration also decreased.

Table 8 showed that *A. nigeriensis* had a high positive significant relationship ($P < 0.05$) with *Philometra, Tabanus* and *Hemeguya*. *Philometra* had a very high positive significant relationship with *Tabanus* ($P < 0.05$).

4.26 RELATIONSHIP BETWEEN THE INTESTINAL PARASITE OF *M. rume* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

Procamallans sp. parasitizing the intestine of *M. rume* were recovered in the months of October to February. During this period the NO_3^- concentration and air temperature decreased gradually to their lowest values in January (0.18 mg/l and 22 °C respectively) and oxygen concentration was very high. Statistical analysis showed significant relationships between the occurrence of the parasite and NO_3^- concentration and water temperature at $P < 0.05$ (Table 9).

Table 8 CORRELATION COEFFICIENT BETWEEN THE PARASITES OF THE BRANCHIAL CHAMBER OF *M. rume*.

	A. nigeriensis	*Philometra*	Tabanus.	*Hemeguya*
A. nigeriensis		0.0026*	0.0394•	0.0050•
		0.0371c	0.0001*	
			0.0271c	0.0296c
Philometra sp	0.0026*		0.001*	
	0.0371c			
Tabanus	0.0394•			
		0.0001*		
	0.0271c			
Hemeguya sp.	0.0050•			
	0.0296c			

• Values are significant at $P < 0.05$ for male

* Values are significant at $P < 0.05$ for female fish

c values are significant at $P < 0.05$ for both sexes.

TABLE 9 CORRELATION COEFFICIENT BETWEEN THE INTESTINAL PARASITES OF *M. rume* WITH PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM.

	Turbidity	pH	Temp	Fe	Mn	NO_3^-	Cl^-	Rain	Air Temp.
Procamallanus						0.0449√			0.0290√
						0.04026*			0.0231*
						0.0284c			0.0152c
Caryophellus							0.0246		0.0001
							0.0192c		0.0001c
Euclinostomum							0.0174√		0.0006
									0.0003*
							0.0204c		0.002c

√ Values significant of $P < 0.05$ for male fish
* values significant at $P < 0.05$ for female fish.
C Values " " $P < 0.05$ for both sexes (combined).

Caryophellaeus and *Euclinostomum spp.* were at their peak infestation between March and May, when the Cl⁻ concentration and water temperature were high, with significant relationship at $P < 0.05$. pH of water was also very low then (< 6.0), turbidity was low and mean dissolved oxygen was about 5.5 mg/L

4.27 RELATIONSHIP BETWEEN THE LENGTH- CLASS OF *M. rume* AND BRANCHIAL CHAMBER PARASITES

The branchial chamber of *M. rume* were highly susceptible to parasitic infestation. The high infection rate was due to *A. nigeriensis*, which had a total of 6,234 individuals infecting the gills irrespective of their age. This was followed by *Hemeguya* infection (310), *Tabanus* (184) and *Philometra* (139) spp. The *Philometra sp.* were mainly found in the young and adult fishes.

The least infected were the young ones (22.1 cm - 29.0 cm) with 87.80% percentage infection. The juveniles and the adult had 98.64% and 93.84% infection rates respectively (appendix 6b).

4.28. RELATIONSHIP BETWEEN THE LENGHT-CLASS OF *M. rume* AND THE GIT PARASITES

The mean infection rate of the GIT amongst the length class of *M. rume* was 34.60%. The adult group (29.1 cm and above) had the highest percentage incidence of infection (44.52%), followed by the juveniles (15.2-22.0 cm) (39.45%) and the sub-adult or young (22.1-29.0 cm) (28.72%) (appendix 7b). There was no significant difference in the rate of infection by individual parasites amongst the different groups ($P > 0.05$).

4.29. RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. rume* AND BRANCHIAL CHAMBER PARASITES

The lowest feeding period of the fish was between December and January, a period

that coincided with the highest infection by *A. nigeriensis*. The highest feeding period was recorded between June to November, during which there was no considerable decrease in *A. nigeriensis* infection. However, infection with *Tabanus* and *Hemegnya sp.* rose considerably from October to December, while the consumption of trichopteran larvae, dragonfly nymphs, oligochaetes and ephemeropteran nymph increased (from July to November).

4.30. RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. rume* AND ITS GIT PARASITES

During the months of March and April, parasitic infection of the GIT was highest (< 62%) as was the feeding intensity (> 80%). *Caryophyllens* and *Euclinostomum spp.* were the most prevalent parasites in the GIT. Items in the stomach that were considerably reduced or absent then were trichopteran larvae, dragonfly nymphs, oligochaetes and ephemerepteran nymph, but the chironomid larvae were abundant. *Procamallanus sp.* that was found in the dry months of October to February.

4.31. RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *M. rume* AND PARASITES OF ITS BRANCHIAL CHAMBER

Mature gonads (Stage IV) in *M. rume* were found in the months of July to September which also coincided with the commencement of high rate of infection of the gill by *A. nigeriensis*. Peak infection period was in October. The period of low infection rate of *A. nigeriensis*, March to June, coincided with the period of predominance of stages I and II gonads in the host. From October to January when *Tabanus* , *Philometra* and *Hemegnya* infection began to rise, most of the gonads were immature (Stage I) and some were already spent (Stage VI). Significant relationship existed between *Hemegnya* and Stages II and IV gonads ($P < 0.05$) and also between *A. nigeriensis* and gonad Stage I only (Table 10).

4.32 RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *M. rume* AND PARASITES OF ITS GIT

The highest intestinal parasitic burden, caused mainly by *Caryophellaeus* and *Euclinostomum spp.*, occurred in the months of March and April when stages I and II gonads were prevalent. However, in the months of June, August and September when infestation was lowest, more matured gonads (stages III and IV) and some spent ones were predominant.

The occurrence of *Procamallanus* in the dry months coincided with the period when the immature gonad stages (stages I and II) as well as spent gonads were predominant. Only *Caryophyllaeus* infection showed high co-occurrence with gonad stages II and III at $P < 0.05$ (Table 10).

4.33. LENGTH-WEIGHT RELATIONSHIP IN *Marcusenius senegalensis*

The exponent "b" of the 225 male and 155 female of *M. senegalensis* were 2.44 and 2.53 respectively. Graphs of the relationship between the length and weight are presented in Figs. 40 and 41, and the value obtained showed that the fish exhibited a negative allometric growth, that is, the fish were thinner as they grow larger.

4.34. FOOD AND FEEDING HABITS OF *M. senegalensis*

Table 11 shows that insects were the major food components consumed by this fish species. Other components included annelids, oligochaetes and plant material. Amongst the insects, the chironomid larvae and pupae predominated, representing 35.6% and 5.1% respectively. The Chironomids occurred in all the stomachs examined throughout the year (Fig.. 42) compared to other food items.

This fish also consumed ephemeropteran and trichopteran larvae, seeds, plant remains and algae. The seeds were mainly found in the month of May. The period of highest feeding intensity of the fish coincided with the rainy season (May to October) during which

TABLE 10 CORRELATION COEFFICIENT BETWEEN THE BRANCHIAL CHAMBER PARASITES AND INTESTINAL PARASITES, WITH THE REPRODUCTIVE CYCLE OF *M. rume*.

Stages	I	II	III	IV	V	VI
Parasites	0.0257*	-	-	-	-	-
Philometra	-	-	-	-	-	-
Tabanus	-	-	-	-	-	-
Hemeguya		0.0248√		0.039√	-	-
		0.0179*		0.025*	-	-
Procamallanus	-	-	-	-	-	-
Caryophyllus	-	0.0036*	0.0231*	-	-	-
Clinostomum	-	-	-	-	-	-

√ Value significant at $P < 0.05$ for male fish

* " " " $P < 0.05$ for female fish.

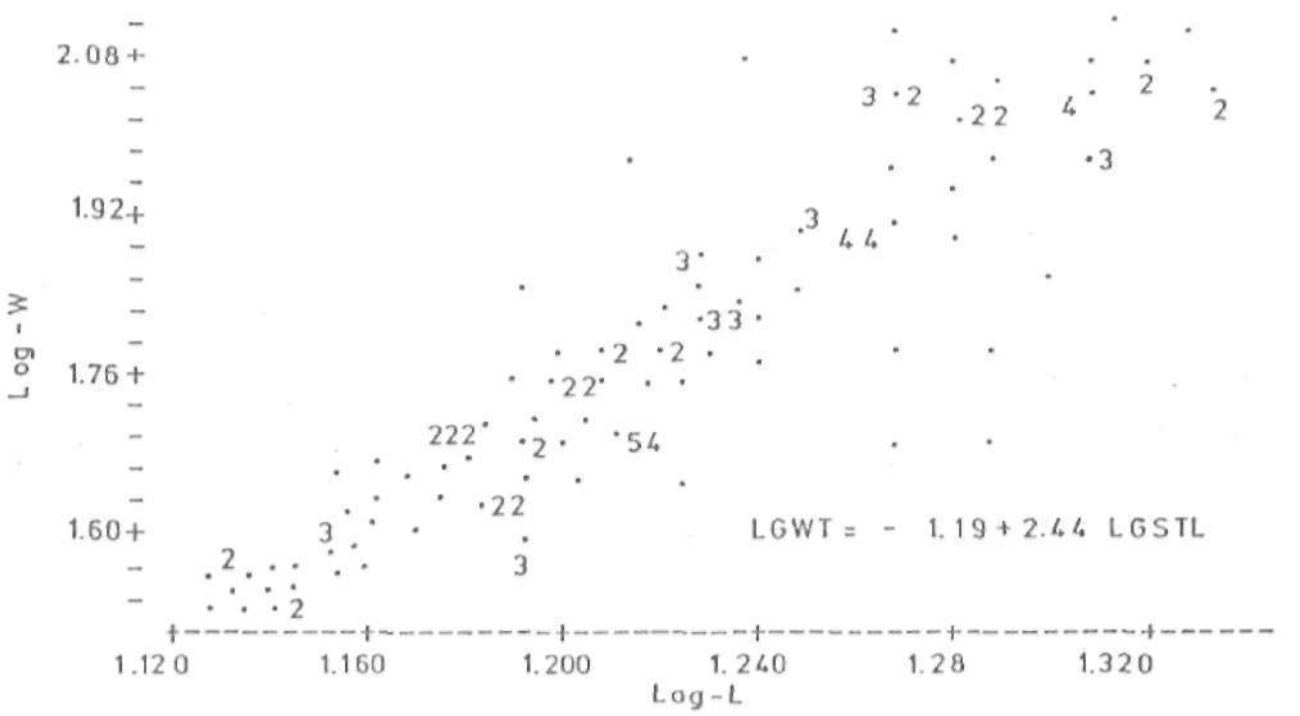


FIG. 40: Length-weight relationship of M. senegalensis (male)

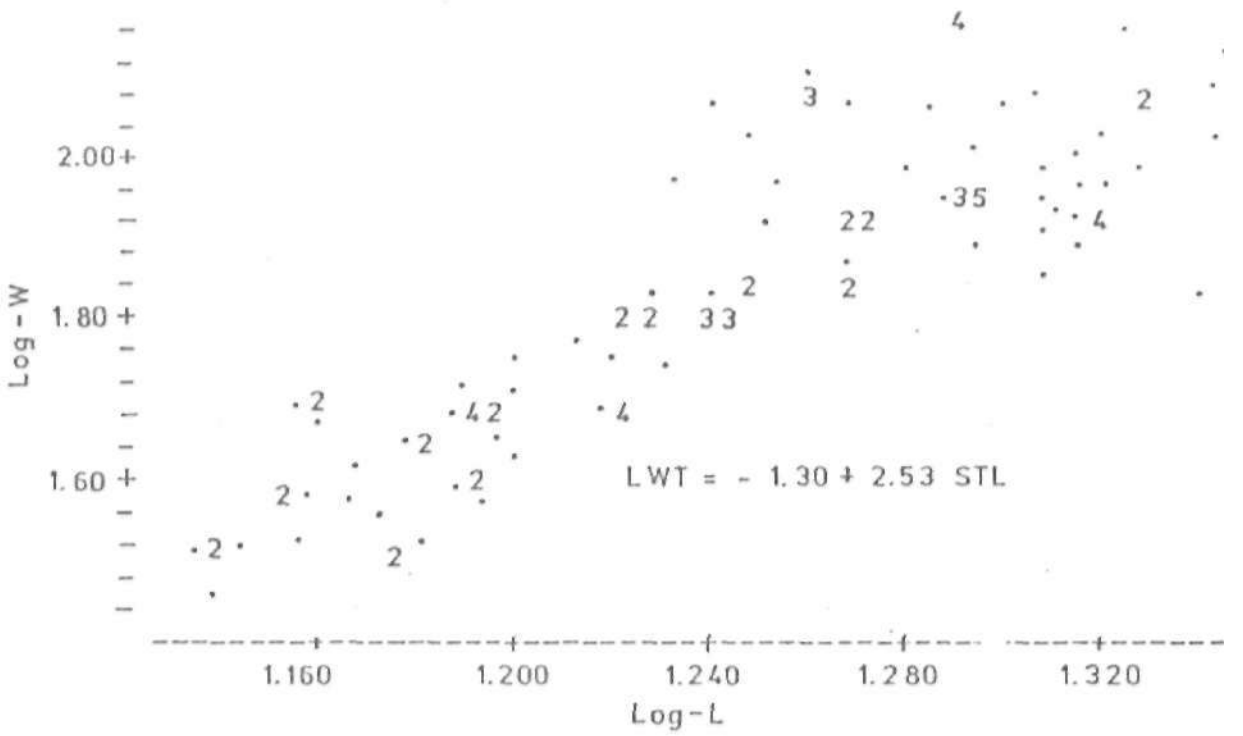


FIG. 41: Length - weight relationship of M. senegalensis (female)

TABLE 11 FOOD ITEMS IN THE STOMACH OF *M. senegalensis*

	Food Items	% frequency of occurrence	%total point
	Insect remains	69.8	11.5
Adult Insect	Hemiptera	2.4	0.2
	Coleoptera	2.1	0.3
	Ephemeroptera Nymph	17.8	4.9
	Dragonfly Nymph	7.2	2.3
Immatured Insect	Damselfly Nymph	7.6	2.5
	Megaloptera larvae	5.8	1.6
	Trichoptera larvae	34.1	7.8
	Coleoptera larvae	31.8	5.1
	Chironomid larvae	90.1	35.6
	Chironomid pupae	32.2	5.1
	Chaoborus larvae	5.4	1.0
Dipteran Larvae	Cchaoborus pupae	7.1	2.1
	Heleidae larvae	19.5	1.8
	Ostracods	26.6	2.5
Crustacea	Clam shrimps	18.2	3.5
	Copepod (Cyclops)	1.8	0.4
Arachinida	Hydrocarina	17.0	0.9
Annelids	Oligochaetes (Tubifid)	9.5	4.1
	Fish eggs	6.3	0.5
	Algae	6.1	0.4
	Plant remains	1.9	0.2
	Seeds	30.1	2.9
	Detritus	19.2	1.9

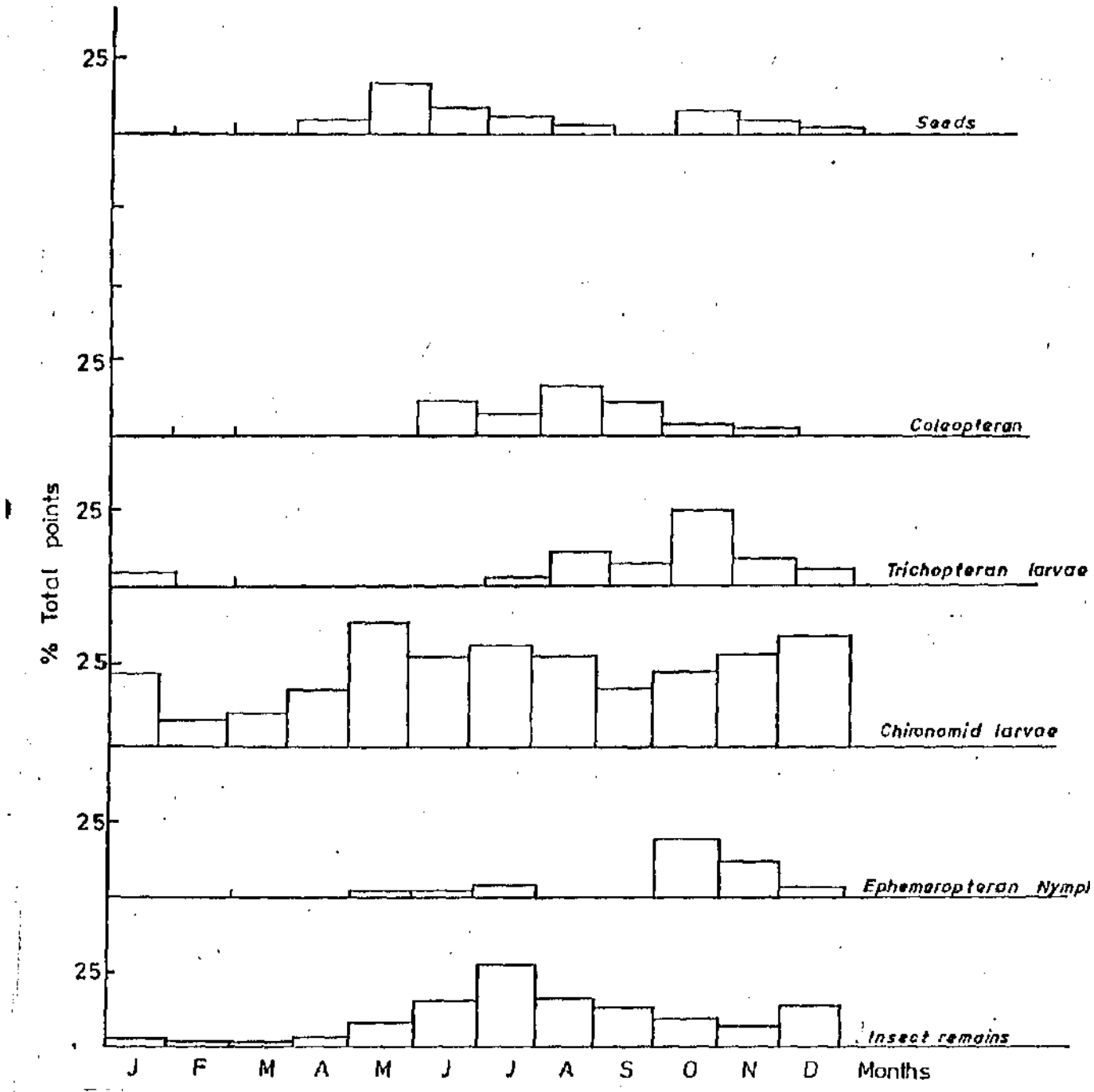


FIG. 42: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH OF *M. senegalensis*

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the feeding intensity was at least 80% (Fig.. 43).

4.35 REPRODUCTIVE CYCLE AND FECUNDITY ESTIMATE IN *M. senegalensis*.

The mature gonads (stage IV) of *M. senegalensis* were found in the months of June to October in the female fish and July to November in males (Apendix11). Most of the spent gonads (stage IV ovaries) occurred from September to November, and mainly in September in male fish (Figs. 44 and 45).

Stage III gonad was first observed in May in male fish, but March in female fish. Stage VI gonads were observed in September to November in female fish and only in October in male fish.

Fecundity estimate of *M. senegalensis* ranged from 4,041 to 7,770 eggs in 15.9cm and 23cm (standard lengths) of fish respectively.

4.36. PARASITES OF THE BRANCHIAL CHAMBER OF *M. senegalensis*

A total of 380 specimens of *M. senegalensis* that comprised of 225 males and 155 females were studied. Of the 225 male fish examined, 166 (73.77%) were infected. Of the 888 parasites recovered from the infected males 634 (71.39%) were *E. sursi* while 254 (28.60%) were *Dactylogyrus vastato.*

The female fish were parasitised by 482 (63.75%) *E. sursi*, 256 (33.86%) *D. vastator* and 18 (2.38%) *Hemeguya* sp.

There was a significant difference in the infection rates of *E. sursi* and in *D. vastator* the male and female fish ($P \leq 0.05$). There were no significant differences in infection rates of the parasites on gill arches 1,3 and 4 ($P > 0.05$). Total infection level by parasites showed infection order in gill arches as $1 > 2 > 3 > 4$.

The monthly occurrence of *E. sursi* in male and female fish showed that heavy infection commenced in September and reached its peak in October and November. A rather low infection was then maintained throughout the year (lowest in July). In contrast, high infection of *D. vastator* occurred in the month of March to May and none from July to

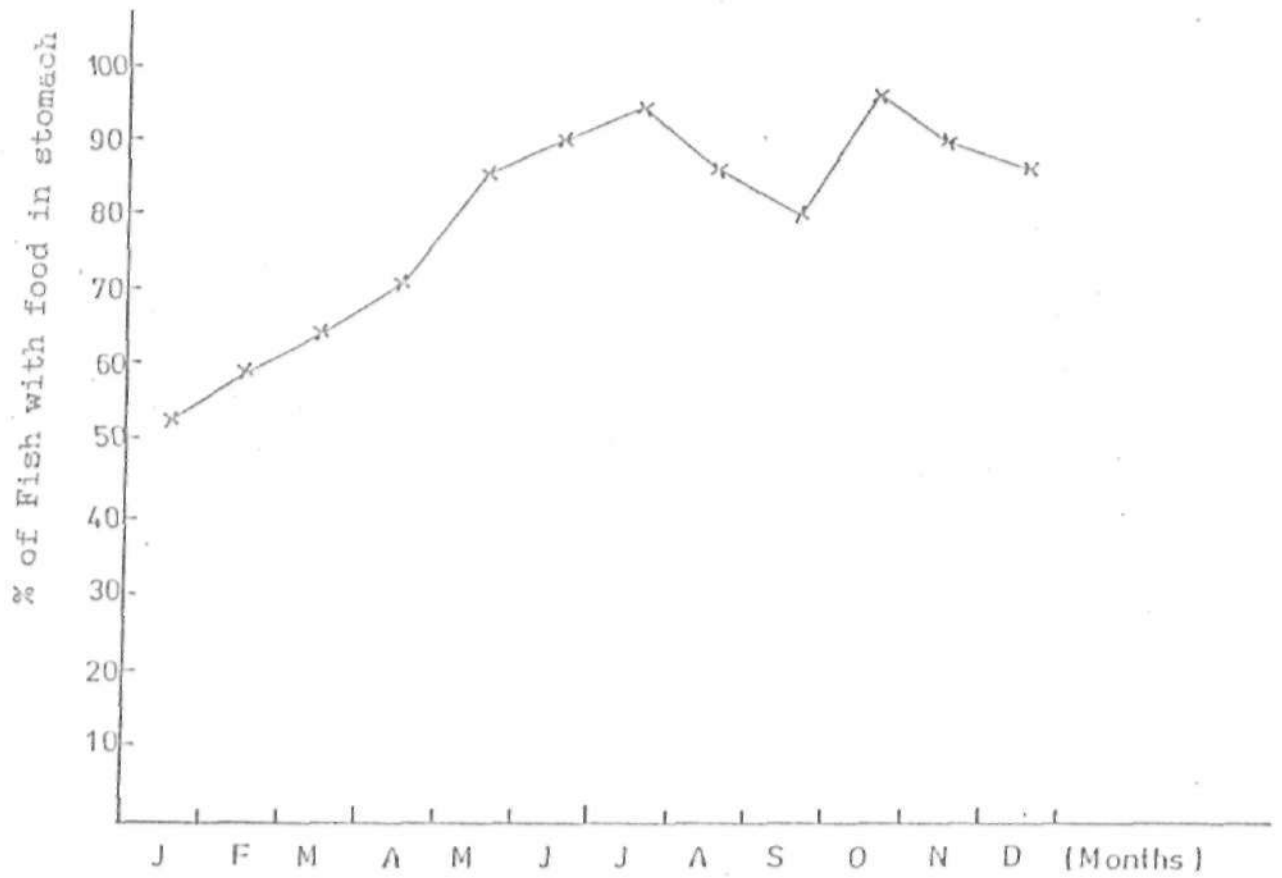


FIG. 43 MONTHLY FEEDING INTENSITY PATTERN OF M. SENEGALENSIS

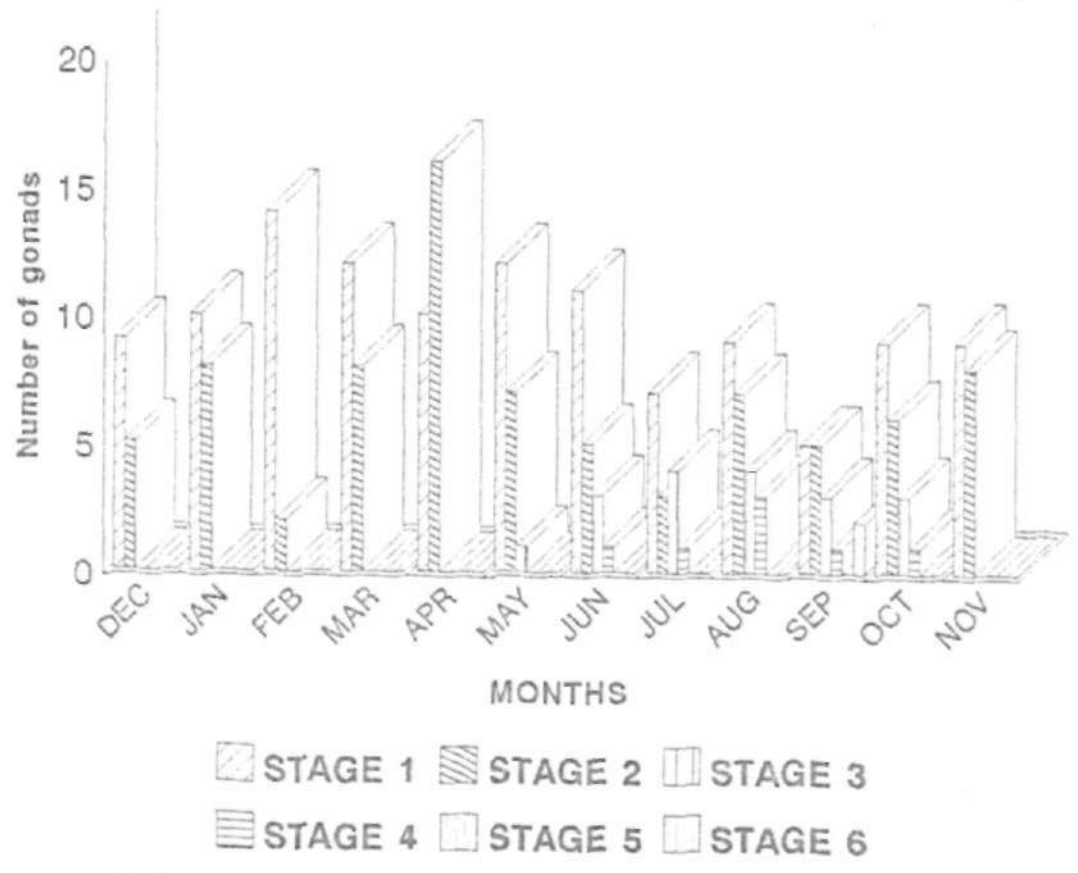


Figure 44: Stages of gonad development in male M. senegalensis

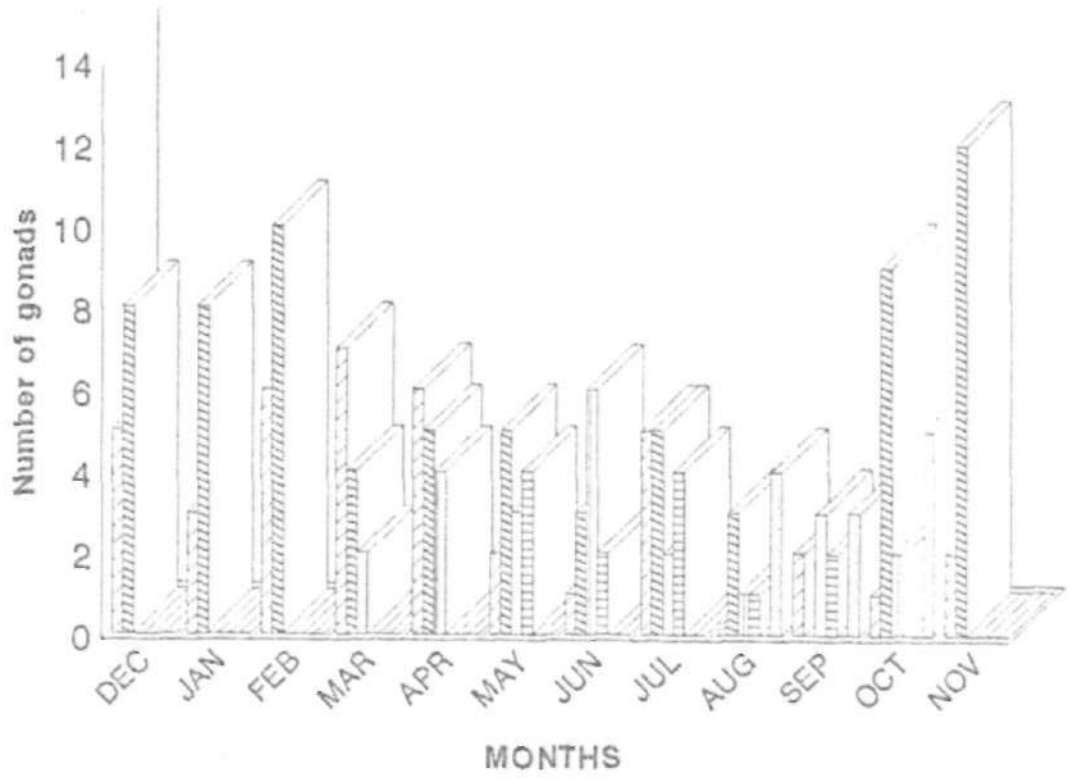


Figure 45: Stages of gonad development in female M. senegalensis

October in male fish, and September to November in female fish, (Fig.s.46, 47 and 48). *Henneguya* occurred only in the months of March to May only in females (Fig. 47). This period coincided with the period when all the three parasites were found. Infection of *E. sarsi* was highest in September to November (Fig. 48). The lowest rates of infection in male fish (15.00% and 33.33%) were observed in the months of July and August respectively. In female fish the lowest incidence of infection (35.50%) occurred in January.

4.37 DESCRIPTION AND PATHOLOGICAL EFFECTS OF BRANCHIAL CHAMBER PARASITES OF *M. senegalensis*

4.37a Description and Pathology of *E.sarsi* and *Henneguya* sp.

The pathological effect of these parasites were similar to the ones described for *H. b. occidentalis* in 4.7a and 4.7d.

4.37b *Dactylogyrus vastator* (Nybelin, 1924)

This parasite, a monogenean that belongs to the family Dactylogyridae, was found at the tip of the gill filaments of female *M. senegalensis*. (Plate XXV)

The length of the specimens ranged from 0.50mm to 0.81mm while the mean width at the widest zone was 0.13mm. At the anterior end, there were two pairs of eyespots. The haptor, has one pair of anchors surrounded by 14 hooklets.

This parasites stimulated elongation and irregular necrotic protrusion of the gill epithelium at the point of attachment. (Plate XXVI).

