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Ecology, Biology and Fishery of Clupisoma Atherinoides (Bloch) (Cypriniformes:Schilbeidae)Ecology, Biology and Fishery of Clupisoma Atherinoides (Bloch) (Cypriniformes:Schilbeidae)

Begum, Mahbuba

University of Rajshahi

ECOLOGY, BIOLOGY AND FISHERY OF *CLUPISOMA ATHERINOIDES* (BLOCH) (CYPRINIFORMES:SCHILBEIDAE)

A DISSERTATION

SUBMITTED FOR FULFILMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY OF THE UNIVERSITY OF RAJSHAHI

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SUBMITTED BY

MAHBUBA BEGUM B.Sc. (HONS.), M.Sc.

FISHERIES RESEARCH LAB.
DEPARTMENT OF ZOOLOGY
UNIVERSITY OF RAJSHAHI
RAJSHAHI – 6205
BANGLADESH

OCTOBER, 1999

DEDICATED

TO MY

BELOVED PARENTS

DECLARATION

I declare that the present work is original and has not been submitted or published elsewhere in part or full for any degree or prize.

Mahbuba Begum
9. 10. 99

October, 1999

Mahbuba Begum
Research Fellow
Department of Zoology
University of Rajshahi
Rajshahi, Bangladesh.

CERTIFICATE

Certified that this is the bonafied research work of Mrs. Mahbuba Begum. The presentation, style, findings and the results which are embodied in this dissertation are the works of her own.

9.10.99

Prof. Dr. M. Abdus Salam Bhuiyan
Department of Zoology
University of Rajshahi.
Rajshahi- 6205, Bangladesh
Research Supervisor

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CHAPTER -3 REPRODUCTIVE BIOLOGY

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ABSTRACT

The physico-chemical condition of the river Padma, ponds and flood plain of the studied areas exhibit more or less variations according to the change of month and season. In the study areas, 4 physical and 3 chemical parameters have been considered. The occurrence of *Clupisoma atherinoides* was influenced by physico-chemical factors mainly, temperature, turbidity, p^H, dissolved oxygen and free carbondioxide. The two years' mean values of these parameters were recorded.

The juvenile and adult of *C. atherinoides* is mainly a carnivorous fish. Its food consists mainly of crustaceans, insects, rotifers, protozoans, algae, debris and detritus. The juvenile and adult *C. atherinoides* are surface feeders. Monthly variations in the percentage composition of the food items in the different stages of the fish were recorded. The fish changed its food and feeding habit seasonally. The feeding intensity was very poor in mature fishes during the spawning period. The immature fishes fed actively throughout the year. The ratio of the total length and alimentary canal length of the juvenile and adult stages of the fish is 1:0.56 and 1:0.61 and it has a shortened alimentary tract. The relationships between the total length and alimentary canal length of the juvenile and adult showed strong linear relationship.

The ovaries of *C. atherinoides* were classified into ten stages. Immature stage, maturing-1 (early developing), maturing-II (late developing), mature, ripe, pre-spawning, spawning, post spawning, spent and resting stage. The ova are also divided into four stages:immature stage, maturing stage, mature stage and ripe stage. The diameters of the ova ranged from 0.042 mm to 0.62 mm. The spawning period extended from May to September. The fecundity ranged from 1,240 to 20,310. The relationships between fecundity with total length, standard length, total weight, gonadal length and gonadal weight were established. The fecundity factor of the species is also provided. The sex ratio of 2100 specimens collected during 24 months of study has been determined. The total male and female ratio was 1:1.15. Females were prominent in natural population of the fish.

The gears used by the fishermen include 3 types of dip nets and one type of trap for fishing of *C. atherinoides*. Fishing of *C. atherinoides* in the river Padma and flood plain area is almost continuous throughout the year. But the entire winter season, the fishing is found in the peak for the species with other small fishes. The fishermen handover their catches to different distant and near markets through a more or less distinguished channel. In between the fishermen and the final consumers there are a few intermediaries. The market price and landing of fish varied in the three surveyed markets. The seasonal price of fishes differed at different markets.

PREFACE

Bangladesh is a riverine country. The inland water areas of the country comprises 1.03 million hectares of rivers, canals and estuaries; 1,14,161 hectares of natural depressions such as the 'beels' and 'haors'; 1,61,943 hectares of ponds and tanks; 5,488 hectares of ox-bow lakes; 68,800 hectares of Karnafuli reservior; 2.8 million hectares of flood plains and 87,300 hectares of brackishwater aquaforms (Rahman, 1989). A total of 260 species of indigenous fin fishes are found in the freshwater and brackishwater habitats of Bangladesh and majority of these fishes are small sized (Rahman, 1989). A total of 133 species of fishes are found in the north-west region of Bangladesh (Bhuiyan *et al.* 1992).

The small indigenous fishes form an important human food item and rich source of complete proteins containing all the essential aminoacids in right proportion. Fish protein is said to be more healthier and cholesterol free and also contains fatty acids which help in cholesterol absorption in the body tissues. The people are advised to take much smaller fish than meat. According to FAO report, (1991), fish contain 72% water, 19% protein, 8% fat, 0.15% calcium 0.25% phosphorus and 0.10% vitamin A,B,C and D. National Household Expenditure survey (NHES) shows that annual fish consumption in Bangladesh peaked in 1985 at 13.2 kg / person, which declined to 12.6 kg / person by 1992. This is in the same agreement with the information developed by North West Area Development Study (NWADS), which shows that the overall fish supply has stagnated, resulting in price increase in real terms of over 2.8% per annum in the Northwest Region (Interim Report Vol. 5, ADB Dhaka, February, 1997).

The small indigenous fishes thus, make a very significant contribution to the daily intake of fish. Moreover, Siddique (1985) reported that in Bangladesh about 80 percent of the population is poor and they mainly depend on small size fish for their daily supply of animal protein at a reasonable price. Another advantages of small size fish is that they easily breed and grow in water bodies, where culture of other major fishes are impossible. However, the ever expanding programme of flood control, drainage and irrigation is interfering with the whole ecological system in fishery resources, thereby causing both loss and degradation of their habitats, which will inevitably lead to diminution and even disappearance of about 95 percent of inland fish production.

Clupisoma atherinoides (Bloch) a small fish forms an important freshwater capture fishery. It has great demand in the market because of its high nutritional value. The fish is eaten by people recovering from illness. The popular belief is that there is a special nutritive and medicinal quality in this fish, which is good for patients and convalescents. Although the fish is commercially highly important, but very little work has so far been done on it. No detailed work has been done on different aspects of the fish except for a short taxonomic study by Day (1878), Ahmed (1953), Bhuiyan (1964), Qureshi (1965), Rahman (1973), Islam and Hossain (1983), Rahman (1989) etc. The present work is a step in the direction of the effort to get as much of information as possible on various aspects of the biology, ecology and fishery of the fish. The work has been divided into 4 parts.

The first part deals with the physico-chemical condition of three types of water bodies (Padma river near Rajshahi, flood plain and pond) to find out some physical parameters viz. air and water temperature, rainfall water transparency and also to find out some chemical parameters viz. p^H , dissolved oxygen (DO), free carbondioxide (CO_2) in water which are the habitats of the fish.

The second part deals with food and feeding habit of the species such as composition of food items, monthly variation in the degree of feeding, seasonal occurrence of various food items, feeding in relation to sexual cycle and the relationship between total length and alimentary canal length.

The third part is the reproductive biology. It deals with the male and female reproductive systems. Developing stages of the ovary and stages of the ova. The reproductive cycle of the fish has been determined using different methods. Fecundity of the fish is estimated. The relationships between fecundity and body lengths and weight and gonadal length and weight has been determined. Fecundity of the individual size group of fish has been estimated monthwise, sex ratio is also determined.

The fourth part deals with the fishery of the species, i.e., gears and fishing method and season, monthwise landing, marketing channel and its activities, marketing margin, marketing costs, profit of intermediaries and seasonal price variation etc.

A FEW WORDS ABOUT *CLUPISOMA ATHERINOIDES* (BLOCH)

Identification

Valid name - *Clupisoma atherinoides* (Bloch)
Local name - Kanta-patasi, Tin kanta, Anaya, Banspati, Batasi, Bataiva

Synonyms:

1794.	*Silurus atherinoides,* Bloch, Nat. Austand. Fische., 8.p.48.
1822.	*Pimelodus angius* and *Urna,* Hamilton. Fishes of the Ganges. pp.177-180.
1878.	*Pseudeutropius atherinoides,* Day, Fishes of India. p.473.
1889.	*Pseudeutropius atherinodes*, Day, Faun. Brit. India, Fish. I. p. 141.
1953.	*Clupisoma atherinoides,* Ahmed, N. Fish fauna of East Pakistan, *Pakistan J. Sci.,* V(I), p.20.
1964.	*Clupisoma atherinoides*, Bhuiyan, Fishes of Dacca. p.72.
1965.	*Clupisoma atherinoides*, Qureshi, Common Freshwater Fishes of Pakistan. p. 33.
1973.	*Pseudeutropius atherinoides* Rahman, A. An aid to the identification of schilbeid cat fishes of Bangladesh, *Bangladesh J. Biol Agri. sci.*, 2(I), p.3
1974.	*Pseudeutropius atherinoides*, Menon, Fishes of the Himalayan and Indo-Gangetic Plains. p.70.
1983.	*Clupisoma atherinoides*, Islam, M.S. and Hossain, M.A. An Account of the Fishes of the Padma Near Rajshahi. *Raj. Fish. Bull-* 1(2):1-31.
1989.	*Pseudeutropius atherinoides*, Rahman. A.K.A., Fresh water fishes of Bangladesh, pp. 181-182

Taxonomy:

Kingdom	Animalia
Sub-Kingdom	Metazoa
Phylum	Chordata
Sub-Phylum	Vertebrata
Super Class	Pisces
Division	Gnathostomata
Class	Osteichthyes
Sub class	Actinopterygii
Super order	Teleostei
Order	Siluriformes (Cypriniformes)
Sub order	Siluroidei
Family	Schilbeidae
Genus	*Clupisoma*
Species	*C. atherinoides*.(Bloch. 1794)

Distinguishing characters:

Shape-size: Body elongated and deeply compressed. Length of head 5 to 5.5, of caudal 5, height of body 4.5 to 5.5 of total length (Bhuiyan 1964). According to Rahman (1989) the total length of the head 4.3-4.6 in standard, 5.4-5.8 in total length. Height 4.0-5.0 in standard; 5.0-6.0 in total length.

Eyes: Eyes situated on the lower surface of the head, its diameter 2.5 to 3 of the length of head.

Fins: Dorsal spine weak and finely serrated posteriorly. The pectoral fin with a strong spine and longer than dorsal spine, stouter and denticulated internally.

Pelvics originate from behind the base of dorsal and six fin rays. Ventral very small. Caudal fin deeply forked. Anal fin long , with 33-40 soft rays. Adipose fin small.

Barbels: 4 pairs of barbels present. Nasal barbel slightly longer than the head, maxillary reach the anal, mandibular pair longer than head.

Scales: Absent.

Teeth: Villiform teeth in narrow bands in jaws, in two widely separated narrow patches on palate. Upper jaw a little longer.

Colour: Colour silvery, greenish along the back with 4 bands along the sides formed by black spot.

Fin rays: D. 1/5-6 ; P_1 . 1/7, P_2. 6; A.33-40.

B.Vi; D_1.1/5-6; D_2.0; p.1/7; V.6; A.33-41 (3/30-38); C.17.

Maximum length: 12.7 cm (Day 1878)

7 cm (Bhuiyan 1964)

8 cm (Rahman 1989)

Longest specimen in the present collection 9.5 cm.

Geographical distribution:

C. atherinoides (Bloch) has a wide range of distribution in the freshwater of Bangladesh, Sind and India (Bhuiyan 1964). It is abundantly available in rivers flood plains, rivulets canals, ponds and ditches of the north western districts of Bangladesh.

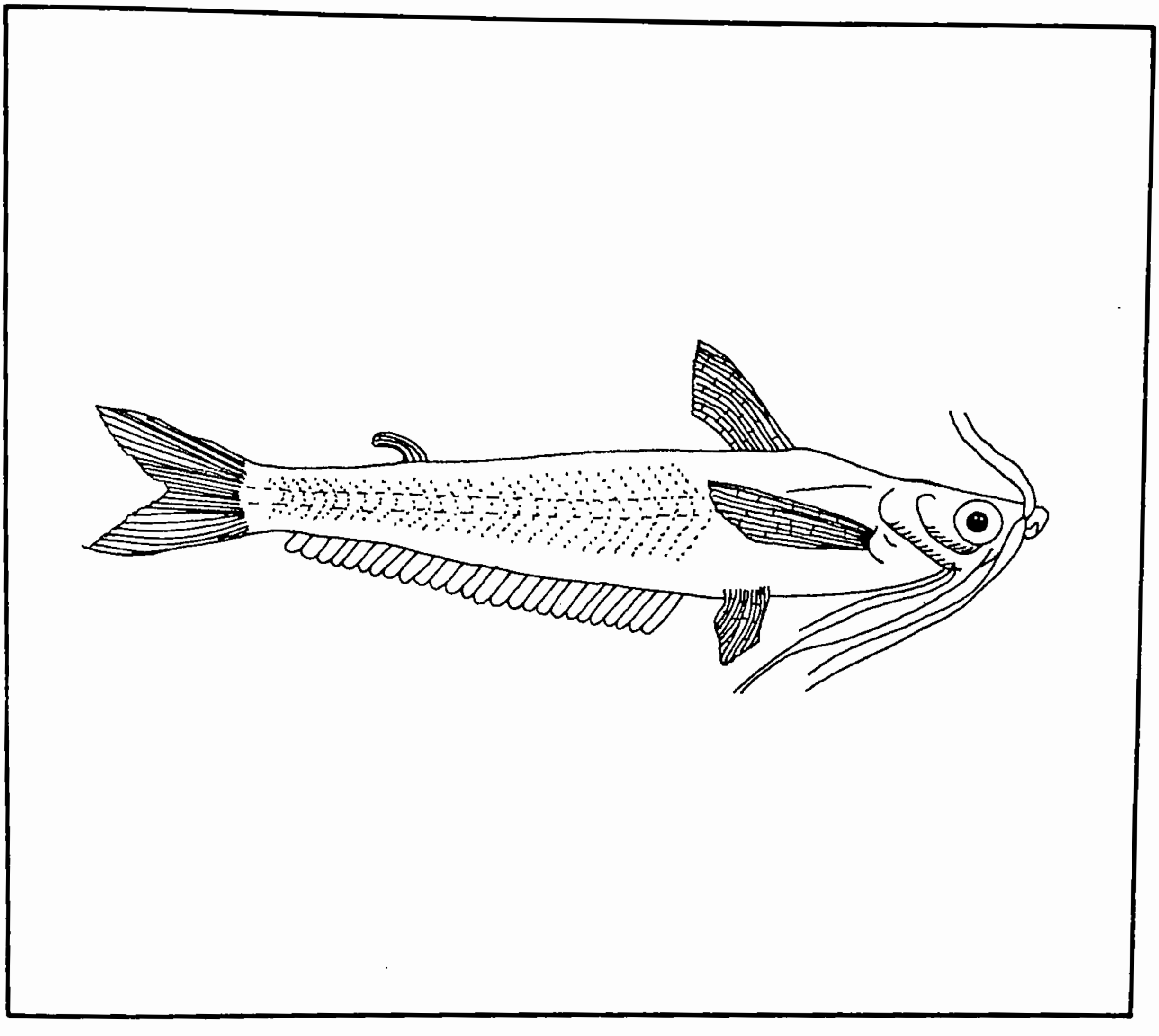

Fig. 1. Clupisoma atherinoides.

REVIEW OF LITERATURE

A large number of literatures are available on the biological works of fishes. Some of the allied references are mentioned below:

Chakraborty *et al.* (1959) observed the abundance, seasonal fluctuations and diurnal variation of plankton in relation to physico-chemical conditions of water in the river Jamuna at Alahabad.

Vyas and Kumar (1968) studied the water conditions of Indrasagar Tank, India. They observed that the periods of high temperature nearly coincided with those of low oxygen content.

Dhawan (1970) studied the hydrobiological factors at Kandla in the gulf of Kutch. He noticed seasonal variation in the temperature, salinity, p^H, dissolved oxygen, inorganic phosphate, nitrate and silicate and their influence on plankton.

Saha *et al.* (1971) worked on the seasonal and diurnal variation in physico-chemical and biological conditions of a perennial freshwater pond of Bangladesh.

Dewan (1973) investigated the ecology of a lake situated at the Bangladesh Agricultural University campus. He stated that the temperature of the air decreased more rapidly than that of water after sunset and ultimately fell below the water temperature. He pointed out that the dissolved oxygen bears an inverse relationship with temperature and free carbon-dioxide; a direct relationship with p^H and total alkalinity and observed the highest values of p^H during summer and winter, and the lowest of the same during monsoon.

Islam *et al.* (1974) studied the physical and chemical factors and their affects upon the general biological condition of the water of the river Buriganga in Bangladesh.

Khalaf and Mac Donald (1975) conducted a hydrobiologcal investigation in the temporary ponds in New Forest. They observed that the p^H of the ponds fluctuated with the change in dissolved oxygen concentration and heavy rainfall which produced an immediate decrease in the p^H of the ponds.

Islam and Mendes (1976) made an observation on the limnology of a jheel in Sher-E-Bangla Nagar in Dhaka.

Chowdhury and Mazumder (1981) conducted a survey on limnology of the Kaptai Lake in Bangladesh. They found that the lake was oligotrophic in nature with acidic to near neutral p^H and low nitrate and phosphate content.

Patra and Azadi (1987) worked on the ecological condition and the planktonic organisms of the Halda river.

Begum *et al.* (1994) observed the physico-chemical parameters of a semi-intensively managed fish pond and noticed fluctuations. The p^H value of the pond water was found to have the lowest variability while carbonate had the highest variability.

Bhuiyan *et al.* (1997) studied the physico-chemical condition in relation to meteorological condition of a fish pond in Rajshahi. They observed that this pond was eutrophic in nature with slightly acidic to alkaline p^H, with high bicarbonate content.

Ehshan *et al.* (1997) made an observation on limnological conditions of the floodplain Halti Beel. They noticed that the p^H values remained slightly alkaline whereas turbidity was found to be higher in the canal.

Ehsan *et al.* (1997) worked on limnology of Chanda beel. They observed that the highest values of dissolved oxygen were recorded in winter and the lowest in summer.

Other workers who worked on the limnology of different water bodies include those of Rockford, 1951; Ruttner, 1953; George, 1964; Verma, 1969; Michael, 1969; Devasy and Gopinathan, 1970; Geisler *et al.* 1975; Mahmood *et al.* 1976; Shafi *et al.* 1978; Ali and Islam, 1983; Ismail *et al.* 1984; Ali *et al.* 1989. Shaha *et al.* 1990 and others.

Mookerjee *et al.* (1946) reported on the food and its percentage composition of the common adult food fishes of Bengal. They observed that the food of *Labeo rohita* consists of algae 35%, higher plants 20%, protozoans 23%, crustaceans 15% and mud and sand 7%.

Hynes (1950) reviewed different methods of food analysis for fishes and stated that if a large number of guts are analysed for food study, result obtained by occurrence, dominance and points methods are approximately the same.

Alikunhi (1952) published a report on the food of young carp fry and found that the fry were mainly phyto-plankton and zooplankton feeders.

Pillay (1952) made a critical review of different methods of food analysis of fishes. He stated that the best method of ascertaining the food and feeding habit of fishes is the examination of its gut contents. In certain fishes, the food of the juvenile may be very much different from that of the adults which makes essential, the study of food of different age group separately.

Misra (1953) observed that *Labeo rohita* was a bottom feeder, *Cirrhina mrigala* a middle feeder and *Catla catla* a surface feeder.

Das and Moitra (1955) studied the food habit of some common fishes of Uttar Pradesh in India and observed that the food of *Labeo rohita* and *Labeo bata* consist of algae, aquatic plants, crustaceans, insects and their larvae and muds and decaying substances. They recorded *Labeo rohita* and *L. bata* as the mid-feeders.

Karim and Hossain (1972) observed that the stomach contents of *Mastacembelus pancalus* included larvae of Lepidoptera, Diptera, Hemiptera and sand grains and debris.

De Silva (1973) noted that the food of *Clupea harengus* and *C. sprattus* comprised mainly crustaceans with copepods contributing the major share.

Lande (1973) recorded that the polychaets were the most important food of plaice, *Pleuronectes platessa* in winter while molluscs were the more important food in summer and autumn.

Doha (1974) studied the food and feeding habit, length weight relationship and condition and breeding habits of *Glossgobius giuris*. He observed that the juveniles were carnivorous and insectivorous, while the adults were piscivorous and molluscs eaters. Cannibalisms were common in both the juveniles and adults.

David and Rajagopal (1975) described the food and feeding habits of different commercial fishes. They stated that during rainy season, submerged vegetation offers masses of decaying food of the fishes. Grasses and their seeds and the terrestrial insects formed important food items of several fishes.

Dewan *et al.* (1979) published a paper on the seasonal pattern of feeding of juvenile major carp *Labeo rohita* in Bangladesh and observed that the change in volume of food of *Labeo rohita* occurs with the change of season. Amount of food consumed was higher in warmer months and was lower in winter. Animal food was not consistently taken by the fish.

Dewan and Saha (1979) studied the seasonal pattern of feeding of *Tilapia nilotica* and found that the fish is a continuous feeder. The fish showed seasonal variation in feeding activity. The feeding activity was greater in summer than in winter. A comparatively greater amount of phytoplankton during winter and debris during summer were recorded in the stomach.

Mustafa and Ahmed (1979) described *Notopterus notopterus* as a predominantly carnivorous, column feeder which consumed mainly protozoans, crustaceans, algae, insects and small quantities of other food items.

Mustafa *et al.* (1981) studied the seasonal patterns of feeding of the fresh water fish *Colisa fasciata* (Bloch). Among the major food items, the fish was found to prefer algae in winter, insect in summer, diatoms and protozoans in autumn.

Bhuiyan and Islam (1988) observed that *Xenentodon cancila* is piscivorous and surface feeder mainly feeding on the major carp fry, minor carps and other fish fry.

Bhuiyan and Islam (1991) recorded that the fishes, crustaceans, protozoans and insects were the most important food items of *Ompok pabda*.

Alam *et al.* (1994) reported that the stomach contents of *Ailia coila* include crustaceans (17.89%), insects (12.42%), fishes (15.95%), annelids (4.54%), algae (8.37%), plant parts (10.05%), debris and detritus (8.94%), and sand and mud (17.29%).

Bhuiyan *et al.* (1997) observed that *Clupisoma atherinoides* is a carnivorous fish and the most important food items are the crustaceans, insects, protozoans, and rotifers.

Bhuiyan *et al.* (1998) studied the food and feeding habit of *Puntius gonionotus* (Bleeker). They observed that *P. gonionotus* is a planktivorous fish.

Besides, a large number of workers studied the food and feeding habits of different fishes some of which are: Hunt, 1952; Frost, 1954; Darnell and Meirotto, 1962; Bhuiyan, 1964; Doha and Haque, 1966; Zisman *et al.* 1974; Shafi and Mustafa, 1976; Jhingran, 1977; Ali and Islam, 1981; Bhuiyan and Haque, 1984; Nargis and Hossain, 1987; Bhuiyan, 1987; Bhuiyan and Islam, 1990; Hossain *et al.* 1990; Bhuiyan *et al.* 1994; etc.

Alkunhi (1953) made observations on the sexual maturity, fecundity, larval development and early growth of *Labeo bata.*

Thomson (1959) worked on the fecundity of the arctic char, *Salevelinus alpinus* and observed that the fish has high fecundity.

Harry (1959) studied the time of spawning, length of maturity and fecundity of the English and Dover soles and noted that the spawning season of these fishes is from November to February, with peak in December and January. The fecundity of English sole was 498,000 in the left ovary and 684,000 in the right ovary.

Desai (1973) studied the maturity, fecundity and larval development of *Tor tor* from the river Narmada and observed that the breeding of the fish commenced in July and continued intermittently till February-March. The fish lived in succession at different times exhibiting prolonged breeding. The peak breeding was observed in July to September. The fecundity of the matured fish varied from 9,330 to 1,35,470.

Tautz and Groot (1975) made a detailed account on the spawning behaviour of chum salmon and rainbow trout.

Blake (1977) described a method for the assessment of fecundity in mormyrid fish and derived a trimodal egg size distribution in the mature prespawning ovary. These modes represented one oocyte and two ova components.

Das (1978) worked on the maturity and spawning in *Mugil cephalus* in Goa waters. He observed that the males of this species matured earlier than the females. He identified six stages of maturity from the ova diameter. The spawning season lasted from September to February with a peak in October.

Nazioka (1979) made observations on the spawning seasons of East African reef fishes. He observed that the spawning of these fishes occurred throughout the year, with 2 peaks in January to March and September to November. The highest peak of breeding was in October.

Bhuiyan and Rahman (1982) worked on the fecundity of *Channa gachua* and recorded the number of ova varying from 487 to 4,482 with a mean of 2,307.

Afroze and Hossain (1983) published a paper on the fecundity and sex-ratio of *Amblypharyngodon mola* (Hamilton).

Islam and Hossain (1984) observed that the fecundity of chela, *Oxygaster bacaila* ranged from 7,146 to 33,997 ova in specimens varying in length from 85 mm to 152 mm.

Bhuiyan and Bhuiyan (1987) worked on the fecundity of *Channa striatus* and recorded the number of ova varying from 1,450 to 23,400.

Afroze and Hossain (1990) studied the sexual maturity and spawning season of *Amblypharyngodon mola*. They observed that the breeding season of the fish extends from May and continue till October. August is the peak breeding season.

Bhuiyan and Islam (1990) worked on the fecundity of *Xenentodon cancila*.

Islam and Hossain (1990) made observations on the fecundity and sex-ratio of the common punti, *Puntius stigma*. They recorded that the fecundity of this fish ranged from 2,475 to 14,461.

Bhuiyan *et al.* (1993) found that the fecundity of *Aspidoparia morar* which varied from 1,431 to 9,223. They observed that the same sized fish possessed widely different number of eggs in their ovaries. For instance, five specimens of *A. morar* had the length of 115 mm each but the fecundity were 3317, 3416, 5995, 8899 and 9223 respectively.

Parween *et al.* (1993) observed that *Esomus danricus* breed from March to July, with a peak in the months from April and May.

Hoque and Hossain (1993) observed that the fecundity of the freshwater cat fish *Mystus vittatus* ranged from 2,534 to 60,746 ova in specimens varying in length from 92 mm to 116 mm.

Alam *et al.* (1994) published a paper on the fecundity of *Ailia coila* (Hamilton-Buchanan) from the river Padma near Rajshahi.

Bhuiyan *et al.* (1995) worked on the fecundity of the fresh water fish *Colisa fasciatas* (Bloch) and they observed that the fecundity of this fish ranged from 45265 to 31527.

Bhuiyan and Afrose (1996) studied the fecundity and sex-ratio of *Oreochromis nilotica*. The fecundity of the matured fish varied from 290 to 1265 and the male and female sex ratio was 1:1.31.

Fatema *et al.* (1997) made observations on the breeding periodicity of *Oxygaster bacaila*. They suggested that *O. bacaila* breed from April to August with the peak in June and July.

Other notable works on the breeding habits, maturity, fecundity, life history etc. of different fishes include those of Simpson, 1951; Lagler, 1956; Pantulu, 1963; Bhatnagar, 1964; Islam and Talbot, 1968; Evans, 1969; Doha and Hye, 1970; 1972; Shafi and Quddus, 1974; Das, 1977; Mustafa *et al.* 1982; Bhuiyan and Rahman, 1984; Islam and Hossain, 1986; Nargis and Hossain, 1988; Hossain *et al.* 1991, 1992; Alam *et al.* 1997. etc.

Kohls (1970) studied the marketing of agricultural products.

Bucksimiar (1977) observed the problem of transport and marketing of marine fishery products and their remedy.

Sabur and Rahman (1979) made on observation marine fish marketing in Bangladesh.

Mazid *et al.* (1997) worked on gear selectivity study of flood plain fishery in Bangladesh.

Sharker (1977) studied the marketing of marine fisheries products.

CHAPTER-1

ECOLOGY

INTRODUCTION

Bangladesh abounds in a large number of rivers, rivulets, ponds, ditches and beels. The biological activities of any kind of aquatic organism are closely related to the physico-chemical condition of the habitat concerned. The present study area comprised the mighty river Padma and adjacent flood plain areas (beel) and ponds which are the habitats of *C. atherinoides*. This species is available more in flood plain area (beel). The production and availability of fish depends on the physico-chemical conditions of the water in which they live. Different environmental factors which determine the characters of water have great importance upon the growth, maturity, reproduction and development of fish.

The relationships between the fish, their biotic and abiotic factors are not isolated phenomenon but changes of one may reflect on the other. Fishes are more dependent on water temperature, turbidity, p^H, dissolved oxygen, free carbondioxide, alkalinity and some salts for growth and development (Nikolsky, 1963). Any change of these parameters may affect the growth, development and maturity of fish (Nikolsky, 1963; Jhingran, 1983).

Up to date, numerous works on the limnology of impounded water of lentic type including ponds, lake or reservoir and few works in lotic environment which included the rivers like the Brahmaputra, the Bhairab, the Halda, the Karnafully, the Meghna including few works in the estuarine water have been done in Bangladesh. But no research work is available on the physico-chemical condition of the fresh water habitat of lotic type including rivers tributaries, rivulets and flood plain in relation to biology and fishery of fish. Some fragmentary works related to physico-chemical parameters of different rivers, tributaries, flood plains, estuaries and coastal areas of lotic type have been done by workers like Rockford (1951), Dutta *et al.* (1954), Chakraborty *et al.* (1959), Devasy and Gopinathan (1970), Jana and Sarker (1971), Islam *et al.* (1974), Mahmood *et al.*, (1976), Shafi *et al.*, (1978), Laal *et al.* (1986), Patra and Azadi (1987), Shaha *et al.*, (1990), Ehshan *et al.* (1997) etc.

The present investigation was carried out to know the physico-chemical condition of three type of water bodies such as the river Padma, flood plain and pond which are the habitats of the fish.

MATERIALS AND METHODS

The study on the physico-chemical condition of the river padma, flood plain area (beel), and pond which are the habitat of *C. atherinoides* was carried out for a period of two years' (1st year June, 1995 to May 1996, 2nd year June, 1996 to May 1997). Except in the flood plain areas no collection was made in the month of March to May because there was no water in the area. Water samples were collected fortnightly from the aforesaid areas. Samples from all areas were collected in all the months of the year.

The water temperature was recorded with mercury thermometer (-1° to 50°C) on the sampling spot. The monthly meteorological recorded data on the air temperature, rainfall were collected from the Meteorological Department, Rajshahi.

The chemical analysis of water sample was done at the sampling spot with the help of a water quality checker (WQC-20A, Japan). The p^H was recorded with the help of a p^H Tester 2TM (Singapore). Dissolved oxygen (DO) was determined by using azide modification of Winker's method (APHA, 1989) and free carbondioxide (CO_2) was measured by titration method with N/44 NaOH soln, using phenolphthalein as indicator (Welch, 1948). Water transparency was recorded by using Seechi disc.

RESULTS AND OBSERVATIONS

The physico-chemical condition of the river Padma, flood plain area (beel) and pond exhibit more or less variations according to the change of month and seasons. The results are based on the direct observation and calculated monthly. 2 years' mean values of different physical and chemical parameters are shown in App. Tables (1-6) and Figures (2-7). Besides the mean value and standard deviation of different physico-chemical parameters as recorded from sampling areas are shown in App.Table (1,2,3,4,5,6).

Physical parameters:

Air Temperature:

Air temperature varied considerably throughout the year. The mean values of average day-night minimum and maximum air temperature were recorded as 17.73°C (January) and 32.76°C (May) in the first year's observation and 16.85°C (January) 33.68°C (April) in the second year's observation in the Padma river area (App. Table 1,2,) (Fig.2). The 2 years' mean values of air temperature was observed as 26.12°C.

In pond area the maximum air temperature was recorded as 18.19°C (Jan.) and 33.94°C (May) in the first year's observation and 16.5°C (Jan), 35.2°C (May) in the second year's observation. The 2 years' average air temperature was observed as 26.71°C (App. Table 5-6) (Fig. 6).

In flood plain (beel) areas the minimum and maximum air temperature was recorded as 16.30°C (January) and 29.84°C (June) in the first year's observation and 17.55°C (January), 30.18°C (June) in the second year's observation. (App.Table-3,4, Fig.4). The 2 years' mean value was 25.48°C.

Water Temperature:

Water temperature of the sampling water bodies showed considerable variations throughout the year. The water temperature fluctuated due to the cause of more or less sunny or rainfall condition. The minimum and maximum water temperature of the Padma river was found to vary from 14.25°C in January to 31.07°C in May (App. Table 1) in the first year's observation and 13.5°C in January, 32.26°C in April in second year's observation (App. Table –2. Fig.2). The 2 years' mean values of water temperature was found as 24.49°C.

In flood plain (beel) area the minimum and maximum water temperature are found as 12.53°C in January and 29.32°C in June in the first year's observation and 13.71°C in January, 29.44°C in June in the second year's observation (App. Table-3,4, Fig.4). The 2 years', mean value of water temperature was found as 23.7°C.

The minimum and maximum water temperature of sampling pond was found as 15.68°C in January and 32.45°C in May in the first year's observation and 13.36°C in January 34.58 in May in the second year's observation (App. Table-5,6, Fig.6). The 2 years' mean value of water temperature was found as 25.28°C.

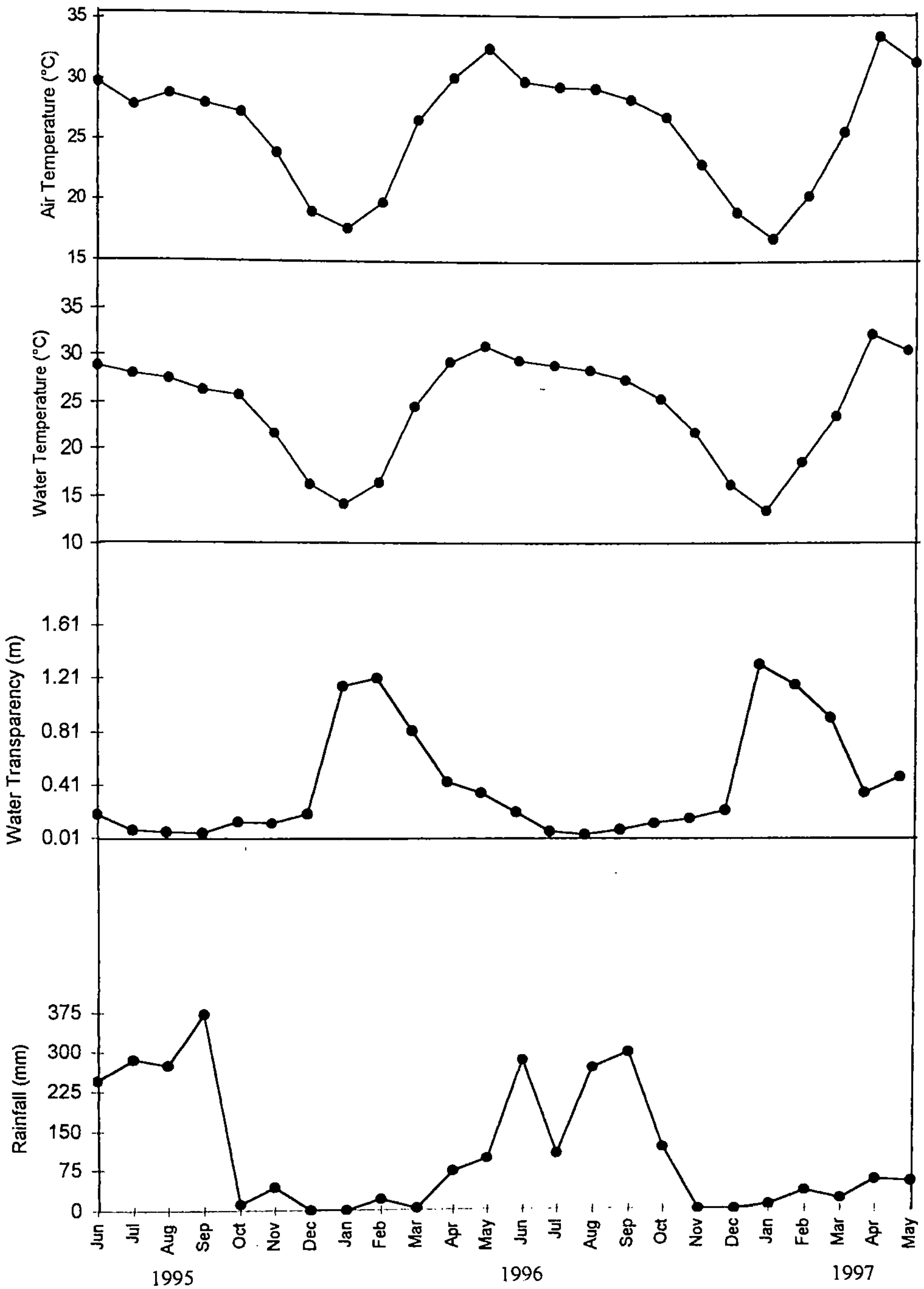

Fig. 2. *C. atherinoides*: Monthly fluctuation of physical parameters of the Padma river near Rajshahi.

