# ECOBIOLOGY OF PEARL SPOT
# (*ETROPLUS SURATENSIS* BLOCH)
# IN GOA WATERS

THESIS SUBMITTED TO

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*BY*


**PARVEEN RATTAN,** *M.Sc.*

**BIOLOGICAL OCEANOGRAPHY DIVISION**
**NATIONAL INSTITUTE OF OCEANOGRAPHY**
**DONA PAULA - 403 004, GOA**




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Grand parents

# CERTIFICATE

As required under the University ordinance 0.19.8, it is stated that the present thesis entitled "Ecobiology of Pearl Spot (*Etroplus suratensis*, Bloch) in Goa waters" contain the results of original investigations. This is to certify that the present research work has not been submitted on previous occasions for any degree or diploma of any University.



Research Guide

(Dr. A. H. Parulekar)

HEAD
BIOLOGICAL OCEANOGRAPHY DIVISION
NATIONAL INSTITUTE OF OCEANOGRAPHY
DONA PAULA, GOA - 403 004.

Candidate

(Parveen Rattan)

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# CHAPTER I

# GENERAL INTRODUCTION

## 1.1 INTRODUCTION

The basic needs of man are undoubtedly the food, shelter and clothing. Although, logically the latter two can be sacrificed to some extent, but the former in a balanced state is essential for survival. Both aquatic and terrestrial ecosystems fulfil the basic needs including food requirements, but the latter contributes maximum to the basic necessities. Area wise, 71% of the planet (earth) is covered by aquatic system in comparison to 29% of terrestrial one. One finds a major difference in trophic levels while looking at the pyramid of exploited food resources from these systems. For example 96% of the harvest from terrestrial system is of primary producers whereas the 80% amount of harvest from aquatic system is comprised of secondary, tertiary and tetra level (FAO, 1968; Whittaker and Likens, 1975; Odum, 1980). Organisms of second, third or higher trophic levels are known to be rich in protein in terms of quantity and quality, particularly in 8 essential amino acids required by man (Burton, 1965). Thus, aquatic systems have the potential to produce quality food for the mankind.

The human population is increasing in a geometrical fashion and there is a need for inexpensive and balanced diet. The time is not far when the food production of terrestrial ecosystem will reach to its maximal. This necessitates the exploration of new resources and the diversification of existing ones. Despite predicted increase in world agriculture production it is unlikely that the increasing demand for protein can be met. In addition, the world fishing industries are faced with increasing costs and declining catches of fish intended for human consumption (Richardson, 1972). Thus, it is the need of the hour to exploit the available aquatic resources in the best possible manner. Inshore fishery has reached a level of almost stagnation and the exploitation of deep sea resources are proving uneconomical because of the inadequate information available about these resources. Thus, there is a place for farmed fish if a techno-economically feasible technology could be developed.

India has a vast coastline of 7200 Km and a brackishwater area of 1.456 million hectare resulting from a network of riverine systems. An area of about 0.902 million hectare has been found suitable for fish culture. However, at present only 55,500 hectares are under cultivation (Srivastava, et al.,1985; Alagarswami, 1991). Traditional brackishwater fish culture is an age old art, being practised by the marginal farmers, especially in some of the coastal states like, Kerala, Goa, West Bengal and Tamil Naidu. The international market demand and the high price paid for shrimp has encouraged the private entrepreneurs to venture into shrimp cultivation on scientific lines. For the last two decades, lot of R & D efforts are concentrated on commercial shrimp cultivation. Consequently, the commercial brackishwater finfish species are somewhat neglected. This has made shrimps a luxury item for a common man in a developing country like India. Thus, finfish cultivation needs to be encouraged through extensive research programmes in order to boost the food production through culture fisheries.

Finfish culture still holds demand in developed countries like Yellow tail (Seriolla quinquiradiata) in Japan and Salmon (Oncorhynchus sp.) in United States of America and Europe. In India, few endemic species like Chanos chanos, Mugil sp., Liza sp., Lates calcarifer, Siganus sp. and Etroplus suratensis (Bloch) have been identified as important species for cultivation. The species belonging to the lowest level of food chain are generally preferred over higher trophic level species, since there is a loss of energy at each trophic transfer.

Etroplus suratensis (Bloch, 1787) commonly known as Pearl Spot and locally (in Konkani and Marathi) as "Kalundra" is an Asian cichlid, having restricted distribution in the lagoons, brackishwater and backwater environment of southern peninsular India and Sri Lanka. In India, its occurrence to the scale of commercial catch on the west coast extends from Goa towards south and up to Chilka lagoon in Orissa on the east coast. Stray numbers are found in coastal Konkan region of Maharashtra up to Bombay. The other species belonging to this genus is an orange chromide (Etroplus maculatus) which is known to occur only in Karnataka, Kerala and Tamil Nadu coast of India and Sri Lanka. Pearl Spot is relatively more popular probably because of its bigger size, better growth and market demand. The exotic counterpart of E. suratensis is an African cichlid Oreochromis mossambicus, the most popular and widely studied species throughout the world in terms of cultivation and test animal. In south east Asian countries like Philippines and Sri Lanka, its cultivation is being encouraged through extensive research programmes. However, either its willing transplantation or accidental escape to the natural water systems has been realized as a menace in various other countries. In a brackishwater fish farm at Ela, Old Goa, O. mossambicus has established to such an extent that it has become difficult to eradicate it from the culture ponds, and almost same is true for the backwaters. In fact, E. suratensis too inhabit brackishwater and backwater systems of Goa. Thus, O. mossambicus is undoubtedly competing with E. suratensis for food and space and with a passage of time it may pose a serious threat.

Etroplus suratensis is a delicacy in Goa and Kerala where its retail price is as high as Rs 70 /- per Kg. Its traditional extensive culture is practised in "Khazans", "Agars" and backwater impoundments in Goa and in "Pokhali fields" in Kerala (Parulekar and Verlencar, 1984). It is a euryplastic species and can be cultured in inland saline waters and even in freshwater systems (Costa, 1983; Dwivedi and Lingaraju, 1986). E. suratensis is also maintained as an aquarium fish because of its attractive colouration. However, the success of any culture of endemic species depends on the efficient management of the farming techniques. In order to do that successfully, the basic information on the biology and ecological requirements of the culturable species should be known.

## 1.2 HISTORICAL REVIEW

The family cichlidae is widely distributed in Africa (including Madagascar), Palestine, South and Central America, Southern India and Sri Lanka (Lagler, *et al.*, 1977). The main factors for the natural distribution of species are : 1) historico-geological factors which lead to geographical isolation 2) ecological factors which demonstrate the requirements and preferences of the species with regard to temperature, salinity, chemical characteristics of the water, current, substrate and behavioural mechanism which reflect feeding and reproductive strategies. It is assumed that Tilapias have evolved from a marine ancestor and their penetration to freshwater is secondary (Myers, 1938; Steinitz, 1954). This could be the possible reason for the marked euryhalinity of certain species in cichlidae (Chervinski, 1961). Tilapias occur naturally in estuaries and coastal lagoons along the coast of west Africa (*T. guineensis*, *Sarotherodon melanotheron*) or along the east coast of Africa (*Oreochromis mossambicus*, *O. hornorum* and *O. placidus*) and Bay of Suez in Red sea (*T. zilli*) (Bayoumi, 1969; Morgan, 1972; Philippart and Ruwet, 1982). At present, Tilapias are well distributed all over the world in diverse habitats right from marine, estuarine and brackishwater to freshwater (rivers, reservoirs and lakes).

*E. suratensis* is restricted to coastal lagoons, estuaries and backwaters of Sri Lanka and southern India with the exception of purposeful transplantation in inland saline soil fish farm, at Sultanpur, Haryana (Dwivedi and Lingaraju, 1986), in freshwater lake at Hydrabad (Rahimullah, 1946) and in man made freshwater reservoir Prakrama Samudra in Sri Lanka (Costa, 1983).

Characterization, identification and classification is of prime importance in biological sciences and the pioneer work in the field of fisheries is that of Gunther (1859 - 1870); Day (1878); Jordan, (1905); Weber and Beaufort (1913 - 1922); Smith (1950); Munro (1955). Later, the detailed information on commercial species and on certain specific groups has been documented by Mishra (1959); Pillay (1962); Whitehead (1972); Jones and Kumaran (1980); F.A.O. (1984); Talwar and Kacker (1984). The metric and meristic characters are highly variable even in the same population depending upon their macro and micro geographical distribution.

There is exhaustive information on the ecological aspects of coastal water of peninsular India (Bal et al., 1946; Pillay, 1954; George and Kartha, 1963; Rao and Madhvan, 1964; Qasim et al., 1969; Haridas, et al., 1973; Gopinathan, et al., 1982; Verlencar and Qasim, 1985; Verlencar, 1987). The physico-chemical and biological aspects of the estuarine system of Goa have been extensively studied (Dehadrai, 1970; Sankarnarayanan and Jayaraman, 1972; Parulekar, et al., 1973; Parulekar and Dwivedi, 1974; Parulekar, et al., 1980; De Souza, et al., 1981; Qasim and Sengupta, 1981; Verlencar, 1982; Ansari, et al., 1986; De Souza and Sengupta, 1986). Ecological studies have shown that, large quantities of energy, in the form of mangrove plant detritus are exported from magrove swamps into the coastal zone (Odum and Heald, 1972; Christensen, 1978; Ong, et al., 1979) and positive correlation have been established between the aerial survey of mangroves and the fishery yield from adjacent waters (Macnae, 1974; Martosubroto and Naamin, 1977). Untawale and Parulekar (1976) have reported that mangrove fringed estuarine system of Goa is enriched by the detritus derived from the mangrove plants, which in turn supports a high detritivorous population.

The benthic communities of the estuarine system of Goa contribute substantially to the detritus food chain of the complicated food web, whose quantity in terms of number and biomass vary seasonally, subjected to various physico-chemical and biological factors. The detailed hydrobiological characteristics with reference to benthic communities have been described by Parulekar and Dwivedi (1974), Parulekar, et al. (1980) and Ansari, et al. (1986). The long term meiobenthic ecological study (Ansari, 1988) revealed similar pattern of the seasonal variation in the the estuaries of Goa.

The basic purpose of population study is to provide information on the optimum exploitation of aquatic resources such as finfish and shrimp. The important contribution on the dynamics of fish population are by Ford (1933); Bertalanffy (1938); Walford (1946); Beverton and Holt (1957); Holt (1965); Qasim (1966); Bhattacharya (1967); Cushing (1968, 1988); Krishnankutty and Qasim (1968); Ricker (1975); Krishnanmurthy and Kaliyamurthy

(1978); Gulland (1983); Pauly (1980, 83, 84, 87); Devaraj (1981, 83) Jayabalan and Ramamoorthi (1986); Vivekanandan and James (1986) and Devaraj and Gulati (1988).

The ecological role of a fish species can be described by studying the food and feeding habits, co-existence of predators, diseases, parasites and competitors. Study of the diet based analysis of the stomach content is now standard practice in fish ecology with the pioneering work of Swynnerton and Worthington (1940); Hynes (1950); Hunt and Carbine (1951); Pillay (1952); Frost (1954); Glen and Ward (1968); Jude (1971) and Crisp, et al. (1978). There is a great deal of information available on the food and feeding habits of fish species endemic to India (Chacko, 1949; Pillay, 1953; Rita Kumari, 1954; Radhakrishanan, 1957; Luther, 1963; Kuthalingam, 1966; Rajan, 1968; Krishnamurthy, 1969).

The study of fish disease and parasite is recent and gaining momentum with the advancement of aquaculture techniques. The incidence of diseases and parasites are increasing in the semi-intensive and intensive culture systems due to the load of high fish density and enormous input of feed and fertilizers. Parasitic diseases are encountered more frequently than the microbial diseases, however the degree of severity and mortality is highly variable. Infestations are more likely to occur in ponds and laboratory culture chambers which are densely stocked. High organic load and unsuitable environmental factors are responsible for parasitic outbreaks as they induce quick succession of parasites. The earlier reports on fish parasites are from zoological point of view (Hofer, 1904; Schaperclaus, 1954; Dogiel, Petrushevski and Polyanski, 1961). The detailed taxonomy of fish parasites has been discussed by Yamaguti (1963), Hoffman (1967) and Kabata (1970, 1985). The parasites from food fishes of India have been described by various workers (Chakravarty, 1939; Khan, 1944; Tripathi, 1952, 54, 57; Abraham and Anantaram, 1955; Hora and Pillay, 1962; Gopalkrishnan, 1963, 64, 66; Pillay, 1963a, 63b, 64, 67; Babu and Raj, 1985a, 85b, 85c). Fin rot disease has been reported from diverse geographical regions (Levin, et al., 1972; Perkins, et al., 1972; Mahoney et al., 1973; Mearns and Sherwood, 1974; Walke, 1975). The occurrence of fin rot disease in marine and brackishwater species and its etiology in Indian environment has been described by Chandramohan, et al. (1976); Brightsingh, et al. (1981); Santha, et al. (1984) and Durairaj, (1984).

The study of reproductive biology with reference to specific environmental requirements, reproductive behaviour, spawning period and parental care, if any, are the basic and essential requisites needed prior to the measures adopted for conservation and propagation of a particular fish species. The earlier work on the reproductive biology is that of Clark (1934); Hickling and Ruttenberg (1936); Panikkar and Aiyar (1939); Palekar and Karandikar (1952); Prabhu (1956); Venkatraman (1956); Radhakrishnan (1962); Parulekar and Bal (1971); Bruton and Boltt (1975); Marshal (1979); Dadzie and Wangila (1980); De silva and Chandrasoma (1980); Philippart and Ruwet (1982); Rana (1988) and Tave (1988).

The proximate composition of a species denotes its nutritional and energy status in comparison to other food materials. Recently, the study of relationship between the type of fat ingested and arteriosclerosis has made the knowledge about proximate composition of fish indispensable to heart specialists (Dyerberg, 1986; Kinsella, 1991). Many specialists recommend to supplement fish in their diet in order to avoid excessive consumption of saturated fatty acids and to obtain adequate protein. Fish processing and canning industries are also interested in the proximate composition, so as to specify on the product in view of the growing awareness of the nutritional standard among the consumers.

Chemical composition of fish can be expected to vary from one species to another, within the same species and within the same individual specimen. The amount of glycogen in bony fish is less than the livestock meat (Kilborn and Mcleod, 1920). The fish is sometimes lean sometimes fat, which means that the fat content in a species varies greatly (Lovern and Wood, 1947), though, the fat is acquired at the cost of water of the tissue (Jacquot and Creach, 1950). Flesh of female fish normally contain more protein than the male, however, it does not have general application (Jowett and Davies, 1938; Kordyl, 1951). In general, there is no difference in the biochemical composition of male and female. The protein content in the female horse mackerel is high at the beginning of sexual cycle, while reverse is obtained after spawning (Arevalo, 1948). The difference in proximate biochemical constituents are more pronounced due to the breeding cycle and seasonal variations (Del Riego, 1948; Goncalves Ferreiro, 1951; Parulekar and Bal, 1969). The seasonal variations in fish composition has also been related to the quality and abundance of food items (Hornell and Naidu,1924; Venkataraman and Chari, 1951, 1953).

## 1.3 STATE - OF - ART

A species grows at different rates in different water bodies, thus suggesting that growth is affected by environmental and behavioural conditions (Lowe-McConnell, 1982). The present concept of speciation is therefore up to the level of population strains, since different strains have been observed to behave independently in culture systems. The variability of strains are exhibited in the form of phenotypes, karyotypes and genotypes. In case of rainbow trout (Oncorhynchus mykiss), 32 natural anadromous rainbow trout populations, 2 natural resident populations and 4 resident hatchery populations have been reported (Hershberger,1992). The tilapias, O. niloticus and O. mossambicus are commonly used for culture practices in Philippines and the former is preferred over the latter, but in natural population they are very much mixed and produce retrogressed hybrids. It becomes difficult for a common culturist to distinguish different species, strains and hybrids. Gel electrophoresis, though expensive and laborious at times, is the most powerful tool for establishing the identity of stocks.

Morphometric characteristics have been used to distinguish between stocks of various marine fish species. Standard morphometrics is the conventional method of recording measurements, whereas the truss morphometrics is the concept developed by Strauss and Bookstein (1982) which measures the distances between two homologous landmarks on the body outline. This technique has been successfully used by various workers to distinguish between the stocks of various fish species (Winans, 1984; McGlade and Boulding, 1985). Truss morphometrics has also been used as a tool to discriminate the sexes of a species (Brzeski and Doyle, 1988).

Karyological study is a genetical based method of establishing speciation. A set of new genetic techniques has been appropriately applied to fish especially rainbow trout and Tilapias over the last decade. These techniques are already making significant contribution to aquaculture and appear to facilitate detailed genetic analysis of the species. Such techniques are to manipulate chromosome sets to produce homozygous diploid and polyploid individuals (Valenti, 1975; Thorgaard and Gall, 1979; Chourrout, 1980; Thorgaard, et al., 1981; Purdom, 1983; Lou and Purdom, 1984; Myers, 1986; Thorgaard, 1986; Penman, et al., 1987; Varadaraj and Pandian, 1989, 1990). Information on the karyology of Indian finfish is rather restricted to only a few species (Srivastva and Das, 1968; Rishi, 1973; Khuda-Bukhsh and Manna, 1974, 1976; Prasad and Manna, 1976; Lakra and Rishi, 1991). Karyological features of *E. suratensis* have been reported by Natarajan and Subrahmanyam

(1974), and Rishi and Singh (1982) from the east coast of India.

Ecological studies pertaining to a species are essential if a species is being considered for culture (Wee, 1982). There are few studies on the hydrobiological characteristics of lagoons, backwaters and brackishwater ponds, which are actually utilised at present for aquaculture purposes (Tampi, 1959; Pillay, et al., 1962; Banergee, 1967; Devassy and Bhattathiri, 1974; Banergee and Banergee, 1975; Nagarajaiah and Gupta, 1983). The algal pasture soils of the milkfish ponds were studied by Tang and Chen (1967). The ecological characteristics of a brackishwater fish pond along the Mandovi estuary have been reported by Sumitra-Vijayaraghavan, et al. (1981). They suggested the incorporation of additional energy in the form of fertilizers and supplementary feed. Water quality in the pyrite bearing tropical soil ponds and their management aspects for appropriate use in aquaculture were discussed by Simpson, et al. (1983). Leaching of pond bund soil as a factor responsible for lowering of water pH during monsoon has been reported from a brackishwater farm in Kerala, west coast of India (Mrithunjayan and Thampy, 1986). Soil characteristics of brackishwater fish ponds of West Bengal region have been described by Chattopadhyay and Mandal (1986). To evaluate the suitability for aquaculture purposes, James and Najmuddin (1986) studied the physico-chemical characteristics of Pillaimadam lagoon, in the Palk Bay along the south east coast of India. The ecological information of a specific species or area becomes much more important if a species or water body is to be considered for transplantation and commercial cultivation on scientific lines.

Age and growth studies form an important part of ecobiology of a species. The most frequently used methods of age determination are the interpretation and counting of growth rings which appear on hard parts of fish such as scales, bones and otolith. The growth rings are considered to be formed once in a year and called as annual marks or annuli. These techniques are more relevant in temperate species and have been regularly used (Rounsefell and Everhart,1953; Lagler, 1956; Ricker, 1958, 1975 ; Lawrie, 1963). However, in tropical waters the length frequency analysis method is the most relevant (Pauly, 1987). The frequency samples have also been dealt with graphical and semi-graphical methods (Harding, 1949; Cassie, 1954; Tanaka, 1956; Bhattacharya, 1967).

A modal class progression analysis has also been used by various workers (Fulton, 1904; Thompson, 1942; Pauly, 1978; Devaraj, 1983; Devaraj and Gulati, 1988; Murty, 1990) for the study of age and growth. A computer based length frequency analysis method (Electronic LEngth Frequency ANalysis : ELEFAN) to estimate growth parameters especially for tropical species was introduced by Pauly (1978). Based on the correlation of mean annual temperature, Pauly (1980) derived an equation to estimate natural mortality. Later, the Ø ' prime was developed to compare the growth performance of different species and in different stocks of the same species (Pauly and Munro, 1984). An equation to estimate asymptotic length and Z/K was derived by Wetherall, *et al.*, (1987) , which comprise a part of the complete ELEFAN package (Gayanilo, *et al.*, 1988). The package has been extensively used for the study of tropical species (Ingles and Pauly, 1984; Dwiponggo, *et al.*, 1986; Sua, 1990; Langi, 1990; Lavapie-Gonzales, 1991; Pauly, 1991; Makwaia and Nhwani, 1992).

The numerical and gravimetric methods of gut content analysis can not fruitfully be used when the food comprises of algal filaments, plant fragments and detritus. Hence, the subjective method of point system was introduced by Swynnerton and Worthington (1940) and Hynes (1950). The second method is the occurrence method and provide a qualitative picture of the food items (Crisp, 1963; Fagade and Olaniyan, 1972). The method has also been used as an indicator to derive interspecific competition (Johnson, 1977). Adoption of both frequency occurrence and numerical/volumetric methods are preferred to provide an indication of homogeneity of feeding in a population, since a single method can not express the dietary importance (Hyslop, 1980). Feeding ecology of *E. suratensis* was described by Prasadam (1971) from the Pulicat lake. He concluded that macrovegetation is the major food item followed by decayed organic matter. Devaraj *et al.* (1975) compared the food of juveniles from Udyavara estuary of Manglore with the local freshwater tank of Yemmekere. The significant observations of this study were the predominance of filamentous algae in the food of estuarine specimens, and detritus and insects in the freshwater ones. Macrophytic fragments were reported to be the major food item of *E. suratensis* collected from three diverse habitats of Sri Lanka (Costa, 1983). The predominance of decayed organic matter and filamentous algae were recorded from the gut of specimens collected from Nethravati - Gurupur estuary (Joseph and Joseph,1988a). However, there is no report on feeding ecology of E. suratensis from Goa waters, though it is highly esteemed and fetches good price in local market.

There is an unimodal approach to the study of diseases and parasites from the angle of a pathologist or parasitologist, though, the combined efforts are essential from an aquaculture point of view. Limited observations and reports are available on the common diseases and parasites harboured by E. suratensis (Panikkar and Aiyar, 1937; Evangeline, 1963; Gussev, 1963; Brightsingh et al., 1981; Wijeyaratne and Gunawardene, 1988).

Some information relating to breeding (Panikkar, 1920, 1924) life history (Bhaskaran, 1946) and biology (Job, et al., 1947) of E. suratensis are available in the form of notes and abstracts. Jones (1937) briefly described the developmental biology of E. suratensis. Prasadam (1971) reported the sex composition and maturity. Jayaprakash and Nair (1981) observed two peaks in breeding season and related them to south-west and north-east monsoons. Sexual maturity, fecundity, and spawning has been discussed by Costa (1983) from three diverse habitats. Six stages of developing oocyte in female ovary were observed by Rita Kumari and Padmanabhan (1976). Seven stages of gonads and nine stages of developing oocyte were distinguished by Pathiratne and Costa (1984).

Fish has been reported to mobilize protein during starvation and at spawning (Groves, 1970 ; Mommsen, et al., 1980; Konagaya, 1982; Kiessling, et al., 1991). Lipids are stored as energy reserves in liver, body tissue and around the coiled intestine (Janagaard, 1967; Hails, 1983; Tveranger, 1985). Fish culture studies are also focused on the effect of dietary constituents on the number and viability of eggs, and brood stock composition (Smith et al., 1979; Takeuchi, et al., 1981; Washburn, et al., 1990). Carbohydrates though, present in small quantity form an important source of energy reserve during emergency (Sheridon, et al., 1985; Kiessling, et al., 1991). The impact of environmental pollutants on the biochemical constituents of fish fauna is a matter of concern and has been dealt to certain extent (Bano, et al., 1981; Vishwaranjan, et al., 1988; Somanath, 1991; Sashtry and Dasgupta, 1991).

An overview of literature revealed that only limited information is available on the karyology, feeding ecology and reproductive biology of E. suratensis from India and Sri Lanka. Most of the earlier studies are brief and their description is limited to simple notes or abstracts. There is a paucity of information on the morphometrics, ecological requirements, population studies, reproductive behaviour, developmental biology, diseases, parasites and proximate composition of E. suratensis in Goa waters. Keeping in view, the adaptation of the species to local environment, its commercial importance and culture potential, the present study was undertaken to generate useful information for its transplantation, propagation and conservation.

## 1.4 OBJECTIVES OF THE STUDY

1. To produce taxonomical baseline data by studying morphometric and meristic characters, and karyology.
2. Ecological requirements of the species essential for transplantation and propagation.
3. To study the population dynamics of the endemic stock of Goa to suggest management practices.
4. To elucidate the ecological role with reference to food and feeding habits, competitors and predators, and diseases and parasites.
5. To study the reproductive and developmental biology with reference to spawning periodicity, fecundity and early ontogeny.
6. Study of the dynamics of proximate biochemical constituents to elucidate its nutritional status.

# CHAPTER II

# TAXONOMY, MORPHOMETRY AND KARYOLOGY

## 2.1 INTRODUCTION

Systematic position and appropriate speciation is an essential part of biological study, as most of the biological events are species-specific. The pioneer work on the fish fauna of Indian sub-continent goes back to nineteenth century (Day, 1878). The marine and freshwater fish fauna of Ceylon was described by Munro (1955). The identification of the important commercial finfish species has been documented by various workers (Mishra, 1959; Whitehead, 1972; F A O., 1984; Talwar and Kacker, 1984). Earlier, E. suratensis has been described only by Day (1878) from India and Munro (1955) from Sri Lanka. However, no locality record for Goa has been documented. Thus, it was felt necessary to re-describe the morphological characters of this species from Goa waters. The other objective of this study was to update morphological characterization in detail and to evaluate any change if there is, with response to regional differences. The same species has been reported (Lowe-McConnell, 1982) to grow at different rates, signifying the impact of localized environmental conditions.

Morphometrics has also been used to distinguish between stocks of various marine fish species such as chinook salmon (Winans, 1984), pollock and haddock (McGlade and Boulding, 1985). Karyotype study of fish is gaining much importance owing to its utilization in fish systematics, hybridization, sex manipulation and polyploidy. Cytological investigation on the species presently undertaken for the study was also carried out with reference to the stock of Goa, though its report has been documented from the stock along the east coast (Natarajan and Subrahmanyam, 1974; Rishi and Singh, 1982). Therefore, in the present study an attempt has been made to establish the morphometric characterization and karyotype of E. suratensis in Goa waters.

## 2.2 MATERIALS AND METHODS

In the present study two morphometric methods were adopted, namely standard morphometrics and the truss morphometrics. The essential morphological characters were recorded in the live fish wherever necessary, as well as in freshly caught fish. The standard morphometrics was recorded with the help of scale and divider. The meristic characters were enumerated visually, and wherever needed were observed under the microscope. The taxonomic classification followed was as described by Berg (1940) and Munro (1955).

Standard morphometrics is a conventional method of recording measurements, whereas, the truss morphometrics is the concept developed by Strauss and Bookstein (1982) that measures the distances between two homologous landmarks on the body outline. The technique of truss morphometrics is more efficient and appropriate than the conventional (Brzeski and Doyle, 1988) as it covers the entire body, and further more, the truss lengths provide localized information about the body shape. The technique has been used successfully by various workers to distinguish between the stocks of various fish species (Winans, 1984; McGlade and Boulding, 1985) and sex discrimination (Brzeski and Doyle, 1988). It is also useful to compare the growth patterns of the species and its hybrids. Therefore, in the present study more stress has been laid on the truss morphometrics.

The earlier work on truss morphometrics is computer based, however, the methodology was modified to suit the local conditions, and the manual mode of operation of the technique facilitate its use in the field. To describe the form of the fish, eleven distinctive homologous landmarks were chosen on the outline of the fish. Each specimen was positioned with its right side against a white sheet of paper placed above a thin thermocol sheet in order to maintain uniformity. The selected landmarks were pricked with a fine needle and subsequently encircled with a mark. Later these points were joined to form truss (Fig. 2.1.), and the truss lengths were measured with divider and standard scale. The truss measurements of male and female specimens were recorded, separately. The truss index with reference to total length was worked out for each truss following the formula:

$$\text{Truss index} = \frac{\text{Truss length (mm)} \times 100}{\text{Total length (mm)}}$$

The mean of all the truss lengths indices was calculated and the body shape was re-constructed by first drawing a J - I truss length (Fig. 2.2.1.). The re-constructed shape is a replica of

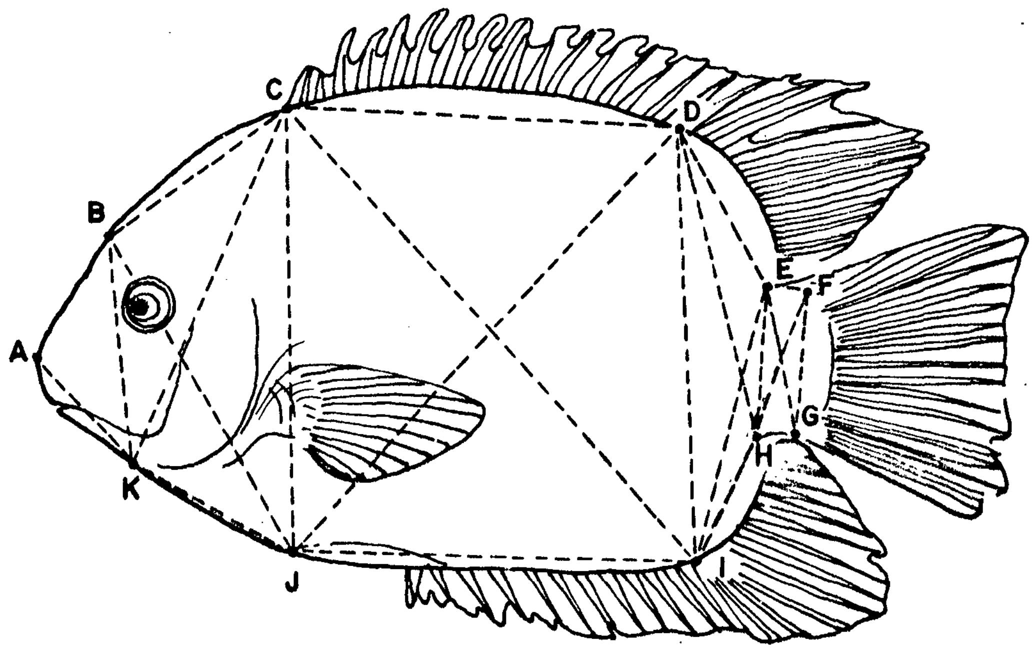



Fig. 2.1 Truss Morphometrics of E. suratensis location of 11 homologous landmarks (A-K) and broken lines indicate truss length.

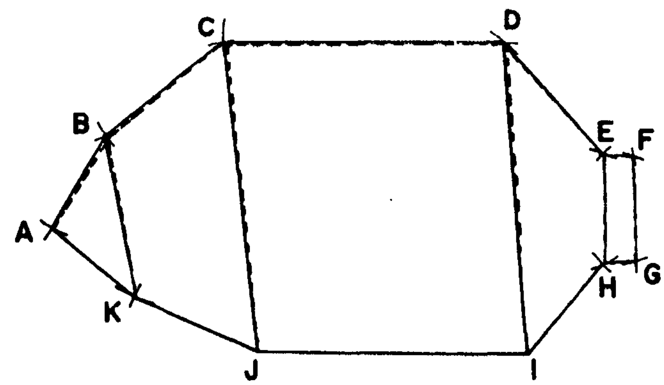



Fig. 2.2.1 Restructured shape of E. suratensis male (—), superimposed with female (------), based on the truss Lengths indices.

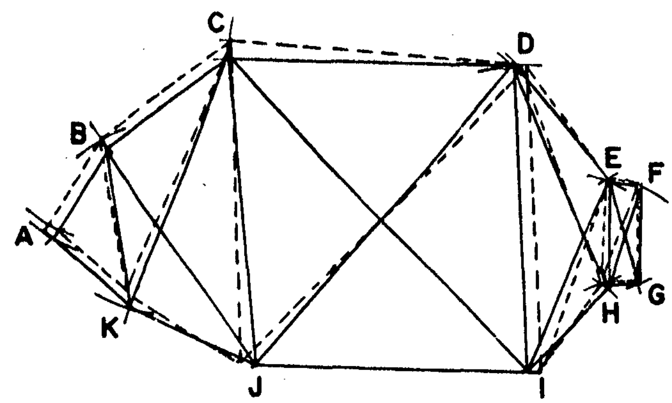



Fig. 2.2.2 Restructured shape of E. suratensis male Goa (—) superimposed with the shape of Chilka lagoon, mixed sex, (-----)

the observed truss lengths in E. suratensis of various sizes.

Live specimens of E. suratensis were obtained from the brackishwater fish farm, Old Goa for studying the karyotype. Five males and five females were used to prepare the chromosome spreads. Colchicine was injected intra-muscularly to each specimen at the rate of 1.5 µg/g body weight. The specimens were sacrificed after three hours, gill tissue removed and suspended in hypotonic solution of 0.075 M KCl for 30 - 40 minutes. Fixation was done in 1:3 (v/v) glacial acetic acid and methanol by giving three consecutive changes of the fixative at an interval of 30 min. each. A cell suspension of the fixed tissue was prepared in 60% acetic acid and the slides were made using the conventional air-dried technique. After staining in dilute Giemsa stain, screening for the enumeration of chromosome number was done under 10 X 100 magnification. Selected metaphases from both the sexes were microphotographed and the karyograms were prepared from the best five plates following method of Levan et al. (1964).

## 2.3 RESULTS

The body of E. suratensis is bilaterally symmetrical with eyes on opposite sides of the head; ventral fins thoracic in position with one spine and five rays. Dorsal fin is long and the pectoral fin is normal; anal spines do not form a separate anterior fin and the first vertebra free from skull; dorsal and anal fins without series of detached finlets; no accessory air breathing organ; mouth with moderate gape; gill openings wide; no denticulated crest on the super-occipital; no bony ridge across the cheek; head without bony plates and spiny projection; ventral fins moderately apart and never forming a sucking disc. All these characters place this species under .......... order Perciformes

Fins with spines, ventrals thoracic in position with one spine and five rays; caudal rays do not overlap hypural; second infraorbital not united with preopercle.

........ sub order Percoidei

Perch like fish with laterally compressed body covered with moderate size ctenoid scales. Dorsal spines numerous; anal spines more than three; teeth small with more than one series in jaws; pseudobranch absent; lateral line interrupted.

........... Family Cichlidae

Anal fins with more than 12 spines ............. Genus Etroplus

Dorsal fin rays more than 14; anal fin rays more than 11; transverse bands ......... Species suratensis

The detailed characters of E. suratensis are as follows: Body slightly elevated; branchiostegals six; pseudobranch absent. Indices of standard length, head length, depth through dorsal, depth through anal and depth through caudal with reference to total length are given in Table 2.1. Mean head length revealed that it comprise about 1/4 of the total

Table 2.1 Mean standard morphometric indices with reference to total length

| Body lengths | Male | Female | Chilka lagoon sample(mixed sex) |
|---|---|---|---|
| Standard length | 76.85±1.46 | 77.22±1.08 | 78.47±0.74 |
| Head length | 24.85±0.93 | 24.80±0.75 | 25.39±0.58 |
| Body length | 52.34±1.30 | 52.42±1.08 | 53.08±0.80 |
| Depth through dorsal fin | 42.13±1.54 | 41.50±1.32 | 42.35±0.52 |
| Depth through anal fin | 46.55±1.98 | 45.52±1.85 | 48.48±0.82 |
| Depth through caudal fin | 14.61±0.65 | 14.50±0.70 | 14.57±0.37 |

length. Caudal fin comprise about 1/5 of the total length. Maximum body depth that is nearly half of the total length was observed at the base of the anal fin. The minimum depth was observed at the base of the caudal peduncle which is 1/7 of the total length. Dorsal profile of the body is raised whereas, the ventral is comparatively round (Plate 2.1). Mouth is terminal, protractile and lower jaw is slightly longer than the upper. There is a prominent outermost single row of teeth on both the jaws and two rows of smaller teeth posterior to the prominent one. Pharyngeal dentition well developed with a triangular lower bone and the upper two oval structures embedded with fine teeth (Fig. 5.1.). Gillrakers are small nodular structures. Dorsal fin is long and originates almost parallel to the pectoral and continues till the caudal peduncle. Most of the part of the dorsal fin is spinuous. Anal fin originates just behind the anus and continues posteriorly parallel to the dorsal with most of its part spinuous. Ventrals in both the sexes are distinguishably separate from each other but their inner margins are confluent with body with a fine membrane. Though, they do not form a disc, seems to form a channel to guide the sex products during spawning as the egg mass was observed in series on the substrate (Plate 6.5.1). The caudal fin is slightly emarginate. Scales are ctenoids and are extended to the caudal base of the rayed dorsal and anal fins. Lateral line is discontinuous. Anus opens to the exterior just in front of the urino-genital opening.

Body colour is light green with eight prominent oblique vertical bands, the first passes over the occiput and the last

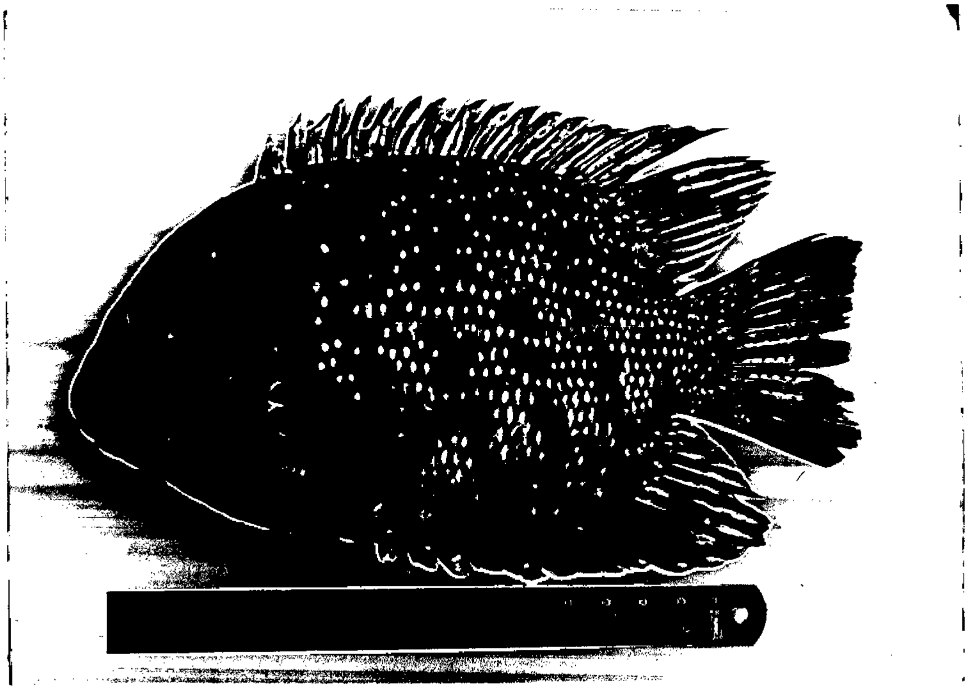


Plate 2.1

across the base of the caudal (Plate - 2.1.). The fish shows a camouflage behaviour, though it is not very distinctive. Many times under natural conditions in the fields as well as in the laboratory, specimens with four additional vertical bands in the head region were observed, which were not as prominent as mentioned earlier. Among these additional bands, the first is in front of the nostrils, second behind the nostrils and in front of the eyes, the third above the eyes and the fourth after origin merges with the first prominent one which passes over the occiput. Most of the scales in the dorsal profile have a white or light yellow pearly spot, while the scales of the lower profile have an irregular black spot that are more prominent in the fish healing from injury in that area. The dorsal, ventral, anal and caudal fins are dark in colour whereas, the pectoral is yellow with a black spot at the base.

The meristic characters include the enumeration of spines and rays of fins, scales and vertebrae. The number of vertebrae varied from 29 - 32 with a mode at 31. A different fin formula was recorded to identify the stock of Goa and is given in Table 2.2 and the variation in meristic characters is shown in Fig. 2.3.

*Etroplus suratensis* is reported to be well distributed in freshwater and brackishwater along the Malabar coast and the Coromandal coast up to Orissa. On the west coast, its distribution is in sizable number up to Goa coast, however it was observed in small numbers along the Konkan coast of Maharashtra up to Bombay. Bloch named it suratensis with the

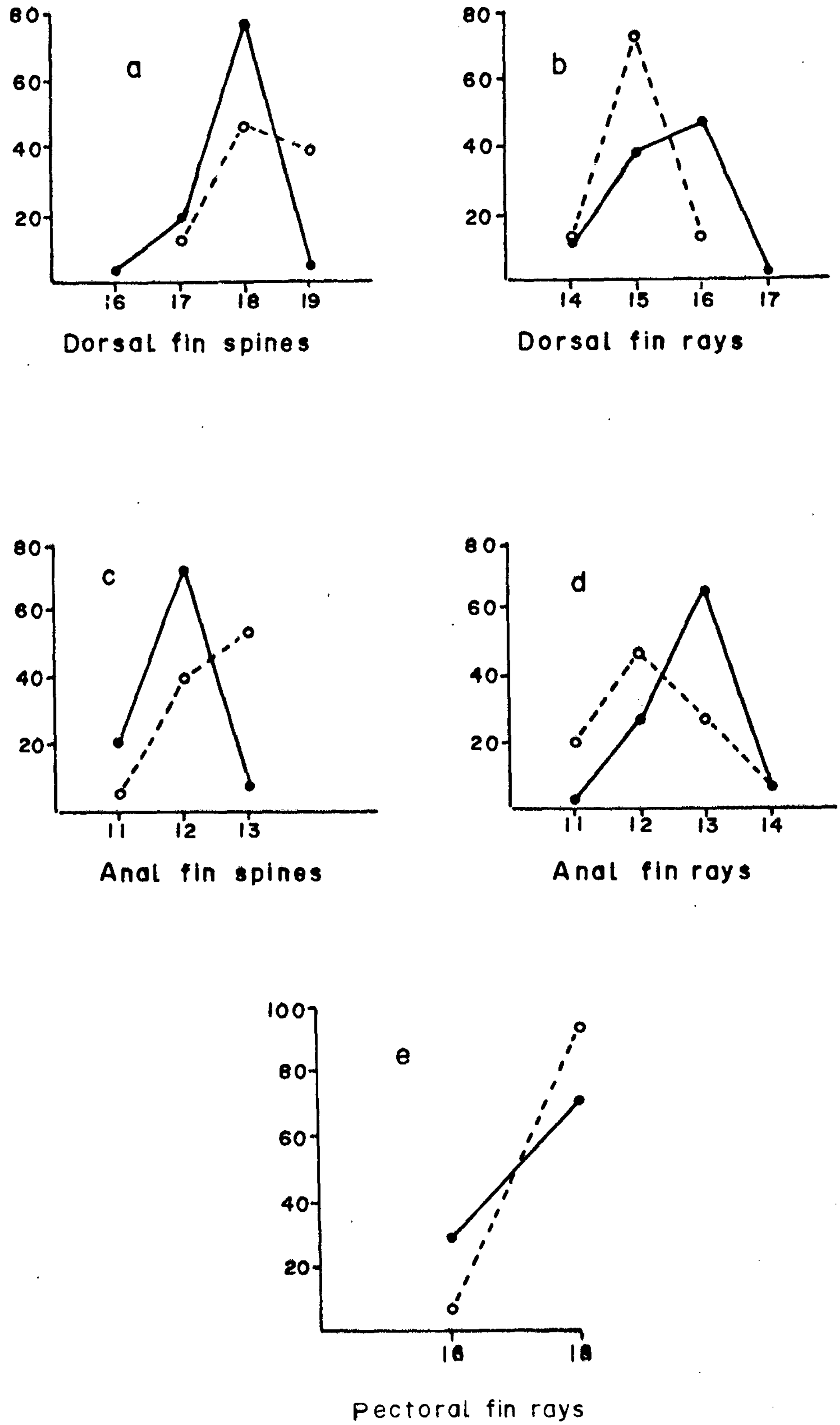



Fig. 2.3.1(a-e) Variation in meristic characters of E. suratensis (Goa ——), (Chilka lagoon ----)

Table 2.2 Meristic characters in <u>E. suratensis</u>

| Authers | Dor. fin | Pect. fin | Vent. fin | Anal fin | Caud. fin | L.line scale | Tra. scales | Vert. |
|---|---|---|---|---|---|---|---|---|
| Day (1878) | $\frac{\text{XVIII-XIX}}{14 - 15}$ | 17 | $\frac{\text{I}}{5}$ | $\frac{\text{XII-XIII}}{11 - 12}$ | 16 | 35-40 | 5.5/17 | - |
| Munro (1955) | $\frac{\text{XVII-XIX}}{14 -15}$ | - | $\frac{\text{I}}{5}$ | $\frac{\text{XII-XIII}}{11 - 12}$ | - | 35-40 | 6/17 | - |
| Present (1993) | $\frac{\text{XVI -XIX}}{14 - 17}$ | 16-17 | $\frac{\text{I}}{5}$ | $\frac{\text{XI - XIII}}{11 - 14}$ | 20 | 35-41 | 5-7/17-19 | 29-32 |

presumption that the specimen handed over to him by a missionary were collected from Surat, however, there is no report of its occurrence from that region till date. It is well distributed in the brackishwater of Sri Lanka.

The comparison of body form between male and female was done by re-constructing the shape of male with the help of mean truss indices and super imposing the same of female (Fig. 2.2.1.). The figure revealed similar body configuration of male and female thus, the truss morphometrics fails to distinguish the sexes. The low standard deviation in all the truss length indices (Table 2.3) also indicate that almost all the body dimensions grow proportionately with the increase in total length. When the reconstructed shape of E. suratensis from Chilka lagoon is super imposed over the male configuration of Goa (Fig. 2.2.2.), it showed difference in body shape. Thus, the variation in body configuration distinguishes the stock of Goa and Chilka lagoon into two different strains (phenotypes). The condition factor (`Kn') value in gutted condition (Chilka lagoon; mean `Kn' = 2.22 $\pm$ 0.08) did not show any significant variation, indicating that in terms of growth in weight, the strains may be similar.

The diploid number of chromosomes was encountered in 286 metaphase plates (139 from males and 147 from females). As shown in Table 2.4., 84.89% cells in males and 84.35 % in females had 48 chromosomes (Plate 2.3). All the chromosomes were acrocentric and the number of fundamental arms (NF) was also 48. Based on the data of five karyotypes, the mean total length of the individual chromosomal pairs and the haploid genome varied between 1.96 $\pm$

Table 2.3 Mean truss length index with reference to total length.

| Truss Lengths | Male (N=50) | Female (N=66) | Chilka lagoon sample (mixed sex) (N=15) |
|---|---|---|---|
| SL | 76.85±1.46 | 77.22±1.08 | 78.47±0.74 |
| AB | 14.17±0.96 | 13.81±1.39 | 12.94±0.99 |
| BC | 20.00±1.12 | 19.98±1.07 | 21.34±1.12 |
| CD | 37.63±1.38 | 37.25±1.52 | 39.38±1.40 |
| DE | 19.56±1.30 | 19.60±1.33 | 18.18±1.35 |
| EF | 3.96±0.63 | 3.96±0.51 | 4.64±0.80 |
| GH | 4.33±0.50 | 4.55±0.68 | 5.04±0.48 |
| HI | 15.43±1.19 | 15.67±1.40 | 14.20±1.00 |
| IJ | 36.07±1.89 | 35.76±1.93 | 39.81±1.27 |
| JK | 18.02±0.81 | 17.77±1.01 | 18.03±0.70 |
| KA | 13.71±0.91 | 13.62±0.86 | 13.72±0.69 |
| BK | 21.73±0.83 | 21.39±1.01 | 21.26±0.72 |
| CJ | 40.80±1.21 | 40.36±1.29 | 42.65±0.67 |
| DI | 40.85±1.52 | 40.39±1.80 | 39.81±1.72 |
| EH | 14.66±0.49 | 14.47±0.92 | 14.44±0.40 |
| BJ | 35.08±1.03 | 34.66±1.29 | 35.64±0.60 |
| CI | 57.39±1.39 | 56.28±1.92 | 59.60±1.19 |
| DH | 31.83±1.34 | 31.55±1.44 | 30.48±1.37 |
| EG | 14.23±0.55 | 14.10±0.71 | 14.35±0.51 |
| CK | 35.49±0.94 | 35.05±0.89 | 36.23±0.68 |
| DJ | 52.55±1.42 | 52.38±1.83 | 54.77±1.41 |
| EI | 28.36±1.22 | 28.25±1.29 | 27.41±0.87 |
| FH | 14.46±0.54 | 14.43±0.75 | 14.57±0.46 |

SL= Standard length.

Table 2.4 Numerical variation of diploid chromosome number noticed in *E.suratensis* (Values in parantheses are the percentages).

| | Chromosome number | | | | |
|---|---|---|---|---|---|
| Sex | 42 | 44 | 46 | 48 | No of cells |
| Male | 1 (0.72) | 9 (6.47) | 11 (7.91) | 118 (84.89) | 139 |
| Female | 1 (0.68) | 8 (5.44) | 14 (9.52) | 124 (84.35) | 147 |

Plate 2.2 Microphotograph showing chromosome of <u>E. suratensis</u> (2N = 48).

Plate 2.3 Photograph showing karyotypes of <u>E. suratensis</u>. based on Plate - 2.2.

Plate 2.2

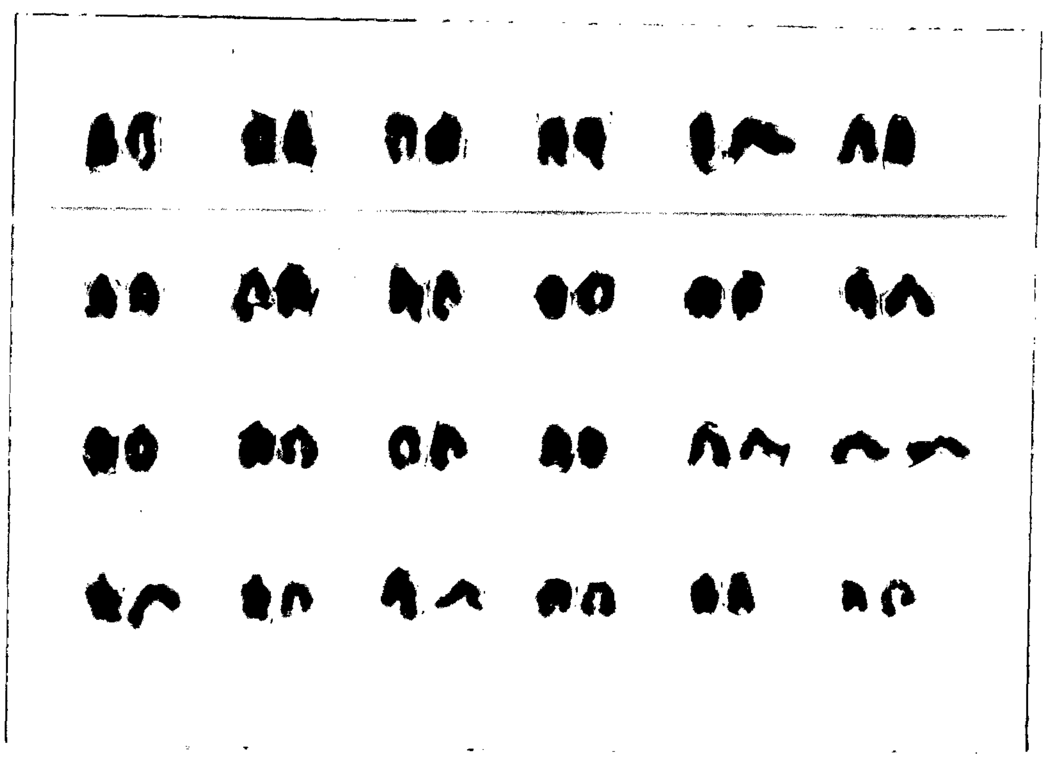


Plate 2.3

0.50 to 3.43 $\pm$0.57 $\mu$m and 37.45 $\pm$ to 82.31 $\mu$m respectively. The relative percentage of chromosome length (RL%) ranged between 3.16$\pm$ 0.14 and 5.70 $\pm$ 0.86 $\mu$m (Table 2.5). However, within each particular karyotype, in spite of noticeable size variation amongst chromosomes, many had exactly the same size. Sex chromosomes could not be distinguished between the two sexes. Six tetraploid spreads, 4 in male and 2 in female were also observed (Plate 2.4).

## 2.4 DISCUSSION

The present study describes a taxonomic formula for the identification of E. suratensis in general and from Goa in particular. The range in meristic characters observed in the present study was found to differ from the earlier reports (Day, 1878; Munro, 1955). Some new information is also added to the morphological characters such as increased number of caudal fin rays two on each side i.e. upper and lower, which are fused and smaller in size and might have probably been overlooked by the earlier workers. The attachment of inner margin of the ventral fins to the main body with thin membrane, four additional vertical bands in the head region, number of vertebrae and the pharyngeal teeth are the other additional information reported.

The study of truss morphometrics revealed that the body configuration in both the sexes is alike. A comparison of these characters with Chilka lagoon specimen indicated that the head

Plate 2·4

Table 2.5 Morphometric data of *E. suratensis* karyotype.

| Chromosome Pair Number | Plate Chromosome | | Mean of 5 spreads | |
|---|---|---|---|---|
| | Length ( µm) | RL% | Length ( µm) | RL% |
| I | 2.88 | 5.67 | 3.43±0.57 | 5.70±0.86 |
| II | 2.63 | 5.18 | 3.16±0.77 | 5.10±0.12 |
| III | 2.50 | 4.93 | 3.03±0.78 | 4.87±0.05 |
| IV | 2.44 | 4.81 | 2.95±0.76 | 4.73±0.05 |
| V | 2.28 | 4.50 | 2.86±0.80 | 4.57±0.10 |
| VI | 2.25 | 4.44 | 2.84±0.78 | 4.54±0.08 |
| VII | 2.25 | 4.44 | 2.82±0.76 | 4.51±0.06 |
| VIII | 2.25 | 4.44 | 2.77±0.74 | 4.43±0.04 |
| IX | 2.25 | 4.44 | 2.73±0.75 | 4.36±0.11 |
| X | 2.25 | 4.44 | 2.69±0.72 | 4.31±0.10 |
| XI | 2.25 | 4.44 | 2.66±0.71 | 4.26±0.12 |
| XII | 2.19 | 4.31 | 2.62±0.72 | 4.17±0.15 |
| XIII | 2.13 | 4.19 | 2.57±0.70 | 4.11±0.11 |
| XIV | 2.13 | 4.19 | 2.54±0.68 | 4.07±0.10 |
| XV | 2.06 | 4.07 | 2.47±0.65 | 3.97±0.06 |
| XVI | 2.00 | 3.94 | 2.44±0.67 | 3.89±0.09 |
| XVII | 2.00 | 3.94 | 2.41±0.66 | 3.85±0.10 |
| XVIII | 1.94 | 3.82 | 2.36±0.65 | 3.77±0.09 |
| XIX | 1.91 | 3.76 | 2.33±0.64 | 3.73±0.08 |
| XX | 1.81 | 3.57 | 2.29±0.62 | 3.66±0.07 |
| XXI | 1.75 | 3.45 | 2.20±0.59 | 3.53±0.10 |
| XXII | 1.59 | 3.14 | 2.14±0.58 | 3.42±0.16 |
| XXIII | 1.50 | 2.96 | 2.06±0.58 | 3.29±0.19 |
| XXIV | 1.50 | 2.96 | 1.96±0.50 | 3.16±0.14 |

region is slightly more elevated than Goa specimens. Further, the central truss in Chilka lagoon specimens is bigger than the specimens of Goa. Thus, in terms of surface area, Chilka lagoon specimens are marginally bigger than those of Goa. The gutted `Kn' values revealed no significant difference, signifying the identical growth pattern. It is too early to speculate that more surface area may provide better opportunity to put on more weight under culture conditions, which needs comparative growth studies. It can be concluded that the truss morphometrics and reconstruction of body shape is a right approach to compare morphologically the different populations/strains of the same species, but alone leads to no where in deciding the suitability of a particular strain for culture practices. Though, it can be a better tool in selection of brood stock within a population and to make comparison with offsprings. Truss morphometrics coupled with gutted condition factor may be of great help to distinguish the different populations and the superiority of one upon the other at preliminary level.

The diploid number of chromosomes ascertained from gill metaphases of <u>E. suratensis</u> from Goa is 48. Earlier, Natarajan and Subrahmanyam (1974) and Rishi and Singh (1982) had reported the same 2n number for this species from the Vellar estuary and Chilka lake, respectively. This confirms the 2n = 48 for <u>E. suratensis</u>. However, there were noticeable differences in the minute details of the karyotypes. Natarajan and Subrahmanyam (1974) described 23 metacentric and 1 subtelocentric pair of chromosomes. Rishi and Singh (1982) reported all acrocentric pairs. Similarly, in the present case all the pairs were acrocentric, but the RL % values were quite apart from those reported by the earlier authors. This can be due to the variation in the condensation behaviour of the chromosomes. Since the methodologies adopted by Rishi and Singh (1982) and the present work were same, there is a possibility that the species in Goa has evolved into a different strain by undergoing some submicroscopic changes on the genic level. The tetraploid cells could either be due to the Colchicine treatment or natural variations. Such tetraploid cells have also been reported in the spermatogonial metaphases of G. niger (Choudhury, 1992) and assigned to technical shortcoming and fusion of cells.

The diploid number of 48 acrocentric chromosomes forms the ancestral and modal karyotype of fishes (Nogusa, 1960; Post, 1965; Roberts, 1967; Ohno et al., 1968). The diploid complement of Etroplus maculatus was reported to be 46, with 10 pairs of metacentric and 13 pairs of acrocentric chromosomes (Natarajan and Subrahmanayam, 1974). The other common representative of the cichlidae family are Oreochromis, Sarotherodon and Tilapia sp. having a karyotype of 2N = 44, with 2 pairs of marker chromosomes that are larger than the others (Crosetti et al., 1988). The decrease in number of chromosomes and variation in biarms could be due to Robertsonian fusion and pericentric inversion. Thus, genetically E. suratensis, is primitive than E. maculatus and the Tilapiinae.

Morphometric studies revealed that both the sexes in E. suratensis are monomorphic in terms of body configuration and dimensions. Based on truss morphometric and karyotype, the stocks of Goa and Chilka lagoon could be distinguished into two different strains. Percentage frequency distribution of meristic characters also varied in these stocks. However, the electrophoretic studies are felt necessary to further confirm the strains.

# CHAPTER III

# ENVIRONMENTAL PARAMETERS

## 3.1 INTRODUCTION

Cultivable fish species apart from their economic importance in aquaculture and fisheries, are important elements of biocoenosis. Ecological factors of the habitat demonstrate the requirement and preferences of the species with regards to different environmental parameters and behavioural mechanism relating to feeding and reproductive strategies. Ecological information can help to select the species for culture, transplantation, prevention of competition for food and spawning grounds and the failure of transplanted stocks. Most of the fish species used in coastal aquaculture are either estuarine or brackishwater. There is a great deal of work on the ecological studies of estuaries (Dehadrai, 1970; Goswami and Singbal, 1974; Parulekar and Dwivedi, 1974; Untawale and Parulekar, 1976; Parulekar et al., 1980; Verlencar and Qasim, 1985; Jagtap, 1987; Ansari, 1988; Ansari and Parulekar, 1993). However, the ecological studies of a specific species are scanty. Information on the ecology of backwaters, which are actually utilized at present for coastal aquaculture are also limited (Tampi, 1959; Pillay et al., 1962; Pakrashi, 1965; Devassy and Bhattathiri, 1974; Banergee and Banergee, 1975; Rajalaxmi et. al. 1988). Therefore, it was felt necessary to study the environmental characteristics of the natural habitat and the semi-enclosed culture pond with reference to *E. suratensis*

3.1.1 Study Area: Geographically Goa is located between Lat. 14$^{o}$

$54' - 15^{o} 48'$ N and Long. $73^{o} 41' - 74^{o} 21'$ E (Fig.3.1.1). Mandovi and Zuari are the two major rivers forming the main estuarine complex of Goa. The average rain fall is around 3400 mm with heavy precipitation during south-west monsoon (June - September). Both the estuaries are used for navigation purpose and specially for the transportation of iron and manganese ore, from the mines located along the bank of these rivers, to the Marmugao harbour. The bank and the backwaters of these estuaries have thick fringing mangrove vegetation which serve as the nursery ground for various estuarine species. The estuaries are rich in finfish and shellfish resources and the fishing activity runs round the year with more intensity during monsoon when the marine capture fishery is suspended.

River Mandovi originates in the Parva ghat of the Sahyadri hills, Karnataka and after traversing through a stretch of about 70.0 km it joins the Arabian sea at Aguada Bay. A large number of tributaries join the river along its course. The catchment area of Mandovi river is about 1150 $Km^2$, which contributes to the flow of river during south-west monsoon. There are three generally accepted seasons on the west coast of India, namely pre-monsoon, monsoon and post-monsoon. Pre-monsoon season extends from February to May and is the warmest period of the year, with occasional showers towards the end of May. This season is followed by south-west monsoon extending from June to September, when Goa receives the maximum rainfall of the year. The post-monsoon period extends from October to January.