4.38 PARASITES OF THE GASTROINTESTINAL TRACT OF *M. senegalensis*.

A total of 89 specimens of *Caryophyllaeus* and *Procamallanus spp* were recovered from 58 (15.26%) of the 380 *M. senegalensis* examined. 54 of the 89 specimens of parasite were recovered from 35 (15.5%) of the 225 male fish and 35 from 23 (14.83) of the 155

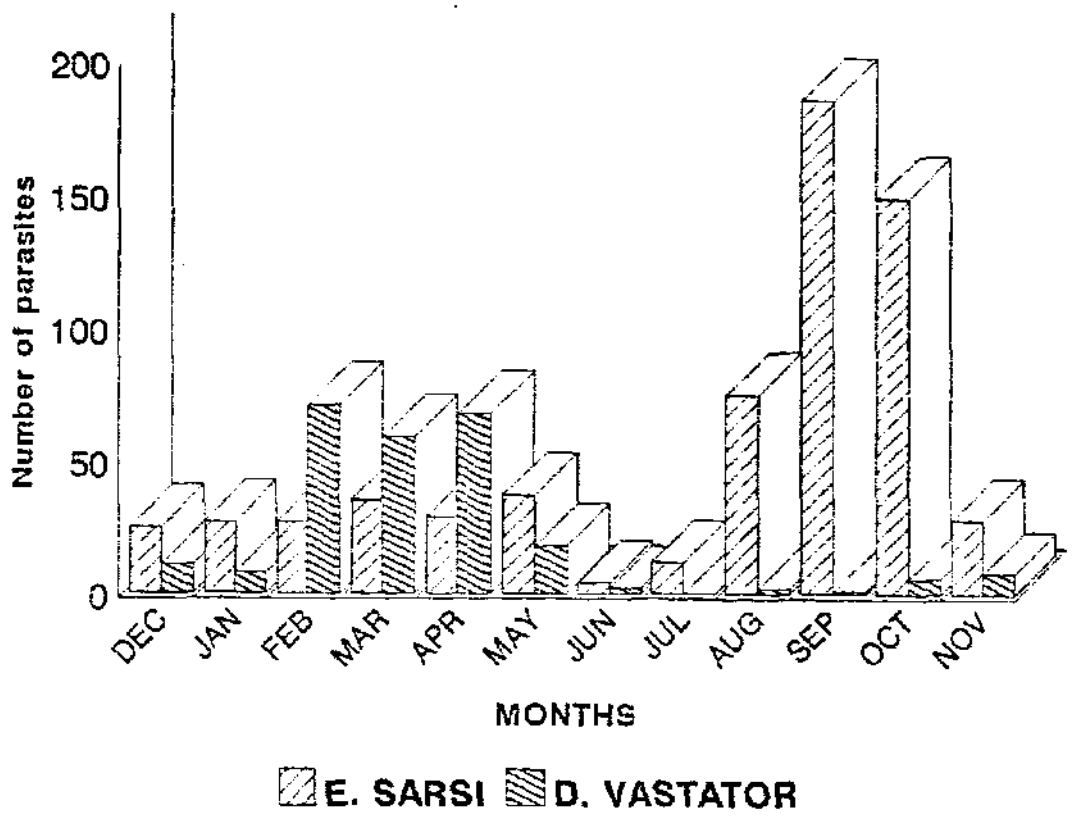


Figure 46: Monthly occurence of parasites in the branchial chamber of male M. senegalensis

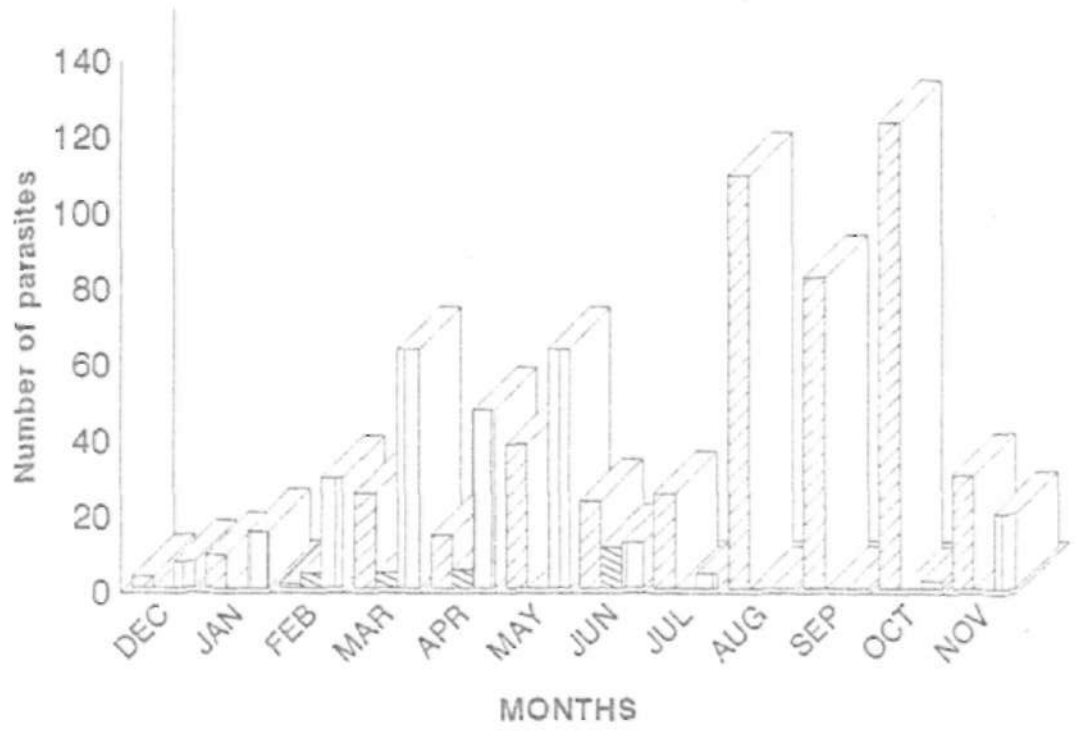


Figure 47: Monthly Occurence of parasites in the branchial chamber of female M. senegalensis

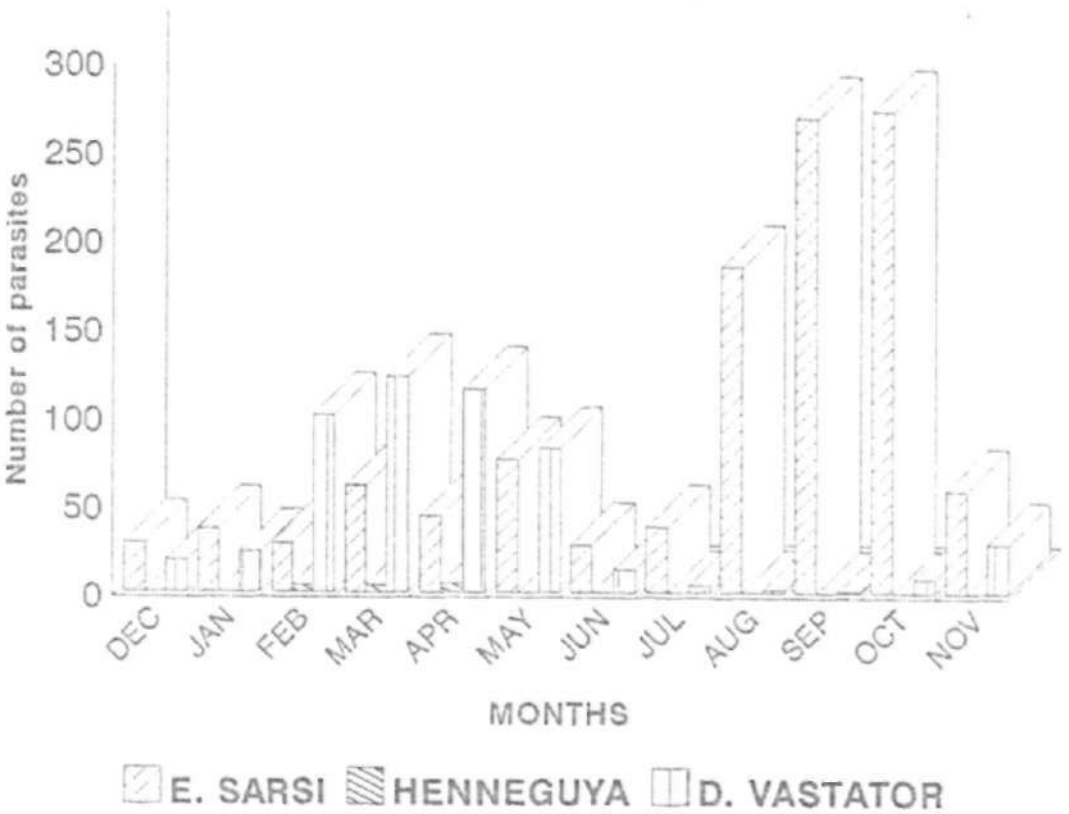


Figure 48: Monthly occurence of parasites in the branchial chamber of M. senegalensis (combined sexes)



PLATE XXV: *Dactylogyrus vastator* from gills of *M. senegalensis* (Mag. x 100)



PLATE XXVI: Elongation of gill epithelium by *D. vastator* (Mag. x 100)

female's fish examined.

The recovered parasites were the procercoids of the Caryophyllidean cestode (*Caryophyllaeus* sp.) and *Procamallanus* sp.

In the male and female fish, the Caryophyllidean infections occurred mainly in the months of February to July (to June in male) and basically absent in the other months of the year, while the *Procamallanus* sp. infections occurred from September to December with peak infection in November (Fig.49).

Male fish were not infected by either of the 2 parasites in the months of January, July and August; and no infections were observed in female fish in the months of December, January and August.

Statistically, there was no correlation in *Caryophyllaeus* and *Procamallanus* sp. infection in the male and female fish ($P > 0.05$).

4.39 DESCRIPTION AND PATHOLOGICAL EFFECT OF THE GIT PARASITES OF *M. senegalensis*

4.39a. ***Procamallanus laeviomchus*** has been described under 4.9.1.

4.39b. ***Caryophylleaus sp.*** (procercoid) has fairly pointed scolex. The mean length was 3.25 mm and width was 0.85 (Plate XXVII) They were retrieved from the intestinal lumen. No pathological effect on host was observed.

4.40 RELATIONSHIP BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *M. senegalensis* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

There was no significant relationship between the gill parasites and rainfall, temperature, turbidity and nitrate concentrations ($P > 0.05$).

In both fish sexes, the peak rainy season periods (June and August) coincided with periods of zero infection rate for *Hemeguya* sp. and very low infection by *D. vastator*.

Dactylogyrus vastator in male fish had a highly significant relationship with pH and

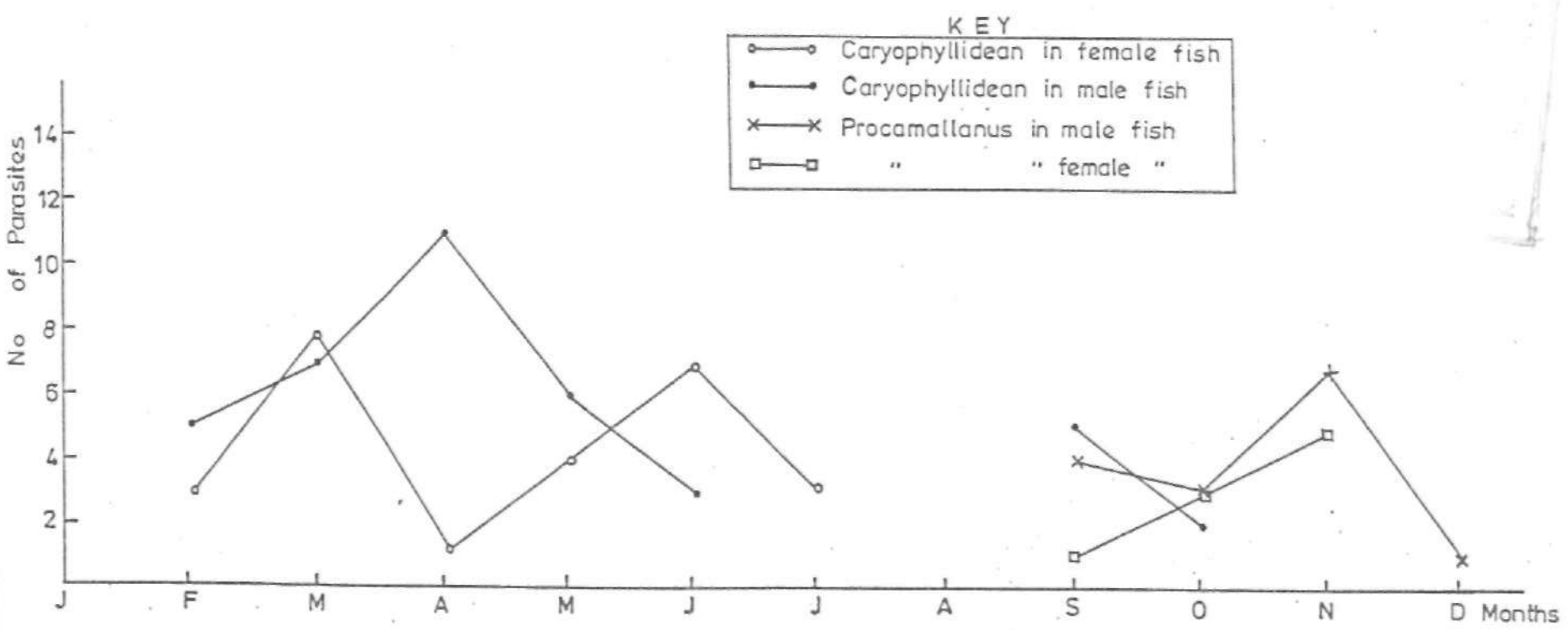


FIG.49 INCIDENCE OF PARASITES IN THE INTESTINE OF MALE AND FEMALE M. SENEGALENSIS.

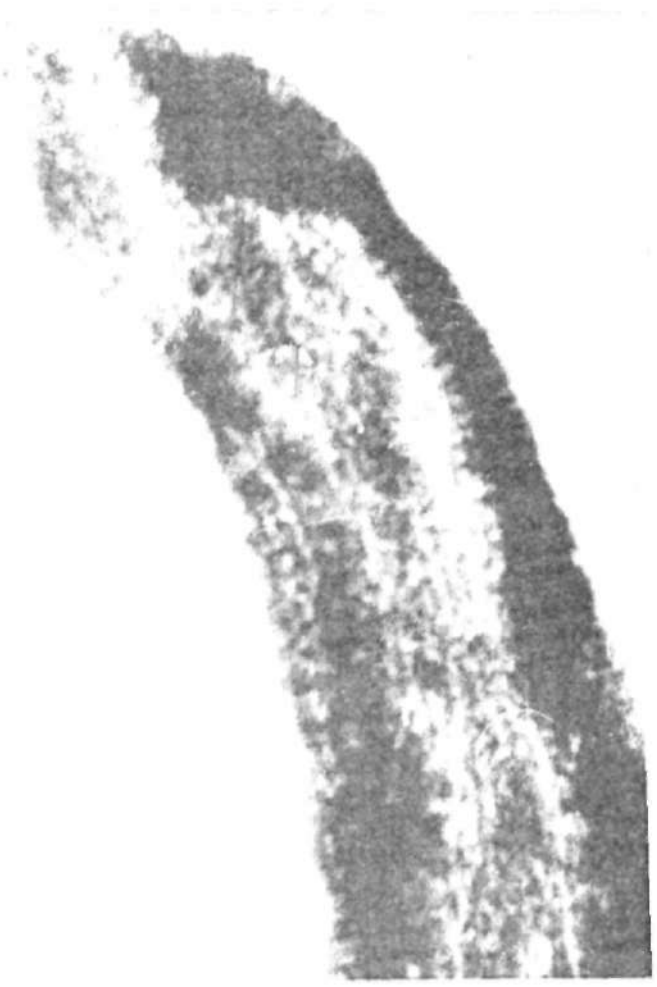


PLATE XXVII: *Caryophyllaeus* sp. (procercoid)
(Mag. x 100)

chloride concentrations ($P < 0.05$) (Table 12). The high incidence of infection by *D. vastator* in male fish from March to May coincided with period of low (< 6) water pH and high chloride concentration (> 2.7 mg/l). *D. vastator* in female fish also showed a significant relationship with chloride concentration.

The infection of both sexes by *E. sursi* had a significant relationship with Fe^{++} concentration ($P < 0.05$). For instance, when infection by *E. sursi* was high (August to November) the monthly Fe^{++} concentrations was also very high (0.40 -0.60mg/l). There was significant relationship between *E. sursi* infection in female fish and chloride concentrations. In both sexes, *E. sursi* and *D. vastator* showed a similar pattern of occurrence between January and July.

4.41 RELATIONSHIP OF THE GIT PARASITES OF *M. senegalensis* WITH PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

Within the month of March to June, when Caryophyllidean infection was highest in male and female fish, the pH of Zaria dam was high ranging from 5.5 to 7.2. During this period the chloride concentration was high while that of manganese dropped.

In both fish sexes infection rate of *Procamallanus sp.* were highest from September to November, a period during which Fe^{++} concentration was also high thus indicating a positive correlation ($P< 0.05$)

4.42 RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *M. senegalensis* AND ITS BRANCHIAL CHAMBER PARASITES

The adult group (19.6 cm >) of *M. senegalensis* were most susceptible to infection (93.75%) followed by the young ones (73.90%) and then the juveniles (13.6 cm - 16.5 cm) (62.10%). All the length-classes appeared to have high parasitic infestation (> 50%) (Appendix 6c).

TABLE 12 CORRELATION COEFFICIENT BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *M. senegalensis* WITH PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM.

Parasites	pH	Fe	Mn	Cl^-	Air Temp.
		*0.0011	*0.0426		
E. sarsi		0.0123•			
		0.0024c			
D. vastator	0.0024•		0.0360•	*0.0011	
				0.0253•	
Hemeguya sp	*0.0033			*0.0388	

* Values are significant at $P < 0.05$ for female fish.

• " " " " " " " male fish

c " " " " " " " when both sexes were analysed together.

4.43 RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *M. senegalensis* AND ITS GIT PARASITES

The mean infection of the intestinal parasites amongst the length-class was 15.26%. The adult (19.6 cm >) had the highest incidence of parasites (17.96%) compared with the juveniles (14.73%) and sub-adult (13.37%) (Appendix 7c).

4.44 RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. senegalensis* AND BRANCHIAL CHAMBER PARASITES

The period of high feeding intensity (> 80%) of this fish was from May to October, with two distinct peaks (> 90%) in July and October. Coincidentally, heavy infection by *E. sarsi* commenced in September and reached its peak in October. The chironomid larvae were the dominant food items in the diet of the fish then, closely followed by the trichopteran and ephemeropteran.

In contrast, high infection rate of *D. vastator* occurred from March to May when the feeding intensity of the fish was low. This coincided with the period when infection by *Hemeguya sp.* was observed in the female fish only, and when other food items such as coleoptera, trichopteran and ephemeropteran larvae, were absent from the stomach of the fish examined.

4.45 RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. senegalensis* AND GIT PARASITES

The intestinal infection by *Caryophyllaeus* sp. occurred mainly between February and June, which, coincided with the low feeding period of January to April, a period during which food items such as the oligochaetes and crustaceans were dominant. *Procammallanus sp.* infection occurred between September to November which was also the high feeding period of the fish.

4.46 RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *M. senegalensis* AND PARASITES OF ITS BRANCHIAL CHAMBER

In the male and the female fish, the matured gonads (stage IV) were observed between June and November whereas heavy infection by *E. sarsi* commenced in September to November, even though low infection was maintained thereafter throughout the year until July.

Infection of *D. vastator* occurred mainly in the dry season of December to May during which stages I and II gonads were prominent. *Hemeguya* sp. infection were also observed in the female fish from March to May. There were significant differences between infections by *E. sarsi* and *Hemeguya* sp. with stage I gonad of the female fish ($P < 0.05$) and high significant differences between *E. sarsi* and stage VI gonad ($P < 0.01$). Significant differences also existed between the infection by *D. vastator* and, stages I and III testis of the male fish sp. ($P < 0.05$). No significant differences between gonad stage IV in all fish with any of the parasites ($P > 0.05$).

4.47. RELATIONSHIP BETWEEN REPRODUCTIVE CYCLE OF *M. senegalensis* AND GIT PARASITES.

In all fish specimens, infection with *Caryophyllaeus sp.* were observed from February to June (dry season). This coincided with the period when gonad stages I, II and III were observed in female fish. There were no correlation between caryophyllid infections and stages of gonads ($P > 0.05$).

The *Procamallanus* infections were observed from September to November during which stages IV gonads (mature) were common in both fish sexes, and stages VI were mainly prominent in the female fish. In the male fish there were no correlation in the *Procamallanus* sp. infection and gonad stages I to III ($P > 0.05$) but correlation existed with stage IV ($P < 0.05$).

In the female fish there was correlation between *Procamallanus* infection and all the stages ($P > 0.05$) except for stage VI gonad ($P < 0.05$).

4.48 LENGTH-WEIGHT RELATIONSHIP OF *Mormyrops deliciosus*.

The length-Weight relationship in *M. deliciosus* showed that the exponent 'b' was 2.57 in the male fish (Fig. 50), and 2.09 in the female (Fig. 51). ANOVA showed positive significant correlation between the length and weight of the male and female species ($P < 0.05$).

4.49 FOOD AND FEEDING HABIT OF *M. deliciosus*.

Fish formed the most important food item in the stomach of *M. deliciosus*. This was followed by the insects, plant remains, seeds and crustaceans. Amongst the insects, the dragonfly and damselfly nymphs, coleoptera larvae and chironomid larvae had the highest percentage frequency of occurrence (Table 13). The insects were mainly found in the stomach of young fish while the adults consumed smaller fish species, most of which were identified as *Oreochromis niloticus*.

Monthly variation in the food items showed that fish were consumed throughout the year although the consumption decreased to about 25% between November and December; during which period, consumption of crustaceans (prawns), damselfly and dragonfly nymphs increased in the diet. Seeds were mainly found in April to June (at the beginning of the rainy season) and October/November, while insect remains were found throughout the year in the diet (Fig. 52).

The fish exhibited high feeding intensity throughout the year (> 50%), though December to February showed the lowest feeding period. The fish exhibited 100% feeding intensity between the months of May to September (Fig.53).

4.50 REPRODUCTIVE CYCLE AND FECUNDITY ESTIMATE IN *M. deliciosus*

The male to female sex ratio (1:1.50) showed that more female fish specimens (110) were obtained compared to males (73).

Fully mature gonads (stage IV) in female fish were found in the month of July to October (Fig. 54) and from August to September in male fish (Fig. 55). Fish with spent

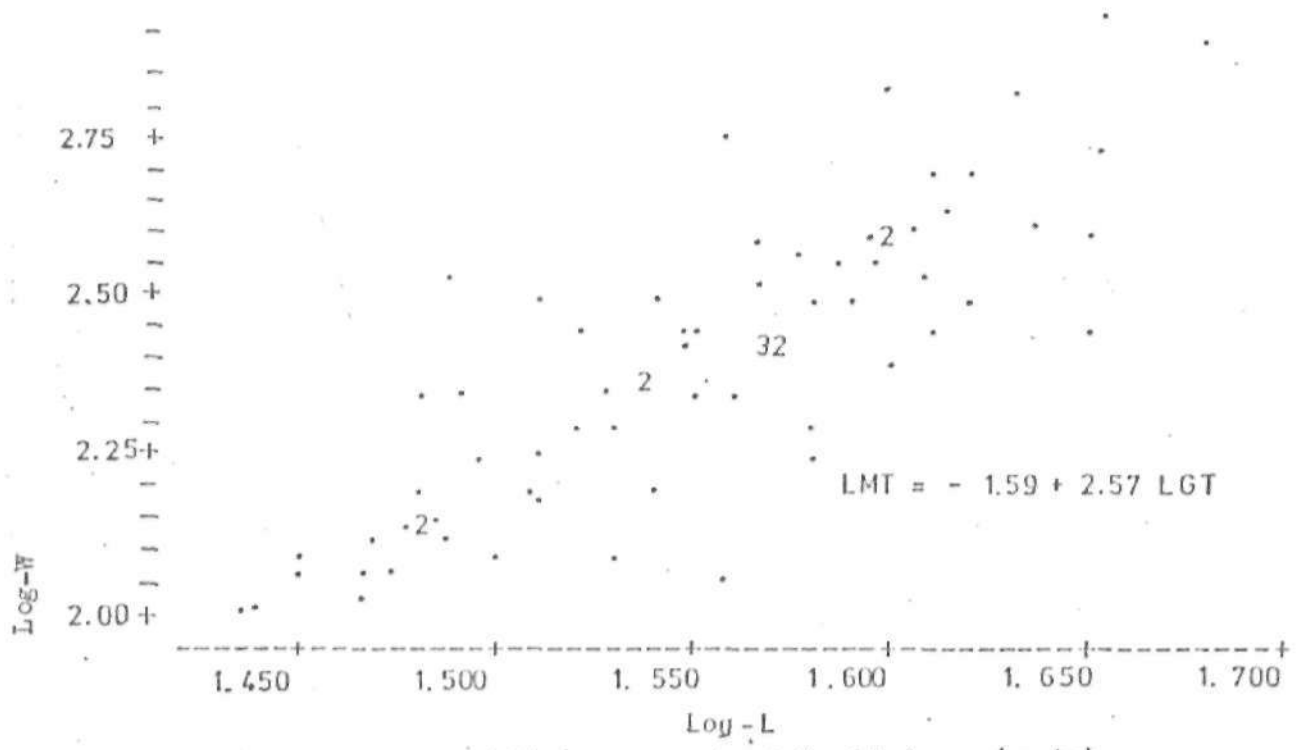


FIG.50: Length-weight relationship of M. deliciosus (male)

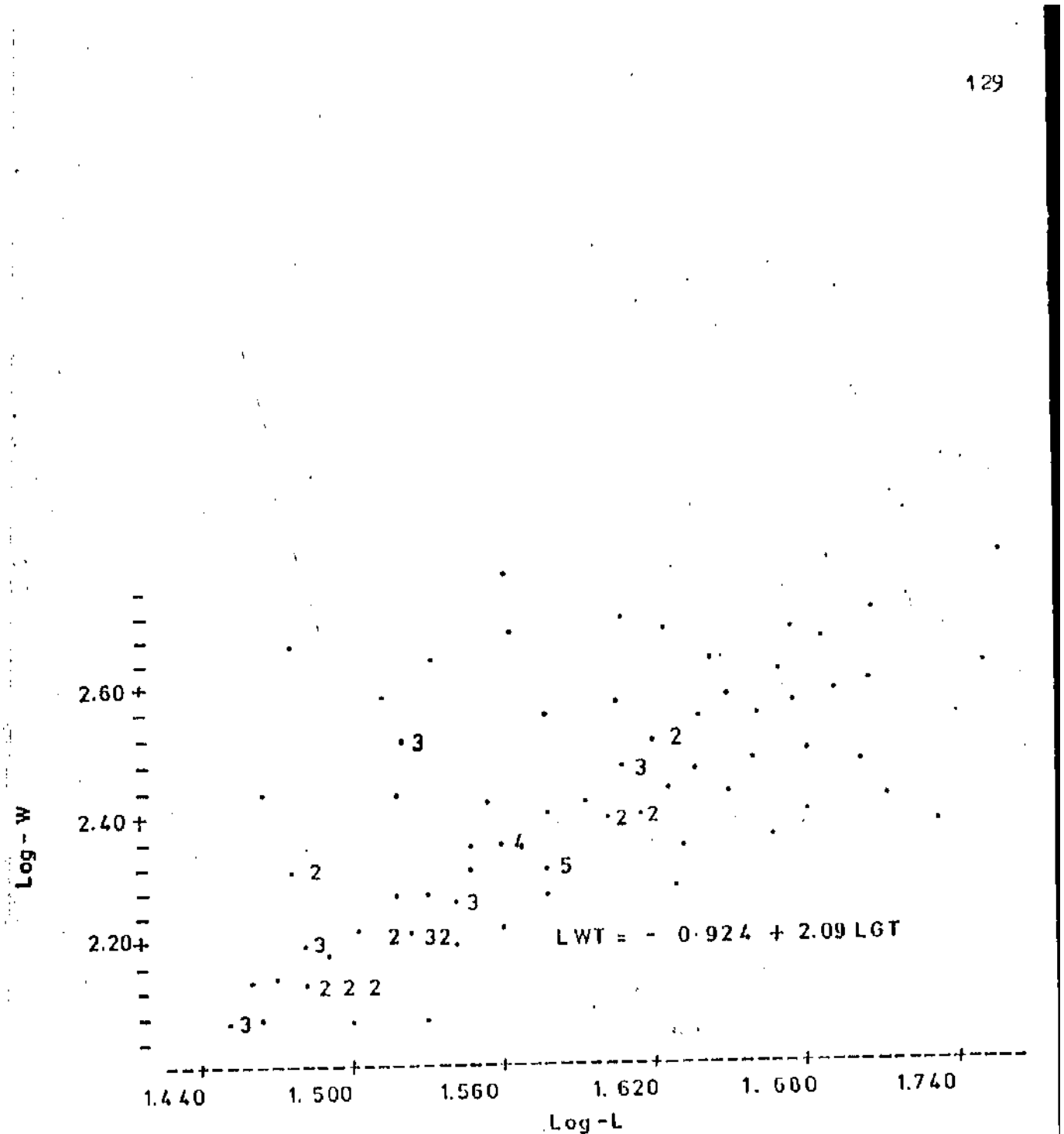


FIG.51: Length-weight relationship of M. deliciosus (female)

Table 13 **FOOD COMPOSITION OF THE STOMACH OF *Momyrops deliciosus*.**

	Food composition	%frequency of occurrence	% Total point
	Insect remains	62.9	9.5
Adult Insect	Hemiptera	12.4	2.6
	Coleoptero	1.9	0.5
	Hemiptera Nymph	4.9	0.6
	Dragonfly Nymph	24.9	7.4
	Damselfly Nymph	20.5	5.2
Immatured Insects	Ephemeropteran Nymph	5.1	0.8
	Trichoptera Larvae	18.5	2.8
	Coleoptera larvae	20.8	6.9
	Chironomid Larvae	13.5	1.4
	Chaobonus pupae	9.5	1.5
	Fish/fish remains	57.5	44.9
	Decapod (Prawns)	6.5	3.8
	Plant remains	18.3	2.0
	Seeds	28.4	4.9
	Sandy Material	3.3	0.6
	Detritus		4.5

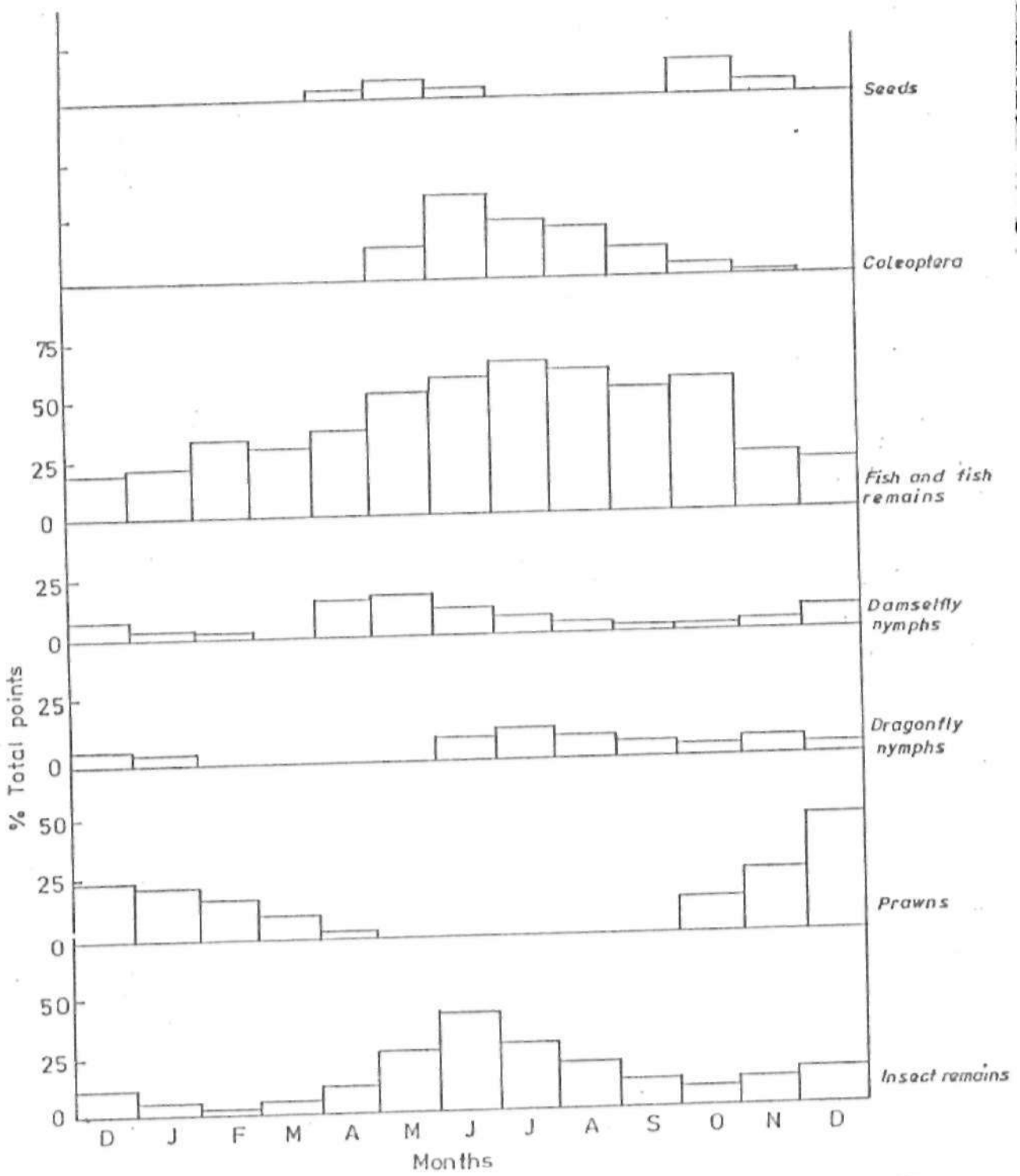


FIG. 52: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH OF *M. deliciosus*