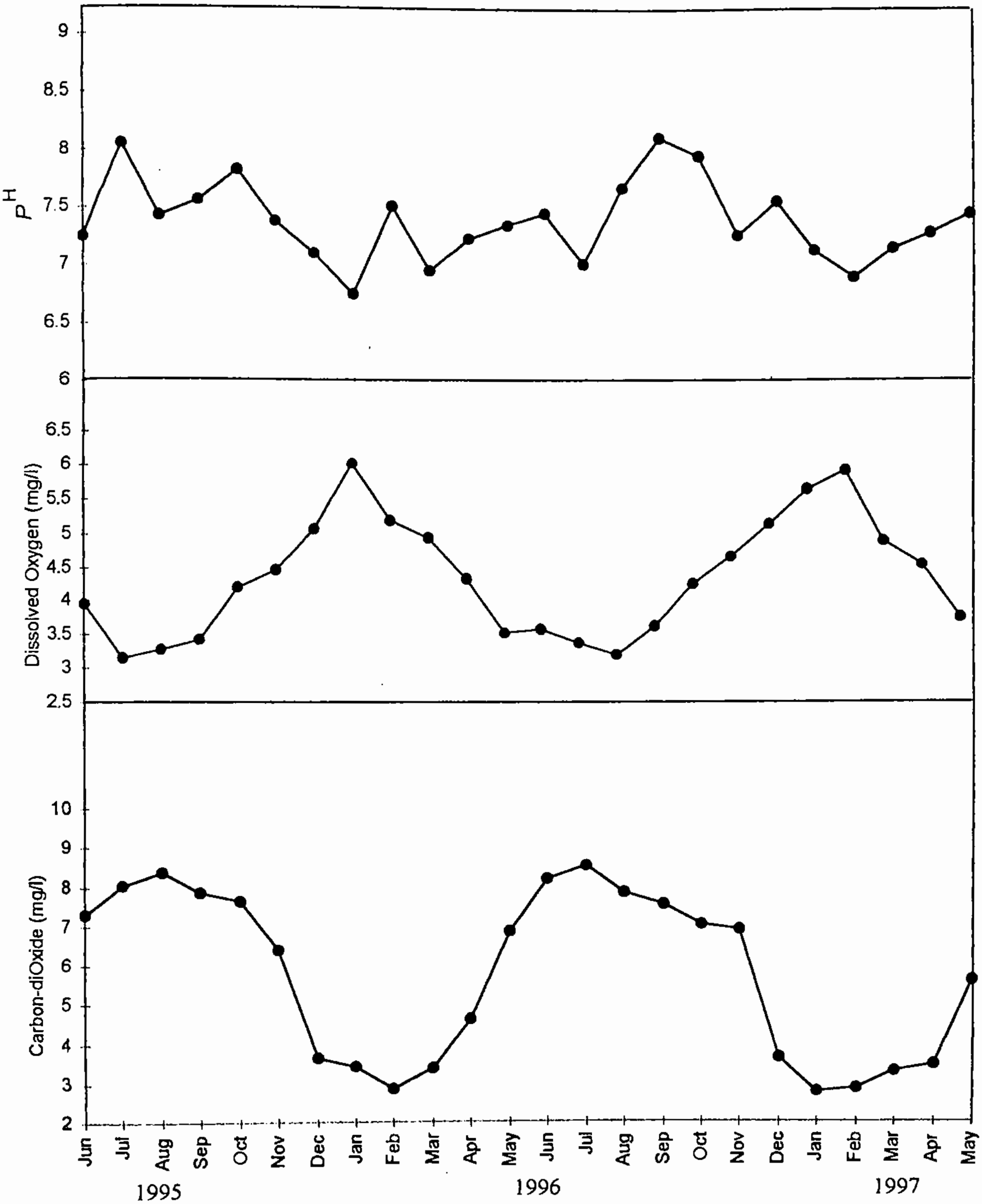

Fig. 3. *C. atherinoides*: Monthly fluctuation of chemical parameters of the Padma river near Rajshahi.

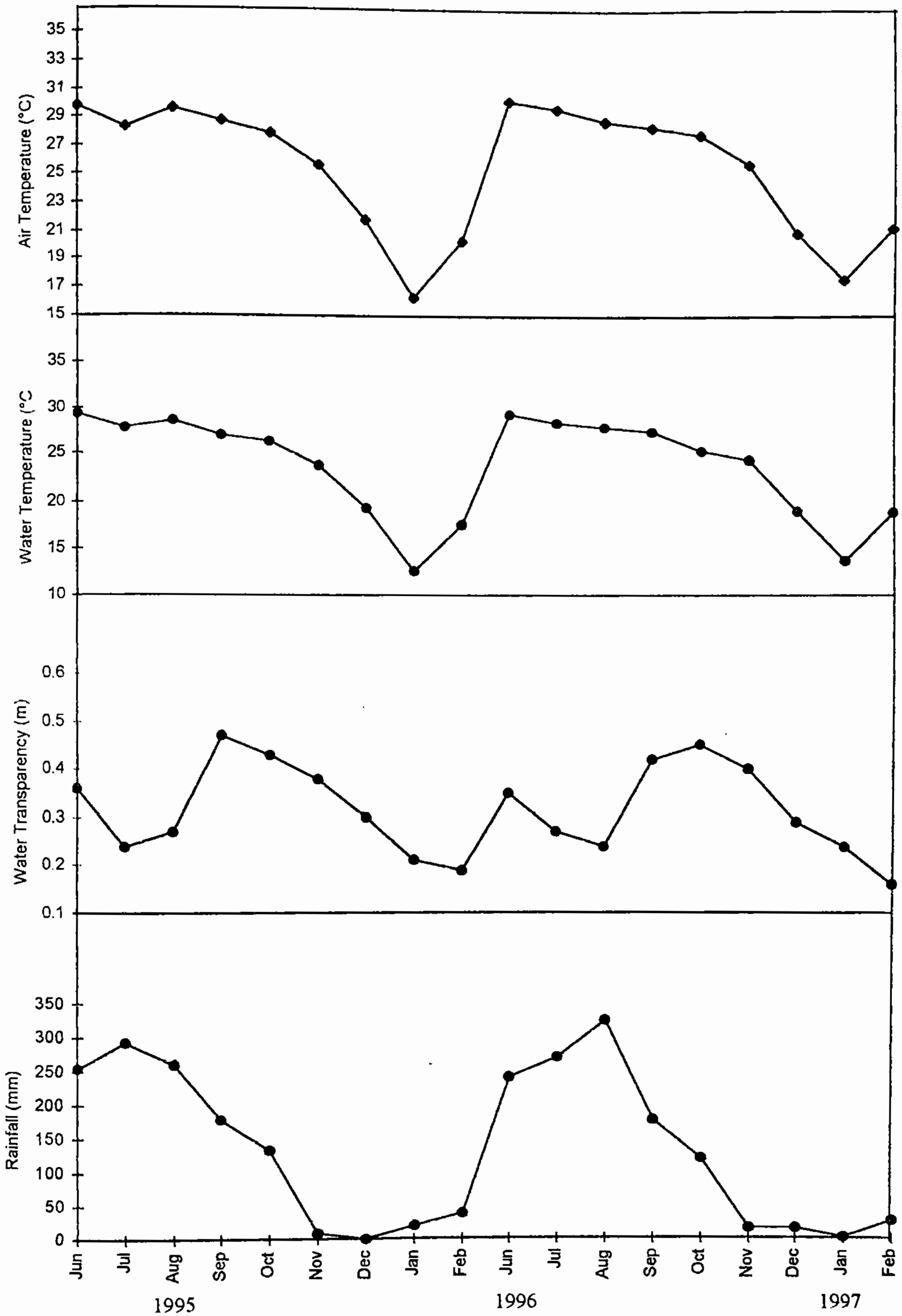

Fig. 4. *C. atherinoides*: Monthly fluctuation of physical parameters of flood-plain area.

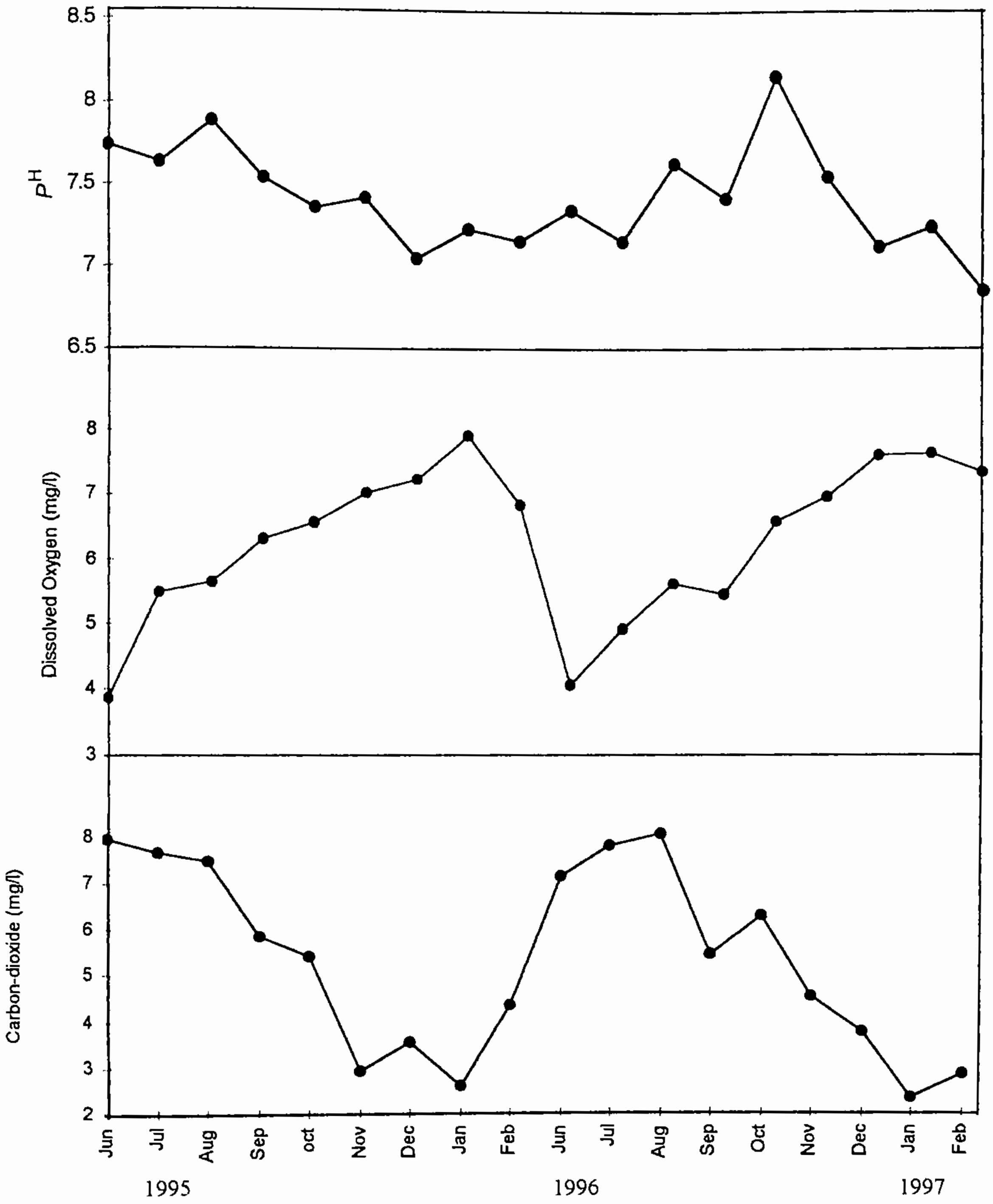

Fig. 5. *C. atherinoides*: Monthly fluctuation of chemical parameters of flood plain area.

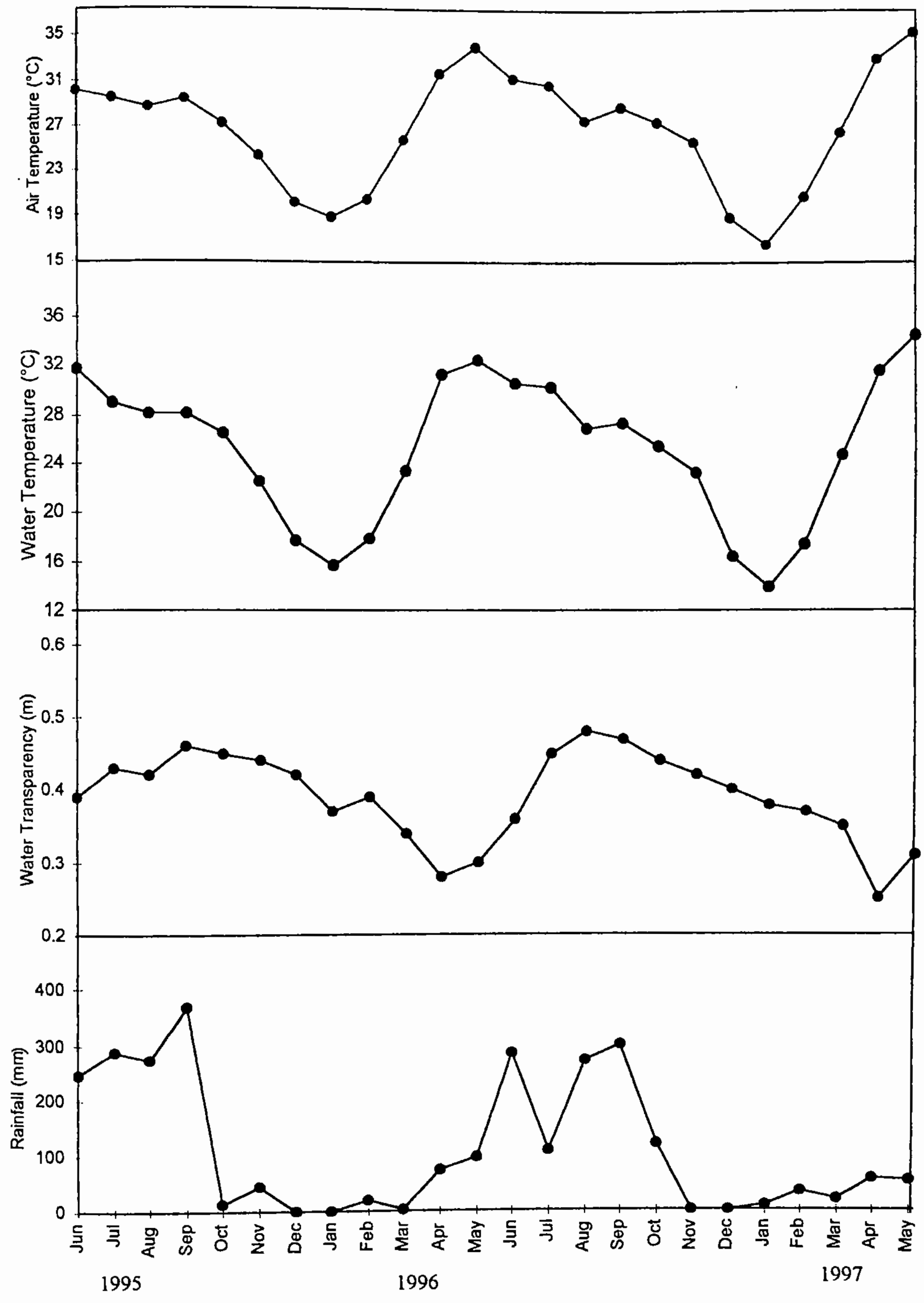

Fig. 6. *C. atherinoides*: Monthly fluctuation of physical parameters of pond.

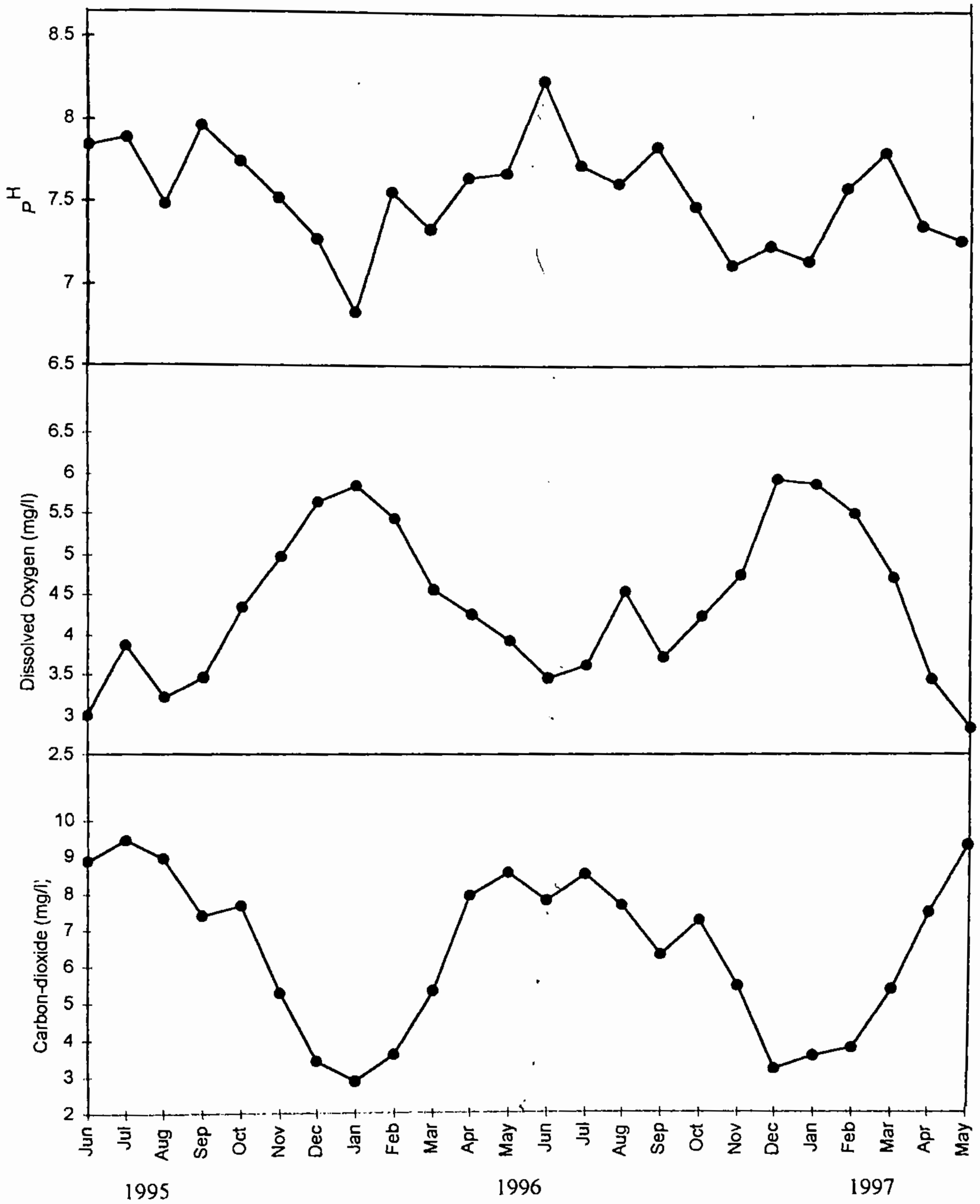

Fig. 7. *C. atherinoides*: Monthly fluctuation of chemical parameters of pond.

Rainfall:

In the study area there is rainfall more or less all the year round. Usually in the winter season rainfall is occasional but in the monsoon or summer season there is frequent and heavy rainfall with gusty wind. In Rajshahi, the minimum rainfall about 1.00 mm was recorded in the month of December while the maximum rainfall about 370 mm was recorded in the month of September and there was no rainfall in the month of January 1996 in the first year's observation. The minimum and maximum rainfall was recorded as 8 mm in January and 298 mm in September respectively. There was no rainfall in the month of November and December in the second year's observation. The 2 years' average rainfall was recorded as 127.33 mm (App.Table-1,2,5,6) (Fig. 2,6).

In flood plain areas the minimum and maximum rainfall was recorded as 0.89 mm in December and 294 mm in July in the first year's observation and 2.00 mm in January and 325 mm in August in the second year's observation (App. Table-3,4 Fig. 4). The 2 years' mean values of rainfall was recorded as 132.77 mm.

Water transparency:

Limits of Secchi disc visibility in the study areas show a marked variation. In the river Padma the monthly mean values of transparency exhibit the maximum 1.21 m in February and the minimum 0.05 m in September in the first year's observation and the maximum 1.32 m in January and the minimum 0.04 m in August in the second year's observation.(App. Table-1,2, Fig.2) The 2 years' mean values of water transparency was found as 0.41 m.

The monthly mean values of water transparency in flood plain areas exhibit the minimum 0.19 m in February and the maximum 0.47 m in September in the first year's observation and the minimum 0.16 m in February and maximum 0.45 m in October in the second year's observation (App. Table-3,4, Fig.4). The 2 years' mean values of water transparency was found as 0.32 m.

In pond the maximum and minimum mean values of water transparency was recorded as 0.46 m in September and 0.28 m in April in the first year's observation and 0.48 m in August, 0.25 m in April (App. Table-5,6. Fig.6) in the second year's observation. The 2 years' mean values of water transparency was found as 0.39 m.

The observation reveals that the water transparency value is mainly due to turbidity caused by the influence of excess accumulation of silts, alluvium, debris, plankton and other suspended materials.

Chemical Parameters:

Hydrogen ion concentration (p^H):

In determining the hydrogen ion concentration of the river Padma it reveals that there is no marked variation in the values of p^H. The maximum mean values of p^H was recorded as 8.06 in July and minimum 6.75 in January in the first year's observation and the maximum mean values of p^H was recorded as 8.12 in September and minimum 6.90 in February (App.Table-1,2 Fig.3) in the second year's observation. The 2 years' mean values of p^H was recorded 7.39 (App.Table-2).

For flood plain areas the minimum and maximum mean values of p^H was recorded as 7.05in December and 7.88 in August in the first year's observation and

6.85 in February 8.15 in October in the second year's observation (App. Table-3,4 Fig.5). The 2 years' mean values of p^H was 7.41.

The minimum mean values of p^H are 6.83 in January and maximum 7.96 in September in the first year's observation and the maximum and minimum mean values are 8.24 in June, 7.12 in November in the second year's observation for pond (App. Table-5,6 Fig.7). The 2 years' mean values of p^H are 7.55.

Dissolved Oxygen (DO):

The dissolved oxygen content of the lotic and lentic water systems are normally affected by some factors such as water current turbidity, temperature, aquatic plant and sunlight as observed in the study areas. The mean values of dissolved oxygen content were recorded as 6.02 mg/l (maximum) in January and 3.15 mg/l (minimum) in July in the first year's observation. The maximum and minimum mean values of dissolved oxygen were 3.21 mg/l in August, and 5.93 mg/l in February respectively in the second year's observation in the river Padma. (App.Table-1,2 Fig.3). The 2 years' mean values of dissolved oxygen content of the river Padma was 4.34 mg/l.

For the flood plain areas the maximum mean values of DO content are recorded as 7.92 mg/l in January and minimum as 3.86 mg/l in June in the first year's observation, and the maximum and minimum mean value of dissolved oxygen were 7.65 mg/l in January and 4.05 mg/l in June respectively in the second year's observation (App. Table-3,4 Fig.5). The 2 years' mean values of dissolved oxygen content of flood plain areas was 6.29 mg/l.

The maximum mean values of DO content are recorded as 5.84 mg/l in January and minimum as 2.98 mg/l in June for pond in the first year's observation and maximum and minimum values 5.92 mg/l in December and 2.83 mg /l in May (App. Table-5,6 Fig.7) in the second year's observation. The 2 years' mean values of dissolved oxygen content of pond was 4.38 mg/l.

Free carbondioxide (CO_2):

The presence of free carbondioxide in flood plain areas is less than in the other studied water bodies. The maximum and minimum values of free carbondioxide were 8.35 mg/l in August and 2.84 mg/l in February in the first year's observation and 8.52 mg/l in July and 2.76 mg/l in January in the second year's observation respectively for the river Padma (App.Table-1,2 Fig.3). The 2 years' mean values of CO_2 was 5.75 mg/l for the Padma river.

The values of free carbondioxide were 7.95 mg/l as maximum in June and 2.57 mg/l as minimum in January for the flood plain area in the first year's observation and maximum and minimum as 8.05 mg/l in August and 2.34 mg/l in December respectively in the second year's observation (App.Table-3,4 Fig.5). The 2 years' mean values of CO_2 was 5.23 mg/l.

For the pond area the maximum values of free carbondioxide were 9.48 mg/l in July and minimum as 2.84 mg/l in January in the first year's observation and maximum, minimum as 9.31 mg/l in May and 3.17 mg/l in December respectively in the second year's observation (App. Table-5,6 Fig.7). The 2 years' mean value was 6.5 mg /l.

Occurrence of *C. atherinoides* in different water bodies:

The occurrence of *C. atherinoides* in Padma river and flood plain areas are almost continuous throughout the year. However the peak period in Padma river and also in flood plain were observed during the monsoon. (June to September). In this time the physico chemical parameters of these water bodies were in favourable condition for the fish. During the monsoon the range of water temperature of river was 26.32°C - 29.52°C and that of flood plain areas was 26.92°C-29.44°C. The range of water transparency of river was 0.04-0.20 m. and that of flood plain was 0.24-0.47 m. The range of p^H value of river was 7.02-8.12 and that of flood plain was 7.15-7.88. The range of dissolved oxygen values of river was 3.15-3.96 mg/l. and that of flood plain was 3.86-6.34 mg/l. The range of free carbondioxide values of river was 7.28-8.52 mg/l. and that of flood plain was 5.84-8.05 mg/l (App. Table 1,2,3,4).

Although the occurrence of *C. atherinoides* was the highest in the monsoon, the water depth of flood plain was also highest, so the capture of this fish was lowest. But in post monsoon (October to February) the water depth of flood plain was the lowest, so the capture of this fish was the highest.

The occurrence of *C. atherinoides* is rare in pond.

Table-1: Eco-biologocal condition and distribution model of *C. atherinoides*

Ecological conditions	Ponds	Flood plain areas	Rivers
a. Soil texture	Mostly clay	Mostly sandy-loamy	Sandy and sandy-loam
b. Water temperature (°C)	Range 13.96(Jan.97) - 34.58 (May 97) Mean 25.28±5.9	Range 12.53 (Jan.96) - 29.44 (Jun.96) Mean 23.7±5.32	Range 13.5 (Jan.97) -32.26 (Apr.97) Mean 24.49±5.63
C. Transparency(m)	Range 0.25 (Apr.97) -0.48 (Aug.96) Mean 0.39±0.06	Range 0.16 (Feb.97) - 0.47 (Sep.95) Mean 0.32±0.092	Range 0.04 (Aug.96)-1.32 (Jan.97) Mean 0.41±0.42
d. Water current	Stagnant	Mostly stagnant, rare in monsoon	very high
e. Oxygen (O_2) mg/l	Range 2.83 (May.97)-5.92 (Dec.96) Mean 4.38±0.94	Range 3.86 9Jul.96) -7.92 (Jan.96) Mean 6.29±1.17	Range 3.15 (July.95) -6.02 (Jan.96) Mean 4.34±0.86
f. Carbondioxide (CO_2) mg/l	Range 2.84 (Jan.96) - 9.48 (Jul.95) Mean 6.5±2.2	Range 2.34 (Dec.96) - 8.05 (Aug.) Mean 5.23±2.02	Range 2.76 (Jan.97) -8.52 Mean 5.75±2.11
g. p^H	Range 6.83 (Jan.96) - 8.24 (Jun..96) Mean 7.55±0.31	Range 6.85 (Feb.97) - 8.15 (Oct.96) Mean 7.41±0.31	Range 6.75 (Jan.96)-8.12 (Sep.96) Mean 7.39±0.35
h. Availability of the species	Rare	Very common	Common during monsoon.

DISCUSSION

The ecological conditions such as the physical and chemical parameters of the river Padma, flood plain area (beel) and pond have been determined. The values of different parameters were calculated through the statistical analysis which can be treated as the useful indicator for the occurrence and abundance of *C. atherinoides*.

The present observation reveals that the annual air temperature cycle maintained a close parallel relationship with annual cycle of water temperature. The temperature of all the studied water bodies usually declined from November and reached the minimum in January and there after increased steadily reaching the maximum during April to June in the river Padma, flood plain area and pond. Differences between air temperature and water temperature are higher during winter and lower in summer, the occurrence of the temperature curve of air and water coincided each other during monsoon/flood season due to sudden fall of air temperature in comparison to the water temperature followed by the heavy rainfall. On the other hand both the curve differ before and after monsoon period due to absence of cooling effect by rainfall and the presence of windless and hot days which prevail in the areas. Similar ideas are also stated by Geisler *et al* (1975); Islam and Mendes (1976).

There is more or less rainfall all the year round. Like other hydrological features rainfall is governed by the monsoon (Mahmood *et al.* 1976; Rahman 1989). The rainfall is also an important ecological factor for aquatic environment. Sahai and Sinha (1969) observed that the chemical factors like nitrate and phosphate were high in rainy season. Rao (1955) reported that the nitrate of water increased with the increase of rainfall. Again Lakshminarayana (1965) observed that the higher values of nitrate and phosphate during monsoon were due to rainfall and flood.

Rainfall also influences the breeding of fishes. Temperature has no specific influence on spawning but cloudy days accompanied by thunder storm and rain, seem to exercise some influence on spawning (Saha *et al.* 1957). Success in majority of fishes have been induced on cloudy and rainy days, specially after heavy showers (Chowdhury, 1960).

In Rajshahi, heavy rainfall is very common during June-September and in flood plain areas, heavy rainfall is very common during May to September.

Water transparency of the studied water bodies shows low value due to greatest turbidity. The turbidity of water is generally due to the suspended inorganic substances and planktonic organisms present in water. Bamforth (1958) reported that the turbidity of water was mainly affected by heavy planktonic bloom, non-living organisms, suspended organic matter, rains, floods and inflowing sediments. According to Jhingran (1983), turbidity due to profusion of plankton is an indication of high fertility but that caused by silt or mud beyond a limit, is harmful to fish and other organisms.

In the river Padma, the minimum values of transparency are found in the monsoon and postmonsoon month like June to September due to strong current of water which washed away huge silt in water including many other suspended matter. From October onwards upto May water become slowly clear with the maximum values of transparency due to absence of such disturbing matters. Lakshminarayana (1965); and Hickman (1979) also made such type of observation.

The water of the natural sources is not chemically pure. It contains different substances in solution giving an acid, neutral or alkaline reaction. The importance of p^H value in fish culture is vast. Michael (1969) by an investigation reported that the p^H range between 7.3 and 8.4 was considered suitable for fish culture. Swingle (1967) observed the relationship of p^H of water to their suitability for fish culture and satisfactory results were obtained from water with p^H ranging from 6.5 to 9.0. He reported that the water having p^H values more than 9.5 were unproductive and above 11.0 marked the death point of fish.

The calculated mean values of p^H of water of the river Padma ranged from 6.75 to 8.06 and 6.90 to 8.12 in the first and second year's observations respectively indicating neutral or slightly alkaline. In flood plain area the calculated mean values of p^H of water ranged between 7.05 to 7.88 and 6.85 to 8.15 in the first and second year's observation respectively. In pond mean values of p^H of water ranged between 6.83 to 7.96 and 7.12 to 8.24 in the first and second year's observation. These values are also indicating neutral or slightly alkaline nature of water. The alkaline values of water was also reported by Verma (1969) and Ruttner (1953) who stated that a eutrophic lake normally maintains alkaline p^H.

Ehshan *et al.* (1997) recorded the values of p^H of water of Halti beel which ranged between 7.1 to 8.03. In our Bangladesh p^H values were recorded in some running water system by Islam *et al.* (1974) as max. 7.8 (July) and min. 6.9 (March) in the river Buriganga and by Patra and Azadi (1987) as max. 8.15 in (October) and min. 6.96 (May) in the river Halda.

Among the dissolved gases, oxygen is the most important factor for the aquatic life. Dissolved oxygen contents of the river Padma increase gradually from October to April and then decrease being lowest in May to September. Chakraborty *et al.* (1959) observed minimum amount of oxygen during monsoon months of Jumna river.

In flood plain area DO contents increase gradually from November reaching the maximum in January and then decrease in June to August. Similar observation was recorded by Vyas and Kumar (1968), George (1964) in Indra Sagar Tank, India. Higher values of DO in winter were possibly due to low temperature and low rainfall. Ehshan *et al.* (1997) reported maximum dissolved oxygen in January where as minimum in June in Halti beel.

In pond the DO contents increase in the month of November to February and decrease in April to September. The same result was noticed by Islam and Mendes (1976), Ali *et al.* (1989) found high value of DO during winter and low value in summer.

In flood plain area the average dissolved oxygen contents is more than the other studied water bodies. The fluctuation in the dissolved oxygen concentration is mainly influenced by the factors like dissolved organic matter, plankton and bottom vegetation.

Carbondioxide is essential ingredient of photosynthetic reaction. According to Chow (1958), carbondioxide concentration of 30 to 40 ppm were liable to make the fish breathe with difficulty and often die when the excess of 30 ppm. Mean values of free carbondioxide (CO_2) show inverse relationship to the oxygen.

In the river Padma, the values of carbondioxide was maximum in the month of May to October and minimum in December to April. In flood plain areas CO_2 was maximum in June to September and minimum in November to February. In pond water CO_2 was maximum in April to October and minimum in December to February.

The free CO_2 content of the river, beel and pond showed seasonal changes which increased during summer and autumn and decreased during winter and spring. Islam and Mendes (1976), Ismail *et al.* (1984), and Patra and Azadi (1987) observed similar results in Bangladesh. Vyas and Kumar (1968) also noted same observation in India.

The high free CO_2 content during summer was possibly due to the high temperature and heavy rainfall with heavy land drainage which speeded up the decomposition of organic matters, low photosynthetic activity which consumed CO_2, low precipitation of free CO_2 as carbonates which agree with Ali and Islam (1983), Chowdhury and Mazumder (1987) and Bhuiyan (1997). In summer the factors responsible for the absorption of oxygen is greater than those that discharge CO_2, with the result that organic matters are decomposed by bacteria and free CO_2 which is liberated in large amount in these season.

The low free CO_2 content during winter months was possibly due to low temperature and low or no rainfall which caused low decomposition of organic matters and addition of CO_2, high photosynthesis which consumed CO_2, high precipitation of CO_2 as bicarbonate in divalent bonds agreeing Patra and Azadi (1987) and Bhuiyan *et al* (1997) in Bangladesh.

The occurrence of different fish in various water bodies varied in different seasons. Same result was observed in *C. atherinoides.* The abundance of *C. atherinoides* in Padma river and flood plain areas are almost continuous throughout the year. However the peak period in Padma river and also in flood plain were observed during the monsoon. (June to September). In this time the physico-chemical parameters of two water bodies were in favourable condition for the fish. During the monsoon the highest value of water temperature was observed in June (29.52°C) and lowest in September (26.32°C) in the Padma river. The highest value of water temperature was recorded in June (29.44°C) and lowest in September (26.92°C) in flood plain areas. The highest and lowest values of water transparency were recorded in June (0.20m) and August (0.04m) in Padma river and September (0.47m) and July (0.24m) in flood plain areas. The highest value of p^H was observed in September (8.12) and the lowest in July (7.02) in the Padma river. In flood plain area the highest and lowest values of p^H was recorded in August (7.88) and July (7.15). The highest and lowest values of dissolved oxygen was recorded in June (3.96 mg/l) and July (3.15 mg/l) in the Padma river and September (6.34 mg/l) and June (3.86 mg/l) in flood plain area. The highest value of free carbondioxide was observed in July (8.52 mg/l) and lowest in June (7.28 mg/l) in the Padma river and the highest and lowest value of free carbondioxide was recorded in September (5.84 mg/l) and August (8.05 mg/l) in flood plain area.

Although the occurrence of *C. atherinoides* was highest in the monsoon, the water depth of flood plain was also highest, so the capture of this fish was lowest. But during the post monsoon (October to February) when flood plain areas become calm and water starts to vacate fishing is made by means of traps placing at suitable places with the help of barricades. Hence throughout the entire post monsoon the fishing is found in the peak for the species with other small fishes.

CHAPTER-2

FOOD AND FEEDING HABIT

INTRODUCTION

All organisms for their survival need food. The nature of food for a particular class of living organisms have relative bearing to the environmental conditions under which they live. Obviously therefore, knowledge about the specification of food in all its analytical standpoint, both qualitatively and quantitatively is essential when one goes in for a culture of a particular life. Study of food and feeding habit of fishes have manifold importance in fishery biology. For successful fish farming, a through knowledge about the food and feeding habit is necessary. The study of the food of fish began to attract the attention of the fishery scientists only towards the close of the last century. As the nature of food depends to a great extent upon the nature of environment, the problem is interesting from specific, as well as ecological points of view.

The food and feeding habit of fishes vary from season to season even within a day. Different fishes consume different types of food. So, the study of food and feeding habit has immense ecological values, because by studying the food and feeding habit the pattern of interspecific competition of fishes can easily be known.

Studies on the food and feeding habit of different fishes have been made by many workers like Hynes (1950), Alikunhi (1952), Das and Moitra (1955). Darnell and Meirotto (1962), Ahmed and Akhtar (1967), Karim and Hossain (1972), Doha (1974), David and Rajagopal (1975), Dewan *et al.* (1979), Mustafa and Ahmed (1979), Mustafa *et al.* (1981), Dewan and Saha (1979), Bhuiyan (1987), Bhuiyan and Islam (1988, 1990, 1991), Bhuiyan *et al.* (1992, 1994, 1997, 1998) and others.

Clupisoma atherinoides (Bloch) is a common freshwater fish which is abundantly found in rivers, ponds, beels, and canals in Bangladesh (Bhuiyan, 1964). No work on the food and feeding habit of this fish is available. The present study deals with the food and feeding habit of *C. atherinoides* (Bloch).