3.1.2 Stations: Preliminary survey was carried out to find out

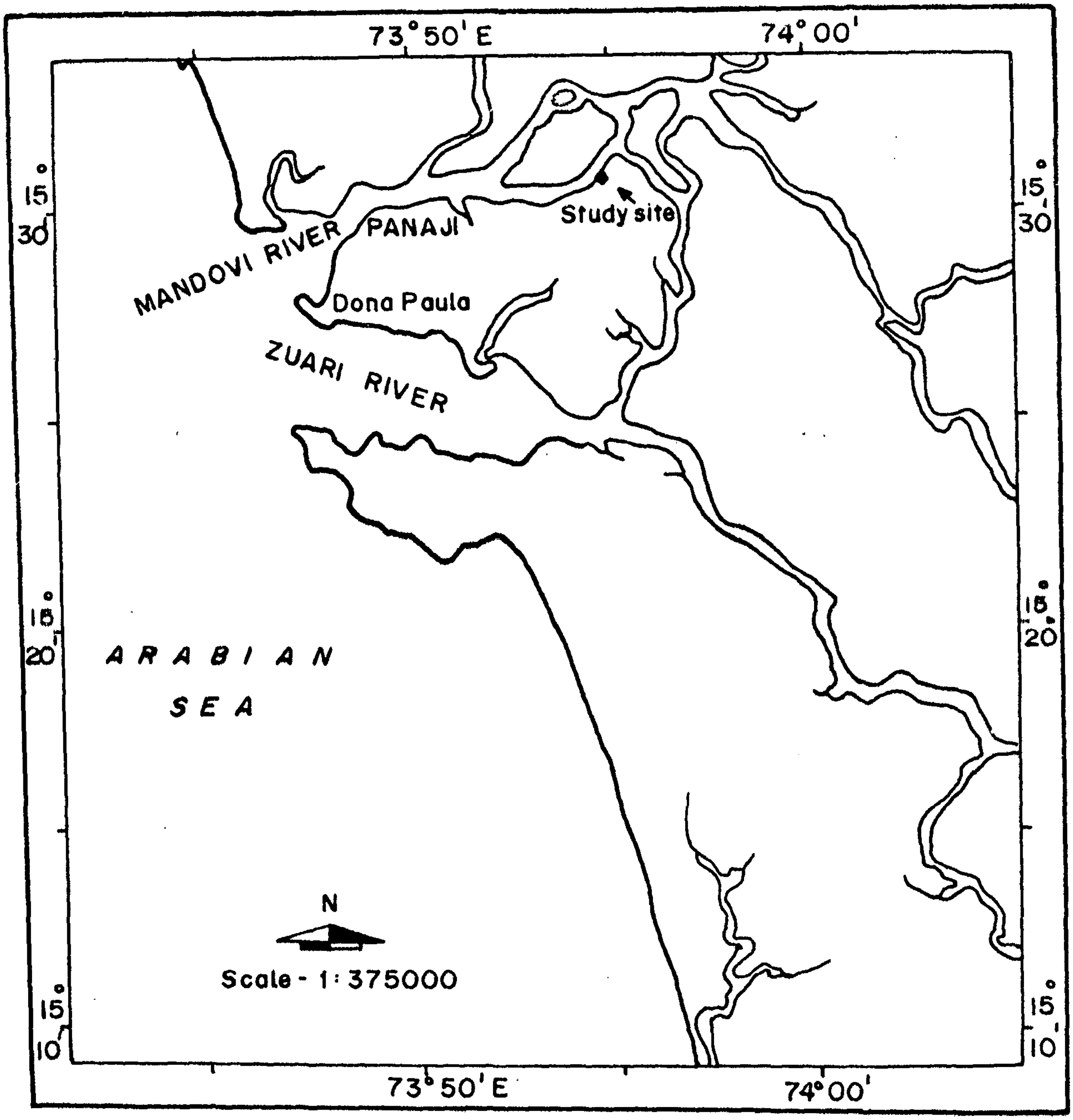



Fig. 3.1.1 Map showing location of the study area.

the natural habitat of *Etroplus suratensis*. The fish was observed to inhabit the backwaters, "Agars" and "Khazan" land along the stretches of both Mandovi and Zuari rivers. It was also observed in the backwaters and estuarine complexes formed by the other minor rivers of Goa namely Teracol, Chapora, Sal, Talpona and Galgibag. To study the environmental characteristics of the natural habitat of *E. suratensis*, station -1 (Fig.3.1.2) was selected in the backwaters and to compare it with brackishwater farm pond conditions, station - 2 was fixed in a fish pond of Goa state fisheries department (Fig. 3.1.2). Station -1 was in the creek located about 8 km upstream from the mouth of the estuary which also supply brackishwater to the main feeding channel of the farm. The distance between the Mandovi estuary and station - 1 is about 70 m. The sluice gate of the pond is about 200 m away from the station - 1. Fish farm is a tidal fed farm and the water is exchanged regularly. The farm management is of semi-intensive type. In the pond multi-species stocking is practised, comprising of *E. suratensis*, *Chanos chanos*, *Oreochromis mossambicus* and mullets. During the preliminary survey (January, 1991), sufficient numbers of *E. suratensis* were observed in the pond with some brooding pairs. The occurrence of brooding pairs of *E. suratensis* indicate optimum propagating environmental conditions. Therefore, the two nearby stations were selected to observe the variation in environmental characteristics in open and semi-enclosed conditions. The sampling programme was carried out from February 1991 to May 1992, so as to cover the major seasons with an overlapping in

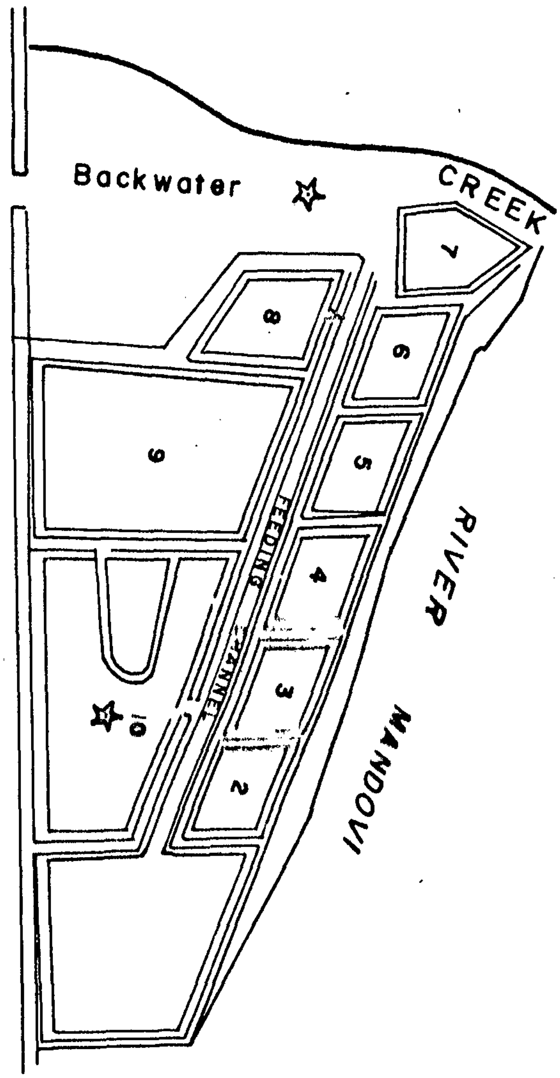



Fig. 3.1.2 Map showing the Location of the brackishwater fish farm and the stuay stations.☆

pre-monsoon period.

## 3.2 MATERIALS AND METHODS

Water samples were collected at fortnightly interval and analysed for hydrobiological parameters such as temperature, salinity, pH, free carbon dioxide, total alkalinity, dissolved oxygen, total suspended matter, particulate organic carbon and chlorophyll-a. Simultaneously, sediment core was collected from three different places and mixed together to form a composite sample for the analysis of pH and organic carbon. Sediment particle size was analysed for the months of April, July and December, to cover the three seasons. Sampling in the pond was carried out fortnightly between 13.00 and 1400 hr., whereas in backwaters during the high tide. Surface water temperature was measured in situ with a mercury thermometer and the values are expressed as degree centigrade. Salinity was estimated following the method described by Strickland and Parsons (1968) and the values are expressed in parts per thousand. pH was measured immediately at the site by using digital pH meter (Phillips, pp - 9046). Free carbon dioxide, total alkalinity and dissolved oxygen were estimated following the methods described in APHA - AWWA - WPCF (1980) and the values are expressed in mg/l.

The total suspended matter was estimated by filtering half litre of water through pre-weighed GF/C ( pore size; 0.45 $\mu$). The residue was dried at 70 $^{o}$C and weighed on digital balance

(Mettler AE - 200) and the values are expressed in mg/l dry weight. Particulate organic carbon was estimated following wet oxidation method described by Parsons et. al. (1984).

Chlorophyll -a estimation was carried out by filtering 500 ml of water through GF/C filter paper, followed by extraction with 90% acetone in dark bottle at < 5 °C (Yentsch and Menzel, 1963). The values are expressed as µg/l.

Sediment pH was estimated at the site with a digital pH meter. Later, sediment sample were dried at 60 °C and pulverised in mortar and pestle, and used for the estimation of organic carbon following the method described by El Wakeel and Riley (1957). Sediment grain size was analysed by the method of Krumbein and Pettijohn (1938).

## 3.3 RESULTS

3.3.1 Temperature: Atmospheric temperature varied from 26.7 °C in the month of July to 34.0 °C in April - May and December. The major fall in temperature was observed to be in the month of July - August, when there was a heavy precipitation. The annual range in atmospheric temperature was 7.2 °C.

The water temperature in the pond varied from 28.0 °C in December to 36.0 °C in April 1991. The annual temperature profile is shown in Fig. 3.2. The annual variation in pond water temperature indicates two peaks, one in October and the other in

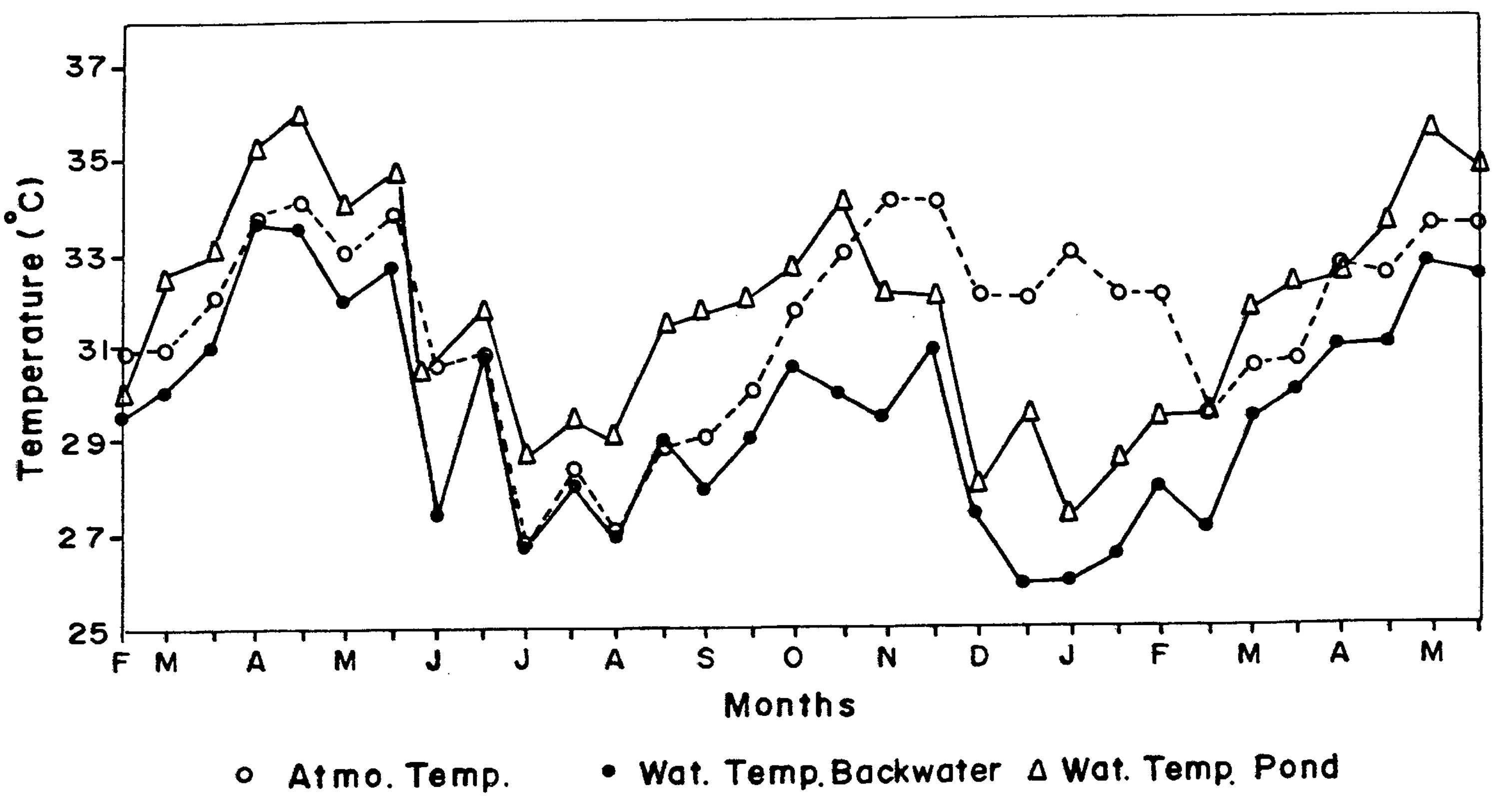



Fig. 3.2 Fortnightly variation in atmospheric & water temperature of backwater and pond.

April - May, and the troughs during July - August and December - January. Low temperature reocrded during July - August was due to cloudiness and intense precipitation, whereas in December - January it could be attributed to short day light period and winter impact .

The annual fluctuation in backwater surface temperature varied from 26.0 $^{o}$C to 33.0 $^{o}$C. The peaks and troughs in backwater were similar to that of pond water. The temperature of backwater was always lower than the pond water except in the first half of June, when 30.5 $^{o}$C was recorded at both the stations. Relatively, higher temperature of pond water could be attributed to the semi-enclosed and stagnant conditions which respond quickly to the atmospheric temperature.

3.3.3 Salinity: The salinity in the pond varied from $3.63 \times 10^{-3}$ in August to $36.18 \times 10^{-3}$ in May. The salinity suddenly fell between second half of June and first half of July due to heavy precipitation. It showed an increasing trend from September and reached the maximum in May. The annual profile in salinity variation is given in Fig. 3.3.

The minimum salinity recorded in backwater was during July - August ($0.18 \times 10^{-3}$) and the maximum ($33.09 \times 10^{-3}$) in May 1992. Freshwater conditions were recorded during July - August resulting from intense precipitation and land run-off. The freshwater flow decreases at the end of the south-west monsoon and the salinity starts increasing gradually, reaching its peak in May when almost marine condition prevails. There is a

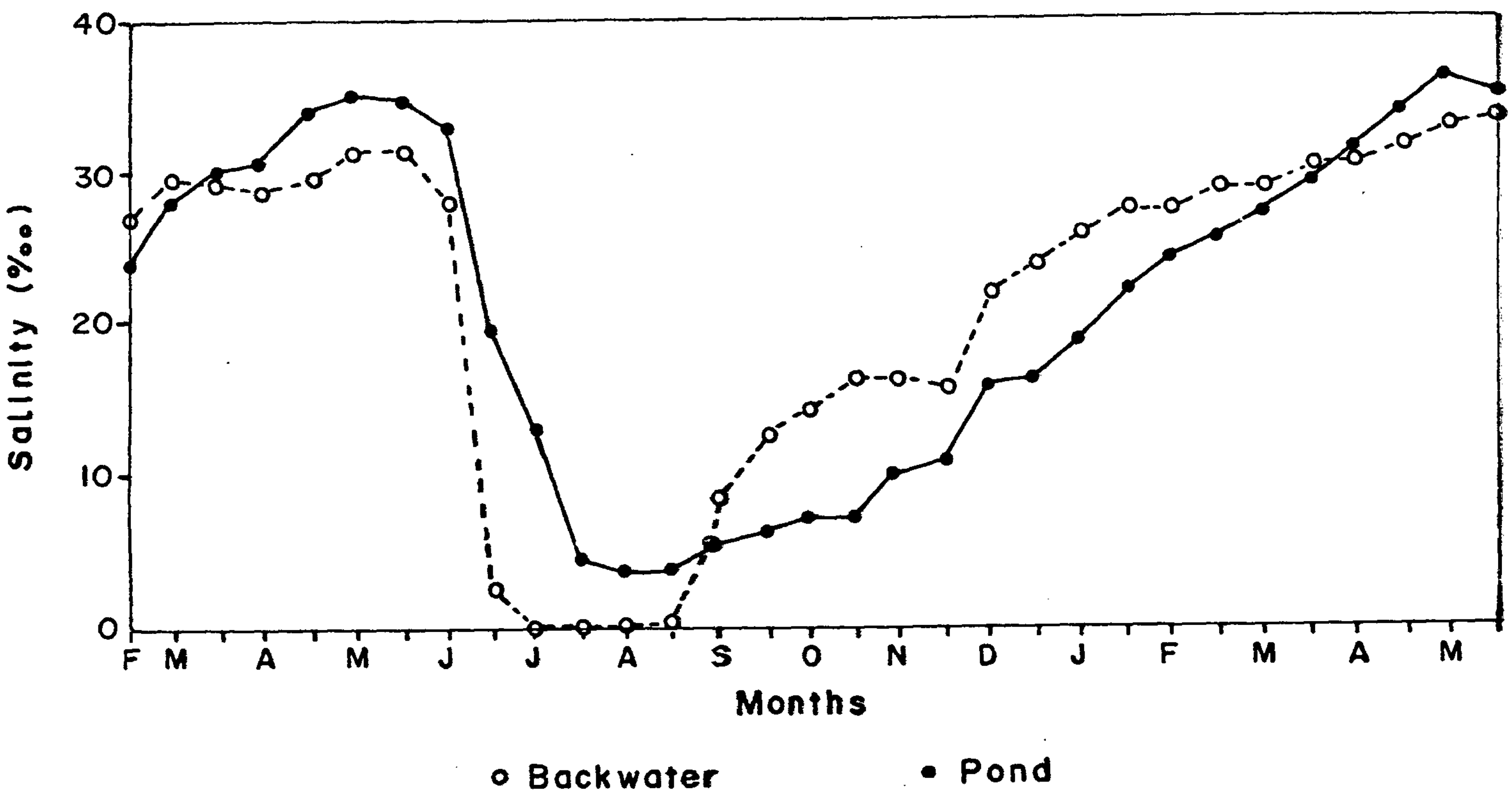



Fig. 3.3 Fortnightly variation in the salinity of backwater and pond.

distinct pattern of salinity variation at both the stations. Pond water salinity was observed to be higher than the backwater during April to August, whereas, September to March it was lower than the backwater. Higher salinity in pond water during April - May is due to faster evaporating conditions in the limited stagnant water and no freshwater influx and mixing. There was a sudden fall in the salinity in the month of June in backwater, whereas, in pond the salinity dropped gradually. The process of gradual decrease in salinity in pond water revealed that there is a limited exchange of pond water during high tide and also the natural catchment area of the pond does not influence the salinity at a faster rate as that of estuary and the backwater. Thus, the condition in the pond during monsoon was slightly saline ($3.63 \times 10^{-3}$), whereas, in backwater it was limnetic.

3.3.3 pH : The pH of the pond water varied within a narrow range of 7.0 to 8.70. The water pH on June 6, 1991 was 7.17, when the free board of the pond dike was applied lime at the rate of 300 Kg/h. The lime application influenced the pH of the water in the next sampling (pH increased to 7.52) i.e. June 22,1991. Thereafter, there was not much precipitation as evident from the pond salinity, and the pH fell to 7.20 on July 6, 1991, since there was not sufficient leaching of the lime applied to pond dike. However, between July 6, 1991 - July 22, 1991, the intense precipitation leached the lime into the pond and the pH increased to 8.7 which gradually decreased till September, and thereafter fluctuated narrowly between 7.10 and 7.44 till May 1992 (Fig.3.4).

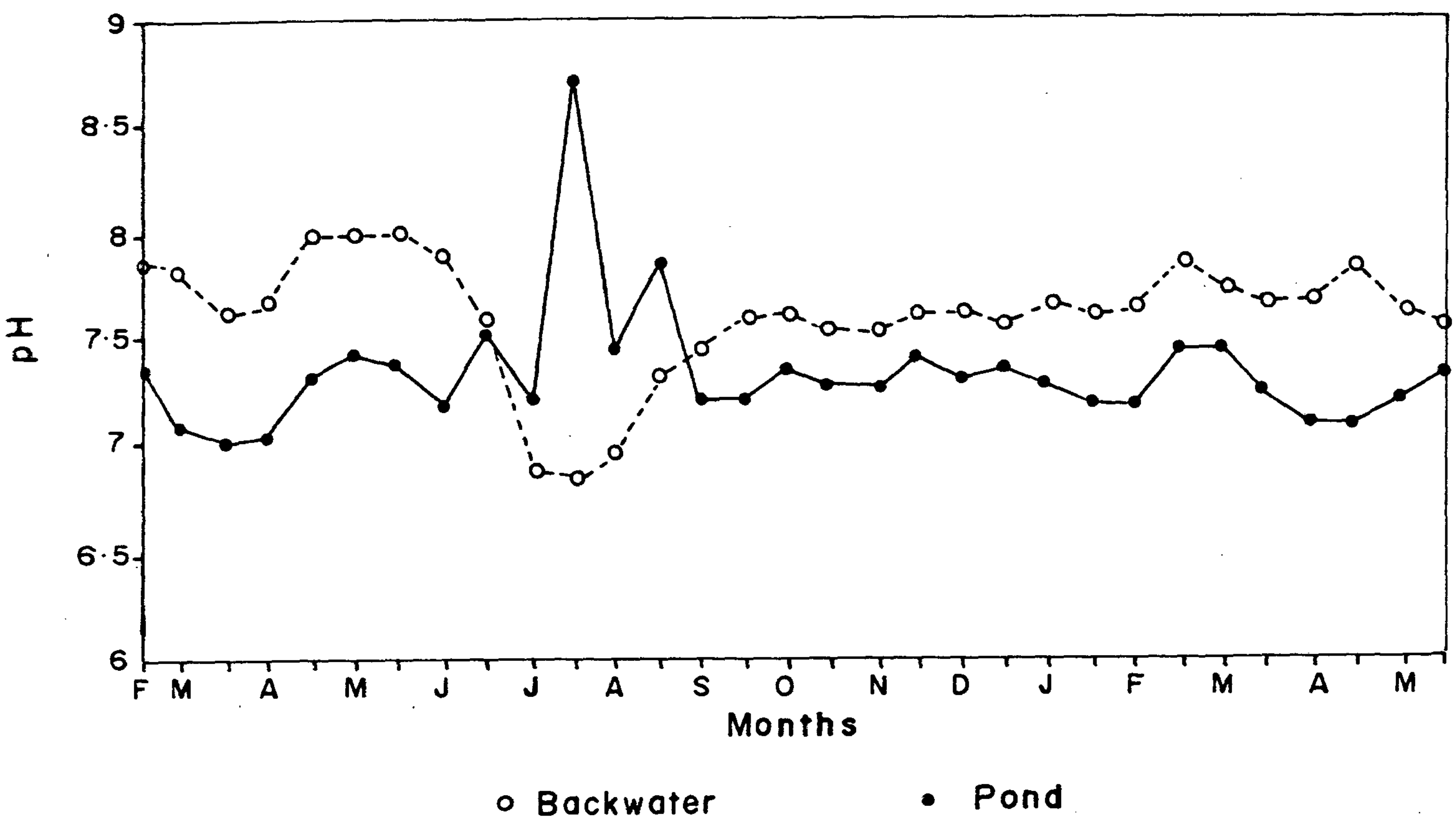



Fig. 3.4 Fortnightly variation in the pH of backwater and pond.

Backwater pH fluctuated between 6.85 and 8.0. During monsoon, the pH gradually decreased to 6.85 with the decrease in salinity. In the second half of August, it started increasing and reached 7.59 in second half of September. During the remaining part of the study, it varied between 7.53 and 8.00. The decrease in pH during monsoon can be attributed to the lack of buffering capacity of the top soil of the catchment area and probably the leaching of the mineral acids of the freshly excavated mines. As the freshwater influx to the estuary decreased, the corresponding salinity increased resulting in an increase in pH of backwater. With the exception in monsoon, when the pond was limed, the pH of the backwater was always higher than the pond.

3.3.4 Free Carbon Dioxide: The presence of high concentration of free carbon dioxide in low oxygenated medium hinders the oxygen uptake by fish. Generally, the carbon dioxide concentrations are high when the dissolved oxygen is low (Boyd, 1982). This happens because carbon dioxide released during respiration is not utilized in the photosynthesis due to lack of sufficient autotrophs. Thus, when dissolved oxygen is low, the photosynthesis do not proceed rapidly. Generally, the concentration of free carbon dioxide occurs during phytoplankton die-off and in cloudy weather.

Free carbon dioxide in pond water varied from below detectable limit to 13.64 mg/l. The concentration of carbon dioxide was high from February 1991 to first half of June 1991. Except in July, when the value was below detectable limit, free

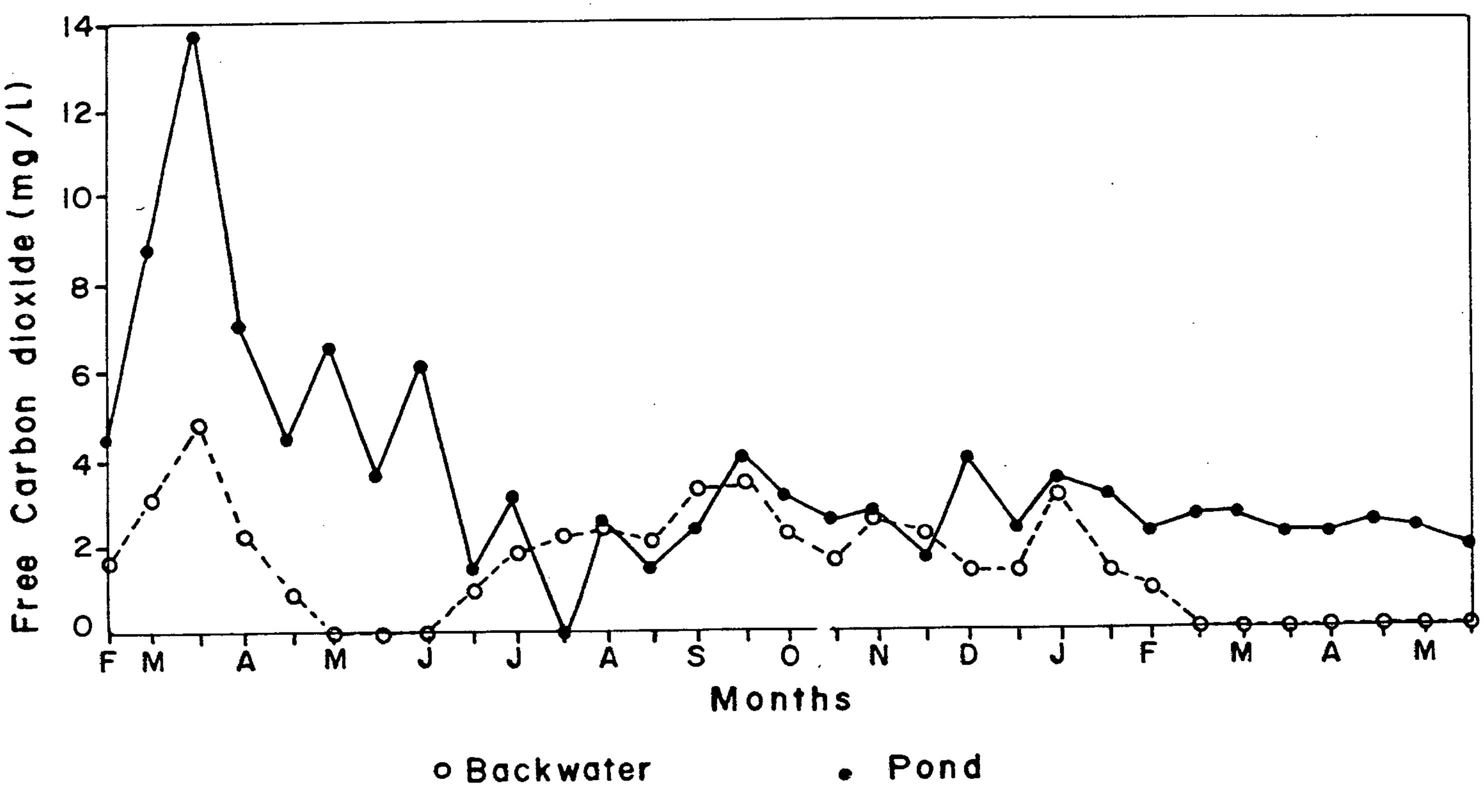



Fig. 3.5 Fortnightly variation in the free carbon dioxide of backwater and pond.

carbon dioxide fluctuated narrowly between 1.76 mg/l and 3.9 mg/l in remaining period of study (Fig.3.5). The concentration of carbon dioxide in backwater ranged from below detectable limit to 4.84 mg/l. Relatively, low concentration of carbon dioxide was recorded in the backwaters . Except some overlapping in the first pre-monsoon period (February 1991 - April 1991), there was a distinct seasonal pattern of free carbon dioxide concentration in backwater. The absence of carbon dioxide during pre-monsoon (May 1991 and February 1992 - May 1992) revealed that there was sufficient growth of autotrophs, and the process of respiration and the photosynthesis proceeded at the same rate. During monsoon and post-monsoon, the respiration exceeded photosynthesis resulting in the higher concentration of carbon dioxide in the water.

3.3.5 Total Alkalinity : The term total alkalinity refers to the total concentration of bases in water expressed in milligrams per litre of equivalent calcium carbonate. Natural waters that contain 40 mg/l or more total alkalinity are considered more productive than waters of lower alkalinity (Moyle, 1945; Mairs,1966). The total alkalinity in the pond water varied from 30.45 mg/l to 81.90mg/l . The lowest level of alkalinity was recorded during monsoon, and the highest in pre-monsoon. The annual profile of total alkalinity is given in Fig.3.6.

Total alkalinity in backwater showed wide fluctuations than in the pond water, and the values fluctuated between 18.90 mg/l and 92.40 mg/l . There was a distinct seasonal pattern in the annual alkalinity profile of the backwater (Fig. 3.6). The

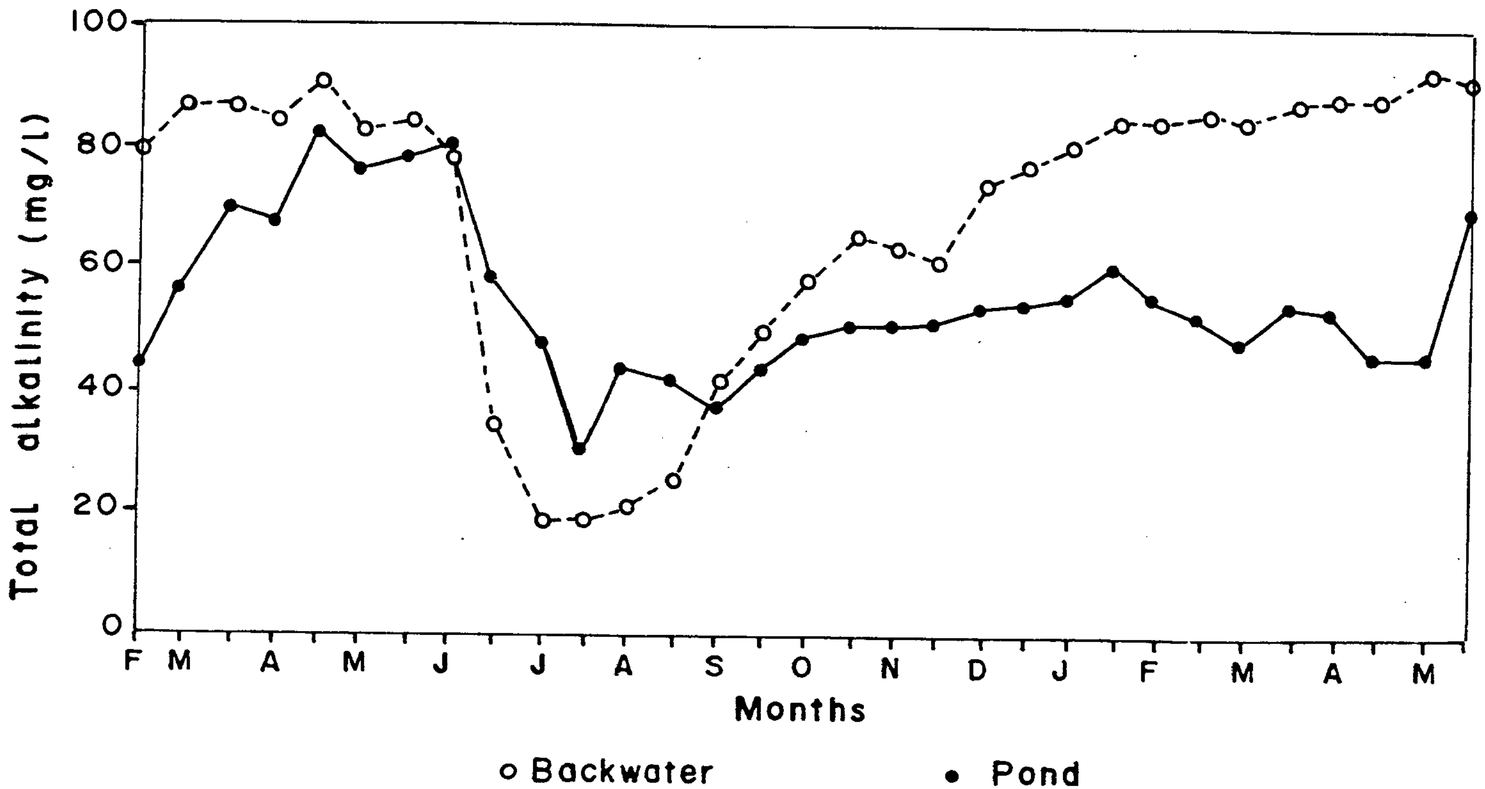



Fig. 3.6 Fortnightly variation in the total alkalinity of backwater and pond.

alkalinity levels were lowest during the monsoon when the corresponding pH and the salinity were also low. At the cessation of monsoon the total alkalinity increased gradually from October to May. Thus, the alkalinity of the backwater depends solely on the buffering capacity of the tidal marine water.

3.3.6 Dissolved Oxygen: Dissolved oxygen (DO) in the pond water varied from 2.55 mg/l to 9.32 mg/l. The lowest value of DO was recorded during first half of June (June,6,1991), which could be due to poor intensity of light as a result of cloudy weather. The DO level was high during remaining part of the monsoon when the salinity was low. The DO level was also low during second half of March and first half of April 1991 when the corresponding chlorophyll-a was poor. During the remaining period of the study the DO fluctuated between 4.28 and 6.85 mg/l (Fig. 3.7).

The dissolved oxygen at the surface of backwater was always high throughout the period of study, and ranged between 4.80 mg/l and 7.5 mg/l . The DO was generally high during the monsoon, which can be attributed to increased oxygenation of run-off water, whereas intermittent peaks i.e. February 1992 and in April 1991 and 1992 corresponds to higher content of chlorophyll-a.

3.3.7 Suspended Matter: The fortnightly variations in suspended matter are given in Fig. 3.8. The values in the pond varied from 18.70 mg/l to 76.60 mg/l with an average of 36.02 $\pm$ 12.50 mg/l. The minimum values were recorded during February and April 1991 when the analogous particulate organic carbon and the

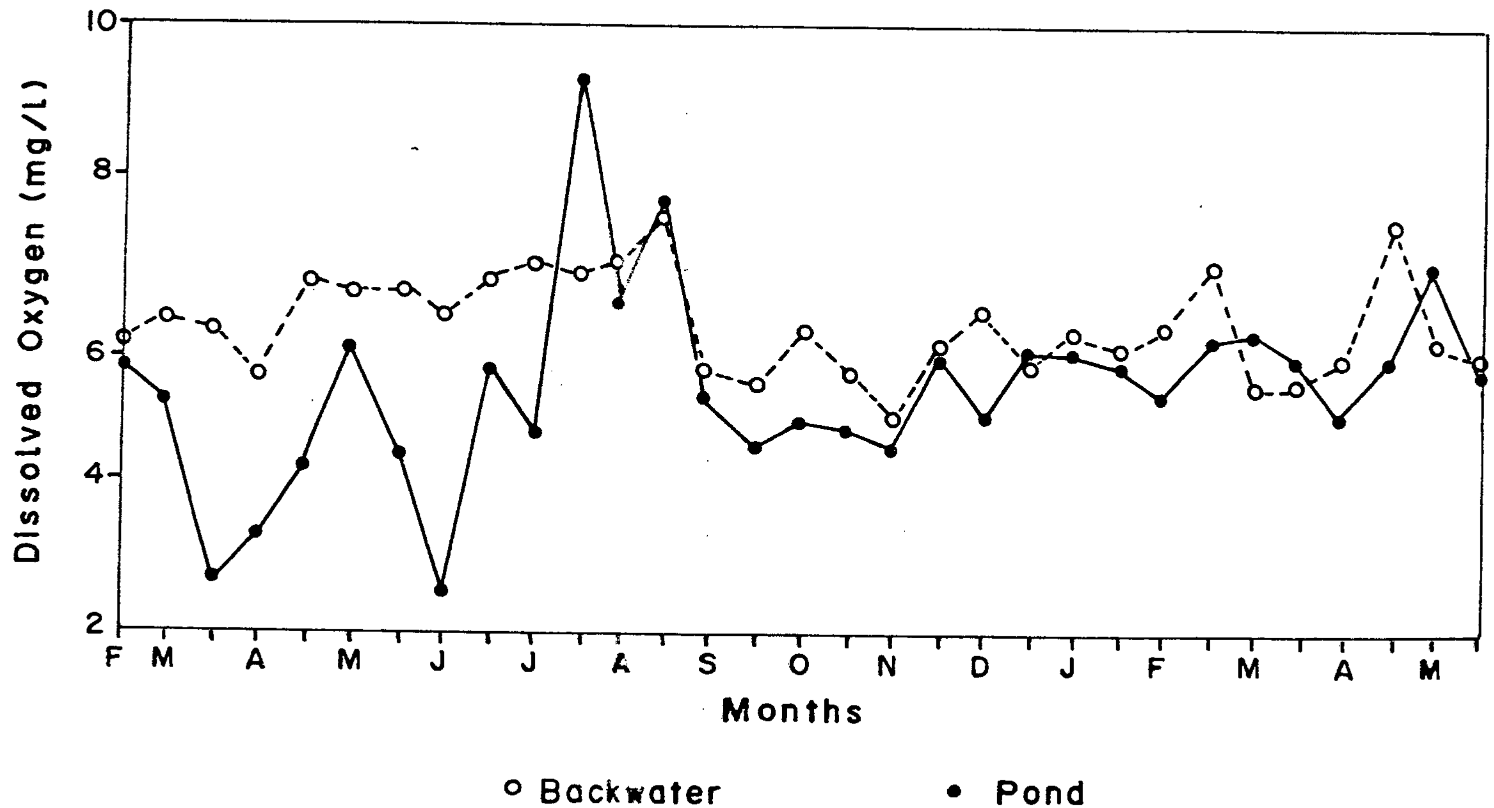



Fig. 3.7 Fortnightly variation in the dissolved oxygen of backwater and pond.

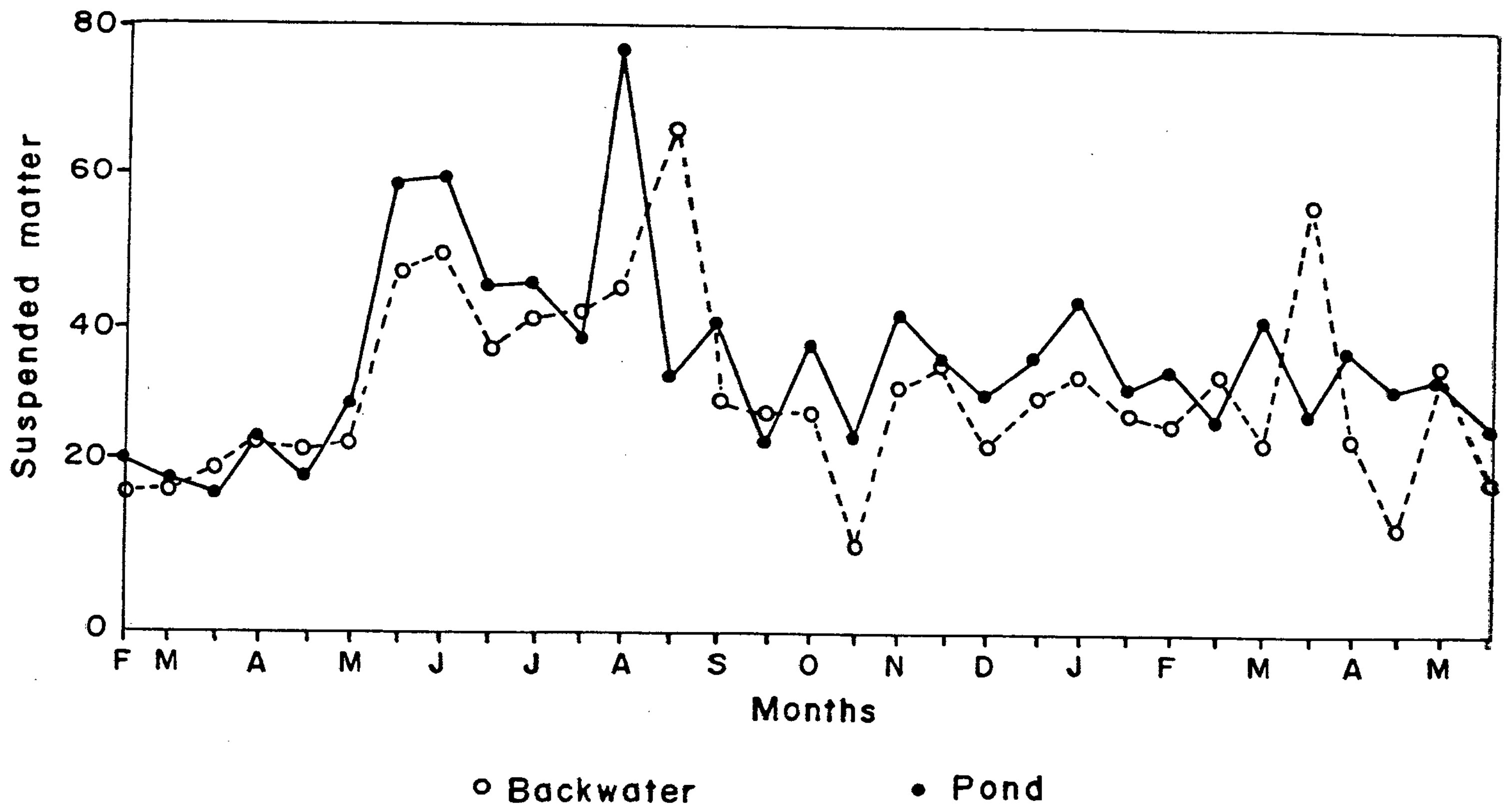



Fig. 3.8 Fortnightly variation in the suspended matter of backwater and pond.

chlorophyll-a were also low. Higher levels of suspended matter were observed during monsoon. During post-monsoon and pre-monsoon, the values were relatively lower and ranged from 26.00 mg/l to 44.20 mg/l.

Suspended matter in backwater showed wide fluctuation during the period of study and the values ranged from 11.80 mg/l to 67.00 mg/l with annual mean of 32.00 $\pm$ 12.31 mg/l. Suspended matter was high (42.00 - 67.00 mg/l) during June to August, whereas the values were low during post and pre-monsoon when it fluctuated between 11.80 and 36.20 mg/l, except second half of March 1992 (56.60 mg/l).

3.3.8 Particulate Organic Carbon: Particulate organic carbon (POC) varied from 0.413 mg/l to 2.459 mg/l. There was not much variation in POC of the pond, except July 1991 and March 1992 when the values were high (2.459 mg/l and 2.188 mg/l, respectively). The minimum value of 0.413 mg/l was recorded in April 1991. During remaining period the POC values ranged narrowly between 0.731 and 1.837 mg/l .

The annual variations in POC of the pond and the backwater are shown in Fig. 3.9. POC in backwater did not show much variation and its concentration varied from 0.470 to 1.748 mg/l with an annual mean of 1.006$\pm$0.326 mg/l . However, there was a distinct pattern of increase and decrease with reference to seasons. POC values were low during monsoon and gradually increased in early post-monsoon followed by a decrease till the end of post-monsoon. The highest value of the annual cycle was

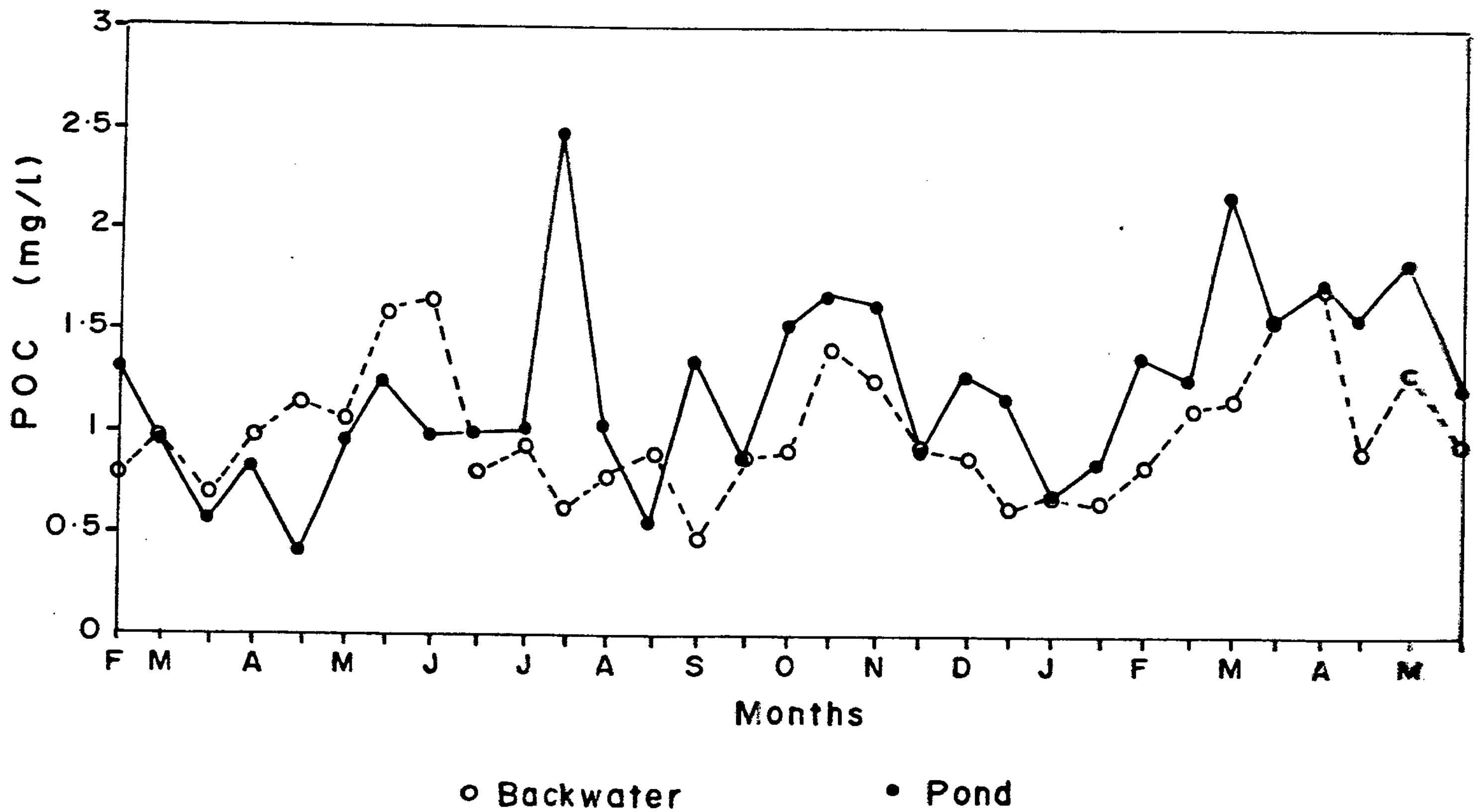



Fig. 3.9 Fortnightly variation in the particulate organic carbon of backwater and pond.

recorded during pre-monsoon.

3.3.9 Chlorophyll-a: In pond water the chlorophyll-a showed wide fluctuations during the period of study and the values varied from 1.97 $mg/m^3$ to 20.415 $mg/m^3$ (Fig. 3.10). The chlorophyll -a values were comparatively low during the pre-monsoon period of 1991. The transparency during this period was very high and the pond bottom could be easily seen. The corresponding suspended matter and the POC were also low during this period. The numerous peaks and troughs were observed between monsoon, post-monsoon and pre-monsoon of 1992, with a major peak in April - May 1992 when the values were between 3.976 and 13.277 $mg/m^3$. Chlorophyll-a content fluctuated during remaining period of study (June 1991 - March 1992).

The minimum values (0.989 $mg/m^3$ and 1.701 $mg/m^3$) of chlorophyll-a in backwater were observed in July and September respectively. The maximum values 22.129 $mg/m^3$ and 22.304 $mg/m^3$ were recorded in May and June 1991, respectively. During rest of the period, chlorophyll-a fluctuated between 4.674 and 18.949 $mg/m^3$, with an annual average of 9.650 $\pm$ 6.196 $mg/m^3$. The concentration showed distinct peaks in May-June 1991, August, February and May 1992 which corresponds to pre-monsoon, monsoon and post-monsoon seasons. Two peaks were observed during pre-monsoon season of 1992, which may be due to pre-monsoon showers and the increase in ambient temperature.

3.3.10 Sediment pH : The sediment up to a depth of 15 cm is highly reactive and influences the pH of the water in shallow

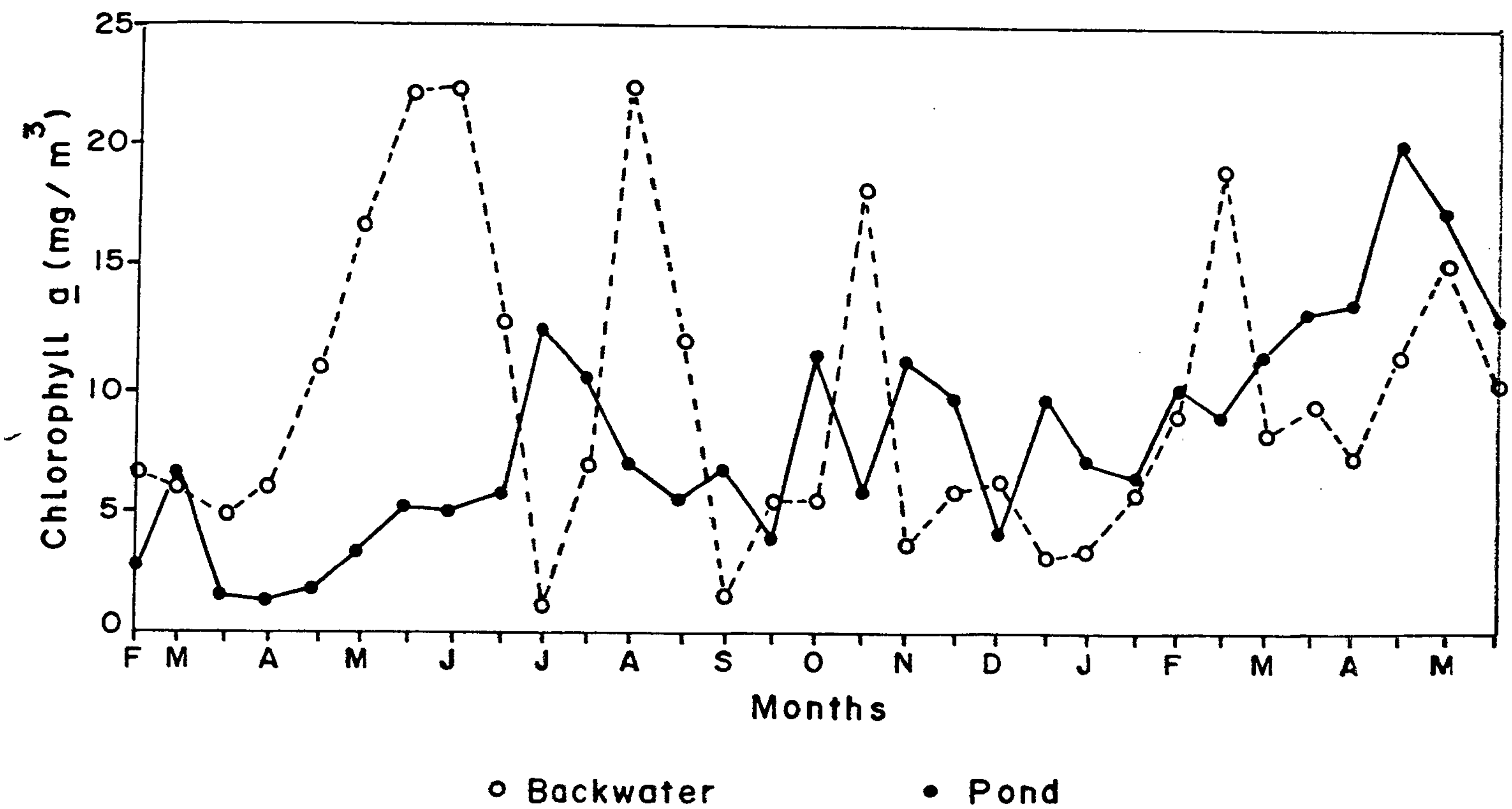



Fig. 3.10 Fortnightly variation in the chlorophyll a of backwater and pond.

water bodies. Monthly variation in the sediment pH of the backwater and the pond is shown in Fig. 3.11. The pond sediment pH varied from 6.45 to 7.30. It gradually decreased from 7.05 to 6.88 in June, thereafter it was neutral to slightly alkaline (7.00 to 7.30) during July - August as a consequence of pond liming on June,6,1991. September onwards it remained stable till February 1992 and later decreased gradually to 6.45 in May, 1992.

The sediment pH was stable (7.05 - 7.15) in backwater from February to June 1991. During second half of June the sediment pH gradually started increasing and reached its maximum (7.69) in September. Thereafter, it gradually decreased till first half of December, and remained stable between 7.05 and 7.27.

3.3.11 Sediment Organic Carbon : The sediment organic carbon aggregated from various sources, play an important role in the nutrition of benthic organisms and nutrient regeneration. The sediment organic carbon in pond varied from 0.91% to 3.12% (Fig. 3.12). The organic carbon was lowest during April 1991. There onwards it fluctuated narrowly between 1.26 and 2.34 % till October 1991. Organic carbon increased to 2.95% in November 1991 and thereafter remained stable till May 1992.

Sediment organic carbon of backwater fluctuated widely, ranging from 0.48 to 3.56% with an annual mean of 2.01 $\pm$ 0.78% (Fig. 3.12). February 1991 to second half of August 1991 the values fluctuated narrowly between 2.45 and 3.56% . There was a gradual fall in the content of organic carbon till October 1991

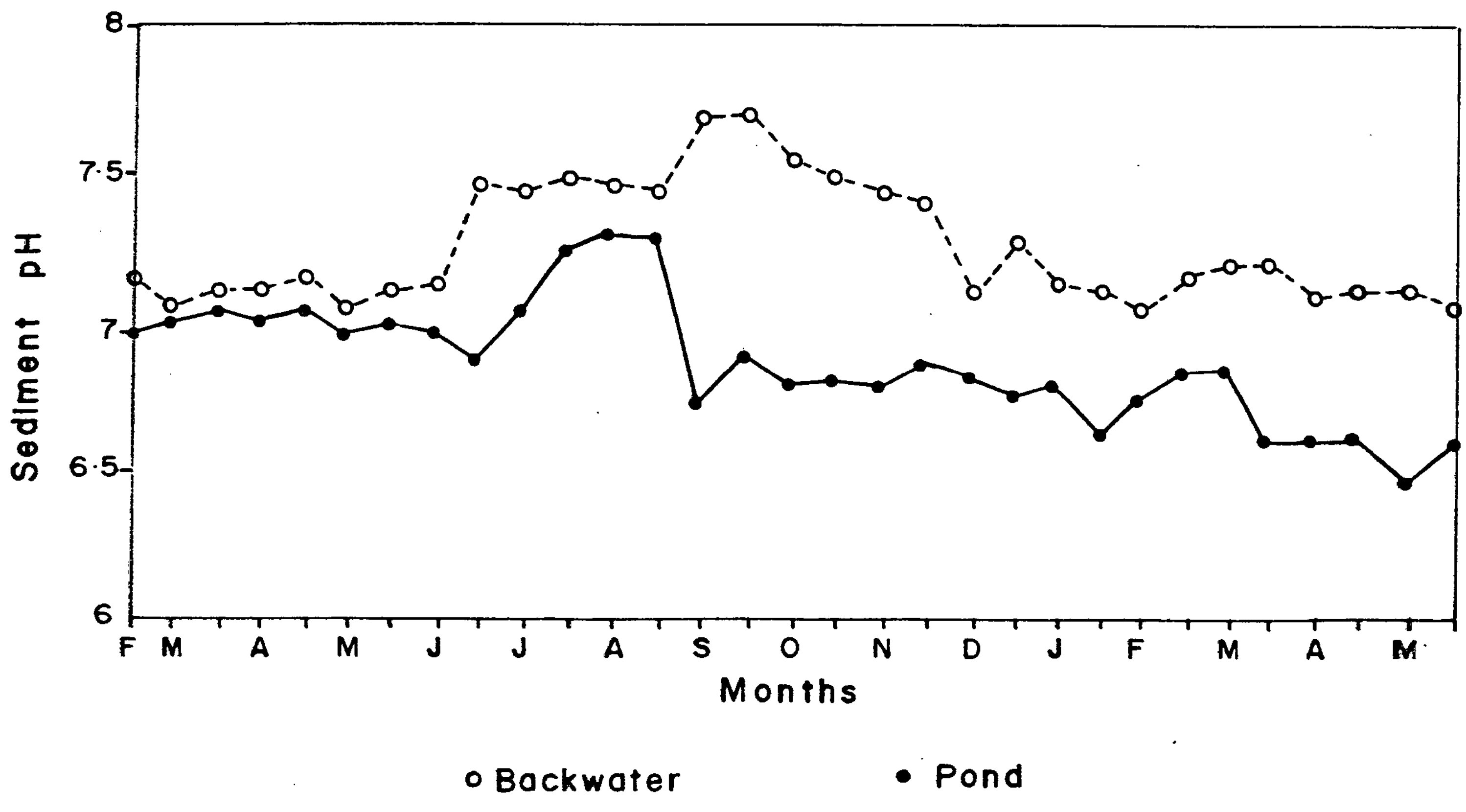



Fig. 3.11 Fortnightly variation in the sediment pH of backwater and pond.

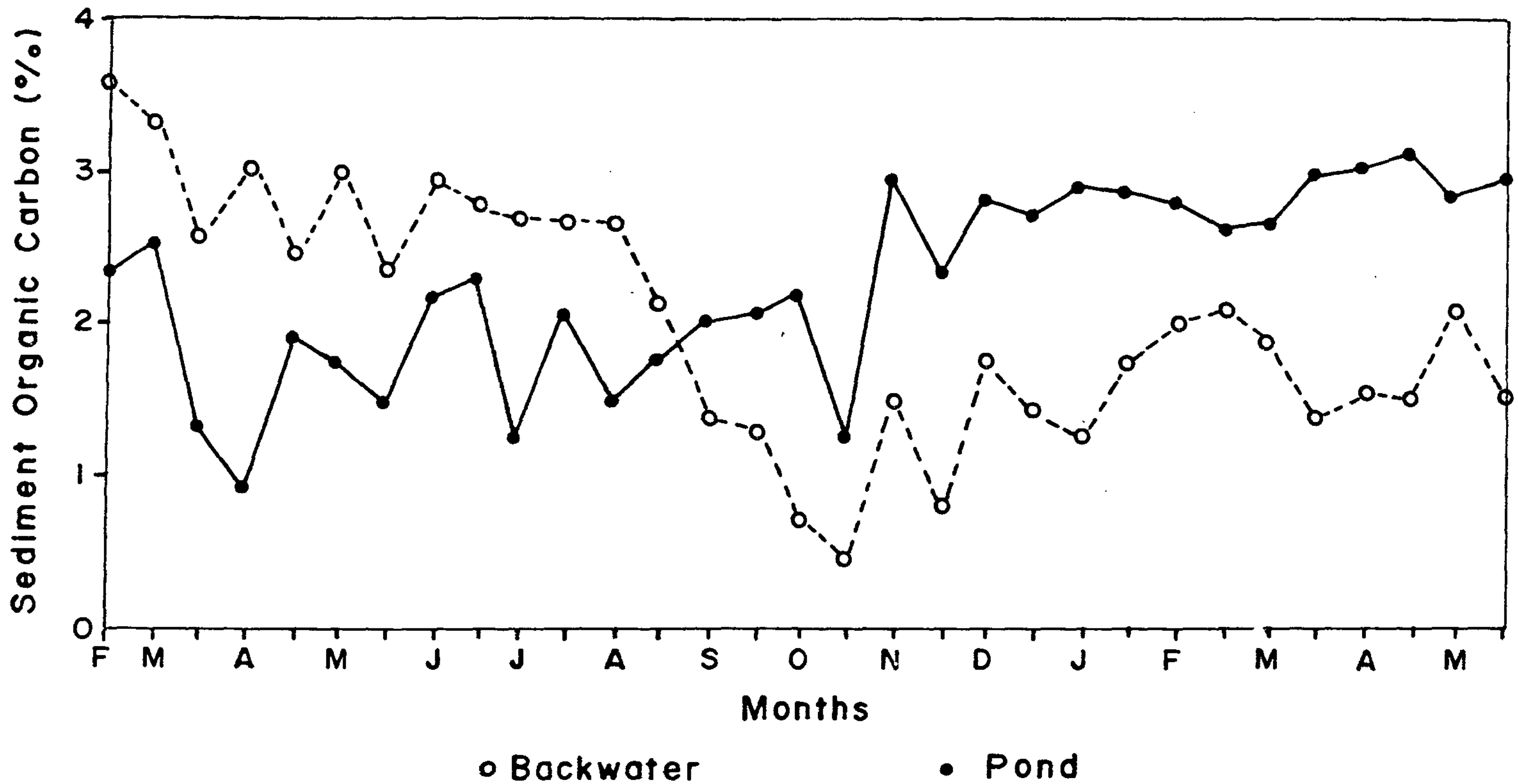



Fig. 3.12 Fortnightly variation in the organic carbon of the sediment of backwater and pond.

when the minimum value of 0.48% was recorded. November onwards the organic carbon started building up and fluctuated between 1.42 - 2.09% till May 1992. Comparatively, the organic carbon was low during the post-monsoon period.

3.3.12 Sediment Grain Size : The seasonal variation in the particle size of the sediment at both the stations is given in Table 3.1. The observations revealed that the sediment was mainly clayey silt. It was grayish black to grayish brown in colour. The sediment is soft and sticky in nature and upon drying becomes very hard.

## 3.4 DISCUSSION

The comparative study of pond and backwater revealed that the temperature, salinity, pH, total alkalinity, suspended matter and sediment pH followed similar trend, with little variations. Dissolved oxygen, free carbon dioxide, POC, chlorophyll-a and sediment organic carbon were observed to behave independently at the two stations, which could be due to the direct human interference and the enclosed nature of the pond. Hydrobiological characteristics of the pond and the backwater seems to be highly influenced by the south-west monsoon resulting in a rhythmic seasonal pattern.

The maximum water temperature in pond and backwater during April - May is due to the increased intensity of solar

Table 3.1 Seasonal variation in sediment particle size.

| | Sand | Silt | Clay | Type of Sedi. |
|---|---|---|---|---|
| | POND | | | |
| Pre-monsoon | 14.55 | 50.00 | 35.45 | Clayey-silt |
| Monsoon | 11.22 | 54.44 | 34.36 | Clayey-silt |
| Post-monsoon | 13.68 | 47.42 | 38.90 | Clayey-silt |
| | BACKWATER | | | |
| Pre-monsoon | 3.21 | 82.04 | 14.75 | Clayey-silt |
| Monsoon | 5.84 | 57.60 | 36.56 | Clayey-silt |
| Post-monsoon | 6.74 | 53.33 | 39.93 | Clayey-silt |

radiation, prolonged photo-period and higher salinity in comparison to the rest of the study period. The other maxima was observed in October and November, when there is clear weather, high inland water table resulting in increased evaporation, high humidity and high atmospheric temperature. Thus, the second maxima of water temperature is a result of increased atmospheric temperature and the former is positively co-related with the later (pond, $r = 0.540$, $p < 0.05$; backwater, $r = 0.769$, $p < 0.001$). Two minima, one in July - August and the other in December - January could be attributed to south west monsoon and north east monsoon respectively. A similar bimodal pattern has been reported in the estuarine complex of Goa by earlier workers (Dehadrai and Bhargava, 1972; Singbal, 1985; Ansari et. al., 1986). Incidentally, the peak breeding season of *E. suratensis* has been observed to coincide with low temperature regime viz. June-July, September, December and January.

The salinity in the estuary, backwater and in coastal farms depends on the tidal cycle, distance from the coast and inland freshwater influx. The salinity at the sampling site showed a unimodal pattern being minimum during July - August and thereafter gradually increased to its maximum until pre-monsoon showers (May-June). Pond salinity was found to be positively correlated with water temperature ($r = 0.459$; $p < 0.01$). The freshwater conditions prevail in backwater during July - August, followed by brackishwater from September to February. Thus, estuarine and backwater fauna including fish are subjected to large salinity variation from time to time depending upon the seasonal salinity cycle.