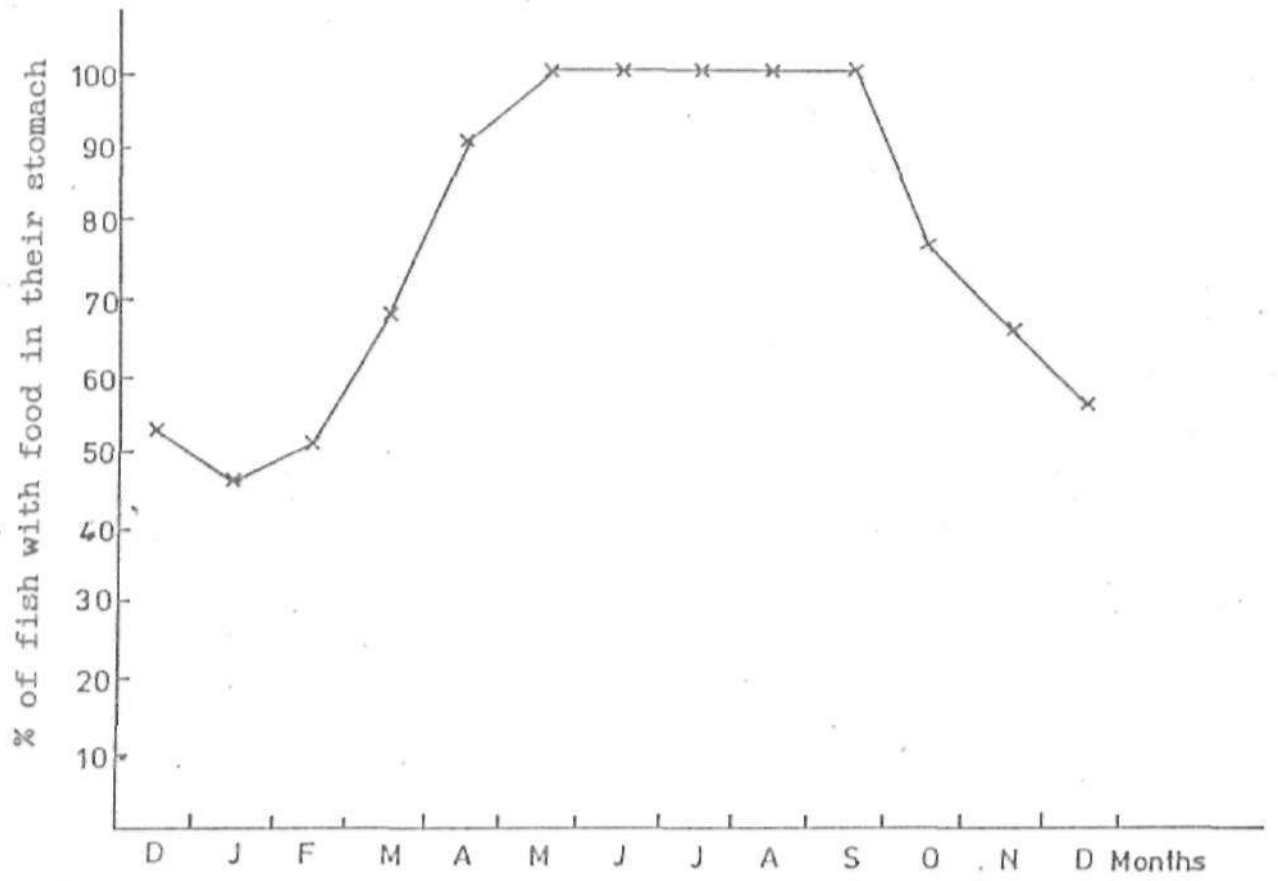


FIG. 53: MONTHLY FEEDING INTTENSITY PATTERN OF *M. deliciosus*

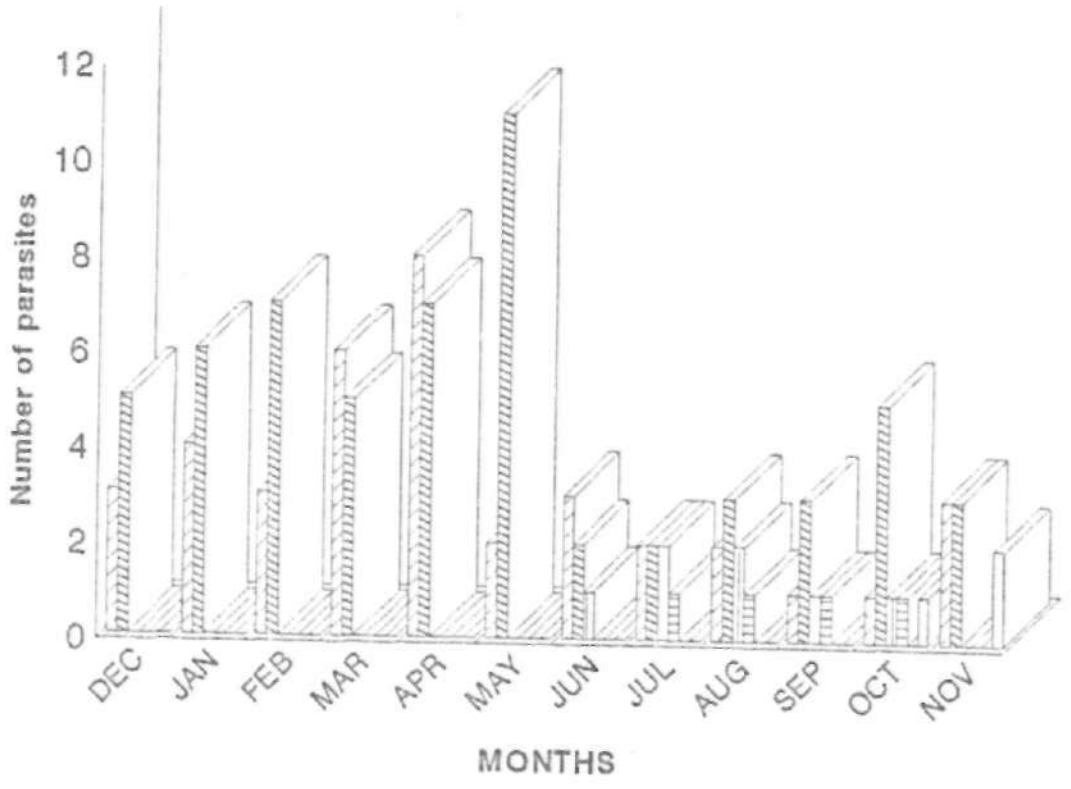


Figure 54: Stages of gonad development in female M. deliciosus

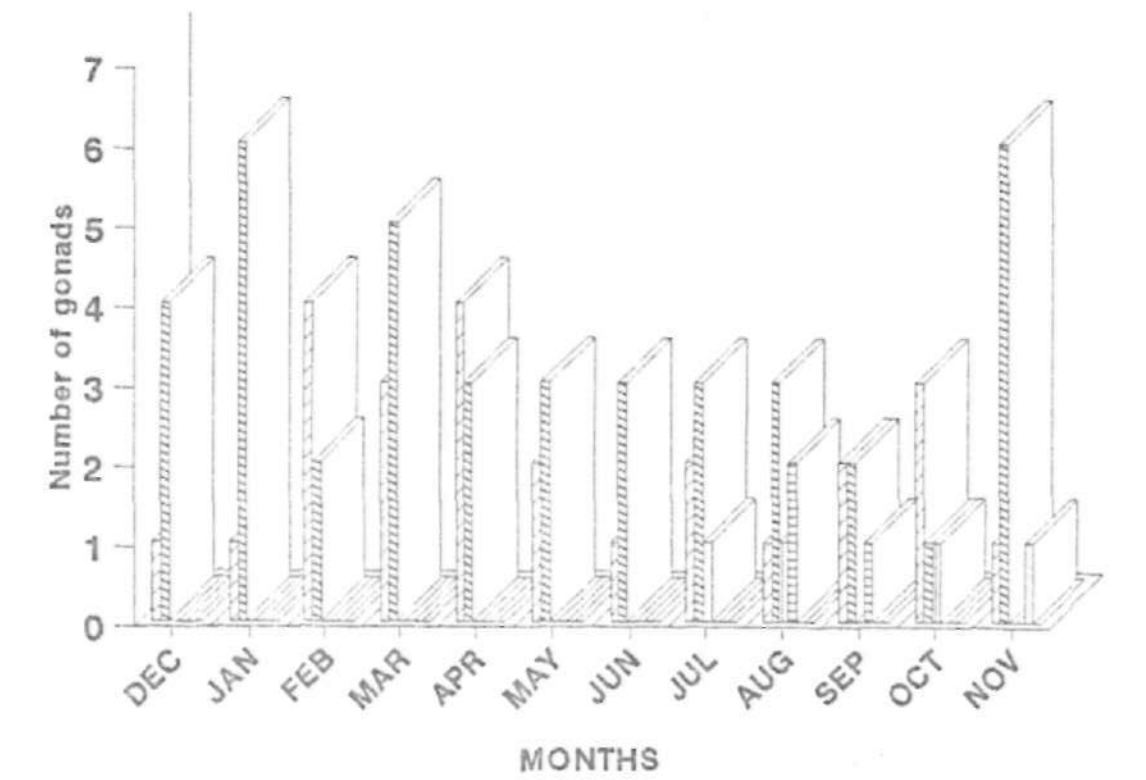


Figure 55: Stages of gonad development in male M. deliciosus

gonads were observed in October and November, during which only one mature female fish was found in each month.

From November to May, only stages I and II gonads were observed in both sexes and by June, a stage III gonad of the female was observed.

The estimated fecundity for this fish ranged from 2216 to 2532 (from fish length of 36.3 cm to 33.1 cm respectively) (Appendix 3d)

4.51. PARASITES OF THE BRANCHIAL CHAMBER OF *M. deliciosus*.

Out of the 183 specimens (73 males and 110 females) examined, 111 (60.65%) were parasitized by a total of 237 parasites composed of *Lamproglena sp.* and *Hirudo sp.* Infection rates in the male and female fish were 57.5% and 62.7% respectively (Appendix13a, 13b and 13c). ANOVA showed that there was no significant differences ($P > 0.05$) in the rates of parasitic infection of the branchial chamber of the male and female fish.

In the male and female fish, the monthly infection pattern of *Lamproglena* sp. in the first six months of the year were similar, with a peak in April, which gradually decreased to zero in June and July (Figs. 56 and 57). A second peak occurred in October in female fish.

Peak infection of the gills by *Hirudo sp.* occurred mainly between November and January in the male fish and November and March in female fish, though fairly high infection rates were maintained between the months of November to March. Between May and October, this parasite was practically absent on the gills (Figs. 56, 57 and 58).

ANOVA showed that the rate of parasitic infection of gill 1 was significantly different from gills 2 and 3 ($P < 0.05$), and there were no correlation in infection of gill arches 2 and 3. The rate of infection of the gills by the two parasites in both sexes were similar (Fig. 59). Infection rate in gill arch 1 was greater than gill arch 2 and 3. Gill arch 4 was not infected by any of the parasites.

4.52 DESCRIPTION AND PATHOLOGICAL EFFECT OF BRANCHIAL CHAMBER PARASITES OF *M. deliciosus*

4.52a. *Lamproglena* sp.

The parasite including egg sac was 2.5-4.2mm in length. The anterior thoracic legs

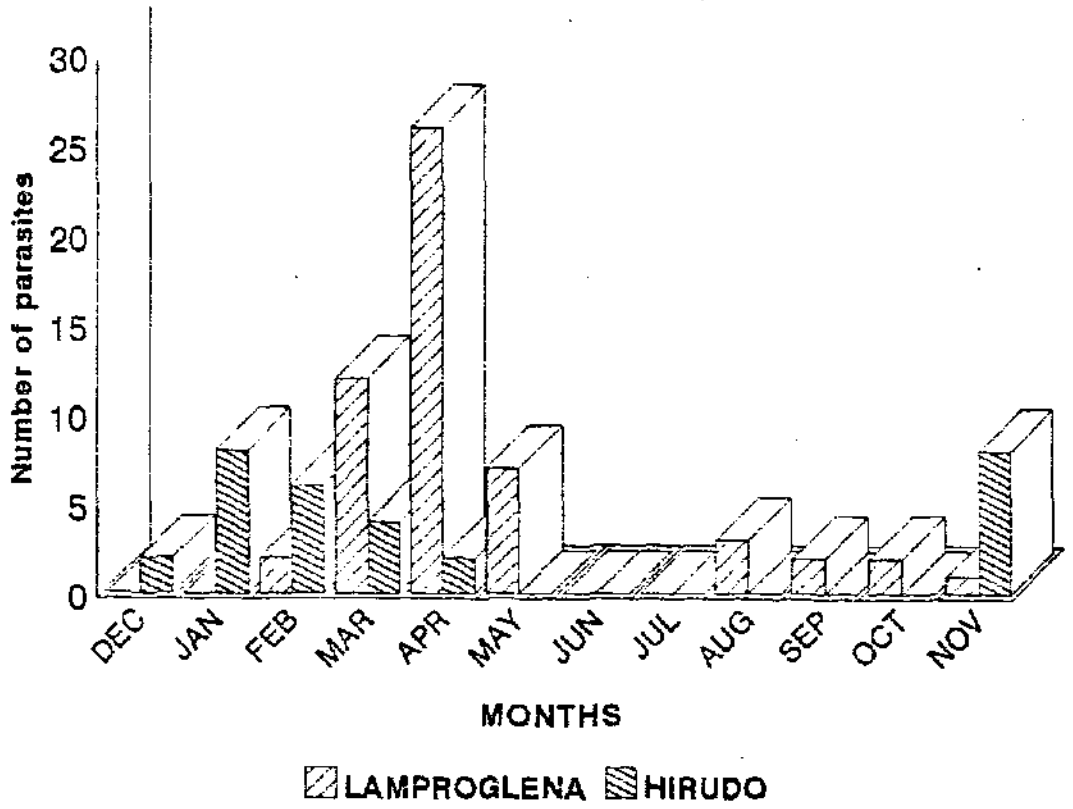


Figure 56: Occurence of parasites in the branchial chamber of male M. deliciosus

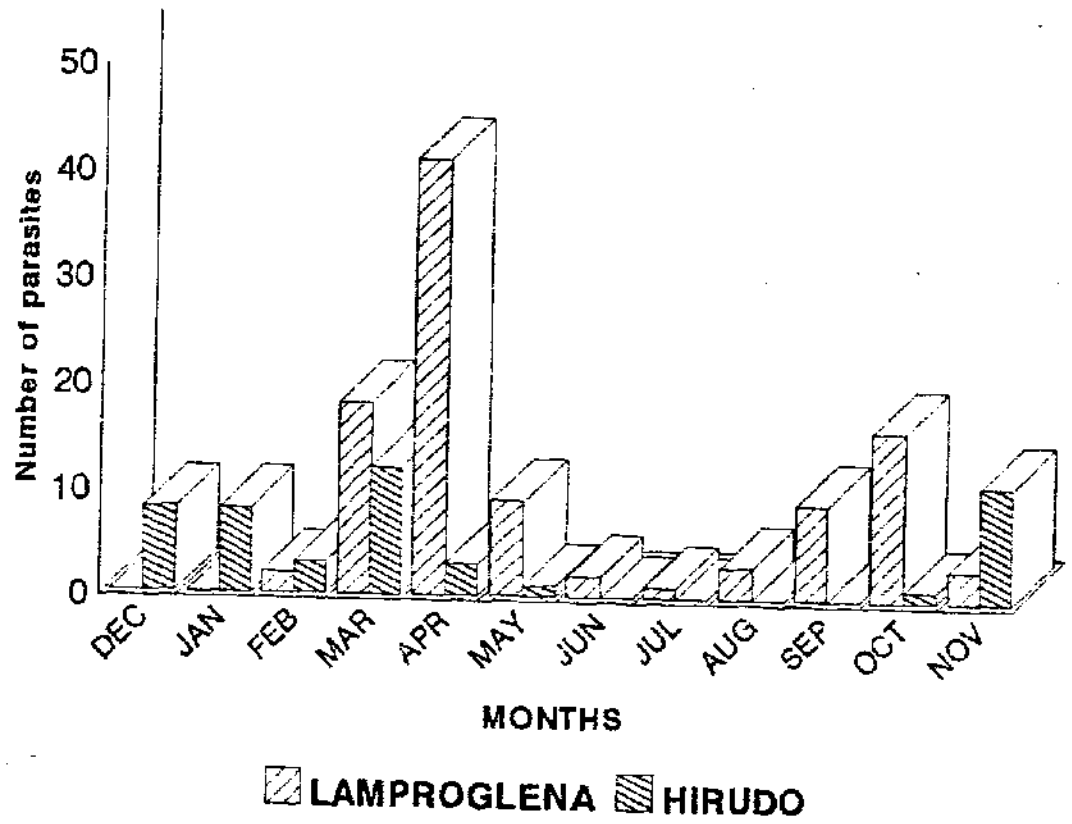


Figure 57: Occurence of parasites in the branchial chamber of female M. deliciosus

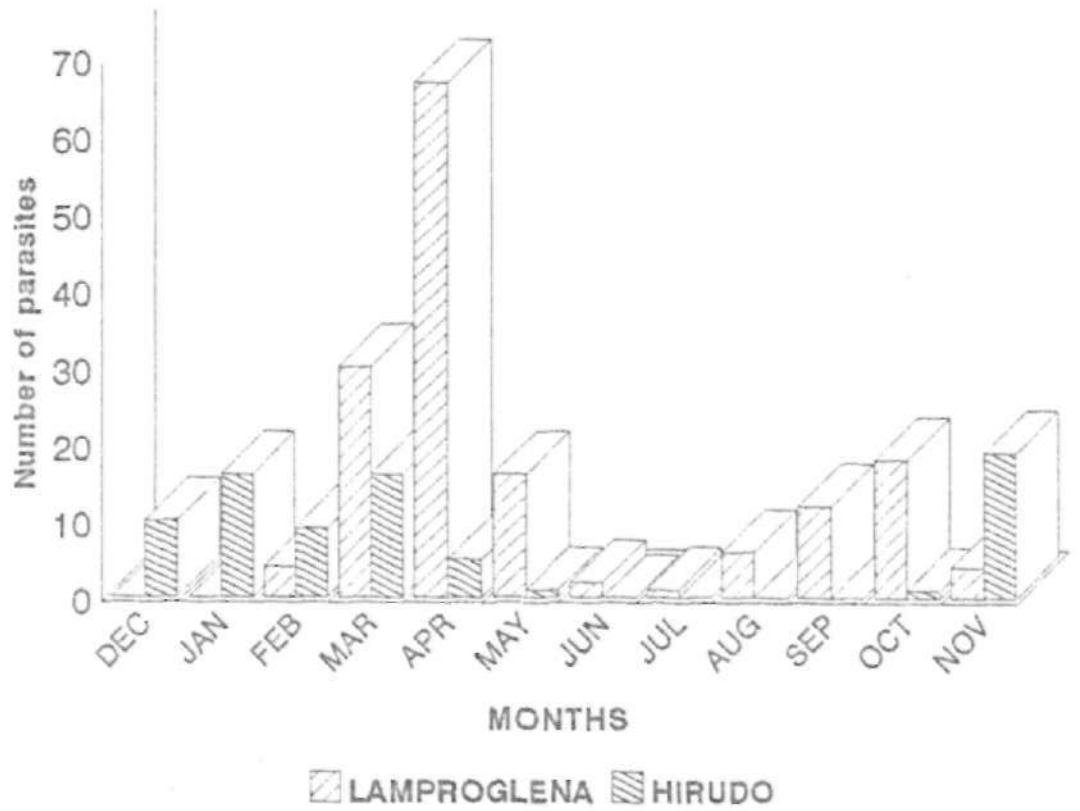


Figure 58: Occurence of parasites in the branchial chamber of M. deliciosus (combined sexes)

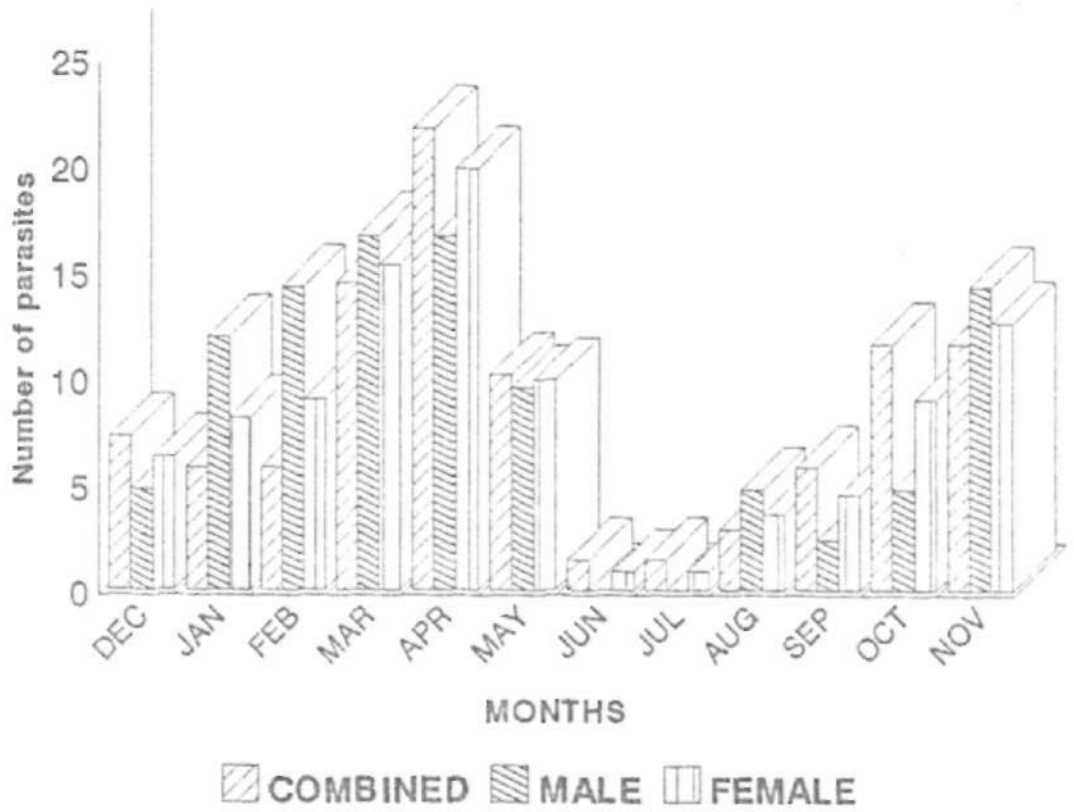


Figure 59: Monthly infection rate of parasites on M. deliciosus (male, female and combined sexes)

were rudimentary while other segments had no appendages. The specimen appeared to have five external segments. The anterior portion consisted of three segments fused to form the cephalothorax. The anterior thorax had six rudimentary legs while other segments had no appendages. The second part may be considered as the abdomen, from where a pair of "string-like" egg sacs arose. The eggs were arranged singly and there were 20-24 eggs per sac (plate XXVIII). The last part, which may be considered as the caudal segment is elongated and roughly "W"-shaped at its extremity.

The parasites did not appear to cause any lesion on the gills. However, the head was embedded in the gill tissue, and may therefore interfere with the functions of the gills. A little depression of the gill primary filament at the point of attachment by the parasites was observed (Plate XXIX).

4.52b. ***Hirudo* (*Rhynchobdellae* sp.)**

This specimen had a very high retractive and extensive ability. It ranged between 20 mm and 50 mm in length.

They were found attached either to the base of the gill arch, close to the "origin" of the gill filament or attached to the gill arch cartilage and also within the opercular cavity. On detachment, they created a small roundish heamorrhagic spot. In a few cases (3) the oral suckers were found attached to the gill arch while the ventral suckers attached to the gill filament, exhibiting a "n"-shaped attachment.

4.53 PARASITES OF THE GIT OF *M. deliciosus*

A total of 190 parasites were recovered from 109 fish. Percentage infection of male and female fish were 67.12% and 53.36% respectively (Appendix 14a, 14b and 14c). The GIT was parasitised by *Procamallanus sp.*, *Neoechinorhinchus sp.* and *Eucestodaria sp.* The *Procamallanus sp.* were found in the intestine and rectal regions while the other species were restricted to the intestine.

In male fish, correlation analysis showed that there was no correlation ($P > 0.05$) between the infection by *Eucestodaria* and *Neoechinorhinchus sp.* and *Paracamallanus*. However, there was a correlation between the infection caused by *Neoechinorhynchus sp.*



PLATE XXVIII: Lamproglena sp. from gills of M. deliciosus
Magnification X 150

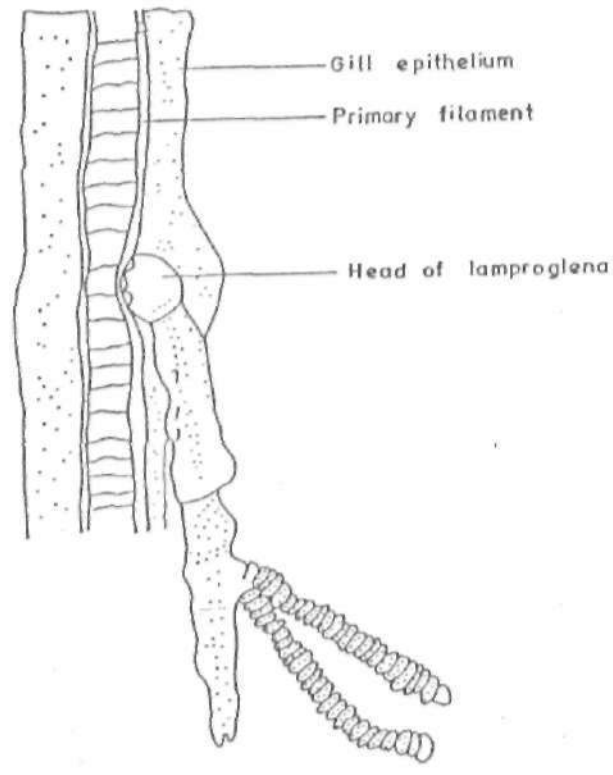


PLATE: XXIX. Lamproglena sp. note depression of primary filament at the point of attachment.

and *Procamallanus* sp. ($P < 0.05$) in both sexes.

Monthly infection in both sexes showed that *Neoechinorhynchus* sp. peaked in August in male fish and July in the female fish. Infection by *Procamallanus sp.* was highest in February and March in male fish and March in female fish (Figs. 60 and 61).

Eucestodaria sp. were absent in the months of July, August and October in both sexes, but its infection rate was higher in female than in male fish. Generally, the female had higher parasitic load than the male (Fig. 62).

4.54. DESCRIPTION AND PATHOLOGICAL EFFECT OF THE GIT PARASITES OF *M. deliciosus*.

4.54a. *Eucestodaria* sp.

This is an unsegmented tapeworm that lacks a digestive tract. The anterior end can be retracted and contains a "sucker" at its apex, with which it attaches itself to the intestine of the host (Plate XX X). No grossly visible damage to the host tissue at the site of attachment of the parasite.

4.54b. *Neoechinorhynchus* sp. (Phylum Acanthocephala).

The length of this parasite varied from 0.99 mm to 1.88 mm while the width range from 0.25-0.57 mm. The proboscis, spherical with 6 short hooks, was followed by a short neck without hook. Just below the neck, there are two rows of 16 - 18 hooks each, the lower row containing larger hooks. The spheroid anterior proboscis had retractive ability (Plate XXXI).

Some of the parasites were found with their proboscis embedded in the epithelial lining of the intestine (Plate XXXII), while in others, destruction as far as the stratum compactum was observed (Plate XXXIII).

4.54c. *Procamallanus laevionchus*.

Description of this parasite is similar to that of *H. b. occidentalis* in 4.9a. No pathological effect of the parasite were seen on host .

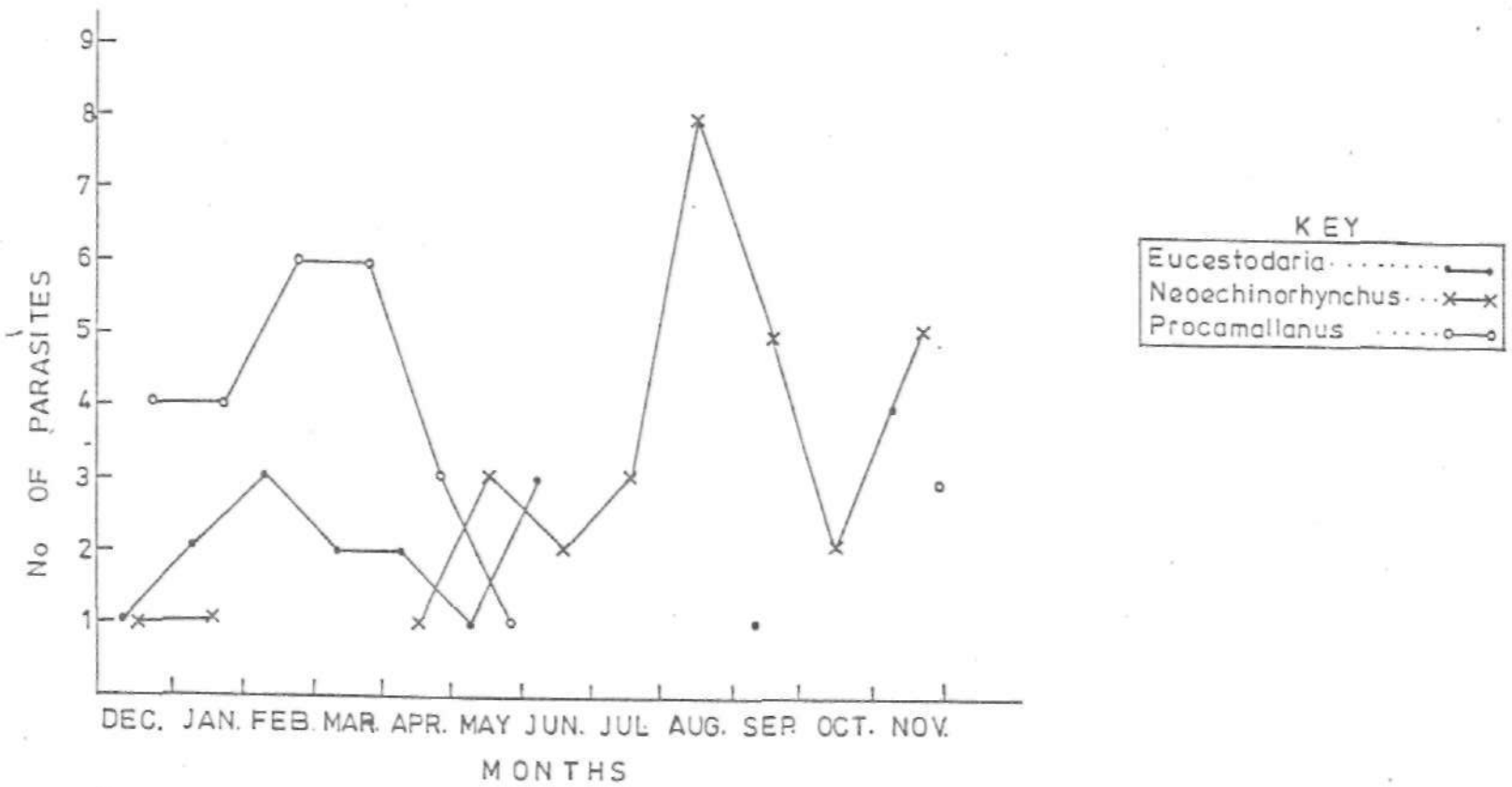


FIG.60 MONTHLY INFECTION OF PARASITES OF THE G.I.T. OF M. DELICIOSUS (MALE)

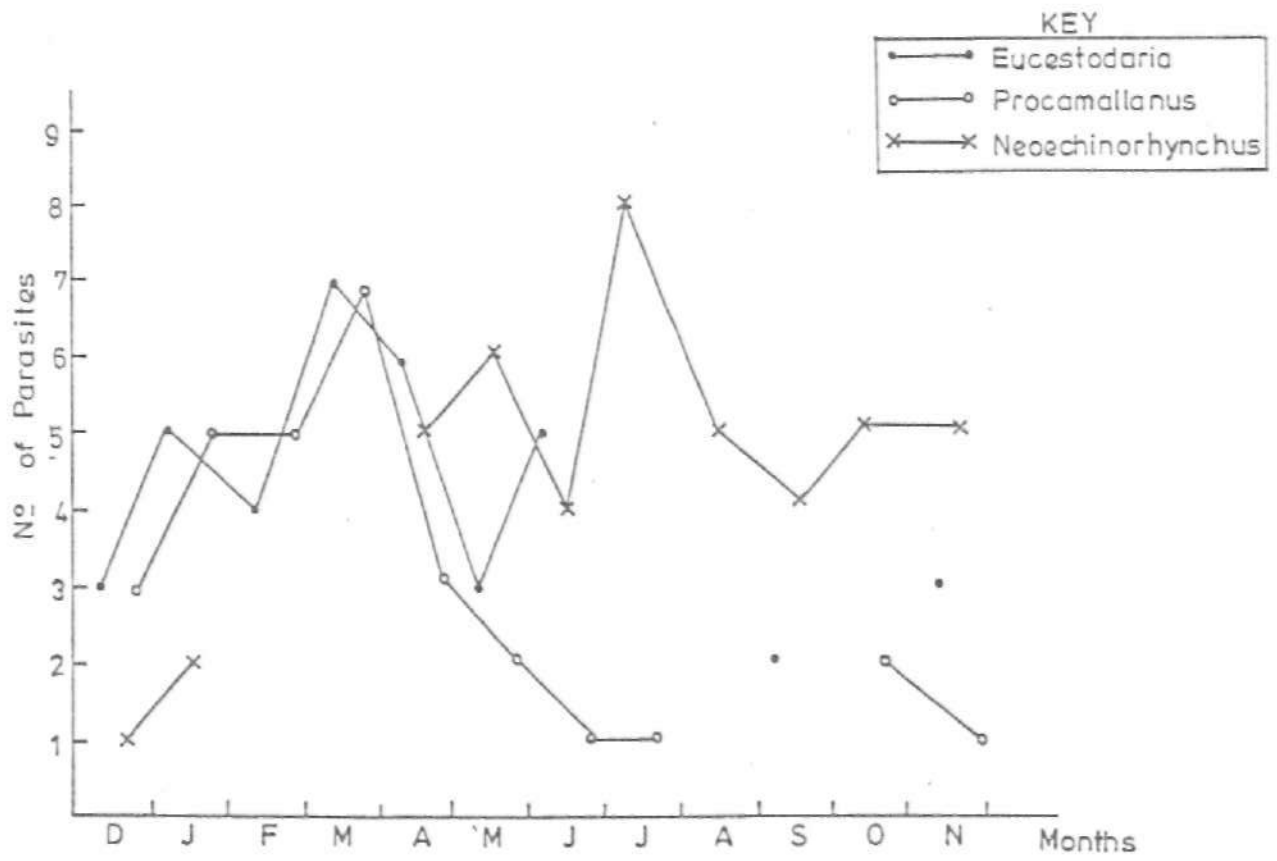


FIG. 61 MONTHLY INFECTION OF PARASITES OF THE G.I.T. OF M. DELICIOSUS (FEMALE)