MATERIALS AND METHODS

For the study of the food and feeding habit of *Clupisoma atherinoides* a total of 600 specimens were collected from local markets, rivers, ponds, beels, canal and ditches in Rajshahi during the period from June 1995 to May 1997. The experiment for estimation of food and feeding habit was done for twice i.e. first observation or first year's observation (June, 1995 to May, 1996) and second year's observation or second observation (June, 1996 to May, 1997). The samples were collected once in every month with the help of dip nets. the specimens were preserved in 10% fromalin solution in order to stop digestion of food items. Out of 600 specimens, 150 juveniles and 450 adult fishes were used in the food analysis.

The stomach contents of all the specimens were noted and the stomachs were classified into full ¾ full ½ full, ¼ full, trace and empty. Food items were dissected out from the gut, individual item separated in petridish and identified under simple and compound microscopes. The undigested food items were sorted into the different taxonomic groups. Gravimetric method (Hynes, 1950) was followed for estimation of the percentage composition of different food items. The food organism particularly the planktons were identified following Ward and Whipple (1959).

Mathematical relationships between the total length (TL) of the fish and the alimentary canal (ACL) of the different stages such as juvenile and adult were established by using the statistical formula:

$y = a + bx$ was followed

where y = Alimentary canal length (ACL)

and x = Total length (TL)

'a' is the interception on the ordinate

and 'b' is the regression co-efficient.

RESULTS AND OBSERVATIONS

The stomach contents of 600 specimens of *C. atherinoides* (150 juveniles and 450 of all sizes) were examined. For analysis of the food and feeding habit of *C. atherinoides* an investigation on the basis of following head lines were under taken..

The food of the juvenile of *C. atherinoides* :

The food analysis of 150 specimens of juveniles (TL 35 mm to 60 mm) of *C. atherinoides* were made. The specimens were collected in the months of October, 1995 to February, 1996 and October 1996 to February, 1997 from the rivers, ponds, beels in Rajshahi district. The result of the food analyses of two observations (first observation from October, 1995 to February, 1996 and the second observation from October, 1996 to February, 1997) are presented in Tables -2,3,4. Table -2 shows the percentages of empty or very poorly fed stomachs in different months of 1995 to 1997. The highest percentage of empty stomachs was recorded in January (31.25%) and the lowest in October (13.33%) in the first observation. In the second observation the highest percentage of empty stomachs was noticed in February (33.33%) and the lowest in December (11.76%). The average percentage of empty stomachs of both the observations was 21.40.

The percentage occurrence of various groups of food items of the juvenile *C. atherinoides* is shown in Table-3. Table-4 shows the list of various food organisms found in the stomach contents of the juvenile of *C. atherinoides* . It is observed from the tables that the food of the juvenile of *C. atherinoides* consisted of crustaceans, insects, protozoans, rotifers, algae, higher plant parts, debris and detritus, sand and muds and unidentified food organisms.

Table:2 Percentage of the empty stomachs of the juvenile of *C. atherinoides* (TL 35 mm to 60 mm)

Year and months		No. of stomachs examined	No. of stomachs with food	No. of empty stomachs	% of empty stomachs
First Observation					
1995	Oct	15	13	2	13.33
	Nov	17	14	3	17.65
	Dec	13	10	3	23.08
1996	Jan	16	11	5	31.25
	Feb	16	12	4	25.00
Second Observation					
1996	Oct	12	10	2	16.67
	Nov	15	13	2	13.33
	Dec	17	15	2	11.76
1997	Jan	14	10	4	28.57
	Feb	15	10	5	33.33
	Total	150	118	32	21.40

Crustaceans:

The occurrence of crustanceans in the stomachs of *C. atherinoides* was the highest (30.06%) among all the groups of food items (Table-3). The highest percentage of crustaceans was observed in the month of December 1995 (31.82%) and the lowest in October, 1995 (26.38%) in the first observation, while in the second observation the highest percentage of crustaceans occurred in the month of February, 1997 (33.08%) and the lowest in October 1996 (27.33%). The average percentage occurrence of crustacens was 30.06.

Table :3 Percentage occurrence of various groups of food items of the juvenile (length 35 mm to 60 mm) of *C. atherinoides* (N-150).

Year and months		No. of specimens examined	Crustaceans	Insects	Protozoans	Rotifers	Algae	Higher plant parts	Debris and detritus	Sand and mud	Unidentified food
First Observation:											
1995	Oct	15	26.38	18.23	7.69	9.23	8.46	3.85	11.54	6.15	8.46
	Nov	17	30.57	19.43	6.52	11.90	7.14	5.95	8.33	2.38	7.76
	Dec	13	31.82	16.36	4.55	8.18	6.36	5.45	12.73	5.45	9.09
1996	Jan	16	29.29	17.86	6.43	10.71	5.71	4.29	10.71	5.00	10.00
	Feb	16	30.83	17.5	5.83	9.17	6.67	4.17	11.67	5.00	9.17
Second observation:											
1996	Oct	12	27.33	16.67	8.67	13.33	7.33	5.33	11.34	3.33	6.67
	Nov	15	29.6	18.4	8.6	12.2	3.2	5.6	9.2	5.2	8.00
	Dec	17	31.25	21.88	7.81	10.94	5.25	4.69	7.81	3.75	6.63
1997	Jan	14	30.43	19.57	6.96	9.57	4.52	4.09	10.87	4.78	9.22
	Feb	15	33.08	15.38	5.38	13.08	4.62	6.15	10.77	3.85	7.69
Average percentage			30.06 ±1.91	18.13 ±1.77	6.84 ±1.30	10.83 ±1.68	5.93 ±1.49	4.96 ±0.79	10.5 ±1.48	4.49 ±1.07	8.27 ±1.06

Table :4 Percentage composition and the list of food organisms of the juvenile of *C. atherinoides* (TL 35 mm to 60 mm).

Food groups	Food items	Percentage
Crustaceans	a) Copepods: i) *Cyclops* ii) *Paracyclops* iii) *Diaptomus* b) Ostracods: i) *Cypris* ii) *Eucypris* c) Cladocerans: i) *Daphnia* ii) *Monia* d) Decapods: i) prawn larvae	30.06
Insects	Mosquito larvae Chironomid larvae Insects pupae and fleas	18.13
Protozoans	*Paramecium* *Vorticella* *Operculina*	6.84
Rotifers	*Keratella* *Brachionus*	10.83
Alage	*Spirogyra* *Ulothrix* *Nostoc* *Diatoma*	5.93
Higher plant parts	Dry stems, leaves, roots etc.	4.96
Debris and detritus		10.50
Sand and muds		4.49

The crustaceans includes copepods, ostracods, cladocerans and decapods. The copepods were represented by *Cyclops*, *Paracyclops* and *Diaptomus*. The ostracods included *Cypris* and *Eucypris*. The cladocerans were represented by *Daphnia* and *Moina*. The decapods included prawn larvae. *Cyclops, Diaptomus* and *Daphnia* constituted the major portion of the percentage composition of crustaceans and were found to occur in all the months of observation.

Insects:

The insect food items included the mosquito larvae and the chironomid larvae. The mosquito larvae were observed to occur in all the months of observation. The chironomid larvae were also common in all the months except in January. In January it was rarely noticed. The highest percentage of insects occurred in November 1995 (19.43%) and in December, 1996 (21.88%) in the first and second observations respectively. The lowest percentage of insects occurred in December, 1995 (16.36%) and in February, 1997 (15.38%) in the first and second observations respectively. The average percentage composition of insects in the stomach contents of the juvenile of *C. atherinoides* was 18.13. It was noted that the highest percentage of occurrence of insects was recorded in December in the second observation, while the lowest percentage occurrence was noticed in this month in the first observation.

Protozoans:

In the first observation the highest percentage of protozoans occurred in October, 1995 (7.69%) and the lowest in December, 1995 (4.55%). In the second observation the highest percentage was noticed in October, 1996 (8.67%) and the lowest in February, 1997 (5.38%). The protozoans were represented by *Paramecium, Vorticella* and *Operculina.* The average percentage occurrence of protozoans was 6.84.

Rotifers:

The highest percentage of occurrence of rotifers in the stomach contents of the juvenile of *C. atherinoides* was recorded in November, 1995 (11.90%) and October, 1996(13.33%) in the first and second observations respectively. The lowest percentage of rotifers occurred in December 1995 (8.18%) and in January, 1997 (9.57%) in the first and second observations respectively. The average percentage composition of rotifers over 10 months of the two observations was 10.83. The rotifers were represented by *Keratella* and *Brachionus*. These two genera were observed in all the months of investigation. In October and November they were very common.

Algae:

The algae food items was represented by *Spirogyra, Ulothrix, Nostoc* and *Diatoma.* The highest and the lowest percentages of occurrence of algae was noticed in October, 1995 (8.46%) and January 1996 (5.71%) respectively in the first observation. In the second observation the highst percentage occurred in October, 1996 (7.33%) and lowest percentage occurred in November, 1996 (3.2%). The average percentage composition of algae in the stomach contents of the juvenile of *C. atherinoides* was 5.93.

Higher plant parts:

The higher aquatic plants included the leaves, dry stems and roots. In the first observation it was recorded that the percentage composition of higher plant parts were the highest in November, 1995 (5.95%) and the lowest in October, 1995 (3.85%). In the second observation the highest percentage of higher plant parts were noticed in February, 1997 (6.15%) and the lowest in January, 1997 (4.09%). The average percentage of occurrence of higher aquatic plant parts was 4.96.

Debris, detritus and semidigested materials:

Debris, detritus and semidigested materials formed the important constituent of the food items in the stomach contents of the juvenile of *C. atherinoides*. The highest percentage of debris, detritus and semidigested matters occurred in December, 1995 (12.73%) and the lowest in November, 1995 (8.33%) in the first observation, while in the second observation the highest percentage occurred in October, 1996 (11.34%) and the lowest in December 1996 (7.81%). The average percentage of occurrence was 10.5. The semidigested matters included most members of the food items as well as some unidentified items in semidigested or fully digested condition..

Sand and muds:

In the first observation the highest percentage of sand and muds in the stomach content of the juvenile of *C. atherinoides* occurred in October, 1995 (6.15%) and the lowest in November, 1995 (2.38%). In the second observation the highest percentage of sand and muds was recorded in November, 1996 (5.2%) and the lowest in October, 1996 (3.33%). The average of both the observations was 4.49%.

Food and feeding habit of the adult *C. atherinoides*:

For studying the food and feeding habit of the adult *C. atherinoides* a total of 450 specimens were collected from ponds and beels of Godagari and Noahata in Rajshahi, and the river Padma during the period from June, 1995 to May, 1997. The result of the investigation is presented below.

Monthly variation in the degree of feeding:

All fishes do not feed in the same intensity. The feeding intensity as well as the feeding condition vary from individuals to individuals. There is seasonal variation in the degree of feeding too.

For determination of the condition of feed or the degree of feeding of *C. atherinoides* all the stomachs examined were classified as 'full' ' ¾ full' '½ full' '¼ full', 'trace' and 'empty' by visual estimation depending on the distension or fullness of the stomachs. The total number of stomachs examined in each month, the actual number and percentage occurrence of stomachs under each category was classified and presented in App. Table-7 and Fig.(8a,8b). Out of 450 stomachs collected in different months over a period of 2 years, it was found that on the average there were 74 (16.44%) full, 85 (18.89%) ¾ full, 90 (20.00%) ½ full, 105 (23.33%) ¼ full, 65 (14.44%) trace and 31 (6.89%) empty stomachs.

Fishes with full, ¾ full, and ½ full stomachs were considered to be actively fed, while fishes with ¼ full, trace and empty stomachs were considered to be very poorly fed or empty. App. Table -7 and 8 show the feeding activities i.e. the percentage of fullness and emptiness of the stomachs of all the months of the two years observation.

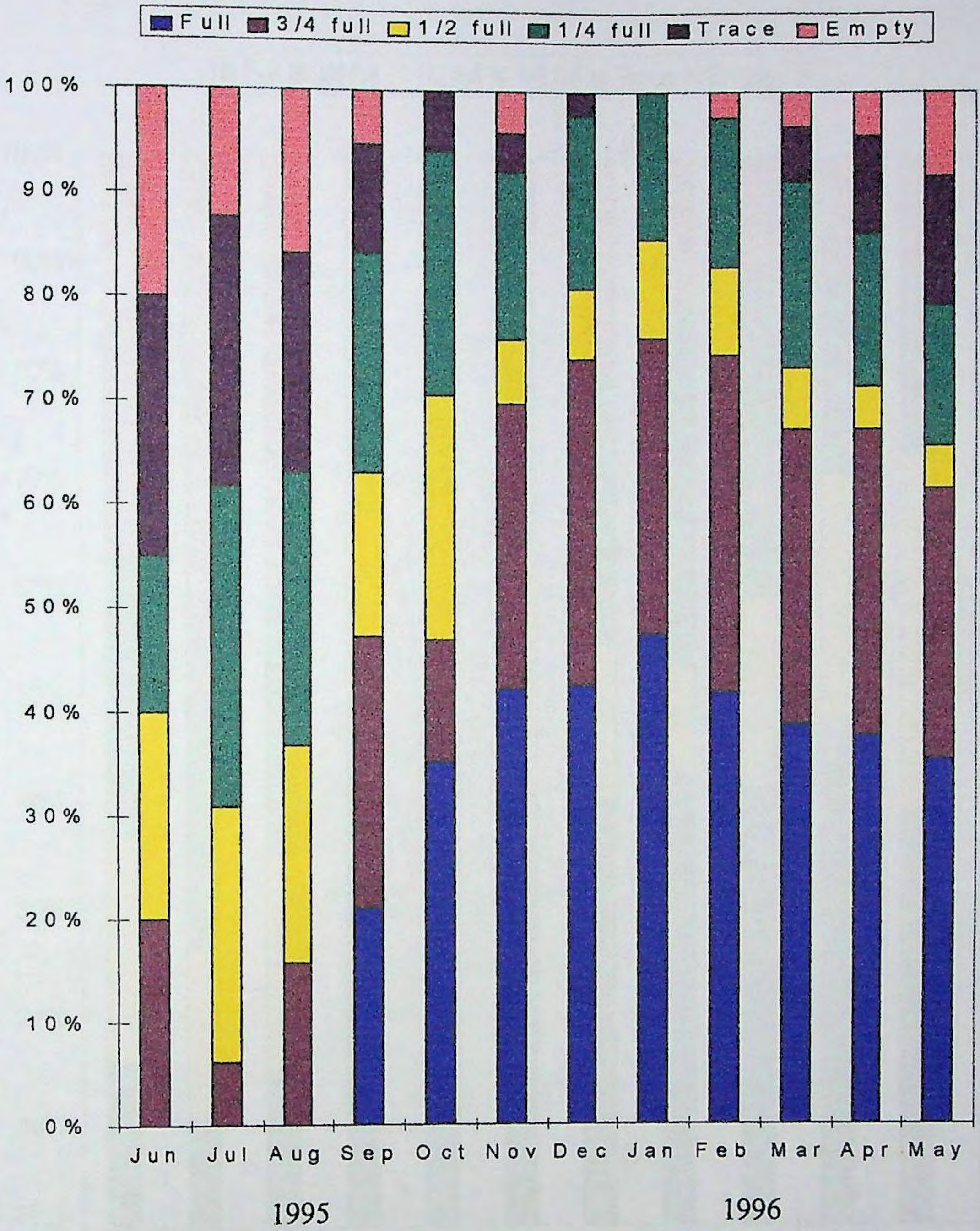

Fig. 8a. *C. atherinoides*: Showing the monthwise percentage of fullness and emptiness of the stomachs during June, 1995 to May, 1996.

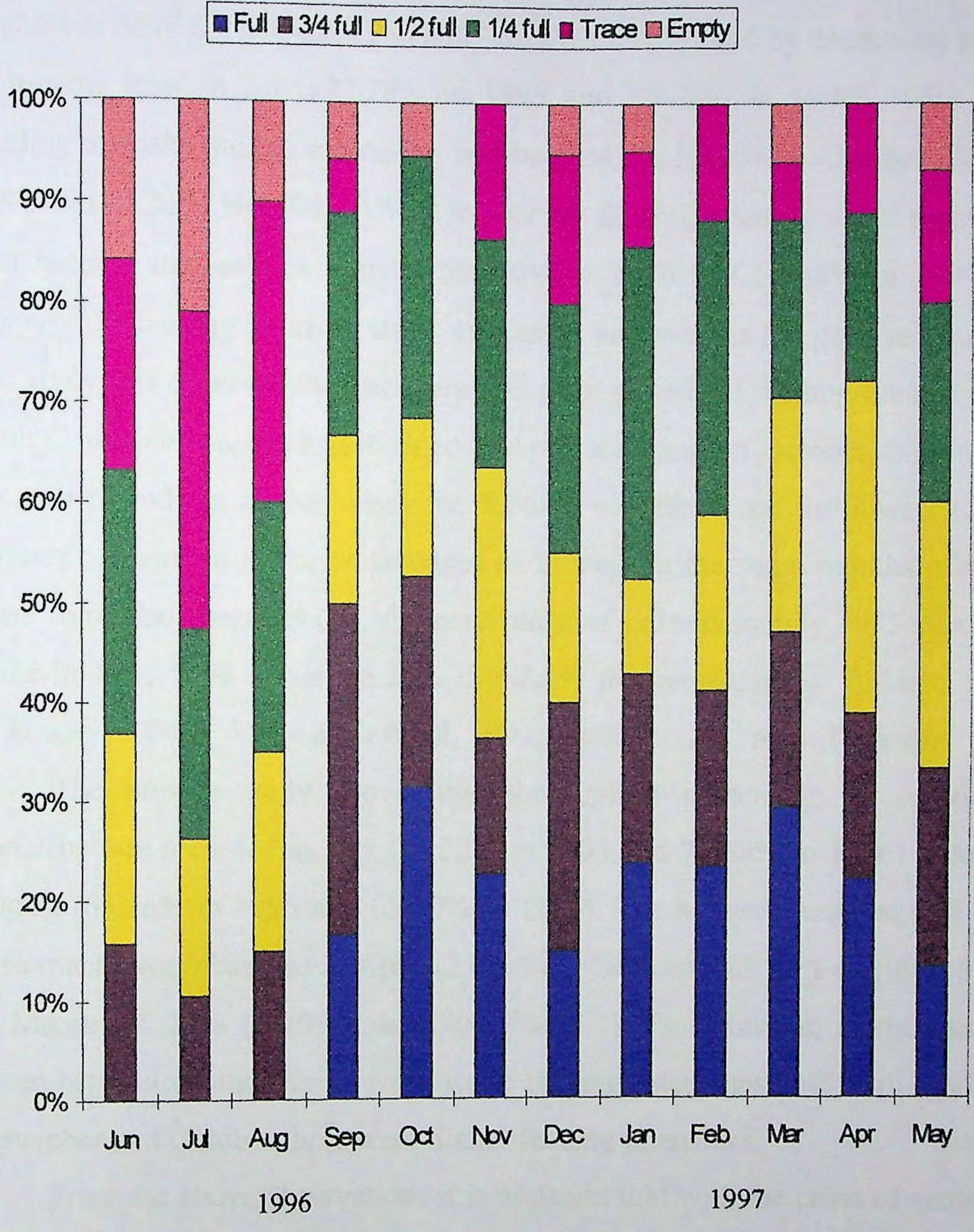

Fig. 8b. *C. atherinoides*: Showing the monthwise percentage of fullness and emptiness of the stomachs during June, 1996 to May, 1997.

The feeding intensity i.e. the percentage of fullness of the stomachs was the highest in April (75.00% in 1996 and 72.22% in 1997) and by decreasing gradually, it became least in July (27.78% in 1995 and 26.32% in 1996). After July the feeding intensity started increasing and became the highest in October (70.58% in 1995 and 68.42% in 1996). After October the feeding intensity again slowed down and became the least in January (50.00% in 1996 and 52.38% in 1997). After January the feeding intensity starts increasing and reaches the peak in April. From this study it is observed that there are two peak periods of feeding intensities of the adult *C. atherinoides* in a year, once in April and again in October. Similarly there are two periods in a year when the feeding intensities are the lowest (July and January). Variation in the percentages of fullness in the same months of different years were also observed e.g., the percentage of fullness in July 1995 was 27.78% while in July, 1996 it was 26.32%. Similarly the percentage of fullness in April, 1996 was 75.00%, where as in April, 1997 it was 72.22% (App. Table-8).

The present study shows that the highest percentage of emptiness of stomachs was recorded in July (72.22% in 1995 and 73.68% in 1996) followed by August (63.16% in 1995 and 65.00% in 1996). The highest percentage of fullness of stomachs was observed in April (75.00% in 1996 and 72.22% in 1997) followed by March (72.22% in 1996 and 70.59% in 1997). Likewise, in the months of December and January there were weak feeding intensities and in the months of September and October there were higher feeding intensities.

From the above observations it is apparent that with the onset of summer i.e. in April the feeding intensity becomes the highest and as the spawning starts the cessation of feeding activities starts and in the month of July it becomes the least. After spawning in July and August the feeding activity starts increasing and in the month of October it reaches the peak. After October the feeding activity again starts decreasing and becomes least in January and after this month the feeding intensity again starts increasing and becomes the highest in April.

Seasonal occurrence of various food items:

Variation occurs in the food of fishes throughout the year. This is primarily due to the changes in the composition of food organisms occurring at different seasons. Seasonal changes in temperature not only influence food composition and the rate of digestion but also the quantity and quality of various food. Studies on seasonal pattern of feeding of fishes have therefore, received considerable attention (Moffet and Hunt, 1943; Hynes, 1950; Sarker, 1973 etc.)

In the present investigation the percentage composition of each item of food found in the stomachs of 450 adult showed marked variation (App. Table -9, Fig 9a,9b & 10). The following food organisms were found in the stomachs of the sampling specimens during the study period (Table-5).

A. Crustaceans:

The crustaceans formed a very significant portion of the stomach contents of the adult *C. atherinoides* . This food item was observed in all the months. It can be seen from the table that the highest percentage of crustaceans occurred in January (41.84%) and the lowest percentage in August (23.53%) in the first observation, while in the second observation the highest percentage of crustaceans occurred in January (43.96%) and the lowest in June (21.43%). The average occurrence of crustaceans in the stomach contents of *C. atherinoides* was 31.33%.

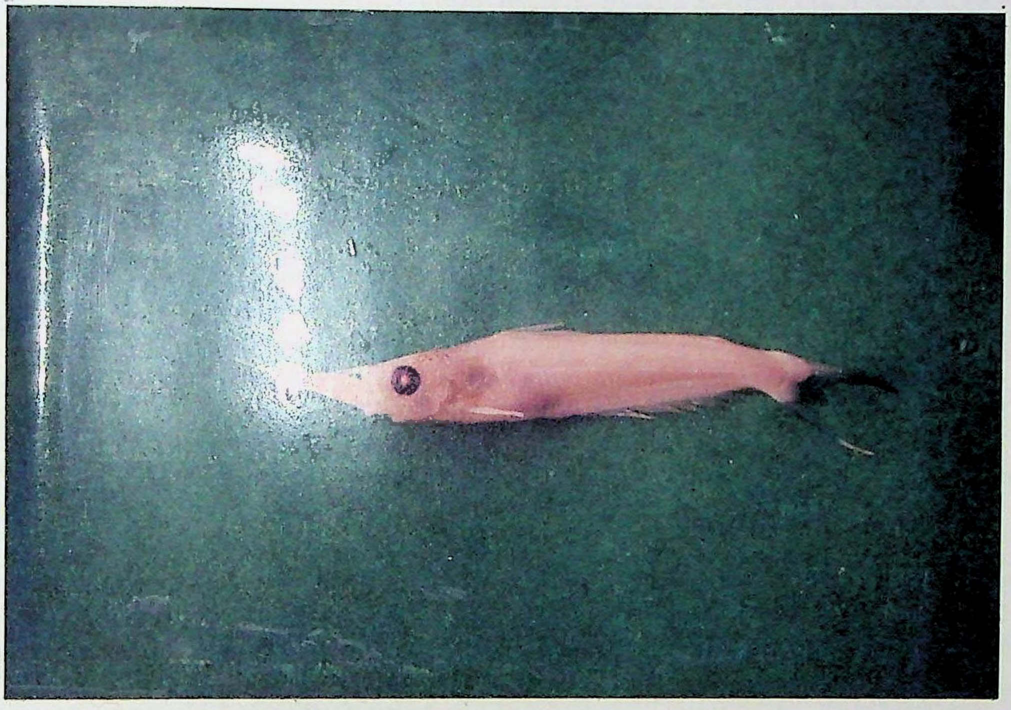

Plate. 1. *C. atherinoides:* Feeding on a young prawn.

The crustaceans comprised copepods (9.50%), ostracods (5.03%), cladocerans (9.30%) and decapods (7.5%). The copepods included *Cyclops* (4.50%), *Paracyclops* (1.50%), *Diaptomus* (3.50%). Ostracods included *Cypris* (3.03%), *Eucypris* (2.00%). The cladocerans included *Daphnia* (6.30%) *Moina* (4.00%) and decapods included prawn larvae (7.5%).

B. Insects:

The insects formed the important food item of the adult *C. atherinoides*. The highest percentage of insects was recorded in February (33.70%) and the lowest in September (14.29%) in the first observation. In the second observation the highest percentage of insects was in December (30.43%) and the lowest in July (15.41%). The average occurrence of insects over two observations was 22.40%.

The insects were represented by mosquito larvae (7.50%), chironomid larvae (5.40%), insects pupae and fleas (7.20%) and *Neomenia* (2.30%).

C. Protozoans:

The protozoans comprised a small portion of the percentage occurrence of the stomach contents of *C. atherinoides*. In the first observation the highest percentage of protozoans was recorded in December (9.47%), followed by January (7.14%), February (6.52%), March (5.75%), June (5.56%), November (5.38%), August (4.90%), September (4.76%), April (4.73%), May (3.77%), October (3.70%), July (3.49%). In the second observation the highest percentage of protozoans was recorded in January (8.79%) followed by February (7.53%), December (6.52%). November (5.81%), September (5.56%), March (4.82%), August (4.26%), October

(4.11%), June (3.57%), July (3.51%), April (3.08%), May (2.94%). The average occurrence of protozoans over two observations was 5.24%.

The protozoans were represented by *Paramecium* (0.04%), *Operculina* (0.80%), *Euglena* (2.50%), *Rotalia* (1.50%), *Vorticella* (0.40).

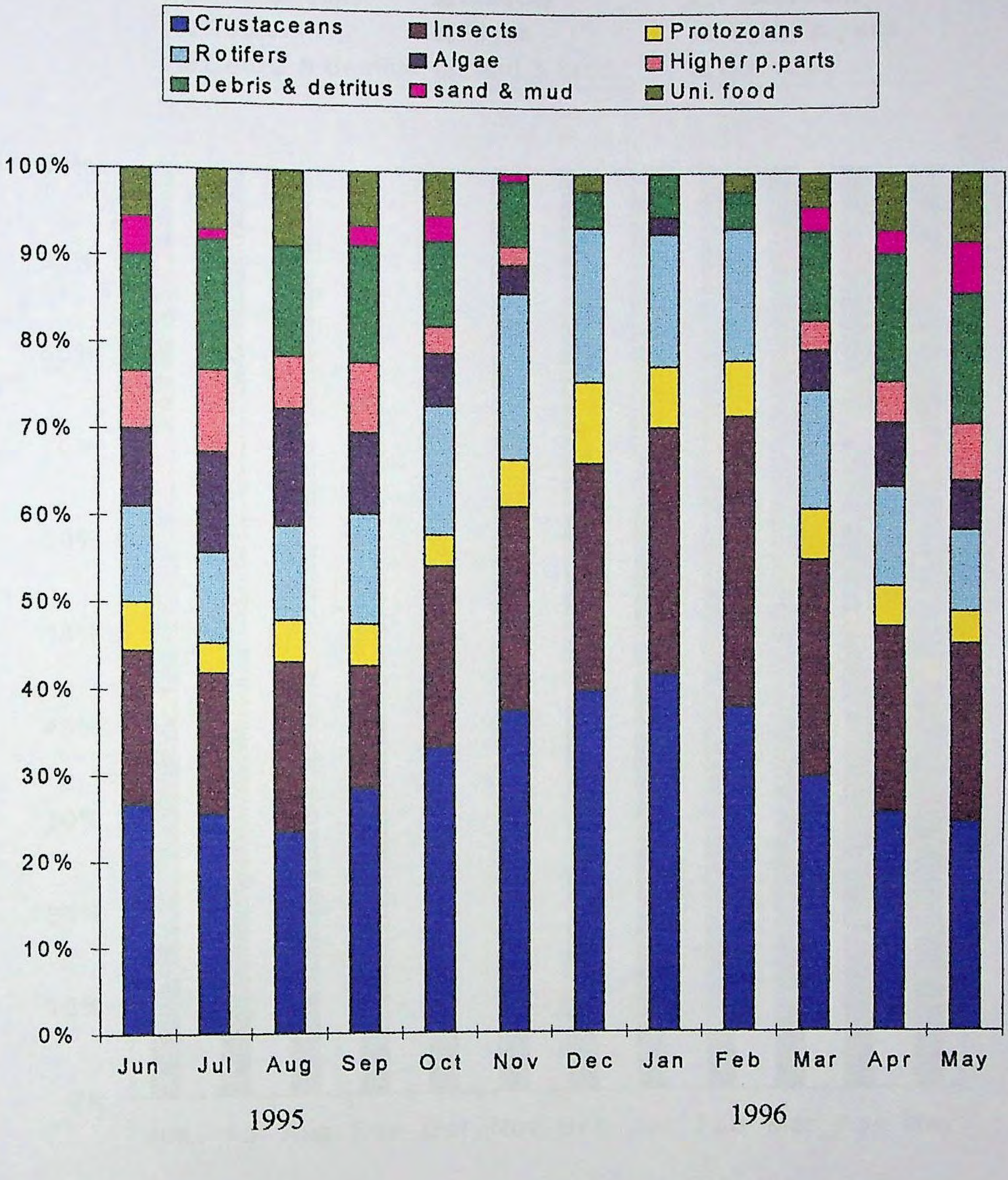

Fig. 9a. *C. atherinoides*: Monthly variation in the percentage composition of different groups of food items of adult during June, 1995 to May, 1996.

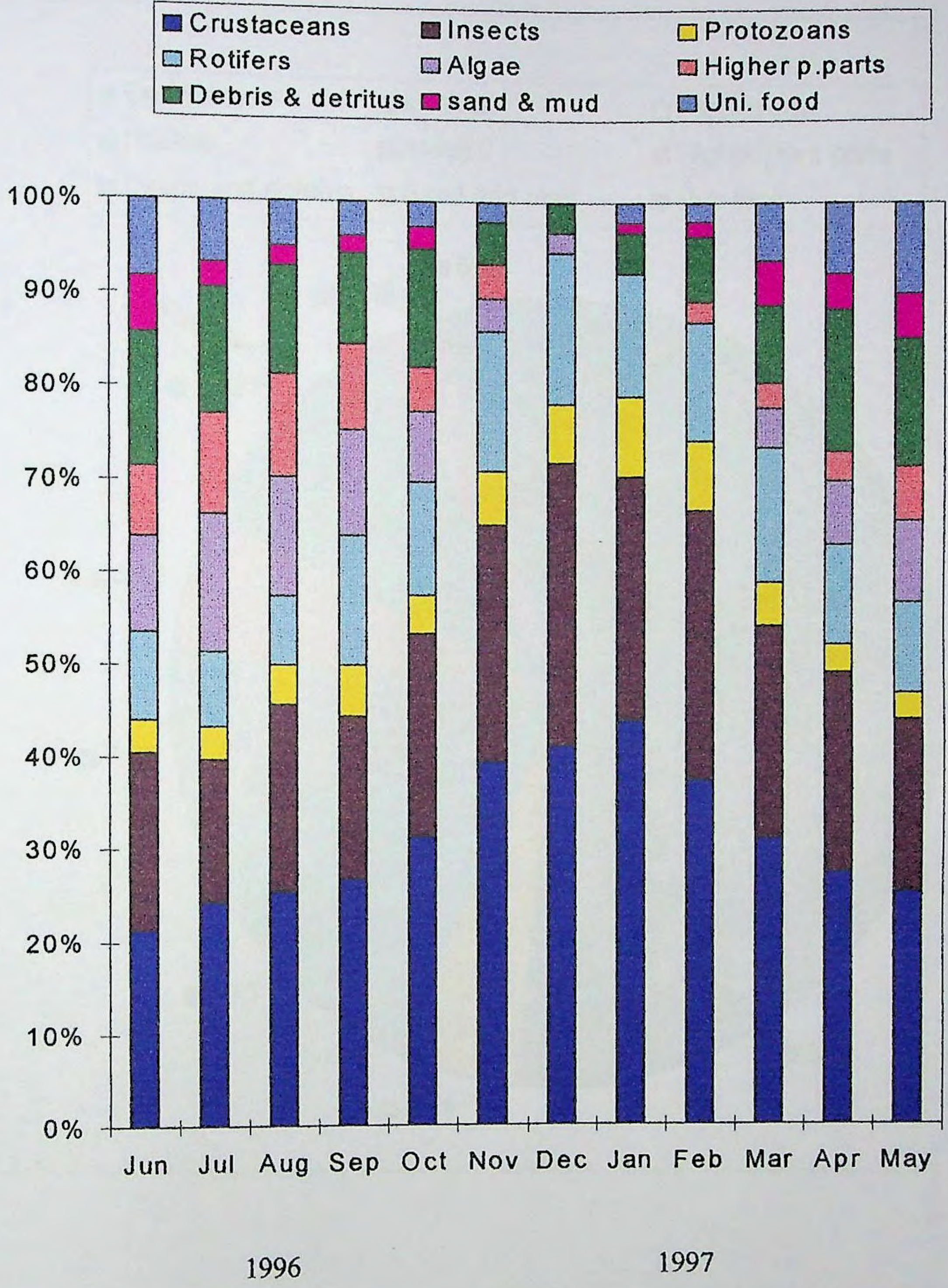

Fig. 9b. *C. atherinoides*: Monthly variation in the percentage composition of different groups of food items of adult during June, 1996 to May, 1997.

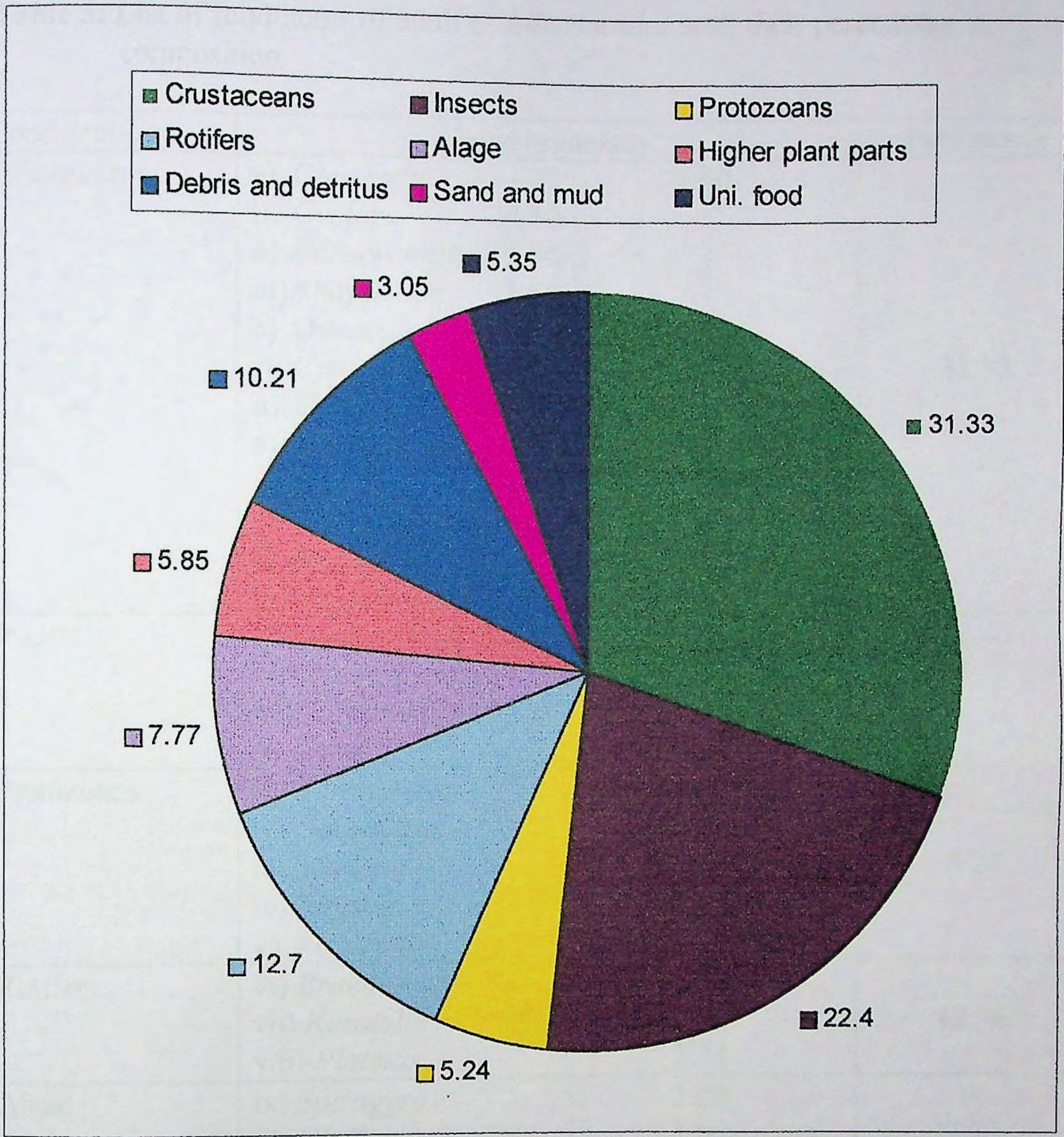

Fig. 10. *C. atherinoides*: Percentage occurrence (mean) of different food items.

