SYSTEMATICS AND BIONOMICS OF EDIBLE CATFISHES OF INLAND WATERS OF CENTRAL KERALA

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In loving memory of my beloved father,

Late Prof. K.T. Kurian

DECLARATION

I hereby declare that the matter included in this thesis entitled "Systematics and bionomics of edible catfishes of inland waters of Central Kerala" is the result of investigations carried out by me in the Department of Zoology, Christ College, Irinjalakuda under the supervision and guidance of Dr. N.D. Inasu, Professor and Head of the Research & P.G. Department of Zoology, Christ College, Irinjalakuda and has not been formed the basis for the award of any Degree/Diploma/Fellowship of any other University or Institute.

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Certificate

This is to certify that the thesis entitled **"SYSTEMATICS AND BIONOMICS OF EDIBLE CATFISHES OF INLAND WATERS OF CENTRAL KERALA"** *submitted to the University of Calicut for the award of Degree of Doctor of Philosophy is a record of original research work done by* **MOLLY KURIAN** *during the period of her study in the Research & P.G. Department of Zoology, Christ College, Irinjalakuda, University of Calicut, Kerala under my supervision and guidance and the thesis has not formed the basis for the award of any Degree/Diploma/Fellowship or similar title to any candidate of any University or Institute.*

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GENERAL INTRODUCTION

CHAPTER - I

GENERAL INTRODUCTION

Fish enjoys a very special consideration and place in human civilization from times immemorial. They are the most numerous of all the vertebrates. About 22,000 species of fishes have been reported so far. They are present in all oceans and most land locked waters. Not only are there many different species of fishes, but also they come in many different shapes and sizes. They range from 1cm *Gobies* to giant shark such as the whale shark (*Rhincodon*), which attains a length near seventy feet and weighs twenty-five tons or more. They find habitat in abyss to spray zone, in thick swamps to rushing torrents of Andes and Himalayas and in warm spring of more than 100°F to freezing ponds and marine waters so cold that antifreez is required in their blood. Most fishes are torpedo shaped, but some are round, others are flat and still others are angular.

Despite this diversity, fish can be simply defined as aquatic poikilothermic vertebrates that have gills through out life and limbs if any, in the shape of fins. They afford food for millions all over the world.

Fish has been an item in the diet of man since time immemorial. Even before man settled in agricultural communities, he depended on fishing and hunting for food. The history of fisheries of India is believed to have its origin in the days before Christ (B.C.) Kautilya refers in his Arthasastra (321, 320 BC) to fishes grown in reservoirs. Fish production in India is mentioned in the records of Pal Dynasty in Bengal (810 - 850 AD).

Fish is highly nutritious and it is perhaps the cheapest but the best animal protein available to man. So the use of fish for food has appreciably increased in recent years. Indian fisheries is now in a transitional phase from the traditional to modern ways of exploitation. Fisheries constitute renewable resources and play a significant role in the economy of the country. So scientific research to upgrade culture practice has become a necessity of the time to uplift fishery and to satisfy world's demand for fish.

Fish food is an important source of proteins and vitamins. According to F.A.O. studies, the per capita fish consumption of an average Indian is only 4.13 kg/annum against 29 kg and 41 kg in U.K. and Japan respectively (CMFRI, 1987). Kerala stands in front line of fisheries with per capita fish consumption rate of 10.1 kg. According to Nikita and Annamalai (2001), fish forms an integral part of the diet of the non- vegetarian population of Kerala. Of the four items of meat, fish, milk and eggs, fish appears to be the most preferred food. Even the lowest income groups spend Rs. 3 per day for fish where as no income groups had expenditure on eggs exceeding a mean of Rs. 2.65. The human population of India by 2020 is expected to be 1.3 billion (world population projection, 2020), which is about 450 million larger than the present. The proportion of fish eating people in India grew from 27.7% in 1987 – 88 to 39.7% in 1996 – 97. Assuming that this proportion will increase to atleast 50%, the total fish eating population in India by 2020 will be around 650 million (C.M.F.R.I., 1997). This shows the necessity to accelerate studies on fishes and improvement of fishery in India. In India fresh water fishery is less developed than marine fishery. But there is immense scope for the development of inland fisheries in our country especially in Kerala. Inland fish production in the country has registered a phenomenal increase in the last five decades. As against 0.24 million tons produced in 1950 – 51, the production of inland fish in the country during 1998 – 99 is estimated at 2.6 million tons resulting in a growth rate of 5.06%. Share of inland production out of total production has increased from 29% in 1950 – 51 to 45.5% in 1998 – 99. In contrast marine production has declined from 71% to 54.6% during the corresponding period. The catch statistics from published works (Anon, 2001) shows that in Kerala, inland fish production during 1999 – 2000 is 73,900 tonnes as against the marine production of 4,75,500 tonnes. The present trend however is that there is a possibility of production going up from inland sector through aquaculture in the coming years. India is the second largest producer of inland fish, only next to China. But it is able to provide only about 8 kg. per capita to the present population (taking 55% as fish eaters) as against the nutritional requirement of 11 kg. The projected domestic requirement of the country by 2020 AD is estimated to be 12 million tons, more than seventy five percentage of which has to come from inland sector. To achieve this national goal, proper development and conservation of inland fishes and their habitat is a must for which a scientific understanding of all types of inland fishery resources is imperative to back up their optimum exploitation.

Kerala has extensive inland water bodies, represented by ponds, lakes, canals, rivers, reservoirs, tanks, swamps, backwaters, estuaries etc. which sustain fisheries of commercial importance. To achieve a full potential in aquaculture production, a vast knowledge of inland water bodies which serve as extensive nursery ground for many fishes is needed. The inland water bodies are highly productive and is always characterised by rich and varied fish fauna. The present work deals with the systematics and bionomics of edible catfishes of inland waters of Central Kerala.

Catfishes, belonging to order Siluriformes, are common fishes of fresh water bodies. They occur from hill streams to sea. They are scaleless fishes with strong dentition and long barbels. All of them are edible. They are also widely used as aquarium fish. They range in size from 5cm to 3 metres. First pectoral and dorsal rays are modified as hard pungent spines or thick rays.

A review of literature on the systematics and biology of catfishes from Indian waters shows that except for a few studies on some specific aspects, no attempt has been made towards a comprehensive study of majority of economically important species of India. The systematics of some of the catfishes was worked out by Day (1865, 1878), Hora & Law (1941), Hora (1936, 1942), Menon (1964), Jayaram (1952, 1953, 1955, 1965, 1966 & 1988) and Nelson (1984). Their work deals with the general fish systematics of India.

Similarly some of the biological aspects of catfishes are described by Chacko (1949), Venkataraman (1960) and Rao (1964). Sekharan (1973) made an assessment of the catfish resources of Andhra Pradesh, Orissa and West Bengal coasts. Ramakrishniah (1986) conducted some studies on the fishery and biology of *Pangasius pangasius* (Ham) of the Nagarjunasagar reservoir of Andhra Pradhesh. The same fish in the natural waters of Bangladesh has been studied by Khalilur *et al.*(1995). Pantulu (1961) gave some details of the biology of *Mystus gulio* (Ham). Thakur and Das (1985) gave an account of the biology of *Heteropneustes fossilis* (Bloch). Thakur & Das (1985a) also described the biology of Magur, *Clarias batrachus.* Vinci (1986) worked out the biology of *Mystus seenghala* (Sykes) from Nagarjunasagar reservoir, Andhra Pradesh. *Mystus seenghala* (Sykes) of the river Brahmaputra in Assam has been studied by Kolekar and Choudhary (1989). Ramakrishnaiah (1983 – 84) gave an account of the biology of *Pseudeutropius teakree* (Day) a schibeid catfish from Nagarjunasagar reservoir. Vijayakumaran (1997) reported the growth and mortality and some aspects of biology of striped eel catfish *Plotosus lineatus*

(Thunberg) from North Andhra Pradesh coast. Inasu (1993) worked out the binomics of *Mystus mystus*. No other works are reported about the bionomics of edible catfishes of Central Kerala.

Food and feeding relationships of a number of freshwater fishes have been worked out by earlier workers. Some important workers in this field are Chacko & Devanesan (1944), Sekharan (1949), Chacko (1949), Kow (1950), Bapat & Bal (1950), Kuthalingam (1961), Mahadevan & Chacko (1962), Natarajan & Jhingran (1961), Martin (1966), Rajan (1965), Michael (1970), James (1967), Chakrabarthy & Singh (1967), Antony (1971 b), Thobias (1973), Qasim (1972), Jyothi (1975), Ritha (1978), Shyam Sunder *et al.* (1984), Khan (1988), De & Datta (1990a), Desai (1992), Sharma (1994), Badapanda (1996), Rao *et. al.* (1998), Basudha & Vishwanath (1999).

Food and feeding of only a few catfishes have been worked out so far. Some important works in this field are by Hartley (1948), Jayaram (1953) (1955), Menon & Chacko (1956), Bhatt (1970) (1971a) (1971b), Sudheeran (1981a), Ramakrishniah (1984), Vinci (1986), Siva Reddy & Babu Rao (1987) and Kolekar & Choudhary (1989) on the food and feeding habits of different species of *Mystus* from various inland waters of India. Vasudevappa & James (1992) have worked out the food and feeding of the marine catfish *Tachysurus dussumieri* (Valenciennes) along the Dakshina Kannada coast, Karnataka. The feeding habits of *Heteropneustes fossilis* (Bloch) from the Brahmaputra river system, Assam was described by Kohli & Goswami (1996). Food preference of the exotic catfish *Clarius gariepinus* (Burchell) was worked out by Mahapatra & Datta (1999).

From outside India, there have been some reports on related species of catfishes, of which mention may be made of the works of Gudger (1918) on the oral gestation of *Felichthys felis,* Monod (1927) on the food of *Arius leudeletic* from the French Cameroons, Nomura (1984) on the biology and vertebrae of the black dotted armoured catfish *Hypostomus nigromaculatus,* Khan *et al.* (1988 & 1991) on the food and length – weight relationship of Malaysian catfish *Mystus nemurus* (C & V), Bhuiyan & Islam (1991) on the food and feeding habits of *Ompok pabda* (Hamilton) from the river Padma, Fagbenro *et al.* (1993) on the biology of feral catfish *Heterobranchus bidorsalis,* Hendrickson (1994) on the biology of Mexican blind catfish of the genus *Prietella,* Marriott *et al.* (1997) on the reproductive and feeding biology of the Natal mountain catfish, *Amphilius natalensis.*

The age and growth studies of different species of the genus *Mystus* (Scopoli) are carried out by Jayaram (1954b), Pantulu (1961), Bhatt (1971c) (1971d), Sudheeran (1981b), Ramakrishnaih (1987), and Pandey (1994). Das (1980) has worked out the age and growth of the marine catfish *Tachysurus tenuispinis* (Day). Gopinatha Menon (1986) gave an account of the age and growth of *Tachysurus thalassinus* (Ruppell) from Mandapam waters. Pandey (1993) gave an account of the age and growth of the fresh water shark, *Wallago attu* from river Padma.

A few ichthyologists have worked on the length – weight relationship of catfishes. Some important works are those of Jayaram (1954a) on *Mystus oculatus,* Dan & Mojumder (1978) on *Tachysurus tenuispinis* (Day), Umesh & Sarma (1996) on *Clarias batrachus* (Linn), Das *et al.* (1997) on catfish *Arius tenuispinis* (Day) and Sunil *et al.* (1999) on *Horabagrus brachysoma* (Gunther).

Another important aspect of Biology of fishes is their reproduction. The spawning and fecundity of fishes are studied by a number of Ichthyologists like De Jong (1939), Jones (1946,1950), Prabhu (1956), Dharmamba (1959), Menon (1961 a), Annigeri (1963), Mathur (1964), Dhulkhead (1967), Kulkarni (1967), Qasim (1973a), Sinha (1975), Parimala & Ramaiyan (1980), Jayabalan (1986), James & Badrudin (1986), Devaraj (1986), Hoda, Shamsul (1995), Sivakami (1995), Dhanze *et al.* (1997), Negi & Dobriyal (1997), Patil *et al.* (1997), Srivastava & Desai (1998), Devadoss (1998), and Suryawanshi & Wagh (1999). But there is very little investigation on the reproductive biology of catfishes except those undertaken by Jayaram (1954c), Bhatt (1971c), Sudheeran (1981c) and Rao *et al.* (1999) on various species of *Mystus* (Scopoli), Rao & Karamchandani (1986) on *O. bimaculatus* from Kulgarhi Reservoir of Madhya Pradesh, Rama Mohana Rao *et al.* (1994) on *Clarius batrachus* (Linnaeus), Sinha (1984 & 1985) on the canine catfish eel *Plotosus canius* (Ham) and Mojumder (1978) on *Tachysurus thalassinus* (Ruppel). Francis (1997) has worked on hormones and their influence on spawning in catfishes. From Central Kerala, there is no other work on the systematics and biology of catfishes except the studies on *Mystus mystus* by Inasu (1993). So the present work now become significant, as studies on Indian catfishes need a review.

Central Kerala lies between 10 - 10 and 10- 40^{o}N latitude and 75-55^{o}E longitude. It is limited at North by Bharathapuzha, at South by Periyar, at East by Western Ghat and at West by Arabian Sea. This region has a large number of rivers, backwaters, streams, reservoirs, ponds and kole lands, which together constitute the inland waters. Some of the important inland water bodies of this area are Chettuvai lake, Azhikode lake, Ponnani – Cochin canal and the rivers Chalakudy, Kechery and Karuvannur and the allied kole lands. The fish systematics in this whole region is not worked out in an integrated manner. The works of Thobias (1978), Antony (1978), Kurup (1981), Inasu (1991) and Kader (1993) deal very limited and isolated portions of fish systematics of Central Kerala.

Felix *et al.* (1994) emphasized the scope of catfishes in the growing industrial aquaculture of India. Catfishes are fairly abundant in the rivers and kole lands of Central Kerala. So the present work of systematics and bionomics of edible catfishes of inland waters of Central Kerala seems to be a work that can generate first hand information in the field of fish systematics and bionomics. This work is undertaken with the hope that it will fill the lacunae in our knowledge of the biology of catfishes and contribute to further development of fishery of catfishes of this part of the country. For harnessing the aquatic resources, a scientific understanding of the fish species with respect to their morphological, biological and adaptive characters along with their natural distribution is imperative to back up their optimum exploitation.

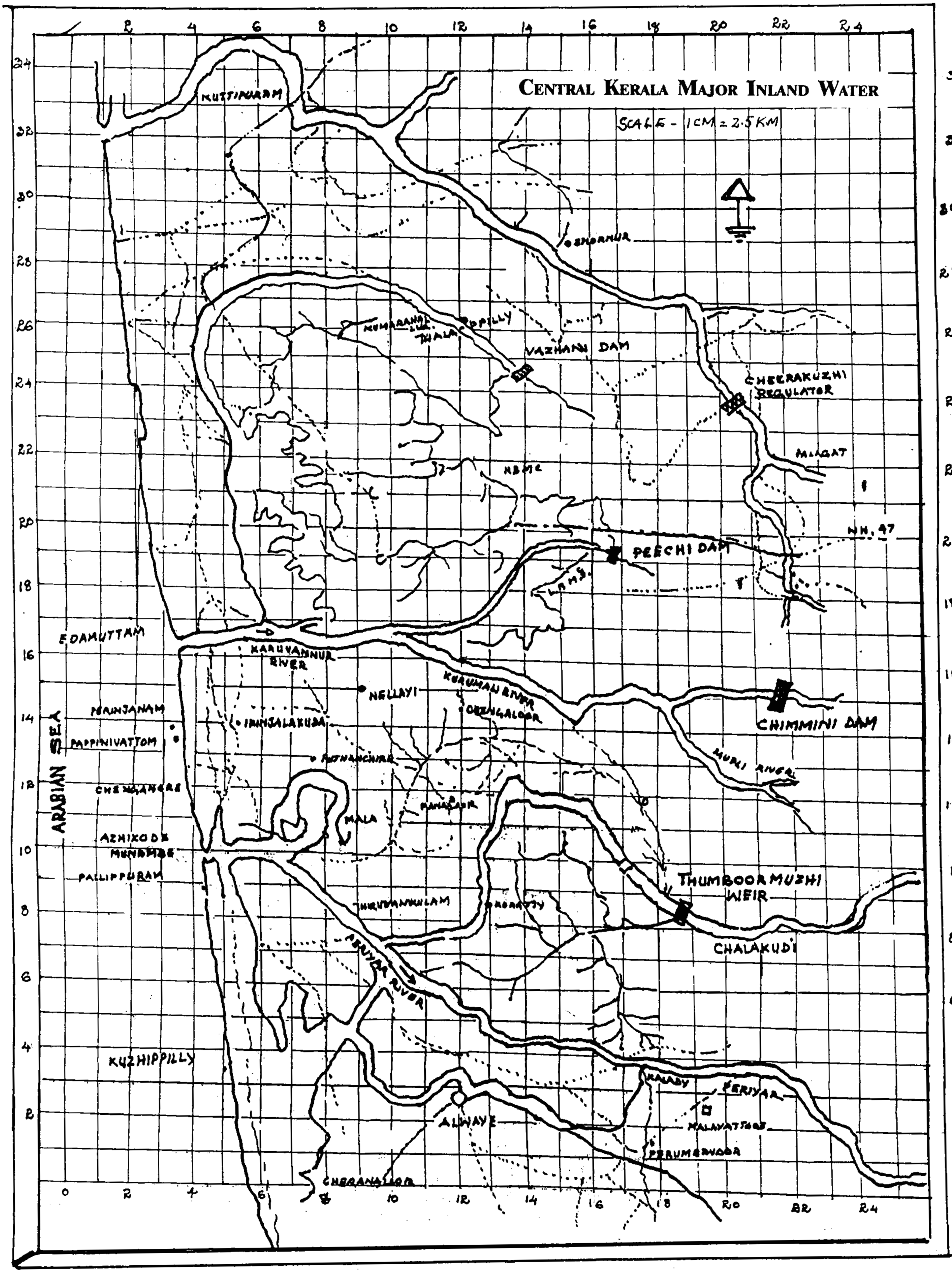
The natural aquatic ecosystems of India are being subjected to considerable stress, the adverse effects of which are being manifested in fish populations they harbour. A need has therefore arisen to conserve the vast & diverse fish genetic resources for their efficient utilization. Any broad programme of conservation of fish genetic resources of the region requires knowledge of the available resources and the salient biological features of the species of commercial value. This is the objective of this research work.

As a result of the present investigation, I have been able to collect data on the systematics of different species of catfishes and also food and feeding, length – weight relationship and the relative condition factor, Age and growth and also the reproduction and fecundity of two species of catfishes *Horabagrus brachysoma* (Gunther) and *Ompok bimaculatus* (Bloch).

Part I of the thesis deals with the study of the systematics of 21 species of catfishes both fresh water and brackish water forms collected from the different inland water bodies of the area studied, with details of synonyms and distribution. A key for the identification of families, genera and species is also included.

In Part II of the thesis, all the observations on the biology of the two species of catfishes, *Horabagrus brachysoma* (Gunther) and *Ompok bimaculatus* (Bloch) are included. The biological studies include food and feeding habits, age and growth, length – weight relationship and the relative condition factor and reproduction and fecundity in detail. The biological data have been analysed wherever necessary by employing standard statistical methods.

Figure showing major inland water bodies of Central Kerala



PART - I

SYSTEMATICS

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11B

SYSTEMATICS

CHAPTER – II

SYSTEMATICS

INTRODUCTION

Fish exhibit extreme diversity in their morphology, in the habitats they occupy and in their biology. They form the main group of vertebrates in the number of individuals and also in the number of species. The correct identification of species is very important for the investigation on any aspect of Biology and distribution of any animal. As a taxonomic group, fish has generated unlimited curiosity of the naturalists from the period as early as that of the great Aristotle. Russel (1785 – 1789) made the first attempt to undertake a systematic study of the Indian fish fauna. He listed about 200 species, mostly fresh water fishes found in the neighbourhood of Calcutta. The first modern writer on Indian fishes, according to Day (1878) was Bloch whose splendid work 'Auslandiche Fische' was published in 1785. In 1794 Dr. Buchanan Hamilton, superintendent of the Botanical gardens, Calcutta took up a study of the fishes of Ganges which lasted for twenty-eight years. It was published in 1822. This was probably the first official systematic catalogue of the Indian fishes. Of the 22,000 fish species known to Science, over 40% live in fresh waters and majority of them live in tropical waters. The inland fish resources of India are the richest in the world. The Indian fish fauna consist of about 2500 species, of which 930 belonging to 326 genera, inhabit the inland waters. For harnessing these aquatic resources, a scientific understanding of the fish species with respect to their morphological, biological and adaptive characters, along with their natural distribution, is imperative to back up their optimum exploitation.

The fish fauna of the rivers and the brackish water lakes of India were taxonomically listed by several authors. The most comprehensive studies on the classification of fishes of the Indo - pacific areas are those of Hamilton - Buchanan (1822) Day (1865, 1878), Gunther (1859, 1864), Weber & de Beaufort (1911 - 36, 1953, 1962), Smith (1949) Munro (1955), Fischer and White head (1974) and Jones and Kumaran (1980). Regan's (1929) was one of the first widely accepted classification of fishes based on taxonomic foundations laid much earlier in the 19th century works of Gunther (1859) and Gill (1872) and in the 20th century by Boulenger (1904). The latest and most widely accepted classification however is by Berg (1940). Our knowledge on the fishes of North and Central Kerala dates from Day (1865) who described several species of fishes from the above area. A review of literature shows that ever since Day's monumental work (1865), no subsequent effort was made to conduct another comprehensive taxonomic study on the fishes of Kerala, especially on inland catfishes, except a few works such as Antony (1971), Thobias (1973), Rangarajan (1973), Kurup (1982) and Inasu (1991). So the fresh water and estuarine catfishes of Central Kerala do require a taxonomic redescription in the light of recent trends used in fish systematics.

The systematics of catfishes of inland water bodies of India were studied by a number of workers such as Day (1865) (1878), Hora (1936, 1942), Menon (1964),, Parameswaran *et al.* (1967), Misra (1976), Jayaram (1977a, 1977b, 1988), Jayaram & Dhanze (1978) and Keishing & Viswanath (1999). But their work deal with the general fish systematics of India. Thobias (1973), Antony (1977), Inasu (1991), Pethiyagoda and Kottelat (1994) and Ajith Kumar *et al.* (1999) worked out the general fish distribution in various water bodies in Trichur district. But a study focussed entirely on the inland catfish distribution of Central Kerala was not worked out by the earlier workers and this work now become significant, as Indian Siluridae and Bagridae need a review. The present work deals with the systematics of 21 species of inland catfishes of Central Kerala. Also a key to the classification of various families of catfishes, their genera and species occurring in this area has been prepared.

MATERIALS & METHODS

Catfishes of different families belonging to the order Siluriformes, occurring in the various inland water bodies such as rivers, ponds, lakes and kole lands were collected from local fishermen. Immediately after collection, they were put in icebox and brought to laboratory. After careful washing, the specimens were kept on a plywood board to spread out the fins by using small pins. A little concentrated formalin was applied on the fins by a small brush and allowed to remain for few minutes to harden those structures and then they were preserved in 5% formalin for detailed studies of morphometric and meristic characters. In the laboratory, the specimens were carefully washed and the following measurements were taken.

Total length : The greatest distance between the most anterior projecting part of the head to the posterior most tip of the caudal fin including filamentous prolongations.

Standard length : The distance from the anterior most part of the head to the end of vertebral column.

Greatest body depth : The vertical measurement from a point in the body of the fish on its back where its height is greatest to a straight line to the ventral surface or profile.

Head length : The distance from the tip of the snout to the most distant point on the opercular membrane.

Eye diameter : The distance between margins of the cartilaginous eye ball across the cornea.

Snout length : The distance from the most anterior midpoint on the snout or upper lip to the front hard margin of the orbit.

Interorbital width : The least distance between the bony rims between the inner margins of the eyes.

Predorsal length : Measurement from the tip of the snout or upper lip or the anterior most part of the head to the structural base of the first dorsal fin ray or spine.

Length of pectoral fin spine: Measured between its origin or place of its insertion into the body to the extreme tip.

Length of caudal peduncle: An oblique measurement from the last point of contact of anal fin posteriorly to the end of vertebral column.

The accurate enumeration of meristic data or counts of fin rays is of diagnostic importance. The number of simple and branched rays of various fins were taken with great care to get the fin formula. The length of barbels (Nasal, Maxillary, Outer mandibular & Inner Mandibular) were also measured.

Outline Classification of Catfishes

Super class	-	Gnathostomata
Class	-	Osteichthyes
S. Class	-	Actinopterygii
Sub Division	-	Teleostei
Infra Division	-	Euteleostei
Super Order	-	Acanthopterygii
Order	-	Siluriformes

The classification of catfishes is not settled and disagreement exists on the inter relationships of the families. In the classical work of Sir Francis Day (1865) all the catfishes are placed in one family Siluridae under the order Physostomi. Boulenger (1904) divided the family Siluridae of Gunther (1864) into 8 subfamilies based on differences in the length of the dorsal and anal fins and in the nature of gill membrane. Regan (1911) considered this grouping as unnatural and classified Siluridae into 23 families. Berg (1940) classified the division Siluri into 2 super families Diplomystoidae and Siluroidae, based on the nature of the maxillaries and also on the nature of the connection of the 5th vertebra with the modified anterior vertebra. The super family Siluroidae is again subdivided into 27 families and he treated Aridae to be the most primitive among this super family. Sir Francis Day placed the family Siluridae under the order Physostomi.

The family Bagridae has been treated by Nelson (1984) under the order Siluriformes of the super order Ostariophysi.

The families of Siluriformes known from Indian waters are arranged according to Nelson (1984).

KEY TO FAMILIES

1	(a)	Adipose dorsal fin absent. Caudal fin rounded, extending forward on the dorsal side of the body.	...	2
	(b)	Caudal fin forked, emarginate or truncate, not extending on the dorsal side of the body.	...	3
2		Body eel like anal fin long and continuous with caudal fin.	...	Plotosidae
3		Adipose dorsal fin absent. Dorsal fin usually absent, if present without spine.	...	11
4		Anal fin usually short with 6 – 20 soft rays (except the genus *Horabagrus* which has 23 – 28 soft rays).	...	5
5		Gill membranes united to each other, but free from isthmus.	...	8

6	Nostrils close to each other, separated by a barbel or valve	...	7
7	Barbels 1 – 3 pairs. Nasal barbel absent. Nostrils separated by a valve. Mainly marine and estuarine.	...	Aridae
8	Dorsal fin with a spine	...	9
9	Nostrils wide apart. Teeth present on the roof of the mouth. Dorsal & pectoral spines strong.	...	Bagridae
10	(a) Dorsal fin base very long, usually with more than 30 rays. An accessory respiratory organ called labyrinthic organ present in the branchial chamber	...	Claridae
	(b) Dorsal fin base short (1 – 7 rays), often absent	...	11
11	(a) Barbels 4 pairs, head greatly depressed, long air sac extends posteriorly from gill chamber	...	Heteropneustidae
	(b) Barbels two or three pairs (No nasal barbel), head fairly compressed, no air sac.	...	Siluridae

FAMILY : **BAGRIDAE**

Body elongate and compressed. Nostrils wide apart, anterior nostrils in the tip of snout & tubular. Posterior nostrils with nasal barbels placed near the eye. Mouth subterminal, teeth on premaxillaries, mandible and prevomer. Barbels usually 8 (six in *Rita*) well developed. Dorsal fin preceded by a spine and with 6 – 8 soft rays. Often a large adipose fin present. Anal fin base short with 8 to 16 soft rays (*Horabagrus* with 23 – 28 rays). Pectoral fin with a strong serrated spine. Caudal fin forked. Air bladder large, free in the abdominal cavity. Vertebrae 34 – 57.

KEY TO GENERA

1 (a) Anal fin base long with 23 – 28 soft rays. Eyes inferior, visible from below ... *Horabagrus*

(b) Anal fin base short to moderate with 8 – 16 soft rays ... 2

2 Pelvic fin with 6 rays. Villiform teeth on palate. Barbels 4 pairs ... 3

3 No pores on ventral surface and sides of head; Maxillary barbels longer, extending beyond the origin of dorsal fin. ... 4

4	(a)	Interneural shield (between basal bone of dorsal fin and occipital process) present	...	*Aorichthys*
	(b)	Interneural shield absent	...	*Mystus*

Genus ***Aorichthys*** Wu

Aoria Jordan 1919, *Proc. Acad.nat.Sci. Philad.,* **70** : 341 (type-species: *Bagrus lamarii* Valenciennes = *Platystoma seenghala* Sykes).

Aorichthys Wu 1939, *Sinensia,* **10** : 131 (Substitute name for *Aoria* Jordan and therefore with same type - species); Jayaram 1972, *Proc. zool. Soc. Calcutta* **24** : 149 – 156 (Review).

Osteobagrus Jayaram, 1954, *Rec. Indian Mus.,* **51** : 529 (type - species: *Pimelodus aor* Hamilton – Buchanan).

Description

Body elongate and compressed. Head large and slightly depressed. Snout spatulate or rounded. Eyes large with free orbital margin. Mouth moderately wide. A distinct interneural shield in between basal bone of dorsal fin and occipital process present. 4 pairs of barbels. Maxillary pair long extending to pelvic fins and even beyond caudal. Dorsal fin with seven rays and a spine. Adipose dorsal fin long, pectoral fin with a serrated spine and 9 – 10 rays. Pelvic fin with 6 rays. Caudal fin forked.

This genus has two species, both in Indian waters.

KEY TO SPECIES

1	(a)	Snout rounded; maxillary barbels extend to the base of caudal fin or even beyond. Width of gape of mouth less than half of head length. Caudal fin with 17 rays.	...	*Aorichthys aor*
	(b)	Snout spatulate. Width of gape of mouth one – third of head length. Caudal fin with 19 – 21 rays. Maxillary barbels shorter, extending not further than Pelvic fin.	...	*Aorichthys seenghala*

Aorichthys seenghala (Sykes)

(Plate – 1)

Platystoma seenghala Sykes, 1841, *Trans. Zool. Soc. Lond.,* **2** : 371 pl. 65, fig. 2.

Macrones seenghala : Day, 1877, *Fishes of India*; 444, pl. 99, fig. 1 ; Day, 1889, *Fauna Br. India,* Fishes **1** : 150.

Mystus (Aorichthys) seenghala : Misra, 1976, *Fauna of India,* Pisces (2nd ed), **3** : 79, fig. 16

Distinguishing Characters

D I 7; A 8 - 9; P I 9; V 5 - 6; C 19 - 22

The average total length of fishes examined is 291 mm. Average standard length is 210mm. Body measurements are expressed in percentage of standard length. Greatest body depth is 17.14; head length 29.52, length of snout 40.32 of head length, Eye diameter 12.3 in head length, Inter orbital space 24.19 in head length, caudal peduncle 16.67. Predorsal length 29.52; length of dorsal spine 11.38, length of pectoral spine 1.06, Barbels – Nasal 10, Maxillary 75.6, Inner mandibular 11.90, Outer mandibular 30.48.

Body elongated and compressed. Snout broad and spatula like. Mouth subterminal. Eyes large, almost in the middle of head, invisible from ventral side, four pairs of barbels. Maxillaries extend beyond anal fin. Dorsal spine weakly serrated on the inner side. Adipose dorsal fin long, about sixteen percentage of total length. Caudal fin deeply forked, upper lobe longer and tapering.

Colour

Greyish – brown above and silvery white below. A clear black spot is found at the base of adipose dorsal fin.

Distribution

Pakistan, Bangladesh, Nepal, China and through out India in the rivers, canals, inundated fields etc.

Remarks

Aorichthys seenghala closely resembles *Aorichthys aor* in having a distinct interneural shield in between basal bone of dorsal fin and occipital process and in the fin ray counts. *Aorichthys seenghala* is however easily distinguishable by the spatulate snout and by the caudal fin with 19 - 22 rays. The present specimens agree well with the descriptions given by Jayaram (1981) and Talwar and Jhingran (1991).

Genus ***Horabagrus*** Jayaram

Horabagrus Jayaram, 1955 , *Bull. natn. Inst. Sci. India, (7)*: 261 (type-species : *Pseudobagrus brachysoma* Gunther); Jayaram, 1966, *Int. Revue ges. Hydrobiol.,* **51**(3): 447- 448 (Review)

Pseudobagrus (nec Bleeker) Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 108.

Description

Body moderately elongated and slightly compressed. Abdomen rounded. Head large, anteriorly depressed. Eyes moderate, lying at about the level of the corner of mouth, visible from below. Mouth subterminal. Barbels 4 pairs. Dorsal fin with a strong spine and 5 – 7 soft rays. Adipose fin small and low. Anal fin long with 23 – 28 soft rays. Pectoral fin with a strong serrated spine and 8 or 9 soft rays. Caudal fin forked.

Genus *Horabagrus* includes 2 species. *Horabagrus brachysoma* and *Horabagrus nigricollaris.*

KEY TO SPECIES

1	(a)	A black saddle shaped bar extending across the dorsum from the humeral region of each side	...	*H. nigricollaris*
	(b)	No saddle shaped bar extending across the dorsum	...	*H. brachysoma*

Horabagrus brachysoma (Gunther)

(Plate – 2)

Pseudobagrus brachysoma Gunther, 1864, *Cat. Fishes Br. Mus.*, **5** : 86 (type – locality : Cochin); Jayaram, 1952, *Ann. Mag. nat. Hist.*, (12) **5** : 982 (type – locality revised); Misra, 1976, *Fauna of India*, Pisces (2nd ed), **3** : 109.

Pseudobagrus chryseus Day, 1865, *Fishes of Malabar* : 185, pl. 13, fig. 2 (type – locality; Kariyannur river, Kerala)

Macrones chryseus : Day, 1877, *Fishes of India:* 443, pl. 99, fig. 3; Day, 1889, *Fauna Br. India,* Fishes, **1** : 148, fig. 63.

Horabagrus brachysoma : Jayaram, 1966, *Int. Revue ges. Hydrobiol.*, **51** (3): 447 fig. 5.

Description

D I 6 – 7; P I 9; V 5; A 23 – 25

Based on 165 specimens ranging in total length from 65mm to 245mm and standard length 45mm to 210mm, morphological studies were conducted.

The average total length of fishes examined is 191mm. Average standard length is 160mm. Body measurements are expressed in percentage of standard length. Greatest body depth is 25.62. Head length 27.5. Length of snout 27.27 of head length. Eye diameter 13.14 in head length. Inter orbital space 63.64 in head length. Length of caudal peduncle 12.5; Predorsal length 36.25; length of dorsal spine 16.88; length of Pectoral spine 15.Average length of Barbels:Nasal-17.57, Maxillary 16.22, Inner Mandibular – 13.5 and Outer Mandibular – 18.02.

Body elongated and slightly compressed. Eyes ventrolateral, visible from underside of head. Mouth subterminal. Barbels 4 pairs. Maxillaries extend downwards to the pectoral fin base. Others are shorter. Dorsal fin with a strong, serrated spine, adipose fin short and low. Caudal fin deeply forked.

Colour

When alive, yellowish above, the flanks golden and ventral side whitish. A remarkable feature of the fish is the presence of a large round black mark on the shoulder, surrounded by a light yellow ring. Dorsal and anal fins orange yellow, greyish at their margins. Caudal fin yellow with a semilunar thick black ring at its base is usually present.

Distribution

India, Kerala rivers & backwaters

Remarks

A very common catfish of Kerala backwaters and rivers. Recently Anuradha (2001) reported the occurrence of this fish in Uttara Kannada district of Karnataka also. Jayaram (1955, 1966) considered *Horabagrus* to be monotypic and considered *Pseudobagrus chryseus* Day, 1865 a synonym of *H. brachysoma.* But later Pethiyagoda and Kottelat (1994) found out a new species from Chalakudy River, *Horabagrus nigricollaris.* It is distinguished from *H. brachysoma* by the colour pattern. It has a black saddle shaped bar extending across the dorsum from the humeral region of each side vs. a black humeral ocellus edged in white in *H. brachysoma.* The present specimen agrees well with the description given by Jayaram (1981) and Pethiyagoda & Kottelat (1994) for *H. brachysoma.*

Genus *Mystus* Scopoli

Mystus Scopoli, 1777, *Introductio ad historiam naturalem* : 451 (type-species : *Bagrus haplepensis* Valenciennes = *Silurus pelusius* Solander); Jayaram, 1959, *Proc. First All-India Congr. Zool.*, (Pt. 2): 633; Jayaram, 1966, *Int. Revue ges. Hydrobiol.*, **51** (3) : 444 – 448 (Synopsis).

<u>Description</u>

Body short or moderately elongated and compressed, Head compressed. Mouth moderately wide, terminal. Eyes fairly large, not visible ventrally. Unequally placed jaws. Villiform teeth in bands on jaws. Barbels 4 pairs, 1 pair nasal, 1 pair maxillary and 2 pairs mandibular, generally extending beyond head. Dorsal fin with a serrated spine and seven soft rays. Adipose fin low of varying length. Anal fin short with 9 – 16 rays. Pectoral fin with a spine serrated along its inner edge and 6 – 10 soft rays. Pelvic fin rays 6. Caudal fin forked.

Mystus Scopoli is a traditional genus revived by Fowler, 1928 to which approximately 30 species are assigned, out of which 19 species in Indian waters.

KEY TO SPECIES

1	(a)	Occipital process extends to basal bone of dorsal fin	...	2
	(b)	Occipital process not reaching basal bone of dorsal fin	...	14

2	(a) Adipose dorsal fin long, inserted close to or almost immediately behind rayed dorsal fin	...	3
	(b) Adipose dorsal fin usually short, inserted after an inter space behind rayed dorsal fin	...	8
3	Vomerine tooth band continuous; caudal peduncle fairly high, its least depth about 2 times in its length	...	4
4	Branchiostegal rays 6. Maxillary barbels extend posteriorly beyond to anal fin origin	...	5
5	Median longitudinal groove on head extends to base of occipital process; a dark spot on the base of caudal fin often present	...	*M. cavasius*
6	(a) Median longitudinal groove on head extends to base of occipital process	...	7
	(b) Median longitudinal groove on head not extending to the base of occipital process	...	9
7	Maxillary barbels very long, extending posteriorly to the middle of anal fin or beyond it	...	8
8	A dark spot at the origin of dorsal fin. Adipose dorsal fin short. Its base 1.2 times interdorsal distance. Branchio stegal rays 10	...	*M. oculatus*
9	(a) One or two longitudinal colour bands on either side of the body	...	10
	(b) No longitudinal bands on the body	...	11

10	(a)	Eye diameter 3.5 – 4 times in head length. Pectoral fin with 6 soft rays; 1 or 2 longitudinal light bands above lateral line	...	*M. montanus*
	(b)	Eye diameter 4.5 – 6 times in head length. Pectoral fin with 9 soft rays. Body has 3 or 4 longitudinal bands, pale blue or dark brown or black above and below lateral line	...	*M. vittatus*
11	(a)	A dark blotch on the base of caudal fin. Occipital crest smooth. 10 Branchiostegal rays	...	*M. armatus*
	(b)	No dark blotch on the base of caudal fin. Occipital crest rugose. Branchiostegal rays 9	...	*M. gulio*
12	(a)	Median longitudinal groove on head reaches base of the occipital process	...	13
	(b)	Median longitudinal groove on head does not reach base of the occipital process	...	14
13		Depth of the body 7.8 – 8.4 times in standard length. 10 black rounded solid spots along lateral line	...	*M. punctatus*
14		Eyes moderate, its diameter 3.5 to 7 times in head length	...	15
15	(a)	Eye diameter 6 – 7 times in head length, maxillary barbels extend posteriorly to the base of anal fin. No dark band along lateral line.	...	*M. microphthalmus*

(b) Eye diameter 3.5 – 4.5 times in head length. Maxillary barbels extend posteriorly to the end of pelvic fins. A dark band along lateral line ... *M. malabaricus*

Mystus gulio (Hamilton-Buchanan)

(Plate – 3)

Pimelodus gulio Hamilton Buchanan, 1822, *Fishes of Ganges:* 201, 379, pl. 23, fig. 66 (type – locality: higher parts of Gangetic estuaries).

Macrones gulio : Day, 1877, *Fishes of India* : 445, pl. 99, fig. 2; Day, 1889, *Fauna Br. India,* Fishes, **1** : 151, fig. 64.

Mystus (Mystus) gulio : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 90, fig. 19.

Description

D I 7 P I 8-9 V 5 A 9 – 12

Based on 8 specimens ranging in total length from 185 – 230 mm (Mean = 210 mm) and standard length from 160– 185 mm (Mean 172 mm) morphological studies were conducted.

Body stout, elongate and depressed. Body measurements are expressed in percentage of standard length. Greatest body depth is 30.07; head length 30.77; length of snout 38.6 of head length, Eye diameter 14 (in head length); inter orbital space 38.63 (in head length). Length of caudal peduncle 14.69; predorsal length 38.46; length of dorsal spine 11.19; length of pectoral spine 16.78. Barbels : nasal 11.19; maxillary 55.94; outer mandibular 27.97; inner mandibular 15.38.

Head depressed, rough on the upper surface. Median longitudinal groove on head is small. Mouth terminal. Maxillary barbles reach beyond the ventrals. Outer mandibular extend beyond the pectoral fin. Inner mandibular about half the size of outer one. Dorsal fin high, its spine strong, serrated on the inner edge. Adipose fin small. Pectoral spine hard, strong and serrated. Ventral fin behind the level of posterior edge of dorsal. Caudal fin forked and its lobes broad. Upper lobe slightly longer.

Colour

Light yellowish grey on the upper portion and yellowish white below:

Distribution

Pakistan, India, Bangladesh and Burma. Inhabits estuaries and tidal rivers and lakes.

Remarks

Mystus gulio is partly marine, but it inhabits rivers and lakes also. It resembles *Mystus armatus* in the nature of the median longitudinal groove on the head not extending to the base of occipital process. But it differs from *Mystus armatus* in the absence of the dark blotch on the base of caudal fin and in the number of branchiostegal rays, which are 9 against 10 in *M. armatus.*

Mystus punctatus (Jerdon)

(Plate - 4)

Bagrus punctatus Jerdon, 1849, *Madras Jour. Lit. & Sci.*, **15** : 339 (type locality : Cauvery river, Western Ghats).

Macrones punctatus : Day, 1877, *Fishes of India:* 445, pl. 100, fig. 3 ; Day, 1889, *Fauna Br. India,* Fishes, **1** : 153.

Mystus maydelli (*nec* Rossell) David *et al.,* 1969, *Bull. Cent. Inland Fish. Res. Inst.,* Barrackpore, (13) : 68.

Mystus (Mystus) punctatus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 102.

Mystus punctatus : Jayaram *et al.,* 1982, *Rec. zool. Surv. India Occ. Pap.,* (36): 87, fig. 27.

Description

D I 7; P I 8; V 5 A 8

Based on 4 specimens ranging in total length from 250 - 290mm (Mean 270mm) and standard length from 200 - 240mm (Mean 220mm), morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 19.37. Head length 26.13. Length of snout 34.4 in head length. Eye diameter 12.06 (in head length) interorbital space 43.1 (in head length). Length of caudal peduncle 17.57. Predorsal length 37.84; length of dorsal spine 10.81, length of Pectoral spine 13.96. Barbels : Nasal 4.5; Maxillary 45.05; Inner mandibular 9.01; Outer mandibular 20.27.

Body elongate and compressed. Head slightly depressed, and its upper surface smooth. Median longitudinal groove indistinct and it reaches base of occipital process. Mouth terminal. Dorsal spine strong and serrated on the upper half. Adipose dorsal with a short base. Pectoral spine longer and stronger than that of dorsal and denticulated internally. Ventrals arise on a vertical line just posterior to the posterior base of the dorsal fin. Caudal fin forked, its upper lobe slightly longer. Barbels 4 pairs. Maxillary barbels reach the middle or end of pelvic fins.

Colour

Dark grey or olive dorsally and slight yellowish ventrally. About 10 distinct black rounded spots along lateral line. Fins other than ventrals dusky.

Distribution

India, Nilgiri hills and the Western Ghats.

Remarks

Mystus punctatus is commonly found in hill streams and is of local fishery value. It is similar to *M. menoda* in the nature of the median longitudinal groove of the head, which reaches the base of occipital process. But *Mystus punctatus* differs from *M. menoda* in the nature of the spots along the lateral line. The spots are solid in *M. punctatus* but they are clusters of small spots in *M. menoda.*

Mystus armatus (Day)

(Plate - 5)

Hypselobagrus armatus Day, 1865, *Proc. Zool. Soc. Lond.* : 289 (type locality: Cochin).

Macrones armatus : Day, 1877, *Fishes of India :* 450, pl. 101, Fig. 3; Day, 1889, *Fauna Br. India,* Fishes, **1'**: 161.

Mystus (Mystus) armatus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 84.

Mystus armatus : *Jayaram, 1977, Rec. zool. Surv. India. Occ. Pap.,* (8): 28, fig. 23B.

Description

D I 7, P I 9, A 8; V 5

Based on 18 specimens ranging in total length from 95 – 140mm and standard length from 73 to 110mm, morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 25.74. Head length 27.72. Length of snout 37.03 of head length. Eye diameter 18.5 (in head length). Interorbital space 40.74 (in head length). Length of caudal peduncle 19.8. Predorsal length 40.59. Length of dorsal spine 9.90. Length of pectoral spine 15.84. Barbels: Maxillary 68.32; Nasal 15.84; Outer mandibular 29.7; Inner mandibular 21.78.

Body elongate and compressed. Head compressed. Occipital process extends to basal bone of dorsal fin. Median longitudinal groove on head do not reach the base of occipital process. Mouth terminal. Dorsal spine finely serrated; adipose fin short. Caudal fin forked. Barbels 4 pairs. Maxillary barbels extend almost upto the base of anal fin. Outer mandibular extends beyond pectoral fin.

Colour

Greyish brown above, lighter below, often with a brown band along the flank. Upper half of dorsal fin darker. A dark blotch at the base of caudal fin.

Distribution

India: Wynaad hills, Western Ghats and Nagaland.

Remarks

Mystus armatus is not of much fishery importance. It is a small catfish reaching a maximum length of only 150 – 160mm. This fish resembles *Mystus gulio* in the nature of median longitudinal groove on the head not extending to the base of occipital process. But *M. armatus* can be easily differentiated from *M. gulio* in having a dark blotch at the base of caudal fin and also in the presence of 10 branchiostegal rays.

Mystus oculatus (Valenciennes)

(Plate – 6)

Bagrus oculatus Valenciennes, 1839, *Hist. nat. poiss.,* **14** : 424 (type – locality : Malabar)

Macrones oculatus : Day, 1877, *Fishes of India* : 448, pl. 98, fig. 4; Day, 1889, *Fauna Br. India,* Fishes, **1** : 156

Mystus (Mystus) oculatus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 98

Description

D I 7; P I 6; V 5; A 8 – 9

Based on 21 specimens ranging in total length from 70 mm to 120mm (mean 95mm) and standard length from 55mm to 102mm (mean 75mm), morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 24.29. Head length 30. Length of snout 38.09 of head length. Eye diameter 23.8 (in head length) Interorbital space 28.57 (in head length). Length of caudal peduncle 20; predorsal length

37.14; length of dorsal spine 14.29; length of pectoral spine 17.14; Barbels: Nasal 17.14; Maxillary 71.43; Inner mandibular 21.43; Outer mandibular 22.86.

Body long and compressed. Head depressed. Median longitudinal groove on head extends to the base of occipital process. Upper jaw slightly longer. Teeth villiform in bands on jaws. Dorsal spine strong moderately. Adipose fin base low. Caudal fin forked. Barbels 4 pairs; maxillary barbels extend to the middle of anal fin. Branchiostegal rays 10.

Colour

Silvery grey above, lighter below. A dark spot at the origin of base of dorsal fin. A dark band along the middle of dorsal fin.

Distribution

India, commonly found in the fresh waters of Kerala and Tamil Nadu. Sometimes inhabits estuaries also.

Remarks

Mystus oculatus attains a maximum length of only 150mm and so it is of minor importance in fisheries. It is similar to *M. cavasius* in the presence of the median longitudinal groove of the head extending to the base of occipital process. But *Mystus oculatus* can be easily differentiated from other catfishes by the presence of a dark spot at the origin of dorsal fin.

Mystus cavasius (Hamilton – Buchanan)

(Plate – 7)

Pimelodus cavasius Hamilton – Buchanan, 1822, *Fishes of Ganges* : 203, 379, pl. 11, fig. 67 (type - locality : Gangetic provinces).

Macrones cavasius: Day, 1877, *Fishes of India :* 447, pl. 100, fig. 1; Day, 1889, *Fauna Br. India,* Fishes, **1** : 155.

Mystus mukherjii Ganguli and Datta, 1975, *Zool. Soc. India. B.S. Chauhan Comm. Vol.*: 293 (type – locality : Subarnarekha river, Bihar).

Mystus (Mystus) cavasius : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 87, fig. 18.

Mystus cavasius : Jayaram, 1977, *Rec. zool. Surv. India. Occ. Pap.,* (8) : 29, fig. 21A.

Description

D I 7; P I 8; V 5 – 6; A 8 – 9.

Based on 5 specimens ranging in total length from 170mm – 205 mm (mean 190 mm) and standard length from 128 mm – 185mm (Mean 150mm), morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 22.06. Head length – 22.79; Length of snout

34.37 of head length. Eye diameter 25 (in head length). Interorbital space 37.5 (in head length); length of caudal peduncle 16.18. Predorsal length 36.76; length of dorsal spine 12.5. Length of pectoral spine 14.71. Barbels : Nasal 22.06; Maxillary 89.71; Inner mandibular 22.79; Outer mandibular 37.5.

Body elongate and compressed. Head conical, occipital process narrow. Median longitudinal groove on head extends to the base of occipital process. Snout obtuse, upper jaw a little longer. Teeth villiform in bands on jaws. Barbels 4 pairs. Maxillary barbels extend posteriorly to caudal fin base. Outer mandibular reaches almost the base of ventral. Dorsal spine weak, feebly serrated. Adipose dorsal fin large and it starts just behind the rayed dorsal fin. Pectoral spine is larger and stronger than dorsal spine and internally denticulated. Caudal fin deeply forked, its upper lobe longer. Branchiostegal rays six.

Colour

Greyish above, becoming yellowish along the abdomen. A black spot covering basal bone of dorsal fin usually present. Occasionally there is a bluish band along lateral line. Dorsal and caudal fins dusky.

Distribution

India, Paksitan, Sri Lanka, Nepal, Bangladesh, Burma and Thailand.

Remarks

Mystus cavasius inhabits fresh water, tidal rivers, lakes and also ponds, ditches and inundated fields. This catfish is a very common food fish in the Indian region. It can be easily differentiated from the other species of *Mystus* in having the median longitudinal groove on the head extending to the base of occipital process and a dark spot on the base of dorsal fin and a long adipose dorsal fin.

Mystus montanus (Jerdon)

(Plate – 8)

Bagrus montanus Jerdon, 1849, *Madras Jour. Lit. & Sci.,* **15** (2) 337 (type – locality: Manantoddy, Wynaad, Kerala State).

Macrones montanus : Day, 1877, *Fishes of India :* 449, pl. 101, fig. 4; Day, 1889, *Fauna Br. India,* Fishes, **1** : 159.

Macrones montanus var. dibrugarensis Chaudhuri, 1913, *Rec. Indian Mus,* **8** : 254, pl. 9, figs 2, 2a, 2b (type – locality : Dibrugarh, Assam); Jayaram, 1977, *Rec. zool. Surv. India. Occ. Pap.,* (8) : 34 (Status discussed).

Mystus (Mystus) montanus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 97.

Mystus (Mystus) vittatus dibrugarensis : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 107.

Description

D I 7; A 9; P I 6; V 5

Based on three specimens ranging in total length from 130 - 138mm (Mean 136mm) and standard length from 100 - 106mm (Mean 104mm), morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 26.92; Head length 25; length of snout 38.46 of head length ; Eye diameter 23.08 (in head length). Interorbital space 38.46 (in head length); length of caudal peduncle 10.58; predorsal length 38.46. Length of dorsal spine 10.58; length of pectoral spine 11.54. Barbels : Nasal 10.58; Maxillary 68.27; Inner Mandibular 24.04; Outer mandibular 29.81.

Body compressed and elongated. Head is also compressed. Median longitudinal groove on the head not extending to occipital process. Mouth terminal. 4 pairs of barbels well developed. Maxillary barbel extends to the base of anal fin. Dorsal spine weak, serrated on its inner edge. Adipose fin narrow and elongated. Caudal fin forked. Branchiostegal rays 10.

Colour

Silvery grey above with a tinge of yellow colour along the abdomen; a dark line along the flank ending in a dark spot at the base of caudal fin; one or two light bands above the lateral line; a bluish spot on the shoulder.

Distribution

Kerala (Wynaad), Karnataka, Maharashtra and Assam.

Remarks

Mystus montanus usually occurs in hill streams. Maximum size attained is only 150mm and so this species of *Mystus* is not important in fisheries. It differs from other species of *Mystus* in having a shoulder spot behind the operculum and a dark blotch at the base of caudal fin.

FAMILY : **SILURIDAE**

Body elongate and compressed. Mostly large sized. Head depressed. Nostrils lie close to each other. Anterior nostrils tubular, posterior pair valved. Barbels one to three pairs. Maxillary barbels usually elongate. Mandibular one or two pairs (sometimes absent). Nasal barbels absent. Gill openings very wide. 8 – 21 branchiostegal rays. Only one rayed dorsal fin, which is devoid of spine and with less than 7 soft rays. Adipose fin absent. Anal fin very long (with upto 93 rays), ends almost near caudal. Pectoral fin with a spine, which is often serrated. Pelvic fins very small or absent.

Siluridae is one of the most distinctive and well-defined families of catfishes. They are usually fresh water forms. Siluridae consist of 9 or 10 genera only 5 occur in India.

KEY TO GENERA

1	(a) One dorsal fin. Gape of the mouth very wide extending beyond eyes posteriorly and eyes not visible from underside of head	...	*Wallago* Bleeker
	(b) Gape of the mouth not wide, not extending beyond eyes posteriorly	...	2
2	Caudal fin forked. Mandibular barbels one pair, often rudimentary. Eyes visible from underside of head	...	*Ompok* Lacepede

Genus ***Wallago*** Bleeker

Wallago Bleeker, 1851, *Natuurk. Tijdschr. Ned.-Indie,* **1** : 265 (type – species : *Silurus mulleri* Bleeker = *Silurus attu* Schneider); Roberts, 1982, *Copeia,* (4) : 890 – 894 (Revision).

Wallagonia Myers, 1938, *Copeia,* (2) : 98 (type – species : *Wallago leerii* Bleeker).

Description

Body elongate and compressed. Head large and depressed. Snout spatulate. Eyes lie completely above the level of the corner of mouth, not visible from underside of head. Mouth subterminal, oblique, gape wide reaching beyond anterior border of eyes. Jaws unequal, lower jaw longer and prominent. Teeth in villiform bands on jaws. Two pairs of barbels, one pair each of maxillary and mandibular. Dorsal fin spineless with 5 rays. Anal fin long with 77 to 96 rays. Pectoral fin with a weak spine and 13 to 15 rays. Pelvic fin with 8 – 10 rays. Caudal fin deeply forked with pointed lobes. Branchiostegal rays 18 – 21.

Wallago comprises large slurids differentiated from other genera in South East Asia by having a relatively large dorsal fin with 5 rays. The genus consists of 3 species, only one occurs in India.

Wallago attu (Schneider)

(Plate – 9)

Silurus attu Schneider, 1801, *Syst. Ichth.*: 378, pl. 75 (type – locality: Malabar)

Wallago attu : Day, 1877, *Fishes of India* : 479, pl. 111, fig. 4; Day, 1889, *Fauna Br. India,* Fishes, **1** : 126, fig. 54; Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 206, fig. 41.

Wallagonia attu : Hora, 1939, *J. Bombay nat. Hist. Soc.,* **41** : (1) : 64, pl. (Rediscription)

Wallago attu valeya Deraniyagala, 1953, *Spolia zeylan.,* **27** : 15 (type-locality : Yakvala, Ceylon); Roberts, 1982, *Copeia,* (4) : 891 (status clarified).

Description

D 5; P I 12 – 14; V 9; A 74 – 78

Based on 8 specimens ranging in total length from 300 to 450 mm and standard length from 270 to 410 mm, morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 17.5. Head length 21.75. Length of Snout 39.28 of head length. Eye diameter 10.71 (in head length). Interorbital space 53.57 (in head length). Length of caudal peduncle 32.5. Predorsal length 29.85, length of pectoral spine : 6.82. Barbels: Maxillary 33.75, Mandibular 7.5.

Body elongate, and compressed. Head slightly depressed. Interorbital space flat. Eyes small. Mouth very wide, its gape extends posteriorly beyond eyes. Barbels only 2 pairs. Maxillary pair long, extend posteriorly beyond the origin of anal fin. Mandibular very short extending only upto the corner of mouth. Dorsal fin short, spineless, inserted slightly in advance of pelvic fins. Pectoral spine weak and poorly serrated on the inner edge. Anal fin long, not confluent with caudal fin. Caudal fin forked, its upper lobe longer.

Colour

Greenish brown above, dull white below. Head slightly darker. Dorsal, anal and caudal fins dusky.

Distribution

Pakistan, India, Sri Lanka, Nepal, Bangladesh, Burma, Thailand, Vietnam, Sumatra and Java. Inhabits fresh water and tidal waters in rivers, tanks, reservoirs etc.

Remarks

Wallagu attu is one of the largest catfishes occurring in the rivers, lakes and tanks of Kerala. It is highly esteemed as food by the common people. It is a voracious predator and is very destructive to other more valuable food fishes like carps. This fish can be easily differentiated from other silurid genera by the huge mouth, the gape of which extends down wards beyond the eyes. It differs from *Pinniwallago* in having one rayed dorsal fin as against two dorsal fins in the latter one.

Genus ***Ompok*** Lacepede

Ompok Lacepede, 1803, *Hist. nat. Poiss.*, **5** : 49 (type – species : *Ompok siluroides* Lacepede = *Silurus bimaculatus* Bloch); Haig, 1951, *Rec. Indian Mus.*, **48** (¾) : 108 – 112 (Review); Parameswaran, 1968, *J. zool. Soc. India*, **19** (½) : 90 – 94 (Review).

Callichrous Hamilton – Buchanan, 1822, *Fishes of Ganges* : **149** (type – species : *Silurus (Callichrous) pabda* Hamilton – Buchanan).

Description

Body elongated and compressed. Head small and depressed. Mouth oblique, its gape not extending to front border of eyes. Lower jaw longer than upper jaw. Eyes small, visible from underside of head. Teeth villiform. Two pairs of barbels, one pair each of maxillary and mandibular. Mandibular barbels often rudimentary. Dorsal fin short with 3 - 5 rays. Anal fin very long with 52 to 75 rays. Pectoral fin with a spine and 11 to 14 rays. Pectoral spine only feebly serrated. Pelvic fin with 6 - 10 rays. Caudal fin forked, free from anal fin. Branchiostegal rays 12 – 15.

The genus consist of seven species. Only four occur in India.

KEY TO SPECIES

1	Maxillary barbels long, extending posteriorly well beyond head; pelvic fin with 7 – 9 rays	...	2
2	(a) Anal fin with 63–69 branched rays	...	*O. malabaricus*
	(b) Anal fin with 48 to 58 branched rays	...	3
3	Anal fin with 57 or 58 branched rays. Maxillary barbels extend posteriorly to anal fin base	...	*Ompok bimaculatus*

Ompok bimaculatus (Bloch)

(Plate – 10)

Silurus bimaculatus Bloch, 1797, *Ichthyol. Hist. nat. des. Poiss.,* **11** : 17, pl. 364 (type – locality : Malabar).

Callichrous bimaculatus : Day, 1877, *Fishes of India* : 476, pl. 110, figs 4, 5;Day, 1889, *Fauna Br. India,* Fishes, **1**:131, fig. 57.

Callichrous macrophthalmus (Blyth) : Day, 1877, *Fishes of India* : 478, pl. 110, figs 2, 3 : Day, 1889, *Fauna Br. India,* Fishes, **1** : 152.

Callichrous gangeticus (Peters) : Day, 1877, *Fishes of India* : 476; Day, 1889, *Fauna Br. India,* Fishes, **1** : 130.

Callichrous sindensis Day, 1877, *Fishes of India* : 476, pl. 110, fig. 1 (type – locality : Sind, Pakistan); Day, 1889, *Fauna Br. India,* Fishes, **1** ; 130; Talwar, 1991, J. *Inland Fish Soc. India.*

Ompok bimaculatus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 189, fig. 35.

Ompok canio (Hamilton – Buchanan) Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 192; Coad, 1981, *Nat. Mus. nat. Sci. Ottawa,* (14) : 15.

Ompok sindensis : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 198.

Description

D 4; P I 12 – 14; V 7 – 8; A 57 – 58

Based on 120 specimens ranging in total length from 150mm to 275mm and standard length from 130mm to 245mm, morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 20.93; Head length 20; Length of snout 34.88 of head length. Eye diameter 11.62 (in head length). Interorbital space 60.46 (in head length). Length of caudal peduncle 4.65. Predorsal length 28.84. Length of pectoral spine 7.91; Barbels : Maxillary 32.56; Mandibular 5.12.

Body elongate and highly compressed. Lower boarder of eyes below the level of cleft of mouth. Mouth oblique. Dorsal fin very short. Anal fin long, inserted well behind dorsal fin. Pectoral spine moderately strong and feebly serrated on its inner edge. Caudal fin deeply forked with pointed lobes. Barbels only 2 pairs. Maxillary barbels long and extend to or slightly beyond anal fin origin, the mandibular pair very short.

Colour

Dorsally dark grey to brownish with a tinge of golden yellow; a large dusky spot on the shoulder behind the gill opening and above the middle of pectoral fin; a small black spot on caudal peduncle. Fins pale golden.

Distribution

Afghanistan, Pakistan, India, Sri Lanka, Bangladesh, Burma, Java, Sumatra and Borneo.

Remarks

Ompok bimaculatus inhabits rivers, tanks and ponds and is a common fresh water food fish in India. It is closely related to *Ompok malabaricus in* the nature of maxillary barbels, which extend posteriorly well beyond head. The difference between the two species is that anal fin is with 63 to 69 branched rays in O. *malabaricus* while O. *bimaculatus* has only 48 to 58 branched rays in anal fin and the caudal fin with rounded lobes in *Ompok malabaricus* while with pointed lobes in *Ompok bimaculatus.*

Ompok malabaricus (Valenciennes)

(Plate – 11)

Silurus malabaricus Valenciennes, 1839, *Hist. nat. Poiss.*, **14** : 353 (type – locality : Malabar)

Callichrous malabaricus : Day, 1877, *Fishes of India* : 478, pl. 111, fig. 1; Day, 1889, *Fauna Br. India,* Fishes, **1** : 133.

Silurus goae Haig, 1951, *Rec. Indian Mus.*, **48** (3/4) : 77, fig. 1 (type – locality : Goa and Trivandrum); Jayaram, 1981, *Handbook zool. Surv. India,* (2) : 211; Talwar, 1991, *J. Inland Fish. Soc. India.*

Ompok malabaricus : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 193, fig.

Description

D 4; P I 11 – 12; A 63 – 65; V 7

Based on 6 specimens ranging in total length from 160mm to 184mm (Mean 168mm) and standard length from 142mm to 161mm (Mean 151mm), morphological studies were conducted. Body measurements are taken in the percentage of standard length. Greatest body depth is 21.74; Head length is 19.88; Length of snout 37.5 of head length; Eye diameter 12.5 (in head length); Length of caudal peduncle 3.11; Predorsal length 33.54; Length of pectoral spine 9.32; Barbels: Maxillary 26.71; Mandibular 7.45.

Body thin, elongate and compressed. Gape of the mouth wide and oblique. Dorsal fin spineless and narrow. Pectoral fin round, its spine moderately strong with serrations on the inner edge. Anal fin with 63 – 65 rays extending from the base of the ventral to the caudal and it is separated from the caudal by a notch. Caudal fin forked, with rounded tips. Barbels two pairs. Maxillary barbels extend slightly beyond the pelvic fin origin. Mandibular barbels very small and slender.

Colour

Silvery or greyish above, paler below; a black spot behind the gill opening.

Distribution

Goa and Kerala

Remarks

O. malabaricus is commonly found in the rivers, streams and lakes of North and Central Kerala and it is highly esteemed as food. The species status of this fish was in dispute till recently. Day (1878) has reported 7 species of fishes under the genus *Ompok* Lacepede in the fresh waters of India. However Hora (1936) recognized only two namely *O. bimaculatus* (Bloch) and *O. Pabo* (Hamilton) as valid species and included the other five species as synonyms under the former. Selvaraj and Karthikeyan (1998) have resurrected the original species status of *O. malabaricus* (Valenciennes), based on their extensive studies on the morphometric and meristic characters of the specimens of *O. bimaculatus* and *O. malabaricus.* The statistical analysis of the data also proves the species status of *O. malabaricus.*

FAMILY : **HETEROPNEUSTIDAE**

Body elongate and compressed. Head flat and greatly depressed; its dorsal and lateral parts covered with osseous plates. Mouth small and terminal. 4 pairs of barbels, all are well developed. Nostrils wide apart. Gill openings wide. Accessory respiratory organs in the form of a long air tube extending upto the tail present. Dorsal fin spineless;

adipose fin absent. Anal fin extremely long and reaches upto caudal fin. Pectoral fin with a strong spine. Pelvic fin with 6 rays. Caudal fin rounded. Branchiostegal rays 7.

These fishes live in stagnant pools and ditches deficient in oxygen. The family Heteropneustidae is represented by a single genus in Indian region.

Genus ***Heteropneustes*** Muller

Heteropneustes Muller, 1840, *Arch. Anat. Physiol* : 115 (type-species : *Silurus fossilis* Bloch); Hora, 1936, *Rec. Indian Mus.*, **38** (2): 208 – 209 (Review).

Saccobranchus Valenciennes, 1840, *Hist. nat. Poiss.*, **15** : 399 (type – species : *Silurus singio* Hamilton – Buchanan = *Silurus fossilis* Bloch)

Description

Head greatly compressed. Mouth terminal, small, lips fleshy and papillated. Dorsal fin small, spineless, inserted above the tip of pectoral fins. Anal fin long, caudal fin rounded. Air bladder greatly reduced, consisting of two thin walled sacs.

This genus is widely distributed in the oriental region having two species, but *H. fossilis* is more common in Kerala.

KEY TO SPECIES

1	(a)	Anal fin confluent with caudal fin; occipital process reaching the base of dorsal fin	...	*H. microps.*
	(b)	Anal fin separated from caudal fin by a deep notch; occipital process not extending to the base of dorsal fin.	...	*H. fossilis*

Heteropneustes fossilis (Bloch)

(Plate - 12)

Silurus fossilis Bloch, 1794, *Naturgesch. Ausl. Fische,* **8** : 46, pl. 370, fig. 2 (type – locality : Tranquebar, Tamil Nadu).

Saccobranchus fossilis : Day, 1877, *Fishes of India* : 486, pl. 114, fig. 1 : Day, 1889, *Fauna Br. India,* Fishes, **1** : 125, fig. 53.

Heteropneustes fossilis : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 135, fig. 24.

Description

D 6; A 55 – 60; P I 8; V 5

Based on 15 specimens ranging in total length from 150mm – 170mm (mean = 159mm) and standard length from 131mm – 152mm (mean = 141mm) morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 17.86. Head length 17.86. Length of snout 16 of head length. Eye diameter 12 (in head length). Inter orbital space 60 (in head length). Length of caudal peduncle 1.43. Predorsal length 32.86; Length of Pectoral spine 10.71. Barbels : Nasal 16.43; Maxillary 25; Outer mandibular 23.57; Inner mandibular 19.29.

Body elongate, well compressed posteriorly. Head depressed. Interorbital space flat and broad. Snout rounded. Mouth small and terminal. Four pairs of barbels, all well developed. Maxillary extends beyond the origin of anal fin. Villiform teeth in band in jaws. Dorsal fin short, spineless, inserted above the tip of pectoral fins. Pectoral fin with a strong spine, serrated along its inner edge and with a few serrations at its anterior end externally. Anal fin long, not confluent with caudal fin. Caudal fin rounded.

Colour

Body uniformly dark brown above, dull white below. Anal and caudal fins more black. Dorsal, ventral and pectoral fins dusky black. Young reddish.

Distribution

Pakistan, Nepal, Bangaladesh, Sri Lanka, Burma, Thailand and India.

Remarks

Heteropneustes fossilis is commonly found in ponds, ditches, swamps and marshes. It can tolerate slight brackish water also. The accessory respiratory organ of the fish enables it to exist in any kind of water. The fish is of economic importance because of its medicinal value. *Heteropneustes* resembles its related genus *Clarias* in having a spineless dorsal fin and in the absence of adipose dorsal fin. The main difference of the two genera is that *Clarias* has a long dorsal fin. *H. fossilis* is differentiated from its co-species *H. microps* in having the anal fin separated from caudal and the occipital process not extending to the base of dorsal fin.

FAMILY : **CLARIDAE**

Body elongate and cylindrical. Head broad and flat. Eyes small or absent. Nostrils widely separated. Mouth terminal and transverse. Teeth in villiform bands on jaws. Barbels 4 pairs, all well developed. Gill opening wide. Accessary respiratory organ (dendritiform organ) usually well developed, sometimes vestigial. Dorsal fin base very long, extending upto caudal, usually spineless with more than 30 soft rays and not confluent with caudal. Adipose dorsal fin absent. Anal fin also very long with more than 40 soft rays and not confluent with caudal fin. Pectoral fin well developed or vestigial; pelvic fin with six rays. Caudal fin rounded.

Although the family has 14 or 15 genera, only 2 occur in India.

KEY TO GENERA

1	(a)	Eyes present. Pectoral fins well developed; lateral line distinct	...	*Clarias*
	(b)	Eyes absent. Pectoral fins vestigial; lateral line faint.	...	*Horaglanis*

Genus ***Clarias*** Scolopi

Clarias Scolopi, 1777, *Introductio ad Historian Naturalem* : 455 (type - species : *Silurus anguillaris Linnaeus)*; Teugels and Roberts, 1987, *Zool. J. Linn. Soc.,* **90** : 95 (type – species designated); Hora, 1936, *Rec. Indian. Mus.*, **38** (3): 347 – 350 (Review).

Description

Body elongate and compressed. Torpedo shaped in side view. Head slightly depressed covered with osseous plates dorsally and laterally. Eyes small, invisible from underside of head. Dorsal and anal fins long based. Pectoral and pelvic fins well developed. Pectoral fin with a strong spine. Lateral line distinct. Accessory respiratory organ called dendritiform organ well developed. Branchiostegal ray 7 – 9.

Four species of *Clarias* occur in the Indian region.

KEY TO SPECIES

1	(a)	Dorsal fin inserted at a considerable distance from the snout, the distance 4.5 – 6 times in length of head	...	*C. batrachus*
	(b)	Dorsal fin placed closer to head the distance 2.1 to 3.5 times in length of head	...	2
2	(a)	Snout rather broad, nasal barbel longer, more than half of head length	...	3
	(b)	Nasal barbel shorter	...	4
3		Pectoral spine strongly serrated on its posterior boarder. Dorsal fin with 66 – 69 rays	...	*C. dussumieri*
4		Maxilliary barbel little longer than head. Dorsal fin with 62 – 82 rays	...	*C. gariepinus*

Clarias dussumieri Valenciennes

(Plate – 13)

Clarias dussumieri Valenciennes, 1840, *Hist. nat. Poiss.*, **15** : 382 (type – locality : Pondicherry; Malabar); Day (Partim), 1877, *Fishes of India* : 484; Day (Partim), 1889, *Fauna Br. India*, Fishes, **1** : 117; Hora, 1941, *Rec. Indian Mus.*, **43** (2); 113, fig. 6 : Misra, 1976, *Fauna of India.*, Pisces (2nd ed.), **3** : 130.

Description

D 66 – 69; A 45 – 59; P I 10 – 11; V 5

Based on 10 specimens ranging in total length from 160 mm – 225mm (mean 190mm) and standard length from 143mm – 205mm (mean (165mm) morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 18.44. Head length is 23.64. Length of snout 28.2 of head length. Eye diameter 7.69 (in head length) Interorbital space 53.84 (in head length). Length of caudal peduncle 1.21. Predorsal length 34.55. Length of pectoral spine 10.3. Barbels: Nasal 18.18; Maxillary 21.21. Outer mandibular 21.21. Inner mandibular 15.15.

Body elongate. Head depressed, snout broad. Mouth terminal, teeth in villiform bands on jaws. Barbels 4 pairs. Maxillary extend beyond pectoral fin base; outer mandibular barbels reach the base of pectoral fins. Inner mandibular shorter. Dorsal fin inserted opposite to the tip of the pectoral fins. Pectoral spine strong, well serrated on its outer edge, but only a few small teeth on its inner margin.

Colour

Black above, lighter ventrally.

Distribution

India (Goa, Karnataka, Kerala and Pondicherry) in ponds, tanks & ditches.

Remarks

Clarias dussumieri is a common catfish of Kerala occurring in ponds, ditches, tanks etc. It can live out of water for sometime, as it possesses an accessory respiratory organ. It is highly esteemed as food. *Clarias dussumieri* is differentiated from its allied species *C. batrachus* in having a dorsal fin closer to head with 66 – 69 rays.

Clarias batrachus (Linnaeus)

(Plate – 14)

Silurus batrachus Linnaeus, 1758, *Systema naturae,* I, ed. **10** : 305 (type – locality: Asia and Africa.)

Clarias magur (Hamilton – Buchanan) Day, 1877, *Fishes of India* : 485, pl. 112, figs. 5, 5a; Day, 1889, *Fauna Br. India,* Fishes, **1** : 115, figs. 48, 49; Misra, 1976, *Fauna of India,* Pisces (2nd ed), **3** : 125, fig. 23.

Clarias jagur (Hamilton – Buchanan) Day, 1877, *Fishes of India* : 484.

Clarias assamensis Day, 1877, *Fishes of India*; 485 type – locality : Goalpara and as high as Suddya, Assam); Day, 1889, *Fauna Br. India,* Fishes, **1** : 117; Hora, 1936, *Rec. Indian Mus;* **38** (3) : 350.

Description

D 70 – 75; A 45 – 58; P1 8 – 11; V5

Based on 5 specimens ranging in total length from 175mm to 194mm (mean 187mm) and standard length from 153mm to 170mm (mean 162mm) morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 19.14. Head length 25.31. Length of snout 29.1 of head length. Eye diameter 7.32 (in head length) Interorbital space 51.22 (in head length). Length of caudal peduncle 2.47. Predorsal length 33.95. Length of pectoral spine 9.26. Barbels: Nasal 14.2; Maxillary 21.6; Outer mandibular 19.75 and Inner mandibular 14.81.

Body elongate, head moderately depressed, occipital process angular and narrow. Mouth terminal; teeth in villiform bands on jaws. Barbels 4 pairs. Maxillaries reach beyond the base of pectoral fins and the nasals extend to gill openings. Dorsal fin starts slightly below the tip of pectoral fins. Pectoral spine strong, serrated on both edges.

Colour

Brown to bluish green superiorly, becoming lighter below ventrally. Often numerous striking white spots on the flanks. Dorsal and anal fins usually with red margins.

Distribution

India, Pakistan, Nepal, Sri Lanka, Bangla desh, Burma, Indonesia, Singapore & Philippines.

Remarks

This catfish is of common occurrence in ponds and rivers and in the mud they lie concealed for hours. The accessory respiratory organ helps the fish to remain out of water for some time. It is highly nutritious and it is used as a test animal for the biological assay of pituitary hormones. This catfish is of culture value and it is cultured in shallow ponds. *C. batrachus* differs from *C. dussumieri* in the nature of dorsal fin which is inserted at a considerable distance from the end of head.

Clarias gariepinus (Burchell)

(Plate – 15)

Silurus (Heterobranchus) gariepinus, Burchell, Trav. Int. S. Afr. i.p 425, fig. (1822)

Clarias capensis (non C & V), A. Smith, III *Zool. S. Afr.* Pisc. pl. XXVII (1845)

Clarias mossambicus, part, Peters. *Mon. Berl. Ac.* 1852, p.682 and Reise Mossamb. IV. P. 32, pl. vi. Figs 1 & 2 and pl. vii. Figs 2 & 3 (1868).

Clarias gariepinus, Gunth. Cat. Fish V.P. 14 (1864); M. Weber, *Zool. Jahrb, Syst.* x 1897, P. 149; *Bouleng. Poiss. Bass. Congo*, p. 254 (1901) and *Proc. Zool. Soc.* 1907, p. 1069.

Description

D 62 – 82; A 46 – 65; P I 8 – 10; V 5

Morphological studies were conducted based on 8 specimens having a total length between 305 – 340mm (Mean 320mm) and standard length from 262 mm to 300mm (mean 275mm). Body measurements are expressed in percentage of standard length. Greatest body depth is 15.27. Head Length is 23.64. Length of snout 23.08 of head length. Eye diameter 6.15 (in head length). Interorbital space 53.85 (in head length). Length of caudal peduncle 2.55. Predorsal length 33.09. Length of pectoral spine 9.09. Barbels : Nasal 14.18. Maxillary 26.55. Outer mandibular 22.91. Inner mandibular 16.36

Body elongate. Head depressed, about 1½ times as long as broad, its upper surface more or less distinctly granulate in the adult, occipital process angular, eyes very small, 3 – 4 times in length of snout. Width of mouth nearly equal to interorbital width. Maxillary barbel longer than head in adult, while a little shorter in young. Outer mandibular barbel about 1½ times as long as inner. Dorsal fin with 62 – 82 rays, its distance from occipital process 1/5 to 2/7 length of head. Anal 50 – 60 not reaching caudal. Pectoral spine serrated on the outer boarder. Ventrals nearly equally distant from end of snout and from caudal or a little nearer former.

Colour

Olive above, uniform or marbled with dark brown, white below. A more or less distinct light vertical bar on the base of caudal, anal edged with red.

Distribution

African countries

Remarks

This catfish is not of Indian origin, but now cultured in large numbers in inland water bodies of our country. So this fish is of fishery interest like the Indian major carps. It attains a greater size than the other species of *Clarias.* It is distinguishable from *Clarias dussumieri* in the nature of the ventral fin which is inserted midway between end of snout and root of caudal and the maxilliary barbel which is longer than head.

FAMILY : **PLOTOSIDAE**

Body elongate and torpedo shaped. Tail usually tapering. Nostrils widely separated, anterior tubular, posterior slit like. Mouth wide. Barbels 4 pairs, well developed. Gill openings wide, extending to above the base of pectoral fins. Two rayed dorsal fins; first small with a serrated spine. Second dorsal very long, confluent with caudal. Adipose dorsal fin absent. Pectoral fins laterally placed with a strong serrated spine. Anal fin also very long, confluent with caudal. A well developed dendritic organ between vent and anal fin present. Caudal fin pointed. Lateral line conspicuous.

Found in Indo-Pacific Ocean; mostly marine occasionally enter into rivers also. 8 genera present, but only one occur in Indian waters.

Genus ***Plotosus*** Lacepede

Plotosus Lacepede, 1803, *Hist. nat. Poiss.,* **4** : 129 (type - species: *Platystacus anguillaris* Bloch = *Silurus lineatus* Thunberg); Gomon and Taylor, 1982, *J.L.B. Smith Inst. Icthyol. Sp. Publ.,* (22) : 1 - 16 (Review).

Description

Body elongate and compressed. Head depressed. Tail tapering. Snout rounded. Nostrils wide apart. Anterior nostril a small tube above upper lip. Mouth transverse. Jaws equal with conical teeth in upper jaw. Two dorsal fins. Second dorsal and anal are long and confluent with caudal. No adipose dorsal fin. Pelvic fin with 11 - 14 rays. Dendritic organ present below anus. Barbels 4 pairs. Air bladder relatively large.

These fishes occur in marine, brackish and fresh waters of tropical and warm temperate regions. Five species, three in India; two common in fresh water.

KEY TO SPECIES

1	Nasal barbels extend behind eyes. No stripes on the body	...	*P. Canius*
2	Nasal barbels short, not extending behind eyes. Body with two or three prominent stripes.	...	*P. lineatus*

Plotosus lineatus (Thunberg)

(Plate – 16)

Silurus lineatus Thunberg, 1787, *K. Vetensk. Akad. Nya Handl.*, **12** : 190 (type - locality : Indian Ocean).

Plotosus arab (Bleeker) Day, 1877, *Fishes of India* : 483, pl. 112, fig. 4; Day, 1889, *Fauna Br. India,* Fishes, **1** : 113; Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 148

Plotosus anguillaris (Bloch) Misra, 1962, *Rec. Indian Mus.*, **57** : 117.

Description

D I 4 – 5; P I 10; V10 – 12 procurrent C 70 – 112 ; A 58 – 80.

Based on two specimens with average total length 283mm and standard length 265 mm, morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 20.49. Head length 22.54. Length of snout 38.18 of head length. Eye diameter 10.9 (in Head length). Interorbital space 45.45 (in head length). Predorsal length 26.64. Length of dorsal spine 7.79. Length of pectoral spine 8.2. Barbels : Nasal 7.79, Maxilliary 8.2, Inner mandibular 8.2, Outer mandibular 7.79.

Body elongate. Head moderate sized, its profile slightly arched from snout to dorsal fin. Mouth transverse. Barbels 4 pairs, short and almost equal in size. Maxillary reach beyond the base of eye. Eyes fairly large. First dorsal fin with a spine serrated on both sides. Continuous dorsal fin arises above the middle of the body almost in line with the anal. Second dorsal and anal fins confluent with the caudal fin. Caudal end tapering.

Colour

Greyish black above, lighter below. Three whitish longitudinal stripes on the body. Anterior dorsal stripe extend from snout to tail behind the continuous dorsal fin. Middle one start from the base of head and the lower most extend from belly, behind the ventral fin. Stripes become faint in the larger and older fishes. Distal end of dorsal fin black.

Distribution

Pakistan, Srilanka, India (Kerala, Maharashtra, Gujarat and Tamil Nadu).

Remarks

This is a marine catfish which migrates to brackish and fresh waters. *P. lineatus* resembles its related species *P. canius* in the nature of the continuous dorsal and anal fins confluent with the caudal fin. But the former can be easily differentiated from the latter by the presence of the three longitudinal stripes extending from head to caudal end.

FAMILY : **ARIDAE**

Body more or less elongate, and large sized. Supra occipital process extends backward to the predorsal plate at the base of dorsal fin. Mouth terminal to inferior. Nostrils close together, posterior with a valve, but without a barbel. Barbels two to six moderate to well developed. Nasal barbels absent. Gill openings wide. Dorsal and pectoral fins with a spine. Adipose dorsal fin present opposite to anal fin. Anal fin moderately long. Caudal fin forked or bifurcate. Gill membranes fused with each other and attached to isthmus. Lateral line usually complete.

These medium to large sized catfishes inhabit coastal waters, particularly river mouths. Some occur only in freshwater and some other species often visit fresh water. About 20 genera; six in Indian region of which five occur in inland waters.

KEY TO GENERA

1	(a)	One pair of barbels	...	2
	(b)	Three pairs of barbels	...	3
2		Maxillary barbels alone present which are stiff and semiosseous	...	*Osteogeneiosus*
3		Palate with teeth. Anterior five vertebrae fused, none of which bear ribs	...	*Arius*

Genus ***Osteogeneiosus*** Bleeker

Osteogeneiosus Bleeker, 1846, *Natuurk Geneesk Archipel. Ned. – Indie,* (2) **3** : 146, 173 (type – species : *Osteogeneiosus macrocephalus* Bleeker = *Silurus militaris* Linnaeus); Jayaram, 1982, *Rec. zool. Surv. India.* Occ. Paper, (37) : 6 – 7 (Review)

Description

Body elongate. Abdomen rounded. Head large, strongly compressed. Eyes fairly small, visible from underside. Jaws unequal, upper jaw projecting before mouth. Teeth villiform in bands on jaws. Barbels only 1 pair : a pair of semiosseous stiff maxillary barbels. Gill membranes united with each other and posteriorly united with isthmus. Dorsal fin short, with one pungent spine and seven rays. Adipose dorsal short. Pectoral fin with 10 or 11 rays and a strong serrated spine. Pelvic fin with 6 rays. Anal fin moderately long. Caudal fin forked. Lateral line complete.