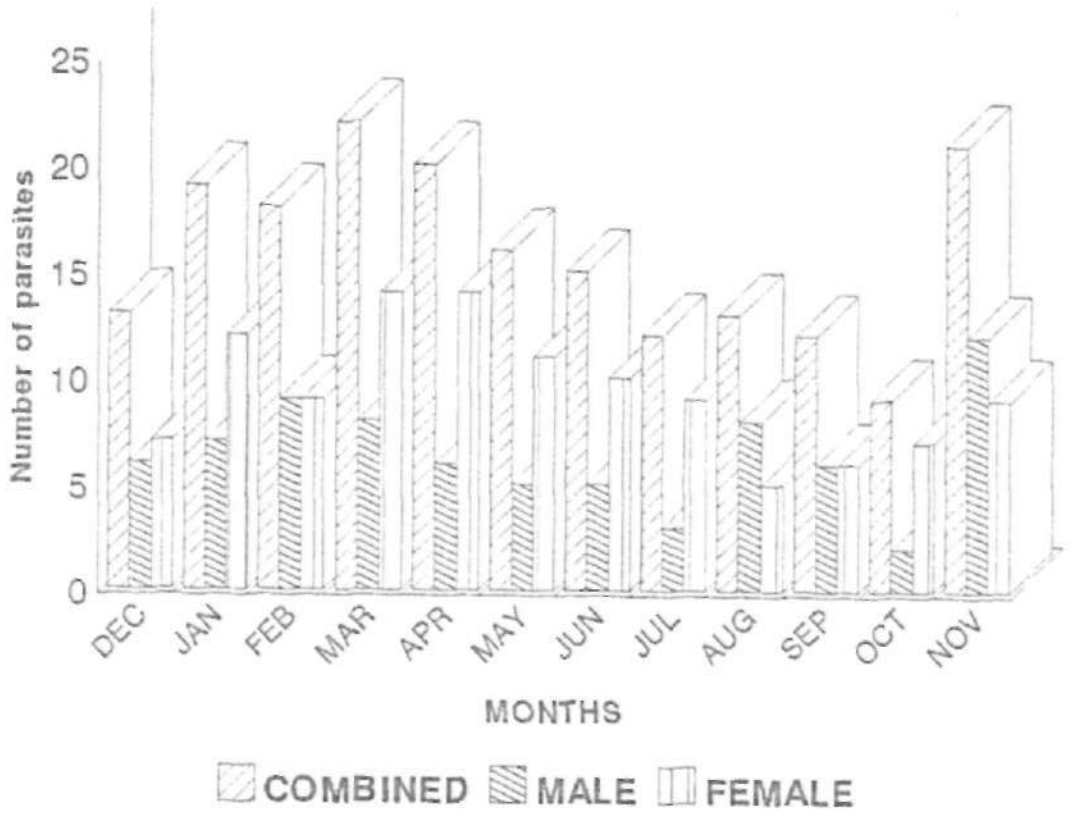


Figure 62: Monthly occurence of total parasites in the gastro-intestinal tract of M. deliciosus



PLATE. XXX: *Eucestodaria* sp. from GIT of *M. deliciosus*
(Mag. x 60)

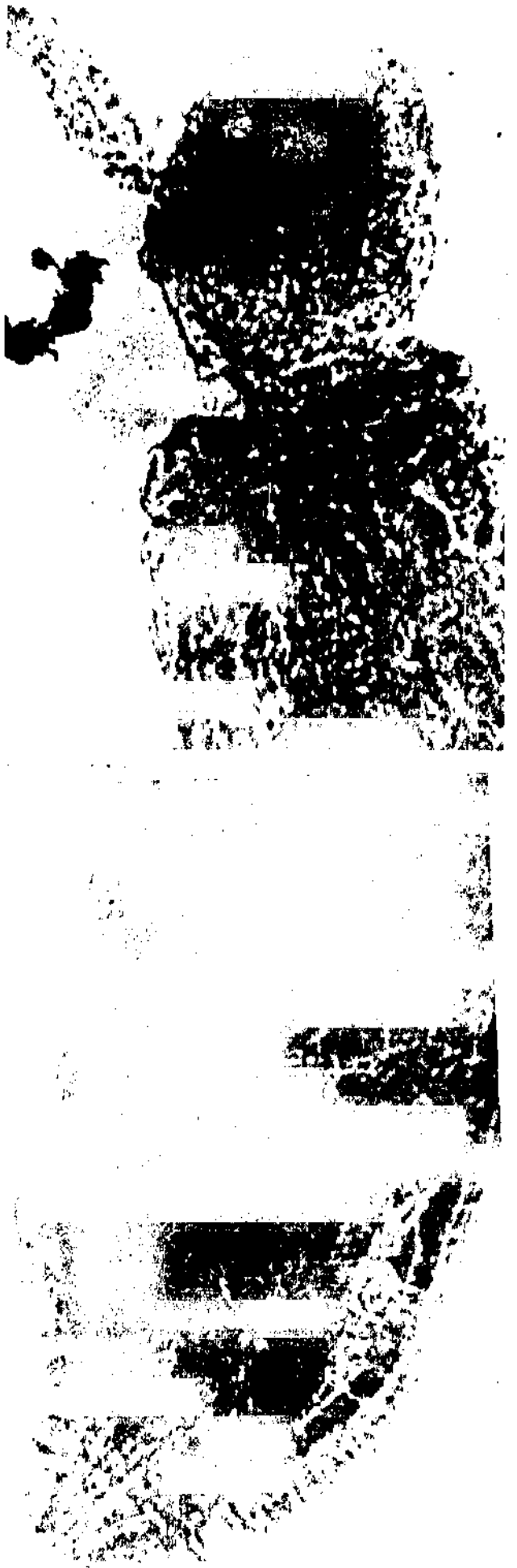


PLATE. XXXI: *Neoechinorhynchus* sp. head region(above) and tail region(below).(Mag. x 100)

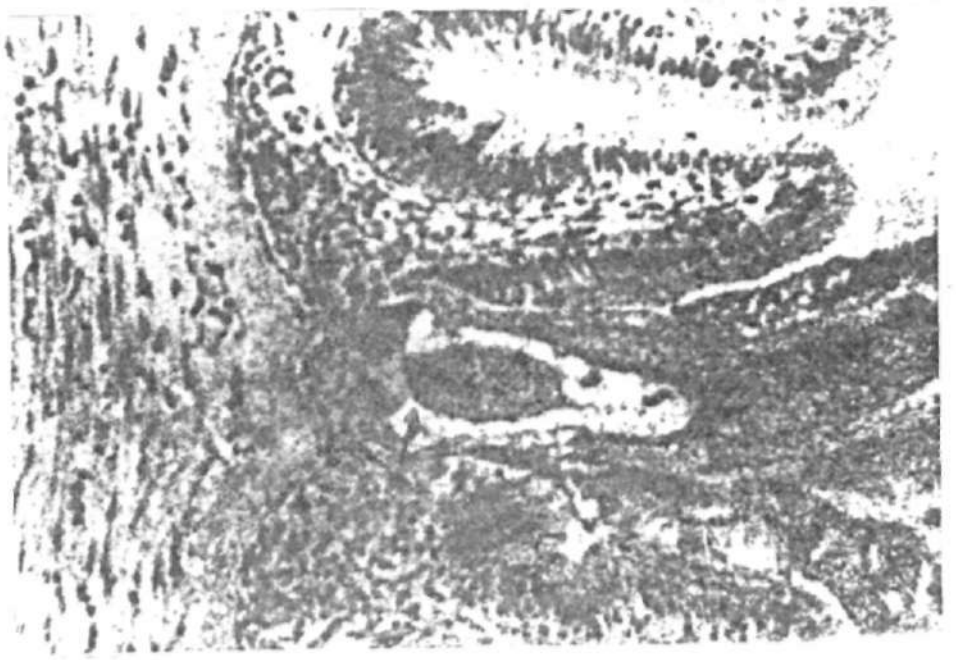


PLATE. XXXII: *Neoechinorhynchus* sp. with proboscis (arrowed) in intestine of *M. deliciosus*
Magnification: x60



PLATE XXXIII: *Neoechinorhynchus* sp. with proboscis (arrowed) in stratum compactum of intestine of *M. deliciosus*
Magnification: x60

4.55. RELATIONSHIP BETWEEN THE BRANCHIAL CHAMBER PARASITES OF *M. deliciosus* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

There was a significant correlation ($P < 0.05$) between *Hirudo* sp., and turbidity and rainfall in male and female fish in Zaria dam. When turbidity of the dam and rainfall were high in May to September, *Hirudo* sp. was absent from the gills and the reverse was the case during the months of December to April.

Lamproglena sp. only showed significant correlation ($P < 0.05$) with rainfall when data for male and female fish were combined. The parasites were predominant in the fish during the dry season and almost absent during the rainy season.

Relationship between the parasites of each of the sexes of fish showed that *Hirudo* sp. and *Lamproglena* sp. infections of the male was similar to that of the female.

4.56. RELATIONSHIP BETWEEN THE GIT PARASITES OF *M. deliciosus* AND PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

When the water pH was lowest (acidic) in March, infection with *Encestodaria* sp. was highest but the parasite was absent in July when the pH was high.

As water turbidity, rainfall and pH values increased during the rainy season, *Neoechinorhynchus* sp infection. also increased. Infection by *Procamallanus* sp. decreased when turbidity, temperature, rainfall, manganese and chloride concentrations started decreasing.

4.57 RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *M. deliciosus* AND BRANCHIAL CHAMBER PARASITES

Juveniles with length-class range of 28.1-36.0cm had 44.6% incidence of infection, sub-adult (36.1-44.0cm) had 72.2% and adults (44.1cm and above) had 78.6% (Appendix 6).

4.58. RELATIONSHIP BETWEEN THE LENGTH-CLASS OF *M. DELICIOSUS* AND GIT PARASITES.

More of sub adults and adults were infected by GIT parasites compared with juveniles; the respective infection rates being 38.53%, 35.77% and 25.68% (Appendix 7). *Neoechinorhynchus* sp. were mainly found in the adult and sub adult groups of fish whereas *Procamallanus* sp. where almost exclusively restricted to the juveniles.

4.59 RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. deliciosus* AND BRANCHIAL CHAMBER PARASITES

Fish were the most important diet in the stomach of *M. deliciosus* particularly in the subadult and adult age groups. The months (November and December) during which consumption were lowest coincided with the period of least infection by *Lamproglena* sp. and high infection of *Hirudo* sp. Although insects were also found in the stomach of *M. deliciosus* throughout the year, they were more abundant from May to August which was a period of low parasitic infection in all age groupings and sexes of this fish.

4.60. RELATIONSHIP BETWEEN THE FOOD AND FEEDING HABIT OF *M. deliciosus* AND GIT PARASITES

Neoechinorhynchus sp. were present throughout the year in the intestine of *M. deliciosus* with the exception of the months of February and March, when the fish food items in the stomach of *M. deliciosus* were considerably lower than other months of the year. Other important dietary items then were the crustaceans.

Procamallanus sp. and *Eucestadarian sp.* infections occurred between the months of November to April when coleopteran insects and dragonfly nymphs were absent from the diet of *M. deliciosus*, while fish and prawns (crustaceans) were predominant.

4.61 RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *M. deliciosus* AND PARASITES OF ITS GILLS

Between the months of July to October, when mature stages III and IV gonads were mostly found in *M. deliciosus*, there was basically no record of *Hirudo* on the gills. However, infection by *Lamproglena* sp. showed a second peak in October (the first being in April). Stages I and II gonads were found during the months of February to May, when *Lamproglena* sp. infection showed the first peak.

There were correlation between the *Lamproglena* infection in the male fish and stage I gonad and with stage II gonad in the female fish ($P < 0.05$). There was correlation between infection by *Hirudo* sp. in male fish and stages II and III gonads, and stages IV and VI gonads in the female fish ($P < 0.05$).

4.62 RELATIONSHIP BETWEEN THE REPRODUCTIVE CYCLE OF *M. deliciosus* AND PARASITES OF ITS GIT

There was no correlation between the infection of the GIT by *Procamallanus* sp. and the stages of gonads of both fish sexes. Though the infection rate of the Eucestodaria was higher in female fish than in the males (absent only in July to October), there was a positive correlation between the parasite in female fish with stages II, IV and VI gonads, but only with stage III in male fish ($P < 0.05$).

Neoechinorhynchus sp. infection had a correlation ($P < 0.05$) with stages III and IV male gonads and only with stage IV gonads in the female fish. This parasite was prevalent during the months of June to November when mature gonads were mainly observed.

4.63. LENGTH-WEIGHT RELATIONSHIP OF *Hippopotamyrus pictus* AND *Petrocephalus bovei*

The Length -weight relationship of *H. pictus* (81 specimens) showed that the exponent "b" was 2.82. This showed negative allometric growth of the fish (Fig.63).

The exponent "b" of *P. bovei* (34 specimens) was 3.59, this was an indication of

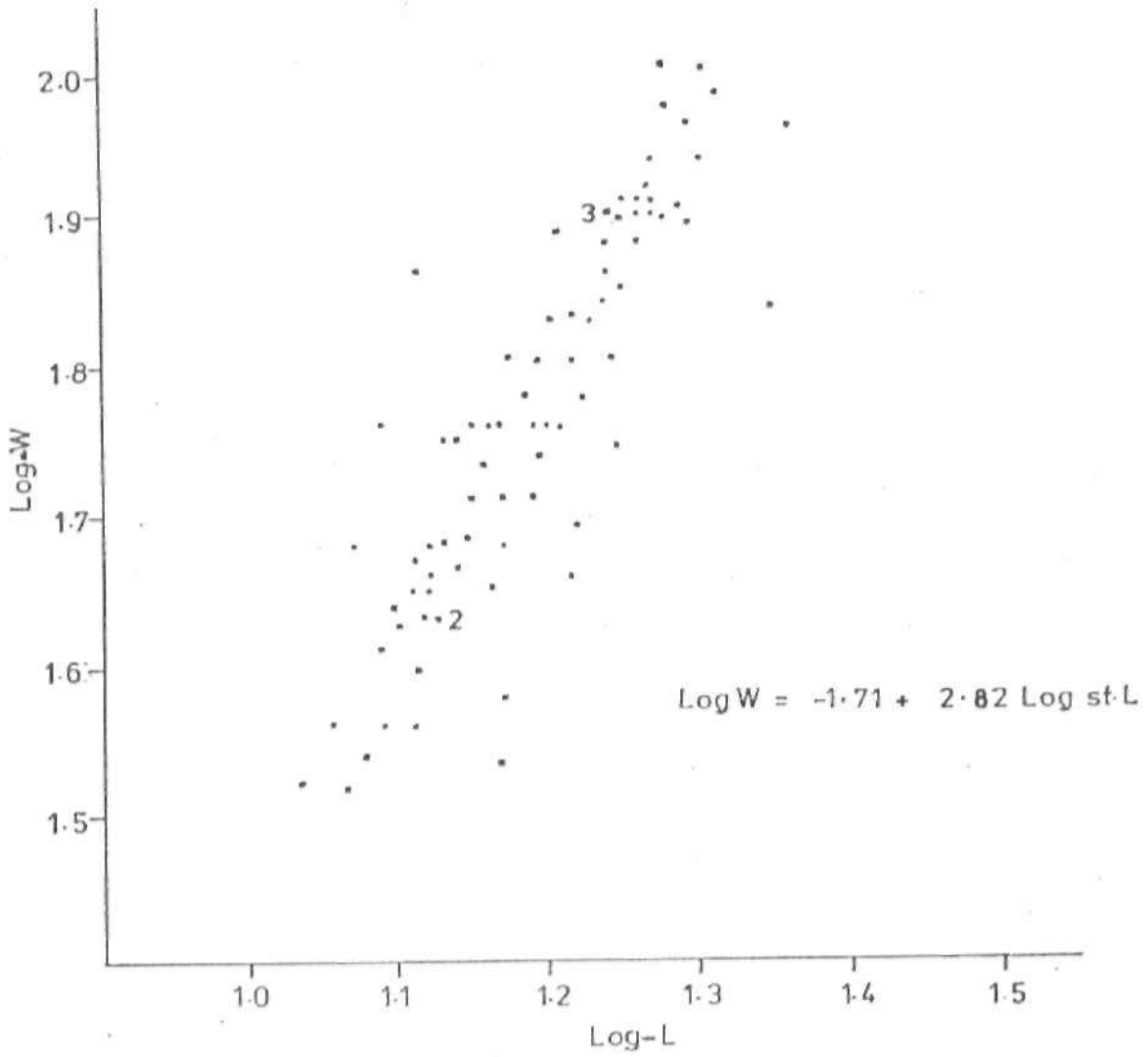


FIG. 63: LENGHT-WEIGHT RELATION OF *Hippopotamus pictus*

allometric growth, i.e. this fish was heavier for its length as it grew (Fig. 64); the weight of the fish did not appear to depend on length.

4.64 FOOD AND FEEDING HABITS OF *H. Pictus* AND *P. Bovei*

Immature insects were the major components of the stomach of *H. pictus*. Of these insects, trichoptera larvae and ephemeropteran nymph constituted 28.7% and 27.0%, followed by chironomid larvae (15.0%). Other items of lesser importance included the dragonfly nymph, coleoptera (adults), ostracods and decapods (Table 14).

The months of July, August, September and October were the highest feeding period (100%) of the year for this fish. When the trichopteran larvae were very plentiful in the months of July to September, the ephemeropteran larvae consumption was low but by October and November it increased. Chironomid larvae were basically consumed throughout the year (Fig. 65). No fish were obtained in the months of January and June.

Petrocephalus bovei consumed about 66.8% of the immature insects. Chironomid and trichopteran larvae, and dragonfly nymph were common in the diet of this fish compared with other insects (Table 15). Insect remains, cyclops, Oligocheates and seeds formed other important items in the stomach. Though these fish were obtained in the months of July, August, September and November, the highest feeding month was September and trichopteran larvae were the most important item in the stomach then. Dragonflies and chironomic larvae were conspicuous in August while trichopteran larvae were conspicuous in September (Fig. 66).

Cyclops and Oligochaetes were mostly found in November. This fish appeared to have consumed a greater variety of food items compared with the other mormyrids studied.

4.65 REPRODUCTIVE CYCLE AND FECUNDITY ESTIMATE IN *H. pictus* AND *P. bovei*

Only six females of *H. pictus* with fully mature gonads (stage IV) were found in August, September and November, it appeared that the fish spawned between the months of August and October, and spent gonads (stage VI) were found in October and November

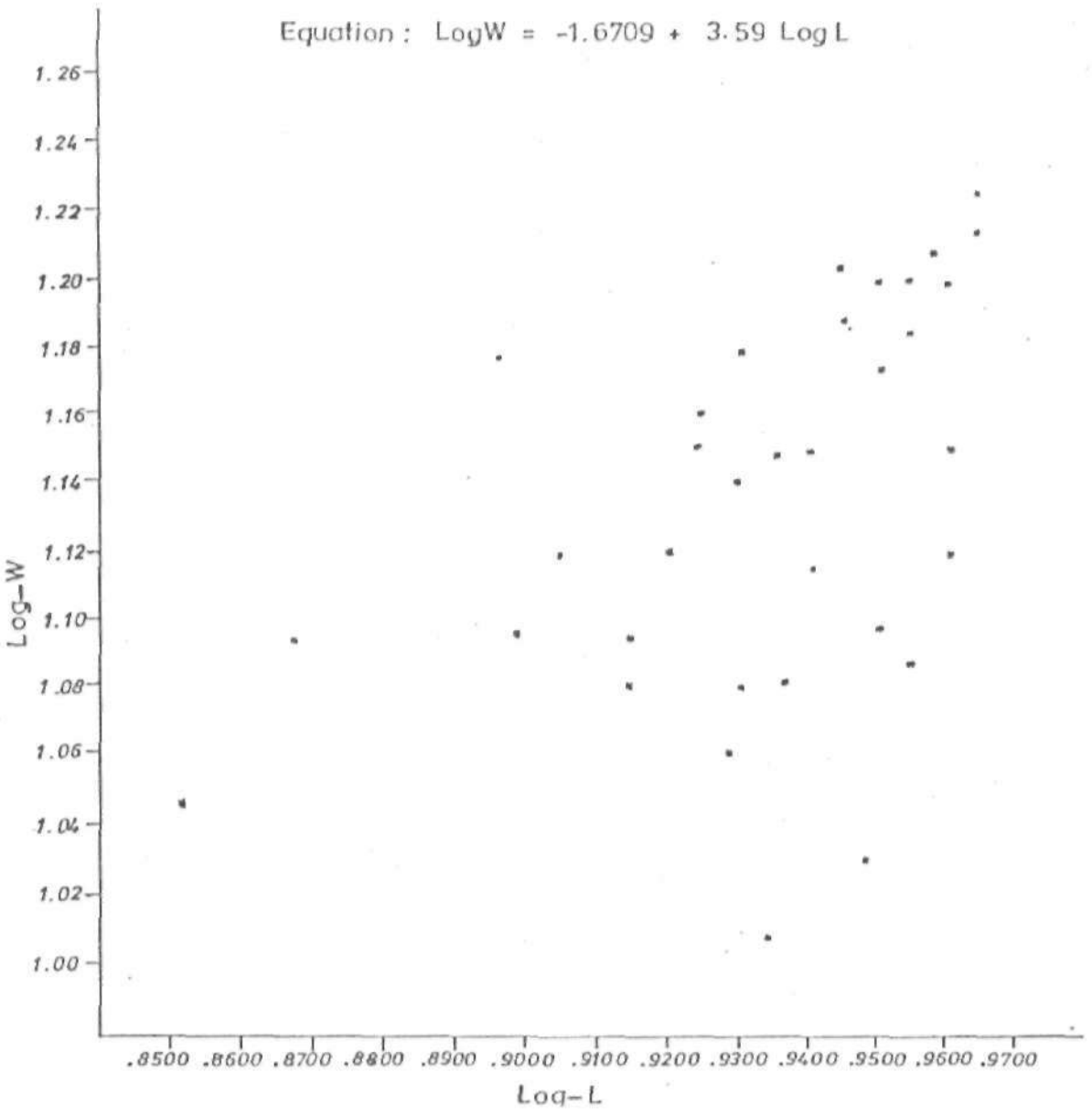


FIG. 64: LENGHT-WEIGHT RELATIONSHIP OF *Petrocephalus bovei*

TABLE 14: FOOD COMPOSITION OF THE STOMACH OF *H. PICTUS*.

	Food Composition	% Frequency of occurrence	% Total point
Immature Insect	Chironomid larvae	60.8	15.2
	Chironomid Pupae	10.3	0.6
	Heleidae Larvae	13.8	1.8
	Trichoptera larvae	62.5	28.7
	Megaloptera larvae	4.2	0.4
	Ephemeroptera nymph	45.6	27.0
	Damselfly Nymph	13.5	0.5
	Dragonfly Nymph	6.5	1.5
Adult Insect	Coleoptera (Adults	6.9	0.8
	Insect remains	58.5	13.2
	Ostracods	2.7	0.4
	Decapods (Shrimps)	3.4	0.6
	Seeds	20.2	5.1
	Detritus	3.2	

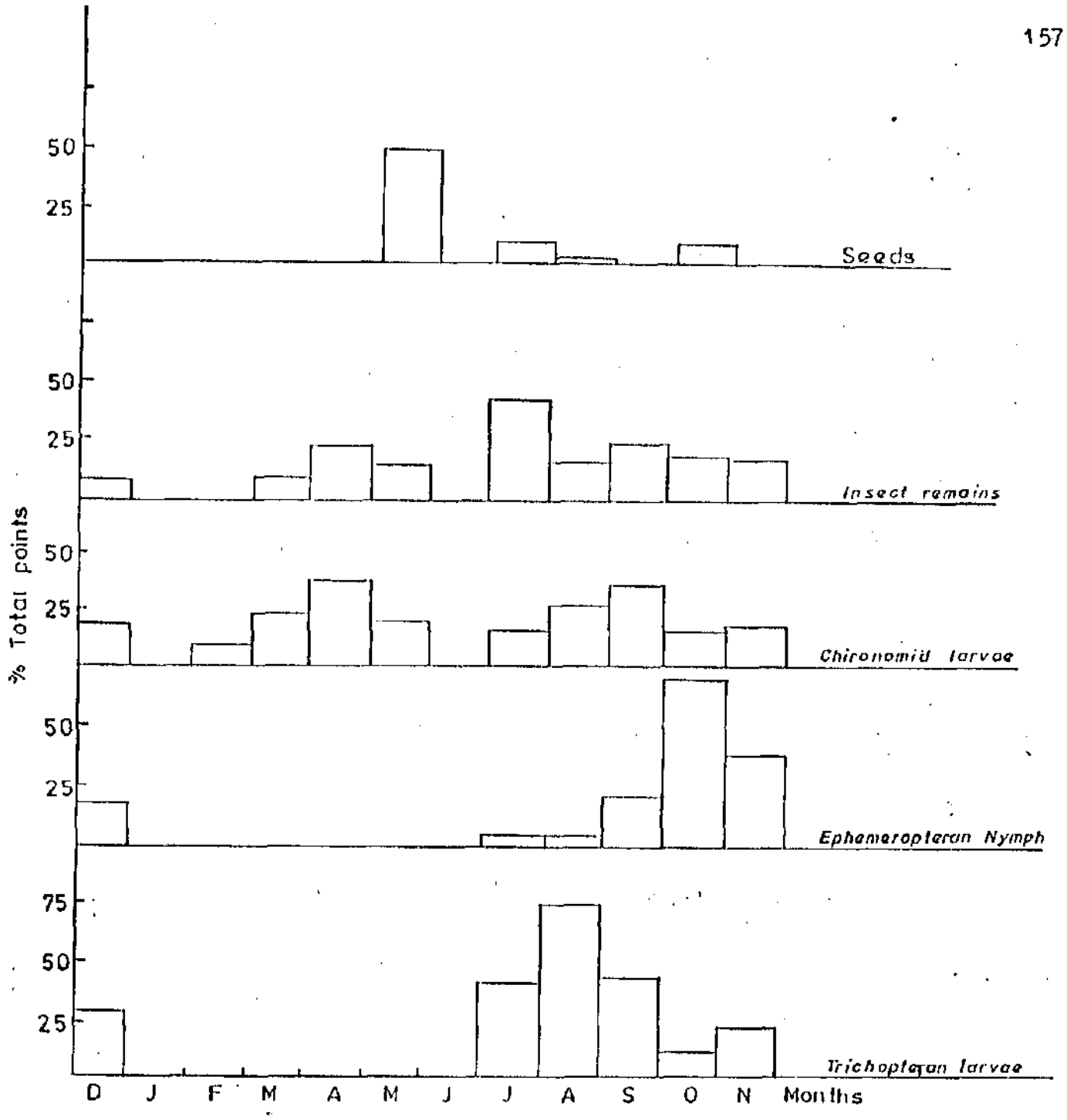


FIG. 65: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH OF *H. pictus*

TABLE 15: FOOD COMPOSITION OF THE STOMACH OF *P. BOVEI*

	Food Composition	% Frequency	% Total point
Immature Insect	Chironomid larvae	70.1	23.5
	Trichopteran larvae	30.6	15.5
	Chaoborus larvae	24.1	6.4
	Heleidae larvae	2.1	0.2
	Megaloptera	1.8	0.1
	Hemipera Nymph	20.0	3.5
	dragonfly Nymph	28.4	12.4
	Damselfly Nymph	6.6	2.7
	Ephemeroptera nymph	6.1	3.1
Adult Insect	Coleoptera (Adult)	8.3	2.1
	Hemiptera (Adult)	2.9	0.8
	Insect Remains	68.0	22.1
Crustacea	Decapods (Shrimps)	2.0	0.3
	Cyclops	13.1	1.7
Mollusc	lamellibranchia	2.1	0.2
	Oligochaetes	4.8	1.1
	Seeds	12.6	2.8
	Others	1.2	

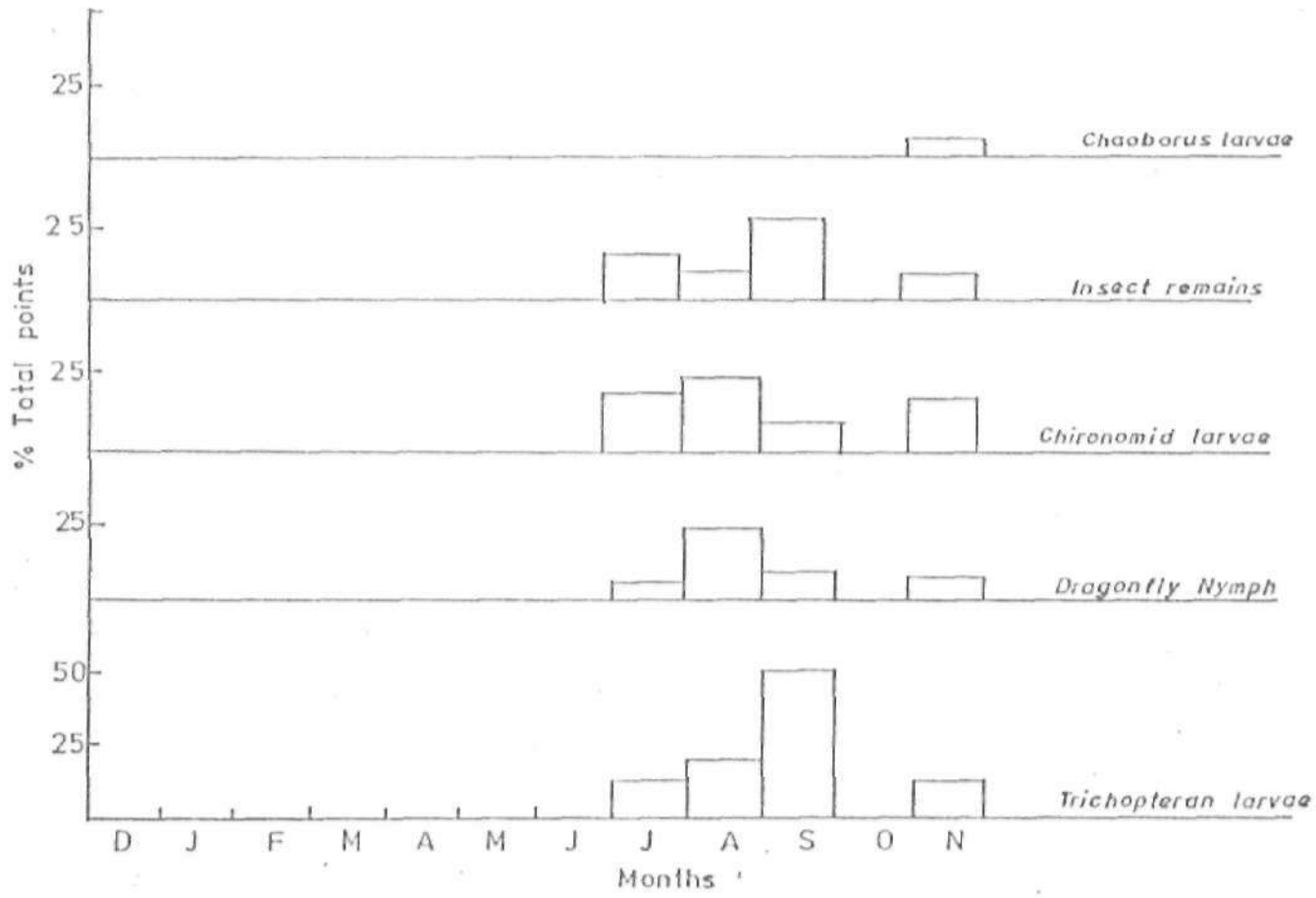


FIG. 66: MONTHLY VARIATION IN COMPOSITION OF DIET IN THE STOMACH OF *P. bovei*.