Table 5: List of food items of adult *C. atherinoides* with their percentage composition.

Food groups	Food organism			Percentage
Crustaceans	a) Copepods:		9.50	31.33
	i) *Cyclops*	4.50		
	ii) *Paracyclops*	1.50		
	iii) *Diaptomus*	3.50		
	b) Ostracods:		5.03	
	i) *Cypris*	3.03		
	ii) *Eucypris*	2.00		
	c) Cladocerans:		9.30	
	i) *Daphnia*	6.30		
	ii) *Moina*	4.00		
	d) Decapods:		7.50	
	i) Prawn larvae			
Insects	Mosquito larvae		7.50	22.40
	Chironamid larvae		5.40	
	Insects pupae and fleas		7.20	
	Neomenia		2.30	
Protozoans	i) *Paramecium*		0.04	5.24
	ii) *Operculina*		0.80	
	iii) *Euglena*		2.50	
	iv) *Rotalia*		1.50	
	v) *Vorticella*		0.40	
Rotifers	vi) *Brachionus*		6.50	12.76
	vii) *Keratella*		3.52	
	viii) *Platyias*		2.74	
Algae	ix) *Spirogyra*		2.50	7.77
	x) *Ulothrix*		1.05	
	xi) *Nostoc*		1.70	
	xii) *Diatoma*		1.50	
	xiii) *Anabaena*		1.02	
Higher plant parts	Dry stems, leaves, roots etc.			5.85
Debris and detritus				10.21
Sand and mud				3.05

D. Rotifers:

The rotifers formed the important food item of *C. atherinoides* and were recorded in all the months of the observation period. The highest percentage of rotifers was observed in November (19.35%) and the lowest in May (9.43%) in the first observation. In the second observation the highest percentage was observed in December (16.3%) and the lowest in August (7.45%). The average percentage of rotifers over the two observations was 12.76. The rotifers included *Brachionus* (6.50%), *Keratella* (3.52%) and *Platyias* (2.74%).

E. Algae:

In the first observation the highest percentage of algae occurred in August (13.73%) and the lowest in January (2.04%). No algae was noticed in the stomach content of the adult *C. atherinoides* in the months of December and February. In the second observation the highest percentage was observed in July (14.86%). No algae was observed in the stomach content of the fish in the months of January and February. The average occurrence of algae was 7.77%. The algae included *Spirogyra* (2.50%), *Ulothrix* (1.05%) *Nostoc* (1.70%), *Diatoma* 1.50%), *Anabaena* (1.02%).

F. Higher plant parts:

Leaves, stems and sometimes the roots of higher aquatic plant parts formed the food items of adult *C. atherinoides*. The highest percentage of higher plant parts occurred in July (9.3%) and the lowest in November (2.15%). No higher plant parts was noticed in the months of December, January and February in the first observation. In the second observation the highest percentage was observed in august (11.06%) and the lowest in February (2.26%). No higher plant parts was observed in the months of December and January. The average percentage of higher plant parts over the two observations was 5.85.

G. Debris and detritus:

Debris and detritus formed a significant percentage of the stomach contents of the adult *C. atherinoides* and were recorded in all the months of the observation period. The maximum quantity of these materials in the first observation was recorded in July (15.12%) and the lowest in December (4.21%). In the second observation the highest percentage was noticed in April (15.38%) and the lowest in December (3.26%). The average occurrence of debris and detritus was 10.21%

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Sand and mud:

The sand and mud formed a small percentage in the stomach content of *C. atherinoides*. The highest percentage of sand and mud was observed in May (6.03%) and the lowest in November (1.08%) in the first observation. In the second observation the highest percentage was observed in June (5.95%) and the lowest in January (1.09%). No sand and mud was noticed in the months of August, December, January and February in the first observation and November and December in the second observation.

The present investigation reveals that the food of adult *C. atherinoides* consists mainly of the animal food viz. crustaceans (31.33%), insects (22.40%), protozoans (5.24%) and rotifers (12.76%). Marked variations in the percentage occurrence of different food in different months were observed. It is inferred that crustaceans, insects, protozoans, rotifers, debris and detritus are the normal food of

C. atherinoides, while algae, higher plant part. sand and mud are the secondary, incidental or occasional food items of the fish.

Feeding in relation to sexual cycle:

In the present investigation, the feeding intensity in mature fishes was found to be very poor during the months of June, July and August (App. Table-7 & 8). This period of poor feeding activities in case of mature fish coincides with the peak spawning season of this fish and suggest a decline in feeding during spawning season. It was also observed that the maximum number of empty stomachs were recorded during the spawning season (June to August). The mature fishes showed active feeding intensities in other months. On the other hand, the immature fishes showed active feeding intensities during the spawning season and also in other months of the year.

Feeding habits:

From the present findings it is noted that the food and feeding habits of *C. atherinoides* has the same type both in juvenile and adult stages. In the juvenile stage (length 35 mm to 60 mm) the food of *C. atherinoides* consists of crustaceans (30.06%), insects (18.13%) protozoans (6.84%), rotifers (10.83%), algae (5.93%) higher plant parts (4.96%), debris and detritus (10.5%), and sand and mud (4.49%).

The food of adult *C. atherinoides* consists of crustaceans (31.33%), insects (22.40%), protozoans (5.24%), rotifers (12.76%), algae (7.77%), higher plant parts (5.85%), debris and detritus (10.21%), sand and mud (3.05%).

The juvenile and adult stage of *C. atherinoides* feeds on higher percentage of crustaceans, insects, rotifers, protozoans, and debris and detritus etc., and a lower percentage of algae, higher plant parts, sand and mud suggesting a surface feeding habit of the fish. So it can be inferred that *C. atherinoides* is a surface feeding carnivorous fish.

Total length (TL) and alimentary canal length (ACL) ratio:

The ratio of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of the fish *C. atherinoides* is shown in Table 6, Figs 11 & 12. It is observed from the table that the alimentary canal of the juvenile has the ratio of 1:0.56 with the total length of the juvenile while the alimentary canal of the adult has the ratio of 1:0.61 with the total length of the fish. It was observed that with the increase of the size of the fish the alimentary canal of the fish also increases. the present observation reveals that since the juvenile and adult of *C. atherinoides* feeds on zooplankton. (crustaceans, insects, protozoans, rotifers) it has a shortened alimentary tract. This is due to the fact that the animal foods are easily digested which require a short digestive tract. On the other hand the herbivorous and omnivorous species need higher quantity of food items and the food items are not easily digested and as such the alimentary tract becomes longer.

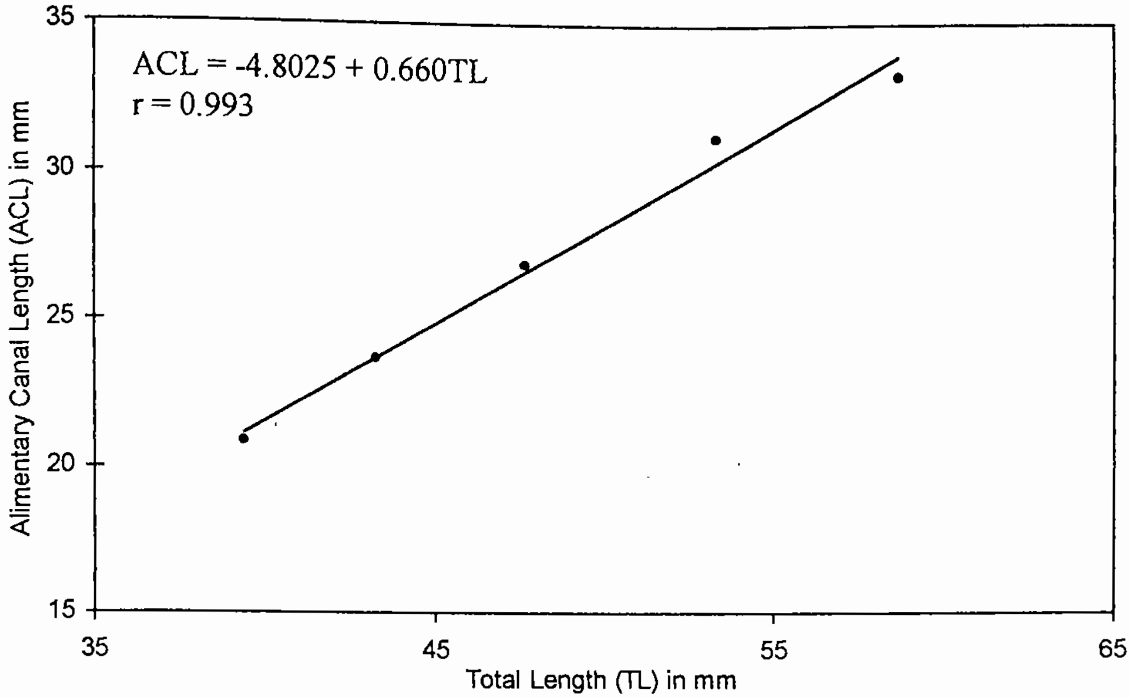


Fig. 11.*C. atherinoides:* Relationship between the alimentary canal length and the total length (Juvenile).

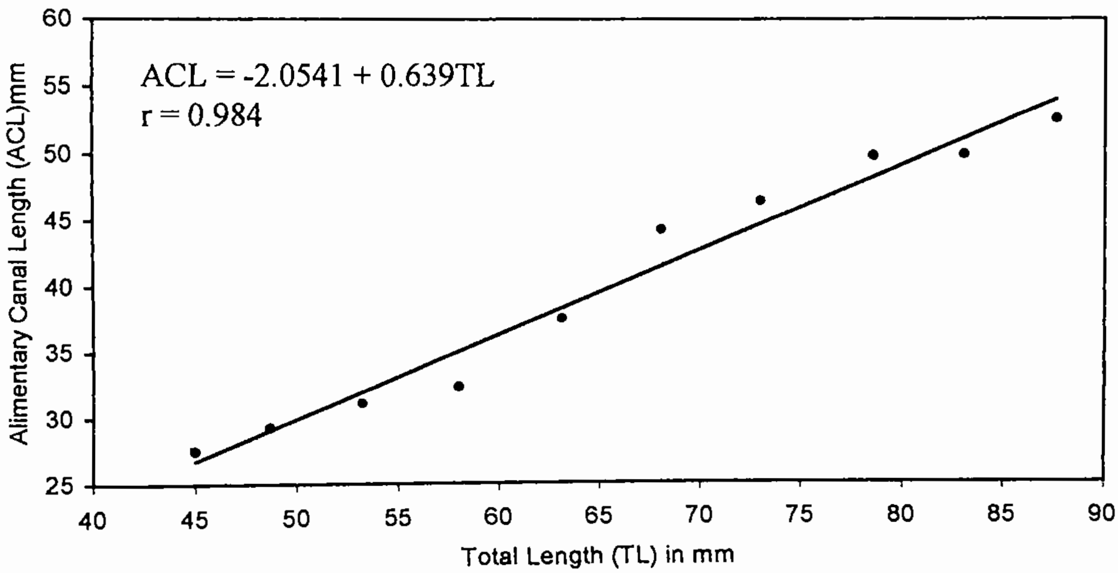


Fig. 12.*C. atherinoides:* Relationship between the alimentary canal length and the total length (Adult).

Table 6: *C. atherinoides*: Total length and alimentary canal length ratio and relationship, values of intercepts (a), regression co-efficient (b) and co-efficient of correlation 'r' of different stages of the fish.

Stage	Mean ratio TL:ACL	Value of a	Value of b	Value of r
Juvenile	1:0.56	-4.8025	0.6606	0.9937
Adult	1:0.61	-2.0541	0.6394	0.9840

Relationship between total length (TL) and alimentary canal length (ACL)

The relationship of the body length (TL) and the alimentary canal length (ACL) of the juvenile and adult stages of *C. atherinoides* were established. To establish the relationship between the above parameters, the values of regression co-efficient 'b' intercept 'a' and the co-efficient of correlation 'r' the statistical formula was followed and the results are given in Table 6 and Figs 11 & 12. The relationship of the alimentary canal length with the total length of the fish was established as follows:

For juvenile ACL $= -4.8025 + 0.6606$ TL ($r = 0.993$)

for adult ACL $= -2.0541 + 0.6394$TL ($r= 0.984$)

All the relationships mentioned above are shown by scatter diagrams. It was observed that in all the cases there existed strong linear relationships.

The regression equations were found to be linear and co-efficient of correlation were highly significant.

DISCUSSION

The food and feeding habit and the body length gut length relationship of the juvenile and adult *Clupisoma atherinoides* were studied. Samples for the present study were collected from different localities of Rajshahi.

The food of the juvenile of *C. atherinoides*:

The food analysis of 150 specimens of the juveniles (TL 35 mm to 60 mm) of *C. atherinoides* revealed that the food of the juveniles consisted of crustaceans, insects, protozoans, rotifers, algae, higher plant parts, debris and detritus, sand and mud. The highest percentage of crustaceans were observed in the month of December 1995 (31.82%) and the lowest in October , 1995 (26.38%) in the first observation, while in the second observation the highest percentage occurred in the month of February, 1997 (33.08%) and the lowest in October, 1996 (27.33%). The highest percentage of insects occurred in November, 1995 (19.43%) and in December, 1996 (21.88%) in the first and second observations respectively. The lowest percentage of insects occurred in December, 1995 (16.36%) and in February, 1997 (15.38%) in the first and second observations respectively. In the first observation the highest percentage of protozoans occurred in October, 1995 (7.69%) and the lowest in December, 1995 (4.55%). In the second observation the highest percentage was noticed in October, 1996 (8.67%) and the lowest in February, 1997 (5.38%). The highest percentage of occurrence of rotifers in the stomach contents of the juvenile of *C. atherinoides* were recorded in November, 1995 (11.90%) and October, 1996 (13.33%) in the first and second observations. The lowest percentage of rotifers occurred in December 1995 (8.18%) and in

January, 1997 (9.57%) in the first and second observation. The highest and lowest percentages of occurrence of algae was noticed in October, 1995 (8.46%) and January, 1996 (5.71%) in the first observation. In the second observation the highest and lowest percentages occurred in October, 1996 (7.33%) and November, 1996 (3.2%). In the first observation it was recorded that the percentage composition of higher plant parts were the highest in November, 1995 (5.95%) and the lowest in October, 1995 (3.85%). In the second observation the highest percentage was noticed in February, 1997 (6.15%) and the lowest in January 1997 (4.09%). The highest percentage of debris and detritus occurred in December 1995, (12.73%) and the lowest in November, 1995 (8.33%) in the first observation, while in the second observation, the highest percentage occurred in October, 1996 (11.34%) and the lowest in December, 1996 (7.81%). In the first observation the highest percentage of sand and mud occurred in October, 1995 (6.15%) and the lowest in November, 1995 (2.38%). In the second observation the highest percentage was recorded in November, 1996 (5.2%) and the lowest in October, 1996 (3.33%).

The average percentage occurrence of the food items of juvenile of *C. atherinoides* was crustaceans (30.06%), insects (18.13%), protozoans (6.84%), rotifers (10.83%), algae (5.93%), higher plant parts (4.96%), debris and detritus (10.5%), sand and mud (4.49%).

The present investigation reveals that the juvenile of *C. atherinoides* is carnivorous in feeding habit, mainly feeding on the animal food viz. crustaceans, insects, protozoans and rotifers, Zisman *et al.* (1974) observed that the bulk of the gut contents of the young grey mullets was the copepods. Dewan *et al.*, (1979) recorded that the most important food item of the juvenile of *Labeo rohita* was the organic detritus, phytoplankton and aquatic macrophytes. Bhowmick (1965) worked on *Glossogobius giuris* and found that crustaceans formed the major food of the juvenile while the most preferred food of the adults was fish.

Monthly variation in the degree of feeding of the adult *C. atherinoides*:

The study of the monthly variation in the degree of feeding of the adult *C. atherinoides* reveals that the highest percentage of emptiness of stomachs was recorded in July (72.22% in 1995 and 73.68% in 1996) followed by August (63.16% in 1995 and 65.00 in 1996). The highest percentage of fullness of stomachs was observed in April (75.00% in 1996 and 72.22% in 1997) followed by March (72.22% in 1996 and 70.59% in 1997). Likewise, in the months of December and January there were weak feeding intensity and in the months of September and October there were higher feeding intensities.

From the above observations it is apparent that with the on set of summer i.e. in April the feeding intensity becomes the highest and as the spawning starts the cessation of feeding activities starts and in the month of July it becomes the least. After spawning in July and August the feeding activity starts increasing and in the month of October it reaches the peak. After October the feeding activity again starts decreasing and becomes least in January and after this month the feeding intensity again starts increasing and becomes the highest in April.

These findings are to some extent in conformity with whose of Khan (1947), who recorded a higher rate of feeding activity during summer and lower rate during winter in *Labeorohita*. Moffet and Hunt (1943) also recorded similar type of observation in blue gills. Bhuiyan *et al.* (1992) recorded similar type of observation in *Aspidoparia morar*. Lande (1973) observed that the food intake of plaice, *Pleuronectes platessa* in winter was scarce and stopped when the water temperature fell below 2-4°C. Feeding activity was higher in summer and autumn.

Seasonal occurrence of various food items of adult *C. aherinoides*

Seasonal occurrences of various food items were studied. The highest percentage of crustaceans occurred in January (41.84%) and the lowest in August (23.53%) in the first observation, while in the second observation the highest percentage of crustaceans occurred in January (43.96%) and the lowest in June (21.43%). Alam *et al.* (1994) observed in *Ailia coila* that the highest percentage of crustaceans were found in January (33.59%). In the first observation the highest percentage of insects was recorded in February (33.70%) and the lowest in September (14.29%). In the second observation the highest percentage of insects occurred in December (30.43%) and the lowest in July (15.41%). Bhuiyan *et al.* (1994) in *Rhinomugil corsula* recorded that the highest percentage of insects occurred in February. The highest and lowest percentage of protozoans was recorded in December (9.47%) and July (3.49%) respectively in the first observation. The highest and lowest percentage of protozoans occurred in January (8.79%) and May (2.94%) respectively in the second observation. The highest percentage of rotifers was observed in November (19.35%) and the lowest in May (9.43%) in the first observation. In the second observation the highest percentage of rotifers was observed in December (16.3%) and the lowest in August (7.45%). Bhuiyan *et al.* (1998) observed in *puntius gonionotus* that the highest percentage of rotifers occurred in January and lowest in July. In the first observation the highest percentage of algae occurred in August (13.73%) and the lowest in January (2.04%). In the second observation the highest percentage of algae was observed in

July (14.86%). No algae was observed in the months of December, January and February, in the first and second observations. The highest and lowest percentage of higher plant parts occurred in July (9.3%) and November (2.15%) respectively in the first observation. In the second observation the highest and lowest percentage of higher plant parts was observed in August (11.06%) and February (2.26%). In the first observation the highest and lowest percentage of debris and detritus was recorded in July (15.12%) and December (4.21%) respectively. In the second observation the highest and lowest percentage of debris and detritus was observed in April (15.38%) and December (3.26%) respectively. The highest percentage of sand and mud occurred in May (6.03%) and June (5.95%) in the first and second observations. The lowest percentage was recorded in November (1.08%) and January (1.09%) in the first and second observations.

This observation shows that the highest percentage of zooplankton in winter season is fed by the juvenile and adult *C. atherinoides*. Krishnomoorthi and Visvesvara (1966) recorded maximum of zooplankton population in December, January, February and March in an Indian lake. Patra and Azadi (1987) also found the peak zooplankton in winter from Halda river in Bangladesh.

The average percentage occurrence of the food items of the adult of *C. atherinoides* was crustacean (31.33%), insects (22.40%), protozoans (5.24%), rotifers (12.76%), algae (7.77%), higher plant parts (5.85%), debris and detritus (10.21%), sand and mud (3.05%).

The present investigation reveals that the most important food item of the adult of *C. atherinoides* was the crustaceans, insects, protozoans, and rotifers, Bhuiyan and Islam (1991) recorded that the most important food item of the adult of *Ompok pabda* was the fishes, crustaceans, protozoans and insects. Hossain *et al* (1990), also made similar observation in *Notopterus notopterus.*

Feeding habits:

From the present findings it is noted that the food and feeding habit of *C. atherinoides* is the same in juvenile and adult stages. The juvenile and adult stage of *C. atherinoides* feed on higher percentage of crustaceans, insects, rotifers, protozoans and debris and detritus etc. and lower percentage of algae, higher plant parts, sand and mud. So it can be inferred that *C. atherinoides* is a surface feeding and carnivorous fish.

Job (1941) concluded that *Therapon jarbua* was a surface feeder due to the presence of insects larvae and adult mosquitoes in its stomach contents. Similarly Mookerjee *et al.* (1946) held that fishes living at the surface feed on crustaceans and algae, whereas the fishes which feed on rotten plants, sands and muds are bottom feeders. Bapat and Bal (1950) included *Herengula punctata* and *Nematolosa nasus* among the bottom feeders since mud and sand were found in large quantities in their stomachs. Das and Moitra (1955) noted that the surface feeders are both omnivorous and carnivorous which feed on algae, rotifers, micro crustaceans and their larvae, the mid or column feeders are herbivorous and carnivorous which feed on algae, aquatic plants, adult crustaceans, insects, fish, mud and sands, and the bottom feeders are herbivorous, omnivorous and carnivorous which feed on decomposed aquatic vegetation, bryozoans, insects, crustaceans, molluscs, fishes, sand, mud etc. They further concluded that the surface feeders feed on surface plants and animals, the mid and column feeders feed on sub-surface food organisms and the bottom feeders feed on mud, decaying substances and bottom fauna and flora.

Feeding in relation to sexual cycle:

In the present investigation, the feeding intensity in mature fishes was found to be very poor during the months of June, July and August. This period of poor feeding activities in case of mature fish coincides with the peak spawning season of this fish and suggest a decline in feeding during spawning season. It was also observed that the maximum number of empty stomachs were recorded during the spawning season (June to August). The mature fishes showed active feeding intensities in other months of the year. Similar type of results were also reported by Bhuiyan and Islam (1988) on *Xenentodon cancila;* Hossain *et al.* (1990) on *Notopterus notopterus*; Bhuiyan and Islam (1991) on *Ompok pabda;* Bhuiyan *et al* (1992) on *Aspidoparia morar*.

Dewan and Saha (1979) mentioned that the low values of feeding intensities of *Tilapia nilotica* in May and June might be associated with the turbidity of the water produced by heavy rainfall. But Thomas (1969) stated that the low feeding activity may not be due to the shortage of food items but due to the spawning season of the fish. He also observed that the fishes in advanced stage of maturity had their abdominal cavities fully occupied by the voluminous ripe gonads and the stomachs were always empty.

In the present study it was observed that the ripe gonads occupied the major portion of the abdominal cavities and the stomachs were empty in the most cases and small in size. Thus the present findings on the feeding intensities of *C. atherinoides* in relation to the sexual cycle are in conformity with that of Thomas (1969).

Total length (TL) and alimentary canal length (ACL) ratio:

The ratio of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of the fish *C. atherinoides* is 1:0.56 and 1:0.61. The present observation reveals that, since the juvenile and adult of *C. atherinoides* feeds on animal foods (crustaceans, insects, protozoans, rotifers) it has a shortened alimentary tract. Similar type of results were also reported by Bhuiyan and Haque, (1984) on *Glossogobius giuris;* Bhuiyan and Islam (1988) on *Xenentodon cancila*; Hossain *et al.* (1990) on *Notopterus notopterus* and Bhuiyan and Islam (1991) on *Ompok pabda.*

The present observation is in conformity with that of Lagler *et al.* (1962) who also showed that the fishes which are carnivorous are provided with shortened alimentary tracts while the herbivorous fishes have highly elongated alimentary tract.

Relationship between total length (TL) and alimentary canal length (ACL):

The relationship of the body length (TL) and the alimentary canal length (ACL) of the juvenile and adult stages of *C. atherinoides* were established as follows

for juvenile ACL = -4.8025 + 0.6606 TL (r=0.993)

for adult ACL = -2.0541 + 0.6394 TL (r=0.984)

Both the relationships mentioned above are shown by scatter diagrams. It was observed that in all the cases there existed strong linear relationships.

CHAPTER-3

REPRODUCTIVE BIOLOGY

INTRODUCTION

The process of the maintenance of the continuity of generation is known as reproduction. Reproduction is a physiological process by which species are perpetuated and by which in combination with genetic change, characteristics of new species first appear (Lagler *et al.*, 1956). Continuity of biological race is maintained by the process of reproduction and failing which they may lead to extinction. Reproduction occupies the most important place in the life processes of all organisms as well as in the studies on the biology of any species of animal especially of economic significance.

Reproduction is a physiological process and is influenced by several factors. Sexuality and sexual anomalies in differentiations are caused by genetic, environmental and hormonal factors either singly or in combination (Adiodi and Adiodi, 1974). Sexual development involves the maturation of structural, physiological and behavioural machinery concerned with mating and reproduction. It is controlled by sex hormones (Charniaux Cotton, 1954). Environmental parameters such as day length, temperature, turbidity, availability and nature of food, interspecific and intraspecific social relations may influence the nature and pattern of reproduction and developmental behaviour (Waterman, 1961).

In course of studying the reproduction of a species, the question to come across prominently is that when and how many times the species breeds in a calendar year. The above factors do not appear suitable for an organism throughout the year and as such the reproductive activities in aquatic organisms are time oriented and something periodical. Giese (1964) concluded that the critical period of population replenishment is usually so timed by environmental variables or certain condition of water that the young are produced at certain periods favourable for their survival.

According to Stephenson, (1934) the habitants of the tropical waters can be classified as:

i) Continuous breeder, which breeds throughout the year

ii) Discontinuous breeder

iii) Annual breeder; and

iv) Breeders - which breed more than once a year.

The time or season when the species breeds is normally termed as the breeding or spawning season of that species. The breeding season repeats in cyclic order in which the organism undergoes maturation changes and gets ready to breed again. The repeated phenomenon is known as "reproductive cycle" or "sexual periodicity". Reproductive cycle in the organism can be determined by several methods and many workers have studied in different fishes (Alikunhi, 1948; Shafi and Quddus, 1974; Hossain *et al.*, 1989, 1991, 1992; Bhuiyan and Afrose, 1996 etc.)

A thorough knowledge of the fecundity of a fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery (Lagler, 1956; Doha and Hye, 1970).

The term fecundity can be expressed as the total number of eggs present in the ovary that should be laid in a single spawning season. Accurate estimate of fecundity is necessary for studying the population dynamics and for proper exploitation of a species.

Clupisoma atherinoides accounts for an important freshwater capture fishery. No published work on the breeding biology of this species is available. Considering the economic importance of this fish an investigation on the reproduction of this fish was undertaken.

The present study is aimed at providing a comprehensive account of the reproductive biology of *C. atherinoides* from the freshwaters of Rajshahi.

Plate. 2. Male and Female *C. atherinoides*

MATERIALS AND METHODS

For the study of reproductive biology samples were collected weekly for a period of 2 years from June, 1995 to May 1997. A total of 100 specimens were collected from different fish landing centres (Rajshahi, Naohata, Godagari) (Fig. 13) of Rajshahi in each month. After collection a total of 2100 specimens were sorted out and preserved in 10% formalin for laboratory studies on monthly basis. All the fishes were separated according to sex and also separate data for gravid females were recorded for sex-ratio and percentage of occurrence of gravid females. Out of 2100 specimens, 1121 specimens were recorded as females (756 non-gravid and 365 gravid) and 979 specimens were recorded as males.

The total length (TL) and standard length (SL) of the specimens were measured nearest to 1 mm by means of a measuring board. The weight of gravid females were taken with the help of a "pan balance" in grams. The gonads were dissected out and the length of individual gonad was measured with the help of a fine point divider and a millimeter scale. The weights of ovaries were taken with the help of an electronic balance. The gonads of representative specimens were measured and weighed to obtain the wet weight.

For the study of the stages of the ovary, selected specimens were dissected to expose the ovary. The length, size and colour were carefully examined and noted.

Ten to fifteen ova were collected from anterior, central and posterior regions of each ovarian lobe of a specimen. Diameter of the collected ova were measured with the help of an ocular micrometer.

A total of 525 females were studied for determining the reproductive cycle. There are more than 15 methods to determine the reproductive cycle of fishes and aquatic organisms. Out of these methods six were used in the present study to determine the reproductive cycle of *C. atherinoides*.

The following methods were applied to study the reproductive cycle of *C. atherinoides*:

These methods were:

1) Percentage of gravid females against time.
2) Gonado somatic index (G.S.I)
3) Gonadal length index (G.L.I)
4) Diameter of ova.
5) Colouration of the ovary.
6) Maximum indices of spermatozoa in the milt of male.

Details of different methods and other relevant existing techniques are mentioned at appropriate place.

A total of 152 gravid females were studied for the estimation of fecundity. The gravimetric method as described by Lagler *et al.* (1956) was applied for the estimation of fecundity.

To estimate the fecundity of ripe ova, first the pattern of distribution of ripe ova in the two lobes of the ovary were determined. A portion of the ovary weighing approximately about 0.05 g to 0.100 g were taken from the middle, anterior and posterior regions of the left ovary and the number of ova was counted. The grand total of ova in the ovary was calculated from the known weight of the sample, the number of ova in the sample and the total weight of the ovary was determined as follows:

$$\text{Estimated fecundity} = \frac{\text{No. of ova in the sample}}{\text{Wt. of the sample}} \times \text{gonadal weight}$$

The sex ratio was tested by the chi-square test to know whether the observed deviations from the ratio of 1:1 of the sexes on the null hypothesis are significant.

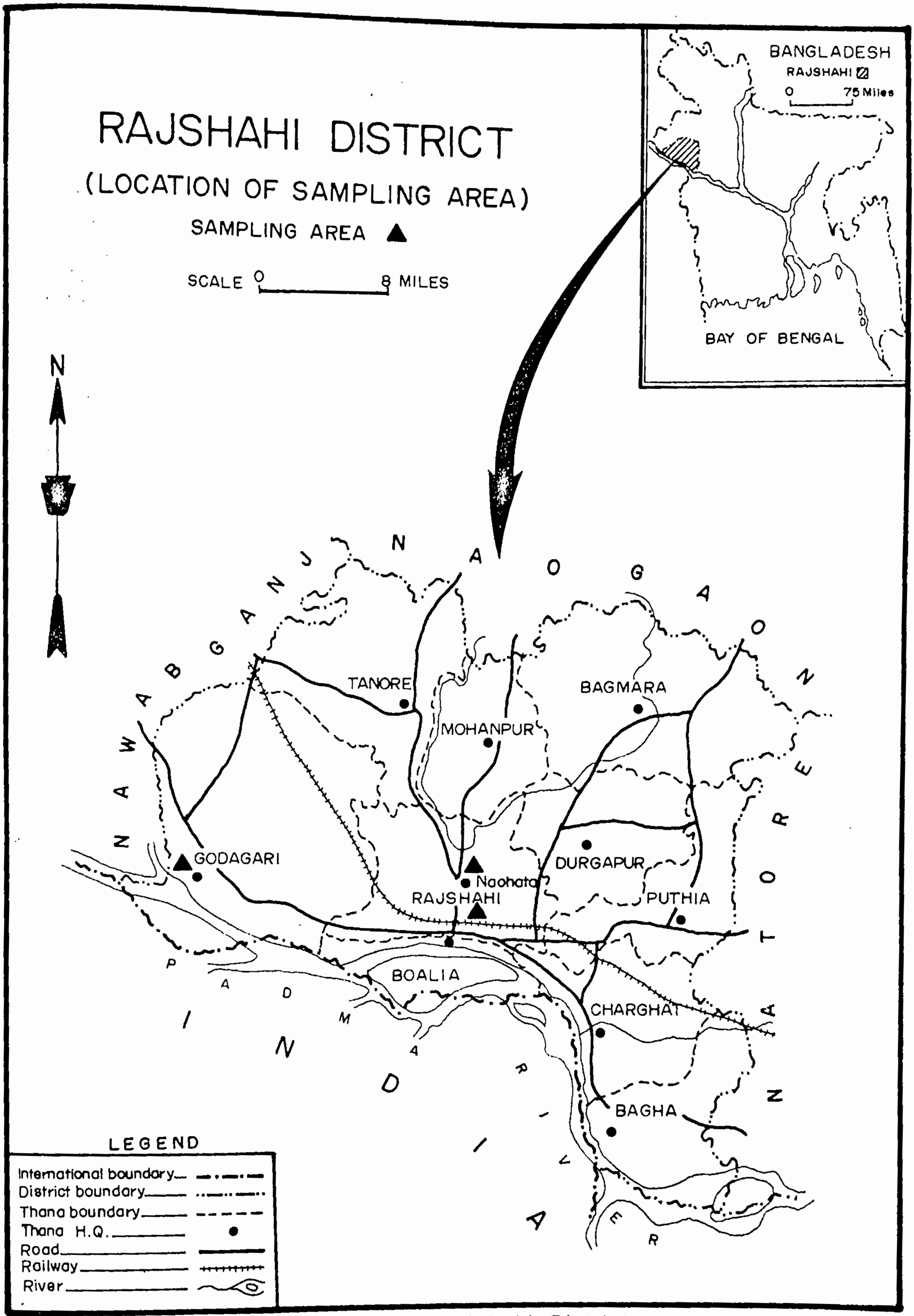


Fig. 13 Map of Rajshahi District.

RESULTS AND OBSERVATIONS

Male Reproductive System:

The male reproductive system of *C. atherinoides* consists of a pair of elongated testes and its ducts. It originates in the abdominal cavity above the alimentary canal and below the kidney. The testes are not equal in size. The left one is larger than the right (Fig. 14) The colour and size vary according to stage of sexual maturity and ripeness.

In January, the testes appeared as a translucent, whitish, narrow and thread like structures. In the body cavity the gut wall was externally well supplied with fat.

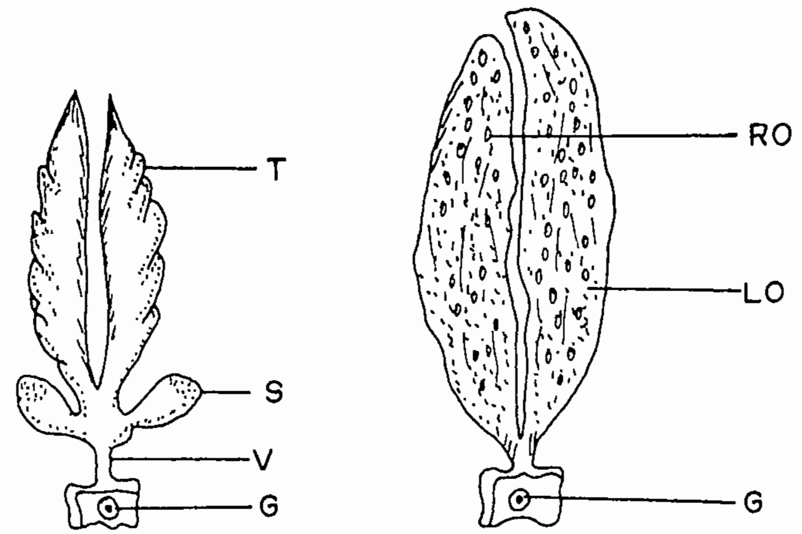
In February-March, the testes were milky-white in colour and occupied 50-55% of the body cavity. The width of the testes increased and the fat deposition from the gut wall was reduced in gonadal development.

In March-April, the testes extended much and two testicular lobes were nearly touching each other. The colour was light creamy and occupied about 60-65% of the body cavity.

In May to August, there was the peak of testicular development with a deep creamy colour. In this time milt oozed out by slight pressure on the abdomen. The fat from the gut wall completely disappeared.

In late August to September most of the specimens were found spent and with flaccid testes.

By October, the testes started to regain their original shape and size. The colour of the testes again changed to white and there was the deposition of fat in the gut wall. This period from October to December has been considered as the resting stage of the testes.



T= testis
S= Seminal vesicles
G= Genital pore
V= Vas deferens
R.O = Right ovary
L.O = Left ovary

Fig. 14. The Reproductive system of <u>Clupisoma</u> <u>atherinoides</u>.

Female Reproductive System

The female reproductive system of *C. atherinoides* consists of a paired ovaries and short oviducts. The left ovary is always larger than the right. They are suspended from high on the sides of the body cavity by a pair of mesenteries ((mesovaria) and thus situated above the alimentary canal. The anterior portion is slightly wider, blunt and rounded, projected into the body cavity and the posterior portion is tapered and open into a short common oviduct which leads out through the genital pore situated on an elevated urinogenital pore behind the anus just in front of the anal fin. The size and extent of occupancy of the ovary in the body cavity vary with the stage of sexual maturity of the female. The colour varies from whitish in young through light yellow when maturing to yellow or golden yellow in ripe stage.

Development stages of ovary:

Different stages of female maturation can be observed by the colour of the ovary and the diameter of the ovum. The developmental stages and maturation of the ovaries and oocytes are required for the determination of the breeding season of the fish. A total of 525 fishes were studied during June 1995 to May 1997 to determine the different stages of ovaries.

However, the development of ovary could be divided into ten stages on the basis of colour, size and the occurrence of different stages of eggs. These are as follows:

Stage 1: Immature Ovary:

The immature ovary is only found in the immature female. In November, December and January it is thin and whitish in colour and can not be visible easily and difficult to distinguish from the testes.

The ovary occupied about one third of the body cavity. The tip of two lobes of the ovary appeared as two flesh-coloured thread like structure (Fig. 15a). Ova are not visible by naked eye. In this stage only immature ova are present. The ova diameter ranged from 0.042 mm to 0.18 mm.