The decrease in salinity can be attributed to the high intensity of precipitation during the south-west monsoon. Most of the estuarine species are euryhaline and spend extra energy to acclimatize to the prevailing conditions. *Oncorhynchus kisutch* and *O. mykiss* have been reported to utilize muscle glycogen reserves while changing from freshwater to seawater (Sheridon *et.al.*, 1985; Kiessling *et. al.*, 1991). Thus, in natural habitat *E. suratensis* might be spending extra energy during the seasonal change in salinity. The freshwater conditions during monsoon and marine during post-monsoon in the natural habitat of *E. suratensis* revealed that it can tolerate both the extremes of the salinity regime. The culture possibilities of *E. suratensis* in inland saline soils has been reported by Dwivedi and Lingaraju (1986). The annual profile of salinity in the natural habitat of *E. suratensis* indicate that it can be cultured in freshwater with better results in terms of growth, since the fluctuations in the environmental parameters is minimised especially in terms of salinity and tidal current. Such transplantation in Parakrama Samudra (Freshwater lake) in Sri Lanka has provided with encouraging results (Costa, 1983).

The salinity variation in the pond followed the backwater trend but never attained freshwater conditions. The decrease in salinity during monsoon could go down to a minimum level of $3.63 \times 10^{-3}$, due to the minimum exchange of water and the presence of salts in the sediment. The present study also infers that intensive brackishwater farming needs to be suspended during

July-August when freshwater condition prevails. However, in case of euryhaline cultivable species the water exchange needs to be minimal to avoid sudden salinity shock and high mortality.

The pH of the river water is strongly influenced by the nature of the terrain through which it flows. pH may vary from river to river and estuary since freshwater has a weak buffering capacity and is regulated by carbon dioxide - carbonate system . This was inferred from a negative relationship between pH and the free carbon dioxide ($r = -0.388$, $p < 0.05$; Table 3.2). The pH showed a unimodal pattern in backwater and decreased to slightly acidic (6.88) during monsoon when the freshwater condition prevails. The pH of water was slightly alkaline during post-monsoon and increased with the rise in salinity at the site. The pH was positively correlated with the salinity ($r = 0.79$; $p < 0.001$) indicating that the pH in backwater is influenced by the tidal salinity. Low pH during monsoon has been reported by various workers (Tampi, 1959; Ramamurthy, 1963; Srinivasan and Pillai, 1973; Nagarajaiah and Gupta, 1983; Singbal, 1985; James and Najmuddin, 1986).

The iron ore mines of Goa contribute to the catchment area of the Mandovi estuary, and traces of pyrite (ferous sulphide), pyrrhotite and chalcopyrite has been reported from these mines and other catchment areas (Prasad Rao et al., 1985; Balakrishnan et al., 1992). Pyrite, pyrrhotite, chalcopyrite and other sulphide containing minerals upon exposure to air and water are reported to produce mineral acids resulting in drastic decrease

Table 3.2 Correlation matrix of different environmental parameters of backwater. ( n = 31 )

| | Atm.Tem. | Wat.Tem. | Salin. | pH | DO | $F.CO_2$ | Tot.Alk. | S.Matter | POC | Chlo.-a | Sedi.pH | Sedi.Org.C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atm.Tem. | 1.0000 | | | | | | | | | | | |
| Wat.Tem. | .7657 | 1.0000 | | | | | | | | | | |
| Salin. | .5341 | .4190 | 1.0000 | | | | | | | | | |
| pH | .4867 | .4310 | .7900 | 1.0000 | | | | | | | | |
| DO | -.0198 | -.0603 | -.2874 | -.1110 | 1.0000 | | | | | | | |
| $F.CO_2$ | -.2974 | -.2849 | -.4346 | -.3888 | -.1549 | 1.0000 | | | | | | |
| Tot.Alk. | .5418 | .4046 | .9878 | .8069 | -.3418 | -.3948 | 1.0000 | | | | | |
| S.Matter | -.3473 | -.1813 | -.4261 | -.3364 | .3154 | -.0925 | -.4730 | 1.0000 | | | | |
| POC | .3133 | .4793 | .3995 | .3850 | -.1371 | -.5945 | .3765 | .1944 | 1.0000 | | | |
| Chlo.-a | .1531 | .2970 | .1329 | .2670 | .3868 | -.5285 | .0849 | .2566 | .5253 | 1.0000 | | |
| Sedi.pH | .5098 | .2884 | -.8443 | -.5814 | -.0598 | .4702 | -.8074 | .2529 | -.3010 | -.2026 | 1.0000 | |
| Sedi.Org.C. | .0172 | .1602 | .0313 | .0466 | .3921 | -.0371 | -.0546 | .1106 | -.0390 | .2166 | -.3373 | 1.0000 |

DF = 30

Significant at 0.1 = 0.2960
0.05 = 0.3494
0.02 = 0.4093
0.01 = 0.4487
0.001 = 0.5541

in pH (Soresen _et al._, 1980; Simpson _et al._, 1983). The similar mechanism of mine drainage has been reported to reduce the pH of lake Toya of Japan (Katsumi _et. al._ 1978). In Malaysia, a drought caused the mangrove swamp to dry out and the acid sulphate soil condition resulted. During precipitation the drainage from these acid sulphate soils reached a river and caused fish kill (Dunn, 1965). The lowering of pH of water in brackishwater ponds with the pond bund leachate during precipitation has also been reported from the south-west coast of India (Mrithunjayan and Thampy, 1986). Thus, extensive mining activity along the bank of Mandovi river may be contributing to the lowering of pH during the south-west monsoon. Therefore, in Goa waters, the application of lime to the culture ponds before the onset of monsoon is recommended so as to have buffering effect during precipitation.

Carbon dioxide is not toxic to fish and most of the fish survive for several days in water containing up to 60 mg/l, provided sufficient oxygen is present (Hart, 1944). Low level of dissolved oxygen and analogous high concentration of carbon dioxide hinder oxygen uptake by fish. Carbon dioxide is released in respiration and utilized in photosynthesis, resulting in the release of oxygen. The increased rate of respiration over photosynthesis rate results in decrease of oxygen level. Boyd (1982) documented that high concentration of carbon dioxide occur in ponds after phytoplankton die-off, due to the loss of thermal stratification and during cloudy weather.

Free carbon dioxide was present in appreciable quantity in pond water during February - June 1991, indicating that the respiration exceeded the photosynthesis. During remaining period it varied within a narrow range. The carbon dioxide was inversely related with chlorophyll-a ($r = -0.526$, $p < 0.01$). In backwater free carbon dioxide was below detectable limit in May-June 1991 and February-May 1992, when the corresponding chlorophyll-a was high. Here too, the carbon dioxide was inversely related to chlorophyll- a ($r = -0.528$, $p < 0.01$; Table 3.2). Thus, in extensive and semi-intensive culture systems, optimum level of phytoplankton needs to be maintained and any extreme values may either lead to the accumulation of carbon dioxide or night time depletion of oxygen and development of stress conditions.

The carbonate and bicarbonate are the predominant bases in most of the waters. Natural waters are more productive when the total alkalinity is in the vicinity of 40 mg/l (Moyle, 1945; Mairs, 1966). Increased fish production in fertilized ponds can be achieved by increasing total alkalinity up to 20 mg/l. However, further increase in alkalinity will not add to the production (Boyd and Walley, 1975). These authors suggested that alkalinity above 20 mg/l is desirable for aquaculture purposes. The total alkalinity in the pond was above the desirable level throughout the period of study except in monsoon when it was just above the optimum level due to the application of lime. The alkalinity in backwater was below the optimum limit during monsoon. The total alkalinity was positively related with salinity, pH and inversely with free carbon dioxide (Table 3.2).

The standing crop of fish is high in ponds receiving fertilizers and feed. The external input of nutrients and the metabolic waste encourages plankton production. Thus, photosynthesis and respiration proceed at rapid rate and the factor favouring respiration over photosynthesis for brief period may cause deficiency of dissolved oxygen (Boyd, 1982). DO was observed to be directly related with chlorophyll-a concentration ($r = 0.360$, $p < 0.05$; Table 3.3). The low values of DO during March -April 1991 are related to the corresponding low values of chlorophyll-a. Low DO level in June when the corresponding chlorophyll-a was optimum could be attributed to the cloudy weather and the high suspended matter in the water. The low level of dissolved oxygen during monsoon has also been reported earlier from this farm (Sumitra-Vijayaraghavan et al., 1981). Therefore, in semi-intensive culture ponds it is desirable and in intensive it is essential to operate paddle wheel aerators especially during monsoon, so as to serve the purpose of water mixing and simultaneous aeration.

The dissolved oxygen level in backwater was well saturated with maximum values during August and April, and fluctuated narrowly during the remaining period of study. The annual profile of dissolved oxygen displayed a positive correlation ($r = 0.387$, $p < 0.05$) with chlorophyll-a, indicating that the minor variations in DO level are due to variable concentration of chlorophyll-a and photosynthesis. Similar results have also been reported by Bhargava et. al. (1973) and De Souza and Sengupta

Table 3.3 Correlation matrix of different environmental parameters of pond water. ( n = 31 ).

| | Atm.Tem. | Wat.Tem. | Salin. | pH | DO | $F.CO_2$ | Tot.Alk. | S.Matter | POC | Chlo.-a | Sedi.pH | Sedi.Org.C. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atm.Tem. | 1.0000 | | | | | | | | | | | |
| Wat.Tem. | .5408 | 1.0000 | | | | | | | | | | |
| Salin. | .4298 | .4590 | 1.0000 | | | | | | | | | |
| pH | -.3104 | -.2006 | -.4127 | 1.0000 | | | | | | | | |
| DO | -.2180 | -.2401 | -.3225 | .7777 | 1.0000 | | | | | | | |
| $F.CO_2$ | .1106 | .2090 | .3863 | -.4640 | -.6267 | 1.0000 | | | | | | |
| Tot.Alk. | .4136 | .3962 | .6761 | -.3905 | -.6265 | .5073 | 1.0000 | | | | | |
| S.Matter | -.4247 | -.3301 | -.2479 | .1665 | .1010 | -.3484 | -.0638 | 1.0000 | | | | |
| POC | -.0331 | .0068 | -.0654 | .3653 | .4245 | -.4718 | -.5004 | .1285 | 1.0000 | | | |
| Chlo.-a | .0258 | .0304 | .0921 | .0192 | .3602 | -.5269 | -.4062 | .1433 | .6047 | 1.0000 | | |
| Sedi.pH | -.4749 | -.1615 | -.3764 | .4880 | .1330 | .2229 | -.0165 | .2354 | -.3165 | -.5634 | 1.0000 | |
| Sedi.Org.C. | .2396 | -.2216 | .2193 | -.0793 | .2431 | -.3721 | -.1745 | -.1042 | .3424 | .5821 | -.6932 | 1.0000 |

DF = 30

Sgnificant at 0.01 = 0.2960
0.05 = 0.3494
0.02 = 0.4093
0.01 = 0.4487
0.001 = 0.5541

(1986).

The increased level of suspended matter in the pond during monsoon is due to the freshwater run-off from the adjacent fields and dikes. Similar trend of suspended matter was also observed in backwater. While studying the ecology of mangroves of Goa, Untawale and Parulekar (1976) reported higher suspended matter during monsoon, inferring that tidal influence and strong wave action enhances the turbidity during monsoon. The higher level of suspended matter was also reported by Jagtap (1987) in the mangrove environment of Goa.

Particulate organic carbon in the pond was high during July and pre-monsoon period. POC was positively related with pH and dissolved oxygen (Table 3.3). Highly positive relationship was observed between POC and chlorophyll-a ($r = 0.605$, $p < 0.001$). The correlation revealed that increase in pH was responsible for improved dissolved oxygen concentration. POC had positive relationship with water temperature, pH and alkalinity (Table 3.3). It showed significant positive correlation with chlorophyll-a ($r = 0.525$, $p < 0.01$). Thus, it can be said that the POC peaks in an annual cycle are due to the autochthonous material since the corresponding chlorophyll-a is also high. The increased level of POC and the corresponding high chlorophyll-a was also observed by Goes (1983) and Verlencar and Qasim (1985) during fair weather. Qasim et. al. (1969) after observing the relationship between seston and chlorophyll-a concluded that phytoplankton formed a considerable portion of the particulate matter in Cochin backwaters. Almost similar trend with minor overlapping was observed by Jagtap (1987) at station-2 of his study in Mandovi estuary, which is very close to the backwater of the present investigation.

Chlorophyll-a in pond water showed three peaks corresponding to monsoon, post-monsoom and pre-monsoon (1992), with the exception of pre-monsoon period of 1991. In backwater, the chlorophyll-a registered numerous peaks . The backwater under study gets exposed during low tide. This influences the photosynthetic activity resulting in the growth of periphyton and diatoms. During high tide, the tidal currents disturb the bottom and probably causes the stratification of phytoplankton in water, thereby registering high chlorophyll-a during pre-monsoon. At the same time, the corresponding suspended matter was also high. The higher level of chlorophyll-a content in the intertidal and subtidal areas during pre-monsoon and monsoon has been documented (Rodrigues, 1984; Gupta, 1987). In these estuaries high sedimentary pigment has also been reported (Ansari,1988). Thus, in the intertidal area of backwaters, the benthic flora gets suspended in the water and contribute to the chlorophyll-a content of the column and surface.

The minimum chlorophyll-a was recorded during July, when the absolute freshwater condition prevailed for the first time after pre-monsoon. Therefore, the lower value of chlorophyll-a could be due to die-off of the brackishwater/marine flora which was abundant during pre-monsoon. Low species diversity and biomass of zooplankton was observed in estuarine environment by Goswami and Selvakumar (1977) during monsoon period. The similar observations were recorded in the benthic community of Mandovi and Zuari estuaries (Ansari _et al._, 1986; Ansari and Parulekar, 1993). Thus, the similar impact of monsoon on flora and chlorophyll-_a_ can not be ignored resulting in low chlorophyll-_a_ content. However, freshwater flora established gradually in inundated stretches of the river specially seasonal freshwater pools, ponds adjoining backwater and in khazans leading to higher chlorophyll-_a_ during the later part of monsoon (August). In the month of August, about 13% of food of _E. suratensis_ was comprised of _Spirogyra_ sp. indicating the predominance of freshwater flora in the backwater. The present observation also strengthen the earlier study of predominance of freshwater flora during monsoon (Devassy and Bhattathiri, 1974). The freshwater run-off from the adjoining areas gets reduced in September and thereafter, the tide influences the salinity regime. This affects the freshwater flora and chlorophyll-_a_ concentration. During post-monsoon the estuarine flora develops gradually, and attains maximum during October when other peak of chlorophyll-_a_ was recorded. The higher concentration of chlorophyll-_a_ with analogous high phytoplankton count was observed by Rivonker (1991) at Dona Paula Bay, Goa. The stable salinity regime is considered to be the probable stimulating factor favouring phytoplankton growth (Raymont, 1966; Qasim _et al._, 1969; Rivonker,1991). Another peak was also observed in February 1992, which could be either due to bottom sediment disturbance or an occasional algal bloom.

The pH of the marine sediment is usually considered as a conservative factor with no effect on benthic organisms (Ganapati and Rao, 1962; Pollock and Hummon, 1971; Ansari, 1988). However, in the enclosed culture systems, where input of organic matter is high, the sediment has direct impact on water quality (Boyd, 1982). Neutral to slightly alkaline pH of pond sediment and water is suggested to be desirable for fish production (Ohle, 1938; Neess, 1949). The pH of the pond sediment was nearly neutral during pre-monsoon (1991), and sudden rise in pH during monsoon is the impact of lime application. However, the sediment pH gradually decreased to acidic in the pre-monsoon of 1992, indicating the deposition and accumulation of organic matter. A highly significant inverse relationship was observed between the sediment pH and the organic carbon ($r = -0.693$, $p < 0.001$). The organic matter upon decomposition produces carbon dioxide and hydrogen sulphide resulting in low pH. Based on these observations, it is suggested that pond needs liming to maintain the optimum pH level.

Backwater sediment pH was stable within a narrow range through out the year. Similar narrow range has been observed in the estuarine sediment of Goa by Shirodkar (1984) and Ansari (1988). A positive correlation was observed between backwater sediment pH and the water carbon dioxide ($r = 0.470$, $p < 0.01$). The carbon dioxide produced in the sediment is readily absorbed by the freshwater or slightly saline water prevailing during this period. This affected a marginal increase in pH level. The leaching of sediment humic acid during monsoon may be another reason for relatively high sediment pH during monsoon. The sediment pH level recorded in the backwater is quite suitable for aquaculture purposes.

The accumulation of organic carbon in sediment is largely due to the production of planktonic, benthic organisms and bacterial biomass (Hepher, 1965) . The organic carbon in the pond was optimum and fluctuated narrowly. The higher level of organic carbon is due to the external input of organic manure and artificial feed. The organic carbon content in the backwater sediment was similar to those reported earlier (Parulekar et al., 1980; Shirodkar, 1984; Ansari, 1988) for Mandovi Estuary. The higher organic carbon during pre-monsoon of 1991, could be due to autochthonous origin since the intertidal areas are rich in periphyton (Nair, 1983; Rodrigues, 1984), whereas during monsoon the higher values could be attributed to terrestrial run-off (allochthonous) (Sankaranarayanan and Panampunnyl, 1979; Parulekar et. al., 1980; Shirodkar, 1984; Ansari, 1988). In the early post-monsoon the sediment organic carbon decreased gradually to its minimum value, a shift period when the surface run-off reduces and the salinity increases. November onwards the sediment organic carbon started building. The values were observed to vary from year to year which could be related to the degree of disturbances caused by the tidal current, and oxidation process. Paropakari (1979) assigned the low value of organic carbon to the oxygenation process. The backwater sediment organic carbon values were much higher than the reported values for the brackishwater area of West Bengal (Chattopadhyay and Chakraborti, 1986).

The behaviour of *E. suratensis* in natural habitat (Negombo lagoon, Sri Lanka) has been described by Ward and Wyman (1977). They experienced that the spawning pair makes a large pit often more than one metre in diameter and 4 - 10 cm in depth. Within this large pit, 6 - 12 smaller pits are made which are 8 - 15 mm deep and wide. The sediment of the lagoon was reported to be sandy covered with several centimeters of flocculated detritus implanted with abundant sea grass *Halophila*, *Halodule*, and alga *Chaetomorpha* sp.

Numerous small nests (5 - 30 no.) were observed during the present field observations without excavating a large pit. These small pits were 4 - 6 cm in orifice and about 6 cm in depth within a radius of less than 0.75 m. This variation tempted to study the sediment structure during different seasons of the year. The sediment structure in the pond and in the backwater was of clayey-silt, a sticky material, which probably makes it difficult for the prospecting brooding pair to dig a large pit in Goa waters. Thus, the sediment nature of Goa waters restrict them to the construction of small pits, however the number is far more than recorded in Negombo lagoon (Ward and Wyman, 1977).

In the present study, the breeding season of *E. suratensis* viz. June-July, September and December-January were observed to coincide with low water temperature ($28.0 \pm 2.5\,^{o}C$). The study also revealed that the *E. suratensis* is subjected to two extremes of salinity i.e. freshwater and marine during the annual cycle. Prolonged exposure and tolerance to freshwater conditions during monsoon season in natural habitat, indicate its culture possibilities in freshwater ponds, lakes and reservoirs. Aquaculture point of view the exchange of water during monsoon period needs to be stopped or minimised, or the pond dikes should be limed to neutralise the acidic effect of leachate. The liming also maintains the optimum total alkalinity desirable for better natural productivity. Reduction in the frequency of water exchange during monsoon may also reduce the rate of siltation in the pond. Extreme salinity variation enforces management aspects to be adopted. The seed stocking and crop harvesting needs to be regulated in such a way that the crop is harvested just prior to the onset of monsoon. During monsoon, euryhaline species such as *E. suratensis* and mullets can be stocked for short culture duration. The precipitation and cloudy weather during monsoon pose the problem of dissolved oxygen depletion. Thus, it is suggested to use paddle wheel aerators, which helps to mix the water and elevate dissolved oxygen. Soft bottom with wooden twigs is desirable as a substratum to simulate natural environment, and which may stimulate spawning under controlled conditions.

# CHAPTER IV

# POPULATION DYNAMICS

## 4.1 INTRODUCTION

Goa has a coast line of about 104 kms, interspersed with seven rivers namely Teracol, Chapora, Mandovi, Zuari, Sal, Talpona and Galgibag. This riverine network provides a vast area of about 250 sq.Km. of estuarine and freshwater wet lands. An area of about 200 ha is under brackishwater cultivation in a traditional way and is mainly confined to Bardez, Tiswadi and Salcete talukas (Parulekar and Verlencar, 1984). Besides this, there is a vast area of mangrove swamps and backwaters which is unutilized. E. suratensis, a brackishwater species, is mainly confined to traditional brackishwater farms locally known as Agars, salt pans (Mitache Agar), Khazans and backwater impoundments. The estimated production of fish from these areas is about 50 tonnes per year (Parulekar and Verlencar, 1984). The catch composition from these areas is mainly comprised of mullets, pearl spot and prawns. About 80% of the catch is comprised of pearl spot and mullets, almost in equal proportion.

There are four major fish markets namely Mapusa, Panjim, Madgaon and Vasco, and on an average basis, the daily E. suratensis landing is about 40 kg. Therefore, on an annual basis 16 tonnes of E. suratensis is sold in these markets. An additional 4 tonnes of landing in small local markets distributed all over Goa, can be expected. Thus, about 20 tonnes of Pearl Spot is captured from these resources annually. Although, the catch is of less quantum, nevertheless it is considered a delicacy and is in demand over other species. It is cultured in traditional fish farms by stocking natural population and the stock is replenished regularly by virtue of its continuous breeding. E. suratensis is mostly captured by operating cast nets, barrier nets (Plate 4.1a) in backwaters between high and low tides and by angling . It is also harvested by draining of the traditional sluice gate operated ponds (Plate 4.1b). Despite its economic value and local demand, there is no information regarding population structure, and the impact of exploitation on the limited natural stock. Thus, an attempt has been made here to elucidate the population structure of E. suratensis in Goa waters.

## 4.2 MATERIALS AND METHODS

Fish samples were collected from the Panjim fish market and the Old Goa backwaters at weekly interval. Panjim fish market gets the catch from Bardez and Tiswadi region, the main areas of estuarine and backwater complex of Mandovi and Zuari rivers. Thus, the samples form a sizable representation of the population. The total length was recorded to an accuracy of 1.0 mm and the weight up to 0.01 g. The weight was also taken immediately after removing the gastro-intestinal tract and the gonads. The monthly pooled length frequency data (Fig. 4.1) was used to calculate theoretical frequency (Fc) by following equation (Sparre et al.,1989) :

Plate 4.1 Capturing methods of _E. suratensis_ in Goa waters. (a) Operation of barrier net (b) Drainage of Khazan, and operation of filter net at the sluice gate of Khazan.

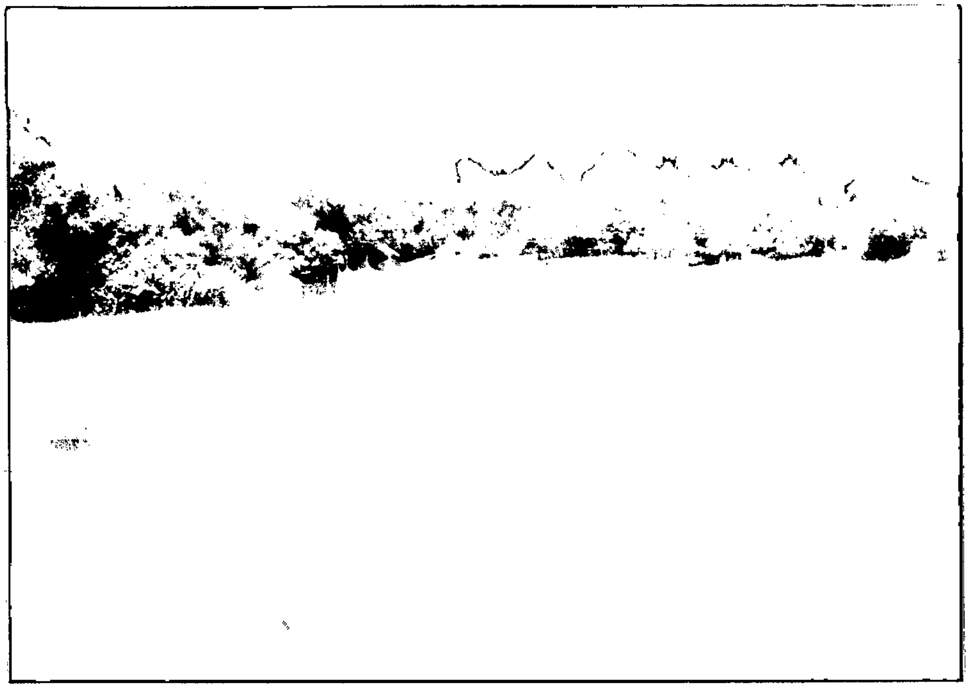


Plate 4.1a

Plate 4.1b

$$Fc\,(x) = \frac{n\ dl}{s\sqrt{2\pi}} \exp\left[ -(x - \bar{x})^2 / (2 s^2) \right] \quad \ldots\ldots \text{ I}$$

where

$n$ = 1002

$dl$ = 10

$s$ = 27.049

$\bar{x}$ = 128.423

$\pi$ = 3.14159

The normal distribution is related to mean values, which has a probability distribution. The probability distribution of each size group was calculated by the following equation :

$$Fc\,(x)/n = \frac{dl}{s\sqrt{2\pi}} \exp\left[ -(x - \bar{x}) / (2 s^2) \right] \quad \ldots\ldots \text{ II}$$

These are also called as theoretical relative frequencies and indicate the probability that a randomly drawn fish will belong to the corresponding length interval. The cumulative theoretical relative frequency and the observed relative frequency were plotted against the upper class interval limit. A special property of the normal distribution is that, there is a probability of 0.159 that an observation is less than $\bar{x} - s$ and the same probability holds for $\bar{x} + s$.

Mean size of the sampled population was also calculated following the equation of Bhattacharya's plot (Bhattacharya,1967):

$$\Delta \ln\ Fc\,(z) = \ln Fc\,(x + dl) - \ln Fc\,(x) \quad \ldots\ldots\ldots \text{ III}$$

The parameter $x + dl/2$ was regressed against corresponding $\Delta \ln Fc(z)$ to derive `a' and `b' values. Further $\bar{x}$ was calculated by the formula, $-a/b = \bar{x}$ ; where $a = 1.755237$ and $b = -0.01366$.

Length-weight relationship of a fish can be expressed by the equation :

$$\log W = \log a + b \cdot \log L \qquad \text{........IV}$$

Where, `a' is a factor and `b' the exponent which helps to derive the weight at length of population of a species. In order to observe, whether the value of `b' is significantly equal to 3, the following equation was used to compute the t - statistic value (Pauly, 1984).

$$t = \frac{s.d.(x)}{s.d.(y)} \cdot \frac{b - 3}{\sqrt{1 - r^2}} \cdot \sqrt{n - 2} \qquad \text{......... V}$$

Where,

s.d. (x) = s.d. of log L = (M = 0.101327; F = 0.086992)

s.d. (y) = s.d. of log W = (M = 0.308344; F = 0.263476)

n = number of fish used in computation (Male = 536 ; Female = 450)

To compare length and weight in a particular sample or an individual, the condition factor (c.f.) is employed. The condition factor was evaluated in live weight as well as in gutted fish with the help of following formula :

$$c.f. = W(g) \times 100 / L^3 \qquad \text{.............VI}$$

The data of Table 4.1 was computerised using ELEFAN - 0 (Electronic LEngth Frequency ANalysis) of the complete ELEFAN package of Gayanilo *et al.* (1988). Length-at-age data in Table 4.2 has been derived from ELEFAN programme and was subjected to Gulland and Holt plot (Gulland and Holt, 1959) to check the growth parameters of Loo and K. The equation is as follows:

$$\Delta L / \Delta t = K\,L\infty - K\,L(t) \qquad \text{.................VII}$$

Using L (t) as the independent variable and $\Delta L / \Delta t$ as the dependent variable the equation becomes a linear regression.

$$\Delta L / \Delta t = a + b\,L(t) \qquad \text{.............VIII}$$

The parameters K and Loo are obtained from :
K = - b and Loo = - a / b.

Modified Ford - Walford plot (Ricker, 1958) was used to compute t0, which is not derived from ELEFAN. The growth parameters obtained were fitted in the von Bertalanffy growth equation :

$$L(t) = L\infty\,[\,1 - \exp(-K(t - t_0))\,] \qquad \text{....... IX}$$

The parameter t0 was derived from the following equation:

$$\ln(L\infty - L_t) = \ln L\infty + K t_0 - K t \qquad \text{..........X}$$

The value of (Loo - L t) was computed and its natural logarithm plotted against age . The regression analysis of (Loo - L t) at age revealed K value, the slope of natural log

Table 4.1 Length frequency of <u>Etroplus</u> <u>suratensis</u> sampled at Goa in 1991-1992 ( N 1002 ).

| Sr.No | TL(mm) | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 4 | - | 5 |
| 2 | 55 | - | - | - | - | 4 | - | - | - | - | - | - | - | 2 | - | 7 | - | 13 |
| 3 | 65 | 3 | 1 | - | - | 3 | 1 | 1 | - | - | - | - | - | 1 | - | 10 | 1 | 21 |
| 4 | 75 | 2 | - | - | - | 5 | 2 | - | - | - | - | - | - | 3 | - | - | - | 12 |
| 5 | 85 | 4 | 1 | - | - | 2 | 4 | 2 | - | - | - | - | 1 | 3 | - | 1 | - | 18 |
| 6 | 95 | 5 | 2 | - | 2 | 5 | 8 | 7 | 2 | - | - | 1 | 3 | 3 | 5 | 0 | 2 | 45 |
| 7 | 105 | - | 10 | 6 | 3 | 7 | 3 | 15 | 10 | - | 5 | 9 | 6 | 7 | 13 | 4 | 8 | 106 |
| 8 | 115 | 4 | 16 | 9 | 9 | 3 | 9 | 12 | 11 | 10 | 7 | 9 | 6 | 6 | 6 | 6 | 4 | 127 |
| 9 | 125 | 5 | 17 | 14 | 17 | 15 | 6 | 12 | 9 | 12 | 9 | 23 | 4 | 7 | 6 | 13 | 14 | 183 |
| 10 | 135 | 3 | 5 | 5 | 9 | 11 | 6 | 7 | 11 | 11 | 16 | 9 | 13 | 13 | 6 | 10 | 13 | 148 |
| 11 | 145 | 4 | 9 | 7 | 6 | 6 | 5 | 6 | 3 | 7 | 10 | 6 | 14 | 9 | 4 | 8 | 13 | 117 |
| 12 | 155 | 2 | 3 | 4 | 3 | 4 | 8 | 4 | 5 | 11 | 3 | 4 | 8 | 14 | 9 | 6 | 12 | 100 |
| 13 | 165 | - | 2 | 5 | - | 2 | 1 | 3 | 1 | 6 | 6 | 4 | 4 | 2 | 7 | 3 | 3 | 49 |
| 14 | 175 | 2 | 2 | - | 1 | - | 4 | 3 | 1 | 1 | 1 | 3 | - | - | 4 | 1 | 5 | 28 |
| 15 | 185 | 1 | - | 1 | 1 | 1 | 3 | 1 | 1 | 1 | - | 5 | 4 | 1 | 1 | 2 | 2 | 25 |
| 16 | 195 | - | - | 1 | - | - | - | - | 1 | - | - | - | - | - | - | - | 1 | 3 |
| 17 | 205 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 |
| 18 | 215 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 |
| Total | | 35 | 68 | 52 | 51 | 69 | 60 | 73 | 55 | 59 | 57 | 73 | 63 | 71 | 63 | 75 | 78 | 1002 |

Table 4.2 Length at age data of <u>Etroplus</u> <u>suratensis</u> derived from ELEFAN programme and corresponding mean weight.

| Sr.No. | TL(mm) | Relative age (year) | Mean weight (g) |
|---|---|---|---|
| 1 | 45 | 0.264 | 2.175 |
| 2 | 55 | 0.332 | 4.350 |
| 3 | 65 | 0.404 | 6.582 |
| 4 | 75 | 0.480 | 11.176 |
| 5 | 85 | 0.562 | 15.710 |
| 6 | 95 | 0.649 | 22.065 |
| 7 | 105 | 0.744 | 29.268 |
| 8 | 115 | 0.846 | 38.413 |
| 9 | 125 | 0.959 | 48.123 |
| 10 | 135 | 1.083 | 61.320 |
| 11 | 145 | 1.222 | 73.591 |
| 12 | 155 | 1.378 | 92.190 |
| 13 | 165 | 1.559 | 109.918 |
| 14 | 175 | 1.772 | 127.632 |
| 15 | 185 | 2.032 | 154.300 |
| 16 | 195 | 2.365 | 177.040 |
| 17 | 205 | 2.829 | 220.630 |
| 18 | 215 | 3.598 | 247.510 |

line and the Y - axis intercept is equal to = $\ln L\infty + K t_0$. Thus, by equating the value, $t_0$ was computed.

The mean weight was computed from the observed data for the corresponding length at age data in Table 4.2. Modified Ford Walford plot (Ricker, 1958) was plotted for weight (W) to derive $W\infty$, K and $t_0$ to fit in the von Bertalanffy growth equation . The parameter $t_0$ was computed as mentioned earlier in the equation - X, by substituting L with W, the equation is :

$$W(t) = W\infty [1 - \exp(-K(t - t_0))] \quad \text{.............XI}$$

The data in Table 4.2 was pooled into half yearly iive weight at age and later used to derive half yearly growth in weight.

The growth indices are used to compare the growth performance of a fish to various species and of the fish raised under culture conditions, with conspecific grown under natural condition. One among these indices is `ø' which is based on the parameters of von Bertalanffy growth equation (Pauly and Munro, 1984). The equation followed to evaluate the growth performance of <u>E. suratensis</u> in Goa waters is :

$$ø = \log K + 2 \log L\infty \quad \text{...........XII}$$

The modified Wetherall <u>et al.</u> (1987) plot of ELEFAN - II was used to obtain a preliminary estimate of $L\infty$. The response surface analysis of ELEFAN - I was then used to refine the estimate of $L\infty$ and obtain a corresponding K (Brody growth co-efficient). The growth parameters ($L\infty$ and K) obtained through

ELEFAN were used to derive total mortality (Z), approximate probabilities of capture by length. Natural mortality (M) was estimated by using the following equation (Pauly, 1980) :

$$\text{Log } M = -0.0066 - 0.279 \log L\infty + 0.6543 \text{ Log } K + 0.4634 \text{ Log } T \quad \text{............XIII}$$

Where, `T' is the annual mean temperature in degree centigrade.

The fishing mortality was worked out by subtracting natural mortality (M) from total mortality (Z) (Z - M). The probability of capture was estimated using a linearized form of a logistic curve of the left ascending part of the catch curve and similarly the recruitment pattern.

## 4.3 RESULTS

The pooled length frequency data along with calculated theoretical frequency is shown in Fig. 4.1. The mean size of the sampled population was 128.423 mm. The curve revealed a normal distribution of the population. The cumulative observed frequency and the cumulative theoretical frequency are plotted in Fig. 4.2, which revealed that there is a probability of 0.841 that a randomly caught fish will belong to a size of 128.423 ± 27.049 mm, which further confirm the normal distribution of the population. The mean size (128.495 mm) calculated through Bhattacharya's plot was observed to confirm with the arithmetic

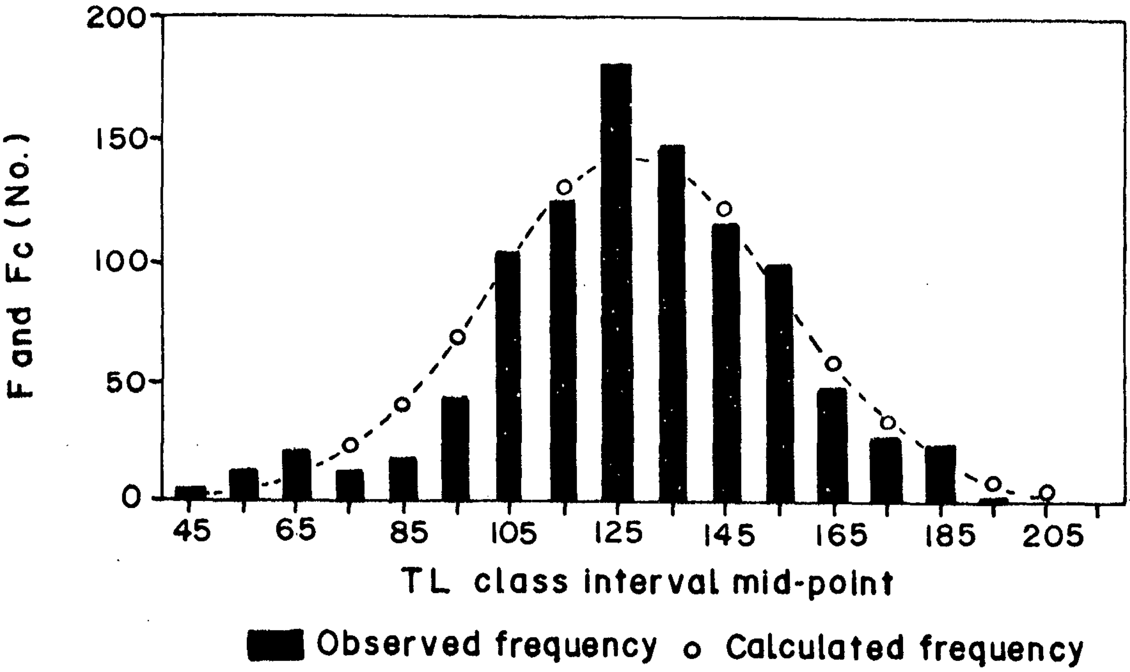



Fig. 4.1 The theoretical frequency, Fc, (the normal distribution curve) and observed frequencies, F(bars) of *E. suratensis*, data 1991-1992.

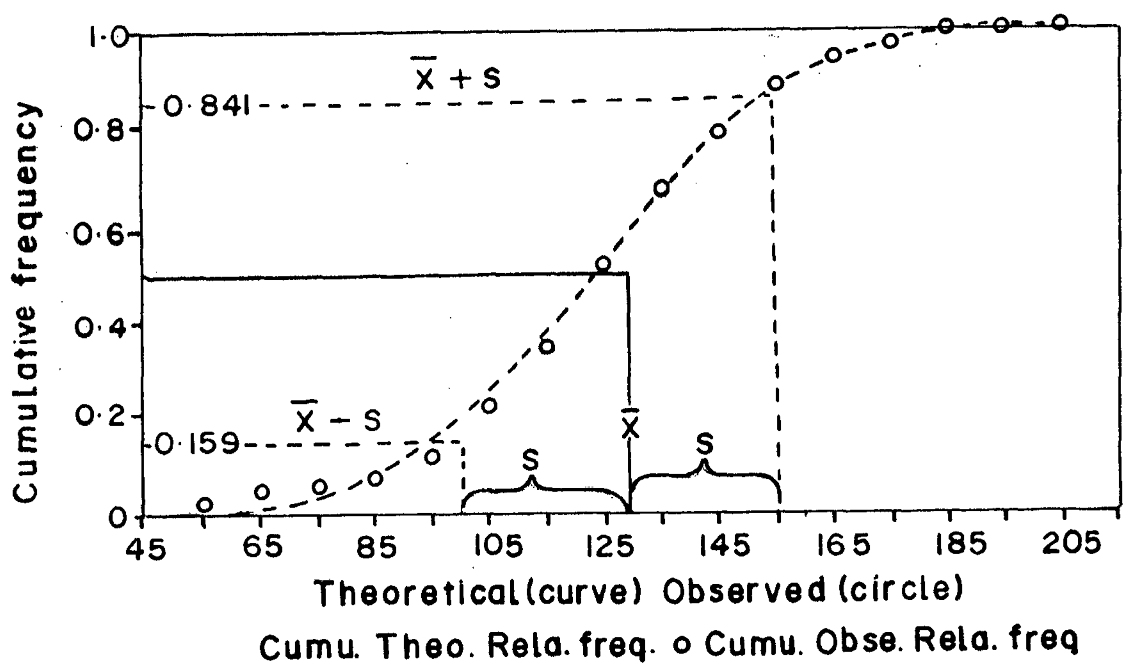



Fig. 4.2 Theoretical (curve) and observed (circle) relative cumulative frequencies, based on Table-4·2

mean (Fig. 4.3).

The length-weight relationship in male and female are depicted in Fig. 4.4.1 & 4.4.2, respectively and the equations are as follows :

$$\text{Male } W = 0.0225927\ L^{3.029066} \quad : t = 2.30482$$

$$\text{Female } W = 0.0240010\ L^{3.007399} \quad : t = 0.43655$$

$$\text{Combined (both sexes)} = 0.0231926\ L^{3.019775} \quad : t = 1.93765$$

The calculated `t' values in all the analysis are well below the tabulated value (2.58 at 99%) of t distribution at DF oo. Thus, the length-weight relationship revealed that the growth of E. suratensis in terms of weight proceeds in the same dimension as the cube of length.

The seasonal variation in condition factor in terms of live weight and the gutted weight for both female and male are shown in Fig. 4.5.1 & 4.5.2, respectively. In male, the `Kn' value in terms of live weight ranged from 2.31 in March to 2.53 in October and January, whereas in gutted condition it varied from 2.10 in March to 2.30 in October. In female, the live weight `Kn' value ranged from 2.32 in March to 2.57 in October, whereas in gutted condition it varied from 2.05 in April 1992 to 2.28 in October 1991. The overall trend of `Kn' values in both the sexes produced similar results, with high `Kn' values during May, October and December 1991 and January 1992 and low values during March and August 1991 and April 1992. On the basis of total length class interval, the minimum `Kn' values of 2.17 and 2.34 were recorded in juveniles belonging to mid-class intervals of 45 mm and 55

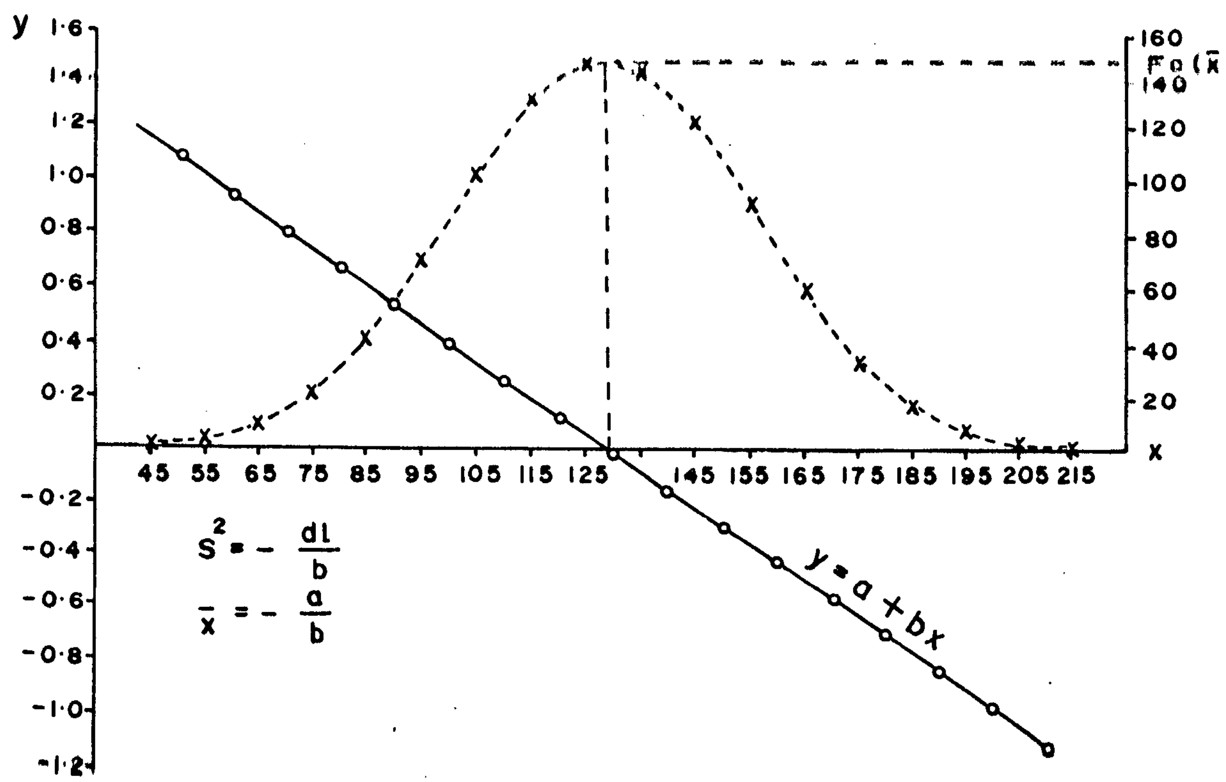



Fig. 4.3 Bhattacharya plot to estimate mean size captured.

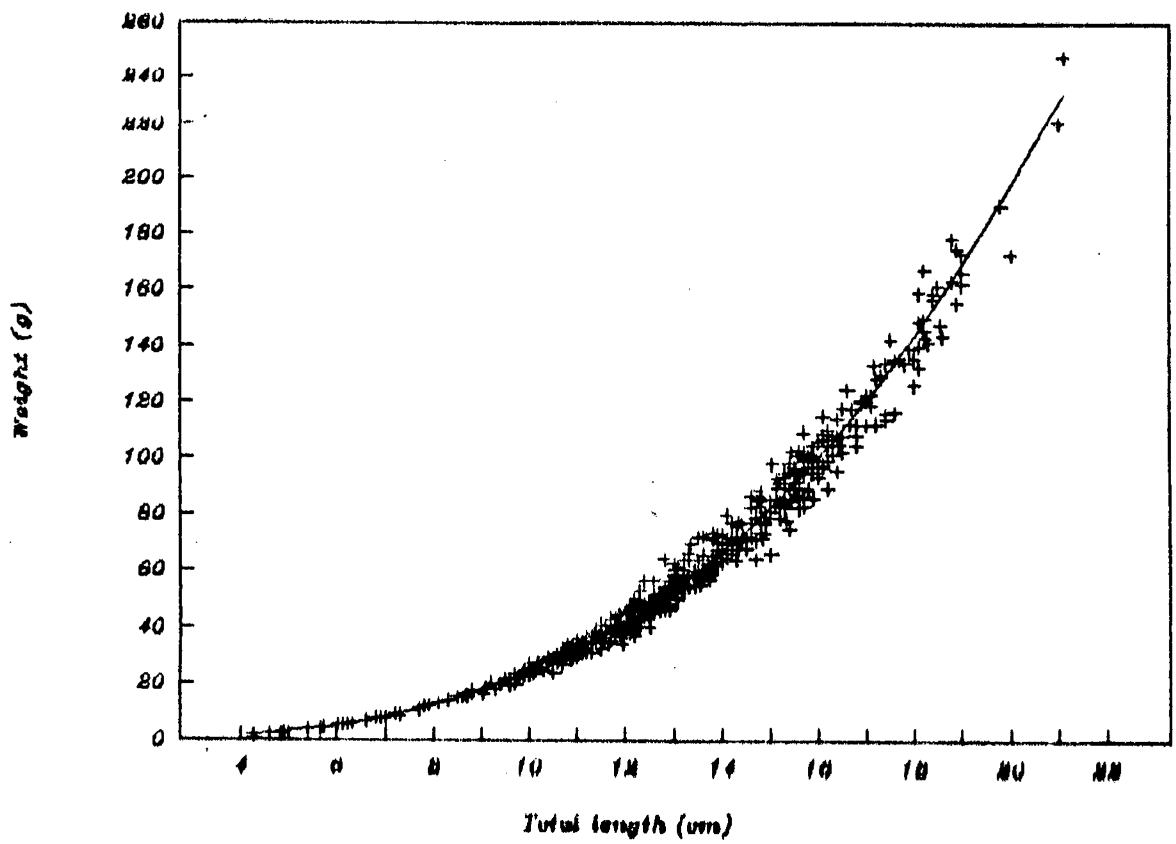



Fig. 4.4.1 Regression analysis between total length (cm) and live weight (g) of *E. suratensis* (male)

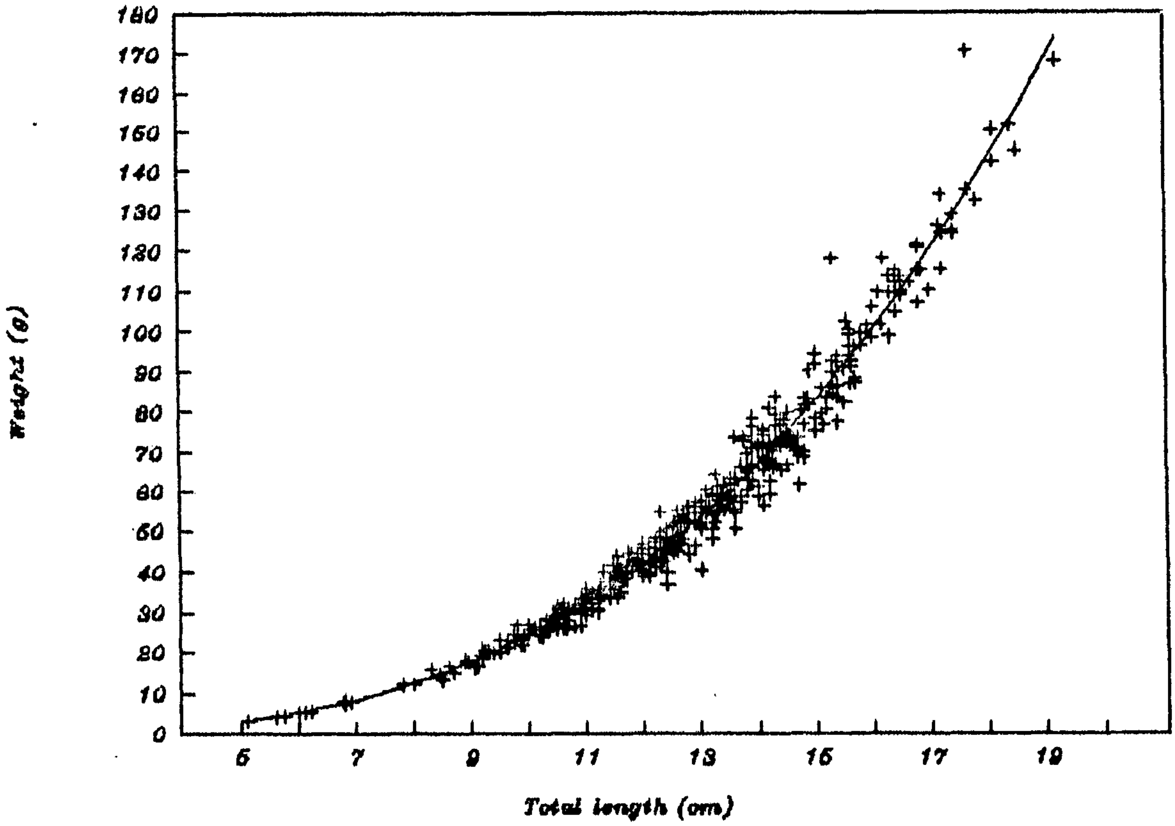



Fig. 4.4.2 Regression analysis between total length(cm) and live weight(g) of E. suratensis (female)

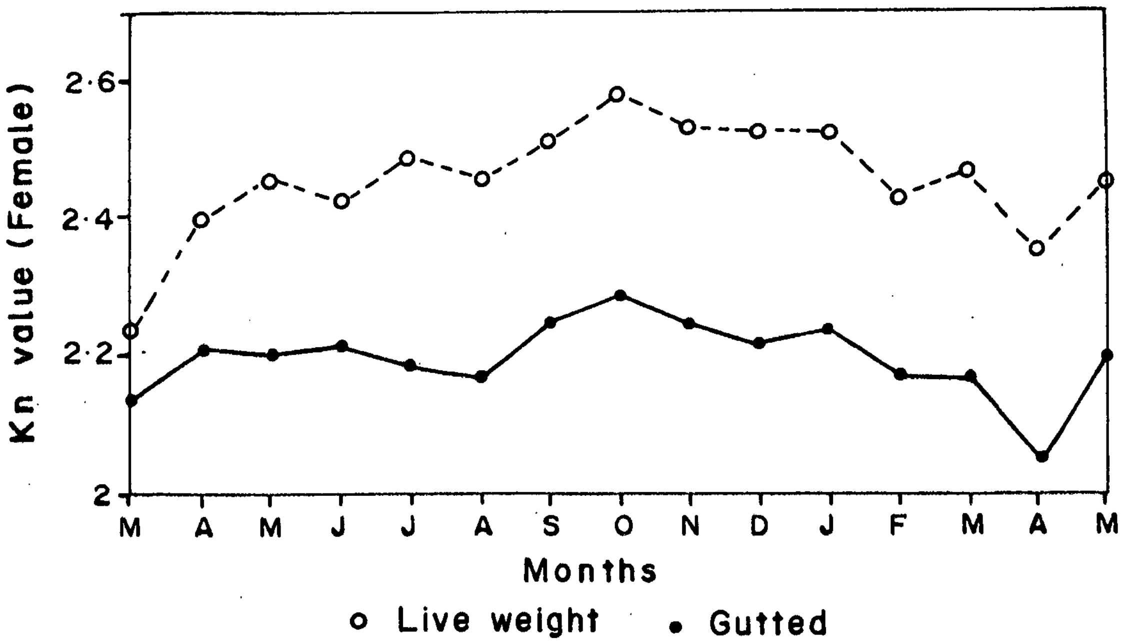



Fig. 4·5·1 Monthly variation in condition factor (kn value) of *E. suratensis* (female)

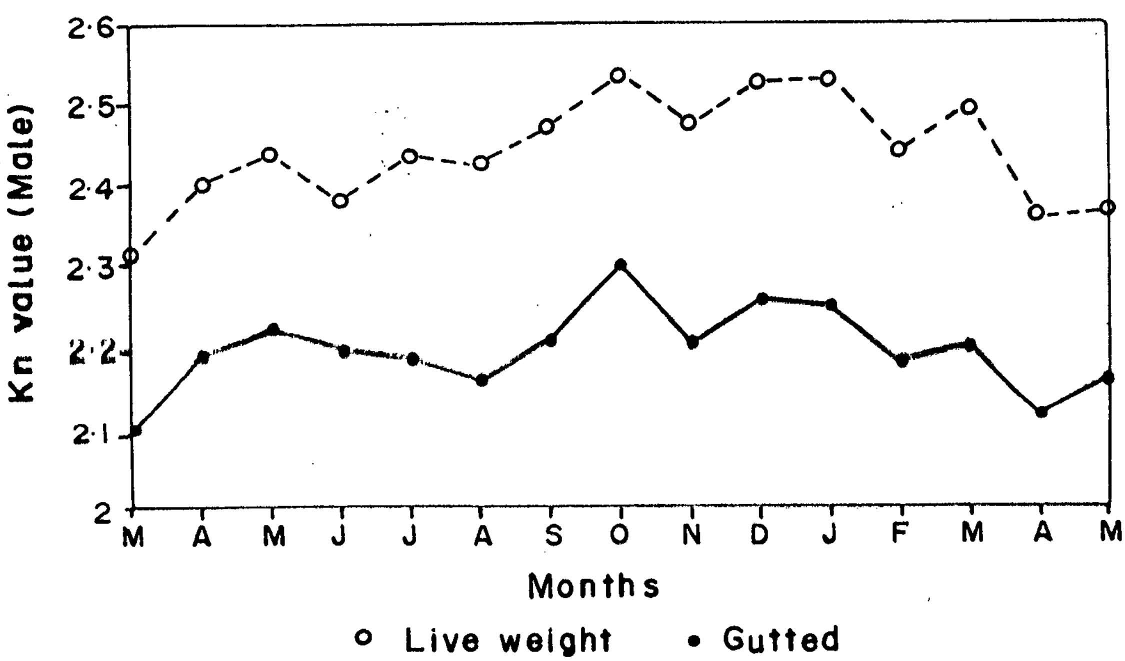



Fig. 4.5.2 Monthly variation in condition factor (kn value) of *E. suratensis* (male)

mm, respectively (Fig. 4.5.3). In both the sexes, the 'Kn' values were low even at 65 mm mid-class interval, but 75 mm onwards till 175 mm the values fluctuated narrowly. However, the 'Kn' value in female from 175 mm and in male 185 mm onwards, started decreasing gradually and reached the value on par with the smallest groups recorded in either sexes.

The preliminary estimates of asymptotic length (Loo) and mortality co-efficient (Z/K) following modified Wetherall plot were estimated to be 217.749 mm and 3.337, respectively (Fig. 4.6 a & b). The refined value of Loo and K computed through response surface analysis were 226 mm and 0.84 $year^{-1}$ respectively. The growth curve using growth parameters (Loo & K) superimposed over restructured length frequency data is shown in Fig. 4.7. As per Gulland and Holt plot (Fig. 4.8.1 and Table 4.3), the asymptotic length was 225.827 mm and the K 0.8399, which equate to the values derived through ELEFAN.