(Appendix 15). Mature males were found from May to October, indicating that males probably matured before the females. Fecundity estimate ranged between 718 to 2401 eggs in *H. pictus* (mean = 1,567).

Amongst the seven females of *P. bovei* that were recognised, five had fully mature gonads (stage IV) in July and August (Appendix 16). No male fish was recognised during the period of study.

Fecundity estimate ranged between 1093 and 1775 (mean = 1411). *P. bovei* had the lowest fecundity estimate amongst the mormyrids (Appendix 3e and f)

4.66 GILL AND GIT PARASITES OF *H. pictus* AND *P. bovei*

Only 17 *E. sarsi* were found in October and November, in nine specimens of *H. pictus*. These were considered to be too few and therefore were not subjected to statistical analysis.

No gill parasites were found in *P. bovei*. and no GIT parasite was obtained in *H. pictus* or *P. bovei*.

CHAPTER FIVE

5.0 DISCUSSION

PHYSICOCHEMICAL PARAMETERS OF ZARIA DAM

The rains in Zaria starts in April and stops in October, while the dry season begins from October to April, and the Northern Guinea Savannah is noted for these two contrasting seasons within a year (Kowal and Knabe, 1972), while two peak rainy months of June and August were also experienced.

The low water temperature of Zaria dam between December and February, must have been in response to the change in air temperature created by the North-East trade winds, (Harmattan). Oladimeji and Wade (1984) and later Awanda (1987) and Balarabe (1989) have also observed low water temperatures in Zaria during this period.

High turbidity during the rainy season particularly in June to August may have been caused by soil erosion in the catchment area exacerbated by the torrential rains of this region. Furthermore, agricultural activities within the catchment area of the dam during the rainy season may have contributed to the observed high turbidity. As the rains decreased and finally stopped in October the turbidity also gradually decreased, and suspended particles settled. This condition prevailed through out the dry season during which turbidity was lowest.

In this study pH was acidic during the dry season and alkaline during the rainy season. The increase in pH in the rainy season could be attributed to run-off from agricultural lands, photosynthesis of microphytes, and carbon dioxide consumption (Russo, 1978; Rippey and Rippey, 1986), while the lowering of pH (acidity) during the dry season may be attributed to the decay of both allocthonous and autochthonous organic material in the dam (EIFAC, 1969; Boyd, 1979; Wade and Anadu, 1987).

Metallic concentration of a lake depends on the component of its catchment area and also on the constituents of fertilizers, insecticides and herbicides used on the farmlands within the catchment area of the lake. This might have contributed to the

increase in total iron concentration during the months of August to September. However, the Manganese concentrations within the aforementioned months was lowest. Say and Whitton (1981), observed that the control of solubility of Fe, Zn, Mg and Ca involve mineral equilibria controlled by pH. A decrease in pH favours the retention time of some metals in free water (Borg, 1983) while the soil of the catchment area and subsurface flow may also influence elemental behaviour (Sprenger *et al.*, 1987). In this study, when the pH decreased between August and November, the Iron concentration was high while the Manganese concentration was low (low throughout the year). Donahue *et al.* (1977) reported that high pH reduce the solubility of important micronutrients like iron, manganese and zinc.

The slightly higher nitrate concentration during the rainy season than in the dry season may be linked to surface run-offs that brings in fertilizers in solution into the dam and also decomposition of organic matter, which is a continuous process throughout the year. Comin *et al.* (1983) stated that high nitrate concentration in lakes is related to inputs from agricultural lands. The decrease in nitrate concentration in the months of December and January may be attributed to nitrate uptake by phytoplanktons and macrophytes or denitrification in the sediments as observed by Rippey and Rippey (1986) and Anyam, (1980).

The concentration of chloride ions was higher in the dry season than in the rainy season. This coincided with decreased pH (acidity) during the dry season and increased pH during the wet season. The alkaline and alkaline earth metals (such as Zn, Mg, K, Ca and Na) which have increased solubility with decrease in pH which were observed during the dry season, may have precipitated and or form weak acid with chloride causing increased acidity of the dam water during the dry season.

Generally, dissolved oxygen in Zaria dam was higher during the dry season than the rainy season. The high oxygen value in December, January and February (dry season) coincided with period of lowest turbidity, and temperature. Maitland (1978) observed that concentration of oxygen in water depends on its contact with atmosphere, photosynthesis by phytoplanktons and aquatic macrtophytes and amount consumed by the system. Following this observation, it can be said that the cool harmattan wind might

have contributed to the increased oxygen concentration during the dry season, whereas the torrential rains created increased turbidity and decreased oxygen concentration, during the rainy season.

LENGTH - WEIGHT RELATIONSHIPS.

The length - weight relationships showed positive correlation in *Hyperopisus bebe occidentalis*, *M. senegalensis*, *M. deliciosus H. pictus* and only the male of *M. rume* were found to be positively correlated. Tesh (1968) reported that in regression equations of fish, when the exponential value (b) is equal to a value between 2 and 3 it indicates that the fish grows symmetrically or isometrically, that is, the weight is not increasing faster than the cube of the length. In this work the values for the above fish species were between 2 and 3, thus indicating isometric growth. A similar observation and values were obtained for *Eutropius niloticus and Schilbe mystus* by Olatunde, (1979), for *Synodontis schall* (Olatunde, 1989), for *Sarotherodon niloticus* (Aramowo, 1982), for *Heterotis niloticus* (Adekeye, 1992) and for *H.b. Occidentalis* (Ipinjolu, *et. al*, 1996). However, if 'b' value is greater than 3, growth is said to be allometric meaning that the fish becomes "heavier for its length" as it grows larger (Tesh 1968). Allometric growth was observed in female *M.rume* and *P. bovei*. These differences in length-weight relationships may be due to sex, the stage of maturity, the seasons and stomach fullness of fish. Allometric growth was also observed in *Cynoglossus canariensis* (Ajayi, 1982) and in female of *Epiplatys sexfasciatus* (Iyang and Anozie, 1987).

FOOD AND FEEDING HABITS

The feeding pattern of the mormyrids showed that they are active feeders, feeding throughout the year. However, lowest feeding periods were mainly during the dry-cold months of the year (December and January) while the high feeding months were May and October (rainy season). Davis and Warren (1968) indicated that the season of

the year, light, temperature and other environmental factors influenced food consumption of fish.

The observation that *H.b. occidentalis* fed principally on plant material (seeds), insects and molluses is similar to that of Blake (1976) in Kainji dam, where he observed that *Povila* nymphs, chironomids and mollusca were the main dietary items in *H.b. occidentalis* in the months of April, June and July (dry season) and seeds were mainly found when the lake started to rise. In this study, seeds were mainly found throughout the months of May to August which coincides with rainy season and the rising period of Zaria dam. In the present study, molluses were consumed throughout the year and also observed to be more important than chironomids which is in contrast to the findings of Blake (1976). The difference may be due to variation in food items in the different habitat. The study of Lewis (1974) in lake Kainji showed that the diet of *H. b. occidentalis* included insect larvae and nymphs, and certain types of grass seed. The variety of food items consumed by this fish may allow it to be classified as an omnivore and this may have contributed to its preponderance in Zaria dam.

M. rume principally fed on insects such as the chironomid and trichopteran larvae. These findings was similar to that of Lewis (1974) in Kainji dam where he observed that chironomid larvae and nymphs of may fly, *Povila adusta,* were most prevalent in the diet of *M. rume*. This, however, contrasts with the observation made by Petr (1968) in lake Victoria, and in lake Kainji where *M. rume* consumed mainly *Povila* nymphs (Blake, 1976). The quantity of detritus in the diet of *M. rume* is higher than that of other mormyrids studied. Thus this fish is a detritus feeder (benthophagous) as well as being insectivorous.

The diet of *M. senegalensis*, contained chironomid larvae and nymphs which were present throughout the year followed by trichopteran and ephemeropteran larvae. A similar observation was made by Petr (1968) in Volta dam and Lewis (1974) in Kainji dam, where this fish species mainly fed on chironomid larvae and *Povila* nymphs (ephemeropteran).This fish also consumed considerable quantity of seeds, algae and plant remains in the months of May to July in Zaria dam. This fish may therefore be considered to be insectivorous but with a tendency to be omnivorous.

The juveniles and adults of *M. deliciosus* showed exceptional feeding habit when compared to other Mormyrids studied. For example, the juveniles fed exclusively on insects while the adult fed on both insects and other smaller fish species identified as *Oreochromis niloticus*. Moreover, this tilapia that forms the major fish prey for *M. deliciosus* is available through the year (Ibrahim pers. Com.) in Zaria dam. Blake (1976), Lewis (1974) and Reed *et al.*, (1967) reported similar findings in this fish species. Insects consumed were mainly dragonfly and damselfly nymphs, coleoptera and chironomid larvae; the decapop crustaceans also formed an important dietary item. The adult of this fish could be considered as piscivorous (ichthyophagous) while the juveniles are principally insectivorous.

H. pictus in Zaria dam fed on *trichopteran* larvae, *ephemeropteran* nymph and then chironomid larvae. In Kainji dam, *H. pictus* fed principally on ephemeropteran larvae and nymphs (*Povilla adusta*), and chironomids (Lewis, 1974 and Blake, 1976).

P. bovei is principally insectivorous. Chironomid and *trichopteran* larvae, and dragonfly nymph were the most important food items. This is in conformity with the work of Okedi (1971) in lake Victoria and that of Lewis (1974) in Lake Kainji. However, of all the mormyrids studied, this fish consumed more variety of food items.

It appeared that the different mormyrids tended to prefer various dietary items depending on the season of the year and availability of the particular diet. The preponderance of insects larvae in Zaria dam may have led to the successful establishment of the mormyrids in the dam and hence increasing availability of varieties of food for the mormyrids.

The fact that the various food items observed are often found in various zones of the aquatic environment suggests that mormyrids feed within various ecological niche which further reduces competition within a particular aquatic zone. Length class of fish may also determine the type and size of diet consumed as was demonstrated by the juveniles and adult of *M. delicious*. In sturgeons, benthic foraging was observed during the post-larval phase and this changed dramatically with development of the fish, into adult (Ross and Bennett, 1997).

SEX REPRODUCTIVE CYCLE AND FECUNDITY

The sex ratios of *H.b. occidentalis*, *M. rume* and *M. deliciosus* indicated that more female than males occurred in their populations. This contrasts with the observations of Imevbore (1970), Willoughby (1974), Olatunde (1989) and Fagade (1979) in which more males of *Synodontis schall* and *Tilapia melanotheron* were found. However, in the populations of *M. senegalensis* and *H. pictus* studied, more males than females were found. In a single species population, if the male to female ratio is 1:1, it shows that there is no difference in longevity of the sexes (Nikolsky, 1969) Therefore a higher ratio of a particular sex may indicate higher survival time of one over the other.

The breeding season (the period when mature gonads were found), of the mormyrids of Zaria dam, generally extended from June to October which coincided with the rainy season. Some delayed and extended spawning periods were observed in the male of *H. pictus* which spawned between May and November. Lowe - McConnell (1977) and Olatunde (1989), suggested that most tropical fishes breed during the rainy season when physico-chemical condition of the aquatic environments are favourable. In contrast, some tropical fishes such as the croakers, *Pseudotolithus senegalensis* and *P. typus* off the coast of Lagos, spawn all year round with peak between December and June (Longhurst, 1964; Anyanwu, 1990).

Of all the mormyrids, *M. senegalensis* was the most fecund fish (4,041 - 7,770) followed by *H.b. occidentalis* (2,025 - 4,192), indicating that these species might reproduce more under hatchery condition. Higher fecundity (7,130 - 73,000) have been observed in *Synodontis schall* in lake Kainji (Willoughby, 1974), and lower (13 - 110) for *Epiplatys sexfasciatus* in Adadu River, South-eastern Nigeria (Inyang and Anozie, 1987). In all the mormyrids, individuals with longest length did not have highest fecundity estimate, Fagade (1978) made a similar observation in *Tilapia guineensis*.

GILL PARASITES

Parasite richness or composition on the gills depends on the behaviour of the parasite, or an intermediate host, on the activity of the parasite and the ecology of the aquatic environment (Kennedy, 1975). Shotter (1976) reported three parasites on the gills of *Merlangius merlangus* from Manx water (UK), Martens and Moons (1995) reported eight gill parasites from *Siganus sutor*, from Nyali Beach (Kenya). In this study, four different types of gill parasites were found on *H.b. occidentalis* and *M.rume*, three on the gills of and *M. senegalensis*, two on *M. deliciosus*, one on *H. pictus* and none on *P. bovei*.

In *H.b. occidentalis* the parasitic composition of the gills consisted of *Henneguya sp.* (a protozoan - Myxosporea), *Clinostomum complanatum* (a digenetic trematode), glochidia of mollusc (a lamellibranch) and *Eargasilus sarsi* (Crustacean - copepod). These parasites have also been found in various fish species. *Henneguya* sp. occur in both East and West African waters, and were found infecting the gills of *Clarias lazera*, *Lates albertianus*, as well as in cichlids, citharinids, cyprinids and siluroids (Paperna, 1973; Abolarin, 1974; Aken'Ova, 1983). Other mormyrids studied, such as *M. rume* and *M. senegalensis* were also infected by *Henneguya* sp.

In this study, *Clinostomum complanatum* was recovered from the gills of *H.b. occidentalis*. Members of the family, Clinostomatidae, particularly *Clinostomum tilapiae* and *Euclinostomum heterostomum* (Lombard, 1960), have been reported to be widespread and they have been found on the gills of fishes (Hoglund, 1991) such as *Barbus* sp., *cichlids*, and in a mormyrid, *Gnathonemous macrolepidotus* in S. Africa (Ortlepp, 1935). An important monogenean parasite found only on the gills of *M. senegalensis* in this study, is *Dactylogyrus vastator*, and this parasite, at least amongst the mormyrids studied appeared to have demonstrated a high degree of host specificity. Other dactylogyrids such as *D. anchoratus* and. *D. minutus* were found on the gills of carp (their specific host) introduced into Africa (Paperra, 1980).

Larvae of bivalve mollusc (glochidia), particularly members of the superfamilies Unionoidea and Mutiloidea, are known to be parasitic on fins and gills of fish and have

been reported from Lakes Victoria and George in young cichlids, cyprinids and *Barbus* spp. (Paperna, 1964; Fryer, 1970; Cheng 1973). This is probably the first time that glochidia are being reported in *H.b. occidentalis* from Zaria dam.

Ergasilus spp. are common in fish such as cichlids and siluriformes of all major African water systems; *E. latus* was reported in *Sarotherodon melanotheron heudelotii* in Ghana, *E. Kandti* were obtained in *Lates* sp. In East and West African water bodies, *E. lizae* in tilapia species and *E. Sarsi* in *Clarias lazera* (Fryer, 1968; Paperna, 1969). In *H.b., occidentalis* of Zaria dam, the adult and subadult females of *E. sarsi* were the only copepods found on the gills. The same observations were also made for *M. senegalensis* and *H. pictus*. *E. sarsi* may appear to occur in phylogenetically related fish, such as the mormyrids, in Zaria dam. This parasite, may be termed as euryxenic (found in hosts linked by ecological similarity) (Aken'ova, and Cribb, 1996). Other copepods parasites such as *Afrolernaea nigeriensis* and *Lamproglena sp.* were found on the gills of *M. rume* and *M. deliciosus* respectively. Paperna (1996) indicated that *Lamproglena* and *Lamproglenoides* spp. from African fish are all endemic and he found *L. monodi* in cichlids, *L. hemprichii* in *Hydrocynus* spp and *L. clariae* in *Clarias* spp., and *Afrolernaea* spp. on Mormyridae.

The nematode parasite, *Philometra beninensis* was the only nematode found beneath the internal surface of the gill cover of *M. rume* from Zaria dam. Representatives of the genus *Philometra* have been reported in freshwater fish of Ukraine (Markevich, 1963), particularly in body cavity, caudal fin and intestine; only *P. sanguinea* was found within the internal surface of the operculum. This is probably the first time that *Philometra* is being reported in mormyrid in Nigeria.

Although leeches infected only one species of mormyrids studied, that is *M. deliciosus*, they have been reported from other fresh water fish families elsewhere in Africa. This families include Bagridae, Claridae, Mormyridae and Cichlidae (Paperna, 1996).

The presence of larvae of *Tabanus* sp. (Tabanidae - Insecta) on the gills of *M. rume* was surprising and maybe, in this instance, be classified as 'accidental' parasite since they are not known to be parasitic, but free living. It is known that eggs of tabanid

flies are laid on stems and leaves of aquatic plants and upon hatching into larvae, they drop into water and migrate to the substratum (Cheng, 1973). It is therefore likely that during its migration to the substratum, it becomes a "temporary/accidental parasite" on *M. rume*, which is a detritus feeder.

In all the mormyrids, the parasites did not show a specific preference for either the right or left gill arches, this study is also in agreement with that of Geets *et al.*, (1997) on the white spotted rabbit fish (*Siganus sutor*) off the Kenyan coast in which there was no significant difference in parasite numbers between left and right gills. This therefore presupposes that gills on both sides of the head of a fish are equally exposed to parasitic infestation

The findings in this study suggest that the level of infestation of the gills of *H.b. occidentalis* and *M. deliciosus* by parasites was independent of the sex of the host, but this was not the case in *M. rume* and *M. deliciosus* as male fish had a higher incidence of infection with *E. sarsi* and *A. nigeriensis* than the females. It is possible that some innate behaviour in male *M. rume* and *M. deliciosus* makes them more susceptible to infection by these copepods.

Explanations have been attributed to microhabitat selection of gill parasites of fish. Llewellyn (1956) postulated that "differences in water volumes passing over the 4 gill arches might be reflected in differences in opportunities of parasites to attach." Paling (1968b) showed that a significant greater water volume passed over the 2nd and 3rd gill arches than over 1st and 4th. It is therefore expected that parasite attached to gills with greater water volume/current passing over them might have lower survival rate, because they have to struggle more against the current and as such, higher survival rate is expected on gills with lower water current passing through it. Therefore the order of intensity of parasite infection in the gills is expected to be 4,1,3,2 or 1,4,2,3. In *H.b occidentalis*, *M. rume*, *M. senegalensis* and *M. deliciosus* investigated, the infection levels of the gill arches shows that gill arch 1 had highest parasitic load followed by 2, whereas gill arch 3 and 4 had lower parasite infections. Therefore the 1,2,3,4 infection pattern was exhibited. This may be due to the fact that the fishes were caught in a lacustrine environment where water flow is almost non-existent.

INFECTION LEVELS BY GILL PARASITES

Amongst the morymrids studied, the level of infection of the gill arches by the crustacean parasites were higher than other parasites. The levels of 45.53%, 90.98%, 67.88% and 67.08% were found in the gill arches of *H.b. occidentalis*, *M. rume*, *M. senegalensis*, and *M. deliciosus* respectively. Paperna (1996) pointed out that in African lakes and rivers infections of fish by ergasilids (copepods) are usually moderate and that confined fish may be heavily infected. The report of heavy infestation by *E. lizae* in the fish *Mugil cephalus* (Raibaut *et al.*, 1975) lends credence to the observation. In a study,93.8% of *Mormyrus longirostris* were infected by *Afrolernae longicollis*, and 56% of *Bagrus meridionalis* with *Learnaea bagri* in lake Malawi. 50% of *Lates albertianus* were infected with *L. barminiana* in lake Alberto . Lower infection rates ranging from 0.5 to 28% have been reported in different fish species in some dam/reservoirs in S. E. Ghana and South Africa (Paperna, 1980).

Other gill parasites that showed fairly high infection levels were *D. vastator* with infection level of 31.02% in *M. senegalensis* and *Rhynchobdella* sp. (leech) with infection rate of 32-48% in *M. deliciosus*. High rate of infection of fish by monogenetic trematode have been reported in fish by Batra (1984). Amongst the mormyrids studied, *D. Vastator* was only found in *M. senegalensis*, indicating that the parasite is host specific. Though the same parasites have been found in other fish species such as carp fry (Paperna, 1963) and *Synodontis* spp. in Zaria (Idris, 1997). The leech, were reported infecting *Clarias lazera* throughout tropical West and East African waters (Oothuizen, 1989) and on *Bagrus* spp., *Oreochromis* spp., *Barbus* spp. and *Protopterus* spp. with various infection levels. Also the presence of the parasite has been associated with aquatic pollution (Williams and Jones, 1994). However, this is the first time it is being reported in *M. deliciosus* in Zaria, Nigeria.

In the mormyrids infected by *Hemegnya* sp., *H.b. occidentalis* had the highest infection level (26.14%) followed by *M. rume* and *M. senegalensis*. In South African, high infection of clinostomatids (76%) have been reported in fish from dams in Transvall, (Britz, *et al.*, 1985), as well as in a mormyrid, *Gnathonemus macrolepidotus* (Ortlepp,

1935). In *H.b. occidentals* in Zaria dam., infection level by *Clinostomum sp* was 19.96% which is not as alarming as that of the Transvaal (Britz *et. al*., 1985).

PATHOLOGICAL EFFECT OF GILL PARASITES.

In this study, the cysts formed by *Hemeguya sp* usually involved one to four gill filaments where they occluded the surface of the gills. It is therefore not unlikely that the cysts reduced the respiratory functions of the gill surfaces where they occurred. However, no inflammatory reaction or necrosis was observed at the point of attachment even when several cysts were removed. Infection of *Hemeguya sp.* at the bases of the gill lamellae have been implicated in circulatory dysfunction and respiratory problems in carp (Kovac- Geyer and Molnar, 1983; Rukyani, 1990). Ruptured *Hemeguya* cysts have been associated with hemorrhaging, sometimes resulting in considerable loss of blood (Kalavati and Narashimhamarti, 1985). These infections have also been known to facilitate the invasion of secondary opportunistic pathogens, thereby, compromising the health of the fish (Paperna, 1996).

Clinostomum complanatum were mostly recovered within the gill cavity of *H.b. occidentalis*, the few attached ones did not cause heamorrhage when detached. This suggests that the parasite probably feeds on mucous secretion from the gill filaments. Lower respiratory efficiency and even death of *Sarotherodon galilaeus* have been associated with *Centrocestus* sp., a clinostomatid which also caused proliferation of the gill epithelium and obliteration of the lamellar structure (Farstey, 1986). Though other clinostomatids, such as *Diplostomum mashonense* and *D. tregenna* were found in the brain, cranial nerves and spinal cord of *Clarias* spp., they did not create debilitating impact on the fish (Khalil, 1963).

The present findings on the pathology of *D. vastator* on the gills of *M. senegalensis* agrees with that of Paperna (1963). *Dactylogyrus vastator*, induced severe hyperplasia of the gill filament epithelium which interfered with respiratory function and caused death in carp (Paperna, 1963). In this study, also *D. vastator* stimulated irregular elongation of the gill epithelium particularly at the tip of the gill filaments in *M.*

senegalensis. Kabata (1985) noted the lack of record of "ill effect" due to dactylogyrid infection in cichlids in Africa or Israel even when infection were high. Hyperemia, increased mucous secretion and extensive hyperplasia of the gill epithelium of eels (*Anguilla* sp.) have been associated with the infection of *Pseudodactylogyrus anguillae* and *P. bini* (Chang and Wu, 1984; Buchmann *et al.*, 1987).

In *M. deliciosus* of Zaria dam, Leeches were found attached to the base of the gill filament and gill arch cartilage where they created heamorrhagic spot at the points of attachment. It is therefore very likely that this parasite feeds on the blood of the gills which probably is rich in oxyhaemoglobin and hence interferes with the respiratory and transportation systems of this fish. Leeches were found in the mouth region of *Bagrus docmac* in Lake Victoria where bite signs and mild tissues changes were observed (Paperna, 1996).The American catfish (*Ictalurus catus*) were infected by leeches and hyperplasia, inflammatory changes and haemorrhages of the dermis were observed (Paperna and Zwerner 1974).

In the mormyrids of Zaria dam *Ergasilus sarsi* (copepod) were found on various parts of gill where, under the low power microscopic magnification, did not appear to create any lesion. Similar observation was made by Shotter (1971) where the copepod, *Clavella uncinata*, did not cause hypertrophy when attached to the gill rakers and dermal tentacles of the mouth of Whiting. Hyperinfection of *A. nigeriensis* and *E. sarsi* in *M. rume* and *M. senegalensis* respectively showed hyperplasic gill epithelium and filament. Fryer (1968) reported "Small foci erosion" of gill filament caused by *E. megacheir* in cichlids and grey mullets, and that prolonged infection may cause fusion of gill lamellae, thus decreasing respiratory function of the gill (Kabata, 1970).

Another copepod, *Lamproglena* sp. found on the gills of *M. deliciosus*, did not cause any lesion but a little depression of the primary gill filament at the point of attachment of the parasite. Intense inflammatory response, tissue granuloma or necrotic lesion caused by *L. cyprinacea*, in *Bagrus sp* have been reported by Kabata (1970, 1985) and Fryer (1968).

The larvae of *Tabanus* sp found on *M. rume* created point lessions on the epithelial tissue of the gills at the point of attachment. However, tabanus larvae is not

known to be parasitic though the adult fly parasitizes cattle and other terrestrial vertebrates.

Philometra spp. have been found in the intestines of cyprinid (*P. intestinalis*)., in body cavity (*P. ovata*) on caudal fin (*P. sanguinea*) between pectoral fin rays, beneath the skin and within the integument of internal surface of cyprinid gill cover (Markevich, 1963). In this study, *P. beninensis* were found under the thin membrane of the inner surface of the operculum of *M. rume* where they caused expansion of the thin epithelial tissue.

Infection of the gills of *H.b. occidentalis* by the larval mollusc (glochidia) in Zaria dam created enlargement of the filament at places of attachment and left a circular mark on the gills when detached or broken. Intense epithelial hyperplasia in the gill around the attached glochidia has been reported recently by Paperna (1996).

PHYSICO-CHEMICAL PARAMETERS AND THEIR RELATIONSHIP WITH GILL PARASITES

Some gill parasites of mormyrids in Zaria dam showed seasonal incidences and no two parasite within a branchial chamber showed peak infection period at the same time. For instance in *H.b. occidentalis* infection by *Henneguya* sp, two peak infection periods (March and October) were recorded and these coincided with the high temperature months of the year and periods of low pH (< 6 in March, about 6.5 in October). The incidence of infection reduced when temperature of the water decreased during the rainy season and cold harmattan periods. During this rainy season, turbidity, Nitrate and chloride concentrations were high and were not related to infection by the parasites.

Henneguya sp. in *M. rume* and *M. senegalensis* showed high incidence of infection during the dry-hot season of the year (March - May) during which water pH was about 5.8. Whereas, the opposite was the case during the cold season. Fryer (1961), Baker (1963) and Paperna (1973) have indicated that infection levels of the Myxosporea seemed to change with seasons of the year. Therefore the rate and intensity of

Hemeguya sp. infection in the mormyrids in Zaria dam is temperature-dependent and pH sensitive.

Other parasites of the mormyrids that exhibited similar temperature dependence as *Hemeguya* sp are *Dactylogyrus vastator* in *M. senegalensis* and *Lamproglena* sp. in *M. deliciosus*. Their peak infection period was the hot dry months of the year (February to May) when water temperature was above 27 °C, pH was less than 6, with low manganese and chloride concentrations. Dogiel (1961) reported that the population of *D. vastator* built up on carp in spring and summer and declined in winter. Breeding temperature of the parasite is around 20-25 °C and below this level, the rate of egg production and generation time as well as the population level falls. *D. anchoratus*, *D. minutus*, *D. extensus* and *D. vastator* of carp are thermophilic, with optimal reproduction at ambient water temperatures of 28-29 °C (Paperna, 1996). Similarly, Lernaeid copepod, *Lernaea cyprinacea*, infecting fish in and outside the tropical regions, is temperature dependent; its rate of development being faster at 20-25 °C, and the generation rate is being considerably reduced at 12-19 °C (Lahav and Sarig, 1964). *Lamproglena* sp. infection in *M. deliciosus* was highest during the hot-dry months of March - May. Copepod, infections of *H.b. occidentalis* and *M. rume* occurred throughout the year but the peaks occurred during the coldest season of the year, November to February, when water temperature was below 22 °C, and the pH at about 6.5. This finding corroborates that of Raibaut *et al.* (1975) that peak infection of *E. Lizae* in the fish, *Mugil cephalus*, occurred when water temperature was 21°C, the infection declining at a higher temperature of 27°C

Infection of *M. deliciosus* by leech occurred mainly during the cold dry season of December to April, when temperature, pH and turbidity were low, dissolved oxygen high. Similarly infection of *M. rume* by *P. beninensis* occurred during the dry season when dissolved oxygen, iron and manganese concentrations were all high. The parasite was absent during wet season when temperature and turbidity were high, iron and manganese concentrations low. Therefore it is not all fish parasite occurrence that could be attributed to variations in all physico-chemical parameters, although parasites with higher year-round prevalence tend to exhibit a regime of infection compared with those having lower rates of infection.

Gehnar (1987) deprived the fish *Gobio gobio* of food and oxygen, and this resulted in a greater number of gyrodactylids per fish than those deprived of oxygen only. He then concluded that oxygen deficiency did not affect the parasites directly. Furthermore, it has been observed that high subtropical summer temperatures coupled with depletion of dissolved oxygen and elevated salinities were detrimental to developing eggs and free living stages of *Ergasilus lizae* in *Mugil cephalus* (Raibaut *et al.*, 1975; Ben-Hassine *et al.*, 1983).

HOST (AGE) LENGTH AND GILL PARASITES

Dogiel (1961) suggested that the number of parasites and its diversity increased with the age of fish. Much as this may be true for some parasites of certain fishes, available literature offered rather conflicting situation because several complex factors which are intricately bound up with age such as feeding and sexual behaviour, create problems for direct analysis of the effects of hostage on parasite. For instance the larvae of *Diclidophora denticulata* on the gills of *Gadus virens* were unable to establish on older fish (Frankland, 1955). Similarly, *Gastrocotyle trachuri* only infected 3 - 4 months old juveniles of *Trachurus trachurus* (Llewellyn, 1962). While the former was attributed to change in host behaviour, the latter was due to post - spawning migration of host away from the infective stages.

However, in this study copepod infection *of H.b. occidentalis* and *M. rume* was higher in the juvenile fishes than adult and sub adult. But Geets *et al.* (1997) found a significantly higher number of copepods (*Hatschekia* sp) on adult rabbit fish in comparison with sub adult. The lack of statistically significant difference in the prevalence of parasite amongst the age groups in *M. rume* throughout the year seems to suggest the presence of the infective stage of *A. nigeriensis* throughout the year in Zaria dam and this may have contributed to the all-year-round infection.

In *M. senegalensis* and *M. deliciosus* studied, the parasite burden increased as the length of fishes increased, with the adults having heavier parasitic load than sub-adult and juveniles. Martens and Moons (1995) investigated rabbit fish from 7 - 21 cm and indicated a positive correlation between gill parasite numbers and fish length. Similar observations were made by Cone and Burt (1981, 1985).

The glochidia infection of *H.b. occidentalis* were mostly found in adult fish whereas *Philometra beninensis* infection were found in juveniles and adults only, the gravid female parasites were mostly found in the adult fish thus supporting the suggestion of Black (1985) that nematode worms are long-lived, that they grow throughout life and that gravid female nematodes did increase in size with age of fish.

FOOD AND FEEDING HABITS, AND GILL PARASITES

The feeding habits of fish in relation to its parasites have been studied mostly with regards to the gastro-intestinal tract parasites of fish of temperate waters (Geets and Ollivier, 1996). Little or no attention has been given to the relationship with branchial chamber parasites. However in carp, ectoparasitic leeches tend to increase when the fish aggregate at bottom of pond for winter, during which they feed little and move sluggishly (Dogiel, 1961). In this study, *M. rume* is the only benthophagous (detritus feeder) fish. Its lowest feeding period in December and January coincided with the highest infection period of *A. nigeriensis*. It is not unlikely that the movement of the fish during this period is slowed down, thereby increasing the chances of being infected by the parasite. This may also account for the increased incidence of *Tabanus* sp. larvae and *Henneguya* infection in *M. rume*.

In *M. deliciosus*, fish were the most favoured food item particularly in adult and sub adult populations during the months of November to January. The months coincided with high incidence of leeches on the gills of *M. deliciosus*. The leeches during this period are mostly found within the littoral zone of the dam where *M. deliciosus* goes to hunt for its diet which consisted of fry and fingerlings of *O. niloticus* which normally move in school at these stage, hence high incidence of the leeches in the gills of *M.*

deliciosus. The infection of *M. deliciosus* by leeches can therefore be attributed to its feeding habit.