Monotypic, inhabits the seas, estuaries and tidal rivers of India, Pakistan, Sri Lanka, Bangladesh etc..

Osteogeneiosus militaris (Linnaeus)

(Plate – 17)

Silurus militaris Linnaeus, 1758, *Systema Naturae,* **1** (ed. 10) : 305 (type – locality : Asia).

Osteogeneiosus militaris : Day, 1877, *Fishes of India* : 469, pl. 108, fig. 4; Day, 1889, *Fauna Br. India,* Fishes, **1** : 190, fig. 69; Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 21.

Osteogeneiosus sthenocephalus Day, 1877, *Fishes of India* : 469, pl.108, fig. 3 (type – locality : Moulmein, Burma); Day, 1889, *Fauna Br. India,* Fishes, **1** : 191; Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 22

Description

D I 7 ; P I 10; V 5; A 14 – 16

Based on 3 specimens ranging in total length from 281 mm to 320mm (mean 302mm) and standard length from 243 mm to 280 mm (mean 261mm) morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 19.16; Head Length 27.59; Length of snout 37.5 of head length. Eye diameter 8.33 (in head length). Interorbital space 69.44 (in head length); Predorsal length 39.46; Length of dorsal spine 11.88, length of pectoral spine 9.2. Maxillary barbel 26.82. Length of caudal peduncle 16.09.

Body elongate. Head compressed. Head shield smooth. A pair of very stiff and osseous maxillary barbels present extending upto the base of pectoral fin. Adipose dorsal fin short and it arises much below the origin of anal. Dorsal and pectoral spines strong and serrated. Caudal fin forked with broad equal lobes.

Colour

Head and back bluish black, underside silvery white. Fins greyish white. Tips of dorsal and adipose fins dark blue.

Distribution

Pakistan, India, Sri Lanka, Bangladesh and Burma in seas, estuaries and tidal rivers.

Remarks

This catfish is commonly found in the lower courses of rivers. It can be easily identified by the single pair of stiff, semiosseous barbels that arise on the snout and extend to the base of pectoral fins. It is similar to other genera of Aridae in the absence of nasal barbels and in the presence of a valve separating the nostrils.

Genus ***Arius*** Valenciennes

Arius Valenciennes, 1840, *Hist. nat. Poiss.*, **15** : 53 (type - species : *Pimelodus arius* Hamilton - Buchanan) : Wheeler and Baddokwaya, 1981, *J. nat. Hist. Lond.*, **15** : 769 (status recognised), Jayaram, 1982, *Rec. zool. Surv. India Occ.* Paper, (37) : 1 - 33 (Review).

Description

Body elongate and fairly compressed. Abdomen rounded. Head large, subconical, depressed with more or less granular or rugose osseous shields on dorsal surface covered with thin skin. Eyes lateral or slightly directed upwards, often visible from underside of head. Mouth moderate, subterminal. Teeth villiform on jaws. Three pairs of barbels: One pair maxillary, two mandibular. Branchiostegal rays 5 or 6.

Most of these fishes are primarily marine, but some are confined to fresh water. The Indian species of this group were previously known (Chandy, 1954; Jayaram 1981) under the generic name *Tachysurus* Lacepede. *Tachysurus* is not an arid catfish as it was illustrated and described as having a rayed adipose fin. (Wheeler and Baddokwaya, 1981). Most of the species are economically important.

KEY TO SPECIES

1	(a) Teeth on the palate in two patches on each side	...	2
	(b) Teeth on the palate in one patch on each side	...	3
2	Snout elongated and a little depressed Barbels very short.	...	*A. Subrostratus*
3	Median longitudinal groove on the top of head reaching to the base of supraoccipital process; and fin rays 20 or 21.	...	*A. arius*
4.	Mouth subterminal snout obtusely rounded	...	5
5.	(a) Tooth patch on palate pear shaped, placed at the posterior extremity of roof of the mouth; palatine teeth globular	...	*A. tenuispinis*

(b) Tooth patch almost triangular shaped, placed anteriorly on the roof of mouth; villiform palatine teeth ... *A. caelatus*

Arius subrostratus (Cuv & Val)

(Plate – 18)

Arius subrostratus, Cuv and Val XV, p. 62; Jerdon, M.J.L. and Sc. 1851, p.146; Bleeker, *Beng. en. Hind.* p. 58; Day, *Fish. Malabar,* p. 177.

Arius rostratus, Cuv and Val. I.C.P. 63; Jerdon, I.C.P. 146; Bleeker, *Beng. En. Hind. p* .56.

Description

D I 7; P I 9 ; V 6 ; A 17 – 19; C 17 – 24

Based on 10 specimens ranging in total length from 170mm to 205mm (mean 187mm) and standard length from 133mm to 170mm (mean 152mm), morphological studies were conducted. Body measurements are expressed in percentage of standard length. Greatest body depth is 20.30; Head length 30.08; Length of snout 50 of head length; Eye diameter 17.5 (in head length). Interorbital space 37.5 (in head length); Predorsal length 42.11; length of dorsal spine 20.30; Length of Pectoral spine 18.8; Length of caudal peduncle 15.04.

Barbels : Maxillary barbel 15.04; Inner mandibular 7.52; Outer mandibular 7.52.

Body elongate and slightly compressed. Head large and depressed. Snout elongated, upper jaw slightly longer. Median longitudinal groove of the head shallow, anteriorly becoming narrow, extending nearly to the base of occipital process. Barbels short, maxillary barbel extends almost up to the eye. Mandibular barbels much shorter. Dorsal spine not strong, rather above half as long as head. First fin ray of the dorsal fin has a long filamentous prolongation. Pectoral scarcely reaches the ventral. Its spine almost equal in length to dorsal spine, internally serrated. Ventral fin reaches anal.

Colour

Silvery grey along the back. A series of about 15 feeble vertical bands on the body.

Distribution

Malabar coast of Kerala

Remarks

This fish is primarily marine, but it is also confined to estuaries and tidal rivers. It can be easily identified from other arid fishes by the filamentous prolongation of the dorsal fin which in young fishes reaches almost to the base of caudal.

Arius tenuispinis (Day)

(Plate – 19)

Arius tenuispinis Day, 1877, *Fishes of India* : 466, pl. 107, fig. 5 (type – locality : Bombay); Day, 1889, *Fauna Br. India,* Fishes, **1** : 187; Talwar, 1976, *Rec. zool. Surv. India,* **69** : 291. (Identity discussed); Jayaram, 1982, *Rec. zool. Surv. India Occ. Paper* (37) : 31, fig. 24 (Diagnostic characters).

Arius satparanus Chaudhuri, 1916, *Mem. Indian. Mus.,* **4** : 430, fig. 6 – 8 (type – locality : Chilka lake, Orissa).

Hemipimelodus tenuispinis : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 18.

Description

D I 7 ; A 13 ; P I 10 ; V 5

Morphological studies were conducted based on 5 specimens ranging in total length from 241mm to 265mm (Mean 252mm) and standard length from 191mm to 214mm (mean 202mm). Body measurements are expressed in percentage of standard length. Greatest body depth is 25.25. Head length 26.73. Length of snout 38.89 of head length. Eye diameter 14.81 (in head length). Inter orbital space 57.41 (in head length). Predorsal Length 36.14. Length of dorsal spine 16.34. Length of pectoral spine 15.84. Length of caudal peduncle 12.38. Barbels : Maxillary barbel 22.77. Inner mandibular 9.9. Outer mandibular 17.33.

Body strong, stout and elongated. Head depressed. Head shield granulated thinly. Median longitudinal groove on the head long, deep extending into supra occipital process. Barbels three pairs. Maxillaries reach the base of pectoral fin. Mouth subterminal. Teeth on palate placed far back in the buccal cavity. Dorsal and pectoral spines thin and slender.

Colour

Cement grey on the dorsal surface of the head and on the dorsal half of the body. Belly silvery grey.

Distribution

East coast of India and Africa.

Remarks

Arius tenuispinis is one of the important marine catfishes constituting a major part of the catfish landings of the country. The fish is often found in brackish waters also. It is highly edible and is different from other catfishes in the nature of attenuated dorsal and pectoral spines.

Arius arius (Hamilton – Buchanan)

(Plate – 20)

Pimelodus arius Hamilton – Buchanan, 1822, *Fishes of Ganges*; 170, 376 (type – locality : estuaries of Bengal).

Arius buchanani Day, 1877, *Fishes of India* : 463, pl. 105, fig. 6 (type – locality : Hoogly river at Calcutta; Burma); Day, 1889, *Fauna Br. India,* Fishes, **1** : 181.

Tachysurus arius : Misra, 1976, *Fauna of India,* Pisces (2nd ed.), **3** : 32, fig. 3.

Arius arius : Jayaram, 1982, *Rec. zool. Surv. India Occ. Paper,* (37) : 16, fig. 12 (Diagnostic characters).

<u>Description</u>

D I 7 ; A 14 – 16 ; P I 10 ; V 5

Morphological studies were conducted based on 8 specimens ranging in total length from 155mm to 220mm (Mean 176mm) and standard length from 127mm to 190mm (Mean 160mm). Body measurements are expressed in percentage of standard length. Greatest body depth is 25.93; Head length 25.93; Length of snout 34.29 of head length. Eye diameter 14.29 (in head length). Inter orbital space 60 in head length. Predorsal Length 36.3. Length of dorsal spine 19.26. Length of Pectoral spine 17.78. Length of caudal peduncle 11.85. Barbels : Maxillary barbel 27.41, Inner mandibular 12.59, Outer mandibular 19.26.

Body robust and elongate. Head depressed with a shallow median groove on the top which do not reach the base of the supra occipital process. Three pairs of barbels. Maxillary barbels extend to anterior one - third of the pectoral fin. Mouth narrow and subterminal. Teeth in a single large ovate patch on each side. Tip of the dorsal spine is prolonged into a filament.

Colour

Dark blue to silvery steel along back, lighter below. Dorsal and pectoral fin margins posteriorly dusky. Adipose fin usually with a black spot.

Distribution

Pakistan, India, Bangladesh and Burma.

Remarks

This catfish is common in estuaries, tidal rivers and brackish water lakes of Central Kerala.

Arius caelatus Valenciennes

(Plate - 21)

Arius caelatus Valenciennes, 1840, *Hist. nat. Poiss.*, **15** : 66 (type - locality : Bombay); Day, 1877, *Fishes of India* : 459, pl. 105, fig. 5; Day, 1889, *Fauna Br. India,* Fishes, **1** : 174, Jayaram, 1982, *Rec. zool. Surv. India Occ. Paper,* (37) : 18, Fig. 13 (Diagnostic characters).

Arius nenga (*nec* Hamilton - Buchanan) Day, 1877, *Fishes of India* : 458, pl. 104, fig. 3; Day, 1889, *Fauna Br. India,* Fishes, **1** : 173, fig. 67.

Tachysurus nenga : Misra, 1976, *Fauna of India,* (2nd ed.), **3**: 50.

Tachysurus caelatus : Misra, 1976, *Fauna of India,* Pisces(2nd ed.), **3**:35, fig. 4.

Description

D I 7; A 16 – 17; P I 9; V 5

Morphological studies were conducted based on six specimens ranging in total length form 154mm to 218mm (Mean 180.6mm) and standard length from 125mm to 180mm (Mean 141.25mm). Body measurements are expressed in percentage of standard length. Greatest body depth is 25.38; head length 24.61; Length of snout 43.75 of head length. Eye diameter 14.1 (in head length). Inter orbital space 59.38 in head length. Predorsal length 36.92 ; Length of dorsal spine 20; length of pectoral spine 19.23; length of caudal peduncle 19.23; Barbels : Maxillary barbel 30.77; Outer mandibular 19.23; Inner mandibular 12.31.

Body elongate and robust. Head depressed, braoder than higher. Upper surface of the head and occipital process strongly granulated. The median longitudinal groove narrow and deep posteriorly and does not reach the supraoccipital process. Barbels three pairs. Maxillary barbels extend beyond the origin of pectoral fins. Teeth villiform in two triangular patches. Dorsal spine very strong. Tip of the dorsal fin produced into a short filament. Upper caudal lobe slightly longer.

Colour

Dark blue to brown on the top of head and back, whitish below, the whole body with a metallic lustre. Adipose fin may be either entirely black or with a black blotch. Tip of the dorsal fin also blackish.

Distribution

India, Pakistan, Sri Lanka, Burma and Bangladesh.

Remarks

Arius caelatus is primarily marine, but it frequently enters brackish waters and rivers. It is common in the backwaters of Central Kerala.

Table - 2.1

List of inland catfishes of Central Kerala with a key of taxonomic group, Scientific Name, Common Name and Vernacular Name

Sl. No.	*Order*	*Family*	*Scientific Name*	*Common Name*	*Vernacular Name*	*Nature of Habitat*	*Status*
1	Siluriformes	Bagridae	*Mystus armatus*	Kerala mystus	Coori	Fresh water	Very common
2	”	”	*Mystus oculatus*	Malabar mystus	Chinna coori	”	”
3	”	”	*Mystus cavasius*	Gangetic mystus	Karadu	”	Common
4	”	”	*Mystus punctatus*	Nilgiri mystus	Karadu	”	Rare
5	”	”	*Mystus montanus*	Wynad mystus	Kallen coori	”	Rare
6	”	”	*Mystus gulio*	Long whiskered catfish	Vella coori	Estuarine	Common
7	”	”	*Aorichthys seenghala*	Giant river catfish	Karadu	Fresh water	”
8	”	”	*Horabagrus brachysoma*	Gunther’s catfish	Manjayeta	Estuarine	”
9	”	Siluridae	*Wallago attu*	Freshwater shark	Attu valay	”	”
10	”	”	*Ompok bimaculatus*	Butter catfish	Thonnivala	”	”
11	”	”	*Ompok malabaricus*	Goan catfish	”	”	”
12	”	Heteropneustidae	*Heteropneustes fossilis*	Singhi	Kadu	Fresh water	”
13	”	Claridae	*Clarias dussumieri*	Valenciennes clariid	Mushi	”	”
14	”	”	*Clarias batrachus*	Magur	Mushi	”	”
15	”	”	*Clarias gariepinus*	African catfish	African mushi	”	Exotic
16	”	Plotosidae	*Plotosus lineatus*	Striped eel catfish	Kadal mushi	Estuarine	Migratory
17	”	Aridae	*Osteogeneiosus militaris*	Soldier catfish	Coori	”	”
18	”	”	*Arius subrostratus*	Theadfin sea catfish	Chundan coori	”	Migratory & Common
19	”	”	*Arius tenuispinis*	Thinspine sea catfish	Etta coori	”	Migratory
20	”	”	*Arius arius*	Theadfin sea catfish	Chundan coori	”	”
21	”	”	*Arius caelatus*	Engraved catfish	”	”	”

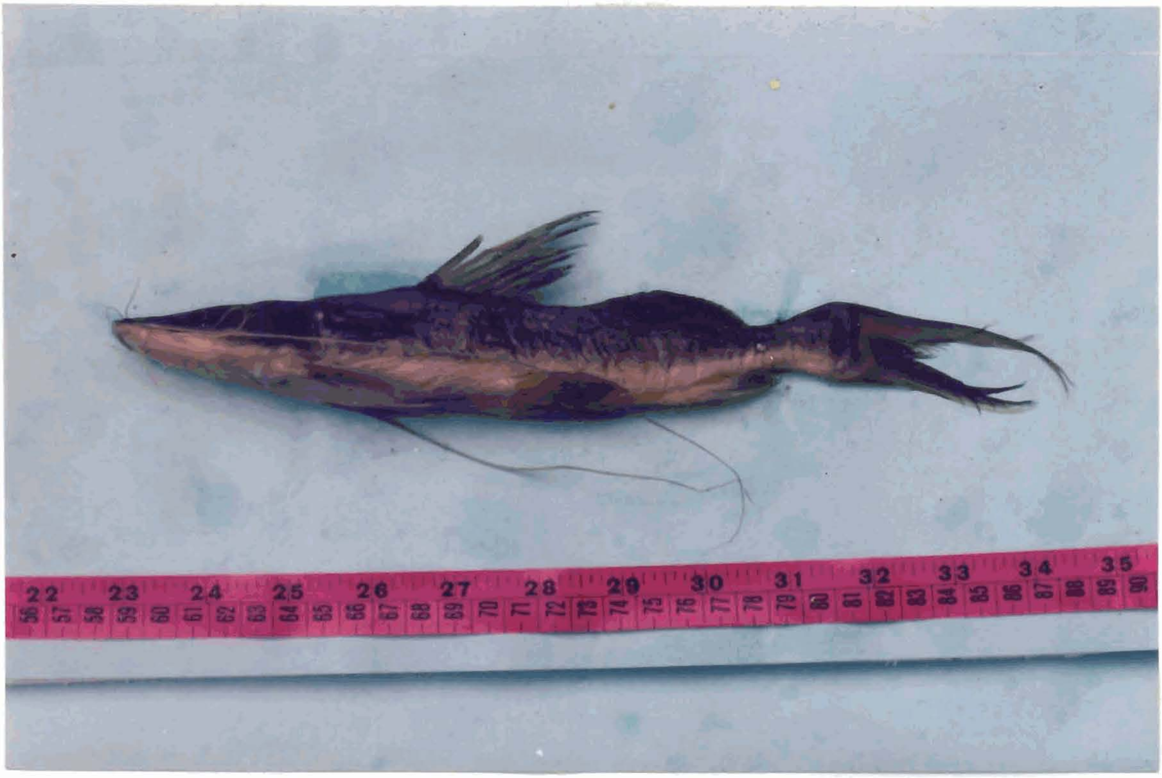

PLATE – 1 : *AORICHTHYS SEENGHALA* (SYKES)

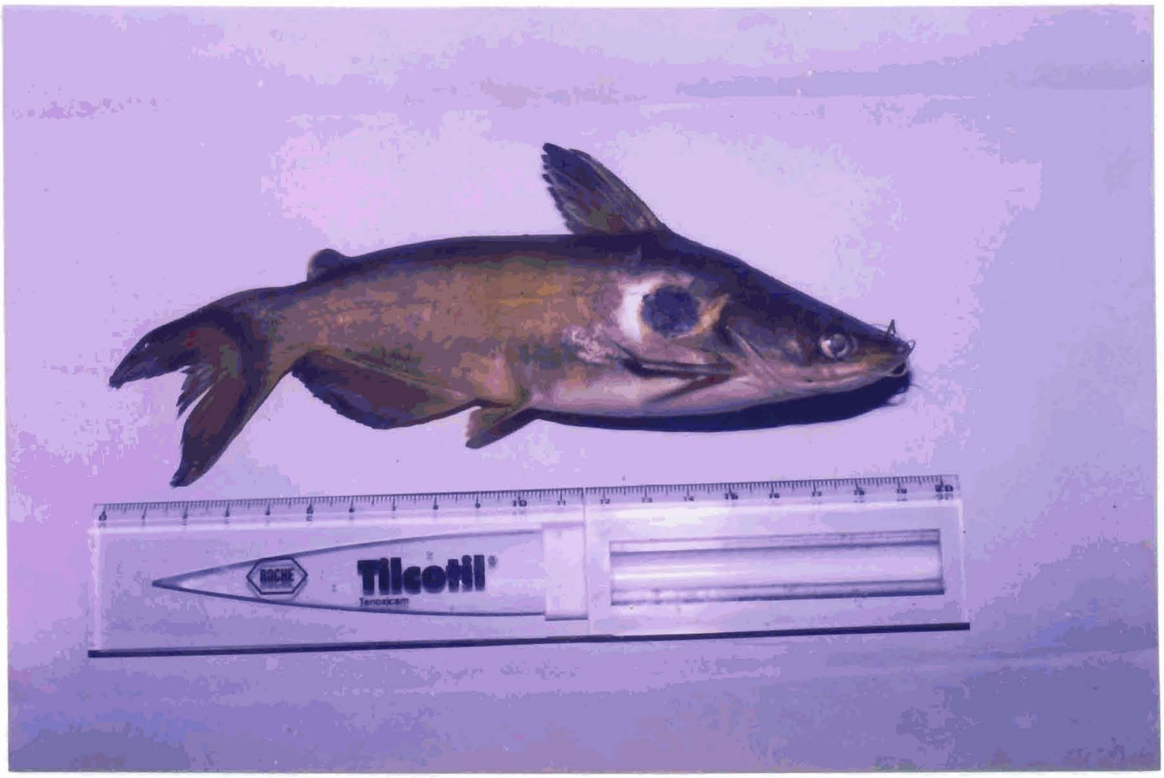

PLATE – 2 : *HORABAGRUS BRACHYSOMA* (GUNTHER)

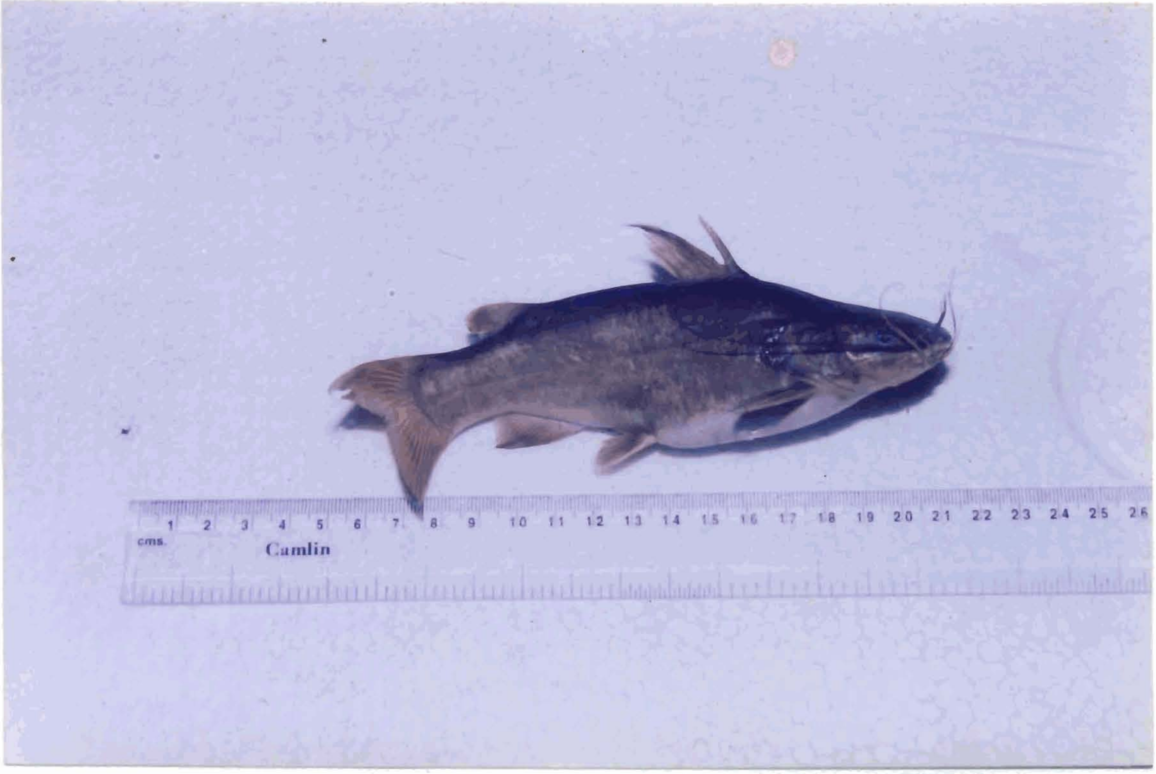

PLATE – 3 : *MYSTUS GULIO* (HAMILTON-BUCHANAN)

PLATE – 4 : *MYSTUS PUNCTATUS* (JERDON)

PLATE – 5 : *MYSTUS ARMATUS* (DAY)

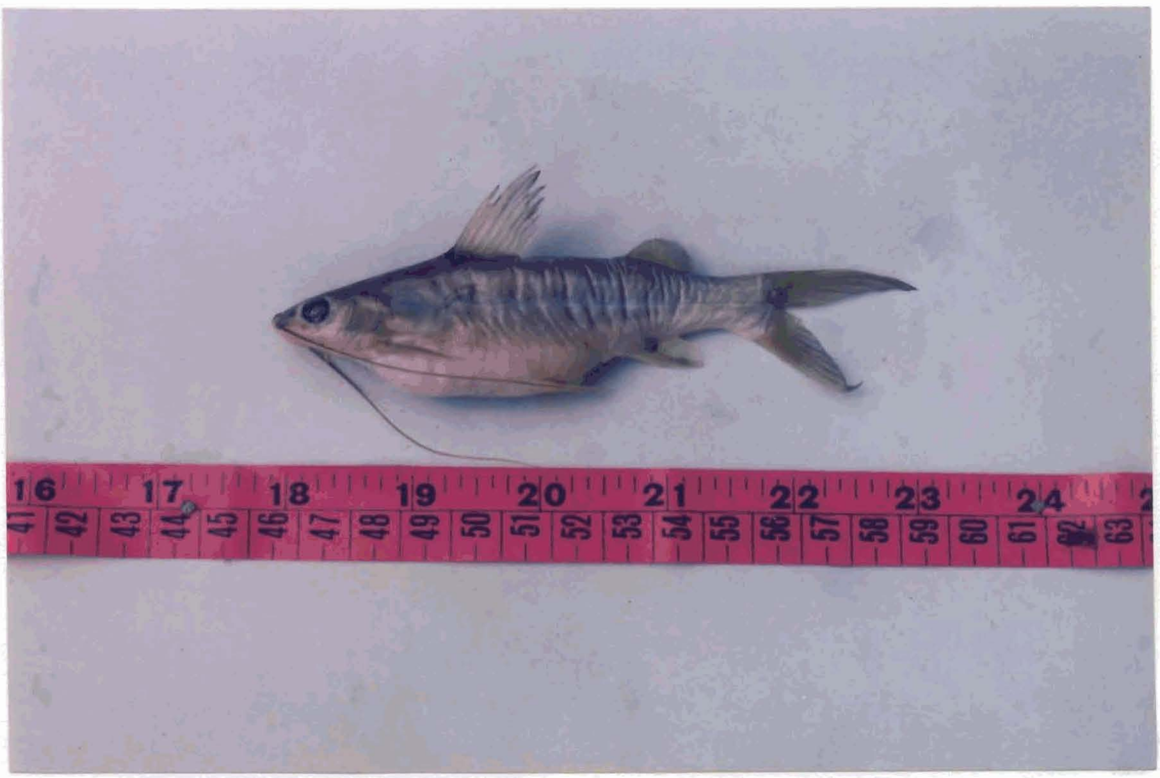

PLATE – 6 : *MYSTUS OCULATUS* (VALENCIENNES)

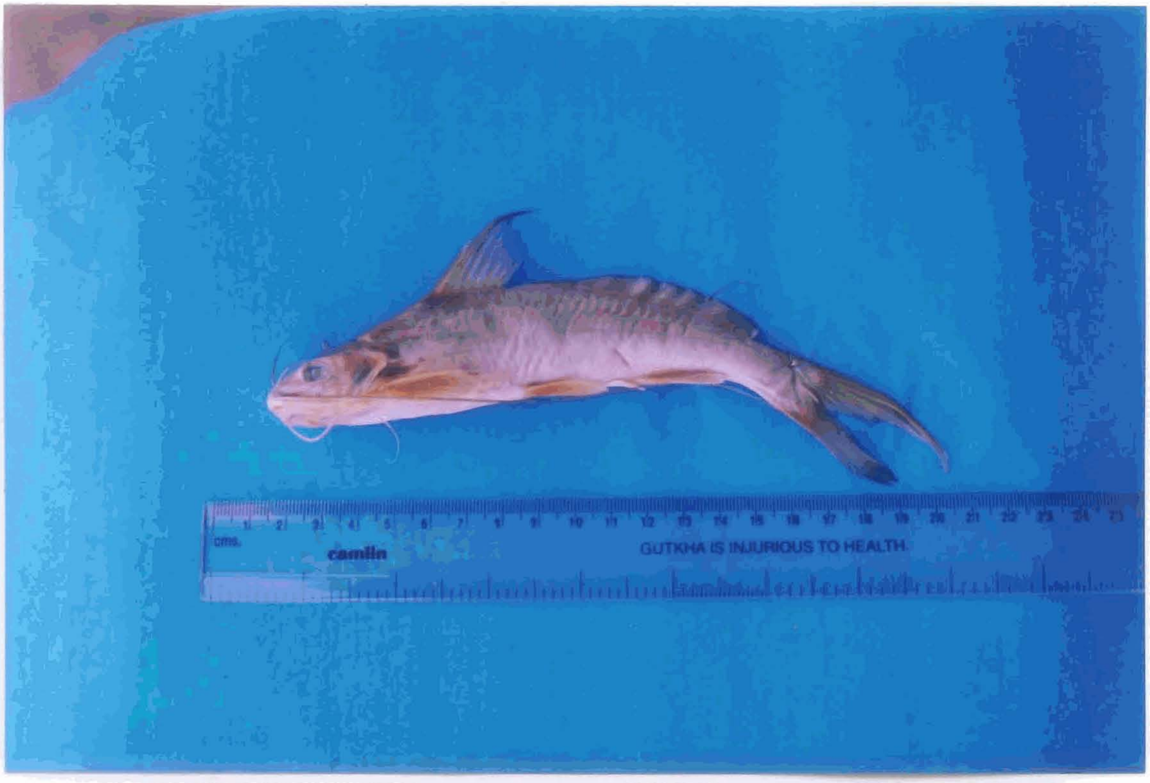

PLATE – 7 : *MYSTUS CAVASIUS* (HAMILTON-BUCHANAN)

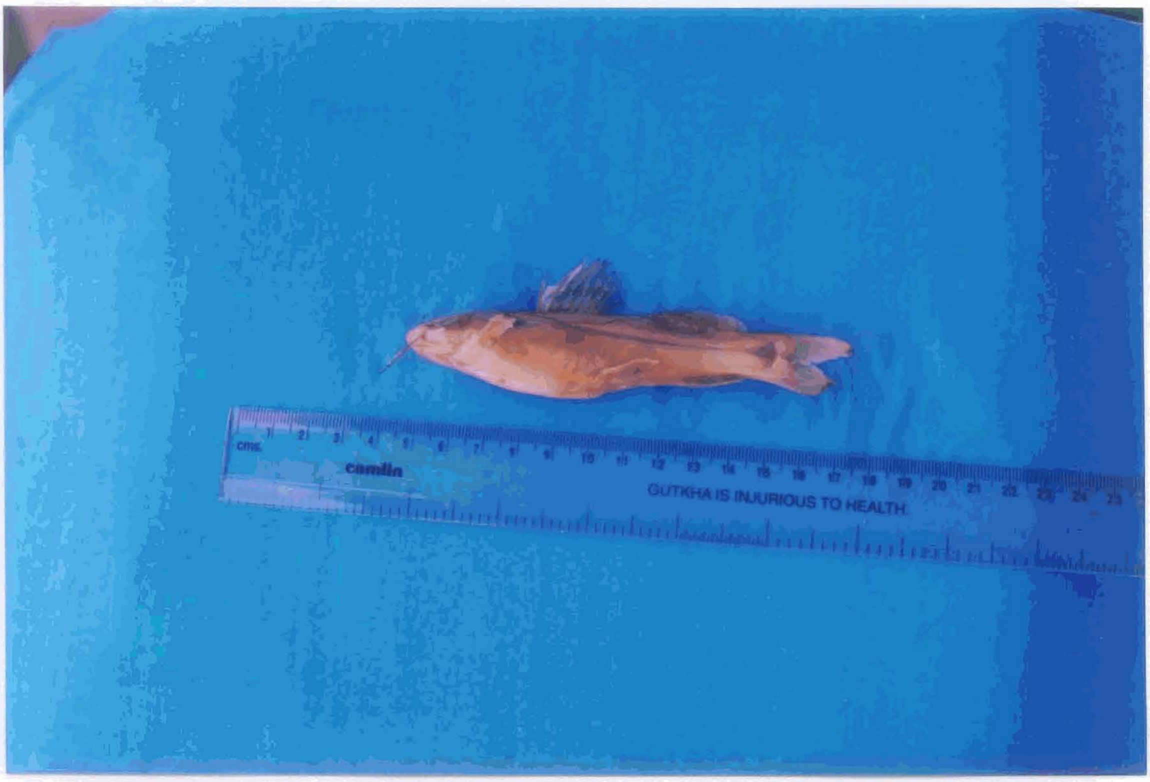

PLATE – 8 : *MYSTUS MONTANUS* (JERDON)

PLATE – 9 : *WALLAGO ATTU* (SCHNEIDER)

PLATE – 10 : *OMPOK BIMACULATUS* (BLOCH)

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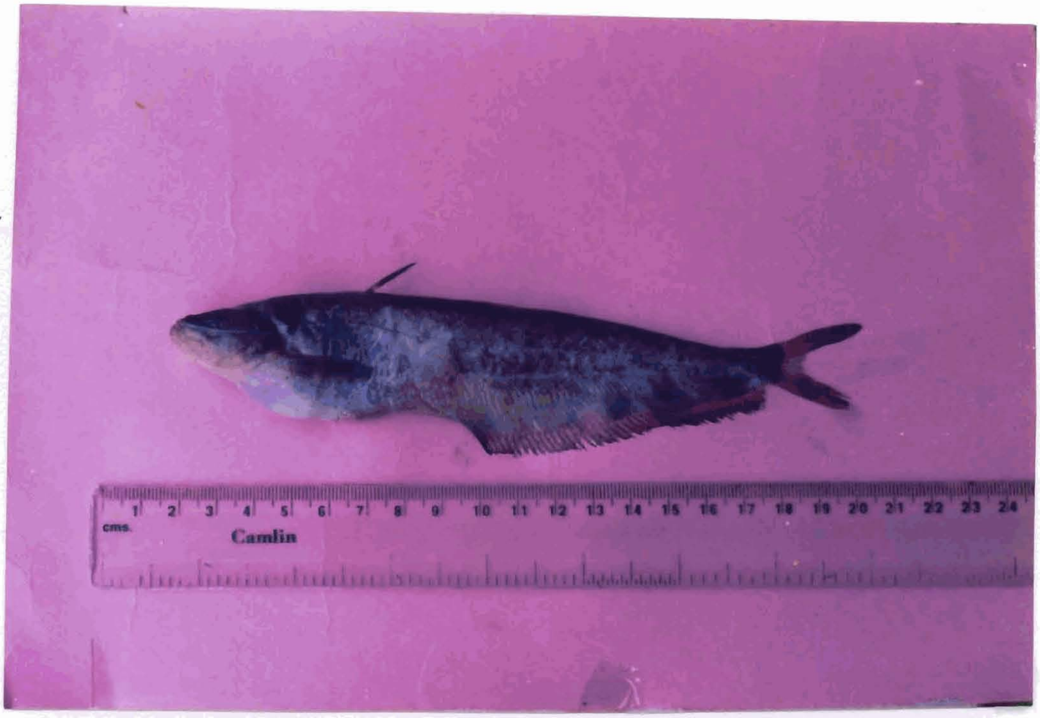


PLATE – 11 : *OMPOK MALABARICUS* (VALENCIENNES)

PLATE – 12 : *HETEROPNEUSTES FOSSILIS* (BLOCH)

18

PLATE – 13 : *CLARIAS DUSSUMIERI* (VALENCIENNES)

PLATE – 14 : *CLARIAS BATRACHUS* (LINNAEUS)

PLATE – 15 : *CLARIAS GARIEPINUS* (BURCHELL)

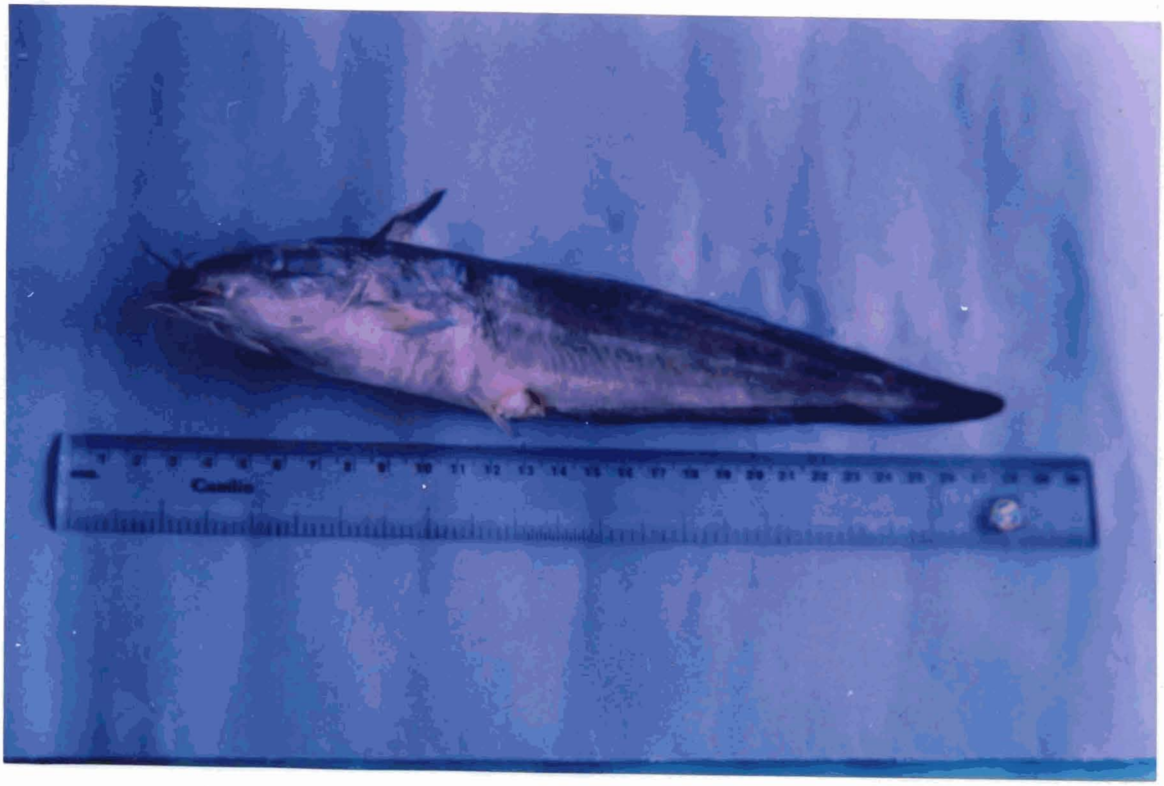


PLATE – 16 : *PLOTOSUS LINEATUS* (THUNBERG)

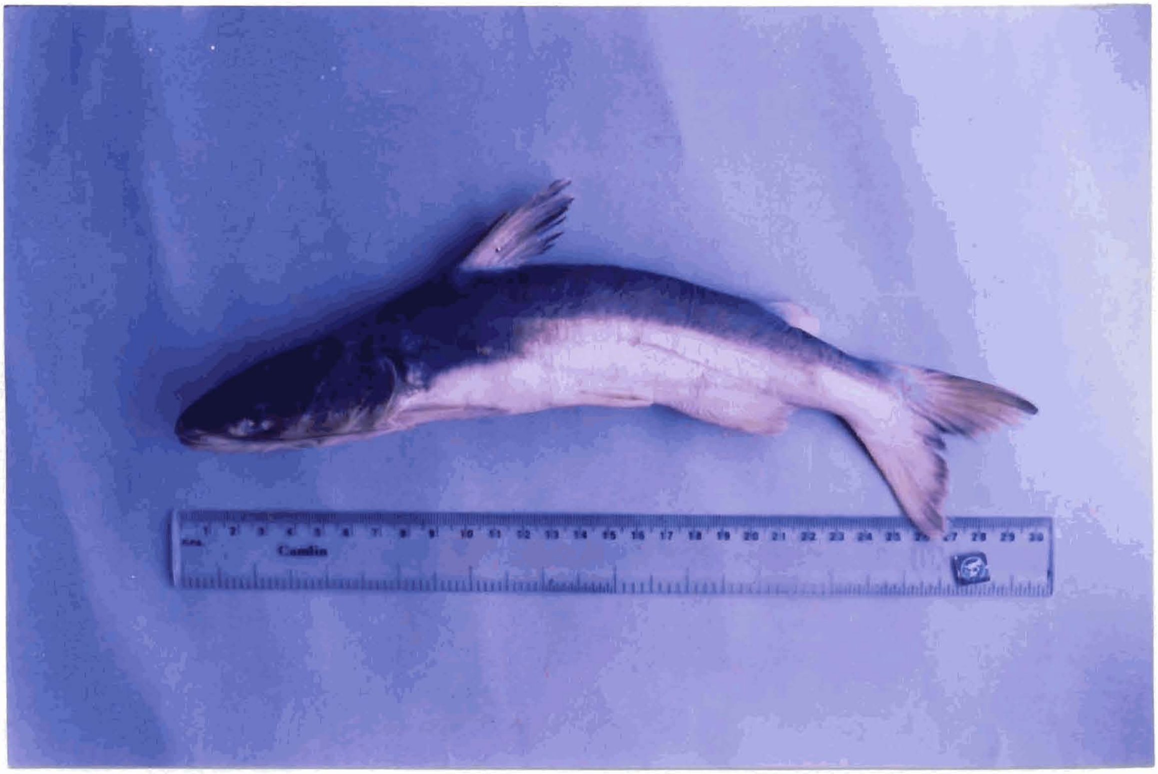


PLATE – 17 : *OSTEOGENIOSUS MILITARIS* (LINNAEUS)

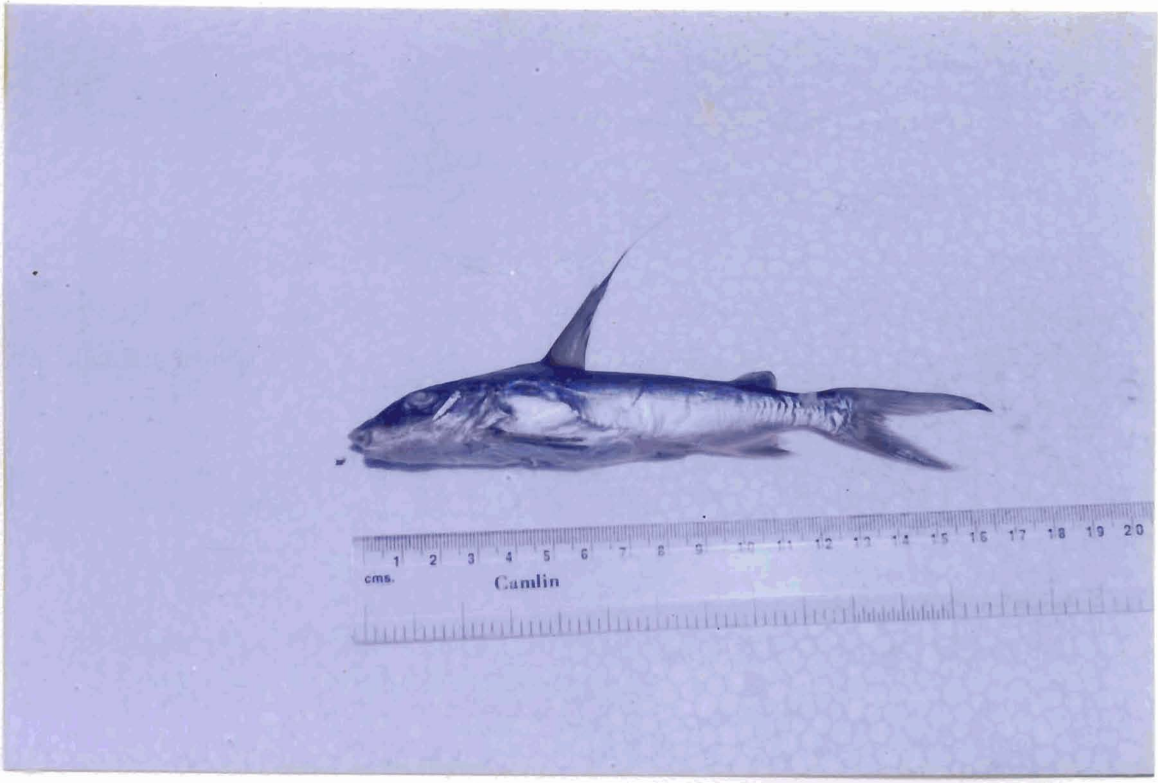


PLATE – 18 : *ARIUS SUBROSTRATUS* (CUV & VAL)

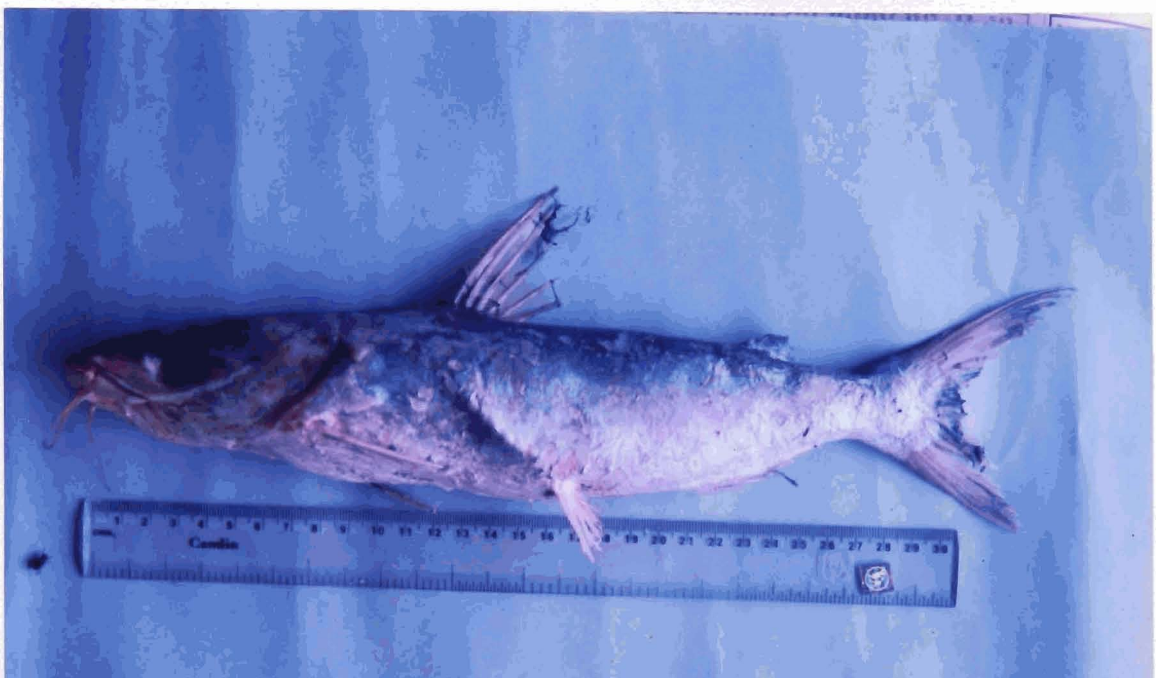


PLATE – 19 : *ARIUS TENUISPINIS* (DAY)

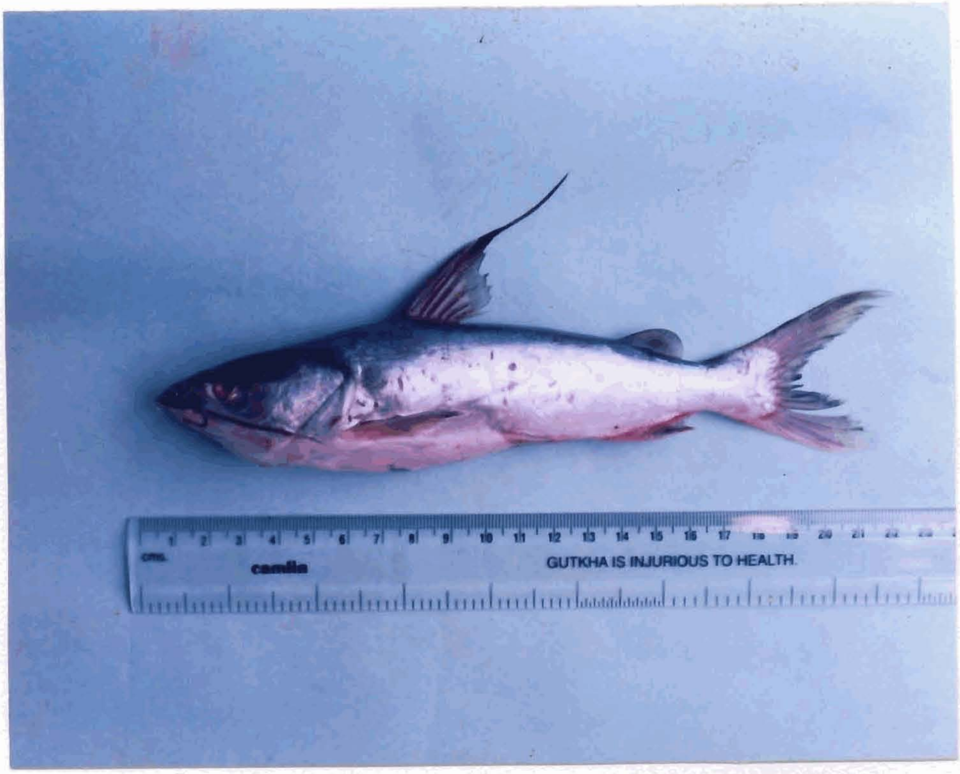


PLATE – 20 : *ARIUS ARIUS* (HAMILTON-BUCHANAN)

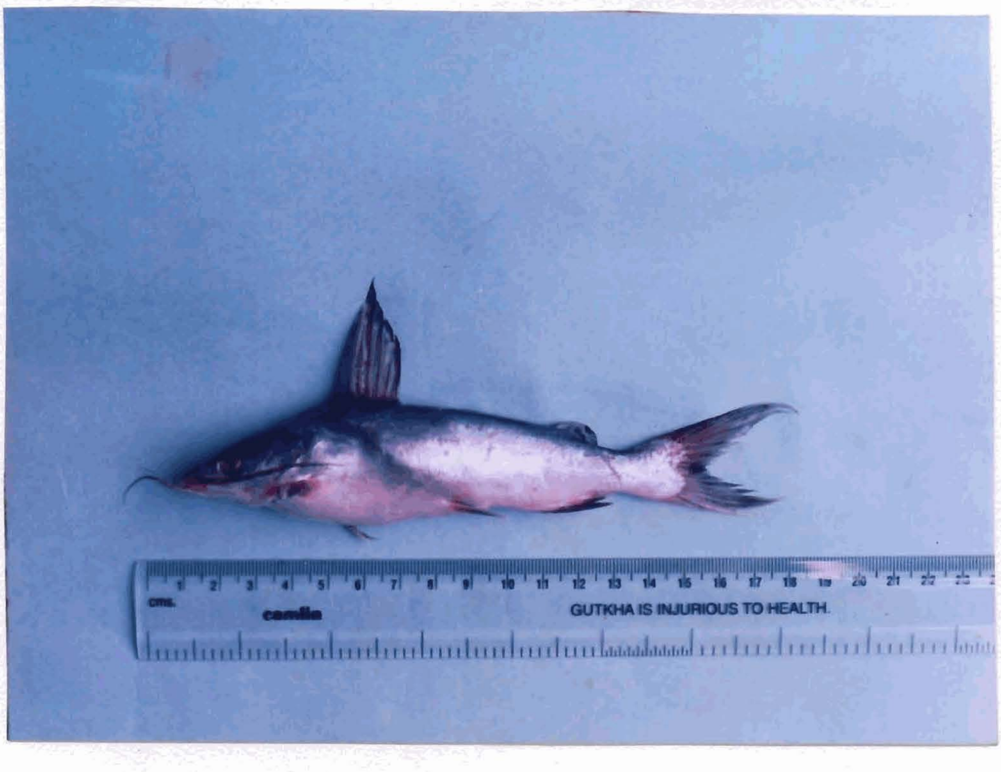


PLATE – 21 : *ARIUS CAELATUS* (VALENCIENNES)

PART - II

BIONOMICS

FOOD AND FEEDING

CHAPTER - III

FOOD AND FEEDING

INTRODUCTION

Organisms require energy for their various vital activities. The only source of energy for animals is the food they consume from the outside medium. Food is an important factor regulating the various activities of the fish and it affects shoaling, behaviour, migration and even the entire fishery. Hence a detailed knowledge of the food and feeding habits of fishes is very essential to improve the fishery potential. Trophic relationships of economic and uneconomic species of fishes will also be useful in understanding their role as prey, predator or competitor. An understanding of the relationship between fishes and food organism especially the favourite food items and their seasonal distribution may help to locate their potential feeding grounds and it provides clue for the prediction and exploitation of fish stocks.

Fishes have become adapted to a wide variety of food. Some of them feed exclusively on plants, others feed on animals, while a large number of species are omnivorous feeding on both plant and animal matters. A wide range of organisms are used as food by the fishes.

The natural food of fishes, according to Schaperclaus (1961) is classified under three groups Viz. (a) Main food or basic food which the fish prefers under favourable conditions and on which it thrives best (b) Occasional food that is well liked and consumed when available (c) Emergency food which is ingested when the preferred food items are not available and on which the fish is just able to survive (d) Incidental food which rarely enters the gut along with other items.

The early significant works on the food and feeding of fishes were by Francis Day (1882), Herdman and Corbin (1892), Scot (1902), Johnstone (1906), Bullen (1912), Lebour (1919 a, 1919 b, 1919 c, 1922, 1924, 1927, 1934), Hardy (1924), Hickling (1927), Neill (1938), Swynnerton and Worthington (1940), Job (1940), Frost (1943), Hynes (1950), Kow (1950), Jones (1952) and Longhurst (1957).

In India, a large number of Ichthyologists have worked on the food and feeding of fishes. To mention a few Alikunhi (1957), Venkataraman (1960), Natarajan and Jhingran (1961), Rao (1964), James (1967), Prasadam (1971), Krishnamoorthi (1971), Qasim (1972), Devaraj (1977, 1998), Sreenivasagam (1981), Neelakantan (1981), Kusuma (1983), Dasgupta (1988), Khan (1988), Kurup (1993), Sharma (1994), Sivakami (1996), Badapanda (1996), Ramakrishniah (1998), Kishor *et al.* (1998), Basudha and Vishwanath (1999) are some of the eminent workers, who have contributed to the knowledge on the food habits of Indian fishes.

But the food and feeding habits of most of the catfishes were not subjected to intensive studies. Gopinatha Menon (1978) studied the food and feeding of marine catfish *Tachysurus thalassinus* (Ruppell). Mojumder and Dan (1979) described the food and feeding habits of *Tachysurus tenuispinis* (Day). Ramakrishniah (1984, 1986), while studying the fishery & biology of the two catfishes *Mystus aor* (Hamilton - Buchanan) and *Pangasius pangasius* (Ham) of the Nagarjunasagar reservoir, Andhra Pradesh described their food and feeding habits. Vincy (1986) worked on the food and feeding of *Mystus seenghala* (Sykes) from Nagarjunasagar reservoir, Andhra Pradesh. Siva Reddy and Babu Rao (1987) conducted studies on the food of *Mystus vittatus* (Bloch) from the highly polluted Hussain Sagar lake, Hyderabad. Khan, *et al.* (1988) described the feeding biology of a tropical fresh water catfish *Mystus nemurus* (C & V) with reference to its functional morphology. Sivakami (1982) studied the feeding habits of *O. bimaculatus* from the Bhavanisagar reservoir, Tamil Nadu. Bhuiyan and Islam (1991) observed the food and feeding habits of *Ompok pabda* (Hamilton) from the river Padma. Shrivastava *et al.* (1992) investigated the diel feeding pattern of some fresh water catfishes like *Mystus seenghala, Mystus bleekeri, Heteropneustes fossilis* and *Ompok bimaculatus* from Kshipra river. Tamubi devi, *et al.* (1992) made a detailed study of the food of catfish *Rita rita* (Ham) of the river Yamuna. Feeding of *Tachysurus dussumeri* has been studied by Vasudevappa and James (1992). Yusuf and Majumdar (1993) worked on the food habits of *Mystus gulio* from the saline sewage fed wet lands at Minakhan. Kohli & Umesh (1996) described the food and feeding habits of *Heteropneustes fossilis* (Bloch) from the Brahmaputra river system, Assam. Vijayakumaran (1997) worked on the biology of striped eel catfish *Plotosus lineatus.* Mahapatra and Datta (1999) studied the food preference of the exotic catfish *Clarius gariepinus* (Burchell). But the feeding and biology of catfishes of Kerala have not been thoroughly investigated. *H. brachysoma* and *O. bimaculatus* are common food fishes occurring in the fresh water bodies of Kerala. In the present study, the food and feeding habits of these two edible catfishes are discussed in detail.

MATERIALS AND METHODS

Fish samples were collected from the fish landing centres and from the local fishermen fortnightly from May 1997 to March 1999. Samples were mainly obtained from the Chalakudy River and the kolelands and backwaters of Thrissur district. Samples were not available during the months March and April and April and May for *Horabagrus brachysoma* and *Ompok bimaculatus* respectively because during severe summer, they never appear in water and so never caught in the nets. The samples consisted of a total of 390 *Horabagrus brachysoma* and 340 *Ompok bimaculatus.* The fish samples were immediately brought to the laboratory and cleaned thoroughly. After removing the moisture by blotting, total length and weight were noted. The stomachs of the fishes were preserved in 5% formalin after noting their weight and detailed analysis of the stomach contents was conducted thereafter.

Various methods have been adopted by Ichthyologists for studying the food of fishes. Some of the important methods are (i) Qualitative method – identifying the organisms in the gut to the nearest taxon possible (ii) Quantitative method. Quantitative analysis was carried out by using both occurrence and points volumetric methods (Hynes, 1950; Pillay, 1952). Since the items of food were smaller in size, their volume could be estimated only by allotment of points, (iii) Index of preponderance proposed by Natarajan and Jhingran (1961) was used to grade the relative importance of the food item as it was found suitable for carnivorous fishes. Among the various methods, the numerical method is the most simple which is a direct count of the various food items in the stomach. The main limitation of this method is that it tends to give undue emphasis to small items with numerical dominance, which may form only a small portion of the bulk of the food. Likewise the occurrence method gives only the frequency of occurrence of the food item, which is the percentage of fish in the sample with a given food item, while the total bulk of the stomach is not taken into account.

The most important factor in the selection of method is that it should suit the diet of the fish to be investigated. For eg., volumetric method is suitable only for carnivorous fishes (James, 1967). According to Hyslop (1980), the best measure of stomach content is the one where both the amount and bulk of a food category are recorded. In tropical regions, the high temperature of water accelerates the process of digestion so that the food remains in recognizable state more in the stomach than in the gut. Hence the diet studies are to be made from stomach and the rest of the gut could be ignored unless there are special reasons for doing so (Qasim, 1972).

The food analysis of *H. brachysoma* and *O. bimaculatus* was done by both qualitative and quantitative methods. The stomach was cut open and its contents were carefully washed into a small petridish. The various items were examined and sorted out using a binocular microscope and then identified. The percentage occurrence of different items of food in different months, was determined by summing the total number of occurrence of all items from which the percentage occurrence of each item was calculated. The extent of feeding was determined by the degree of distension of stomach and the amount of food contained in it and they were graded into three groups (i) 'Heavy' - when the stomach was gorged with food and was fully distended (ii) 'Medium' - when the stomach was half full and slightly distended (iii) 'Empty' - when the stomach was without any food. An empty stomach has only shrunken wall with little mucous. The degree of fullness of stomach was determined on the basis of distension of stomach folds (Rao 1964). The fishes with full stomach were categorised as actively fed, with half full stomach as moderately fed and with empty (trace) stomach as poorly fed. Diet analysis was done in relation to month, sex and size groups. The size groups, 0 – 15cm group & 15 – 30cm group were made based on the total length of fishes. For the sex wise study, the specimens were grouped into males and females.

Depending on the degree of fullness of stomach, points such as 50, 25, 0 are given to 'Heavy', 'Medium' and 'Empty' stomach respectively. The size of the food organism and its abundance are equally important in diet analysis. The points gained by each food item were summed and expressed in percentage in order to obtain the percentage composition of food items for different months. This method gives a rough estimation of both qualitative and quantitative data without any detailed count.

Feeding index was worked out as suggested by Kow (1950) to assess the feeding intensity. According to Kow, the feeding index is expressed as the ratio between the number of specimens with heavy & medium feeding intensity to the total number of specimens examined.

$$\text{Feeding index} = \frac{\text{Number of fish with heavy \& medium stomach}}{\text{Number of fish examined}} \times 100$$

To find out the feeding rhythm, samples were collected at an interval of 12 hrs. for a period of 24 hours and the condition of the gut of the fish from each collection was estimated.

The degree of fullness of stomach was noticed every month and percentage occurrence of stomach with different feeding intensities was worked out in order to arrive at the feeding intensity in relation to size and season. G.S.I. (Gastrosomatic Index) is calculated using the equation.

$$\text{G.S.I.} = \frac{\text{Weight of the stomach}}{\text{Weight of fish}} \times 100$$

Gut content analysis was conducted for both *H. brachysoma* and *O. bimaculatus* for a period of twenty two months and a comparative study of food of both the species was undertaken in order to find out whether there is any interspecific competition between the two species which live usually in the same habitat.

The pharyngeal teeth and their role in feeding mechanism was studied in *Horabagrus brachysoma* & *Ompok bimaculatus.* The study of pharyngeal teeth was done by dissecting and exposing the buccal cavity of the fish. The upper & lower jaws were separated by cutting their junction along one lateral side. The upper & lower jaws of the fish were twisted each other and pinned firmly on the dissection board. The entire buccal cavity was washed and cleaned using distilled water. A hand lens was used for the clear observation of pharyngeal teeth. Their number and arrangement were studied carefully and magnified diagrams were prepared. The size of the tooth and the gap between the adjacent teeth were measured using ocular and stage micrometer. The role of pharyngeal teeth in the feeding mechanism was concluded by analysing the results of its gut content analysis.

RESULTS

Percentage composition of food

The present study on the food of *H. brachysoma* and *O. bimaculatus* provide data on the nature of food habits, the varieties of food items and the feeding rates at different seasons, in different size groups, and in sex groups.

Horabagrus brachysoma (Gunther)

The main food items found in the gut of *H. brachysoma* during May 1997 – February 1999 includes crustacean exoskeletal fragments (35.29%), semidigested food (23.4%), fat droplets (14.37%), algal tissues (10.96%), animal tissues (9.17%), miscellaneous (4.03%), prawn (1.75%) and fish scales (1.05%) (Table – 3.2, Fig. 3.9). Crustacean fragments in the diet varies between 30 – 40% in both male and female groups during most of the months of 1997 – 98 and 1998 – 99 (Figs. 3.1 & 3.2). Crustaceans often identified in the gut were the adults and juveniles of crabs of the genus *Scyllus* and *Thelphusa*. The Semidigested food in the gut of *H. brachysoma* generally varies between 20 – 30% during the study period except during July, September and October 1998 in females (Table 3.2, Figs. 3.13 & 3.14). Fat droplets in the gut of the fish vary between 10 – 20% during 1997 – 98 and 1998 – 99. Algal tissues vary between 10 – 15% (Fig. 3.13 & 3.14). Miscellaneous food items include gastropod & pelecypod molluscs, worms, plant matters, insect larve, spicules, fish eggs, sand particles etc.

The mean values of the percentage composition of various food items in the gut of *H. brachysoma* male sex group and female sex groups do not vary more than two percentage. The order of preference of food items is also same in both the sex groups (Table 3.1 & 3.2). Similarly the percentage composition of different diets in the gut of 1 – 15cm length group and 15 – 30 cm length group of *H. brachysoma* also do not differ above two percentage. The order of preference of food items is also same in both these length groups (Table 3.3 & 3.4) (Fig. 3.15 & 3.16).

Feeding Intensity

The study of feeding intensity of the fish *H. brachysoma* indicates the sign of a carnivorous diet. In a carnivorous animal, the fullness of stomach cannot be very common. The present study categorises the condition of the stomach into three – 'Empty', 'Medium' and 'Heavy'. The study conducted in each month revealed that the 'Empty' stomach outnumber the 'Medium' and 'Heavy' in this species. This condition is very common in carnivorous fishes. In *H. brachysoma* 64.39% of the fishes were with 'Empty' stomach, 32.94% of the fishes with 'Medium' and only 2.67% of the fish was with 'Heavy stomach (Table 3.10). This pattern is more or less represented in the male and female sex groups of the species. 71.06% of the male fish were with 'Empty' stomach, 25.42% with 'Medium' stomach and 3.51% of the fish with 'Heavy' stomach (Table 3.9). In females 57.72% of the fish showed 'Empty' stomach, 40.45% showed 'Medium' stomach and 1.83% of the fish were with 'Heavy' stomach (Table 3.10, Fig. 3.21).

But clear difference from this pattern is observed in the two length groups of the species. 1 – 15cm length group showed a positive sign in the fullness of stomach. In this length group, only 49.15% of the fish showed 'Empty' stomach, 47.46% of the fish showed 'Medium' stomach and 3.39% of the fish showed 'Heavy' stomach (Table 3.11). This length group (1 – 15cm) is the 'growing group' which shows the maximum rate of growth so that the rate of feeding also should be high in this length group. But in 15 – 30cm length group 67.16% of the fish showed 'Empty' stomach and only 31.35% of the fish showed 'Medium' stomach and 1.49% with 'Heavy' stomach (Table 3.12, Fig. 3.22). Monthly study of feeding intensity shows that maximum number of 'Heavy' stomachs were found in the month of July and August which may be the post spawning period of the fish. In the month of June, the peak spawning season, all the fishes obtained were with 'Empty' stomach.

Feeding Index

The feeding index of the species *H. brachysoma* is calculated as 35.61 (Table – 3.10). But the feeding index in female sex group (42.28) is much higher than the feeding index of male sex group (28.94) (Table

– 3.9 & 3.10). The 'growing group', 1 – 15cm length group clearly shows a very high feeding index (50.85) (Table 3.11) than that of 15 – 30cm length group (32.84) (Table – 3.12). The monthly trends in feeding index shows that the value is maximum in July (75%) and minimum (Nil) in June.

Feeding Rhythm

The study of feeding rhythm shows that *H. brachysoma* is slightly more active during night time. It is evidenced by slightly higher gastrosomatic index during night (1.78) against 1.23 during day time. Any how this slight difference in gastrosomatic index during night and day cannot be considered to categorise the species as nocturnal or diurnal.

Gastrosomatic Index

Table 3.17 & 3.18 & Fig. 3.25 & 3.26 show the Gastrosomatic Index (G.S.I.) of *H. brachysoma* for males, females 1 - 15cm size group & 15 – 30cm size group from May 1997 to February 1999. Maximum G.S.I. is found during the month of July (4.45) in males & females pooled for the two years. In males the value is much higher in July (4.56) compared to the other months, as well as to females where maximum G.S.I. is only 2.94. Similarly in the two size groups also maximum G.S.I. is found during July.

Ompok bimaculatus (Bloch)

Qualitative and quantitative analysis

Analysis of the stomach contents of *O. bimaculatus* revealed that the fish is predominantly a carnivore, eventhough it feeds on plant materials also. The important gut contents observed in the stomach of the fish during June 1997 – March 1999 are fish tissues, prawn, crustacean exoskeleton, semidigested food, fat droplets, algal tissues and miscellaneous, similar to that of *H. brachysoma.* Fish tissues which varies between 34 – 50% (mean 40.91) (Table 3.6, Fig. 3.11) forms the most important food item in both male and female during June 1997 – March 1999. Fish items were chiefly constituted by the juveniles and adults of *Puntius, Chela, Aplocheilus,* etc. The semidigested food in the gut of *O. bimaculatus* generally varies between 15 – 30 percentage (mean 19.03) except during January and October 1998 and January and March 1999 (Fig. 3.17 & 3.18). Fat droplets vary between 10 – 20 percentage (mean 15.18) during most part of the observation period. Crustacean exoskeleton in the gut of *Ompok* varies usually between 5 – 15 percentage (mean 8.7) except June 1997 and 1998. In June, Crustacean fragments form the main stomach content in females (39%). Algal tissue (8.07%) and miscellaneous (6.58%) were also found in the gut during most of the months. Prawns (1.54%) were found occasionally during November and January. Miscellaneous food items found in the gut were water bugs, leaf bits, insect larvae, spicules worms etc..

Percentage composition in Males and Females

Males and females of *O. bimaculatus* do not show much difference in the mean percentage composition of various food items especially fish tissues, semidigested food, fat droplets and miscellaneous. Prawns were recorded more from the gut of males (2.53%) than females (.55%) (Table 3.5 & 3.6, Fig. 3.11), Crustacean exoskeletal fragments were found more in females (10.5%) than males (6.89%). Similarly algal tissues also showed variations in percentage composition in both males and females. The mean value of algal tissues in males is 10.74%, while in females it is only 5.4%. The order of preference of food items is same in both the sex groups.

Percentage composition of food in different length groups

The percentage composition of various food items in the gut of *O. bimaculatus* 1 – 15cm length group and 15 – 30cm length group do not vary more than 2 percentage except crustacean exoskeleton and miscellaneous. Crustacean exoskeleton is more observed in 15 – 30cm group (8.05%) than 1 – 15 cm length group (5.39%). Similarly miscellaneous items were more in amount in the gut of 1 – 15cm length group (11.11%) as against the 15 – 30 cm length group where the mean percentage composition of 'miscellaneous' particles is only 8.6% (Table 3.7 & 3.8, Fig. 3.12). The order of preference of food items is also same in both these length groups.

Feeding Intensity

The study of feeding intensity also approves the carnivorous nature of the fish, *O. bimaculatus*. Feeding intensity is expressed by the condition of the stomach as 'Empty', 'Medium' and 'Heavy'. Monthly analysis of the gut contents of the fish indicates the supremacy of the 'Empty' stomach over 'Medium' and 'Heavy' stomachs similar to *H. brachysoma* indicating the carnivorous nature of the fish. In *O. bimaculatus* 50.99% of the fishes were with 'Empty' stomachs, 43.68% of the fishes were with 'Medium' stomach and only 5.33% with 'Heavy' stomach (Table 3.14, Fig. 3.23). This ratio is almost similar in the males and females of the species. In males 46.91% was with 'Empty' stomach, 46.92% with 'Medium' stomach and 6.17% with 'Heavy' stomach (Table 3.13). While in females 55.06% were with 'Empty' stomachs, 40.45% with 'Medium' and 4.49% was with 'Heavy' stomach (Table – 3.14).

But the feeding intensity of the two length groups of the fish is different from the above pattern. The younger group (1-15cm) had lesser number of 'Empty' stomachs than the adult group (15 – 30cm). In 1 – 15cm size group, only 38.3% of the fishes were with 'Empty' stomach, 51.06% with 'Medium' stomach and 10.64% with 'Heavy' stomach (Table 3.15). But in the 15 – 30cm size group, 55.12% of the fishes were with 'Empty' stomach, 41.73% with 'Medium' stomach and 3.15% with 'Heavy' stomach (Table 3.16, Fig. 3.24). This difference in the feeding index in the smaller size group gives clear evidence for the higher rate of feeding which is essential for maximum growth. Monthly study of feeding intensity shows that 'Heavy' stomachs were maximum in the month of September. During June & July, the spawning season of the fish, 'Heavy' stomachs were never found in the fish samples.

Feeding index

The feeding index of *O. bimaculatus* is found to be 49.02 (Table 3.14) Contradictory to *H. brachysoma* in *O. bimaculatus* feeding index of male sex group (53.09) is much higher than that of female sex group (44.94) (Table 3.13 & 3.14). The growing group (1 - 15cm length group) has a very high feeding index (61.7) compared to the feeding index of 15 - 30cm length group (44.88) (Table 3.15 & 3.16). The monthly trends in feeding index shows that the value is maximum in July in females and in August in males.

Feeding Rhythm

Observation of feeding rhythm of *O. bimaculatus* reveals that there is some diurnal variation in the rate of feeding during day and night. The fish is found to be more active during daytime contradictory to *H. brachysoma*. This is proved by the higher gastrosomatic index during day (4.237) as against 2.03 during night.

Gastrosomatic index

Gastrosomatic index (G.S.I.) of males, females, 1-15cm size group & 15 - 30cm size group of *O. bimaculatus* are illustrated in Tables 3.19

& 3.20, Fig. 3.27 and 3.28. Maximum G.S.I. of 3.7 is found during September in both males & females together. In males the G.S.I. value is highest during September (4.53), while in females the value is maximum during November (3.37). But the G.S.I. values in the smaller size groups are higher in the month of August (5.59) while in the larger size group, maximum G.S.I. is found during November (2.93).

Role of Pharyngeal teeth in Feeding

Pharyngeal teeth are present in the buccal cavity of a number of predacious fishes. A detailed study of pharyngeal teeth was conducted on *H. brachysoma* & *O. bimaculatus* to reveal their correlation with the feeding biology of the fish. Pharyngeal teeth are well developed in *O. bimaculatus* and the total number of teeth observed is 363, 178 in the upper jaw and 185 in the lower jaw (Pl. – 24 & 25). The teeth in the upper jaw are larger in size than those of lower jaw and they are of 1100μ length (Table 3.22). The gap between the adjacent teeth is 300μ. The pharyngeal teeth in the lower jaw are with 950μ average lengths and the gap between adjacent teeth is 200μ.

In *H. brachysoma* also pharyngeal teeth are well developed and their total number is 938 (Table 3.21). Upper jaw carries 407 teeth and lower jaw bears 531 teeth (Pl. – 22 & 23). The average length of pharyngeal teeth in the upper jaw is 700μ and the gap between the adjacent teeth is 200μ. In the lower jaw the average length of the tooth is 500μ and the gap in between the teeth is 150μ.

DISCUSSION

The study concluded that *Horabagrus brachysoma* (Gunther) and *Ompok bimaculatus* (Bloch) are predominantly carnivorous fishes eventhough they feed on vegetable matters also. Both these species feed almost on the same type of food materials, but the percentage composition of the food items vary for the two fishes. Crustaceans form the most preferred food item of *H. brachysoma* (35.29%), while in *O. bimaculatus* it is only 8.7%. In *O. bimaculatus,* fishes form the most important food item (40.91%) as it is revealed by the presence of large amounts of fish tissues and fish scales in the gut of the fish through out the study period. In *H. brachysoma* fish scales form only 1.05%. While the percentage composition of other food items is almost similar in both the species of fishes. Fat droplets accounted 14.37% in the gut of *H. brachysoma*, while in the gut of *O. bimaculatus*, it is 15.18%. Algal tissues constituted 10.96% in *H. brachysoma* and the same in *O. bimaculatus* was 8.07%. The prawn tissue accounted 1.75% in *H. brachysoma* and 1.54% in *O. bimaculatus.* According to the present study, the niche requirements of the two species are different and so both the species of fishes can be cultured together in the same culture tank without much competition. Gastrosomatic index of the two fishes studied indicate that *H. brachysoma* feed intensively during July, while *O. bimaculatus* feed vigorously during September as shown by the higher G.S.I. during those months. These may probably be the periods immediately following spawning. Jayaprakash (1999) reports that in

Cynoglossus macrostomus active feeding is found immediately after spawning.

Sivakami (1982) reported insect/insect larve as the most preferred food item in the gut of *O. bimaculatus* from the Bhavanisagar reservoir, Tamil Nadu. Qayyum and Qasim (1964) based on riverine collections observed the adults of *O. bimaculatus* to feed mainly on fishes with insects forming the secondary item of food. The present observations agree almost with the latter view as it has been found that *O. bimaculatus* in the inland waters of Central Kerala is clearly piscivorous in nature feeding mainly on small fishes. Silva and Davis (1987) reported the piscivorous nature of *O. bimaculatus* in Sri Lankan waters. Parameswaran *et al.* (1970) found the larger adults of this species to be both insectivorous and piscivorus. Bhuiyan and Islam (1991) reported the occurrence of fishes, crustaceans, protozoans, insects and algae in the gut of *O. pabda*. So most of the earlier reports agree with the piscivorous nature of *O. bimaculatus* as reported by the present one.

There are no previous reports on the feeding habits of *H. brachysoma* except the work of Inasu *et al.* (1997) on the role of pharyngeal teeth in the feeding biology of some catfishes. Inasu *et al.* (1997) reported the occurrence of crustaceans in the gut of *H. brachysoma*. The food and feeding of some bagrid catfishes were studied by some previous workers. Khan *et al.* (1988) reported that the adults of *Mystus nemurus* feed predominantly on fishes followed by crustaceans. Vinci (1986) reported that *Mystus seenghala* is a carnivorous piscivorous fish. But the present study on the gut contents of *H. brachysoma* (Table 3.1 & 3.2) reveals crustaceans to be the most favoured food item of the fish. Vijayakumaran (1997) analysed the food of striped eel-catfish *Plotosus lineatus* and found out that the fish is a carnivore feeding mainly on copepods, gastropods, crustacean larvae & most frequently crab juveniles. Ramakrishniah (1986) reported crab remains from the gut of the catfish, *Pangasuius pangasius* of the Nagarjunasagar Reservoir in Andhra Pradesh. The present study is in conformity with the work of Vijayakumaran (1997) & Ramakrishniah (1986) as crab remains and other crustacean fragments were often found in the gut of *H. brachysoma.*

The study of feeding intensity suggest that both *H. brachysoma* and *O. bimaculatus* are carnivorous in nature. In *H. brachysoma* 64.39% of the fishes were with 'Empty' stomach, while in *O.bimaculatus* 50.99% of the fishes had 'Empty' stomach. In both *H. brachysoma* and *O. bimaculatus* , the younger group was with lesser number of 'Empty' stomach than the adult group. Menzel (1960) reported that feeding efficiency and growth rate of *Epinephelus guttatus* decreases with increase in size.

The study of feeding rhythm shows that *H. brachysoma* is slightly more active during night than day time. Active feeding at night is reported in *Megalaspis cordyla* by Sreenivasan (1974). He has suggested that in carnivorous fishes, the prey being larger in size, its visibility is not affected in diminished light and the search for food can be accomplished even in low illumination. But *O. bimaculatus* is found to be more active during day time. The same nature is observed by Silva and Davis (1987) in *O. bimaculatus* from the lake Parakrama Samudra, Sri Lanka. They also reported a strong diurnal piscivorous feeding behaviour in this species. Karekar & Bal (1958) and Rao (1964) reported that feeding takes place only to a limited extent in darkness and that too probably by contact. Maitland (1965) explained that passive feeding depending on natural habitat may occur at night. Northcote & Lorz (1966) stated that intensity of light influences prey selection & variation in feeding can occur according to day – night changes.

The study of pharyngeal teeth in these two species of catfishes reveal that they are well developed in both these fishes. Compared to *O. bimaculatus, H. brachysoma* has larger number of pharyngeal teeth (938). The total number of pharyngeal teeth in the lower jaw was always higher than that of upper jaw in both the fishes studied (Table 3.21 & 3.22). So the gap between the adjacent pharyngeal teeth in the lower jaw was always found lower than that in the upper jaw. Eventhough the number of pharyngeal teeth is lesser in *O. bimaculatus* (383), the size of teeth is greater in this fish (average length 1100 – 950μ) compared to *H. brachysoma* (average length 700 - 500μ). The pharyngeal teeth in the upper jaw are found to be larger and longer than those of lower jaw in both fishes.

This study reveals that pharyngeal teeth have got great role in feeding live prey. The gut content analysis of both species of fishes shows that they are highly carnivorous fishes (Table 3.2 & 3.6). The main food of *H. brachysoma* is crustaceans and that of *O. bimaculatus* is fish and they usually feed on live organisms. The percentage composition of gut contents of these fishes clearly prove the carnivorous feeding habit of these fishes. Crustacean fragments, fish tissues, animal tissues, fat droplets and prawns were found in the gut of both fishes. Crustaceans are always fed in live condition. Crustaceans get easily damaged soon after their death (Kurian, 1982). So fishes take crustaceans only in live condition. Inasu *et al.* (1997) reported the role of pharyngeal teeth in the feeding of five species of catfishes, *O. bimaculatus* , *Wallago attu, H. brachysoma, Mystus oculatus* and *Heteropneustes fossilis* and suggested that all these catfishes are carnivorous feeding on live prey and the pharyngeal teeth help in feeding live organisms. The present work agrees fully with the above report as *H. brachysoma* and *O. bimaculatus* feed mainly on live organisms like crustaceans and fishes.