Modified Ford-Walford plot (Ricker, 1958) (Table 4.4 & Fig. 4.8.2) was used to derive $t_0$ in order to fit in the von Bertalanffy growth equation. The von Bertalanffy growth equation for total length of E. suratensis in Goa waters is as follows:

$$L(t) = 226 [ 1 - \exp.( -0.84 ( t - 0.000139 )) ]$$

where,

$L\infty$ = 226 mm

K = 0.84

$t_0$ = 0.000139

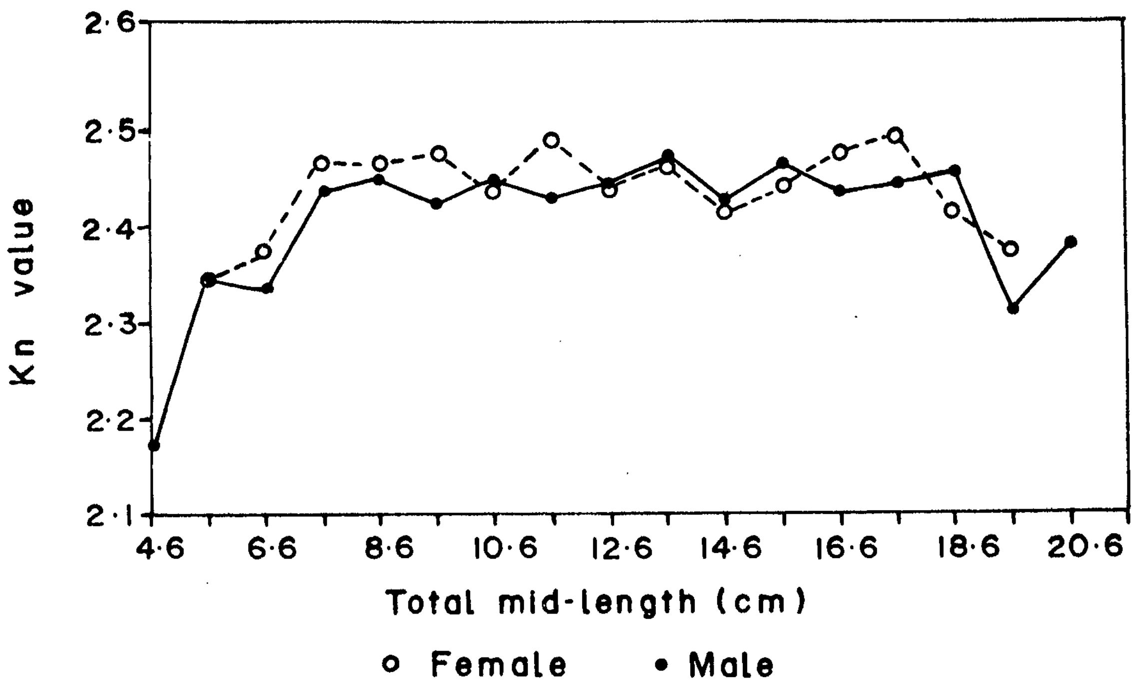



Fig. 4.5.3 Variation in condition factor (kn value) in different size groups of E. suratensis

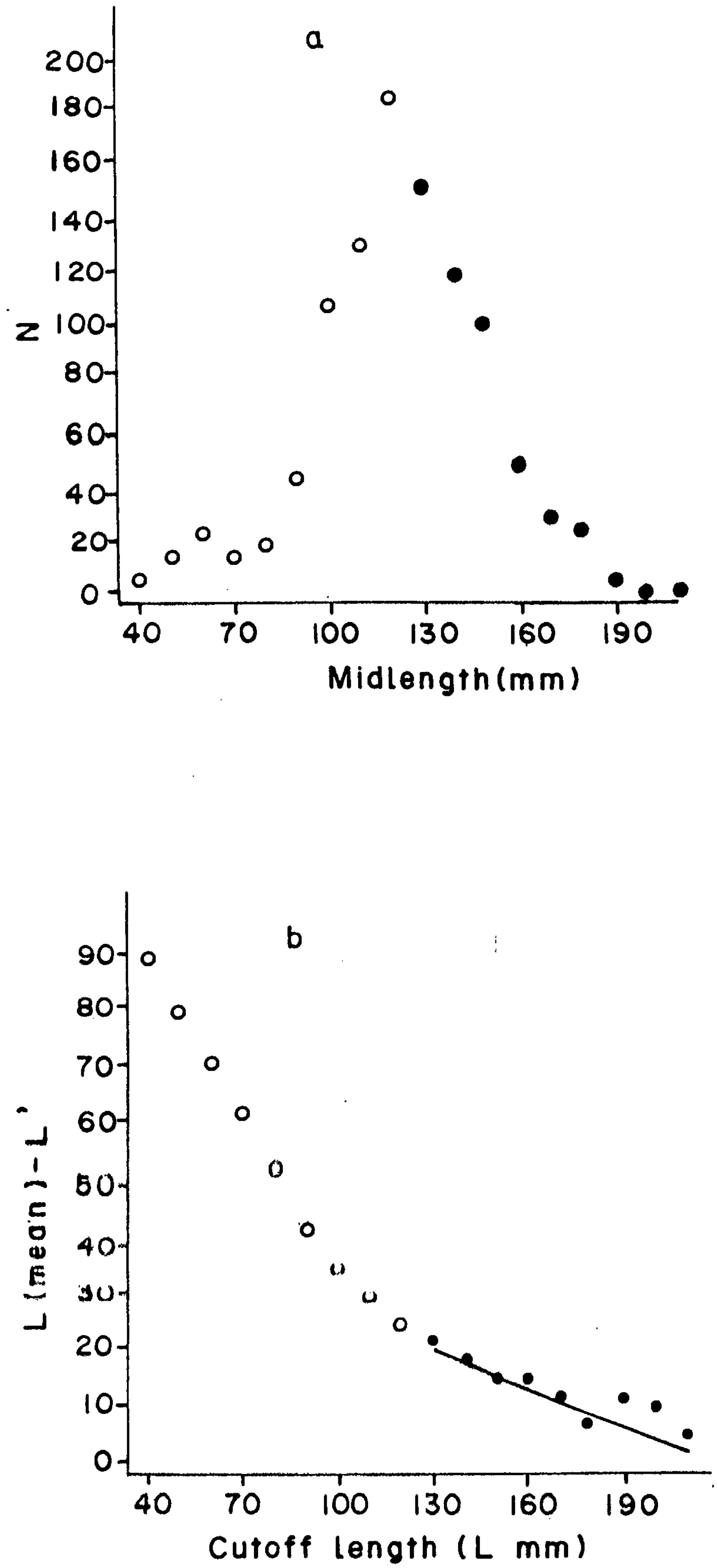



Fig. 4.6 (a & b) Wetherall plot for esimating L∝ and Z/K from length-frequency data of <u>E. suratensis</u> in Goa waters, 1991-1992 the regression equation is Y = 50·21 +(-0.231xX) (r = -0.980) ie L∝ = 217·749 mm and Z/K = 3·33

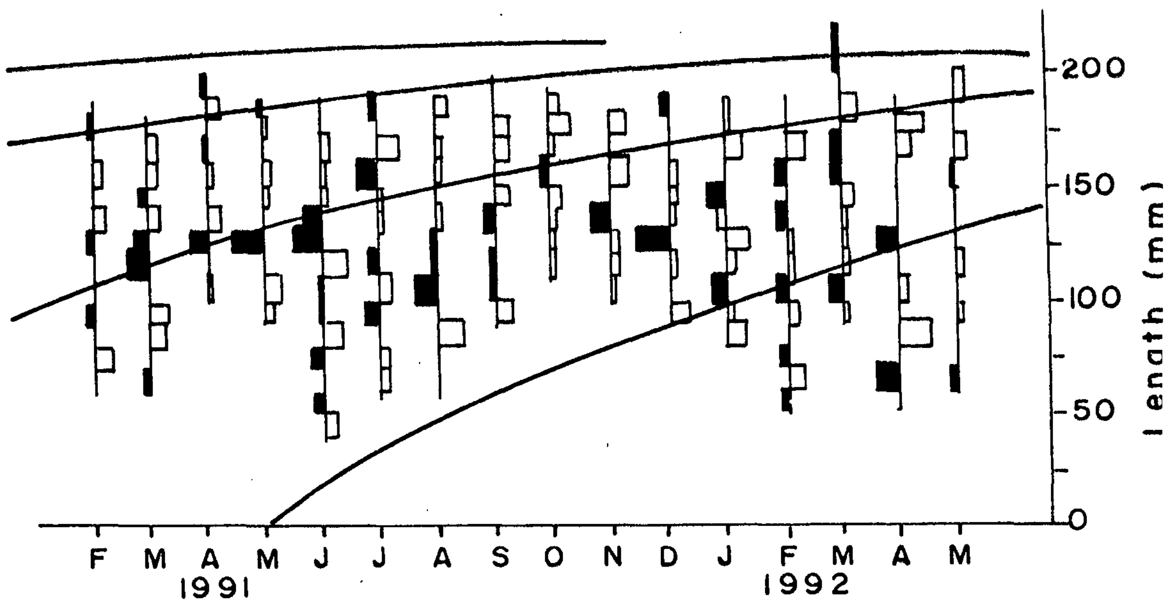



Fig. 4.7 Restructured length-frequency data and growth curve for E. suratensis in Goa waters, 1991-1992 ($L_\infty$ = 226 mm, K = 0.84$^{-1}$)

Table 4.3 Input data for Gulland and Holt plot (data derived from Table 4.2).

| Sr.No. | t | Δt | l(t) | Δl(t) | Δl(t)/Δt | l(t+Δ t+l(t)/2 |
|---|---|---|---|---|---|---|
| 1 | 0.264 | | 45 | | | |
| | | 0.068 | | 10 | 147.058 | 50 |
| 2 | 0.332 | | 55 | | | |
| | | 0.072 | | 10 | 138.888 | 60 |
| 3 | 0.404 | | 65 | | | |
| | | 0.076 | | 10 | 131.578 | 70 |
| 4 | 0.480 | | 75 | | | |
| | | 0.082 | | 10 | 121.951 | 80 |
| 5 | 0.562 | | 85 | | | |
| | | 0.087 | | 10 | 114.942 | 90 |
| 6 | 0.649 | | 95 | | | |
| | | 0.095 | | 10 | 105.263 | 100 |
| 7 | 0.744 | | 105 | | | |
| | | 0.102 | | 10 | 98.039 | 110 |
| 8 | 0.846 | | 115 | | | |
| | | 0.113 | | 10 | 88.495 | 120 |
| 9 | 0.959 | | 125 | | | |
| | | 0.124 | | 10 | 80.645 | 130 |
| 10 | 1.083 | | 135 | | | |
| | | 0.139 | | 10 | 71.942 | 140 |
| 11 | 1.222 | | 145 | | | |
| | | 0.156 | | 10 | 64.102 | 150 |
| 12 | 1.378 | | 155 | | | |
| | | 0.181 | | 10 | 55.248 | 160 |
| 13 | 1.559 | | 165 | | | |
| | | 0.213 | | 10 | 46.948 | 170 |
| 14 | 1.772 | | 175 | | | |
| | | 0.260 | | 10 | 38.461 | 180 |
| 15 | 2.032 | | 185 | | | |
| | | 0.333 | | 10 | 30.030 | 190 |
| 16 | 2.365 | | 195 | | | |
| | | 0.464 | | 10 | 21.551 | 200 |
| 17 | 2.829 | | 205 | | | |
| | | 0.769 | | 10 | 13.003 | 210 |
| 18 | 3.589 | | 215 | | | |

Table 4.4 Length at age and corresponding weight of *E. suratensis* used for fitting Walford line (as per Ricker, 1975).

| | | | | Loo = 226 mm | | Woo = 400 g | |
|---|---|---|---|---|---|---|---|
| Sr.No. | Age(Years) | TL(mm) | Wt.(g) | (Loo - Lt) | ln(Loo - Lt) | (Woo - Wt) | ln(Woo - Wt) |
| 1 | 0.404 | 65 | 6.582 | 161 | 5.0814 | 393.418 | 5.9746 |
| 2 | 0.480 | 75 | 11.176 | 151 | 5.0172 | 388.824 | 5.9631 |
| 3 | 0.562 | 85 | 15.710 | 141 | 4.9487 | 384.290 | 5.9513 |
| 4 | 0.649 | 95 | 22.065 | 131 | 4.8751 | 377.935 | 5.9347 |
| 5 | 0.744 | 105 | 29.268 | 121 | 4.7957 | 370.732 | 5.9154 |
| 6 | 0.846 | 115 | 38.413 | 111 | 4.7095 | 361.587 | 5.8905 |
| 7 | 0.959 | 125 | 48.123 | 101 | 4.6151 | 351.877 | 5.8632 |
| 8 | 1.083 | 135 | 61.320 | 91 | 4.5108 | 338.680 | 5.8250 |
| 9 | 1.222 | 145 | 73.591 | 81 | 4.3944 | 326.409 | 5.7881 |
| 10 | 1.378 | 155 | 92.190 | 71 | 4.2626 | 307.810 | 5.7294 |
| 11 | 1.559 | 165 | 109.918 | 61 | 4.1108 | 290.082 | 5.6701 |
| 12 | 1.772 | 175 | 127.632 | 51 | 3.9318 | 272.368 | 5.6071 |
| 13 | 2.032 | 185 | 154.300 | 41 | 3.7135 | 245.700 | 5.5041 |
| 14 | 2.365 | 195 | 177.040 | 31 | 3.4339 | 222.960 | 5.4069 |
| 15 | 2.829 | - | 220.63 | - | - | 179.370 | 5.1894 |
| 16 | 3.598 | - | 247.51 | - | - | 152.490 | 5.0270 |

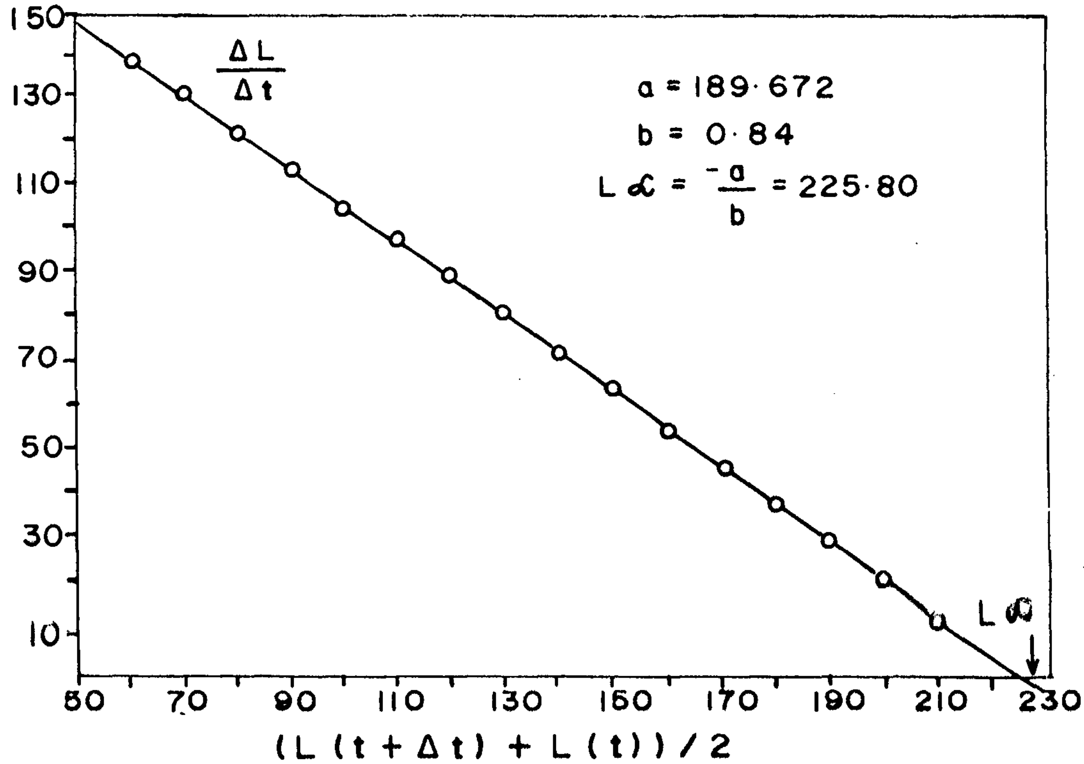



Fig. 4.8.1 GulLand and Holt plot corresponding to table 4.3 to estimate $L\infty$ of E. suratensis of Goa waters. ( y = 189·6722 + (− 0·83994 X)), (r = 0·9999), $L\infty$ = − a/b = 226 mm

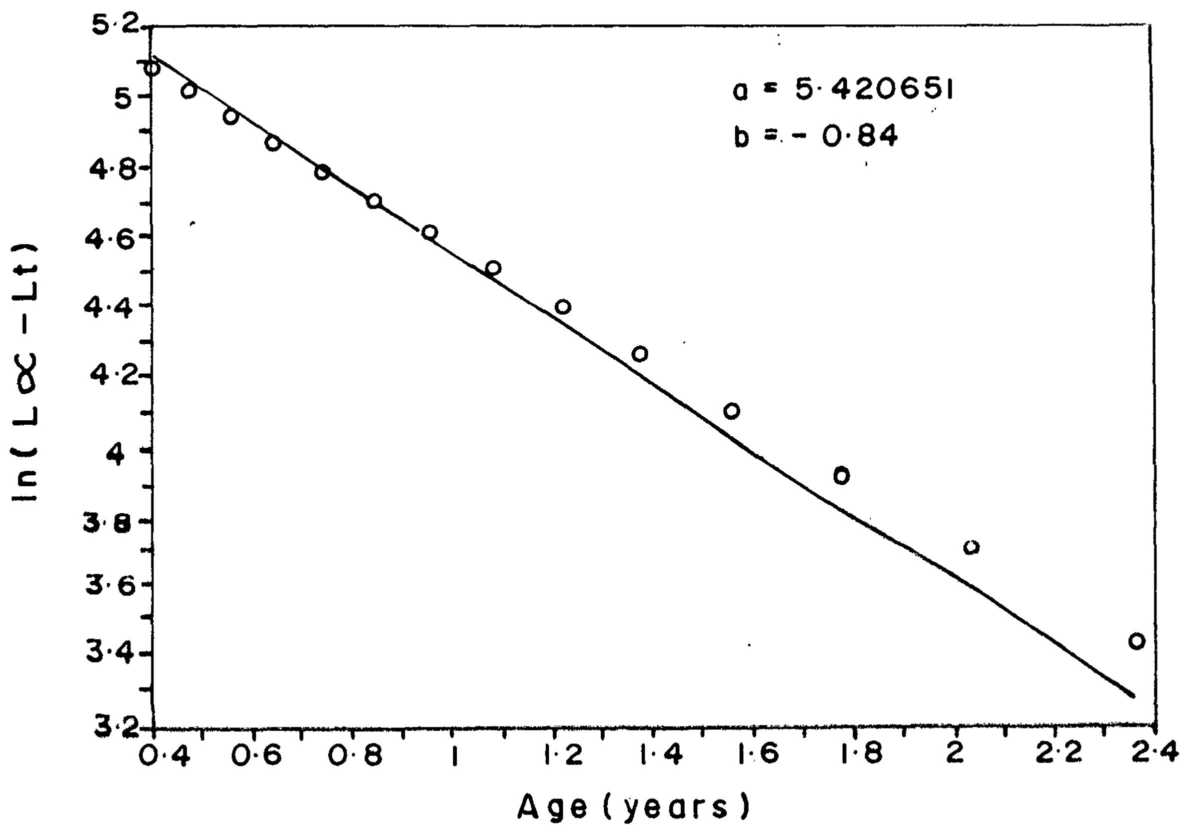



Fig. 4.8.2 Walford graph for Length to estimate $t_0$ (y = 5·4206 + (− 0·84 X)).

Similarly, the growth equation (Table 4.4 & Fig. 4.9 A & B) for weight above 0.6 years of age is as follows :

$$W(t) = 400 [ 1 - \exp.( - 0.31367 ( t - 0.484136 ))]$$

where,

$W\infty$ = 400 g

$K$ = 0.31367

$t_0$ = 0.484136

The live weight at age and the half yearly growth increment are plotted in Fig. 4.10. The results indicate that in first half year of age after hatching, the growth increment is only 13.443 g, whereas from 0.5 year to 1.5 years it ranged from 41.270 - 46.334 g. One and a half year onwards the growth increment gradually decreased. A growth increment of 43.590 g from 2.5 to 3.0 years could be an error due to less number of samples obtained in this class group. The reduction in growth increment could be attributed to the involvement of the fish in continuous reproduction after 1.5 years of age. The growth performance index Ø ' of E. suratensis (L∞ = 226 mm) in natural population of Goa is 2.632.

Figure 4.11 shows the catch curve of E. suratensis corresponding to the length frequency sample. The total mortality was estimated to be 3.836 $year^{-1}$ from the descending right arm of the curve. The annual mean water temperature recorded during the present study was 29.6 $^{o}C$ . Thus, the natural mortality as per equation XIII was computed to be 1.77 $year^{-1}$ . Therefore, the fishing mortality (F = Z - M) was F = 2.066 and

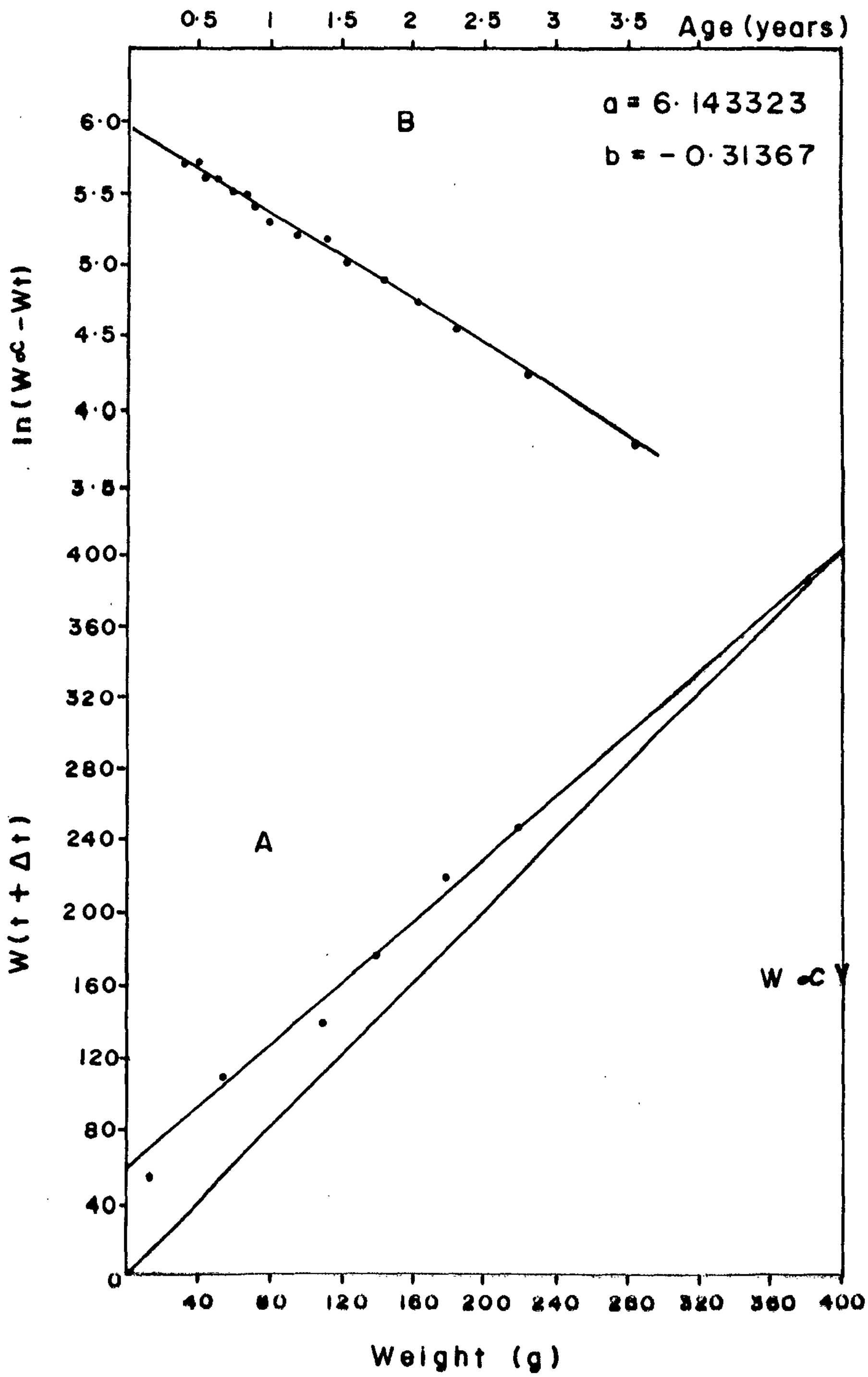



Fig. 4.9 Walford graph for weight of E. suratensis of Goa waters to estimate $W_{\infty}C$ and corresponding $t_0$.

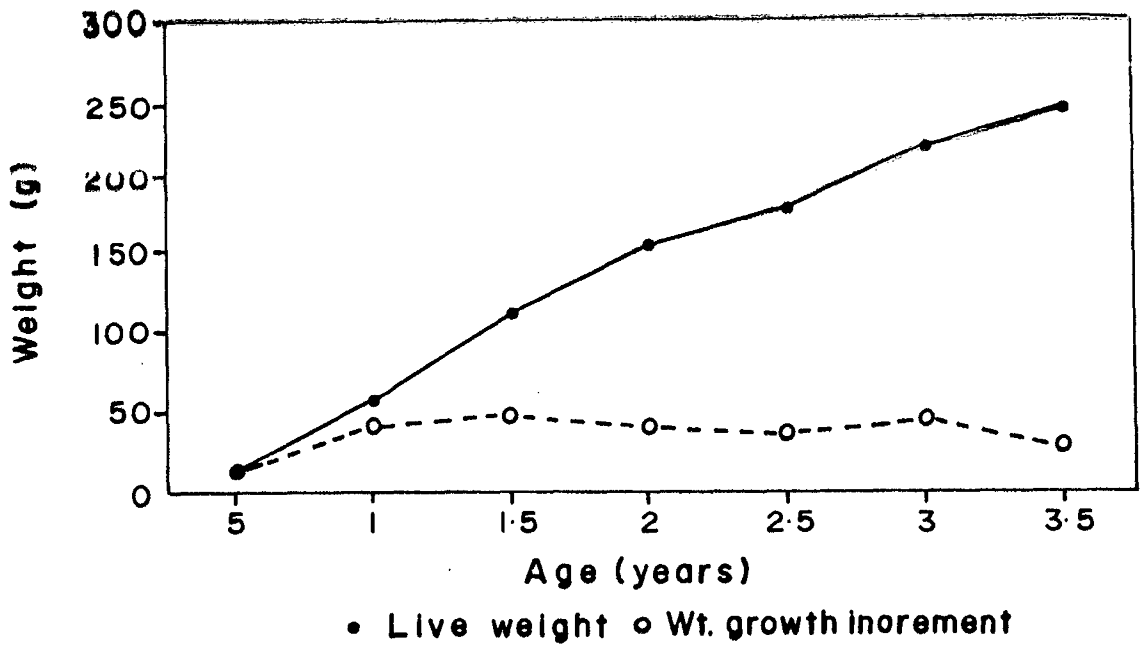



Fig. 4.10 Live weight at age and half yearly growth increments of E. suratensis in Goa waters.

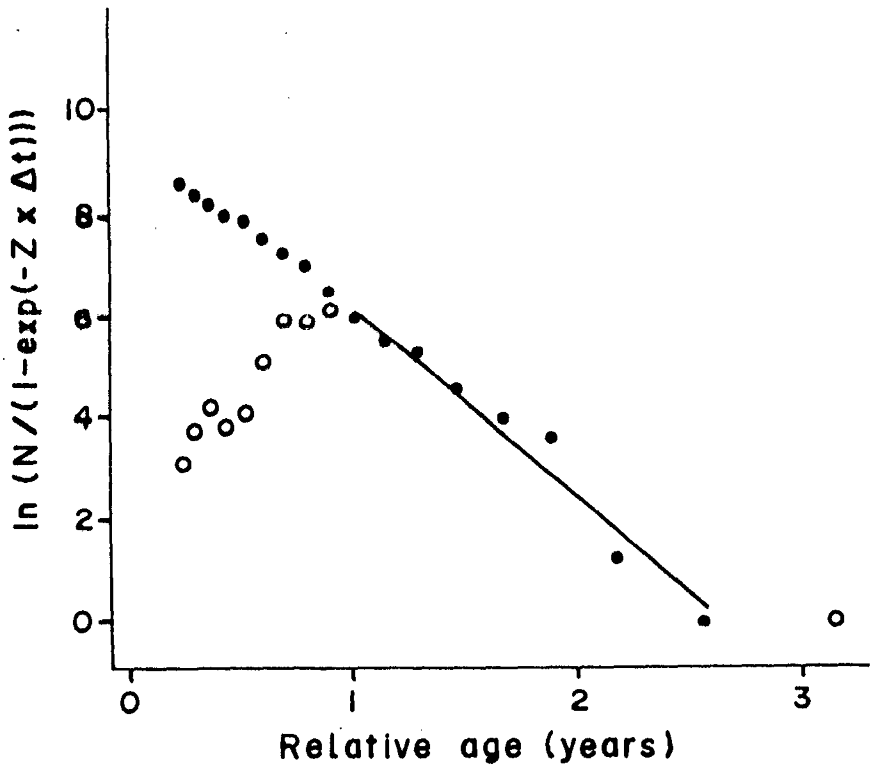



Fig. 4.11 Length-converted catch curve of *E. suratensis* in Goa waters, 1991-1992 ( $Z = 3.836^{-1}$ )

the exploitation rate $E = (F/Z) = 0.535$.

The probability of capture estimated from the analysis of the left ascending arm of the catch curve for E. suratensis of Goa waters is shown in Fig. 4.12 a & b. The resultant curve was fitted by using linearized form of logistic curve and the corresponding regression yielded the value of $a = -8.80$; $b = 0.0700$ and $r = 0.9635$ with $Lc_{50} = 125.846$ mm.

The recruitment pattern of E. suratensis in Goa waters is shown in Fig. 4.13. The pattern showed two prolonged breeding seasons spread over the year, one being more prominent than the other.

## 4.4 DISCUSSION

The population of E. suratensis in Goa waters is normally distributed. This could be due to the continuous spawning behaviour of the species and the simultaneous indiscriminate (non-selective) fishing. The methods employed are non-selective as mentioned earlier. The mean size of the sample was 128.4 mm which corresponds to a relative age of 1 year.

Length-weight relationship in both sexes revealed that the weight in growth is isometric which means that it has a changing body form and specific gravity or the weight grows to the cube of the length. In most of the fish species the length-weight relationship exponent `b' is equal to 3 (Ricker, 1975; Pauly,

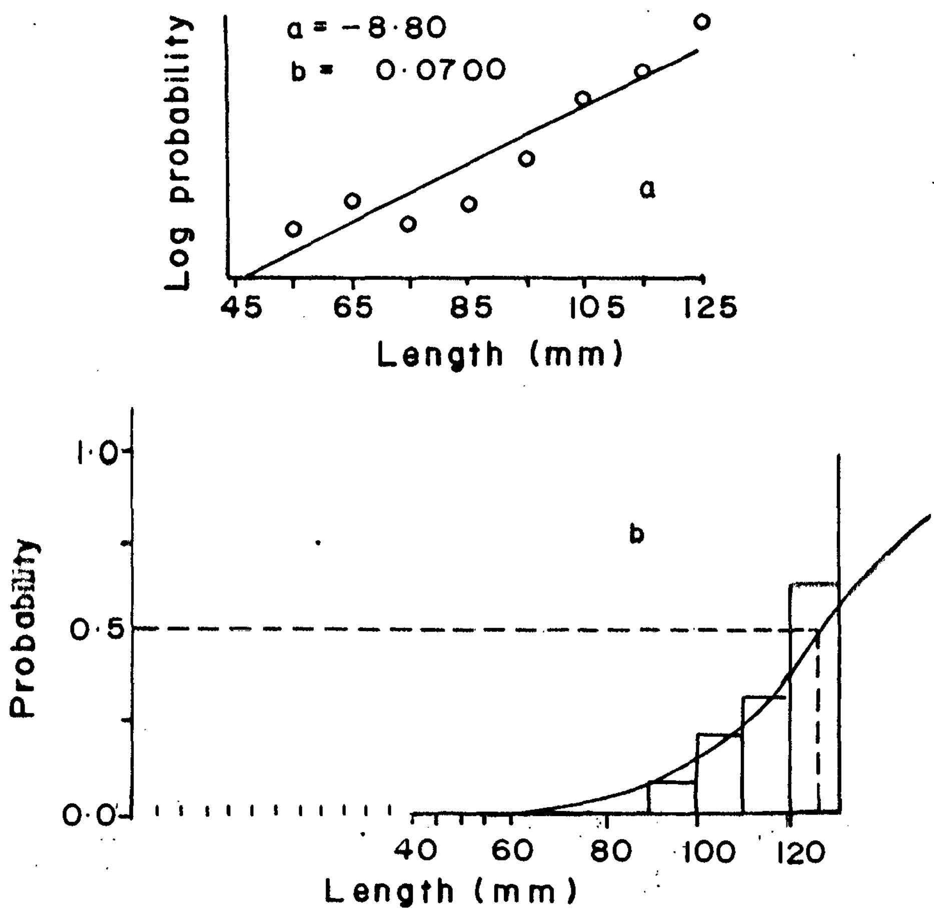



Fig. 4.12 (a & b) Probability of capture of *E. suratensis* caught by various methods in Goa waters, 1991-1992 (y = −8·80 + 0.070 x X (r = 0.963)

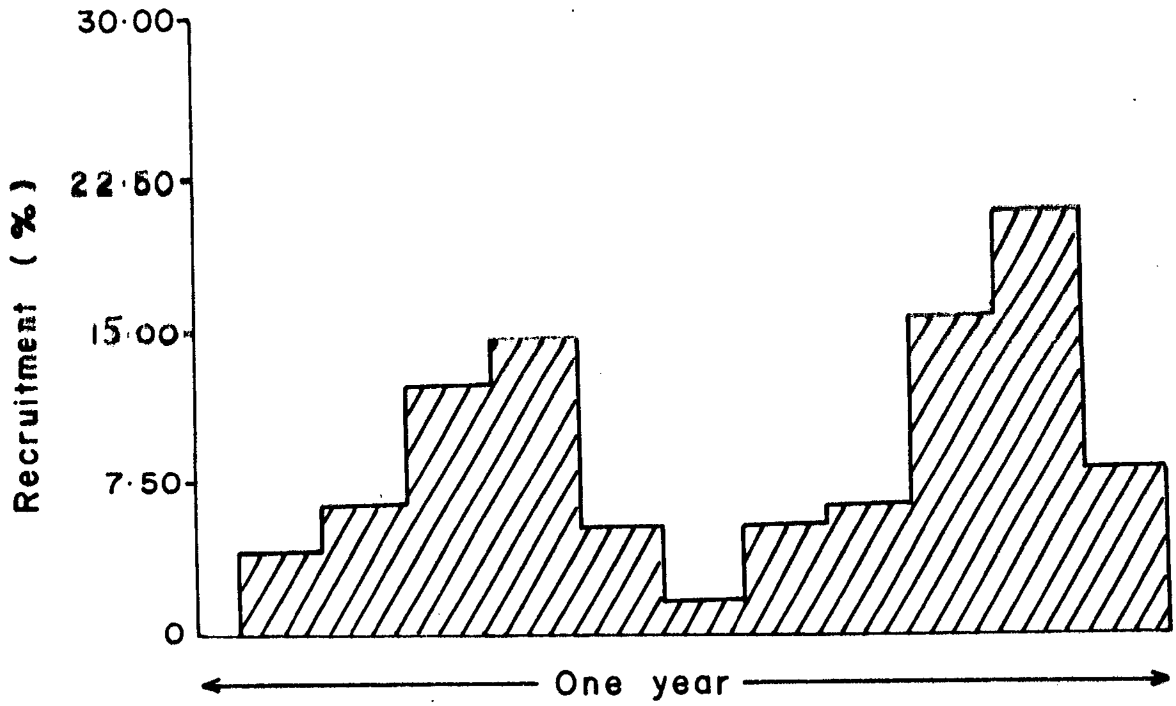



Fig. 4.13 Recruitment pattern of E. suratensis in Goa waters, 1991-1992

1984). The present length-weight relationship is in accordance with the earlier report of Prasadam (1971), indicating similar length-weight growth in both the populations.

Condition factor (`Kn') in both the sexes on live weight basis as well as in gutted condition showed similar trend, which indicate that the feeding activity in terms of quantity is almost uniform throughout the year. However, the highest values during October could be attributed to the better feeding conditions during monsoon and post-monsoon, as the backwaters are known to be enriched by the extraneous nutrients carried from land during south-west monsoon followed by rich flora and fauna during late monsoon and post-monsoon. While discussing (<u>vide infra</u>) the food and feeding habits, it was concluded that <u>E. suratensis</u> basically feeds on filamentous algae and plant material, but shift to detritus in the absence or scarcity of former. In the gut content of fish the maximum plant material was recorded during July-August. These observations revealed that abundance of flora during monsoon is the possible reason for better condition of <u>E.</u> <u>suratensis</u> during post-monsoon. The findings, further inferred that in extensive culture system the stocking should be planned, so that the crop is harvestable in October when the maximum yield can be obtained. The other peaks during May-June and December-January could be attributed to the breeding season. The high value in April 1991 and low during April 1992 could be due to inter-annual shift in breeding cycle.

The low `Kn' value in juveniles (41 - 70 mm) is due to the fact that they do not follow the equation of length-weight relationship ($W = a L^3$) as in adults. The length-weight relation equation in the juveniles was $W = a L^{3.2}$. The `Kn' values were constant from 75 mm mid-length to 175 mm in female and up to 185 mm in male. Thereafter, it decreased with increase in size, which could be assigned to the exhausted condition of fish because of protracted spawning and parental care.

The asymptotic length (Loo = 226 mm) estimated through ELEFAN programme and confirmed with Gulland and Holt plot holds true, as the maximum total length of E. suratensis reported by different workers (225 mm and 240 mm) lie within the close limit of Loo estimated during the present study (Costa, 1983; Joseph and Joseph, 1988b). It is also mentioned that Loo should be higher than L max. (Beverton, 1963; Inter. Game. Fish. Asso., 1978; Pauly, 1981). Generally, there is a good agreement between the largest length recorded from a given stock and the estimated asymptotic length (Loo) (Tayler, 1958). It is further suggested that Loo is equal to L max./ 0.95 and accordingly the estimated asymptotic length of E. suratensis was 222.105 mm which is in close agreement to the estimated value of 226 mm through ELEFAN programme. The growth curve in Fig. 4.7 and the relative age derived from the curve revealed that in Goa waters, E. suratensis attains a size of 130 mm, 185 mm and 210 mm in Ist, IInd and IIIrd years, respectively. In Chilka lagoon, the average growth has been reported to be 105 mm, 175 mm and 245 mm in Ist, IInd and IIIrd years, respectively (Jhingran and Natarajan, 1966). However, the present estimated growth for the first year (130 mm) is in accordance with the culture experiment of Lazarus and Nandakumar (1986) who obtained a size of 138 mm at the time of harvest, when the age of fish based on age at stocking was about one year.

In culture conditions, when E. suratensis was stocked at a weight of 3.69 g (64.3 mm, about 5 months old) it could attain a weight of 64.70 g in a rearing period of 208 days i.e. a daily growth rate of 0.292 g . In another experiment, when a seed of 0.075 g was stocked , it could gain a weight of 39.40 g in 204 days with a growth rate of 0.193 per day (Lazarus and Nandakumar, 1986).

The present data based on natural population indicate that a fish of 13.443 g (80 mm TL, about 6 month old) attained a weight of 109.918 g in about one year at a daily growth rate of 0.261 g. The present findings and the work of Lazarus and Nandakumar (1986) infer that the ideal size of stocking of E. suratensis is between 64 - 80 mm (5 - 6 month old) with an average weight of 3.69 - 13.443 g respectively, and the ideal age of harvesting the crop is 1.5 years when the maximum growth increment is achieved. Further increase in culture period may not be economical, since the growth rate start decreasing, and the quantity and the cost of feed involved increases. Consequently the seed should be reared in nursery ponds up to a size of 65 - 80 mm at high stocking densities, and thereafter thinned or transferred to the culture ponds. However, the ideal stocking density needs to be investigated.

*E. suratensis* attains its first maturity during 1.0 - 1.4 years of age, therefore by manipulating the culture strategies it may still be possible to attain better growth as described here. The similar efforts such as monosex culture (Male) in Tilapias have proved fruitful (Anderson and Smitherman, 1978; Melard and Philippart, 1981).

The growth performance index (Ø ') of *E. suratensis* in natural stock of Goa indicates its superiority over the exotic species *O. mossambicus*. Pauly *et al.* (1988) further concluded that the growth performance of Tilapia is higher in culture conditions than the nature. Thus, it could be anticipated that the growth performance of *E. suratensis* would be still better than the present estimated value from wild stock.

It is difficult to evaluate the results since the information on such type of work is not available for *E. suratensis* . High natural mortality (M) is attributable to the higher mean annual temperature and the short life span of the fish. The exploitation rate as worked out presently is 0.54, which is very high. Natural mortality = optimum fishing mortality (M = F opt.) is very high for the stock of fish and shrimp occupying low in food chain (Francis, 1974; Caddy and Csirke, 1983). Based on various simulations, Beddington and Cooke (1983) concluded that for higher values of M (natural mortality more than 1) in small tropical fish, the equation M = F opt. over estimates by a factor of 3 - 4 . Pauly (1984) mentioned that the exploitation rate of small fish is as low as in the vicinity of 0.2 . Length frequency statistics also indicate that 29% of the stock gets the opportunity to spawn once and only 10% twice. Therefore, the higher rate of exploitation of *E. suratensis* in Goa waters needs realistic measures to manage this limited resource.

Basically, the stock are managed by regulating the mesh size, by defining closed areas or closed seasons and ranching. The first three management strategies are difficult to implement because of the inadequacies of the locally employed fishing methods and private ownership of land or lease. The most effective management practices could therefore be to produce and release hatchery seed in natural waters and to commercialize the seed production technology.

# CHAPTER V

# BIONOMICS

## 5.1 INTRODUCTION

To evaluate the role of fish in biological balance it is essential to understand the food and feeding habits of each species co-existing in an ecosystem. The information can characterize the competitors, predators and different sub-food chains, and their energy pathways operating in the system. However, the role of fish in an aquatic system will not be complete until pathogens and parasites harboured by species are studied, since they are a part of the system and are also responsible for emaciation and fish mortality. Such detailed studies provide valuable information about a species destined for culture practices. Thus, for convenience the present chapter is dealt under three sections : 5A) Food and Feeding Habits; 5B) Predators and Competitors; 5C) Diseases and Parasites.

## 5A.2 FOOD AND FEEDING HABITS

The role of fish as a component to structure, control and contribution to the flow of energy through an ecosystem can be ascertained only if a first hand information on its diet is made available. Fish communities are usually characterized as pelagic and demersal and accordingly obtain their energy from food items available in the respective ecosystem. On the basis of feeding habits and gut content composition they are categorised as herbivorous, zooplankton feeders, detritivores, carnivores and predators. Although, this classification looks simple, in true sense it is an interlocked web of different food chains in a dynamic aquatic ecosystem.

Many fish species shift from one type of feeding habit to other during their life cycle. The juveniles of Sardinella longiceps feed mainly on crustaceans whereas the adults predominantly feed on larger phytoplankton dominated by diatoms. (Raja, 1969). The occurrence of benthic organic detritus in the gut of S. longiceps is not because of benthic feeding habits but due to the suspension of the bottom mud (Longhurst and Pauly, 1987). Rastrelliger kanagurta is capable of utilising wide range of food organisms such as microscopic algal material, copepods, other small planktonic organisms including medusae, pelagic penaeids, larval and juvenile fish (George, 1964). Luther (1962) reported decayed organic matter, algae and foraminifera as the main food item in Mugil cephalus from India, while Blaber (1976) mentioned its preference to gastropods, Assminea sp., foraminiferans and diatoms. The stomach content of Mugil cephalus from Swartkops estuary comprised predominantly diatoms and algae while, animal materials were present insignificantly. The food of M. cephalus measuring less than 25 mm, in Sri Lanka Lagoon was comprised mainly of diatoms (55%), green algae (22.3%), blue-green algae (6%) and other material, however, the animal matter contributed only 1%. The percentage occurrence of detritus and sand particles increases with increasing body length, thus signifying the gradual transition from a planktonic to a benthic feeding habit ( De Silva and Wijeyaratyne, 1977).

*Tilapia zilli* a cichlid is a macrophyte feeder and feed preferentially on filamentous algae, aquatic macrophyte and vegetable matter of terrestrial origin. However, this specialised feeding habit does not restrict it from consuming detritus and animal matter in certain stages of development, and certain period of the year, and in certain water bodies poor in aquatic vegetation (Spataru, 1978). Similarly *Oreochromis mossambicus* captured from vegetation zone feed on diatoms, vegetable debris and mud, but those captured from open waters feed on aerial insects like Coleoptera and Hemiptera (Bruton and Boltt, 1975).

The earlier studies suggested that the fish of same species may have different diets in different habitats and in the same habitats their diet may vary from year to year, or season to season depending on the availability of the food material. The energy flow pathways also vary in different geographical areas and environments depending upon the endemic flora and fauna. Thus, the study of food and feeding habit of a candidate species in a localised environment is important.

### 5A.2.2 MATERIALS AND METHODS

To study the food and feeding activity of *E. suratensis*, samples were collected at weekly interval from fish market of Panjim, Goa and were also caught from backwaters with the help of cast net. The specimens were measured for total length and weight, and were dissected for the removal of alimentary canal.

The digestive tract of each fish was removed carefully, and the stomach and intestine were weighed separately to evaluate gastro-somatic index (GSI). Simultaneously, the maturity stages of the females were also recorded to infer relation if there is any, between the feeding activity, food composition and the breeding cycle. Each gut was preserved separately in 10% formaldehyde, neutralized with 4.0 g of Na H2 Po4 / litre. The preservative was highly effective in retaining the shape and pigment of the food items especially chlorophyll even after a storage period of one and a half year. Fifteen numbers of E. suratensis were also obtained in November 1992, from Chilka lagoon, Orissa for comparative study.

The complete picture of dietary importance cannot be expressed by adopting single method. Consideration for both frequency occurrence and numerical/volumetric method can provide an indication of homogeneity of feeding in a population (Hyslop, 1980). The preliminary analysis of samples revealed that the gut was full of algal filaments, diatoms, plant fragments and detritus, thus, it was not possible to adopt numerical method and the difficulty in absolute segregation of different categories of food items prevented the use of volumetric and gravimetric methods. Hence, the subjective method of point system (Swynnerton and Worthington, 1940; Hynes, 1950) was followed, where each category is awarded points proportional to its estimated contribution to stomach and intestine volume. To estimate the contribution of individual food item in the gut, the points 100, 75, 50, 25, 12.5 and 0 were allotted for single group dominance, predominant, common, little , very little and absent respectively. During the study, plant material, micro and macrophytes were identified by following standard taxonomy procedure (Subrahmanyam, 1946; Fritsch, 1965; APHA, AWWA and WPCF, 1980; Lawson and John,1982; Tseng,1983) and fauna by Gosner (1971) and APHA, AWWA and WPCF (1980). In the second method, the occurrence of each food item in the gut was recorded and expressed as percentage of all those containing food (Dineen, 1951; Dunn, 1954; Kennedy and Fitzmaurice, 1972). The method provides a qualitative assessment of the food composition (Crisp, 1963; Fagade and Olaniyan, 1972). This method has also been used as an indicator of interspecific competition by assuming that when the occurrence of food item exceeds 25% in two or more species the competition is likely (Johnson, 1977).

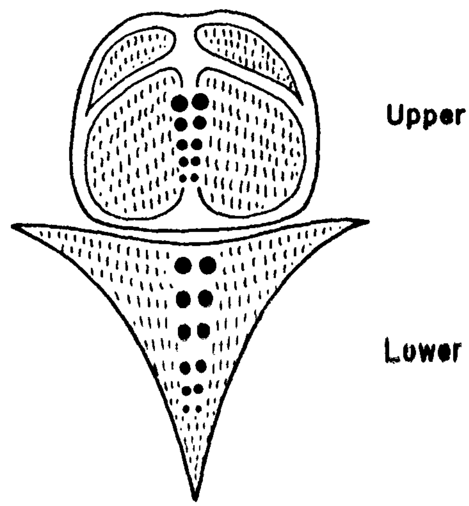
The intensity of feeding was recorded as gorged, full, three fourth, half, one fourth, little and empty depending upon the degree of distension of the stomach and intestine. Accordingly, the points 125, 100, 75, 50, 25, 12.5 and 0 respectively were allotted and expressed as percentage. Generally, the stomach is considered for evaluating the food and feeding, however, in case of herbivorous fish the alimentary canal is very long and retain most of the food for prolonged period. In the present species also the alimentary canal is long and has relatively more capacity to retain food than the stomach. Therefore, the alimentary canal was stretched into a straight line and the food retaining part was measured in relation to its total length and recorded as percentage of fullness, except in instances where it was gorged and heavily distended laterally is expressed as 125 % . The mean percentage of stomach and intestine was expressed in terms of percentage of fullness of gut.

Co-existing fish fauna was recorded during the field visits and later categorised into predators and competitors based on the available information on their food and feeding habits.

### 5A.2.3 RESULTS

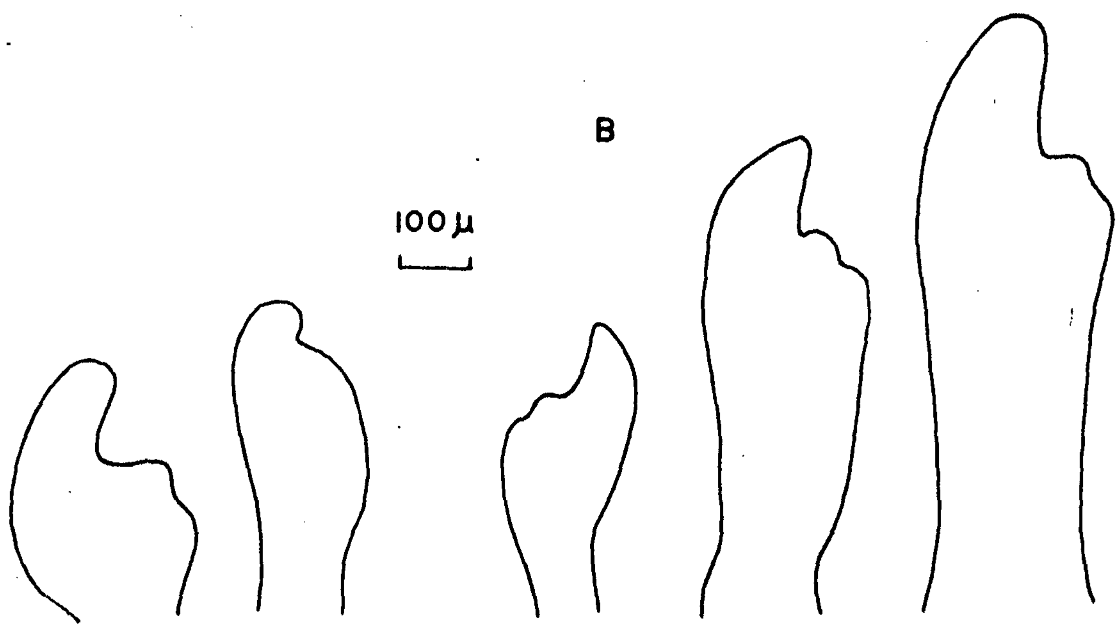
5A.2.3.1 Feeding Apparatus and Digestive Tract: The study of feeding apparatus and digestive tract is of prime importance, since these structures are responsible for the ingestion of specific potential food items. The feeding apparatus and the digestive tract of E. suratensis is comprised of mouth, buccal cavity, pharynx, oesophagus, stomach and intestine. Mouth is protrusible and the feeding is effected by the simultaneous process of protruding and retracting . The jaws are bounded by lips. The cleft of the mouth is slightly oblique with the lower jaw pointing upward. Both upper and lower jaws are lined by three rows of teeth, the outermost series being chisel like incisors, specialized for cutting weeds or scraping algae from the rocks. The inner series are comparatively very small. Vomarine teeth are absent. The posterior part of the short fleshy tongue is embedded in the floor of the buccal cavity and the anterior is free. It helps to push the food to the pharynx. Pharynx consists of four gill arches, each lined with a row of short nodular gill rakers on either side. There are two closely bound ovoid pads on the roof of the pharynx (Fig. 5.1). Each pad can be distinguished in two patches, partitioned by a thick membrane.. The anterior patch is smaller, broad, tapering towards its posterior and lined by numerous small teeth. The posterior patch is larger, broader and stout. It is also lined by numerous rows of small teeth and the innermost row is of comparatively bigger 5 molar like teeth arranged in a decreasing order of size. The floor of the pharynx is provided with a median triangular pad with anterior pointed and a posterior broad base. There are two median rows of molar like teeth, relatively bigger in size. Each row is comprised of 6 teeth arranged in increasing order of size. Rest of the pad is lined by numerous hook like teeth. Each row of molar like teeth of upper pads fits into the counterpart on the lower pharyngeal pad (Fig.5.1). These median rows of teeth probably assist in making the food into bits and the other pharyngeal teeth push the food to oesophagus. Oesophagus is short and measures from 3-5 mm in length. The stomach is an ovoid sac like structure broader anteriorly and tapering towards the posterior end. The size of the stomach varied from 7.0 X 4.0 mm (in 57 mm TL) to 25.0 X 9.0 mm (160 .0 mm TL), though it has a stretching capacity depending upon the fullness of stomach. The intestine is a long tubular structure coiled in the visceral cavity and lastly opening into an anus in front of the urino-genital aperture. Intestine is highly elastic and the length vary depending upon the quantity of food consumed. About 980 specimens were measured for intestine

A




Pharyngeal teeth apparatus (diagramatic)

B




Teeth

Fig. 5.1 Pharyngeal teeth (A) apparatus, (B) teeth length and the ratio of intestine length to total length of fish varied from 2.77 ± 0.74 : 1 to 3.82 ± 0.70 : 1.

**5A.2.3.2 Annual Cycle of Food Composition:** The percentage composition and the percentage frequency occurrence of different food items recorded in the gut are given in Table 5.1 and 5.2, respectively.

CYANOPHYCEAE: The members of the blue green algae were observed throughout the year in the gut content and their composition in terms of percentage of volume varied from 1.35 in January to 26.3 in May. The principal genera of blue green algae observed were *Oscillatoria, Phormidium, Lyngbya, Microcoleus, Anabaena, Merismopedia* and *Spirulina*. Among all the species, *Oscillatoria* was most predominant round the year and its contribution varied from 0.66 to 20.86% . *Phormidium* was second in rank except in the months of December and January, when it was absent. The contribution of blue green algae was relatively poor in September, October, December and January. Analysis of gut content of fish of Chilka lagoon showed the contribution of blue green algae as 6.53%, and the major contributing species were *Oscillatoria, Phormidium, Lyngbya* and *Microcoleus*. The percentage occurrence of different species, when pooled in groups was found to vary from 16% in January to 164.87% in May. The percentage occurrence of *Oscillatoria* alone ranged from 6% in January to 59% in May. The second dominant species in terms of percentage occurrence was *Phormidium*, which ranged from nil in December - January to 40.54% in May. Other species occurred intermittently and the percentage occurrence varied from nil to 27.03. The

Table - 5.1. Annual variation in percentage composition of different food items in the gut of *E. suratensis*.

| Food items | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Chilka lagoon (Nov.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cyanophyceae** | | | | | | | | | | | | | |
| *Oscillatoria* | 5.13 | 22.49 | 20.86 | 6.88 | 7.48 | 9.1 | 1.90 | 3.0 | 3.79 | 2.03 | 0.66 | 10.81 | 3.35 |
| *Phormidium* | 0.85 | 2.20 | 2.61 | 1.94 | 3.83 | 0.27 | 1.77 | 1.12 | 1.41 | - | - | 1.17 | 1.90 |
| *Lyngbya* | 0.25 | - | - | 1.53 | - | - | 0.31 | 0.57 | 1.62 | 0.65 | 0.69 | 0.23 | 0.89 |
| *Microcoleus* | - | - | 0.43 | 1.85 | 2.03 | - | - | - | - | - | - | 0.58 | 0.39 |
| *Anabaena* | 0.03 | 0.32 | 0.97 | 0.12 | - | - | 0.04 | - | 0.30 | - | - | 0.06 | - |
| *Merismopedia* | 1.48 | - | 0.12 | - | - | - | 0.04 | 0.05 | 0.49 | 0.06 | - | 0.43 | - |
| *Spirulina* | 0.03 | 0.05 | 1.32 | 2.73 | 0.27 | - | - | - | - | - | - | - | - |
| **Chlorophyceae** | | | | | | | | | | | | | |
| *Spirogyra* | - | - | - | - | - | 13.81 | 6.98 | 0.05 | - | - | - | - | 23.44 |
| *Rhyzoclonium* | 3.44 | 0.72 | - | 2.47 | 1.21 | 0.84 | 5.01 | 4.23 | - | 0.24 | 1.84 | 2.15 | - |
| *Enteromorpha* | 2.51 | 1.31 | 4.49 | 0.48 | - | - | 4.98 | 4.11 | 3.37 | 13.69 | 11.42 | 13.40 | 3.51 |
| *Cladophora* | - | - | - | 3.13 | - | 0.24 | - | - | - | - | 1.62 | 3.48 | 0.78 |
| *Chaetomorpha* | - | - | - | - | - | 0.54 | - | - | - | - | - | 2.23 | 27.73 |
| **Other micro and macrophytes** | | | | | | | | | | | | | |
| *Sphacelaria* | 0.06 | - | - | - | - | - | - | 0.07 | 1.42 | 0.88 | 1.66 | 0.66 | - |
| *Polysiphonia* | 1.37 | 1.59 | 0.56 | 2.03 | - | - | 2.04 | 0.51 | 2.59 | 4.33 | 6.66 | 5.25 | 0.39 |
| *Catenella* | - | - | - | 4.37 | - | 1.63 | - | - | - | - | 1.21 | 4.85 | - |
| *Halophila* and others | 0.54 | - | 2.93 | 3.12 | 24.16 | 30.66 | 10.28 | 2.55 | 2.42 | 4.19 | 7.05 | 9.52 | 25.33 |
| Diatoms | 3.92 | 9.00 | 1.08 | 1.59 | 2.54 | 1.74 | 2.69 | 4.05 | 2.56 | 1.53 | 0.61 | 0.46 | - |
| Detritus | 66.02 | 59.36 | 59.78 | 56.28 | 46.60 | 37.70 | 57.19 | 56.96 | 57.75 | 52.35 | 46.86 | 34.89 | 11.16 |
| **Benthic fauna** | | | | | | | | | | | | | |
| Sponges | - | - | - | - | 2.08 | - | - | - | 7.97 | 6.23 | 1.46 | - | 0.22 |
| Hydrozoans | 3.65 | 0.59 | - | 2.41 | - | - | 1.60 | 4.61 | 7.14 | 2.68 | 2.20 | 0.93 | - |
| Bryozoans | - | - | - | - | - | - | - | 0.99 | 3.62 | 8.90 | 14.14 | 8.13 | - |
| Turbellarians | 0.20 | 0.14 | 2.11 | 0.38 | 0.17 | 0.32 | - | - | 0.08 | - | 0.23 | 0.05 | - |
| Nematodes | 0.29 | 0.25 | 0.17 | 0.38 | - | 0.07 | 0.09 | 0.35 | 0.40 | 0.06 | 0.08 | 0.41 | - |
| Polychaete egg mass | 9.71 | - | - | - | - | - | - | - | - | - | - | - | - |
| Crustaceans | 0.51 | 0.65 | 1.24 | 1.50 | 0.69 | 0.32 | 1.70 | 2.41 | 0.94 | 1.16 | 0.51 | 0.05 | - |
| Molluscs | - | - | - | 2.73 | 2.63 | - | 2.78 | 12.50 | - | - | - | - | 0.89 |
| Fish scales | - | 0.57 | 0.68 | 3.72 | 1.97 | 0.92 | 0.10 | 0.14 | - | - | - | - | - |
| Miscellaneous | - | 0.73 | 0.66 | 0.28 | 4.34 | 2.45 | 0.48 | 1.70 | 2.11 | 1.00 | 1.02 | 0.21 | - |

Table - 5.2. Annual variation in percentage occurrence of different food items in the gut of *E. suratensis*.

| Food items | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Chilka lagoon (Nov.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cyanophyeae** | | | | | | | | | | | | | |
| *Oscillatoria* | 30.65 | 51.11 | 59.46 | 19.35 | 32.43 | 47.22 | 24.24 | 38.64 | 54.34 | 10.87 | 6.00 | 43.40 | 42.85 |
| *Phormidium* | 9.68 | 33.33 | 40.54 | 19.35 | 21.62 | 2.78 | 12.12 | 9.09 | 19.56 | - | - | 24.53 | 21.43 |
| *Lyngbya* | 3.23 | - | - | 16.13 | - | - | 3.03 | 2.27 | 19.56 | 6.52 | 10.00 | 5.66 | 7.14 |
| *Microcoleus* | - | - | 8.11 | 3.23 | 13.51 | - | - | - | - | - | - | 7.55 | 7.14 |
| *Anabaena* | 1.61 | 2.22 | 24.32 | 3.23 | - | - | 3.03 | - | 4.35 | - | - | 1.89 | - |
| *Merismopedia* | 12.90 | - | 5.41 | - | - | - | 3.03 | 2.27 | 6.52 | 6.52 | - | 11.32 | - |
| *Spirulina* | 1.61 | 2.22 | 27.03 | 3.23 | 10.81 | - | - | - | - | - | - | - | - |
| **Chlorophyceae** | | | | | | | | | | | | | |
| *Spirogyra* | - | - | - | - | - | 30.55 | 15.15 | 2.27 | - | - | - | - | 57.14 |
| *Rhyzocloaium* | 19.35 | 20.00 | - | 16.13 | 8.11 | 2.78 | 45.45 | 36.36 | - | 2.17 | 4.00 | 7.55 | - |
| *Enteromorpha* | 12.90 | 6.66 | 18.91 | 6.45 | - | - | 21.21 | 18.18 | 19.56 | 28.26 | 26.00 | 35.85 | 14.28 |
| *Cladophora* | - | - | - | 3.23 | - | 2.78 | - | - | - | - | 4.00 | 9.43 | 7.14 |
| *Chaetomorpha* | - | - | - | - | - | 2.78 | - | - | - | - | - | 9.45 | 64.28 |
| **Other micro and macrophytes** | | | | | | | | | | | | | |
| *Sphacelaria* | 1.61 | - | - | - | - | - | - | 2.27 | 28.26 | 13.04 | 16.00 | 5.66 | - |
| *Polysiphonia* | 11.29 | 8.89 | 10.81 | 12.90 | - | - | 21.21 | 11.36 | 23.91 | 23.91 | 28.00 | 32.08 | 7.14 |
| *Catenella* | - | - | - | 9.68 | - | 2.78 | - | - | - | - | 4.00 | 11.32 | - |
| *Halophila* and others | 1.61 | - | 18.91 | 6.45 | 27.03 | 38.89 | 24.24 | 11.36 | 6.52 | 15.22 | 14.00 | 24.53 | 57.14 |
| **Diatoms** | 53.22 | 64.44 | 43.24 | 35.48 | 27.03 | 63.89 | 54.54 | 65.91 | 73.91 | 43.48 | 38.00 | 49.05 | - |
| **Detritus** | 91.94 | 91.11 | 100.00 | 96.77 | 67.57 | 72.22 | 93.94 | 88.63 | 95.65 | 95.65 | 96.00 | 96.22 | 78.57 |
| **Benthic fauna** | | | | | | | | | | | | | |
| Sponges | - | - | - | - | 2.07 | - | - | - | 23.91 | 13.04 | 10.00 | 1.89 | 7.14 |
| Hydrozoans | 24.19 | 4.44 | 5.41 | 16.13 | - | - | 9.09 | 27.27 | 47.83 | 30.43 | 20.00 | 15.09 | - |
| Bryozoans | - | - | - | - | - | - | 3.03 | 15.91 | 34.78 | 28.63 | 32.00 | 16.98 | - |
| Turbellarians | 4.84 | 6.66 | 27.03 | 9.68 | 2.70 | 8.33 | - | - | 2.17 | - | 8.00 | 1.89 | - |
| Nematodes | 9.68 | 6.66 | 5.41 | 9.68 | - | 5.55 | 3.03 | 9.09 | 10.86 | 4.35 | 4.00 | 13.21 | - |
| Polychaete egg mass | 14.52 | - | - | - | - | - | - | - | - | - | - | - | - |
| Crustaceans | 11.29 | 22.22 | 13.51 | 9.68 | 5.41 | 8.33 | 12.12 | 36.36 | 15.22 | 15.21 | 8.00 | 1.89 | - |
| Molluscs | - | - | - | 6.45 | 2.70 | - | 3.03 | 13.64 | - | - | - | - | 7.14 |
| **Fish scales** | - | 2.22 | 5.41 | 16.13 | 8.11 | 11.11 | 3.03 | 13.64 | - | - | - | - | - |
| **Miscellaneous** | - | 4.44 | 5.41 | 3.23 | 13.51 | 11.11 | 12.12 | 18.18 | 19.56 | 8.69 | 6.00 | 3.77 | - |

percentage frequency occurrence of more than 100% indicates the predominance of more than one species during that period, though different species may be present in other period.

CHLOROPHYCEAE: The different species of green algae recorded in the gut were Spirogyra, Rhizoclonium, Enteromorpha, Cladophora and Chaetomorpha. Amongst, Enteromorpha contributed to the food items significantly, ranging from nil (July - August) to 13.40% in February. Rhizoclonium was the second highest, except in May and November when it was absent in the gut. Spirogyra was found only in the month of August, September and October and contributed 13.18, 6.98 and 0.05%, respectively. The frequency percentage occurrence of Spirogyra ranged from 2.27 in October to 30.55 in August. The frequency percentage of Rhizoclonium was more in September and October with the values of 45.45 and 36.36 respectively. The percentage occurrence of Enteromorpha in the gut varied from nil to 35.85. The overall contribution of chlorophyceae group ranged from 1.21% in the month of July to 21.26% in February (Fig. 5.2.1).

In Chilka lagoon samples, the percentage contribution of different species of green algae viz. Spirogyra, Chaetomorpha, Enteromorpha and Cladophora was 23.44, 27.37, 3.51 and 0.78 respectively. The total contribution of the members of the chlorophyceae group was 55.46 % .

OTHER PLANT MATERIALS: The other plant material observed in the gut were of mixed groups such as Sphacelaria, Polysiphonia, Catenella, Halophila and other unidentified plant fragments.

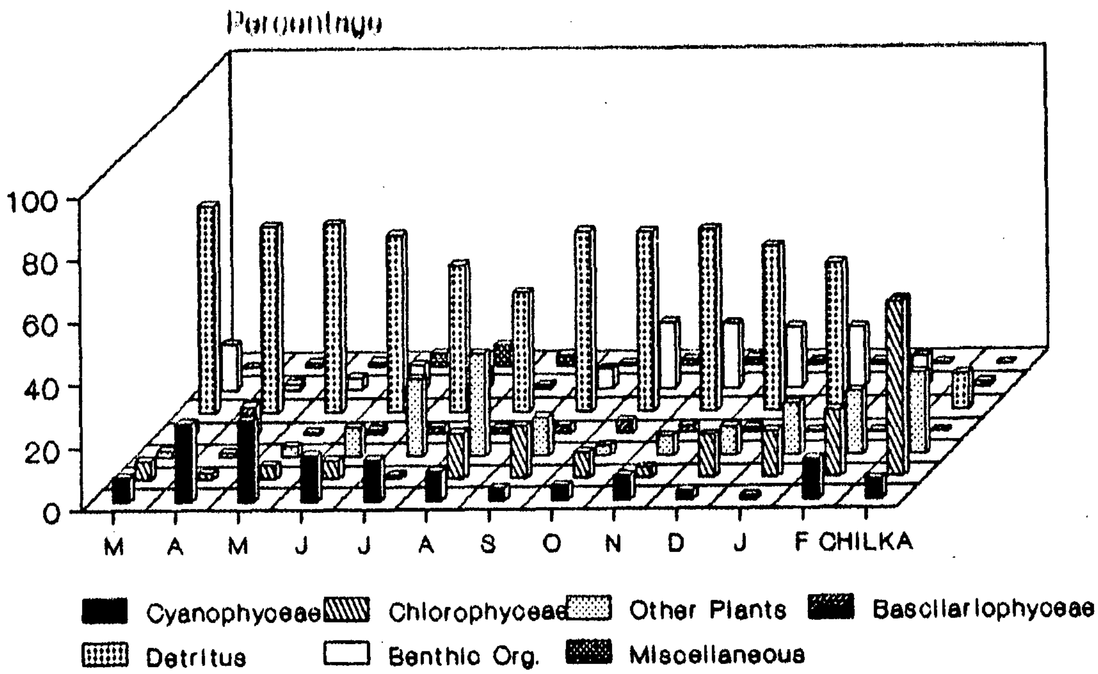



Fig. 5.2.1 Monthly variation in the food composition of E. suratensis

Polysiphonia contributed to the food of E. suratensis in small quantity (nil in July - August to 6.66% in January) through out the year. Sphacelaria was observed in small quantity (0.06 - 1.66%) from October to March only. Catenella was recorded only in June, August and January in very small quantity. Sea grass Halophila and other plant fragments were present in the gut throughout the year except April. The contribution of plant material was high in July, August and September when the plant fragments of terrestrial origin were also present significantly. The overall contribution of macrophytes ranged from 1.59 in April to 32.29% in August (Fig. 5.2.1).