SEX OF HOST IN RELATION TO GILL PARASITES

The branchial chamber parasite and their relationship with the sex of fishes are not well understood. Generally, most gill parasites are found equally within the sexes. But some gill parasites occur more on a particular sex than the other for only a short period. For instance, in *M. senegalensis* of Zaria dam, *Hemeguya* sp. infection occurred only on the female fish in March to May when gonad stage I were most prominent. In the male of *M. deliciosus*, stages II and III testes appeared to have high significant correlation with *Rhynchodbdellae* sp. infection, while it was stages IV and VI (matured and spent ovaries) in the female fish.

Dactylogyrus vastator infection of the gills of carp attains high reproductive rate in summer when the fish congregate for sprawing (Kennedy, 1975). Paling (1965) attributed the high incidence and abundance of the gill monogenean *Discocotyle sagittata* in male trout over the age of five to great attraction to the mucus of males for the larval onchomiracidia, it is not unlikely that the male host hormones may be involved. Therefore parasite presence and distribution on gills in separate sexes may not be attributed to a particular cause but a combination of several.

PARASITES OF THE GIT

In fishes, the most common site in which endoparasites, particularly the helminths, are found is the alimentary canal. The alimentary canal could be said to be the most unfavourable canal in the fish because it contains carbohydrate, fat and protein-digesting enzymes, with pH ranges from 1.5 - 8.4. Besides, it undergoes rapid and continuous chemical, physiological, and mechanical changes associated with entry, digestion, absorption, passage of food apart from being practically deprived of oxygen

(Cheng, 1973). Despite all these, parasites are able to survive in the gastro-intestinal tract of fishes.

In this study on the mormyrids of Zaria, six endoparasitic helminths were found. The trematode, *Euclinostomum heterostomum* was found in *M. rume* only, the cestodes, *Caryophylleus* sp. were found in *M. rume* and *M. senegalensis* while Eucestodaria spp. was found in *M. deliciosus*. The nematode, *Procamallanus laeviconchus* was found *in H.b. occidentalis, M. rume*, *M. senegalensis* and *M. deliciosus*, and *Rhadinorhynchus horridus* (Acanthocephala) was found exclusively in *H.b. occidentalis*.

The digenetic trematode, *C. complanatum* has been recorded also in muscle of *Synodontis membranaceus* (Ukoli, 1969), in skin, viscera and muscles (Williams and Jones 1994), metacercariae of *Euclinocstomum heterostomum* in the liver of *Channa punctata* (Gupta and Agarwal, 1984). *Euclinostomum* sp. in peritoneal wall of *Macropleurodus* and *Haplochromis* spp. (Khalil and Thurston, 1973), in gills and muscles of *Oreochromis niloticus* (Britz, *et al.*, 1984, 1985).

Bhagavathiammai and Ramalingam (1983) found *Euclinostomum heterostomum* in the brain, cranial nerves and spinal cord of *Channa punctata*, [*Diplostomum mashonense* and *D. tregemna* in *Clarias spp.* (Beverly-Burton, 1963, Khalil, 1963)]. In the present study, *E. heterostomum* was found in the gills of *H.b. occidentalis*. The finding in this study seems to lend credence to suggestion from previous studies that *E. heterostomum* is not organ specific but rather a migrating parasite. The presence of the parasite in the intestine of *M. rume* as seen in the study, is suggesting that the intestine is an additional site for the parasite.

The cestode, *Caryophyllaeus* sp. has been classified as one of the most problematic cestodes of fish (Williams and Jones, 1994). *Caryophyllaeus fimbriceps* was reported by Bauer (1959, 1968) in the intestine of carp, *C. laticeps*, in dace (*Leuciscus leuciscus*) and in the bream (*Abramis brama*) (Kennedy, 1968; Anderson, 1974) and *Caryophyllaeides fennica* in *Rutilus rutilus* (Borgstrom and Halvorsen; 1968). The *Caryophyllaeus* sp. was found in the intestine of *M. rume*. Paperna (1996) indicated that the Caryophyllideans have not been found in exotic carp farmed in tropical and South Africa.

The eucestodarian parasite of *M. deliciosus* has not been reported as common parasite of fish but rather as parasite of the intestines of donkeys, horses, sheep, goats and cattle (Soulsby, 1982). The parasite eggs may have been passed out in the faeces of infected cattle and other animals that visit Zaria dam frequently, into the aquatic environment from where the fish probably ingested them. This parasite therefore may be an accidental parasite in *M. deliciosus*.

The nematode, *Procamallanus laevionchus* has been reported in several fish spp. such as *Synodontis membranaceus*, *Ophiocephalus obscurus*, *Tilapia zilli* and *Clarias lazera* in Nigeria (Ugwuzor, 1987; Onwuliri and Mgbemena, 1987). It has also been found in the eel, *Anguilla mossambica*, (Jubb, 1961), Pike, Perch, cyprinids and salmonids in the USSR (Markevich, 1963). This shows that the parasite is widely distributed amongst different fish hosts' stomach and intestine. This parasite was found in the stomach of *H.b. occidentalis* and also in the intestine of the other mormyrids studied.

The Acanthocephalla, *Rhadinorhynchus horridus*, was recovered from the intestine of *H.b. occidentalis* during the pre-impoundment survey of parasites in River Niger (Awachie, 1965). The host-specificity of this parasite has also been confirmed by this study. This therefore suggests that *R. horridus* is oioxenic (i.e. found as parasite on a single host species) (Aken'Ova and Cribb, 1996) in Nigerian waters. R. *horridus* was also found in a mormyrid, *Gnathonemus cyprinoides* (Petrochenko, 1971) in Egypt. The other acanthocephala, *Neoechinorhynchus* sp., found in *M. deliciosus* in this study was also reported in *Tilapia* spp. and *Clarias lazera* (Onwuliri and Mgbemena, 1989). This species have been reported in several fish species from all continents (Petrochenko, 1971), suggesting that the parasite is stenoxenous, that is has broader host specificity.

SITE PREFERENCE OF GIT PARASITES

The GIT is the most favoured site for adult digeneans, cestodes, nematodes and acanthocephalan (Mettrick and Podesta, 1974) and various activities going on within a

particular part of the GIT may dictate the type and presence of a particular helminth parasite. Crompton (1973), Crompton and Nesheim (1976) and Mackenzie and Gibson (1970) have indicated that distribution and survival of helminth parasite of the GIT may be related to digestive activity and Williams and Jones (1994) citing several authors classified some helmith parasites found in different segments of the GIT. An interesting aspect of the groupings is that no particular class or phylum (with the exception of the acanthocephalans) could be categorically found restricted to specific site within the GIT but rather in various parts and organs of fishes. However in this study, the trematode, *Euclinostomum heterostomum* in *M. rume* was found in the mid intestine, the cestodes were found in the mid intestines of *M. rume*, *M. senegalensis* and *M. deliciosus*. *Procamallanus laevionchus* (Nematode) are ubiquitous within the GIT of the mormyrids - in stomach of *H.b occidentalis*, stomach and mid intestine of *M. rume*, intestine of *M. senegalensis* and intestine and rectal region of *M. deliciosus*. The matured acanthocephala (*R. horridus*) showed preference for the mid intestinal and rectal regions of *H.b. occidentalis* while the immature ones were mostly found within the first 20 mm of the GIT. Kennedy and Lord (1982), in their study on site specificity of *Acanthocephalus clavula* of *Anguilla anguilla* in natural and artificial infection, concluded that the site specificity of the parasite was not very precise and variation existed from host to host, and that *A. clavula* could survive and mature in all regions of the intestine.

INFECTION LEVEL OF THE GIT PARASITES

Infection level of the parasites varied from host to host depending on several factors. Geets and Ollevier (1996) indicated that over-dispersed distribution of parasites within host ensures that infection is kept at a low level with only a few hosts becoming heavily infected. This study agrees with that of Geets and Ollevier in that infection levels of *M. rume* (34.59%) and *M. senegalensis* (15.26%) were low compared to *H.b. occidentalis* (60.95%) and *M. deliciosus* (60.65%).

Amongst the parasite of the mormyrids studied, *Cayophyllaeus* sp. in *M.*

senegalensis and *R. horridus* in *H. b. occidentalis* showed high prevalence of 73.03% and 60.95% respectively. Others of notable prevalence is *Procamallanus laevionchus* (45.69%) in *M. rume* and *Neoechinorhynchus* sp (46.39%) in *M. deliciosus*. Parasite species tend to act as regulator of host populations, the degree of the regulatory function being related to both host and parasite population (mortality and recruitment) densities. Therefore dynamic equilibrium of host and parasite populations is essential to the continuous association between both (Hine and Kennedy, 1974 Kennedy, 1974; Wanstall *et al.*, 1990; Geets and Ollevier, 1996). Nevertheless, heavily infested host may be killed by the parasites or become easily susceptible to predators.

PATHOLOGICAL EFFECT OF THE GIT PARASITES ON HOSTS

The digenetic trematode, *Euclinostomum heterostomum* in the intestine of *M. rume* in this study did not show any clinical effect.

This may be due to its low prevalence in the fish; experimentally hyperinfected *Oreochromis niloticus* fingerlings by *E. heterostomum* died within 30 - 35 day (Donges, 1974).

Effect of helminthic infections in fishes vary depending on the organ infected and the parasitic load; even though high worm burdens and visible structural damage may not necessarily lead to death (Paperna, 1996).

The cestodes obtained from the mormyrids did not show any pathological effect on the intestinal lining and light microscopic studies of the scolices have shown the lack of attachment structures such as hooks and suckers. Caryophllidean cestodes have been implicated in causing damage and obstruction to the intestine of carp (Mitchell and Hoffman, 1980). It is therefore not unlikely that the parasite obtains nutrient from its host through its tegument and its head may be used for firm mechanical attachment to the intestinal wall of host when parasite population is high. Paperna (1996) indicated that damage to host by the parasite is rarely evident but may pose a potential risk to native fish species such as *Clarias* spp. and *Heterotis niloticus* introduced to farming. Similarly, the Eucestodarian in *M. deliciosus* did not cause any clinical lesion despite its attachment to host. It is very likely that the pathogenicity of most cestodes depends on the gross structure of the scolex.

The nematode, *Procamallanus laevionchus* did not cause any clinical sign in stomach and intestines, they were simply found within the intestinal lumen. This is in contrast with the findings of Paperna (1964) and Khalil (1971) in which *Procamallanus*, *Rhabdochona* and *Spinitectus* spp. were not pathogenic inspite of their firm attachment by their buccal capsule to the stomach and intestines of fishes. However, physical damage of the attachment site may expose it to opportunistic infections.

The Acanthocephala, *Rhadinorhynchus horridus*, in the intestine of *H.b. occidentalis* did not inflict any mechanical damage to the intestinal wall since most were found within the intestinal lumen - suggesting that this parasite absorbs nutrient through their body - and only a few created pathological effect at the point of attachment. On the contrary, most of the *Neoechinorhynchus* sp. recovered from *M. deliciosus* had their proboscis anchored, and destruction of the stratum compactum of the intestinal wall was evident. Taraschewskil (1988) suggested that the depth of penetration by the proboscis of an acanthocephalan may vary in different host fish. Extensive inflammation, peritonitis and systemic clinical changes (anurhersia) have been reported. In Juvenile cichlids (< 60mm) a single attached specimen of *Acanthogyrus tilapiae* obstructed the digestive tube (Douellou, 1992a and b)

SEASONALITY OF THE GIT PARASITES IN RELATION TO PHYSICO - CHEMICAL PARAMETERS OF ZARIA DAM

Seasonal inducing factors may operate to produce slight peaks in abundance in predominantly non seasonal cycles or to produce well - defined cycles in both incidence and intensity of infection (Kennedy, 1975). Bauer (1959) discussed the importance of the season of the year, age and physiological condition of host, effect of temperature, salinity, oxygen, pH, light and pressure on the seasonality of certain helminth parasites of fishes.

The acanthocephala, *Rhadinorhynchus horridus* in *H.b. occidentalis* studied maintained a high and constant level of incidence of infection throughout the year with the exception of the months of July and August that coincided with the second peak rainy month of the year. Though there were fluctuations in the physico-chemical parameters of Zaria dam they had no relationship with monthly changes of the parasite population . Kennedy (1975) reported that the acanthocephalan, *Pomphorhynchus laevis* breeds all year round in the fish of River Avon in England. Valtonen (1983) also found no pronounced seasonal changes in prevalence and intensity of infection of *Coregonus lavaretus* infected with *Echinorhynchus salmonis*.

The Young acanthocephalans, acanthella and cystacanth stages were found throughout the year but mostly in the first 20mm of the intestine particularly in March to June. This suggests that recruitment occurs throughout the year and that it is higher during the aforementioned months. This probably gave rise to the preponderance of adult parasite population in the intestinal and rectal region during the months of September to December, suggesting that *R. horridus* hatches, grows, matures and reproduces in *H. b. occidentalis* throughout the year.

Brown (1986) attributed the presence of *P. laevis* throughout the year in *Leuciscus cephalus* and *Salmo gairdneri* to density-dependent establishment. The establishment of only one parasite in the GIT of *H.b. occidentalis* could have prevented it from tolerating others thereby forestalling the establishment of others.

In contrast to *H.b. occidentalis* which harboured a single parasite throughout the year, *M. rume* was infected by three parasites, one trematode, one cestode and one Nematode that

exhibited seasonal incidence in their distribution.

The nematode, *Procamallanus laevionchus* infection in *M. rume* appeared in October reached a peak in November. A fairly high incidence was maintained in December and January, after which it declined between March and September. Most of the *P. laevionchus* were found in the stomach and a few in the intestine. Geets and Ollevier (1996) indicated that nematodes are equipped with alimentary canal and therefore are free to roam around the intestine. However, it is also possible that *P.*

laevionchus in *M. rume*, migrate from the stomach to the intestine with the food of the fish. The incidence of this parasite showed significant relationship with NO_3^- concentration and water temperature of Zaria dam. Furthermore, the other two parasites, *Caryophyllaeus sp.* and *Euclinostomum heterostomum* were absent when the nematode infection was at its peak. The different times of infection by these parasites maybe a system strategy for avoiding competition. Furthermore, it could be that the nematode made the stomach and intestine less suitable for the establishment of other parasites or induced a host response which did not favour other parasites.

A fairly stable equilibrium was maintained between *Caryophyllaeus* and *E. heternostomum* infections of *M. rume*. Both showed peak infection in April which had high significant correlation with water temperature, chloride, pH, dissolved oxygen and turbidity. The interaction of the two parasites in *M. rume* may be said to be a low inter-specific competitive interaction characterised by simultaneous infection that is not detrimental to the two species. It is also likely that the dietary demand and behaviour of the parasites in the GIT differ thereby enabling close interaction. Crompton (1973) suggested that digenean parasites fed mainly on mucosa and epithelial tissues of host, while the caryophillids may be attached to a spot in the GIT or absorb semi-digested food through their body (tegument). This might be the explanation for the coexistence between *E. heterostomum* and the caryophillidean cestode in this study. Kennedy (1975) concluded that "inter-specific competition can occur and is usually, detrimental to one or both species, but it is of fairly rare occurrence and little significance in controlling the size of parasite populations".

In *M. senegalensis* the two GIT parasites, *Caryophyllaeus* sp. and *Procamallanus laevionchus* exhibited segregated infection pattern with the former parasite occurring between February and July with a peak in April, and the latter occurring between September and December with a peak in November.

None of the parasites were found in the months of January, (cold dry season) and August (cold wet season). It is possible that other factors other than physico-chemical, may be responsible for the absence of the parasites in the fish. In comparing the helminth burdens of male and female brown trout, *Salmo trutta*, Thomas (1964) showed that the

majority of the parasitic species were independent of, and had no effect on each other. The two aforementioned parasites in *M. senegalensis* therefore did not confer resistance against each other neither were they competing. Food preference of the fish host at different times of the year may be responsible for the segregated infection.

In *M. deliciousus*, three main GIT parasites encountered were *Eucestodaria*, *Neoechynorhynchus* and *Procamallanus* spp.. The last two parasites showed highly significant relationship with Rainfall, turbidity, manganese and chloride concentrations while the first two showed high relationship with pH, manganese and chloride concentrations.

An interesting aspect of the incidences of these parasites is the higher co-occurrence of *Eucestodaria* and *P. laevionchus*. When their incidences were high (Dec - March) *Neeochinorhynchus* sp. infection was basically low or absent. Conversely in the month of July, August, September and October (Wet Season) *Neoechinorhynchus* infection was very high and other parasite were also nearly absent; though there were overlaps of infection. Since most of the *Neoechinorhynchus* sp. obtained had their proboscis in the GIT, they may, however, have rendered the habitat less suitable for other parasites thus inducing a host response that could be effective against other parasites. Lee (1981) demonstrated antagonism between *Acanthocephalus lucii* on one side, and *Proteocephalus percae* and *Camallanus lacustris* in the intestine of *Perca fluviatilis* on the other side. His conclusion favoured the mutual exclusion theory. A similar situation might be obtained in *M. senegalensis* in this study. In contrast, Kennedy (1975) and Esch *et al.*, (1988) have cautioned that the effect of one parasite population over the other may be erratic, fortuitous and unpredictable. Therefore inferences on parasite population in fish must be made with caution.

PARASITES OF THE GIT AND THEIR RELATIONSHIP TO LENGTH CLASS OF FISH

Changes in abundance of parasites with host size or age and change in diet is a well known phenomenon (Geets and Ollevier, 1996). In this study, the massive infection

of the GIT of *H.b. occidentalis* by *R. horridus* increased with the length class of the fish though no statistical difference within the length-classes. Dogiel (1961) suggested that the number and diversity of parasites increased with age of fish. The observed high infection (> 50%) in all age groups might negatively influence condition and growth of this fish. Valtonen (1983) and Amin (1985) concluded that *Echinorhynchus salmonis* infection in *Coregonus* sp. increased with increase in age of the fish, whereas *Acanthocephalus lucii* infection of pike was independent of host age, but the incidence and level of infection increased with age of host (Kennedy, 1975).

Therefore, in *M. rume* and *M. senegalensis*, percentage infection of the juveniles and adult fishes were higher than the sub adult, even though there was no statistical significant difference in population of parasites of the different length classes. This may be due to the schooling behaviour and diet of the fishes. Geets and Ollevier (1996) studied the infection of some helminths in *Siganus sutor* and concluded that intensities of infection by two of the parasites are negatively correlated with host size. This present study suggests that parasites of the GIT of *M. rume* and *M. senegalensis* were independent of host size.

In *M. deliciosus* the sub adult and adults had higher parasite load than the Juveniles. The acanthocephalan parasites, *Neoechionrhynchus* sp. were mostly found in sub adult, and adult fish species than in the juveniles, suggesting that food/diet is probably responsible for the shift in parasite species. This inference can be drawn because the diet of the adult fish, in addition to immature insects, included smaller fishes (*Oreochromis niloticus*) that probably were infected with *Neoechynorhynchus* sp, indicating the presence of invertebrate(s) and two vertebrate host in the life cycle of the parasite.

DIET OF FISH IN RELATION TO PARASITES OF THE GIT

Cannon (1972), Kennedy (1975), Scott (1975) and Diamant (1989) related abundance of parasites in the GIT of fishes to change in diet. In *H.b. occidentialis* the molluscs, gastropods and ostracods, and chironomid larvae were present in the stomach

throughout the year and these food items may have served as intermediate hosts for the acanthocephalan of *H.b. occidentalis*. In March when the parasite intensity was highest, the feeding intensity of the fish was also high and the aforementioned diets were most abundant. The reverse was the case in July and August. Petrochenko (1971) and Shotter (1975) have implicated ostracods, megalopteran larvae, *Lymnaea* sp., various crustaceans and amphipods as intermediate invertebrate host of several acanthocephalans.

Despite the similarly in the diets of *H.b. occidentalis* and *M. deliciosus*, they were infected by different genera of Acanthocephala the former being infected by *R. horridus* and the latter by *Neoechinorhynchus rutili*. Petrochenco (1971) indicated that animals which live under similar ecological conditions are expected to be infected by the same parasite(s). However, morphology, biochemistry and physiological features differ and therefore interchange of parasites may not occur. Therefore the minor differences in diet and probably in biochemistry and physiology of the two fish species may have dictated the species of acanthocephala that infected them. In all fish examined, no two types of acanthocephalan were found in one fish species, thus further stressing the host and organ specificity of these worms.

In *M. rume*, the months of March to May witnessed high parasitic infection of the GIT during which the feeding intensity was also very high. Then *Caryophyllaeus* sp. and *E. heterostomum* were the prevalent parasites. Similarly *Caryophyllaeus* infection in *M. senegalensis* was high between February and June. Available literature indicated that the oligochaetes are the intermediate host of the caryophyllids while the molluscs, particularly the gastropods were the intermediate host of *E. heterostomum* (Cheng, 1973). Both types of intermediate hosts were found in the stomach of *M. rume* as well as in *M. senegalensis*. Personal observation also pointed to *Bulinus* sp. or *Lymnaea* sp as likely intermediate host of *E. heterostomum* because they were found in the stomach of the fish. Water birds, such as Herons, Pelicans and king fishers were found in the vicinity of Zaria dam (Ezealor, Pers, Comm.) and these birds have been implicated as the definitive host of clinostomatids (Ukoli, 1969).

It is also likely that the high infection of *Procamallanus* sp. in October and January in *M. rume* and September and December in *M. senegalensis*, was due to the abundance of copepod intermediate host (Cheng, 1973) in the diet and the ostracods and clam shrimps were observed in the stomachs of the fishes during this period. *Procamallanus* sp. infection in *M. deliciosus* started in October, reached a peak in March, after which it started decreasing gradually and disappearing by July/August. The commencement of infection by this parasite in *M. deliciosus* is somehow, related to its occurrence in *M. rume* and *M. senegalensis*, thus suggesting that a similar food item may be responsible for coincidental period of infection in the three fish species; though protracted in *M. deliciosus* than in the others.

The amphipod (crustacean) has been suggested as the intermediate host of *Eucestodaria* sp. (Cheng, 1973) and the decapod (Prawns) may be intermediate host of this parasite in *M. deliciosus* of Zaria dam. The diet of the fish contained the prawns between October and April while Eucestodaria infection was also high between November and June.

It may be necessary to examine some of the implicated intermediate hosts for the larvae or infective stages of parasites as a first step to elucidating some life cycles of the helmith parasites found in the mormyrids of Zaria dam.

The importance of the infective larval stages of helminths in relation to feeding habit of host were emphasised by Hine and Francis (1980) and Sousa (1994). Geets and Ollevier (1996) indicated that helminth parasites sharing the same intermediate host would often co-occur in individual vertebrate host since they are acquired simultaneously when the definitive host feeds on this intermediate host.

SEX OF HOST IN RELATION TO GIT PARASITES

Hickman (1960), Lees and Bass (1960) Kennedy (1975) reported higher incidence of helminth parasites in male frogs than in females just before the breeding season and suggested that female hormones increased the host resistance to infection. In *H.b. occidentalis* studied, there is no significant difference in the monthly infection rate

of the male and female fish by *R. horridus*. However, in the dry season when the incidence of the parasites were very high in both fish sexes, the gonads were immature. It therefore does not appear as if sex of host influenced the incidence of this parasite. However, the sex ratio of the parasite is in favour of the female parasite i.e. 1:4. This may be an inherent natural selection phenomenon in maintaining the reproductive capacity and continuity of the species, *R. horridus*.

In *M. rume* lowest incidence of parasites were recorded when mature gonads (stages III and IV) were prominent. Percentage infection suggested that the females appeared to be more susceptible to infection than the males. Kennedy (1968) indicated that the degree of infection by *Caryophyllaeus laticeps* in dace (*Leuciscus leuciscus*) was generally higher in female (in December to June) and also postulated that the host hormone levels might have played an important role in seasonal maturation of caryophillaeids. In *M. rume* and *M. senegalensis* studied, *Caryophyllaeus* sp. infection was higher in February to June when gonads were immature. In *M. senegalensis* there was a high significant difference between *Procamallanus* sp. infection with stage IV (mature) gonads in both male and female fish. However, the reverse was the case of this parasite in male and female of *M. deliciosus*. Clearly, the differences in parasite incidence may imply that a single cause (sex or gonad stage) may not be responsible for distribution of this parasite but rather, a combination of other factors.

The Eucestodarian infection was higher in female *M. deliciosus*. A higher positive correlation also existed between the parasite and stage IV and VI gonads in the female fish. This indicated that, as the hormone responsible for production of eggs increased, the incidence of the parasites also increased. A similar observation was also made for the infection of both sexes of the same fish by *Neoechinorhynchus rutili*.

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION

- The parasites of the branchial chamber and alimentary canal in relation to length-weight relationship, food and feeding habit, reproductive cycle and fecundity of the Mormyrids in addition to the physicochemical parameters of Zaria Dam, were studied between December, 1993 and November, 1995.
- The marked rainy and dry seasons of Zaria contributed directly to the fluctuations of some physicochemical parameters determined in Zaria Dam.
- 2133 fish specimens used comprised of 793. *H.b. occidentalis*, 662 *M. rume*, 380 *M. senegalensis*, 183 *M. deliciosus*, 81 *H. pictus*, and 34 *P. bovei*.
- All males and females of fish, except *P. bovei* and females of *M. rume*, exhibited isometric growth.
- The mormyrids are active feeders, feeding almost throughout the year on various invertebrates. Only adult *M. deliciosus* is piscivorous. The various food items found in the mormyrids indicate that they feed within various ecological niches. This reduces competition within any particular zone, hence the successful establishment of the mormyrids in Zaria Dam.
- The breeding season of the mormyrids is June to October (rainy season); *M. senegalensis* had highest fecundity while *P. bovei* had the lowest.
- The gills of *H.b. occidentalis* were parasitised by *Henneguya* sp., *Clinostomum complanatum*, *glochidia* and *Ergasilus sarsi*. *Afrolernaea nigeriensis*, *Tabanus* sp., *Henneguya* sp. and *Philometra beninensis* are the parasites of *M. rume*.
- The gill parasites of *M. senegalensis* are *E. sarsi*, *Henneguya* sp., and *Dactylogyrus vastator*. The parasites, *Lamproglena* sp. and *Hirudo* sp. were found in *M. deliciosus*. Only *E. sarsi* were found on the gills of *H. pictus* and none on the gills of *P. bovei*. All these parasites exhibited seasonal fluctuations in prevalence. *Ergasilus sarsi* and *D. vastator* may pose serious threat to fish production in Zaria Dam.
- The cysts of *Henneguya* sp. occluded the surface of the gills and therefore may reduce respiratory functions. *Dactylogyrus vastator* found on the gills of *M. senegalensis* stimulated elongation of the tips of gill filaments. The attachment of the

leech to the gills of *M. deliciosus* caused haemorrhagic spots at the points of attachment. The copepods created point depression at the point of attachment. *P. beninensis* caused expansion of the thin epithelial tissue of the inner surface of the operculum of *M. deliciosus*. The larval mollusc (glochidium) created circular mark on the gill filaments of *H.b. occidentalis*.

- The gill parasites did not show specific preference for either the right or left gill arches. The parasites of the mormyrids showed seasonal prevalence and most are temperature dependent and pH sensitive (e.g. *Henneguya* sp. *Hirudo* sp. and *P. beninensis*).
- The infection of *H.b. occidentalis* and *M. rume* by copepods, which was recorded throughout the year, showed a higher prevalence in juvenile fish than adult and sub-adult.
- The lowest feeding period in *M. rume*. (December to January), coincided with the highest prevalence infection by *A. nigeriensis*. The infection of *M. deliciosus* by leeches in November to December, is attributable to its feeding behaviour.
- Most gill parasites did not exhibit preference for sex of host, however, in *M. senegalensis*, infection by *Henneguya* sp. occurred only in female fish in March to May, when gonad stage I was prominent.
- The intestinal parasites of *H.b. occidentalis* was *Rhadinorhynchus horridus*. The parasites of *M. rume* were *Procamallanus laevionchus*, *Caryophylleus* and *Euclinostomum complanatum*. *Caryophyllaeus* sp. and *P. laevionchus* are the parasites of *M. senegalensis*. *M. deliciosus* was parasitised by *P. laevionchus*, *Neoechinorhynchus* sp. and *Eucestodaria* sp. Infection by the acanthocephalan and nematodes are likely to be on the increase and therefore should be monitored closely.
- *Euclinostomum heterostomum* and the caryophyllidean cestodes were found in the mid intestine of *M. rume*, *M. senegalensis* and *M. deliciosus*. *Procamallanus laevionchus* was ubiquitous within the GIT of the mormyrids. The *Acanthocephalan* showed preference for the mid intestinal and rectal regions.
- The infection levels of the GIT parasites were lower in *M. rume* and *M. senegalensis* compared with *H.b. occidentalis* and *M. deliciosus*.

- *Neoechinorhynchus* sp. of *M. deliciosus* destroyed the stratum compactum of the intestinal wall while other GIT parasites did not show any clinical signs.
- The fluctuation of the physicochemical parameters of Zaria Dam had no direct relationship to *R. horridus* infection of the intestine of *H.b. occidentalis*. Recruitment of the parasite therefore, took place throughout the year. Whereas *P. laevionchus* infection in *M. rume* was high in November to January (cold harmattan season) other parasites such as *Caryophyllaeus* sp. and *E. heterostomum* were absent. The reverse was the case in March to September - thus the negative interaction exhibited between *P. laevionchus* and other intestinal parasites in *M. rume* was related to pH, turbidity, temperature and nitrate concentration variation of the dam. In *Marcusenius senegalensis*, *Caryophyllaeus* sp. and *P. laevionchus* exhibited segregated infection pattern which was positively correlated with iron concentration of the water in Zaria Dam. The parasites of *M. deliciosus*, *Eucestodaria*, *Neoechinorhynchus* and *Procamallanus spp.* Were influenced by the physicochemical parameters of Zaria Dam, thus indicating seasonal occurrence of these parasites.
- Infection of the GIT of *H.b. occidentalis* by *R. horridus* increased with the age of the fish. In *M. rume* and *M. senegalensis*, prevalence of infection of the juveniles and adult were higher than the sub-adult fishes, whereas in *M. deliciosus*, the adults had higher parasitic load than the juveniles. The increasing and decreasing numbers of parasites may be associated with increasing host size and change in diet.
- The diets of the mormyrids, such as the molluscs, gastropods, ostracods and chironomids are implicated as intermediate hosts of various parasites found in the GIT of the mormyrids. It is however necessary to examine these diets to ascertain their involvement as 'carriers' of infective stage of parasites.
- The sex of *H.b. occidentalis* did not appear to influence the incidence of *R. horridus* in its GIT. On the other hand, the females of *M. rume* appeared to be more susceptible to infection than the males. In *M. deliciosus*, infection by *Eucestodaria* and *Neoechinorhynchus* spp. were higher in the female when the gonads were in advanced stage of maturation. This suggests that the hormone responsible for the production of eggs favoured the incidence and establishment of parasites.

- The complex interactions between the physicochemical parameters of Zaria Dam and the aspects of the biology of the mormyrids directly or indirectly influenced the annual incidence of the parasites of their gills and GIT. A survey of the benthic fauna of Zaria Dam, continuous monitoring of the physicochemical parameters of the dam, a study of the biology of other fish species and their parasites would give an insight into boosting fish production and control of parasites.