Table – 3.1

Percentage composition of various food items in the gut of *H. brachysoma* (Gunther) Male from May 1997 to February 1999

Year	*Month*	*Crustacean Exoskeleton*	*Prawn*	*Animal Tissues*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Fish Scales*	*Misce-llaneous*
1997	May	35	---	--	25	15	20	---	5
	June	47	3	2	28	13	2	---	5
	July	30	3	45	12	10	---	---	---
	August	28	12	13	32	13	2	---	---
	September	48	---	3	27	19	3	---	---
	October	42	---	13	23	10	4	8	---
	November	37	2	7	29	21	4	---	---
	December	37	---	2	30	14	17	---	---
1998	January	25	---	---	15	---	25	---	35
	February	30	---	5	10	20	20	---	15
	March	---	---	---	---	---	---	---	---
	April	---	---	---	---	---	---	---	---
	May	40	5	3	25	15	10	---	2
	June	---	---	---	---	---	---	---	---
	July	30	---	35	15	12	8	---	---
	August	43	---	17	17	10	13	---	---
	September	34	---	6	24	28	3	---	5
	October	39	---	5	26	22	8	---	---
	November	44	1	6	21	23	5	---	---
	December	35	---	4	28	15	18	---	---
1999	January	25	---	---	20	---	28	---	27
	February	30	---	5	18	10	25	---	12
Average		**35.73**	**1.37**	**9**	**22.37**	**14.21**	**11.32**	**.42**	**5.58**

Table – 3.2

Percentage composition of various food items in the gut of *H. brachysoma* (Gunther) Female from May 1997 to February 1999

Year	*Month*	*Crustacean Exoskeleton*	*Prawn*	*Animal Tissues*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Fish Scales*	*Misce-llaneous*
1997	May	35	---	10	22	17	16	---	11
	June	40	3.3	3.3	24	15	3.3	---	---
	July	50	---	---	25	25	---	---	---
	August	33	3	9	36	14	5	---	---
	September	---	---	---	---	---	---	---	---
	October	34	---	3	28	4	19	12	---
	November	35	3	6	26	24	6	---	---
	December	33	---	---	36	16	10	---	5
1998	January	29	3	2	27	5	25	2	7
	February	30	5	---	25	10	20	5	5
	March	---	---	---	---	---	---	---	---
	April	---	---	---	---	---	---	---	---
	May	35	5	5	25	10	10	5	5
	June	40	---	6	21	15	18	---	---
	July	29	---	46	9	14	2	---	---
	August	27	14	15	21	16	7	---	---
	September	32	---	22	15	17	12	---	2
	October	44	---	16	12	28	---	---	---
	November	46	---	25	21	6	---	2	---
	December	32	---	---	40	15	10	---	3
1999	January	30	2	4	25	10	20	3	6
	February	28	2	5	26	15	18	3	3
Average		**34.84**	**2.12**	**9.33**	**24.42**	**14.53**	**10.59**	**1.68**	**2.47**
Male & Female Average		**35.29**	**1.75**	**9.17**	**23.4**	**14.37**	**10.96**	**1.05**	**4.03**

Table – 3.3

Percentage composition of various food items in the gut of *H. brachysoma* (Gunther) 1 - 15cm Length Group from May 1997 to February 1999

Year	*Month*	*Crustacean Exoskeleton*	*Prawn*	*Animal Tissues*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Fish Scales*	*Misce-llaneous*
1997	May	40	---	5	30	10	15	---	---
	June	57	---	---	38	5	---	---	---
	July	---	---	---	---	---	---	---	---
	August	40	---	18	25	10.5	9.5	---	---
	September	45	---	15	20	20	---	---	---
	October	36	---	8	24	6	12	14	---
	November	37	4	5	26	24	4	---	---
	December	35	---	---	30	13	22	---	---
1998	January	---	---	---	---	---	---	---	---
	February	28	---	7	20	15	20	---	10
	March	---	---	---	---	---	---	---	---
	April	---	---	---	---	---	---	---	---
	May	50	---	---	30	10	10	---	---
	June	---	---	---	---	---	---	---	---
	July	22	---	48	12	18	---	---	---
	August	40	---	30	10	20	---	---	---
	September	35	---	15	10	35	---	---	5
	October	43	---	15	20	22	---	---	---
	November	45	1	13	20	16	4	1	---
	December	30	---	---	35	15	20	---	---
1999	January	33	---	---	30	14	10	10	3
	February	35	---	---	32	10	15	8	---
Average		**36.29**	**.29**	**10.53**	**24.24**	**15.47**	**8.32**	**1.94**	**1.06**

Table – 3.4

Percentage composition of various food items in the gut of *H. brachysoma* (Gunther) 15 - 30cm Length Group from May 1997 to February 1999

Year	*Month*	*Crustacean Exoskeleton*	*Prawn*	*Animal Tissues*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Fish Scales*	*Misce-llaneous*
1997	May	38	---	8	20	12	22	---	---
	June	40	4	3	23	17	3	---	10
	July	35	2	34	15	14	---	---	---
	August	30	8	11	34	15	2	---	---
	September	49	---	2	28	19	2	---	---
	October	44	---	8	28	10	10	---	---
	November	36	---	9	30	20	5	---	---
	December	35	---	1	34	15	12	---	3
1998	January	29	2	2	25	4	25	2	11
	February	30	---	5	23	10	22	5	5
	March	---	---	---	---	---	---	---	---
	April	---	---	---	---	---	---	---	---
	May	40	5	4	22	15	5	4	5
	June	40	---	6	21	15	18	---	---
	July	31	---	43	10	13	3	---	---
	August	32	10	14	22	14	8	---	---
	September	33	---	14	22	19	9	---	3
	October	41	---	9	19	26	5	---	---
	November	47	---	22	18	13	---	---	---
	December	32	---	5	33	12	15	---	3
1999	January	28	3	2	31	5	20	4	7
	February	25	2	2	35	10	18	5	3
Average		**35.75**	**1.8**	**10.2**	**24.65**	**13.9**	**10.2**	**1**	**2.5**

Table – 3.5

Percentage composition of various food items in the gut of *O. bimaculatus* (Bloch) *Male* from June 1997 to March 1999

Year	*Month*	*Fish Tissues*	*Prawn*	*Crustacean Exoskeleton*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Miscell-aneous*
1997	June	40	—	—	25	19	16	—
	July	45	—	—	30	12	13	—
	August	36	—	3	18	17	11	15
	September	37	—	3	20	15	—	25
	October	38	9	5	20	20	—	8
	November	38	—	7	32	20	—	3
	December	31	—	4	17	27	16	5
1998	January	52	—	—	5	22	21	—
	February	48	—	—	30	12	10	—
	March	45	—	5	27	11	12	—
	April	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—
	June	50	—	—	20	17	13	—
	July	—	—	—	—	—	—	—
	August	40	—	30	—	—	30	—
	September	35	—	15	15	20	15	—
	October	25	25	30	10	10	—	—
	November	27	—	—	15	18	—	40
	December	40	10	—	25	5	20	—
1999	January	47	—	—	10	23	15	5
	February	46	4	14	15	12	5	4
	March	48	—	15	10	10	7	10
Average		**40.42**	**2.53**	**6.89**	**18.11**	**15.26**	**10.74**	**6.05**

Table – 3.6

Percentage composition of various food items in the gut of *O. bimaculatus* (Bloch) *Female* from June 1997 to March 1999

Year	*Month*	*Fish Tissues*	*Prawn*	*Crustacean Exoskeleton*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Miscell-aneous*
1997	June	32	—	38	20	10	—	—
	July	40	—	12	30	18	—	—
	August	40	—	10	10	25	15	—
	September	50	—	—	23	27	—	—
	October	47	—	8	23	22	—	—
	November	34	6	7	18	19	—	16
	December	42	—	—	25	16	17	—
1998	January	39	3	16	5	19	15	3
	February	35	—	10	30	10	—	15
	March	50	—	—	25	12	5	8
	April	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—
	June	30	—	40	15	15	—	—
	July	50	—	—	30	20	—	—
	August	54	—	13	13	1	19	—
	September	34	—	3	26	11	3	23
	October	38	—	10	8	37	7	—
	November	36	—	13	26	8	—	17
	December	54	—	—	30	7	6	3
1999	January	36	2	18	10	17	13	4
	February	40	—	—	25	5	—	30
	March	47	—	12	7	3	8	23
Average		**41.4**	**.55**	**10.5**	**19.95**	**15.1**	**5.4**	**7.1**
Male & Female Average		**40.91**	**1.54**	**8.7**	**19.03**	**15.18**	**8.07**	**6.58**

Table – 3.7

Percentage composition of various food items in the gut of *O. bimaculatus* (Bloch)

***1 – 15cm Length Group* from June 1997 to March 1999**

Year	*Month*	*Fish Tissues*	*Prawn*	*Crustacean Exoskeleton*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Miscell-aneous*
1997	June	40	—	—	25	16	9	10
	July	33	—	—	38	14	3	12
	August	30	—	—	14	14	8	34
	September	35	—	—	19	15	—	31
	October	50	—	—	25	25	—	—
	November	40	—	10	35	15	—	—
	December	42	—	—	28	22	8	—
1998	January	30	10	13	17	12	8	10
	February	50	—	5	22	11	3	9
	March	42	—	7	21	9	6	15
	April	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—
	June	—	—	—	—	—	—	—
	July	—	—	—	—	—	—	—
	August	40	—	30	10	—	20	—
	September	28	—	12	23	10	10	17
	October	40	—	—	—	60	—	—
	November	27	—	—	15	18	—	40
	December	50	—	—	27	5	13	5
1999	January	45	—	—	14	19	15	7
	February	48	—	15	20	10	7	—
	March	45	—	5	25	10	5	10
Average		**39.72**	**.56**	**5.39**	**21**	**15.83**	**6.39**	**11.11**

Table – 3.8

Percentage composition of various food items in the gut of *O. bimaculatus* (Bloch)

***15 - 30cm Length Group* from June 1997 to March 1999**

Year	*Month*	*Fish Tissues*	*Prawn*	*Crustacean Exoskeleton*	*Semi Digested Food*	*Fat Droplets*	*Algal Tissues*	*Miscell-aneous*
1997	June	40	—	12	20	18	10	—
	July	46	—	10	24	12	8	—
	August	39	—	5	21	21	14	—
	September	47	—	4	23	22	—	4
	October	39	8	6	20	20	—	7
	November	36	4	7	23	19	—	11
	December	33	—	3	20	23	18	3
1998	January	48	—	9	3	21	19	—
	February	36	—	10	23	15	11	5
	March	48	—	9	25	9	5	4
	April	—	—	—	—	—	—	—
	May	—	—	—	—	—	—	—
	June	43	—	13	18	17	9	—
	July	50	—	—	30	20	—	—
	August	53	—	15	10	1	21	—
	September	36	—	—	27	12	—	25
	October	33	8	20	12	20	7	—
	November	36	—	13	26	8	—	17
	December	49	5	—	29	7	10	—
1999	January	38	3	16	12	15	10	6
	February	20	—	—	10	10	—	60
	March	45	—	9	11	—	5	30
Average		**40.75**	**1.4**	**8.05**	**19.35**	**14.5**	**7.35**	**8.6**

Table – 3.9
Feeding intensity of male *H. brachysoma* (Gunther)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	May	6	100	—	—
	June	12	100	—	—
	July	6	—	33.33	66.66
	August	14	57	43	—
	September	18	66.66	33.33	—
	October	10	80	20	—
	November	14	85.71	14.29	—
	December	12	83.33	16.67	—
1998	January	4	100	—	—
	February	6	100	—	—
	March	—	—	—	—
	April	—	—	—	—
	May	6	100	—	—
	June	—	—	—	—
	July	4	—	100	—
	August	6	66.66	33.34	—
	September	12	33.34	66.66	—
	October	10	60	40	—
	November	16	62.5	37.5	—
	December	10	80	20	—
1999	January	8	75	25	—
	February	6	100	—	—
Average			**71.06**	**25.42**	**3.51**

Table – 3.10
Feeding intensity of female *H. brachysoma* (Gunther)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	May	8	75	25	—
	June	6	100	—	—
	July	4	100	—	—
	August	16	50	37.5	12.5
	September	---	---	---	---
	October	12	50	50	—
	November	12	83.33	16.67	---
	December	12	66.66	33.34	—
1998	January	14	42.85	57.15	—
	February	12	33.34	66.66	—
	March	---	---	—	---
	April	---	---	---	—
	May	8	75	25	—
	June	14	100	---	---
	July	18	---	77.77	22.23
	August	14	57.14	42.86	—
	September	10	20	80	---
	October	12	50	50	---
	November	12	50	50	—
	December	8	50	50	---
1999	January	6	33.33	66.67	---
	February	10	60	40	---
Average			**57.72**	**40.45**	**1.83**
Male & Female Average			**64.39**	**32.94**	**2.67**

Table – 3.11
Feeding intensity of 1 – 15cm Size Group of *H. brachysoma* (Gunther)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	May	4	---	100	---
	June	4	100	---	---
	July	---	---	---	---
	August	6	33.33	33.33	33.34
	September	2	100	---	---
	October	16	62.5	37.5	---
	November	16	75	25	---
	December	8	75	25	---
1998	January	---	---	---	---
	February	4	---	100	---
	March	---	---	---	---
	April	---	---	---	---
	May	4	50	50	---
	June	---	---	---	---
	July	4	---	50	50
	August	4	---	100	---
	September	6	33.33	66.67	---
	October	6	33.33	66.67	---
	November	20	60	40	---
	December	6	33.33	66.67	---
1999	January	4	---	100	---
	February	4	---	100	---
Average			**49.15**	**47.46**	**3.39**

Table – 3.12
Feeding intensity of 15 – 30cm Size Group of *H. brachysoma* (Gunther)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	May	10	100	---	---
	June	14	100	---	---
	July	8	25	50	25
	August	24	58.33	41.67	---
	September	16	75	25	---
	October	6	66.66	33.34	---
	November	10	100	---	---
	December	16	75	25	---
1998	January	16	50	50	---
	February	14	71.43	28.57	---
	March	---	---	---	---
	April	---	---	---	---
	May	10	100	---	---
	June	14	100	---	---
	July	18	---	88.89	11.11
	August	18	66.66	33.34	---
	September	16	25	75	---
	October	16	62.5	37.5	---
	November	8	50	50	---
	December	12	83.33	16.67	---
1999	January	10	80	20	---
	February	12	100	---	---
Average			**67.16**	**31.35**	**1.49**

Table – 3.13
Feeding Intensity of Male *O. bimaculatus* (Bloch)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	June	6	—	100	—
	July	6	66.67	33.33	—
	August	22	45.45	45.45	9.10
	September	14	14.29	66.67	42.86
	October	18	33.33	20	—
	November	10	80	22.22	—
	December	18	66.67	33.33	11.11
1998	January	12	66.66	100	—
	February	8	—	100	—
	March	6	—	—	—
	April	—	—	—	—
	May	—	—	—	—
	June	4	100	—	—
	July	—	—	—	—
	August	4	—	100	—
	September	4	50	50	—
	October	4	100	—	—
	November	4	100	—	—
	December	6	—	100	—
1999	January	10	60	40	—
	February	2	100	—	—
	March	4	100	—	—
Average			**46.91**	**46.92**	**6.17**

Table – 3.14
Feeding Intensity of Female *O. bimaculatus* (Bloch)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	June	8	25	75	—
	July	4	—	100	—
	August	2	100	—	—
	September	6	100	—	—
	October	4	100	—	—
	November	10	80	—	20
	December	12	66.66	33.34	—
1998	January	16	37.5	62.5	—
	February	6	—	100	—
	March	8	25	75	—
	April	—	—	—	—
	May	—	—	—	—
	June	4	50	50	—
	July	4	—	100	—
	August	20	70	20	10
	September	26	53.85	38.46	7.69
	October	8	100	—	—
	November	14	57.14	28.57	14.29
	December	8	75	25	—
1999	January	8	25	75	—
	February	4	50	50	—
	March	6	66.67	33.33	—
Average			**55.06**	**40.45**	**4.49**
Male & Female Average			**50.99**	**43.68**	**5.33**

Table – 3.15
Feeding Intensity of 1 – 15cm Size Group of *O. bimaculatus* (Bloch)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	June	4	50	50	—
	July	4	50	50	—
	August	12	16.67	66.67	16.66
	September	10	20	20	60
	October	2	100	—	—
	November	2	100	—	—
	December	4	50	50	—
1998	January	4	—	100	—
	February	6	—	100	—
	March	8	—	100	—
	April	—	—	—	—
	May	—	—	—	—
	June	—	—	—	—
	July	4	50	50	—
	August	2	—	—	100
	September	4	—	100	—
	October	4	100	—	—
	November	4	100	—	—
	December	4	—	100	—
1999	January	6	33.33	66.67	—
	February	4	100	—	—
	March	6	100	—	—
Average			**38.3**	**51.06**	**10.64**

Table – 3.16
Feeding Intensity of 15 – 30 cm Size Group of *O. bimaculatus* (Bloch)
Percentage of fish with various stomach

Year	*Month*	*No. of Fish*	*'Empty'*	*'Medium'*	*'Heavy'*
1997	June	10	---	100	---
	July	6	33.33	66.67	—
	August	14	71.43	28.57	---
	September	10	60	40	—
	October	20	40	60	---
	November	18	77.78	11.11	11.11
	December	26	69.23	23.08	7.69
1998	January	24	58.33	41.67	---
	February	8	---	100	---
	March	6	33.33	66.67	---
	April	---	---	---	---
	May	—	—	—	—
	June	8	75	25	—
	July	4	---	100	---
	August	22	63.64	36.36	—
	September	26	61.54	30.77	7.69
	October	8	100	---	---
	November	14	57.14	28.57	14.29
	December	10	60	40	---
1999	January	12	50	50	---
	February	4	—	100	---
	March	4	50	50	—
Average			**55.12**	**41.73**	**3.15**

Table – 3.17

Monthly Gastrosomatic Index (G.S.I.) in the Male & Female Sex Groups of *H. brachysoma* (Gunther) from May 1997 to February 1999

Year	*Month*	*G.S.I.*		
		Male	*Female*	*Total Average*
1997	May	1.24	.99	1.1
	June	.92	.82	.89
	July	5.59	1.34	4.53
	August	1.99	2.42	2.22
	September	1.29	—	1.29
	October	1.39	2.35	1.91
	November	1.12	1.37	1.23
	December	1.13	1.54	1.34
1998	January	.99	1.89	1.78
	February	1.34	1.9	1.72
	March	—	—	—
	April	—	—	—
	May	1.06	.91	.97
	June	—	.71	.71
	July	3.54	4.55	4.37
	August	1.7	2.02	1.92
	September	1.6	1.91	1.74
	October	1.65	2.07	1.88
	November	1.7	1.7	1.7
	December	1.36	1.53	1.43
1999	January	1.36	2.07	1.66
	February	1.04	1.9	1.58

Table – 3.18

Monthly Gastrosomatic Index (G.S.I.) in 1 – 15cm & 15 – 30cm Size Groups of *H. brachysoma* (Gunther) from May 1997 to February 1999

Year	*Month*	*G.S.I.*	
		1 – 15cm	*15 – 30cm*
1997	May	1.81	.81
	June	1.19	.80
	July	---	4.53
	August	3.6	1.95
	September	1.7	1.24
	October	2.46	1.23
	November	1.39	.99
	December	1.42	1.29
1998	January	---	1.78
	February	2.47	1.5
	March	---	---
	April	---	---
	May	1.57	.74
	June	---	.71
	July	6.68	3.86
	August	2.58	1.85
	September	1.8	1.72
	October	2.32	1.72
	November	1.71	1.67
	December	1.71	1.09
1999	January	2.06	1.5
	February	3.1	1.07

Table – 3.19

Monthly Gastrosomatic Index (G.S.I.) in the Male & Female Sex Groups of *O. bimaculatus* (Bloch) from June 1997 to March 1999

Year	*Month*	*G.S.I.*		
		Male	*Female*	*Total Average*
1997	June	2.36	2.19	2.26
	July	2.01	2.48	2.2
	August	3.28	.78	3.07
	September	6.31	1.05	4.74
	October	2.92	1.03	2.57
	November	1.55	3.51	2.53
	December	2.42	1.58	2.09
1998	January	1.87	2.74	2.37
	February	2.72	2.35	2.62
	March	2.69	2.69	2.69
	April	---	---	---
	May	---	---	---
	June	1.66	1.98	1.82
	July	---	2.34	2.34
	August	2.34	4.74	2.74
	September	2.75	2.09	2.67
	October	1.67	1.51	1.54
	November	1.47	3.23	2.83
	December	2.64	1.57	2.03
1999	January	1.89	1.96	1.92
	February	1.47	2.06	1.86
	March	1.51	2.46	2.08

Table – 3.20

Monthly Gastrosomatic Index (G.S.I.) in 1 – 15cm & 15 – 30cm Size Groups of *O. bimaculatus* (Bloch) from June 1997 to March 1999

Year	*Month*	*G.S.I.*	
		1 – 15cm	*15 – 30cm*
1997	June	2.38	2.21
	July	2.32	2.11
	August	4.11	2.33
	September	7.71	1.77
	October	1.57	2.67
	November	1.53	2.64
	December	2.29	2.06
1998	January	4.64	1.99
	February	2.39	2.69
	March	2.51	2.94
	April	---	---
	May	---	---
	June	---	1.82
	July	---	2.34
	August	7.08	2.34
	September	3.36	2.56
	October	1.78	1.48
	November	1.47	3.23
	December	2.19	1.96
1999	January	1.9	1.94
	February	1.5	2.59
	March	1.6	2.79

Table – 3.21

Arrangement of pharyngeal teeth in the Buccal cavity of *H. brachysoma* (Gunther)

Jaw	*Total No. of teeth*	*Teeth on the right side*	*Teeth on the left side*	*Average length of a pharyngeal tooth* (μ)	*Average gap between adjacent teeth (μ)*
Upper Jaw	407	201 (16 rows)	206 (16 rows)	700	200
Lower Jaw	531	269 (28 rows)	262 (28 rows)	500	150
Total	**938**	**470**	**468**		

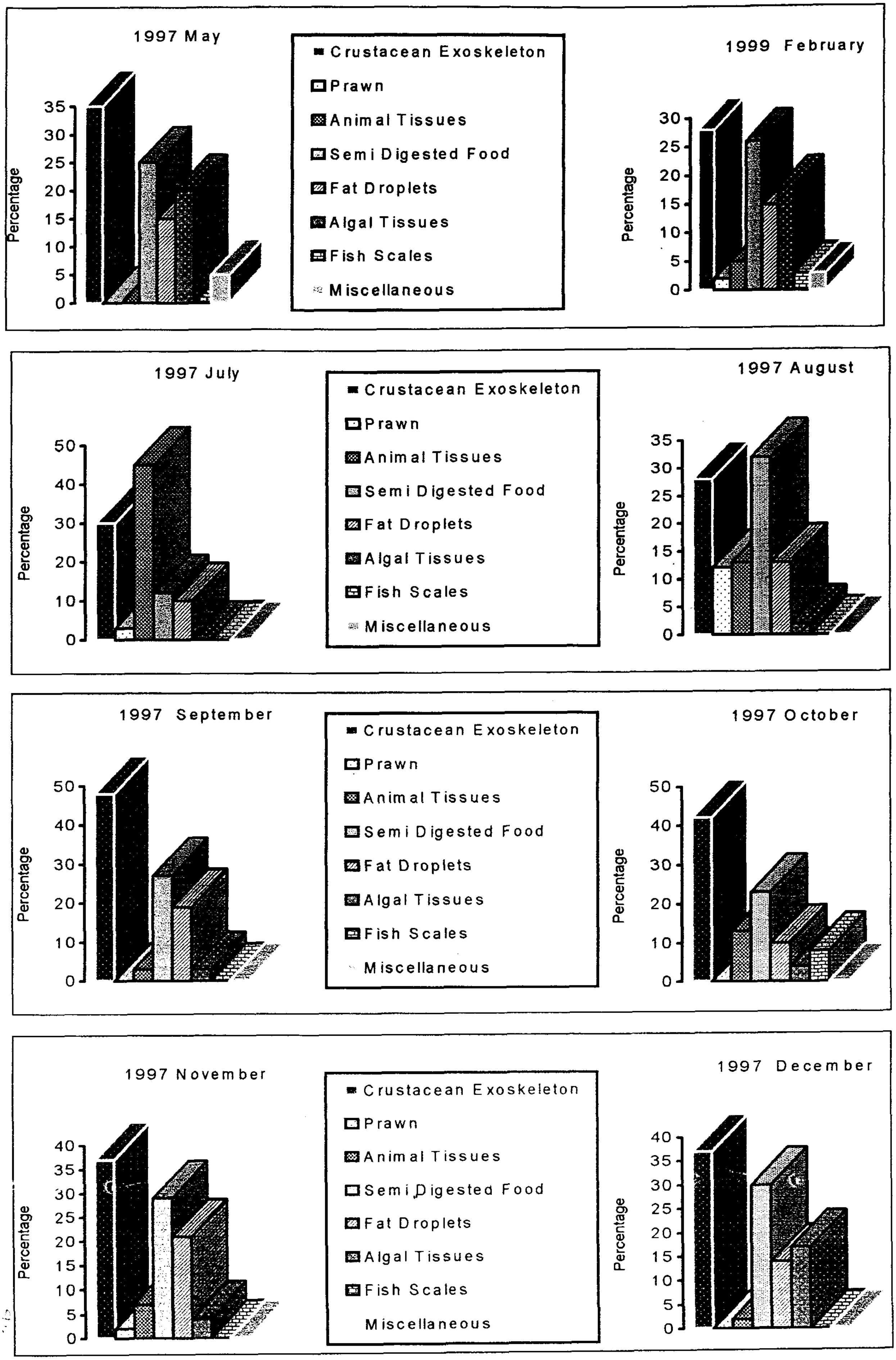
Table – 3.22

Arrangement of pharyngeal teeth in the Buccal cavity of *O. bimaculatus* (Bloch)

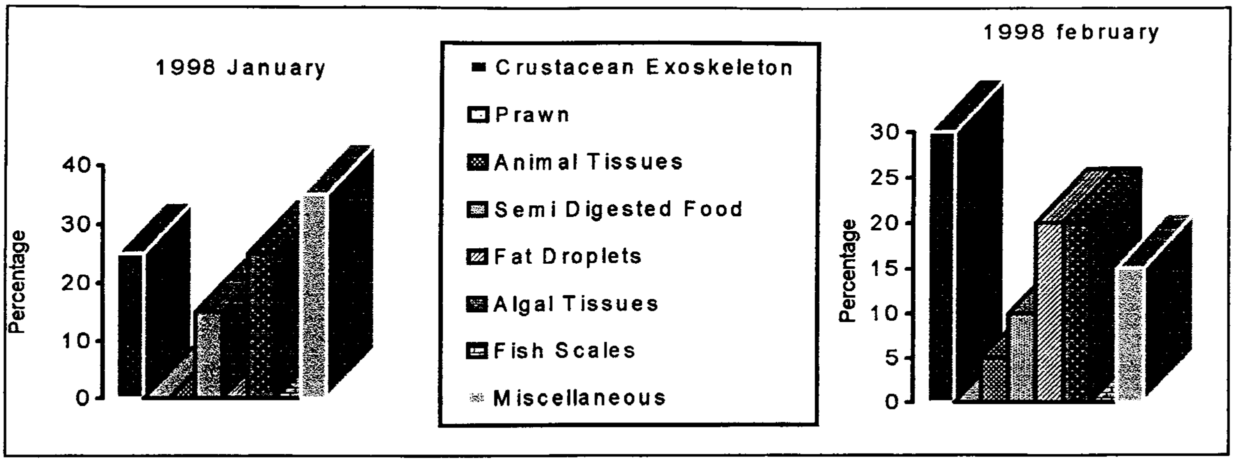
Jaw	*Total No. of teeth*	*Teeth on the right side*	*Teeth on the left side*	*Average length of a pharyngeal tooth* (μ)	*Average gap between adjacent teeth (μ)*
Upper Jaw	178	90 (15 rows)	88 (15 rows)	1100	300
Lower Jaw	185	90 (14 rows)	95 (14 rows)	950	200
Total	**363**	**180**	**183**		

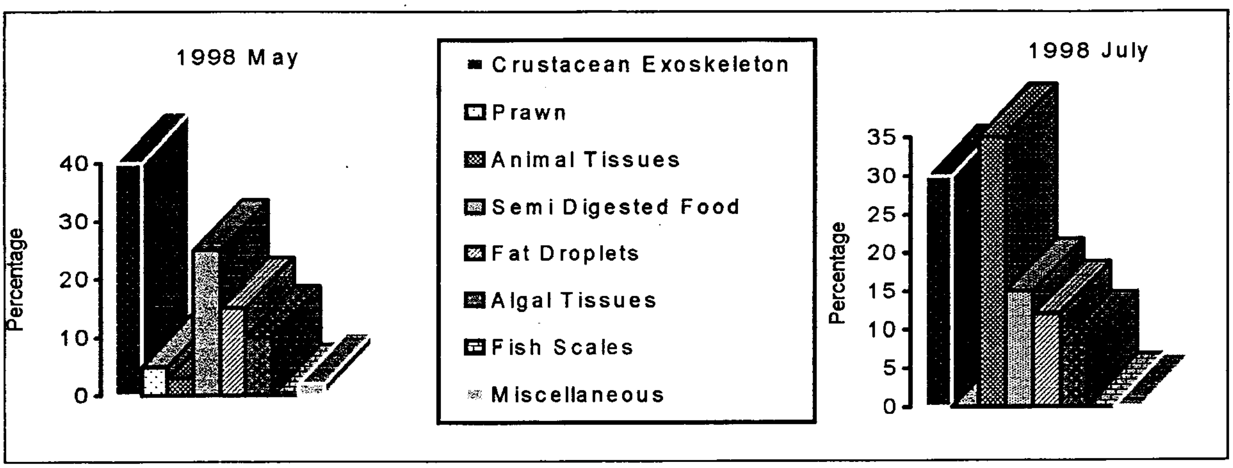
Monthly average percentage composition of various food items in the gut of Male *H. brachysoma* from May 1997 – February 1999

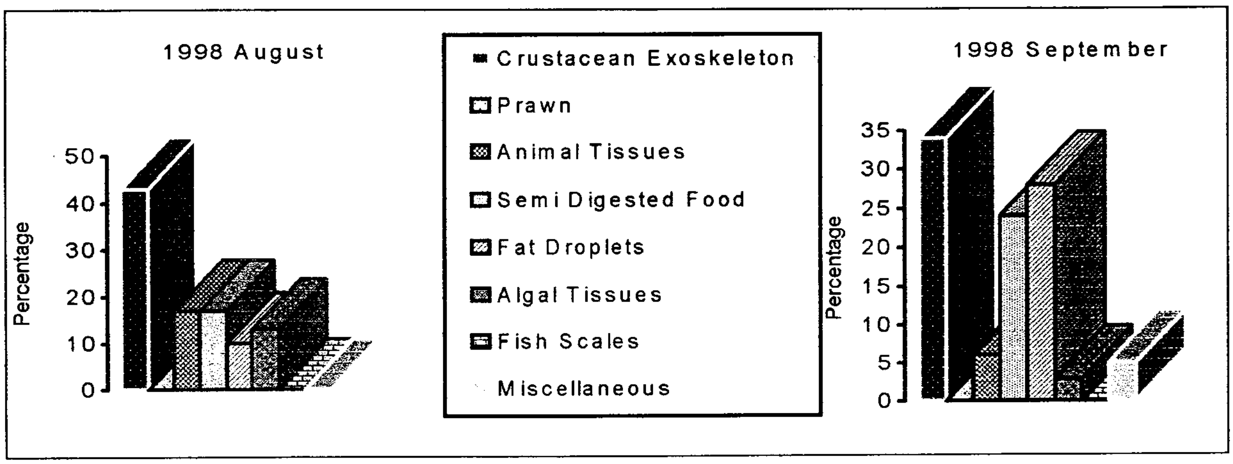
Fig. – 3.1

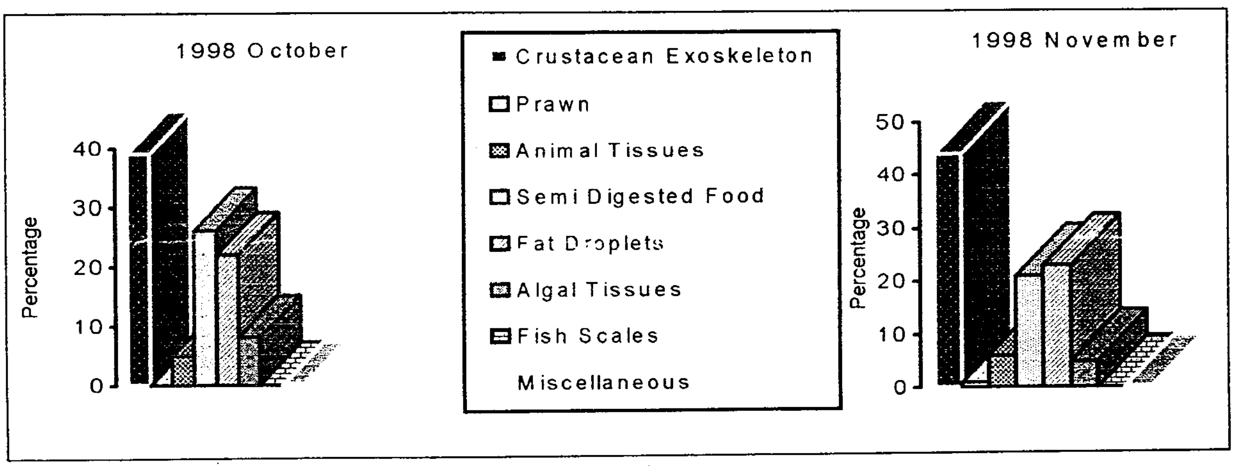


(Contd........Fig. – 3.1)

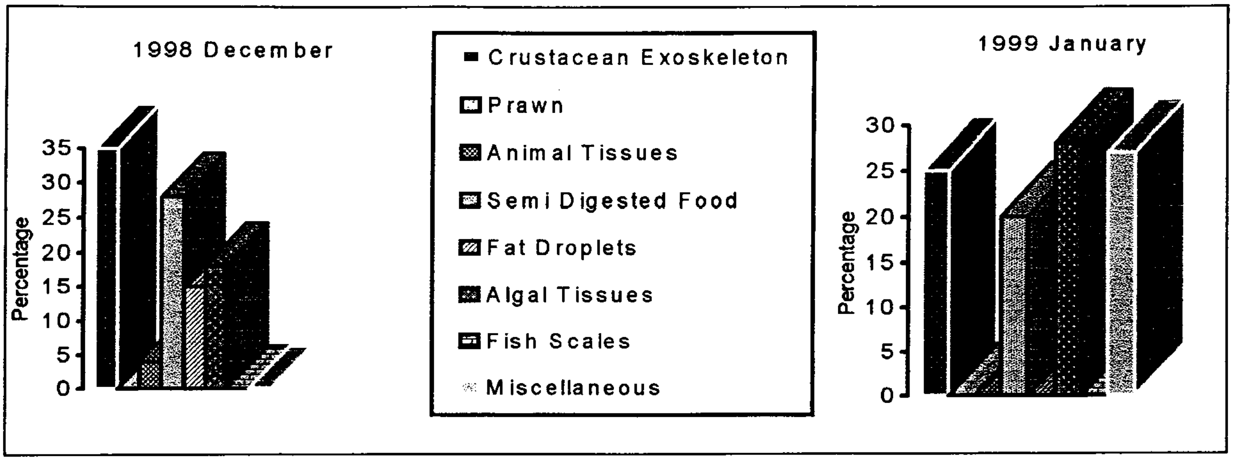

1998 January
1998 february
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

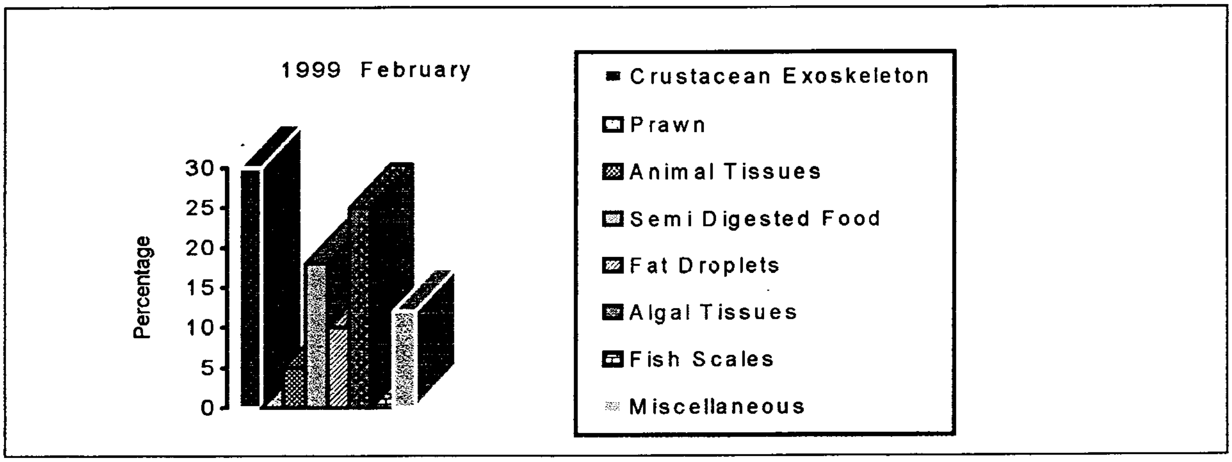

1998 May
1998 July
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous


1998 August
1998 September
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous


1998 October
1998 November
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

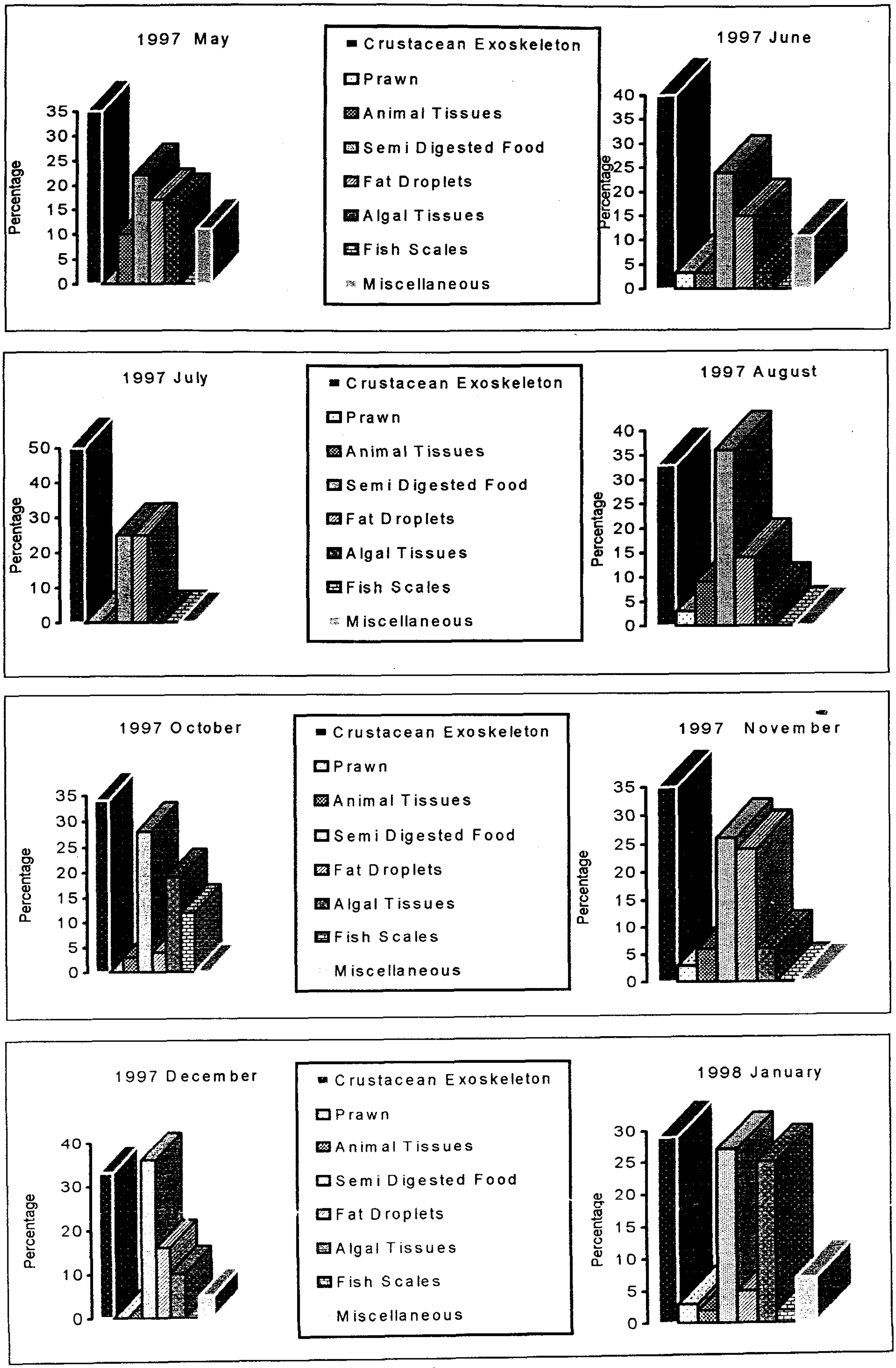
(Contd.........Fig. – 3.1)


1998 December
Percentage
35
30
25
20
15
10
5
0
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1999 January
Percentage
30
25
20
15
10
5
0

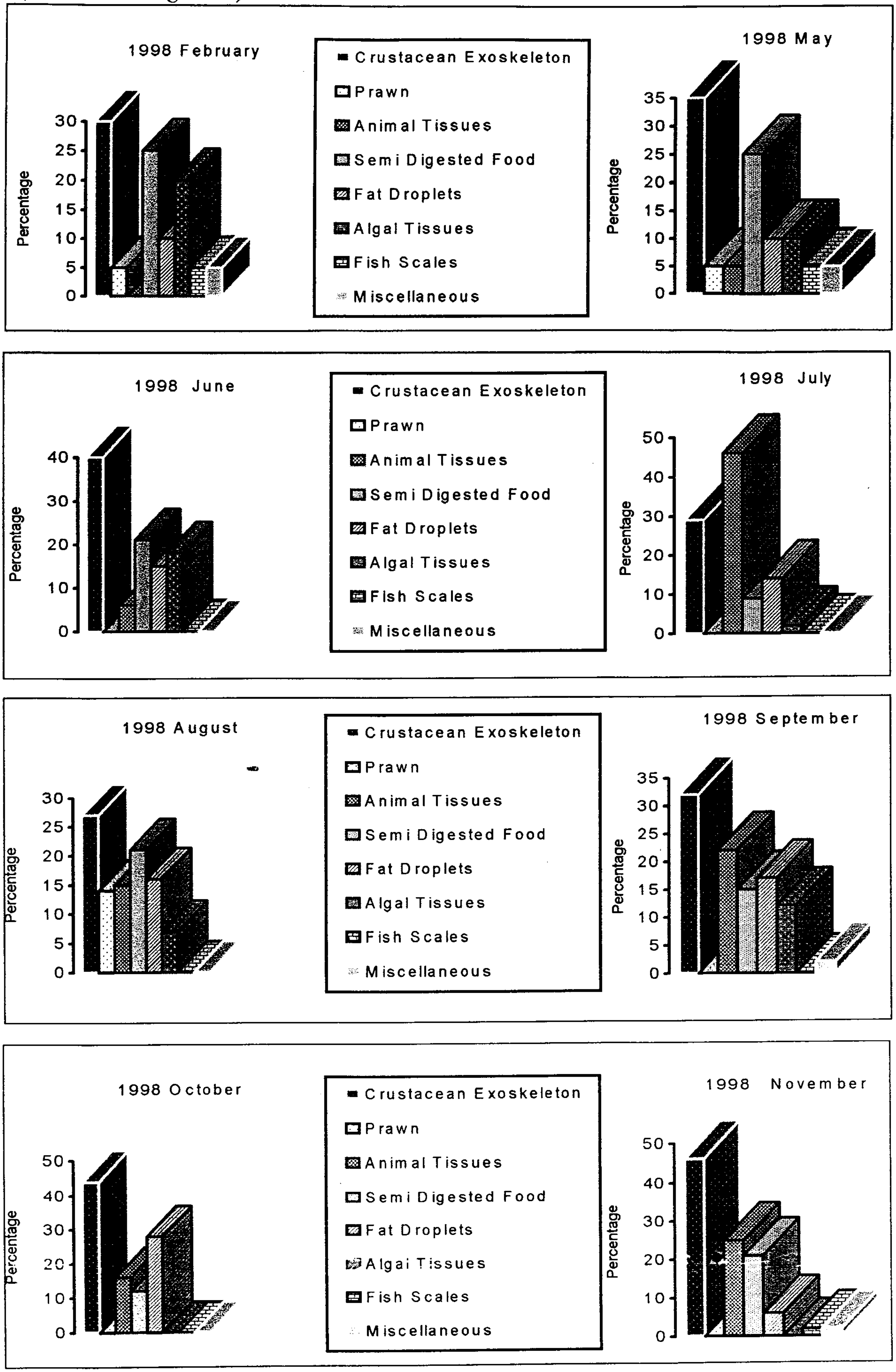

1999 February
Percentage
30
25
20
15
10
5
0
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

Monthly average percentage composition of various food items in the gut of Female *H. brachysoma* from May 1997 – February 1999

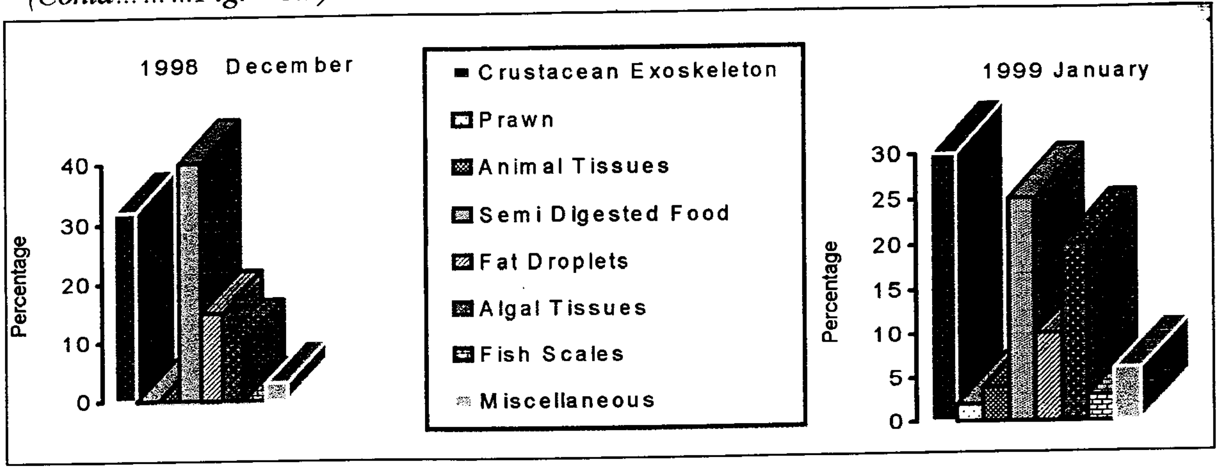
Fig. – 3.2



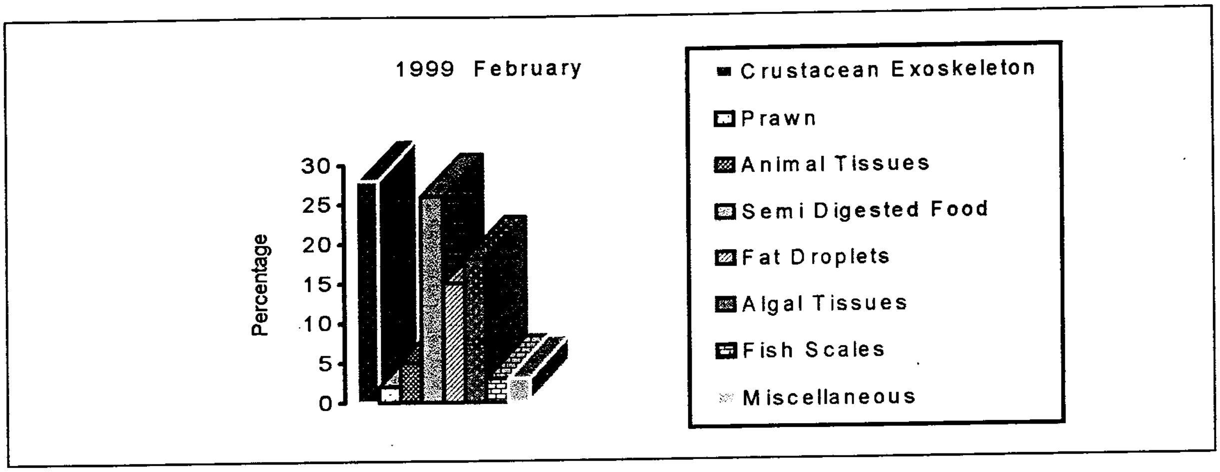
(Contd.........Fig. – 3.2)


1998 February
Percentage
0
5
10
15
20
25
30
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1998 May
Percentage
0
5
10
15
20
25
30
35
1998 June
Percentage
0
10
20
30
40
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1998 July
Percentage
0
10
20
30
40
50
1998 August
Percentage
0
5
10
15
20
25
30
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1998 September
Percentage
0
5
10
15
20
25
30
35
1998 October
Percentage
0
10
20
30
40
50
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algai Tissues
Fish Scales
Miscellaneous
1998 November
Percentage
0
10
20
30
40
50

(Contd.........Fig. – 3.2)



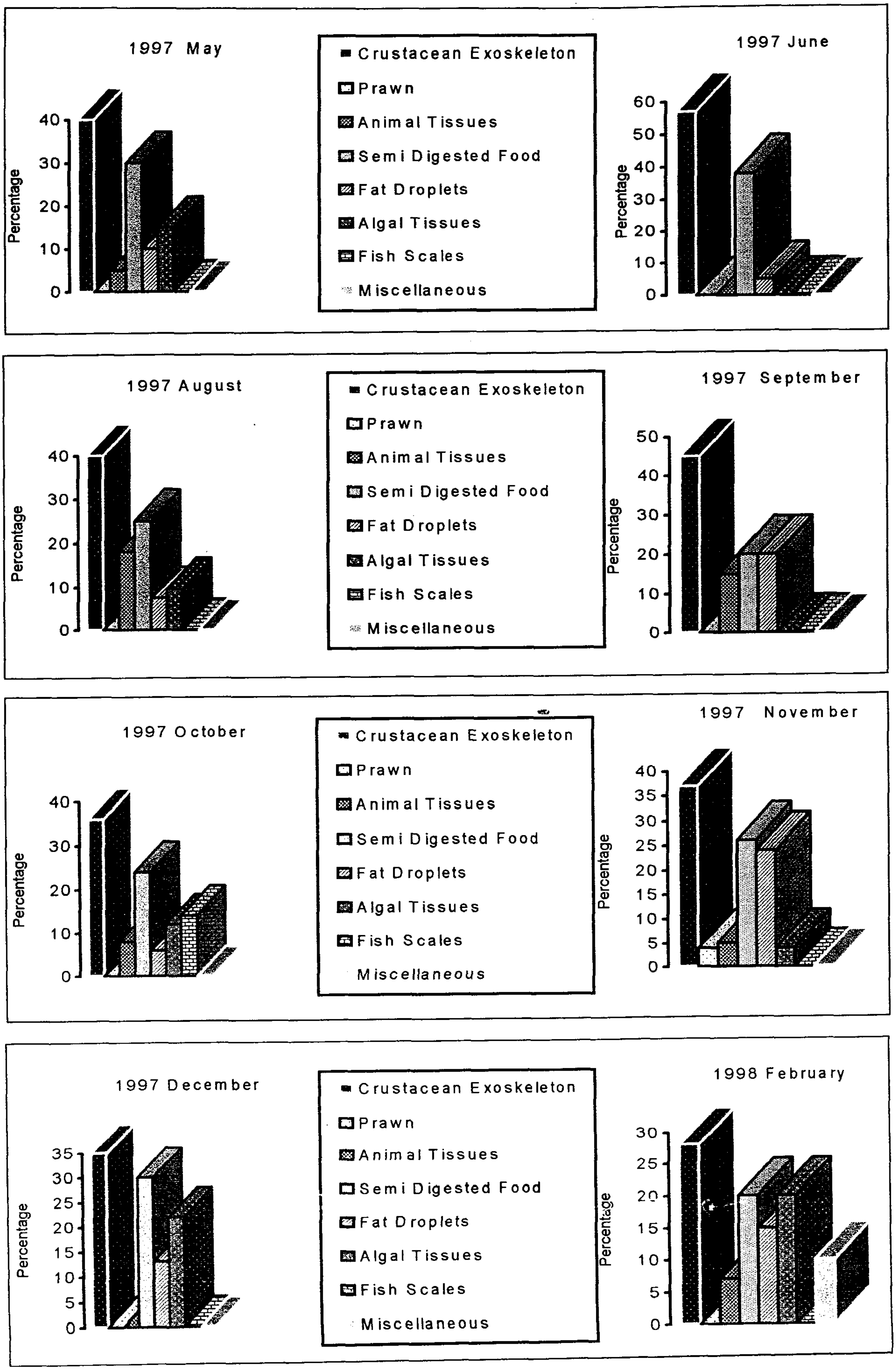
1998 December
Percentage
40
30
20
10
0
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1999 January
Percentage
30
25
20
15
10
5
0



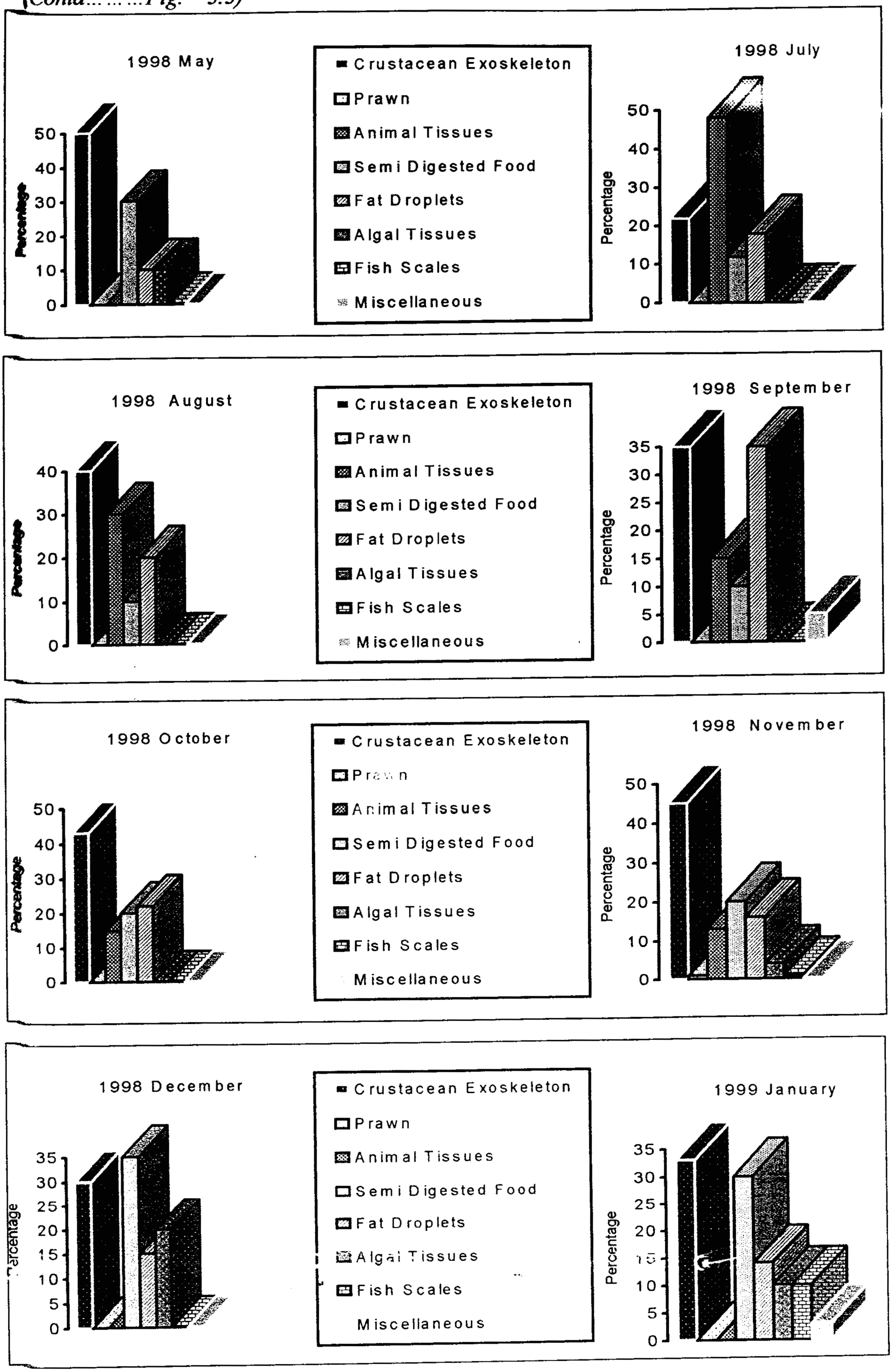
1999 February
Percentage
30
25
20
15
10
5
0
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

Monthly average percentage composition of various food items in the gut of *H. brachysoma* 1-15 cm from May 1997 – February 1999

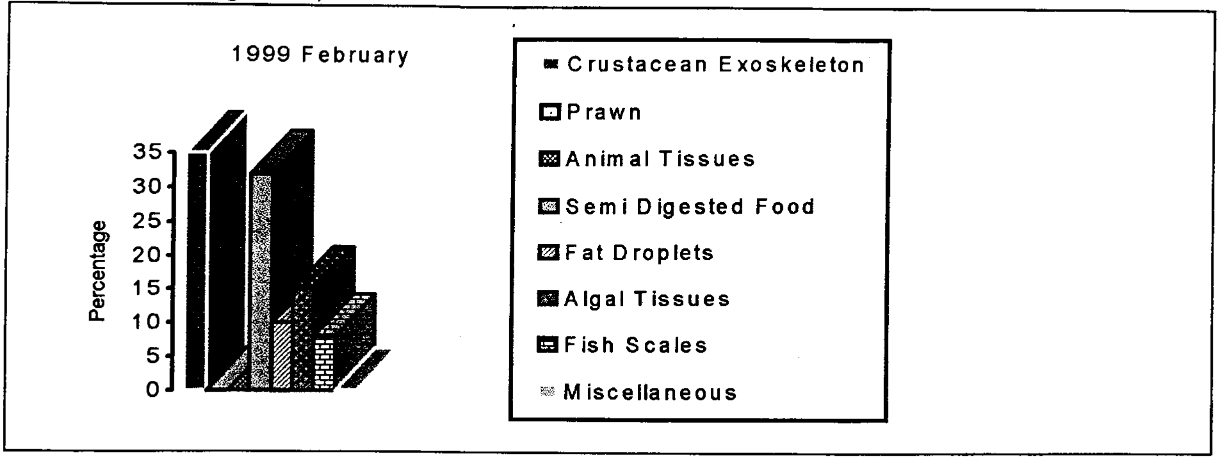
Fig. – 3.3



(Contd……...Fig. – 3.3)


1998 May
1998 July
1998 August
1998 September
1998 October
1998 November
1998 December
1999 January
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

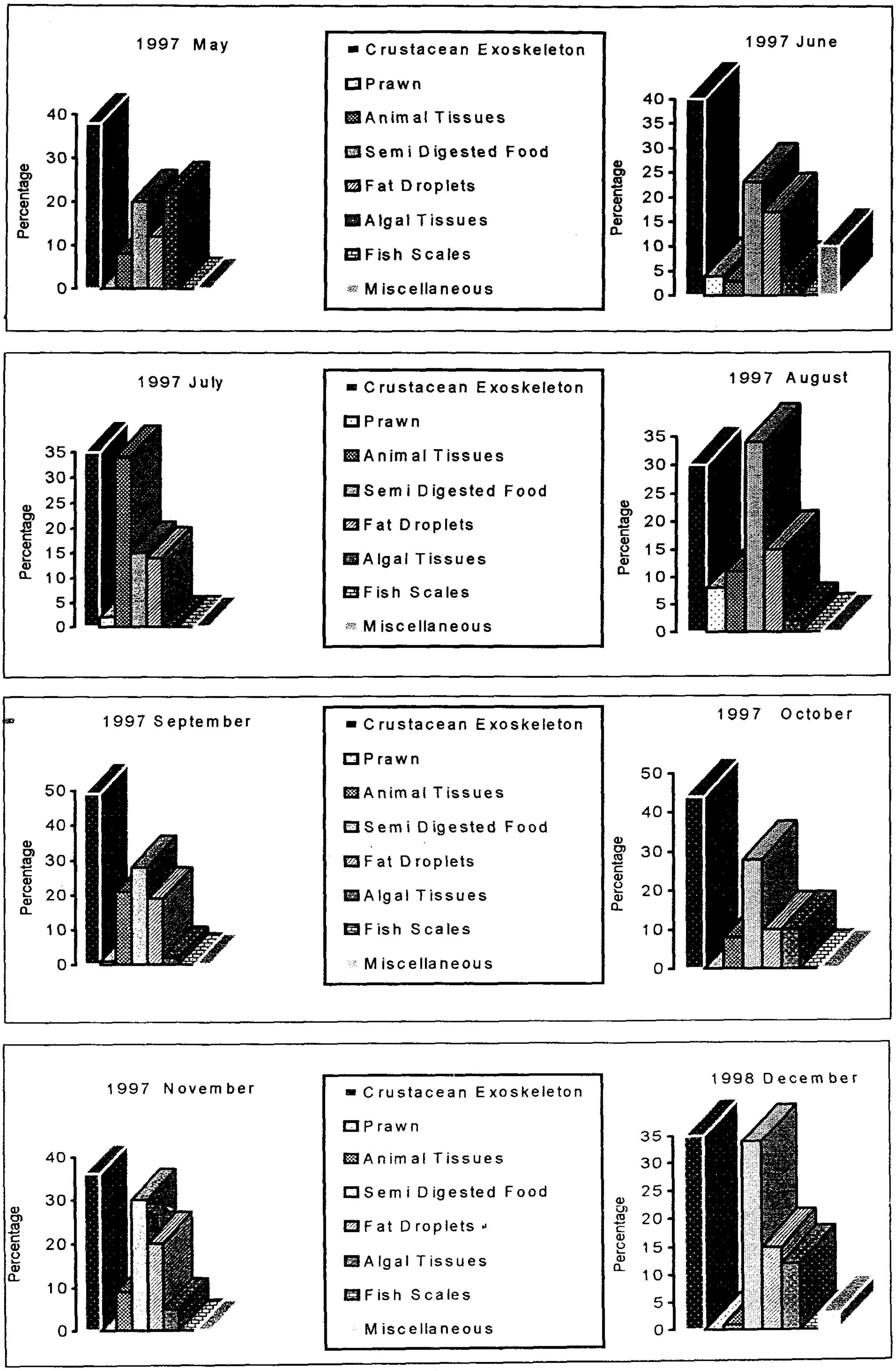
(Contd………Fig. – 3.3)



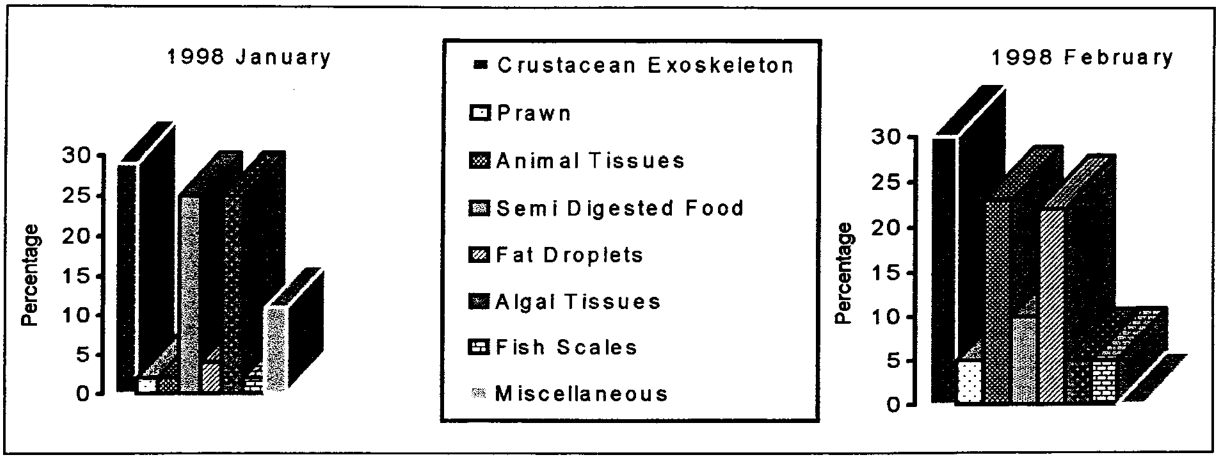
1999 February
35
30
25
20
15
10
5
0
Percentage
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous

Monthly average percentage composition of various food items in the gut of *H. brachysoma* 15-30 cm from May 1997 – February 1999

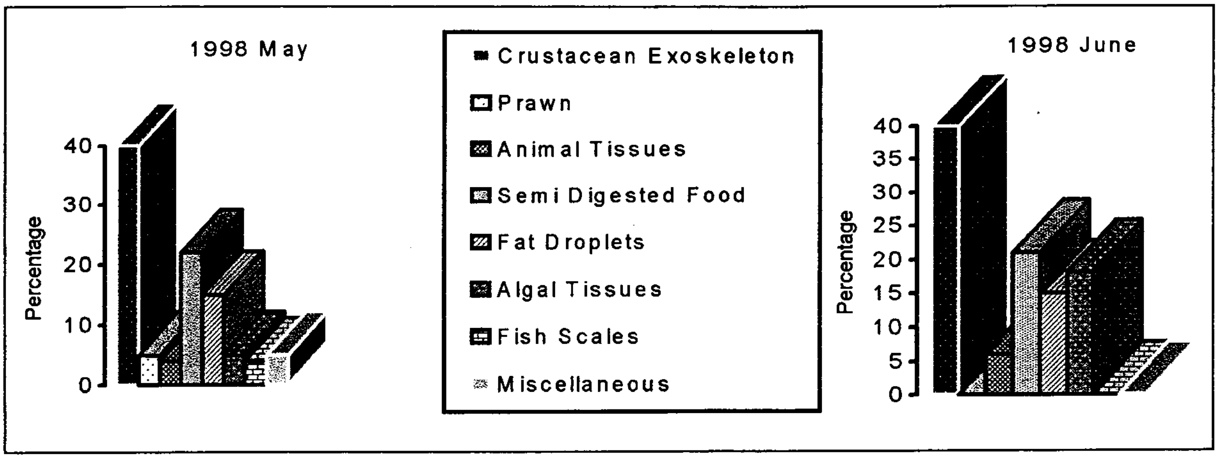
Fig. – 3 - 4



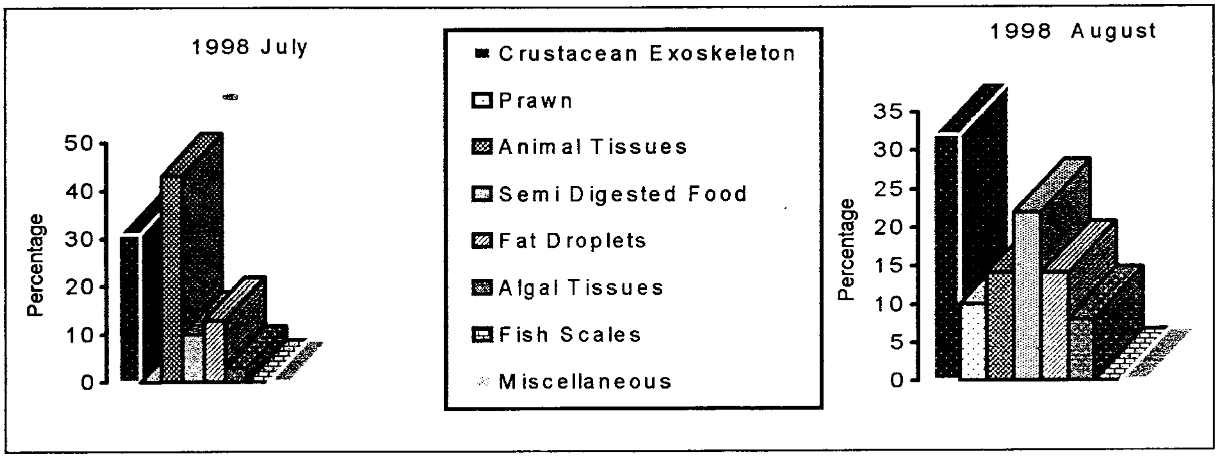
(Contd.........Fig. – 3.4)



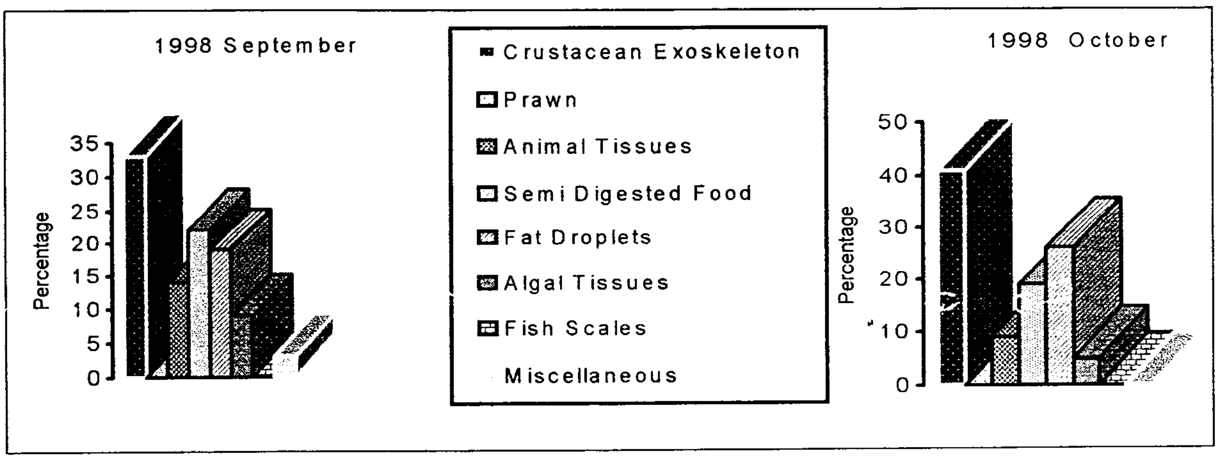
1998 January
1998 February
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
Percentage



1998 May
1998 June
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
Percentage

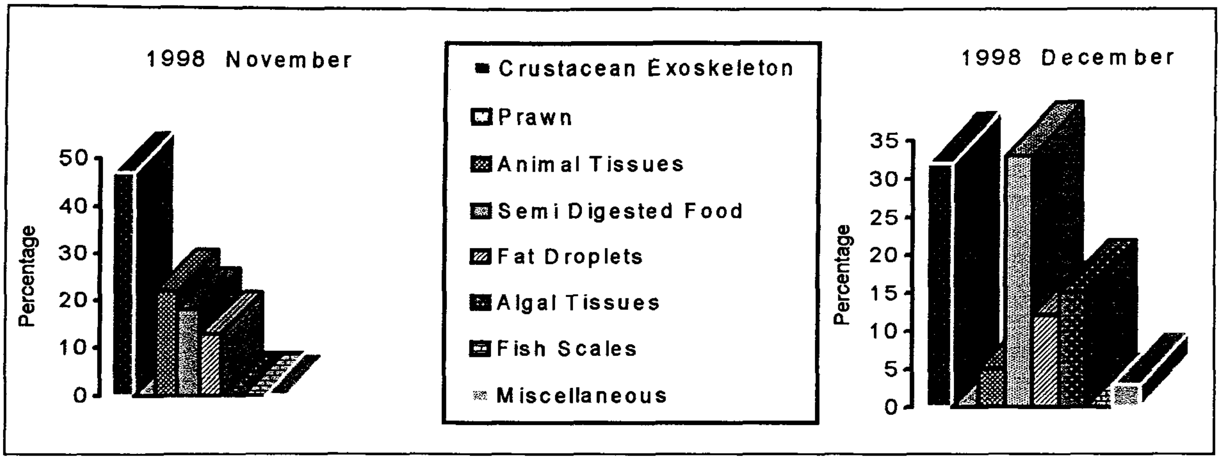


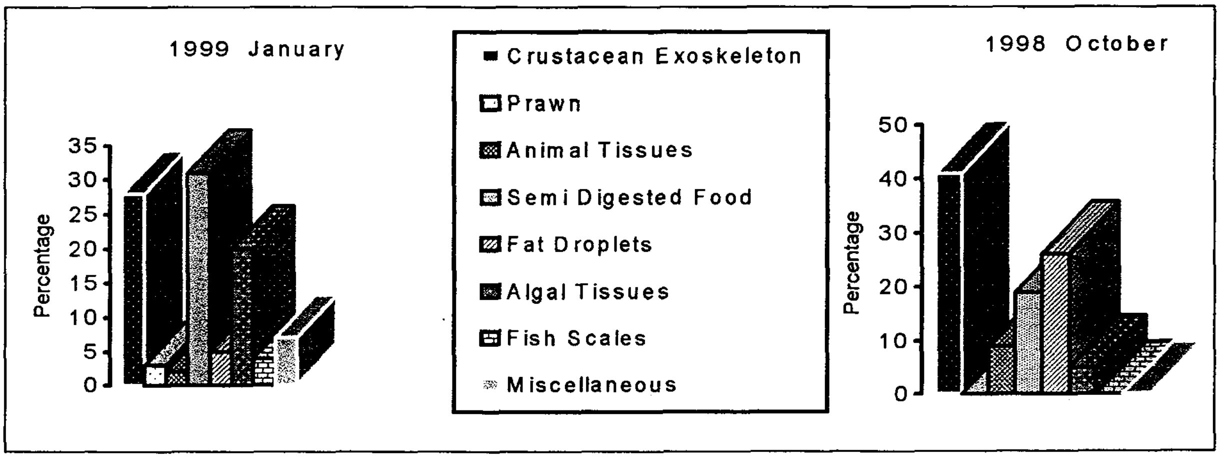
1998 July
1998 August
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
Percentage



1998 September
1998 October
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
Percentage

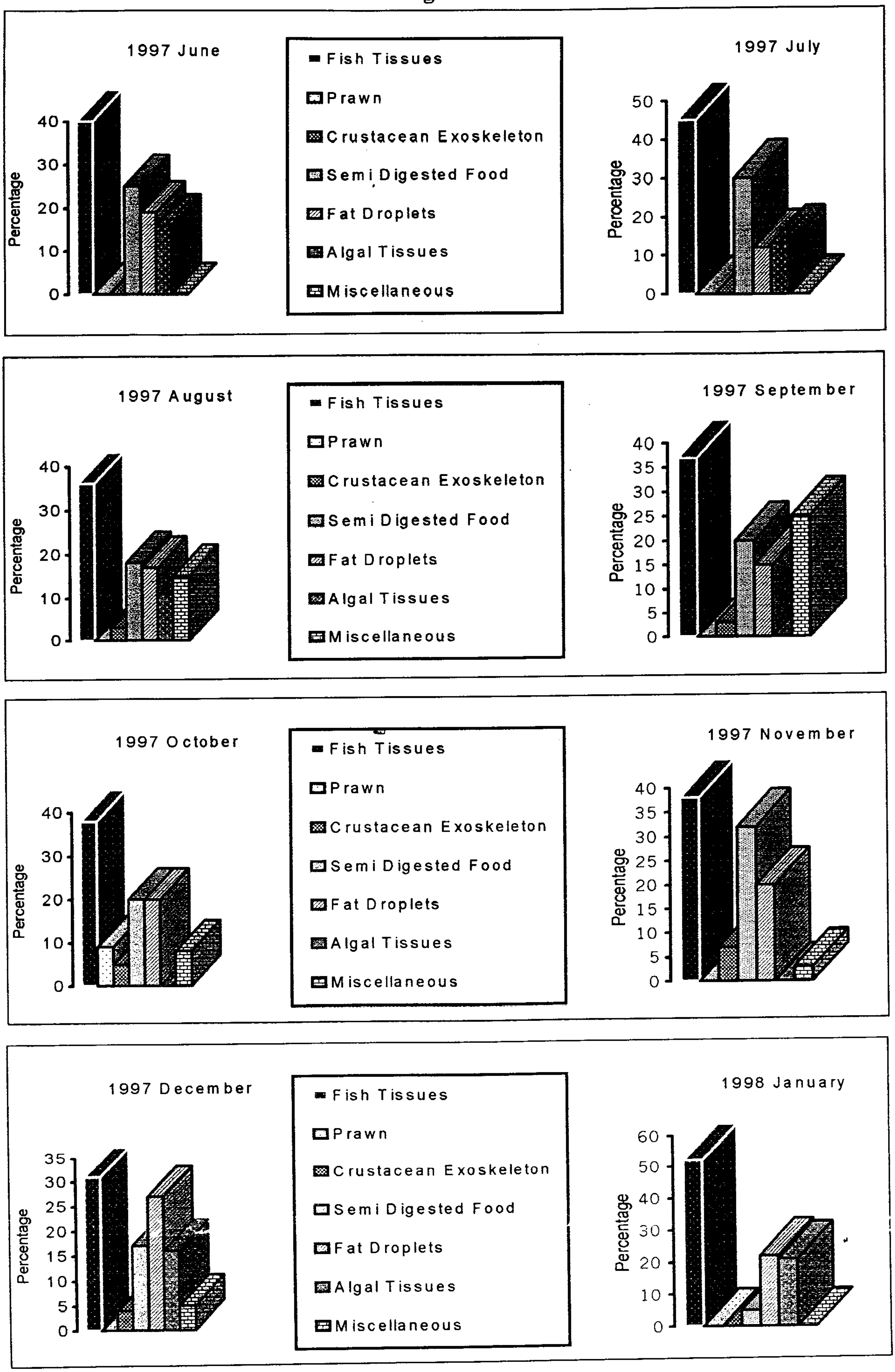
(Contd.........Fig. – 3.4)


1998 November
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1998 December
Percentage
0
10
20
30
40
50
0
5
10
15
20
25
30
35

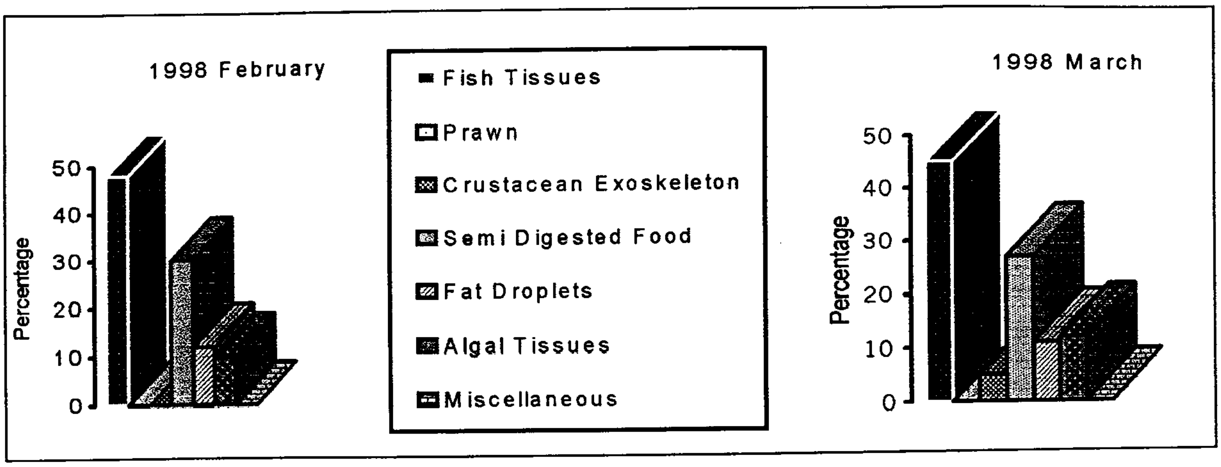

1999 January
Crustacean Exoskeleton
Prawn
Animal Tissues
Semi Digested Food
Fat Droplets
Algal Tissues
Fish Scales
Miscellaneous
1998 October
Percentage
0
5
10
15
20
25
30
35
0
10
20
30
40
50

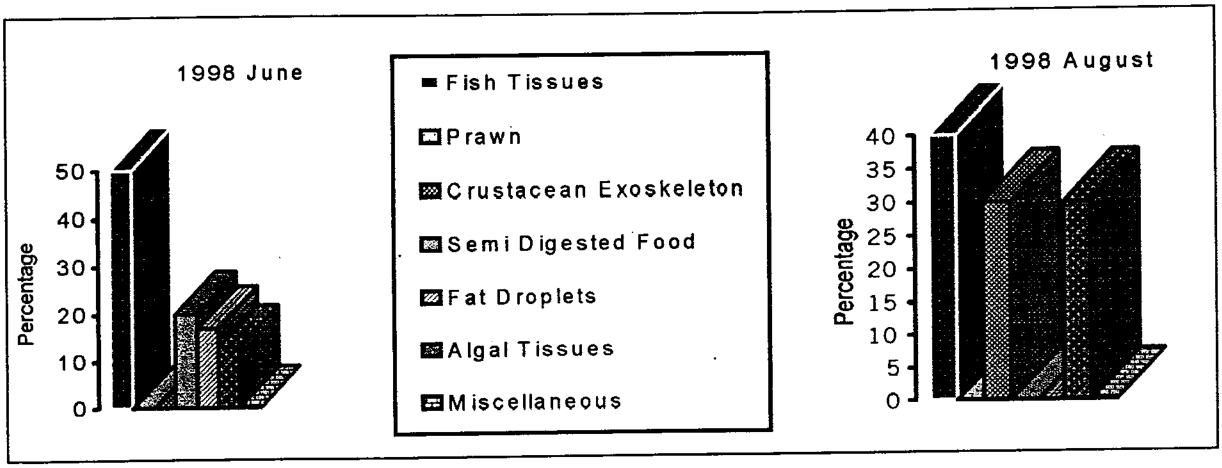
Monthly Average Percentage composition of various food items in the gut of Male *O. bimaculatus* from June 1997 – March 1999

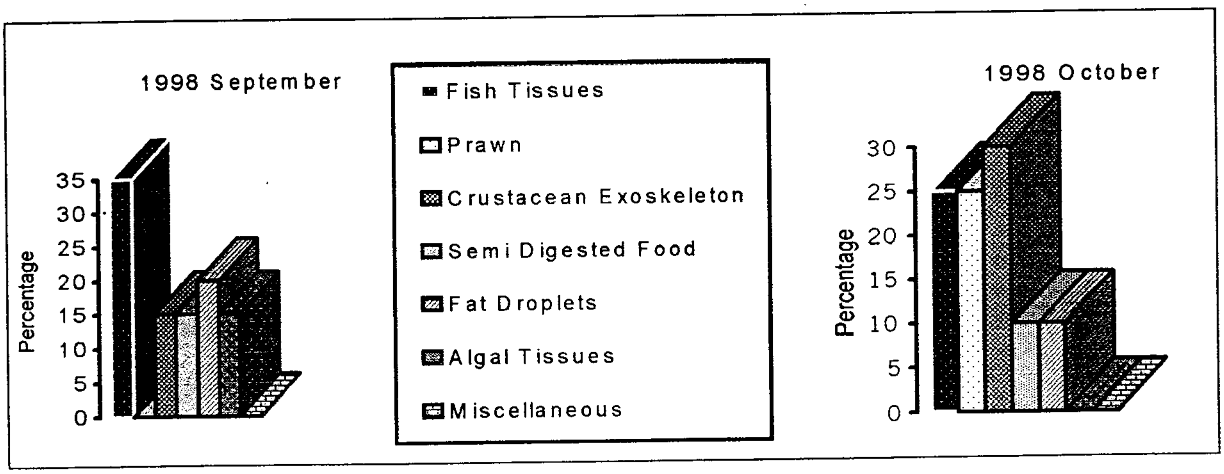
Fig. – 3.5

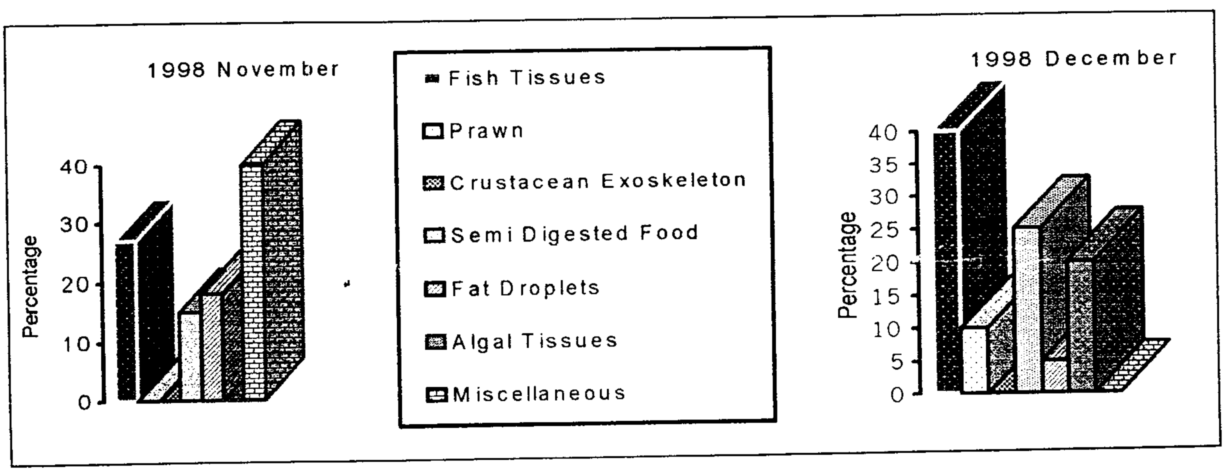


(Contd..... Fig. – 3.5)