Stage II: Maturing-I (early developing):

Similar appearance of ovaries are found like stage I. The colour of the ovary was still whitish and occupied about 40-50% of the body cavity (Fig. 15b). This stage was found in February. No granulosa layer and yolk vesicles are found. In this stage also only immature ova are present but the larger ova are more than immature ova. The ova diameter ranged from 0.095 mm to 0.28 mm.

Stage III: Maturing-II (late-developing):

In March the ovary grows in weight and size. The tunica became relatively thin. In this stage immature ova are frequently found. Ogonia and maturing ova are also found. The colour of the ovary became light-yellow and occupied about 60% of the body cavity (Fig. 15c). The ova diameter ranged from 0.18 mm to 0.36 mm.

Stage IV: Mature:

In April to mid May the ovary occupies about 60-75% of the body cavity (Fig. 15d). The colour of the ovary changed to yellow. The ovarian wall was slightly thin. Immature and maturing ova are found with the mature ova. The percentage of occurrence of mature ova were maximum. The diameter ranged from 0.30 mm to 0.45 mm.

Stage V: Ripe ovary:

Most of the gravid females caught during late June to August had a ripe ovary (Fig. 15e). At this stage the ovary occupied about 80% of the body cavity and yellow / golden yellow in appearance. The ova were clearly seen through the wall of ovary. Oocytes were transparent. They were partially free and ooze out with little pressure on the abdomen. The ova diameter ranged from 0.45 mm to 0.62 mm.

Stage VI: Pre-spawning:

This stage is very much similar to stage V from external observation. At this stage the oocytes became fully free and ooze out with little pressure on the abdomen. The ovary and oocytes were found yellow / golden yellow in colour. (Fig.15f).

Stage VII: Spawning:

Thinner oviduct wall was found at this stage. (Fig. 15g). The oocytes were sometimes found scattered around the genital pore of the female.

Stage VIII: Post spawning:

This stage exists for a very short period of time. The weight of the ovary reduced to about 80% but occupied about 50% of the body cavity very loosely (Fig.15h).

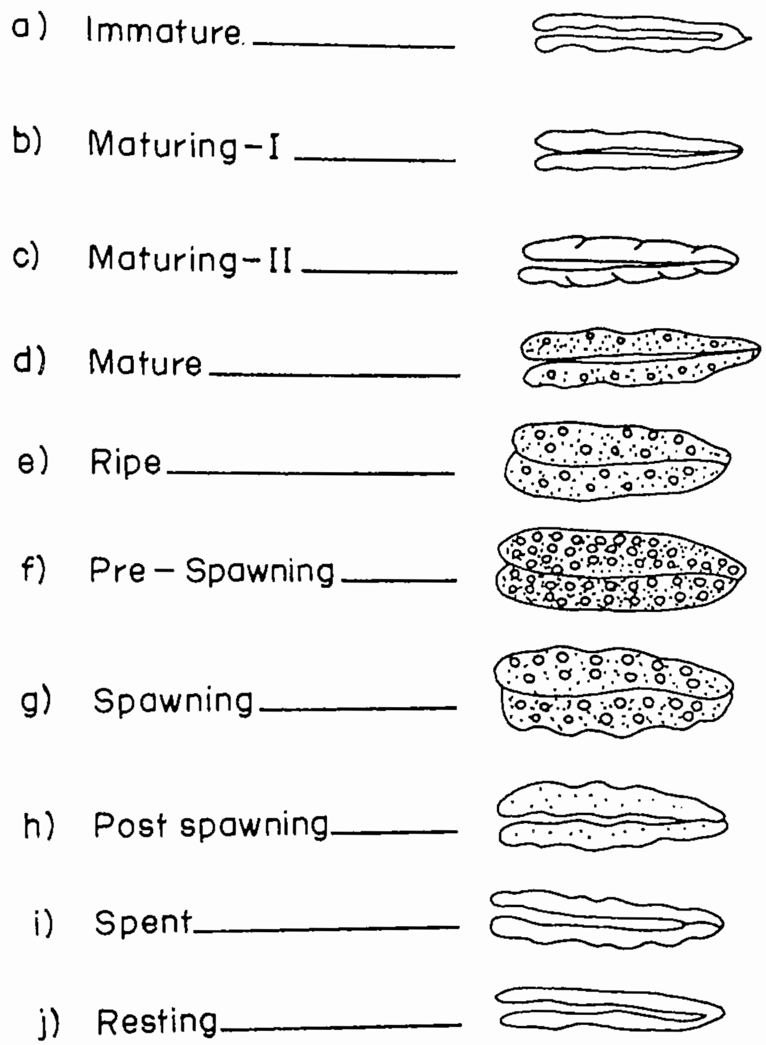


Fig. 15. (a – j) *C. atherinoides*: Showing the stages of ovarian development.

Stage IX: Spent:

At this stage the ovary lost all the oocytes (Fig.15i). but still contained some ruptured and collapsed post ovulatory follicles forming an irregular series of folds.

Stage X: Resting:

At this stage the wall of the tunica contracted and reduced with a corresponding increase in diameter (Fig.15j). The size and number of oocytes were also found in appearing condition. This condition was observed in the matured females from October to February.

Stages of Ova:

Immature:

The ova are not clearly visible by the naked eye but can be visible under microscope (Plate-3A). The ova are small in size, irregular in shape, transparent, yolks are not seen and whitish in colour. The ova diameter ranged from 0.042 mm to 0.18 mm. (mean 0.92±0.014 mm) (Table -7).

Maturing:

In this stage the ova increased in size but not clearly defined without microscope. Under microscope it has been found that the eggs are slightly opaque due to the deposition of yolk at the central position. The ova becomes light yellow in colour (Plate-3B). The ova diameter ranged from 0.18 mm to 0.36 mm (Mean 0.30±0.049) Table -7).

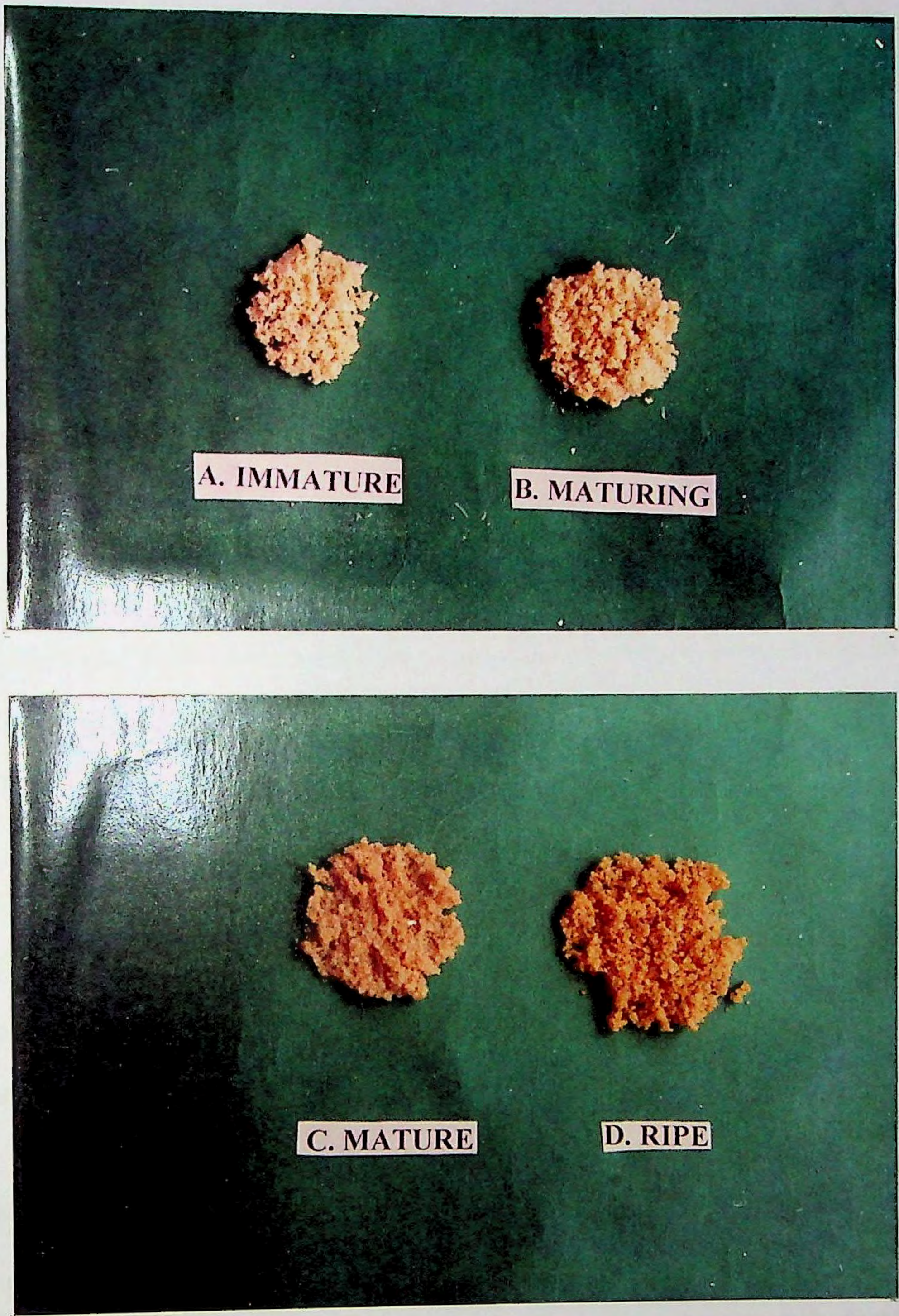


Plate. 3 (A-D): *C. atherinoides:* Different developmental stages of ova.

Table -7: *C. atherinoides:* Different stages of ova diameter with range, mean ± sd and colour.

Stages	Ova diameter		Colour
	Range (mm)	Mean±sd	
Immature	0.042-0.18	0.092±0.014	Whitish
Maturing	0.18-0.36	0.30±0.049	Light yellow
Mature	0.36-0.45	0.39±0.105	Yellow
Ripe	0.45-0.62	0.55±0.123	Golden yellow

Mature:

In this stage the eggs are more or less spherical in shape. The eggs remain completely opaque with visible nucleus. The eggs became yellow in colour and yolk deposition was complete (Plate-3C). The ova diameter ranges from 0.36 mm to 0.45 mm (mean 0.39 ±0.105 mm) (Table-7).

Ripe:

Ova were clearly seen through the wall of ovary. The eggs become yellow / golden yellow in colour (Plate-3D). In this stage the eggs attain the highest size and range from 0.45 to 0.62 mm (mean 0.55±0.123 mm) (Table-7).

Reproductive cycle:

Reproductive behaviour in fishes is cyclic, more or less regularly periodic (Lagler *et al.*, 1967). The reproductive act in some fishes occurs only once in a very short life time, while in other fishes, it occurs in moderately long life span. Several other species spawn more than once in a year more or less continually. After spawning, new group of oocytes is formed, which gradually mature to become ready for the next season.

Percentage of gravid female against time:

The data obtained from June 1995 to May 1997 (24 months) reveal that the gravid females of *C. atherinoides* occur during the period from March to October (App.Table-10, Fig -16). However, the maximum percentage of gravid females were found in the month of July, 1996 (94.23%) and July, 1995 (93.75). The next percentage were found in the months of June (84.21%), August (69.49%), May (56.67%), September (40.35%), April (31.03%), March (17.65%), October 7.55%), in the first year and June (85.00%), August (70.69%), May (57.58%), September (42.42%), April (29.63%), March (16.67%), October (8.33%) in the second year. No gravid female was found during the months from November to February of each year. From the above observation it may be concluded that the species possesses single breeding season extending from May to September with the peak in June to August.

Limitation of the methods:

It is very difficult to estimate accurately the proportion of gravid female in the natural population. The number of gravid females caught may not be representative of the actual situation in the natural population. So far for an accurate estimation of the breeding periodicity of *C. atherinoides* a number of methods have been applied. From the available data it would appear that this species breeds during May to September with a peak season during June to August.

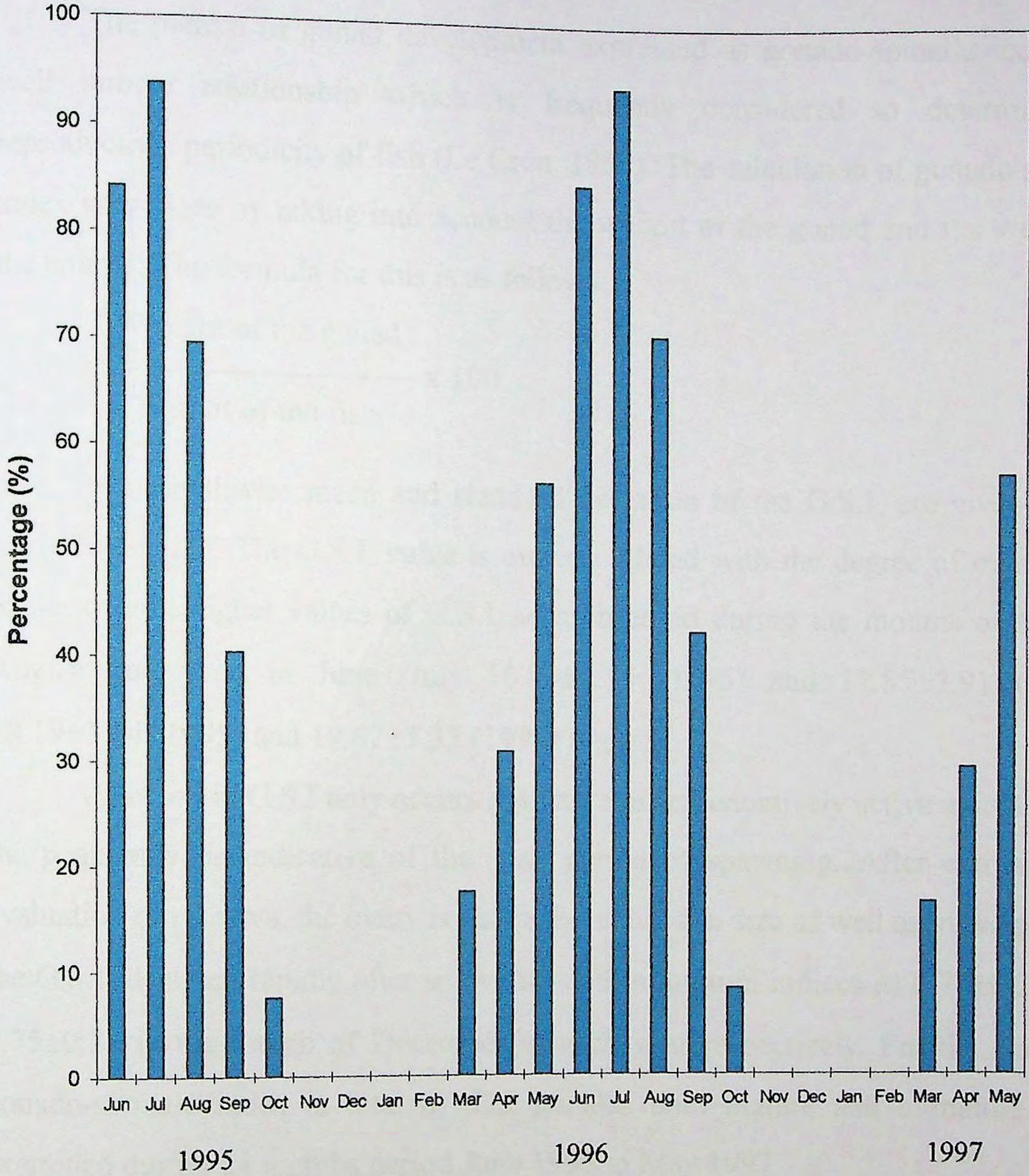


Fig. 16. *C. atherinoides*: Monthly percentage occurrence of gravid females during June, 1995 to December, 1997.

Gonado-Somatic index (G.S.I):

The pattern of gonad development expressed as gonado-somatic index is a well known relationship which is frequently considered to determine the reproductive periodicity of fish (Le Cren, 1951). The calculation of gonado somatic index was made by taking into account the weight of the gonad and the weight of the animal. The formula for this is as follows:

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

The monthwise mean and standard deviation of the G.S.I. are given in the (App.Table -11). The G.S.I. value is directly related with the degree of maturation of the ovary. Higher values of G.S.I. was observed during the months of May to August and peak in June /July 16.84±4.33 (1995) and 17.85±3.91 (1996); 18.19±3.74 (1995) and 19.62±3.35 (1996) Fig-17.

Variation in G.S.I only occurs in mature or reproductively active animals, and the peak may be indicative of the peak period of spawning. After extrusion or evaluation of ripe ova, the ovary is suddenly reduced in size as well as in weight. So the G.S.I. declined rapidly after spawning with minimum indices as 0.73±0.21 and 0.75±0.21 in the month of December of each year respectively. For the study of gonado-somatic index, a total of 525 females both mature and immature were examined during 24 months period June 1995 to May 1997.

Gonadal length index (G.L.I):

This is another method for the determination of the reproductive periodicity which is similar to the gonado-somatic index, but calculation of gonadal length index was made by taking into account the length of the gonad and the length of the animal. The formula for this is as follows:

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

Not only the proportional weight of the ovary increases with the appearance of the ripe ova but also the length of the ovary increases in relation to body length. The gonadal length index was calculated for each individual by using the formula given above and the monthwise average was found by dividing the total of the values by the number of the fish examined. The variation of the gonadal length index due to the variable condition of the gonad for 24 months are presented in Fig.18.

For the study of gonadal length index, a total of 525 females both mature and immature were examined during 24 months period from June, 1995 to May 1997. The monthwise mean and standard deviation of the G.L.I. are given in the (App.Table-11). The mean G.L.I values (Fig.-18) indicate that the G.L.I. follows the similar pattern of fluctuation like G.S.I. Maximum indices as 24.96±1.77 and 26.97±1.9; 25.07±2.43 and 27.77±1.22 for ovaries were recorded in June and July during 1995 and 1996 respectively. Minimum mean value was 8.47±0.37 and 8.67±0.50 for the month of December 1995 and 1996 respectively.

This method is a simple and accurate one for the determination of spawning periodicity.

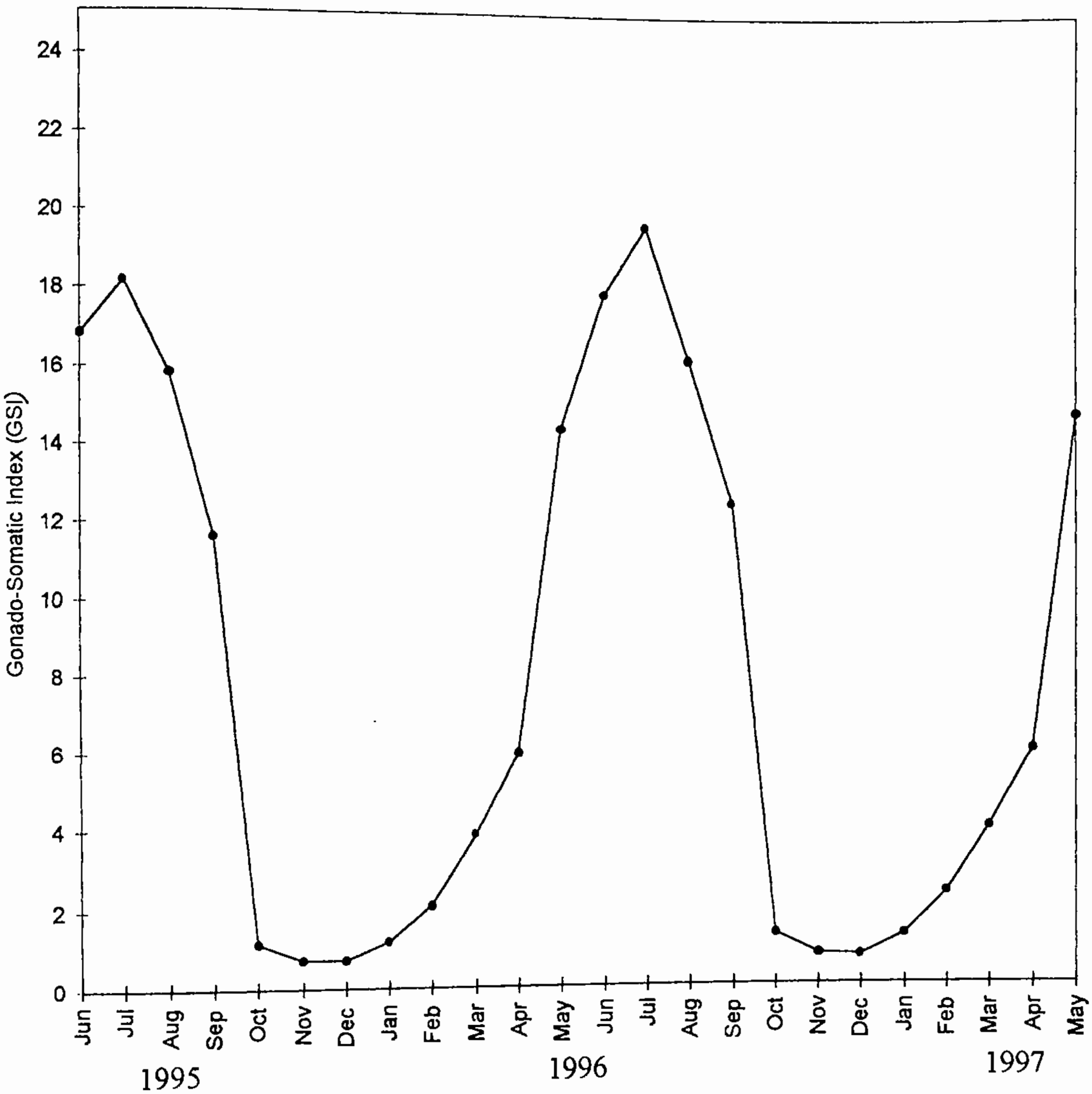


Fig. 17. *C. atherinoides:* Monthly mean gonado-somatic index (GSI).

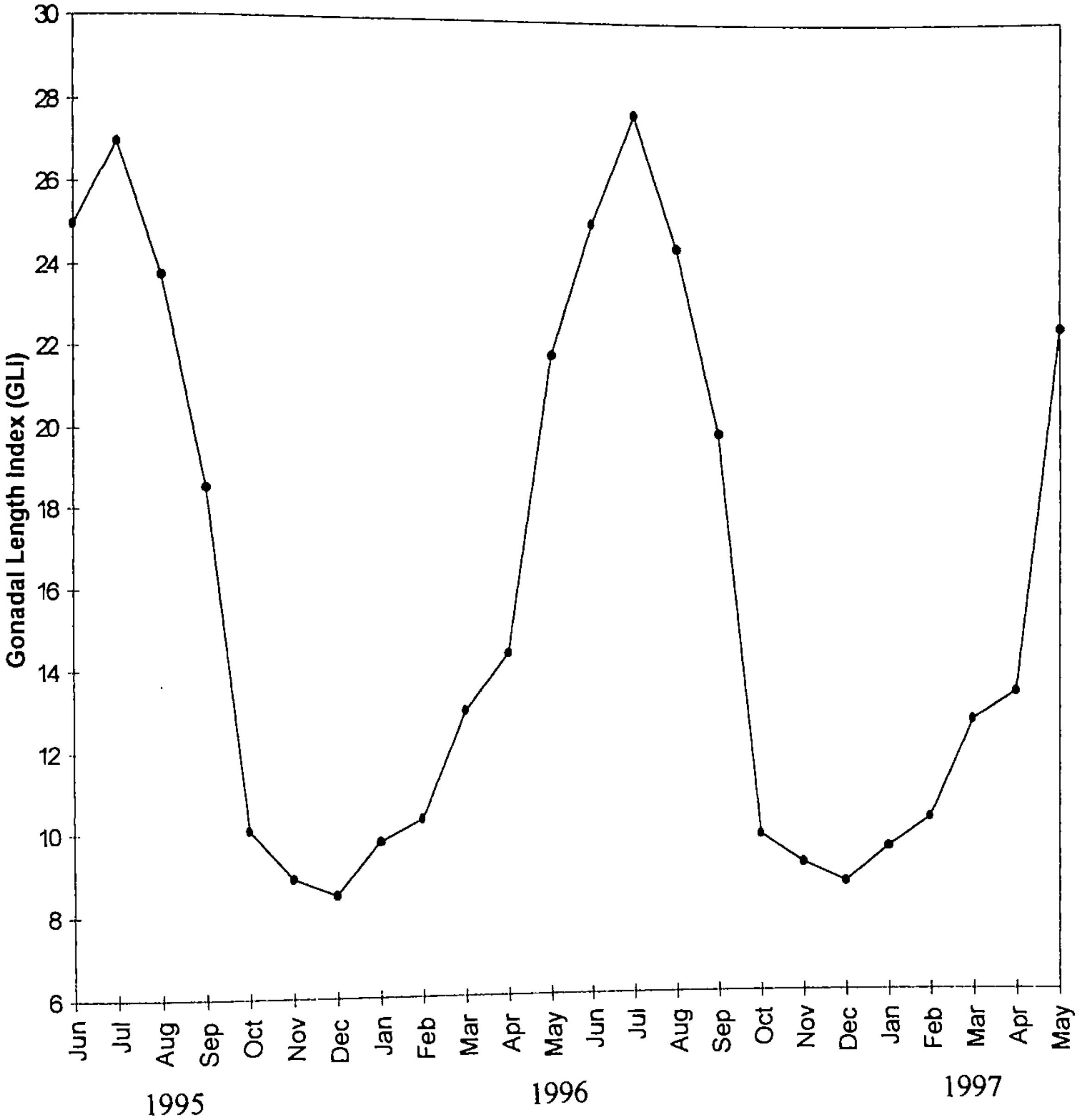


Fig. 18. *C. atherinoides:* Monthly mean gonadal length index (GLI)

Diameter of ova:

To detect the reproductive cycle, the investigation of the diameters of ova throughout the year is an important phenomenon. The sample of the ovarian eggs were taken from the anterior, middle and posterior region of the ovary. Microscopical measurements of the diameters of 10 to 15 ova for each specimen were taken at random and the average was calculated. After summing up the monthwise average diameter of ova was determined.

This changes in the pattern of diameter of ova are found only in mature female in relation to seasonal variation. The maximum mean diameter of ova was obtained as 0.56 mm (July 1995) and 0.57 mm (July 1996) and the minimum value as 0.055 mm (December 1995) and 0.052 mm (December 1996). However, during the months of June, July and August of the years, the ova were always of maximum size. The trend of increment of ova diameter started from March, and from October the average diameter was found to decrease suddenly (App.Table-11, Fig.19). Except the months of May to August maturing or immature or residual ova in the ovary were more frequent in other months.

Mature and ripe ova are commonly found in the ovary of mature female between May to August, peak in June to August and this is the period of highest reproductive activity of *C. atherinoides*.

Colouration of the ovary:

The colour of the ovary helps in determining the reproductive cycle of fishes. The changes in the colour of ovary depend on the degree of sexual maturity of the ova. The colour of the ovary varies from species to species. The colour may be green, red, orange, yellow, white, brown etc. (Lagler, 1956).

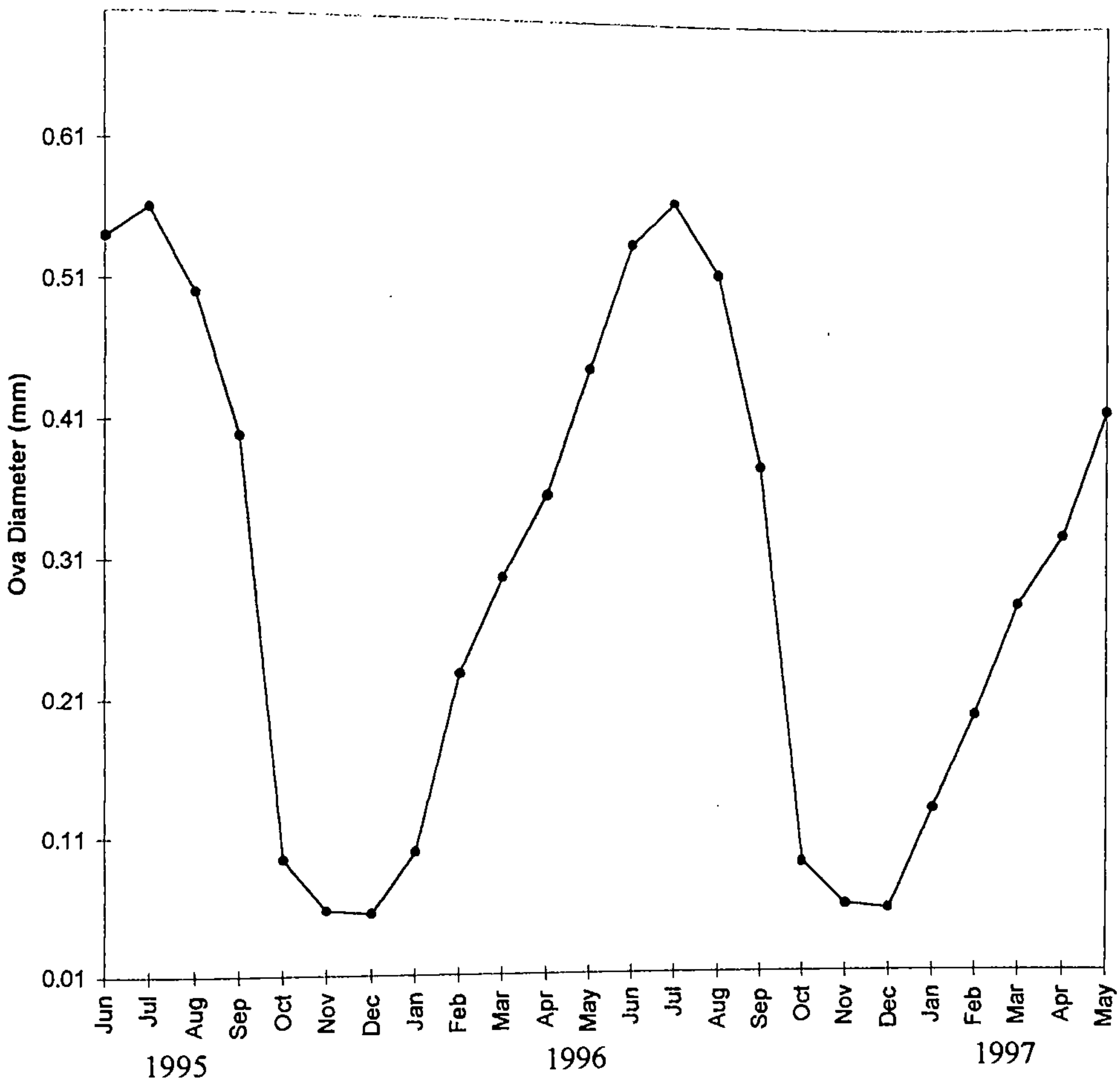


Fig. 19. *C. atherinoides:* Monthly changes in diameter of ova.

In *C. atherinoides* the immature ovary is whitish and transparent. With the increase of yolk deposition, the ovary becomes faint light yellow to yellow, and opaque as well. The ripe and fully mature ovary is yellow to golden yellow in colour. However, the spent ovary again becomes white in appearance (App.Table-11). Particularly in June to August all adult female gravid possessed yellow /golden yellow ovary which indicated ripeness.

In the present investigation the yellow and golden yellow coloured ovary was observed in May, June, July and August which indicated that the breeding season of the fish was in these months.

Maximum indices of spermatozoa in the milt of male:

During March to September the posterior portion of the vas deferens of male fishes were found more massive than the other months of this year. During this period most of the mature males in the catch were observed with extruded milt at the opening of the male aperture. Slight pressure on the posterior ventral side of the abdomen was enough to release the milt from the vas deferens of adult male during this period.

Fecundity:

The term fecundity is defined as the total number of eggs in the ovary of a fish (Nikolsky, 1963). The fecundity is the number of eggs being ready for the next spawning by a female (Royce, 1972). However fecundity appears to bear some broad relationship with the care or nature of the eggs (Lagler *et al.* 1967). For example, in poorly fecund fish, parental care is highly developed. So, to make the population constant fecundity does not fluctuate widely due to low mortality rate and predator. Again the fishes with high fecundity show great fluctuation in their abundance. They do not take care of their eggs, the eggs are subjected to several injury due to excessive temperature, parasitic and predatory attack, etc., after spawning and most of them do not survive up to hatching.

Thus fecundity is one of the important aspects of fish biology and population dynamics (Severtsov, 1941). A thorough knowledge on fecundity of the fish is essential for evaluating the commercial potentialities of its stock, life history, practical culture and actual management of the fishery (Lagler, 1956; Doha and Hye, 1970). Fecundity also determines the index of density dependent factor affecting the population size (Das, 1977).

Estimation of fecundity on the basis of number of ova present in the ovary is not purely accurate because of the following reasons:

i) not all the ova contained in the ovary are released in single spawning season;

ii) some of the ova are reabsorbed in the ovary, which are known as arteric oocytes

iii) constituents of the germinal strand which are present all the time are retained after egg laying.

Several workers have made significant contribution to the study of fecundity of different fishes. Notable among them are Simpson (1951), Lehman (1953), Bhatnagar (1964), Gupta (1968), Doha and Hye (1970), Das (1977), Shafi and Quddus (1974), Bhuiyan and Rahman (1982), Islam and Hossain (1984), Nargis and Hossain (1988), Bhuiyan and Islam (1990), Islam and Hossain (1990), Hossain *et al.* (1992), Bhuiyan *et al.* (1993), Alam *et al*, (1994), Bhuiyan and Afrose (1996), etc.

In the present study, the gravimetric method as followed by Lagler (1956), Pantulu (1963), Bhatnagar (1964), Islam and Talbot (1968), Evans (1969), Doha and Hye (1970), Bhuiyan *et al.* (1993) have been followed for the estimation of fecundity.

To establish the mathematical relationships of ripe ova with total length, standard length, gonadal length, gonadal weight, total body weight and the values of the regressions and correlation co-efficients, the intercepts and standard errors were estimated by least square method.

Estimation of fecundity:

For the estimation of fecundity a total of 152 matured female specimens of *C. atherinoides* were selected. It was observed that the number of eggs varied from 1240 (for a fish with total length 78 mm and body weight 3.12 g) to 20310 (for a fish with total length 93 mm and body weight 9.34 g). However the smallest fish in the sample with a total length 68 mm and body weight 2.38 g shows the fecundity of 1664 and the largest fish with a total length 93 mm and body weight 9.34 g shows the fecundity 20310. The average fecundity was 5728.21±2456.94 for the mean body length and weight of 80.71±7.87 mm and 4.65±1.37 g. respectively.

The variation of fecundity is very common in fish and the number of eggs produced by an individual female is dependent on various factors such as size, age, condition types of species of samples (Lagler *et al.* 1967) etc.

Relationship of fecundity with different parameters:

The relationship between fecundity and total body length, fecundity and total body weight, fecundity and standard length, fecundity and gonadal length, fecundity and gonadal weight were estimated from the observed data and the values of intercepts (a), regression coefficient (b) and co-efficient of correlation (r) were computed (Table-8) from those data by using the statistical formula y=a+bx (regression equation).

Relationship between fecundity (F) and total length (TL):

The relationship between the fecundity and the total length is shown by the scatter diagram in Fig.20 The mean value of fecundity was 5728.21±2456.94 and the mean value of total length was 80.71±7.87 mm. The regression equation was found to be linear and the co-efficient of correlation is highly significant (r=0.966) (Table-8).

Relationship between fecundity (F) and standard length (SL):

The scatter diagram shows the relationship between fecundity and standard length of *C. atherinoides* (Fig.21) The mean fecundity was 5728.21±2456.94 and mean standard length 64.98±6.34 mm. the regression equation was found to be linear and the co-efficient of correlation was highly significant (0.966) (Table-8).

Relationship between fecundity (F) and total body weight (TW):

This is a correlation between the fecundity and total weight of the females. The individual values of the body weight were plotted against the respective fecundity and showed by the scattered diagram. The relationship between these two variables of *C. atherinoides* as shown in Fig.22 was of linear type. The mean total body weight was 4.65±1.37 g.

The regression equation was found to be linear and the co-efficient of correlation was highly significant. (r=0.984) (Table-8).

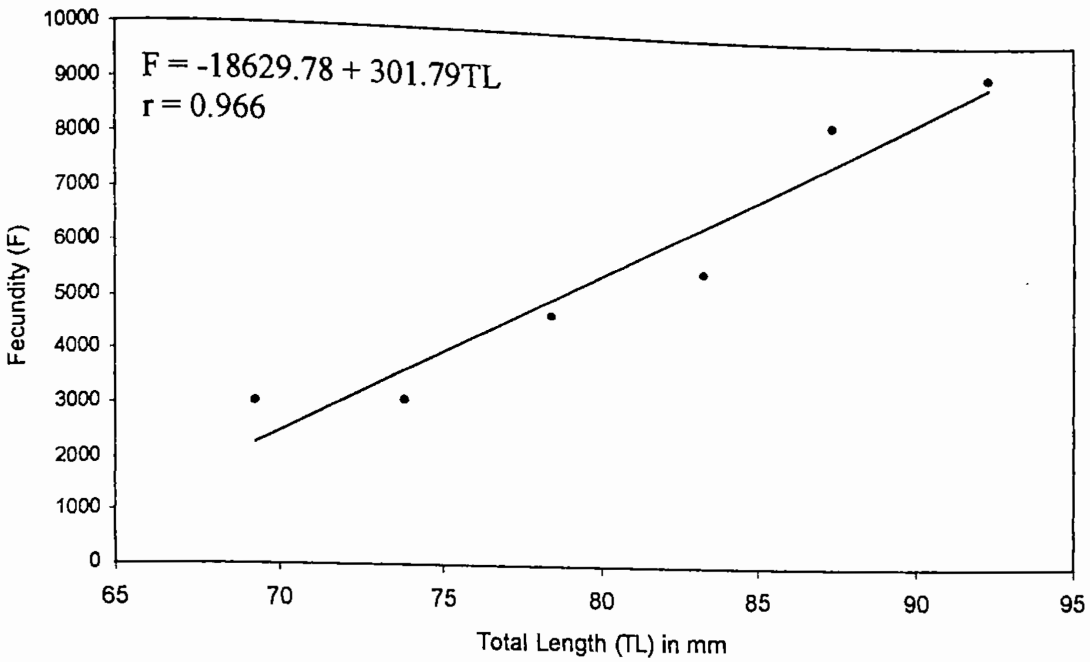


Fig. 20.*C. atherinoides:* Relationship between fecundity and the total length.