The macrophytes present in the gut of Chilka lagoon samples were Polysiphonia and Halodule which contributed up to 25.72% . In terms of percentage frequency occurrence, the contribution of Sphacelaria varied from nil to 28.26% ; Polysiphonia from nil to 32.8%; Halophila and other plant material from nil to 38.89% .

BASCILARIOPHYCEAE: Diatoms were present throughout the year in the gut content of E. suratensis, though in small quantity, ranging from 0.46% in February to 9.0% in April. The different species observed in the gut were Navicula, Nitzschia, Pleurosigma, Diatoma, Cymbella, Surirella, Melosira, Pinnularia and Skeletonema. The percentage occurrence of diatoms was very high throughout the year ranging from a minimum value of 27.05 in July to 73.91 in November. However, in Chilka lagoon samples the diatoms were absent.

BENTHIC ORGANISMS: Benthic organisms collectively contributed from 0.71% in August to 20.86% in October. The overall contribution of benthos was high from October to March. The major taxa contributing to the gut content were sponges, hydrozoans, bryozoans, turbellarians, nematodes, polychaete egg mass, crustacean appendages and bivalve molluscs. Crustacean appendages contributed insignificantly (0.05 to 2.41%), though were present throughout the year. The contribution of nematodes was nil in July to o.40% in November, turbellarians from nil in September - October and December to 2.11% in May. Bryozoans contributed significantly only from October to February, ranging from 0.99% to 14.20%. Hydrozoans were present in small quantity ranging from nil (May, July and August) to 7.14% (November). Sponges were found only in July and November to January in a range of 1.46% to 2.08% . Molluscs were represented by Modiolus sp. which was observed in the guts only during June - July and September - October and contributed from 2.63 to 12.57 % to the food items. The other characteristic feature was the occurrence of polychaete egg mass in a significant quantity (9.71%) in March. Some of the guts were exclusively full of either Modiolus sp. or polychaete egg mass. The other food organism recorded in the gut was a folliculinid ciliate which is an epibiont. Hydrozoans dominated in terms of percentage occurrence from October to March with a peak value of 47.83% in November. Bryozoans, occurred from September to February, their contribution was significant ranging from 3.03% to 34.78%. Nematodes occurred in low percentage frequency throughout the year. Rest of the organisms were occurring either seasonally or intermittently in variable frequency percentage.

In Chilka lagoon samples, benthos contribution was very poor and were represented by sponges (0.22%) and bivalve molluscs (0.89%).

DETRITUS: The decayed organic material was the single most dominant item in the food content throughout the year, which ranged from 34.89% in February to 66.02% in March. Relatively, the percentage contribution of detritus was less in July, August, January and February viz. 46.60, 37.70, 46.86 and 34.89 respectively (Table 5.1).

Detritus, in terms of percentage frequency occurrence formed the major food item through out the year with a minimum value of 67.57 in July to 100 % in May.

MISCELLANEOUS: The other material observed in the gut were fish scales, sand, small wood fragments etc. which do not contribute to the energy source but probably entered accidentally along with other food items such as detritus. Their contribution ranged from nil to 6.31% . These items were comparatively more in June - August. The incidence of fish scales and sand was low, ranging from nil to 19.56% .

5A.2.3.3 Food in Different Size Groups: The percentage composition of different food items present in the gut of different length class groups is presented in Table 5.3 and Fig. 5.2.2 . In a size group of 41 - 60 mm the major items contributing to the food were blue green algae (84.37%) and the rest were diatoms (3.12%) and detritus (12.5%) . In the size

Table - 5.3. Food composition in the gut of different size groups (mm) of *E. suratensis*.

| Food items | Size groups 41-60 | 61-100 | 101-140 | 141-180 | 181-220 |
|---|---|---|---|---|---|
| **Cyanophyceae** | | | | | |
| *Oscillatoria* | 57.42 | 9.47 | 8.78 | 5.43 | 9.30 |
| *Phormidium* | 23.00 | 1.60 | 1.65 | 1.32 | 0.47 |
| *Lyngbya* | - | 0.24 | 0.68 | 0.37 | - |
| *Microcoleus* | 3.95 | 0.32 | 0.76 | 0.07 | - |
| *Anabaena* | - | 0.07 | 0.04 | 0.13 | - |
| *Merismopedia* | - | 0.32 | 0.06 | 0.11 | - |
| *Spirulina* | - | - | 0.49 | 0.11 | - |
| **Chlorophyceae** | | | | | |
| *Spirogyra* | - | - | 1.04 | 2.19 | 7.50 |
| *Rhyzoclonium* | - | 2.32 | 2.63 | 1.76 | 0.23 |
| *Enteromorpha* | - | 6.23 | 3.98 | 5.30 | 7.50 |
| *Cladophora* | - | 0.08 | 0.73 | 1.45 | - |
| *Chaetomorpha* | - | - | - | 1.05 | - |
| **Other micro and macrophytes** | | | | | |
| *Sphacelaria* | - | 1.14 | 0.59 | 0.34 | - |
| *Polysiphonia* | - | 1.36 | 2.14 | 2.18 | - |
| *Catenella* | - | - | 1.64 | 1.72 | - |
| *Halophila* and others | - | 8.73 | 9.78 | 10.27 | 12.19 |
| **Diatoms** | 3.12 | 3.12 | 2.16 | 1.91 | 0.94 |
| **Detritus** | 12.50 | 56.80 | 51.31 | 50.06 | 55.31 |
| **Benthic fauna** | | | | | |
| Sponges | - | 2.56 | 0.52 | 1.12 | 1.25 |
| Hydrozoans | - | 0.88 | 2.55 | 1.83 | - |
| Bryozoans | - | 1.04 | 5.13 | 2.77 | - |
| Turbellarians | - | 0.24 | 0.17 | 0.44 | 0.31 |
| Nematodes | - | 0.08 | 0.25 | 0.18 | - |
| Polychaete egg mass | - | - | - | 0.70 | - |
| Crustaceans | - | 1.04 | 1.19 | 0.53 | - |
| Molluscs | - | 0.16 | 1.08 | 3.65 | - |
| **Fish scales** | - | 1.28 | 0.17 | 0.73 | 2.50 |
| **Miscellaneous** | - | 0.80 | 0.52 | 2.20 | 2.50 |

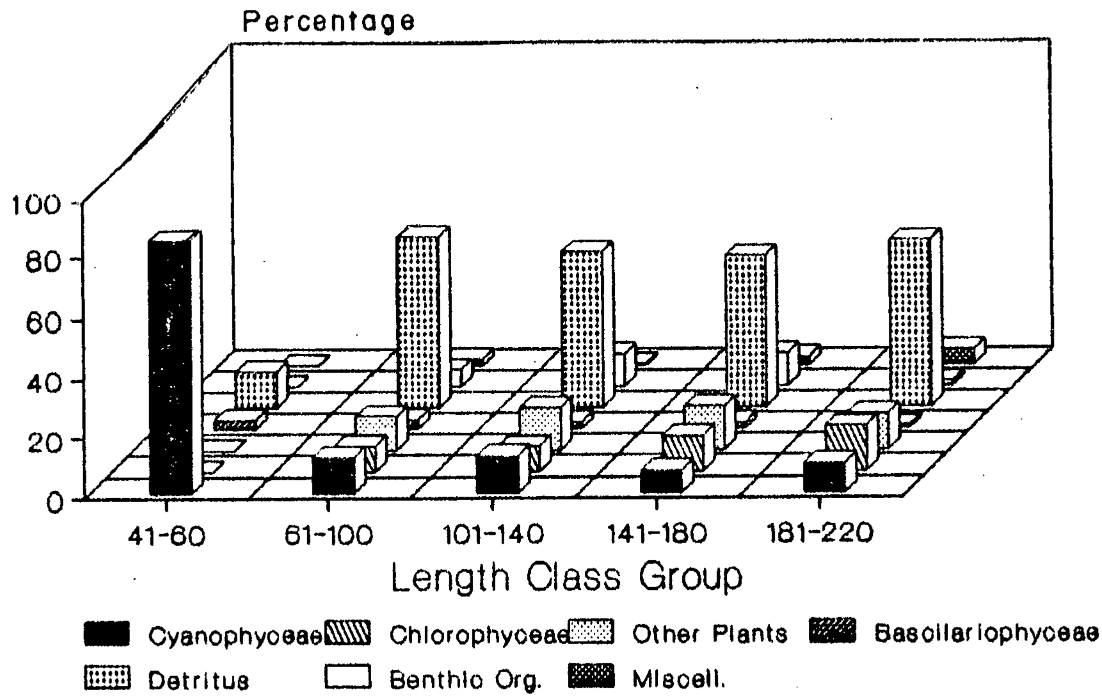



Fig. 5.2.2 Variation in food composition of E. suratensis in different size groups.

group of 61 - 100 mm, 101 - 140 mm, 141 - 180 mm and 181 - 220 mm there was no major difference in the food item except the size groups of 61 - 100 mm and 181 - 220 mm where the percentage of benthic organisms was comparatively less. The incidence of occurrence of blue green algae decreased with the increase in size whereas green algae, other macrophytes, diatoms, detritus and benthic organisms were equally poised (Table 5.4).

5A.2.3.4 Feeding Intensity: Seasonal variation in feeding intensity in terms of fullness of gut and gastro-somatic indices is given in Fig. 5.3.1 and 5.3.2, respectively . Considering the stomach fullness as a criteria to evaluate feeding intensity, the values varied from 9.49% in December to 53.97% in July. The degree of fullness of intestine was taken separately to evaluate the feeding intensity and the values ranged from 14.26% in June to 59.84% in November. Therefore, the mean values of both stomach and intestine (gut) were considered to express the feeding intensity. The feeding peaks in the year were May (44.36%), July (48.35%) and November (45.44%) with an annual average of 33.15±10.06% . The minimum feeding was recorded in June (17.37%) and December (20.26%).

The maximum feeding intensity (64.06%) was observed in size class of 41 - 60 mm, followed by 141 - 180 mm group (47.27%) whereas in rest of the groups it was almost uniform (Fig. 5.3.3). In Chilka lagoon specimens, the feeding intensity was very high, to the tune of 80.35% . Another unusual phenomenon observed was of the percentage of occurrence of empty gut, which varied from 6.0% in the month of March to 49.29% in August, with

Table - 5.4. Percentage occurrence of food items in the gut of different size groups ( mm ) of *E. suratensis*.

| Food items | Size Groups 41-60 | 61-100 | 101-140 | 141-180 | 181-220 |
|---|---|---|---|---|---|
| **Cyanophyeae** | | | | | |
| *Oscillatoria* | 100.00 | 46.15 | 33.33 | 28.87 | 20.00 |
| *Phormidium* | 100.00 | 20.51 | 21.60 | 8.45 | 10.00 |
| *Lyngbya* | - | 5.13 | 6.79 | 6.34 | - |
| *Microcoleus* | 25.00 | 2.56 | 4.94 | 1.41 | - |
| *Anabaena* | - | 2.56 | 1.23 | 1.41 | - |
| *Merismopedia* | - | 2.56 | 1.85 | 3.52 | 10.00 |
| *Spirulina* | - | - | 4.32 | 1.41 | - |
| **Chlorophyceae** | | | | | |
| *Spirogyra* | - | - | 3.09 | 4.93 | 10.00 |
| *Rhyzoclonium* | - | 7.69 | 16.05 | 4.27 | 10.00 |
| *Enteromorpha* | - | 25.64 | 11.73 | 19.72 | 10.00 |
| *Cladophora* | - | 2.56 | 1.23 | 3.52 | - |
| *Chaetomorpha* | - | - | - | 3.52 | - |
| **Other micro and macrophytes** | | | | | |
| *Sphacelaria* | - | 5.13 | 8.64 | 6.34 | - |
| *Polysiphonia* | - | 12.82 | 16.66 | 10.56 | - |
| *Catenella* | - | - | 3.70 | 2.82 | - |
| *Halophila* and others | - | 15.38 | 17.90 | 20.42 | 30.00 |
| **Diatoms** | 100.00 | 35.90 | 34.57 | 28.87 | 20.00 |
| **Detritus** | 100.00 | 89.74 | 93.21 | 88.73 | 90.00 |
| **Benthic fauna** | | | | | |
| Sponges | - | 5.13 | 1.85 | 4.23 | 10.00 |
| Hydrozoans | - | 5.13 | 19.75 | 13.38 | - |
| Bryozoans | - | 5.13 | 15.43 | 9.86 | - |
| Turbellarians | - | 7.69 | 3.09 | 7.75 | 20.00 |
| Nematodes | - | 2.56 | 6.79 | 4.23 | - |
| Polychaete egg mass | - | - | - | 0.70 | - |
| Crustaceans | - | 12.82 | 14.20 | 7.04 | - |
| Molluscs | - | 2.56 | 1.23 | 4.23 | - |
| **Fish scales** | - | 7.69 | 3.70 | 2.11 | 10.00 |
| **Miscellaneous** | - | 7.69 | 8.02 | 8.45 | 10.00 |

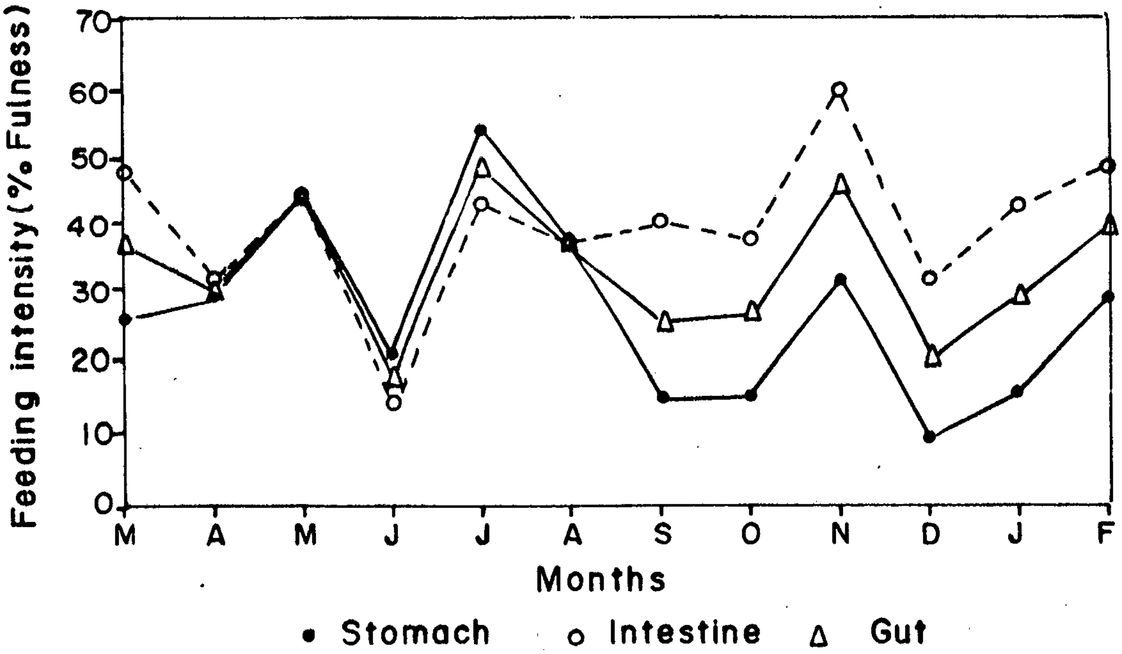



Fig. 5.3.1 Monthly variation in feeding intensity (% fullness) of E. suratensis.

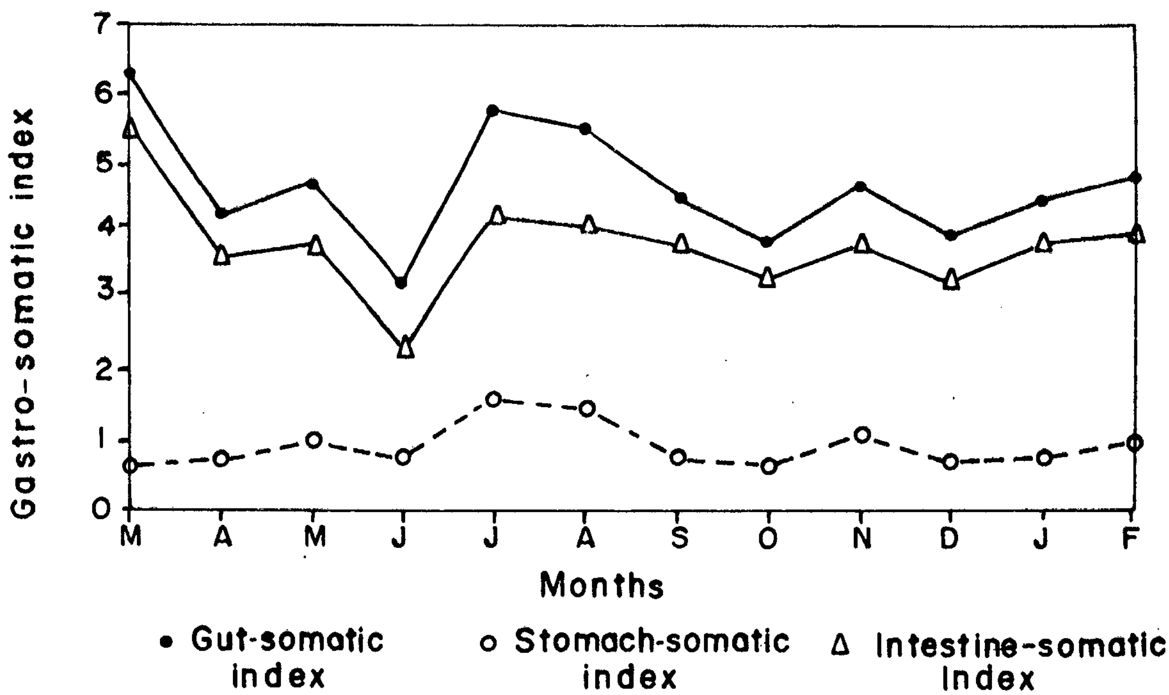



Fig. 5.3.2 Monthly variation in gastro-somatic index of E. suratensis

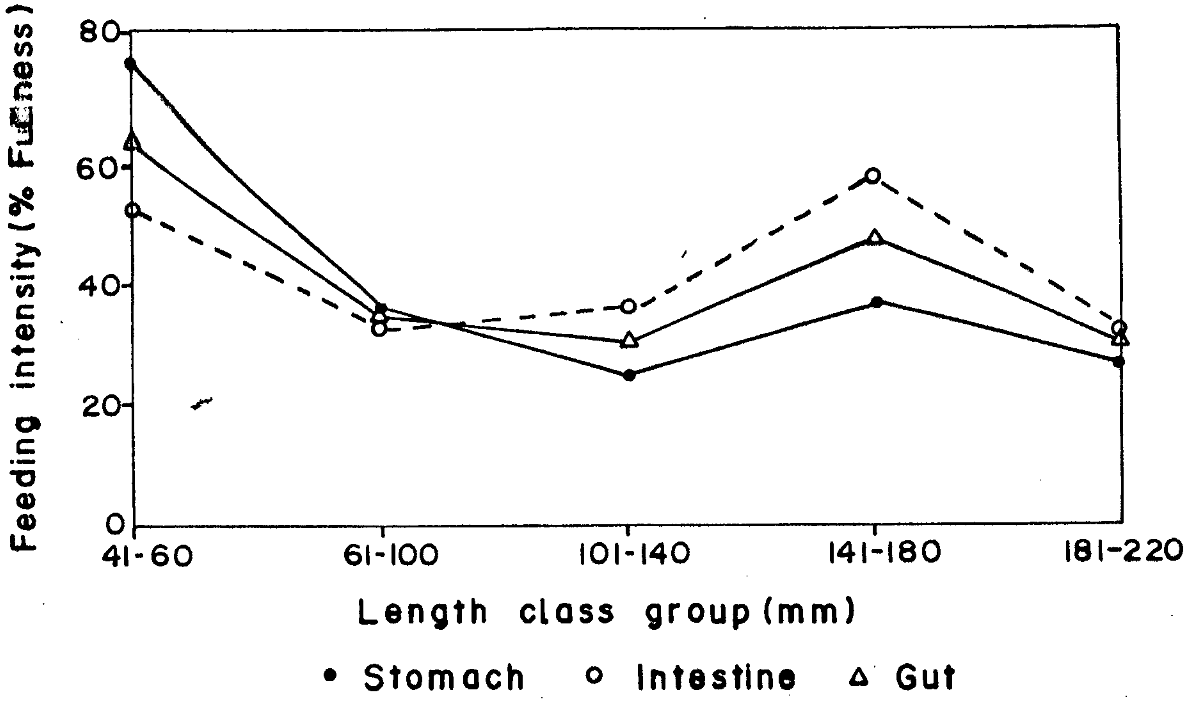



Fig. 5.3.3 Monthly variation in feeding intensity (% fullness) of E. suratensis.

an annual mean of 28.67 ±12.50% (Fig. 5.3.4). Prevalence of empty guts over different size groups revealed that empty guts were regularly found in all size classes except 41 - 60 mm group (Fig. 5.3.5a). Thereafter, the prevalence of empty guts was observed to be linked with different maturity stages of female (Fig. 5.3.5b) It was observed that in immature virgin and matured specimens the percentage of empty guts was high (23.33%) otherwise they were always uniformly distributed. The observation of feeding intensity in different gonadal maturity stages of female revealed that it was poor (28.92% and 13.97%) in matured and ripe specimens respectively, whereas in other stages of maturity it was higher than 33.82% .

## 5A.2.4 DISCUSSION

The analysis of gut content of _E. suratensis_ from Goa waters revealed that detritus comprised the maximum part of its food throughout the year. The occurrence of different types of food items in the gut indicates that it is an omnivorous species, feeding on algae, macrophytes, benthic organisms such as hydrozoans, nematodes, turbellarians, sponges, polychaete egg mass, crustaceans, molluscs etc. _Spirogyra_ sp. has been reported to be a preferred food item of _E. suratensis_ (Alikunhi, 1957). Earlier, it was described as an herbivorous species, feeding mainly on _Oedogonium_, _Spirogyra_, _Oscillatoria_, _Lyngbya_, _Cladophora_, _Volvocales_ and decayed plant material (Hora and Pillay, 1962). _E. suratensis_ has been reported to feed

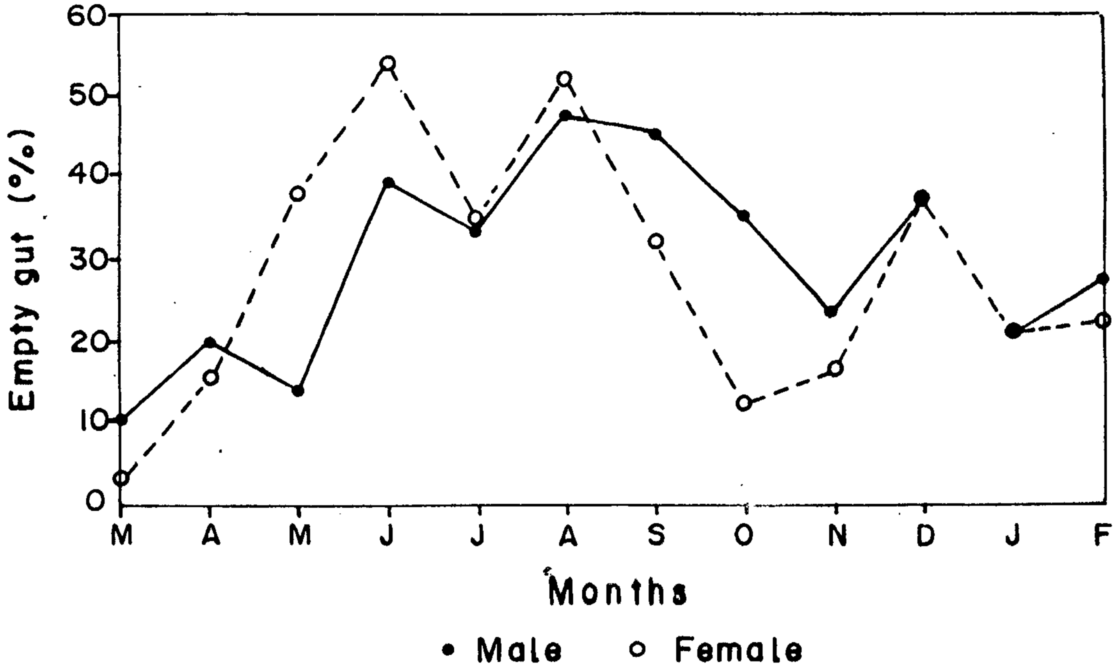



Fig. 5.3.4 Monthly variation in percentage frequency occurrence of empty gut in E. suratensis

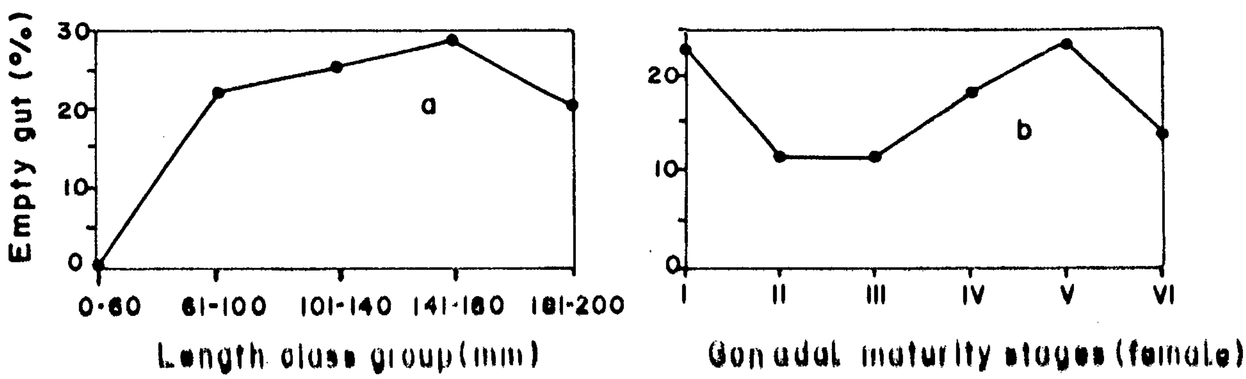



Fig 5.3.5 (a-b) Percentage frequency occurrence of empty gut (a) different size groups (b) different gonadal maturity stages of female.

predominantly on aquatic weeds, gastropods, bivalves, insects, mysids etc. (Jhingran and Natarajan, 1966). In Pulicat lake, the food of E. suratensis comprised mainly of filamentous algae, macrovegetation, detritus, hydrozoans, sponges and bryozoans (Prasadam, 1971). While studying the juveniles of E. suratensis, Devaraj et al. (1975) described the filamentous algae, detritus, microcrustaceans, insect larvae and plant material as the main food item. Costa (1983) studied the food and feeding habits of E. suratensis from three different habitats in Sri Lanka and described it as an omnivorous species, feeding on blue green algae, green algae, diatoms, fragments of higher plants, rotifers, cladocerans, copepods, ostracods, molluscs, oligochaetes, chironomid larvae, spicules or gemmules of sponges, sand particles, fish eggs and detritus, as observed in the present study. Jayaprakash and Padmanabhan (1985) recorded the blue green algae, higher aquatic plants, rotifers, insect larvae, cladocerans,copepods, molluscs, detritus and polychaete worms in the gut of E. suratensis from the south-west coast of India.

A perusal of earlier work reveals that E. suratensis prey upon different food items depending upon the availability in the environment. However, in the present study the early juvenile stages up to a size group of 60 mm were found to graze mainly on epiphyton such as blue green algae (84.37%), a small amount of detritus (12.5%) and fraction of diatoms (3.12%). In this size group, detritus and diatoms probably might have entered in the gut alongwith blue green algae, which traps the suspended organic matter and also colonise diatoms. This was further confirmed from the field observation, by collecting submerged material on which a shoal of young ones was grazing heavily. The composite material grown over the substrate was observed under the microscope and was found to comprise of Oscillatoria, filamentous bacteria Baggotia sp., diatoms, harpacticoid nauplii, nematodes, ciliates, rotifers, heterotrophic flagellates and organic matter (Plate 5.1). The young ones prefer shallow areas and surface waters, where there is an ample growth of epiphyton. Thus, while grazing on these epiphytes the other associated organisms and detritus are also consumed.

The role of unicellular algae in the nutrition of Tilapia was documented by Pantastico et al. (1985). From nutritional point of view, the members of the group cyanophyta are rich in protein viz. Spirulina (C P 68.90%), Oscillatoria (C P 25.60%) and Anabaena (C P 28.45%). Encouraging results in terms of survival and growth have been reported in silver carp when reared on the diet of cyanophyta members (Pantastico et al., 1986). Based on the growth results of these herbivorous fish and the occurrence of high percentage of blue green algae in the guts of juveniles of E. suratensis it can be inferred that pearl spot juveniles derive their protein demand from protein rich cyanophyta in the natural habitat. Therefore, rich growth of cyanophyta should be encouraged by providing additional substrate in nursery ponds in order to obtain higher survival rate and healthy seed.

?late 5.1 Photograph showing the submerged grass with settled suspended organic matter, epiflora and the epifauna.

Plate 5.1

In higher size groups, detritus comprised the maximum percentage of food, followed by chlorophyceae, cyanophyceae, and other macrophytes in almost equal ratio (Table 5.3). Diatoms comprised a small part of the food item in all the size groups. The percentage contribution of benthic and sedentary sessile organisms was significant (10.89 - 11.22%) in the size group of 101 - 180 mm, in comparison to lower and higher groups which can be attributed to more demand for quality protein (amino acids) by this size group, a most active breeding stage. Secondly, the herbivorous fish has a low protein diet (Opuszynski, 1992), but during the breeding phase the protein deficiency might be compensated by ingestion of animal food. In higher size groups, fish scales, sand, wooden fragments were observed in small quantity, which might have been ingested while grazing upon detritus. Thus, it can be concluded that juveniles (less than 60 mm) primarily prefer filamentous blue green algae subjected to their availability, whereas detritus and diatoms are consumed as associated material. In higher groups the diet is of mixed nature.

The observations (Table 5.1) further revealed that the role of an individual food item in the annual cycle is not so prominent except Oscillatoria sp. which contributed to the food of E. suratensis throughout the year, though in small quantity. However, each food group represented by different species displayed a definite annual pattern. Blue green algae was significantly predominant in the guts during April - May, probably because of its more abundance in the environment during this period. During the period from June to September and January - February, the collective contribution of plant material was significant which can be assigned to the abundance of terrestrial plant fragments carried by land run-off during monsoon period and better plant growth during monsoon and post-monsoon resulting from the enrichment of nutrients as a consequence of land run-off. The role of benthic organisms was evident during October to March, and their predominance coincided with the breeding season.

Most fish are opportunistic, feeding on items abundant at that time and the same is true with herbivores. The ingestion of animal food together with plants is an inevitable phenomenon of the feeding behaviour of herbivorous fish. Fish which tear or bite plants and scrap, whisk or suck sedimented detritus and algae also ingest small animals living on the bottom or in association with plant. Amino acids a product of protein digestion are important dietary components and essential for growth. Growth promoting amino acids are not synthesized by fish and are obtained from the diet. In the guts of some Tilapias the animal remains are rare whereas, in others the invertebrates clearly make up a significant proportion of the diet and probably ingested intentionally (Abdel - Malek, 1972; Spataru and Zorn, 1978; Whitefield and Blaber, 1978). Inclusion of invertebrates in the diet may be an important variable in the feeding strategy of Tilapias, but the actual role is still an enigma (Bowen, 1982). Anchovy require higher supply of protein from their food at spawning, because energy expenditure is high.

High energy demand during spawning turns the Engraulis capensis into egg cannibalism and the mix diet of eggs, phytoplankton and zooplankton provides energy and protein necessary for spawning (Valdes, 1993). The protein content in macrophytes eaten by marine herbivorous fish ranges from 1.6 to 7.0% (Opuszynski,1992). The animal protein is rich in eight essential amino acids (Burton,1965). Therefore, ingestion of animal food by herbivorous fish fulfil the deficiency of protein in terms of quantity and quality. In the present case too, the guts of some specimens were exclusively full of animal material like hydrozoans, bryozoans, sponges, polychaete egg mass and molluscs, indicating intentional browsing of fish on these organisms. Thus, E. suratensis, though predominantly a herbivorous fish and the animal matter is consumed along with plant and detritus, in certain instances it may actively prey upon invertebrates (animal matter) to augment its protein demand.

The quantity of detritus in the gut was relatively less during July - August and January - February, the rest was compensated by plant material during this period. Thus, the substitution of detritus by plant material indicate that E. suratensis prefers latter depending upon its availability and abundance, since the former is always there in plenty throughout the year. In Chilka lagoon samples also, the micro and macrophyte composition in the gut was 87.71%, though the availability of detritus was not a limiting factor. In some samples, the guts were exclusively full with blue green algae, green algae and sea grass Halophila sp., indicating that the fish might have come across rich beds of vegetation. Thus, the substitution of detritus by micro and macrophytes during certain period of the annual cycle, exclusive occurrence of vegetation in some guts, high percentage of vegetation in the guts of juveniles and Chilka lagoon samples indicate that E. suratensis is basically a herbivorous species, though it can thrive on detritus, epi-flora and fauna in the absence of micro and macrophytes. Further, the strong jaw teeth suitable for browsing over epiphytes, pharyngeal teeth to cut, tear and grind the plant material into fragments and long intestine also support its herbivorous nature. Odum (1970) suggested that the ratio between gut and body length increases with age as the fish changes its diet dominated by diatoms to plant detritus. He further mentioned that mullets adjust morphologically to the type of food available in the environment by lengthening the intestine for coarser diet. An intestine to fish ratio of 3.2 : 1 in Mugil cephalus is adequate to assimilate a diatom diet, while longer intestine is needed to extract from plant detritus and blue green algae. Morais (1976) observed the ratio of intestine length to standard length of M. cephalus on an average of 4.47 to 4.65 : 1 and mentioned that it was morphologically well adapted to digest either micro algae, macro plants and detritus diet. The ratio of intestine length to fish standard length in predominantly herbivorous species like Tilapia rendalli and T. melanotheron was reported to be between 7 : 1 and 10 : 1 (Caulton, 1976; Pauly, 1976). Thus based on food and feeding apparatus and the length of intestine to total length ratio (3.82 : 1) it can be said that E. suratensis is well adapted to the ingestion and digestion of microalgae and detritus diet. Opuszynski (1992) while discussing the herbivorous nature of fish, reported that a fish consuming more than 50% of plant material during any season or a part of its life can be categorised as herbivorous. He further added that herbivorous fish does require animal matter which is rich in protein and essential for growth.

The other food items which have not been reported by earlier workers were Polysiphonia, Catenella, sea grass Halophila, polychaete egg mass and bivalve, Modiolus sp.. Johnson (1977) considered the occurrence of 25% of a single item in two or more species as an indicator of interspecific competition. Thus, percentage frequency occurrence of more than 25% of a single item can be considered as a preferred food. Following this criteria, the preferred food items of E. suratensis in Goa waters are; Oscillatoria, Phormidium, Spirulina, Spirogyra, Enteromorpha, Sphacelaria, Polysiphonia, diatoms, hydrozoans, bryozoans and detritus. Some of the food items like blue green algae, Enteromorpha sp., diatoms and other fauna though occurred in small volume, the percentage occurrence was high (> 25%).

Fish feeding on filamentous algae, molluscs, worms and whose guts contain a fair proportion of sand grains are bottom feeders (Menon and Chacko, 1956). Accordingly, Jayaprakash and Padmanabhan (1985) categorised E. suratensis as bottom feeder. Based on the presence of fair amount of detritus in the gut observed in the present study, it may be possible to place it in the same category. However, the feeding behaviour either bottom or surface is a result of consequence of availability of preferred food item. In the field as well as in the laboratory experiment with Enteromorpha, it was observed to feed on the algal mass irrespective of the place whether bottom or surface. Therefore, E. suratensis is not strictly a bottom feeder but changes its mode of feeding depending upon the availability of the food.

Fish scales, sand grains and small wood pieces in the gut are probably the consequence of detritus composition in the habitat. However, in the present case, sand particles and fish scales were mostly found in the guts having little food, which means the food ingested alongwith these material has been already evacuated. Thus, the frequency occurrence of these items is enhanced due to retention in the gut for a prolonged period, as they are indigestible and do not slide smoothly in the gastric tract. Thompson (1954) described the function of sediment as grinding mill in the degradation of plant cell wall in case of mullets. The absence of sand particles especially in guts full of vegetation further support the fact that fish does not ingest sand intentionally to grind the plant material, but is ingested as a part of the detritus.

The feeding was at its peak in July and November, and the lowest in June and December. Higher rate of feeding in July can be attributed to the more abundance of live vegetation and terrestrial vegetation through monsoon run-off and in November due to high percentage of maturing and spent fish. Similarly, the poor availability of plant material in June and December coupled with higher percentage of matured specimens may be the possible reason for low feeding activity. The feeding activity was high (64.06%) in juveniles (41 - 60 mm) followed by 47.27% in 141 - 180 mm size group where the percentage of maturing and spent fish was high (Fig. 5.3.3). This could be attributed to increased requirement of energy during active breeding period for gonadal development and maturity (Karekar and Bal, 1958; Jayaprakash and Padmanabhan, 1985). In other size groups the feeding activity was uniform.

Another striking feature of the present study was the occurrence of high percentage of empty guts thoughout the year with a peak from June to September and December. Similar, observations have been made by Prasadam (1971), Devaraj et al. (1975) and Joseph and Joseph (1988a). The reason assigned to high percentage of empty stomach are regurgitation, periodicity in feeding, availability of food, physiological state and ill health (Bull, 1928; Philips,1929; Pillay, 1952; Joseph and Joseph, 1988a). In culture tanks, the regurgitation was not observed, where as being partially detrivore, the availability of food can not be a limiting factor. Furthermore, the high percentage of empty guts were also associated with poor feeding activity in June and December. The empty guts did not reveal any relationship either with different size group classes or with different gonadal maturity stages except in juveniles where no empty gut was recorded. Therefore, the possible reason for the high percentage of empty guts may be due to poor or no feeding during night time. The poor feeding intensity (13.97) in ripe fish can be attributed to the active involvement in courtship behaviour, compressed digestive tract due to fully developed ovary and the physiological state in relation to maturity. Feeding intensity was high in late maturing and spent stages, probably to meet the more energy requirement in comparison to other stages.

In a particular batch of uniform size sample, similar feeding intensity, similar food composition have been observed, which indicate movement of contemporary fish in groups and resorting to group feeding. This was confirmed in the field where shoals varying in number from 6 to 25 were frequently observed to move and feed together.

The stomach evaluation underestimates the feeding intensity as compared to intestine, because of its smaller size. Therefore, in case of herbivorous fish the average of both or the gut as a whole is suggested to be evaluated for analysis. E. suratensis is predominantly a herbivorous fish and prefers filamentous algae. However, in the absence or deficit of plant material it turns into detritivorous habit. E. suratensis can therefore be utilized as a biological mean to control aquatic vegetation in ponds and lakes, and phytofouling because of its scraping habit. This nature of turbation of bottom can help to work out the bottom soil and release the nutrients, resulting in enrichment in pond productivity. It can also be used in composite fish culture in association with Indian major carps to exploit the vegetation of the pond system. In culture systems, more space in the form of substratum needs to be provided for the development of algal growth, a preferred food item.

## 5B.3 PREDATORS AND COMPETITORS

In estuaries and backwaters the co-existing fish species along with E. suratensis were Lates calcarifer, Mugil cephalus, Megalopsis cyprinoides, Therapon jarbua, Glossogobius sp., Oreochromis mossambicus, Aplocheilus sp., Elops sp., Chanos chanos, Siganus sp., Ambassis sp., Sillago sihama, Lutjanus sp., Scatophagus sp. and gobids. The information on predation and competition in E. suratensis is based on on the reports available on the food and feeding habits.

### 5B.3.1 Predators

In estuaries and backwaters of Goa, the commonly occurring major predatory species are Lates calcarifer, Megalopsis cyprinoides, Therapon jarbua, Glossogobius sp. and Elops sp. A larvicidal fish Aplocheilus sp. is very common in backwaters of Goa and peninsular India. Forty days old fry of E. suratensis (15 - 17 mm) were observed to be preyed by Aplocheilus sp. within few minutes, when released in a shallow tank. In nature E. suratensis display parental care and nurse the young ones up to a size group of 20 - 30 mm, until they become independent. Parents are ferocious and guard the brood vigilantly. However, if the parents are caught or get separated from brood, the young ones may become an easy prey to Aplocheilus. Thus, the entry of Aplocheilus in E. suratensis nursery ponds is to be strictly restricted. The other species of predatory fish mentioned above are highly carnivorous and predacious.

In brackishwater farm a few Glossogobius caught in a cast net, had in their gut the young ones of E. suratensis. There is no certainty about the impact of predation on the natural population. However, in nature, E. suratensis spawns 600 to 4000 in a clutch, but the broods of fry carried by the parents were observed in a range of approximately 200 - 400 nos. Further, shoals of juveniles (40 - 60 mm) were observed in a range of 30 - 40 nos. Adults were always recorded in a group of 6 - 25. They certainly move in a shoal and the successive reduction in number in a shoal can be attributed to either separation of clonals in small groups or reduction in numbers in a shoal resulting from predation, natural, fishing or disease mortality. Since, E. suratensis spawns in shallow sheltered areas, the predation from fish eating birds such as Kingfisher and herons, as well as otters cannot be denied. There is a need of intensive field research in this regard to establish the prey predator relationship and the extent of population damage from predation, since the abundance of E. suratensis population is restricted in spite of its prolific year round breeding.

### 5B .3.2 Competitors

The contribution of plankton, benthos, detritus, epiphytes and macrophytes to the transport of energy and nutrients in an ecosystem can be evaluated by determining the food of individual organism or the pathways of food chain. The non predacious species co-existing with E. suratensis in Goa waters are mainly Mugil cephalus, Liza tade, Ambassis, Gobids and an exotic species O. mossambicus. The species of lesser abundance are Chanos chanos, Lutjanus, Sillago sihama, Siganus sp. and Scatophagus sp.

Mullets are the most predominant species in the coastal waters, estuaries and backwaters. The decayed organic matter (37.6%), blue green algae (17.8%), diatoms (10.8%), foraminiferans (2.09%), copepods (1.71%) and sand grains (29.39%) comprised the major food items of Mugil cephalus from Mandovi and Zuari estuaries of Goa (Das, 1977). The diet of juveniles (20 - 55 mm) is mainly comprised of bascillariophyceae (55.0%), green algae (22.30%), blue green algae (6.10%) and animal material (1.0%) (De Silva and Wijeyaratyne, 1977). The decayed organic matter, algae and foraminifera as the main food items of M. cephalus has been reported by Luther (1962). In Mugil parsia the bulk of stomach content comprised of decayed organic matter followed by algae (Oscillatoria sp.) (Ghosh et al., 1974). In detritus dominated system the un-recognizable material could be bacteria, fungi and protozoa of potential food value, which probably suffice the energy needs of the fish (Thompson, 1954).

The fingerlings of Liza tade feed on floating and attached myxophyceae, whereas, adults prey on the algae, diatoms and organic matter (Pillay, 1953). Further, it was stated that grey mullet M. tade prefer fresh or decomposing algae and when these are not available, it subsists on decaying macrovegetation. Mugil cephalus fry feed on phytoplankton, diatoms and epiphytic cyanophyceae; fingerlings prey on detritus and diatoms; and the adults consume blue green algae, green algae, detritus, small crustaceans and foraminiferans (Jhingran, 1982). The food of Oreochromis mossambicus is mainly comprised of macrophytes, benthic algae, phytoplankton, periphyton, zooplankton, fish larvae, fish eggs and detritus (Naik, 1973; Man and Hodgkiss, 1977; Bowen, 1979 and 1980). Tilapias that feed on macrophytes also ingest the attached algae, bacteria and detritus. Despite the diversity of food resources exploited by Tilapias, their diets are qualitatively very similar (mixture of algae, bacteria and detritus with or without macrophytes) (Bowen, 1982).

The food of Scatophagus larvae comprised of phytoplankton, diatoms and zooplankton, Acartia, Oithona and Temora. The juveniles and the adults mainly prey on Enteromorpha, Cladophora, Chaetomorpha and sea grass Halophila sp. (Thangaraja and Ramamoorathi, 1985).

Siganus spinus is a herbivore, browsing on benthic algae such as Padina, Cladophoropsis, Gelidium, Hypnea, Dictyota, Sphacelaria and Ectocarpus (Jones, 1968). Filamentous algae has been reported as the main food of Siganus jarvus. The common food material observed in the gut were, <u>Oscillatoria</u>, <u>Phormidium</u>, <u>Enteromorpha</u>, <u>Gracilaria</u>, <u>Halophila</u>, <u>Cymodacea</u> sp., bits of jelly fish, polychaete egg mass, polychaete worms, amphipods and gastropod egg masses (Balasubrahmanyam and Natarajan, 1984). The juveniles and adults of Siganids are primarily herbivores (Okada, 1966; Jones, 1968; Kalyamurthy and Janardan Rao, 1972; Von Westernhagen, 1974), occasionally, the gut may contain amphipods and copepods (Jones, 1968), sponges and foraminiferans (Hiatt and Strasburg, 1960) and fish larvae, crustacean larvae and siliceous spicules (Lam, 1974).

The food of <u>Chanos chanos</u> in estuarine environment comprised of bascillariophyceae, myxophyceae, chlorophyceae, diatoms, lamellibranchs and fish eggs whereas in ponds a plant animal complex (lab - lab) formed by the benthic green and blue green algae, diatoms, protozoans, copepods, bacteria, ostracods, worms , detritus, and decayed and live filamentous algae (Gopalkrishanan, 1972). The food of <u>Sillago sihama</u> is mainly of copepods, mysids, prawn larvae, tintinnids, polychaete and small fish (Radhakrishnan, 1957; Krishnamurthy, 1969; Gowda <u>et al.</u>, 1988).

The perusal of food and feeding habits of commonly co-existing species revealed that they prefer filamentous algae, blue green algae, green algae, macrophytes and diatoms, though can thrive on decayed organic matter in the absence of former. The almost similar food and feeding habits infer intergeneric and interspecific competition. Within any ecosystem most species of mullet avoid interspecific competition by selecting particles of different sizes. If at all there is any competition, it is reduced to minimum by preying on decayed organic matter which is nearly always present in excess (Blaber, 1977; Brusle, 1981). Mullets though utilize the plant detritus food as energy source, exhibit preference for living microphytes when both food sources are present in abundance. Such algal diet has a higher caloric content than detritus. Detritus may be a source of essential nutrients or provides assistance in break down of plant material (Oren, 1971). The present observation on food and feeding habits of E. suratensis also revealed its preference to filamentous and micro algae.

Different species of finfish co-inhabiting with E. suratensis are highly flexible in feeding ecology and switch over to detritus food chain in the absence of micro and macrophytes. The algal diet has higher caloric content than detritus (Oren, 1971). In natural systems the competition for plants is minimised by switching to detritus chain. The impact of competition for algal food on the growth and survival of an individual species at present is an enigma. In culture ponds, where the stocking density is high, the interspecific competition for algal as well as detritus food cannot be ignored. Thus, based on the food and feeding habits, mullets, milkfish, rabbit fish, pearl spot and Tilapias are not compatible species in polyculture systems. Since, the principle of polyculture system is to associate species of diverse food and feeding habits in order to exploit different food niches. These species at the most can be associated with Sillago sihama and prawns in polyculture systems.

## 5C.4 COMMON DISEASES AND PARASITES

Fish diseases and parasites have been less studied until last decade, since aquaculture activity was restricted to extensive and semi-intesive culture systems. At low stocking density, the water quality remains undisturbed and the incidence of infection is less. Secondly, the detection of disease is equally difficult at low densities in large water bodies. The advancement in intensive culture techniques, obviously invite quick environmental deterioration leading to the outbreak of diseases resulting in heavy mortality. The high stocking density further increases the chances of mortality as a consequence of en masse infection. Further, the fish is invariably transported either in the form of seed or brood stock, which may carry the localized diseases and parasites and spread all over. Therefore, it is essential to study the localized diseases and parasites of at least culturable species so that therapeutic and prophylactic measures could be developed.

The two reasons why there are few reports on the disease and parasites of E. suratensis than those of other culturable species are : 1) Its distribution is restricted to only peninsular India and Sri Lanka and no importance has so far been given to the study of its diseases, since the culture itself is practised in traditional way. 2) Probably the thick coat of scales which protect it from various external injuries and infections. In the present study, the common diseases and parasites from the natural population and from the laboratory culture tanks are described.

Observations on parasites were carried out on 205 specimens ranging in size from 85 mm to 165 mm in the months of March to June 1991 and the parasites identified as per Gussev (1963); Babu and Raj (1985a); Kabata, 1985. Fish were also maintained in the laboratory, and during the rearing period in few specimens "fin rot" disease was observed and the etiology was investigated. The infected specimens were treated with nitrofurazone (Colorni and Paperna, 1983) and the complete cure with the regeneration of the fin was observed in a period of 7-10 days. Other contagious infections observed in the laboratory reared specimens was of monogenean in gill filaments. In this case, only symptoms could be recorded, but the therapy could not be performed as the specimen died in a couple of days. 1002 specimens were examined to investigate the incidence of an isopod parasite.

### 5C.4.1 Diseases

Fin rot was observed to be the most frequently occurring disease in *E. suratensis*, when reared in captivity. Incidentally, epizootic ulcerative syndrome causing mass mortality in brackishwater fish was also recorded from the wild population of south Goa.

5C.4.1.1 Fin rot Disease: E.suratensis is generally found in a shoal of 6 - 25 numbers in natural waters. Initially, it seems to be territorial when stocked and reared in small culture tanks, and needs to be provided with sheltered hiding place, probably because of its timid nature. Hiding places further increased the territorial instinct and the fish developed nibbling habit,and damaged each others caudal fin which later aggravated to a fin rot disease. The same disease was also reported by Brightsingh et al. (1981), when they tried to rear it in an aquarium. However, the primary cause of infection was not assigned.

CLINICAL SIGNS: Initially, the caudal fin membrane is eroded, which slowly progressed towards the caudal peduncle, and in a couple of days the fin ray membrane part of the dorsal, anal and pectoral fin started eroding (Plate 5.2.1). The swimming behaviour of the fish got affected. It became inactive with folded fins and preferred to hide at the bottom.

ETIOLOGY: The affected part of the caudal peduncle was removed, and homogenized in normal saline and plated over nutrient agar and vibrio agar. Pour plates were incubated at room temperature. The dominant colonies were isolated and the bacteria were identified as gram negative rods of Vibrio, Pseudomonas, and Aeromonas. Brightsingh et al. (1981) reported the dominance of Pseudomonas, Vibrio, Aeromonas, Bacillus and Corynebacterium as an associated flora with fin rot disease of E. suratensis . The specific pathogenicity of the bacteria causing fin rot has been reported by Mahoney et al. (1973), Brightsingh

**Plate 5.2.1** Photograph showing eroded caudal fin (Fin rot disease).

**Plate 5.2.2** Photograph showing necrotic lesions (Epizootic Ulcerative Syndrome).

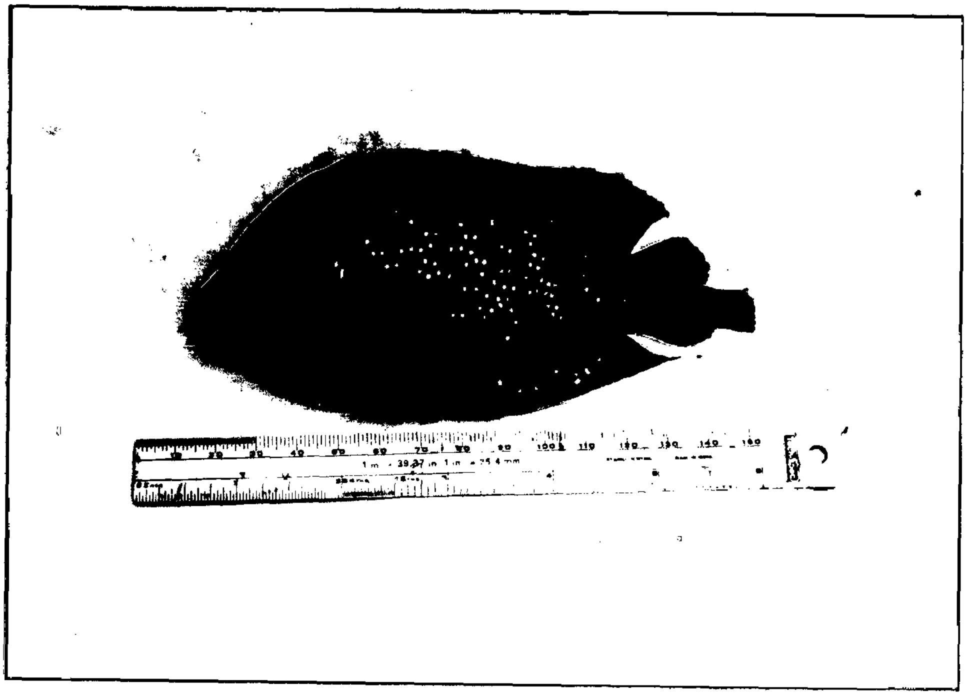


Plate 5.2.1

Plate 5.2.2

et al. (1981), Karunasagar et al. (1986 & 1988) and Kumar et al. (1986). Pseudomonas, Micrococcus, Alcaligenes, Vibrio, Arthrobacteria and Cytophaga are reported to be the associated flora of E. suratensis caught from the backwaters of Kerala (Surendran and Iyer, 1985). Similar associated bacterial flora has been reported from Sardinella longiceps and Rastrelliger kanagurta (Karthiyani and Iyer, 1967; Surendran and Iyer, 1976). These studies indicate that Pseudomonas, Vibrio, Aeromonas and Cytophaga are the most common microbes in marine and brackishwater environment and in the fish species, though the incidence of fin rot disease in natural waters is rather low. Brightsingh et al. (1981) inferred that probably dense bacterial population and environmental stress are the pre-requisites of epizootics. In a study of fin rot in brook trout (Salvelinus fontinalis), Bullock (1968) suggested that the primary cause of bacterial invasion is the lesion resulting from nutritional deficiency, injury and other predisposing factors. Thus, injury by nibbling, transportation or handling is the primary cause paving the way to the opportunistic Vibrio, Pseudomonas and Aeromonas resulting in fin rot disease.

THERAPY: The number of infected specimen were limited and were maintained for other experiments, therefore, various therapeutic agents and their concentrations could not be tried. Based on the earlier information (Colorni and Paperna, 1983), a commercial anti-bacterial agent sold under the trade name of "Furacin" (manufactured by ESKAYEF Ltd. Devanhalli Road Bangalore - 49), was tried. This commercial preparation consists of 0.2% of nitrofurazone w/w an active anti-bacterial agent. It is water soluble and self content with emulsifier. Furacin was applied in a fish tank of about 500 L water capacity at the rate of 0.4 to 0.5 mg/L of nitrofurazone for three successive doses on alternate days. Within a couple of days, the fish started moving freely and the fins were regenerated within a period of 7 - 10 days. Thereafter, the fish was reared for four months until used for further experiments. Colorni and Paperna (1983), reported that nitrofurazone cannot control the systemic infection, however, it has a practical value as general disinfectant. It does not interfere negatively with tissue re-generation (Kubota and Hagita, 1963). Thus, the fin rot disease in E. suratensis may be a superficial epidermal infection, which could have further led to systemic infection. The fast re-generation of fin could be an added advantage of the use of nitrofurazone as a therapeutic agent.

5C.4.1.2 Epizootic Ulcerative Syndrome (EUS): A case of severe ulcerative conditions occurring suddenly and causing mass mortality in the wild stock of brackishwater fish of Curtorim and Sridao area of Goa was observed during the monsoon season of 1993. The fish species affected were Mugil cephalus, Arius sp., Ambassis commersoni, Diodon sp., Therapon jarbua, Puntius sp., Glossogobius sp., Scatophagus sp., Siganus sp. and E. suratensis. Lesions with necrotic tissue and red patches were observed all over the body (Plate 5.2.?). The intestine was empty and the visceral parts were ulcerative. The similar outbreak of disease has been also reported earlier from different parts of India

(Anon., 1991; Kumar et al., 1991) and from Asia Pacific region (Anon., 1981; Rodgers and Burke, 1981; Coates et al., 1984; Roberts et al., 1986; Anon., 1988). The signs recorded in the infected fish were similar to those of EUS, reported earlier. The pattern of prevalence of epizootic (1989 in north-eastern states of India; 1990 in Sri Lanka and in 1991 in Kerala) indicates that the disease first errupted in the north-eastern states and later spread down south along the east coast, followed by an upward trend along the west coast of India.

In Goa, the incidence of EUS was as high as 90% in the Curtorim and Sridao areas, whereas the northern part of Goa was free from the epizootic. The prevalence of the disease coincided with the onset of the south-west monsoon, when the prevailing salinity in the brackishwater area was almost freshwater. The primary etiological agent is still an enigma, however, the preliminary findings indicate the possible role of virus in the epizootic (Anon., 1991; Kumar et al., 1991). In Goa waters, the prevalence of disease was only for a period of one month and latter subsided by the end of monsoon and simultaneous increase in salinity. There is no further report of epizootic from the earlier affected areas, indicating that in a couple of years, the local fish fauna gets immune to the virulent virus strain. In natural waters no prophylactic and control measures can be adopted, though, in culture systems the application of lime at the rate of 600 Kg/h in three instalments has been recommended (Kumar et al., 1991).

## 5C.4.2 Parasites

The detailed study pertaining to skin, gills, and fins parasites on the natural population of _E. suratensis_ was carried out on 205 specimens. Observations to detect parasites on the fish reared in culture tank were also made. The different parasites recorded during the present study were _Trichodina_ sp. (Ciliate), _Ancyrocephalus_ sp. (Monogenea), _Caligus_ (Copepoda) and _Cymothoa krishnai_ (Isopoda).

5C.4.2.1 Trichodina sp.: Only one type of organism was recorded in five specimens from natural population. It was located in gill filaments, with low number (5 -10 per gill arch) in all the specimens except in one where the population was in hundreds. The parasite was identified to be a `ciliate'. The generic level of identification was carried out by following description mentioned by Kabata (1985). Hemispherical body and the distinctive internal ring of denticles placed this parasite under the order Peritrichida and the suborder Mobilina. The adoral spiral of approximately $360^{o}$ and shape of the denticles, place this parasite under the genus _Trichodina_ sp. (Plate 5.2.3).

MORPHOLOGICAL CHARACTERS: The cell is roughly hemispherical, bellshaped and concave along its aboral surface; body cavity is completely surrounded by adoral cilia; marginal and lateral cilia present; cell diameter ranges from 25.22 - 34.92 μ; attached disc diameter 17.46 - 21.34 μ; denticulate ring diameter 13.58 - 17.46

**Plate 5.2.3 Microphotograph of a ciliate parasite *Trichodina* sp.**

**'late 5.2.4 Microphotograph of a monogenean parasite *Ancyrocephlus* sp.**

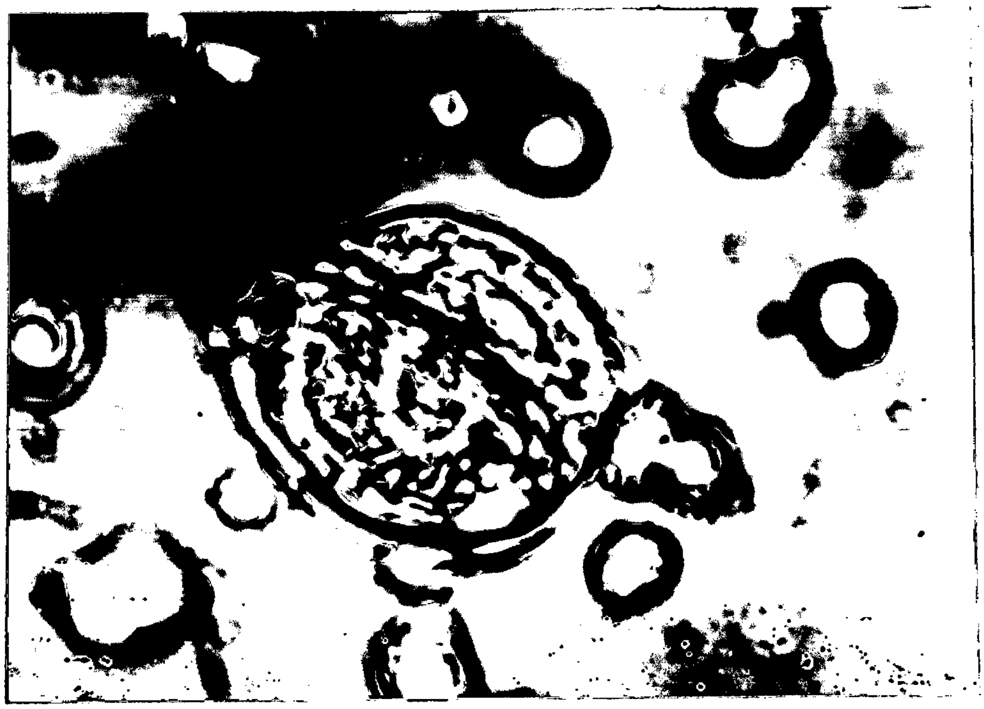


Plate 5.2.3

Plate 5.2.4

µ; border membrane, 2.91 - 3.88 µ ; length of denticle 3.88 - 5.33 µ; macronucleus horse shoe shaped.

5C.4.2.2 Ancyrocephalus sp.: About 10 specimens were observed to be infected in gills by the Ancyrocephalus sp., a member of monogenea group. The intensity of infection was 1 - 5 numbers per gill arch. However, the same species infected the laboratory reared specimens, where the intensity was 30 - 70 numbers per arch. The diagnosis could be done probably at a later stage, when one or two specimens started dying every day. Delay in diagnosis restricted the use of therapeutic agents as the whole stock of more than 20 specimens died in few days.

CLINICAL SIGNS: The fish became inactive, remained at the water surface and started gasping, indicating respiratory stress. The fish could be caught easily. Overall colour of the fish turned dark. Opercula appeared to be somewhat open. The colouration of gills turned pink rather than the original brick red and the edge of the gill filaments had grayish colouration. The gill filament appeared clotted and necrotic.

MORPHOLOGICAL CHARACTERS: The parasite was identified as per the key described by Tripathi (1957). Body elongated and sides almost parallel; anterior end truncate; two pairs of eye spots with the posterior overlapping the pharynx; three pairs of head organs present; haptor demarcated from the body by a constriction and broader than the length; two separate equal horizontal bars on the haptor which lies one above the other; vagina not prominent and is on the right side of the body; vitellaria from behind the pharynx to the end of the body. In preserved specimens the length of the Ancyrocephalus sp.(Plate 5.2.4) recorded from E. suratensis varied from 58.80 - 124.95 µ; breadth 36.75 - 51.45 µ; haptor length 29.1 - 34.92 µ; haptor breadth 38.80 - 64.02 µ; anchor length 23.28 - 25.20 µ; horizontal bar length 21.34 - 25.22 µ.

5C4.2.3 Caligus sp.: Three copepod parasites were recorded from the branchial chamber of different hosts. The parasites were identified as Caligus sp. (Plate 5.2.5) as per Pillay (1963 a & b) and Kabata (1985).