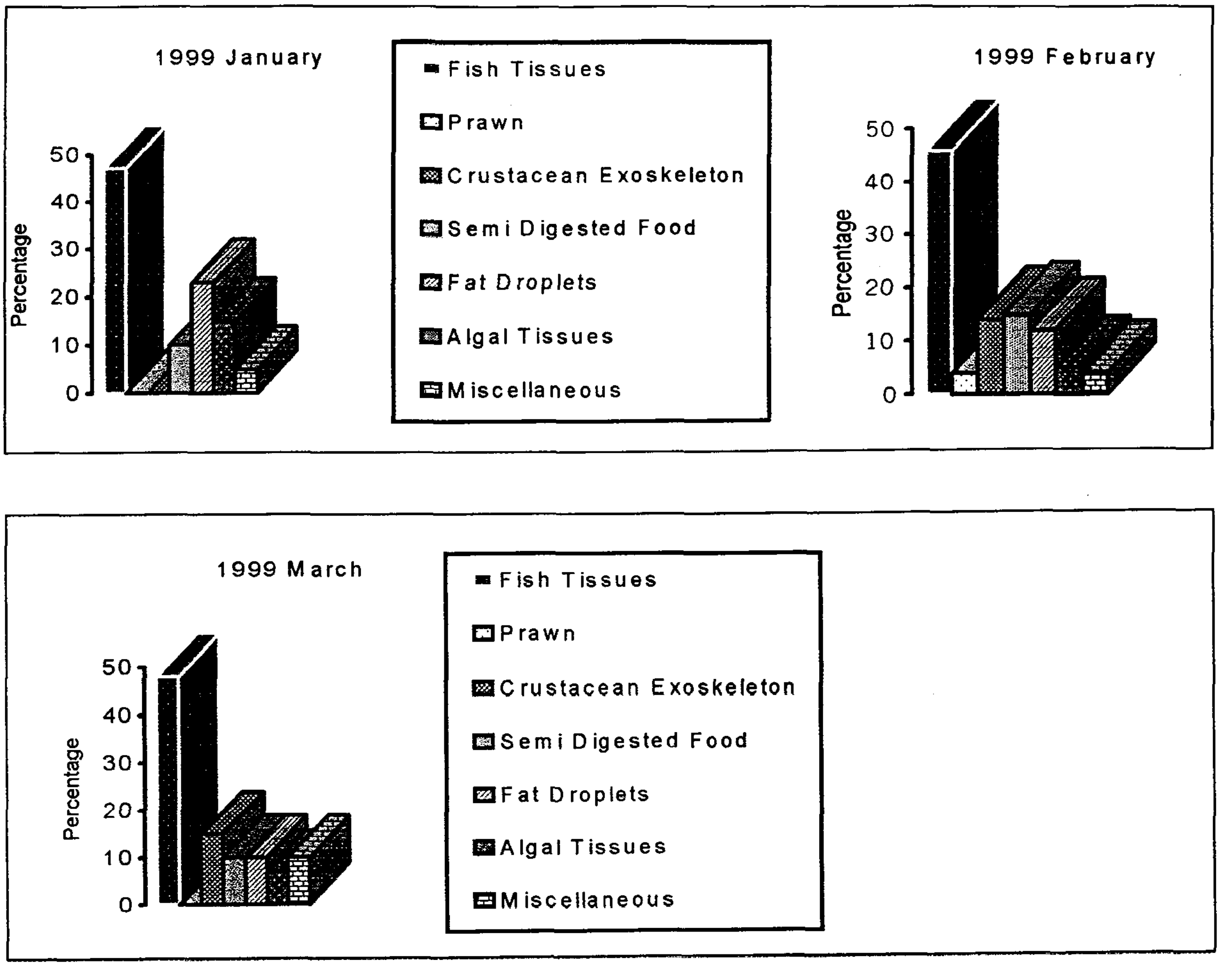

1998 February
Percentage
0
10
20
30
40
50
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 March
Percentage
0
10
20
30
40
50


1998 June
Percentage
0
10
20
30
40
50
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 August
Percentage
0
5
10
15
20
25
30
35
40


1998 September
Percentage
0
5
10
15
20
25
30
35
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 October
Percentage
0
5
10
15
20
25
30

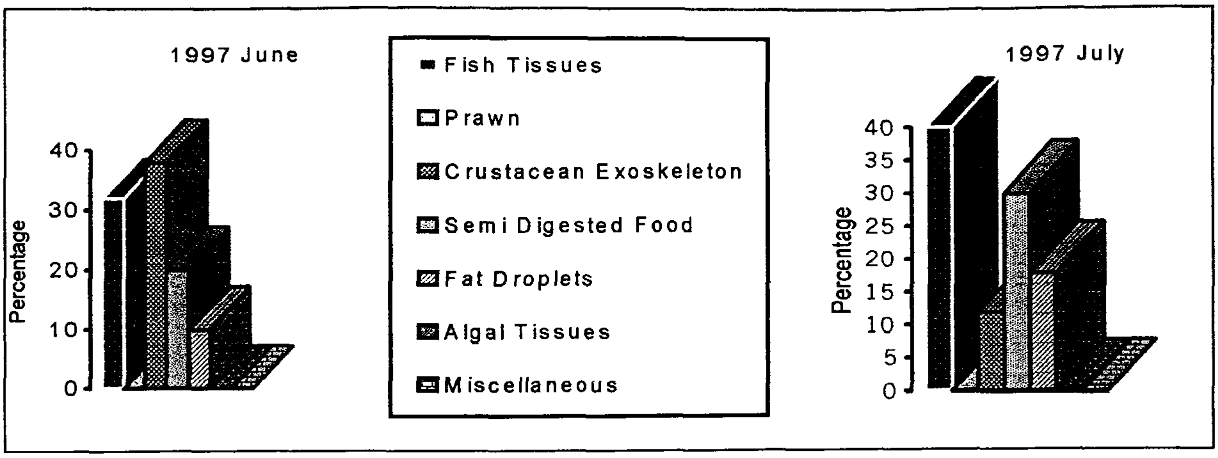

1998 November
Percentage
0
10
20
30
40
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 December
Percentage
0
5
10
15
20
25
30
35
40

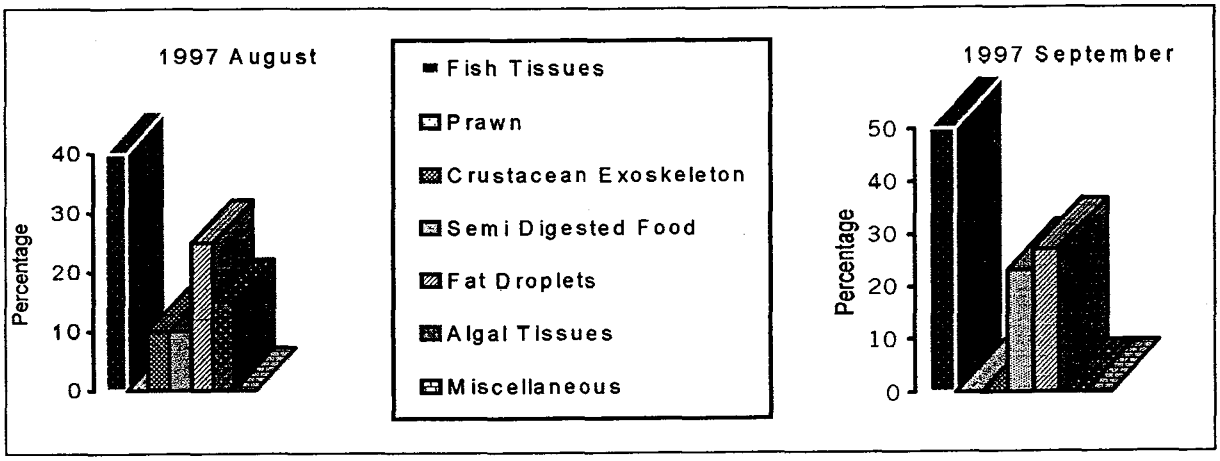
(Contd..... Fig. – 3.5)

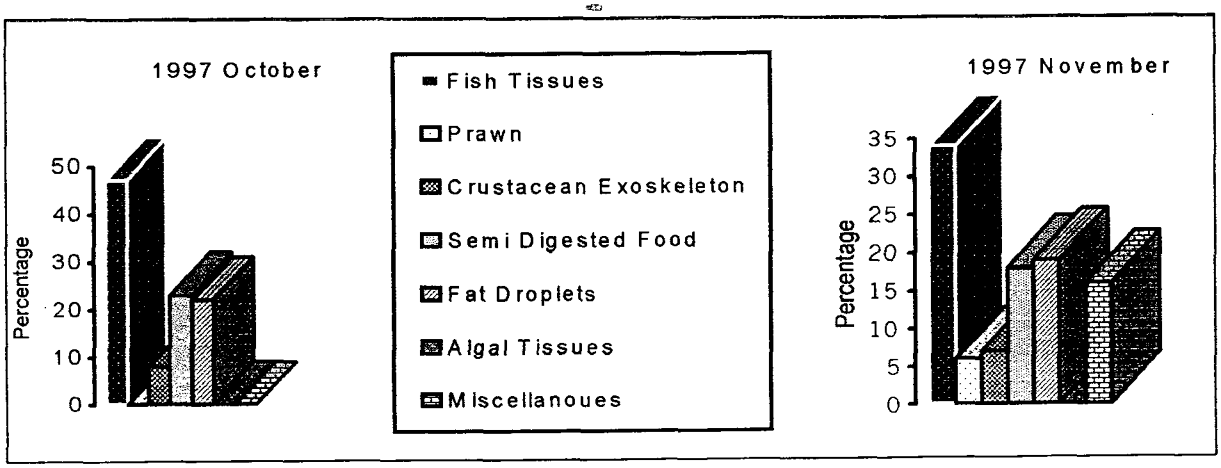

1999 January
1999 February
1999 March
Percentage
0
10
20
30
40
50
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous

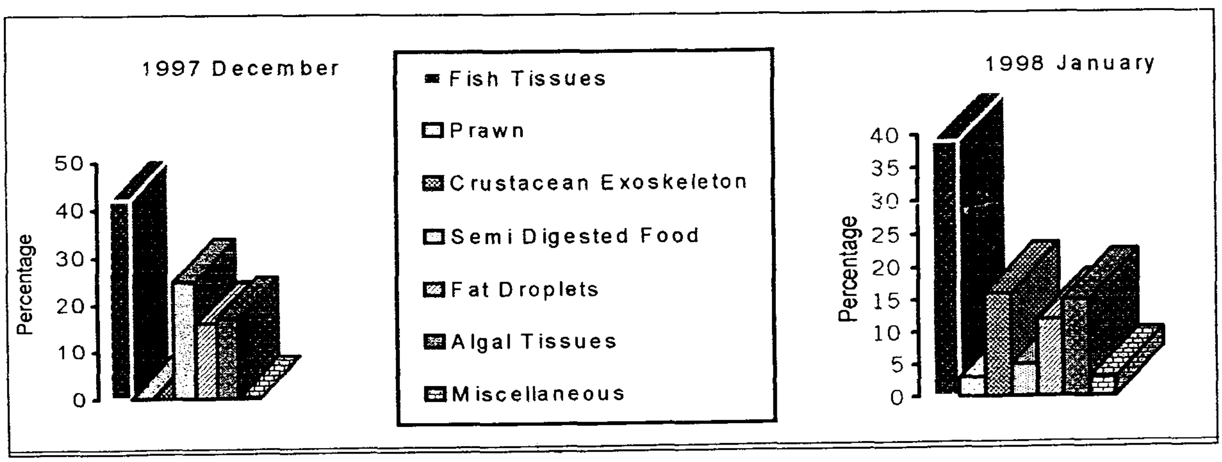
Monthly Average Percentage composition of various food items in the gut of Female *O. bimaculatus* from June 1997 – March 1999

Fig. – 3.6

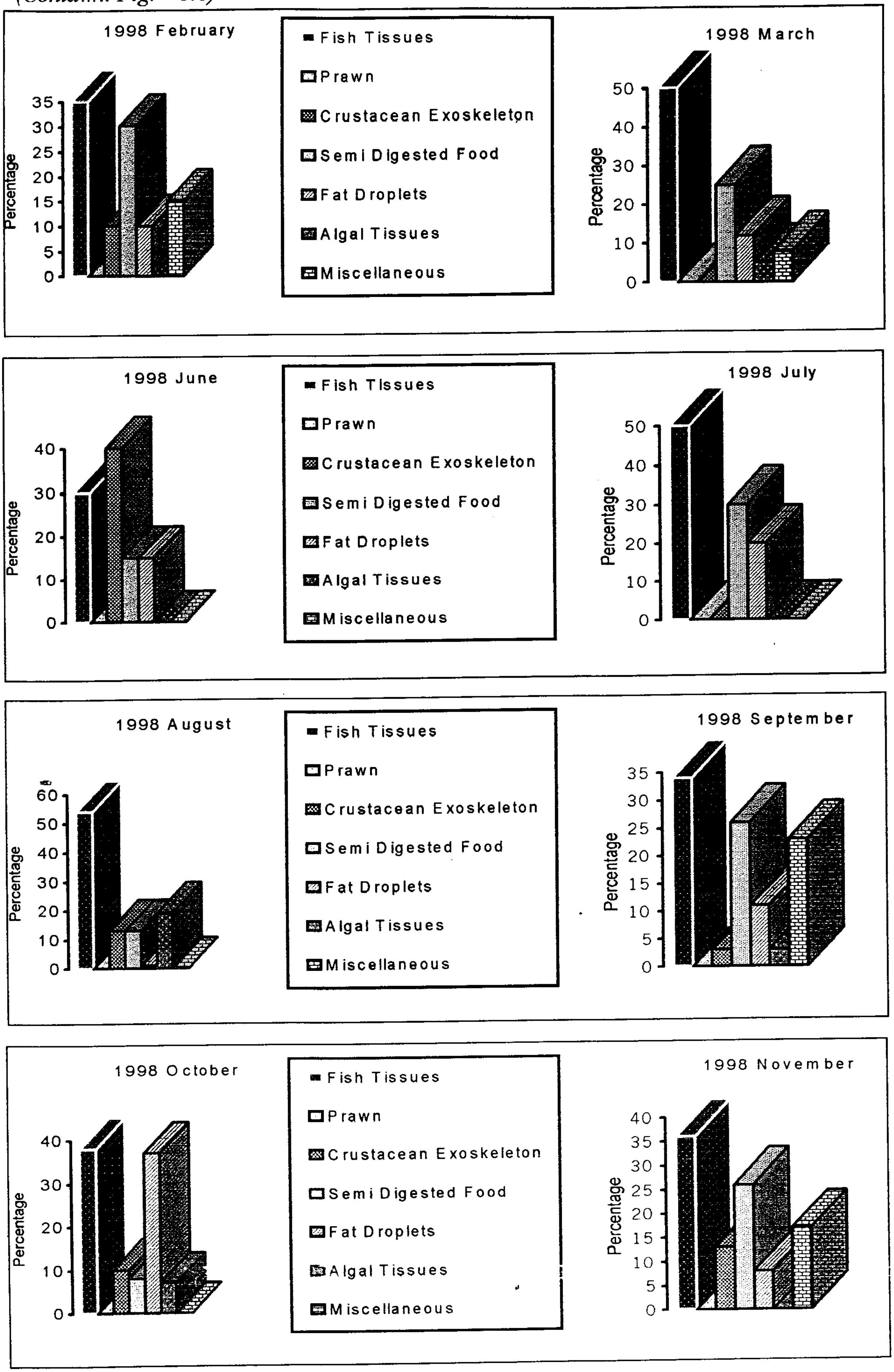




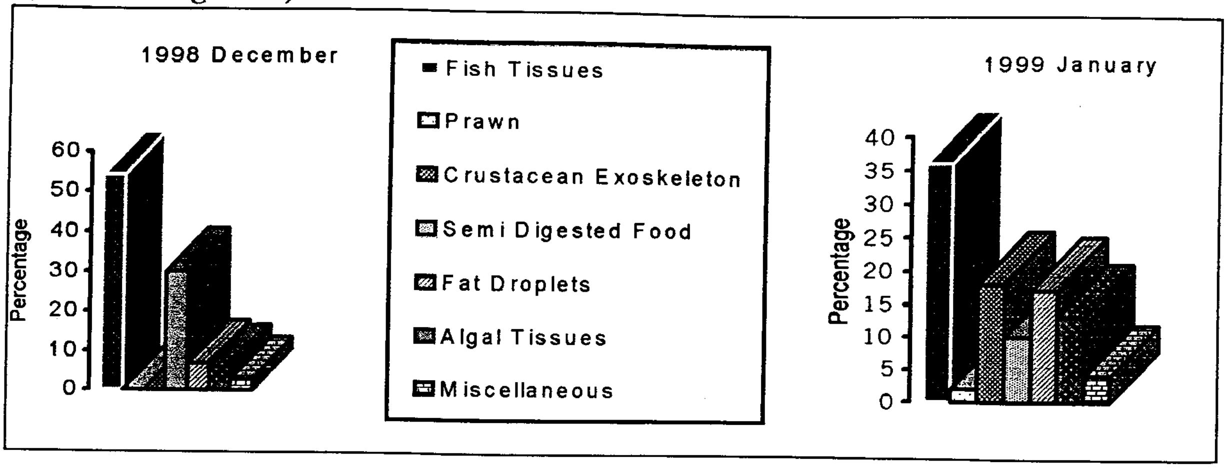




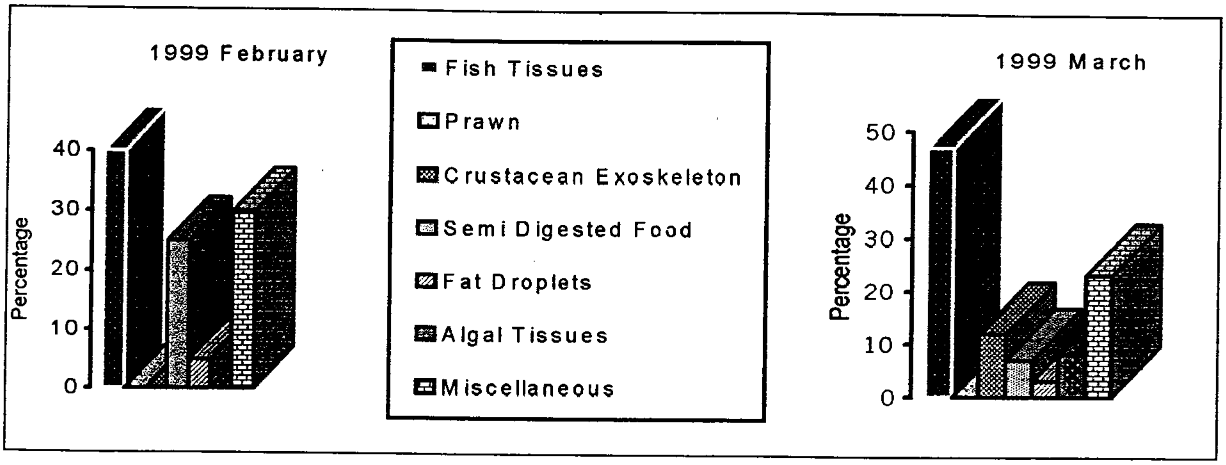
(Contd..... Fig. – 3.6)


1998 February
1998 March
1998 June
1998 July
1998 August
1998 September
1998 October
1998 November
Percentage
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous

(Contd..... Fig. – 3.6)



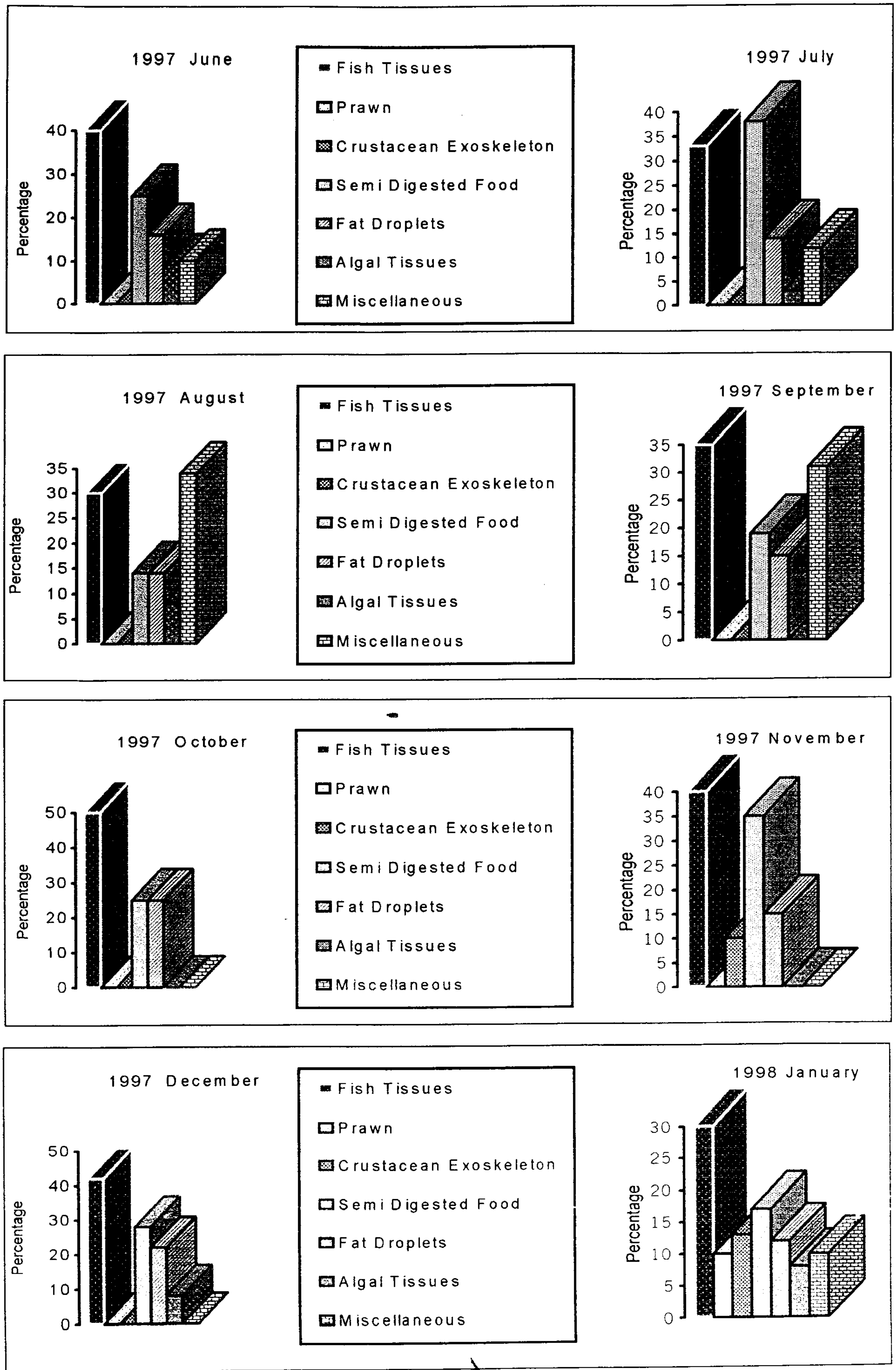
1998 December
Percentage
60
50
40
30
20
10
0
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 January
40
35
30
25
20
15
10
5
0



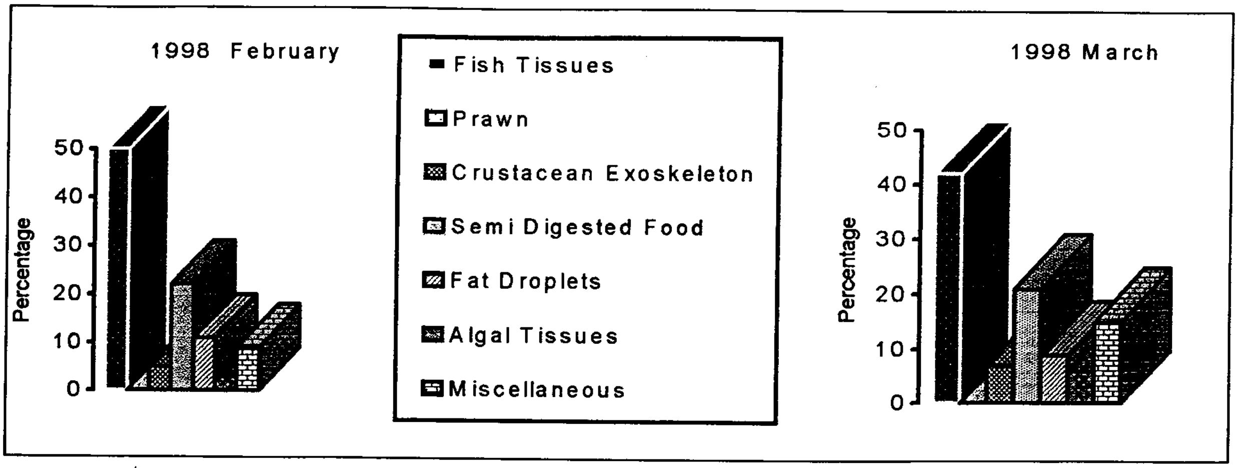
1999 February
Percentage
40
30
20
10
0
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 March
50
40
30
20
10
0

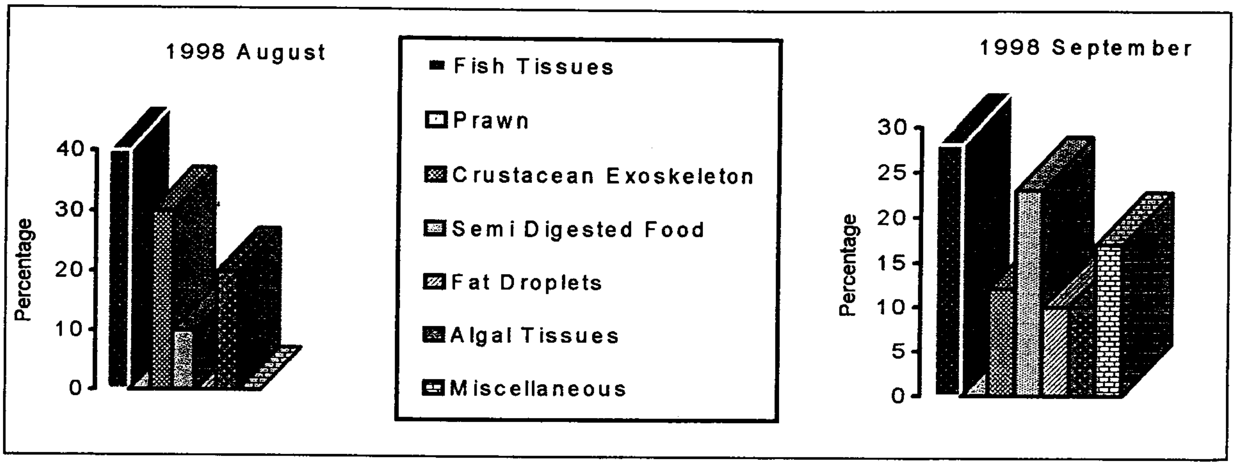
Monthly Average Percentage composition of various food items in the gut of *O. bimaculatus* 1 - 15 cm from June 1997 – May1999

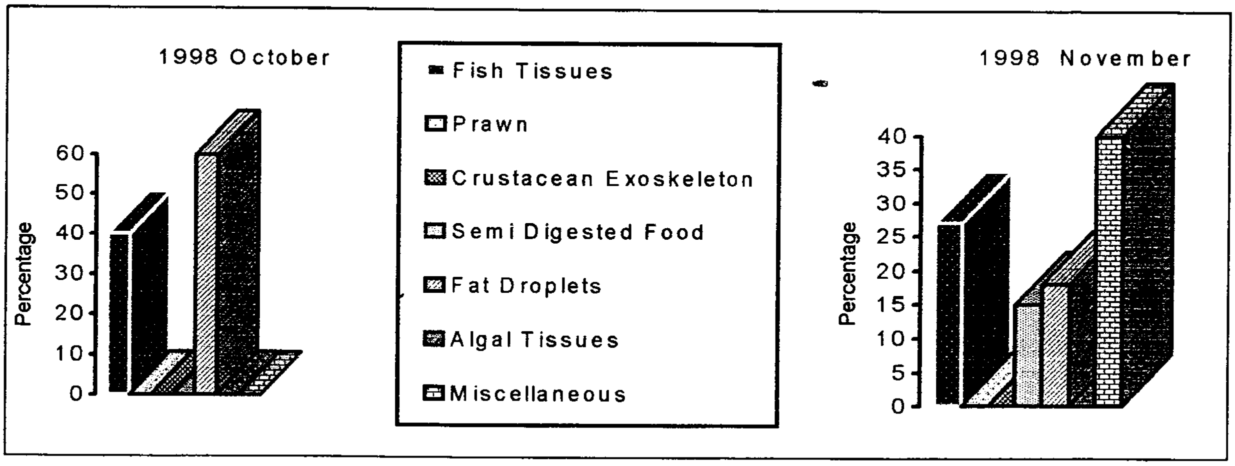
Fig. – 3.7

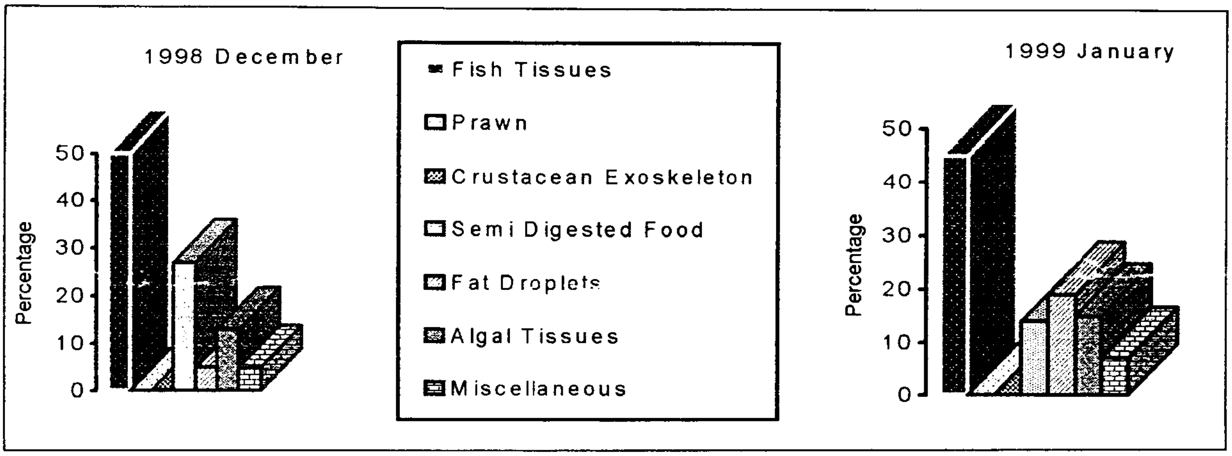


(Contd..... Fig. – 3.7)

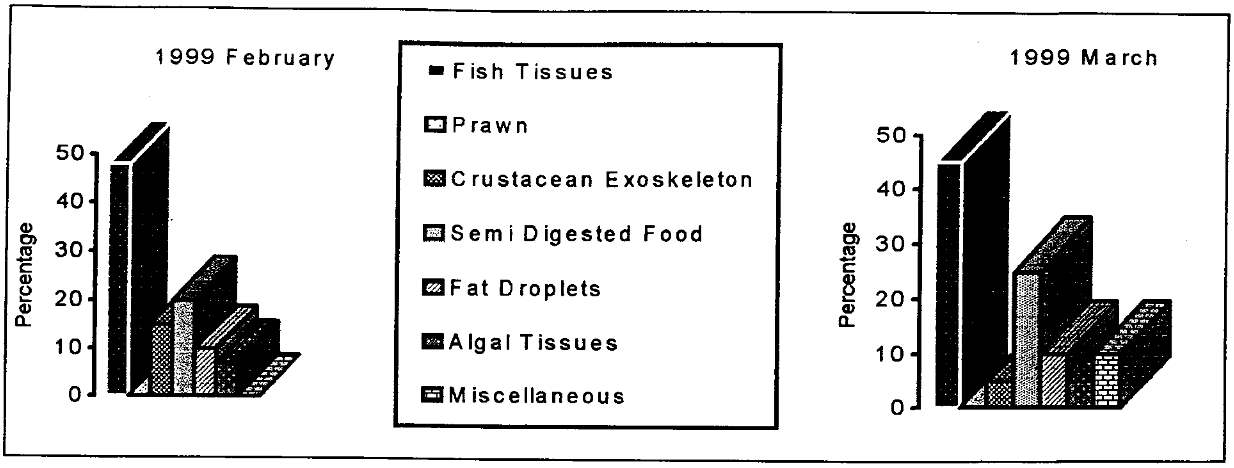

1998 February
Percentage
0
10
20
30
40
50
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 March
Percentage
0
10
20
30
40
50


1998 August
Percentage
0
10
20
30
40
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 September
Percentage
0
5
10
15
20
25
30


1998 October
Percentage
0
10
20
30
40
50
60
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1998 November
Percentage
0
5
10
15
20
25
30
35
40


1998 December
Percentage
0
10
20
30
40
50
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 January
Percentage
0
10
20
30
40
50

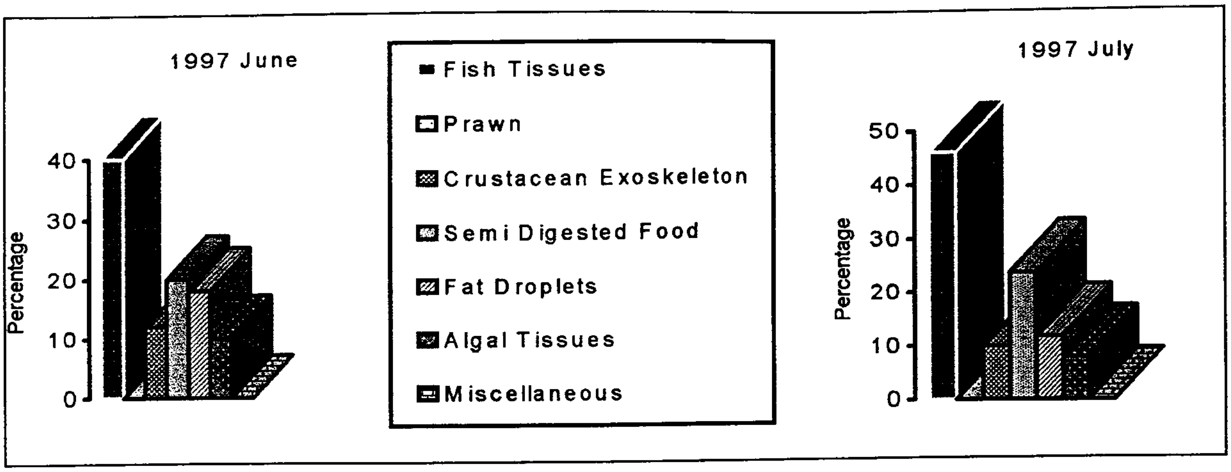
(Contd..... Fig. – 3.7)

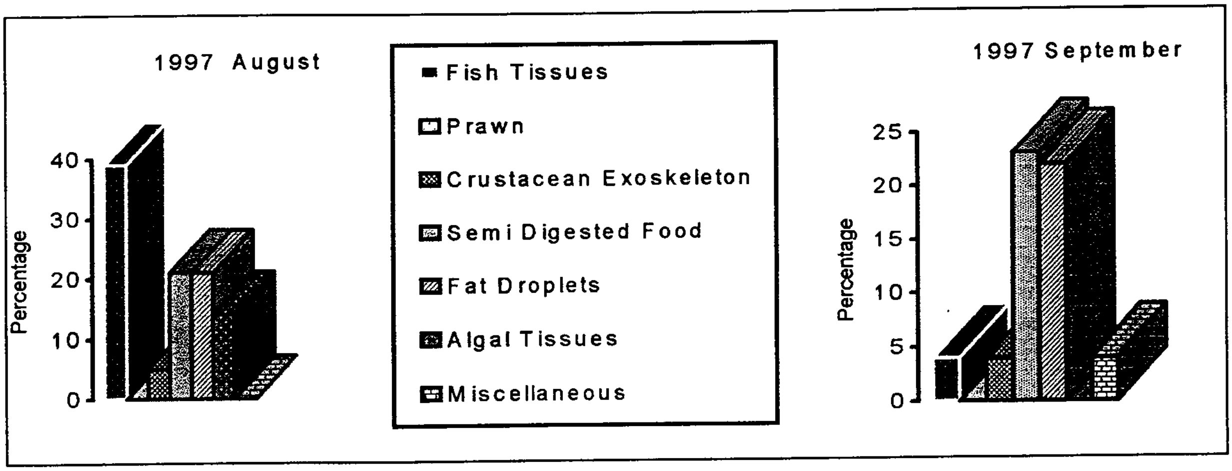


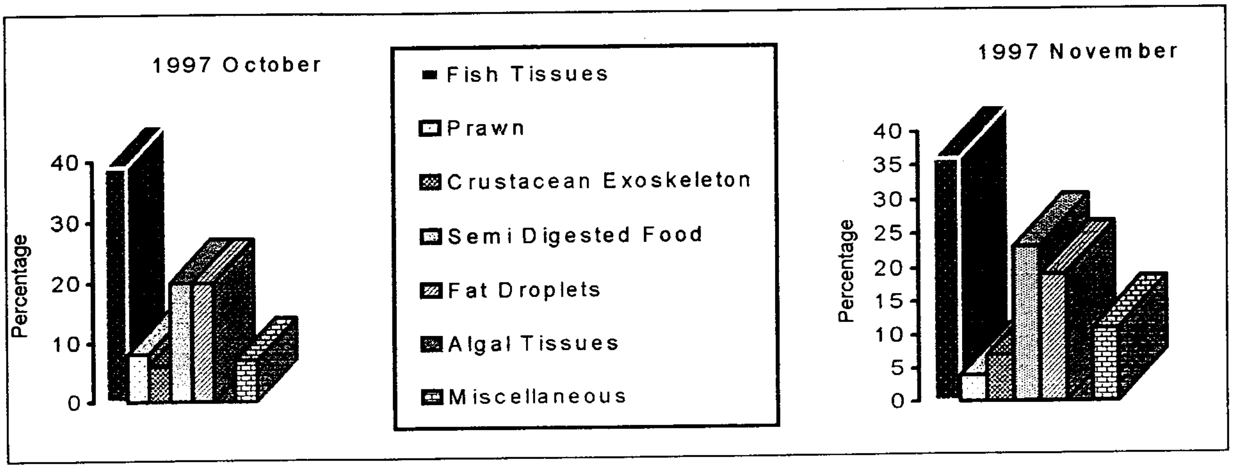
1999 February
Percentage
50
40
30
20
10
0
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 March
Percentage
50
40
30
20
10
0

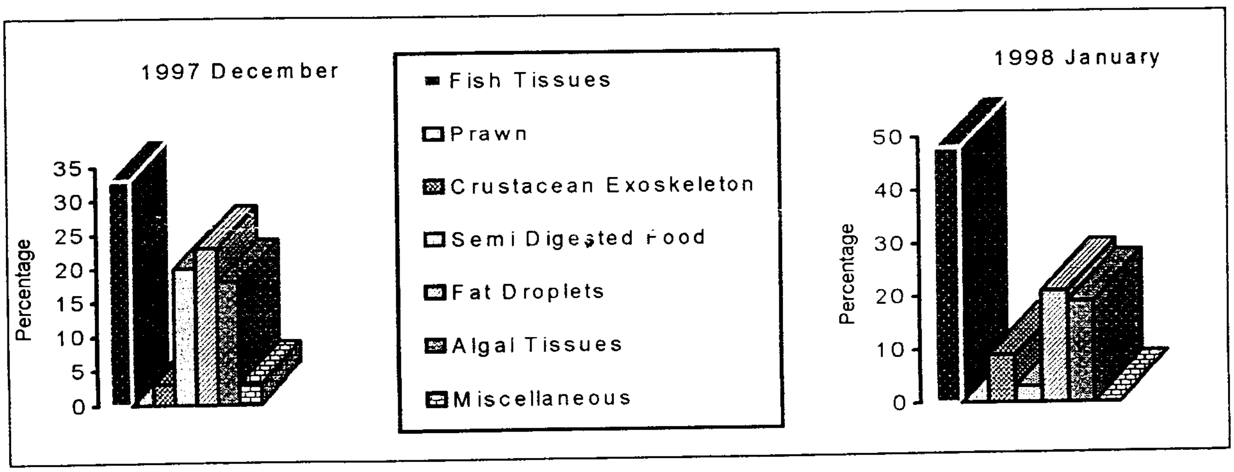
Monthly Average Percentage composition of various food items in the gut of *O. bimaculatus* 15 - 30 cm from June 1997 – March 1999

Fig. – 3.8

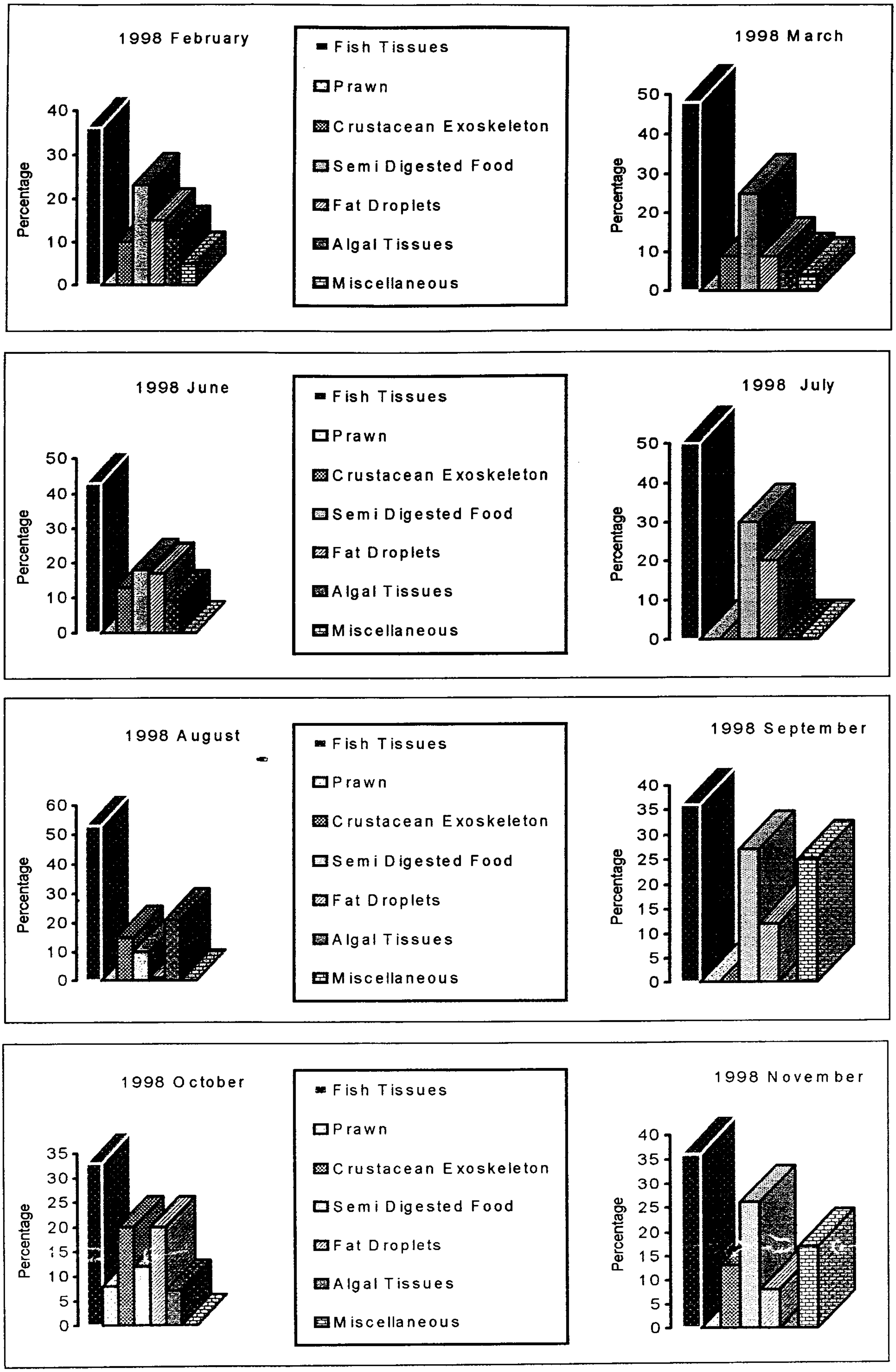








(Contd..... Fig. – 3.8)


1998 February
1998 March
1998 June
1998 July
1998 August
1998 September
1998 October
1998 November
Percentage
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous

(Contd..... Fig. – 3.8)

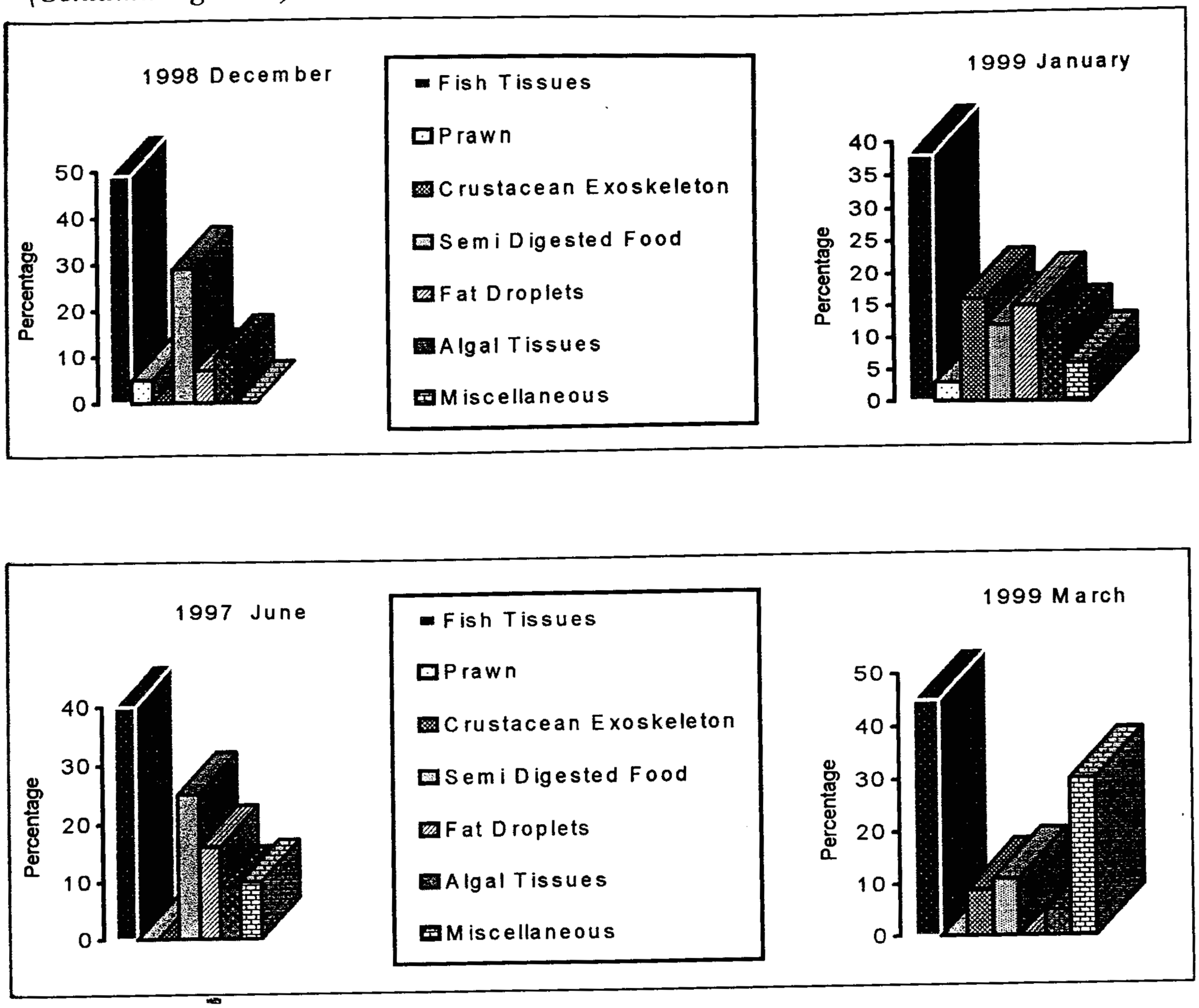
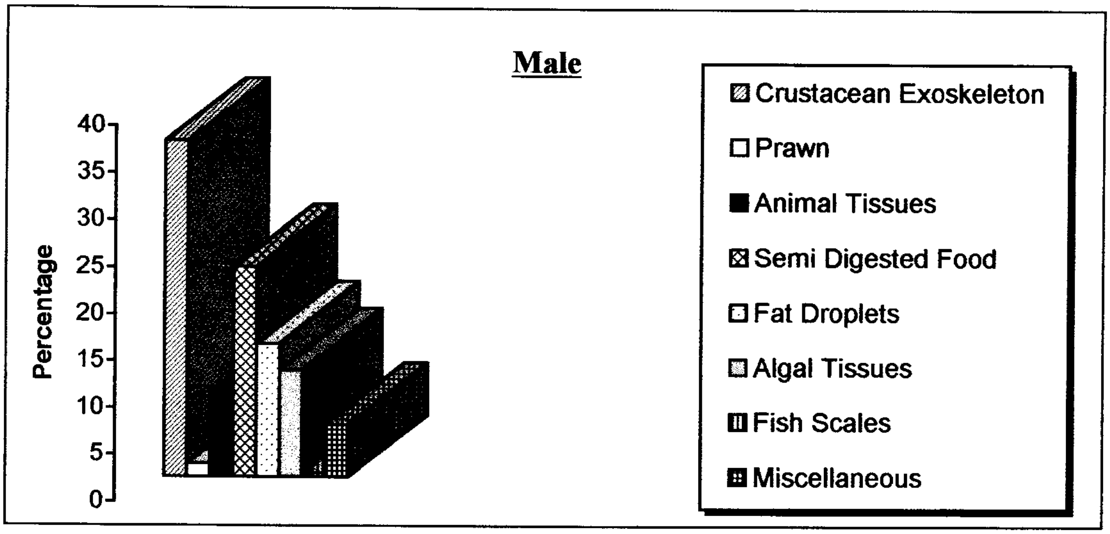
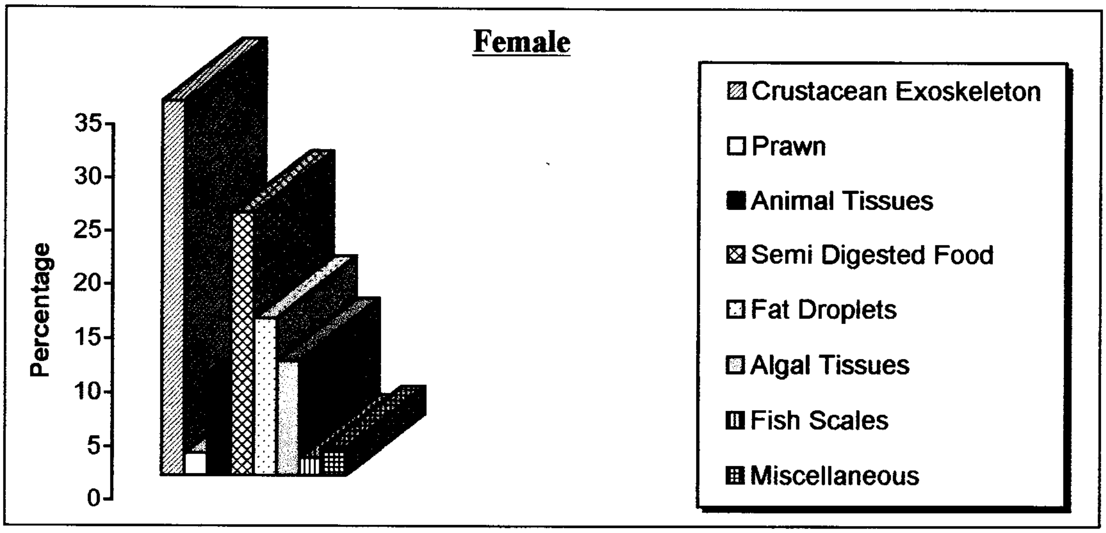

1998 December
Percentage
50
40
30
20
10
0
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 January
Percentage
40
35
30
25
20
15
10
5
0
1997 June
Percentage
40
30
20
10
0
Fish Tissues
Prawn
Crustacean Exoskeleton
Semi Digested Food
Fat Droplets
Algal Tissues
Miscellaneous
1999 March
Percentage
50
40
30
20
10
0

Fig. – 3.9
Average percentage composition of various food items in the gut of *H. brachysoma* (Gunther) from May 1997 to February 1999





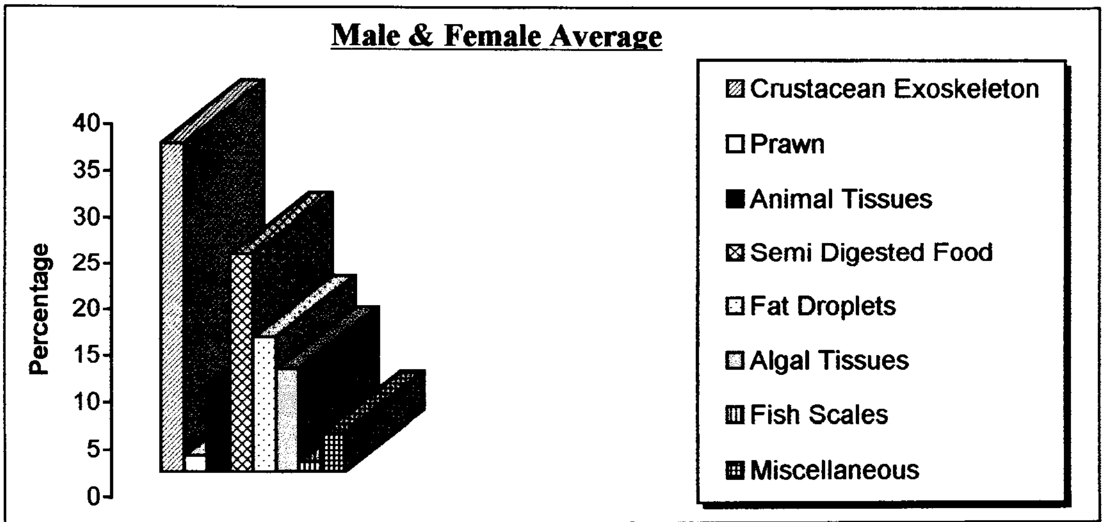
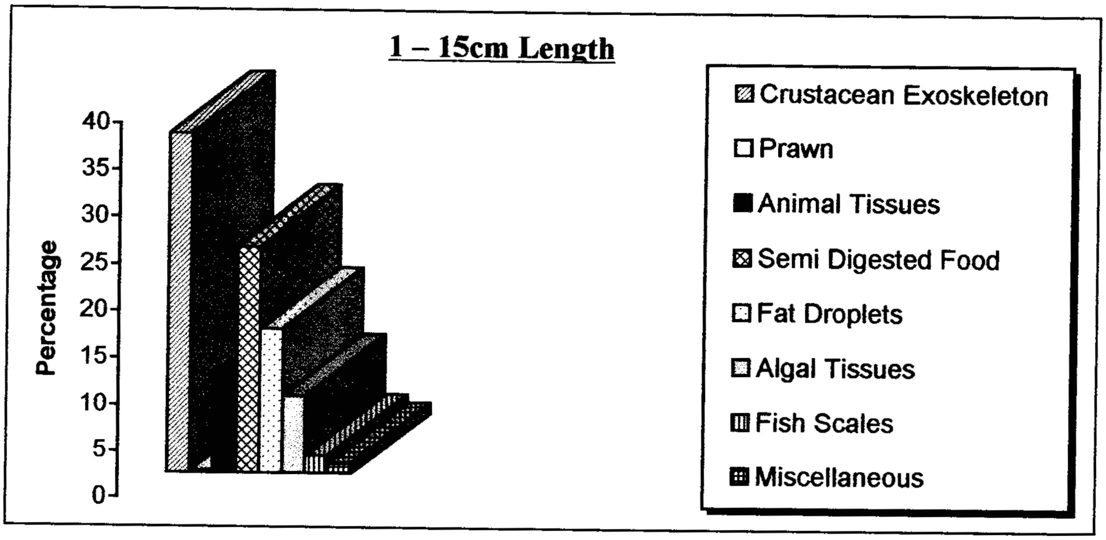
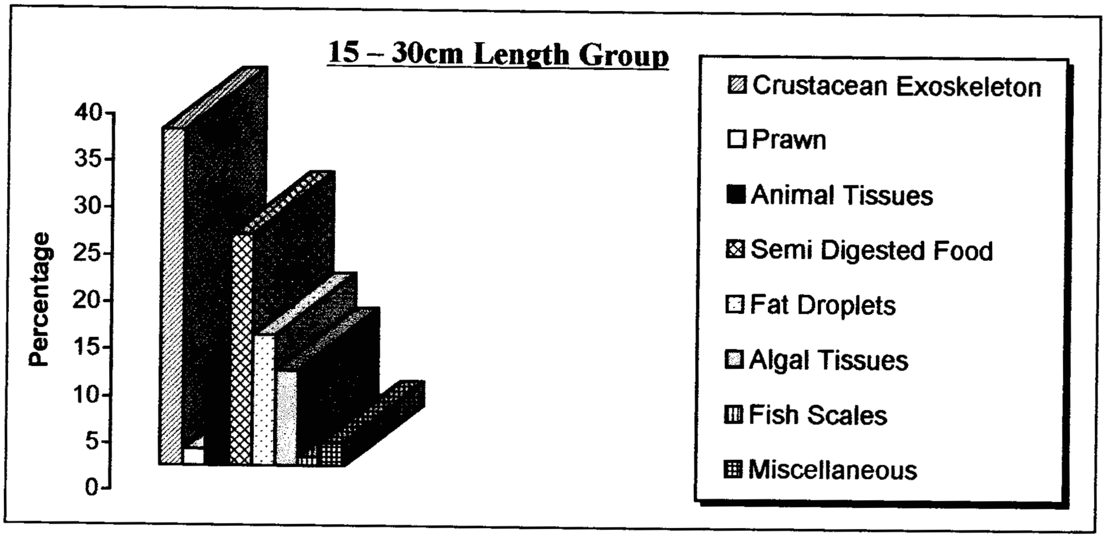


Fig. – 3.10
Average percentage composition of various food items in the gut of *H. brachysoma* (Gunther) from May 1997 to February 1999





104 K

Fig. – 3.11
Average percentage composition of various food items in the gut of *O. bimaculatus* (Bloch) from June 1997 to March 1999

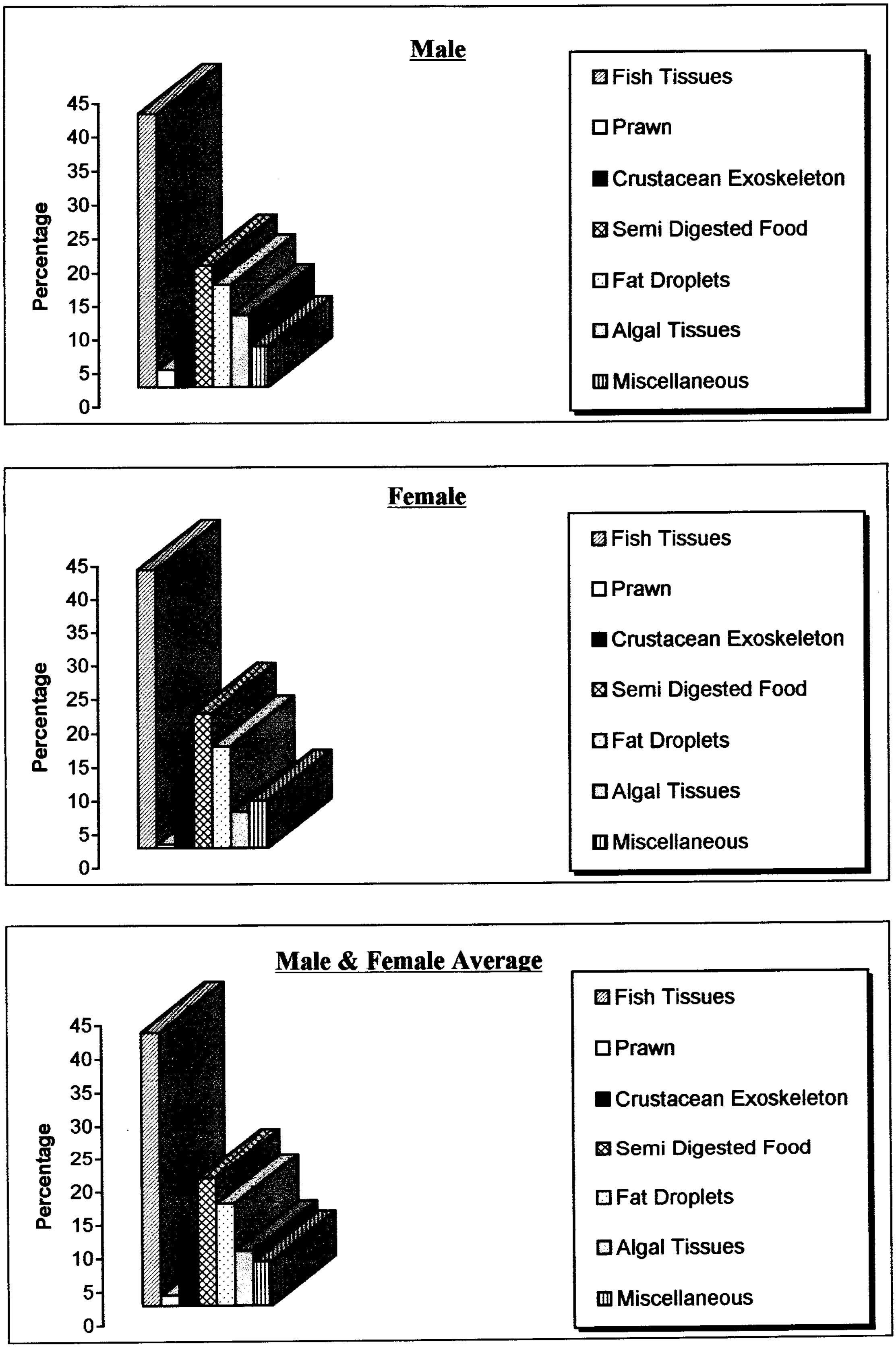
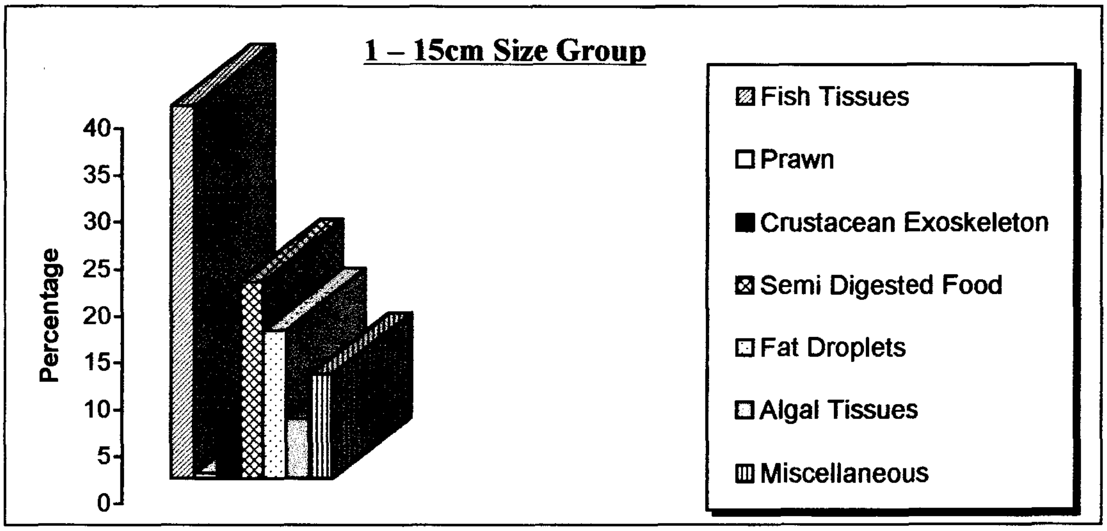


Fig. – 3.12
Average percentage composition of various food items in the gut of *O. bimaculatus* (Bloch) from June 1997 to March 1999



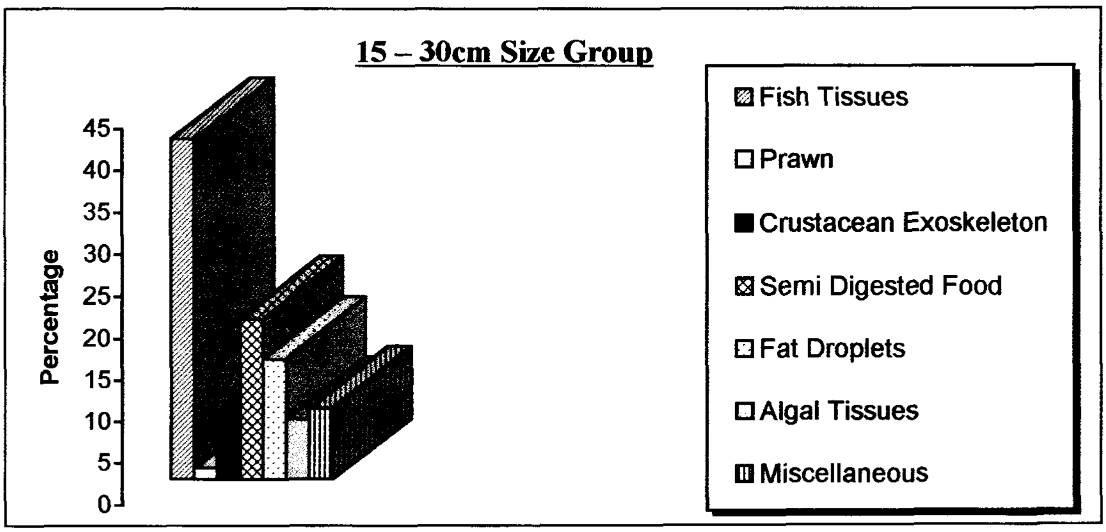
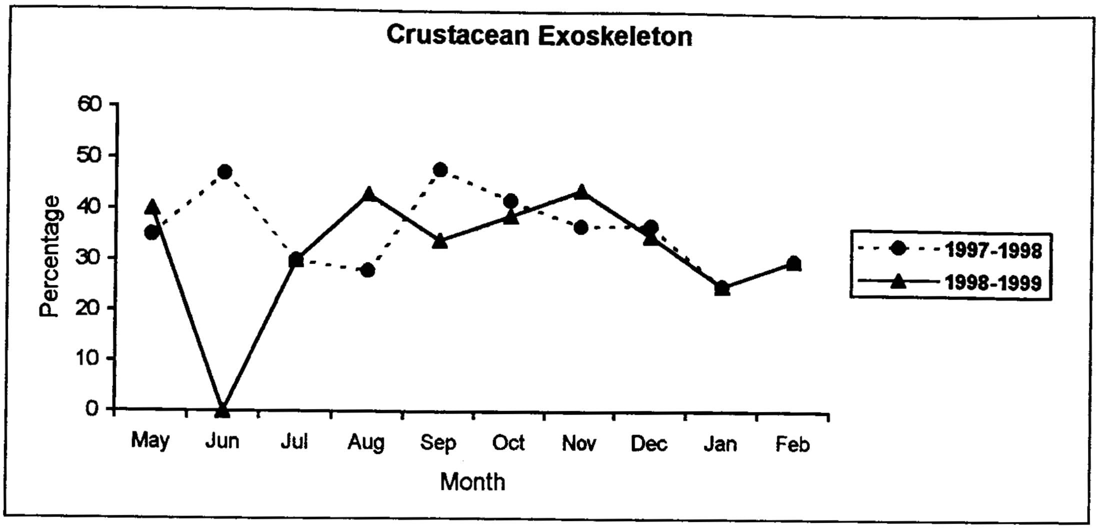
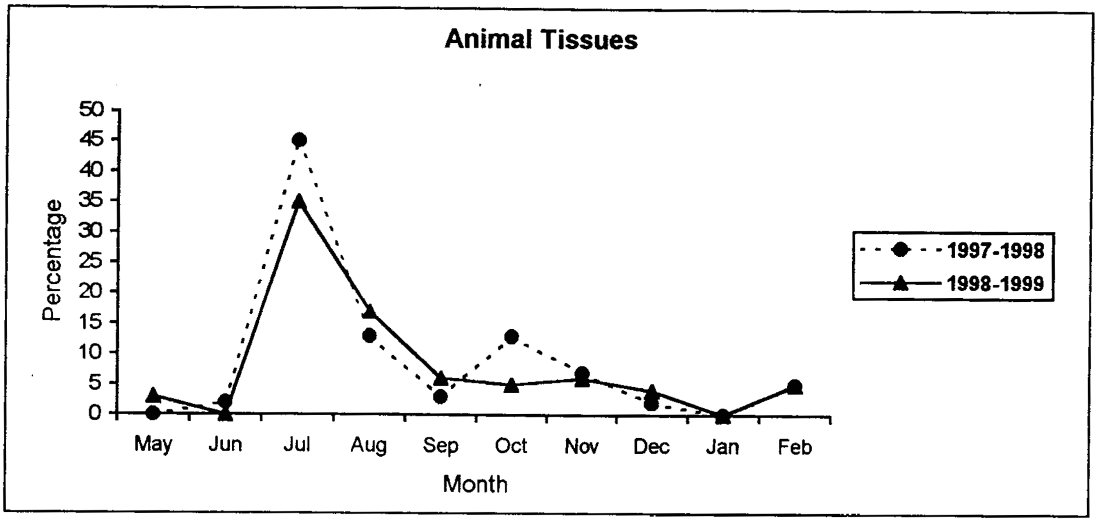
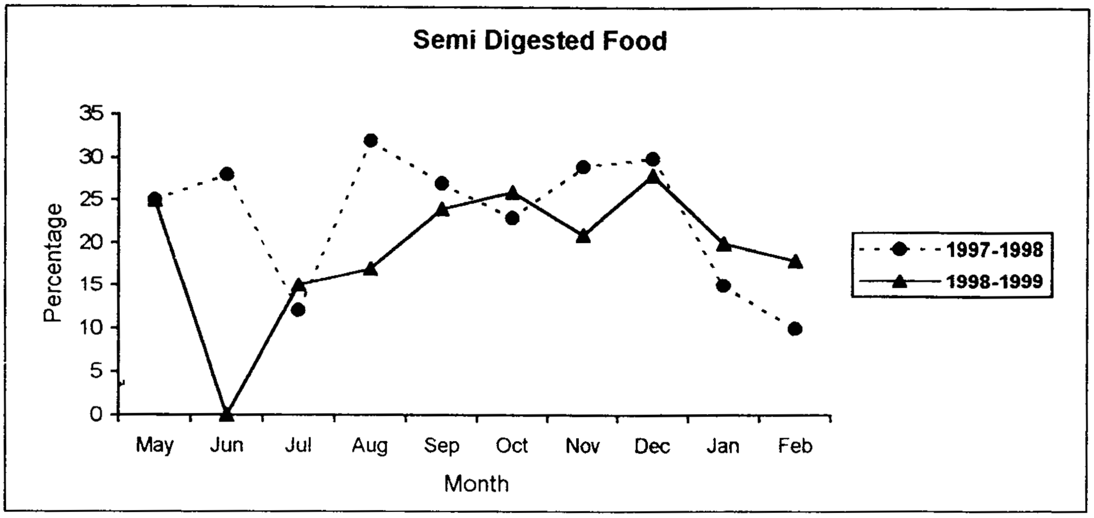


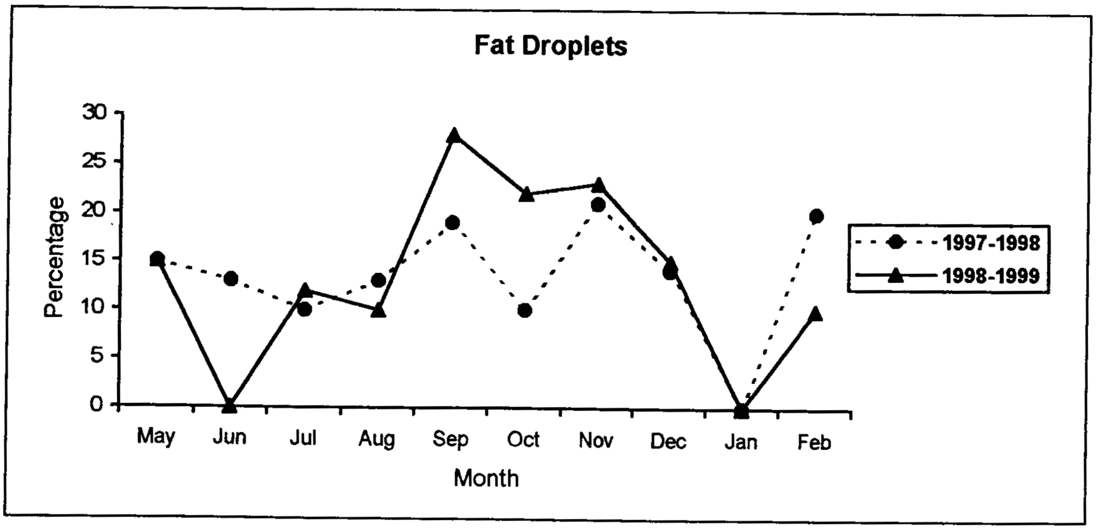
Fig. – 3.13
Percentage Composition of various food items in the gut of Male *H. brachysoma* (Gunther) during 1997 – 1998 & 1998 - 1999







(Contd....Fig. – 3.13)



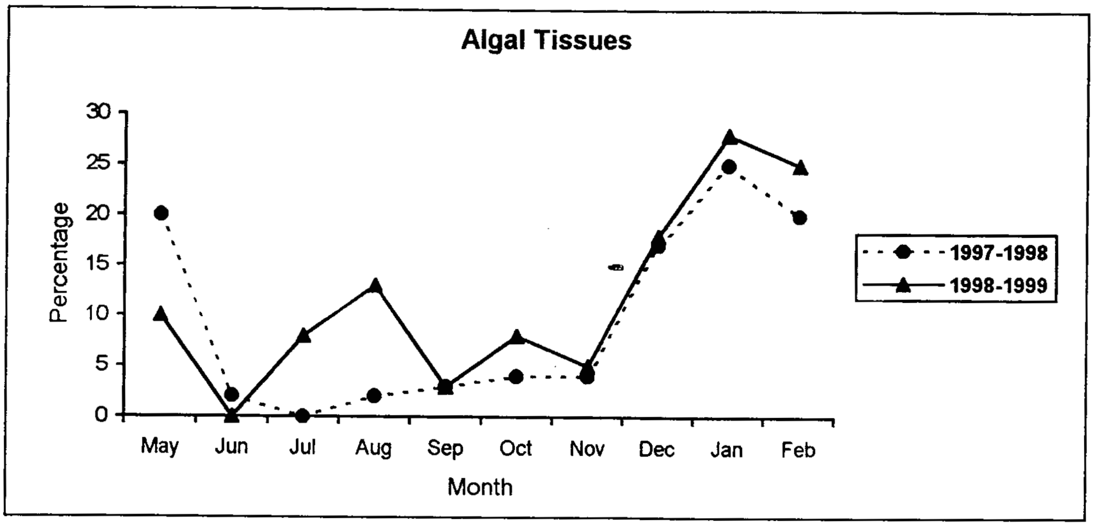
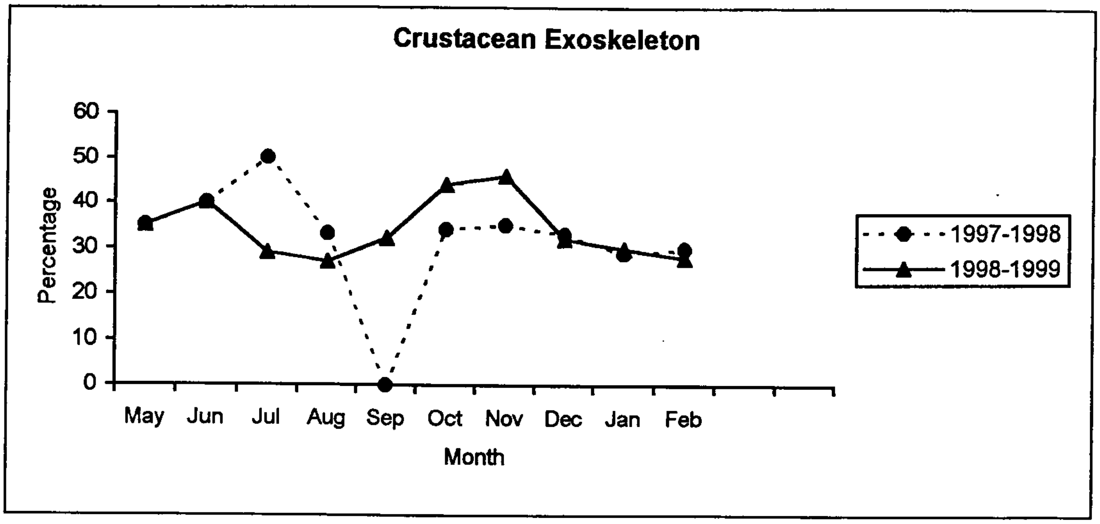
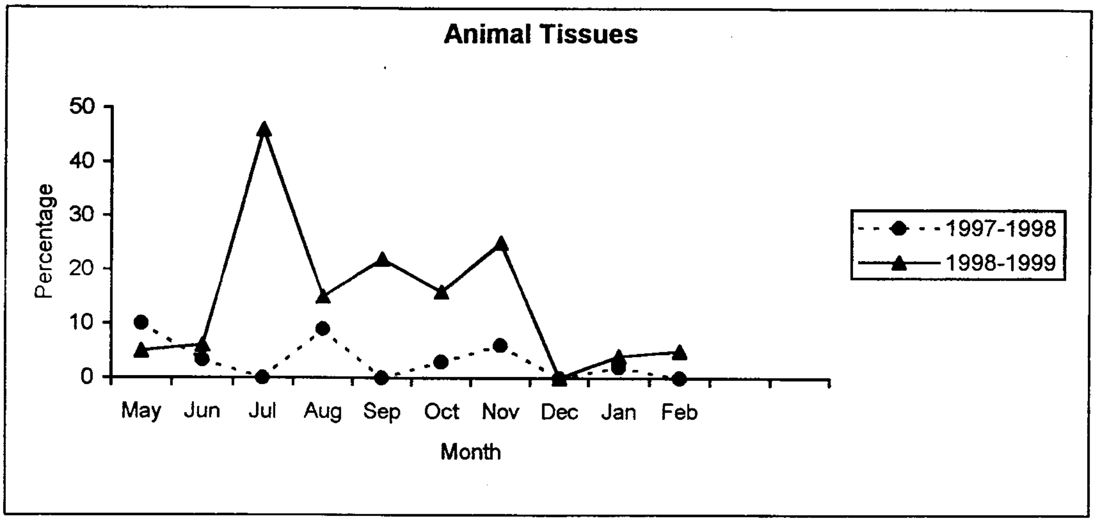
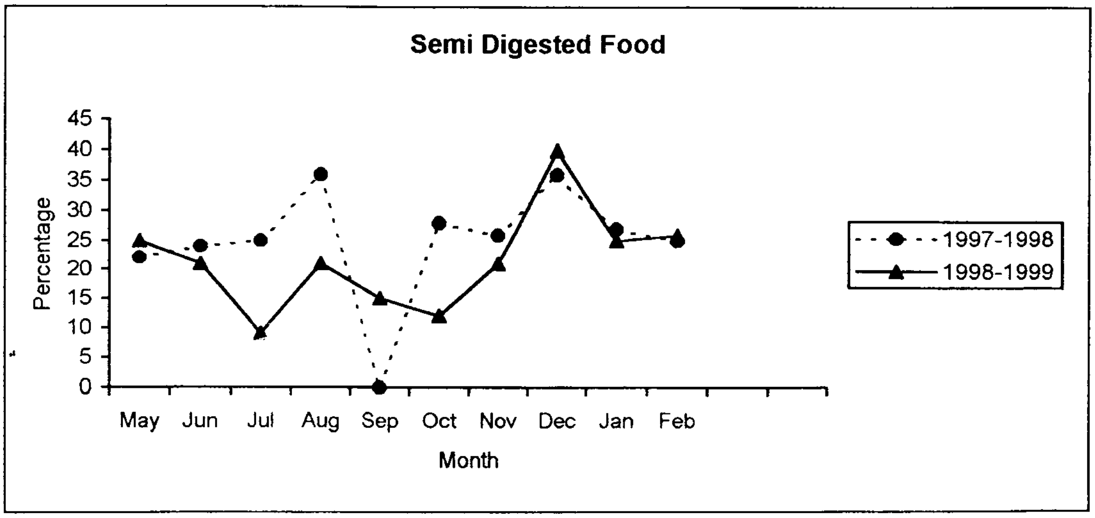


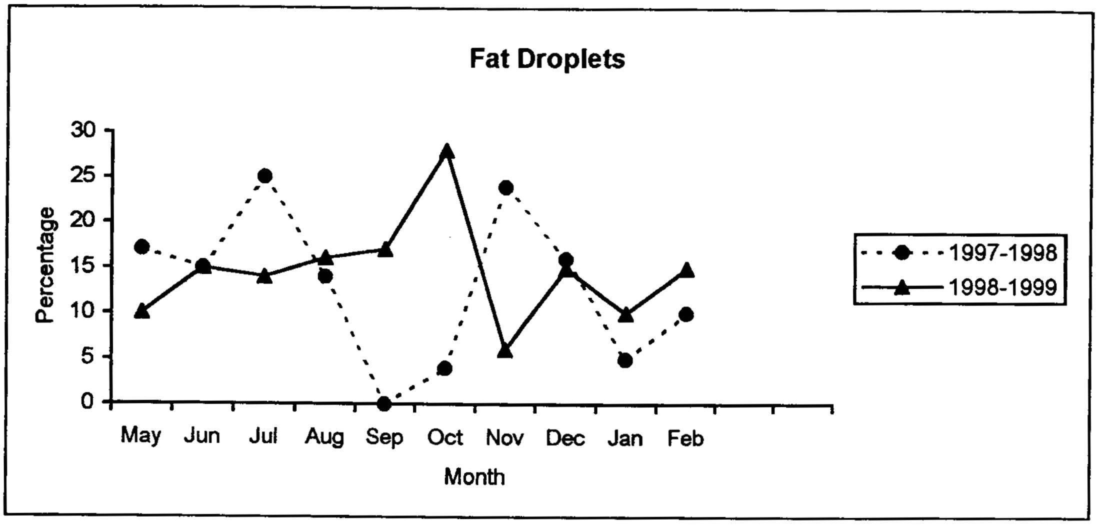
Fig. – 3.14
Percentage Composition of various food items in the gut of Female *H. brachysoma* (Gunther) during 1997 – 1998 & 1998 - 1999







(Contd..... Fig. 3.14)