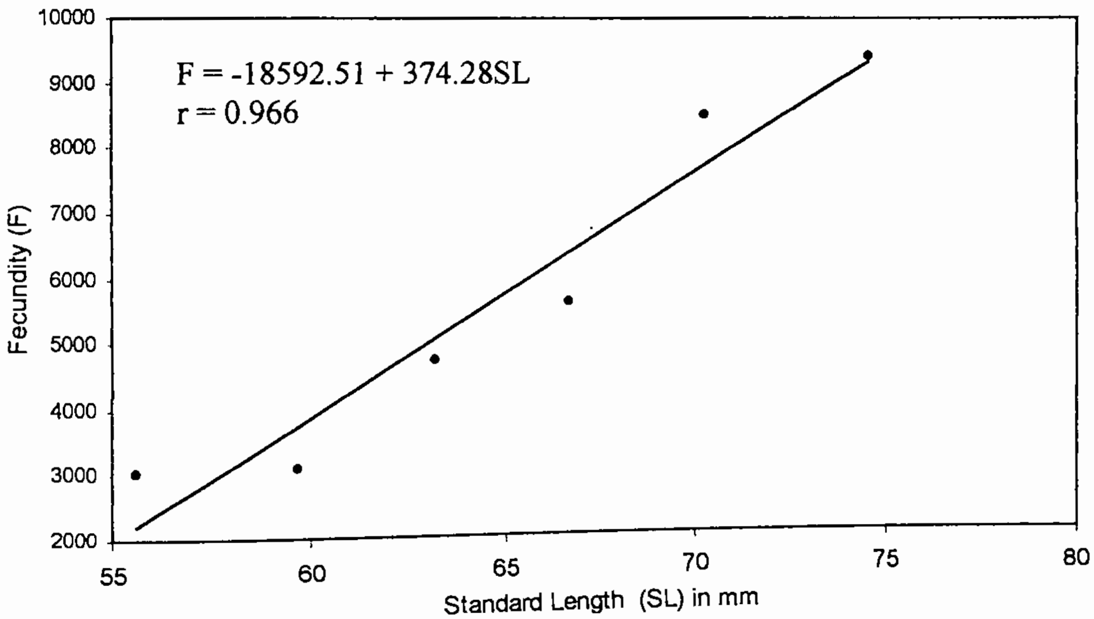


Fig. 21.*C. atherinoides:* Relationship between fecundity and the standard length.

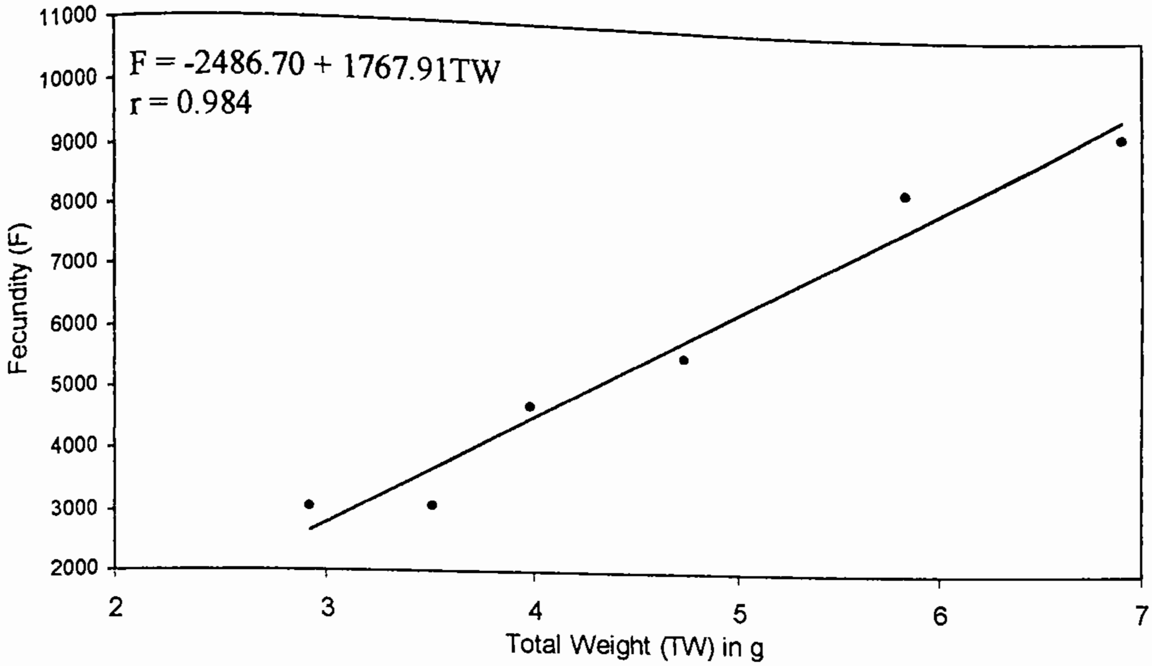


Fig. 22.*C. atherinoides:* Relationship between fecundity and total weight.

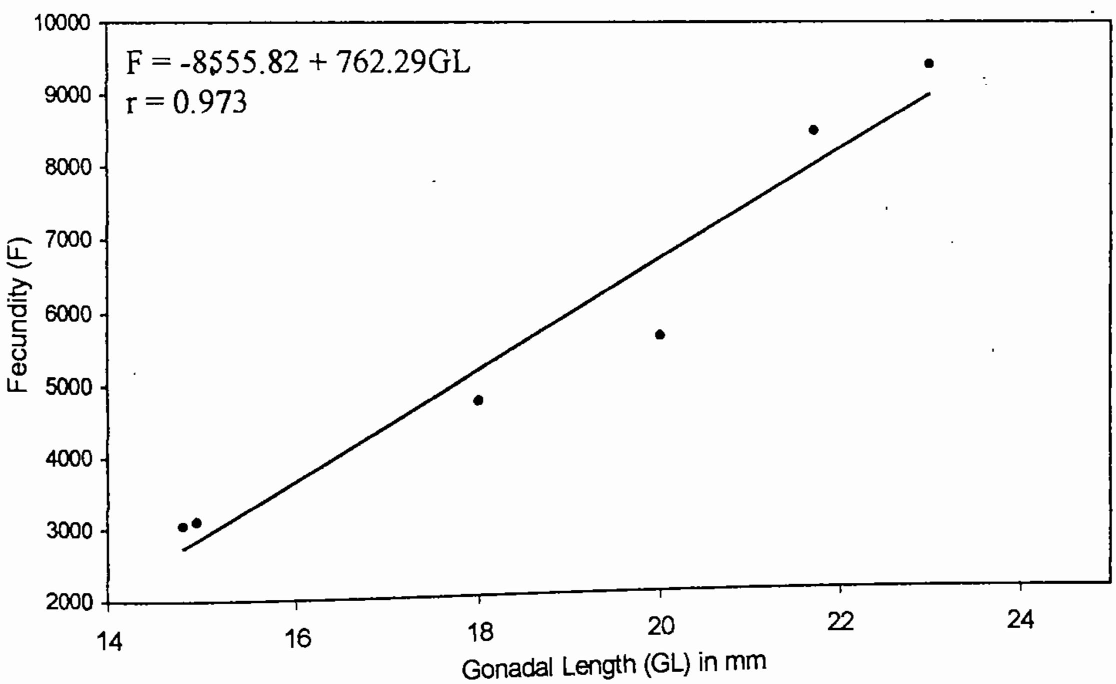


Fig. 23.*C. atherinoides:* Relationship between fecundity and gonadal length.

Relationship between fecundity (F) and gonadal length) (GL):

The scatter diagram of fecundity and gonadal length suggested a linear relationship between the two variables (Fig .23) The mean value of gonadal length was 18.74±3.13 mm.

The value of co-efficient of correlation was highly significant (r=0.973) (Table-8).

Relationship between fecundity (F) and gonadal weight (GW):

The scatter diagram of fecundity and gonadal weight showed a linear relationship between the two variables (Fig.24). The mean value of gonadal weight was 0.78±0.29g.

The value of co-efficient of correlation was highly significant (r=0.987) (Table -8).

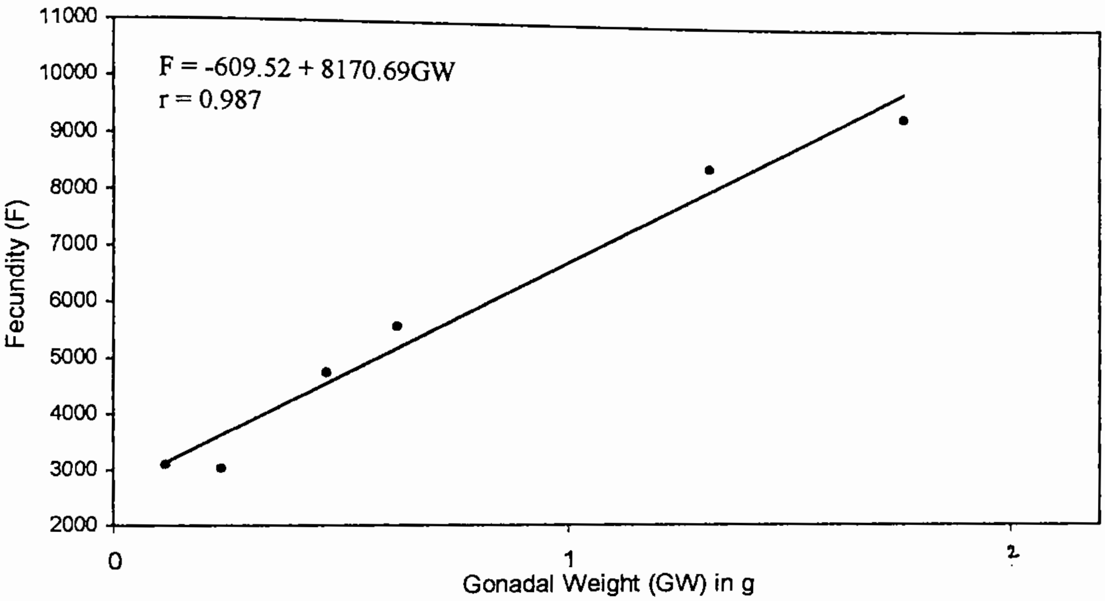


Fig. 24. *C. atherinoides:* Relationship between fecundity and gonadal weight.

Table-8: *C. atherinoides*: Relationships between fecundity and other variables.

Ordinate	Abscissa	Value of 'a'	Value of 'b'	Value of 'r'
Fecundity (F)	Total length (TL)	-18629.78	301.79	0.966***
Fecundity (F)	Standard length (SL)	-18592.51	374.28	0.966***
Fecundity (F)	Total weight (TW)	-2486.70	1767.91	0.984***
Fecundity (F)	Gonadal length (GL)	-8555.82	762.29	0.973***
Fecundity (F)	Gonadal weight (GW)	-609.52	8170.69	0.987***

*** Highly significant (P< 0.001)

Fecundity factor:

Fecundity factor can be defined as the number of eggs in the female of a given length (Table-9). In other words fecundity factor is a tabular presentation with respect to length of the animal. The total length of the female was classified into 6 size groups of 5 mm class interval. The mean values of fecundity of the lowest and highest size groups were 3045±1212 eggs and 9413.67±6319.99 eggs respectively. Whereas, the highest mean value of fecundity was observed in a size group of 91-93 mm as 9413.67±6319.99 eggs. Normally the individual variation was more. Because of individual variation and greater reproductive potentiality variation in different female group seems difficult to comment.

Table -9: *C. atherinoides*: Fecundity factor with respect to total length, total weight and weight of egg mass. The range, mean and standard deviation for each case are provided.

Total length			Total body weight in grams			Weight of gravid egg mass in grams			Estimated fecundity			No. of fish observed
Min	Max	mean ±sd	Min.	Max	mean± sd	Min	Max	mean± sd	Min	Max	mean ±sd	
68	70	69.2 ±0.75	2.38	3.20	2.92 ±0.30	0.20	0.91	0.52 ±0.26	1664	4733	3045 ±1212	5
71	75	73.79 ±1.15	2.8	4.2	3.50 ±0.38	0.22	1.20	0.46 ±0.21	1371	8580	3097.21 ±1729.13	19
76	80	78.35 ±1.44	2.82	4.79	3.98 ±0.53	0.27	1.18	0.63 ±0.22	1240	9221	4745.48 ±1898.20	43
81	85	83.26 ±1.52	3.46	5.80	4.73 ±0.55	0.23	1.34	0.71 ±0.21	1368	12062	5595.29 ±2092.93	54
86	90	87.34 ±1.43	5.05	7.11	5.84 ±0.54	0.34	1.70	1.06 ±0.35	1806	15070	8472.59 ±3468.91	22
91	93	92.33 ±0.82	5.48	9.34	6.90 ±1.14	0.30	3.15	1.28 ±0.89	1612	20310	9413.67 ±6319.99	9
Total		80.71 ±7.87			4.65 ±1.37			0.78 ±0.29			5728.21 ±2456.94	152

Sexual dimorphism:

Some species of fishes exhibit well marked sexual dimorphism between the two sexes (Haq, 1977). For breeding purpose, it is necessary to separate male and female fish rapidly and accurately by observing some external characters. It is rather difficult to differentiate the sexes of fishes, except the breeding season. In the breeding season, the female fishes become obvious by their bulging abdomen.

The genital pore, the size of the head, the shape of the body and abdomen, the fins and the body colouration of both the sexes were examined for finding a practical way of discerning the sexes. The area of genital pore was observed to be quite helpful for identification of the sexes. Besides the genital pore, the body shape and colouration were also examined for differentiation of the sex.

In the present study for identification of the sexes of *C. atherinoides* different body shape, genital papilla, colouration etc. were investigated. In male *C. atherinoides* the genital papilla is a soft, elongated tubular structure broader at the base and gradually tapering towards the end (Fig.25). The genital papilla is light yellow in colour, situated at the base of the anal fin. The body of the male fish is always elongated, colour is more greenish black in the dorsal side in comparison with that of the female.

In female *C. atherinoides*, the genital aperture is round, yellowish in colour and situated in the same area as in the male. The female genital aperture is not so distinct like the genital papilla of the male. The other distinctions of the female from the male are the body shape and colouration. The body and abdominal region is always broader and colour is also light in comparison with that of the male.

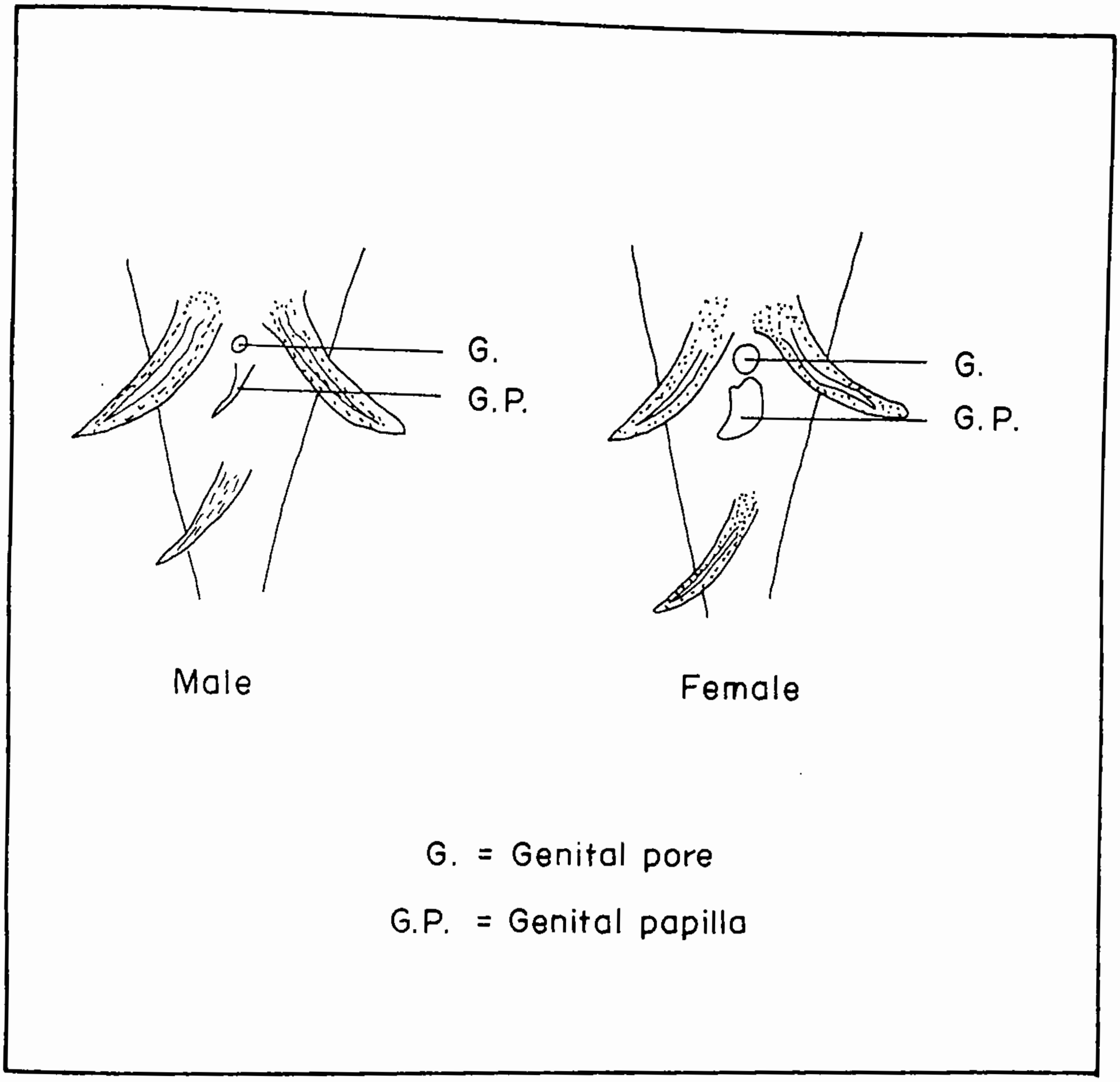


Fig. 25. *C. atherinoides*: Showing the male–female genital pores and papillae.

Sex ratio:

For determination of the sex ratio, a total of 2100 specimens of *C. atherinoides* were collected during the period from June 1995 to May 1997. Out of this 2100 specimens 979 were males and 1121 were females. The total male and female ratio was 1:1.15 i.e. the female number was more than the number of male. The month wise male and female ratio for each year is shown in Fig.26 and App.Table 12. It is obvious from the table that the females are predominant during the months of January, March, April, May, Augusts, September of each year, while the males are predominant in the rest of the months.

The chi-square test was made to see whether the sex difference is statistically significant or insignificant. The test was made from the actual number of males and females. If the population is unbiased in terms of distribution pattern of male and female sexes, then the occurrence of the two sexes are 50% in each case in the random sampling. The results of the test are given in App. Table -13.

Since the calculated value is higher than the table value both at 5% and 1% level of significance in each case, it is obvious that the male and female distribution in the natural population is significantly different.

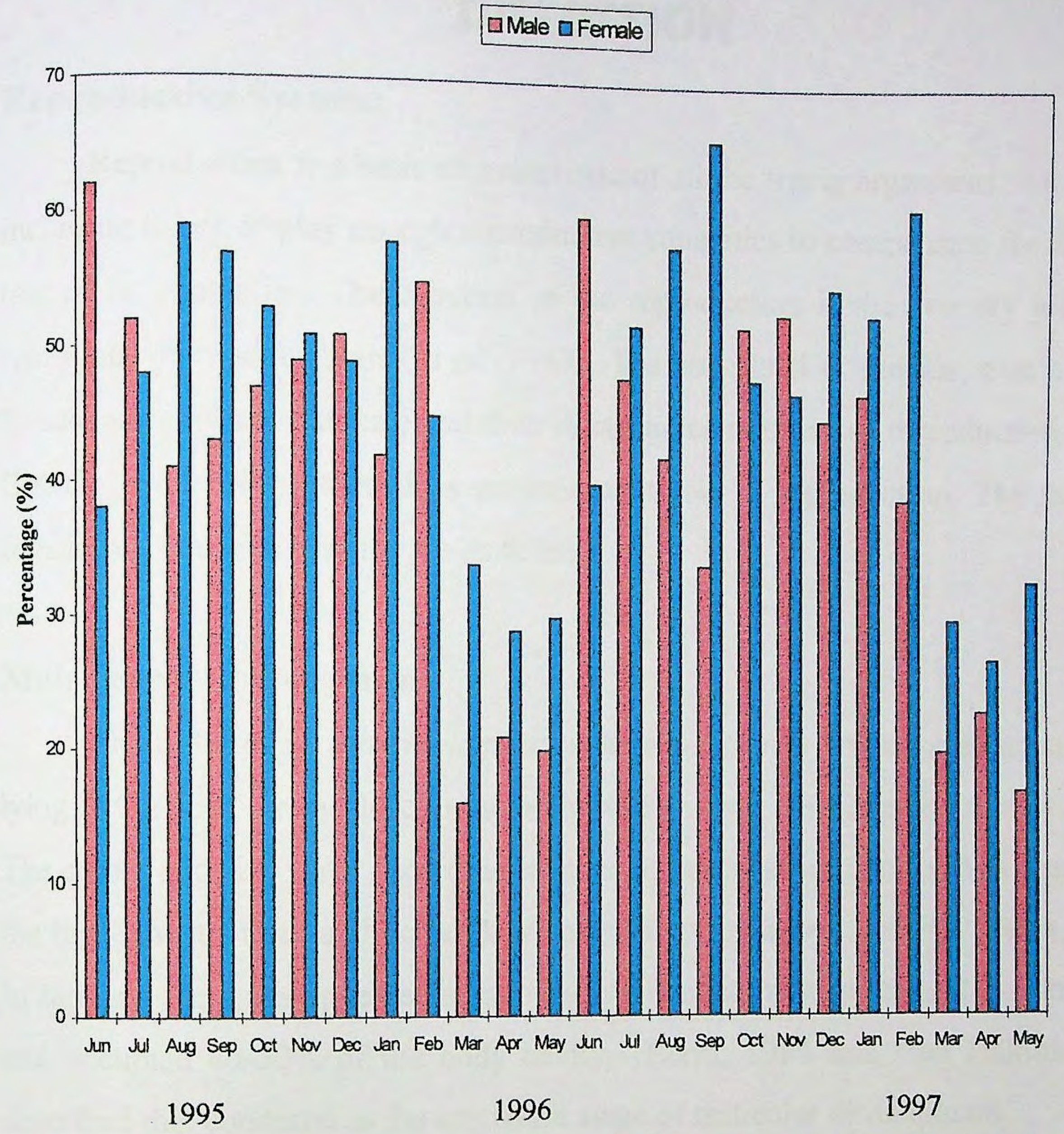


Fig. 26. *C. atherinoides:* Monthly percentage distribution of male and female.

DISCUSSION

Reproductive System:

Reproduction is a basic characteristic of all the living organisms. All animals including fishes display enough reproductive capacities to compensate for the death rate of its population. The function of the reproduction is the primary job of the reproductive system (Lagler *et al.* 1967). The sex gland or gonads, ovaries in the female and testes in the male and their ducts are component of reproductive system. But the endocrine system plays an important role in reproduction. The male and female reproductive systems are as follows.

Male reproductive system:

The testes of *C. atherinoides* are elongated, paired structures of unequal size lying in the body cavity close to the body wall and are suspended by a mesorchium. The colour and size varys according to stage of sexual maturation and as opposed to the higher vertebrates and do not have permanent germinal epithelia (Berra, 1984). In January, the testes appeared as translucent, whitish, narrow, thread like structures and occupied 40-50% of the body cavity, Berra, 1984 and Abu Hakima 1984; described this condition as the immature stage of testicular development.

In the successive months, the testes attain the maturing (February to March) and developing (March to April) stages and finally became fully mature or ripe in the months of May to August. The colour and size of the testes also change accordingly. The fully mature testes were deep creamy in colour and occupy about 60-70% of the body cavity. The milt comes out by slight pressure on the abdomen. The fat from the gut wall completely disappeared at mature stage. The tubule walls remain very thin.

By late August to September most of the specimens were found with spent, flaccid testes and width decreased. Testes regain original position and colour within the month of October. This pattern of developmental changes of testes as reported for *C. atherinoides* are also found in a variety of fish species e.g., *Carassius auratus* (Clemens and Reed, 1967); *Sebastodes pancispinis* (Moser, 1967); *Panecilia reticulate* (Pandey, 1969); *Prototroctes Maraena* (Berra, 1984); *Acanthopagrus* sp. (Abu Hakima, 1984).

Female reproductive system:

The female reproductive system of *C. atherinoides* comprises the paired ovaries situated at the same location as the male gonads. The female gonad is a sac-like structure filled with ova of different sizes. The shape, size and colour of the ovaries depend on the stage of maturation of the developing ova.

According to the degree of maturation the ovaries are divided into ten stages (the terminology used according to Kestaven, 1960; Farmer, 1974; Treasurer and Holliday, 1981. Different stages of ovaries are immature, maturing (early developing), maturing (late developing), mature, ripe, pre spawning, spawning, post spawning, spent and resting.

Immature ovaries were thin, whitish thread like structure, occupying one third of the abdominal cavity. In this stage only immature ova were present. Ova diameter ranged from 0.042 mm to 0.18 mm. The maturing (early developing) ovaries occupy about 40-50% of the body cavity. The colour of the ovary still remained whitish. In this stage also only immature ova were present but the larger ova were more numerous. No granulosa layer and yolk vesicles were found. Ova diameter ranged from 0.095 mm to 0.28 mm. The maturing (late developing) ovaries gained weight and size, colour became light yellow and occupied about 60% of the body cavity. Ova diameter ranged from 0.18 mm to 0.36 mm. The mature ovary occupied about 60-75% of the body cavity. The colour of the ovaries change to yellow, in this stage immature and maturing ova were found with the mature ova. The percentage of occurrence of mature ova were maximum. The ova diameter ranged from 0.30 mm to 0.45 mm.

Ripe ovaries were yellow / golden yellow and occupied about 80% of the body cavity. The ova were clearly seen through the wall of the ovary. Oocytes were transparent. The ova diameter ranged from 0.45 mm to 0.62 mm.

After spawning, the ovaries became reduced in size and dull coloured. After a short spent phase the ovaries regain their original whitish colour and strap shape rapidly. This condition was observed in the matured females from October to December. Similar conditions were reported by several authors in their studies on ovarian development in other teleosts (e.g, Foucher and Beamish, 1977, 1980; Taylor and DiMichelle, 1980; Treasurer and Holliday, 1981; Robb, 1982) which breed once in a year like *C. atherinoides*.

Reproductive cycle:

The time and season when species breeds is normally termed as the breeding or spawning season of that species. The breeding season repeats in cyclic order in which the organism undergoes maturation changes and thereby gets ready to breed again. This repeated phenomenon is known as reproductive cycle (Milton and Arthington 1983). The reproductive cycle in fishes and shell fishes is guided by several environmental factors together with the endocrine activities. Both light and temperature are important factors controlling the development of gonads in fish.

According to Kinne (1971) most of the stages of reproduction often depend on certain conditions of water movement, i.e., for the liberation of spermatozoa and fertilization of eggs.

Histological studies of the ovaries and ova diameter provide knowledge on the seasonal changes in the ovaries.

Stephenson (1934) observed 4 types of reproductive cycle in the animals of tropical water which are:

i. Continuous breeder

ii. Discontinuous breeder.

iii. Annual breeder.

iv. More than one reproductive cycle in a year.

Reproductive activities of most aquatic animals in tropical and sub-tropical areas where environment is relatively uniform throughout the year, are controlled at least in part by temperature and length of day light (Royce, 1972; Hoque and Ahmed, 1993). These two factors may function separately or jointly on the fish biology. Temperature appeared to be extremely important in regulating reproductive cycle of Cypriniformes (Vlaming, 1972). However, photoperiod appeared to be more critical than temperature in determining the timing of the reproductive cycle in *Gambusia affinis* (Milton and Arthington, 1983). After heavy shower during monsoon period (late May to early August) some physico-chemical changes in the water bodies probably stimulate the reproductive activities of Indian major carps (Jhingran, 1977).

The annual reproductive cycle of the fish was determined by different methods. Out of these methods six were applied in the present study to determine the breeding cycle of *C. atherinoides*.

These methods are:

i. Percentage of ovagerous female against time: (Farmer, 1974; Hossain *et al.* 1989),

ii. Appearance of ripe gametes in the gonad (diameter of ova): (Das, 1978)

iii. Gonado-somatic index (GSI): (Dewan and Negabushanum, 1974).

iv. Gonadal-length index (G.L.I): (Qasim, 1973).

v. Coluration of gonad (ovary): (Alves and Desousa Tome, 1969).

vi. Maximum indices of abundance of spermatozoa: (Heydorn, 1965)

All the six methods showed that *C. atherinoides* breed during in May to September with a peak in June to August. Hossain *et al.* (1989) recorded that the breeding period of *Notopterus notopterus* is June to September. Works done by others include those of Nargis and Hossain, (1992) on *Anabus testudineus* Parween *et al.* (1993), on *Esomus danricus*; Fatema *et al,* (1997) on *Oxygaster bacaila* etc.

Out of all these methods, gonadal length index (G.L.I.) was the most suitable method for this species.

Fecundity:

A perfect knowledge on fecundity of fishes is essential for evaluating the commercial potentialies of its stock for study of its life history, practical culture and actual management of its fishery (Lagler, 1956; Doha and Hye, 1970; Das 1977). A review of the literature indicates that different workers studied on the fecundity of different fishes at different time. Among them are: Doha and Hye (1970) who worked on *Hilsa ilisha* of the Padma river; Das (1977) on *Mugil cephalus*; Shafi and Quddus (1974) on *Puntius stigma*; Ahmed *et al.* (1978) fecundity and larval development of *Tilapia nilotica* (Linn); Bhuiyan and Rahman (1982) on *Channa gachua*; Bhuiyan and Rahman (1984) on *Channa punctatus*; Bhuiyan and Bhuiyan (1987) on *Channa striatus*, Islam and Hossain (1984) on *Oxygaster bacaila*; Nargis and Hossain (1988) on *Anabas testudineus*; Bhuiyan and Islam (1990) on *Xenentodon cancila*; Hossain *et al.* (1992) on *Ompok pabda*; Bhuiyan *et al.* (1993) on *Aspidoparia morar*; Haque and Hossain (1993) on *Mystus vittatus;* Alam et al (1994) on *Ailia coila;* Bhuiyan *et.al.* (1995) on *Colisa fasciatus;* Bhuiyan and Afrose (1996) on *Oreochromis nilotica* (L) and others

The present study was undertaken with a view to determining the fecundity of *Clupisoma atherinoides*. Gravimetric method (Lagler, 1956) was used to determine the fecundity of this species. Authors like Pantulu (1963), Bhatnagar (1964), Islam and Talbot (1968), Evans (1969), Doha and Hye (1970), Karim and Hossain (1972), Shafi and Quddus (1974), Mustafa *et al.* (1982), Bhuiyan and Rahman (1984), and Bhuiyan *et al.* (1993) etc. were followed.

The relationship between the fecundity with the total length, standard length, total weight, gonadal length and gonadal weight indicates that the number of eggs increased linearly with the increase of these five variables. All the relationship showed that the values of the regression co-efficient ($P<0.001$) were highly significant.

The number of eggs varied from 1240 (total length 78 mm and body weight 3.12g) to 20310 (total length 93 mm and body weight 9.34 g). The mean fecundity was 5728.21±2456.94 eggs for mean total length of 80.71±7.87 mm and a mean body weight of 4.65±1.37g. The number of eggs produced by a female is dependent on various factors such as size, age and condition of fishes, types of the samples (Lagler *et al.* 1967) etc.

It was found that all the above mentioned relationships were positively correlated and the number of eggs were related more to the weight of the fish than to the length. Simpson (1951) found that fecundity was related nearly to the cube of the length and was thus directly proportional to the fish weight. Mookerjee and Mazumder (1996) reported that the reproductive capacity of the species varied according to the availability of space, food etc. During the estimation of fecundity it was found that *Clupisoma atherinoides* spawns once in a year, mainly May to August.

Sexual diomorphism:

Sexual dimorphism is necessary for breeding purpose to separate male and female accurately by studying some external characters. different workers used different morphological features to identify the sex by looking at the secondary sexual characters. In the present study the genital papilla, body shape and colour were the important features used in identifying the sex dimorphism.

In male *C. atherinoides* the genital papilla is a soft, elongated tubular structure broader at the base and gradually tapering towards the end. The genital papilla is light yellow in colour, situated at the base of the anal fin. The body of the male fish is always elongated, colour is more greenish black in the dorsal side in comparism with that of the female.

In female *C. atherinoides* the genital aperture is round, yellowish in colour and situated in the same area as in the male. The female genital aperature is not so distinct like the genital papilla of the male. The other distinctions of the female from the male are the body shape and colouration. The body and abdominal region is always broader and colour is also light in comparison with that of the male. Doha (1974) studied the sex diomorphism of *Glossogobius giuris*. The sexes of cat fish of Bangladesh through external characters were determined by Haq (1977). Lagler *et al.* (1967) reported that body shape is an important secondary sexual character. In the present study, body shape, colouration, fins were employed to differentiate the sexes.

Sex-ratio:

The sex-ratio of *Clupisoma atherinoides* for 979 males and 1121 females is shown in monthwise distribution. (App.Table-12). The total male and female ratio was 1:1.15 i.e. the female number was more than male. The female dominated during the months of August, September, October, November, January, March, April and May in the first observation and July, August, September, December, January, February, March, April and May in the second observation. But in the other months of the year the females were higher than the males.

The chi-square test shows that the males and females distribution in the natural population is significantly different from the expected ratio. Similar type of results were also reported by Islam and Hossain, (1990); Bhuiyan *et al.* (1993); Bhuiyan and Afrose, (1996).

CHAPTER-4

FISHERY

INTRODUCTION

Fishes and fisheries products have more or less local and world wide demands either as food or as byproducts and therefore, there should be well organized marketing system for the people of Bangladesh as because fishes are the second staple food and the foreign exchange earner.

For fishing purpose, varieties of fishing gears and crafts are necessary. The fishing gears along with vessels, auxiliary equipments and men constitute the "fishing unit". Most of the fishing gears have to break off operations after a certain period of activity for rest and repair work (Ahmed, 1953). Some crafts are also essential to assure a good and effective fishing. The small indigenous fishes are caught in Bangladesh using a variety of gears. A total 10 types of nets, (seine nets, dip nets, fixed nets, cast nets, etc.) and 8 type of traps (Dohar, Anta, Kholson, Jangla etc.) are found in this area. The fishes are also caught with bare hands.

C. atherinoides, a small fish forms an important freshwater capture fishery, which is found in rivers, canals, beels, ponds and ditchs of Bangladesh. It is caught largely from flood plain (beel) areas with other small size fishes. Dip nets are used for its fishing.

The present work deals with the fishing method fishing gears used for catching of *C. atherinoides,* fishing season, fish landing, the existing marketing channel and its activities, marketing margin, marketing cost and profit of the different intermediaries of the fish markets in Rajshahi.

MATERIALS AND METHODS

Study area:

The study area consisted of different fish catching and landing centres of Rajshahi. The species is abundantly found in the rivers and beel areas. The site of the study area was selected on the basis of frequent landing of the species, these are Godagari, Noahata and Shaheb Bazar. The fishing of *Clupisoma atherinoides* was investigated on the basis of interviews made from the different fishermen. A questionnaire was made for this purpose (App. Table 14).

Data Collection:

Information regarding the fishery of *C. atherinoides* has been collected by visiting various fishing and landing centres of Rajshahi. In every possible case measurements of different fishing nets, traps were recorded. Mode of operation, materials used, advantages and disadvantages of their uses etc., were also recorded from interviews of experienced persons at different places. Survey was carried on different seasons of the year.

Information on marketing system of *C. atherinoides* was also collected from different fish landing centres of Rajshahi on the basis of interviews taken from different fish traders (e.g. farias, beparias, aratdars and retailers) engaged with the business of the studied species.

The data pertaining to daily landing, total landing of *C. athernoides* were collected from the aratdars of each landing centre, because they keep the records for the convenient of their tax collection. The mean daily landing of each month was recorded for that particular month.

RESULTS AND OBSERVATIONS

Fishing Method:

From the prehistoric times various types of fishing methods have developed. The term 'fishing' means to capture fish by any process. For this purpose varieties of fishing crafts, gears, traps etc. are made which have undergone evolution in different parts of the world giving rise to various methods of the present day. Various type of locally made traditional crafts and gears are used in Rajshahi since centuries for capturing *Clupisoma atherinoides* along with other small size fishes. Mostly three types of dip nets are used for the fishing of *C. athernoides*. The following gears are used in capturing fishes in Rajshahi.

Fishing Nets:

'Veshal' or 'Khora' Jal:

'Veshal jal' or 'khora jal' is triangular in shape (Fig.27a). Two margins of the net are attached to the bamboo frames to apply the name for "khora". The mesh size was found as 0.5 to 1.5 cm. The landing capacity of this net was found as 1 kg to 7 kg per catch according to the population density and fishing season of the species. The nets were found to be in use in rivers and also in beels. The net was found to be operated either from a boat permanently set up with the help of bamboo sticks.