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APPENDIX I

MEAN MONTHLY PHYSICO-CHEMICAL PARAMETERS OF ZARIA DAM (DEC. 1993 - NOV. 1995)

MONTH PARAMETERS	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN	JUL.	AUG.	SEPT	OCT	NOV	YEAR MEAN
Turbidity (cm)	12.22	11.65	11.75	11.40	15.12	68.00	147.75	106.50	111.32	49.50	38.45	20.75	50.36
pH	7.1	6.6	5.8	5.5	5.9	7.0	7.2	8.1	7.0	6.5	6.5	6.7	6.65
Temp.(°C)	21.6	23.1	25.0	27.0	29.3	28.7	28.2	26.7	26.4	27.1	29.0	26.7	26.56
Fe (mg/l)	.25	.21	.15	.16	.16	.14	.10	.57	.57	.42	.50	.42	.26
Mn (mg/l)	.13	.13	.15	.16	.11	.11	.13	.10	.10	.10	.10	.10	.12
NO_3 (mg/l)	.21	.18	.26	.26	.26	.27	.27	.25	.25	.25	.25	.25	.24
Cl (mg/l)	2.55	2.70	2.64	2.78	2.70	2.70	2.65	2.52	2.50	2.50	2.50	2.50	2.60
DO_2	7.39	7.69	6.3	6.05	5.36	5.68	5.05	6.66	5.98	5.67	6.11	6.42	6.19
RAIN (mm)	0.0	0.0	0.0	0.0	20.4	120.1	231.9	169.2	218.6	82.5	69.2	0.0	75.99

APPENDIX 2

MEAN STAGES OF GONADS IN *H. b.* OCCIDENTALIS (Dec. 1993 – Nov. 1995)

MONTH	SEX	I	II	III	IV	V	VI	NO.EXAMINED
DECEMBER	*M	13	5	-	-	-	-	18(34)
	*F	6	9	1	-	-	-	16
JANUARY	M	27	7	-	-	-	-	34(61)
	F	9	18	-	-	-	-	27
FEBRUARY	M	16	9	-	-	-	-	25(53)
	F	13	15	-	-	-	-	28
MARCH	M	14	21	-	-	-	-	33(95)
	F	29	31	2	-	-	-	62
APRIL	M	6	16	2	-	-	-	24 (75)
	F	21	27	4	-	-	-	51
MAY	M	17	29	10	-	-	-	56(93)
	F	18	15	4	-	-	-	37
JUNE	M	3	7	16	2	-	-	28(47)
	F	2	11	6	-	-	-	19
JULY	M	5	8	11	3	-	1	27(52)
	F	4	3	13	5	-	-	25
AUGUST	M	8	19	6	7	-	-	40(89)
	F	9	17	21	2	-	-	49
SEPTEMBER	M	2	5	13	1	-	-	21(48)
	F	5	8	10	2	-	2	27
OCTOBER	M	9	17	-	-	-	-	26(54)
	F	5	6	10	8	-	-	28
NOVEMBER	M	10	39	1	-	-	-	49(93)
	F	14	23	6	-	-	-	43

*M = Male
*F = Female

Total M = 381 } 793
Total F = 412 }

APPENDIX 3

FECUNDITY ESTIMATE OF THE FEMALE MORMYRIDS

Standard length (cm)	Wt. Fish (g)	Wt. Ovary (g)	Total Wt. of dried eggs (g)	Mean Wt. of three sub-samples of 200 eggs	Fecundity estimate
A. *H. b. Occidentalis*					
33.6	250	4.88	.816	.0704	2318
27.1	212.3	3.71	.705	.0614	2296
34.6	271.3	5.98	.954	.0768	2483
30.4	251.5	8.84	2.574	.1261	4082
35.50	375.2	9.58	2.419	.1154	4192
31.3	240.2	4.75	.924	.0678	2726
31.5	220.0	5.10	.928	.0733	2532
24.2	133.0	2.17	.561	.0554	2025
31.2	240.0	7.95	2.132	.132	3357
27.8	223.3	4.01	.811	.0733	2213
B. *M. rume*					
30.1	210.6	4.95	1.109	.0765	2899
28.6	155.6	2.09	.815	.1225	1331
34.4	325.1	5.76	1.402	.1766	1588
34.2	340.9	4.98	1.211	.1693	1430
36.1	390.1	11.93	2.630	.1995	2636
33.2	315.1	6.21	1.954	.2394	1632
32.8	339.2	3.65	1.019	.1899	1073
35.2	360.9	8.15	2.670	.1985	2690
28.7	155.6	5.72	1.695	.1352	2507
23.2	159.9	2.64	.654	.1211	1080

Appendix 3 cont.

Standard length (cm)	Wt. Fish (g)	Wt. Ovary (g)	Total Wt. of dried eggs (g)	Mean Wt. of three sub-samples of 200 eggs	Fecundity estimate
C. *M. senegalensis*					
17.3	65.0	9.68	3.462	.1951	3549
17.4	65.6	9.06	3.399	.1312	5181
16.5	63.65	8.14	2.941	.1291	4514
14.9	47.9	9.41	3.614	.1719	4205
21.3	119.0	18.15	6.931	.1784	7770
18.4	115.0	14.31	2.615	.1194	4380
18.5	100.6	10.32	3.286	.1319	4982
17.9	70.0	13.82	3.912	.1259	6214
15.9	48.8	10.18	3.667	.1815	4041
17.4	65.5	10.09	3.811	.1295	5886
D. *M.deliciosus*					
36.3	234.4	11.16	2.79	.2518	2216
39.8	251.2	9.01	2.25	.1956	2301
44.7	275.1	11.00	2.66	.2216	2401
33.9	199.5	7.98	1.90	.1652	2300
33.1	281.8	9.39	.2.35	.1865	2532
E. *H. pictus*					
18.8	81.8	4.40	1.14	.0881	2401
18.6	88.5	4.35	1.11	.0774	2257
17.4	70.0	3.72	1.00	.0532	1156
13.0	46.4	2.30	.38	.0141	718
14.8	47.3	2.50	.41	.0337	1015
15.6	55.3	2.75	.87	.0374	1856

Appendix 3 cont.

Standard length (cm)	Wt. Fish (g)	Wt. Overly (g)	Total Wt. of dried eggs (g)	Mean Wt. of three sub-samples of 200 eggs	Fecundity estimate
F *P. bovei*					
9.3	17.1	1.80	.47	0.0881	1492
8.5	15.0	0.91	.15	0.0943	1775
9.2	17.4	1.70	.27	0.0594	1366
8.6	14.0	1.60	.49	0.0642	1093
9.0	16.1	1.85	.57	0.06758	1332

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Appendix 4a

MEAN MONTHLY OCCURRENCE OF PARASITES IN THE BRANCHIAL CHEMBER OF MALE *H .b. Occidentalis* (Dec. 1993 – Nov. 1995)

MONTH	PARASITES	Gill Arches				TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
		1	2	3	4				
DECEMBER	*Hennegya*	-	-	-	-	-	18	8	44.40
	Clinestomum	-	-	-	-	-			
	Mollusc	4	-	-	-	4			
	E.sarsi	13	4	1	-	18			
JANUARY	*Henneguya*	-	-	-	-	-	34	21	61.76
	Clinostomum	-	-	-	-	-			
	Mollusc	9	13	13	-	22			
	E.sarsi	21	8	6	-	35			
FEBRUARY	*Henneguya*	3	-	-	-	3	25	10	40.00
	Clinostomum	-	-	-	-	-			
	Mollusc	5	-	-	-	5			
	E.sarsi	9	4	-	-	13			
MARCH	*Henneguya*	34	14	2	-	50	33	28	84.84
	Clinostomum	-	-	-	-	-			
	Mollusc	1	1	-	-	2			
	E.sarsi	13	14	-	-	29			
APRIL	*Henneguya*	8	2	3	-	13	24	20	83.33
	Clinostomum	-	-	-	-	-			
	Mollusc	4	-	-	-	4			
	E.sarsi	6	5	-	-	11			
MAY	*Henneguya*	4	-	-	-	4	56	17	30.36
	Clinostomum	-	-	-	-	-			
	Mollusc	1	-	-	-	1			
	E.sarsi	12	6	-	-	18			
JUNE	*Henneguya*	2	2	-	-	4	28	13	46.43
	Clinostomum	-	-	-	-	-			
	Mollusc	-	-	-	-	2			
	E.sarsi	20	2	-	-	22			

		Gill Arches							
JULY	*Henneguya*	-	-	-	-	-	27	20	74.07
	clinostomum	9	5	-	-	14			
	Mollusc	-	-	-	-	-			
	E.sarsi	18	5	2	-	25			
AUGUST	*Henneguya*	-	-	-	-	-	40	34	85
	Clinostomum	25	22	10	1	58			
	Mollusc	-	-	-	-	-			
	E.sarsi	17	8	-	-	25			
SEPTEMBER	*Henneguya*	23	4	-	-	27	21	21	100.00
	Clinostomum	20	8	1	-	29			
	Mollusc	-	-	-	-	-			
	E.sarsi	13	1	-	-	14			
OCTOBER	*Henneguya*	19	12	-	-	31	26	26	100.00
	Clinostomum	11	3	-	-	14			
	Mollusc	-	-	-	-	-			
	E.sarsi	8	-	-	-	8			
NOVEMBER	*Henneguya*	5	1	-	-	6	49	41	83.67
	Clinostomum	40	5	-	-	45			
	Mollusc	19	6	-	2	27			
	E.sarsi	26	24	8	4	62			
Total		424	179	35	7	645	381	259	67.97

Overall % Infection

Henneguya -138 (21.39%)
Clinostomum - 160(24.80%)
Mollusc - 67 (10.38%)
E.sarsi - 280 (43.40%)

APPENDIX 4 b

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL OF FEMALE *H. b. occidentalis*. (Dec. 1993 – Nov. 1995)

MONTH	PARASITES	OPERCULUM	Gill Arches				TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
			1	2	3	4				
DECEMBER	*Henneguya*	-	-	-	-	-	-	16	7	43.75
	Clinostomum	-	-	-	-	-	-	16	7	
	Mellusc	-	2	-	-	-	9			
	E.sarci	-	16	10	2	2	30			
JANUARY	*Henneguya*	-	-	-	-	-	-	27	14	51.85
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	7	-	-	-	7			
	E.sarci	-	9	2	-	-	11			
FEBRUARY	*Henneguya*	-	6	-	-	-	6	28	13	46.42
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	2	1	-	-	3			
	E.sarsi	-	-	-	-	-	5			
MARCH	*Henneguya*	-	37	5	-	-	42	62	31	50.00
	Clinostomum	-	-	-	2	-	2			
	Mollusc	-	2	-	-	-	2			
	E.Sarsi	-		-	-	-	-			
APRIL	*Henneguya*	-	7	3	-	-	10	51	10	19.6
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	4	-	-	-	4			
	E.sarsi	-	-	-	-	-	4			
MAY	*Henneguya*	-	8	2	1	-	11	37	19	51.35
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	10	5	-	-	15			
JUNE	*Henneguya*	-	-	-	-	-	-	-	-	36.84
	clinostomum	-	-	-	-	-	-	19	7	
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	12	1	-	-	13			
JULY	*Henneguya*	-	-	-	-	-	-	25	8	32.00
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	11	-	-	-	11			

AUGUST	*Henneguya*	-	-	-	-	-	-	49	39	79.59
	clinostomum	-	18	15	-	-	33			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	22	4	-	-	26			
SEPTEMBER	*Henneguya*	-	4	1	-	-	5	27	21	77.78
	Clinostomu	-	10	5	-	-	15			
	mollusc	-	-	-	-	-	-			
	E.sarsi	-	13	2	-	-	15			
OCTOBER	*Henneguya*	-	20	13	-	-	33	28	23	82.14
	Clinostomu	-	-	-	-	-	-			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	19	5	1	-	25			
NOVEMBER	*Henneguya*	-	-	-	-	-	-	43	38	88.37
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	12	3	-	-	15			
	E.sarsi	-	23	13	6	2	44			
TOTAL			286	90	12	4	392	412	231	56.06

OVERALL % INFECTION

Henneguya - 107 (28.38%)
Clinostomum - 50 (13.26%)
Mollusc - 23 (6.10%)
E. sarsi - 197 (52.25%)

APPENDIX 4c

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF *H.b.* Occidence (MALE AND FEMALE COMBINED) (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OPERCULUM	Gill Arches				TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION.
			1	2	3	4				
DECEMBER	*Henneguya*	-	-	-	-	-	-	34	15	44.11
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	13	-	-	-	13			
	E.sarci	-	29	14	3	3	49			
JANUARY	*Henneguya*	-	-	-	-	-	-	61	35	57.37
	clinostomum	-	-	-	-	-	-			
	Mollusc	-	16	13	6	-	35			
	E.sarsi	-	30	10	-	-	40			
FEBRUARY	*Henneguya*	-	9	-	-	-	9	53	23	43.40
	clinostomum	-	-	-	-	-	-			
	Mollusc	-	7	-	-	-	7			
	E.sarsi	6	14	4	-	-	18			
MARCH	*Henneguya*	-	71	19	2	-	92	95	59	62.10
	Clinostomum	-	-	-	2	-	2			
	Mollusc	-	1	1	-	-	2			
	E.sarsi	-	15	14	2	-	31			
APRIL	*Henneguya*	-	15	5	3	-	23	75	30	40.00
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	8	-	-	-	8			
	E.sarsi	-	6	5	-	-	11			
MAY	*Henneguya*	-	12	2	1	-	15	93	36	38.71
	clinostomum	-	-	-	-	-	-			
	mollusc	-	1	-	-	-	1			
	E.sarsi	-	22	11	-	-	33			
JUNE	*Henneguya*	-	2	2	-	-	4	47	20	42.55
	Clinostomum	-	-	-	-	-	-			
	Mollusc	-	2	-	-	-	2			
	E.sarsi	-	32	3	-	-	35			

jULY	*Henneguya*	-	-	-	-	-	-	52	28	53.85
	Clinostomum	-	9	5	-	-	14			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	29	5	2	-	36			
AUGUST	*Henneguya*	-	-	-	-	-	-	89	73	82.02
	Clinostomum	-	43	37	10	1	91			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	39	12	-	-	51			
SEPTEMBER	*Henneguya*	-	27	5	-		32	48	42	87.5
	Clinostomum	-	30	11	1	-	42			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	26	3	-		29			
OCTOBER	*Henneguya*	-	39	25	-	-	64	54	49	90.74
	Clinostomum	-	11	3	-	-	14			
	Mollusc	-	-	-	-	-	-			
	E.sarsi	-	27	5	1	-	33			
NOVEMBER	*Henneguya*	-	5	1	-	-	6	92	79	85.86
	clinostomum	-	40	5	-	-	45			
	Mollusc	-	31	9	-	2	42			
	E.sarsi	-	49	37	14	6	106			
TOTAL			710	269	47	11	1037	793	490	61.79

Yearly % infection

Henneguya - 245 (26.14%)
Clinostomum - 210 (19.96%)
Mollusc - 90 (8.55%)
E.Sarsi - 477 (45.53%).

APPENDIX 5a

NUMBER OF PARASITES IN THE INTESTINE OF *H. b.* OCCIDENTALIS (MALE)

MONTHS	OESOPHAGUS	STOMACH	1st 2CM of the Intestine (Deodenum	Small intestine	Rectum	Total Male	Female	Total Acanthela (Acantho-cephala)	Total Parasites	No of Fish Examined	No. Infected	%Infection
DECEMBER	-	-	3 1	10 38	1 8	11	39	3 47	50	18	15	83.33
JANUARY	-	-	7 11	27 111	7 32	34	127	7 154	161	43	29	
FEBRUARY	-	-	3 2	10 43	3 12	13	47	3 57	60	25	19	76.00
MARCH	-	2 (Nematodes)	17 1	22 16 92	10 46	32	140	33 139	172	33	33	100.00
APRIL	-	-	6	14 9 46	4 17	18	60	15 63	78	24	23	95.83
MAY	-	1 (Nematodes)	13	13 11 88	6 28	19	122	25 116	141	56	43	76.78
JUNE	-	-	3 3	10 41	5 24	15	56	3 68	71	28	22	78.57
JULY	-	-	1	4 20	2 11	6	26	1 31	32	27	15	55.55
AUGUST	-	-	6	6 24	3 15	9	36	- 45	45	40	18	45.00
SEPTEMBER	-	-	2	17 90	3 13	20	85	2 103	105	21	19	90.48
OCTOBER	-	-	-	11 50	2 13	13	50	- 63	63	26	20	76.92
NOVEMBER	-	1	3 5	35 185	7 34	42	182	3 224	225	49	49	100.0
						223 : 1 :	972 4	95 1110				

APPENDIX 5b

NUMBER OF PARASITES IN THE INTESTINE OF H.B. OCCIDENTALIS (FEMALE)(Dec. 1993 – Nov. 1995)

MONTHS	OESOPHAGUS	STOMACH	1ST 20mm OF THE INTESTINE (DEODENUM)	SMALL INTEST-INE	RECTUM	TOTAL MALE	FEMA-LE	TOTAL ACHAN THELA (ACANT HOCEPH ALA)	TOTAL PARASI-TES	NO OF FISH EXAMI-NED	NO INFECT--ED	% INFECTE D
DECEMBER	-	-	1	3	2	5	17	1	22	16	14	87.50
			-	13	8			21				
JANAURY	-	-	4	18	6	24	84	4	108	27	26	96.30
			6	67	31			104				
FEBRUARY	-	-	2	8	3	11	37	2	48	28	21	75.00
			1	32	13			46				
MARCH	-	2	12	30	10	40	174	12	214	62	62	100.00
		(nematode)		157	45			202				
APRIL	-	-	16	16	5	21	100	16	121	51	48	94.12
				79	26			105				
MAY	-	1	29	13		13	92	29	105	37	34	91.90
		(nematode)		61	15			76				
JUNE	-	-	11	2	4		-				17	89.47
			2	12	19	16	67	13		19		
				49				70				
JULY	-	-	2	5	-		26	2		25	17	68.00
				20	9	5		29	83			
AUGUST	-	1	1	2	8		25	1	31	49	22	44.90
		(nematode)		10	24	10		34				
SEPTEMBER	-	-	1	17	2		60	1	35	27	20	74.10
			63	63	15	19		78				
OCTOBER	-	-	1	16	2	18	52	1	79	28	19	67.86
				56	13			69				
NOVEMEBER	-	-	2	23	10	33	135	2	70	43	37	86.05
			6	115	45			116	168			

APPENDIX 5c

PARASITES OF THE GASTRO-INTESTINAL TRACT OF *H.B. OCCIDENTIALS* (MALE AND FEMALE COMBINED) (Dec. 1993 – Nov. 1995)

MONTHS	OESOPHAGUS	STOMACH	1ST 20M OF INTESTINE	INTESTINE	RECTUM	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	-	-	4	13	3	72	34	29	85.30
			1	51	16				
JANUARY	-	-	11	45	13	269	61	55	90.16
			17	178	63				
FEBRUARY	-	1	5	18	6	108	53	40	75.47
		nematode	3	75	25				
MARCH	-	-	29	16	20	386	95	95	100.00
			1	52	91				
				249					
APRIL	-	2	22	9	9	199	75	71	94.66
		nematode	-	30	43				
				125					
MAY	-	-	42	11	6	246	93	77	82.80
				26	43				
				149					
JUNE	-	-	14	2	9	154	47	39	82.99
			5	22	43				
				90					
JULY	-	1	4	9	2	63	52	32	61.54
		nematode	-	40	20				
AUGUST	-	-	1	8	11	80	89	40	44.94
			6	34					
SEPTEMBE R	-	-	3	27	5	184	48	39	81.25
			-	153	28				
OCTOBER	-	-	5	27	4	133	54	39	72.22
			11	106	26				
NOVEMBER	-	-	5	359	17	393	93	86	92.47
			5	300	79				
						2289	793	642	60.95

APPENDIX 6

RELATIONSHIP BETWEEN CLASS LENGTH AND INFECTION IN THE BRANCHIAL CHAMBER OF THE MORMYRIDS

6a. *H. B.* Ocidentalis

Age Group	Class Interval	No Examined	No Infected	% Infection
Juveniles	15.1-22.0M-	129	97	75.19
Young	22.1-29	453	249	54.96
Adult	29.1 >	211	144	68.24
		793	490	61.79

6b. *M. rume*

Juveniles	15.1-22.0	147	145	98.64
Young	16.6-19.	369	342	87.80
Adult	29.1 >	146	137	93.75
		662	606	77.63

6c. *M. Senegalensis*

Juveniles	13.6-16.5	95	59	62.10
Young	16.6-19.5	157	116	73.90
Adult	19.6 >	128	120	93.75
		380	295	77.63

6d. *M. delicious*

Juvenile	28.1-36	83	37	44.59
Young	36.1-44	72	52	72.22
Adult	44.1 >	28	22	78.57
		183	111	60.65

APPENDIX 7
RELATIONSHIP BETWEEN CLASS LENGTH AND INFECTION OF THE GASTROINTESTINAL TRACT OF THE MORMYRIDS

7a. *H. b. ocidentalis*

Age group	Class Internal	No Examined	No Infected	% Infection
Juveniles	15.1-22.0	129	76	58.91
Young	22.1-29.0	453	377	63.22
Adult	29.1	211	189	69.57
		793	642	60.95

7b. *M. rume*

Juveniles	15.1-22.0	147	58	39.45
Young	22.1-29.0	369	106	28.72
Adult	29.1	146	65	44.52
		662	229	34.60

7c. *M. senegalensis*

Juveniles	13.6-16.5	95	14	14.73
Young	16.6-19.5	157	21	13.37
Adult	19.6	128	23	17.96
		380	58	15.26

7d. *M. deliciosus*

Juveniles	28.1-36.0	83	28	25.68
Young	36.1-44.0	72	42	38.53
Adult	44.1	28	39	35.77
		183	109	60.65

APPENDIX 8
THE STAGES OF GONADS IN M.RUME (Dec. 1993-Nov. 1995)

MONTH	STAGES SEX	I	II	III	IV	V	VI	NO EXAMINED
DEC.	M	14						25
	F	21						28
JAN.	M	25	12					37
	F	28	11					39
FEB.	M	20	9					39
	F	21	13					34
MARCH	M	18	6					24
	F	13	17					30
APRIL	M	10	9					19
	F	14	17	2				33
MAY	M	16	16	1				33
	F	23	10	4				37
JUNE	M	10	9	4				23
	F	12	13	1				26
JULY	M	8	2	10	2			22
	F	10	10	12	3			35
AUGUST	M	7	4	7	3			21
	F	12	5	9	4			31
SEPTEMBER	M	7	3	4	1			15
	F	6	8	9	3	2		28
OCTOBER	M	9	5	3	1			19
	F	16	8	2	1		5	32
NOVEMBER	M	11	5	1				17
	F	16	6	3				25

- *M = Male = 284
- *F = Female = 378.

APPENDIX 9a

MONTHLY OCCURRENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF MALE *M.rume* (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OPERCULUM	Gill Arches				TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
			1	2	3	4				
DECEMBER	Afrolearnaea		243	182	30	4	459	25	24	96
	Philometra	13					13			
	Tabanus		4	-	-	-	4			
	Henneguya		8	2	1	-	11			
JANUARY	Afrolearnaea		234	162	34	3	433	37	37	100
	Philometra	9	4	-	-	-	9			
	Tabanus		-	-	-	-	-			
	Henneguya		5	1	1	-	7			
FEBRUARY	Afrolearnaea		205	178	90	17	490	29	29	100
	Philometra	15		-	-	-	15			
	Tabanus		1	-	-	-	1			
	Henneguya		9	4	-	-	13			
MARCH	Afrolearnaea		71	54	19	-	144	24	23	95.83
	Philometra	10	-	-	-	-	10			
	Tabanus		3	-	-	-	3			
	Henneguya		4	6	1	1	14			
APRIL	Afrolearncaea		28	13	-	-	41	19	17	89.47
	philometra	-			-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		14	6	-	-	20			
MAY	Afrolearnaea		31	5	7	1	44	33	26	78.79
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		17	3	-	-	20			
JUNE	Afrolearncaea		45	17	10	8	80	23	19	82.60
	Philometra	-								
	Tabanus						-			
	Henneguya		23	2	-	-	25			

JULY	Afrolcarnaea		105	78	30	25	238	22	18	81.81
	Philometra	-					-			
	Tabanns		-	-	-	-	-			
	Henneguya		6	1	1	-	8			
AUGUST	Afrolearnaea	-	195	200	120	70	585	21	20	95.24
	Philometra									
	Tabanus		1	-	-	-	1			
	Henneguya		2	-	-	-	2			
SEPTEMBER	Afrolearnea		273	140	93	10	516	15	15	100
	Philometra	-					-			
	Tabanus		15	5	-	-	20			
	Henneguya		6	1	1	-	8			
OCTOBER	Afroleanea		392	210	77	13	692	19	19	10
	Philometra	-					3			
	Tabanus		21	18	4	-	43			
	Henneguya		7	3	-	-	10			
NOVEMBER	Afroleanea		206	93	45	10	354	17	17	100
	Philometra	-					11			
	Tabanus		9	3	1	-	13			
	Henneguya		12	6	-	-	18			
TOTAL		11	2194	1393	567	162	4377	284	264	92.96

Overall % Infection

Afrolearnaea - 4075 (93.10%)
Philometra - 61 (1.39%)

Tabanus - 85 (1.94%)
Henneguya - 156 (3.56%)
4377

APPENDIX 9b

MONTHLY OCCURRENCE OF PARASITES ON THE BRACHIAL CHAMBER OF FEMALE *M. rune*. (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OPERCULUM	Gill arches 1	2	3	4	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	Afrolearnaea		302	117	80	10	509	28	28	100
	Philometra	19	-	-	-	-	19			
	Tabanus		18	5	6	4	33			
	Henneguya		7	2	-	-	9			
JANUARY	Afrolearnaea		317	141	80	17	555	39	39	100
	Philometra	15	-	-	-	-	15			
	Tabanus		7	13	1	-	21			
	Henneguya		5	6	3	1	15			
FEBRUARY	Afroleanaea		189	75	13	-	277	34	33	97.0
	Philometra	3	-	-	-	-	3			
	Tabanus		5	-	-	-	5			
	Henneguya		1	5	2	-	8			
MARCH	Afrolearnaea		17	12	1	1	31	30	27	90.0
	Philometra	-	-	-	-	-	-			
	Tabanus		-	4	1	-	5			
	Henneguya		18	6	1	-	25			
APRIL	Afrolearnaea		11	7	-	-	18	33	28	84.85
	Philometra	-	-	-	-	-	-			
	Tabanus		1	-	-	-	1			
	Henneguya		22	3	6	-	31			
MAY	Afrolearnea		8	-	-	-	8	37	25	67.57
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		19	8	2	-	29			
JUNE	Afrolearnea		7	-	-	-	7	26	20	76.92
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		13	1	1	-	15			

JULY	Afrolearnaea		31	14	2	3	50	35	34	97.14
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		2	1	-	-	3			
AUGUST	Afrolearnaea		90	16	-	10	116	31	29	93.55
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		3	1	-	-	4			
SEPTEMBER	Afrolearnaea		70	11	5	1	87	28	27	96.42
	Philometra	2	-	-	-	-	2			
	Tabanus		-	-	-	-	-			
	Henneguya		1	-	-	-	1			
OCTOBER	Afrolearnaea		66	14	11	4	95	32	32	100
	Philometra	17	-	-	-	-	17			
	Tabanus		6	2	-	-	8			
	Henneguya		-	1	-	-	1			
November	Afrolearnaea		253	105	31	18	408	25	25	100
	Philometra	22	-	-	-	-	22			
	Tabanus		14	7	4	1	26			
	Henneguya		8	3	1	1	13			
TOTAL		78	1510	580	251	71	2490	378	347	91.80

OVERALL % Infection

Afrolearnaea	- 2159	(86.71%)
Philometra	- 78	(3.13%)
Tabanus	- 99	(3.97%)
Henneguya	- 154	(6.18%)
	2.490.	

APPENDIX 9c

MONTHLY OCCURRENCE OF PARASITES ON THE BRANCHIAL CHAMBER OF MALE AND FEMALE *M.rume* (COMBINED) (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OPERCULUM	1	2	3	4	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
			Gill arches							
DECEMBER	Afrolearnaea		545	299	110	14	968	53	52	98.11
	Philometra	32	-	-	-	-	33			
	Tabanus		222	5	6	4	37			
	Henneguya		15	4	1	-	20			
JANUARY	Afrolearnaea		551	303	114	20	988	76	76	100.00
	Philometra	24	-	-	-	-	24			
	Tabanus		7	13	1	-	21			
	Henneguya		10	7	4	1	22			
FEBRUARY	Afrolearnaea		394	253	103	17	767	63	62	98.41
	Philometra	18	-	-	-	-	18			
	Tabanus		6	-	-	-	6			
	Henneguya		10	9	2	-	21			
MARCH	Afrolearnaea		38	66	20	1	175	54	50	92.60
	Philometra	10	-	-	-	-	10			
	Tabanus		3	4	1	-	8			
	Henneguya		22	12	4	1	39			
APRIL	Afrolearnaea		39	20	-	-	59	52	45	86.54
	Philometra	-	-	-	-	-	-			
	Tabanus		1	-	-	-	1			
	Henneguya		36	9	6	-	51			
MAY	Afrolearnaea		39	5	7	1	52	70	46	65.71
	Philometre	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		36	11	2	-	49			
JUNE	Afrolearnaea		52	17	10	8	87	49	39	79.59
	Philometre	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		36	3	1	-	40			

JULY	Afrolearnaea		136	92	32	28	288	57	52	91.23
	Philometra	-	-	-	-	-	-			
	Tabanus		-	-	-	-	-			
	Henneguya		8	2	1	-	11			
AUGUST	Afrolearnaea		285	216	120	80	701	52	49	94.23
	Philometra	-	-	-	-	-	-			
	Tabanus		1	-	-	-	1			
	Henneguya		5	1	-	-	6			
SEPTEMBER	Afrolearnaea		343	151	98	11	603	43	42	97.67
	Philometra	2	-	-	-	-	2			
	Tabanus		15	5	-	-	20			
	Henneguya		7	1	1	-	9			
OCTOBER	Afrolearnaea		458	224	88	17	787	51	51	100.00
	Philometra	20	-	-	-	-	20			
	Tabanus		27	20	4	-	51			
	Henneguya		7	4	-	-	11			
NOVEMBER	Afrolearnaea		459	198	76	28	761	42	42	100.00
	Philometre	33	-	-	-	-	33			
	Tabanus		23	10	5	-	38			
	Henneguya		20	9	1	1	21			
TOTAL		139	3706	1973	817	232	6867	662	606	91.54

OVERALL % INFECTION

Afroleanaea	-	6234 (90.78%)
Philometra	-	139(2.02%)
Tabanus	-	184 (2.67%)
Henneguya	-	310 (4.51%)

APPENDIX 10a
MONTHLY PARASITIC INFECTION OF THE GIT OF MALE *M. rume.* (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OESOPHAGUS	STOMACH	1ST 20M OF INTESTINE	INTESTINE	RECTUM	TOTAL PARASITES	NO OF FISH EXAMI-NED	NO INFECTED	% INFECT-ION
DECEMBER	*Procamallanus*	-	8	-	4	-	12	25	7	28.00
	Caryophylleus									
	Euclinostomum									
JANUARY	*Procamallanus*				8	-	27	37	13	35.13
	Caryophylleus	-	18		-					
	Euclinostomum				1					
FEBURARY	*Procamallanus*				5					24.14
	Caryophylleus	-	-	-	-	-	11	29	7	
	Euclinostomum				6					
MARCH	*Procamallanus*				-					
	Caryophylleus	-	-	-	14		24	24	16	66.66
	Euclinostomum				10	-				
APRIL	*Procamallanus*				-					
	Caryophylleus	-	-	-	13		30	19	13	68.42
	Euclinostomum				17	-				
MAY	*Procamallanus*				-					
	Caryophylleus	-	-	-	12	-	23	33	11	33.33
	EuClinostomum				11					
JUNE	*Procamallanus*				-					
	Caryophylleus	-	-	-	2	-	2	23	2	
	EuClinostomum				-					8.70
JULY	*Procamallanus*				-					
	Caryophylleus	-	-	-	2	-	6	23	2	
	Euclinostomum				4					8.70
AUGUST	*Procamallanus*				-					
	Caryophylleus	-	-	-	4	-	4	21	3	
	Euclinostomum				-					14.30
SEPTEMBER	*Procamallanus*				-					
	Caryophylleus	-	-	-	3	-	5	15	4	
	Euclinostomum				2					26.66

Appendix 10a Continued

OCTOBER	*Procamallanus*				-					
	Caryophylleus	-	6	-	8	-	15	19	10	
	Euclinostomum				1					52.63
NOVEMBER	*Procamallanus*				6					
	Caryophylleus	-	14	-	1	-	21	17	8	
	Euclinostomum				-					47.05
TOTAL			46		134		180	284	97	34.15

OVERALL % INFECTION

Procamallanus - 77 (42.77%)
Caryophyllaeus - 52(28.88%)
Euclinostomum - 51 (28.33%)
180

APPENDIX 10b
MONTHLY PARASITIC INFECTION OF THE GIT OF FEMALE *M.rune* (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	OESOPHAGUS	STOMACH	1ST 20M OF INTESTINE	INTESTINE	RECTUM	TOTAL PARASTES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	*Procamallanus*				7					
	Caryophylleus	-	18	-	-	-	26	28	12	42.86
	Euclinostomum				1					
JANUARY	*Procamallanus*				3					
	Caryophllaeus	-	11	-	-	-	14	39	8	20.51
	Euclinostomum				-					
FEBRUARY	*Procamallanus*				1					
	Caryophylleus	1	4	-	3	-	18	34	11	32.35
	Euclinostomum				9					
MARCH	*Procamallanus*				-					
	Caryophylleus	-	1	-	17	-	31	30	18	60.00
	Euclinostomum				13					
APRIL	*Procamallanus*	-			-					
	Caryophylleus		-	-	19	-	41	33	21	63.64
	Euclinostomum				22					
MAY	*Procamallanus*				-					
	Caryophylleus	-	-	-	11	-	28	37	15	40.54
	Euclinostomum				17					
JUNE	*Procamallanus*				-					
	Caryophylleus	-	-	-	7	-	10	26	6	23.08
	Euclinostomum				3					
JULY	*Procamallanus*				1					
	Caryophylleus	-	4	-	9	-	14	35	10	28.57
	Euclinostomum				-					
AUGUST	*Procamallanus*				-					
	Caryophylleus	-	2	-	3	-	10	31	6	19.35
	Euclinostomum				5					
SEPTEMBER	*Procamallanus*				-					
	Caryophylleus	-	-	-	-	-	3	28	2	7.14
	Euclinostomum				3					
OCTOBER	*Procamallanus*				5					
	Caryophylleus	-	13	-	2	-	25	32	13	40.62
	Euclinostomum				5					

Appendix 10 b Continued

NOVEMBER	*Procamallanus*				4					
	Caryophylleus	-	24	-	3	-	31	25	10	40.00
	Euclinostomum				-					
TOTAL		1	77		173		250	378	132	34.92

OVERALL % Infection

Procamallanus - 98 (39.2%)
Caryophylleus - 74 (29.6%)
Euclinostomum - 78(31.2%)
250.