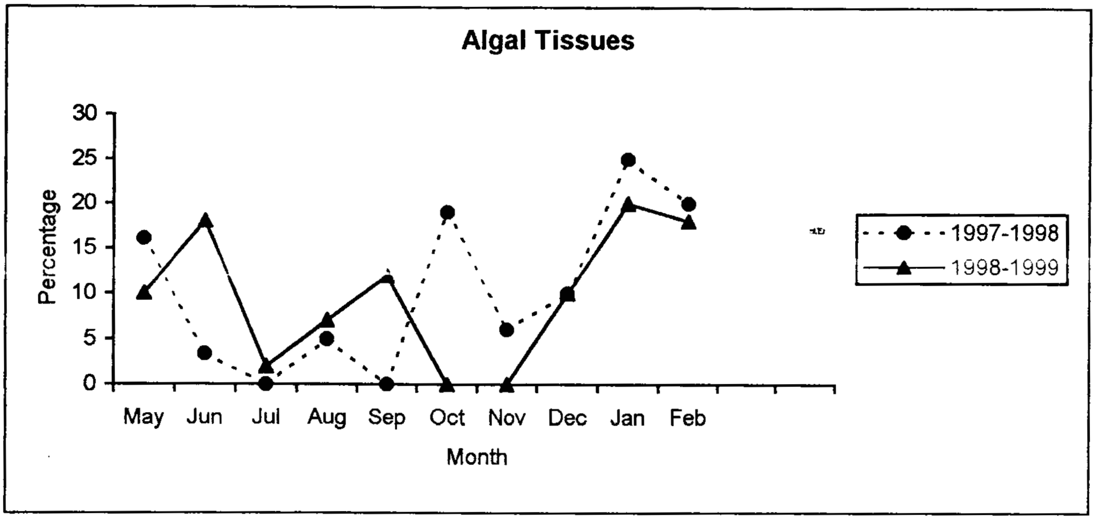
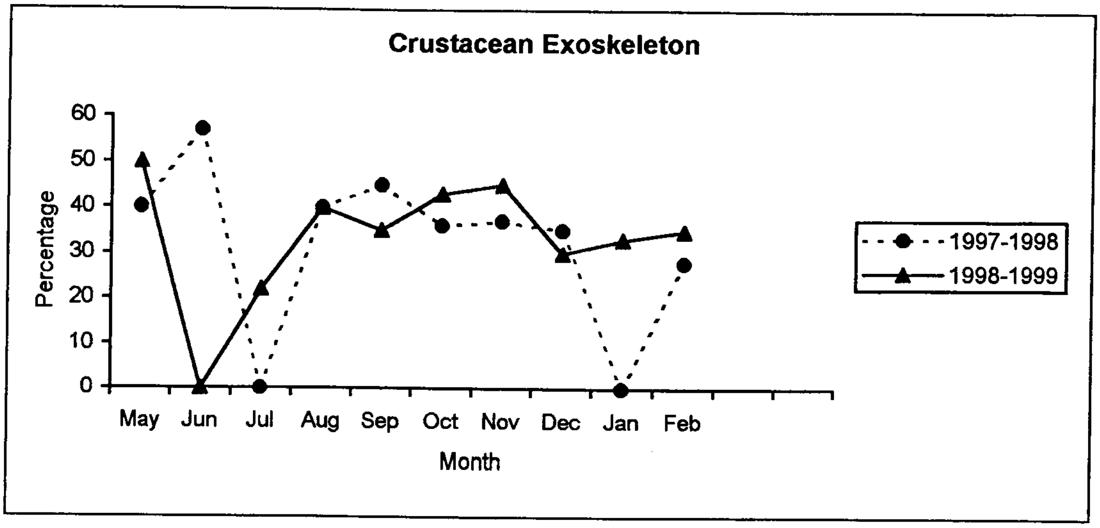
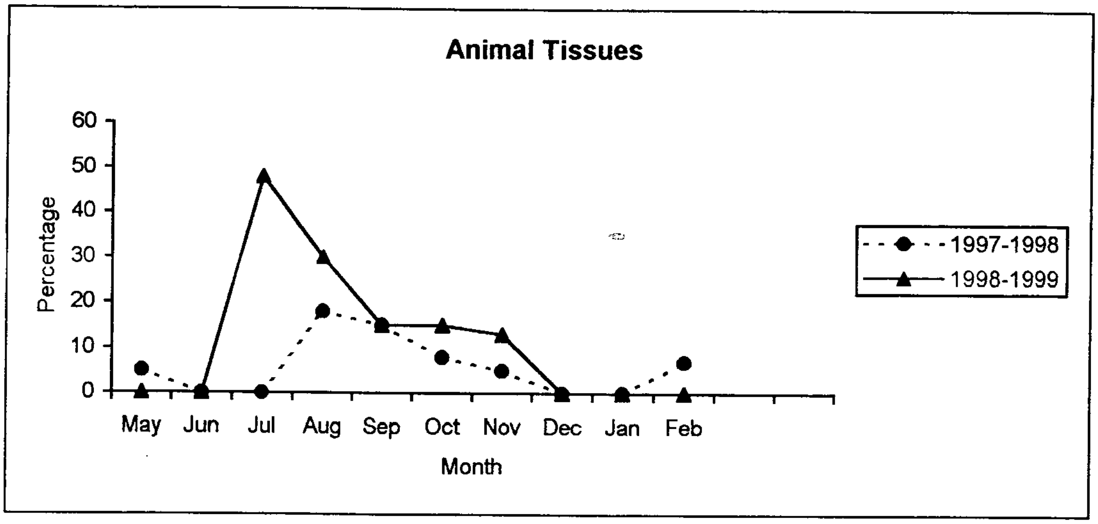
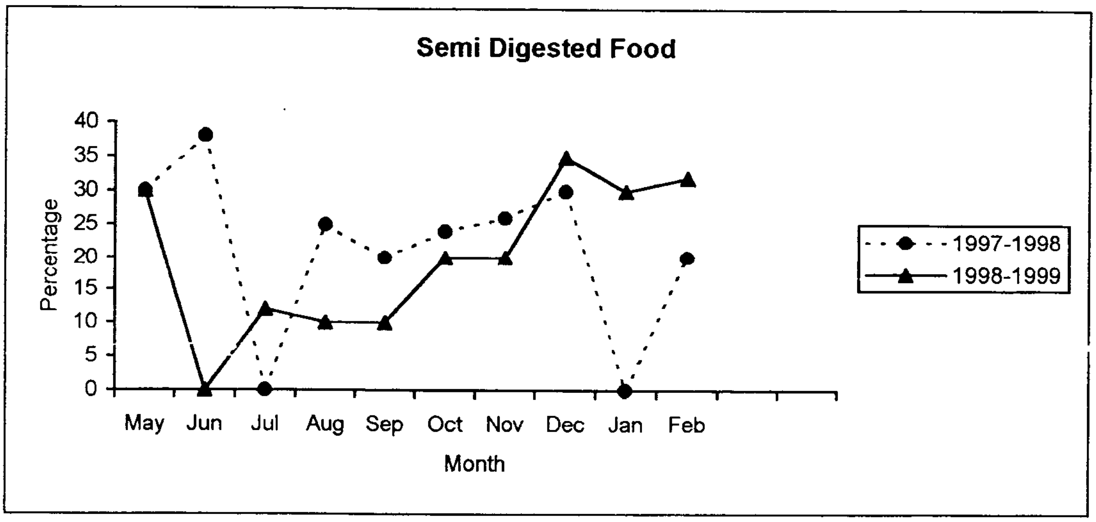


Fig. – 3.15

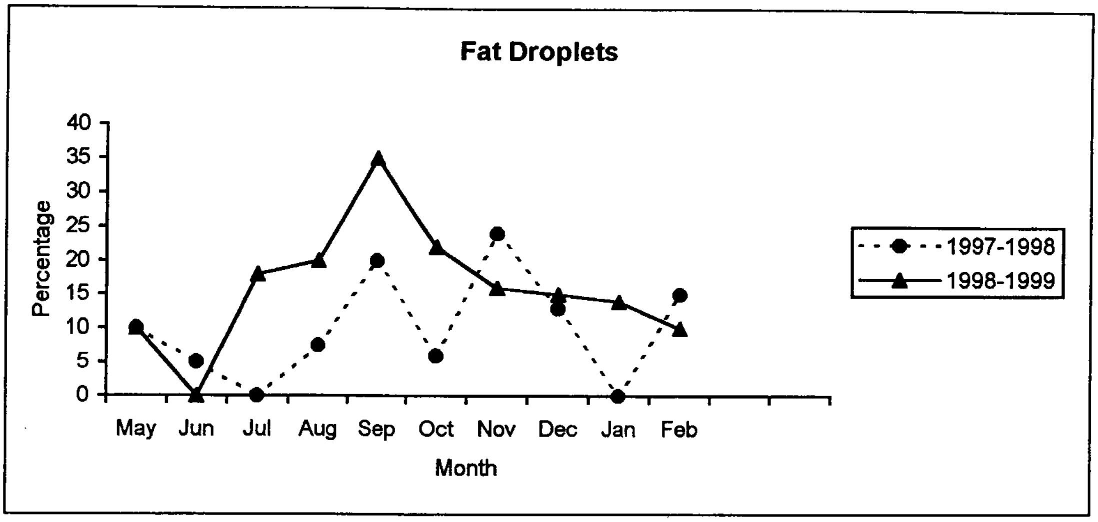
Percentage Composition of various food items in the gut of 1.15 cm Length Group *H. brachysoma* (Gunther) during 1997 – 1998 & 1998 - 1999







(Contd….. Fig. – 3.15)



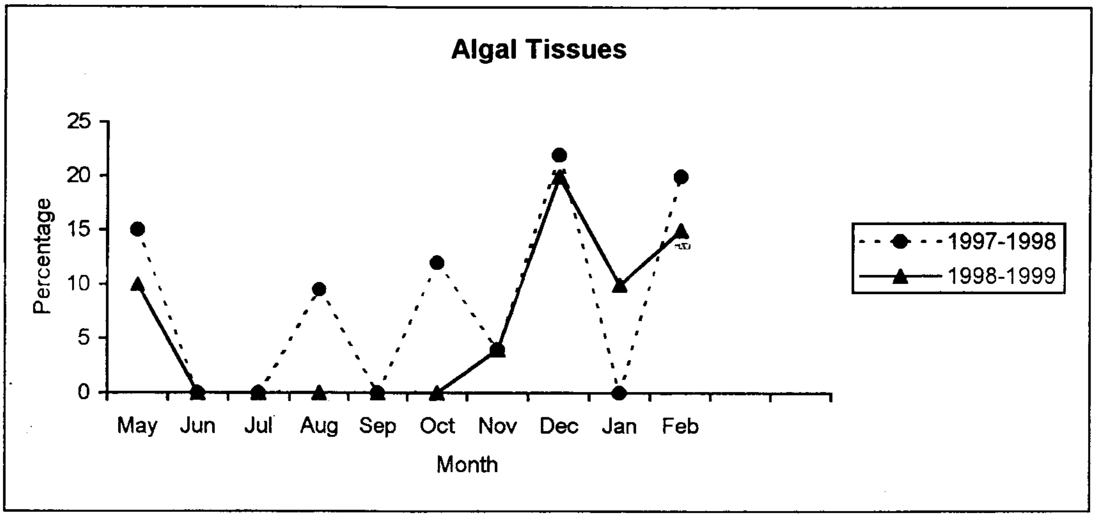
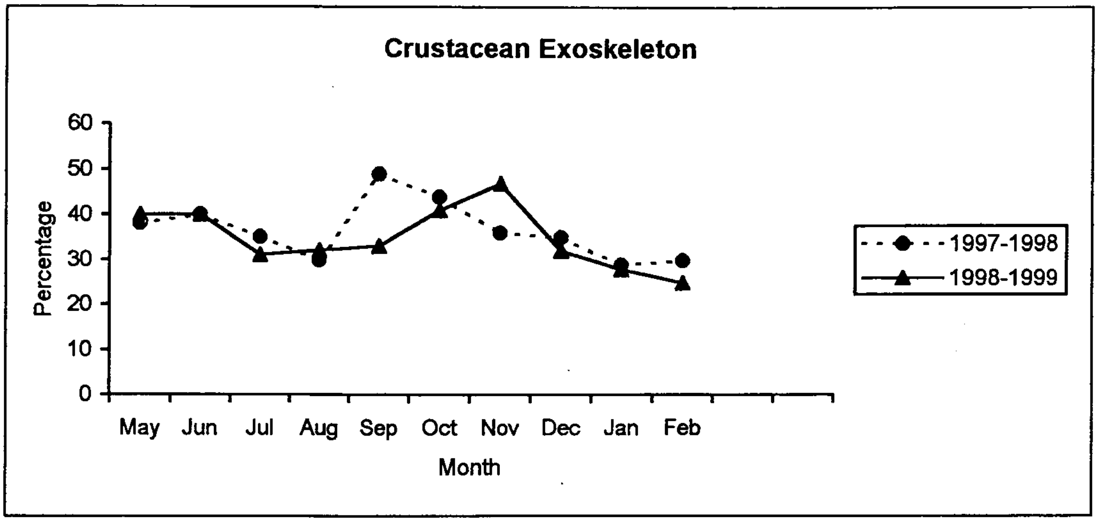
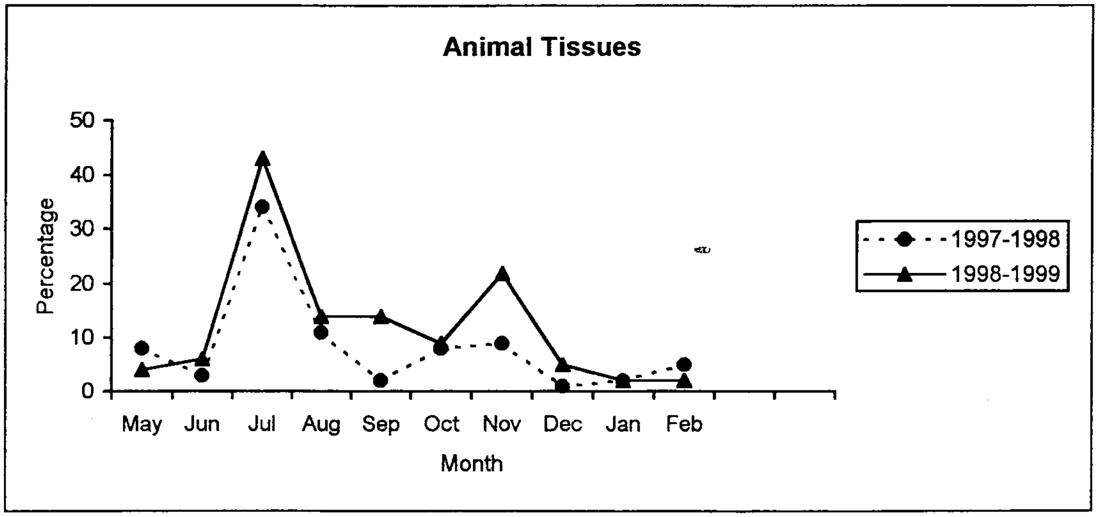
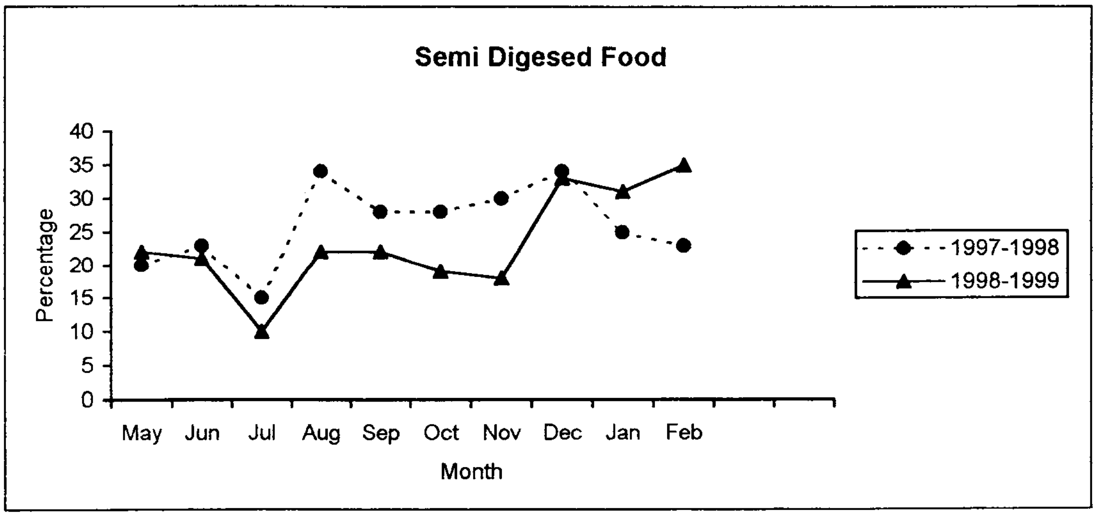


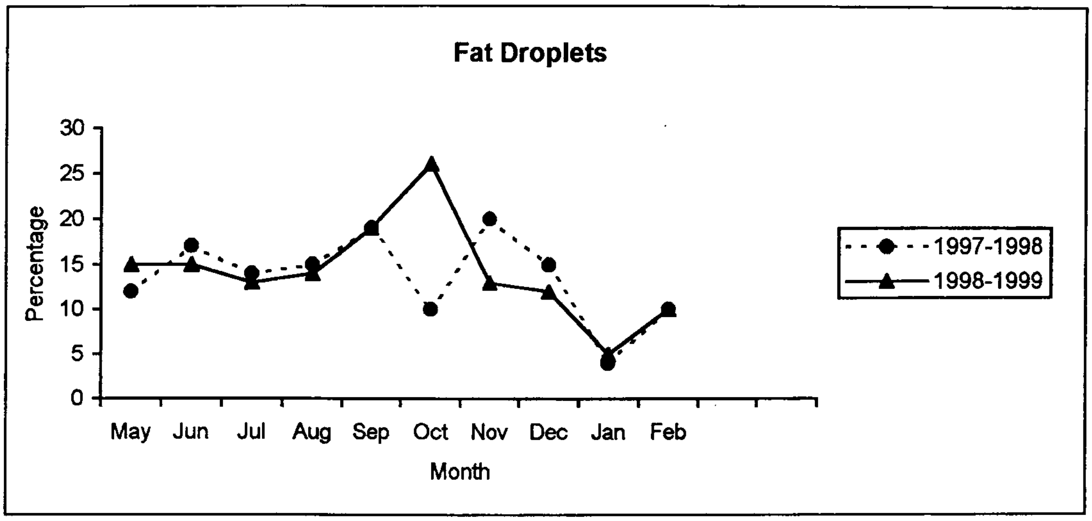
Fig. – 3.16
Percentage Composition of various food items in the gut of 15-30cm Length Group *H. brachysoma* (Gunther) during 1997 – 1998 & 1998 - 1999







(Contd..... Fig. – 3.16)



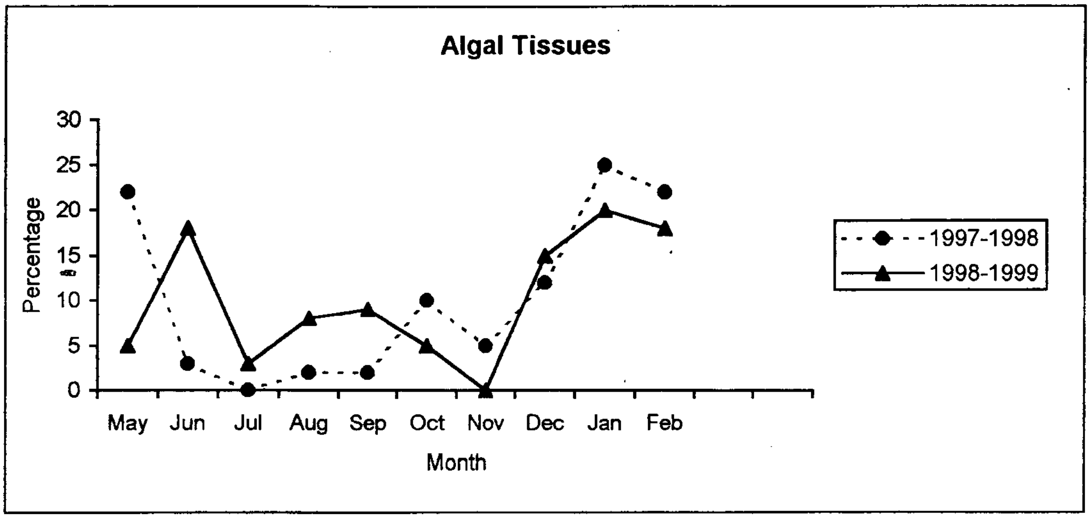
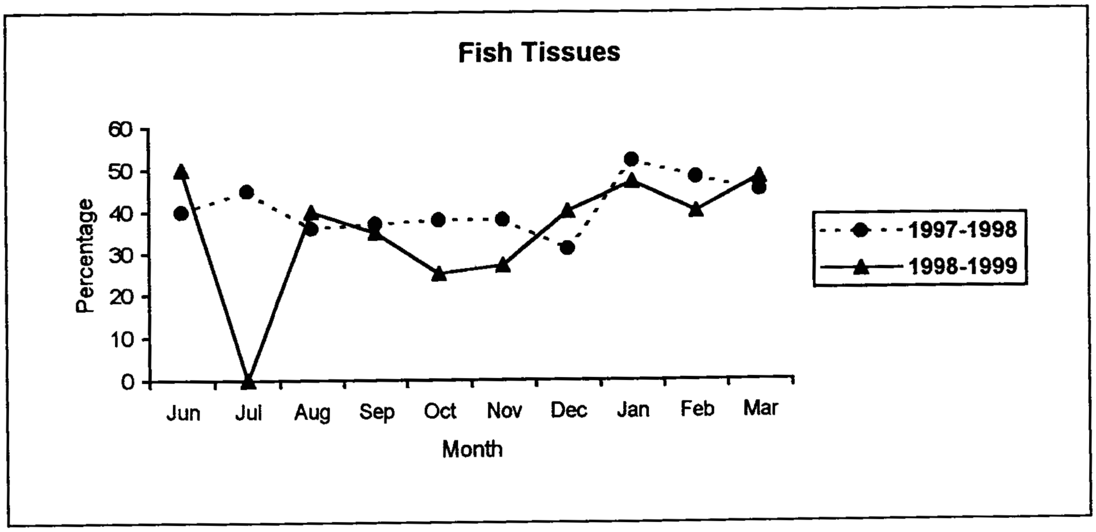
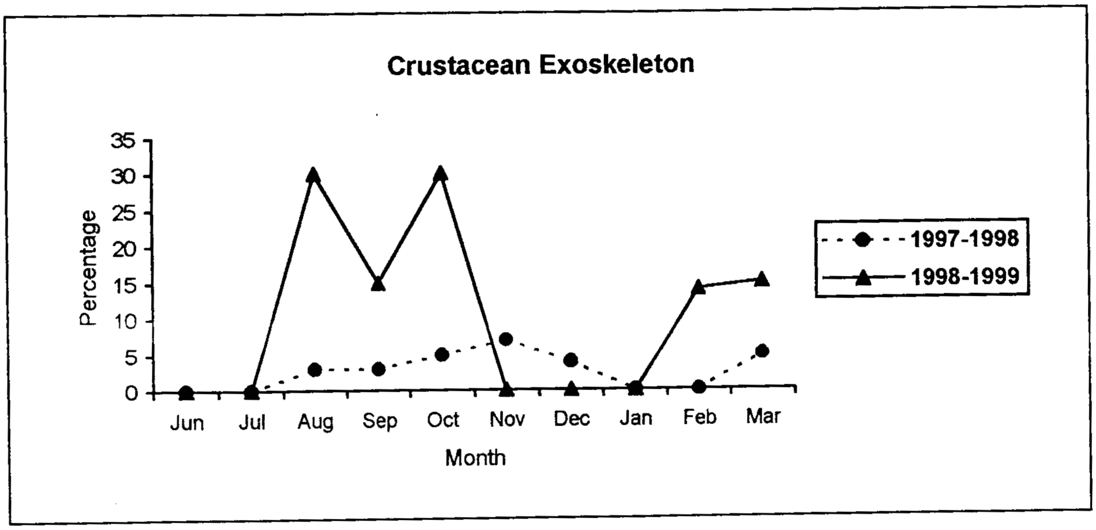
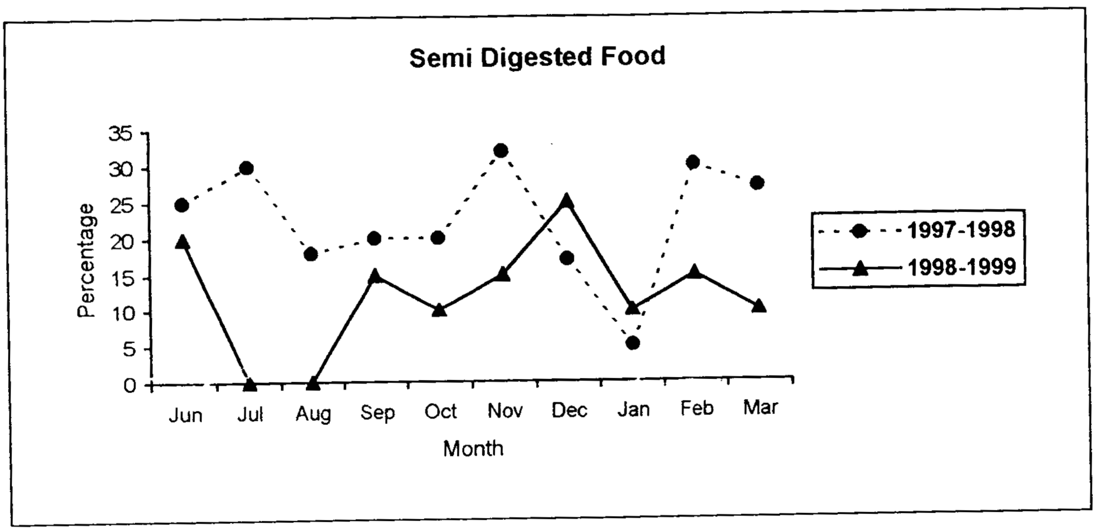


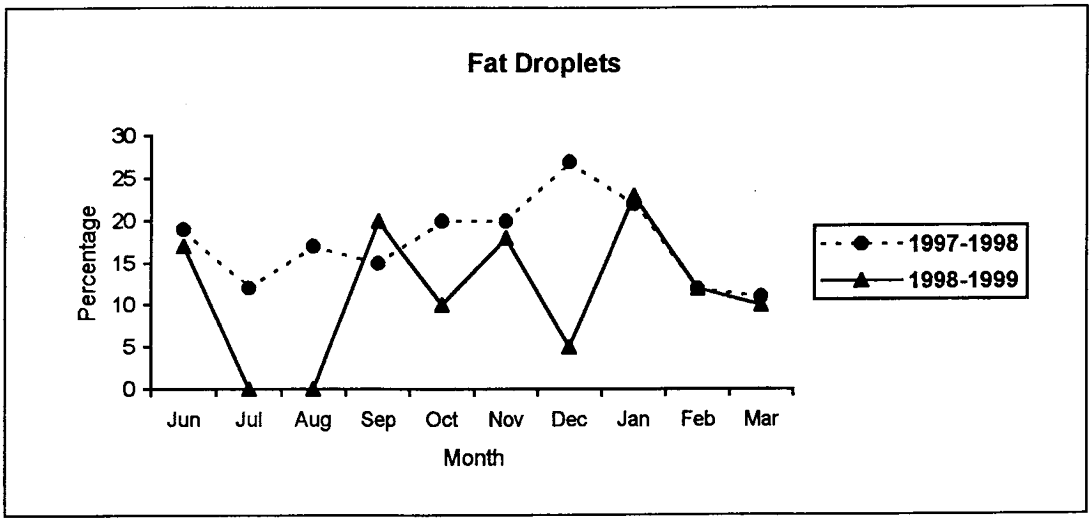
Fig. – 3.17
Percentage Composition of various food items in the gut of Male *O. bimaculatus* (Bloch) during 1997 – 1998 & 1998 - 1999







(Contd....... Fig. – 3.17)



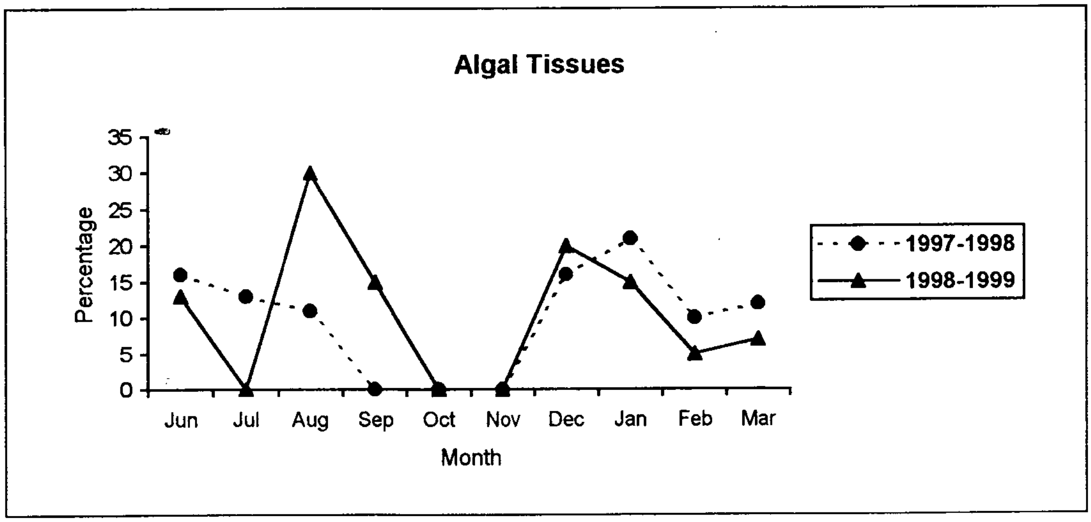
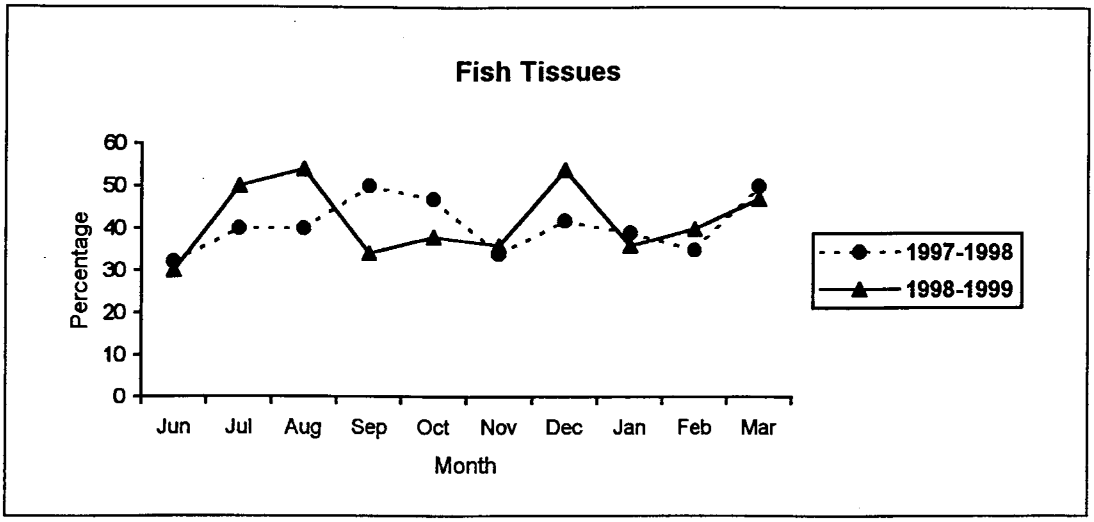
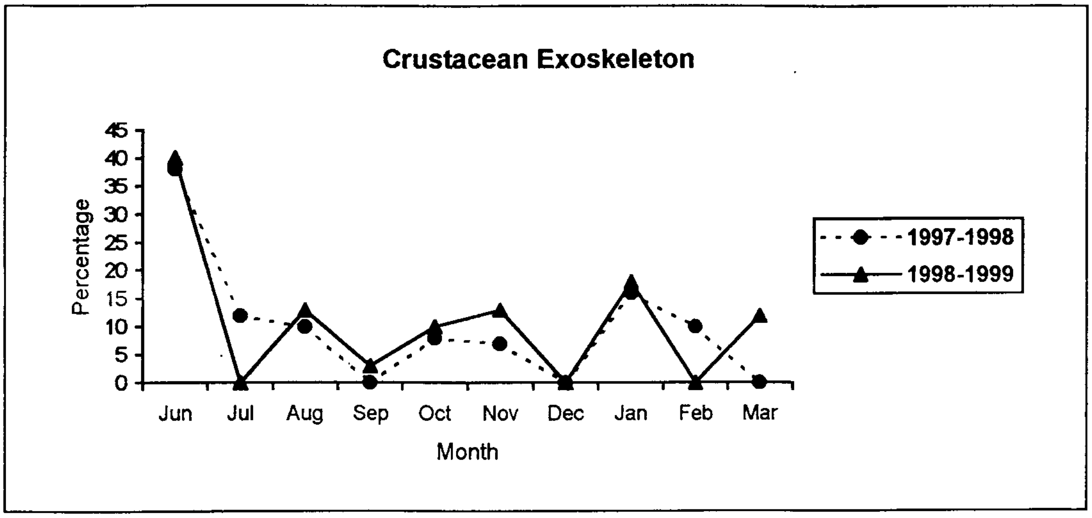
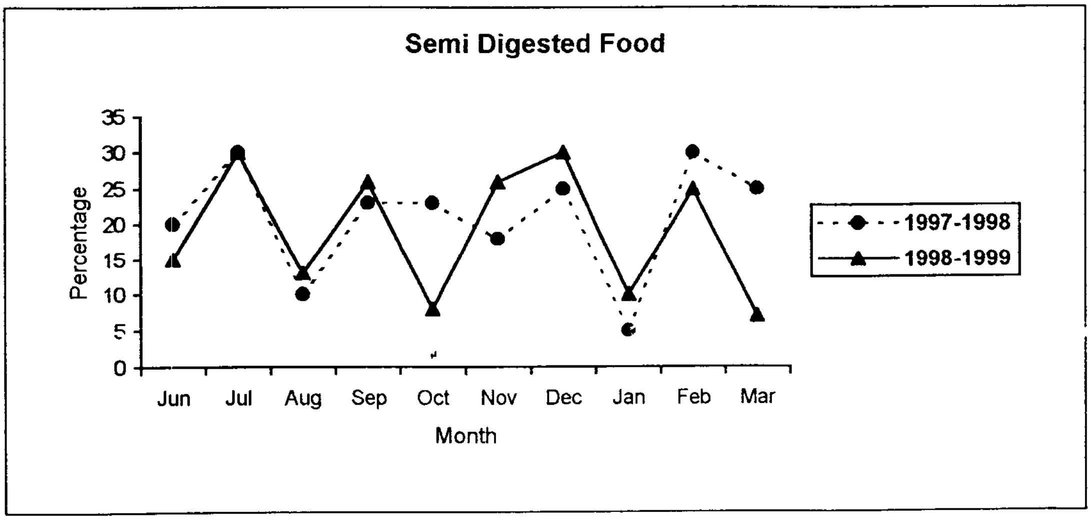


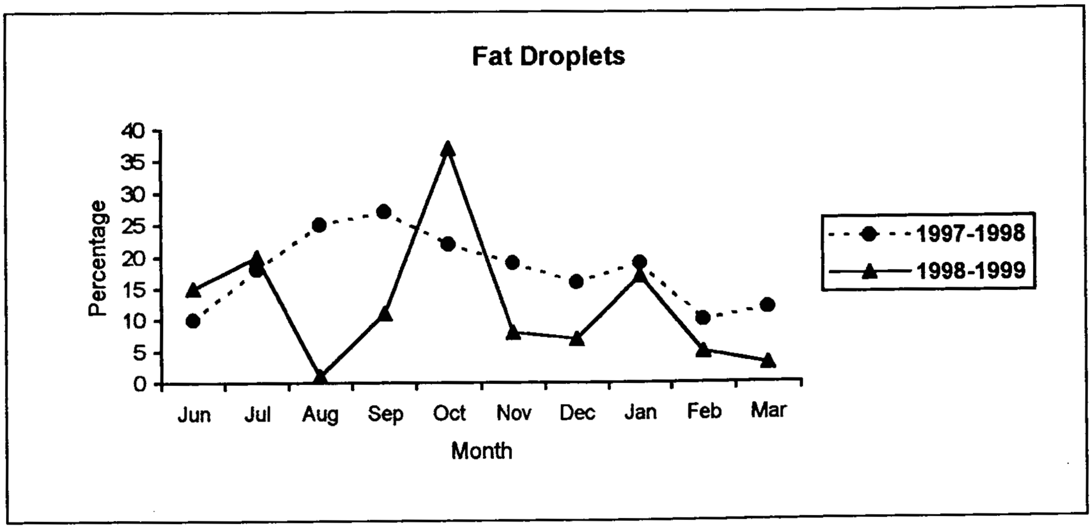
Fig. – 3.18
Percentage Composition of various food items in the gut of Female *O. bimaculatus* (Bloch) during 1997 – 1998 & 1998 - 1999







(Contd……. Fig. – 3.18)



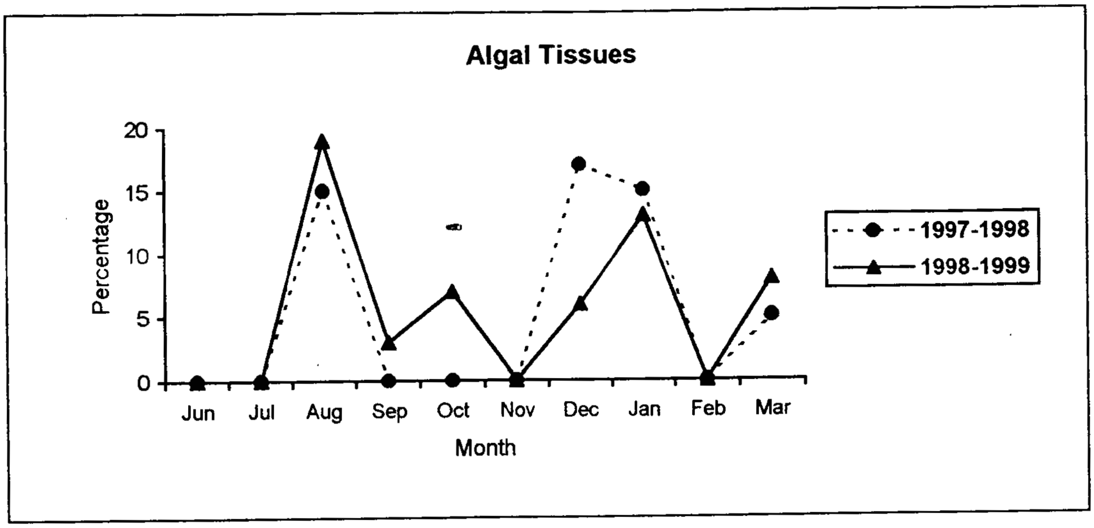
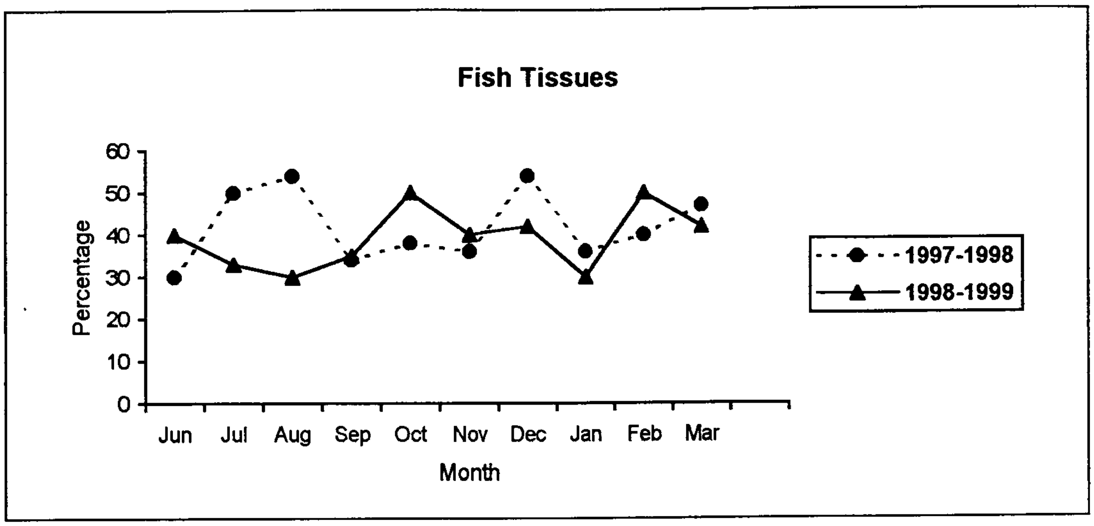
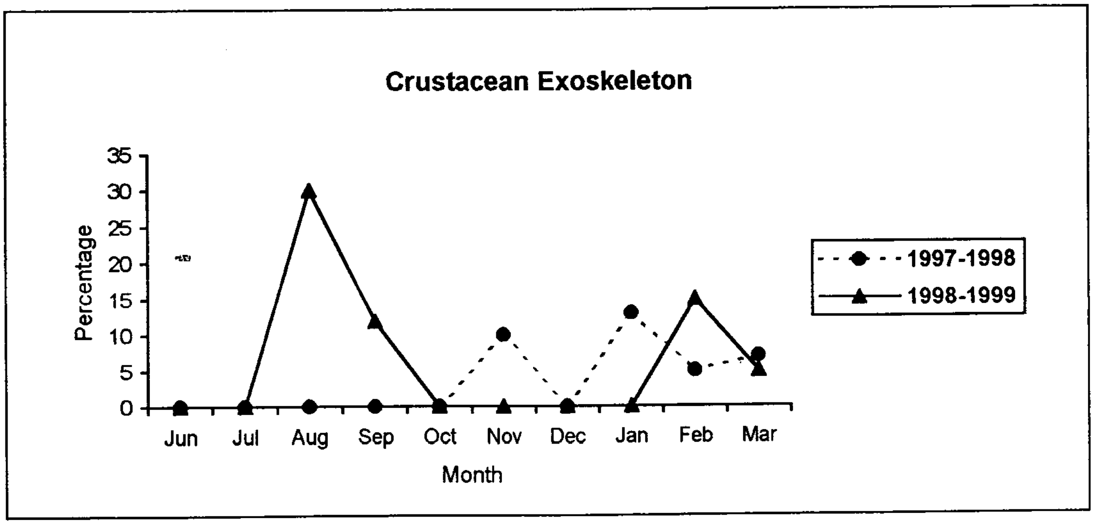
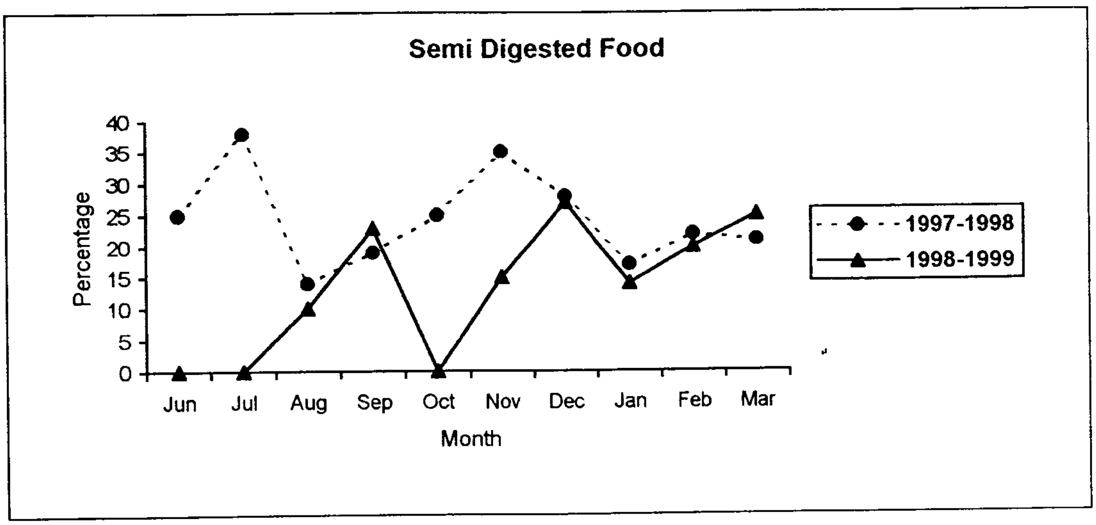


Fig. – 3.19

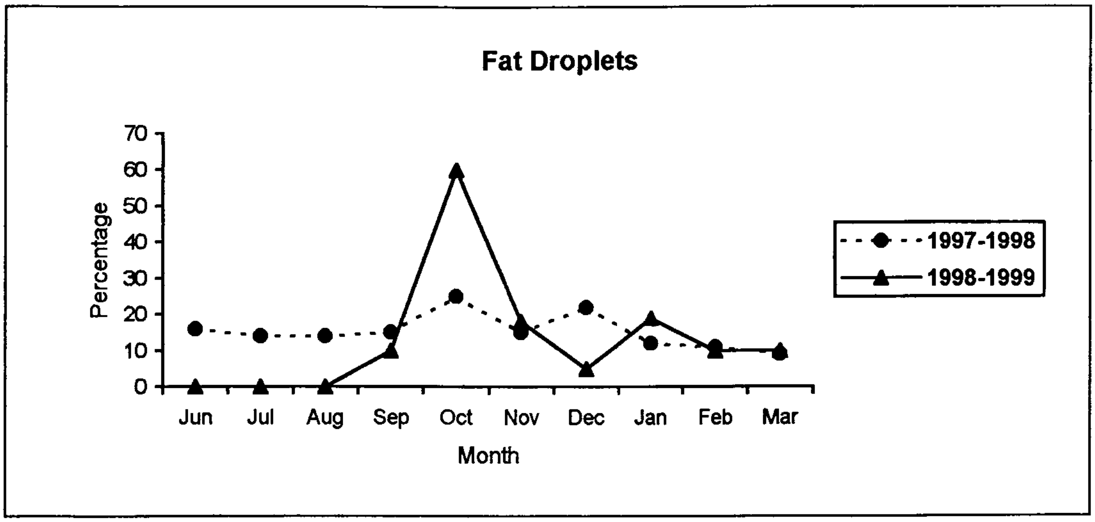
Percentage Composition of various food items in the gut of 1-15cm Length Group *O. bimaculatus* (Bloch) during 1997 – 1998 & 1998 – 1999







(Contd…… Fig. - 3.19)



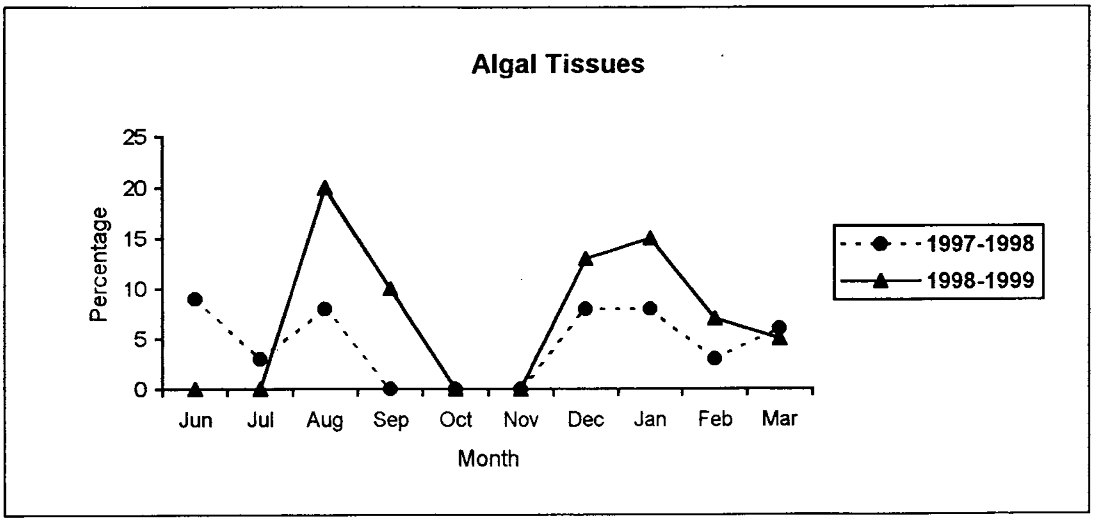
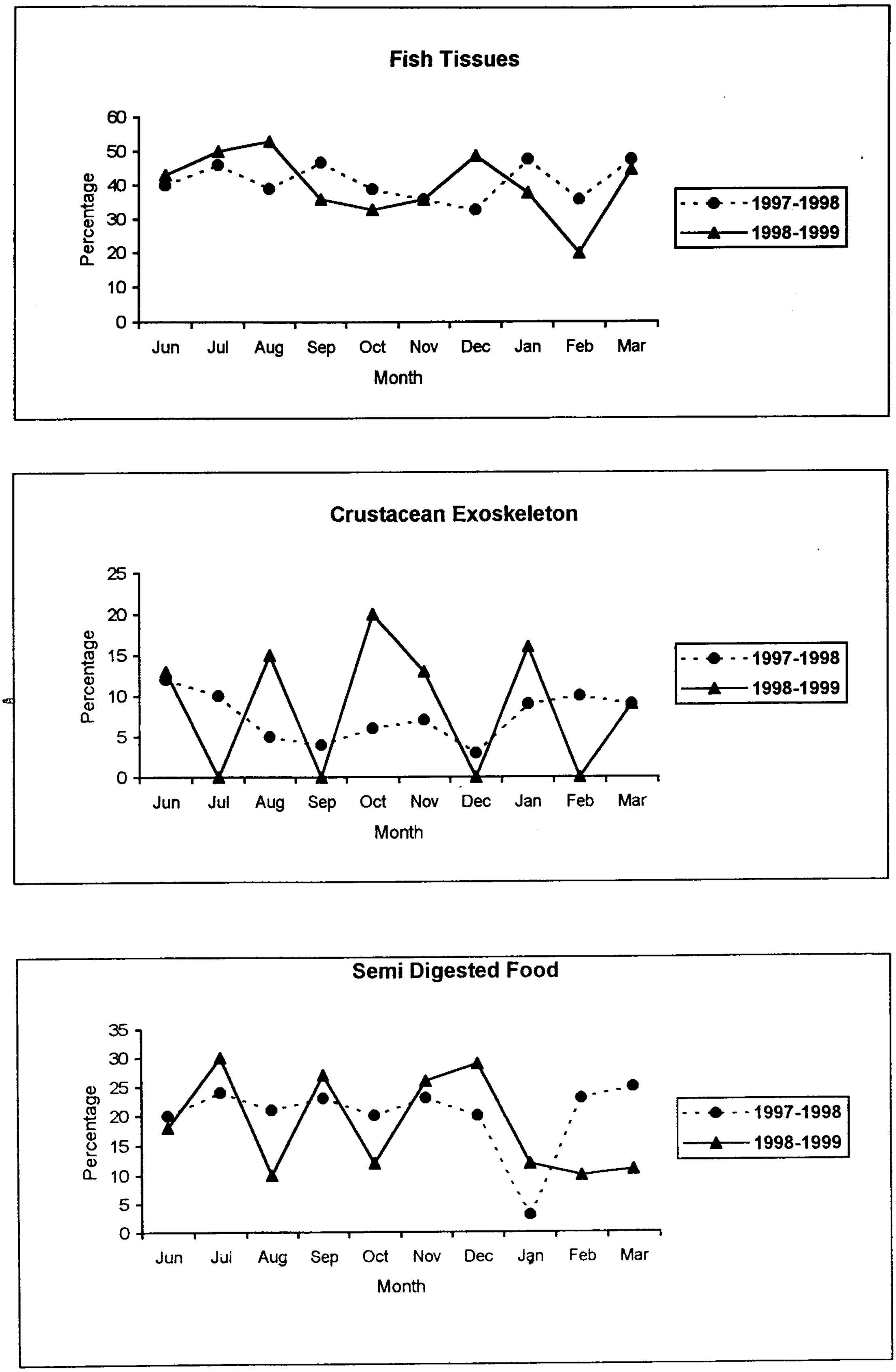


Fig. - 3.20
Percentage Composition of various food items in the gut of 15-30cm Length Group *O. bimaculatus* (Bloch) during 1997 – 1998 & 1998 - 1999



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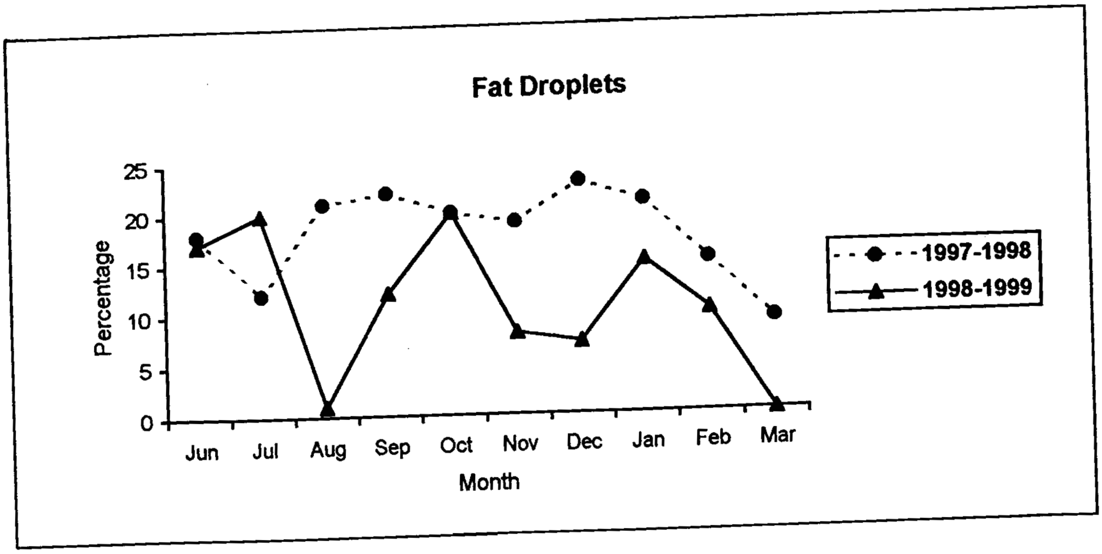


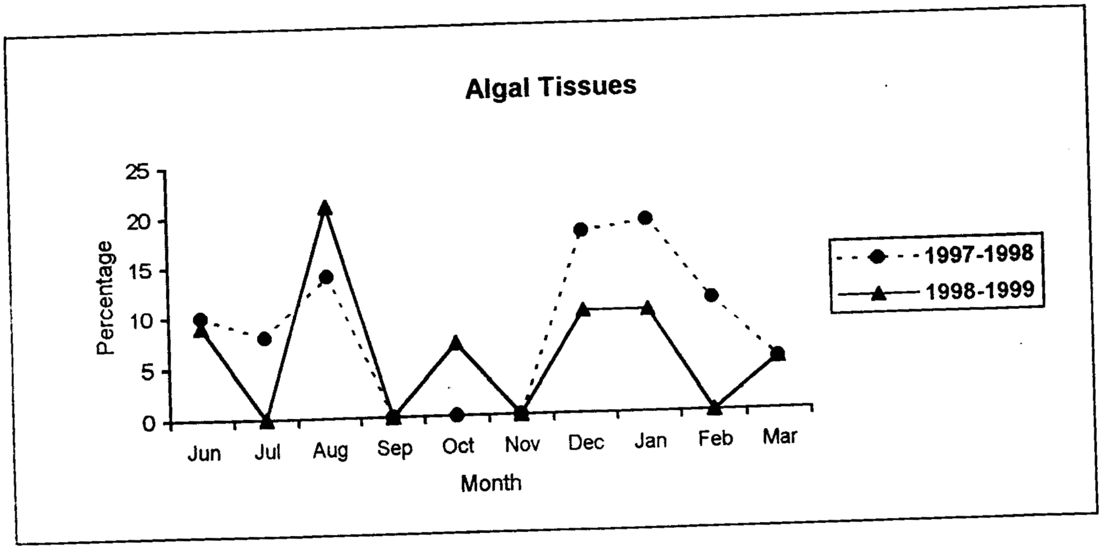
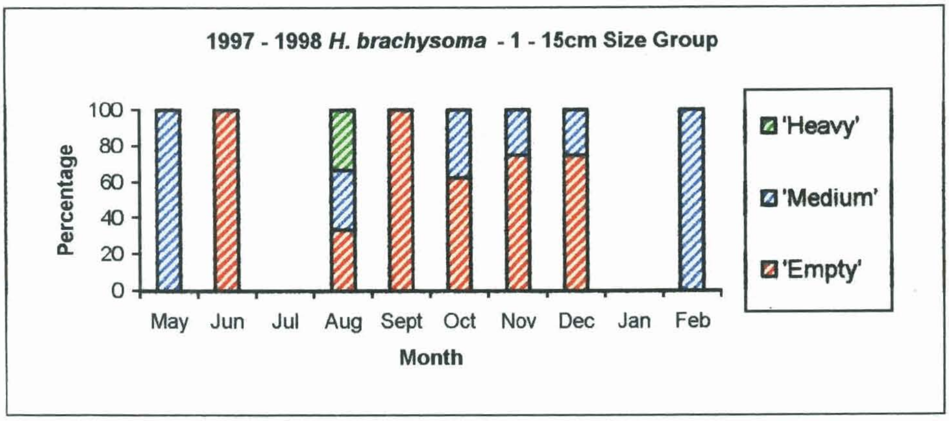


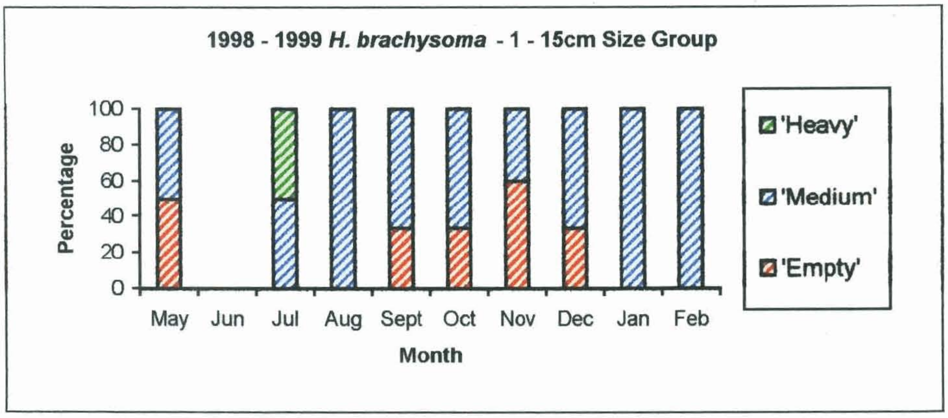
Fig. – 3.21

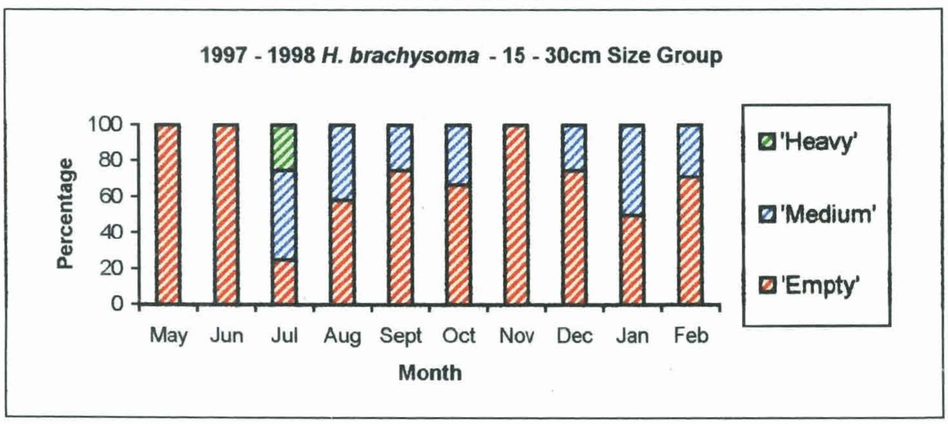
Feeding intensity of *H. brachysoma* (Gunther) average % of fish with various stomach during 1997 – 1998 & 1998 – 1999

Fig. – 3.22

Feeding intensity of *H. brachysoma* (Gunther) average % of fish with various stomach during 1997 – 1998 & 1998 – 1999







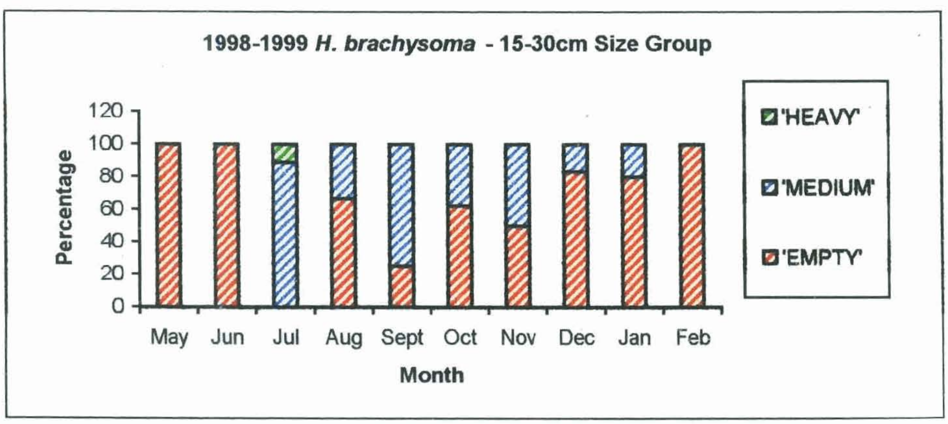
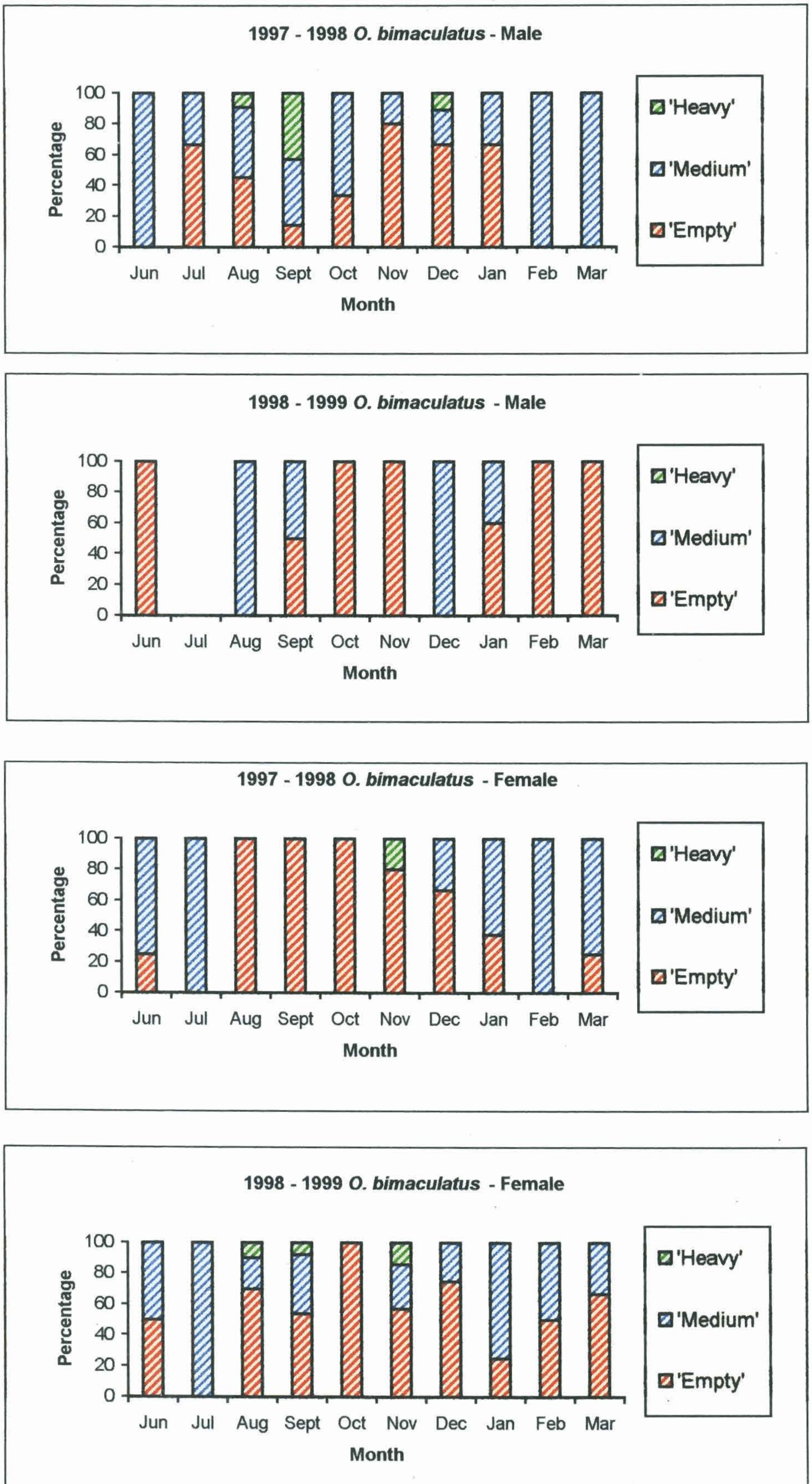


Fig. – 3.23

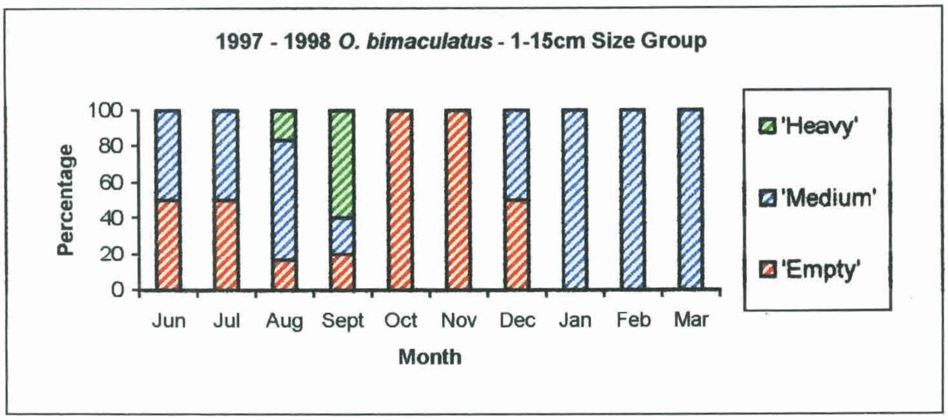
Feeding intensity of *O. bimaculatus* (Bloch) average % of fish with various stomach during 1997 – 1998 & 1998 – 1999

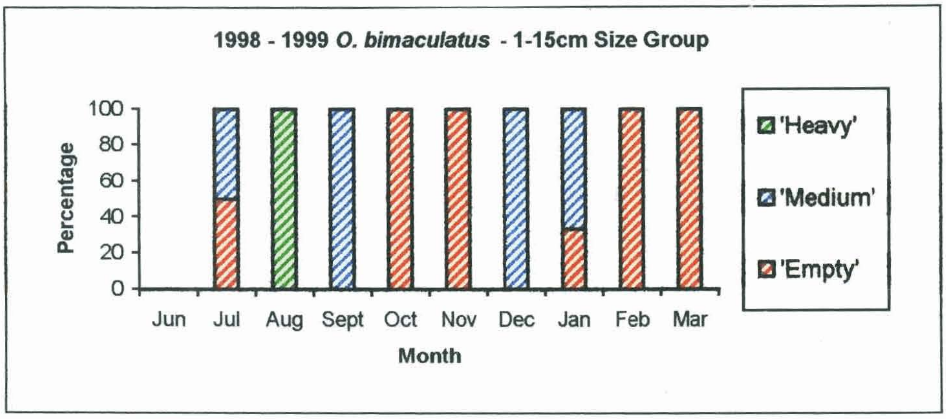


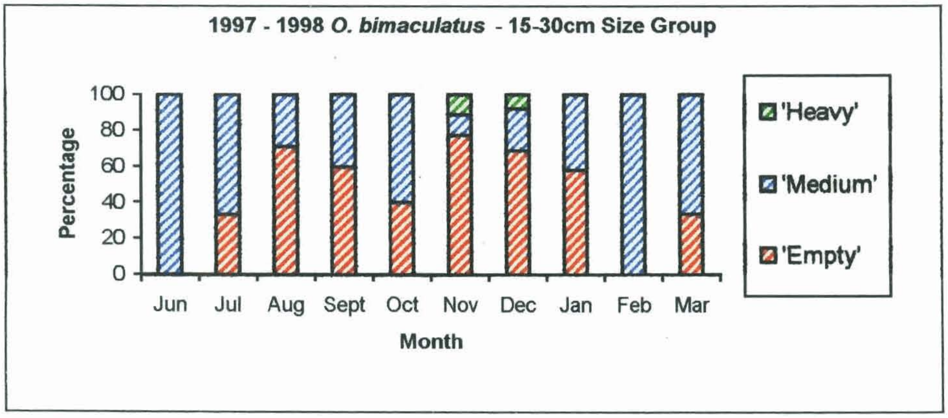
104 af

Fig. – 3.24

Feeding intensity of *O. bimaculatus* (Bloch) average % of fish with various stomach during 1997 – 1998 & 1998 – 1999







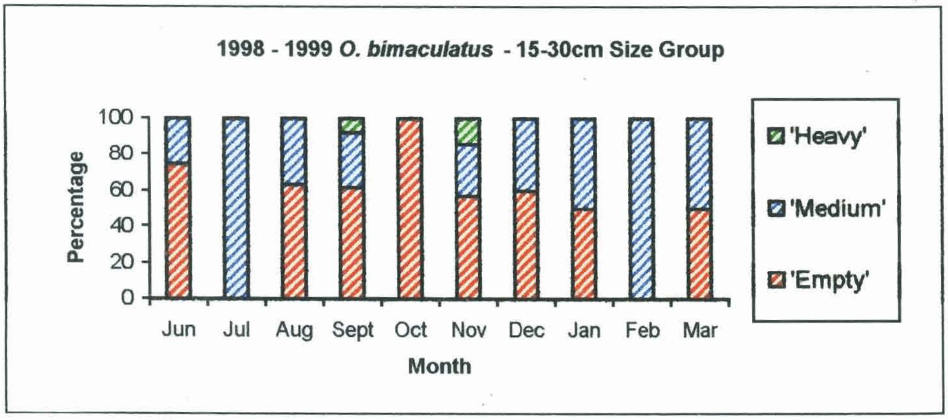
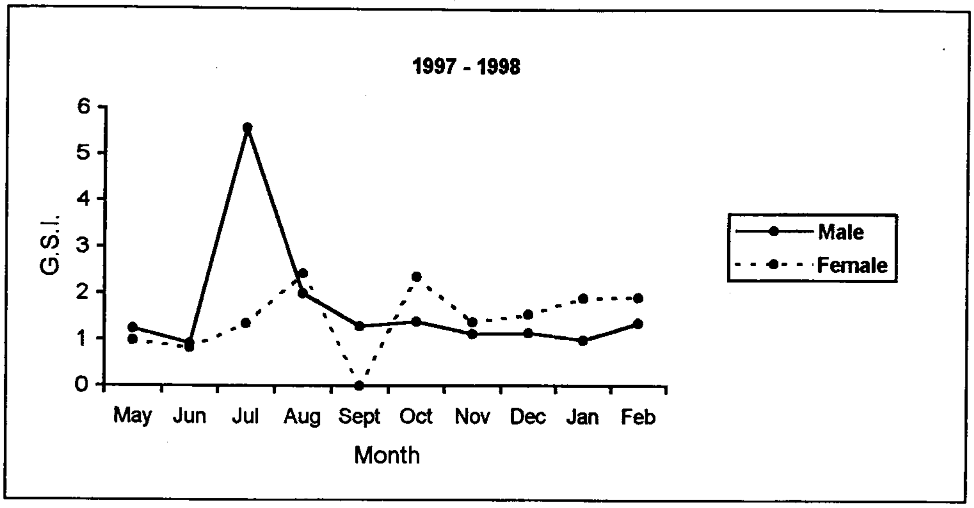
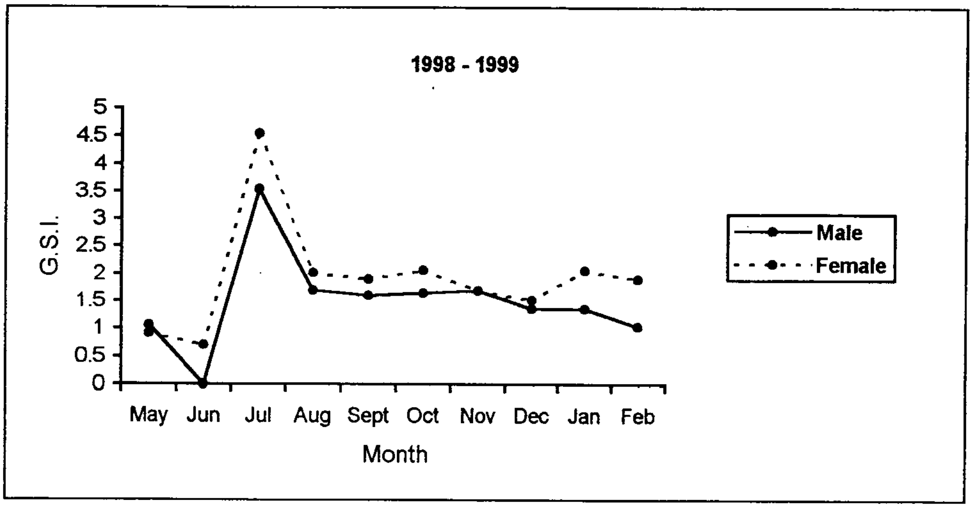
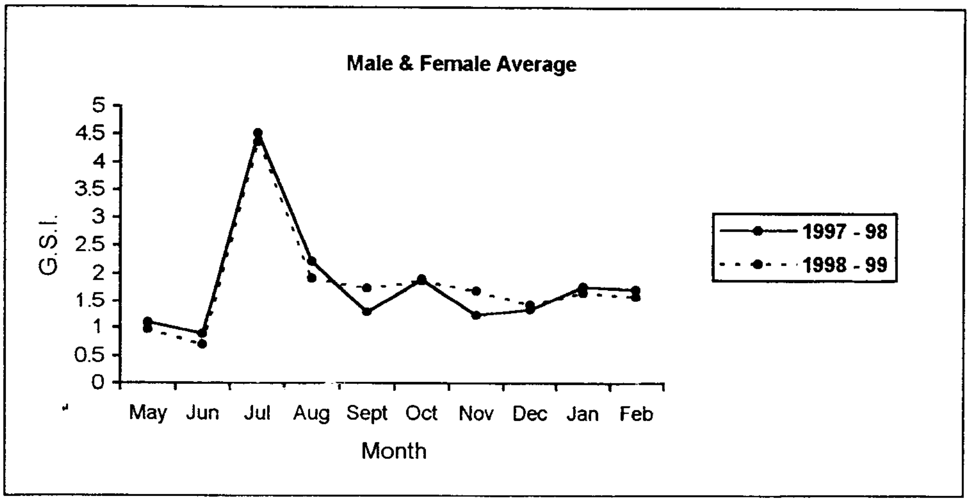


Fig. – 3.25
Monthly Gastrosomatic Index (G.S.I.) in the males and females of *H. brachysoma* (Gunther) from May 1997 to February 1999







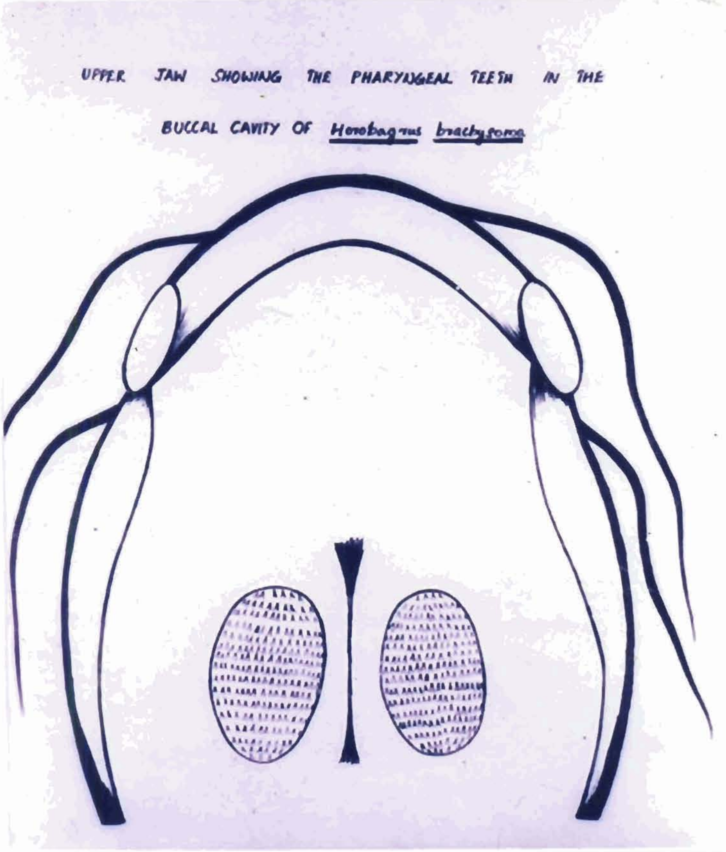


PLATE – 22

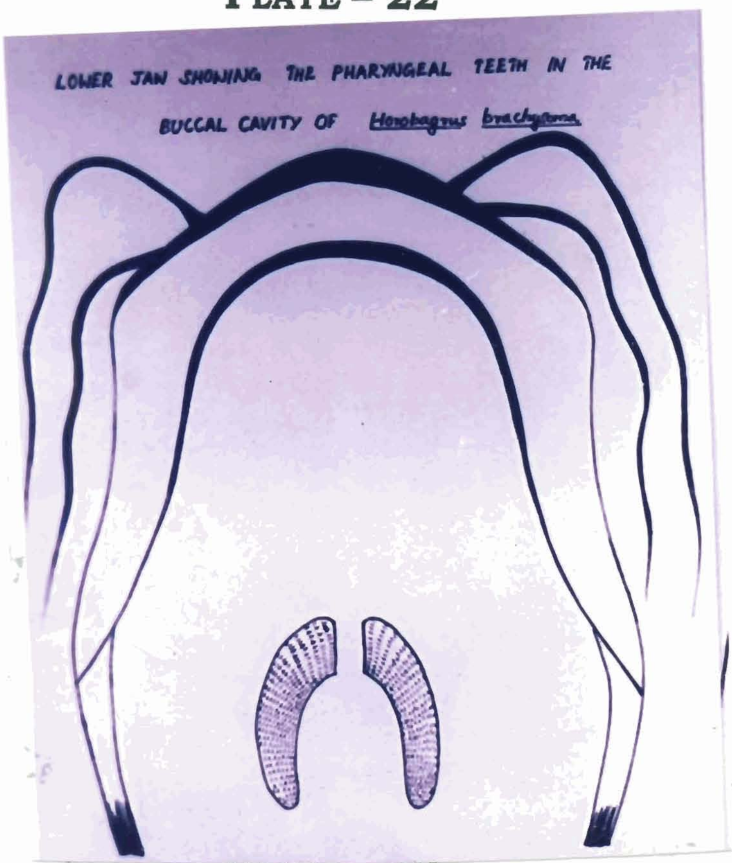


PLATE – 23

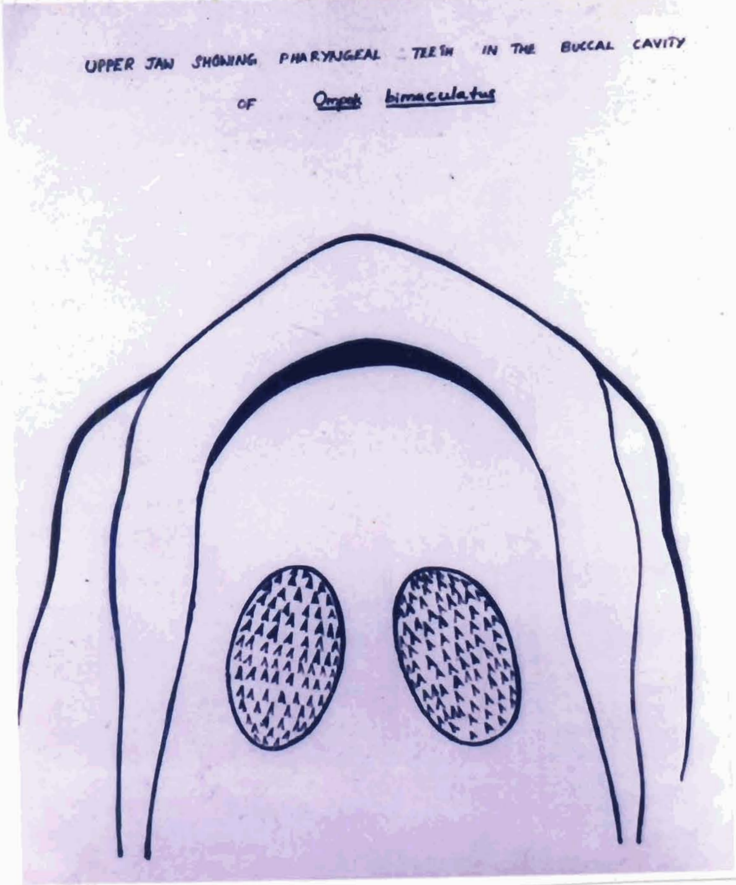


PLATE – 24

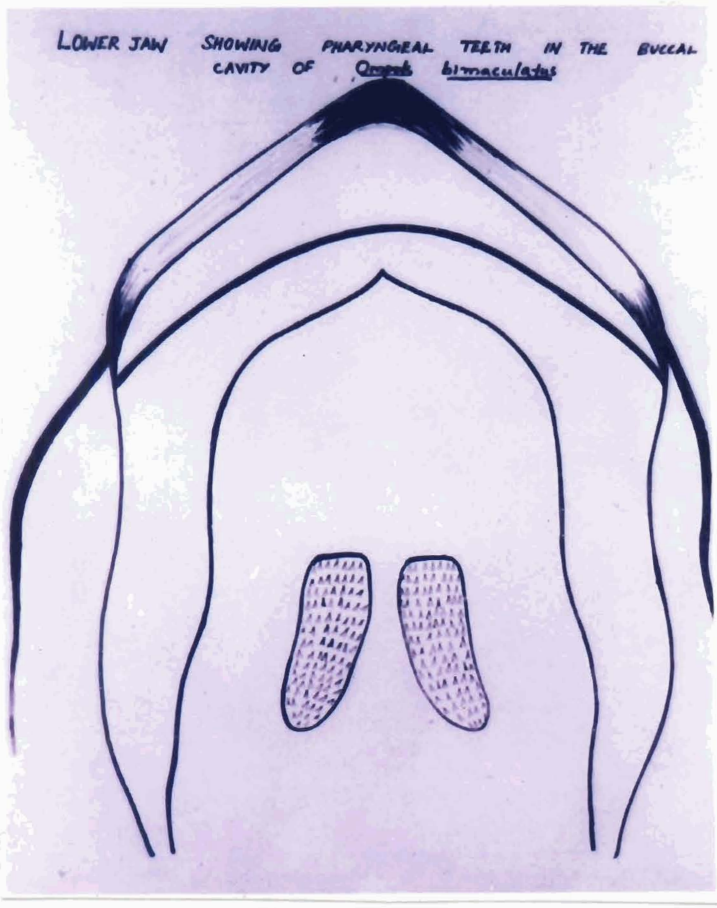


PLATE – 25

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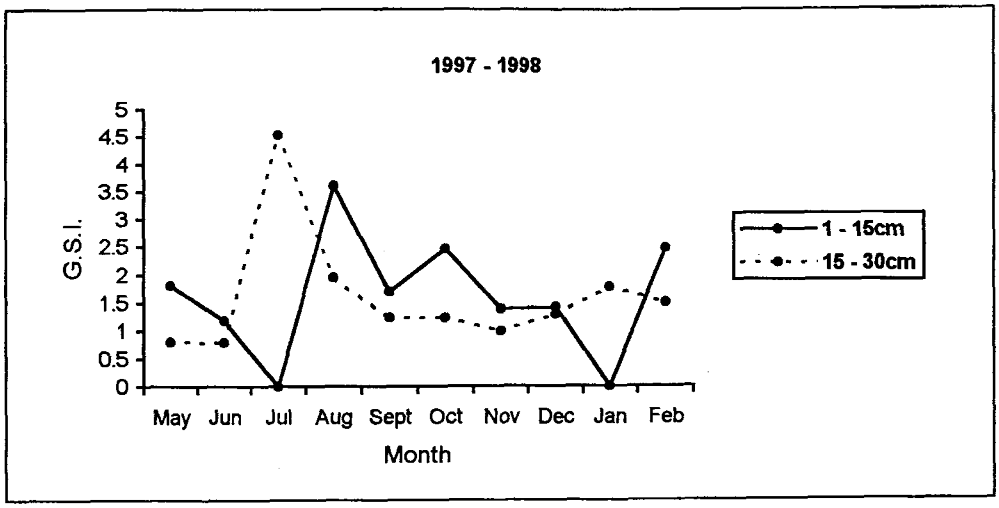
Fig. – 3.26
Monthly G.S.I. in the 1 – 15cm and 15 – 30cm Size Groups of *H. brachysoma* (Gunther) from May 1997 to February 1999



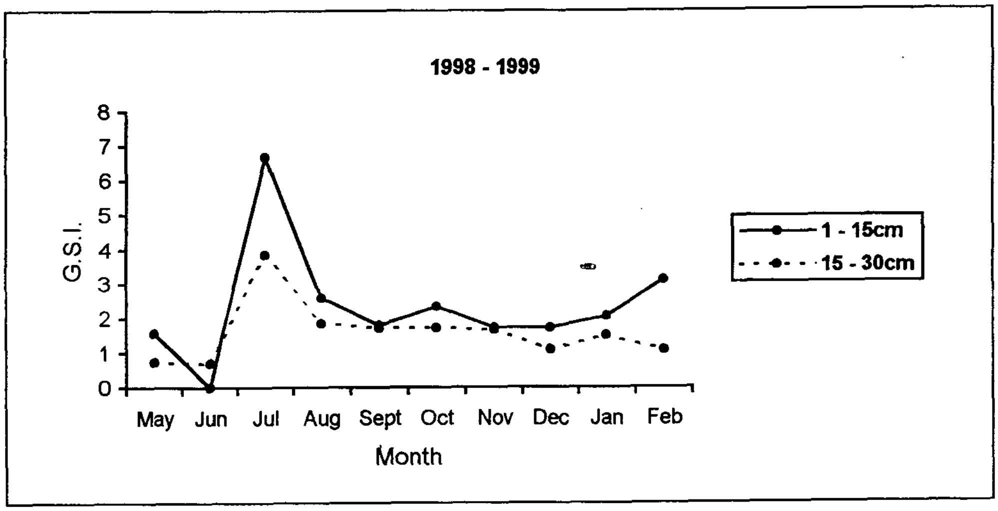
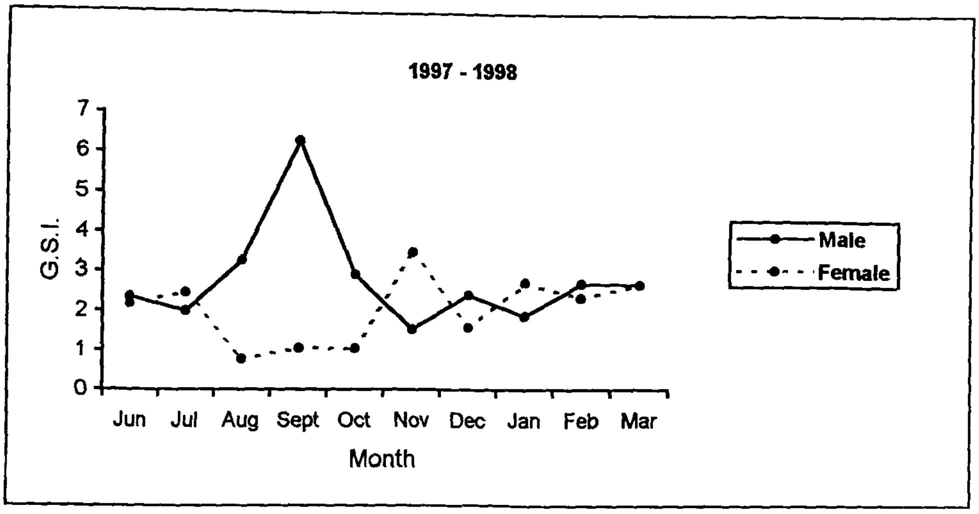
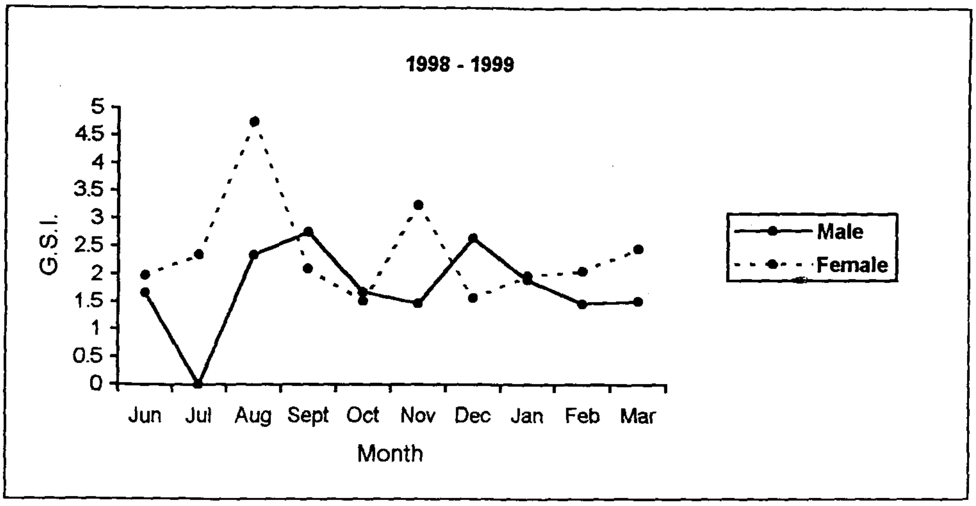


Fig. – 3.27
Monthly Gastrosomatic Index (G.S.I.) in the males and females of *O. bimaculatus* (Bloch) from June 1997 to March 1999





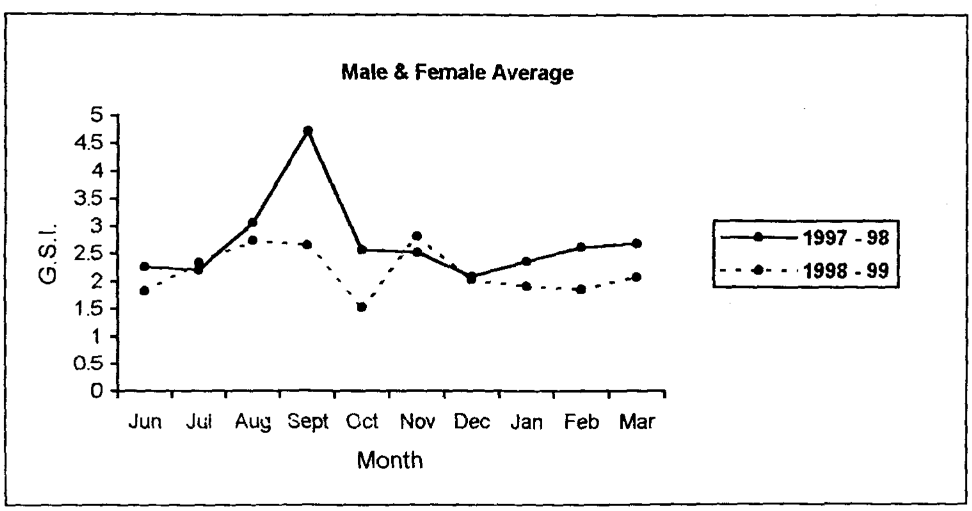
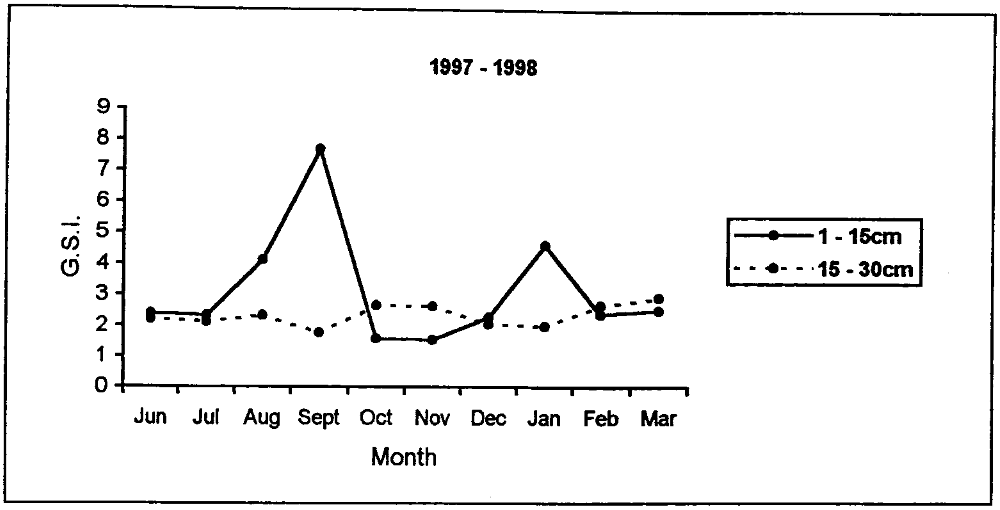
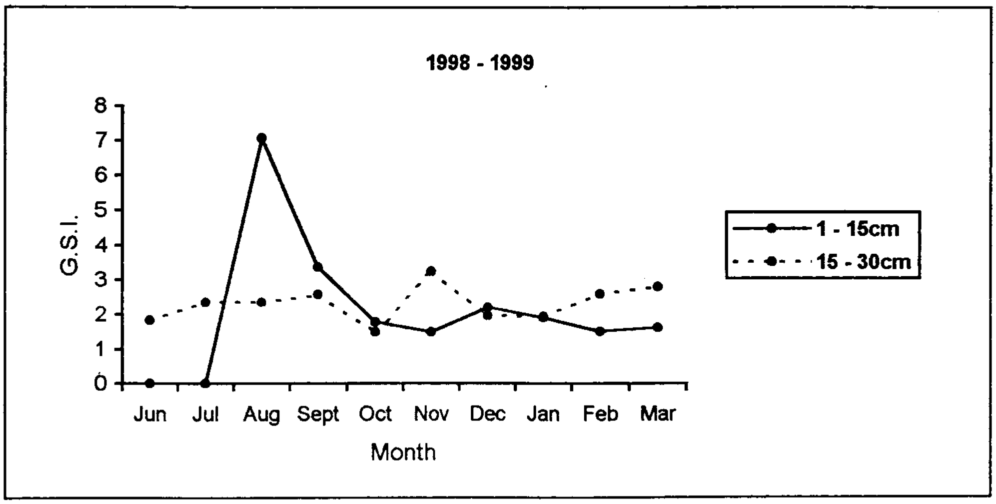


Fig. – 3.28
Monthly G.S.I. in the 1 – 15cm and 15 – 30cm Size Groups of *O. bimaculatus* (Bloch) from June 1997 to March 1999





AGE AND GROWTH

CHAPTER – IV

AGE AND GROWTH

INTRODUCTION

In biological studies of commercially important fishes, determination of the age and growth is significant as it contributes to the understanding of the age – class structure of the stock and the role played by various year classes in the fluctuations of the fishery. A knowledge of the age and growth of fish is also essential to understand the dynamic features of population and helps to determine the quantity of fish that could be produced in a fish population against time. In order to provide biological information relevant to mariculture, detailed knowledge on the growth of candidate species, their seasons of maximum growth, age at marketable size, age at maturation and spawning and fecundity in relation with age is highly essential. Thus a knowledge of these parameters is an essential pre-requisite for successful fishery management. The age and growth studies of fishes was first proposed by Peterson in 1895 who evolved a method for determining the age of fish from length – frequency curves.