Veshal jal is used in rivers and beels. Materials required to make this net is nylon thread, ropes of nylon and jute yarn and several bamboo poles and sticks.

The length of the veshal jal varies from 10-15 m. Similarly the length of front margin is 7-12m.

Dharma Jal:

'Dharma jal' is another type of dip net extensively used is capturing this fish in comparatively smaller water bodies, and along the bank of the rivers where the water level is low. Professional fishermen very often use this net. Generally the non-professionals and children were found to use the net when the water level decreased.

The net is square or rectangular in shape, four corners of the net are attached with the four ends of two bows (made of splitted bamboo) placed normally at right angles to each other. A bamboo handle of suitable length is attached at the junction point of the two bows. The mesh size was found as 0.5 to 1.5 cm. During operation, the net is kept sunk into the water with the help of this bamboo and time to time the net is pulled up to collect fish. A single man can handle the net (Fig.27b). The landing capacity of this net was found as ¼ kg to 1.5 kg per catch according to the population density and fishing season of the species.

'Thela Jal'

'Thela jal' is another type of dip net used extensively in shallow waters to catch this fish along with other smaller fishes. The net is triangular in shape attached to a bamboo frame and easy to handle by a single person. The nets found were made of nylon thread and cotton cord. The mesh size varies from 0.5 to 1.5 cm. (Fig.27c). The landing capacity of this net was found as ¼ kg to 1.5 kg per

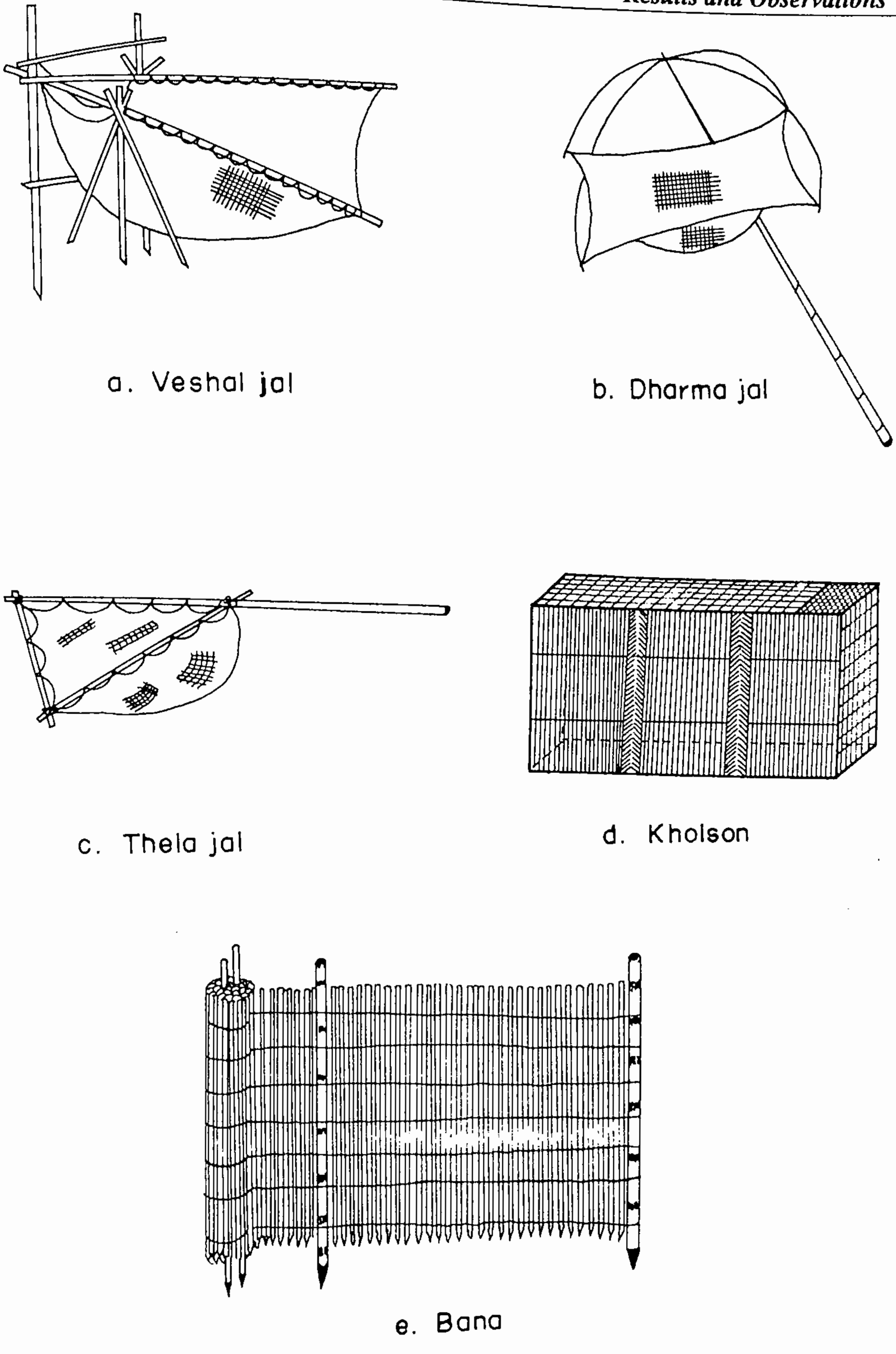


Fig. 27. (a–e) *C. atherinoides*: Different types of gears.

catch according to the population density and fishing season of the species. Thela jal is used in beel, areas.

The net is easy to handle. It is dipped under water and pushed to some distance and raised up to collect the catch.

Fishing Traps:

Kholson:

'Kholsons' are very popular trap used extensively by professional and non-professionals during most of the time of a year. The trap is a rectangular one, made of splitted bamboo sticks. This trap is used normally in small water bodies or beel or near the bank of the rivers and they are set either with a barricade (bana) or alone (Fig.27d). Kholsons are set with the help of sticks and branches along with some aquatic plants.

The kholson usually measure about 0.60 to 1.25 m in length, 0.15 to 0.23 m in breadth and 0.45 to 0.60 m in height, having 2 or 3 openings (nearly top to bottom) with valves made of pointed bamboo splits, which allow the fish to enter but prevent backward movement.

Barricades:

Bana (bana, halapat or pati):

The bana or pati is used in every category of water like beel or channel either independently or operating the traps and nets. It is a screen (Fig.27e) made up of thin split bamboo pieces interconnected by jute threads.

Fishing season:

Fishing of *C. atherinoides* in the Padma river and beel areas are almost continuous throughout the year. During the period of monsoon and (June to September), beel teems with flooded water and choppy and fishing is made along with other fishes by setting nets and traps against the water current at a suitable place. Due to wide spread of fishes in this period, only those fish, which come out of their whole for spawning or feeding and fall into the water course infront of nets and traps are caught, so the percentage of catch is comparatively less than the other parts of the year. The conditions are just reversed during the winter season (November to February) when beel becomes calm and water starts to vacate, fishing is made by means of traps placing at suitable places with the help of barricades. Hence throughout the entire winter season the fishing is found in the peak for the species with other small fishes.

Monthwise landing of *C. atherinoides:*

In the first and second observation the highest landing of the fish was in the month of November (480 and 425 kg) and the lowest quantity was in the month of April (25 and 18 kg) in Shaheb Bazar. The highest landing of the fish was in the months of December (285 kg) and November (327 kg) and lowest in the month of April (15 and 10 kg) in Godagari Bazar in the first and second observation. In Noahata Bazar the highest landing of the fish was in the month of November (310 and 275 kg) and lowest in the months of April (10 kg) and May (12 kg) in the first and second observation (App.Table-15 Fig.28). The peak supply period of the fish in the local market was the winter season.

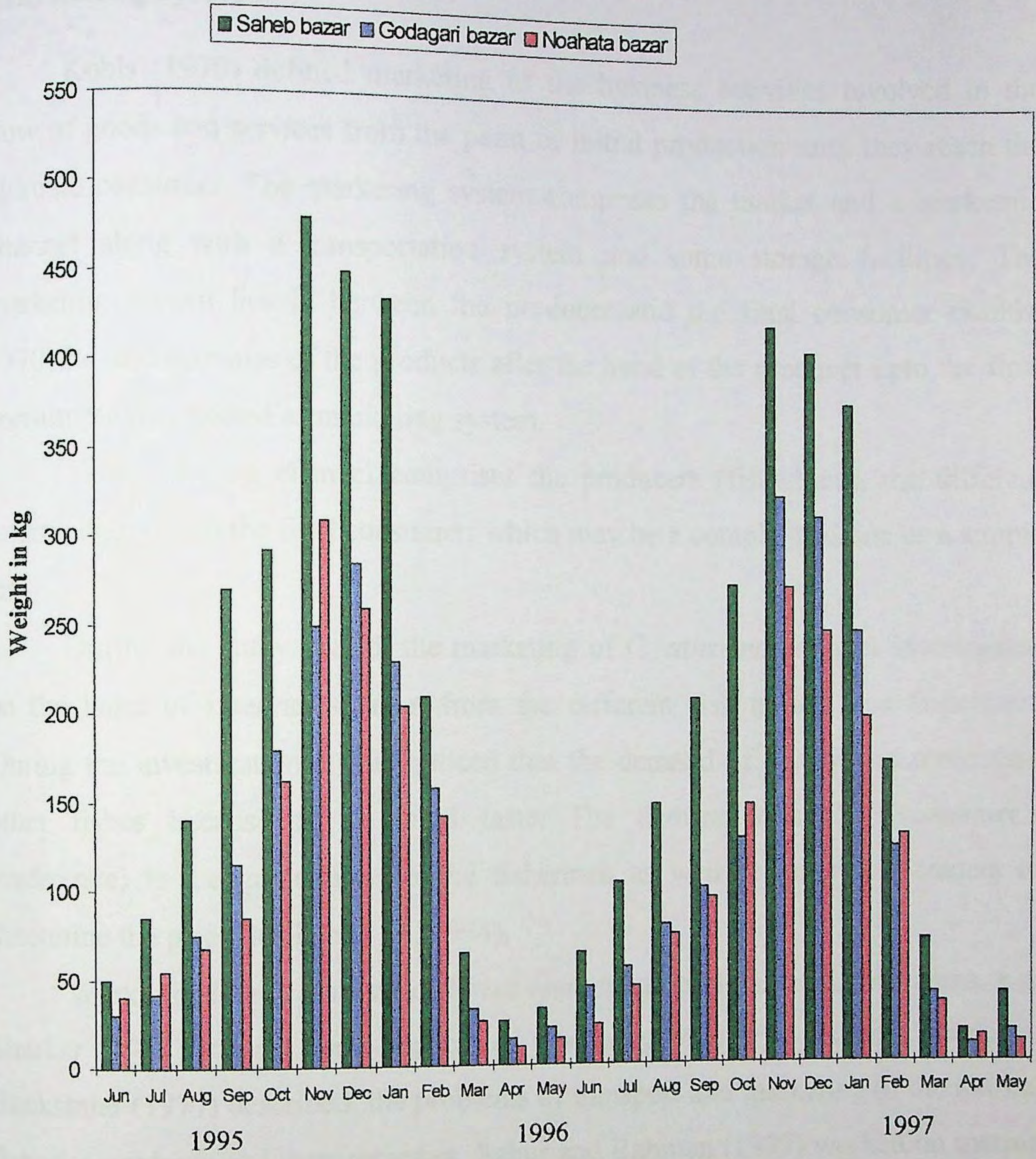


Fig. 28. *C. atherinoides:* Showing the monthwise landing in three fish markets during June, 1995 to May, 1997.

Marketing system:

Kohls (1970) defined marketing as the business activities involved in the flow of goods and services from the point of initial production until they reach the ultimate consumer. The marketing system comprises the market and a marketing channel along with a transportation system and some storage facilities. The marketing system lies in between the producer and the final consumer (Kohls, 1970) i.e. the activities of the products after the hand of the producer upto the final consumption is treated as marketing system.

The marketing channel comprises the producers (fishermen), the different intermediaries and the final consumer; which may be a complicated one or a simple one.

During the study period, the marketing of *C. atherinoides* was investigated on the basis of interviews taken from the different fish traders and fishermen. During the investigation it was noticed that the demand of this fish is more than other fishes because of its good taste. The demand elasticity (consumer's preference) is the guide line for the fishermen as well as other fish traders to determine the price (Mollah *et al.*, 1974).

Works had been done on different marketing problems of fishery items, e.g. Sharker (1977) studied some aspects of marketing of marine fisheries products. Bucksmiar (1977) described the problems of transport and marketing of the marine fisheries products and their remedies. Sabur and Rahman (1979) worked on marine fish marketing. Hossain (1996) reported on the marketing system of prawns and small indigenous fishes. But no such works had been done on the *C. atherinoides*.

Marketing Channel and its Activities:

The producers or fishermen were found to distribute their catches (*C. atherinoides*) to different far and near markets through a more or less distinguished channel. However, in many cases such distinguished channels were not found (at the far interior producing areas). In between the fishermen and the final consumers, there were a few intermediaries (Table-10). The activities of the fishermen and the different intermediaries as found are described below:

Fishermen:

The first and most important basic concern of the marketing channel are fishermen or growers. They catch the fishes from natural fishery grounds such as river ponds, beels, baors, canals etc. throughout the year. However, culture of *Clupisoma atherinoides* has not yet been established in Bangladesh. After catching the fishes the fishermen sell their commodity in fresh condition either directly to the consumers in the nearby market or to any intermediaries (Table-10). Good socio-economic condition, transportation and absence of proper preservation are the main factors that prevent the fishermen from going to the far markets or a big town, where they could get higher price of this fish.

Farias:

The farias are the second basic person of the marketing channel. Normally, farias gather at the fishing stations or at the transporting centres. They purchase fish in fresh condition and supply to any nearest business centres or market for direct selling to the beparis (the primary wholesalers) (Table-10). They have direct communication to the distant markets. The faria's profit is directly related to the distance of the markets. They get only benefit (profit) usually in lesser at nearest transporting centre but more at far market. They have small size of capital investment and sometimes take advance from the beparis for purchasing fish and a link thus established with the definite bepari.

Table-10: *C. atherinoides*: Marketing channel and cost involvement.

Grower Received	100%	88.40%	82.40%	69.88%	59.90%	52.90%
Faria Cost+profit Total				4.20+10.05 14.25%	2.15+6.50 8.65%	3.50+7.35 10.85%
ARATDER cost+profit Total						0.45+2.75 3.20%
BEPARI cost+profit Total					6.10+11.05 17.15%	5.90+11.75 17.65%
ARATDER cost+profit Total			0.40+3.15 3.55%	0.42+3.35 3.77%	0.35+3.50 3.85%	0.40+3.50 3.90%
RETAILER cost+profit Total		0.85+10.75 11.60%	0.85+13.20 14.05%	0.85+11.25 12.10%	0.85+9.60 10.45%	0.85+10.65 11.50%
Consumer Paid	100%	100%	100%	100%	100%	100%

Beparis:

The beparis are the third step of the marketing channel. The beparis have medium to large sized capital investment. They purchase fish from the farias or even from the fishermen directly and sell their consignment to the retailers through the aratdars (commission wholesalers) (Table-10). they often take advance money from the aratdars and also finance the farias sometimes even the fishermen. The beparis mainly assemble at the transporting centres.

Aratders:

The aratders are the fourth basic person of the marketing channel, who act as wholesaler and commission agent in the market. They usually purchase fishes from farias and beparis, sometimes directly from the fishermen (Table-10). They are permanent fish dealer having a license from the proper authority. Aratders normally possess permanent establishment and act in between the beparis and the retailers. They help the beparis to sell their fish and charge a fixed commission on the amount transacted. Aratders give cash payment to the beparis but supply fishes to the retailers on credit by auction. The aratders offer a provisional accommodation for the different intermediaries and take a risk for sale after the handover of fish from any type of intermediaries.

In many cases, aratders require a large amount of capital investment for financing the beparis and farias, which is termed as "dadon" often fishermen take dadon for repairing or purchasing gears (nets and traps) and crafts.

Retailers:

The retailers are the important link of the marketing channel of small and large markets. They are engaged in small range of business with either less amount of capital investment or without any investment. The retailers purchase fish from the wholesalers or aratders and even from the fishermen and sell directly to the consumers (Table-10). They purchase fish from the wholesalers on credit and make payment after selling fishes. The number of retailers are more in the markets. Some of them are permanent fish retailers, while others are engaged as temporary. In some case the beparis including fishermen act as retailers depending on the market structure and situation.

Hawkers also sell this fish door to door in the village and residential areas of the towns.

Consumers:

Consumers are the last link of marketing channel. They are not businessmen. They purchase fish from the retailers for their own consumption. The number of consumers in the market depends on price of fish and their purchasing capacity or quality and freshness of fish.

Normally *Clupisoma atherinoides* is not directly transported to the wholesalers of Rajshahi, Godagari and Noahata fish markets, the selling begins from the producing area by the fisherman himself and some percentage of the products reach a main market through different intermediaries. The intermediaries (e.g. faria) again sell the product at the nearby smaller markets and also hand over to another intermediary (e.g. bepari) for selling at a big market.

Marketing Characteristics:

Pattern of Ownership:

Most of the wholesalers and aratders of Shaheb Bazar, Shalbagan, Binodpur and Laxmipur fish markets of Rajshahi Metropolitan City perform their business under sole tradership, family or partnership. There are a few co-operative form of business organization only by name, which are not worth mentioning and not at all well organized like other business firms.

Experience of the middleman:

The result of survey shows that most of the aratders, wholesalers and retailers are well experienced. The retailers have the experience of 1 to 20 years of business. Amongst them the wholesalers and the aratders are the most experienced businessmen. Sometimes even they run the business from generation to generation. On the other hand, some of the retailers have been continuing their business for 30 to 40 years. New faces are also coming considerably. Some temporary retailers are also found there. Those who are fishermen have occupational experiences as well. They are often more experienced than the other middleman.

Capital Structure:

The capital invested by the middlemen, are divided into two parts, such as fixed capital and fluctuating or running capital. Fixed capital includes in license fees, investment for godown, weighing instruments and articles for recording accounts of the business while fluctuating capital is used for cash purchase of the commodity, packing charges, carrying charges, donations and salami to various inspecting agents. The aratders and the wholesalers are much more powerful in respect of their capital. Often they give advance (payment) to the retailers or fishermen for more profit.

Containers:

Different type of containers are used for carrying the fish. After harvesting, *C. atherinoides* along with other fishes are collected in a small bamboo made container called as 'kholoi' for smaller amount and when sold locally, this 'kholoi' is generally used to carry the fishes. For larger amount and distant markets the fishes are carried in bamboo made baskets called as 'dali' or 'dala' and also fish are carried in bamboo made small size baskets called as 'jhuri' sometimes the fishes are carried in aluminum made container called as 'harhi' (Fig.29).

Transportation:

Generally fishes are transported by truck, bus, train, rickshaw, van, tomtom, boat etc. Some fishermen bring their fishes by themselves carrying on the heads. During the transporting, ice is given along with the *C. atherinoides* for distant and in adverse weather condition and no other modernised methods are taken.

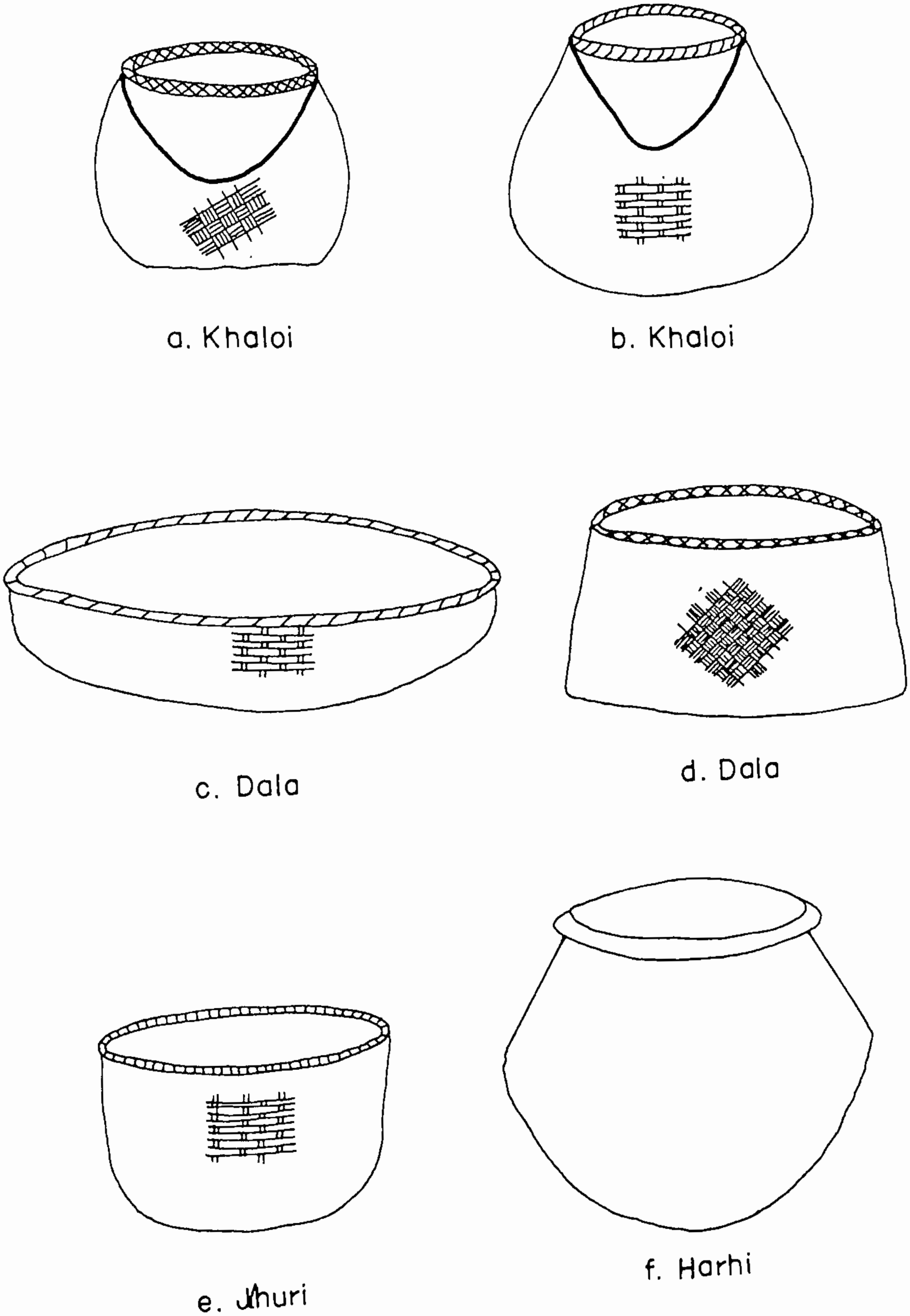


Fig. 29. (a–f) *C. atherinoides*: Containers for transportation.

Marketing Margin:

The difference between the amount paid by the consumers for their products and the amount received by the producers in referred to as the 'total marketing margin' or 'total marketing bill' (Kohls, 1970). The term price spread is often used synonymously with the term marketing margin (Sabur and Rahman, 1979). This margin or bill includes all the cost of moving the commodity from the point of production to the point of consumption and of handling at all levels in the marketing machinery. The total marketing margin usually consists of margins at several stages of distribution, and in each case the margin is the difference between the buying and the selling price of each distributor. Thus marketing margin consists of two component parts:

i) Marketing costs for performing various functions

ii) Profit of the intermediaries (Sabur and Rahman, 1979).

The market prices of the studied species were found to vary among the three markets (e.g. Rajshahi, Godagari, Noahata). The total marketing margins per kg of the species, with the margins of the intermediaries as found at the different markets are given in App.Table-16.

The highest total margins was found at Rajshahi market as Tk.35.00 per kg. The lowest total margin was obtained as Tk.22.00 at Noahata market.

The highest margin for 'farias' was obtained as Tk.9.75 per kg at Rajshahi market and the lowest margin was found as Tk.6.00 per kg at Noahata market. The bepari's highest margin was observed as Tk. 14.00 at Rajshahi market and the lowest margin was obtained as Tk.8.50 per kg at Godagari market. The highest and lowest margin for farias were recorded as 11.25 and 7.50 Tk./kg at Rajshahi and Noahata markets (App.Table 16, Fig.30)

The highest price paid by the consumers was found as Tk. 120 per kg at Rajshahi market. The lowest consumers price was obtained as Tk. 82.00 per kg at Noahata fish market. the fishermen get the maximum price for their commodity at the market of Rajshahi as Tk. 85.00 per kg which was 70.83 percent of the consumers price. The lowest price obtained by the fishermen was found as Tk. 60.00 per kg at Noahata, which was 73.17 percent of the consumers price respectively (App.Table-16).

Marketing Cost:

The variation in the market price is mainly due to the marketing costs involved for different markets. the highest total marketing cost was obtained at Rajshahi as Tk. 5.25 per kg and the lowest was found as Tk. 3.25 per kg at Noahata (App.Table-16, Fig.31).

The highest cost for 'farias' was obtained as Tk. 1.75 per kg at Rajshahi and the lowest as 1.00 Tk/kg at Godagari. The highest and lowest costs of beparis were obtained as 3.00 and 1.75 Tk/kg at Rajshahi and Noahata fish markets respectively. The highest costs for 'retailers' were obtained as Tk. 0.50 per kg and 0.50 Tk/kg at Rajshahi and Godagari fish markets and lowest as 0.25 Tk/kg at Noahata market.

Profit of Intermediaries:

The highest total profit was found at Rajshahi as Tk. 29.75 per kg and the lowest profit was found as Tk. 18.75 per kg at Noahata. The highest profit earned by 'farias' was obtained as Tk. 8.00 per kg at Rajshahi fish market and the lowest as 4.75 Tk/kg at Noahata market. The 'beparis' highest profit was found as

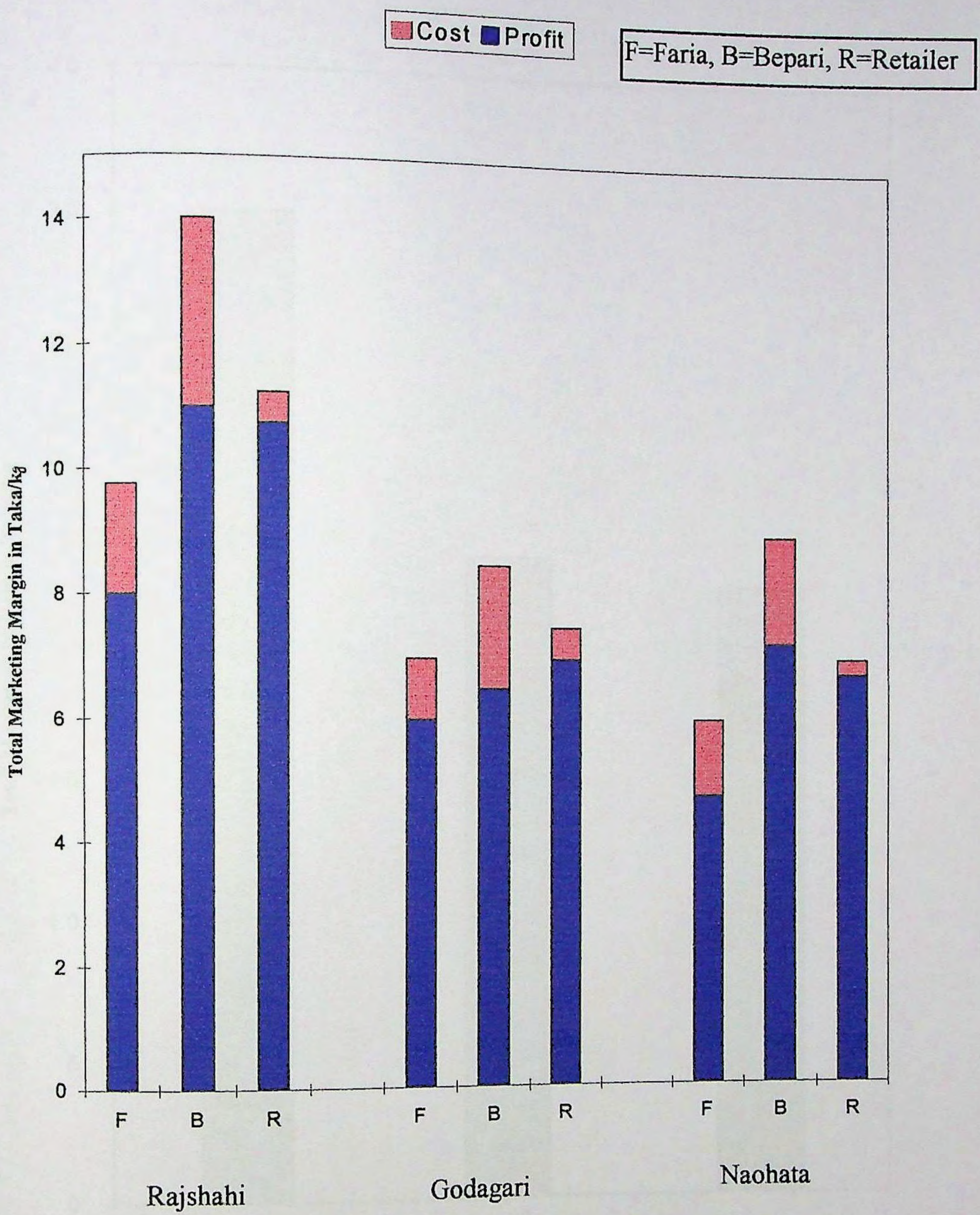


Fig. 30. *C. atherinoides:* Total Marketing margins of intermediaries of different markets.

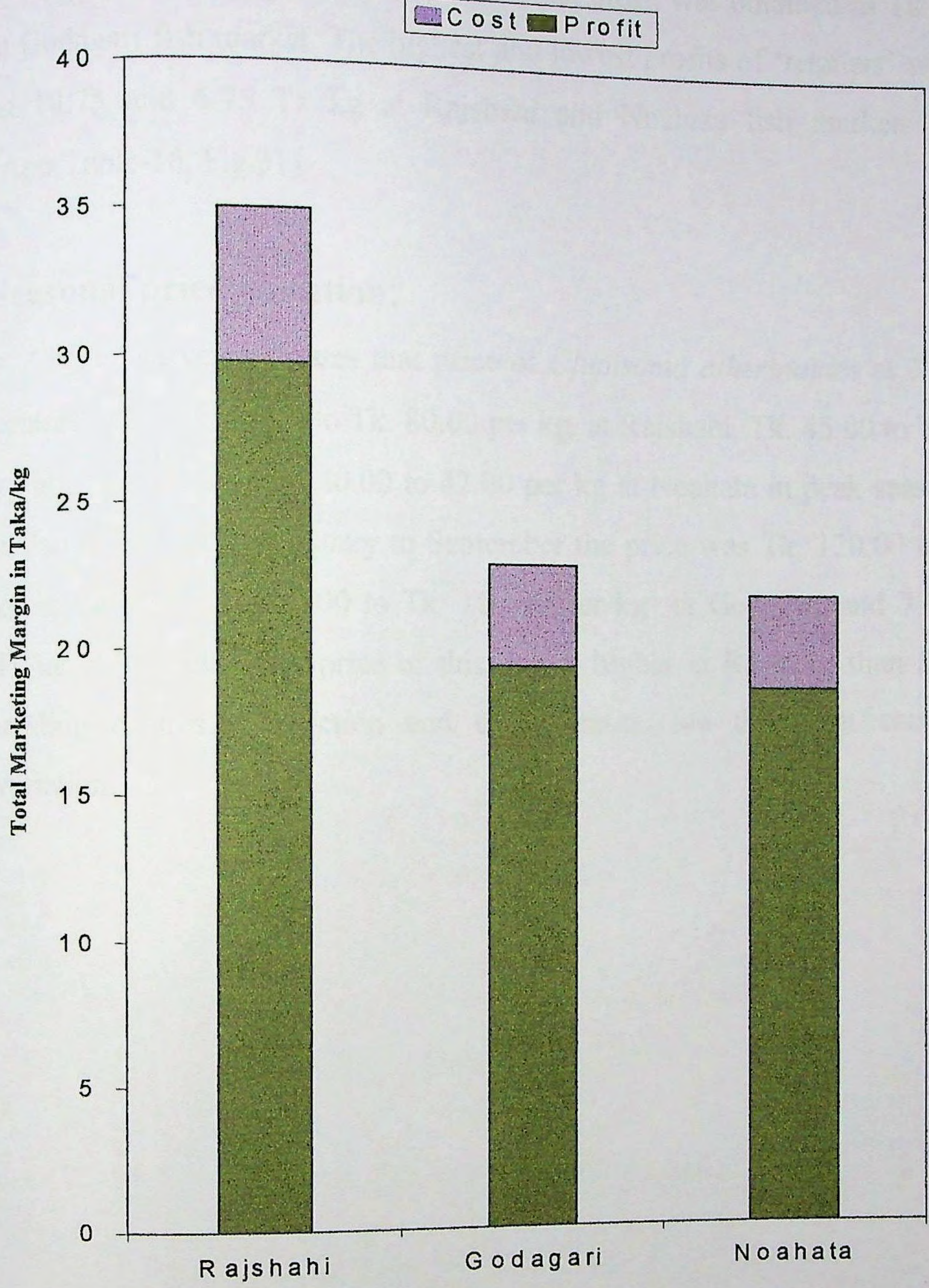


Fig. 31. *C. atherinoides:* Total Marketing margins of different markets.

Tk. 11.00 per kg at Rajshahi and the lowest profit was obtained as Tk. 6.50 per kg at Godagari fish market. The highest and lowest profits of 'retailers' were recorded as 10.75 and 6.75 Tk./kg at Rajshahi and Noahata fish markets respectively. (App.Table-16, Fig.31).

Seasonal price variation:

The survey indicates that price of *Clupisoma atherinoides* at 3 fish landing centres were Tk. 60.00 to Tk. 80.00 per kg. at Rajshahi, Tk. 45.00 to Tk. 48.00 per kg at Godagari and Tk. 40.00 to 42.00 per kg at Noahata in peak season (October to January). But in February to September the price was Tk. 120.00 to 160.00 per kg at Rajshahi; Tk. 80.00 to Tk. 100.00 per kg at Godagari and 75.00 to 90.00 Tk/kg at Noahata. The price of this fish is higher at Rajshahi than the other fish landing centres. Production and transportation are the main causes of price variation.

DISCUSSION

The gears which are used in catching *Clupisoma atherinoides* consist of three types of net and one type of trap, barricade etc, have been described. The fishermen also use 'kholson' accompanied with the 'barricades' for catching *C. atherinoides* particularly during the post monsoon to spring along with other small size fishes. The fishermen use 'veshal jal' 'dharma jal' and 'thela jal' for catching *C. atherinoides* during the monsoon or flood season.

Fishing of this species in Padma river and beel areas are almost continuous throughout the year. However the peak period was observed during the winter season. The monthwise landing of *C. atherinoides* at 3 fish markets (Shaheb Bazar, Godagari and Noahata Bazar) of Rajshahi is shown in App. Table-15. In the first and second year's observation the highest landing of the fish was in the month of November in Shaheb Bazar (480 and 425 kg) December and November in Godagari Bazar (285 and 327kg) and November in Noahata Bazar (310 and 275 kg). The peak supply period of the fish in the market was the winter season.

After harvesting, *C. atherinoides* and other fishes are also collected in a small bamboo made container called 'kholoi'. For smaller quantity and when sold locally, this 'khaloi' is generally used to carry the fish. For larger quantity and distant markets the fishes are carried in bamboo made baskets called as 'dali' or 'dala' and the fishes are covered normally with some aquatic plants.

The nature of marketing channel or distribution channel of commodities is found to depend on the distance between the producing areas and the markets and on the condition of transportation system. The channel becomes more complex regarding the greater distance and undeveloped communication system. There is no definite methodical marketing channel of *C. atherinoides*.

The marketing channel comprises a few intermediaries (e.g. farias, beparis, aratdars and retailer) in between the fishermen and the consumers. The whole marketing system of the studied species at Rajshahi remains in the hand of the private traders, and the fishermen are compelled to handover their catches to these intermediaries at a price determined by them. The fishermen sell their catches at the local and nearby markets of the producing areas to earn more profit.

Thakur (1974) described the importance of analysis of marketing margin to determine the marketing efficiency. In an efficient marketing system, the margin will be small as the percentages of marketing costs and profits of the traders remain low. The marketing cost depends mainly on the distance between the producing areas and the markets and on the efficiency of the transporting system. The cost involved in the marketing of *C. atherinoides* for different markets such as, Rajshahi, Noahata and Godagari are found to vary mainly for the profit of intermediaries and transportation cost. As a whole the net profit per kg earned by the retailers are higher than the others.

Depending on the producing season of *C. atherinoides* the price varies among the markets. As a whole the marketing cost is higher at Rajshahi market which is Tk. 5.25 per kg and the total profit is also higher at Rajshahi market, as Tk. 29.75 per kg. The price received by the fishermen was the highest at Rajshahi throughout the year. When the fishermen sell directly to the consumers, they receive a good share of the consumers price.

SUMMARY

SUMMARY

CHAPTER-1

The physico-chemical condition of the river Padma, flood plain area and pond exhibit more or less variations according to the change of month and seasons.