MORPHOLOGICAL CHARACTERS: Unfortunately, all the three specimens were females bearing following characters: Cephalothorax covered dorsally by sub-circular sucker like shield; carapace broader than long with maximum width below the median line and two lateral incisions; anterior margin with fringed plates; lunules big, sub-circular; posterior margin of the thoracic zone slightly protruding beyond the tip of lateral zones; fourth leg bearing segment narrower than the posterior margin of the cephalothorax and the genital segment; genital segment flask shaped and slightly longer than the abdomen; lateral setae on the posterior margin of the genital segment; abdomen single segmented and sub-rectangular; five setae on each uropod, four prominent sub-equal in length with the fourth being the largest. Total length, 2.60 - 2.75 mm; cephalothorax, 1.00 - 1.05 mm; maximum width of cephalothorax, 1.15 - 1.25 mm; width of thorax at the centre 0.50 - 0.60 mm; length of the leg bearing segment, 0.28 - 0.35 mm; length of genital segment, 0.55 - 0.60 mm; maximum width of

Plate 5.2.5 Microphotograph of a copepod parasite _Caligus_ sp.

late 5.2.6 Photograph showing male (small) and female (bigger) isopod parasite _Cymothoa krishnai_.

Plate 5.2.5

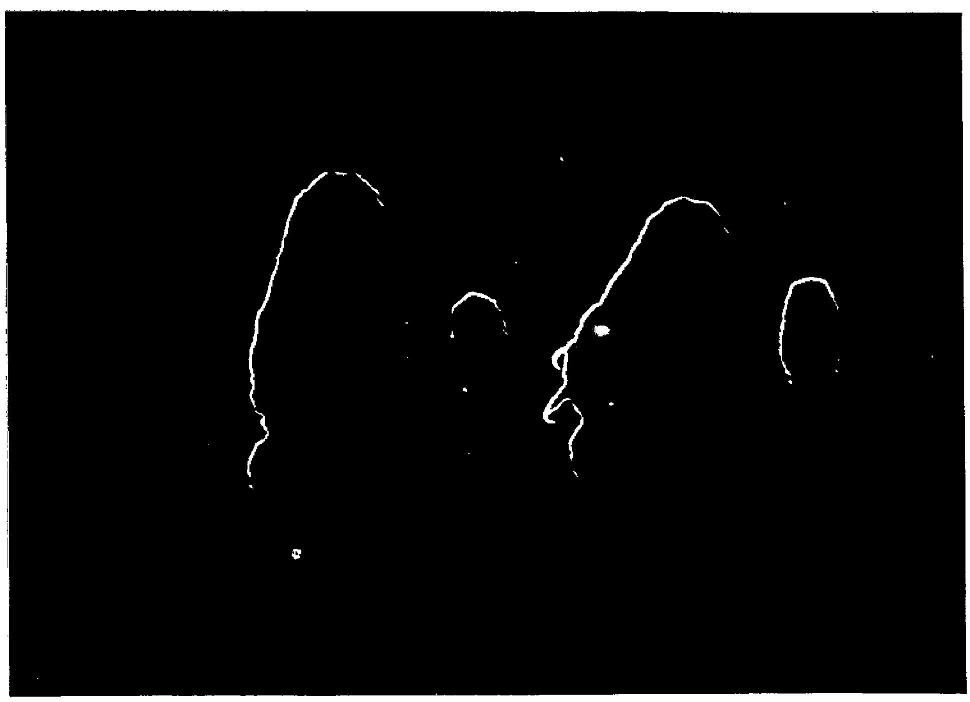


Plate 5.2.6

genital segment, 0.44 - 0.48 mm; length of abdomen, 0.46 - 0.55 mm; width of abdomen, 0.23 - 0.26 mm; length of uropods, 0.11 - 0.13 mm.

5C.4.2.4 Cymothoa krishnai (Babu and Raj, 1985a): Four pairs of isopod parasites were recorded from the buccal cavity and the bucco-pharyngeal cavity of different hosts. The parasites were identified as male and female of Cymothoa krishnai (Plate 5.2.6) following standard key. The species was confirmed from Dr. S. Jayadev Babu, Professor, Sir, Theagaraja college, Madras. The striking feature of the observation was that the parasites were recorded in the form of male and female pair in a single host. The female is distinctly bigger than the male.

MORPHOLOGICAL CHARACTERS: Female: Body short, stout and obovate; cephalon triangular constricted at the antenal area; cephalon convex posteriorly with prominent posterio-lateral angle; cephalon sunk in the first peraeonite; eyes very small; first four peraeonites of sub-equal length; first peraeonite relatively long, anterio-lateral parts acute and posterior margins slightly convex; second to fifth peraeonites are in increasing order of width, posterior margins convex; maximum width of parasite is at the fifth peraeonite; sixth and seventh peraeonites are short and narrow than the fifth with the posterior margin concave having the posterio-lateral processes extending up to the last pleonite; legs prehensile, arranged in a gradual increasing order of size and curved dactli; seventh leg is the largest and inwardly produced into a blunt process.

Pleon triangular, with the posterior margin broad and the anterior immersed in the peraeon; a median ridge on the pleon; pleonite sub-equal in length, but arranged in increasing order of breadth; breadth of telson is double of its length; telson broader than pleon; uropods inwardly produced and shorter than the telson; both rami with apical setules.

Light brown pigment throughout the dorsal part of the body, with dark colouration at the cephalon, first peraeonite, at the base of pleon and proximal part of telson. Total length, 18.00 - 19.25 mm; length of cephalon, 1.75 - 3.00 mm; peraeon length, 10.50 - 11.00 mm; maximum breadth at peraeon, 8.50 - 9.00 mm; pleon length, 2.50 - 3.25 mm; maximum breadth at pleon, 5.0 mm; telson length, 3.00 - 4.00 mm; telson breadth, 6.50 - 7.00 mm; weight, 0.440 - 0.465 g.

Male: Body oblong, sides sub-parallel; cephalon triangular and sunk in the first peraeonite; eyes relatively large and conspicuous; first peraeonite slightly long with anterio-lateral and posterio-lateral angles produced, posterior margin convex; peraeonites from second to fifth arranged in increasing order of length with straight margin; sixth and seventh peraeonites sub-equal, both with anterio-lateral and posterio-lateral angle, posterior margin convex; seventh peraeonite shorter than the sixth; pleon narrow and sunken in the peraeon ; all pleonites sub-equal and placed in an increasing order ; telson broader than the length; uropods short with apical setule.

Body uniformly coloured with brown pigment on the dorsal side, comparatively darker at the cephalon and pleon. Total length, 7.00 - 10.00 mm; cephalon length, 1.25 - 1.5 mm; peraeon length, 4.75 - 6.50 mm; maximum breadth at peraeon, 3.50 - 4.25 mm; pleon length, 1.50 - 1.75 mm; maximum breadth of pleon, 2.50 - 3.00 mm; telson length, 2.00 - 2.75 mm; telson breadth, 2.75 - 3.50 mm; weight, 0.045 - 0.065 g.

### 5C.4.3 DISCUSSION

Fin rot disease and *Ancyrocephalus* sp. infestation seem to be the major threats to the culture of *E.suratensis*. Nitrofurazone can be used as prophylactic measure and to control fin rot disease in culture systems, provided the diagnosis is done before it could attain the stage of systemic infection. Epizootic ulcerative syndrome is a deadly disease causing mass mortality in short duration, however, the trend indicates that the stock gets immune after the first attack. The extent of damage done by *Trichodina* sp. could not be adjudged from the present study, since the host specimens were collected from the market. *Caligus* sp. and *Cymothoa krishnai* were recorded in very low intensity and incidence of infestation, thus, it does appear that the extent of damage to the standing stock may not be severe. Monogenean parasites, *Ancyrocephalus etropli* and *Ceylonotrema colombensis* have been reported to infest the gill filaments of *E. suratensis* (Gussev, 1963). *Cymothoa indica* was reported to infest various fish species including *E. suratensis* in Adyar estuary and fish farm (Panikkar and Aiyar, 1937; Evangeline, 1963). Similarly, *C. krishnai* has also been reported to infest various estuarine fish species in Pulicat lake, but not *E. suratensis* (Babu and Raj, 1985a). *Trichodina* sp., *Caligus* sp., and *C. krishnai* are the new records for *E. suratensis* and also to the estuarine complex of Goa.

# CHAPTER VI

# REPRODUCTION AND DEVELOPMENTAL BIOLOGY

## 6.1 INTRODUCTION

In aquaculture, the primary concern is to obtain maximum number of seed of the highest possible quality of any culturable species. The availability of quality seed is a limiting factor for advancement of aquaculture and this is particularly important in the farming of any commercial species. A matter of concern of parallel importance is the ability to control fish reproduction. This has become an important aspect of present day culture, because of the demand of continuity in supply of table fish and fish seed throughout the year. This requirement can only be met, if sufficient information is generated pertaining to size at first maturity, reproductive behaviour, fecundity, spawning periodicity and developmental biology of the candidate species.

Maturation and spawning in E. suratensis has been studied in different habitats (Jayaprakash and Nair, 1981; Costa, 1983; Joseph and Joseph, 1988b). There is a great deal of uncertainty and variability about the sex ratio, gonado-somatic index and reproductive behaviour. If such variabilities are bound to exist in different populations, it becomes essential to investigate the reproduction of a candidate species in different environments. The same species grows at different rate in different water bodies suggesting that environmental differences are more potent than genetic differences in determining maturation and maximum size (Lowe-McConnell, 1982). Further, it has been reported that, in case of Tilapia the great plasticity in growth in natural waters indicates that the research on environmental and behavioural factors affecting growth and the switch to reproduction is likely to be more helpful for culture than search for faster growing genetic strains. There is a lack of sufficient information on the breeding behaviour and developmental biology of E. suratensis except a brief description by Jones (1937). Therefore, the present study on reproduction and developmental biology has been supplemented with field observations in order to elucidate the variability if any, resulting from differences in habitat or to support the previous work.

## 6.2 MATERIALS AND METHODS

Fish sample were collected at weekly interval over a period of 16 months (Feb., 1990 to May 1992) from Panjim fish market and were also caught from the backwaters of the Mandovi estuary, Old Goa. Total length and weight of individual specimen was recorded and the sex was determined by observing the gonads of dissected specimens. Morphological characters and the weight of each gonad were recorded and preserved in 7% neutral formaldehyde for further studies. In case of female, different gonadal maturity stages were categorised based on the morphological characteristics and the ova diameter. Matured ova are elliptical in shape and the maximum length of the ova is considered as ova diameter (Prabhu, 1956). Different stages of ova were distinguished based on size and morphological characters observed under the microscope. At each stage of maturity, ova size frequency was studied in 8 - 10 specimens to delineate the periodicity in spawning. The ripe ova are large enough to be distinguished and can easily be separated from other batches. Therefore, all the matured ova in each ripe ovary were counted and the fecundity was estimated from 42 specimens of variable total length. Average monthly gonado-somatic index (gonad wt. x 100/ body wt.) was calculated in order to infer the spawning season. The mean ovum volume was estimated by volume displacement method. The mean wet weight of matured ovum was measured by weighing a batch of 200 ova each from 17 ripe ovaries. Similarly, mean dry weight of ovum was calculated.

Spawning efforts (fecundity x dry wt. of ovum) per spawning batch were calculated as described by Blaxter and Hunter (1982). Field observations were also carried out to understand the spawning ethology. The fertilized eggs were collected from the natural habitat on three occasions to study the different developmental stages in the laboratory. The fertilized eggs (embryos) were kept for hatching in $25 \times 10^{-3}$ salinity and different developmental stages at regular interval of time were recorded by observing under a projectina microscope. The hatchlings were reared up to fry stage on decapsulated *Artemia* cysts obtained from New Technology Ltd., Halow - Kent, England and the growth parameters were recorded at an interval of 10 days. All the measurements and drawings were carried out over a projectina microscope. All the characters presented here pertaining to larval development are based on live specimens.

## 6.3 RESULTS

6.3.1 General Morphology of Gonads: The ovaries are paired structures lying ventral to the air bladder and attached to the dorsal wall of the coelom by a short thick mesovarium. Ovaries are cylindrical and closely apposed to one another throughout the length. Posteriorly, the ovaries are fused to form a common short muscular oviduct which opens to the exterior immediately behind the anal opening. A rare specimen of a single tubular, and functional matured ovary was also recorded (Plate 6.1a). Another rare specimen of paired ovary was recorded in which one ovary was blind without any opening to the oviduct (Plate 6.1b). The normal ovary was functional and matured, whereas, the abnormal was partly comprised of disintegrating ripe ova and the rest liquified ova. Probably, this ovary matures simultaneously as per the physiological state of the fish and later the ova becomes atretic, since there is no passage to release them. This process might be repeated in the ovary according to the spawning cycle.

The testes are also paired structures, lying immediately below the air bladder. These are thin capillary type and comparatively longer than the ovaries. Each testis remain separate for most of its length. Posteriorly, each testis unites to form a common sperm duct which opens to the exterior

Plate 6.1 Photograph showing abnormal ovaries (a) single functional ovary (b) Upper non-functional ovary without opening to oviduct and the lower normal functional one.

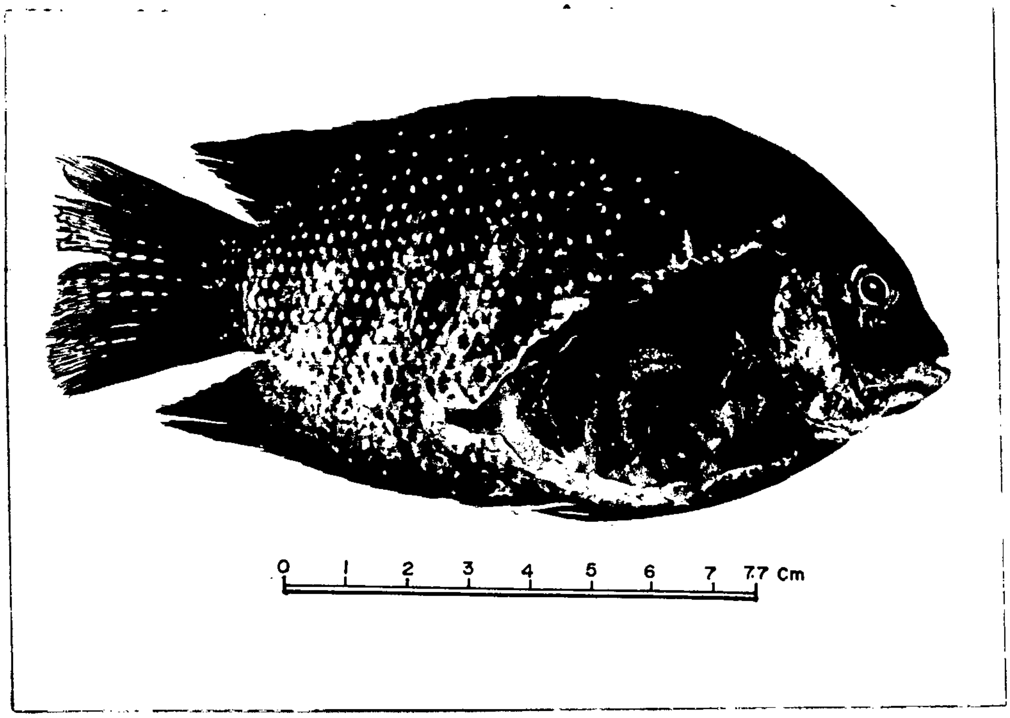



Plate 6.1 a

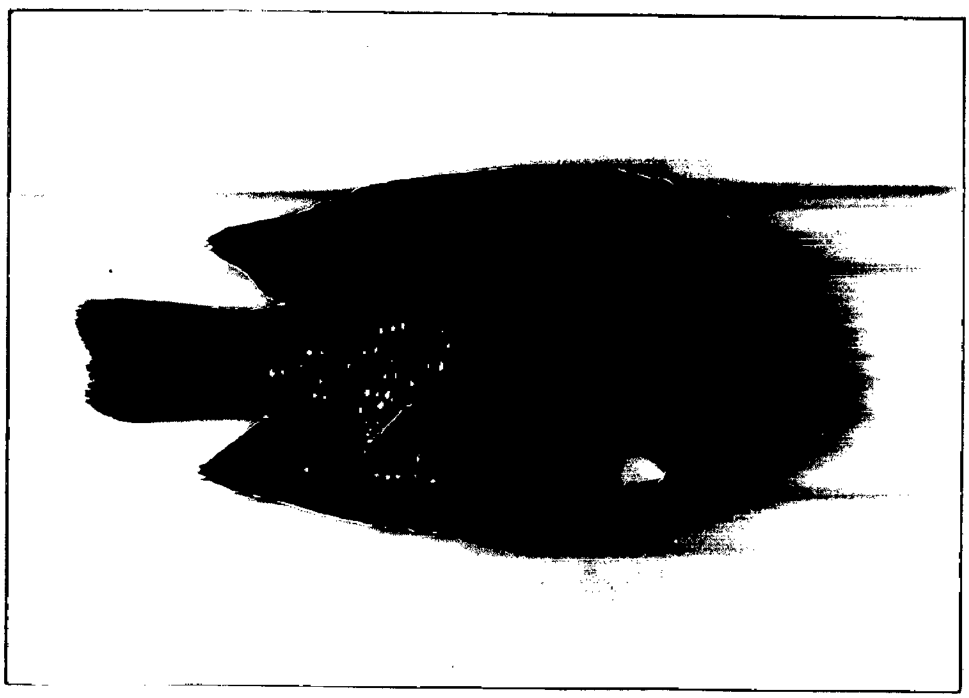


Plate 6.1 b

along with urinary duct into a common gonopore just behind the anal opening.

6.3.2 Sexual Dimorphism: Sexual dimorphism is apparent in many groups of fish, though some groups are monomorphic. Some groups show secondary sexual characters which are linked to spawning activity (Tilapia aurea; Fishelson, 1966). In E. suratensis, no external observable characters are known to distinguish female from male. During the present study, the sex distinguishing character was observed only in the urino-genital papilla. In female, the genital papilla is more swollen and the swelling extends anteriorly up to the anus (Plate 6.2a). Posteriorly, the papilla is blunt with wide urino-genital opening. Because of the extensive swelling and compression due to papilla, the anus opening becomes narrow. In ripe female, the enlarged mature gonads can be felt externally by the presence of comparatively hard and marginally swollen dorsal part of visceral cavity. In male, the papilla is relatively less swollen and the swelling does not extend up to the anus, as a result the anus looks much wider (Plate 6.2b). Posteriorly, the papilla is pointed with narrow opening. These sex differentiating characters are more pronounced after attaining first maturity and in the following successive stages of maturity of a female fish. The sexing becomes easier by using magnifying glass. However, it needs experience to reach high level of accuracy. More than 125 specimens were sexed based on these characters and counter checked by dissecting and observing the gonads. This method was found reliable up to a degree of 85%. Furthermore, this method

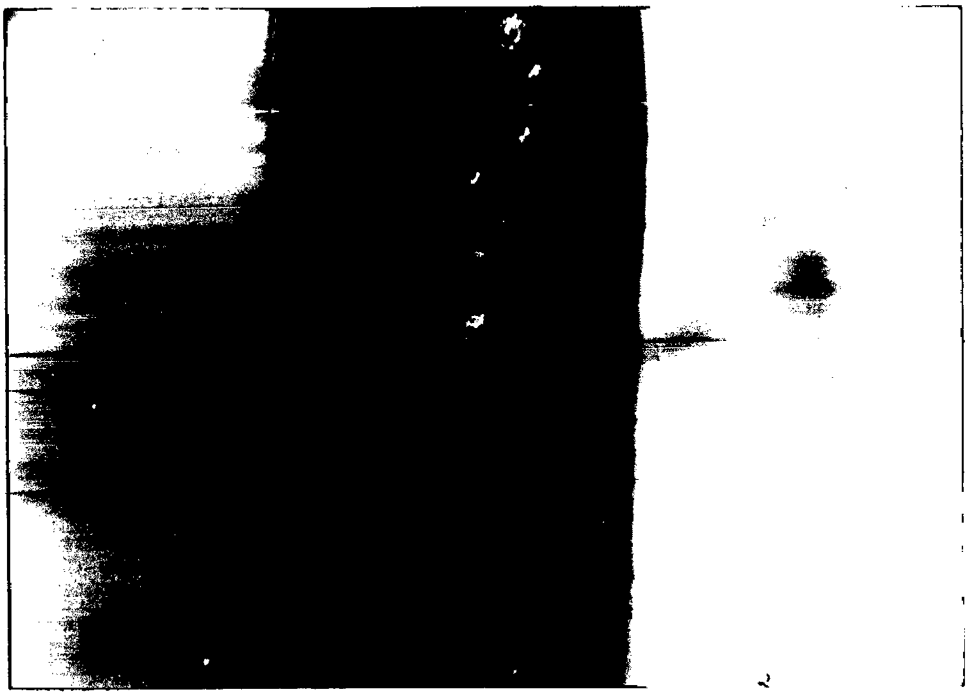


Plate 6.2a

Plate 6.2b

of sexing may be helpful in pairing for controlled breeding.

Internally, the sexes can easily be distinguished by observing the gonads. The smallest size at which the sex could be distinguished by observing gonads was 60.00 mm.

6.3.3 Stages of Developing Oocyte: The different developing stages of oocyte may conveniently be described based on size and morphological characters and are shown in Plate 6.3.

Stage - I: The oocytes of this stage were found in nests in large numbers. The size of the oocyte varied from 17.85 to 35.70 µ. The oocyte has a distinct centrally placed nucleus surrounded by cytoplasm.

Stage - II: The size of IInd stage oocytes ranged from 35.70 - 78.54 µ. Their number is more in the ovary than other stages. The nucleus is prominent in the centre of the cell. A thin layer of follicular cells could be seen on the oocyte. The shape of the oocyte was highly variable depending upon their location in the ovary and degree of compression, which in turn vary according to the maturity stage of the ovary.

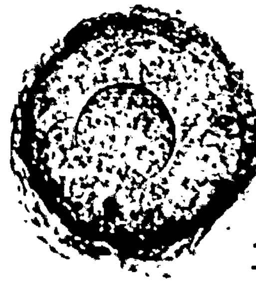
Stage - III: The oocyte shape was spherical and the size varied from 64.26 - 149.94 µ. The nucleus could still be seen in the oocyte. A thin layer (zona radiata) was formed between the oocyte and the follicular cells.

Stage - IV: The size of the oocyte varied from 135.60 - 199.92 µ. Minute yolk vesicles were formed in the cytoplasm which made the

Plate 6.3 Photograph showing different stages of intra-ovarian ova of *E. suratensis*. stage -I 35.70 µ, stage - II 57.12 µ, stage - III 99.96 µ, stage - IV 142.80 µ, stage - V 199.92 µ, stage - VI 321.30 x 242.76 µ, stage - VII 749.70 x 442.68 µ, stage - VIII 1049.58 x 585.48 µ, stage - IX 1435.14 x 756.84 µ, stage - X 2042.04 x 1035.30 µ.

I

II



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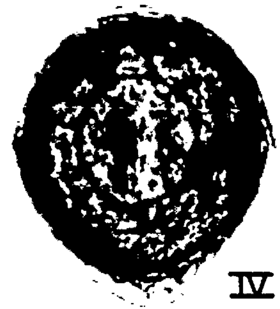

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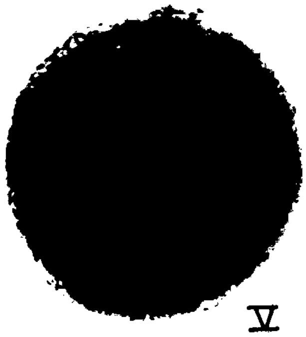

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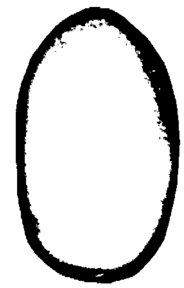

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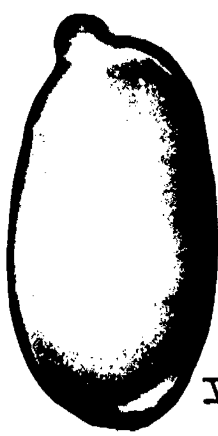

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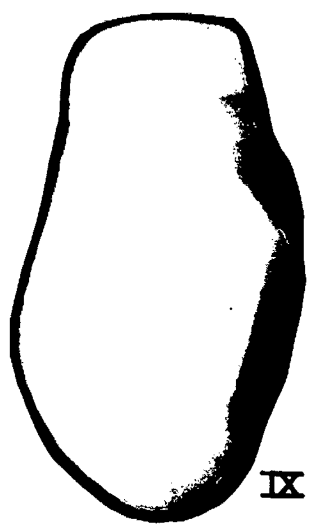

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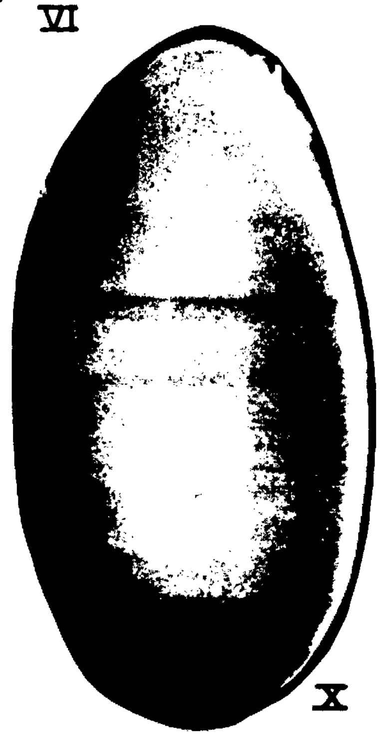


X

oocyte opaque and reduced the visibility of nucleus. The zona radiata became thick.

Stage - V: The size of the oocyte ranged from 185.65 - 214.20 µ. The yolk granules increased in number and the oocyte looked like a dark spherical structure. The nucleus is completely invisible.

Stage VI: The oocyte which was spherical in the previous stage, started attaining oval/elliptical shape by gradual elongation of the cell. The oocyte is narrow anteriorly and broader posteriorly. The size ranged from 271.32 - 464.68 X 249.9 - 357.0 µ.

Stage VII: The oocyte is elliptical in shape and the size ranged from 514.08 - 799.68 X 349.86 - 442.68 µ.

Stage VIII: The oocyte further increased in size as a result of more deposition of yolk and the size ranged from 856.80 - 1213.80 X 499.8 - 685.4 µ.

Stage IX: The size of the oocyte ranged from 1285.5 - 1600.00 X 756.84 - 963.9 µ.

Stage X : This is a ripe stage and the size varied from 1499.40 - 2400 X 1035.30 - 1246.50 µ

6.3.4 Maturity Stages of Ovary: Based on the morphological characters, occurrence of different stages of oocyte and the modal size of the largest group of ova, the following maturity stages (Plate 6.4.1) could be distinguished. The modal size of largest group of ova is variable in each specimen, hence typical

Plate 6.4.1 Photograph showing different maturity stages of ovary of *E. suratensis*.

Plate 6.4.2 Photograph showing different maturity stages of testes of *E. suratensis*.

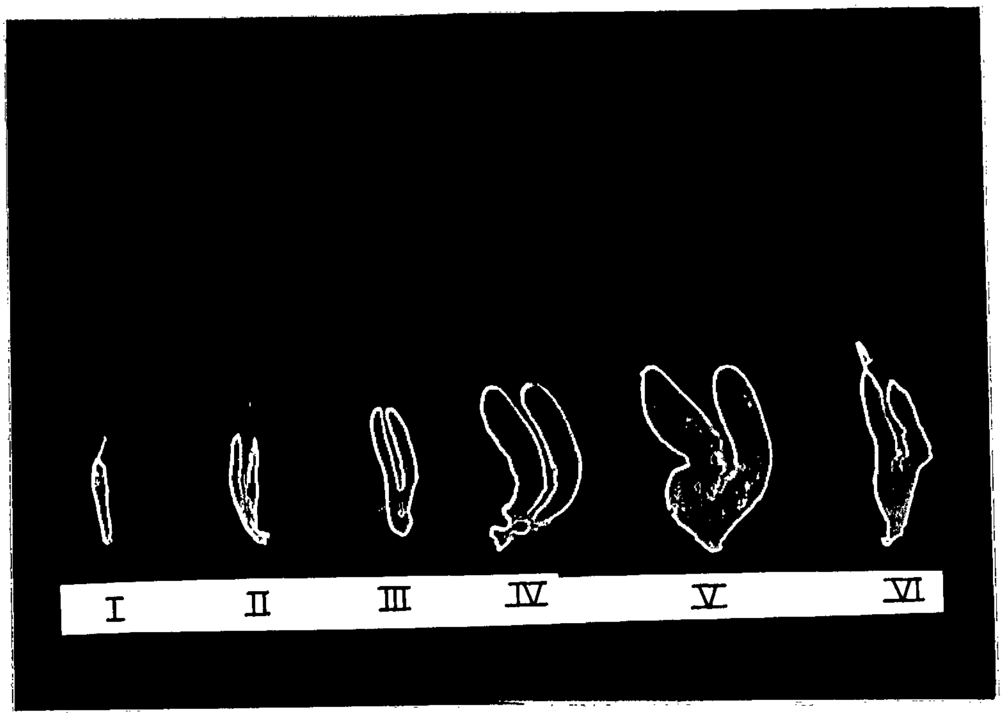



Plate 6.4.1.

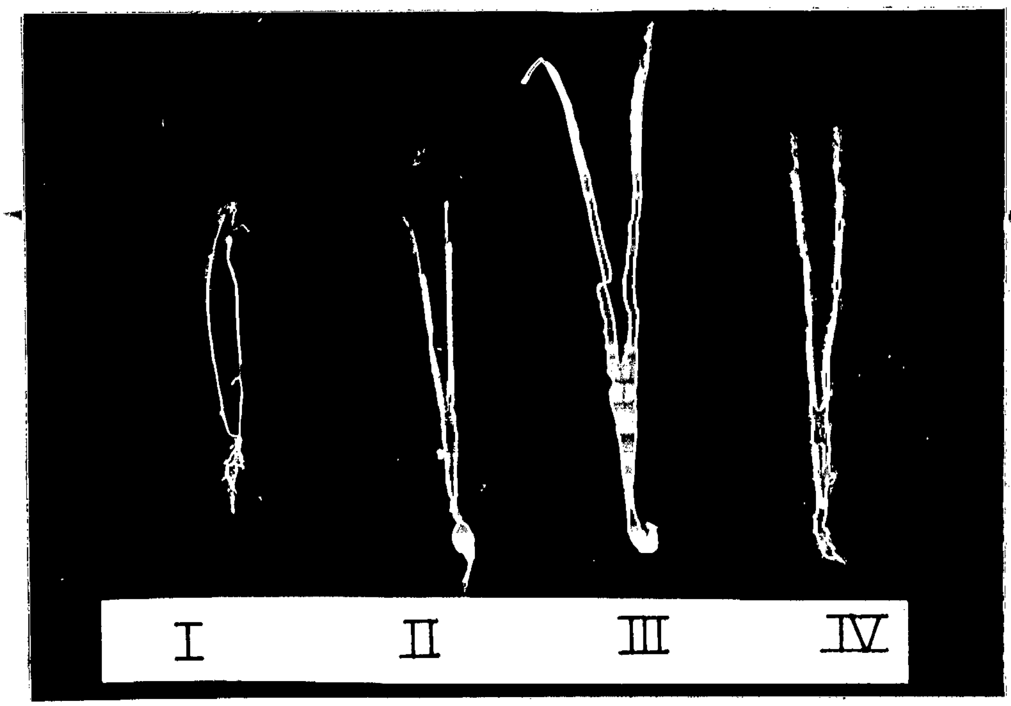



Plate 6.4.2

examples are cited in the figures.

Immature virgin: The ovaries are small, narrow tubular structures. They are light pink, translucent and the oocyte are invisible to the naked eye. First four stages of oocyte can be seen frequently, however V and VI stages of oocyte were rare. The modal size of largest group of ova varied from 128.52 - 214.2 µ (Fig. 6.1.1).

Developing virgin: The ovary increased in size and diameter. The ovary wall is thick and the colour of the ovary is light yellow. Oocytes are slightly visible to the naked eye. First VII stages of oocyte can be distinguished under the microscope. The modal size of the largest group of ova varied from 600 - 800 µ (Fig. 6.1.2).

Early maturing: The ovary becomes more round and the ovary wall is thin. Developing oocytes are clearly visible. First VIII stages of oocytes can be seen. The modal size of largest group of ova varied from 900 - 1200 µ (Fig. 6.1.3).

Late maturing: The ovary gains more weight and the ovary wall becomes still thin. The ovary appears brown in colour. Two batches of ova can easily be distinguished with a naked eye, based on their size. The matured ova are brown in colour whereas, the second batch is white or light yellow in colour. The blood supply to the ovary is pronounced. First nine stages can be distinguished, however sometimes VIII stage is absent. The modal size of largest group of ova varied from 1300 - 1500 µ (Fig. 6.1.4 I & II).

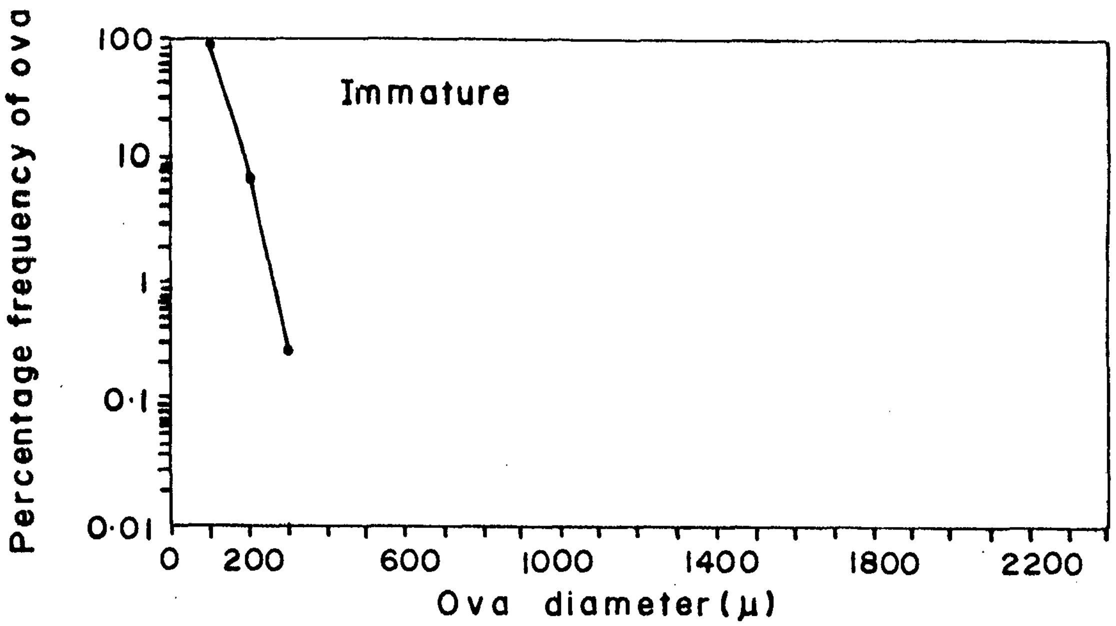



Fig. 6.1.1 Percentage frequency occurrence of intra-ovarian ova diameter in immature virgin stage.

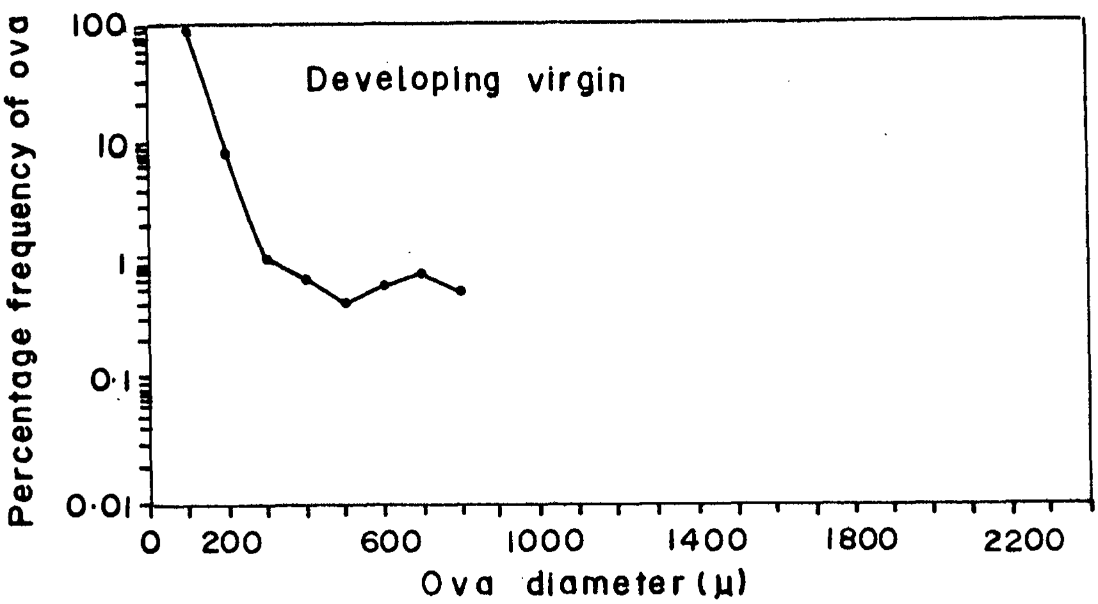



Fig. 6.1.2 Percentage frequency occurrence of intra-ovarian ova diameter in developing virgin stage.

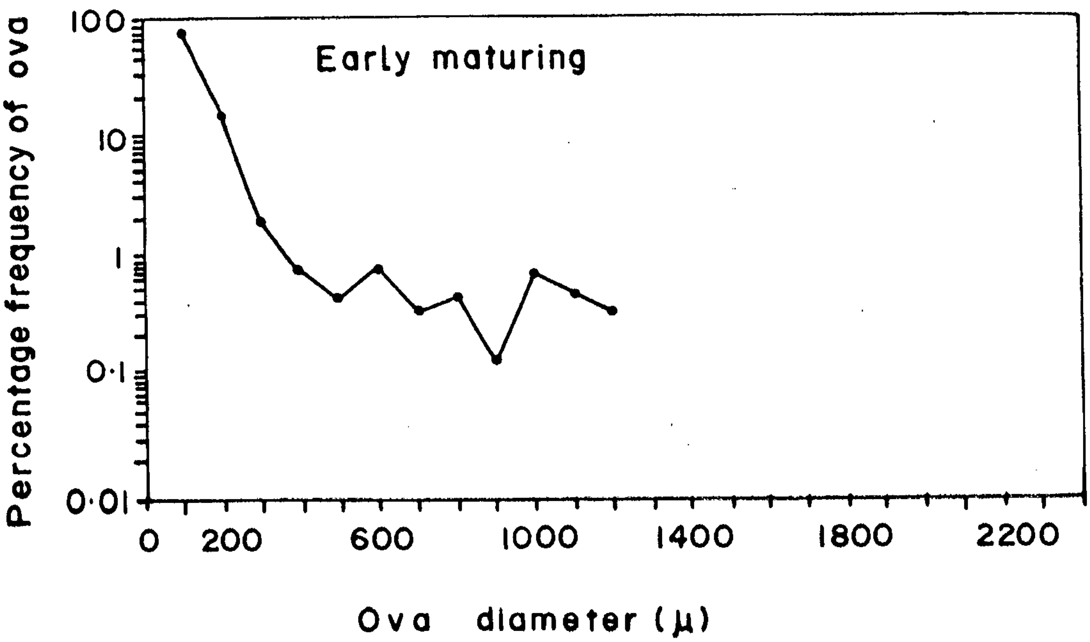
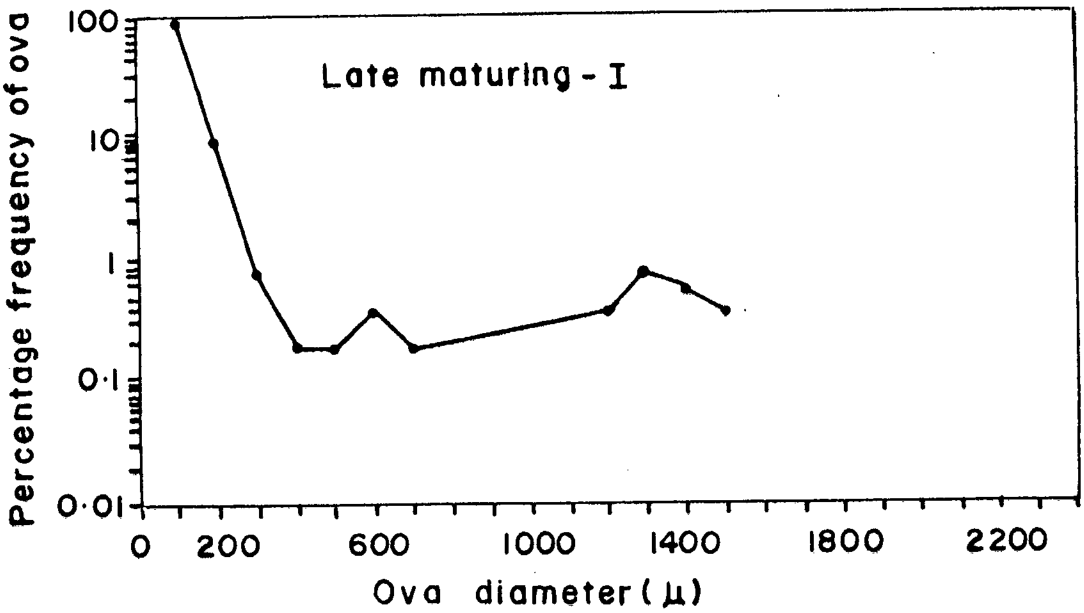



Fig. 6.1.3 Percentage frequency occurrence of intra-ovarian ova diameter in early maturing stage.



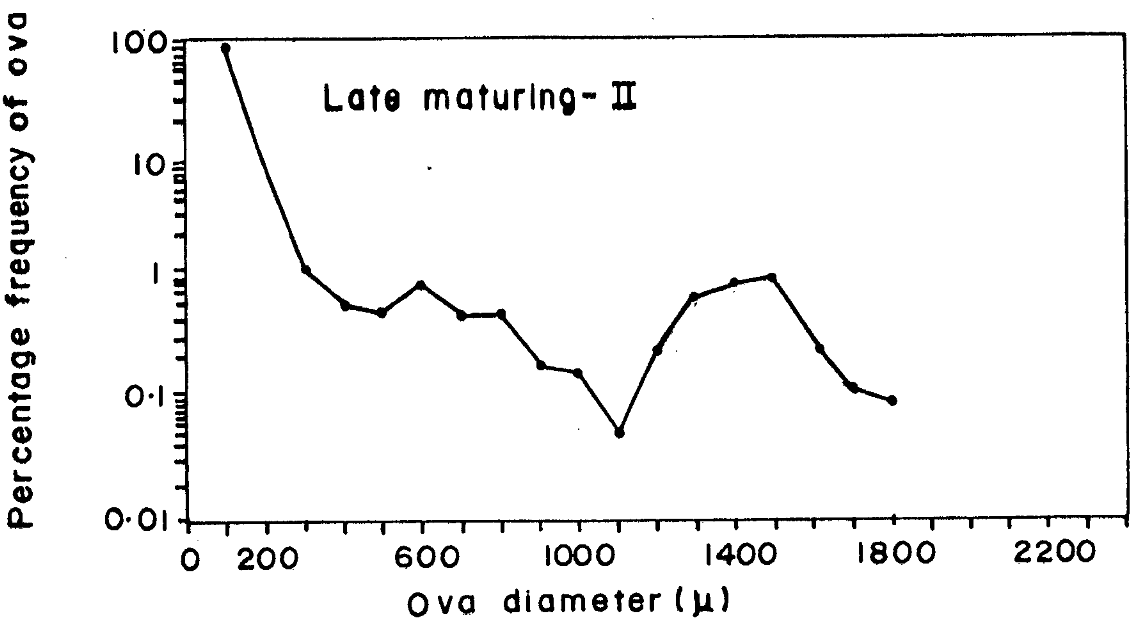




Fig. 6.1.4 (I & II) Percentage frequency occurrence of intra-ovarian ova diameter in late maturing stage.

Ripe: The ovary is completely swollen and bulged. It is dark brown in colour and occupy most of the space in visceral cavity. The blood capillaries increase in size and the blood supply is highly vascularized. Except ninth stage or VIII and IX stage of ova, all the other stages can be seen under the microscope. The modal size of largest group of ova varies from 1600 - 2300 μ (Fig. 6.1.5 I & II).

Spent: Typically full spent ovaries did not occur in the samples, because of the presence of second batch of ova belonging to VII or VIII stage, which had accumulated sufficient yolk up to a certain extent. The ovary looks flaccid ,slender, dirty brown in colour with a yellowish tinge. The modal size of largest group of ova varied from 600 - 1200 μ (Fig. 6.1.6 I & II).

6.3.5 Ovarian Cycle: The ovarian cycle based on the occurrence of different developing stages of oocyte, modal size of largest group of ova and maturity in various stages of ovary is shown in Fig. 6.2.1. In immature virgin, the largest size of ova was of 300 μ, but the oocyte stage may vary from first IV stages to VI stage, and V and VI stages were rare. In developing virgin, all the VII stages of ova were present and the modal size of largest ova varied from 600 - 800 μ. In early maturing stage, VIII stages of oocyte were seen and the modal size of largest group of ova was 900 - 1200 μ. In late maturing stage, in some specimens all the nine stages of oocyte were present whereas in others VIII stage was absent. The modal size of largest group of ova was 1300 - 1500 μ. Similarly, in ripe ovary IX stage of ova was always

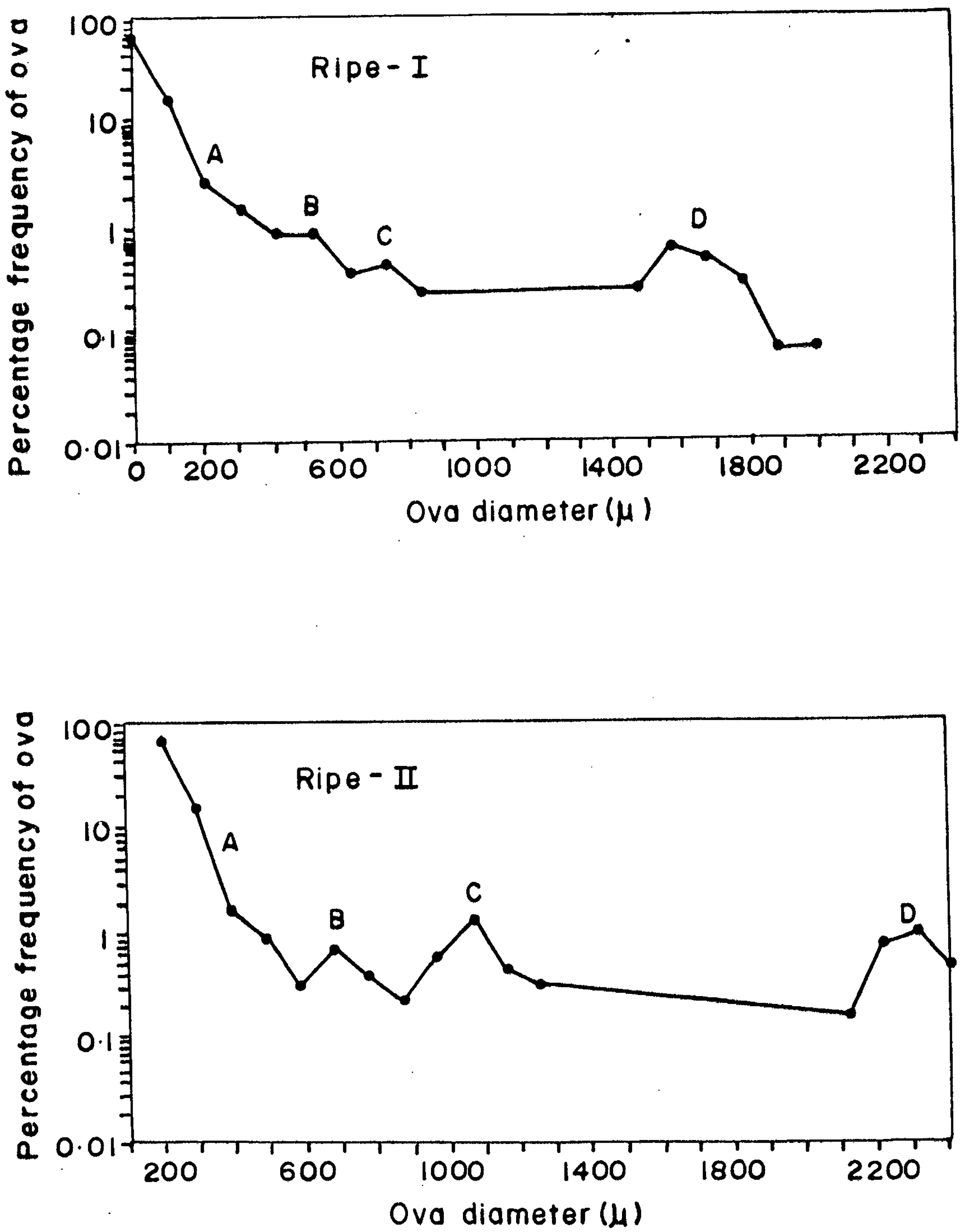
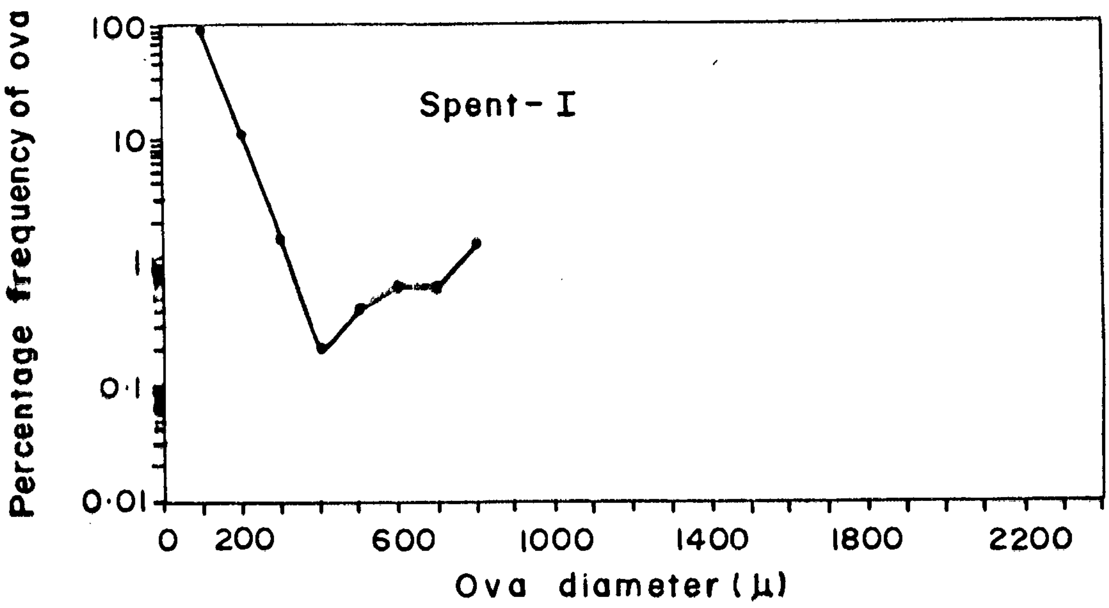



Fig. 6.1.5 (I & II) Percentage frequency occurrence of intra-ovarian ova diameter in ripe stage.



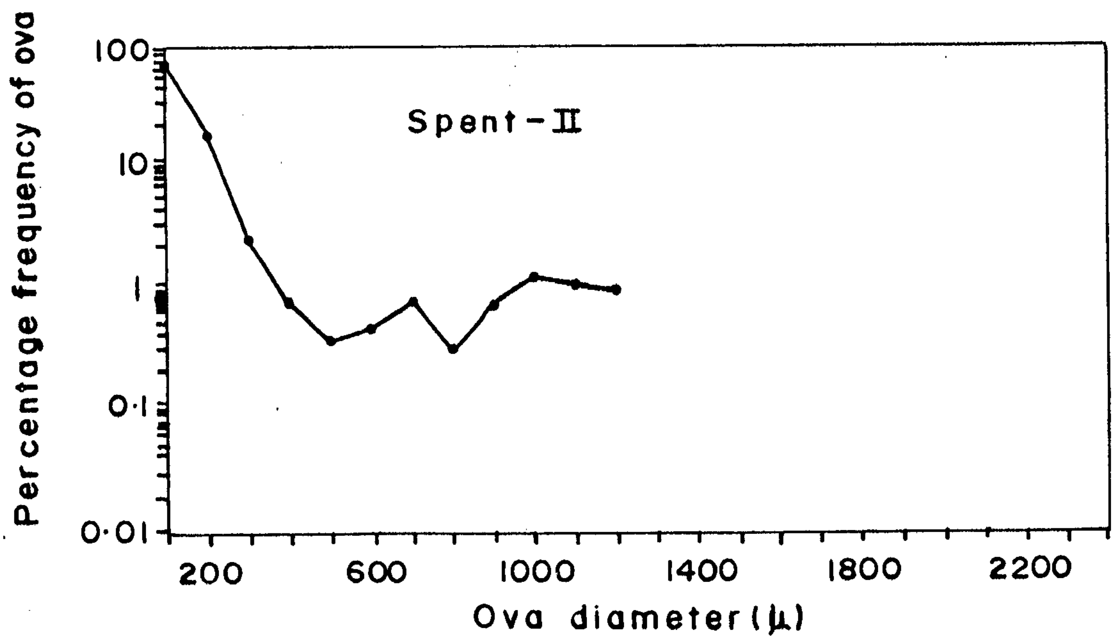




Fig. 6.1.6 (I & II) Percentage frequency occurrence of intra-ovarian ova diameter in spent stage.

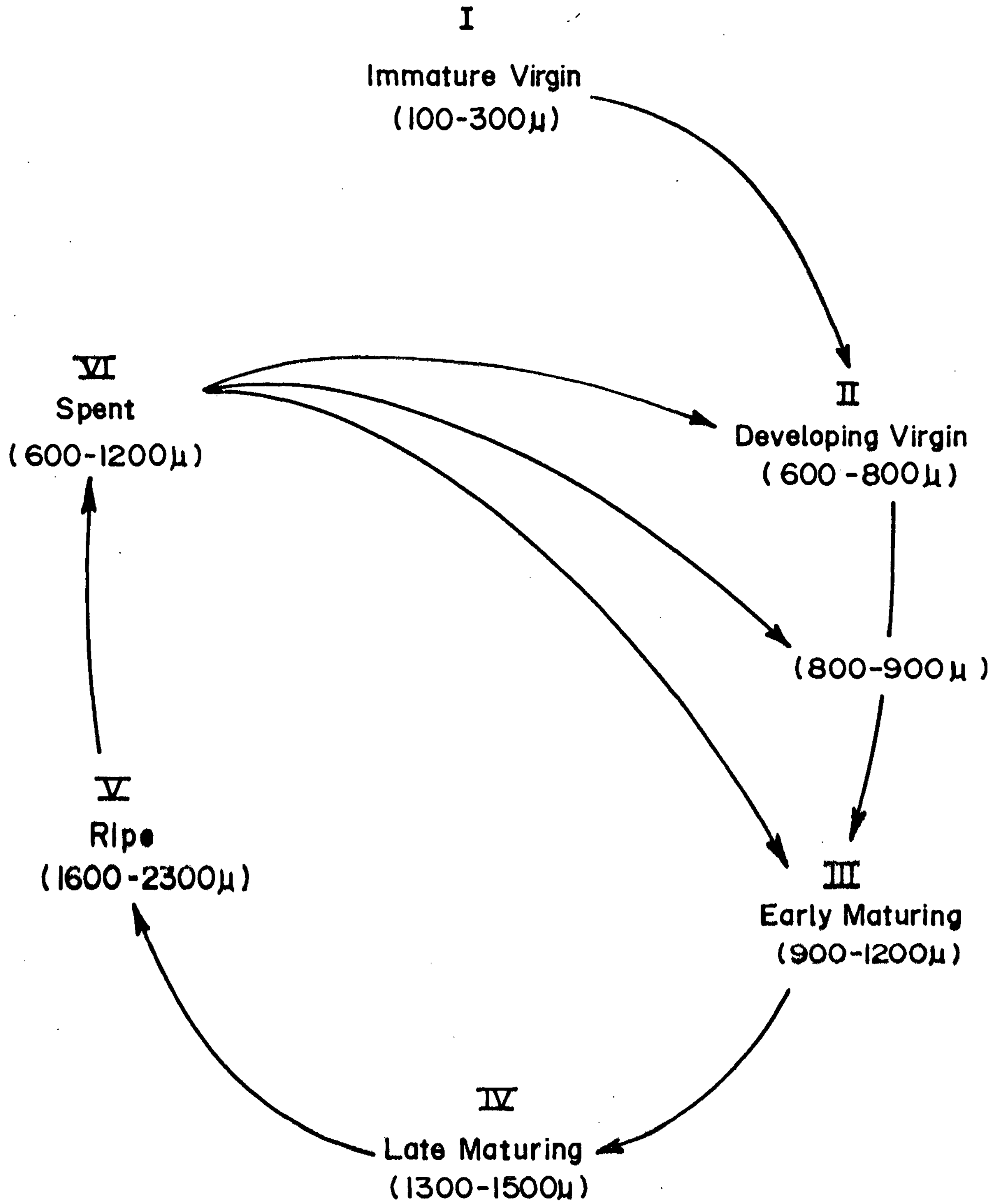



Fig. 6. 2. 1 Ovarian cycle based on modal size group of ova in different gonadal maturity stages.

absent but in some specimens VIII stage of oocyte was also absent. In spent stage the size of largest group of oocyte is highly variable. In some specimens, the largest group of oocyte were represented by VII stage of oocyte while in others by VIII stage. Thus, a group of females maturing and spawning at a time may not spawn at the same period in the following successive spawning season. This could be attributed to the variable size of the secondary batch of oocytes in different individuals.

**6.3.6 Maturity Stages of Testes:** Testes of *E. suratensis* are very small in size and only four stages could be distinguished morphologically (Plate 6.4.2).

Immature stage: Testes were very fine thread like and translucent. The length varied from 20 - 25 mm and diameter from 0.25 - 0.35 mm.

Maturing stage: They were comparatively long, broad, opaque and white in colour. The size varied from 28 - 35 mm in length and 0.50 - 0.75 mm in diameter.

Ripe stage: Gonads were bulged, lobulated and white in colour. Blood supply was prominent. The size varied from 38 - 61 mm in length and 1.00 - 1.75 mm in diameter.

Spent: The testes appeared empty, translucent and shrunk. The size varied from 35 - 57 mm in length and 0.75 - 1.25 mm in diameter.

**6.3.7 Sex Ratio:** The distribution of sex ratio over different months of the year and different length class intervals is shown in Fig. 6.3.1 and Fig. 6.3.2, respectively. The minimum percentage of males (43.12%) was recorded in the month of May 1991 and the maximum (64.00%) in April 1992 and the analogous percentage of females in the respective months was 56.88% and 36.00% . However, the overall sex ratio of males to females was 54.50 : 45.50 (1 : 0.85), which is very close to a ratio of 1:1, indicating that male and female number in a population is almost in equal proportion. The distribution of sex ratio in different length groups ranging from 51 - 60 mm through 141 - 150 mm showed that overall the males formed 51.28% and the females 48.72% of the population. In class groups ranging from 151 - 160 mm through 191 - 200 mm the ratio of males to females was 64.88 : 35.12. Females were absolutely absent in class groups ranging from 201 - 220 mm (Fig. 6.3.2)

6.3.8 Size at First Maturity: In females, the different gonadal maturity stages were spread over different class intervals. The percentage frequency distribution of different gonadal maturity stages in various class intervals is shown in Fig. 6.4.1. All the female fish were in immature reproductive stage up to a size group of 81 - 90 mm. The smallest size of ripe stage fish recorded was of 110 mm. In a size group of 111 - 120 mm, about 3.0% were ripe and the same percentage was of spent spawners. In 121 - 130 mm size group about 10.0% had attained their first maturity. About 30.0% specimens attained their first maturity in a size group of 131 - 140 mm. In a size group of 141 - 150 mm, about 77.49% attained their first maturity. Thus, the female <u>E.</u>

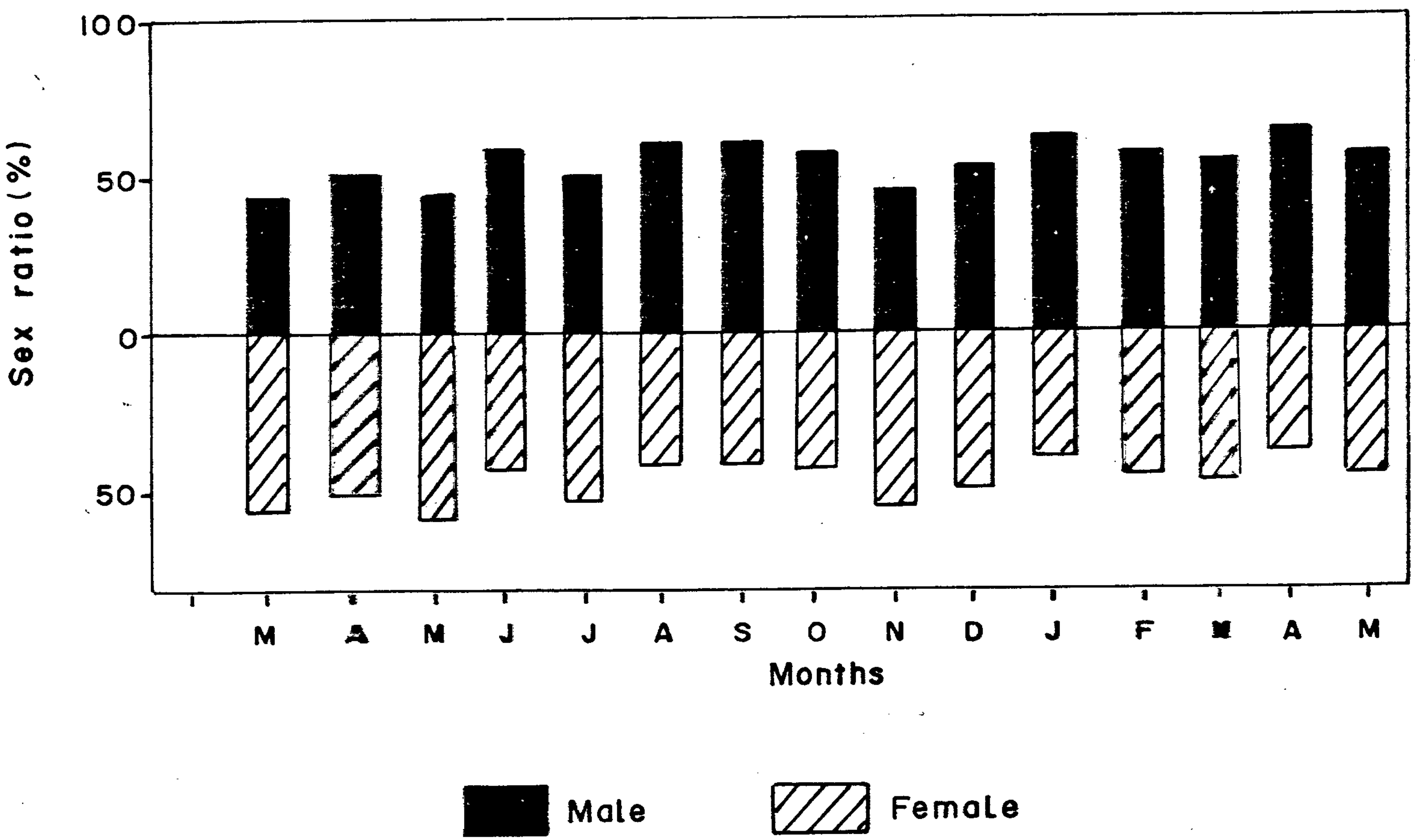



Fig. 6.3.1 Monthly variation in sex ratio of <u>E. suratensis</u>

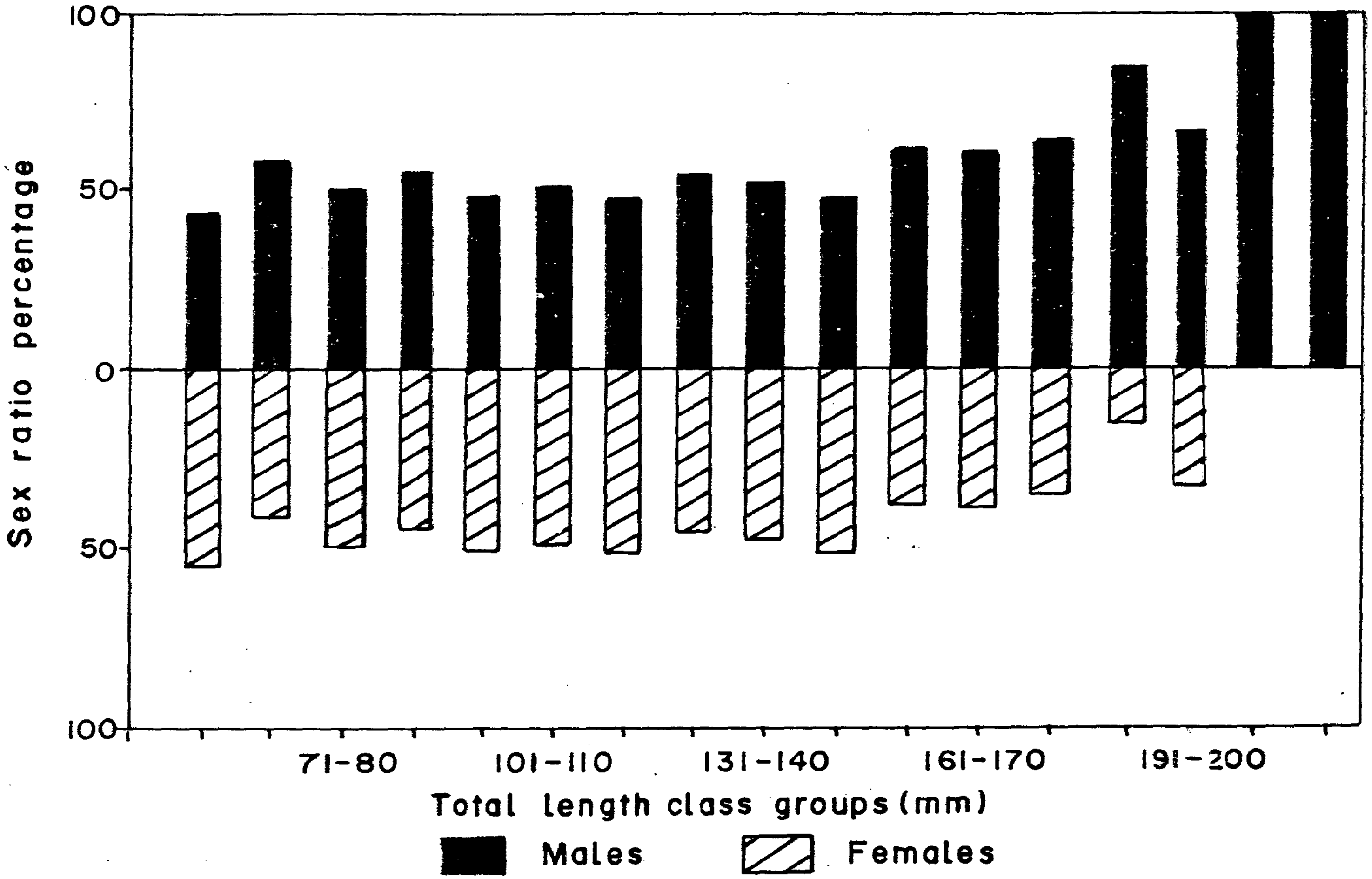



Fig. 6.3.2 Variation in sex ratio of E. suratensis in different size groups.