In fishes, age and growth can be determined by direct and indirect methods.

Direct Methods

1. Tagging and recapture. The fishes are tagged and released back into water after noting down their length at the time of release and again recaptured and noted the length.

2. Culturing the fish in cages or ponds or other enclosed or semienclosed habitat providing proper environment and suitable food and studying their growth in captivity.

Indirect Methods

1. Markings (annual / seasonal) found on the hard parts such as scales, otoliths, fin rays and skeletal parts.

2. Noting the diameter and weight of the eye lens.

3. Peterson's or the length frequency distribution method.

The direct methods are preferable as they offer direct evidence, but are difficult to implement, as appropriate infra structure facilities are required to carry out the programme. Even though length frequency method has been one of the most popular techniques for age determination of fishes all over the world, this method is not used in the present study due to the non-availability of the fish during certain seasons. Therefore the eye lens and the hard parts such as otolith, vertebra and operculum are used for age determination in the present study.

The use of skeletal hard parts has become an accepted procedure for the determination of age of many fishes especially in temperate waters. During summer and autumn, fish in their ecosystem tend to register maximum growth due to optimum food supply and environmental condition, particularly the temperature. The growth becomes slow during winter and spring when both the food availability and environmental factors are relatively at low levels. Corresponding to the seasonal changes, the annual markings in the hard parts are seen as widely spaced or opaque zones due to fast growth followed by narrower and more transparent spaced zones owing to slow growth. Certain fresh water fishes of the monsoon tropics also show seasonal growth marks that correspond to the onset of dry season. The growth zones can be measured and the correspondence between body growth and the growth of bony parts can be established.

A lot of literature is available on the use of hard parts in the study of fish growth from outside India. Chugunov (1926) and Van oosten (1929) have reviewed the literature on age determination of fishes by scales and other skeletal structures and have commented on the validity of different methods. Maier (1906) reviewed the history of age determination from seventeenth to the end of nineteenth centuries. The earlier reviews on this topic are given by Thompson (1902) and Graham (1929) and the recent ones may be referred to in the works of Bagenal (1974), Pauly (1978), Xucai *et al.*(1986), Lee & Yeh

(1989), Francis (1990), Barger (1990), Campana (1990) and Megalofonoce (2000).

In India also, various studies have been conducted on the determination of age of fishes by using skeletal structures. To mention a few are the works of Muthiah (1982), Rao *et al.* (1986), Soni and George (1986), Maruthamuthu and Manickam (1988), De and Datta (1990), Afser (1992), Rawat and Nautiyal (1996), Kurup B. Madhusoodana (1997), Saha *et al.* (1997) and Seshappa (1999).

The ocular lens has been used previously as a technique for the estimation of age of mammals and birds (Friend 1967). But in the animals, this technique can be used only to distinguish between juveniles and adults. Later various authors concluded that the eye lens could be used to estimate the age of fishes {Carlton, Jackson (1968), Burkett, Jackson (1971), Douglas (1987) and Crivelli (1980)}. Laith Al – Hassan (1992) employed ocular lens diameter as an age indicator of the catfish *Heteropneustes fossilis* and *Ilisha elongata* collected from Iraq. Al- Hassan *et al.* (1991, 1999) used eye lens diameter to estimate the age of *Mystus pelusius* and two sparid fishes. But so far no such work has been done for Indian catfishes.

A lot of literature is available from Indian catfishes on the use of hard parts for the determination of age. Gopinatha Menon (1986) has described the age and growth of *Tachysurus thalassinus* (Ruppell) Ramakrishniah (1987) has studied the age and growth of *Mystus aor* from Nargarjuna sagar reservoir. Pantulu (1961, 1962) has determined the age of *Mystus gulio* and *Pangasius pangasius* by the use of pectoral spine. He has also described the age of *Osteogeniosus militaris* (Linn) (1963). Pandey (1993, 1994) has studied the age of *Wallago attu* and *Mystus aor* (Hamilton) from River Padma. Dan (1980) has worked out the age and growth of the marine catfish *Tachysurus tenuispinis* (Day).

The aim of the present study is to evaluate and use the best of several bony structures such as vertebra, pectoral spine, operculum and otolith and the eye lens to estimate the age and to the determine the growth of *H. brachysoma* and *O. bimaculatus* from the inland waters of Central Kerala.

MATERIALS AND METHODS

Fish samples of various size groups of *H. brachysoma* and *O. bimaculatus* were collected. All the fish were weighed and measured, weights were taken to the nearest gram. Total length was measured in mm from the tip of the snout to the tip of the caudal fin. Otoliths, vertebrae, operculum and the eye lens were removed from the fresh fish for age analysis.

1. Vertebrae

Fresh fish were cooked in boiling water to remove the flesh. When the muscles were sufficiently soft, they were removed with the help of a scalpel and the vertebrae from different regions of the column were removed, washed and dried in air. Later it was cleared in ether for about eighteen hours to remove the fat and subsequently placed in xylol for 3-5 minutes until the growth ring becomes clearly visible. The vertebrae thus prepared from both the fishes, *H. brachysoma* and *O. bimaculatus* were examined under reflected light, which makes the narrow transparent zones appear black, and the broad opaque zones appear white. Faint concentric rings were seen on the surface, but they were not clear and easy to interpret in fish of different sizes.

2. <u>Operculum</u>

The operculum is the largest bone of the opercular complex and it was examined for seasonal marks. The opercular bones of several fresh fish of various sizes were removed, and boiled in water for 2 - 3 minutes. After removal of pieces of skin and flesh, they were cleaned in water, dried and immersed in ether for a few hours to remove the fat, dried again and cleared with xylol. This bone also showed some indistinct markings along the edge, but attempts to make them clearer were not fruitful.

3. <u>Otolith</u>

The otoliths of *H. brachysoma* and *O. bimaculatus* have shown certain markings or rings, which are clearer than those on the vertebrae or the operculum. Hence a detailed study of these structures was made.

The otoliths are two small elongated calcareous bodies broader at the anterior end and narrow posteriorly. Each otolith is convex towards the external side and concave along the inner surface. In the fresh fish they are translucent while in the preserved fish they become opaque. Examination of otoliths from fresh fish under the low power of binocular microscope by reflected light revealed an opaque centre and one or more alternating transparent rings (narrow) and opaque areas (wide), the number of rings depending upon the size of the specimen. Both the otoliths from the same fish are alike. Otolith of the left side was made use of in the present study for uniform observation.

Otoliths were removed by cutting through the otic capsules at the base of the cranium with the help of a scalpel. Otoliths were washed, dried and stored in envelopes for detailed examination later.

Cleaned otolith did not show the transparent and opaque zones straight away and it was also difficult to locate the nucleus. The otolith of *H. brachysoma* was found larger in size than that of *O. bimaculatus* and hence it was found necessary to grind its convex surface gently over a carborundum (Menon, 1950) taking care that the edge was not damaged. The otoliths of *O.bimaculatus* were kept in glycerine for a week for clearing, before counting the number of opaque rings. Otoliths of both the fishes were examined in glycerine under a binocular microscope with reflected light (eye piece 10 x and objective 5 x). Measurements were taken using an ocular micrometer. At this magnification, each ocular micrometer division is equivalent to 0.0325mm. Measurements were taken from the focus, the centre of the central opaque zone, to the outside margin of the dorsal edge, which forms the otolith radius (OR). Measurements were made to each annulus along this line for back calculation of lengths. Each otolith was examined thrice at different times and an accurate count was taken for the analysis of growth characteristics. The relationship between otolith radius and the total length of the fish was worked out by the least square method.

The Lee method (Carlander, 1981) of back calculating body length from prior annuli was used.

$$Li = a + [(Lc - a) (O_1 / OR)]$$

Where Li = Length at the time of annulus formation

a = Intercept

Lc	=	Length at the time of capture
O_1	=	Otolith radius at the time of annulus formation
OR	=	Otolith radius at the time of capture

4. Ocular lens

Lenses were extracted from fresh samples of *H. brachysoma* and *O. bimaculatus.* They were dried at room temperature and the diameter is measured individually to the nearest mm. The weight of each lens was also taken to .001gm (1mgm) using an electronic balance. The measurement of the lens of each side of the animal was kept separate. The relationship between fish length and the diameter and weight of the lens was found out statistically.

RESULTS

In *H. brachysoma* and *O. bimaculatus*, otoliths are well developed and they show clear hyaline rings, which are identified and studied for determination of age. On the assumption that each of these rings in the otolith is formed annually, the translucent rings were counted and the number of these rings was taken to be the age of the fish in years. This assumption is reasonable since fish of equal length were nearly always found to be of equal age. The age of *H. brachysoma* ranged from less than a year to three years while in *O. bimaculatus* only upto two year old fishes were observed. Three year old fishes did not provide an adequate sample, since younger specimens were mostly used for this study. The length of different age groups showed that body size is moderately spread within an age group, while length overlapped in the different age groups (Fig. 4.5 - 4.8). This is one of the reasons why use of the eye lens diameter and weight as an age indicator is recommended. The eye lens studies also indicate that the average lens diameter and weight increased with age for the two species studied.

Horabagrus brachysoma (Gunther)

Otolith

Otoliths of 40 males and 54 females ranging in size from 120 - 300mm were studied and the rings identified. In males, 19 fishes were with 1 ring, 16 with 2 rings and 3 fishes with three rings, while in females 28 fishes with one ring, 16 fishes with 2 rings and 6 fishes with three rings were observed (Table 4.1). The mean total length of the fishes with one, two and three rings in males were 164.4, 226.8 and 252mm and in females 180, 225.7 and 251mms respectively.

Relation between otolith radius and fish length

Regression of total length on otolith radius of *H. brachysoma* showed a linear relationship for both males and females. The regression equation of total length on otolith radius is expressed as:

Males : TL = .73223 + .84718 OR (r = .89425)

Females : TL = .95059 + .66650 OR (r = .59149)

Scatter diagrams of length against otolith radius are presented for males and females (fig. 4.1 & 4.2). It is noticed that the growth of the otolith is proportional to the growth of the fish and the linear relationship is more pronounced in males than females.

Back calculation of length from otolith

Results of back calculation of total length using otolith in *H. brachysoma* males and females are presented in tables 4.5 & 4.6. The mean back calcuclated lengths for the first three years of life of *H. brachysoma* males were 139.89, 193.85 and 226.75mm and the females were 135.05, 193.09 and 224.97mm respectively. Mean total length at capture for each age group is greater than the average calculated length. According to Burnett - Herkes (1978), this difference is as a result of growth between the time of formation of the last ring and the time of capturing the fish.

Eye lens as an age indicator

It is observed that in *H. brachysoma,* average lens diameter and weight increased with age in both males & females (Fig. 4.17 – 4.20). In males, the results showed that the eye lens diameter of the third year class did not overlap with the range of the second year class. Between the first year class and the younger ones also there was no overlap. In females only the first year class was well differentiated in eye lens diameter from the younger individuals. The eye lens weight of the various year classes of *H. brachysoma* showed overlap in both males and females except the first year class of females from the younger fishes. The average lens diameter for 0 – 3 years in males were 1.72, 2.09, 2.63 and 3.07mm respectively. In females, the corresponding values were 1.77, 2.26, 2.56 and 2.89mm and for males and females pooled the average lens diameter for the age groups were 1.74, 2.17, 2.59 and 2.98mm. The average lens weight in the age groups from 0 – 3 years in males were 5.5, 8.89, 16 and 23.67mgm and in females 4.5, 11.5, 16.29 and 21.5mgm. For males and females pooled, the corresponding values were 5, 10.19, 16.15 and 22.59 mgm.

<u>Relationship between fish length and eye lens diameter</u>

Regression of total length on eye lens diameter of *H. brachysoma* showed a linear relationship for both males & females i.e. eye lens diameter increases with the increase of body length. The regression equation of total length on eye lens diameter is expressed as:

Males : TL = - 1.41476 + .78878 LD (r = .83070)

Females : TL = - 0.00499 + 2.94912 LD (r = .9422)

Scatter diagrams of length against eye lens diameter are presented for males and females (fig. 4.10 and 4.12).

Relationship between fish length and eye lens weight

The regression equation of total length on eye lens weight of *H. brachysoma* is expressed as

Males : TL = - 3.57094 + 2.04871 LW (r = .81208)

Females : TL = - 3.26261 + 1.91212 LW (r = .69933)

Scatter diagrams of total length of fish against eye lens weight are presented separately for males and females. (Fig. 4.9 & 4.11). It is noticed that the relationship is isometric' i.e. eye lens weight increases with the increase of body length of both males and females of *H. brachysoma.* But total length of males have a better correlation than that of females with repsect to eye lens weight.

Ompok bimaculatus (Bloch)

Otolith

Otoliths were collected and prepared from 18 males ranging in size from 120 – 220mm and 89 females having a size range 120 – 280mm and the annual rings were observed. In the sample of males, nine fishes had one ring and six fishes had two rings; while in females sixty two fishes were with one ring and twenty five fishes with two rings. The mean total length of the fishes with one and two rings in males were 159.2mm and 198.3mm and in females 196mm and 226.9mm respectively.

Relation between Otolith Radius and fish length

Regression of total length on otolith radius of *O. bimaculatus* showed a linear relationship for both males and females. The regression equation of total length on otolith radius is expressed as

Males : T.L. = 0.66624 + 0.65229 OR (r = .81690)

Females : T.L. = 0.67543 + 0.6348 OR (r = .69165)

Scatter diagrams of length against otolith radius are presented for males and females (Fig. 4.3 & 4.4). It is observed that the growth of otolith is proportional to the growth of the fish and the linear relationship is better noticed in males than females.

Back calculation of length from otolith

The back calculated total length using otolith in *O. bimaculatus* males & females are presented in tables 4.7 & 4.8. The mean back calculcated lengths for the first and second years of life of *O. bimaculatus* males were 92.45mm and 160.47mm and females were 112.75mm and 188.24mm. Mean total length at capture for each age group is greater than the average calculated length.

Eye lens

The diameter and weight of the eye lens of the various age groups of *O. bimaculatus* were noted and it is observed that the average lens diameter and weight increased with age of the fish in both males and females (Fig. 4.21 - 4.24). The average eye lens diameters for 0 - 2 years in males were .99, 1.26 and 1.58mm respectively and the corresponding values in females were 1.18, 1.44 and 1.6mm. For males & females pooled, the values were 1.09, 1.35 and 1.59mm. The average eye lens weight in males for 0 - 2 years were 1.2, 2.7 and 4.2mg respectively and for females the corresponding values were 1.2,3.18 and 4mg. For both males and females pooled, the values were 1.2, 2.94 and 4.1mgm. Even though there was considerable increase in the average lens diameter and weight with age, there was overlap between the values of the various age groups except the lens weight of the various age groups of the males.

Relationship between fish length and eye lens diameter

The regression analysis of total length on eye lens diameter of *O. bimaculatus* showed a linear relationship for both males and females. ie. eye lens diameter increases with the increase of body length. The regression equation of total length on eye lens diameter is expressed as:

Males : T.L. = - 2.15571 + 1.02344 LD (r = .95002)

Females : T.L. = -1.13142 + .67669 LD (r = .82102)

Scatter diagrams of length against eye lens diameter are presented for males and females (Fig. 4.14 & 4.16).

Relationship between fish length and eye lens weight

The regression equation of total length on eye lens weight of *O. bimaculatus* is expressed as

Males : T.L. = -5.35841 + 2.60789 LW (r = .87088)

Females : T.L. = -4.60056 + 2.20954 LW (r = .8177)

Scatter diagrams of total length of fish against eye lens weight are presented separately for males and females (Fig. 4.13 & 4.15). It is noticed that the relationship is isometric i.e. eye lens weight increases with the increase of body length of both males and females of *O. bimaculatus.*

DISCUSSION

For a long time from the beginning of fishery research, the length frequency study initiated by Peterson (1895) was the only method available for use in age determination of fishes. The discovery of regularly formed growth rings or annuli in the scales, otoliths and other hard parts has provided a dependable additional and alternative method to assess the age and the size of the fish at various phases in its past life history. Van Oosten (1929) established the following criteria that must be satisfied before the check marks on scales or bones can be considered annuli. (i) Scales or bones must stay constant in number and identity through out the life of the fish (ii) Growth of the scale or bone must be proportional to the overall growth of the fish

(iii) Growth check marks must be formed at approximately the same time each year and (iv) back calculated lengths should agree with empirical lengths of younger age groups.

Regression analysis of otolith on the fish length of *H. brachysoma* and *O. bimaculatus* revealed a linear relationship indicating that their growth is proportional to the growth of the fish fulfilling Van oosten's second criterion. The back calculated lengths obtained adopting Lee's formula were also in reasonable agreement with the empirical length of the various age groups. According to Russel (1942) growth is seasonal and periodic, slowing down or ceasing in the winter months in most cases and this annual rhythm of growth is mirrored on the structure of certain parts such as scales, otoliths, vertebrae and the opercular bones which show alternating rings or bands indicating summer and winter growth. The present study of the otoliths of the two species of catfishes *H. brachysoma* and *O. bimaculatus* fully agree to this statement of Russel, as clear alternating dark and light rings (zones) are found in the otoliths of both fishes. Possibilities of the occurrence of false rings were overcome in a large majority of cases after a more detailed study of the nature of true rings themselves in each case and doubtful cases were discarded. The false rings are caused by the variations in the seasons and places of capture of the samples, environmental changes, food, temperature, salinity etc.

Dan (1980) found opaque and hyaline rings in the otoliths and opercular bones of the catfish, *Tachysurus tenuispinis,* the hyaline rings showing an age of 3 years for a fish of 39.7cm length. Gopinatha (1986) found good annuli in the otoliths, vertebrae as well as pectoral spines of *Tachysurus thalassinus* at Manglore. He detected 1 to 4 rings in fishes ranging in length from 251.3mm to 523.6mm. Pantulu (1961, 1962, 1963) has successfully used the pectoral spines for age determination of catfishes and he could trace the annual rings in the sections of the pectoral spines. Ramakrishniah (1986) observed transparent and opaque bands alternating each other around a central medullary cavity in *Pangasius pangasius.*

The eye lens studies of the two catfishes *H. brachysoma* and *O. bimaculatus* indicate that as the fish grows, the eye lens also enlarges in diameter and weight. So eye lens can also be utilized for age studies. In the present study, it is noted that even though the average lens diameter and weight increased with the age of the fish in both the catfishes, there was overlap between these parameters of the various age groups. This result is in conformity to the previous works of Al-Hassan *et al.* (1999), Carlton and Jackson (1968) and Burkett and Jackson (1971). Carlton and Jackson (1968) who worked with a small sample size of fish not older than five years concluded that the overlap between the age group distributions is too great after the first year for any accurate age determination. The present observations fully agree with this view, as it has been found that in both the males and females of *H. brachysoma* and *O. bimaculatus,* the first age group was fully differentiated from the 'O' age group in the eye lens diameter and weight; while in the other age groups the ranges of these parameters mostly overlapped. In both the species, the non-overlap cases are in support of the results of Douglas (1987) on *Salmo trutta.* The presence of overlap in lens weight correlates with the development of sexual maturity (Crivelli, 1980) as overlap was not usually found in young fishes.

Gerking (1966) opined that different environments altered the growth rate in the blue gill. These environmental conditions should be considered when using the lens technique. According to Burkett and Jackson (1971) temperature is the most important environmental variable for fishes to be considered in applying the lens technique. Thus eye lens studies are important in the age determination of the catfishes, *H. brachysoma* and *O. bimaculatus.*

Table - 4.1

Number & size of fish in the various age groups of *H. brachysoma* (Gunther)

Size Group (mm)	Male					Female				
	No. of Fish	Age Group				No. of Fish	Age Group			
		0	1	2	3		0	1	2	3
120-140	1	1	---	---	---	2	2	---	---	---
140-160	2	1	1	---	---	2	2	---	---	---
160-180	18	---	16	2	---	16	---	14	2	---
180-200	5	---	2	3	---	18	---	12	4	2
200-220	2	---	---	2	---	4	---	2	2	---
220-240	2	---	---	2	---	---	---	---	---	---
240-260	8	---	---	6	2	4	---	---	4	---
260-280	---	---	---	---	---	5	---	---	4	1
280-300	2	---	---	1	1	3	---	---	---	3
Total	**40**	**2**	**19**	**16**	**3**	**54**	**4**	**28**	**16**	**6**
Mean Total Length		**136**	**164.4**	**226.8**	**252**		**141**	**180**	**225.7**	**251**

Table - 4.2

Number & size of fish in the various age groups of *H. brachysoma* (Pooled)

Size Group (mm)	No. of Fish	Age Group			
		0	1	2	3
120-140	3	3	----	----	----
140-160	4	3	1	----	----
160-180	34	----	30	4	----
180-200	22	----	13	7	2
200-220	7	----	3	4	----
220-240	2	----	----	2	----
240-260	12	----	----	10	2
260-280	5	----	----	4	1
280-300	5	----	----	1	4
Total	**94**	**6**	**47**	**32**	**9**
Mean Total Length		**142**	**178.1**	**226.1**	**251.9**

Table - 4.3

Number & size of fish in the various age groups of *O. bimaculatus* (Bloch)

Size Group (mm)	Male				Female			
	No. of Fish	Age Group			No. of Fish	Age Group		
		0	1	2		0	1	2
120-140	3	3	---	---	2	2	---	---
140-160	7	---	7	---	6	---	6	---
160-180	1	---	1	---	9	---	9	---
180-200	4	---	---	4	33	---	24	9
200-220	3	---	1	2	21	---	15	6
220-240	---	---	---	---	12	---	8	4
240-260	---	---	---	---	4	---	---	4
260-280	---	---	---	---	2	---	---	2
Total	**18**	**3**	**9**	**6**	**89**	**2**	**62**	**25**
Mean Total Length		**128.7**	**159.2**	**198.3**		**132**	**196**	**226.9**

Table - 4.4

Number & size of fish in the various age groups of *O. bimaculatus* (Pooled)

Size Group (mm)	No. of Fish	Age Group		
		0	1	2
120-140	5	5	---	---
140-160	13	---	13	---
160-180	10	---	10	---
180-200	37	---	24	13
200-220	24	---	16	8
220-240	12	---	8	4
240-260	4	---	---	4
260-280	2	---	---	2
Total	**107**	**5**	**71**	**31**
Mean Total Length		**130**	**191.3**	**221.4**

Table - 4.5

Back calculated total length (mm) from otoliths of *H. brachysoma* (Gunther) - Male

Age Group	No. of Fish	Mean Total Length at capture (mm)	Back calculated T.L.		
			1	2	3
1	19	164.4	145.58	---	---
2	16	226.8	130.04	191.69	---
3	3	252	144.06	196.01	226.75
Mean back calculated Length (mm)			**139.89**	**193.85**	**226.75**

Table - 4.6

Back calculated total length (mm) from otoliths of *H. brachysoma* (Gunther) - Female

Age Group	No. of Fish	Mean Total Length at capture (mm)	Back calculated T.L.		
			1	2	3
1	28	180	163.37	---	---
2	16	225.7	122.05	204.96	---
3	6	251	119.72	181.21	224.97
Mean back calculated Length (mm)			**135.05**	**193.09**	**224.97**

Table - 4.7

Back calculated total length (mm) from otoliths of *O. bimaculatus* (Bloch) - Male

Age Group	No. of Fish	Mean Total Length at capture (mm)	Back calculated T.L.	
			1	2
1	9	159.2	84.21	---
2	6	198.3	100.69	160.47
Mean back calculated Length (mm)			**92.45**	**160.47**

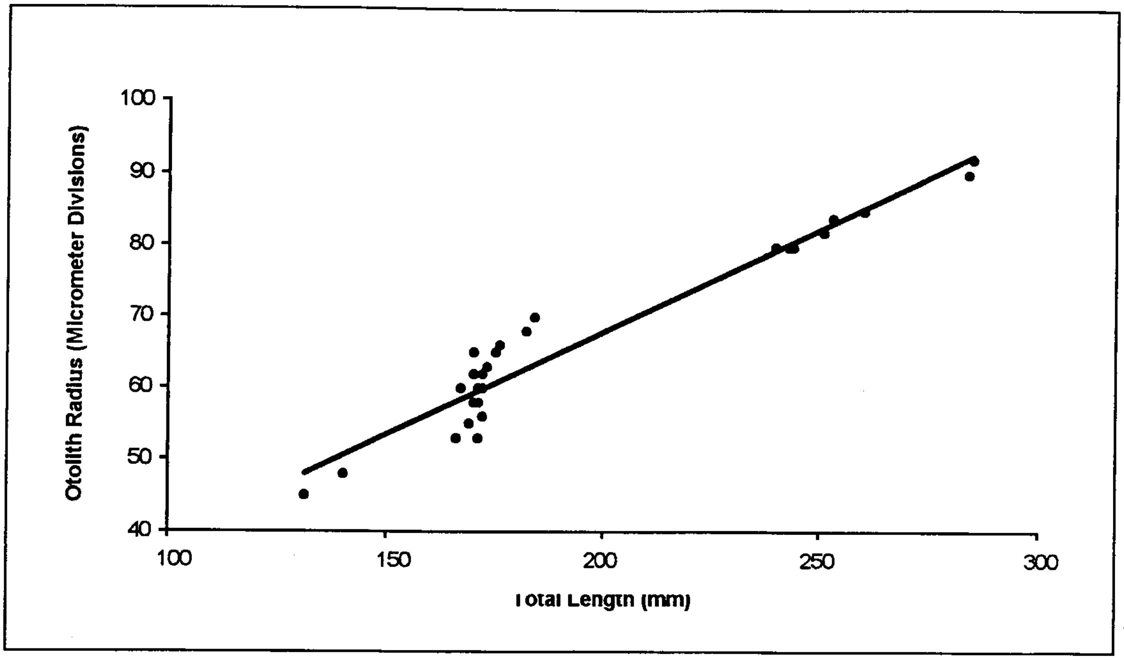
Table - 4.8

Back calculated total length (mm) from otoliths of *O. bimaculatus* (Bloch) - Female

Age Group	No. of Fish	Mean Total Length at capture (mm)	Back calculated T.L.	
			1	2
1	62	196	116	---
2	25	226.9	109.49	188.24
Mean back calculated Length (mm)			**112.75**	**188.24**

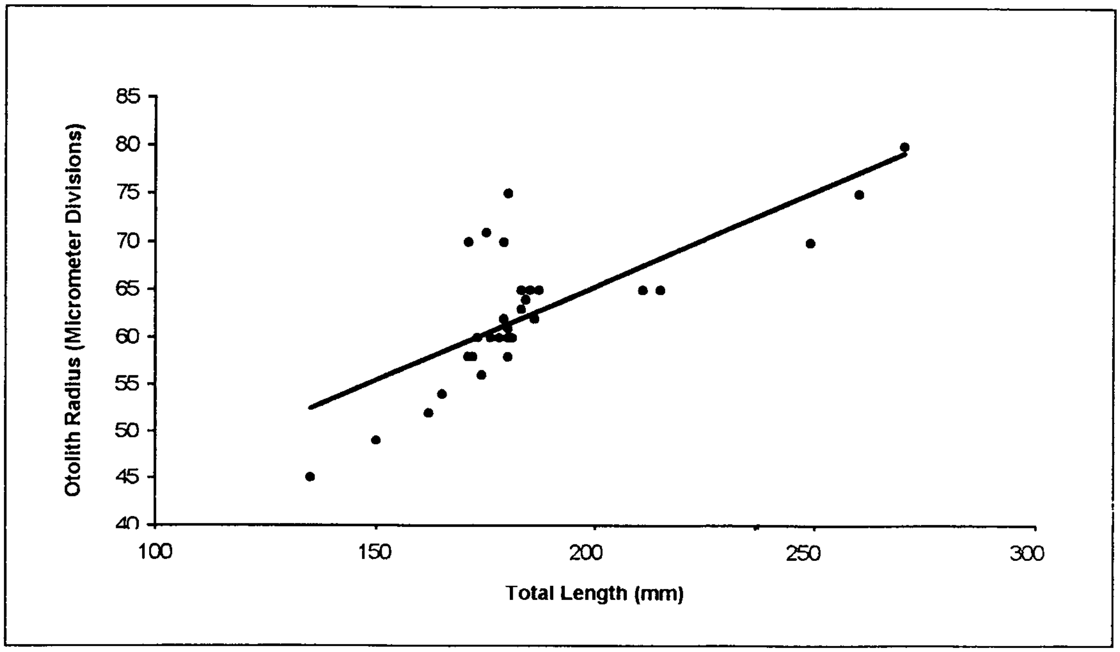
Relation between total length of fish and otolith radius in *H. brachysoma* (Gunther) - Male

Fig. – 4.1



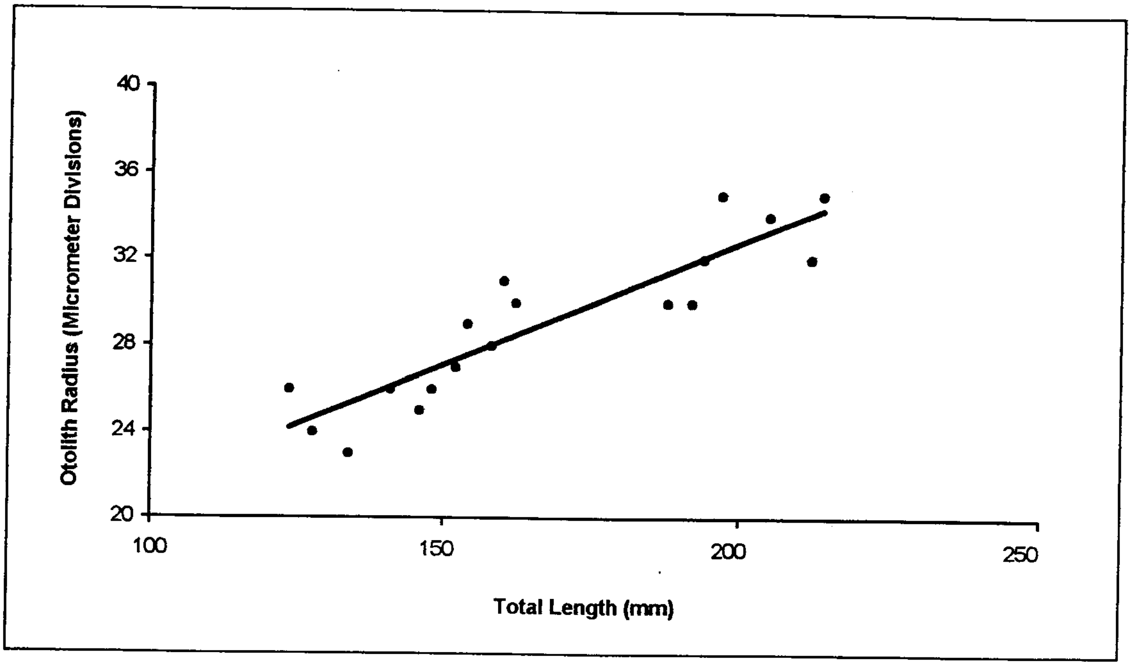
Relation between total length of fish and otolith radius in *H. brachysoma* (Gunther) - Female

Fig. – 4.2



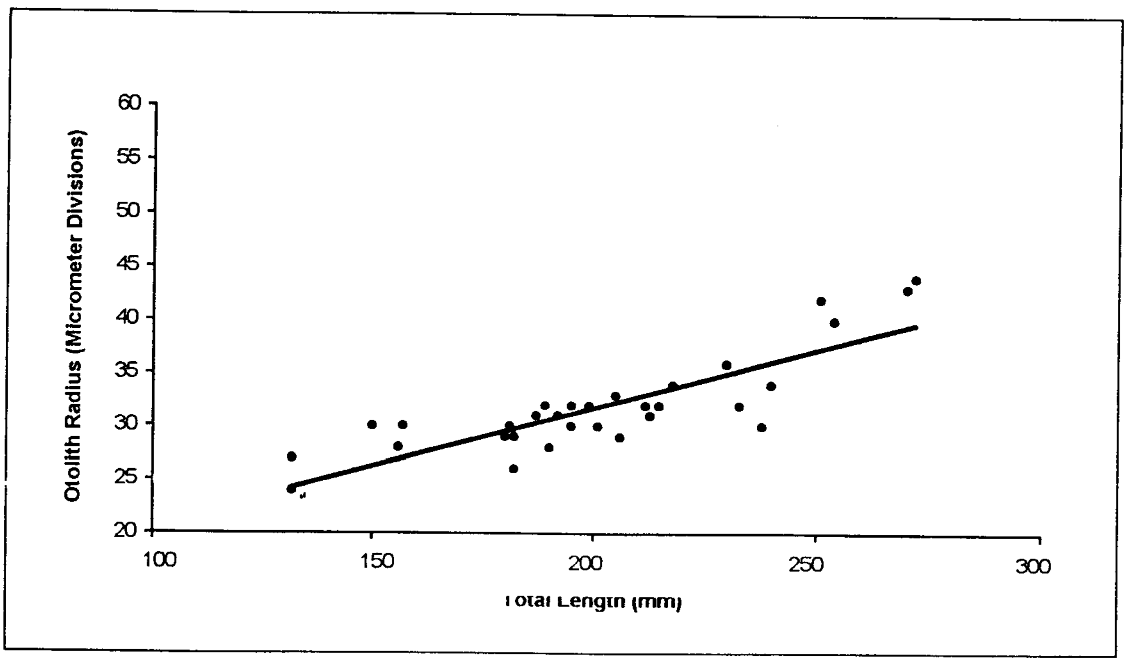
Relation between total length of fish and otolith radius in *O. bimaculatus* (Bloch) - Male

Fig. – 4.3



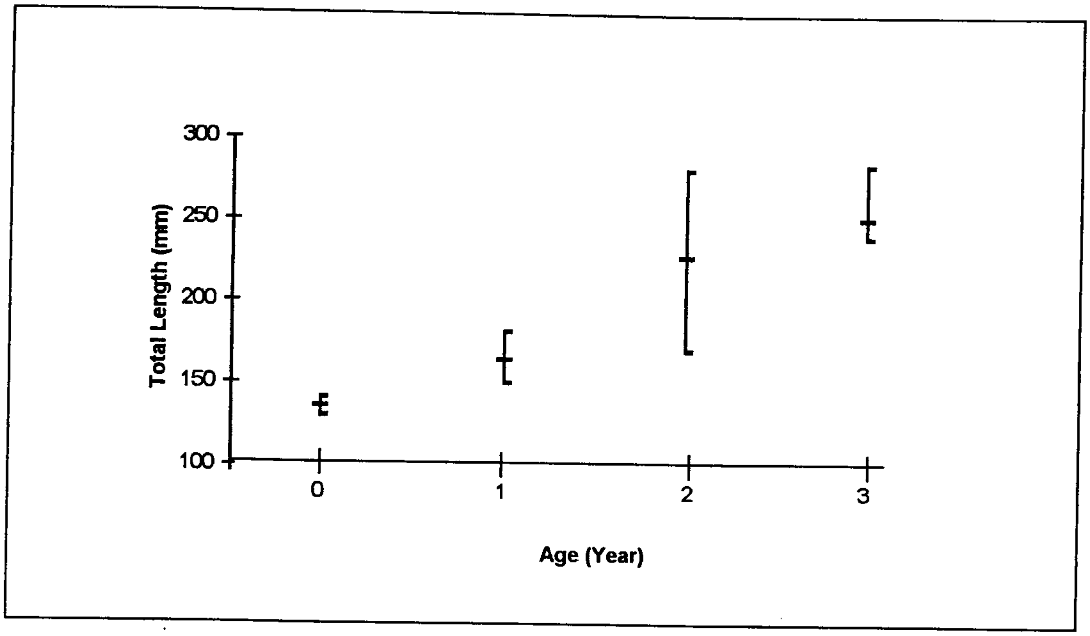
Relation between total length of fish and otolith radius in *O. bimaculatus* (Bloch) – Female

Fig. – 4.4



Total length versus age in
***H. brachysoma* (Gunther) – Male**

Fig. – 4.5



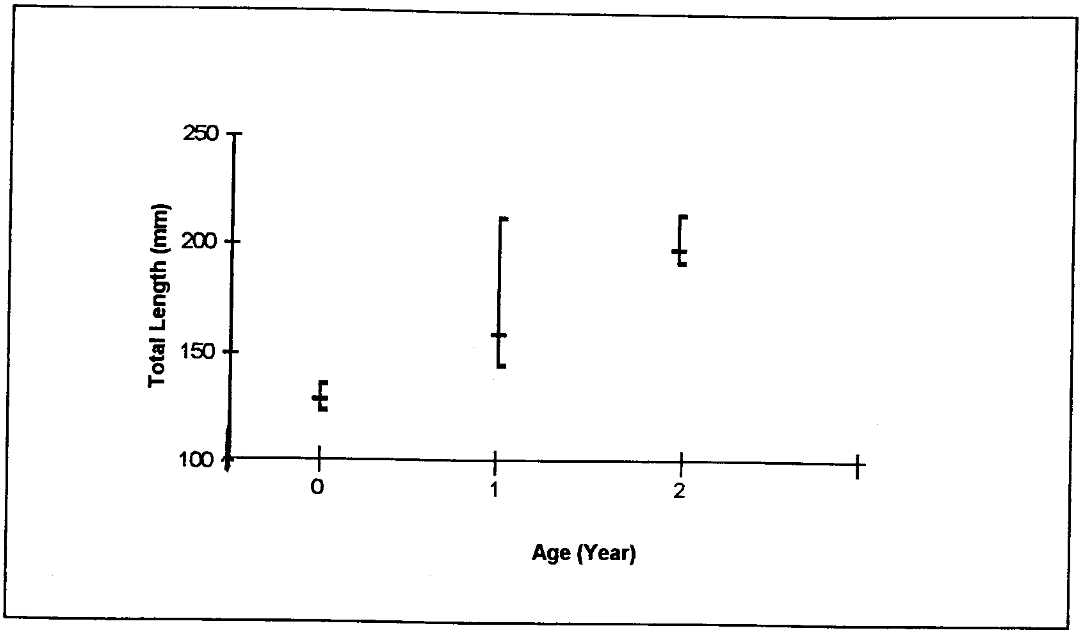
Total length versus age in
***H. brachysoma* (Gunther) – Female**

Fig. – 4.6

(Vertical bars represent range and horizontal lines represent mean length)

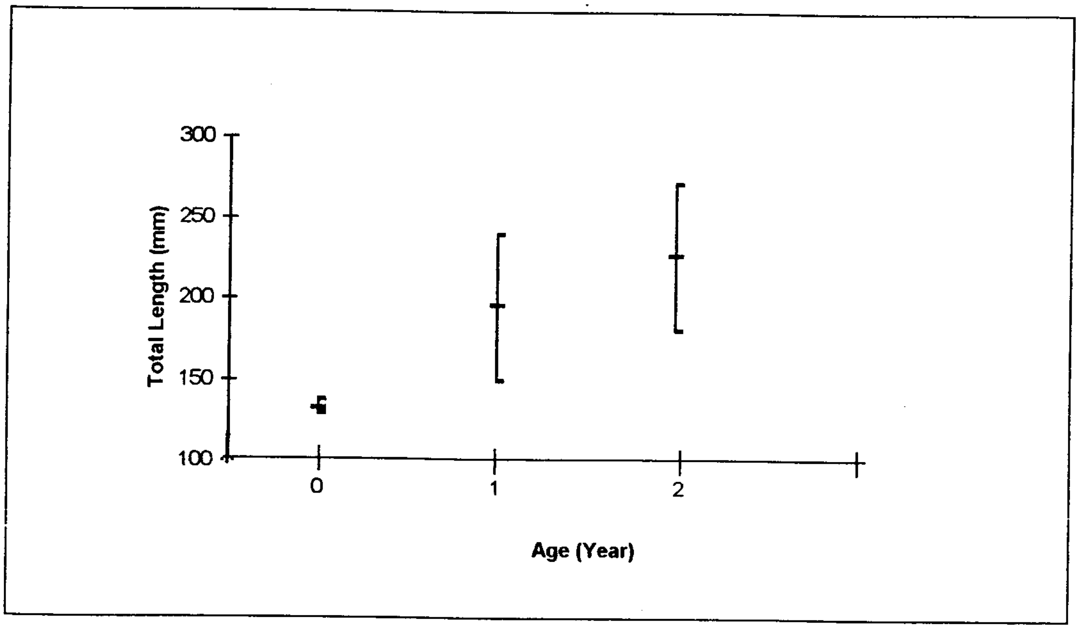
Total length versus age in
***O. bimaculatus* (Bloch) – Male**

Fig. – 4.7



Total length versus age in
***O. bimaculatus* (Bloch) – Female**

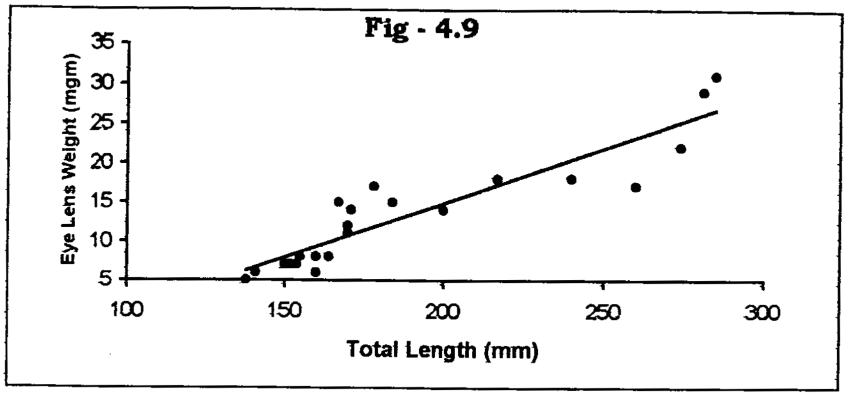
Fig. – 4.8



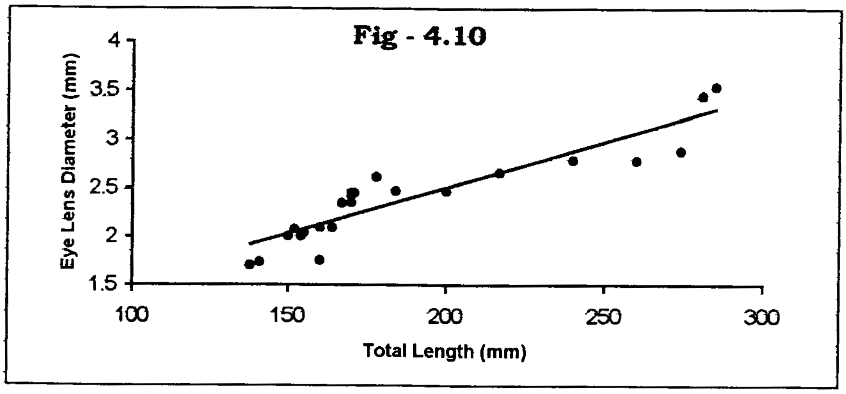
(Vertical bars represent range and horizontal lines represent mean length)

HORABAGRUS BRACHYSOMA (Gunther)

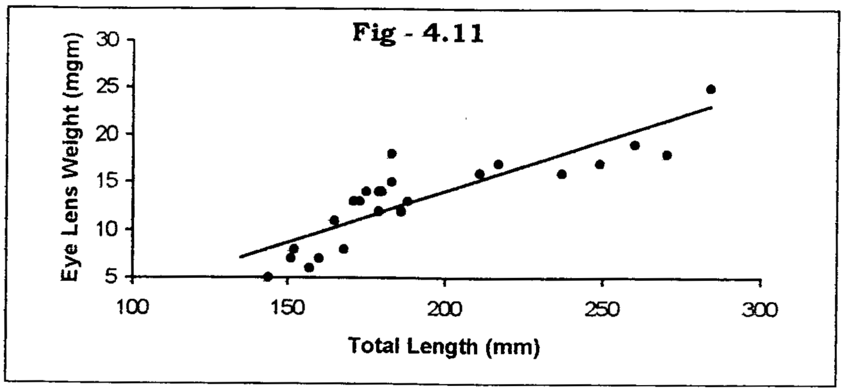
Relation between Total Length of Fish & Eye Lens Weight - Male



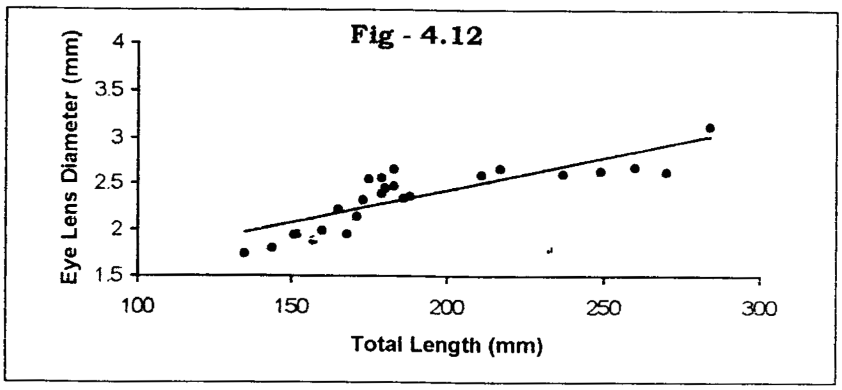
Relation between Total Length of Fish & Eye Lens Diameter - Male



Relation between Total Length of Fish & Eye Lens Weight - Female

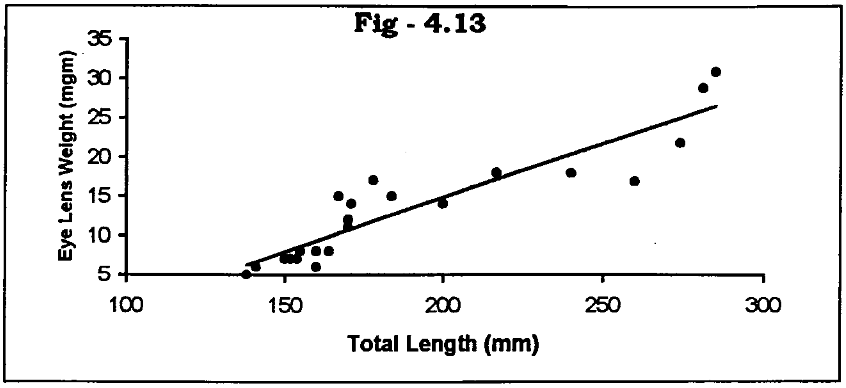


Relation between Total Length of Fish & Eye Lens Diameter- Female

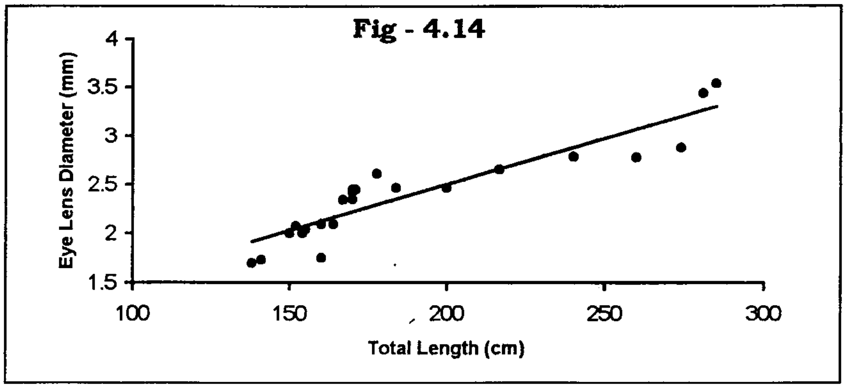


OMPOK BIMACULATUS (Bloch)

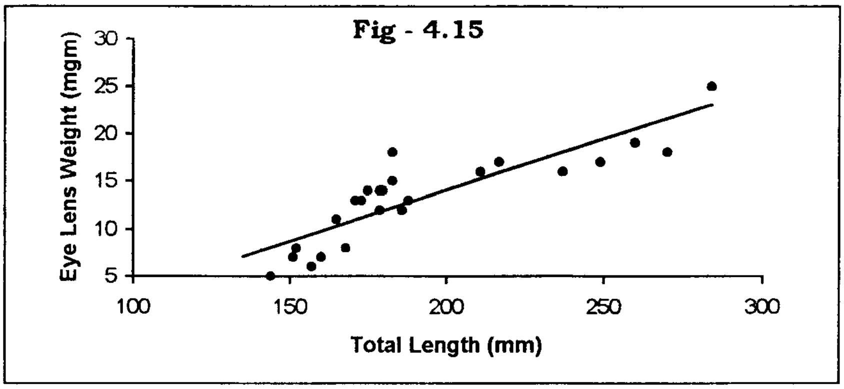
Relation between Total Length of Fish & Eye Lens Weight - Male



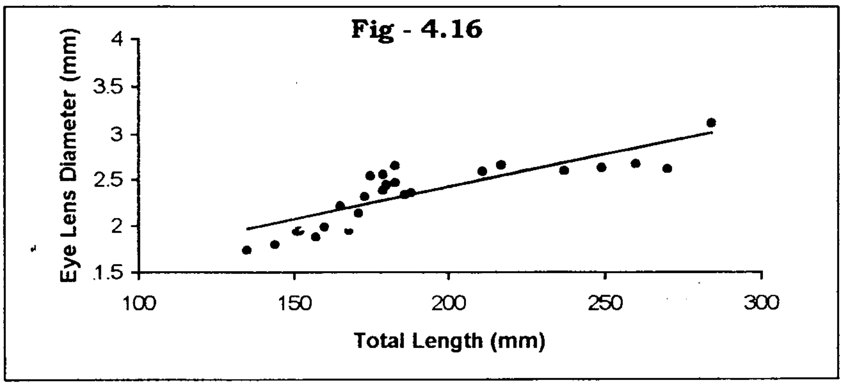
Relation between Total Length of Fish & Eye Lens Diameter - Male



Relation between Total Length of Fish & Eye Lens Weight - Female



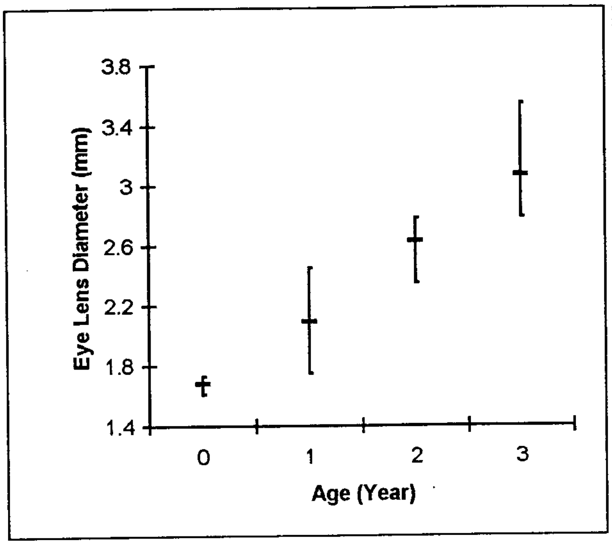
Relation between Total Length of Fish & Eye Lens Diameter- Female



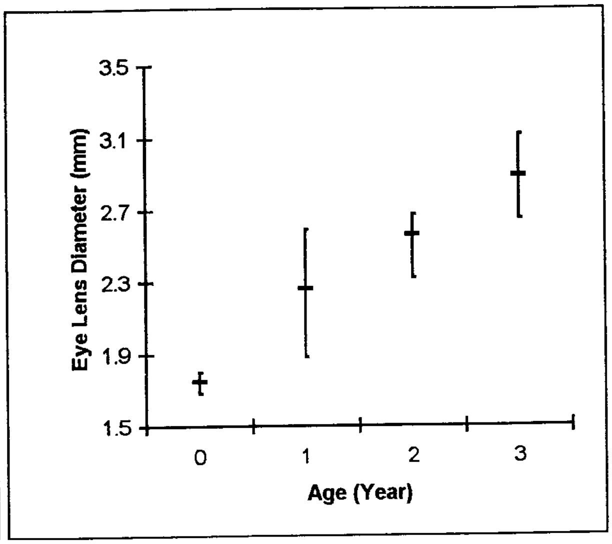
HORABAGRUS BRACHYSOMA **(Gunther)**

Age Versus Eye Lens Diameter

Male **Fig. - 4.17**

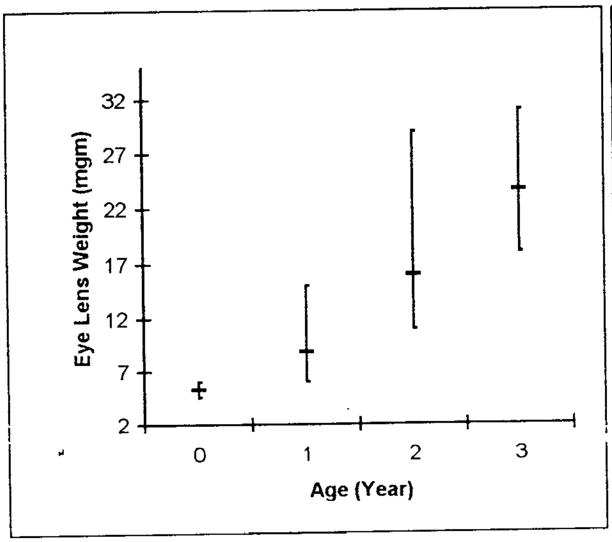


Female **Fig. - 4.18**

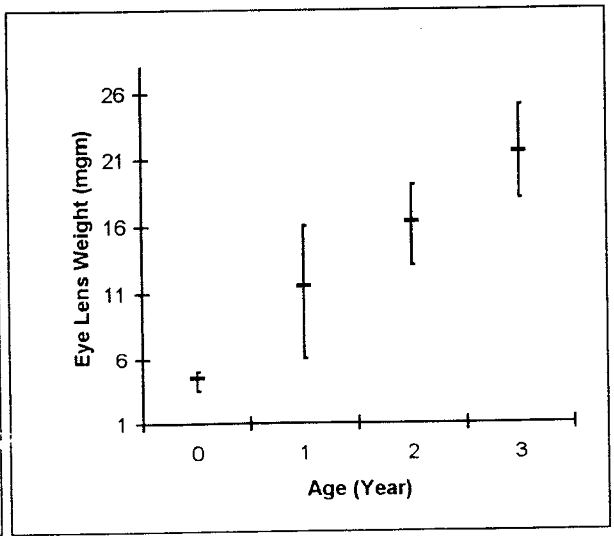


Age Versus Eye Lens Weight

Male **Fig. - 4.19**



Female **Fig. - 4.20**



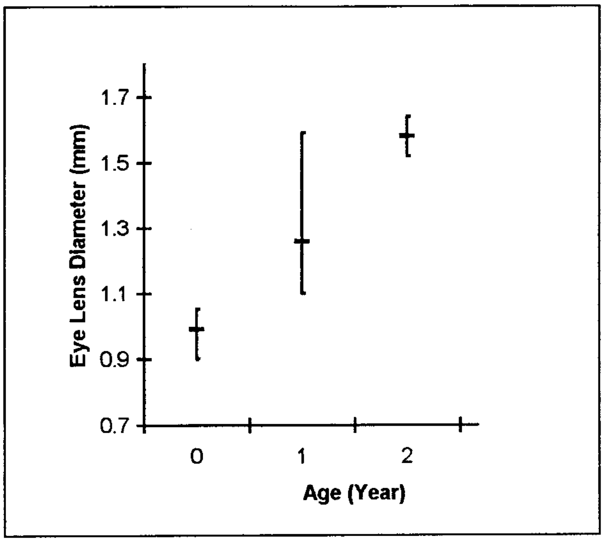
(Vertical lines represent range and Horizontal lines represent mean)

OMPOK BIMACULATUS (Bloch)

Age Versus Eye Lens Diameter

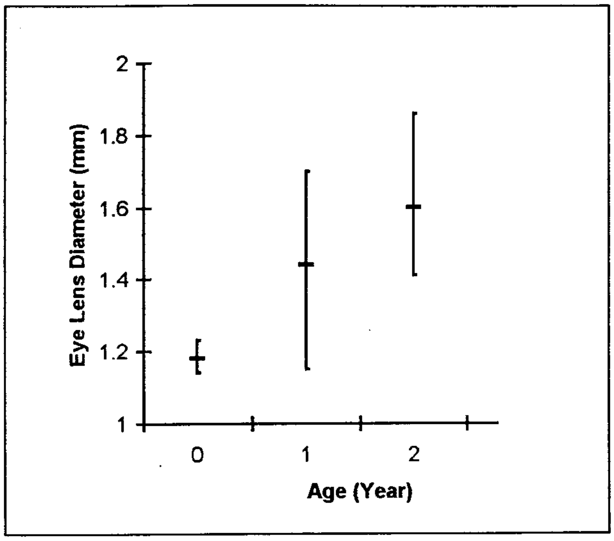
Male

Fig. - 4.21



Female

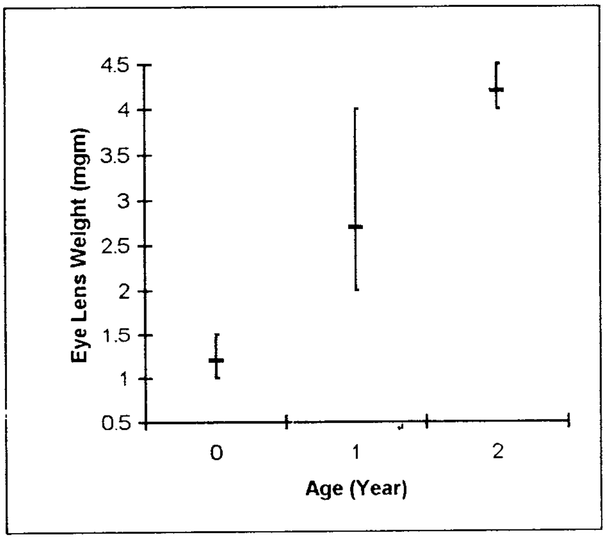
Fig. - 4.22



Age Versus Eye Lens Weight

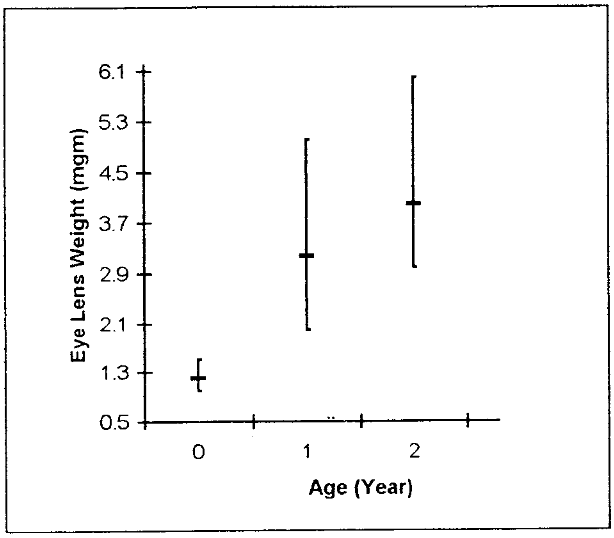
Male

Fig. - 4.23



Female

Fig. - 4.24



(Vertical lines represent range and Horizontal lines represent mean)

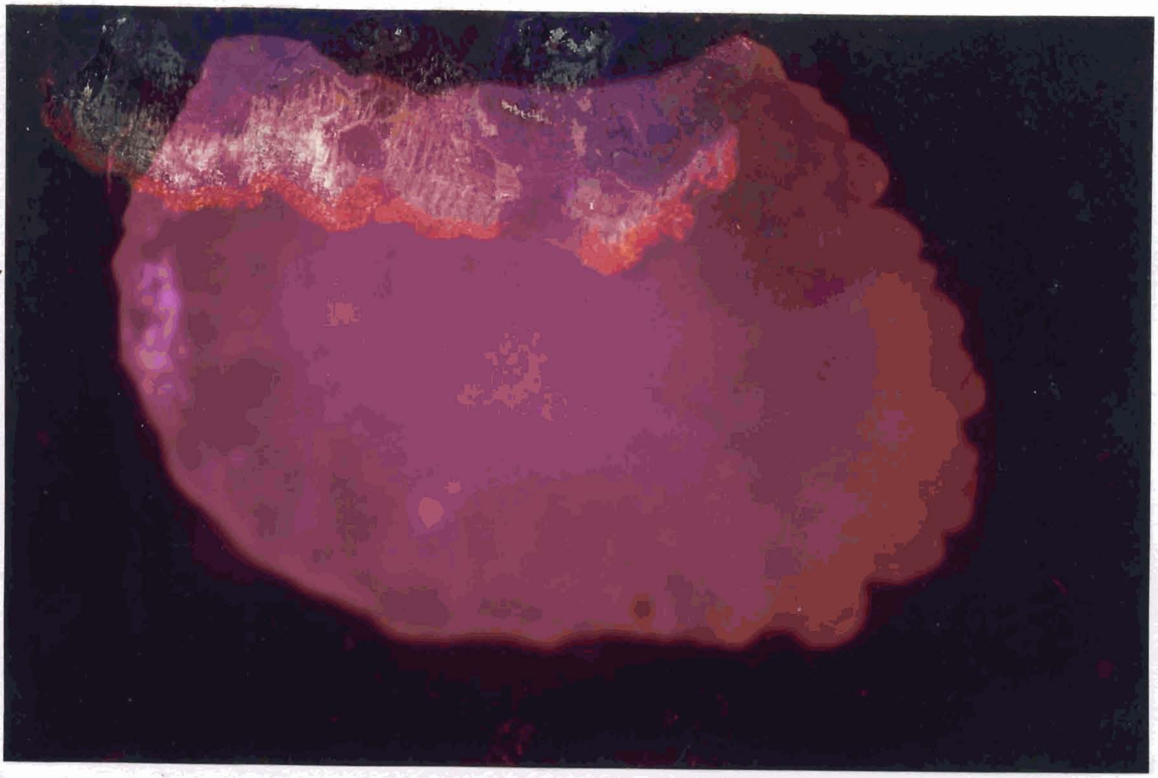


PLATE – 26 : OTOLITH OF *HORABAGRUS BRACHYSOMA*

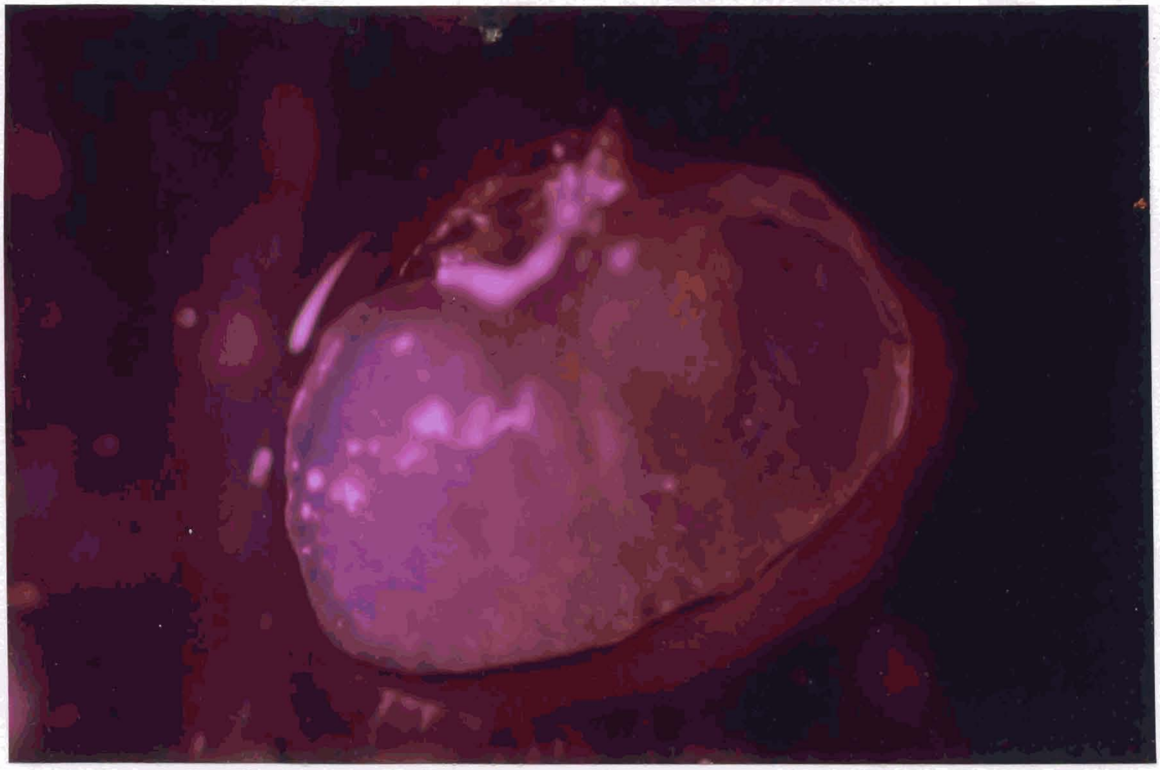


PLATE – 27 : OTOLITH OF *OMPOK BIMACULATUS*

LENGTH-WEIGHT RELATIONSHIP

AND

RELATIVE CONDITION FACTOR

CHAPTER – V

LENGTH – WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR

INTRODUCTION

In biological studies of fishes, length – weight relationship is very important. The significance of this study is first revealed by Le Cren (1951) and according to him the study of the relationship between length and weight has two main objectives. First, to determine a mathematical relationship between the two variables, length and weight, so that if one is known, the other could be computed. Second, to measure the variations from the expected weight for a particular length of fish or groups of fish indicating some biological parameters like fatness, gonad development, spawning season or general well being. It is also useful in the estimation of weight – growth parameter 'W'oo corresponding to length – growth parameter 'L'oo, which forms one of the important parameters in the yield per recruit studies.

It is a fact, that with increase in length of fish, the weight also increases, but in a more rapid way, thereby showing that the weight of fish is a function of length. Since length is a linear measure and the weight a measure of volume, it was generally found that for fishes, the relation between length & weight could be expressed by the hypothetical cube law $W = cL^3$ where W represents the weight of fish, 'L' its length and 'c' a constant. However this equation is found valid only in cases where specific gravity and body form remain constant, obeying isometric growth pattern, in which the exponent of length (L) is found to be equal to 3 (Allen, 1938). But what happens actually is that the fish do not keep constancy in growth and body form as they pass through several stages in the course of development (Veznetsov, 1953). In such cases, each of the stage may have its own length – weight relationship, often resulting in allometric form of growth deviating from the exponential value of 3. Hence a generalised parabolic equation, $W = aL^b$ where W = Weight, L = Length 'a' a constant equal to 'c' and 'b' another constant to be derived empirically, has been found to explain the relationship between length and weight better than the cube formula (Le Cren 1951). The exponential value of 'b' in the parabolic equation is found to vary from 2.5 to 4 (Hile, 1936 and Martin, 1949).

The equation $W = aL^b$ can be transformed into linear function by taking logarithmic values of the length and weight data and the values of 'a' and 'b' can be estimated by regression analysis. Then the equation takes the form of

$\text{Log } W = \log a + b \text{ Log } L$ or $y = a + bx$ where $Y = \log W$, $x = \log L$, $a = \log a$, the intercept of the line on the 'Y' axis and 'b' an exponent.

Beverton & Holt (1957) has stated that the value of 'a' and 'b' may vary within wide limits for very similar data and are sensitive to quite unimportant variations in the latter. They further suggested that instances of important variations from isometric growth (b = 3) in adult fishes are rare. However as shown by Blackburn (1960) in the case of Australian barracouta, *Thyrsites atun*, the value of 'b' was considerably below '3'.

Exhaustive data on length and weight representing wide-ranging sizes can be grouped into short length classes and the average length and weight of each class can form the input data for linear regression analysis. The length – weight relationship obtained from such a method would form a representative relationship for the population. But if the sample consists of only fishes of a particular size group, the relationship so established would then become a biased one.

In India, an attempt to study the length – weight relationship in fishes by the modern statistical method has been perhaps first made by Jhingran (1952) on three species of major carps namely, *Labeo rohita, Cirrhina mrigala* and *Catla catla.* Literature on the length – weight relationship and the relative condition factor of a large number of marine and fresh water teleosts are available. To mention a few are *Trichiurus haumela* (Prabhu, 1955), *Coilia dussumieri* (Bal and Joshi, 1956), Mackerel (Pradhan, 1956, Udupa and Bhatt, 1983), *Sillago sihama* (Radhakrishnan, 1957), *Sardinella longiceps* (Antony Raja, 1967), *Trichiurus lepturus* (James, 1967), *Sardinella albella* and

S. gibbosa (Sekharan, 1968), *Nemipterus japonicus* (Krishnamoorthi, 1971), *Labeo calbasu* (Anil Chatterji *et al.*, 1980), *Leiognathus dussumieri* (James and Badrudeen, 1981), *Johnieops vogleri* (Muthiah, 1982), *Leiognathus bindus* (Murthy, 1983), *Cyprinus carpio* (Shyam,1984), *Oreochromis urolipis* (Pratap and Mkamba, 1987), *Stolephorus devisi* (Rao, 1988), *Tilapia mossambicus* (Gopinathan, 1988), *Tenulosa ilisha* (De & Datta, 1990), *Liza parsia* (Kurup and Samuel, 1992), *Megalaspis cordyla* (Sivakami, 1995), *Hilsa ilisha* (Pandey, 1995b), *Catla catla* (Pandey, 1995, and Sarkar *et al.* 1997) Carps (Dhanze, 1996, Dhanze & Dhanze, 1997), *Caranx kalla* (Kalita and Jayabalan, 1997), *Aristichthys nobilis* (Mahapatra and Datta, 1998), *Cirrhinus mrigala* (Pandey, 1998 and Sarkar *et al.*, 1998), Rays (Sadashiv, 2000), *Epinephelus tauvina* and *Epinephelus malabaricus* (Shanmugam *et al.*, 2000) *Rasbora daniconius* (Sunil, 2000).

Very little literature is available on the length – weight relationship and the relative condition factor of Indian catfishes. Some of them are *Tachysurus tenuispinis* by Dan and Mojumder (1978), *Mystus vittatus* by Sultan (1981), *Ompok bimaculatus* by Sivakami (1987), *Clarias batrachus* by Umesh & Sarma (1996) and Umesh *et al.* (1996), *Arius tenuispinis* by Das *et al.* (1997) and *Horabagrus brachysoma* by Sunil *et al.* (1999).

The present work attempts to give a detailed account of the length–weight relationship and the relative condition factor of the two catfishes

Horabagrus brachysoma and *Ompok bimaculatus* from the inland waters of Central Kerala.

MATERIALS AND METHODS

Samples of *H. brachysoma* and *O. bimaculatus* were collected from the fish landing centres and from the local fishermen. A total of 87 males & 106 females of *H. brachysoma* and 80 males & 88 females of *O. bimaculatus* were used in this study. Fresh samples were used for recording length and weight. The total length was measured in mm from tip of the snout to the tip of the upper caudal lobe. Weight was taken upto .01gm for both fishes. The length data were grouped into 10mm interval and the average length and weight of the various size groups were determined. Length – weight relationship was calculated separately for males and females. Scatter diagrams of length against weight and logarithms of lengths and weight were plotted for both males and females.

The length – weight relationship can be expressed as

$$W = aL^b$$

For adopting this general exponential equation, least square computations were made using log L (x) and log W (y) for obtaining values of Σx, Σx^2, $\bar{x}$, Σy, Σy^2, $\bar{y}$ and Σxy where Σ denotes summation and $\bar{x}$ and $\bar{y}$ mean values of x and y respectively. The regression coefficient or slope of the regression line (b) was computed using the equation.

$$b = \frac{\Sigma xy - (\Sigma x)(\Sigma y)/N}{\Sigma x^2 - (\Sigma x)^2/N}$$

Where N = number of samples. The intercept (a) was determined by the formula.

$a = \bar{y} - b\bar{x}$. Using these values, linear equation of length–weight relationship,

Log W = log a + b log L or Y = a + bx was obtained. When these logarithmic values were converted into antilogarithms, the exponential form of $W = aL^b$ was obtained.

The significance of variation between the regression coefficient of both sexes was tested by subjecting to analysis of covariance following Snedcor and Cochran (1967).

The estimates of regression coefficient of males & females were tested for finding the significance of variation from the expected value of 3 by employing the 't' test using the formula.

$$t = \frac{b - B}{Sb}$$ Where B is equal to 3.

RESULTS

A Total of 87 males of *H. brachysoma* having a total length varying from 65 to 245mm and weight ranging between 3.6 and 190 gms and 106 females ranging in total length from 113mm to 260mm and weight from 15.6gm to 240gm were used for studying the length – weight relationship. Samples of *O. bimaculatus* consisting of 80 males of size range 120 – 205mm in total length and 11.4 – 63.5 gms in weight and 88 females of 140 – 271mm in total length and 14 – 165.5gm in weight were also used in length – weight studies.

Horabagrus brachysoma (Gunther)

The general equation $W = aL^b$ as applied to the males, females and the pooled of *H. brachysoma* are

Male $W = 0.000013651 \times L^{2.971594}$

Female $W = 0.000008343 \times L^{3.072898}$

Pooled $W = 0.000010689 \times L^{3.022459}$

The same equation in the logarithmic form is given as

$$\text{Log } W = \text{Log 'a'} + \text{'b' log } L$$

Applying this equation, to the males, females and pooled are

Male $\text{Log } W = -4.86481 + 2.971594 \text{ Log } L$ ($r = .947977$)

Female $\text{Log } W = -5.07866 + 3.072898 \text{ Log } L$ ($r = 0.949606$)

Pooled $\text{Log } W = -4.97105 + 3.022459 \text{ Log } L$ ($r = 0.948679$)

Scatter diagrams are prepared plotting lengths against weight for males and females in Fig. 5.1 and 5.2. The logarithmic form of relationship is shown in Fig. 5.3 and 5.4.

Analysis of variance to the regression coefficients of males and females and male and female pooled (Table 5.2) showed that the values were statistically significant and the cubic formula $W = aL^3$ is strictly applicable to the length – weight relationship of *H. brachysoma*. The values of 't' were calculated as for

Male	=	2.971594 – 3/.075504	=	-.3762
Female	=	3.072898 – 3/.069414	=	1.0502
Pooled	=	3.022459 – 3/0.050866	=	.4415

Which did not show significant difference at 5% level from the expected value of 3 indicating weight growth in the species is isometric (Table 5.3).