In the study areas, 4 physical and 3 chemical parameters have been considered. The 2 years' mean values of these parameters in the river Padma stand as air temperature 26.12°C, water temperature 24.49°C water transparency 0.41m, rainfall 127.33 mm, p^H 7.39, dissolved oxygen 4.34 mg/l and free carbondioxide 5.75 mg/l. In flood plain area the parameters stand as air temperature 25.48°C water temperature 23.7°C water transparency 0.32 m, rainfall 132.77 mm, p^H 7.41, dissolved oxygen 6.29 mg/l and free carbondioxide 5.23 mg/l. In pond the air temperature is 26.71°C, water temperature 25.28°C water transparency 0.39 m, rainfall 127.33 mm, p^H 7.55, dissolved oxygen 4.38 mg/l and free carbondixide 6.5 mg/l.

The abundance of *C. atherinoides* in Padma river and flood plain areas are almost continuous throughout the year. However the peak period was observed during monsoon in Padma river and post monsoon in flood plain areas.

CHAPTER-2

For studying the food and feeding habit of *Clupisoma atherinoides* a total of 600 specimens were collected from local markets, rivers, ponds, beels and ditches in Rajshahi during the period from June 1995 to May 1997. Out of 600 specimens, 150 juveniles and 450 adult fishes were used in the food analysis.

The food of juvenile of *C. atherinoides* comprised on the average as crustaceans (30.06%), insects (18.13%), protozoans (6.84%), rotifers (10.83%), algae (5.93%), higher plant parts (4.96%), debris and detritus (10.5%), and sand and mud (4.49%). There were fluctuations in the percentage occurrence of food items in different months of the year. Variations in the percentage composition of the food items in the same month of different observations were also noticed. The juveniles of *C. atherinoides* are surface feeders.

The study of the monthly variation in the degree of feeding of the adult *C. atherinoides* reveals that the feeding intensities in the months of April (percentage of fullness of stomachs were 75.00 in 1996 and 72.22 in 1997), March (percentages of fullness of stomachs were 72.22 in 1996 and 70.59 in 1997) and October (percentages of fullness of stomachs were 70.58 in 1995 and 68.42 in 1996) were the highest. Similarly in the months of July (percentages of fullness were 27.78 in 1995 and 26.32 in 1996) and August (percentages of fullness were 36.84 in 1995 and 35.00 in 1996) the feeding intensities were the least. Variations in the percentage of fullness in the same month of different years were also noticed.

The average percentage occurrence of the food items of the adult of *C. atherinoides* was crustaceans (31.33%), insects (22.40%), protozoans (5.24%), rotifers (12.76%), algae (7.77%), higher plant parts (5.85%), debris and detritus (10.21%) and sand and mud (3.05%).

The feeding intensity with respect to the breeding cycle revealed that the poorest feeding activity was observed in the months of July and August which are the spawning season of the fish. Active feeding activity for both male and female, juvenile and adult were observed in other months of the year.

The juvenile and adult of *C. atherinoides* showed the surface feeding habit.

The ratio of the total length (TL) and alimentary canal length (ACL) of the juvenile and adult stages of the fish *C. atherinoides* is 1:0.56 and 1:0.61 and it has a shortened alimentary tract. The relationships between the gut lengths and the body lengths of the juvenile and adult showed that there existed strong linear relationships in all the cases.

CHAPTER-3

Reproductive Biology:

The male and female reproductive systems of *Clupisoma atherinoides* are described separately. At the breeding season the difference of the genitalia was used for sex differentiation of the fish, otherwise the fishes were sexed according to the primary sex characters, after dissection.

The male reproductive system of *C. atherinoides* consists of a pair of elongated testes and its ducts. It originates in the abdominal cavity above the alimentary canal and below the kidney. The colour and size vary according to stage of sexual maturation. Gross anatomy of *C. atherinoides* testes showed progressive enlargement from January to the peak of the spawning season in late May to August. The testes change from a translucent, whitish, narrow, thread like structure to pear shaped mass of deep creamy colour. In this time milt oozes out by slight pressure on the abdomen. After spawning most of the fishes were found with flaccid testes.

The female reproductive system of *C. atherinoides* consists of a paired ovaries and short oviducts. The left lobe of the ovary was always larger than the right lobe. Two lobes unite posteriorly before opening through the genital pore situated just in front of the anal fin. The shape, size and colour of the ovary vary according to the degree of maturation. The colour varies from whitish in young through light yellow when maturing to yellow in ripe stage. After spawning the ovaries become reduced in size and dull in colour. On the basis of developmental stages of the ova the ovary is divided into ten stages. Immature stage, maturing-1 (early developing), maturing-II (late developing), mature, ripe, pre-spawning, spawning, post spawning, spent and resting stage. The ova are also divided into four stages: immature stage, maturing stage, mature stage and ripe stage.

Six methods have been employed to determine the breeding seasons of *C. atherinoides*. These methods are: percentage of gravid females against time, diameter of ova, gonado-somatic index, gonadal length index, colouration of the ovary, and maximum indices of spermatozoa in the milt. All these methods showed that the peak breeding season of this species is June to August.

The fecundity of *C. atherinoides* ranged from 1240 to 20310 eggs and mean value was 5728.21±2456.94. The relationships between fecundity and total length, fecundity and standard length, fecundity and total weight fecundity and gonadal length, fecundity and gonadal weight of the female show straight line linear regressions. The value of co-efficient of correlation (r) was highly significant.

The fecundity factor of the species is also provided. The sex ratio of 2100 specimens collected during 24 months of study has been determined. The total male and female ratio was 1:1.15 i.e. the female number was more that of the male. The chi-square test shows that the males and females distribution in the natural population is significantly different.

CHAPTER-4

Fishing and Marketing:

For fishing of *Clupisoma atherinoides* along with other small size fishes, various type of nets and traps are used in Rajshahi, viz. 'veshal jal', 'dharma jal', 'thela jal', 'kholson' and 'barricades' (bana). Fising of C *atherinoides* in the river Padma and beel areas are almost continuous throughout the year. But entire winter season and early part of the summer are found as the peak period for fishing. During the years June 1995 to May 1997 (24 months) total landing of C. *atherinoides* were 4860 kg 2931 kg 2685 kg) in three sampling areas respectively i.e. Shaheb bazar, Godagari and Noahata bazar.

The fishermen handover their catches (*C. atherinoides*) to different distant and near by markets through a more or less distinguished channel. In between the fishermen and the final consumers, there are a few intermediaries (e.g. faria, beparis, aratdar and retailer). The fishermen themselves sell their products at their own localities or nearby 'hats' when the catch is of smaller quantity.

Different type of containers were found to be used for carrying *C. atherinoides*, viz khaloi, dala or dali, jhuri and alluminium made harhi.

Generally fishes are transported by truck, bus, train, rickshaw, van, tomtom, boat etc. Some fishermen bring their fishes by themselves carrying on the heads.

The market price of *C. athernioides* varied among the three markets (e.g. Rajshahi, Godagari, Noahata). The highest total margins were found at Rajshahi market as Tk. 35.00 per kg. The lowest total margins were obtained as Tk. 22.00 per kg at Noahata market.

The variation in the market price is mainly due to the marketing costs involved for different markets. The highest total marketing cost was obtained at Rajshahi and the lowest at Noahata and Godagari. The highest total profit was found at Rajshahi as Tk. 29.75 per kg and the lowest profit was found as Tk. 18.75 per kg at Noahata.

The prices of *C. atherinoides* of 3 fish landing centres (Rajshahi, Godagari and Noahata) were Tk. 60.00 to Tk. 80.00 per kg at Rajshahi, Tk. 45.00 to 48.00 per kg at Godagari and Tk. 40.00 t0 42.00 per kg at Noahata in peak season (October to January). But in February to September the price was Tk. 120.00 to 160.00 per kg at Rajshahi, Tk. 80.00 to 100.00 per kg at Godagari and Tk. 75.00 to Tk. 90.00 per kg at Noahata. The price of this fish is higher at Rajshahi market than the other fish landing centres.

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APPENDICES

APPENDICES

Appendix Table-1. *C. atherinoides:* Monthly mean values (mean ±sd) of different physical and chemical parameters of Padma river near Rajshahi during June, 1995 to May, 1996.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transpare-ncy m	Rain-fall mm	P^H	DO mg/l	CO_2 mg/l
1995	Jun	29.67±3.41	28.95±2.53	0.19±0.07	246	7.25±0.33	3.96±0.67	7.28±1.12
	Jul	27.78±2.29	28.09±1.72	0.07±0.02	287	8.06±0.34	3.15±0.81	8.04±0.71
	Aug	28.82±4.01	27.54±1.53	0.06±0.01	274	7.43±0.41	3.27±0.64	8.35±1.02
	Sep	27.97±3.49	26.32±1.62	0.05±0.01	370	7.56±0.45	3.43±0.81	7.85±0.91
	Oct	27.35±3.72	25.85±2.81	0.13±0.02	13	7.82±0.51	4.22±0.97	7.62±1.08
	Nov	23.92±4.63	21.67±2.14	0.12±0.02	44	7.38±0.38	4.47±0.89	6.40±0.36
	Dec	19.12±5.83	16.35±2.44	0.19±0.02	1	7.10±0.27	5.07±0.78	3.65±0.43
1996	Jan	17.73±6.88	14.25±2.09	1.15±0.04	Nil	6.75±0.38	6.02±0.93	3.42±0.45
	Feb	19.92±7.23	16.42±6.05	1.21±0.05	21	7.51±0.46	5.20±0.67	2.84±0.34
	Mar	26.71±7.39	24.60±7.58	0.82±0.06	4	6.95±0.16	4.95±0.72	3.37±0.36
	Apr	30.25±7.47	29.45±2.33	0.43±0.10	73	7.24±0.29	4.34±0.71	4.61±0.39
	May	32.76±5.64	31.07±3.28	0.35±0.17	95	7.36±0.37	3.52±0.56	6.86±0.43

(1st year's observation: June 1995 to May 1996)

Appendix Table-2. *C. atherinoides:* Monthly mean values (mean ±sd) of different physical and chemical parameters of Padma river near Rajshahi during June, 1996 to May, 1997.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transpare-ncy m	Rain-fall mm	p^H	DO mg/l	CO_2 mg/l
1996	Jun	30.02±4.08	29.52±0.36	0.20±0.04	284	7.46±0.49	3.58±0.38	8.20±0.37
	Jul	29.62±3.31	29.10±0.64	0.06±0.02	106	7.02±0.29	3.39±0.77	8.52±0.44
	Aug	29.45±3.21	28.58±0.85	0.04±0.02	270	7.68±0.48	3.21±0.47	7.84±0.49
	Sep	28.54±3.02	27.45±0.67	0.07±0.01	298	8.12±0.53	3.62±0.42	7.55±0.57
	Oct	27.00±4.31	25.53±0.80	0.12±0.02	118	7.95±0.25	4.25±0.47	7.05±0.47
	Nov	23.07±6.73	21.95±0.19	0.15±0.03	Nil	7.26±0.29	4.67±0.53	6.91±0.35
	Dec	19.08±7.07	16.27±0.65	0.21±0.03	Nil	7.56±0.57	5.14±0.38	3.63±0.50
1997	Jan	16.85±7.12	13.50±0.96	1.32±0.06	8	7.13±0.47	5.65±0.45	2.76±0.71
	Feb	20.43±7.39	18.73±0.37	1.16±0.04	35	6.90±0.34	5.93±0.52	2.87±0.52
	Mar	25.72±7.28	23.56±0.50	0.91±0.10	19	7.15±0.40	4.90±0.49	3.29±0.31
	Apr	33.68±3.49	32.26±0.40	0.35±0.06	55	7.28±0.28	4.54±0.36	3.45±0.45
	May	31.42±6.19	30.65±0.65	0.47±0.07	53	7.44±0.24	3.75±0.71	5.62±0.58
	Average Mean ±sd	26.12±4.83	24.49±5.63	0.41±0.42	127.33 ± 120.77	7.39±0.35	4.34±0.86	5.75±2.11

(2nd year's observation June 1996 to May 1997)

Appendix Table-3. *C.* atherinoides: Monthly mean values (mean±sd) of different physical and chemical parameters of flood plain (beel) area during June, 1995 to February, 1996.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transpare-ncy m	Rain-fall mm	p^H	DO mg/l	CO_2 mg/l
1995	Jun	29.84±6.12	29.32±0.82	0.36±0.09	255	7.74±0.43	3.86±0.57	7.95±0.53
	Jul	28.25±6.09	27.85±0.33	0.24±0.07	294	7.63±0.28	5.48±0.63	7.64±1.01
	Aug	29.56±5.12	28.62±0.82	0.27±0.04	262	7.88±0.23	5.65±.79	7.48±0.73
	Sep	28.76±4.86	26.92±0.28	0.47±0.03	180	7.54±0.17	6.34±0.67	5.84±0.54
	Oct	27.83±5.23	26.35±0.21	0.43±0.04	135	7.36±0.30	6.57±0.45	5.43±0.32
	Nov	25.65±5.03	23.83±0.36	0.38±0.05	9	7.42±0.31	7.03±0.33	2.92±1.12
	Dec	21.85±6.51	19.31±0.64	0.30±0.04	0.89	7.05±0.27	7.25±0.41	3.56±0.74
1996	Jan	16.30±4.13	12.53±0.98	0.21±0.03	20	7.23±0.28	7.92±0.80	2.57±0.49
	Feb	20.29±2.05	17.46±0.74	0.19±07	39	7.16±0.40	6.85±0.78	4.36±0.78

(1st year's observation June 1995 to May 1996)

Appendix Table-4. *C. atherinoides*: Monthly mean values (mean±sd) of different physical and chemical parameters of flood plain (beel) area during June, 1996 to February, 1997.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transpare-ncy m	Rain-fall mm	p^H	DO mg/l	CO_2 mg/l
1996	Jun	30.18±3.58	29.44±0.55	0.35±0.04	240	7.34±0.49	4.05±0.59	7.13±0.73
	Jul	29.65±3.26	28.35±0.69	0.27±0.05	270	7.15±0.78	4.93±0.64	7.80±0.68
	Aug	28.83±2.32	27.92±0.83	0.24±0.07	325Õ	7.63±0.45	5.62±0.59	8.05±0.61
	Sep	28.36±3.41	27.43±0.66	0.42±0.06	178	7.42±0.21	5.46±0.66	6.31±0.76
	Oct	27.90±4.51	25.32±0.81	0.45±0.04	120	8.15±0.75	6.59±0.72	4.55±0.51
	Nov	25.75±3.06	24.45±0.75	0.40±0.04	15	7.55±0.57	6.98±0.45	3.75±0.76
	Dec	20.87±4.21	18.96±0.82	0.29±0.08	17	7.12±0.53	7.62±0.75	2.34±0.47
1997	Jan	17.55±3.34	13.71±0.93	0.24±0.05	2	7.24±0.45	7.65±0.45	2.83±0.64
	Feb	21.19±2.74	18.75±0.89	0.16±0.06	28	6.85±0.43	7.35±0.64	3.58±0.43
	Average Mean ±sd	25.48±4.42	23.7±5.32	0.32±0.092	132.77 ± 115.21	7.41±0.31	6.29±1.17	5.23±2.02

(2nd year's observation June 1996 to May 1997)

Appendix Table-5. *C. atherinoides*: Monthly mean values (mean±sd) of different physical and chemical parameters of pond at Rajshahi during June, 1995 to May, 1996.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transparency m	Rain-fall mm	p^H	DO mg/l	CO_2 mg/l
1995	Jun	30.12±3.88	31.67±0.64	0.39±0.02	246	7.85±0.64	2.98±0.56	8.86±0.50
	Jul	29.50±3.29	28.92±0.54	0.43±0.01	287	7.89±0.37	3.87±0.56	9.48±0.70
	Aug	28.64±3.97	28.15±0.30	0.42±0.05	274	7.48±0.28	3.21±0.68	8.98±1.78
	Sep	29.33±3.28	28.12±0.39	0.46±0.04	370	7.96±0.26	3.45±0.52	7.39±0.39
	Oct	27.11±4.68	26.52±0.85	0.45±0.05	13	7.75±0.33	4.34±0.67	7.65±0.52
	Nov	24.28±6.72	22.65±0.69	0.44±0.03	44	7.52±0.30	4.96±0.61	5.30±0.29
	Dec	20.08±2.08	17.56±0.46	0.42±0.08	1	7.28±0.46	5.65±0.43	3.41±0.28
1996	Jan	18.19±5.01	15.68±0.48	0.37±0.04	Nil	6.83±0.48	5.84±0.55	2.84±0.54
	Feb	20.4±4.11	17.85±0.28	0.39±0.02	21	7.56±0.41	5.43±0.46	3.57±0.37
	Mar	25.75±3.34	23.42±0.41	0.34±0.03	4	7.34±0.31	4.56±1.07	5.33±0.51
	Apr	31.63±2.59	31.25±0.33	0.28±0.06	73	7.65±0.24	4.26±0.25	7.93±0.52
	May	33.94±5.04	32.45±5.93	0.30±0.09	95	7.68±0.21	7.68±0.21	8.54±0.57

(1st year's obsetvation June 1995 to May 1996)

Appendix Table-6. *C.atherinoides* Monthly mean values (mean±sd) of different physical and chemical parameters of pond at Rajshahi in during June 1996 to May, 1997.

Year	Months	Physical parameters				Chemical Parameters		
		Air Temp. °C	Water Temp. °C	Water Transparency m	Rain-fall mm	p^H	DO mg/l	CO_2 mg/l
1996	Jun	31.23±3.71	30.6±0.81	0.36±0.04	284	8.24±0.24	3.46±0.59	7.82±0.52
	Jul	30.65±3.58	30.24±0.78	0.45±0.04	106	7.73±0.68	3.62±0.37	8.53±0.34
	Aug	27.48±2.44	26.95±0.48	0.48±0.05	270	7.62±0.47	4.54±0.71	7.66±0.41
	Sep	28.70±3.75	27.39±0.75	0.47±0.06	298	7.85±0.58	3.73±0.66	6.31±0.73
	Oct	27.42±5.09	25.51±0.59	0.44±0.08	118	7.48±0.24	4.23±0.54	7.24±0.50
	Nov	25.54±3.34	23.2±1.35	0.42±0.05	Nil	7.12±0.49	4.75±0.82	5.45±0.34
	Dec	18.86±3.65	16.45±0.94	0.40±0.07	Nil	7.23±0.44	5.92±0.49	3.17±0.36
1997	Jan	16.5±2.37	13.96±1.59	0.38±0.06	8	7.14±0.23	5.86±0.31	3.54±0.46
	Feb	20.57±4.08	17.34±0.61	0.37±0.04	35	7.58±0.19	5.5±0.43	3.75±0.41
	Mar	26.41±5.01	24.74±0.88	0.35±0.03	19	7.8±0.31	4.71±0.73	5.36±0.47
	Apr	32.85±5.97	31.52±0.87	0.25±0.02	55	7.35±0.23	3.44±0.53	7.48±0.86
	May	35.2±4.71	34.58±1.06	0.31±0.05	53	7.26±0.74	2.83±0.41	9.31±0.57
	Average Mean ±sd	26.71±5.06	25.28±5.91	0.39±0.06	127.33 ± 120.77	7.55±0.31	4.38±0.94	6.50±2.20

(2nd year's observation June 1996 to May 1997)

Appendix Table-7 :Monthly variation in the percentage occurrence of the fullness and emptiness of the stomachs of 450 adult specimens of *C. atherinoides* during June , 1995 to May, 1997 (2 years).

Year	Months	No. of stomachs examined	Fullness						Emptiness					
			Full		¾ full		½ full		¼ full		Trace		Empty	
			Actual No.	%	Actual No.	%	Actual No.	%	Actua l No.	%	Actual No.	%	Actual No.	%
1995	Jun	20	0	0.00	4	20.00	4	20.00	3	15.00	5	25.00	4	20.00
	Jul	18	0	0.00	1	5.56	4	22.22	5	27.78	6	33.33	2	11.11
	Aug	19	0	0.00	3	15.79	4	21.05	5	26.32	4	21.05	3	15.79
	Sep	19	4	21.05	5	26.32	3	15.79	4	21.05	2	10.5	1	5.26
	Oct	17	6	35.29	2	11.76	4	23.53	4	23.53	1	5.88	0	0.00
	Nov	21	4	19.05	3	14.29	6	28.57	5	23.81	1	4.76	2	9.52
	Dec	19	3	15.79	5	26.32	2	10.53	6	31.58	2	10.53	1	5.25
1996	Jan	20	4	20.00	2	10.00	4	20.00	6	30.00	3	15.00	1	5.00
	Feb	18	4	22.22	5	27.78	2	11.11	4	22.22	2	11.11	1	5.56
	Mar	18	5	27.78	4	22.22	4	22.22	3	16.67	2	11.11	0	0.00
	Apr	20	5	25.00	6	30.00	4	20.00	2	10.00	3	15.00	0	0.00
	May	16	2	12.5	3	18.75	4	25.00	4	25.00	2	12.5	1	6.25
	Jun	19	0	0.00	3	15.79	4	21.05	5	26.32	4	21.05	3	15.79
	Jul	19	0	0.00	2	10.53	3	15.79	4	21.05	6	31.58	4	21.05
	Aug	20	0	0.00	3	15.00	4	20.00	5	25.00	6	30.00	2	10.00
	Sep	18	3	16.67	6	33.33	3	16.67	4	22.22	1	5.55	1	5.56
	Oct	19	6	31.58	4	21.05	3	15.79	5	26.32	0	0.00	1	5.26
	Nov	22	5	22.73	3	13.64	6	27.27	5	22.73	3	13.64	0	0.00
	Dec	20	3	15.00	5	25.00	3	15.00	5	25.00	3	15.00	1	5.00
1997	Jan	21	5	23.81	4	19.05	2	9.52	7	33.33	2	9.52	1	4.76
	Feb	17	4	23.53	3	17.65	3	17.65	5	29.41	2	11.76	0	0.00
	Mar	17	5	29.41	3	17.65	4	23.53	3	17.65	1	5.88	1	5.88
	Apr	18	4	22.22	3	16.67	6	33.33	3	16.67	2	11.11	0	0.00
	May	15	2	13.33	3	20.00	4	26.67	3	20.00	2	13.33	1	6.67
	Total	450	74		85		90		105		65		31	
	Mean Sd			22.05 ±6.09		18.92 ±6.60		20.09 ±5.71		23.28 ±5.39		14.97 ±8.09		9.09 ±5.28

Appendix Table 8: Seasonal feeding activity of *C. atherinoides* (based on number of fish, percentage of fullness and emptiness).

Year	Months	No. of fishes examined	Percentage of fullness	Percentage of emptiness
1995	Jun	20	40.00	60.00
	Jul	18	27.78	72.22
	Aug	19	36.84	63.16
	Sep	19	63.16	36.84
	Oct	17	70.58	29.41
	Nov	21	61.91	38.09
	Dec	19	52.64	47.36
1996	Jan	20	50.00	50.00
	Feb	18	61.11	38.89
	Mar	18	72.22	27.78
	Apr	20	75.00	25.00
	May	16	56.25	43.75
	Jun	19	36.84	63.16
	Jul	19	26.32	73.68
	Aug	20	35.00	65.00
	Sep	18	66.67	33.33
	Oct	19	68.42	31.58
	Nov	22	63.64	36.36
	Dec	20	55.00	45.00
1997	Jan	21	52.38	47.61
	Feb	17	58.83	41.17
	Mar	17	70.59	29.41
	Apr	18	72.22	27.78
	May	15	60.00	40.00

1st observation: June 1995 to May 1996, 2nd observation: June 1996 to May 1997.

[N.B. Fullness includes full, ¾ full, ½ full stomachs. Emptiness includes ¼ full, trace and empty stomachs.]

Appendix Table-9: Monthly variation in the percentage occurrence of various groups of food items in the stomachs of adult *C. atherinoides* (N=450) during the period from June, 1996 to May, 1997 (2 years).

Year	Months	No. of specimens	Crustaceans	Insects	Protozoans	Rotifers	Algae	Higher plant parts	Debris and detritus	Sand and mud	Unidentified food
1995	Jun	20	26.67	17.78	5.56	11.11	8.89	6.67	13.33	4.44	5.55
	Jul	8	25.58	16.28	3.49	10.47	11.63	9.3	15.12	1.16	6.97
	Aug	19	23.53	19.61	4.90	10.78	13.73	5.88	12.75	-	8.82
	Sep	19	28.57	14.29	4.76	12.70	9.52	7.94	13.49	2.38	6.35
	Oct	17	33.33	20.99	3.70	14.81	6.17	3.09	9.88	2.96	5.06
	Nov	21	37.63	23.65	5.38	19.35	3.23	2.15	7.53	1.08	-
	Dec	19	40.00	26.32	9.47	17.89	-	-	4.21	-	2.11
1996	Jan	20	41.84	28.57	7.14	15.31	2.04	-	5.10	-	-
	Feb	18	38.04	33.70	6.52	15.22	-	-	4.35	-	2.17
	Mar	18	29.89	25.29	5.75	13.79	4.6	3.45	10.34	2.87	4.02
	Apr	20	25.68	21.62	4.73	11.49	7.43	4.73	14.86	2.70	6.75
	May	16	24.53	20.75	3.77	9.43	5.66	6.60	15.09	6.03	8.11
	Jun	19	21.43	19.05	3.57	9.52	10.24	7.62	14.29	5.95	8.33
	Jul	18	24.32	15.41	3.51	8.11	14.86	10.81	13.51	2.7	6.76
	Aug	20	25.53	20.21	4.26	7.45	12.77	11.06	11.7	2.13	4.89
	Sep	18	26.85	17.59	5.56	13.89	11.48	9.26	9.81	1.85	3.7
	Oct	19	31.51	21.92	4.11	12.33	7.53	4.79	12.74	2.33	2.74
	Nov	23	39.53	25.58	5.81	15.12	3.49	3.72	4.65	-	2.09
	Dec	20	41.3	30.43	6.52	16.3	2.17	-	3.26	-	-
1997	Jan	21	43.96	26.37	8.79	13.19	-	-	4.40	1.09	2.2
	Feb	17	37.63	29.03	7.53	12.90	-	2.26	6.99	1.61	2.04
	Mar	17	31.33	22.89	4.82	14.46	4.22	2.77	8.43	4.81	6.27
	Apr	18	27.69	21.54	3.08	10.77	6.92	3.08	15.38	3.85	7.69
	May	15	25.49	18.63	2.94	9.8	8.82	5.88	13.73	4.9	9.8
	Average		31.33 ±6.75	22.4 ±4.86	5.24 ±1.71	12.76 ±2.94	7.77 ±3.77	5.85 ±2.79	10.21 ±4.09	3.05 ±1.55	5.35 ±2.45

(1^{st} observation: June, 1995 to May, 1996, 2^{nd} observation: June 1996 to May, 1997)

Appendix Table-10: *C. atherinioides:* Monthly percentage of gravid females for 2 years.

Year	Months	Total number of specimens	Total male	Female			
				Total	Non gravid	Gravid	Percentage of gravid
1995	Jun	100	62	38	6	32	84.21
	Jul	100	52	48	3	45	93.75
	Aug	100	41	59	18	41	69.49
	Sep	100	43	57	34	23	40.35
	Oct	100	47	53	49	4	7.55
	Nov	100	49	51	51	0	-
	Dec	100	51	49	49	0	-
1996	Jan	100	42	58	58	0	-
	Feb	100	55	45	45	0	-
	Mar	50	16	34	28	6	17.65
	Apr	50	21	29	20	9	31.03
	May	50	20	30	13	17	56.67
	Jun	100	60	40	6	34	85.00
	Jul	100	48	52	3	49	94.23
	Aug	100	42	58	17	41	70.69
	Sep	100	34	66	38	28	42.42
	Oct	100	52	48	44	4	8.33
	Nov	100	53	47	47	-	-
	Dec	100	45	55	55	-	-
1997	Jan	100	47	53	53	-	-
	Feb	100	39	61	61	-	-
	Mar	50	20	30	25	5	16.67
	Apr	50	23	27	19	8	29.63
	May	50	17	33	14	19	57.58
	Total	2100	979	1121	756	365	32.56

Appendix Table-11. *C. atherinoides*: The monthwise gonado-somatic index (G.S.I), gonadal length index (GLI), Ova diameter and colour of ovaries with range, mean, standard deviation and number of female fish examined (N=525) during June, 1995 to May, 1997.

Year	Months	Number of fish examined	Gonado-somatic index			Gonadal length index			Ova diameter (mm)			Colour of ovaries
			Range		Mean±sd	Range		Mean±sd	Range		Mean±sd	
			Min.	Max.		Min.	Max.		Min.	Max.		
1995	Jun	25	12.21	24.59	16.84±4.33	23.17	28.26	24.96±1.77	0.52	0.58	0.54±0.14	yellow/golden yellow
	Jul.	22	14.19	24.93	18.19±3.74	23.48	29.06	26.97±1.90	0.55	0.62	0.56±0.19	yellow/golden yellow
	Aug	25	11.95	23.34	15.82±2.50	20.83	27.02	23.73±2.36	0.46	0.54	0.50±0.20	yellow/golden yellow
	Sep	23	3.57	17.01	11.62±3.10	12.28	22.78	18.53±2.95	0.32	0.47	0.40±0.17	yellow
	Oct	23	0.85	1.82	1.16±0.35	8.17	11.43	10.09±0.74	0.056	0.18	0.095±0.042	whitish
	Nov	25	0.41	0.95	0.75±0.18	6.01	10.58	8.86±0.66	0.042	0.096	0.057±0.019	whitish
	Dec	22	0.35	0.91	0.73±0.21	5.23	9.72	8.47±0.37	0.045	0.090	0.055±0.008	whitish
1996	Jan	22	0.55	1.77	1.19±0.41	6.38	10.71	9.77±0.56	0.065	0.15	0.10±0.034	whitish
	Feb	23	0.75	2.85	2.11±0.74	8.57	12.81	10.32±1.09	0.083	0.30	0.23±0.064	light yellow
	Mar	18	1.27	4.83	3.86±1.38	9.25	14.96	12.99±1.28	0.15	0.36	0.30±0.11	light yellow
	Apr	16	2.85	7.25	5.97±1.61	10.5	16.86	14.40±1.95	0.28	0.40	0.36±0.15	light yellow
	May	16	9.05	19.32	14.35±2.82	19.33	25.62	21.83±2.18	0.36	0.52	0.45±0.19	yellow
	Jun	22	13.95	24.75	17.85±3.91	22.31	28.75	25.07±2.43	0.48	0.58	0.54±0.16	yellow/golden yellow
	Jul	23	14.25	25.47	19.62±3.35	25.57	29.25	27.77±1.22	0.52	0.60	0.57±0.17	yellow/golden yellow
	Aug	25	12.83	21.35	16.17±3.09	20.45	27.86	24.45±3.14	0.45	0.57	0.52±0.21	yellow/golden yellow
	Sep	26	5.42	18.15	12.43±3.05	16.07	23.29	19.83±2.60	0.30	0.45	0.38±0.13	yellow
	Oct	27	0.83	1.85	1.29±0.38	7.24	11.05	9.86±0.65	0.062	0.15	0.092±0.038	whitish
	Nov	23	0.35	0.91	0.78±0.19	5.82	10.66	9.13±0.64	0.048	0.086	0.059±0.009	whitish
	Dec	21	0.30	0.89	0.75±0.21	4.15	10.48	8.67±0.50	0.045	0.075	0.052±0.006	whitish
1997	Jan	22	0.51	1.85	1.25±0.46	6.23	11.34	9.50±0.38	0.070	0.18	0.13±0.053	whitish
	Feb	23	0.82	3.05	2.35±0.81	8.05	12.8	10.26±1.05	0.095	0.28	0.20±0.071	light yellow
	Mar	15	0.95	6.14	4.01±1.24	10.15	15.32	12.71±1.57	0.18	0.35	0.28±0.047	light yellow
	Apr	18	2.05	7.45	6.05±2.01	11.28	16.44	13.42±1.68	0.25	0.40	0.33±0.13	light yellow
	May	20	11.15	20.05	14.73±3.06	20.16	25.81	22.45±2.05	0.32	0.50	0.42±0.19	yellow

Appendix Table-12: Monthly male and female distribution and their sex ratios of *C. atherinoides* for 2 years.

Year	Months	Total number of specimens	Number of males	Number of females	Sex-ratio male:female	X^2 values
1995	Jun	100	62	38	1:0.61	5.76*
	Jul	100	52	48	1:0.92	0.16 NS
	Aug	100	41	59	1:1.44	3.24 NS
	Sep	100	43	57	1:1.33	1.96 NS
	Oct	100	47	53	1:1.13	0.36 NS
	Nov	100	49	51	1:1.04	0.04 NS
	Dec	100	51	49	1:0.96	0.04 NS
1996	Jan	100	42	58	1:1.38	2.56 NS
	Feb	100	55	45	1:0.82	1.00 NS
	Mar	50	16	34	1:2.13	6.48*
	Apr	50	21	29	1:1.38	1.28 NS
	May	50	20	30	1:1.5	2.00 NS
	Jun	100	60	40	1:0.67	4.00*
	Jul	100	48	52	1:1.08	0.16 NS
	Aug	100	42	58	1:1.38	2.56 NS
	Sep	100	34	66	1:1.94	10.24**
	Oct	100	52	48	1:0.92	0.16 NS
	Nov	100	53	47	1:0.89	0.36 NS
	Dec	100	45	55	1:1.22	1.00 NS
1997	Jan	100	47	53	1:1.13	0.36 NS
	Feb	100	39	61	1:1.56	4.84 *
	Mar	50	20	30	1:1.5	2.00 NS
	Apr	50	23	27	1:1.17	0.32 NS
	May	50	17	33	1.1.94	5.12*
Total		2100	979	1121	1:1.15	56.00 **

NS = Not significant

* = $P < 0.05$

** = $P < 0.01$

Appendix Table-13: Chi-square heterogeneity test of the observed sex ratios in *C. atherinoides*.

Source	Degrees of freedom	Chi-square value
Total chi-square	24	56.00 **
Over all chi-square	1	9.6 **
Chi-square heterogeneity	23	46.4 **

Appendix Table-14: Questionnaire of investigation

Name of the interviewee:

Age: ....

Village: ....

Thana: ....

District: ....

Date: ....

Questions and informaiton:

1. What is your profession? ....
2. How long have you been involved in fishing? ....
3. Is this profession your family tradition? Yes/No. ....
4. Are you literate? Yes/No. ....
5. Cost of your fishing / trade. ....
6. What is the amount of daily fishing in your fishing area. ....
7. Is the daily amount of catch increasing / decreasing? ....
8. What is the species composition of your catch. ....
9. Location of fishing area and its description. ....
10. Different species of fish available in different periods of year? ....
11. 11.When the larger sized fishes are obtained? ....
12. In which month the total catch is the ....
    (a) Lowest .... (b) Highest ....
13. When do you get larger quantity of *C. atherinoides*
    (a) Winter .... (b) Summer .... (c) Other....................
14. Problems of fishing ....
15. Fish selling are ....
16. Do you sell fresh fish / dry fish? ....
17. What is the mode of transportaiton? ....
18. Is earning from fishing sufficient for your family? ....
19. Is there any co-operative society in your area? ....
20. What do you think about the development of your profession....................
21. Is there any credit system from the GO/NGO's....................

Investigation on the methods of catching of the fish:

Description of nets:

(a) Names ....
b) Shape ....Size: ....
(c) Type of fish catching
d) No. of persons needed................
(e) Cost ....
f) How the nets are used? ....
(g) Preservation method. ....

Description of traps:

(a) Name ....
b) Shape .... Size ....
(c) Cost ....
d) Method of trapping ....
(e) Preservation of traps ....

Appendix Table-15: Monthwise landing of *C. atherinoides* in three sampling areas (Shaheb bazar, Godagari and Naohata) during June, 1995 to May, 1997. (2 years).

Year	Months	Shaheb bazar landing in kg	Godagari bazar landing in kg	Noahata bazar landing in kg
1995	Jun	50	30	40
	Jul	85	42	54
	Aug	140	75	68
	Sep	270	115	85
	Oct	292	180	162
	Nov	480	250	310
	Dec	450	285	260
1996	Jan	435	230	205
	Feb	210	158	143
	Mar	65	32	25
	Apr	25	15	10
	May	32	21	15
	Jun	65	45	23
	Jul	105	56	45
	Aug	150	80	75
	Sep	210	102	96
	Oct	276	130	150
	Nov	425	327	275
1997	Dec	410	315	250
	Jan	380	250	200
	Feb	175	125	132
	Mar	72	40	35
	Apr	18	10	15
	May	40	18	12
	Total	4860	2931	2685

(1st observation June 1995 to May 1996, 2nd observation June 1996 to May 1997)

Appendix Table-16: Price spread of *C. atherinoides* of different fish landing centres.

	Rajshahi		Godagari		Noahata	
	Tk / kg	% of consumers price	Tk/ kg	% of consumers price	Tk/kg	% of consumers price
A.						
Price received by fisherman	85.00	70.83	64.00	73.56	60.00	73.17
Marketing cost of farias	1.75	1.46	1.00	1.44	1.25	1.22
Profit of farias	8.00	6.67	6.00	6.61	4.75	6.09
Margin of farias	9.75	8.13	7.00	8.05	6.00	7.32
B.						
Price paid by beparis	94.75	78.96	71.00	81.61	66.00	80.49
Marketing cost of beparis	3.00	2.5	2.00	2.30	1.75	2.13
Profit of beparis	11.00	9.17	6.50	7.47	7.25	8.84
Margin of beparis	14.00	11.67	8.50	9.77	9.00	10.98
C.						
Price paid by retailers	108.75	90.63	79.50	91.38	75.00	91.46
Marketing cost of retailers	0.50	0.42	0.50	0.57	0.25	0.30
Profit of retailers	10.75	8.96	7.00	8.05	6.75	8.23
Margin of retailers	11.25	9.38	7.50	8.62	7.00	8.54
D.						
Total Marketing margin	35.00	29.17	23.00	26.44	22.00	26.83
E.						
Price paid by consumer	120.00	100.00	87.00	100.00	82.00	100.00