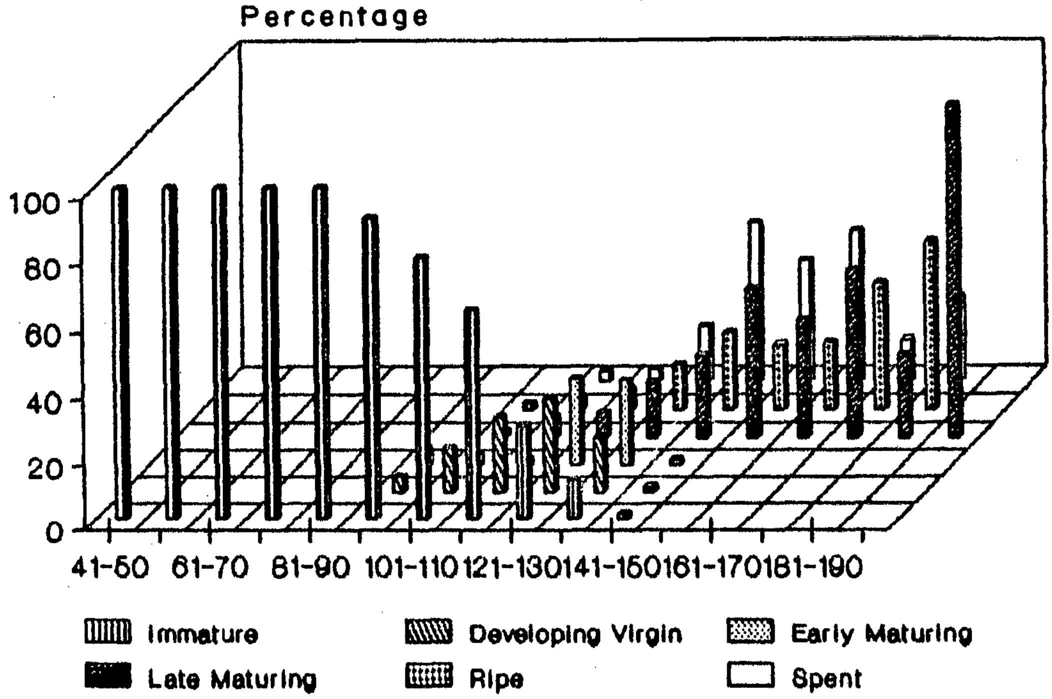



Fig. 6.4.1 Percentage frequency distribution of different gonadal maturity stages of female _E. suratensis_ in various size groups.

suratensis in Goa waters attains its first maturity at 110 mm size and continue up to 150 mm with maximum number of individuals maturing in a size group of 141 - 150 mm. In case of male, the smallest ripe size obtained was of 125 mm. The different maturity stages spread over different class intervals are given in Fig. 6.4.2. Though, the male fish start attaining first maturity relatively at a bigger size (125 mm), the maximum individuals (78.58%) attaining first maturity were obtained in the size group of 141 - 150 mm. Thus, both male and female mature almost at the same size and age with little variation in the smallest size of maturity.

6.3.9 Spawning Season: The annual variation in percentage frequency distribution of different maturity stages is given in Fig. 6.5.1. The immature stage was present throughout the year. Developing virgin were also present through out the year except in June 1991, when the percentage of mature specimen was maximum. In April 1992, immature dominated the population. Early maturing stage was recorded throughout the year except April 1991, when developing virgin were most dominant, and again in April 1992 when immature stage was dominant. Late maturing stage were present throughout the year with its dominance during July 1991, January - February and May 1992.

Ripe fish was observed to occur throughout the year with its peak in June, July, October and December 1991 and March - May 1992. Spent fish was also encountered throughout the year. The occurrence of different maturity stages through out the year reveals that the fish spawns round the year. Seasonal variation

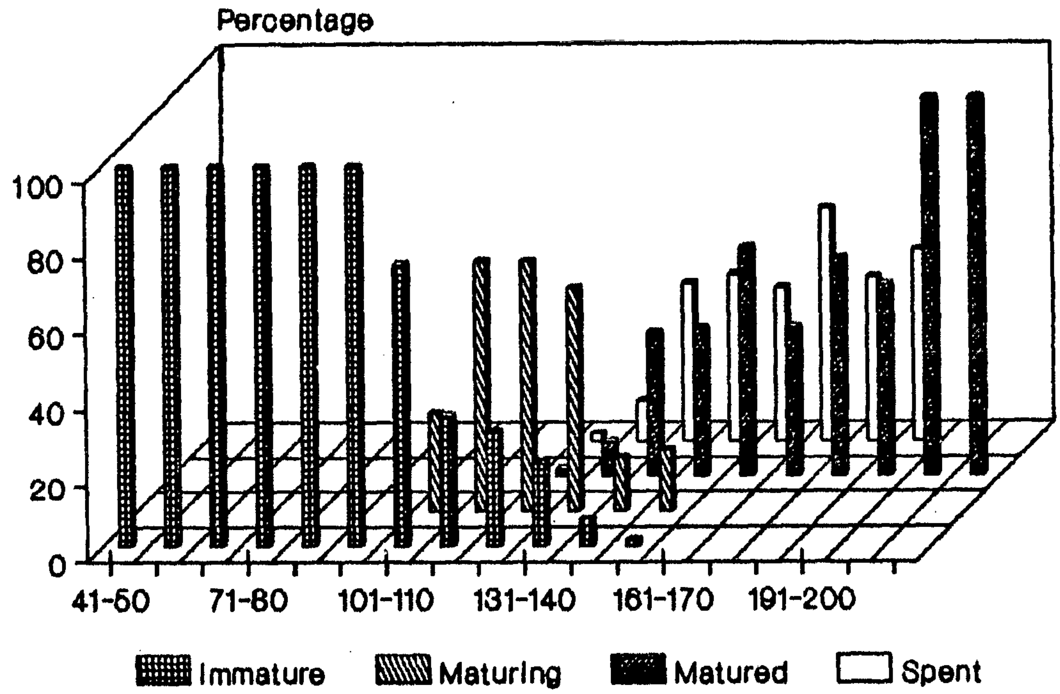



Fig. 6. 4. 2 Percentage frequency distribution of different gonadal maturity stages of male _E. suratensis_ in various size groups.

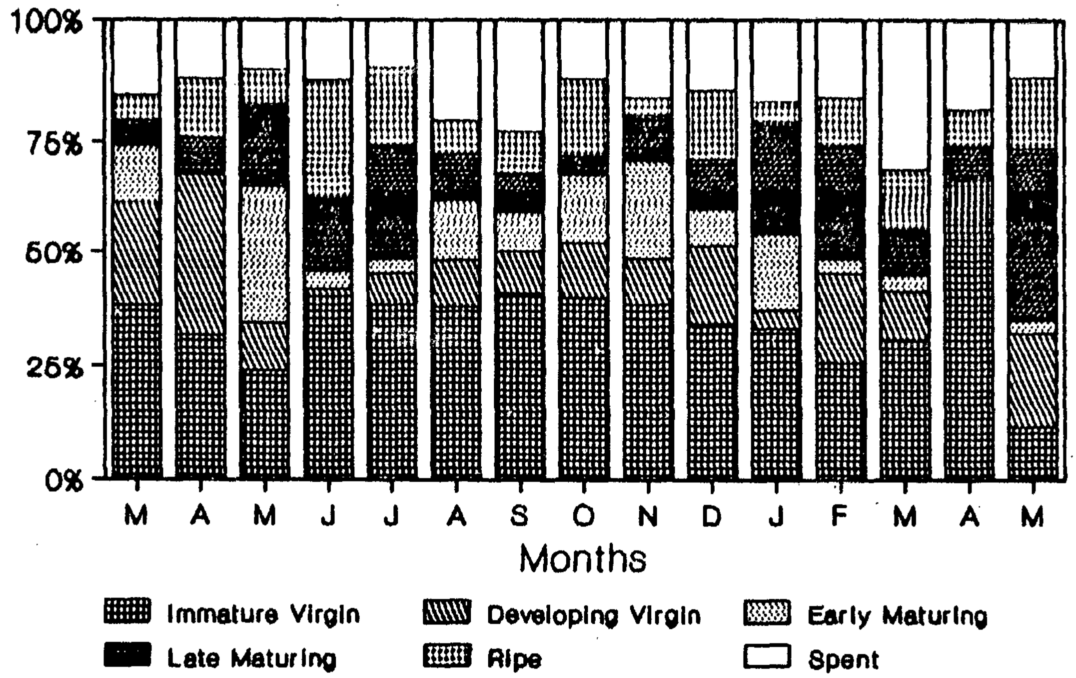
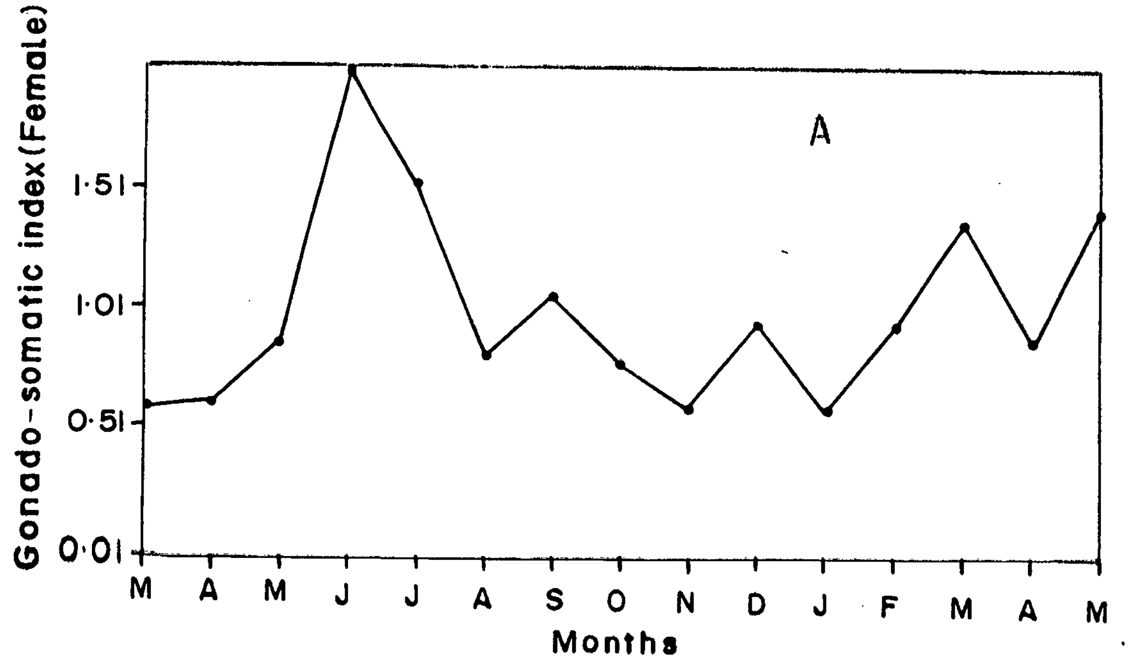



Fig. 6.5.1 Monthly variation in percentage frequency distribution of different gonadal maturity stages of female *E. suratensis*.

in gonado-somatic index of female and male is given in Fig. 6.5.2A and Fig. 6.5.2B, respectively. Wide fluctuation observed in gonado-somatic index over an annual cycle reveal that the spawning season is prolonged (June and September to March) and the fish spawns intermittently. The percentage frequency distribution of different maturity stages in the samples above 131 mm was worked out to delineate the peak spawning season, since the presence of lower immature groups in large numbers in the sample restrict the formation of peaks of ripe and spent stages. The lowest group of 131 mm was considered since about 30% fish was matured in this class group (131 - 140 mm). Accordingly, the maximum number of matured and spent spawners were obtained in June, September and November - January and March - April (Fig. 6.5.3), which corroborates the field observations and regular presence of adult with brood.

6.3.10 Spawning Periodicity: Frequency occurrence of ova of various diameter in fully ripe ovaries ranging in size from 120 mm to 176 mm were observed under the microscope to delineate the spawning periodicity as described by earlier workers (Clark, 1934; Hickling and Rutenberg, 1936; Dejong,1939; Prabhu, 1956). Two distinct patterns in ova size were observed; one in ripe virgin (Fig. 6.1.5I) and the other of ripe second or more number of times (Fig.6.1.5II). In case of ripe virgin, the modal size of ripe ova i.e. ready to shed was at mode `D' (1600 $\mu$) and the second batch at mode `C' was not completely separate from mode `B' which in its turn was still to get separated from mode`A'. In a fish ripe second or more number of times, the second batch



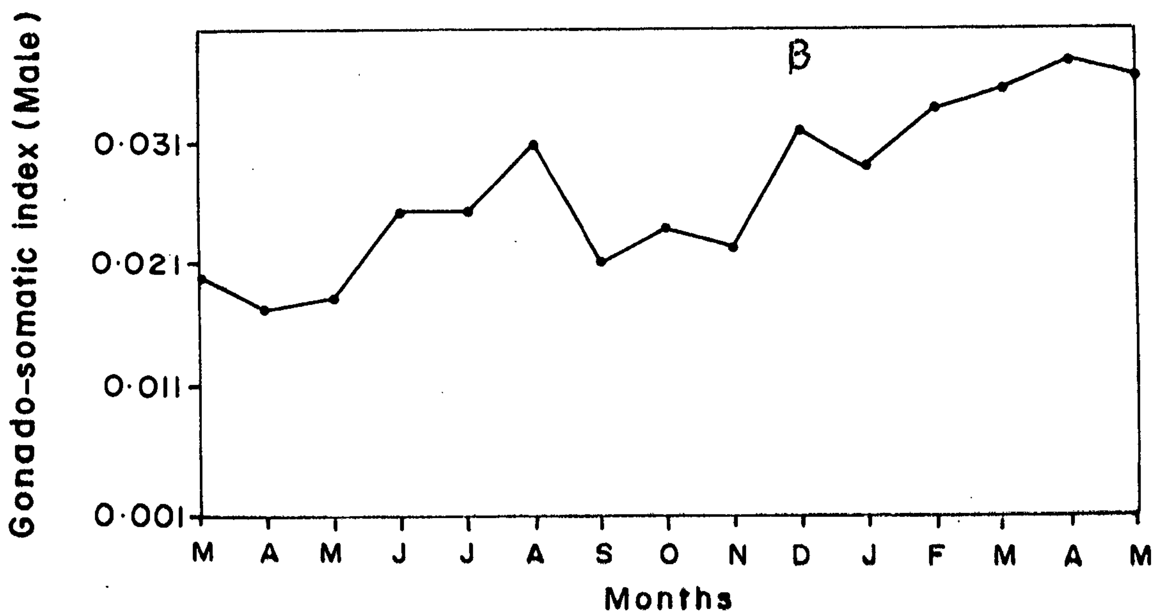




Fig. 6.5.2 (A & B) Monthly variation in gonado-somatic index of E. suratensis.

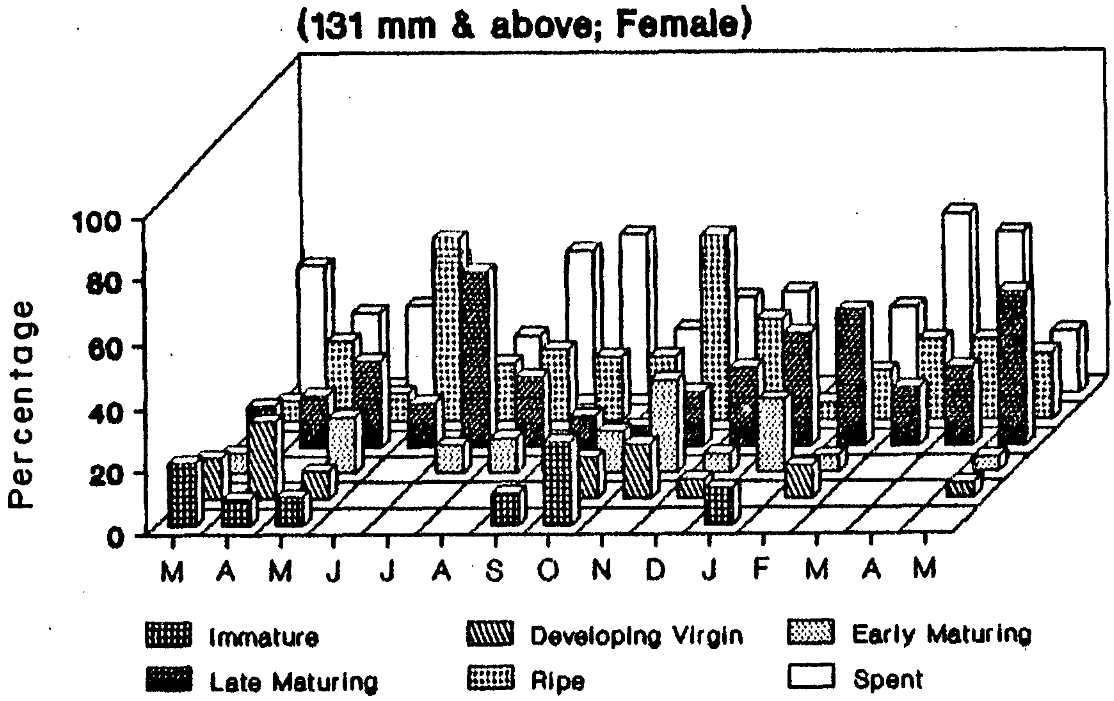



Fig. 6.5.3 Monthly variation in percentage frequency distribution of different gonadal maturity stages of female _E. suratensis_ in 131 mm and above size groups.

of ova of mode `C' were distinctly separate from modes `B' and `D', whereas the third batch of ova at mode `B' was about to get separated from mode `A' as the fish sheds ripe ova of mode `D' ova. The percentage of first batch of ripe ova ranged from 2.05 - 2.55 in all the ripe fish studied, whereas, the percentage of second batch of ova in a fish ripening second or more times was 2.39 - 3.66, but in ripe virgin it was only 0.83 - 0.85. This suggests that the second batch of ova was not yet completely separated in ripe virgin.

In ripe virgin, the separation of second batch of ova of mode `C', oocytes of stage seven are elliptical and have accumulated sufficient yolk, indicating that the fish spawns more than once in a year, probably twice. In the second case, there were three modes, one of oocyte X stage, second of oocyte VII and the third of oocyte VII stage. This indicates that in the second case, the period of three successive batches of spawning will be less than the same number of spawning in ripe virgin. Hence, in such spawners, the possibility of spawning thrice in a year or so cannot be ignored. Further, the fish spawns intermittently throughout the year as evident from the occurrence of ripe and spent spawners every month. Therefore, in the first year of maturity the ripe virgin may be spawning twice in a year and thereafter more than twice overlapping over an annual cycle.

6.3.11 Fecundity: The ripe or matured ova of <u>E. suratensis</u> can be readily ascertained at full maturity, based on their size and size difference from the second batch. In annual spawners, the fecundity is defined as the number of matured ova per fish per year and is also termed as the absolute fecundity or total fecundity. However, in multiple spawners, especially in Tilapia there are different versions of fecundity such as number of mature oocytes produced in the ovary, number of fry produced in the life time and number of fry produced over twelve month period. Therefore, in order to avoid confusion, the fecundity here has been described as the number of fully matured ova in a ripe ovary or number of matured ova per clutch. The relative fecundity dealt here is as the number of matured ova per clutch per unit body weight (kg) of matured fish. Relative fecundity is an useful working index for the farmers because it enables egg production capability to be related to different age groups, their weight, feed rate etc. .

Fecundity was estimated in 42 matured spawners ranging in size from 110 to 178 mm, and in weight from 29.34 to 170.45 g. The total fecundity varied from 757 to 3,715 ova per clutch, whereas relative fecundity varied from 13,526 - 34,753 ova per kg of fish per clutch. Regression of fecundity and ovary weight against various variables revealed that fecundity increases with increase in fish size, fish weight and ovary weight (Figs. 6.6.1 to 6.6.5). Typical regression equations on fecundity and ovary weight obtained are as follows :

$F = -3130.13 + 33.56\ FTL(mm)$; $P < 0.001$; $r = 0.7411$

$F = 234.47 + 19.45\ FWT\ (g)$; $P < 0.001$; $r = 0.7254$

$F = 744.908 + 356.79\ OWT\ (g)$ $P < 0.001$; $r = 0.7753$

$OWT = -0.2365 + 0.0402\ FWT\ (g)$; $P < 0.001$; $r = 0.7487$

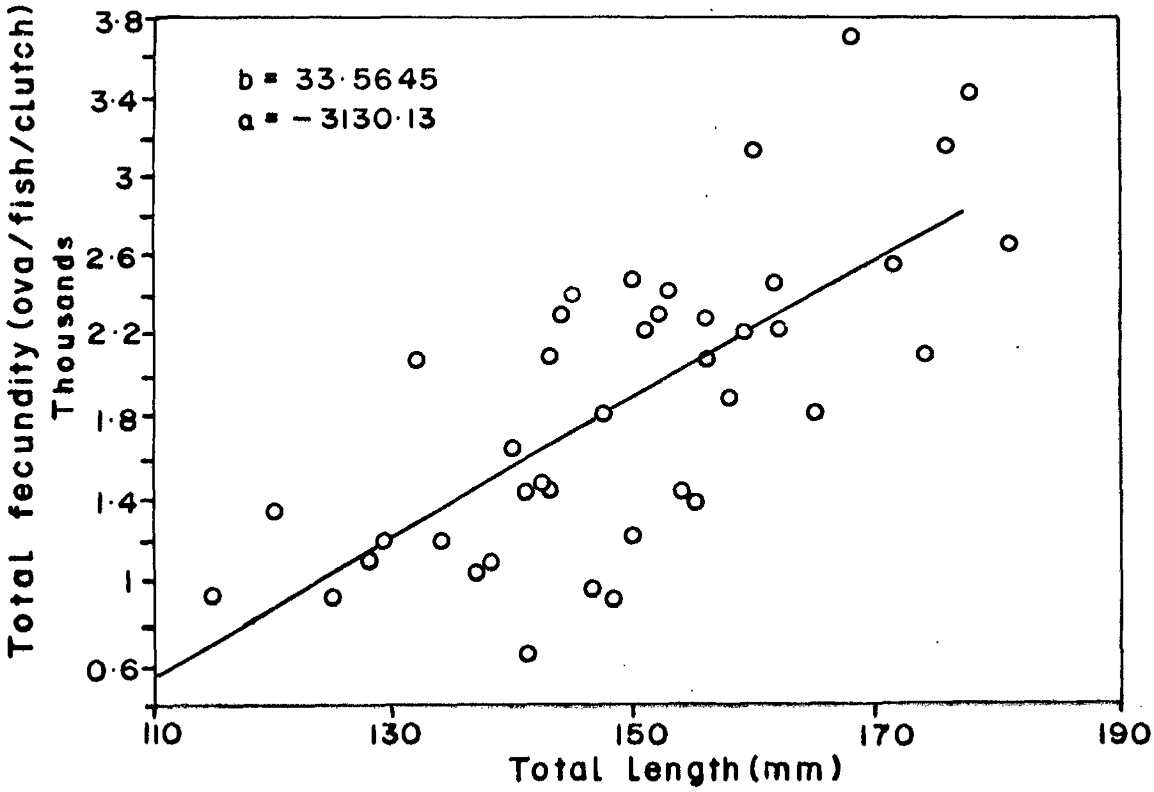



Fig. 6.6.1 Fecundity on total length regression of *E. suratensis*

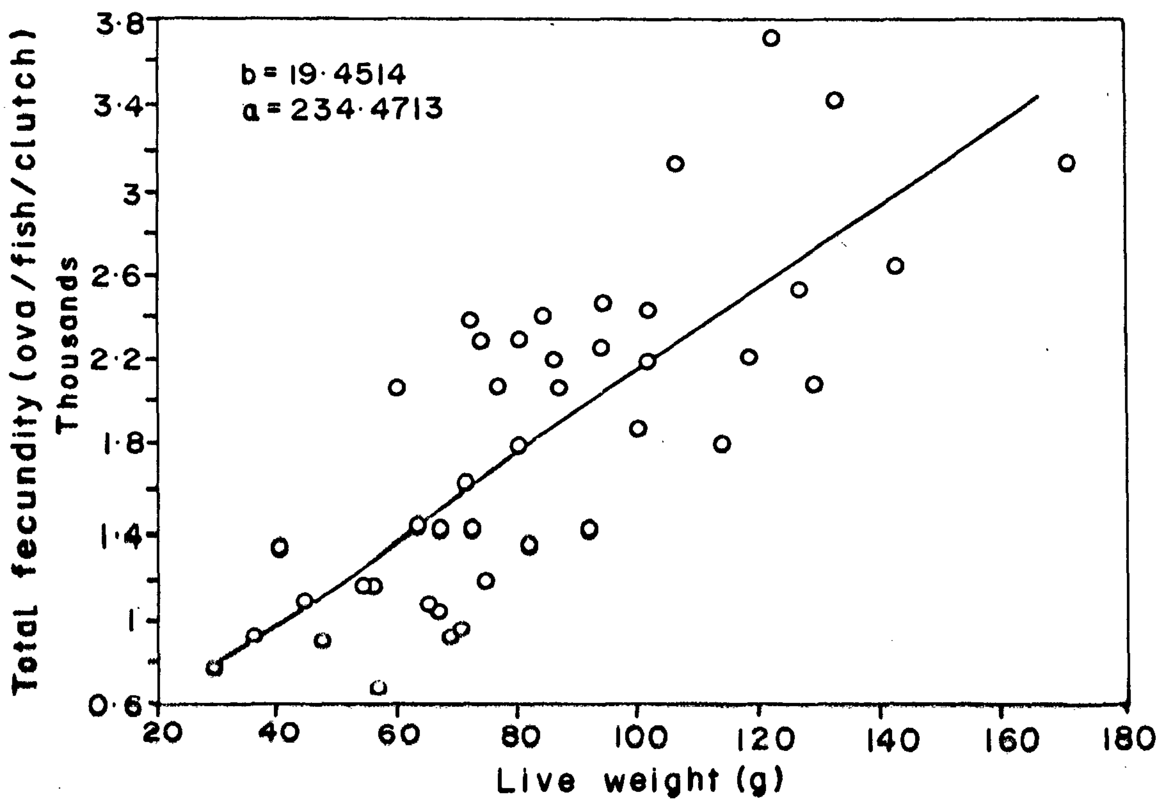



Fig. 6.6.2 Fecundity on live weight regression of *E. suratensis*

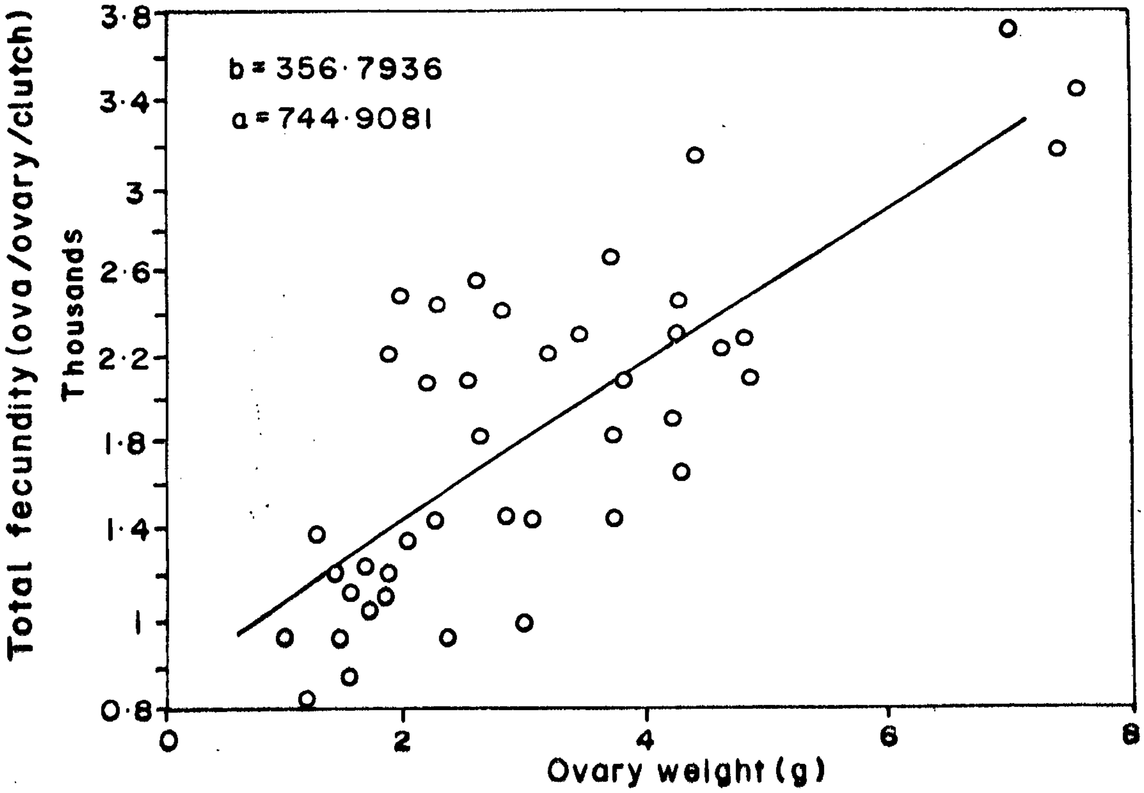



Fig. 6.6.3 Fecundity on ovary weight regression of E. suratensis

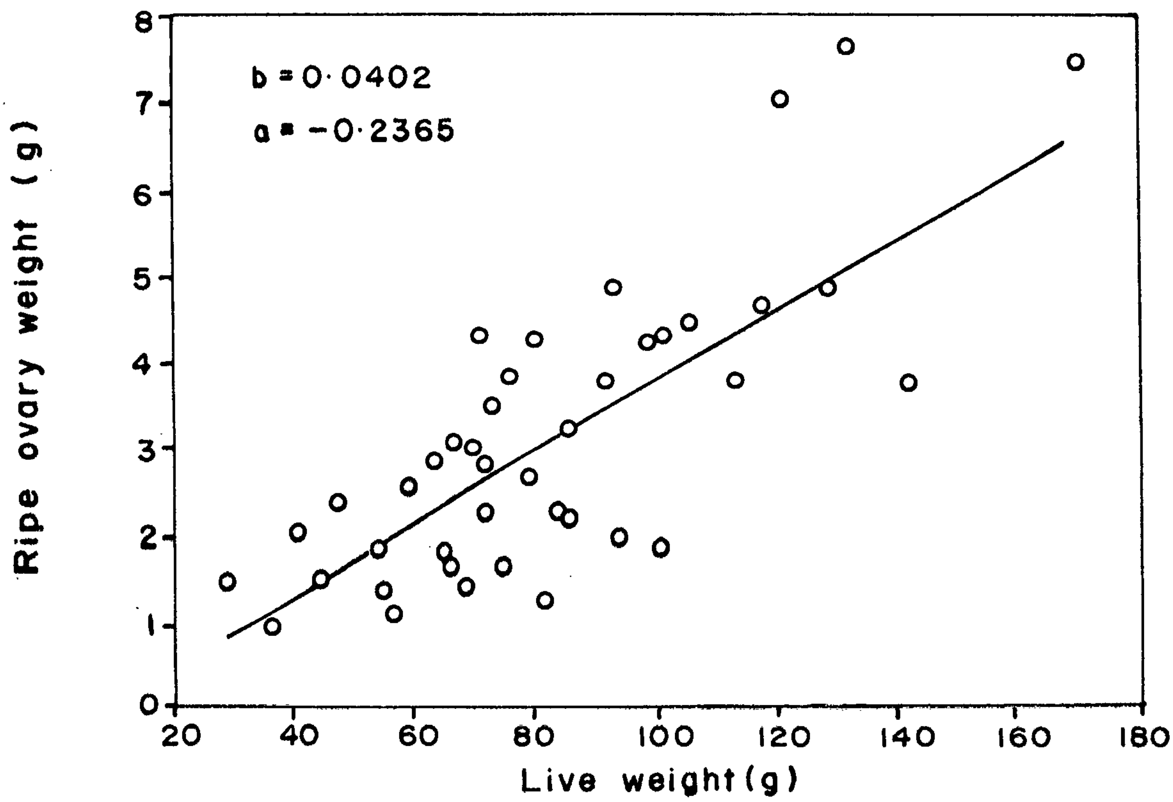



Fig. 6.6.4 Ripe ovary weight on live weight regression of E. suratensis.

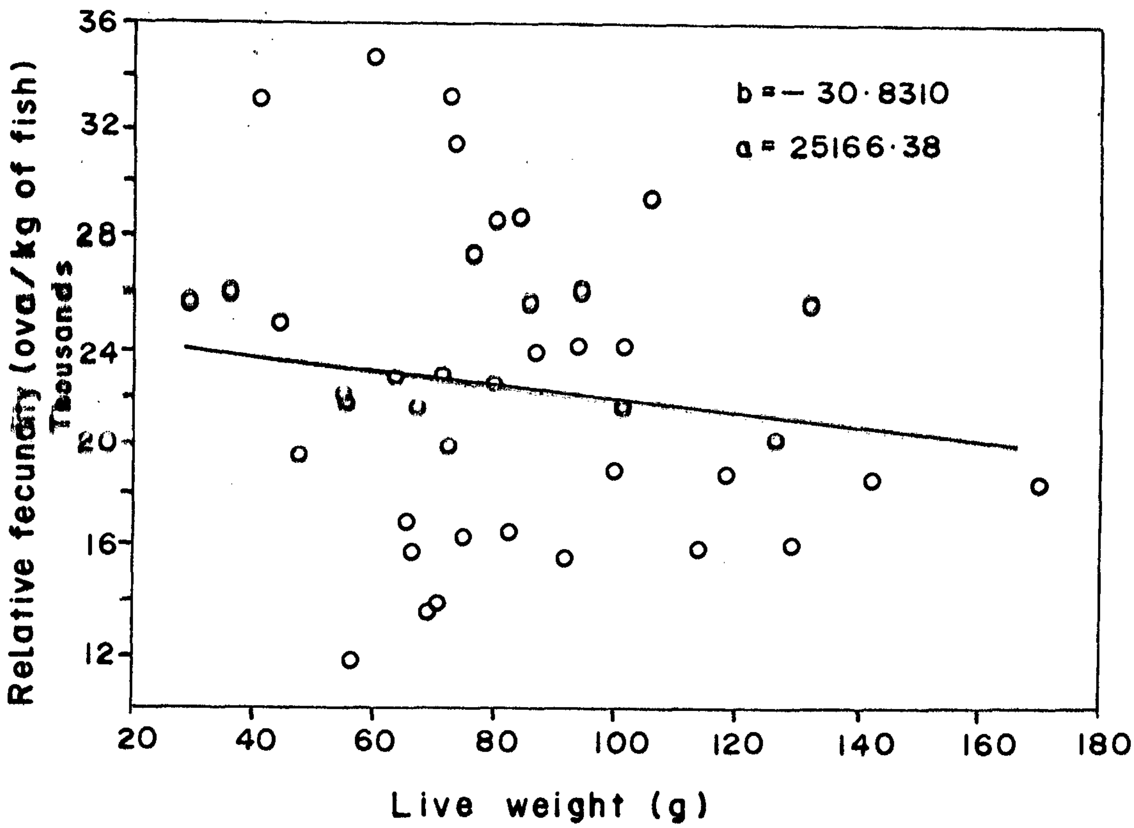



Fig. 6.6.5 Relative fecundity on live weight regression of E. suratensis.

RF = 25166.38 + (-30.83 ) FWT (g); $P<0.1$; $r = -0.1617$ insignificant
F = Fecundity; FTL = Fish total length; FWT = Fish weight; OWT = Ovary weight; RF = Relative fecundity.

Relative fecundity though showed inverse relationship with fish weight, it was insignificant. Egg quality in terms of egg size has been reported to be important in case of trout, where smaller eggs experience increased mortality (Pitman, 1979; Small, 1979). Therefore, ova size was measured in terms of volume, weight and dry weight in 17 ripe ovaries. The volume of an ovum varied from 1.25 - 1.86 $mm^3$, wet weight 1.37 - 2.08 mg and the dry weight 642 - 982 µg. The ovum volume, wet weight and dry weight did not show any significant relationship with fish weight and fecundity. Thus, the size of ova depends upon the condition of the spawner. However, to certain extent the larger specimens may produce comparatively bigger ova.

6.3.12 Spawning Efforts: Spawning efforts (fecundity X dry weight of ovum) per spawning batch was worked out as described by Blaxter and Hunter (1982). Spawning effort varied from 0.486 to 2.763 g/batch/fish. The regression of spawning efforts on fish length, weight and ovary weight revealed linear relationships indicating that the energy spent in terms of spawning efforts increase with fish size, weight and ovary weight. This could be the possible reason for slow growth in female after attaining first maturity. The typical regression equations are as follows:

SE = 0.02592 + 0.01549 FWT (g); $P < 0.001$; $r = 0.8696$ (Fig.6.7.1)
SE = 0.03866 + 0.00073 F (No.); $P < 0.001$; $r = 0.9222$ (Fig.6.7.2)

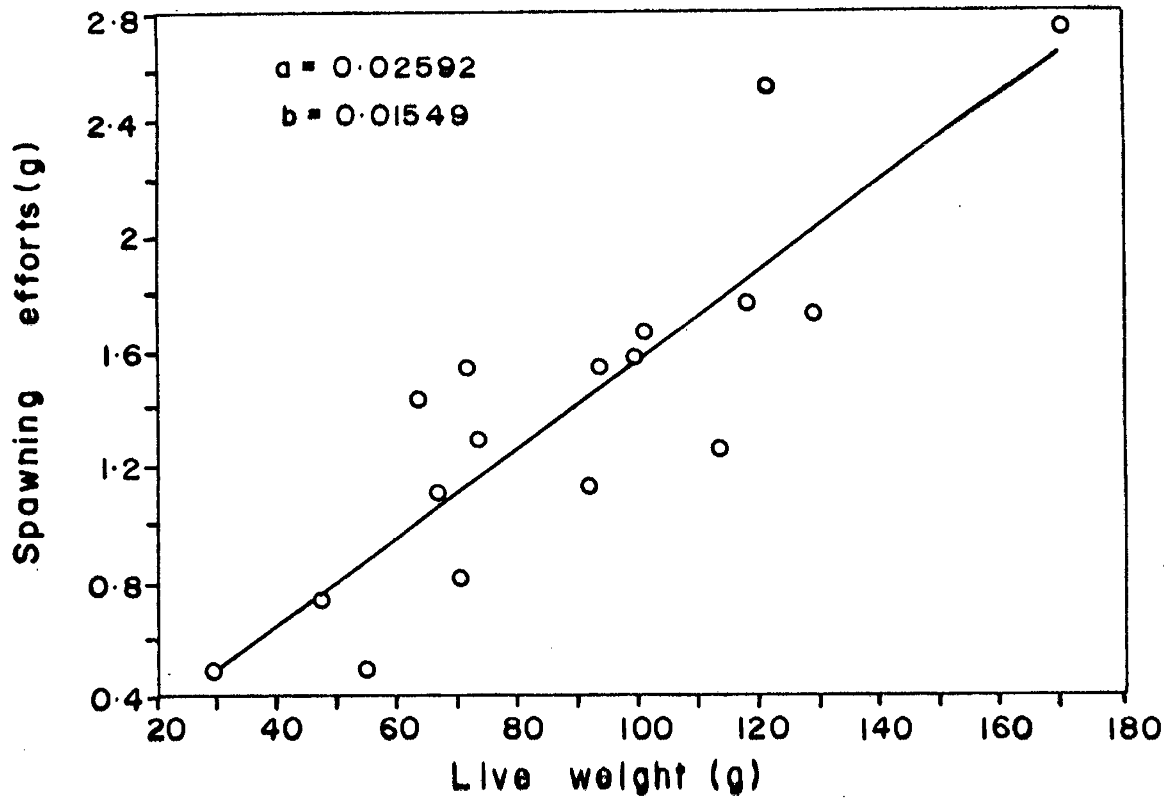



Fig. 6.7.1 Spawning efforts on live weight regression of E. suratensis.

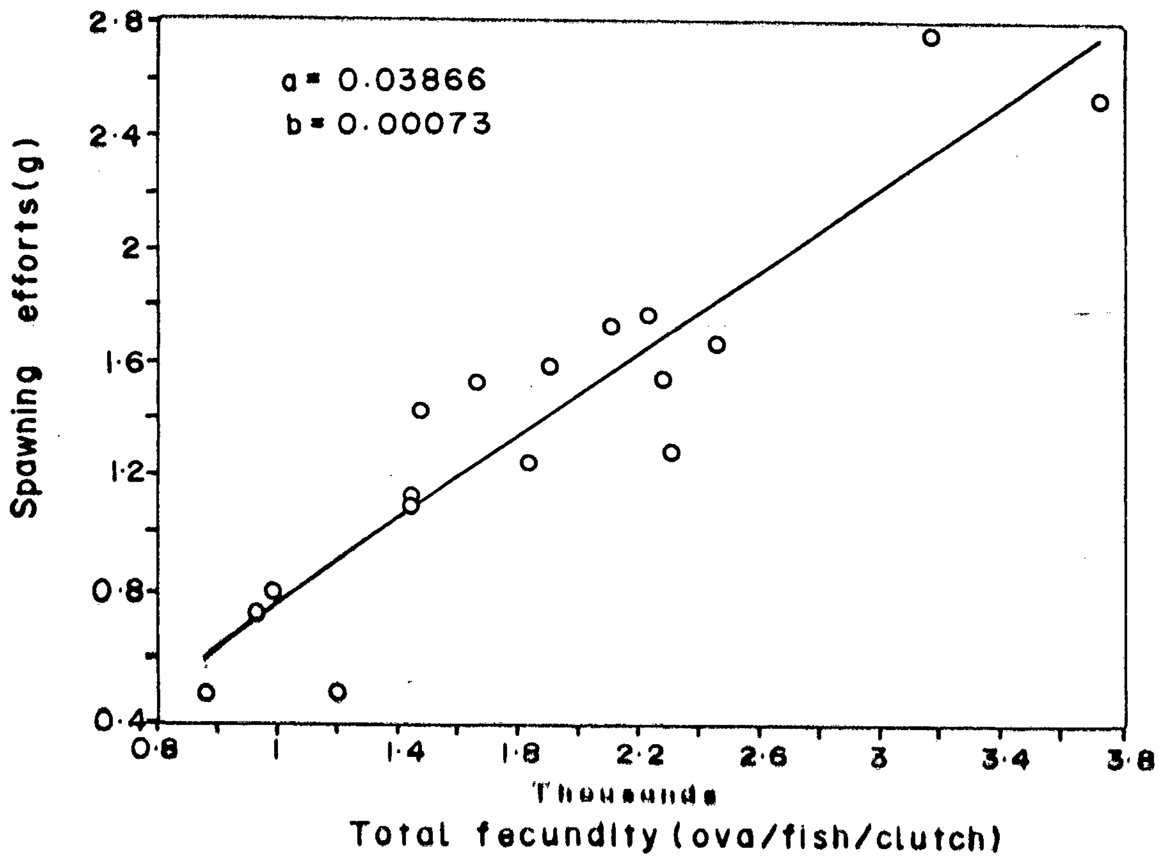



Fig. 6.7.2 Spawning efforts on total fecundity regression of E. suratensis.

$SE = -0.10341 + 0.38074\ OWT(g)$; $P < 0.001$; $r = 0.9671$ (Fig.6.7.3)

SE = Spawning efforts; FWT = Fish weight; F = Fecundity (clutch); OWT = Ovary weight.

Spawning efforts per batch showed a significant positive relationship with fish size, fecundity and ovary weight, indicating more energy expenditure in reproduction as the fish grows in size. This could be the reason that after attaining first maturity, the somatic growth of female slows down in comparison to male, which in turns progressively outnumber the female in higher size groups.

6.3.13 Reproductive Ethology: Parental care is a distinct characteristic of cichlids and E. suratensis is no exception. Reproductive guild of each species is related to oxygen supply for the developing young and prevention of predation upon them (Kryzhanovsky, 1956; Soin, 1968). Pairing takes place prior to spawning, followed by courtship. During the courtship male chases the female, and under the intense play they move in circular fashion at very high speed, due to which it becomes very difficult to distinguish the sexes. After some time all of a sudden, both the partners stop moving, followed by guivering, glancing at the mate, and forward and backward play. Actual process of spawning could not be seen, but parents guarding eggs and eleuthroembryos, spawn and juveniles were frequently observed. Both the parents were observed to guard the brood. The eggs were observed to be laid on wooden twigs whose bark is degraded (Plate 6.5.1). The bark is finely cleaned by the

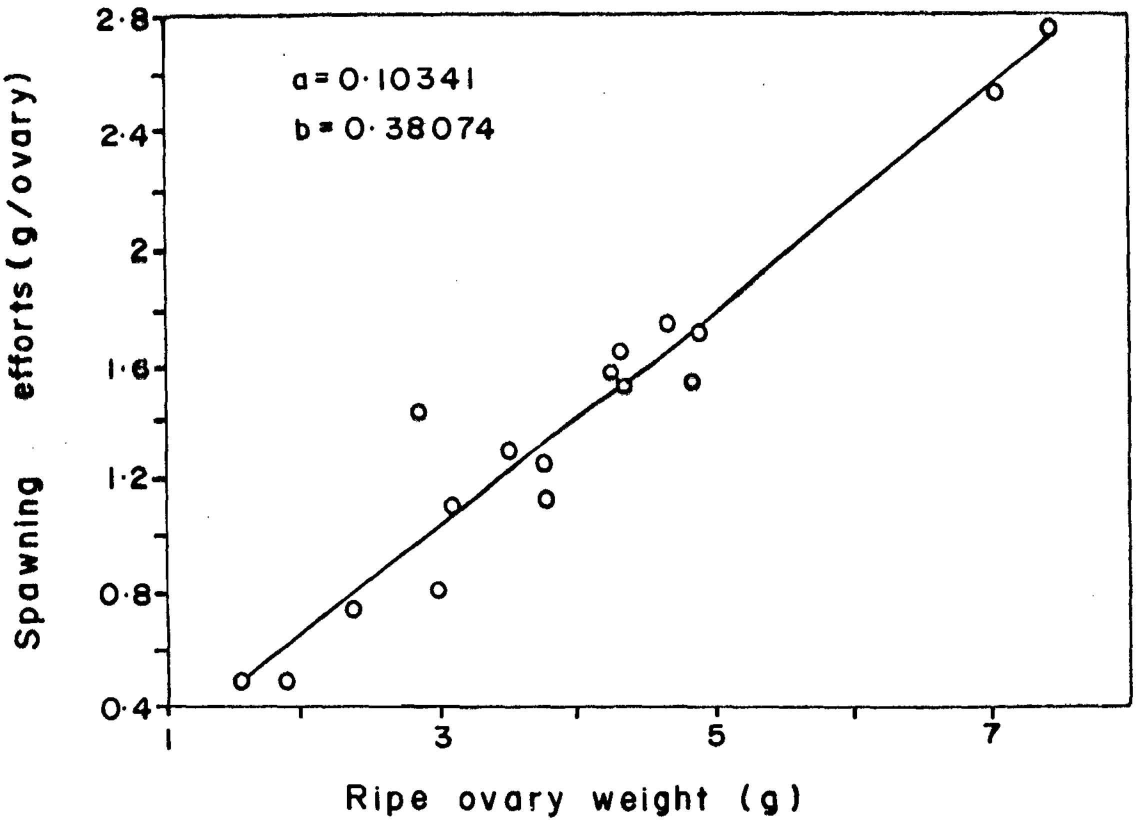



Fig. 6.7.3 Spawning efforts on ripe ovary weight regression of E. suratensis

Plate 6.5.1 Egg mass of _E. suratensis_ laid on wooden stick.

Plate 6.5.2 Photograph showing numerous nests built in the sediment by _E. suratensis_.

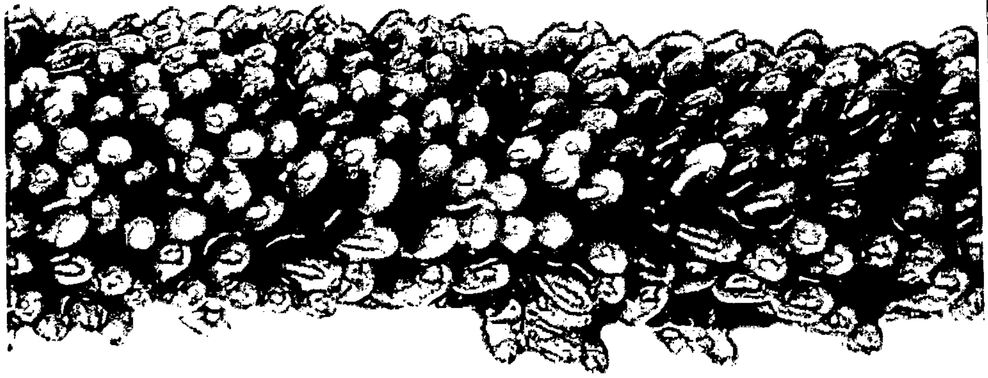


Plate 6.5.1

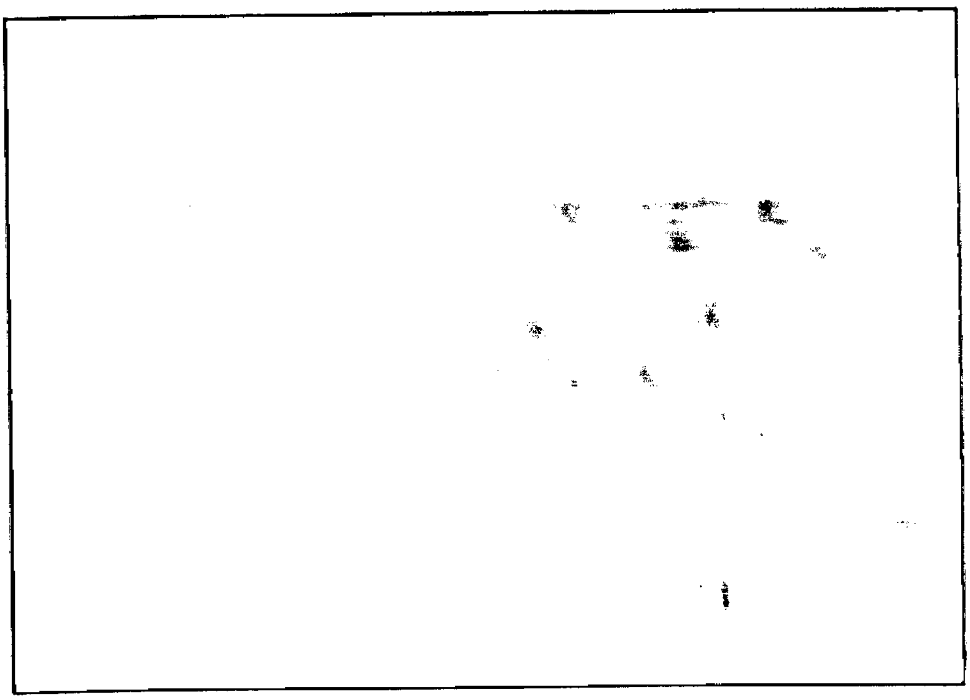


Plate 6.5.2

prospective parents before spawning. The cleaned part could easily be seen beyond the egg laid portion. Spawning over various substrates such as leaves of Halophila sp., mangrove branch, molluscan shell, coconut shell, stones etc. has also been reported (Panikkar,1920; Ward and Wyman, 1977; Samarakoon, 1983).

The eggs are guarded by the parents alternately, while one stays very close to the brood and the other goes for food and probably to survey the nearby area to ascertain the presence or absence of predators. Frequently, the parents nip the eggmass to clear the settled suspended matter, growth of bacteria, fungi and other foreign particles.

Generally, the fish is timid and escapes quickly because of external disturbance, as one tries to approach them, or even the moving shadow itself is sufficient to scare them and the fish will not return to the same place so quickly. However, the brooding pairs are bold and do not leave the brood until one goes very near (about 3 meters) or disturb by throwing some objects near the brood. Brooding parents may leave the brood for some time when disturbed, but become alert and again return to the brood within few minutes. This behaviour of boldness and quick return to the original place is an indication that the fish is brooding eggmass or eleuthroembryos. After egg hatching, the eleuthroembryos are transferred to the nests, either built during courtship or after spawning. Numerous nests (5 - 30 numbers; Plate 6.5.2) are made whose depth and diameter vary from 4 - 6 cm. All these nests are made in the close vicinity within a radius of 0.50 - 0.75 m. Actual shifting of eleuthroembryos could not be observed. However, a brood located at one place was observed to be transferred to a nearby nest within few hours and the original nests being abandoned. On many occasions, eleuthroembryos located at one spot could be traced at a different place on the following day. At night both the parents were found very close to the brood in comparison to the alternate supervision observed during the day time. Seven to eight days old spawn shift on their own in the adjacent nests. The brooding parents act aggressive and ferocious, and even scared the Megalopsis sp., Oreochromis sp. and mullets which were two to three times bigger than their size. In March, a brood was located in shallow area (about 15 cm. deep) and one of the parents was observed to incline at an angle over the brood to protect them from the direct sunlight and heat. Spawn of about 12 days old, start swimming in the water under the supervision of the parents in a whirlpool fashion giving a cloudy look. At this stage the nest is abandoned, but any disturbance makes the spawn to go to the bottom and gather at one place. In clear shallow waters, the parents could easily be seen with broods (Plate 6.6.1 & 6.6.2). However, in deep and turbid waters, the parents alongwith spawn could be seen on the water surface during early morning hours (6.00 - 9.00 AM). Parents were observed to guard the juveniles, until the later attained a size of 2 - 3 cm.

6.3.14 Early Ontogeny: The knowledge of early developmental stages and larval rearing of cultivable species is essential in order to develop the seed production techniques and other management strategies. The earlier work on the developmental

Plate 6.6.1 Parent guarding the wrigglers.

Plate 6.6.2 Close view of the wrigglers and the nest after the parent is disturbed.

Plate 6.6.1

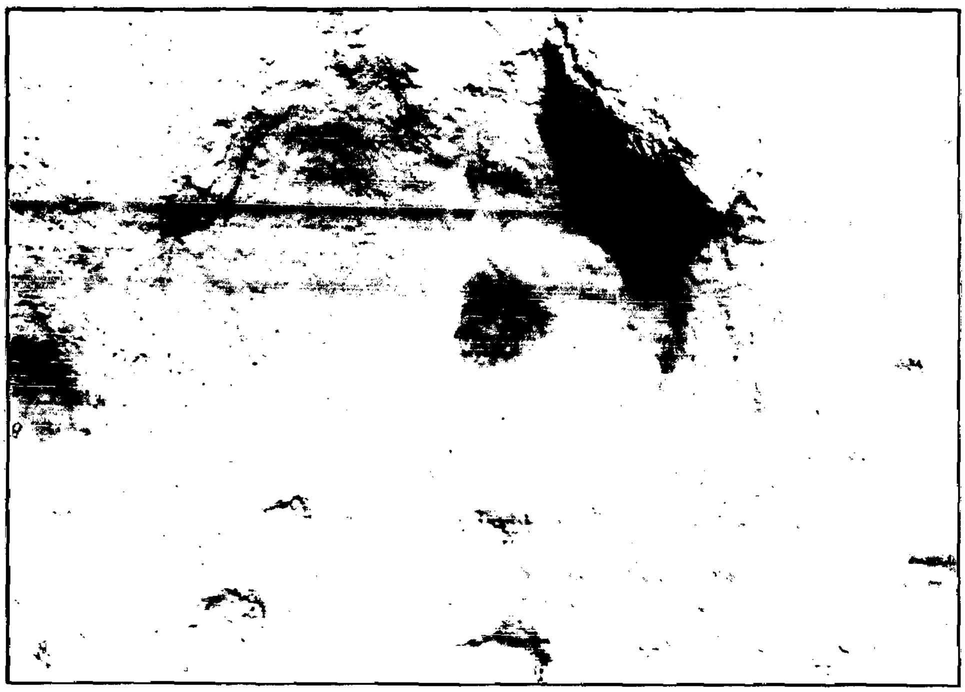


Plate 6.6.2

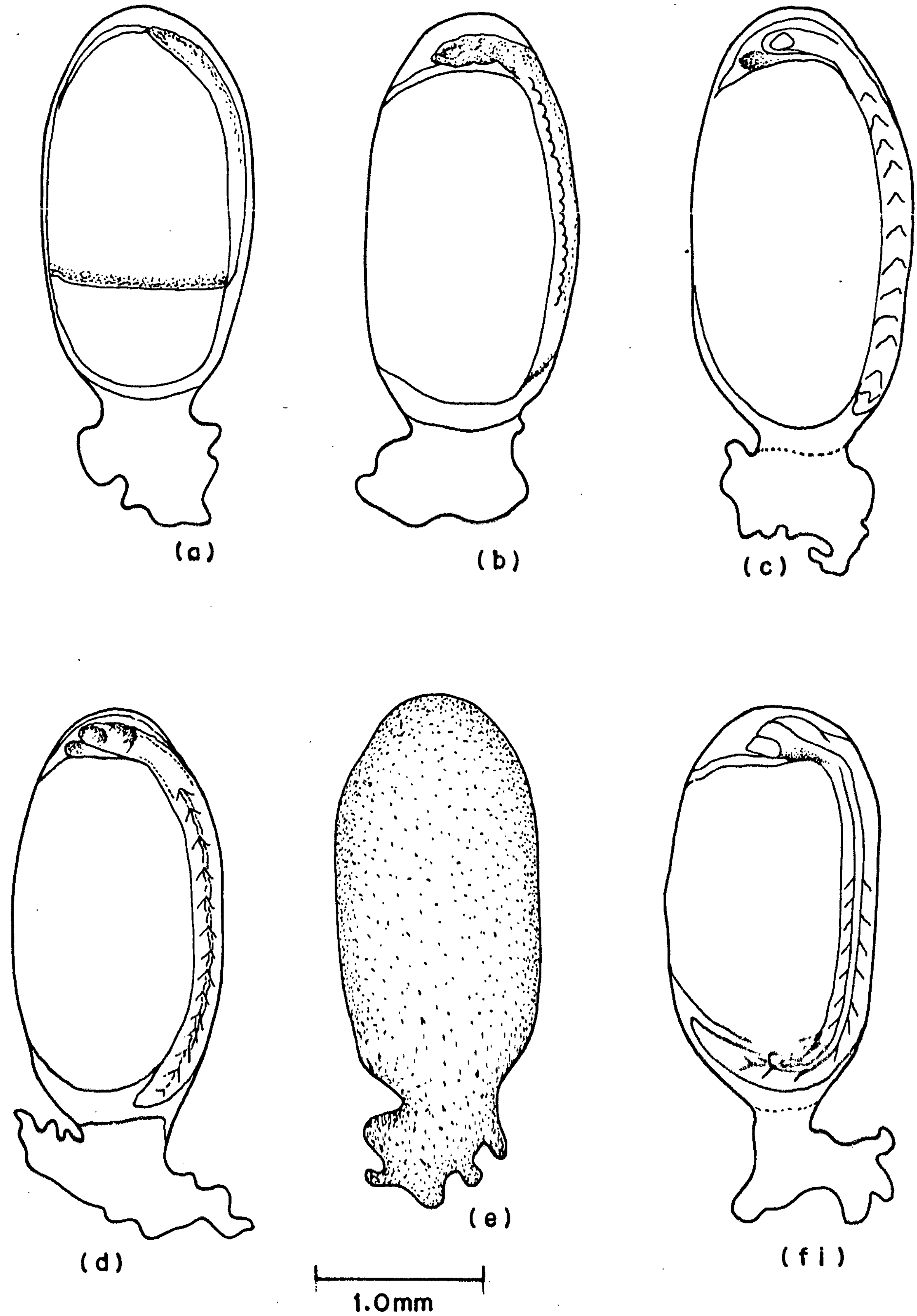
biology of E. suratensis is of Jones (1937). The fertilized eggs collected from the field on three occasions were incubated in glass jar in the laboratory until hatching. Different developmental stages were observed at regular interval under the microscope and the drawings were prepared over the projectina microscope. The earliest stage collected from the field was of late gastrula, which correspond to 28 hours stage as described by Jones (1937). From this stage onwards the observations were recorded at regular interval. All the information presented in the text and figures (Fig. 6.8) is obtained from the live specimens.