Ompok bimaculatus (Bloch)

The general equation $W = aL^b$ as applied to the males, females and the pooled are

Male	W	=	$0.000008854 \times L^{2.938853}$
Female	W	=	$0.000002881 \times L^{3.162504}$
Pooled	W	=	$0.000003513 \times L^{3.122595}$

The same equation in the logarithmic form is given as

$$\text{Log W} = \text{Log 'a'} + \text{'b' log L}$$

Applying this equation, to the males, females and pooled are

Male Log W = -5.05284 + 2.938853 Log L (r = 0.896034)

Female Log W = -5.54033 + 3.162504 Log L (r = 0.952299)

Pooled Log W = -5.45424 + 3.122595 Log L (r = 0.946591)

Scatter diagrams are drawn plotting length against weight for males and females (Fig. 5.5 and 5.6). The two sets of data show a close relationship as is revealed from the figures. The logarithmic form of relationship is presented in Fig. 5.7 and 5.8 and the regression line fitted to the data indicate a straight-line relationship between the 2 variables.

While the above formula holds goods for the length – weight relationship of *O. bimaculatus*, the significance of variation in the estimate of 'b' for this species from the expected value for ideal fish (3.0) was tested by the 't' test as given by the formula t = b – B/Sb. The values of 't' were as follows

Male = 2.938853 – 3/.113347 = -0.5395

Female = 3.162504 – 3/.076322 = 2.1291

Pooled = 3.122595 – 3/.057568 = 2.1296

The values of male were not significant at 5% level while the values of female and the pooled were significant at 5% level, but not significant at 1% level (Table 5.6). Hence the cubic formula $W = aL^3$ is a proper representation of the length weight relationship of *O. bimaculatus* . The analysis of variance proved that the length – weight relationship between males, females and pooled were statistically highly significant (Table 5.5.).

DISCUSSION

The study of length – weight relationship in the two species of catfishes, *H. brachysoma* and *O. bimaculatus* shows an exponential relationship when lengths were plotted against weight. Similarly logarithms of length plotted against logarithms of weight gave linear form of relationship. In both *H. brachysoma* and *O. bimaculatus*, the females showed higher regression coefficients and were above the expected value of 3 while in males, the values were lesser and in *O. bimaculatus* it was less than 3. The pooled values were also above 3. This clearly indicates a higher rate of weight increase in females compared to males. The results of the present study on the length – weight relationship of *H. brachysoma* is in general agreement with the earlier reports of the same study (Sunil *et al.*, 1999) suggesting that females had a higher regression coefficient (3.129) than males (3.077). But Sivakami (1987) reported that in *O. bimaculatus* from Bhavanisagar reservoir, males had a higher value of b (2.83802) than females (2.72247). The present study does not agree with this as in *O.*

bimaculatus the females had a higher regression coefficient (3.16250 4) than males (2.938853).

In *H. brachysoma* the value of 't' for males & females did not show significant difference at 5% level from the expected value of 3 indicating that growth in the species is isometric. Sunil *et al.* (1999) also suggested that the regression coefficient is not significantly different from 3 and *H. brachysoma* has an isometric growth both for males and females as it is found in the present study. Goswamy and Sarma (1996) has also reported that in the catfish *Clarias batrachus* from the Brahmaputra river, the length – weight relationship shows an isometric pattern of growth and the weight of the adult fish proportionately increases almost of the cube of its length. Dan and Mojumder (1978) reported that in the catfish *Tachysurus tenuispinis*, the length – weight relationship shows no significant deviation in the regression coefficients in respect of sexes as well as zones.

In *O. bimaculatus*, the value of 't' in male was not significant at 5% level, while in females; the value was significant at 5% level, but insignificant in 1% level. Sivakami (1987) reported that in *O. bimaculatus* from Bhavanisagar reservoir, the 't' value in both sexes were significant at 5% level and the value of the exponent indicated a deviation from the cube law. Sunil (2000) in his observation on the length – weight relationship of *Rasbora daniconius* (Ham) have recorded that the weight in relation to total length is highly significant in the adults of the fish and it follows the allometric growth pattern.

RELATIVE CONDITION FACTOR

Studies of length – weight relationship of the fish reveals the fact that the actual weight of the fish shows variations from the expected weight for the length of individual fish or groups of individuals. These variations are due to nutritional, physiological, environmental and biological changes affecting the fish. According to Le Cren (1951) the variations from the expected weight for a particular length of individual fish or groups of fish is an indication of condition of the fish due to various factors like fatness, general well being or gonad development Tester (1940) has remarked that variations occur in the specific gravity of the flesh of the fish and Kestevan (1947) discussed their importance in studies on condition. Usually the density of the fish is maintained as the same as that of the surrounding water and hence changes in weight for length are due to changes in form or volume and not specific gravity. Such changes are revealed and analysed by the condition factor or coefficient of condition or Ponderal index (Hile, 1936; Thompson, 1943) which is expressed by the formula $K = \frac{100\,W}{L^3}$ where K = the condition factor, W = the weight of the fish and L = length of fish. This formula is based on comparison with ideal fish, which shows cubic relationship.

The value of 'K' will be changed if the fish does not obey the cube law in its length – weight relationship. Factors like age, sex, stage of maturity, racial differences, availability of food, environment and degree of parasitization may affect 'K' indirectly through the value of the exponent. These factors could be eliminated by using the calculated length – weight relationship $W = aL^n$ (Le Cren 1951). The condition factor so calculated is called the relative condition factor (Kn) and it is expressed by the formula.

$$Kn = \frac{W}{aL^n}$$ or otherwise be denoted as

$$Kn = \frac{W}{\hat{w}}$$ Where W represents the observed weight and $\hat{w}$ represents the calculated weight of the fish obtained from the length weight relationship. Therefore the difference between condition factor (K) and relative condition factor (Kn) is that the former measures the deviation of an individual from the average weight for length, while the latter measures the deviation from a hypothetical ideal fish.

Very little literature is available on the relative condition factor of catfishes of Kerala. So a detailed study was made on the relative condition factor of the two catfishes, *H. brachysoma* and *O. bimaculatus*. The average relative condition factor (Kn) was calculated separately for males and females in different months and also in 10cm size groups using the equation $Kn = \frac{W}{\hat{w}}$

'Kn' in *Horabagrus brachysoma* (Gunther)

87 males and 106 females ranging in total length from 60mm to 250mm were used for the study. Using the length – weight relationship formula, the calculated weight of all the specimens

separately for males and females were worked out in both month wise and size group wise following the formula of Le Cren (1951).

Relative condition factor in relation to size

The mean 'Kn' values for males ranging in size from 60mm – 250mm and females from 110mm – 240mm are represented in the fig. 5.9. It can be seen that in males 'Kn' values are less than 1 in lower size groups from 80 – 150mm groups. While the smallest size group (60 – 70mm) has a 'Kn' value of 1.0812. From 151mm onwards 'Kn' values increase above 1 upto 200mm size group. In the 161 – 170mm group, it becomes the highest value and then slightly deceases. From 201mm onwards there is again fall in the value of 'Kn' except the largest size group (241 – 250mm) where 'Kn' value is 1.0517. In females, the 'Kn' values are lesser in lower size groups. It gradually increases in 131 – 140mm group and then slowly decreases in the next two size groups. In the 161 – 170mm group 'Kn' value increases steeply and reaches the maximum level. In the next group it slightly decreases. In 191 – 200mm size the value becomes very low. In the next two size groups, 'Kn' value increases and it again falls in 221 – 230mm group. In the largest size group (231 – 240mm) there is slight increase in 'Kn' value. The increase in 'Kn' values from 131mm onwards may be due to the onset of maturation process and the fall in condition factor in 215mm indicates spawning and this length corresponds to the 50% of maturity length. The condition above this length showed rise and fall alternatively.

Relative condition factor in different months

Mean 'Kn' values for different months in the male and female *H. brachysoma* are shown in Fig. 5.10. In males 'Kn' values were low in December, January and February. In May it increases, again drops in June and in July the value again increases steeply. Higher values of 'Kn' can be noticed till November.

In females 'Kn' is low in January, slightly increases in February. In June there is decline of 'Kn' value. In July & August, it progressively increases, again decline in September and then slowly increases in. October and in November there is slight decrease and again the value comes down in December and January. The increase in 'Kn' value in May correspond with the period of maturation of gonads. The fall in the condition during June and July may be due to spawning of the fish as these months form the spawning season of *H. brachysoma.*

'Kn' in *Ompok bimaculatus* (Bloch)

80 males and 88 females having a size range between 120mm and 275mm were used for studying the relative condition facor of *O. bimaculatus.* 'Kn' is calculated separately for males and females of various size groups and of different months.

Fig. 5.11 shows the mean 'Kn' values of *O. bimaculatus* for different size groups of males ranging from 120mm to 205mm and females of 140 – 271mm size range. It may be seen that in males the

'Kn' values showed a gradual decrease from 120 – 130mm size group to 150mm. In 151 – 160mm group there is a slight increase of the value and in the next size group (161 – 170) 'Kn' comes to the least level, then again increases in the next two size groups and afterwards declines in the two largest size groups. Since comparatively higher values are found in the lower size groups, it is assumed that in these immature fishes the high 'Kn' values may be due to the accumulation of fat prior to spawning and the fall of 'Kn' in 161 – 170mm group may be due to spawning of the fish. Similarly the rise in 'Kn' in 171 – 180 and 181 – 190 groups and the decline in 191 – 200 and 201 – 210 size groups seem to be influenced by the subsequent spawning of the fish.

Similar observations were found in females of *O. bimaculatus* also. The younger size groups from 140mm to 180mm had comparatively higher 'Kn' values and in 181mm to 200mm groups 'Kn' values were low and further it increases from 201mm onwards upto 240mm and then gradually decreases and in the highest size group (261 – 270mm) the value becomes very low. The higher 'Kn' values in the immature fishes may be due to the building up of gonad. 'Kn' values were found fluctuating at higher lengths. This may be associated with the maturation and spawning cycle. The minimum size at maturity of female *O. bimaculatus* is 230mm and it is found that from 241 mm onwards there is a tendency for decline of 'Kn'.

The monthly trends in mean 'Kn' values of *O. bimaculatus* are shown in Fig. 5.12. In general, in both males and females 'Kn' values were low in June, July and March. In males, the value reaches maximum during November and reduces in December, remains almost constant in January and February and further reduced in March.

In females, the lowest 'Kn' value of .8761 is found in June. Then the value gradually increases in the succeeding months till September and again there is decline of 'Kn' in October and November and further it increases in December, there is slight decline of 'Kn' in January, then rises in February and in March, it again becomes low. The low 'Kn' values of both males & females in June and July may be due to loss in weight of gonads as a result of spawning.

Comparison of relative condition factor in *H. brachysoma* and *O. bimaculatus*

Fig. 5.13 and 5.14 show the comparison of relative condition factor in the two species of catfishes *H. brachysoma* and *O. bimaculatus*, (male & female pooled) in the different size groups of the fishes and during different months. In *H. brachysoma*, the maximum 'Kn' value (1.1999) is found in 161 - 170mm size group. While in *O. bimaculatus*, maximum 'Kn' is in 231 - 240mm group (1.1285). Similarly the minimum 'Kn' value in *H. brachysoma* (.891) is in the 111 - 120mm size group, while in *O. bimaculatus* the minimum value is in 261 - 270mm group (.9751). The monthly fluctuations of 'Kn' values also differ in the two fishes. In *H. brachysoma*, maximum 'Kn' is found in October (1.215) while in *O. bimaculatus* the maximum value is in September (1.2666). Similarly the minimum 'Kn' values are also different in two fishes during various months. In *H. brachysoma* the lowest 'Kn' is in January (.9627), while in *O. bimaculatus*, the lowest value of 'Kn' is found in June (.8218).

Majority of authors have reported that variations in the condition factor are closely related to the sexual cycle of the fish and the increase or decrease of 'Kn' value is due to a similar fate in the weight of gonads before and after spawning (Le Cren, 1951; Pantulu, 1961; Devaraj, 1973). While some others are of opinion that the monthly fluctuations in 'Kn' values are independent of the breeding cycle and can be better related to the feeding rhythm (Qasim, 1957; Bal and Jones, 1960; Blackburn, 1960 and Bhatt, 1970).

In the present observations also the high and low values of 'Kn' in *H. brachysoma* and *O. bimaculatus* are related to the spawning cycle of the fish. Hickling (1930) and Hart (1946) have reported that variation in 'Kn' is related to the attainment of first maturity. Sivakami (1987) observed in *O. bimaculatus* that the major fluctuations in 'Kn' values might be attributed to the spawning activity of the species rather than feeding activity. She also reported that the values were high in smaller size groups as reported in the present study. Blackburn (1960) in his studies on the Australian barracouta *Thyrsites atun* remarked that it was not possible to interpret the changes in the condition of this fish in relation to sexual cycle or the food consumed, but it may depend on several other factors. Devaraj (1973) observed a steep fall in 'Kn' value of the snakehead *Ophiocephalus marulius* when the young ones change their food habits from a macro invertebrate diet to piscivorous diet. The present study doesn't show much relation between feeding intensity and 'Kn' values especially in *H. brachysoma,* where the feeding intensity is higher in lower size groups (upto 150mm) but they have only low 'Kn' values. In *O. bimaculatus* also feeding intensity is higher upto 150mm size and their 'Kn' values are comparatively higher. So it can be concluded that in *O. bimaculatus* sexual cycle as well as the feeding intensity have some role in regulating the 'Kn' values.

Table - 5.1

Length – Weight Relationship of Male, Female & Pooled of *H. brachysoma* (Gunther)

Group	N	Σ X	ΣY	Σ XY	Σ X^2	Σ Y^2	b	a	r
Males	87	192.0604	152.3608	343.5000	430.0106	280.0886	2.9716	- 4.8648	0.9480
Females	106	238.9420	195.0576	444.2451	539.4751	370.6101	3.0729	- 5.0787	0.9496
Pooled	193	431.0025	347.4184	787.7451	969.4857	650.6987	3.0225	- 4.9711	0.9487

Table - 5.2

Analysis of variance for *H. brachysoma* (Gunther) Length – Weight Regression

Source	Degree of Freedom	Sum of Squares	Mean of Squares	F. Value	Probability
Males	85	0.5459	0.0064	1485.7390	1.2991 E – 55
Females	104	0.4305	0.0041	1959.7406	2.6734 E – 69
Pooled	191	0.9973	0.0052	3429.2062	5.6514 E - 124

Table - 5.3

Statistical analysis to test deviation from the Cube Law

Group	b	DF	Sb	$t = \frac{b-3}{Sb}$	P – Value
Males	2.9716	85	0.0755	- 0.3762	1.2991 E – 55
Females	3.0729	104	0.0694	1.0502	2.6734 E – 69
Pooled	3.0225	191	0.0509	0.4415	5.6514 E – 124

Table - 5.4

Length – Weight Relationship of Male, Female & Pooled of *O. bimaculatus* (Bloch)

Group	N	Σ X	ΣY	Σ XY	Σ X^2	Σ Y^2	b	a	r
Males	80	177.4568	117.3017	261.2348	393.9885	175.3935	2.9389	-5.0528	0.8960
Females	88	202.2234	151.9832	351.2567	465.3406	269.1302	3.1625	-5.5403	0.9523
Pooled	168	379.6802	269.2850	612.4915	859.3291	444.5237	3.1226	-5.4542	0.9466

Table - 5.5

Analysis of variance for *O. bimaculatus* (Bloch) Length – Weight Regression

Source	Degree of Freedom	Sum of Squares	Mean of Squares	F. Value	Probability
Males	78	0.3528	0.0045	672.2497	4.3289 E – 40
Females	86	0.3169	0.0037	1716.9284	1.3187 E – 58
Pooled	166	0.6884	0.0041	2942.0922	1.5667 E - 107

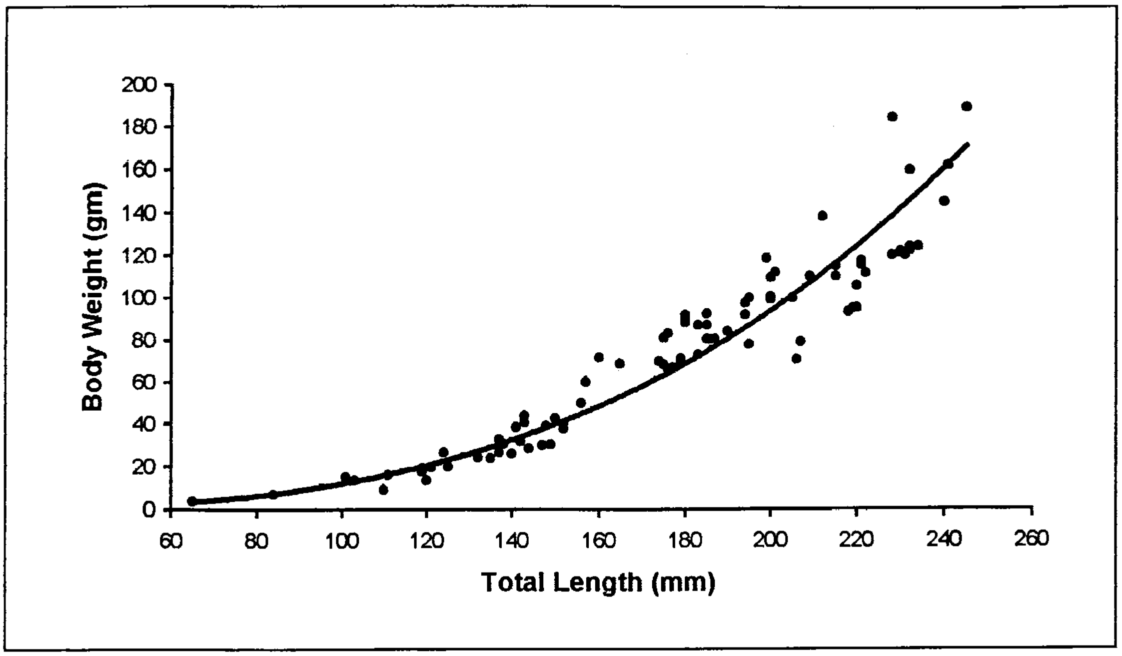
Table - 5.6

Statistical analysis to test deviation from the Cube Law

Group	b	DF	Sb	$t = \frac{b-3}{Sb}$	P – Value
Males	2.9389	78	0.1133	-0.5395	4.3289 E – 40
Females	3.1625	86	0.0763	2.1291	1.3187 E – 58
Pooled	3.1226	166	0.0576	2.1296	1.5667 E - 107

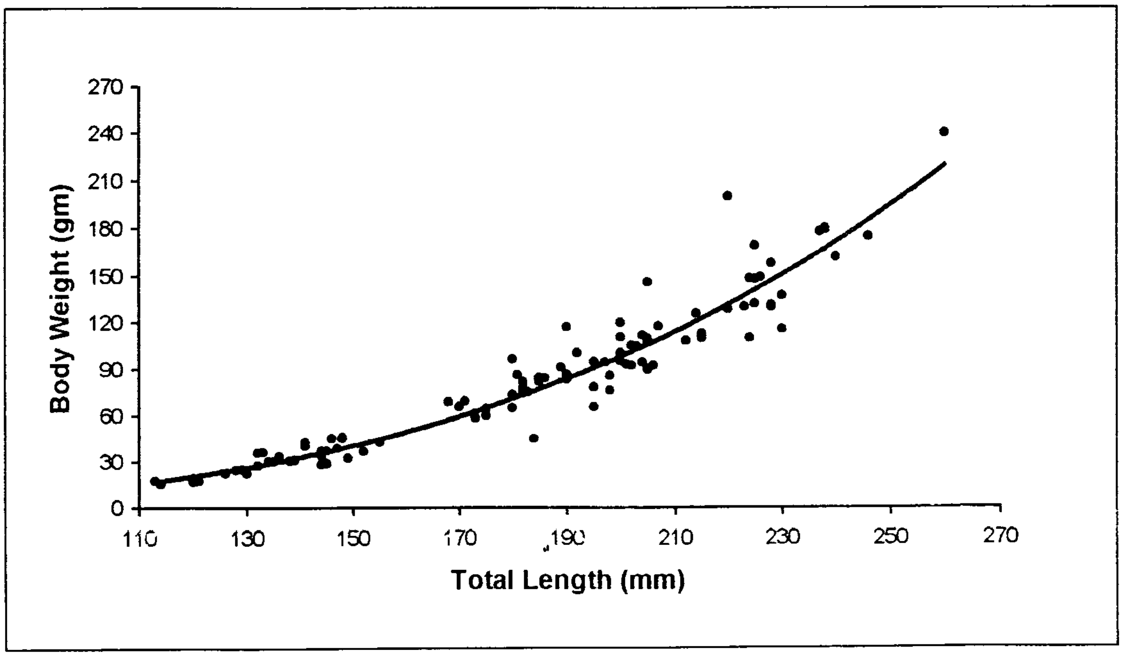
Total Length against Body Weight of Males of
***H. brachysoma* (Gunther)**

Fig. – 5.1



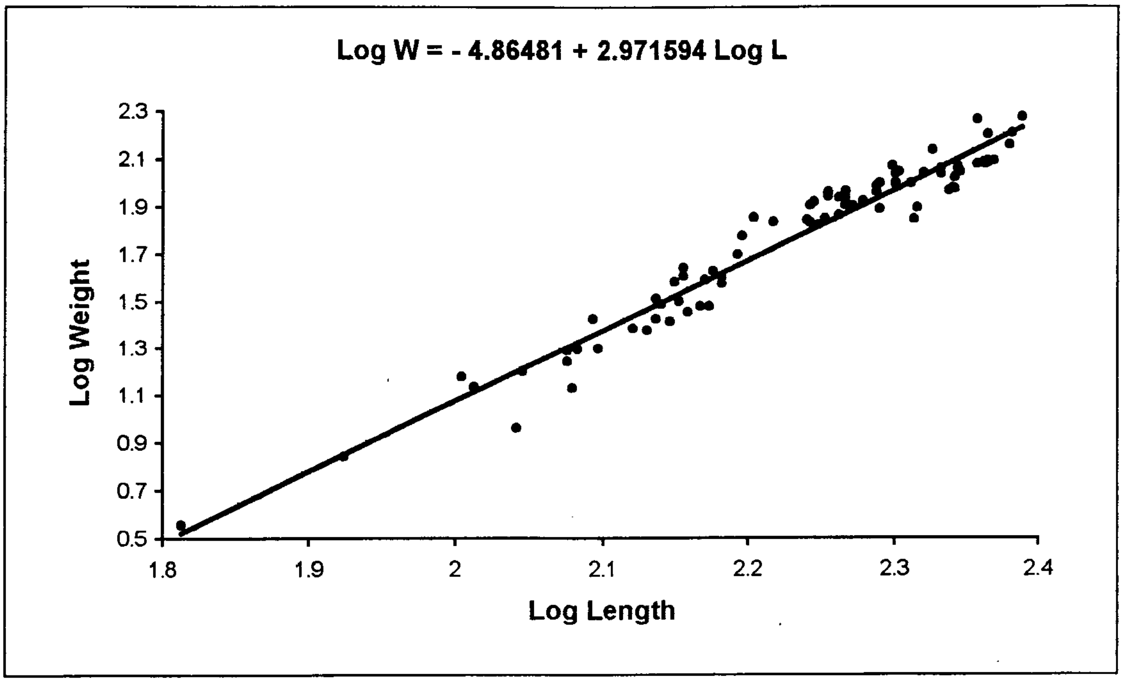
Total Length against Body Weight of Females of
***H. brachysoma* (Gunther)**

Fig. – 5.2



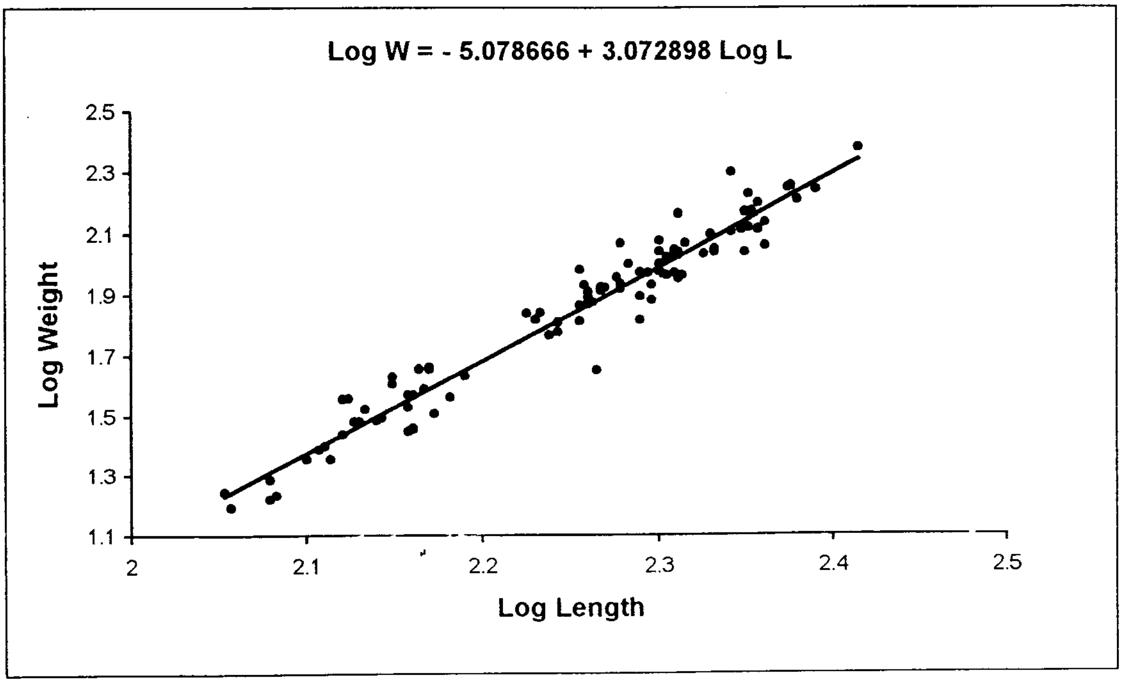
Logarithmic relationship between Length & Weight for Males of *H. brachysoma* (Gunther)

Fig. – 5.3



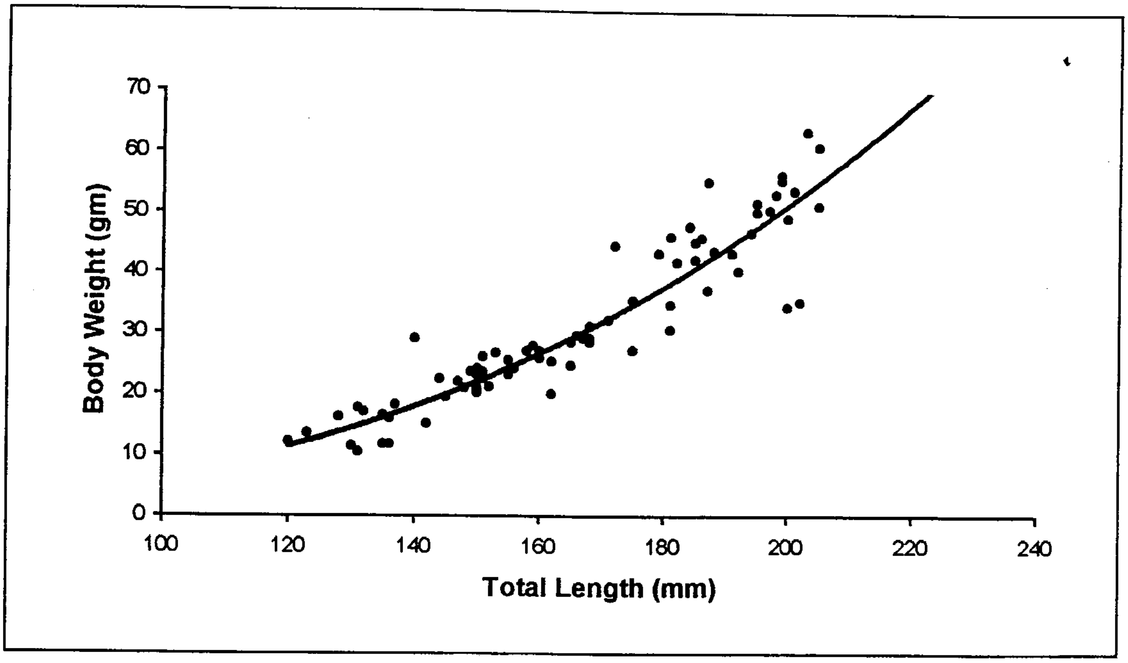
Logarithmic relationship between Length & Weight for Females of *H. brachysoma* (Gunther)

Fig. – 5.4



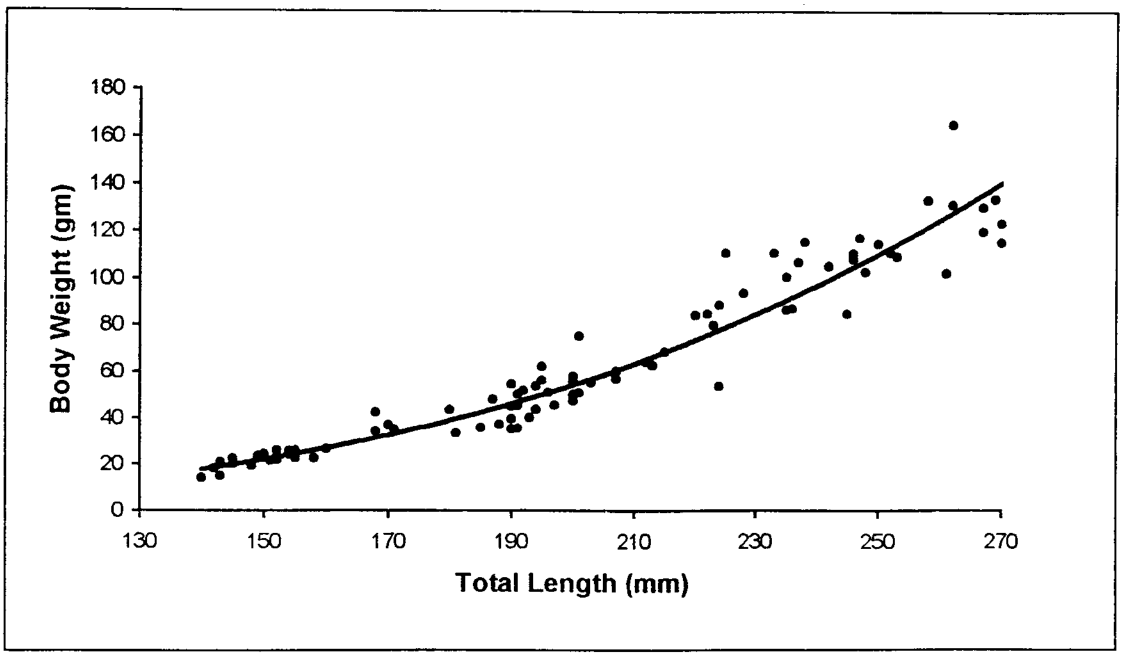
Total Length against Body Weight of Males of *O. bimaculatus* (Bloch)

Fig. – 5.5



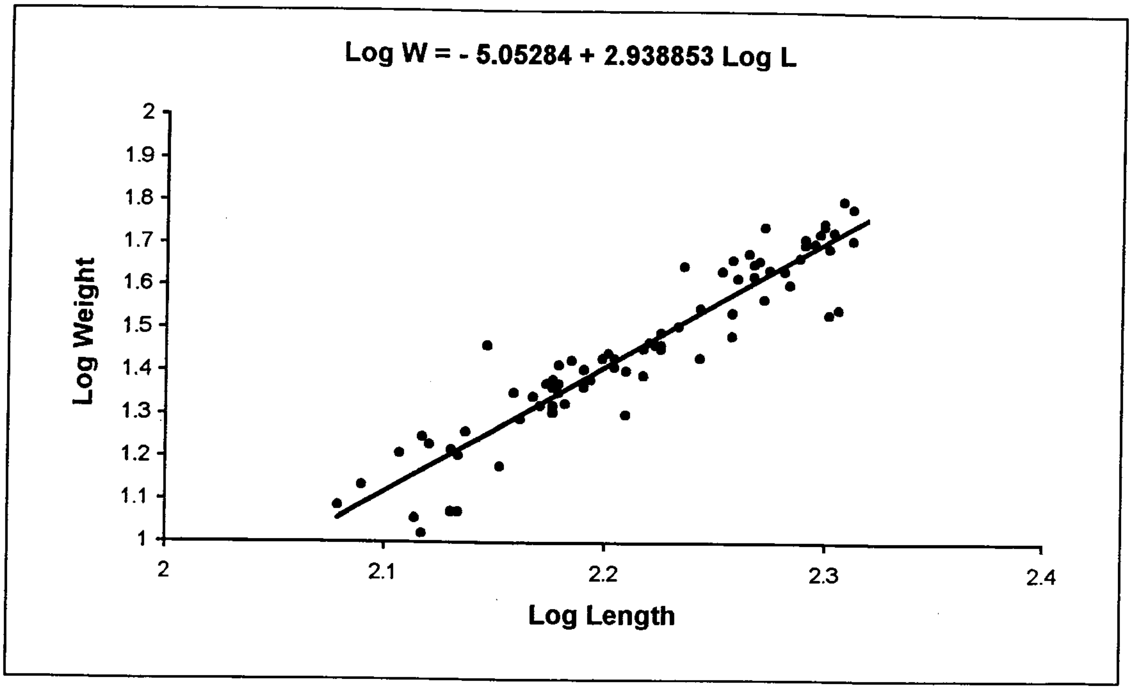
Total Length against Body Weight of Females of *O. bimaculatus* (Bloch)

Fig. – 5.6



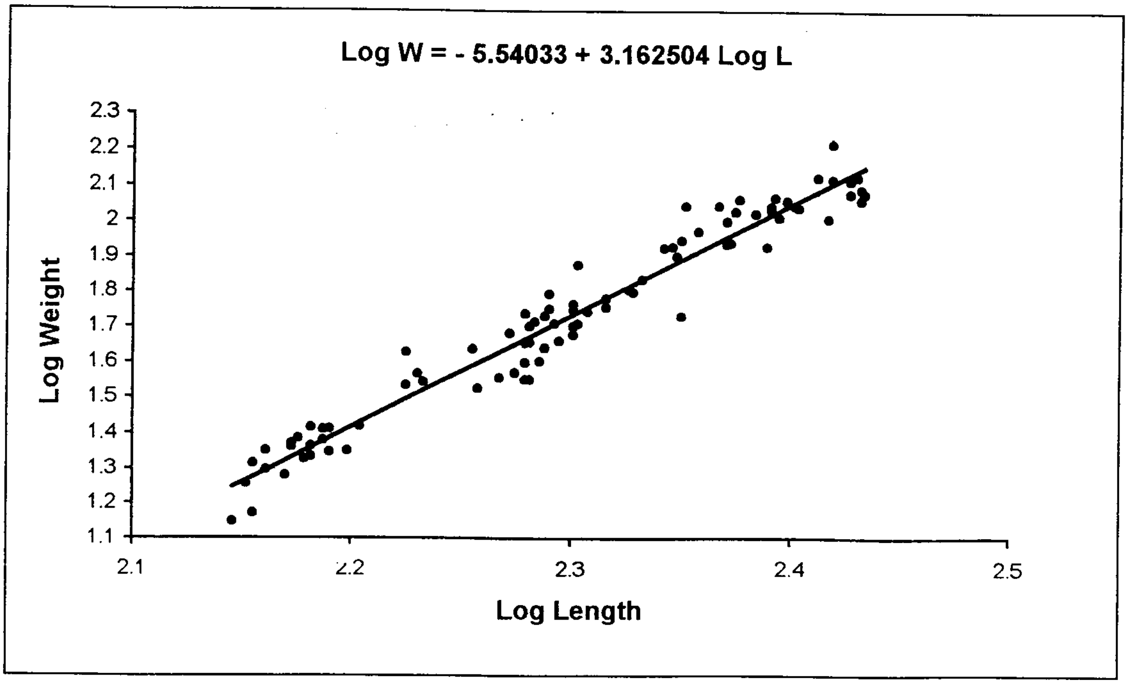
Logarithmic relationship between Length & Weight for Males of *O. bimaculatus* (Bloch)

Fig. – 5.7



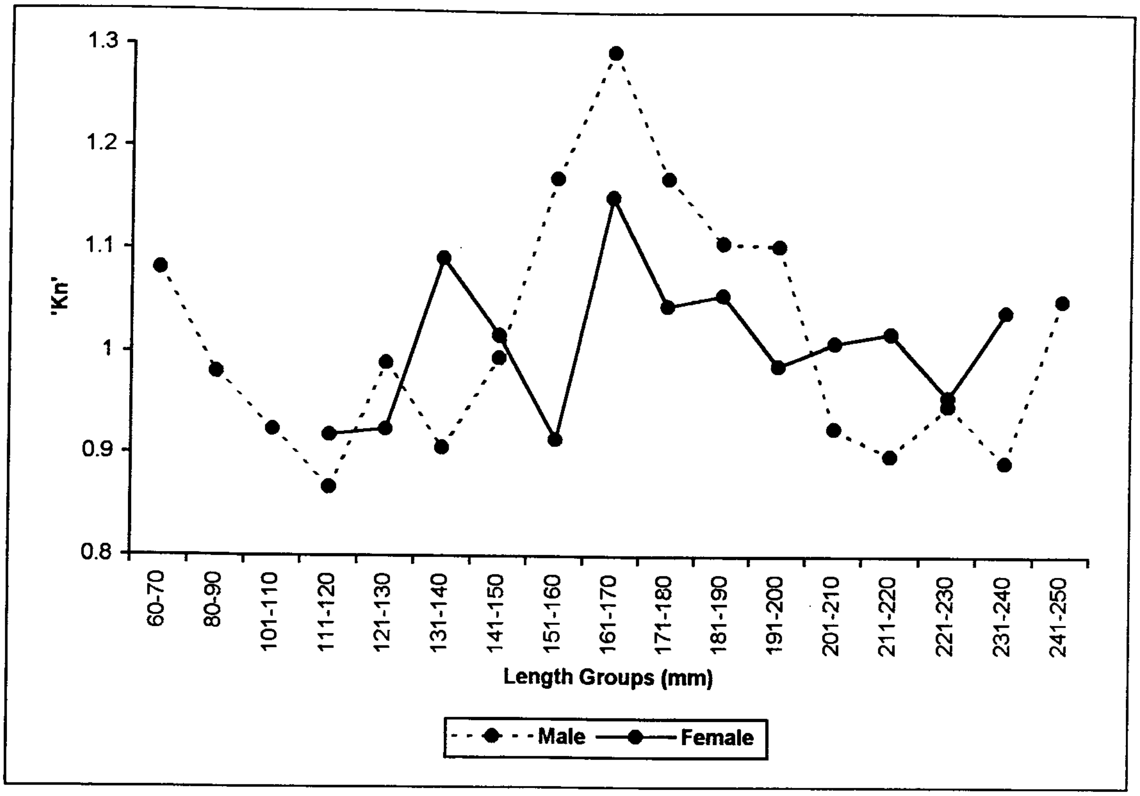
Logarithmic relationship between Length & Weight for Females of *O. bimaculatus* (Bloch)

Fig. – 5.8

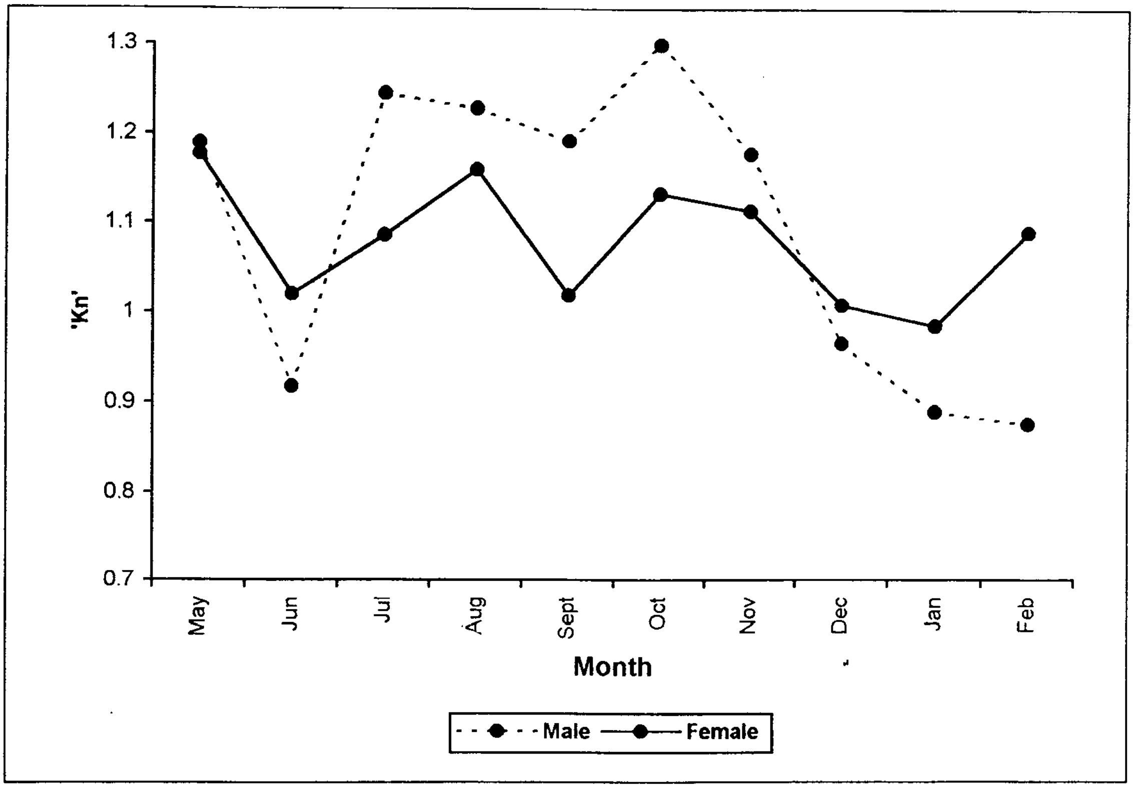


Relative condition factor in different size groups of
***H. brachysoma* (Gunther)**

Fig. 5.9

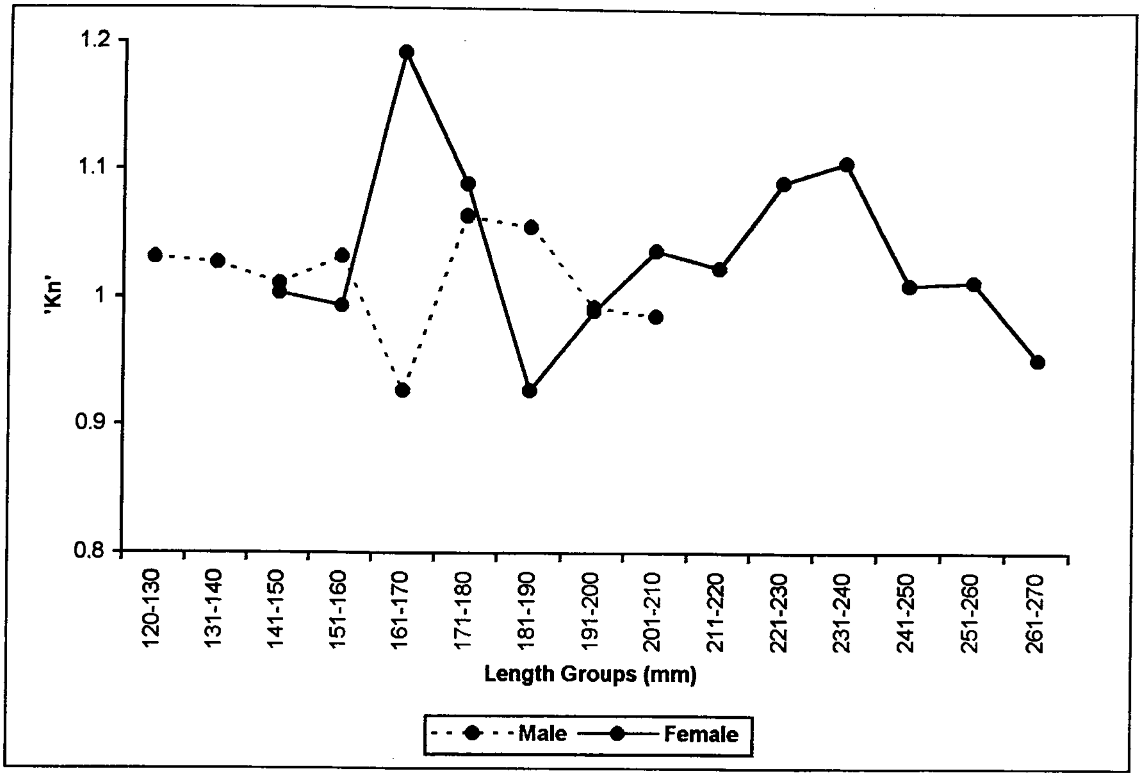


Relative condition factor of *H. brachysoma* (Gunther) during different months (1997 - 98 & 1998 - 99 Pooled)
Fig. 5.10



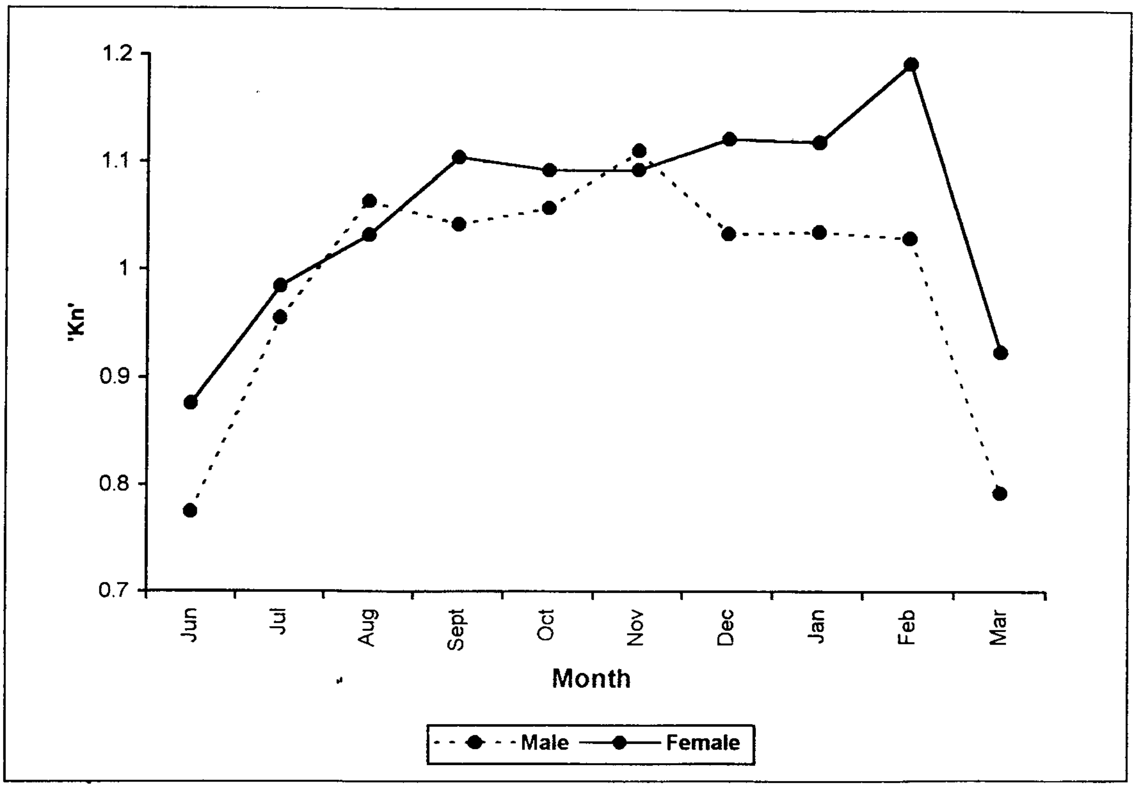
Relative condition factor in different size groups of *O. bimaculatus* (Bloch)

Fig. 5.11



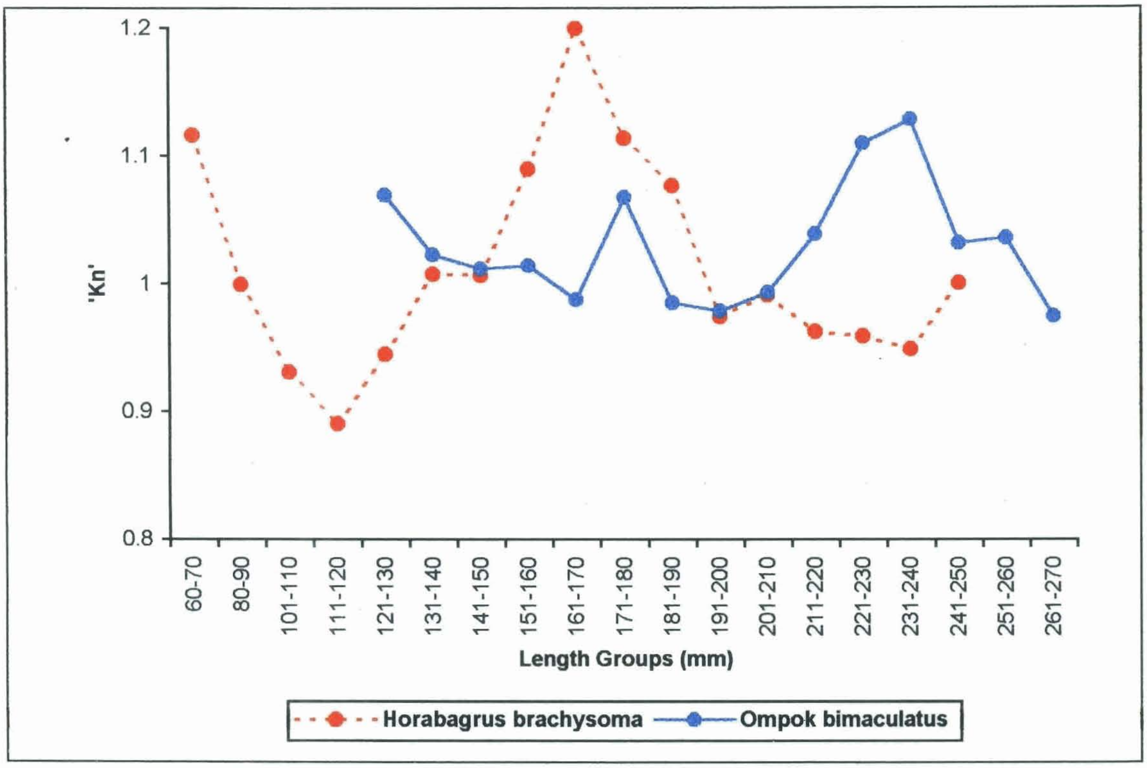
Relative condition factor of *O. bimaculatus* (Bloch) during different months (1997 - 98 & 1998 - 99 Pooled)

Fig. 5.12



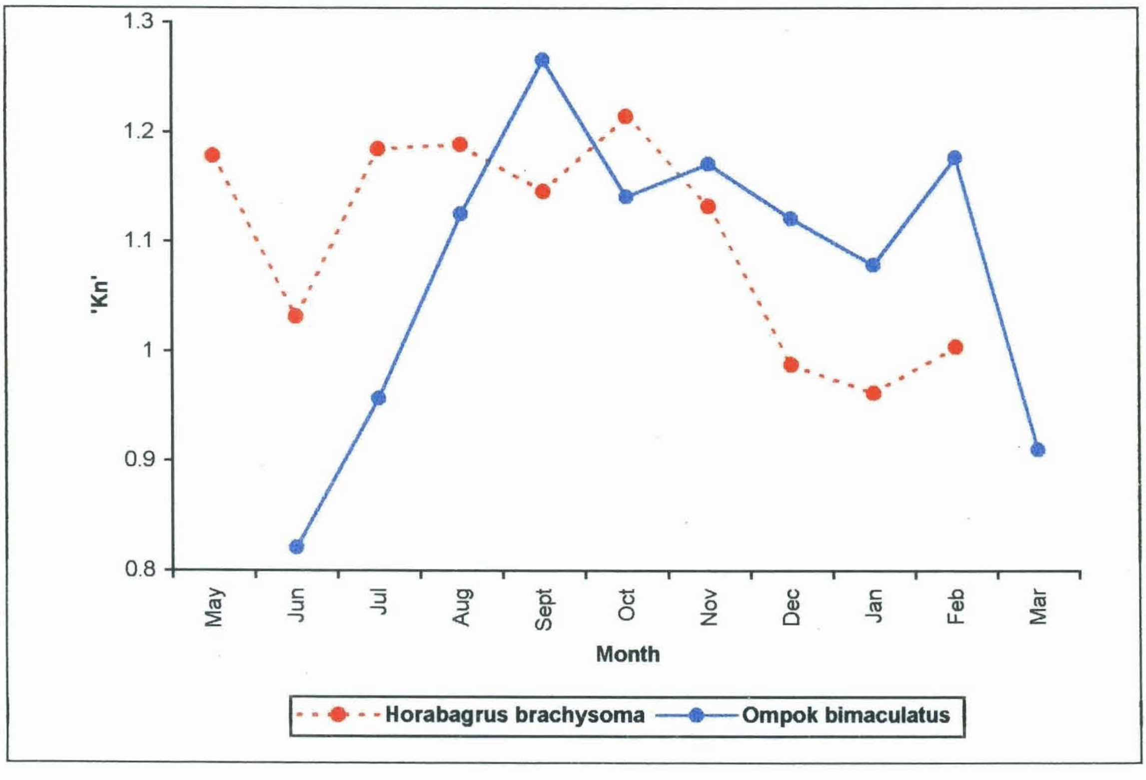
Comparison of relative condition factor of *O. bimaculatus* (Bloch) & *H. brachysoma* (Gunther) in different size groups

Fig. 5.13



Comparison of relative condition factor of *O. bimaculatus* (Bloch) & *H. brachysoma* (Gunther) in different months

Fig. 5.14



REPRODUCTION

CHAPTER - VI

REPRODUCTION

INTRODUCTION

A thorough knowledge of the reproductive biology of the fish species is of great importance in fishery biology for the rational exploitation and proper management of the fishery resources as well as for the development of intensive aquaculture of fishes through selective breeding, brood stock development, domestication and genetic improvement. Studies on the maturation and depletion of gonads are basically aimed at understanding and predicting the changes, which the population as a whole undergoes during the year. The information of sex ratio is useful to estimate the reproductive potential in animals. Fishes exhibit a complexity of reproductive tactics and traits. The reproductive tactics are the variations in the general pattern, which the fish adapts in response to the fluctuations in the environment. The reproductive traits include various aspects like size/age at first maturity, size / age dependent fecundity, sex ratio, nature of gametes and the time of spawning season (Wootton, 1984). A study on these reproductive parameters is essential in the determination of population stock size from the number of eggs, periodicity of the strength of broods (year class recruitment), spawning time and place and sex composition of exploited stock. Knowledge of the minimum length at sexual maturity is essential to ensure a sustained yield by regulating the mesh size of the net, to ensure that the smaller fish may also have an opportunity to spawn at least once in their lifetime.

Reproduction and fecundity of fishes have been studied by a number of fishery biologists from different parts of the world. To mention a few important contributions are from Fulton (1899), Clark (1934), Hickling and Rutenberg (1936), Dejong (1939), Hickling (1940), Simpson (1951), June (1953), Yuen (1955), Mac Gregor (1957), Howard and Landa (1958), Otsu and Uchida (1959), Yoshida (1966), Macer (1974), Crossland (1977), Fox (1978), Hunter and Goldberg (1980), Wee (1982), Williams & Clarke (1982) Wootton (1984), Davis (1985), Eltink (1987), Kilambi (1986), Wijeyaratne and Costa (1987), Cole (1990), Colin (1992) and Suzuki *et al.* (2000).

Some of the Indian contributors on the subject include Hornell (1910), Panikkar and Aiyar (1939), Jones (1950), Alikunhi (1953), Pradhan & Palikar (1956), Prabhu (1956), Qasim and Qayyum (1961), Jhingran (1961), Rao (1963,1964), Raju (1964), Antony Raja (1967), James (1967), Parulekar and Bal (1971), Varghese (1973, 1980), Qasim (1973a), Devaraj (1977, 1983, 1986, 1987), James and Baragi (1978), Somavanshi (1980, 1985), Jayabalan (1986), Reddy and Neelakantan (1993), Narasimham (1994), Kurup and Kuriakose (1994), Sivakami (1995), Krishnakumar & Balakrishnan (1995), Negi & Dobriyal (1997), Srivastava and Desai (1998), Devadoss (1998) and Suryawanshi & Wagh (1999).

There are only a few works on the reproductive biology of catfishes from outside India. Khan *et al.* (1990) have worked on the reporoductive biology of a tropical catfish, *Mystus nemurus* Cuvier and Valenciennes in Chenderoh Reservoir, Malaysia. Marriott *et al.* (1997) have described the reproductive biology of the Natal Mountain catfish, *Amphilius natalensis* from the Songimvelo game reserve, South Africa. Thompson *et al.* (1996) reported the breeding biology of some pelagic cyprinids and catfish in Lake Malawi / Niassa. Hostache and Mol (1998) have described the reproductive biology of the neotropical armoured catfish *Hoplosternum littorale.* Wang *et al.* (1992) described the reproductive biology of the Bagrid catfish *Mystus macropterus* in the Jialing River, China. Nomura (1984) described the biology of the black dotted armoured catfish *Hypostomus nigromaculatus* from Mogi Guacu river, Sao Paulo.

Investigations on the reproductive biology of catfishes from the Indian waters are very much limited. David (1963) has described the sexual dimorphism and fecundity of the estuarine bagrid, *Mystus gulio* (Ham). Reproduction of *Mystus gulio* from Cooum backwaters, Madras and the lake Pulicat has been studied by Pandian (1967) and Kaliyamurthy (1981). Pantulu (1963) has studied the fecundity and spawning of *Osteogeniosus militaris* (Linn). Mojumder (1978) has reported the maturity and spawning of the catfish *Tachysurus thalassinus* (Ruppel) off Waltair coast. Sinha (1984, 1985) has recorded the fecundity and spawning of the canine catfish eel *Plotosus canius* Ham. Rao & Karam Chandani (1986) have worked on the spawning biology of *O. bimaculatus* from the Kulgarhi reservoir of Madhya Pradesh. Naama and Yousif (1987) have reported the spawning and fecundity of *Arius thalassinus* (Rupp). Sudha and Shakunthala (1989) have described the reproductive biology of *Mystus vittatus* (Bloch). Siva Reddy and Rao (1991) have studied the gonadosomatic index and fecundity of *Heteropneustes fossilis* (Bloch) from Hussain Sagar lake, Hyderabad. Dobriyal and Singh (1993) have investigated the reproductive biology of a hill stream catfish *Glyptothorax madraspatanum* from Garhwal, Central Himalaya, India. Ramamohana Rao *et al.* (1994) have worked on the breeding and seed production of the Asian catfish *Clarias batrachus* (Linnaeus). Rao *et al.* (1999) have reported the breeding biology and fecundity in Mystus species from Mehadrigedda stream of Vishakhapatnam. Molly and Inasu (1997, 1999) have studied the sexual dimorphism of two edible catfishes *H. brachysoma* and *O. bimaculatus.*

But the reproductive biology of catfishes of Central Kerala has not been investigated before except the work of Inasu (1993) on *Mystus mystus.* In the present study, the reproduction, fecundity and the related parameters of *H. brachysoma* and *O. bimaculatus* are discussed in detail.

MATERIALS AND METHODS

Fish samples were collected from the local fishermen and from the fish landing centres and fish markets, fortnightly from May 1997 to March 1999. Samples were mainly obtained from the Chalakudy River and the kolelands of Muriyad and Thrissur. Samples were not obtained during the months March, April and April, May for *H. brachysoma* and *O. bimaculatus* respectively because during severe drought, they are never caught in the nets. The fish samples consisted of a total number of 388 *H. brachysoma*, of which 180 were males and 208 were females and a total of 336 *O. bimaculatus* including 154 males and 182 females. The fish samples were cleaned in the laboratory and after removing the moisture by blotting, total length and weight of each fish was noted. Fish were dissected to record sex and stage of maturity. The ovaries were removed and weighed and they were preserved in 5% formalin.

Ovaries were classified into five maturity stages on the basis of morphological observations. For classification of maturity stages; the international council for the exploration of sea (ICES) scale (Wood, 1930 and Lovern and Wood, 1937) was adopted. The fresh ovaries were examined thoroughly for studying the morphological features and the organization of the ovary. The preserved material was used for microscopic examination. For the purpose of studying the duration and frequency of spawning, diameter of different ova were measured and recorded following the procedures adopted by Clark (1934), Hickling and Rutenberg (1936), June (1953), Rao (1963) and James (1967). An ocular and stage micrometer which had a calibrated value of 0.0137mm for each micrometer division (md) was used to measure the diameter of ova. Eggs were sampled from the middle portion of the ovary, as there was no difference in the size of the ova from different parts of the ovary. Ova measuring less than 5 md were not measured, as they were present in large numbers in all the ovaries except the immature ovaries (Stage I). Smaller ova were also measured from immature ovaries for studying the progressive growth of ova.

Gonadosomatic Index (G.S.I.) was estimated applying the method of June (1953) as the ratio of the wet gonad weight to somatic weight expressed as a percentage.

$$G.S.I. = \frac{\text{Weight of gonad}}{\text{Weight of the fish}} \times 100$$

The average size at first maturity was determined by plotting the percentages of fishes from Stage – III onwards, against their length groups. Maturity curves were drawn to the scatter plots so as to estimate the length at which 50% of the fish mature.

The sex – ratio distribution was studied by employing the Chi-square test (X^2), using the equation of Fisher (1970) as followed by

Dhulkhed (1971). To test whether the observed sex ratio in each month and individual length group differs significantly from the expected ratio, the following chi-square equation was followed.

$$\text{Chi-square} = \frac{\Sigma (O - E)^2}{E}$$

O = Observed number of males and females in each month / length group.

E = Expected number of males and females in each month / length group.

For the purpose of fecundity estimation, ovaries in Stages – III and IV only were considered. After removing the moisture from the ovaries with blotting paper, they were weighed in a monopan electronic balance to the nearest .001gm. A small portion of the ovary was separated and weighed to the nearest 0.001gm. The sample was placed on a microslide and ova were teased out. All the mature ova were counted and the fecundity was estimated employing the formula.

$$\frac{\text{Total weight of the ovary}}{\text{Weight of the samPle}} \times \text{Number of ova in the sample}$$

Relative fecundity was calculated as the number of eggs per gram body weight. The relationship between fecundity and different variables like fish length, fish weight and ovary weight was worked out by the least square method.

$$F = a \times b$$

Where F = Fecundity, x = Fish length or fish weight or ovary weight, a = constant and b = regression coefficient. The exponential relationship was transformed into a straight-line relationship based on logarithms by the following equation.

$$\text{Log fecundity} = \log a + b \text{ Log } x$$

RESULTS

H. brachysoma and *O. bimaculatus* are catfishes with distinct sexual dimorphism. In *H. brachysoma,* males are slightly larger than females, while in *O. bimaculatus*, females are much larger and heavier than males. In both these fishes, the male and female reproductive organs lie in the posterior part of the abdominal cavity and are attached dorsally to the abdominal wall by a thin membranous mesorchium or mesovarium. The gonads are free anteriorly and posteriorly they are connected and open to the exterior by a common genital aperture.

In both *H. brachysoma* and *O. bimaculatus,* the female reproductive organs consist of a pair of ovaries lying longitudinally in the body cavity. The right and left ovaries are almost symmetrical. When fully mature, the ovaries occupy the entire body cavity. Each ovary is cylindrical in shape with conspicuous venation. The maximum weight of the ovary obtained in *H. brachysoma* is 23.1gm and *O. bimaculatus* is 5.2gm.

Stages of Maturity

On the basis of the examination of morphological features such as shape, size and colour of the ovary and microscopic structure of ova, five maturity stages could be recognized in females. As the macro and microscopic structure of the ovaries in the two species are almost similar, a general description common for these species is given below.

Stage – I – Immature

The ovaries appeared small, narrow cylindrical or club shaped. They were glassy transparent and occupy about one third of the body cavity. The colour of the ovary is pink to light reddish. Ova not visible to the naked eye. Under the microscope ova appeared small, transparent, yolkless and not easily separable. Ovaries measured about 10 – 25mm in length and 0.15 to 1gm in weight. Ova diameter varied between 88 and 300μ.

Stage – II – Maturing

The ovaries are light yellow or yellowish brown occupying about one half of the body cavity. Ova round and some were partially yolk laden. The ovary measured 20 – 30mm in length and 1 – 2.5gms in weight. Ova diameter varied from 165 to 670μ.

Stage – III – Mature

Ovary yellowish occupying two third to three forth, of the body cavity. Majority of ova round and fully yolk laden. Veination clear. The length of the ovary was about 30 – 45mm and the weight varied between 2.5 – 6gms. Majority of ova were with a diameter varying from 500μ to 1200μ.

Stage – IV – Ripe

Ovaries long, almost round and occupy about the full length of the body cavity with some ova visible to the exterior. The colour of the ovary was golden yellow or orange yellow. Blood vessels were prominent on the ovary surface. Eggs increased in diameter and easily separable. Ova diameter varied between 800μ and 1500μ. Ovarian wall was observed to be very thin, delicate and easily rupturable. The ovary measured about 35 – 50 mm in length and 5 – 10 gms or above in weight.

Stage – V – Spent

Ovaries in this stage appeared quite shrunken and flaccid, translucent with prominent blood vessels occupying almost half of the body cavity. Colour of the ovary light yellow or pinkish. Few unspawned, yolky ova were also visible.

Distribution of ova in the ovary

In order to understand the distribution of ova in the different part of the ovary, mature ovaries of both *H. brachysoma* and *O. bimaculatus* were collected. From the left ovary, three portions from anterior, middle and posterior regions were cut out and teased on microslides. The ova diameter measurements of ova in each part were noted separately. It is found that the three regions showed a similar pattern of distribution of immature, maturing and mature ova. Similarly the distribution of ova in the right ovary was also found to be uniform in both the species of fishes. In all further studies, ova diameter studies were made from a sample taken from the middle region of the ovaries.

Horabagrus brachysoma (Gunther)

Sexual dimorphism

In *H. brachysoma* males are slightly larger and heavier than females of the same age group. Males overtake females in all morphological measurements. The dorsal profile of the male has a more downward slope anteriorly. The hump like ridge found on the dorsal side of the female body close to the anterior base of the dorsal fin is more prominent than that found in male. Eyes are more bulged in females than males. A prominent dark cross band is noted on the dorsal side of the head in female in between the two pectoral fins, while it is absent in the male. Dorsal spine and pectoral spine in female are slightly longer than those in the male.

Maturity stages

Five maturity stages were identified among the females of *H. brachysoma*. They were (i) Immature (ii) Maturing (iii) Mature (iv) Ripe (v) Spent. Immature stage (54.81%) was dominating among the females of *H. brachysoma* (Table 6.1). They were found during all months except June. Next largest group is Maturing Stage (20.19%) followed by Spent (9.62%), Mature (8.65%) and Ripe Stages (6.73%). So in the collections the ripe stage was found to be the least numbered among the females of *H. brachysoma*. Ripe and spent fishes were found only during June, July and August. The percentage occurrence of different maturity stages in the various size groups of *H. brachysoma* (Table 6.3) revealed that in size groups from 110 - 170mm, majority of the fishes were immature. Maturing fishes were found from 171mm onwards. Ripe stages occur from 181mm to 230mm.

Development of ova to maturity

The ova diameter frequency polygons are shown in Fig. 6.7. Ovaries in Stage – I has only one size group of ova, their diameter ranging between 100 and 220μ. In Stage – II ova diameter ranges between 310 and 670μ. In Stage – III ovaries showed a batch of ova emerging from the immature stock to form a mode at 1080μ with the size extending upto 1170μ. In stage – IV further progression of the mature group of ova is evident and the ripe ova form a single mode at

1332μ, the size of ova ranging upto 1500μ. In Stage – V only some maturing eggs is discernible along with a few residual eggs.

Minimum size at maturity

For the purpose of determining the minimum size at first maturity, only the fishes in Stage – III (Mature) and above were considered and their percentage in each length group were plotted against the midlength of the size groups. Maturity curves were drawn to the scatter plots so as to estimate the length at which 50% of the fish mature.

The maturity curve shows that 50% of the females of *H. brachysoma* mature at 215mm length (Fig. 6.5).

Gonadosomatic Index

The Gonadosomatic Index is calculated to study the relationship between the gonad index and maturity. The G.S.I. was calculated for individual fish in different months using the formula,

$$\text{Gonadosomatic Index} = \frac{\text{Ovary Weight}}{\text{Weight of the fish}} \times 100$$

The average gonadosomatic index for each month was calculated during 97 – 98 and 98 – 99 by dividing the total value of indices for each month by the number examined. The results are shown in Table 6.9 and Fig. 6.9. Maximum G.S.I. was obtained in the month of June (6.76) followed by July (3.69) and August (1.298). In September G.S.I.

is 1.28 and in the succeeding months the value becomes very low. In January it again increases to 1.47.

Spawning season

The high values of G.S.I. during the months of June, July and August indicate that these months form the main breeding season of *H. brachysoma* eventhough some individuals may breed during January also as revealed by the slightly higher gonadosomatic index during that month. The ova diameter measurements in the females of *H. brachysoma* also indicate that June – August form the breeding season of the species because the highest ova diameter measurements are obtained in the month of June (1458μ), August (1333μ) and July (1113μ). Monthly percentage occurrence of different maturity stages of *H. brachysoma* (Table 6.1) also prove the fact that the spawning season of the fish is June – August. Only during these months, ripe and spent stages are found in the collections.

Sex Ratio

Sex ratio studies were done mainly to ascertain whether there existed any difference in sex ratio in various size groups and during different months. The samples were grouped and studied month wise and in different size groups. The observed sex ratios were tested against an expected ratio 1 : 1 by the method of chi – square.

The month wise sex ratio in *H. brachysoma* during 1997 – 98 and 1998 – 999 are given in Table 6.5. The sex ratio in this fish was found to be 1 : 1.23 (97 – 98 and 98 – 99 pooled). This indicates that female sex group slightly out number the male sex group in the population. The chi-square test gives an average value of 4.03. The monthly sex ratio was significant during January & July 1998. Sex ratio in various length groups of *H. brachysoma* during 1997 – 98, 1998 – 99 and 1997 – 98 and 1998 – 99 Pooled are given in the Table 6.7. Males and females occur in almost all the size groups except 100 – 110mm group where females are absent and the 251 – 260mm group where females alone occur. The sex ratio was significant in the 221 – 230mm size group in 1997 – 98 and 201 – 210mm group in the year 1998 – 1999.

Fecundity

Fecundity was calculated from the total number of mature ova destined to be released in the current spawning season. Twenty four fishes of the size range 181 – 238mm in total length and 78.2 – 178gms in weight were used for fecundity estimation. Determination of absolute fecundity was based on the gravimetric method (Mac Gregor, 1957; Bagenal, 1957).

The fecundity of twenty four fishes examined are presented in the Table 6.11 along with the total length and weight of fish, weight of the ovary, number of ova per gm. body weight and number of ova per mgm. ovary weight. The fecundity varied between 1500 and 21184. The highest fecundity was found in a fish of 225mm total length and 148gms weight. The lowest fecundity of 1500 ova is found in a fish of total length 182mm and weight 78.2gms. Though there were slight variations within the size groups, the fecundity usually increased with increase of body length, body weight and ovary weight.

To find out the relationship between length of the fish and fecundity in *H. brachysoma*, the absolute fecundity estimated for 24 fishes were plotted against their total length in a scatter diagram (Fig. 6.11). A straight-line relationship was observed between these two variables. Similarly the relationship between fecundity and weight of the fish and fecundity and ovary weight were also studied by plotting these values against fecundity in scatter diagrams (Fig. 6.12 & 6.13). The relationship between fecundity and these parameters are worked out and the equations are given below:

Relations between fish length (L) and fecundity (F) (Fig. 6.11)

$$\text{Log } F = -4.0176 + 3.36459 \text{ Log } L$$

$$(r = .30179)$$

Relation between fish weight (W) and fecundity (Fig. 6.12)

$$\text{Log } F = .71603 + 1.48342 \text{ Log } W$$

$$(r = .428731)$$

Relation between ovary weight (OW) and fecundity (Fig. 6.13)

$$\text{Log F} = 2.98325 + .8527 \text{ Log OW}$$

$$(r = .95049)$$

It is observed that fecundity increased with increase in weight of the ovary and to some extent with the total length and weight of the fish.

Ompok bimaculatus (Bloch)

Sexual dimorphism is very clear and conspicuous in *O. bimaculatus.* Females are larger and heavier than the males of the same age group. The dorsal profile of the head in male has a clear downward slope anteriorly which is not seen in female. A conspicuous wide crescent shaped groove is present on the ventral side of the head in female, which is absent in male. Eyes in females are larger and more bulged than that of male. The maxillaries do not extend beyond the pectorals in female, while in male they extend beyond pectorals. The body of female is darker than that of males.

Stages of maturity

Five maturity stages were identified in *O. bimaculatus* also. They were immature, maturing, mature, ripe and spent. Immature stages were found during all the months of the study period and they form the dominant group in the samples (65.93%) (Table - 6.2). During December, February and March, the fish samples consisted of 100% of immature ones. During the month of August all the stages were present in the samples. Maturing and mature stages constitute 8.79% each in the samples. Ripe stage formed only 3.3%, the smallest group in the sample. Ripe stage formed only 3.3%, the smallest group in the sample. The spent fishes form 13.19% of the samples. Studies of the percentage occurrence of different maturity stages of ovary in various size groups revealed that from 140mm to 210mm majority of the fishes were immature. Maturing fishes were found from 161mm onwards and mature fishes from 181mm. In the 271 – 280mm group, 100% of the fishes were mature. The percentage occurrence of ovary in different stages of maturity during different months is presented in Fig. 6.3 & 6.4.

Development of ova to maturity

The ova diameter measurements and the frequency polygons presented in Fig. 6.8 shows that in the Stage I, majority of ova were in the size range of 88 to 300μ. In Stage II, maturing ova were noticed and their diameter varies between 165μ and 500μ. In Stage III, the ova undergo further maturation and there is the progression of single mode of maturing ova having the mode at 900μ with the size of the ova reaching upto 1000μ. In Stage IV further development of mature ova is evident with the mode shifting to 1200μ, the ova diameter ranging up to 1300μ. In Stage V only some maturing eggs were noticed along with a few residual eggs.

Minimum size at maturity

Maturity curves were drawn for *O. bimaculatus* by plotting the number of mature fishes (Stages III, IV & V) against the midlength of the size groups. The curve shows that 50% of the females of *O. bimaculatus* (Fig. 6.6) mature at 230mm total length.

Gonadosomatic Index

The gonadosomatic index of individual fish of *O. bimaculatus* in different months was calculated and the average G.S.I. for each month was found out during 1997 – 98 and 1998 – 99. The results are shown in Table 6.10 and Fig. 6.10. Maximum G.S.I. was observed in the month of June (4.44) followed by July and August (2.97 and 2.68). During the other months, G.S.I. was found to be below 1.

Spawning season

In *O. bimaculatus* also spawning season extends from June to August as revealed by the higher gonadosomatic index during these months and this is the only spawning season of *O. bimaculatus*. The ova diameter measurements of the fish also indicate that June – August forms the breeding season of the species because the highest ova diameter measurements are obtained in these months (June 1111μ; July 972μ and August 1194μ). Monthly percentage occurrence of different maturity stages of *O. bimaculatus* shows that mature stages of the fish are found only during these months (Table 6.2), which is another evidence for taking June – August as the breeding season.

Sex Ratio

The month wise sex ratio in *O. bimaculatus* during 1997 – 98 and 1998 – 99 are given in Table 6.6. The overall sex ratio of male : female during the 2 years 1 : 1.13. The sex ratio during 1997 – 98 is 1 : .67 and during 1998 – 99 is 1 : 2.49. The females out number the males in the population during most of the months except August, October and December. The chi-square test gives a total average value of 1.286. The monthly sex ratio was significant during August and October 1997 and August, September and November 1998.

Sex ratio in various length groups of *O. bimaculatus* during 1997 – 98, 1998 – 99 and 1997 – 98 and 1998 – 99 Pooled are given in the Table 6.8. Females were totally absent in 120 – 130 and 131 – 140mm size groups. Males were present only upto 210mm. In all the higher length groups from 211mm onwards only females were present in the population. From 151mm to 190mm, all the size groups were male dominated. The size wise sex ratio also showed a dominance of females. The sex ratio was significant in 161 – 170mm and 181 – 190mm size groups during 1997 – 1998 and in 191 – 200mm group during 1998 – 1999.

Fecundity

Twenty four fishes of the size range 185 - 272mm in total length and 36 - 122gms in weight were used for fecundity estimation of *O. bimaculatus* . The fecundity of 24 fishes examined is presented in the Table 6.12 along with the total length, weight of fish, weight of ovary, number of ova per gm. body weight and number of ova per mgm. ovary weight. The fecundity varied between 2200 and 5800. The highest fecundity of 5800 ova was observed in two fishes of 233mm and 272mm total length and 111.1gm and 122gm weight respectively. The lowest fecundity was 2200 ova found in a fish of total length 185mm and weight 36gms. Though there were slight variations within the size groups, the fecundity usually increased with increase of length, body weight and ovary weight. Further average fecundity was calculated for various size groups.

To find out the relationship between fecundity and total length of the fish, body weight and ovary weight, the absolute fecundity estimated for the twenty-four fishes were plotted against these parameters in scatter diagrams (Fig. 6.14, 6.15 & 6.16). A straight-line relationship was observed between fecundity and the length, weight or ovary weight. The relationship between fecundity and these parameters were worked out and the equations are given below:

Relation between fish length (L) and Fecundity (F) (Fig. 6.14)

$$\text{Log } F = -0.60431 + 1.793191 \text{ Log } L$$

$$(r = .793225)$$

Relation between fish weight and fecundity (Fig. 6.15)

$$\text{Log } F = 2.43787 + 0.62647 \text{ Log } W$$

$$(r = .871245)$$

Relation between Ovary Weight (OW) and Fecundity (Fig. 6.16)

$$\text{Log } F = 3.3753 + 0.438089 \text{ Log } OW$$

$$(r = .40526)$$

It is observed that in *O. bimaculatus* the fecundity increased with increase in length as well as increase in weight of the fish, but to a less extent with the ovary weight of fish.

DISCUSSION

In teleost fishes, there are diverse systems of classification of maturity stages. The most accepted system is the ICES Scale (Lovern & Wood, 1937) with suitable modifications. Usually examination of female gonad is preferred for the description of reproductive cycle (West, 1990). The present work is mainly focussed on the study of female gonad. Qasim (1973) opined that in the fishes of tropical waters, the classification of gonads should be limited to about five maturity stages. In the present study of the reproduction of

H. brachysoma and *O. bimaculatus,* five maturity stages have been distinguished based on the macroscopic and microscopic examination of the ovary and ova respectively. They are the Immature, Maturing, Mature, Ripe and the Spent stages. The earlier authors have reported seven maturity stages (Immature, Maturing I, Maturing II, Mature, Ripe, Spawning and Spent) in *O. bimaculatus* (Sivakami, 1982).

According to Hickling and Rutenberg (1936) and de Jong (1939), teleostean fishes have been found to exhibit different types of spawning habits. Some have a short spawning, once a season. In some others spawning takes place only once, but over a long period. In the third group fishes are expected to spawn twice in a season and in the last group fishes spawn intermittently over a long period. An examination of ova diameter frequencies of mature ovaries of *H. brachysoma* and *O. bimaculatus* indicates that in both these fishes spawning season is from June to August, which is the period of South – west monsoon in Kerala. In *H. brachysoma* some fishes spawn during December – January also. There are no different batches of eggs maturing at different periods in the same season, but different individuals mature at different times, thus prolonging the breeding season as reported by Sheshappa and Bhimachar (1955). Sivakami (1982) has observed that the spawning season of *O. bimaculatus* from Bhavanisagar Reservoir (Tamil Nadu) is from September to January with some individuals breeding during other months also. No previous reports are available on the breeding biology of *H. brachysoma.* But a number of studies are conducted on the breeding of related genus *Mystus.* Vinci (1986) studied the biology of *Mystus Seenghala* and reported that the fish spawns from April to August as revealed by the higher gonadosomatic index during those months and the occurrence of higher percentage of mature and spent fishes at this time. Inasu (1991) reported that *Mystus mystus* breeds from September to January. There are earlier reports about the spawning habits of *Mystus gulio.* The fish spawns in October in Cooum backwaters (Pandian, 1966) while in July in Hooghly estuary (Pantulu, 1961). In both these places the monsoon rains begin at this time. This suggests that the onset of heavy monsoon is the triggering factor for *Mystus gulio* to spawn. The present study is in conformity with the above view as *H. brachysoma* and *Ompok bimaculatus* (Bloch) spawns during the heavy South - west monsoon that starts in June in Kerala. Monsoon rain has been shown to induce spawning in many inland fishes (Qayyum and Qasim, 1964a).

The study of Gonadosomatic Index in *H. brachysoma* shows that it has maximum G.S.I. during June (6.76) (Table - 6.9). Then it decreases to 3.69 in July and during August it becomes 1.298. In *O. bimaculatus* also the maximum Gonadosomatic Index of 4.44 is found in June and in July the G.S.I. reduces to 2.965 and it becomes 2.68 in August. This clearly indicates that in both these fishes the breeding season coincides with the South - West monsoon ie. June–August.

The monthly percentage occurrence of various stages of maturity in female *H. brachysoma* shows that Ripe and Spent stages of ovary are found only during June – August. In *O. bimaculatus* also mature and spent ovaries occur only during these months. This is an additional proof revealing the spawning season of these fishes.

The minimum size at maturity of *H. brachysoma* is 215mm and that of *O. bimaculatus* is 230mm total length. Sivakami (1982) reported that in *O. bimaculatus* of Bhavanisagar reservoir, the minimum size at maturity is 242 mm.

Menon (1947) observed that among fishes of all sizes belonging to Siluridae, the proportion of males is higher by 11.6%. But in the present study on the sex ratio of *H. brachysoma* females slightly dominated during most of the time. (Ratio between male and female is 1: 1.23) (Table 6.7). Males and females occur in all the size groups except 100 – 110mm group where females are absent and the 251 – 260mm group where females alone occur. In *O. bimaculatus* also females outnumber the males during most of the months (1 : 1.13), Table 6.6). According to Nikolsky (1963), the sex ratio differs from one population to another of the same spices and varies from year to year even in same species population. The present study of *O. bimaculatus* supports the above view of Nikolski as the sex ratio of *O. bimaculatus* varies in the two years studied. The male: female ratio during 1997 – 98 is 1: .67, while during 1998 – 99 the ratio is 1: 2.49. The same incidence is found in *Mystus oculatus* (Bhatt, 1971c) where the ratio of the percentage of males to females ranged from 33.58 : 66.42 during 1963 to 41.00 : 58.91 during 1964. Qasim (1966) opined that the preponderance of one sex in the population of fish is due to the sexual difference in the growth rate between sexes. Instances of dominance of one sex have been reported in *Sardinella longiceps* by Antony Raja (1972), *Garra mullya* by Somavanshi (1980) & *Amblygaster sirm* by Veerappan *et al.* (1997).

The study of sex ratio in the various length groups of *O. bimaculatus* presents certain interesting features. Females were totally absent from 120mm to 140mm; while males were present only upto 210mm. In all the higher length groups from 211mm onwards, only females were present in the collections. This clearly supports the view of Molly and Inasu (1997 & 1999) that females are much larger and heavier than that of males, thus proving the phenomenon of sexual dimorphism in the fish.

In the present study, fecundity of *H. brachysoma* and *Ompok bimaculatus* (Bloch) were estimated by counting all the mature ova and the relationship between fecundity and body length, body weight and ovary weight were studied.