APPENDIX 10c

MONTHLY PARASITIC INFECTION OF THE GIT OF MALE AND FEMALE *M. rume* (COMBINED) (Jan. 1993 – Dec. 1995)

MONTHS	PARASITES	OESOPH-AGUS	STOMACH	1ST 20M OF INTESTINE	INTESTINE	RECTUM	TOTAL PARAS-ITES	NO OF FISH EXAMIN-ED	NO INFECTED	% INFEC-TION
DECEMBER	*Procamallanus*				11					
	Caryophylleus	-	26	-	-	-	38	53	19	35.85
	Euclinostomum				1					
JANUARY	*Procamallanus*				11					
	Caryophylleus	-	29	-	-	-	41	75	21	27.63
	Euclinostomum				1					
FEBRUARY	*Procamallanus*				6					
	Caryophylleus	-	4	-	3	-	29	63	18	28.57
	Euclinostomum				15					
MARCH	*Procamallanus*				-					
	Caryophylleuss	1	1	-	31	-	55	54	34	62.96
	EuClinostomum				23					
APRIL	*Procamallanus*				-					
	Caryophylleus	-	-	-	32	-	71	52	34	65.38
	Euclinostomum				39					
MAY	*Procamallanus*				-					
	Caryophylleus	-	-	-	23	-	51	70	26	37.14
	Euclinostomum				28					
JUNE	*Procamallanus*				-					
	Caryophylleus s	-	-	-	9	-	12	49	8	16.33
	Euclinostomum				3					
JULY	*Procamallanus*				1					
	Caryophylleuss	-	4	-	11	-	20	57	13	22.81
	Euclinostomum				4					
AUGUST	*Procamallanus*				-					
	Caryophylleus	-	2	-	7	-	24	52	9	17.31
	Euclinostomum				5					

Appendix 10 c Continued

SEPTEMBER	*Procamallanus*				-					
	Caryophylleus	-	-	-	3	-	8	43	6	13.95
	Euclinostomum				5					
OCTOBER	*Procamallanus*				13					
	Caryophylleus	-	19	-	3	-	40	51	23	45.10
	Euclinostomum				5					
NOVEMBER	*Procamallanus*				10					
	Caryophylleus	-	38	-	4	-	52	42	18	42.86
	Euclinostomum				-					
TOTAL							430	662	229	34.60

OVERALL % INFECTION
Procamallanus - 175 (40.69%)
Caryophyllaeus - 126 (29.30%)
Euclinostomum 121 (28.13%)
430.

APPENDIX 11

STAGES OF THE GONDADS IN M. SENEGALENSIS

(Jan. 1994 – Dec. 1995)

MONTH	SEX	I	II	III	IV	V	VI	NO EXAMINED
JAN.	M	9	5					14
	F	5	3					8
FEB.	M	10	8					18
	F	3	8					11
MARCH	M	14	2					16
	F	6	10	2				16
APRIL	M	12	8					20
	F	7	4	2				13
MAY	M	10	16					26
	F	6	5	4				15
JUNE	M	12	7	1				20
	F	2	5	3	4			14
JULY	M	11	5	3	1			20
	F	1	3	6	2			12
AUGUST	M	7	3	4	1			15
	F	5	5	2	4			16
SEPTEMBER	M	9	7	4	3			23
	F	-	5	1	1		4	9
OCTOBER	M	5	5	3	1		2	17
	F	2	-	3	2		3	10
NOVEMBER	M	9	6	3	1			19
	F	1	9	2			5	17
DECEMBER	M	9	8					17
	F	2	12					14

M = MALE = 225
F = FEMALE = 155

APPENDIX 11A

MONTHLY INCIDENCE OF PARASITES IN THE GIT OF MALE *M. senegalensis* (Jan. 1994 – Dec. 1995)

MONTHS	PARASITES	OESOPHA-GUS	STOMACH	INTESTINE	RETUM	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
JANUARY	*Caryophyllaeus*	-	-	-	-	-			
	Procamallanus	-	-	-	-	-	14	-	00
FEBRUARY	*Procamallanus*	-	-	5	-	5			
	Caryophllaaeus	-	-	-	-	-	18	3	16,66
MARCH	*Procamallanus*	-	-	7	-	7			
	Caryophllaaeus	-	-	-	-	-	16	5	31.25
APRIL	*Procamallanus*	-	-	11	-	11			35.00
	Caryophllaaeus	-	-	-	-	-	20	7	
MAY	*Procamallanus*	-	-	6	-	6			
	Caryophllaaeus	-	-	-	-	-	26	4	15.38
JUNE	*Procamallanus*	-	-	3	-	3	20	2	10.00
	Caryophllaaeus	-	-	-	-	-			
JULY	*Procamallanus*	-	-	-	-	-			
	Caryophllaaeus	-	-	-	-	-	20	-	00
AUGUST	*Procamallanus*	-	-	-	-	-			
	Caryophllaaeus	-	-	-	-	-	15	-	00
SEPTEMBER	*Procamallanus*	-	-	5	-	9	23	6	26.10
	Caryophllaaeus	-	-	4	-				
OCTOBER	*Procamallanus*	-	-	2	-	5	17	3	17.65
	Caryophllaaeus	-	-	3	-				
NOVEMBER	*Procamallanus*	-	-	-	-	7	19	4	21.05
	Caryophllaaeus	-	-	7	-				
DECEMBER	*Procamallanus*	-	-	-	-	-			
	Caryophllaaeus	-	-	7	-	7	17	1	5.90
TOTAL					54	54	225	35	15.55

OVERALL % INFECTION
Caryophllidaeus - 39 (92%)
Procamallanus - 15 (27.77%)
54

APPENDIX 11b

MONTHLY INCIDENCE OF PARASITES IN THE GIT OF FEMALE *M. senegalensis* (Jan. 1994 – Dec. 1995)

MONTHS	PARASITES	OESOPHA-GUS	STOMACH	INTESTINE	RECTUM	TOTAL PARASITE	NO OF FISH EXAMINED	NO INFECTED	% INFECTED
JANUARY	*Caryophyllaous*	-	-	-					
	Procamallamus	-	-	-	-	-	8	0	00
FEBRUARY	*Caryophyllaous*	-	-	3	-	-			
	Procamallamus	-	-	-	-	-	11	2	18.18
MARCH	*Caryophyllaous*	-	-	8	-	-			
	Procamallamus	-	-	-	-	-	16	5	31.25
APRIL	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	1	-	-	13	1	7.69
MAY	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	4	-	-	15	2	13.33
JUNE	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	7	-	-	14	5	35.71
JULY	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	3	-	-	12	2	16.16
AUGUST	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	1	-	-	16	0	00
SEPTEMBER	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	1	-	-	9	1	5.26
OCTOBER	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	3	-	-	10	2	20.00
NOVEMBER	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	5	-	-	17	3	17.65
DECEMBER	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	-	-	-	14	0	00
TOTAL				35	-	-	155	23	14.83

OVERALL % INFECTION
Caryophyllaeus - 26 (74.28%)
Procamallanus - 9 (25.71%)

APPENDIX 11c

MONTHLY INCIDENCE OF PARASITES IN THE GIT OF MALE AND FEMALE M. senegalensis (Combined) (Jan. 1994 – Dec. 1995)

MONTHS	PARASITES	OESOPHAGUS	STOMACH	INTESTINE	RECTUM	TOTAL PARASITES	NO OF FISH EXAMINED	NO. INFECTED	% INFECTION
JANUARY	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	-	-	-	22	0	00
FEBUARY	*Caryophyllaous*	-	-	8	-	-			
	Procamallamus	-	-	-	-	8	29	5	17.24
MARCH	*Caryophyllaous*	-	-	15	-	-			
	Procamallamus	-	-	-	-	15	32	10	31.25
APRIL	*Caryophyllaous*	-	-	12	-	-			
	Procamallamus	-	-	-	-	12	33	8	24.24
MAY	*Caryophyllaous*	-	-	10	-	-			
	Procamallamus	-	-	-	-	10	41	6	14.63
JUNE	*Caryophyllaous*	-	-	10	-	10			
	Procamallamus	-	-	-	-	10	34	7	20.59
JULY	*Caryophyllaous*	-	-	3	-	-			
	Procamallamus	-	-	-	-	3	32	2	6.25
AUGUST	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	-	-	-	31	0	00
SEPTEMBER	*Caryophyllaous*	-	-	5	-	-			
	Procamallamus	-	-	5	-	10	32	7	21.87
OCTOBER	*Caryophyllaous*	-	-	2	-	-			
	Procamallamus	-	-	6	-	8	27	5	18.52
NOVEMBER	*Caryophyllaous*	-	-	-	-	-			
	Procamallamus	-	-	12	-	12	36	7	19.44
DECEMBER	*Caryophyllaous*	-	-	-	-	-		1	
	Procamallamus	-	-	1	-	1	31		3.22
TOTAL					-	89	380	58	15.26

APPENDIX 12

THE STAGES OF GONADS IN *M. DELICIOSUS*. (Dec. 1993 – Nov. 1995).

MONTHS	E	I	II	III	IV	V	VI	TOTAL EXAMINED
DECEMBER	M	1	4					5
	F	3	5					8
JANUARY	M	1	6					7
	F	4	6					10
FEBRUARY	M	4	2					6
	F	2	7					9
MARCH	M	3	5					8
	F	6	5					11
APRIL	M	4	3					77
	F	8	7					15
MAY	M	2	3					5
	F	2	11					13
JUNE	M	1	3	1				4
	F	3	2					6
JULY	M	2	3	1				5
	F	2	2	2	1			7
AUGUST	M	1	3	1	2			7
	F	2	3	2	1			8
SEPTEMBER	M	2	2	1	1			6
	F	1	3	1	1			6
OCTOBER	M	3	1	1	-	-		5
	F	1	5	1	1	1		9
NOVEMBER	M	1	6	-		1		8
	F	3	3	-		2		8
TOTAL		58	91	11	7	4		183

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APPENDIX 12a

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF MALE & FEMALE M.SENEGALENSIS (COMBINED)(Jan. 1994 – Dec. 1995)

MONTHS	PARASITES	GILL COVER	Gill Arches 1	2	3	s4	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
JAN.	*E.sarsi*	-	9	16	3	-	28	22	10	45
	D.vastator		2	-	6	10	18			
FEB.	*E.sarsi*	-	11	13	9	2	36	29	17	58.62
	D. vastator		11	5	-	7	23			
MARCH	*E. sarsi*	-	4	2	18	4	28	32	30	93.75
	Henneguya		3	1	-	-	4			
	D. vastator		77	19	3	1	100			
APRIL	*E. sarsi*	-	6	12	39	3	60	33	32	69.70
	Henneguya		4	-	-	-	4			
	D. vastator		87	30	4	1	122			
MAY	*E. sarsi*	-	8	19	13	3	43	41	41	100.00
	Henneguya		3	2	-	-	5			
	D. vastator		80	23	10	2	115			
JUNE	*E. sarsi*	-	10	51	12	2	75	34	30	88.23
	D. vastator		68	8	5	-	81			
JULY	*E. sarsi*	-	12	10	5	-	27	12	13	40.62
	D. vastator		8	5	-	-	13			
AUGUST	*E. sarsi*	-	17	10	-	-	37	31	16	51.61
	D. vastator		4	-	-	-	4			
SEPTEMBER	*E. sarsi*	-	145	26	11	2	184	32	27	84.37
	D. vastator		2	-	-	-	2			
OCTOBER	*E. sarsi*	-	176	70	14	8	268	27	26	96.30
	D. vastator		1	-	-	-	1			
NOV.	*E. sarsi*	-	101	132	25	14	272	36	34	94.44
	D. vastator		1	3	4	-	8			
DEC.	*E .sarsi*		10	18	25	5	58	31	16	61.30
	D. vastator	-	-	-	8	20	28			
TOTAL			860	377	214	83	1,644	380	295	77.63

OVERALL % INFECTION

E. sarsi = 1116 (67.88%)

D. vastator = 510 (31.02)

Henneguya Sp. = 18 (1.09%)

1,644

478918

APPENDIX 12b.

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF MALE *M. SENEGALENSIS* (Jan. 1994 – Dec. 1995)

MONTH	PARASITES	GILL COVER	Gill Arches 1	2	3	4	TOTAL PARASITE	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
JAN.	*E. sarsi*	-	6	16	3	-	25	14	7	50.00
	D. vastator		-	-	6	5	11			
FEB.	*E. sarsi*	-	5	11	9	2	27	18	11	61.11
	D. vastator		4	1	-	3	8			
MARCH	*E. sarsi*	-	3	2	18	4	27	16	16	100.00
	D. vastator		58	13	-	-	71			
APRIL	*E. sarsi*	-	1	9	22	3	35	20	19	95.00
	D. vastator		39	19	1	1	59			
MAY	*E. sarsi*	-	6	10	11	2	29	26	26	100.00
	D. vastator		47	18	3	-	68			
JUNE	*E. sarsi*	-	3	32	2	-	37	20	17	85.00
	D. vastator		17	1	-	-	18			
JULY	*E. sarsi*	-	4	-	-	-	4	20	3	15.00
	D. vastator		2	-	-	-	2			
AUGUST	*E. sarsi*	-	10	2	-	-	12	15	5	33.33
	D. vastator		-	-	-	-	-			
SEPTEMBER	*E. sarsi*	-	62	12	1	-	75	23	19	82.61
	D. vastator		2	-	-	-	2			
OCT.	*E. sarsi*	-	105	60	13	8	186	17	16	94.11
	D. vastator		1	-	-	-	1			
NOV.	*E. sarsi*	-	86	41	19	3	149	19	17	89.49
	D. vastator		1	3	2	-				
DEC..	*E. sarsi*	-	7	10	8	3	28	17	8	47.06
	D. vastator		-	-	2	6	8			
TOTAL							888	225	166	73.77

OVERALL % INFECTION

E. sarsi = 634 (71.39)

D. vastator = 254 (28.60)

888

APPENDIX 12c.

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BANCHIAL CHAMBER OF FEMALE *M.SENEGALENSIS* (Jan. 1994 – Dec. 1995)

MONTH	PARASITES	GILL COVER	Gill Arches 1	2	3	4	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTION	% INFECTION
JAN.	*E. sarsi*	-	3	-	-	-	3	8	3	37.50
	D. vastator		2	-	-	5	7			
FEB.	*E. sarsi*	-	6	2	1	-	9	11	6	54.54
	D. vastator		7	4	-	4	15			
MARCH	*E. sarsi*	-	1	-	-	-	1	16	14	87.50
	Henneguya		3	1	-	-	4			
	D. vastator		19	6	3	1	29			
APRIL	*E. sarsi*	-	5	3	17	-	25	13	13	100.00
	Henneguya		4	-	-	-	4			
	D. vastator		48	11	3	1	63			
MAY	*E. sarsi*	-	2	9	2	1	14	15	15	100.00
	Henneguya		3	2	-	-	5			
	D. vastator		33	5	7	2	47			
JUNE	*E. sarsi*	-	7	19	10	2	38	14	13	92.85
	D. vastator		51	7	5	-	63			
JULY	*E. sarsi*	-	8	10	5	-	23	12	10	83.33
	D. vastator		6	5	-	-	11			
AUG.	*E. sarsi*	-	17	8	-	-	25	16	11	68.75
	D. vastator		4	-	-	-	4			
SEPT.	*E. sarsi*	-	83	14	10	2	109	9	8	88.89
	D. vastator		-	-	-	-	-			
OCT.	*E. sarsi*	-	71	10	1	-	82	10	10	100.00
	D. vastator			-	-	-	-			
NOV.	*E. sarsi*	-	15	91	6	11	123	17	17	100.00
	D. vastator		-	-	2	-	2			
DEC.	*E. sarsi*	-	3	8	17	2	30	14	11	78.57
	D. vastator		-	-	6	14	20			
TOTAL							756	155	131	84.52

'Overall % Infection

E. sarsi = 482 (63.75%)
D. vastator = 256 (33.86%)
Henneguya = 18 (2.38%)
756

APPENDIX 13a

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF MALE *M. Deliciosu* (Dec. 1993 – Nov. 1995)

MONTHS	PARASITES	GILL COVER	Gill Arches 1	2	3	4	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	*Lamproglena*	-	-	-	-		2	5	2	40.00
	Hirudo		2	-	-	-				
JANUARY	*Lamproglena*	-	-	-	-	-	8	7	5	71.42
	Hirudo		8	-	-	-				
FEBRUARY	*Lamproglena*	-	2	-	-	-	2	6	6	100.00
	Hirudo		6	-	-	-	6			
MARCH	*Lamproglena*	-	10	2	-	-	12	8	7	87.5
	Hirudo		4	-	-	-	4			
APRIL	*Lamproglena*	-	24	2	-	-	26	7	7	100.00
	Hirudo		2	-	-	-	2			
MAY	*Lamproglena*	-	7	-	-	-	7	5	4	80.00
	Hirudo		-	-	-	-				
JUNE	*Lamproglena*	-	-	-	-	-	-	4	-	00.00
	Hirudo		-	-	-	-	-			
JULY	*Lamproglena*	-	-	-	-	-	-	5	-	00.00
	Hirudo									
AUGUST	*lamproglena*	-	3	-	-	-	3	7	2	28.60
	Hirudo									
SEPTEMBER	*lamproglena*	-	2	-	-	-	2	6	1	16.66
	Hirudo									
OCTOBER	*Lamproglena*	-	2	-	-	-	2	5	2	40.00
	Hirudo						2			
NOVEMBER	*Lamproglena*	-	1	-	-	-	1	8	6	75.00
	Hirudo		8				8			
TOTAL			81	4	-	-	85	73	42	57.53

Overall % Infection

Lamproglena = 55 (67.90%)

Hirudo = 30 (37.03%)

81

APPENDIX 13b

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF FEMALE *M.deliciosus* (Dec.1993-Nov.1995)

MONTHS	PARASITES	GILL COVER	Gill Arches				TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
			1	2	3	4				
DECEMBER	*Lamproglena*	-	-	-	-	-		8	5	62.5
	Hirudo		8				8			
JANUARY	*Lamproglena*	-	-	-	-	-		10	4	40.0
	Hirudo		7	1			8			
FEBAURY	*Lamproglena*	-	2	-	-	-	2	9	4	44.44
	Hirudo		3				3			
MARCH	*Lamproglena*	-	16	2	-	-	18	11	10	90.90
	Hirudo		11	1			12			
APRIL	*Lamproglena*	-	35	4	2	-	41	15	15	100.00
	Hirudo		3				3			
MAY	*Lampgroglena*	-	6	2	1	-	9	13	7	53.85
	Hirudo		1				1			
JUNE	*Lamproglena*	-	-	2	-	-	2	6	1	16.67
	Hirudo		-	-	-	-	-			
JULY	*Lamproglena*	-	1	-	-	-	1	7	1	14.28
	Hirudo									
AUGUST	*Lamproglena*	-	1	-	2	-	3	8	2	25.00
	Hirudo									
SEPTEMBER	*Lamproglena*	-	8	1	-	-	9	6	4	66.67
	Hirudo		-	-	-	-	-			
OCTOBER	*Lamproglena*	-	13	3	-	-	16	9	8	88.88
	Hirudo		1				1			
NOVEMBER	*Lamproglena*	-	2	1	-	-	3	8	8	100.00
	Hirudo		11	-	-	-	11			
TOTAL			129	17	5	-	151	110	69	62.73

Overall % Infection

Lamproglena - 104 (68.88%)

Hirudo - 47 (31.12%)

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APPENDIX 13c

MEAN MONTHLY INCIDENCE OF PARASITES IN THE BRANCHIAL CHAMBER OF MALE AND FEMALE *M.deliciosus* (Combined) (Dec.1993–Nov.1995)

MONTH	PARASITES	GILL COVER	Gill Arches				TOTAL PARASITES	NO OF FISH	NO INFECTION	% INFECTION
			1	2	3	4				
DECEMBER	*Lamprolena*	-	-	-	-	-	-	13	7	53.85
	Hirudo		10				10			
JANUARY	*Lamprolena*	-	-	-	-	-	-	17	9	52.94
	Hirudo		15	1			16			
FEBRUARY	*Lamprolena*	-	4	-	-	-	4	15	10	66.67
	Hirudo		9							
MARCH	*Lamprolena*	-	26	4	-	-	30	19	17	89.47
	Hirudo		15	1			16			
APRIL	*Lamprolena*	-	59	6	2	-	67	22	222	100.00
	Hirudo		5				5			
MAY	*Lamprolena*	-	13	2	1	-	16	18	11	61.11
	Hirudo		1				1			
JUNE	*Lamprolena*	-	-	2	-	-	2	10	1	10.00
	Hirudo		-							
JULY	*-L-amprolena*	-	1	-	-	-	1	12	1	8.33
	- Hirudo		-							
AUGUST	*-Lampro-lena*		4	-	2	-	6	15	4	26.67
	Hirudo									
SEPTEMBER	*Lamprolena*	-	10	2	-	-	12	12	5	41.67
	Hirudo									
OCTOBER	*Lamprolena*	-	15	3	-	-	18	14	10	71.43
	Hirudo		1				1			
NOVEMBER	*Lamprolena*	-	3	1	-	-	4	16	14	87.50
	Hirudo		19				19			
TOTAL			210	225	5	-	237	183	111	60.65

Overall % Infection

Lamproglena - 159 (67.08%)

Hirudo - 77 (32.48%

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APPENDIX 14 .a

MEAN MONTHLY INCIDENCES OF PARASITES IN THE GIT OF MALE *M. Deliciosus* (Dec.1993-Nov.1995)

MONTHS	PARASITES	OESOPHAGUS	STOMACH	INTESTINE	RECTUM	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	*Eucestodaria*	-	-	1	-	6	5	4	80.00
	Neoechinorhyn.			1	-				
	Procamallanus			2	2				
JANUARY	*Eucestodaria*	-	-	2	-	7	7	4	57.14
	Neoechinorhyn.			1	-				
	Procamallanus			3	1				
FEB.	*Eucestodaria*	-	-	3	1	9	6	5	83.33
	Neoechinorhyn.			-	-				
	Procamallanus			2	4				
MARCH	*Eucestodaria*	-	-	2	-	8	8	6	75.00
	Neoechinorhyn.			-	-				
	Procamallanus			3	3				
APRIL	*Eucestodaria*	-		2	-	6	7	4	57.14
	Neoechinorhyn.			1	-				
	Procamallanus			1	2				
MAY	*Eucestodaria*	-	-	1	-	5	5	3	60.00
	Neoechinorhyn.			3	-				
	Procamallanus			-	1				
JUNE	*Eucestodaria*	-	-	3		5	4	3	75.00
	Neoechinorhyn.			2	-				
	Procamallanus			-					
JULY	*Eucestodaria*	-	-	-	-	3	5	2	40.00
	Neoechinorhyn.			3	-				
	Procamallanus			-	-				
AUGUST	*Eucestodaria*	-	-	-	-	8	7	6	85.71
	Neoechinorhyn.			8	-				
	Procamallanus			-	-				

Appendix 14a Continued

SEPTEMBER	*Eucestodaria*	-	-	1	-	6	6	4	66.66
	Neoechinorhyn.			5	-				
	Procamallanus			-	-				
OCTOBER	*Eucestodaria*	-	-	-	-	2	5	1	20.00
	Neoechinorhyn.			2	-				
	Procamallanus								
NOVEMBER	*Eucestodaria*	-	-	4		12	8	7	87.50
	Neoechinorhyn.			5	-				
	Procamallanus			-	3				
TOTAL				61	16	77	73	49	67.12

OVERALL % INFECTION

Eucestodaria - 19 (31.14%)
Neoechinorhynchus - 31 (50.81%)
Procamallanus - 11 (18.03)
61

APPENDIX 14b

MEAN MONTHLY INCIDENCE OF PARASITES IN THE GIT OF FEMALE *M. delicious* (Dec.1993-Nov.1995)

MONTHS	PARASITES	OESO-PHAGUS	STOMACH	INTESTINE	RECTUM	TOTAL PARASITES	NO.OF FISH EXAMINED	NO OF FISH INFECT-ED	% INFECT-ION	INTEN-SITY
DEC.	*Eucestodaria*	-	-	3	-	7	8	5	62.50	5.2
	Neoechinorhynchus			1	-					
	Procamallanus			2	1					
JAN.	*Eucestodaria*		-	5	-	12	10	8	80.00	10.6
	Neoechinorhynchus	-		2	-					
	Procamallanus			3	2					
FEB.	*Eucestodaria*	-	-	4	-	9	9	6	66.66	7.9
	Neoechinorhynchus			-	-					
	Procamallanus			2	2					
MARCH	*Eucestodaria*	-	-	7	-	14	11	9	81.82	12.4
	Neoechinorhynchus			-	-					
	Procamallanus			2	5					
APRIL	*Eucestodaria*	-	-	6	-	14	15	8	53.33	12.4
	Neoechinorhynchus			5	-					
	Procamallanus			1	2					
MAY	*Eucestodaria*	-	-	3	-				46.15	9.7
	Neoechinorhynchus			6	-	11	13	6		
	Procamallanus			1	1					
JUNE	*Eucestodaria*	-	-	5	-	10	6	4	66.67	8.8
	Neoechinorhynchus			4	-					
	Procamallanus			1	-					
JULY	*Eucestodaria*	-	-	-	-	9	7	3	42.86	7.9
	Neoechinorhynchus			8	-					
	Procamallanus			1	-					
AUGUST	*Eucestodaria*	-	-	-	-	5	8	2	25.00	5.3
	Neoechinorhynchus			5	-					
	Procamallanus			-	-					

Appendix 14b Continued

SEPT.	*Eucestodaria*	-	-	2	-					
	Neoechinorhynchus			4	-	6	6	3	50.00	5.3
	Procamallanus			-	-					
OCT.	*Eucestodaria*	-	-	-	-	7	9	3	33.33	6.2
	Neoechinorhynchus			5	-					
	Procamallanus			1	1					
NOV.	*Eucestodaria*	-	-	3	-					
	Neoechinorhynchus			5	-	9	8	5	62.5	7.9
	Procamallanus			-	1					
TOTAL				97	16	113	110	62	56.36	

OVERALL % INFECTION

Eucestodaria - 38 (39.17%)
Neoechinorhynchus - 45 (46.39%)
Procamallanus - 14 (14.43%)
97

APPENDIX 14c.

MEAN MONTHLY INCIDENCE OF PARASITIES IN THE GIT OF MALE & FEMALE *M.Deliciosus* (Combined) (Dec.1993-Nov.1995)

MONTHS	PARASITES	OESOPH-AGUS	STOMACH	INTESTINE	RECTUM	TOTAL PARASITES	NO OF FISH EXAMINED	NO INFECTED	% INFECTION
DECEMBER	*Eucestodaria*	-	-	4	-	13	13	8	69.23
	Necechinorphynchus			2	-				
	Procamallanus			4	3				
JANUARY	*Eucestodaria*	-	-	7	-				
	Necechinorphynchus			3	-	19	17	12	70.59
	Procamallanus			6	3				
FEBRUARY	*Eucestodaria*	-	-	7	-	18	15	11	73.33
	Necechinorphynchus			-	-				
	Procamallanus			4	7				
MARCH	*Eucestodaria*	-	-	9	-	22	19	15	78.95
	Necechinorphynchus			-	-				
	Procamallanus			5	8				
APRIL	*Eucestodaria*	-	-	8	-	20	22	12	54.54
	Necechinorphynchus			6	-				
	Procamallanus			2	4				
MAY	*Eucestodaria*	-	-	4	-	16	18	9	50.00
	Necechinorphynchus			9	-				
	Procamallanus			1	2				
JUNE	*Eucestodaria*	-	-	8	-	15	10	7	70.00
	Necechinorphynchus			6	-				
	Procamallanus			1	-				
JULY	*Eucestodaria*	-	-	-	-	12	12	5	41.67
	Necechinorphynchus			11	-				
	Procamallanus			1	-				
AUGUST	*Eucestodaria*	-	-	-	-	13	15	8	53.33
	Necechinorphynchus			13	-				
	Procamallanus			-	-				

Appendix 14c Continued

SEPTEMBER	*Eucestodaria*	-	-	3	12	12	6	58.33
	Neoechinorhynchus			9	-			
	Procamallanus			-	-			
OCTOBER	*Eucestodaria*	-	-	-	2	9		20.00
	Neoechinorhynchus			2	-	5		
	Procamallanus			-	-			
NOVEMBER	*Eucestodaria*	-	-	4	-	8		87.5
	Neoechinorhynchus			5	-	7		
	Procamallanus			-	12			
TOTAL				61	77	49	110	67.12

OVERALL % INFECTION

Eucestodaria - 57 (36.07%)
Neoechinorhynchus - (48.10%)
Procamallanus - 25 (15.82%)

APPENDIX 15

STAGES OF GONADS IN *H.pictus*
(Dec.1993–Nov.1995)

MONTHS	I	II	III	IV	V	VI	TOTAL EXAMINED
DECEMBER	1F	-	-	1M	-	-	1M 1F
FEBURARY	2F	-	-	-	-	-	2F
MARCH	-	-	-	-	-	-	-
APRIL	-	-	2M	-	-	-	2M
MAY	-	-	5M	1M	-	-	6M
JULY	-	1F	1F	4M	-	-	4M 2F
AUGUST	-	-	4M	2M	-	-	6M
SEPTEMBER	-	-	10M	2M	-	-	12M
OCTOBER	-	-	3M	2F 1M	-	1F	2F 4M
NOVEMBER	-	-	2F	1F	-	1F	1F 4F

F = FEMALE
M = MALES

APPENDIX 16

STAGES OF GONADS IN *P.bovei*

(July 1995–Nov. 1995)

MONTHS	I	II	III	IV	V	VI	TOTAL EXAMINED
JULY	-	-	1F	2F	-	-	3F
AUGUST	-	-	-	3F	-	-	3F
SEPTEMBER	-	-	-	-	-	-	-
NOVEMBER	-	-	-	-	-	1F	1F

F = Females.

APPENDIX 17: MEASUREMENT OF SOME PARASITES

(a) Measurement of *Caryophyllaeus* sp.

Length (mm)	Width (mm)
7.8	1.5
9.6	1.7
10.5	3.0
10.3	2.8
7.5	3.1
11.0	3.0
10.8	3.2
8.5	2.2
9.6	1.8
9.8	1.9
10.2	2.7
7.5	1.9

(b) Measurement of *Cliostomum complanatum* of *H.b. occidentalis*

Length (mm)	Width (mm)	Oral Sucker	Ventral Sucker
4.50	1.40	0.12	0.36
4.86	1.51	0.18	0.41
5.55	1.46	0.15	0.46
4.62	1.50	0.20	0.41
6.15	1.87	0.22	0.52
2.84	1.31	0.14	0.41
3.76	1.57	0.16	0.34
5.40	1.80	0.30	0.66
3.55	1.42	0.13	0.32
3.00	1.35	0.14	0.39

(c) Measurement of *Heneguya* Cyst in *H.b. occidentalis*

Diameters of rounded Cysts (mm)	Length of some elongated Cysts (mm)
0.20	1.20
0.65	2.41
0.34	1.00
0.81	1.69
0.95	3.25
0.77	2.81
0.42	3.88
1.00	4.00
0.20	2.91
0.99	3.45

(d) Measurement of *Ergasilus sarsi* (females) in *H.b. occidentalis*

Body Length (mm)
0.90
0.75
0.66
1.25
1.00
0.81
1.34
1.49
1.40
0.69

(e) **Measurement of *Procamallanus laevionchus* in *H.b. occidentalis***

Length (mm)	Width (mm)
7.50	0.80
6.50	0.53
8.90	0.88
10.50	1.00
11.50	0.90
5.45	0.25
7.80	0.60
9.50	1.15
6.60	0.30
5.20	0.25

(f) **Measurement of *Neoechinorhynchus* sp. in *H.b. occidentalis***

Length (mm)	Width (mm)
1.74	0.42
1.27	0.38
0.99	0.44
1.50	0.49
1.56	0.57
1.80	0.35
1.20	0.25
1.35	0.55
1.88	0.56

(g) **Measurement of Acanthocephala (*Rhadinerhynchus horridus*) in *H.b. occidentalis***

Length (mm)	Width (mm)
31.50	0.91
27.50	1.03
27.30	0.65
15.60	0.39
25.50	0.69
15.00	0.52
12.60	0.37
13.80	0.48
15.60	0.53
12.00	0.23
28.50	0.76
9.00	0.22
9.80	0.46
13.50	0.54
12.20	0.23
18.10	0.30
15.00	0.43
20.10	0.79
12.60	0.35
9.70	0.43
38.50	1.20

(h) **Measurement of** *Lamproglena* sp.

	Length (mm)
	3.2
	2.5
	3.6
	2.8
	2.9
	3.4
	4.1
	3.1
	3.2
	2.8
	4.2
	3.6