According to Sivakami (1982) the fecundity of *O. bimaculatus* varies from 6016 to 19440. In the present study, fecundity of *O. bimaculatus* is found to vary from 2200 to 5800 and that of *H. brachysoma* varies between 1500 and 21184, with wide variation among individuals of the same size. This may be probably due to a number of factors such as abundance of food, age, climatic factors etc. (Bagenal, 1966, Winters, 1971). Compared to the lower fecundity of (25 – 165ova) of Tachysurid catfish (Menon and Muthiah, 1987), which ensure better survival, by mouth breeding, fecundity of these catfishes are higher.

According to Hickling (1940) and Nikolskii (1965) fecundity varies in the same species in different periods or under different environmental conditions. Fecundity has been shown to increase as square of length of fish (Clark, 1934) or as cube of length {Simpson [1951], Bagenal [1957], Varghese [1961 and 1976] or a fourth power of length (Farran, 1938) or more than fourth power of length (Varghese, 1980). Varghese (1973) observed that the fecundity of Rohu, *Labeo rohita* increased at a rate of 3.96 times the length. Varghese (1980) reported that in *Coilia dussumieri*, the fecundity increased at a rate of 4.82 times the length.

As true for many fishes, in general, in *H. brachysoma* and in *O. bimaculatus,* the number of eggs increased with size of the fish, weight of the fish and ovary weight. However in *H. brachysoma* it is noticed that rate of increase of fecundity is much higher with the increase in weight of the ovary but lesser with the increase in length and weight of the fish. This is due to the fact that the fecundity of the individual fish of the same length or weight varies. Therefore it was not possible to fit any of the relationship discussed above for data on the fecundity of

H. brachysoma as far as the relation with the length and weight of the fish are concerned. This observation is in conformity with the earlier reports of James (1967) on *Eupleurogrammus intermedius,* Siva Reddy and Babu Rao (1991) on *Heteropncustes* fossilis, Somasekharan (1977) on *Johnius sina* and Appa Rao (1990) on *Pentaprion longimanus.* While in *O. bimaculatus,* the fecundity increased to a greater extent with the weight and total length of the fish compared to the increase of fecundity with the weight of the ovary. This observation agrees with the view of Sivakami (1982) on *O. bimaculatus* of Bhavanisagar reservoir where there is a linear relationship between fecundity and weight and also between fecundity and the total length of the fish.

Table - 6.1

Monthly percentage occurrence of different stages of Maturity in the Females of *H. brachysoma* (Gunther)

Month	No. of Fish	I Immature		II Maturing		III Mature		IV Ripe		V Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 – 1998											
May	8	6	75	2	25	---	---	---	---	---	---
Jun.	6	---	---	4	66.67	2	33.33	---	---	---	---
Jul.	4	---	---	---	---	---	---	4	100	---	---
Aug.	16	12	75	---	---	---	---	---	---	4	25
Sept.	---	---	---	---	---	---	---	---	---	---	---
Oct.	12	10	83.33	---	---	2	16.67	---	---	---	---
Nov.	12	10	83.33	2	16.67	---	---	---	---	---	---
Dec.	12	6	50	4	33.33	2	16.67	---	---	---	---
Jan.	14	4	28.57	4	28.57	6	42.86	---	---	---	---
Feb.	12	4	33.33	8	66.67	---	---	---	---	---	---
1998 – 1999											
May	8	2	25	6	75	---	---	---	---	---	---
Jun.	14	---	---	---	---	---	---	6	42.86	8	57.14
Jul.	18	10	55.56	2	11.11	---	---	2	11.11	4	22.22
Aug.	14	8	57.14	---	---	---	---	2	14.28	4	28.58
Sept.	10	6	60	2	20	2	20	---	---	---	---
Oct.	12	12	100	---	---	---	---	---	---	---	---
Nov.	12	12	100	---	---	---	---	---	---	---	---
Dec.	8	4	50	2	25	2	25	---	---	---	---
Jan.	6	2	33.33	2	33.33	2	33.34	---	---	---	---
Feb.	10	6	60	4	40	---	---	---	---	---	---
1997 – 1998 & 1998 – 1999 (POOLED)											
May	16	8	50	8	50	---	---	---	---	---	---
Jun.	20	---	---	4	20	2	10	6	30	8	40
Jul.	22	10	45.45	2	50.09	---	---	6	27.28	4	18.18
Aug.	30	20	66.66	---	---	---	---	2	6.67	8	26.67
Sept.	10	6	60	2	20	2	20	---	---	---	---
Oct.	24	22	91.67	---	---	2	8.33	---	---	---	---
Nov.	24	22	91.67	2	8.33	---	---	---	---	---	---
Dec.	20	10	50	6	30	4	20	---	---	---	---
Jan.	20	6	30	6	30	8	40	---	---	---	---
Feb.	22	10	45.45	12	54.55	---	---	---	---	---	---

Table - 6.2

Monthly percentage occurrence of different stages of Maturity in the Females of *O. bimaculatus* (Bloch)

Month	No. of Fish	I		II		III		IV		V	
		Immature		Maturing		Mature		Ripe		Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 - 1998											
Jun.	8	4	50	---	---	4	50	---	---	---	---
Jul.	4	2	50	---	---	2	50	---	---	---	---
Aug.	4	---	---	---	---	2	50	2	50	---	---
Sept.	8	2	25	---	---	4	50	---	---	2	25
Oct.	4	4	100	---	---	---	---	---	---	---	---
Nov.	10	10	100	---	---	---	---	---	---	---	---
Dec.	12	12	100	---	---	---	---	---	---	---	---
Jan.	16	14	87.5	2	12.5	---	---	---	---	---	---
Feb.	6	6	100	---	---	---	---	---	---	---	---
Mar.	8	8	100	---	---	---	---	---	---	---	---
1998 - 1999											
Jun.	4	---	---	---	---	2	50	---	---	2	50
Jul.	4	---	---	4	100	---	---	---	---	---	---
Aug.	20	8	40	4	20	2	10	2	10	4	20
Sept.	26	6	23.08	6	23.08	---	---	---	---	14	53.84
Oct.	8	6	75	---	---	---	---	---	---	2	25
Nov.	14	12	85.71	---	---	---	---	2	14.29	---	---
Dec.	8	8	100	---	---	---	---	---	---	---	---
Jan.	8	8	100	---	---	---	---	---	---	---	---
Feb.	4	4	100	---	---	---	---	---	---	---	---
Mar.	6	6	100	---	---	---	---	---	---	---	---
1997 – 1998 & 1998 – 1999 (POOLED)											
Jun.	12	4	33.33	---	---	6	50	---	---	2	16.67
Jul.	8	2	25	4	50	2	25	---	---	---	---
Aug.	24	8	33.33	4	16.66	4	16.67	4	16.66	4	16.67
Sept.	34	8	23.53	6	17.65	4	11.76	---	---	16	47.06
Oct.	12	10	83.33	---	---	---	---	---	---	2	16.67
Nov.	24	22	91.67	---	---	---	---	2	8.33	---	---
Dec.	20	20	100	---	---	---	---	---	---	---	---
Jan.	24	22	91.67	2	8.33	---	---	---	---	---	---
Feb.	10	10	100	---	---	---	---	---	---	---	---
Mar.	14	14	100	---	---	---	---	---	---	---	---

Table - 6.3

Percentage occurrence of different stages of Maturity of Female *H. brachysoma* (Gunther) in various size groups

Size Group (mm)	No. of Fish	I Immature		II Maturing		III Mature		IV Ripe		V Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 – 1998											
110 – 120	4	4	100	---	---	---	---	---	---	---	---
121 – 130	4	2	50	---	---	2	50	---	---	---	---
131 – 140	14	14	100	---	---	---	---	---	---	---	---
141 – 150	10	10	100	---	---	---	---	---	---	---	---
151 – 160	---	---	---	---	---	---	---	---	---	---	---
161 – 170	---	---	---	---	---	---	---	---	---	---	---
171 – 180	6	6	100	---	---	---	---	---	---	---	---
181 – 190	12	6	50	6	50	---	---	---	---	---	---
191 – 200	8	4	50	2	25	2	25	---	---	---	---
201 – 210	8	---	---	4	50	2	25	2	25	---	---
211 – 220	10	---	---	4	40	---	---	4	40	2	20
221 – 230	16	2	12.5	4	25	8	50	---	---	2	12.5
231 – 240	4	---	---	2	50	2	50	---	---	---	---
1998 - 1999											
110 – 120	4	4	100	---	---	---	---	---	---	---	---
121 – 130	6	6	100	---	---	---	---	---	---	---	---
131 – 140	2	2	100	---	---	---	---	---	---	---	---
141 – 150	16	16	100	---	---	---	---	---	---	---	---
151 – 160	4	4	100	---	---	---	---	---	---	---	---
161 – 170	4	4	100	---	---	---	---	---	---	---	---
171 – 180	8	6	75	1	12.5	---	---	---	---	1	12.5
181 – 190	16	10	62.5	---	---	---	---	2	12.5	4	25
191 – 200	14	---	---	4	28.57	---	---	4	28.57	6	42.86
201 – 210	14	2	14.29	6	42.86	2	14.28	---	---	4	28.57
211 – 220	8	4	50	2	25	---	---	2	25	---	---
221 – 230	10	---	---	6	60	2	20	2	20	---	---
231 – 240	2	---	---	2	100	---	---	---	---	---	---
241 – 250	2	---	---	---	---	---	---	---	---	2	100
251 - 260	2	---	---	---	---	---	---	---	---	2	100

(Contd..... Table – 6.3)

Percentage occurrence of different stages of Maturity of Female *H. brachysoma* (Gunther) in various size groups

Size Group (mm)	No. of Fish	I		II		III		IV		V	
		Immature		Maturing		Mature		Ripe		Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 – 1998 & 1998 – 1999 (POOLED)											
110 – 120	8	8	100	---	---	---	---	---	---	---	---
121 – 130	10	8	80	---	---	2	20	---	---	---	---
131 – 140	16	16	100	---	---	---	---	---	---	---	---
141 – 150	26	26	100	---	---	---	---	---	---	---	---
151 – 160	4	4	100	---	---	---	---	---	---	---	---
161 – 170	4	4	100	---	---	---	---	---	---	---	---
171 – 180	14	12	85.72	1	7.14	---	---	---	---	1	7.14
181 – 190	28	16	57.14	6	21.43	---	---	2	7.14	4	14.28
191 – 200	22	4	18.18	6	27.27	2	9.09	4	18.18	6	27.27
201 – 210	22	2	9.09	10	45.45	4	18.18	2	9.09	4	18.18
211 – 220	18	4	22.22	6	33.33	---	---	6	33.34	2	11.11
221 – 230	26	2	7.69	10	38.46	10	38.46	2	7.69	2	7.69
231 – 240	6	---	---	4	66.67	2	33.33	---	---	---	---
241 – 250	2	---	---	---	---	---	---	---	---	2	100
251 - 260	2	---	---	---	---	---	---	---	---	2	100

Table - 6.4

Percentage occurrence of different stages of Maturity of Female *O. bimaculatus* (Bloch) in various size groups

Size Group (mm)	No. of Fish	I Immature		II Maturing		III Mature		IV Ripe		V Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 – 1998											
140 – 150	14	14	100	---	---	---	---	---	---	---	---
151 – 160	8	8	100	---	---	---	---	---	---	---	---
161 – 170	4	4	100	---	---	---	---	---	---	---	---
171 – 180	2	2	100	---	---	---	---	---	---	---	---
181 – 190	8	6	75	---	---	2	25	---	---	---	---
191 – 200	12	8	66.66	---	---	4	33.34	---	---	---	---
201 – 210	6	6	100	---	---	---	---	---	---	---	---
211 – 220	4	2	50	2	50	---	---	---	---	---	---
221 – 230	8	6	75	---	---	---	---	---	---	2	25
231 – 240	---	---	---	---	---	---	---	---	---	---	---
241 – 250	2	---	---	---	---	2	100	---	---	---	---
251 – 260	6	2	33.33	2	33.33	---	---	2	33.34	---	---
261 – 270	4	1	25	---	---	1	25	---	---	2	50
271 - 280	2	---	---	---	---	2	100	---	---	---	---
1998 - 1999											
140 – 150	8	8	100	---	---	---	---	---	---	---	---
151 – 160	12	12	100	---	---	---	---	---	---	---	---
161 – 170	2	---	---	2	100	---	---	---	---	---	---
171 – 180	2	2	100	---	---	---	---	---	---	---	---
181 – 190	8	4	50	---	---	2	25	---	---	2	25
191 – 200	18	14	77.78	4	22.22	---	---	---	---	---	---
201 – 210	4	2	50	2	50	---	---	---	---	---	---
211 – 220	6	2	33.33	2	33.33	---	---	---	---	2	33.34
221 – 230	4	---	---	---	---	---	---	1	25	3	75
231 – 240	12	4	33.33	2	16.67	2	16.66	2	16.67	2	16.66
241 – 250	12	6	50	---	---	---	---	---	---	6	50
251 – 260	2	---	---	---	---	---	---	---	---	2	100
261 – 270	12	4	33.33	2	16.67	---	---	2	16.66	4	33.34

(Contd….. Table – 6.4)

Percentage occurrence of different stages of Maturity of Female *O. bimaculatus* (Bloch) in various size groups

Size Group (mm)	No. of Fish	I Immature		II Maturing		III Mature		IV Ripe		V Spent	
		No.	%	No.	%	No.	%	No.	%	No.	%
1997 – 1998 & 1998 – 1999 (POOLED)											
140 – 150	22	22	100	---	---	---	---	---	---	---	---
151 – 160	20	20	100	---	---	---	---	---	---	---	---
161 – 170	6	4	66.67	2	33.33	---	---	---	---	---	---
171 – 180	4	4	100	---	---	---	---	---	---	---	---
181 – 190	16	10	62.5	---	---	4	25	---	---	2	12.5
191 – 200	30	22	73.33	4	13.33	4	13.34	---	---	---	---
201 – 210	10	8	80	2	20	---	---	---	---	---	---
211 – 220	10	4	40	4	40	---	---	---	---	2	20
221 – 230	12	6	50	---	---	---	---	1	8.33	5	41.67
231 – 240	12	4	33.33	2	16.67	2	16.66	2	16.67	2	16.66
241 – 250	14	6	42.86	---	---	2	14.28	---	---	6	42.86
251 – 260	8	2	25	2	25	---	---	2	25	2	25
261 – 270	16	5	31.25	2	12.5	1	6.25	2	12.25	6	37.5
271 - 280	2	---	---	---	---	2	100	---	---	---	---

Table - 6.5

Monthly distribution of Sex Ratio and Chi-square Test in *H. brachysoma* (Gunther)

Month	Total No. of Fish	Male	Female	Sex Ratio	Chi - square	Remarks
1997 - 1998						
May	14	6	8	1 : 1.33	.286	N.S.
Jun.	18	12	6	1 : .5	.2	N.S.
Jul.	10	6	4	1 : .67	.4	N.S.
Aug.	30	14	16	1 : 1.14	.1333	N.S.
Sept.	9	9	---	1 : 0	---	
Oct.	22	10	12	1 : 1.2	.18	N.S.
Nov.	26	14	12	1 : .86		N.S.
Dec.	24	12	12	1 : 1	---	
Jan.	16	2	14	1 : 7	9	S.
Feb.	18	6	12	1 : 2	2	N.S.
1998 - 1999						
May	14	6	8	1 : 1.33	.286	N.S.
Jun.	14	---	14	0 : 14	---	
Jul.	22	4	18	1 : 4.5	8.9091	S.
Aug.	20	6	14	1 : 2.33	3.2	N.S.
Sept.	22	12	10	1 : .83	.1818	N.S.
Oct.	22	10	12	1 : 1.2	.1818	N.S.
Nov.	28	16	12	1 : .75	.5714	N.S.
Dec.	18	10	8	1 : .8	.2222	N.S.
Jan.	14	8	6	1 : .75	.2857	N.S.
Feb.	16	6	10	1 : 1.67	1	N.S.
1997 – 1998 & 1998 – 1999 (POOLED)						
May	28	12	16	1 : 1.33	.5714	N.S.
Jun.	32	12	20	1 : 1.67	2	N.S.
Jul.	32	10	22	1 : 2.2	4.5	S.
Aug.	50	20	30	1 : 1.5	2	N.S.
Sept.	31	21	10	1 : .48	3.9032	N.S.
Oct.	44	20	24	1 : 1.2	.3636	N.S.
Nov.	54	30	24	1 : .8	.6667	N.S.
Dec.	42	22	20	1 : .91	.0952	N.S.
Jan.	30	10	20	1 : 2	3.3333	N.S.
Feb.	34	12	22	1 : 1.83	2.9412	N.S.
Total	377	169	208	1 : 1.23	4.03	S.

N.S. : Non Significant
S. : Significant

Table - 6.6

Monthly distribution of Sex Ratio and Chi-square Test in *O. bimaculatus* (Bloch)

Month	Total No. of Fish	Male	Female	Sex Ratio	Chi-square
1997 - 1998					
Jun.	14	6	8	1 : 1.33	.2857
Jul.	10	6	4	1 : .67	.4
Aug.	26	22	4	1 : .18	12.4615*
Sept.	22	14	8	1 : .57	1.6364
Oct.	22	18	4	1 : .22	8.9091*
Nov.	20	10	10	1 : 1	---
Dec.	30	18	12	1 : .67	1.2
Jan.	28	12	16	1 : 1.33	.5714
Feb.	14	8	6	1 : .75	.2857
Mar.	14	6	8	1 : 1.33	.2857
1998 – 1999					
Jun.	8	4	4	1 : 1	----
Jul.	5	1	4	1 : 4	1.8
Aug.	24	4	20	1 : 5	10.6667*
Sept.	30	4	26	1 : 6.5	16.1333*
Oct.	10	2	8	1 : 4	3.6
Nov.	18	4	14	1 : 3.5	5.5556*
Dec.	14	6	8	1 : 1.33	.2857
Jan.	18	10	8	1 : .8	.2222
Feb.	6	2	4	1 : 2	.6667
Mar.	10	4	6	1 : 1.5	.4
1997 – 1998 & 1998 – 1999 (POOLED)					
Jun.	22	10	12	1 : 1.2	.18
Jul.	15	7	8	1 : 1.14	.0666
Aug.	50	26	24	1 : .92	.08
Sept.	52	18	34	1 : 1.89	4.9231*
Oct.	32	20	12	1 : .6	2
Nov.	38	14	24	1 : 1.71	2.6316
Dec.	44	24	20	1 : .83	.3636
Jan.	46	22	24	1 : 1.09	0869
Feb.	20	10	10	1 : 1	---
Mar.	24	10	14	1 : 1.4	.6667

* Significant

Table - 6.7

Sex Ratio & Chi-square Test in *H. brachysoma* (Gunther) in different Length Groups

Length Group (mm)	Total No. of Fish	Male	Female	Sex Ratio	Chi-square
1997 – 1998					
100 –110	8	8	---	1 : 0	---
111 –120	8	4	4	1 : 1	---
121 – 130	6	2	4	1 : 2	.6667
131 - 140	20	6	14	1 : 2.33	3.2
141 – 150	18	8	10	1 : 1.25	.2222
151 – 160	6	6	---	1 : 0	---
161 – 170	2	2	---	1 : 0	---
171 – 180	20	14	6	1 : .43	3.2
181 – 190	18	6	12	1 : 2	2
191 – 200	18	10	8	1 : .8	.2222
201 – 210	16	8	8	1 : 1	---
211 – 220	18	8	10	1 : 1.25	.2222
221 – 230	22	6	16	1 : 2.67	4.5455*
231 – 240	14	10	4	1 : .4	.8571
241 – 250	2	2	---	2 : 0	---
1998 – 1999					
100 –110	2	2	---	---	---
111 –120	8	4	4	1 : 1	---
121 – 130	10	4	6	1 : 1.5	.4
131 - 140	8	6	2	1 : .33	2
141 – 150	28	12	16	1 : 1.33	.5714
151 – 160	8	4	4	1 : 1	---
161 – 170	4	---	4	---	---
171 – 180	16	8	8	1 : 1	---
181 – 190	26	10	16	1 : 1.6	1.3846
191 – 200	20	6	14	1 : 2.33	3.2
201 – 210	18	4	14	1 : 3.5	5.5556*
211 – 220	12	4	8	1 : 2	1.3333
221 – 230	18	8	10	1 : 1.25	.2222
231 – 240	6	4	2	1 : .5	.6667
241 – 250	4	2	2	1 : 1	---
251 - 260	2	---	2	---	---

* Significant

(Contd….. Table – 6.7)

Sex Ratio & Chi-square Test in *H. brachysoma* (Gunther) in different Length Groups

Length Group (mm)	Total No. of Fish	Male	Female	Sex Ratio	Chi-square
1997 – 1998 & 1998 – 1999 (POOLED)					
100 –110	10	10	---	---	---
111 –120	16	8	8	1 : 1	---
121 – 130	16	6	10	1 : 1.66	1
131 - 140	28	12	16	1 : 1.33	.5714
141 – 150	46	20	26	1 : 1.3	.7826
151 – 160	14	10	4	1 : .4	.8571
161 – 170	6	2	4	1 : 2	.6667
171 – 180	36	22	14	1 : .64	1.7778
181 – 190	44	16	28	1 : 1.75	3.2727
191 – 200	38	16	22	1 : 1.38	.9474
201 – 210	34	12	22	1 : 1.83	2.9412
211 – 220	30	12	18	1 : 1.5	1.2
221 – 230	40	14	26	1 : 1.86	3.6
231 – 240	20	14	6	1 : .43	3.2
241 – 250	6	4	2	1 : .5	.6667
251 - 260	2	---	2	---	---

Table - 6.8

Sex Ratio & Chi-square Test in
***O. bimaculatus* (Bloch) in different Length Groups**

Length Group (mm)	Total No. of Fish	Male	Female	Sex Ratio	Chi-square
1997 – 1998					
120 – 130	4	4	---	---	---
131 – 140	8	8	---	---	---
141 – 150	30	16	14	1 : .87	.1333
151 – 160	26	18	8	1 : .44	3.8462
161 – 170	18	14	4	1 : .29	5.5556*
171 – 180	8	6	2	1 : .33	2
181 – 190	28	20	8	1 : .4	5.1429*
191 – 200	26	14	12	1 : .86	.1538
201 – 210	14	8	6	1 : .75	.286
211 – 220	4	---	4	---	---
221 – 230	8	---	8	---	---
231 – 240	---	---	---	---	---
241 – 250	2	---	2	---	---
251 – 260	6	---	6	---	---
261 – 270	4	---	4	---	---
271 - 280	2	---	2	---	---
1998 – 1999					
120 – 130	4	4	---	---	---
131 – 140	2	2	---	---	---
141 – 150	14	6	8	1 : 1.33	.286
151 – 160	20	8	12	1 : 1.5	.8
161 – 170	6	4	2	1 : .5	.6667
171 – 180	6	4	2	1 : .5	.6667
181 – 190	12	4	8	1 : 2	1.3333
191 – 200	24	6	18	1 : 3	6*
201 – 210	6	2	4	1 : 2	.6667
211 – 220	6	---	6	---	---
221 – 230	4	---	4	---	---
231 – 240	12	---	12	---	---
241 – 250	12	---	12	---	---
251 – 260	2	---	2	---	---
261 – 270	12	---	12	---	---

* Significant

(Contd..... Table – 6.8)

Sex Ratio & Chi-square Test in *O. bimaculatus* (Bloch) in different Length Groups

Length Group (mm)	Total No. of Fish	Male	Female	Sex Ratio	Chi-square
1997 – 1998					
120 – 130	8	8	---	---	---
131 – 140	10	10	---	---	---
141 – 150	44	22	22	1 : 1	---
151 – 160	46	26	20	1 : .77	.7826
161 – 170	24	18	6	1 : .33	6*
171 – 180	14	10	4	1 : .4	2.5714
181 – 190	40	24	16	1 : .66	1.6
191 – 200	50	20	30	1 : 1.5	2
201 – 210	20	10	10	1 : 1	---
211 – 220	10	---	10	---	---
221 – 230	12	---	12	---	---
231 – 240	12	---	12	---	---
241 – 250	14	---	14	---	---
251 – 260	8	---	8	---	---
261 – 270	16	---	16	---	---
271 - 280	2	---	2	---	---

* Significant

Table - 6.9

Monthly Average Gonadosomatic Index of

***H. brachysoma* (Gunther)**

Month	Gonadosomatic Index		
	1997 – 98	1998 – 99	Average
May	.941	.62	.781
June	3.18	10.342	6.76
July	6.24	1.143	3.69
August	.564	2.032	1.298
September	----	1.28	1.28
October	.52	.453	.487
November	.404	.428	.416
December	.895	.809	.852
January	2.206	.736	1.471
February	.63	.47	.55

Table – 6.10

Monthly Average Gonadosomatic Index of

***O. bimaculatus* (Bloch)**

Month	Gonadosomatic Index		
	1997 – 98	1998 – 99	Average
June	4.31	4.56	4.44
July	4.19	1.74	2.965
August	4.33	1.03	2.68
September	1.23	.676	.953
October	.21	.25	.23
November	.42	.756	.588
December	.13	.214	.172
January	.29	.186	.238
February	.2	.195	.197
March	.24	.25	.245

Table - 6.11

Fecundity in relation to Total Length, Body Weight & Ovary Weight of *H. brachysoma* (Gunther)

Sl. No.	Total Lt. (mm)	Body Wt. (gm)	Ovary Wt. (gm)	No. of Ova/gm Body Wt.	No. of Ova/mgm Ovary Wt.	Fecundity
1	181	86	22	179.07	0.7	15400
2	182	78.2	1.2	19.18	1.25	1500
3	195	84.2	9.1	38.36	0.35	3230
4	198	85.7	9	36.64	0.35	3140
5	200	120	23.1	109.38	0.57	13125
6	201	93	3.4	23.66	0.65	2200
7	202	121.4	22.5	130.15	0.70	15800
8	204	112	8.2	54.69	0.75	6125
9	205	90	2.5	25.56	0.92	2300
10	207	120.2	8.5	58.4	0.83	7020
11	214	126	6.5	38.1	0.74	4800
12	214	126	6	39.76	0.835	5010
13	221	144.5	35	138.75	0.57	20050
14	223	130	5.2	23.27	0.58	3025
15	225	148	39.1	143.14	0.54	21184
16	225	169	4.7	14.91	0.54	2520
17	226	151.2	37	139.55	0.57	21100
18	228	158	3	19.3	1.02	3050
19	228	165.5	15.1	79.24	0.869	13115
20	228	130	4.8	29.23	0.79	3800
21	230	115.5	13.1	113.33	0.999	13090
22	232	162	28.5	111.11	0.632	18000
23	237	178	4.1	21.91	0.95	3900
24	238	170.5	36.1	123.75	0.584	21160

Table - 6.12
Fecundity in relation to Total Length, Body Weight & Ovary Weight of *O. bimaculatus* (Bloch)

Sl. No.	Total Lt. (mm)	Body Wt. (gm)	Ovary Wt. (gm)	No. of Ova/gm Body Wt.	No. of Ova/mgm Ovary Wt.	Fecundity
1	185	36	3	61.11	0.73	2200
2	188	37.2	3.3	64.52	0.73	2400
3	190	41.1	3.4	61.56	0.74	2530
4	193	40.2	3.2	62.19	0.78	2500
5	198	54.25	3.5	51.98	0.81	2820
6	200	50.5	4	99.01	1.25	5000
7	201	72.4	3.8	63.19	1.2	4574
8	205	58.1	4.1	87.95	1.25	5110
9	231	90	3.9	45.56	1.05	4100
10	232	87.1	4	48.79	1.06	4250
11	233	98	4.3	47.19	1.076	4625
12	233	111.1	5.1	52.21	1.14	5800
13	236	87.2	4.2	51.72	1.07	4510
14	246	113.2	4.25	46.64	1.24	5280
15	250	115	4.2	46.96	1.29	5400
16	252	111.2	2.1	44.06	2.33	4900
17	258	115	2.2	43.04	2.25	4950
18	260	102	5.1	54.12	1.08	5520
19	261	102.3	5.4	45.94	0.87	4700
20	265	110	5.5	44.09	0.88	4850
21	268	116	5.1	45	1.02	5220
22	271	120.2	2.5	42.43	2.04	5100
23	272	120.5	5.6	46.89	1.01	5650
24	272	122	5.8	47.54	1	5800

Percentage occurrence of maturity stages in females of *H. brachysoma* (Gunther)

Fig. – 6.1

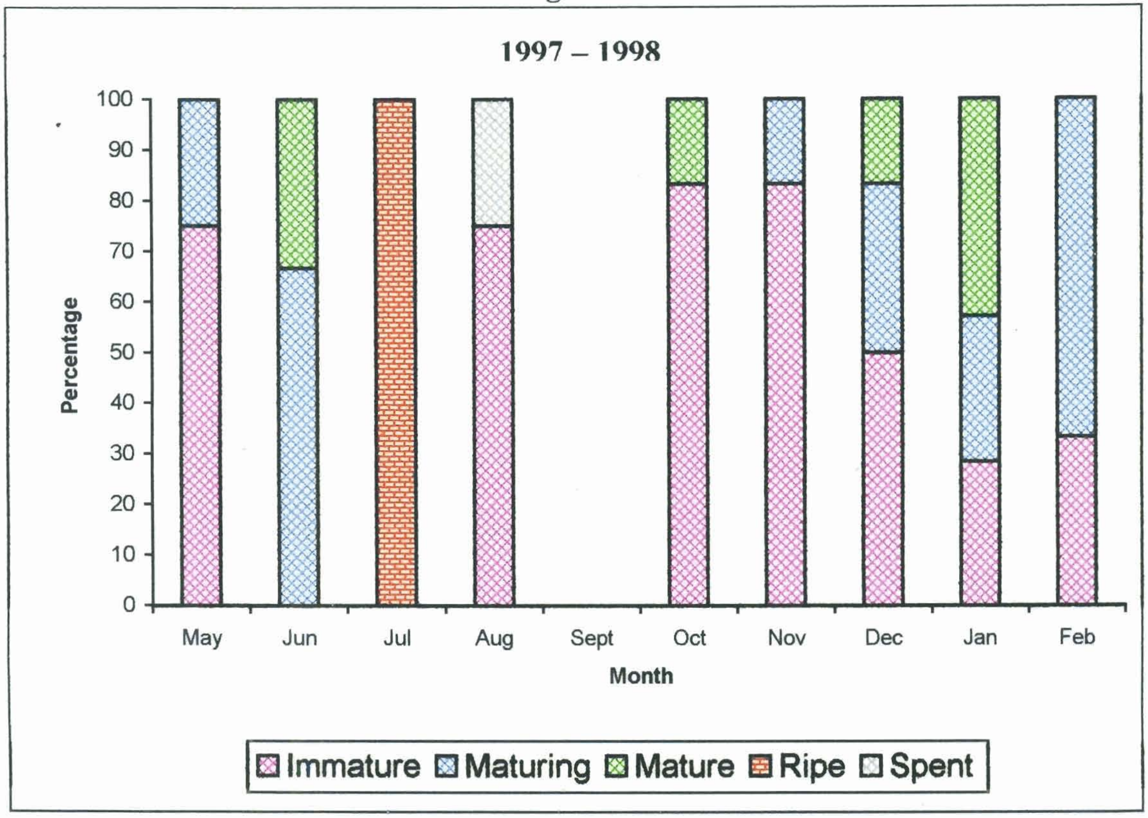
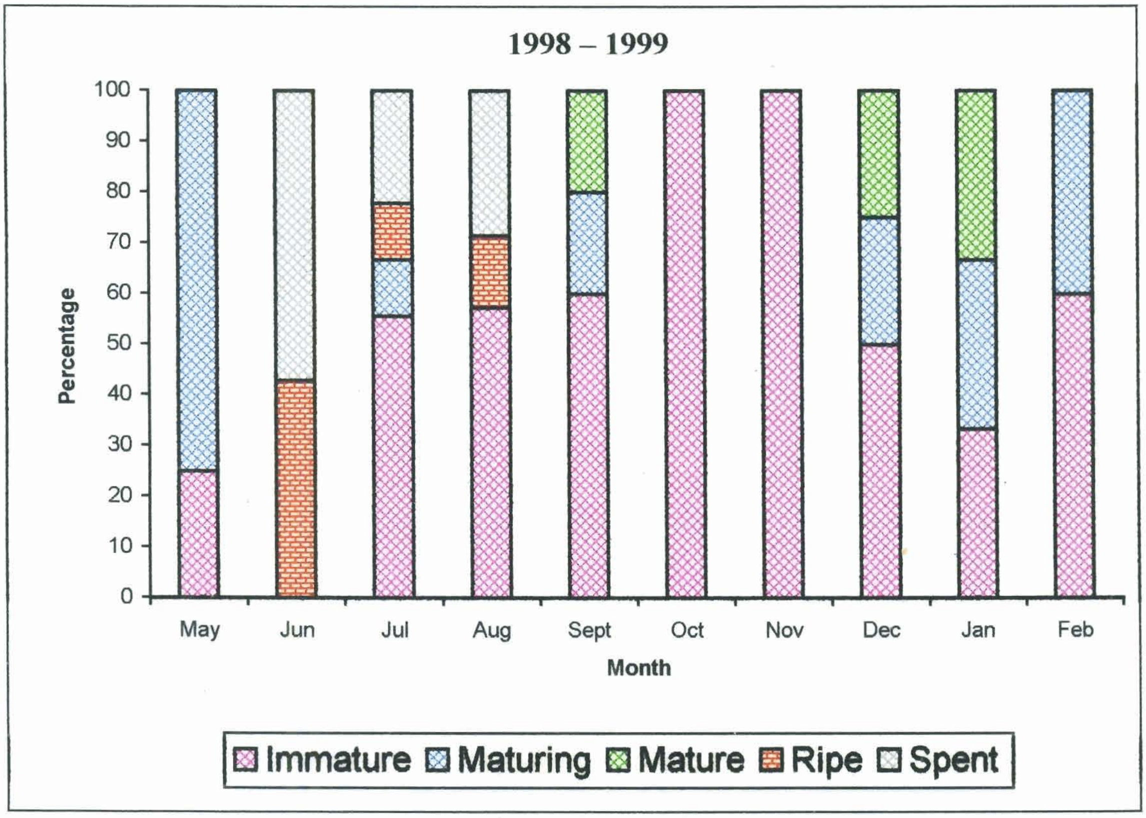


Fig. – 6.2



130

170P

Percentage occurrence of maturity stages in females of
***O. bimaculatus* (Bloch)**

Fig. – 6.3

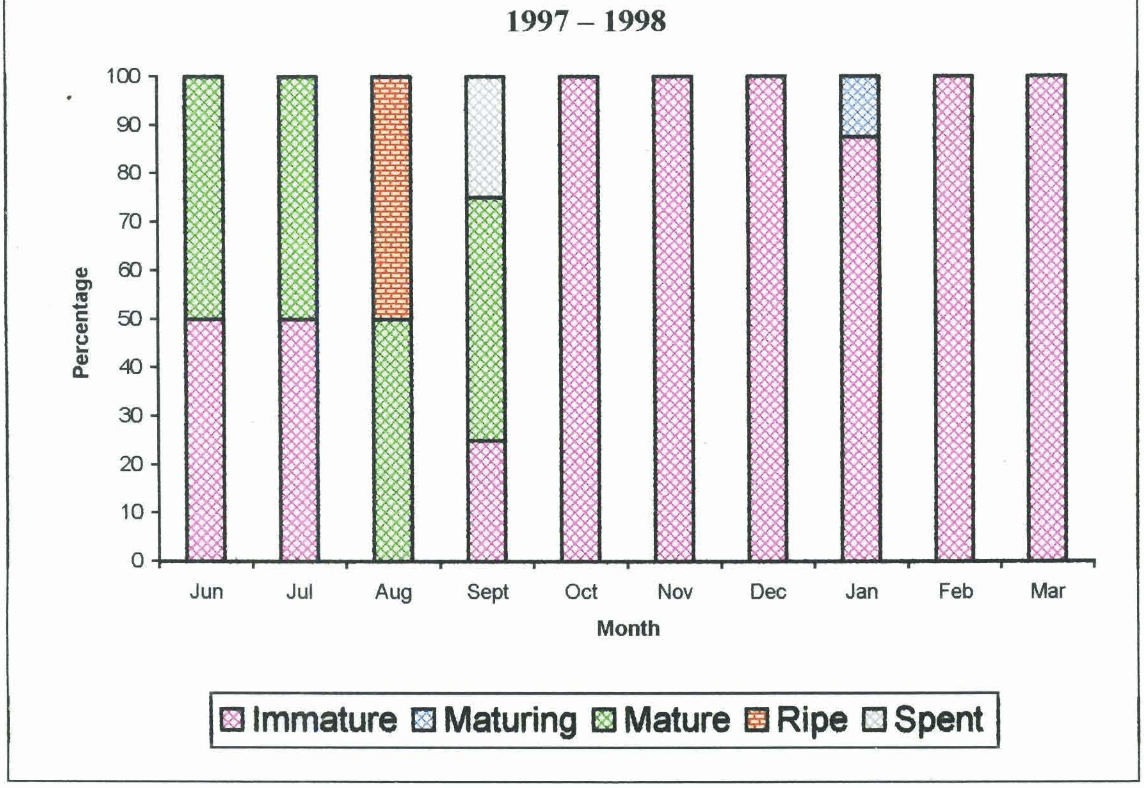
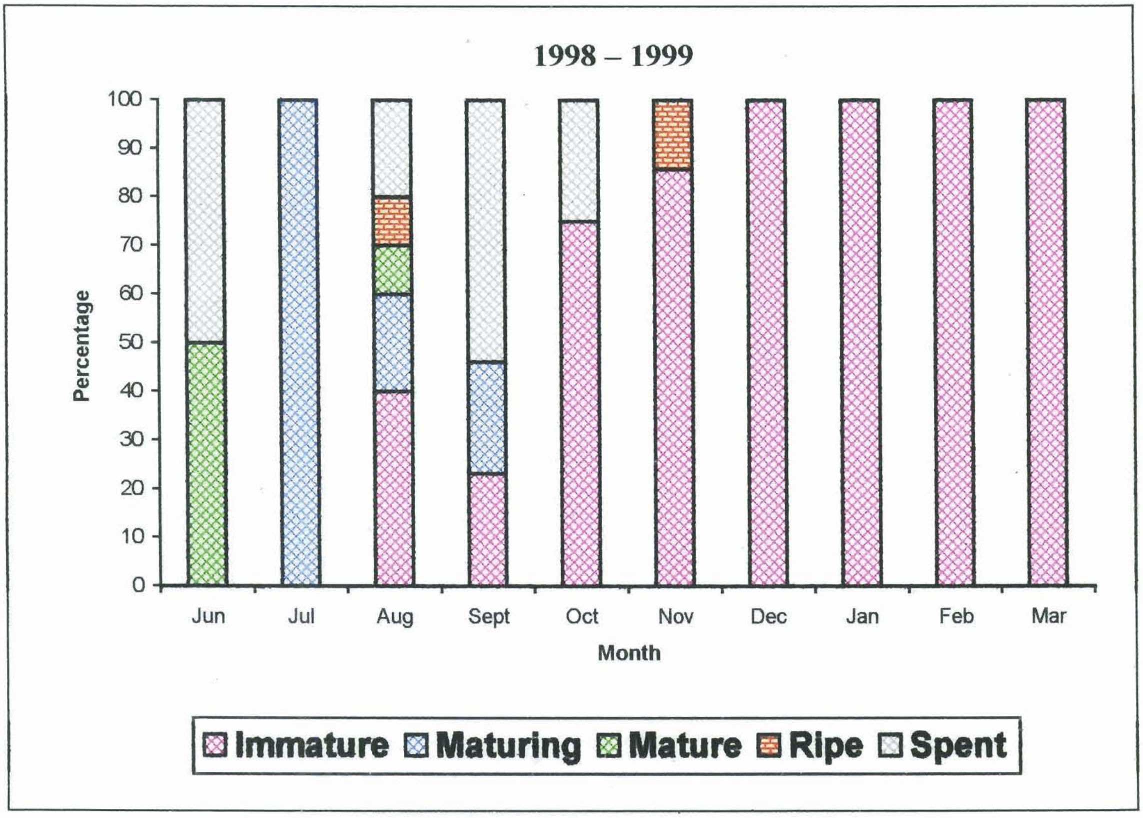


Fig. – 6.4

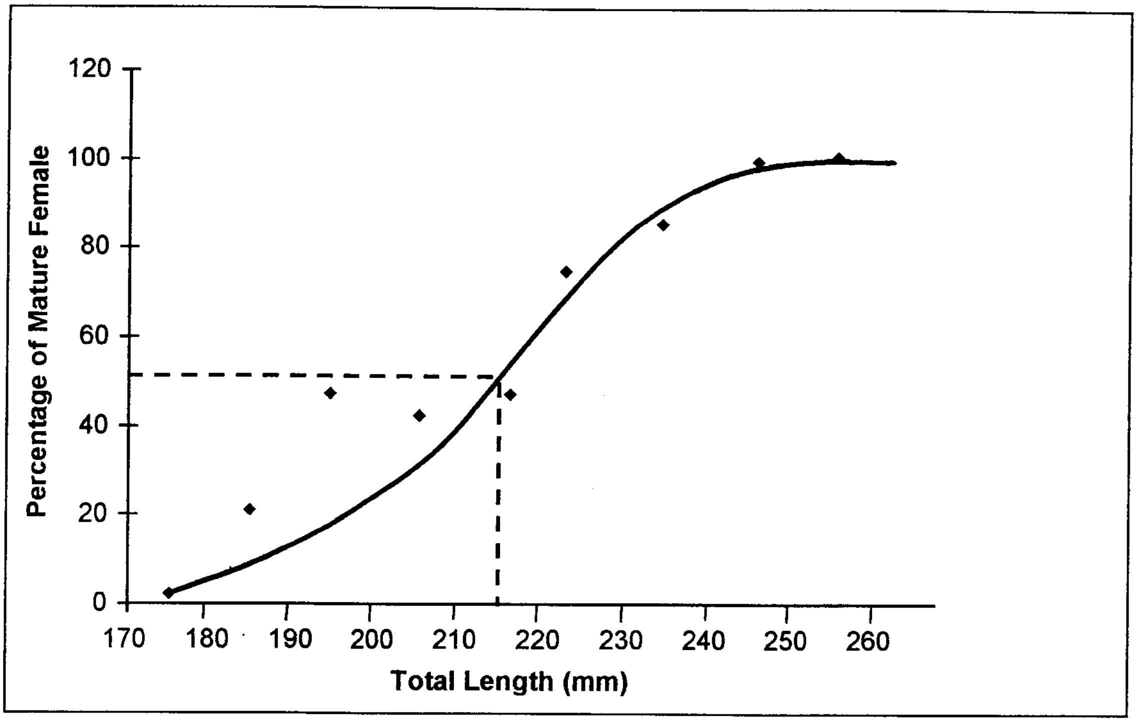


131

170 Q

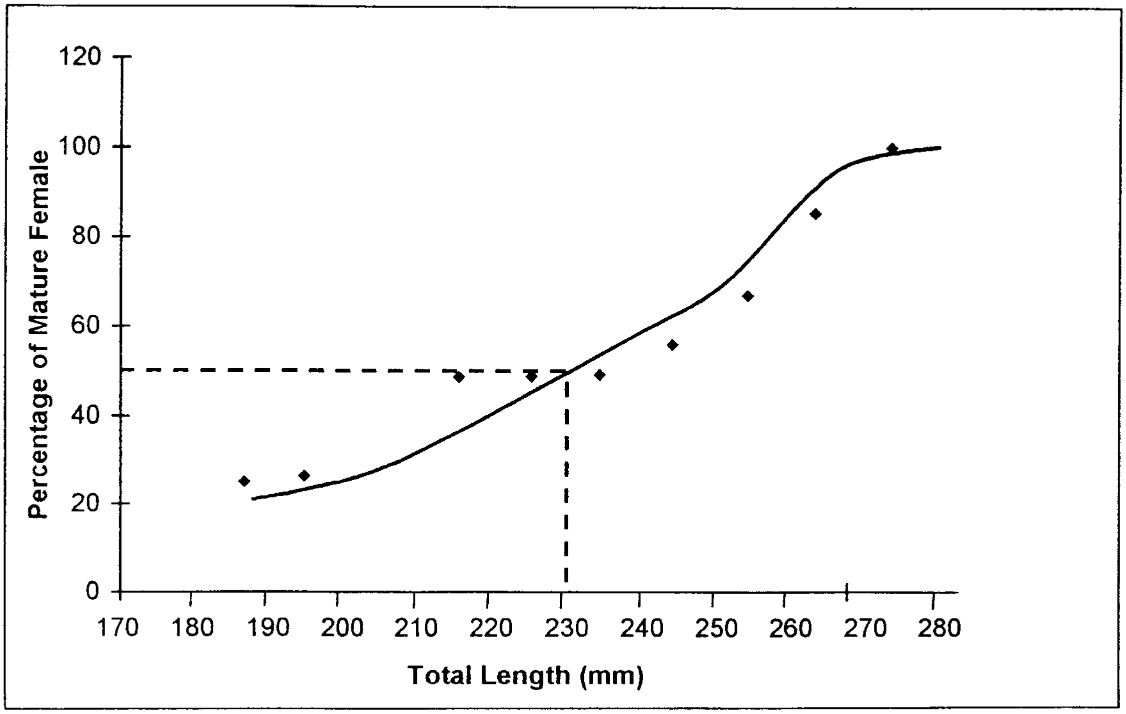
Size at first maturity in *H. brachysoma* (Gunther) Female

Fig – 6.5

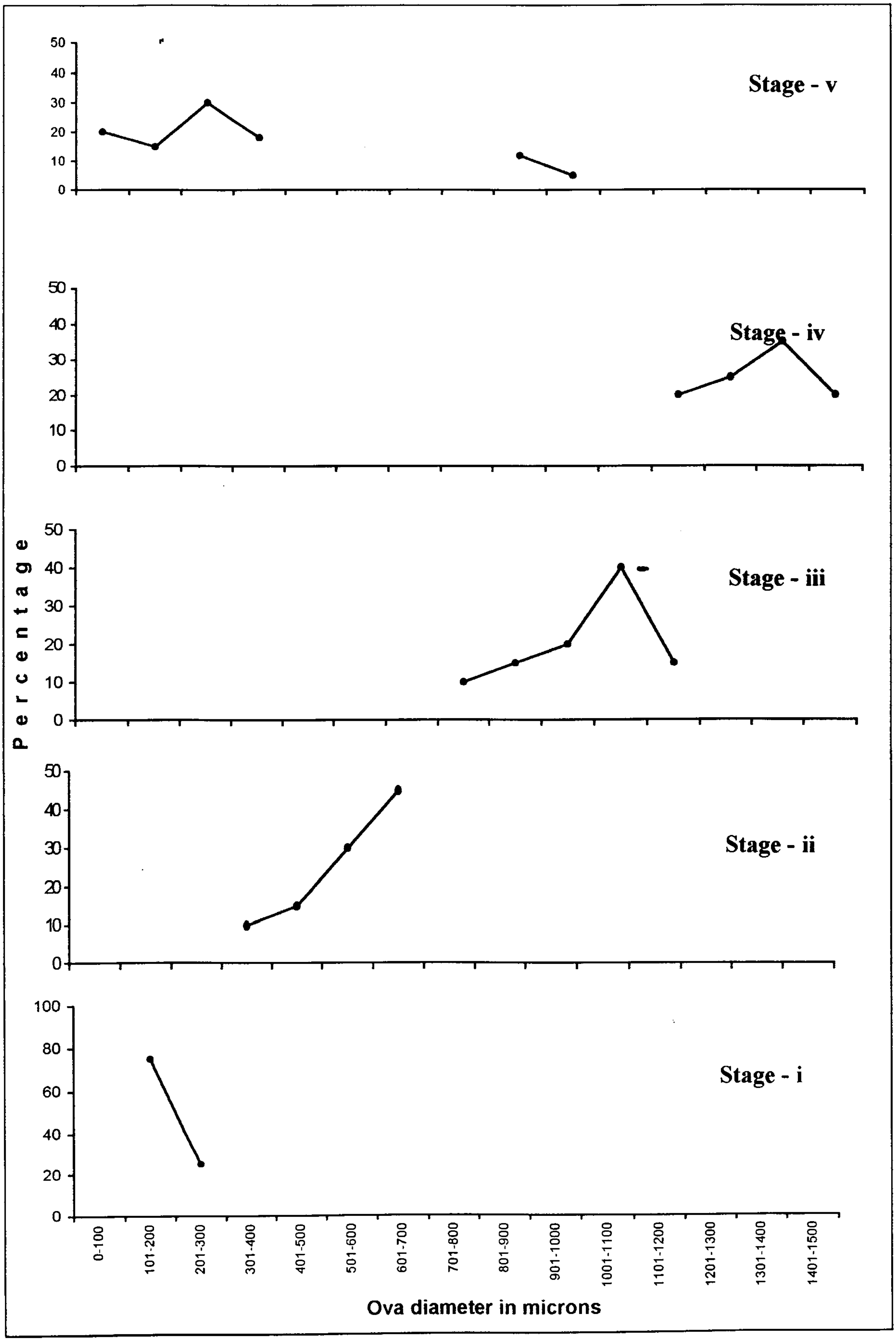


Size at first maturity in *O. bimaculatus* (Bloch) Female

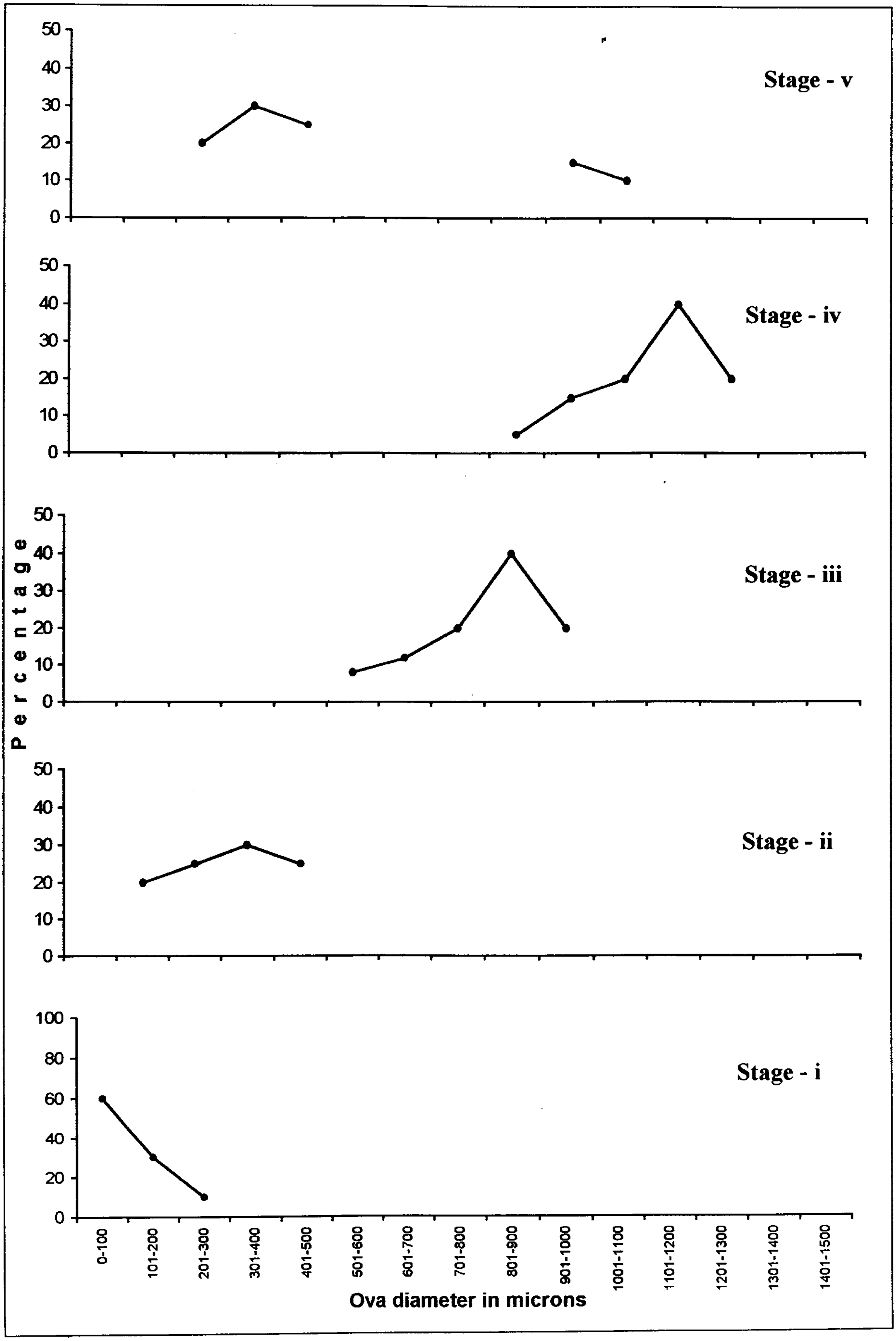
Fig – 6.6



Progression of ova diameter in different maturity stages of *H. brachysoma* (Gunther)
Fig. 6.7

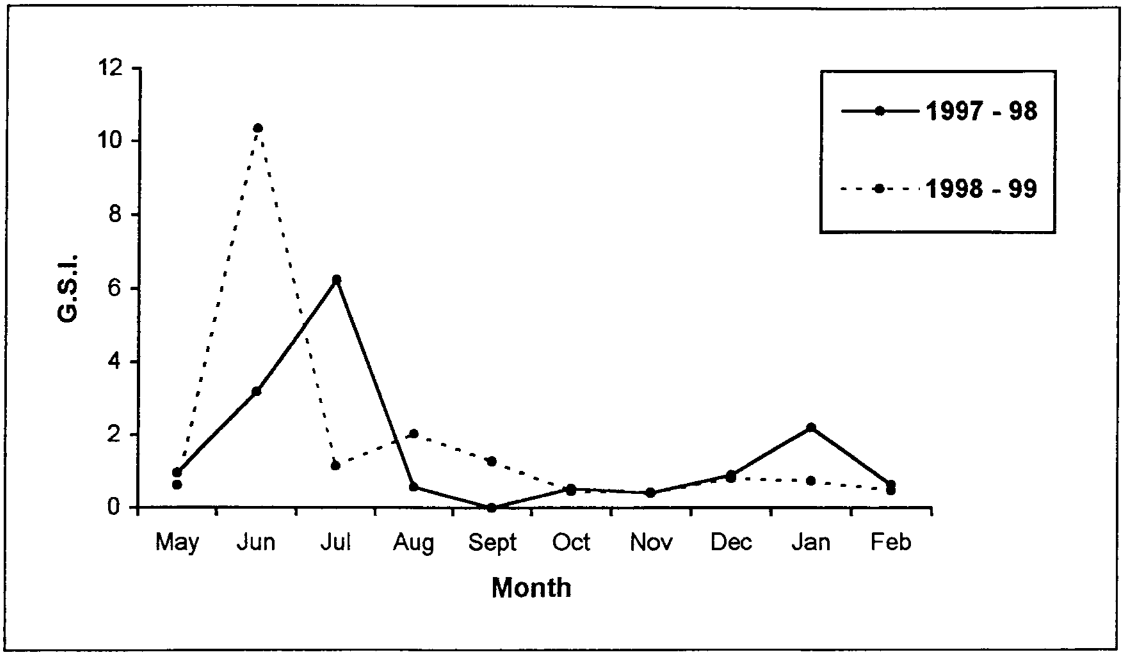


Progression of ova diameter in different maturity stages of *O. bimaculatus* (Bloch)
Fig. 6.8



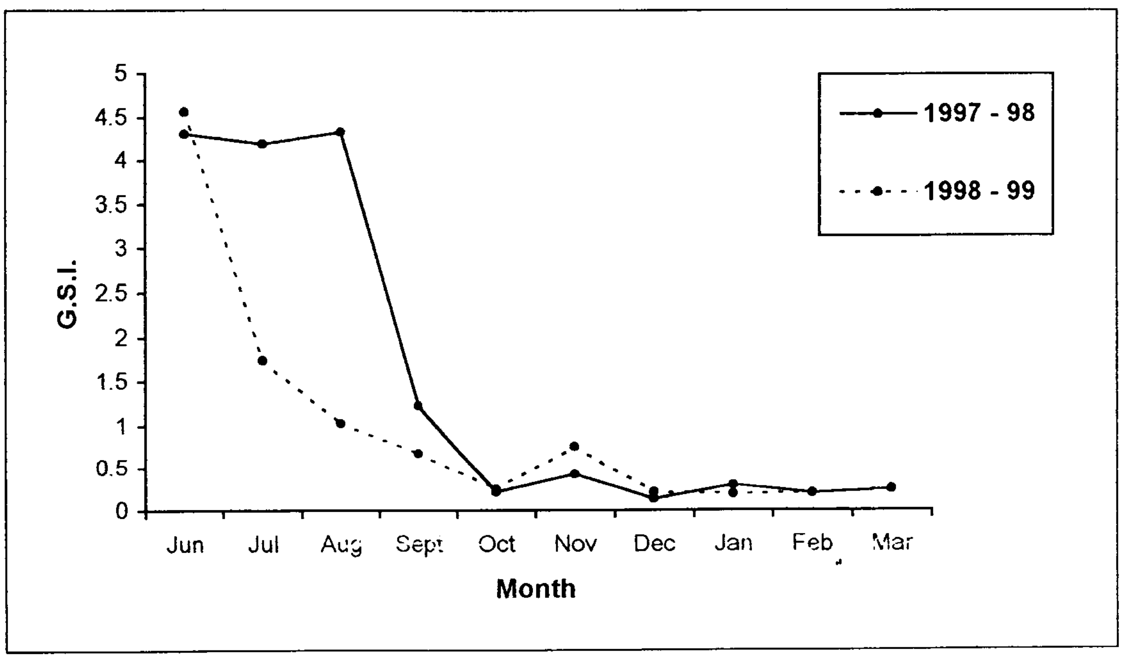
Monthly Average Gonadosomatic Index of
***H. brachysoma* (Gunther) Female**

Fig. - 6.9



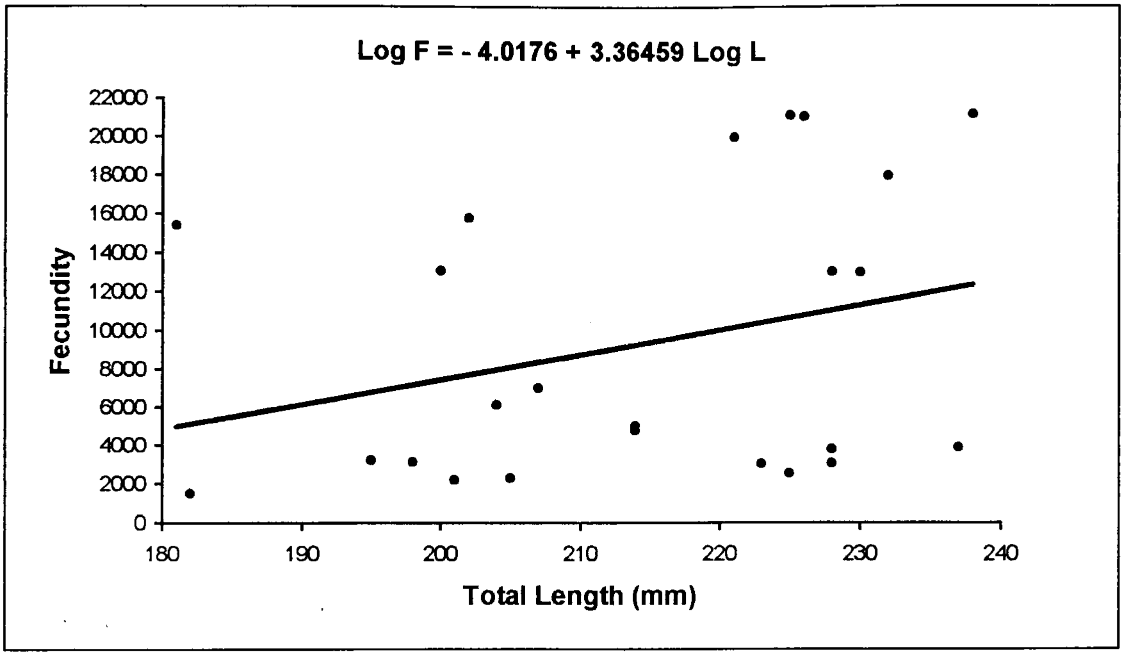
Monthly Average Gonadosomatic Index of
***O. bimaculatus* (Bloch) Female**

Fig. - 6.10



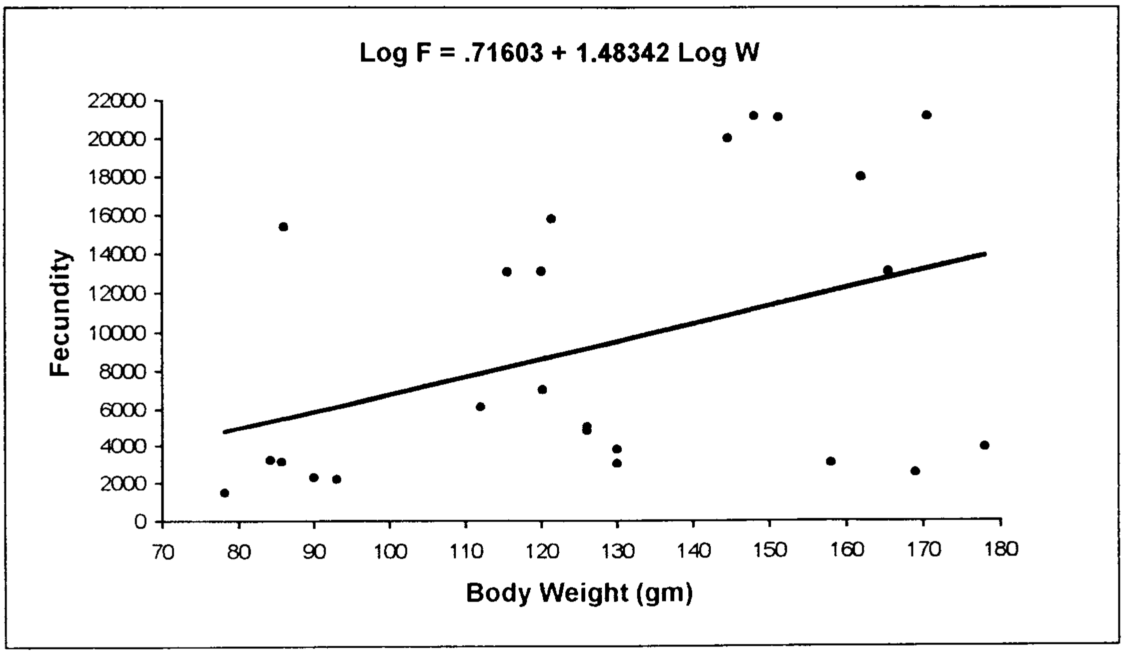
Relationship between Fecundity and Total Length in
H. brachysoma **(Gunther)**

Fig. - 6.11



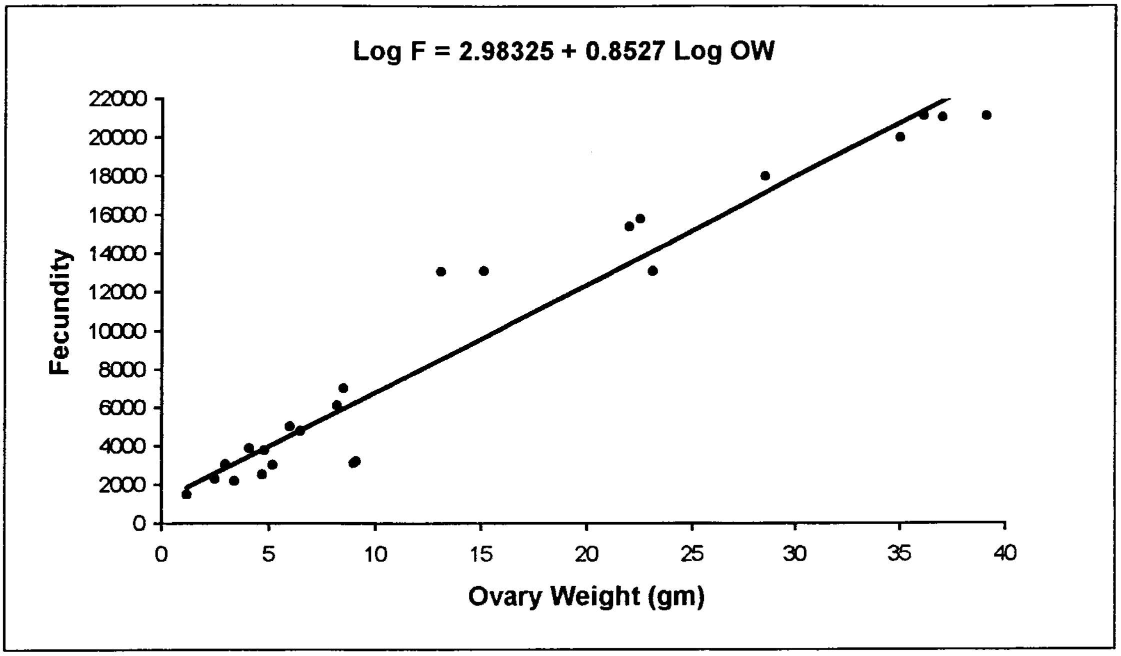
Relationship between Fecundity and Body Weight in
H. brachysoma **(Gunther)**

Fig. - 6.12



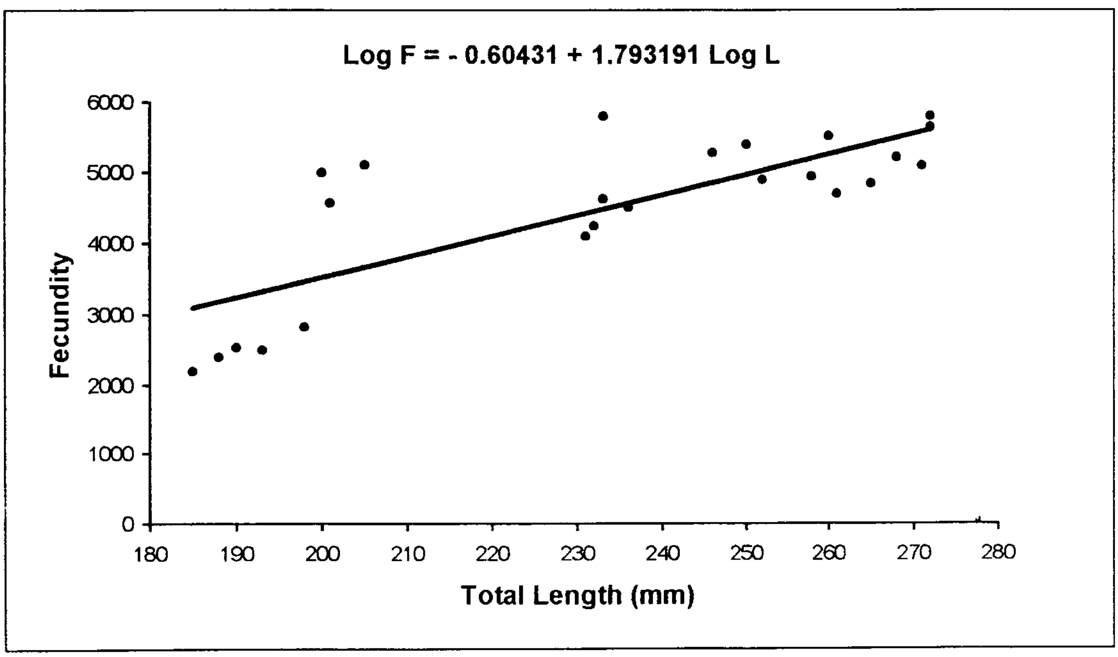
Relationship between Fecundity and Ovary Weight in *H. brachysoma* (Gunther)

Fig. - 6.13



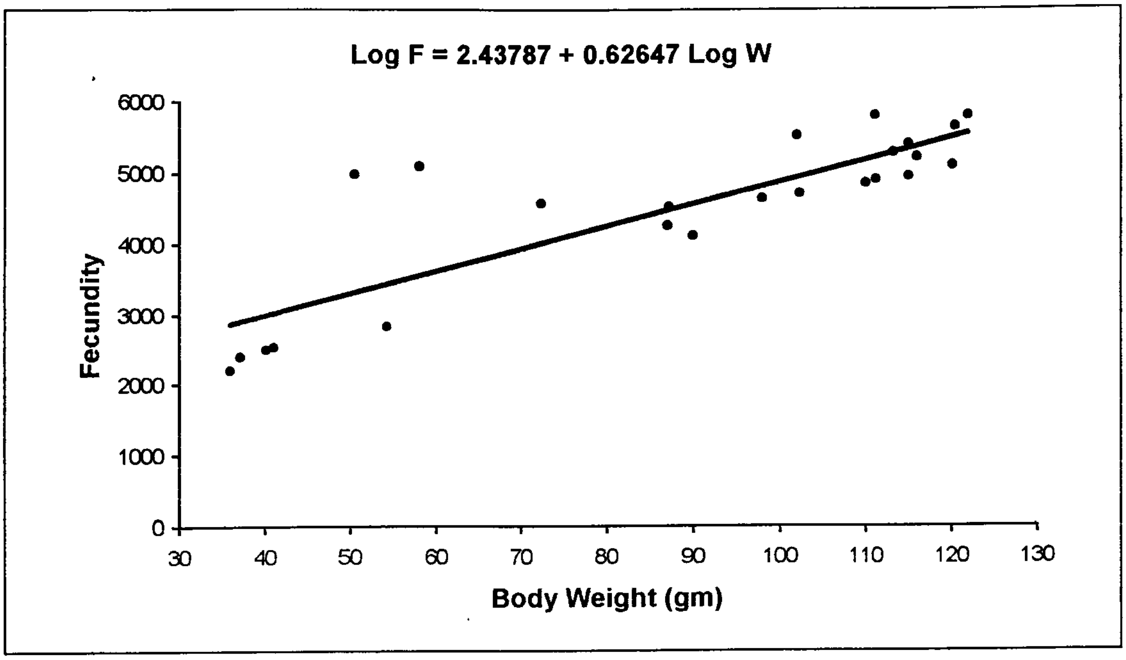
Relationship between Fecundity and Total Length in *O. bimaculatus* (Bloch)

Fig. - 6.14



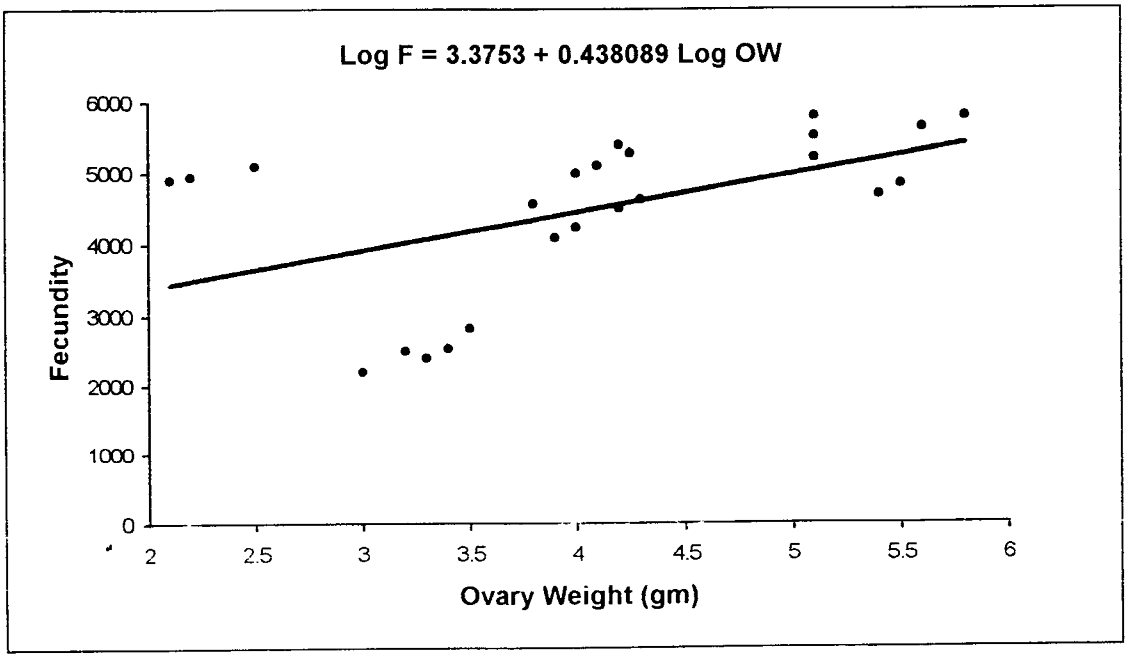
Relationship between Fecundity and Body Weight in *O. bimaculatus* (Bloch)

Fig. - 6.15



Relationship between Fecundity and Ovary Weight in *O. bimaculatus* (Bloch)

Fig. - 6.16



SUMMARY

CHAPTER - VII

SUMMARY

The present study deals with the systematics of edible catfishes of inland waters of Central Kerala and the bionomics of two important species of catfishes of the area, *Horabagrus brachysoma* (Gunther) and *Ompok bimaculatus* (Bloch). Catfishes in general are scaleless fishes with strong dentition and long barbels. They belong to the order Siluriformes. All are edible fishes and they occur from hillstreams to sea. The present work is based on the analysis of regular samples collected during May 1997 to March 1999 from the rivers and kolelands (flooded paddy fields) of the area. The entire work is analysed in six chapters and the contents of each chapter are briefly described below:

CHAPTER - I : GENERAL INTRODUCTION

A short account of fishes, their role in the diet of man and the importance of fishery science are described. Some common features of catfishes and their importance and scope in aquaculture are also mentioned. A review of literature on the systematics and biology of catfishes from Indian waters and abroad is given in detail. The necessity to undertake a detailed study on the systematics and biology of edible catfishes of Central Kerala is also mentioned.

CHAPTER – II : SYSTEMATICS

The systematic position of twenty one species of catfishes commonly found in the area has been reviewed. They are *Aorichthyes seenghala* (Sykes), *Horabagrus brachysoma* (Gunther), *Mystus armatus* (Day), *Mystus oculatus* (Valenciennes), *Mystus gulio* (Hamilton – Buchanan), *Mystus punctatus* (Jerdon), *Mystus cavasius* (Hamilton – Buchanan), *Mystus montanus* (Jerdon), *Wallago attu* (Schneider), *Ompok bimaculatus* (Bloch), *Ompok malabaricus* (Valenciennes), *Clarias dussumieri* (Valenciennes), *Clarias batrachus* (Linnaeus) *Clarias gariepinus* (Burchell), *Heteropneustes fossilis* (Bloch), *Osteogeniosus militaris* (Linnaeus), *Arius subrostratus* (Cuv & Val), *Arius tenuispinis* (Day), *Arius caelatus* (Valenciennes), *Arius arius* (Hamilton – Buchanan) and *plotosus lineatus* (Thunberg). The morphometric characters of the species studied are also given. A key to the families, genera and species of these catfishes are prepared and presented.

CHAPTER – III : FOOD AND FEEDING

The food and feeding habits of *H. brachysoma* and *O. bimaculatus* based on collections from the various inland water bodies were studied and the results compared. The total length and weight of each fish was noted and the stomachs were preserved in 5% formalin after noting their weight and the detailed analysis of stomach contents was conducted thereafter by quantitative and qualitative methods. The food items were examined under a binocular microscope and then identified. The percentage occurrence of different food items in different months, sexes and size groups were determined. The stomachs were graded into three groups, 'Heavy', 'Medium', and 'Empty' based on the distention of stomach and the amount of food contained in it. Feeding index was calculated by dividing the number of fish with 'Heavy' and 'Medium' stomach into hundred by the number of fish examined. Feeding rhythm was also worked out by collecting fish samples at 12-hour interval for a period of 24 hours and the condition of gut from each collection was estimated. Gastrosomatic index was calculated using the equation.

$$G.S.I. = \frac{\text{Weight of the stomach}}{\text{Weight of the fish}} \times 100$$

The pharyngeal teeth and their role in feeding was also studied in the two fishes.

The study on the food of *H. brachysoma* and *O. bimaculatus* revealed that the two fishes are carnivorous in nature.

In *H. brachysoma*, crustaceans form the main gut content in both males and females through out the study period. Semidigested food, fat droplets, algal tissues, unidentified animal tissues, prawn, fish scales and miscellaneous items were also found in the gut. The percentage composition of food items do not vary much in males and females and 1 – 15cm and 15 – 30cm size groups. The monthly study of feeding intensity reveals that 'Empty' stomachs outnumber the 'Medium' and 'Heavy' stomachs in this species. Feeding intensity was found to be maximum during July and August. The study of feeding rhythm shows that the fish is slightly more active during night time. Maximum G.S.I. was found in the month of July.

The main food of *O. bimaculatus* is fish as it is found in the gut during most of the months in both males and females. The other gut inclusions were same as that of *H. brachysoma.* The percentage composition of different items of food does not vary much in the males and females of this species except prawn, crustacean fragments and algal tissues. Similar to *H. brachysoma,* in *O. bimaculatus* also 'Empty' stomachs were more noticed in the samples, which prove the carnivorous nature of the fish. Compared to younger group, adult fishes had more number of 'Empty' stomachs. Monthly study of feeding intensity shows that 'Heavy' stomachs were maximum in the month of September. *O. bimaculatus* shows some feeding rhythm. The fish is found to be more active during daytime contradictory to *H. brachysoma,* which is revealed by the higher gastrosomatic index during day. Monthly studies of G.S.I. show that *O. bimaculatus* had maximum G.S.I. in September. Pharyngeal teeth are well developed in both the species of fishes.

CHAPTER – IV : AGE AND GROWTH

Age and growth of *H. brachysoma* and *O. bimaculatus* were studied by counting the number of periodic rings or zones on the skeletal structures such as otoliths, opercular bones and the vertebrae and also by the eye lens studies. The fishes were examined and the total length, weight, sex and stage of maturity were noted for each fresh specimen. The left opercular bone, left otolith and the vertebrae were removed. Eye lens were removed from both sides of the fish and their diameter and weight were recorded. The otoliths of *H. brachysoma* were ground and made thin, while otoliths of *O. bimaculatus* were kept in glycerine for a week for clearing before counting the number of rings. Otoliths of both the fishes were examined in glycerine under the microscope and observed the rings. Similar, but faint rings were noticed in the operculum and vertebrae also. On the assumption that each of these rings in the otolith is formed annually, the translucent rings were counted and the number of these rings was taken to be the age of the fish in years. In *H. brachysoma,* fish upto three rings were observed.

The mean total length of *H. brachysoma* with one, two and three rings in males was 164.4, 226.8 and 252 mm and in females 180, 225.7 and 251 mm respectively. Regression of total length on otolith radius of the fish showed a linear relationship for both males and females. The Lee method was followed for back calculating body length from prior annuli. In *O. bimaculatus* fishes with either one ring or two rings were only observed and the mean total length in males with one ring and two rings were 159.2mm and 198.3mm and in females 196mm and 226.9mm respectively. Regression of total length on otolith radius showed a linear relationship in both sexes of *O. bimaculatus.*

Eye lens studies of *H. brachysoma* and *O. bimaculatus* show that in both fishes, eye lens weight and diameter increase with increase in total length and age of fish, eventhough there was overlap between the values of the various age groups. Regression studies showed a linear relationship between total length and eye lens diameter and weight in both the fishes.

CHAPTER – V : LENGTH – WEIGHT RELATIONSHIP AND RELATIVE CONDITON FACTOR

The study of length – weight relationship was based on 193 specimens of *H. brachysoma* (87 males and 106 females) and 170 specimens of *O. bimaculatus* (80 males and 90 females). The length – weight relationship was determined separately for males and females of both the fishes using the parabolic formula $W = aL^b$. The values obtained for *H. brachysoma* were

Males : $W = 0.00001365 \times L^{2.971594}$

Females : $W = 0.000008343 \times L^{3.072898}$

Pooled : $W = 0.000010689 \times L^{3.022459}$

The length – weight relationship in *O. bimaculatus* was

Males : $W = 0.000008854 \times L^{2.938853}$

Females : $W = 0.000002881 \times L^{3.162504}$

Pooled : $W = 0.000003513 \times L^{3.122595}$

The significance of variation between the regression coefficients of both sexes was tested by subjecting to analysis of covariance and it is found that the values were statistically highly significant in both fishes. 't' test was conducted to test the significance of variation of regression coefficient from the expected value of 3 using the formula.

$$t = \frac{b - B}{Sb}$$ where B is equal to 3.

The 't' test indicated that the growth in weight is isometric in *H. brachysoma* and *O. bimaculatus.*

<u>Relative condition factor</u>

The relative condition factor (Kn) was worked out separately for both males and females of *H. brachysoma* and *O. bimaclilatus* using the formula.

$$Kn = \frac{W}{\hat{W}}$$ where 'W' represents the observed weight $\hat{W}$ represents the calculated weight of the fish obtained from the length – weight relationship. 'Kn' was calculated both monthwise and in relation to size groups. In *H. brachysoma* males, the lower size groups had generally 'Kn' values, less than 1. In females also, 'Kn' values were lesser in lower size groups. Monthly fluctuations were also noticed in this fish. Maximum 'Kn' is found in October. Contradictory to

H. brachysoma, in *O. bimaculatus* comparatively higher values were found in the lower size groups. Monthly studies of 'Kn' in *O. bimaculatus* show that 'Kn' values were low in June, July and March. The value is maximum in September. The variations in 'Kn' value are related to the sexual cycle and the feeding rhythm.

CHAPTER - VI : REPRODUCTION

A total of 208 females of *H. brachysoma* and 182 females of *O. bimaculatus* were used for the study of reproduction. Fish were dissected to record the sex and stage of maturity. Sexual dimorphism was studied in both the fishes. It is found that in *H. brachysoma* males are slightly larger, while in *O. bimaculatus* the females are much larger and heavier than that of males. Ovaries were removed and weighed and classified into 5 maturity stages on the basis of morphological studies. The stages were Stage I – Immature, Stage II – Maturing, Stage III – Mature, Stage IV – Ripe and Stage V – Spent. Diameter of ova at various stages of the ovary were measured by ocular and stage micrometer. Gonadosomatic index was calculated using the formula.

$$\text{G.S.I.} = \frac{\text{Weight of the Ovary}}{\text{Weight of the fish}} \times 100$$

Monthly average G.S.I. was calculated for both the fishes. Maximum G.S.I. was obtained in the month of June in both *H. brachysoma* and *O. bimaculatus* followed by July and August. By observing the maximum G.S.I. and maximum percentage of maturity stages during different months, the spawning season is calculated. It is found that both in *H. brachysoma* and *O. bimaculatus* spawning season is from June to September. The minimum size at maturity of *H. brachysoma* was 215mm total length and that of *O. bimaculatus* was 230mm. The sex ratio was studied in various size groups and in different months. The sex ratio of male and female *H. brachysoma* was 1 : 1.23 and of *O. bimaculatus* was 1 : 1.13. This indicates that females slightly out number the males in both the fishes. Males & females occur in almost all size groups in *H. brachysoma,* while in *O. bimaculatus,* males were present only upto 210mm. Fecundity of 24 specimens of both the species ranging in length from 181mm to 271mm was studied. For estimating fecundity the total number of mature ova were counted. Fecundity varied between 1500 and 21,184 in *H. brachysoma*, while in *O. bimaculatus*, it ranged between 2200 and 5800. The relation between fecundity and length/weight of the fish and ovary weight were determined using the formula $F = CL^n$. (F = fecundity, C is a constant, L is the length in mm / weight in mgm and n is an exponent. Though there were slight variations within the size groups, the fecundity usually increased with increase of body length, body weight and ovary weight. Scatter diagrams were drawn plotting fecundity against these parameters. A straight-line relationship was observed between fecundity and length, weight or ovary weight in both the species of fishes.

LIST OF PUBLICATIONS

LIST OF PUBLICATIONS

- MOLLY KURIAN AND N.D. INASU. 1997. Sexual dimorphism of two inland edible catfishes *Ompok bimaculatus* (Bloch) and *Horabagrus brachysoma* (Gunther). *J. Inland Fish Soc. India.* **29** (2) : 34 – 39.

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