28 ± 1 hour stage: At this stage the embryonic axis is elongated and covers about 3/4 of the yolk. The germ ring also covers about 3/4 of the yolk. The embryonic head folds start lifting the cephalic end of the embryo from the yolk.

31 ± 1 hour stage: The germ ring encloses the entire yolk leaving a small portion of the blastopore. The embryo elongates and the cephalic end is completely lifted from the yolk and covers the anterior portion of the egg. The optic cups can be seen and the rudimentary somites also originate at this stage. Posteriorly, the tail portion almost reaches to the blastopore. In other words the embryo covers 1/2 of the yolk circumference.

34 ± 1 hour stage: The embryo grows in length and breadth. The optic cups become prominent. The myotomes attain inverted - V '∧' shape. The tail portion starts getting separated from yolk which until now was growing alongwith the sides of the yolk. Rudiments

Fig. 6.8.1 Early developing stages of embryo of E. suratensis. a) 28 $\pm$1 hour post fertilization stage; b) 31 $\pm$ 1 hour stage; c) 34 $\pm$1 hour stage; d) 37 $\pm$ 1 hour stage; e) spoiled egg; f) 40 $\pm$ 1 hour stage, i. lateral view, ii. ventral view, iii dorsal view; g) 48 $\pm$ 1 hour stage; h) 57 $\pm$ 1 hour stage; i) egg shell after hatching.


(a)
(b)
(c)
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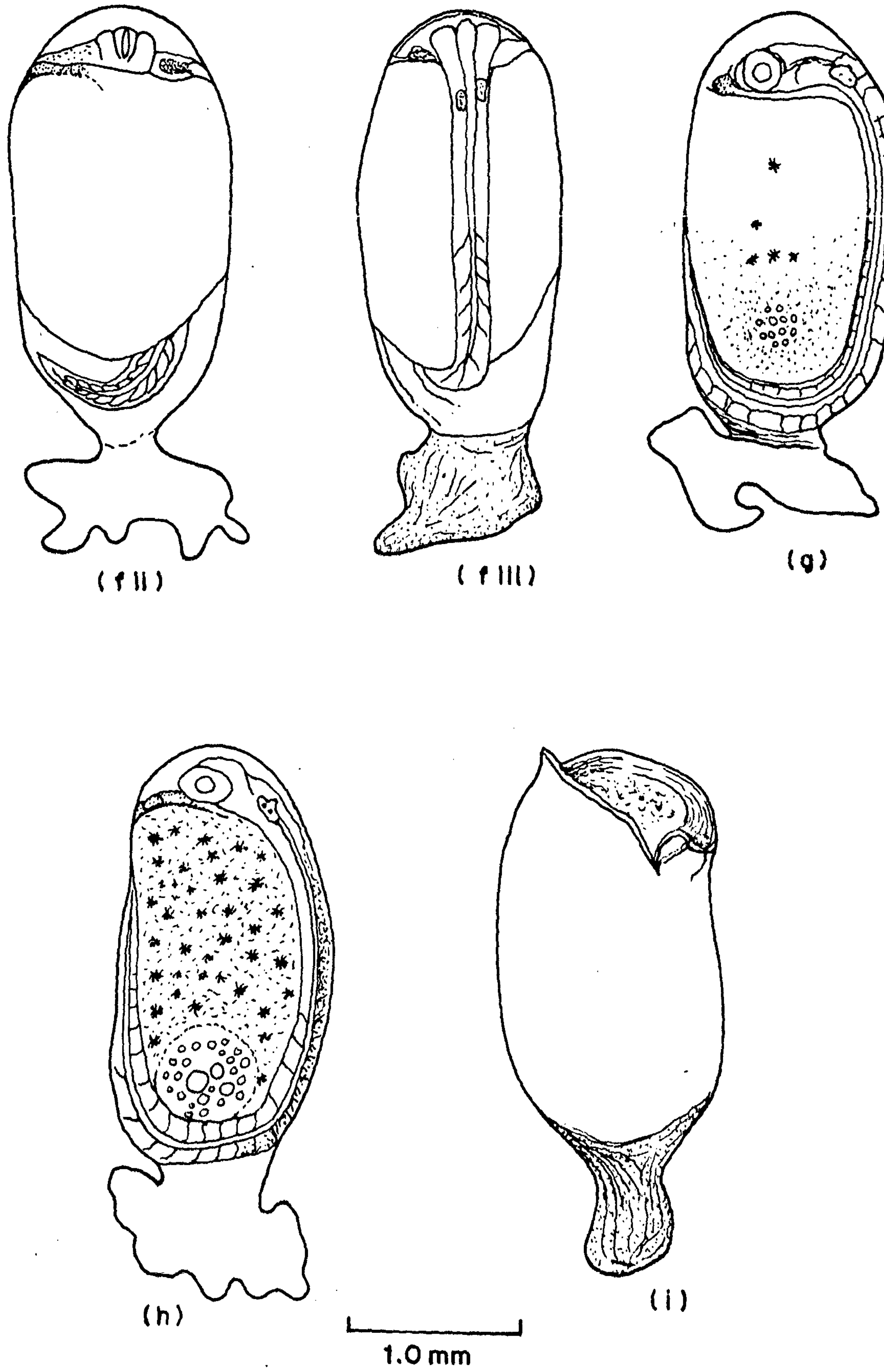

(f II)
(f III)
(g)
(h)
(i)
1.0 mm

of heart with light movement of fluid can be seen but no red blood corpuscles.

37 ± 1 hour stage: There is a reduction in the yolk and the tip of the tail gets separated from yolk. Head can be easily distinguished from the rest of the body. Rhythmical flow of the fluid can be seen in the heart. Neural keel is well defined. The eyes become larger.

40 ± 1 hour stage: There is further elongation of embryo. The tail becomes pointed, well defined and lift off the posterior portion of the egg yolk, a space resulting from the simultaneous reduction of the yolk. The central nervous system is prominent. Rudiments of mouth, and first appearance of red blood corpuscles, imparting pink colour to the heart can also be observed in this stage. The head is much broader with prominent optic lobes.

48 ± 1 hour stage: The somites increase in number resulting in the elongation of the embryo. The embryo covers almost 3/4 circumference of the yolk sac. The eye lens is well developed but the eyes are not pigmented. The heart beats rapidly and the red corpuscles can be seen circulating in the dorsal aorta. The oil globules coalesce. Few chromatophores can be seen on the posterior portion of the yolk sac. For the first time, auditory vesicle appears at this stage. The larvae start wriggling intermittently.

57 ± 1 hour stage: The embryo encircles more than 90% of the yolk sac circumference. The heart which was syncytium appears

chambered. Numerous chromatophores could be seen on the yolk sac. Oil globules in large number are seen inside the larger globules on the posterior margin of the yolk sac. The spontaneous flexing of embryo within the turgid chorion increases. Auditory vesicles become more prominent. Heart beats can easily be counted and vary from 145 to 160 per minute.

<u>60 to 75 hours stage</u>: Hatching initiates after 60 hours of post fertilization and continues till 75 hours. The continuous flexing of embryo gives slight twist to it inside the chorion and break the anterior part of the weaker chorion (Schoots <u>et al.</u>, 1982). resulting in the tail part coming out first. Thus, the tail becomes free and its continuous flexing provides more thrust to the yolk sac and head to come out of the egg shell (Fig. 6.8.1 i). Few developing eggs were removed from the stalk and incubated separately, which made the hatching process difficult since the egg shell also started moving alongwith flexing movements of the tail. Some eggs got detached from the stalk prior to hatching because of the vigorous movements of the tail and faced the same difficulty. Successful hatching was achieved when few eggs were incubated in freshwater, though, the eggs were collected from the brackishwater medium of $28 \times 10^{-3}$ salinity.

The hatching percentage was very poor, to the tune of about 20% which was due to the spoilage of eggs during $37 \pm 1$ hour to $48 \pm 1$ hour stages of post spawning, when most of the eggs turned white. These spoiled eggs were found to be infected by microbes, fungi and infested with oligohymenophores of the genera <u>Vorticella</u> sp. and <u>Epistylis</u> sp.. A similar situation is likely to exist in the natural conditions. Although, the total fecundity ranged from 506 to 3715 eggs, a brood of 100 to 800 numbers could only be observed in the field. Poor hatching rate is a common phenomenon in the cases where the development period is more than 30 hours, a sufficient time for the epifauna and the pathogens (bacteria, fungi, algae, protozoans etc.) to come in contact, settle and develop rapidly. Many times, the failure or poor hatching in Cyprinus carpio is due to infection carried alongwith aquatic weeds provided as substrate (personal experience). The similar problem of bacterial and fungal infection resulting in poor hatching or sometimes complete failure of the batch has been reported in Oreochromis sp. (Shaw and Aronson, 1954; Mires, 1973; Rothbard and Pruginin, 1975; Lee, 1979; Rothbard and Hulata, 1980). This opens a new area of research, especially dealing with improved techniques of hatching for better survival.

The different larval stages from hatchling to spawn stage are shown in Fig. 6.9.1. In just hatched wrigglers, the tail part remained curved for sometimes (Fig. 6.9.1a). Later (20 - 30 minutes post hatching) it straightens because of intermittent flexing of the tail. The tail becomes broader at the caudal end. Large oval yolk sac with scattered chromatophores is present ventral to the body. Oil globules are scattered in the yolk sac. Rudiment of the mouth is covered with membrane. Wrigglers move over the substratum by keeping the head downwards and the ventral side (yolk sac) upwards. This posture of movement protect the yolk sac from being damaged due to the friction with the substratum. The size of the hatchling varied from 4.4 - 4.8 mm.

Caudal fin folds start developing.

One day old hatchling: The size varied from 5.5 - 5.8 mm. The heart lies ventral to the head. The blood supply develops along the ventral margin of the yolk. Mouth is not opened yet. Pigmentation develops on the eyes. Few chromatophores appear on the body behind the head. Rudiments of the digestive tract as straight tube could be seen behind the dorso-posterior region of the yolk sac (Fig. 6.9.1b). Caudal fin folds are well developed. Notch start developing at the prospective place of anus.

2 days old : Mouth opens clearly and the movements of the lower jaw can be observed. Rudiments of gills also appear at this stage. Cement glands on the head are more prominent as reported by Jones (1937). Fine network of chromatophores develop behind the head region and few can be seen in the middle of the body. Eyes become still dark in colour. The size varied from 5.7 - 6.0 mm. Caudal fin folds initiate to get separated from the caudal peduncle.

3 days old: There is a clear demarcation in the development of upper and lower jaws, a further progress in the mouth opening which was merely a slit in the earlier stage. The lower jaw moves frequently. Chromatophores also develop on the head region. Gill arches with the origin of gill filaments could be seen. Rudimentary pectoral fin can be seen at this stage. Fine network of chromatophore threads is observed on the yolk sac, which were star shaped earlier. The yolk sac reduces in size and two large oil globules can be seen. Rudiment of anus, bulging and coiling

of alimentary canal also start developing at this stage. The size varied from 5.9 - 6.2 mm. The blood supply in the visceral cavity is also visible.

4 Days old: There is not much increase in size, which varied from 6.2 - 6.3 mm. Occasionally, the fish start swimming in the water column with the help of pectoral and caudal fins. The yolk sac reduces in size and only single oil globule can be seen. Dark pigmentation of fine network of chromatophore threads can be seen on the dorsal side of the yolk sac and on the body. The alimentary canal becomes coiled and the blood supply in the visceral cavity is prominent. Gill arches have more gill filaments.

5 days old: The earlier wrigglers, start swimming in the water column and develops gregarious nature. There is further improvement in the development of mouth as the jaws are more strong and covered with lips. Well developed gill arches, filaments and rudiments of gillrakers can also be seen at this stage. Alimentary canal is more coiled. Vertebral column is visible as microscopic beads. Rudiments of caudal fin rays also originate at this stage. Cement glands start diminishing. Heart beats can be seen but the heart proper is not visible due to development of chromatophores in this region and increase in thickness of epidermis. Red spot of the caudal fin fold is visible. Size varied from 6.2 - 6.4 mm.

6 days old: Size varied from 6.2 - 6.5 mm. The hatchlings swim freely and respond to external stimuli such as shadow etc.

Plate 6.7.1 Spawn reared in the laboratory.

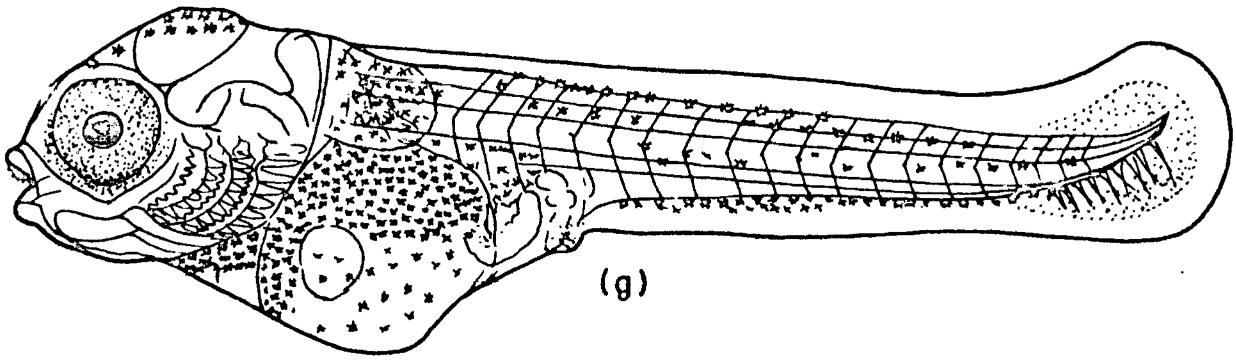
Plate 6.7.2 Photograph showing the growth of spawn to fry stage.

Rudimentary teeth appear on the jaws. Gills become less visible. Posterior part of the intestine is green and opens into the anus. Caudal fin rays are still rudimentary. Red spot on the lower part of the caudal fin is still there. Chromatophores are prominent over the head, few also appear along the body length and caudal fin folds.

7 days old: Yolk sac is very much reduced in size and the gills are completely covered due to the development of the opercular bone. The digestive tract is fully developed and the movement of the anus sphincter muscles are visible. On the caudal fin, a notch appears and the caudal fin rays are fully developed. Microscopic melanophores can also be seen on the caudal fin.. Chromatophores are well developed above the eye, head and abdomen. The origin of branchiostegals can also be seen at this stage. Remnants of oil globules are still visible. The size ranged from 6.4 - 6.7 mm.

8 days old: The size varied from 6.7 - 7.22 mm. Yolk sac is completely absorbed with the absence of oil globule is present. Caudal fin notch disappears. Chromatophores are more pronounced over eye, head and abdomen. Spawn start feeding at this stage. It also develops the capability to keep itself floating in the water column. Branchiostegals are well developed. The spawn resembles to a sub-adult. The weight of the spawn varied from 1.9 - 2.8 mg.

6.3.15 Rearing of Spawn: The spawn after passing through the wriggling period or yolk sac stage of about 8 days is now ready to feed, and was reared in the laboratory (Plate 6.7.1) for a



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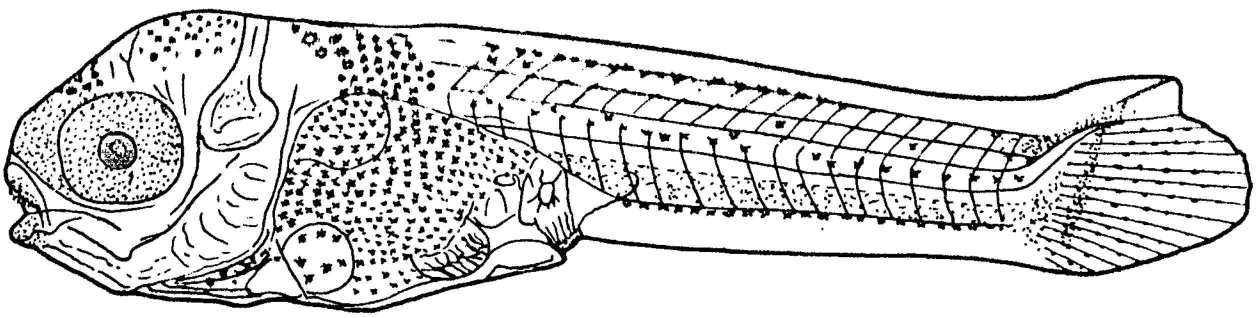

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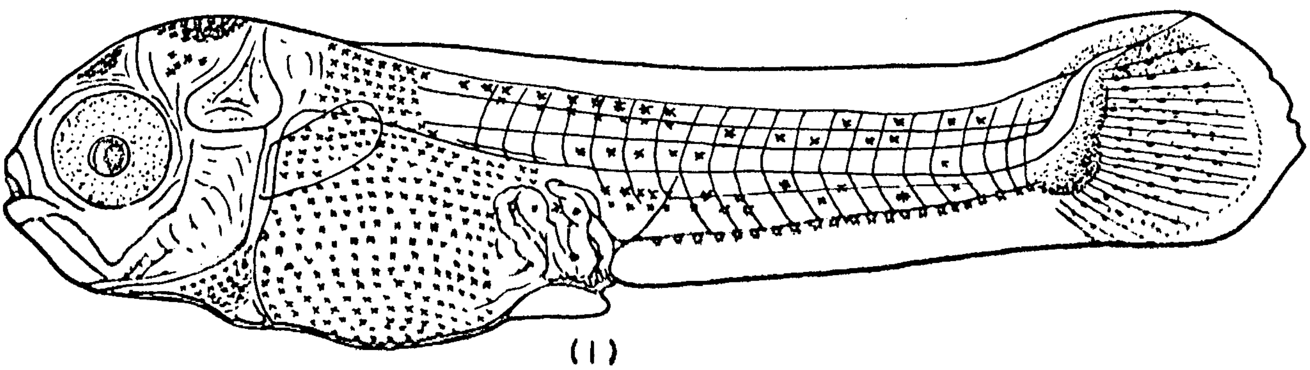
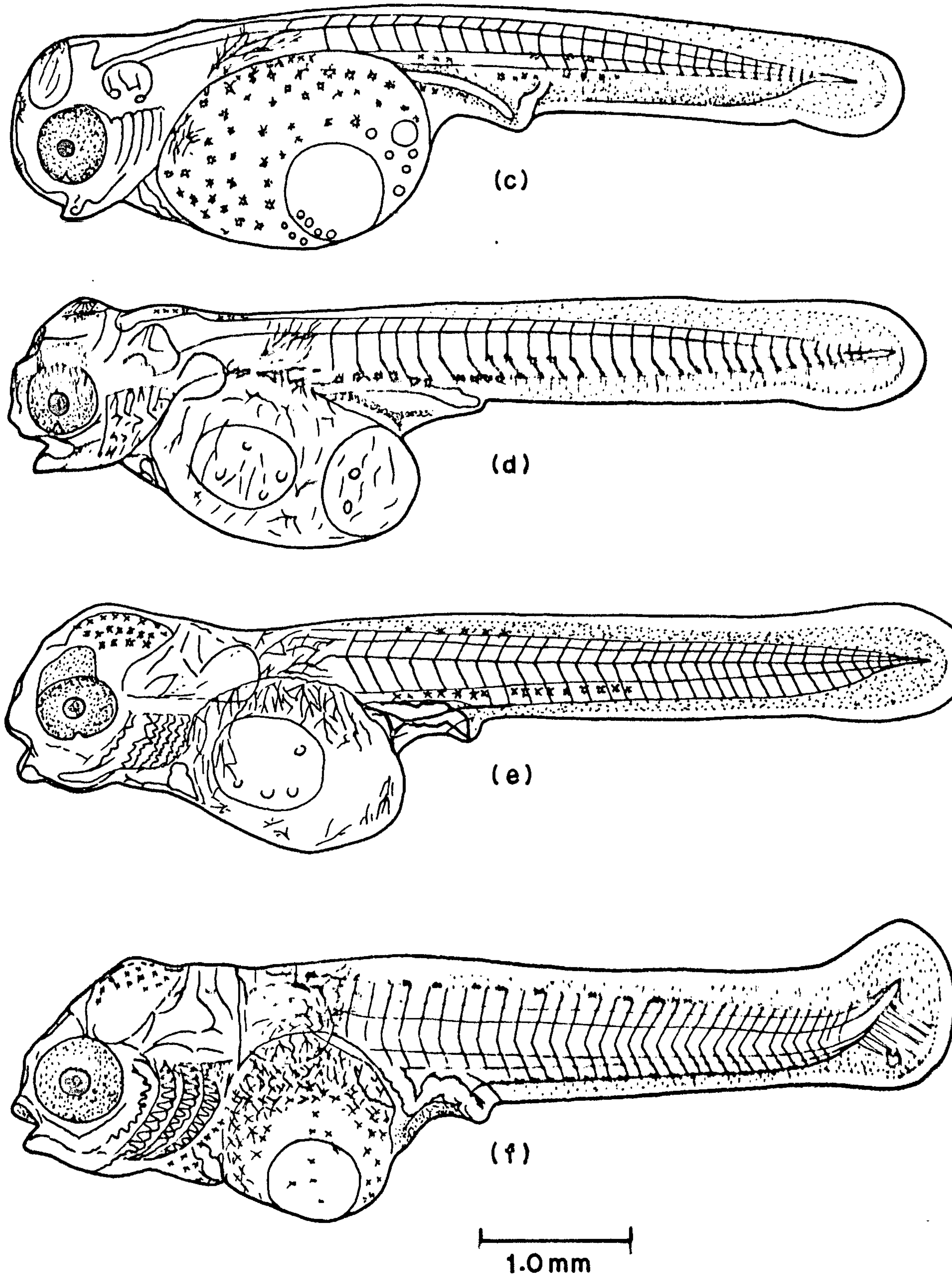


(i)

1.0 mm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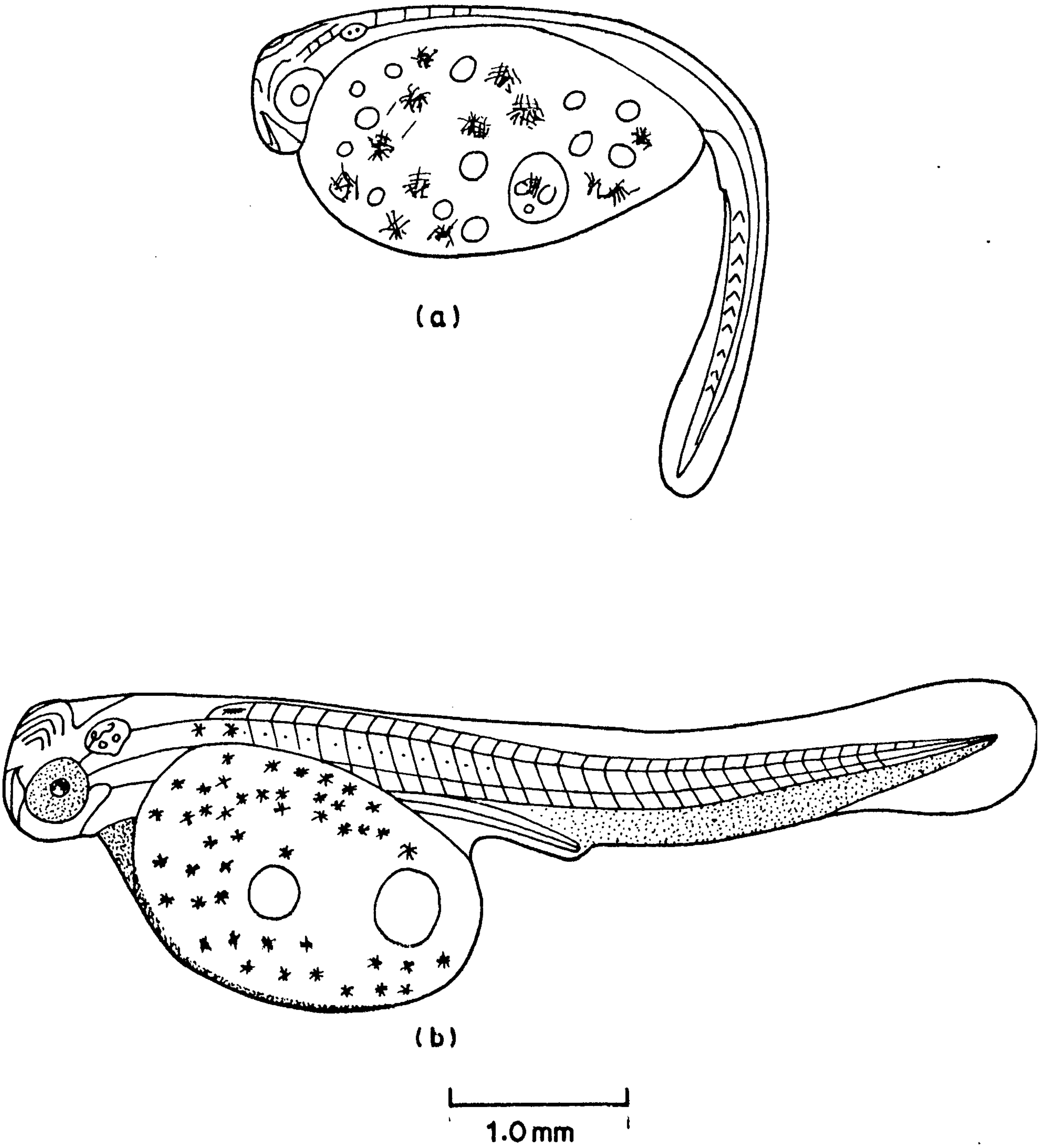

(a)
(b)
1.0 mm

Fig. 6.9.1 Larval stages of _E. suratensis_ from hatchling to spawn stage, a) few minutes old hatchling; b) one day old; c) two days old; d) three days old; e) four days old; f) five days old; g) six days old; h) seven days old; i) eight days old (spawn).

Plate 6.7.1

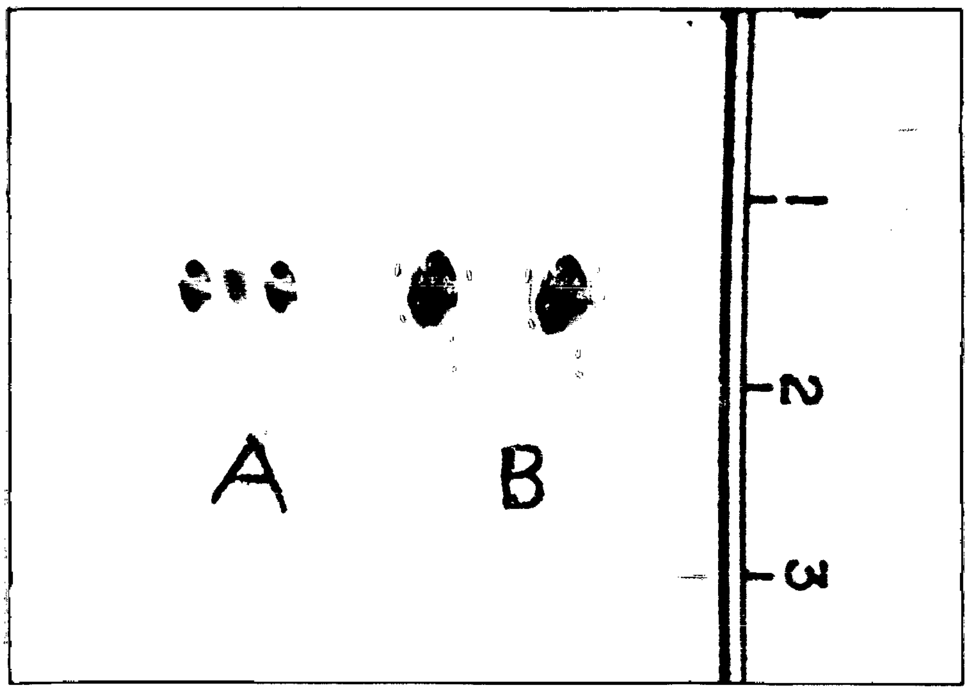



Plate 6.7.2

period of one month until it attained the size of fry stage (15.0 mm TL) (Plate 6.7.2). The salinity of the water medium was maintained at 25 $\pm 1$ ppt. During the rearing period it was fed on decapsulated *Artemia* eggs. For the first 10 days, it was fed at the rate of 10 - 15 eggs per spawn four times a day. From twentieth and thirtieth day onwards, it was fed at the rate of 20 - 25 eggs and 40- 50 eggs per spawn four times a day, respectively. Micro-zooplankton collected from the estuary was also tried as feed on two occasions. The spawn does not seem to possess the capability to catch the zooplankton, but can efficiently pick up the *Artemia* eggs settled at the bottom. While feeding, it makes a 45 - 60$^{\circ}$ angle and pick up the eggs one by one from the bottom. *Artemia* eggs appear to be the most suitable food for the rearing of *E. suratensis* larvae, since only 3% mortality was observed, that too during handling process. Every 10 days during rearing period, 5 specimens were sacrificed to observe the increase in length, width and body weight. The observed growth parameters with respect to time are depicted in Figures 6.10.1, 6.10.2 and 6.10.3. The length weight relationship for the first 30 days of feeding was worked out to be as follows :

$$W = -56.21240 \times TL\ (mm) + 7.511864 \quad (Fig.\ 6.10.4)$$

At this stage, the fry (Plate 6.7.1) is ready to be released in the rearing ponds provided they are free from predators. Even the existence of few larvicidal fish of the genus *Aplocheilus* sp. can damage the fry population significantly. However, in

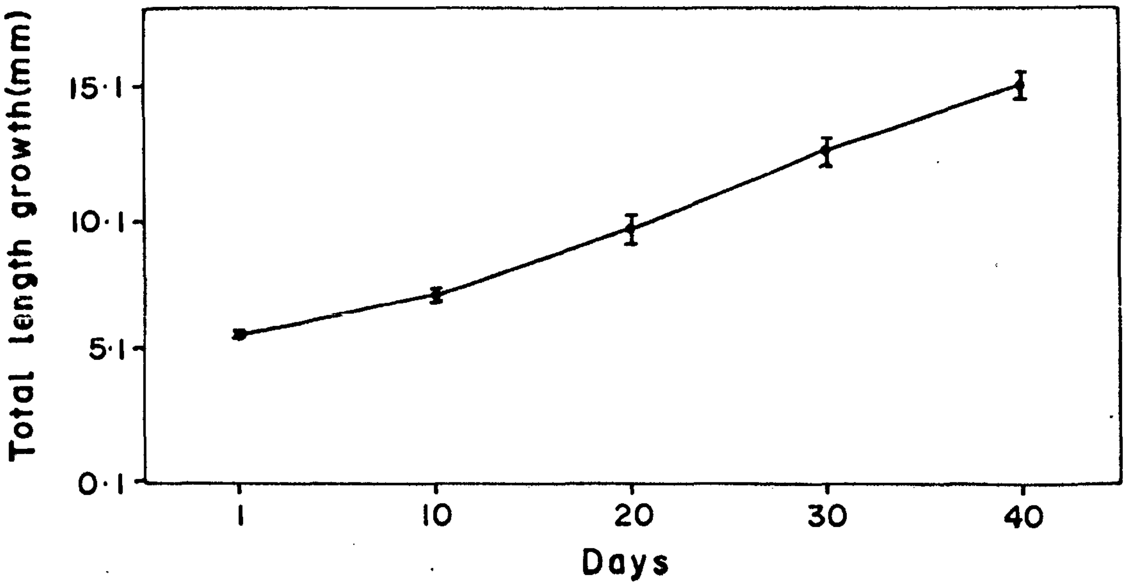



Fig. 6.10.1 Growth in total Length of E. suratensis spawn reared in Laboratory.

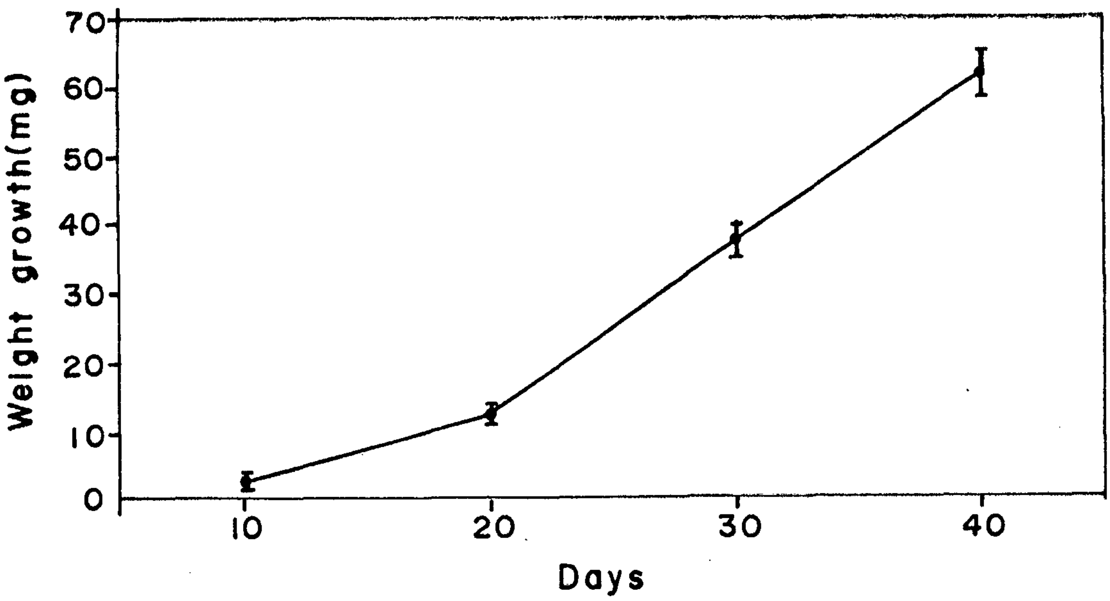



Fig. 6.10.2 Growth in weight of E. suratensis spawn reared in laboratory.

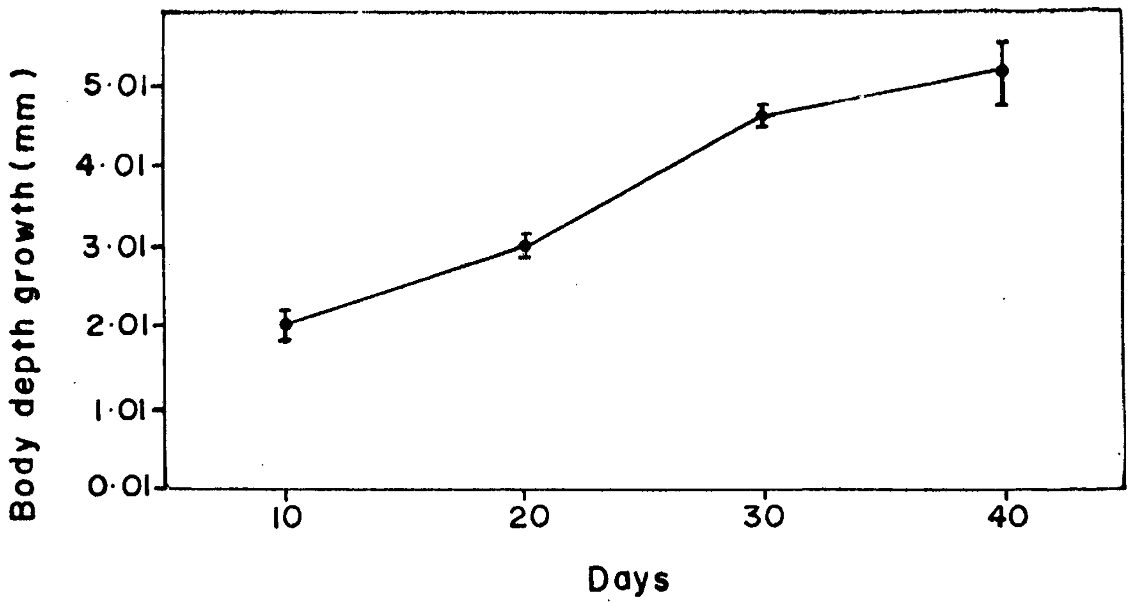



Fig. 6.10.3 Growth in body depth of E. suratensis spawn reared in laboratory.

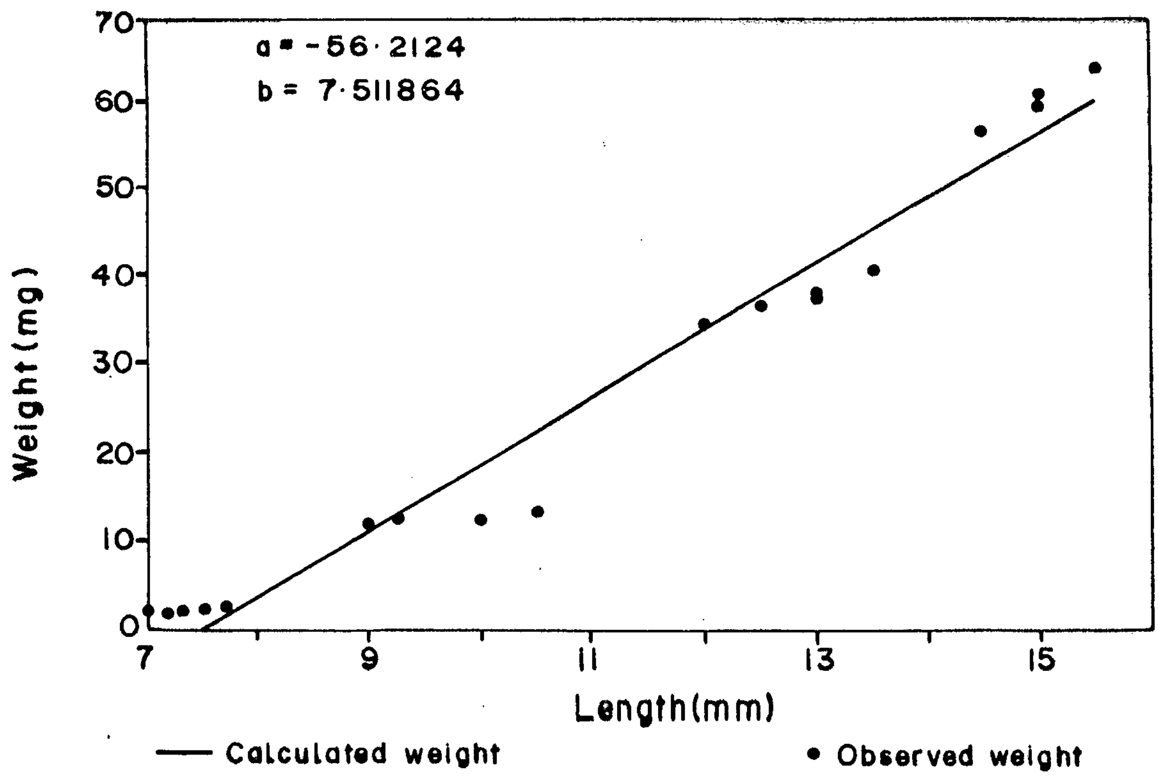



Fig. 6.10.4 Weight on total length regression of E. suratensis spawn reared in laboratory.

nature this stage is still under the protection of parents.

## 6.4 DISCUSSION

Morphological differences with regards to the degree of papilla swelling in female and male <u>E. suratensis</u> is reported as a main sex distinguishing character especially during matured stage. In female the enlarged gonads can be felt externally by the presence of comparatively hard and marginally swollen dorsal part of visceral cavity. The variation in papilla coupled with other characters is widely used in commercially controlled breeding of Indian major carps. The use of genital papilla in distinguishing sex has also been argued in case of <u>Oreochromis aureus</u>, <u>Saretherodon galilaeus</u>, <u>Tilapia zilli</u> and <u>Liza ramada</u> (Chervinski, 1983a and 1983b). Ten stages of developing oocyte could be distinguished based on size and morphological characters. Six oocyte stages of <u>E. suratensis</u> have been described through histological studies of gonads (Rita kumari and Padmanabhan, 1976). The morphological characters and size of the presently described VI stage corresponds to their IV stage. Later stages could not be compared due to lack of information on size and external morphology. Pathiratne and Costa (1984) described IX stages of oocyte which corresponds to the present study, though the missing stage could not be detected due to lack of figures and dimensions in terms of length. The size of oocyte varied from the smallest of 17.87 µ to the fully matured of 2400 µ. The presence of large size ova indicates sufficient stored energy for prolonged developmental period i.e. until the first feeding stage. The large size of ova is also related to the better survival rate, since the fecundity is low which in turn is related to parental care (Perrone and Zaret, 1979). The study of ova also help to understand the process of ova development, to delineate different maturity stages and spawning periodicity.

The sex ratio of male to female up to a size group of 150 mm is 1:0.95, and 1:0.54 in size group of 151 - 190 mm. The dominance of males in the upper size groups i.e. after attaining first maturity could be attributed to differential growth pattern in male and female, since in the latter most of the energy is diverted to reproductive efforts. In Zambezi Sarotherodon sp., the sexual differences in size were reported to be marked after maturation, with the female growth slowing down more than the male and all the large size fish were males (Lowe-McConnell, 1982). In lagoons, ponds and rivers, Sarotherodon niloticus males grow larger than the females (Banks et.al., 1965). In ponds, Tilapia zilli males too grow faster than the females (Chervinski, 1971). A sex ratio of 1:1 in E. suratensis has been reported by Costa (1983), but with no details about size groups. Joseph and Joseph (1986b) reported male to female ratio of 0.37:1, and attributed the differences to sex in age, maturity, gear selectivity, physiological activity and differential natural and fishing mortality which may be true to that population.

E. suratensis female start maturing at a size of 110 mm as evident from the smallest size recorded during the present observations. Further, the percentage of female spawners attaining first maturity went on increasing up to a size group of 141-150 mm, when 70.49% of spawners were represented by fully matured and spent stages, whereas 24.08% were in late maturing stage. Maximum number of males (78.58%) also attain their first maturity at a size of group of 141-150 mm, though the minimum size recorded was 125 mm. The size at first maturity in female is reported to be 150-180 mm (Hora and Pillay, 1962) 105 mm (Jhingran and Natarajan, 1966) 135-144 mm (Jayaprakash and Nair, 1981) 80 - 89 mm in Negombo lagoon, 90 - 99 mm in Colombo lake, 150 - 159 mm in Prakrama samudra (Costa, 1983) and 163 mm in Nethravathi Gurupur estuary near Mangalore (Joseph and Joseph, 1988b). The variation in size at first maturity could be attributed to various ecological factors, including availability of quality food and physiological state of an individual spawner. Such variations have also been reported in Tilapia species. The maturation is delayed in large and deep lakes, while early maturation is attained under adverse conditions such as small water bodies, habitat likely to dry up, shortage of food, intense fishing and shortage of water (Lowe-McConnell, 1975, 1982; Fryer and Iles, 1972 ; Dudley, 1979). They attributed early maturation to altricial life style, which means early maturation, increased fecundity, smaller eggs, faster growth and short life span resulting as a consequence of marked alteration in environmental conditions and increased adult mortality. Even the increased fishing pressure has also been reported to bring down the minimum spawning size to 18 cm from 28 cm in case of S. niloticus

(Pullin, 1982). Thus, the variation in first maturation size of *E. suratensis* in different ecological areas or in different water bodies of the same area may be an altricial form in response to local conditions.

The occurrence of different maturity stages throughout the year reveals that the fish spawn round the year, with its peak in June, September, December and March when maximum percentage of matured and spent spawners were recorded. Further, the peaks of gonado-somatic index was also recorded during these months. Jayaprakash and Nair (1981) reported June-July and November - March as the peak breeding season, and correlated it with south-west and north-east monsoons. However, in Goa waters the broods have been observed in the field during December and February and the area receives only south-west monsoon. This indicates that monsoon rainfall does not have any direct impact on the spawning of *E. suratensis*. However, the fact that it prefers calm waters (Samarakoon, 1983) cannot be denied, since it has never been recorded from main estuary, but from the backwater impoudments and secondly is a nest builder which needs stable bottom. It has been reported to spawn during August, November, January and February in Nethravathi-Gurupur estuary (Joseph and Joseph, 1988b). *E. suratensis* spawns several times in a year in Negombo lagoon and Colombo lake but only once i.e. January-April in Prakrama samudra (Costa, 1983). The findings of the present study and the earlier information reveal that it breeds throughout the year and spawn easily in enclosed water bodies unlike other culturable brackishwater species such as mullets, milk fish and sea bass. Thus, from an aquaculture potential point of view, E. suratensis has an added advantage of producing fish seed round the year. However, the relative synchronization between the sexual cycles of individual female can be a problem when mass production of homogenous fry is required for intensive cultivation.

In mature virgin, the ova of second mode `C' had attained almost half the size (in length) of matured ova, though not yet completely separated from mode `B'. Thus, after shedding the mode `D' ova, the mode `C' will be shifting to mode `D' and the fish will be spawning second time in a year. The ovary also comprises different stages of oocyte described earlier in mode `A'. Fish spawning second time or more had three distinct modes, `D', `C' and `B' Viz. 2300 μ, 1000 μ and 600 μ size besides various stages of oocytes in mode `A'. This multimodal pattern indicates that the development of oocytes in batches is a continuous process in succession and the fish spawns intermittently. Thus, it corresponds to type - D as described by Prabhu (1956), though Jayaprakash and Nair (1981) have clubbed the mode `B' and `C' and categorised it in type - C, i.e. spawning twice in a year. Similarly, multimodal pattern of intra-ovarian oocytes has been reported in other cichlids viz. Tilapias (Siddiqui, 1977; Peters, 1983) which spawn 3 - 4 times in a year (T. rendalli, De Bont, 1950; S. variabilis, Fryer, 1961; S. mossambicus, Bruton and Boltt, 1975). Hence, in the second year of breeding, E. suratensis must be spawning more than two times in a year.

The fish lay eggs over the pre-selected hard substratum which is cleaned prior to spawning. Both the parents guard the fertilized eggs and the hatchlings are placed in a nest made in either mud or sand substratum . Therefore, for controlled spawning it is essential to provide wooden structures for laying eggs and soft bottom to facilitate nesting. Both the parents guard the juvenile shoal from either side while, the young ones swim freely and feed. Sometimes, one parent may chase the intruder for short distance and again join the shoal. Parents were observed to guard the juveniles until the latter attain the size of 20 - 25 mm and according to laboratory rearing the age of juveniles may be 2 - 3 months. This observation reveals that under normal circumstances the minimum period in two successive spawnings could be at least 3 months. In laboratory, the sympatric <u>E. maculatus</u> has been recorded to raise 12 broods per year when robbed of its brood in comparison to 3 or 4 broods in natural conditions (Ward and Wyman, 1977). Panikkar (1924) spawned a pair of <u>E. suratensis</u> five times in succession at a mean interval of 19.2 days by removing the previous broods. The size difference in two successive modes of C and D is so high that the maturation of second batch (mode `C') in 19 days is somewhat interesting and needs to be re-investigated, though the fact of partial spawning under laboratory conditions cannot be ruled out. However, in natural environment too, the parents may be separated from brood either by the predators or adverse ecological conditions and fish might be spawning for the second time much earlier than the usual time taken after the completion of parental care. Such information, further supports the fact that *E. suratensis* spawns intermittently throughout the year, and the number of spawnings per year is variable depending upon the individual spawner, feeding, localized environmental conditions and the time devoted to the earlier brood care.

Fecundity showed a linear relationship with fish size and weight. However, the fecundity is highly variable within the fish of same size and age. This could be attributed to the percentage of eggs following the second batch, the feeding activity preceding spawning or it may fluctuate between low and high alternately. It needs to be investigated through controlled spawning.

The rearing of developmental stages opened a new area of research pertaining to the hatching technology, since prolonged developmental period predispose the fertilized eggs to various microbial infections, epifauna and parasites. The developmental period within the egg has been observed to be the most susceptible, when maximum mortality (about 80 %) occurs. The eggs are attached very closely and an initial infection in few may quickly spread over the entire egg mass resulting in the mass mortality. This basic problem of poor hatching rate has also been reported in *Oreochromis* sp. (Shaw and Aronson, 1954; Mires, 1973; Rothbard and Prugiini, 1975; Lee, 1979; Rothbard and Hulata, 1980). The embryo hatches in 60 - 75 hours of post fertilization at $28 \pm 1\,^{o}C$. The spawn start first feeding after eight days of post hatching. Rearing from spawn to fry revealed that they lack the capability to capture zooplankton but prey upon the slow moving benthic micro-organisms. The decapsulated *Artemia* eggs were proved to be an ideal food for young ones. The spawn was reared solely on *Artemia* eggs from 2.26 $\pm$ 0.313 mg to 61.56 $\pm$ 3.573 mg in 30 days without any mortality. However, no information is available to compare the growth rate. After the yolk sac stage, a minimum period of 30 days nursery rearing is essential for the spawn to attain fry stage, ready to be released in rearing ponds.

# CHAPTER VII

# PROXIMATE BIOCHEMICAL COMPOSITION

## 7.1 INTRODUCTION

Aquatic ecosystems are regarded as a potential food source for human and animals . The development in agriculture technology has increased the production of food grains, nevertheless, this has been accompanied by phenomenonal increase in human population. Thus, the major question is whether the increase in food production can keep up with the exponential growth of the human population. Besides hunger, the deficiency of essential amino acids (protein), fatty acids (lipid), vitamins etc. seems to be a matter of concern especially in developing countries. Deficiency of protein and vitamins, leads to mental and physical disorder and predisposes to various kinds of diseases. The biological value of fish and marine animals is highly rated by nutrition physiologists. Fish protein contains relatively high percentage of methionine, lysine and tryptophan (Meseck, 1962). Moreover, fish lipid, vitamins and minerals are considered as valuable source for nutrition.

Generally, the whole body biochemical composition is an indication of fish quality. Therefore, proximate composition of a species helps to assess its nutritional value in comparison to other organisms. Proximate composition is also required by the nutrition experts and individuals interested in caloric content of the food for weight control. Recently, cardiologists are recommending the use of fish in food to obtain adequate protein without excessive fatty acids and lipid (Dyerberg, 1986; Kinsella, 1991). Industries involved in the production of balanced diet as well as fast foods, need to know proximate composition of the basic ingredients of the food. Further, as a biologist it is important to understand the dynamics of organic constituents with reference to change in season, size, reproductive stage and sex, as the former seems to depend on the latter, to a greater extent (Phillips et al., 1966; Groves, 1970; Somvanshi, 1983; Sinha and Pal, 1990).

Studies on fish culture have also paid attention to the effects of dietary organic constituents on the number and viability of eggs and brood stock body composition (Smith et al., 1979; Takeuchi et al., 1981; Washburn et al., 1990). The proximate composition of fish ovaries has been well documented (Apparao, 1967; Devauchelle et al., 1988; Washburn et al., op. cit.). In addition, the influence of environmental pollutants has also been well known (Bano et al., 1981; Sahib et al., 1983; Vishwaranjan et al., 1988; Jyoti et al., 1989; Somanath, 1991; Sashtry and Dasgupta, 1991).

The present study was undertaken to elucidate the dynamics of biochemical components of muscle and ovary of E. suratensis with reference to different maturity stages, size/age and seasons.

## 7.2 MATERIALS AND METHODS

Male and female specimens of E. suratensis were collected separately every month over a period of 16 months, from February 1991 to May 1992. Body muscle samples (free from skin and scales) from five to six fish were pooled together and used for the analysis of biochemical components. Similarly, a composite sample of fish representing different sizes, maturity stages of fish and ovary was taken to study the dynamics of biochemical constituents in these tissues. The moisture content was estimated by drying the pre-weighed wet sample at 70 $^{o}$C until a constant weight was obtained. The difference in weight was calculated and expressed as percentage moisture content of the sample. The dried samples were then finely powdered in a mortar and pestle and stored in desiccator until further analysis.

Protein was estimated following the method of Herbert <u>et al.</u> (1971) with slight modifications to suit the fish samples. The care was however taken not to deviate from the basic principle of the analysis. A random sample of constant weight (5.0 mg) was extracted with different volume of NaOH viz, 1, 2, 4, 6, 8 and 10 ml to find out the suitable volume of NaOH for the maximum extraction of protein. The results of this analysis (Fig. 7.1) revealed that a volume of 6 ml to 10 ml were suitable for extraction. Therefore, this volume of NaoH was used for the extraction of protein from fish samples. To a known sample (4.4 to 5.1 mg), 10 ml of 1N NaOH was added and sample was extracted at 80 $^{o}$C for half an hour in a water bath . Thereafter, it was cooled at room temperature, and neutralised with 10 ml of 1N HCl. The extracted sample was centrifuged at 2000 rpm for 10 minutes, and an aliquot of the sample (10 ml) was further diluted

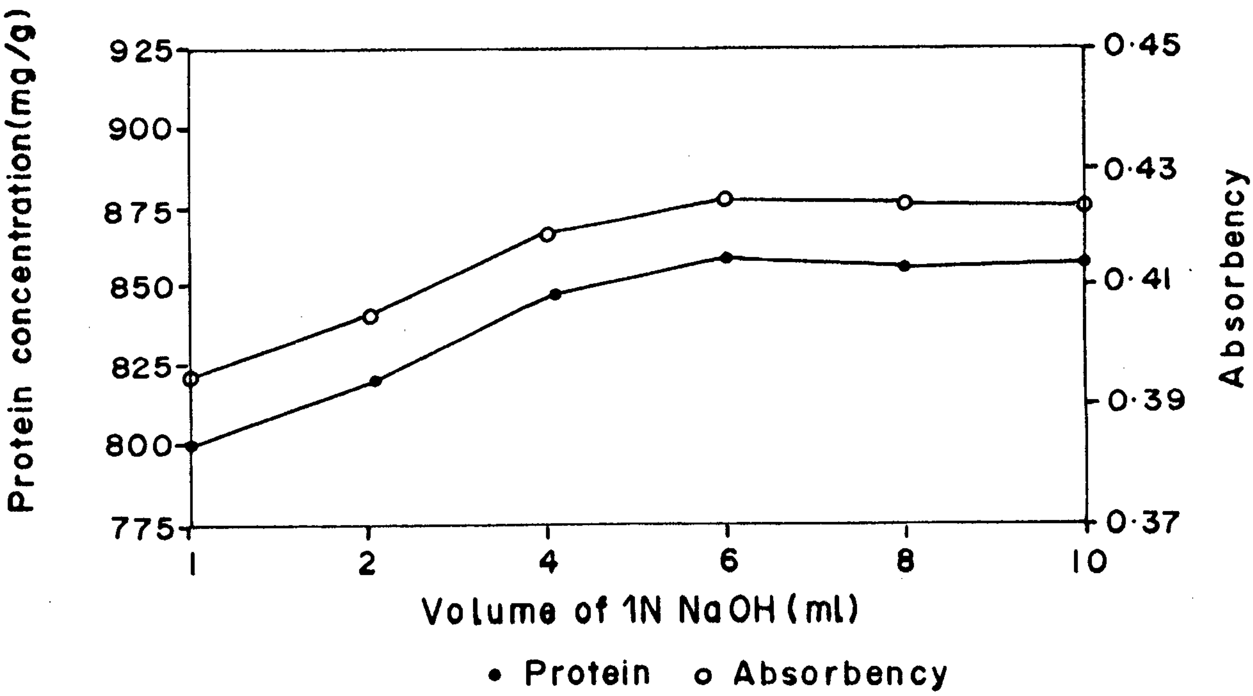



Fig. 7.1 Evaluation of the efficiency of sodium hydroxide for the extraction of protein.

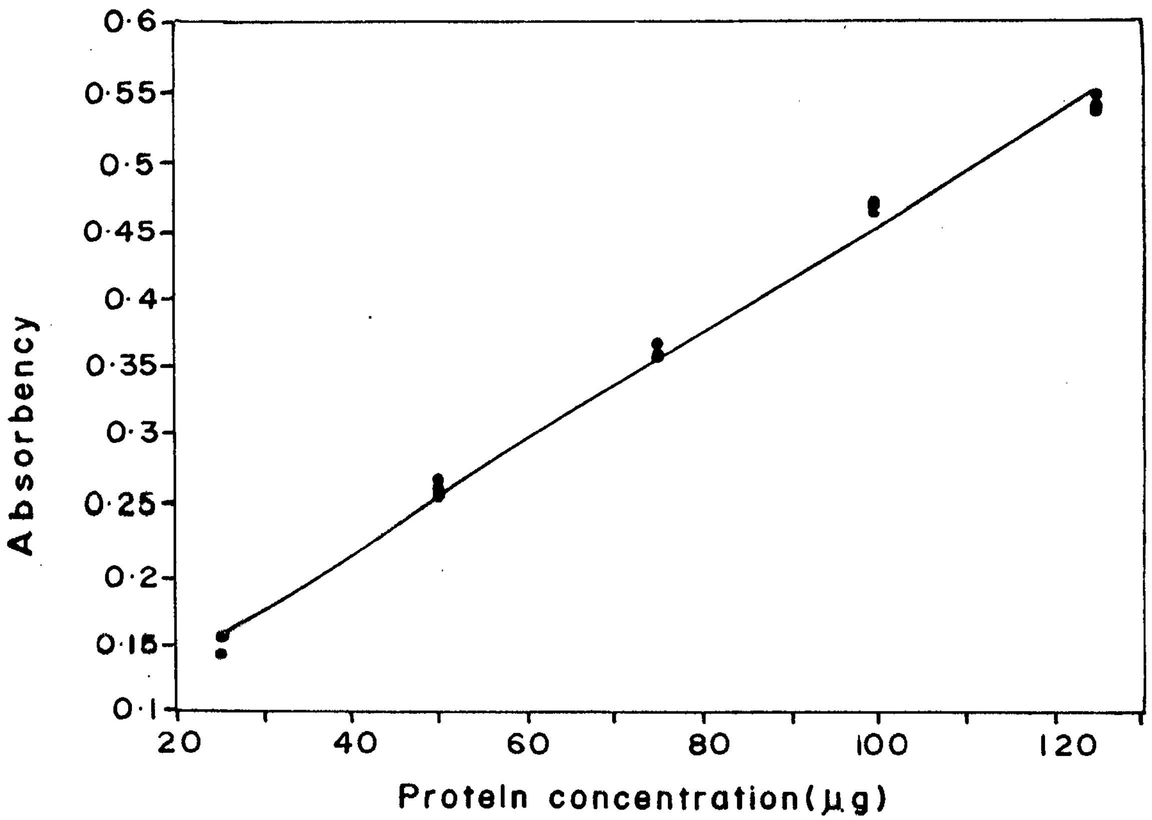



Fig. 7.2 Regression analysis between protein concentration and absorbency.

with equal volume of distilled water. From this diluted sample, 1 ml was taken and treated with 2.5 ml of mixed reagent (Carbonate-tartrate-copper) and 0.5 ml of 1N Folin's-Ciocalteace reagent. After 30 minutes, sample absorbency was read at 750 nm in Beckman DU-6 Spectrophotometer. Appropriate blanks and standards (Bovine-serum-albumin) were treated similarly to obtain a standard calibration curve (Fig. 7.2). All the results expressed as mg/g of dry sample.

Carbohydrate was estimated by using the phenol sulphuric acid method (Dubois et. al., 1956) as suggested by Hitchcock (1977). However, prior to final analysis a random sample of constant weight (5.0 mg) was treated with different volumes viz, 1, 2, 4, 6 and 8 ml of 80% sulphuric acid in order to find out the optimum requirement of sulphuric acid to extract the absolute carbohydrate from the sample. It ia clear from Fig. 7.3, that 2 ml of 80% sulphuric acid is the best suited volume to extract carbohydrate from 4-5 mg of dried fish sample and the same was used throughout the analysis. A known sample of 4.4 to 5.2 mg was treated with 2 ml of 80% sulphuric acid and was allowed to digest for 21 hours at room temperature. 2 ml of phenol reagent (5%) followed by 5ml of concentrated sulphuric acid were added to the digested sample and allowed to cool. The mixture was centrifuged and absorbency measured at 490 nm. Analar grade D-glucose was used as standard to draw a straight line (Fig 7.4). All the concentrations are expressed as mg/g dry sample.

Lipid was estimated by the method of Parsons et al. (1984). A known sample (5.0 - 7.5 mg) was homogenized in 8 ml of

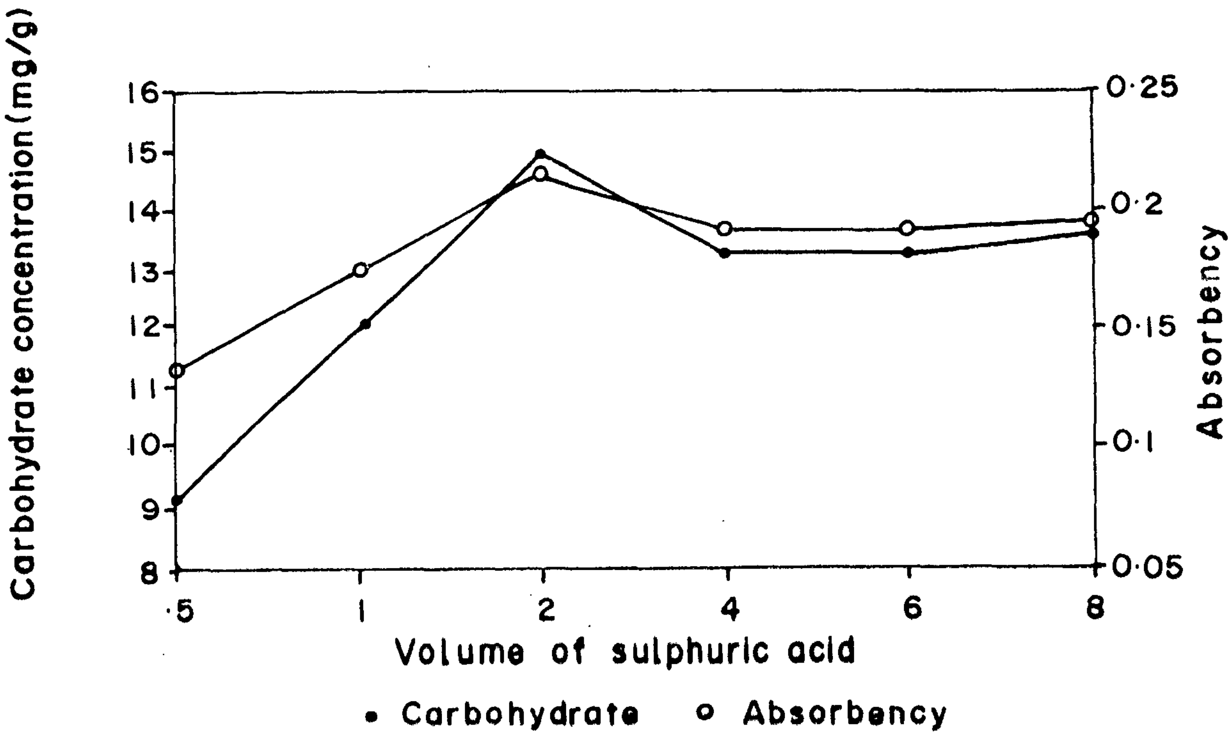



Fig. 7.3 Evaluation of the efficiency of sulphuric acid for the extraction of carbohydrate.

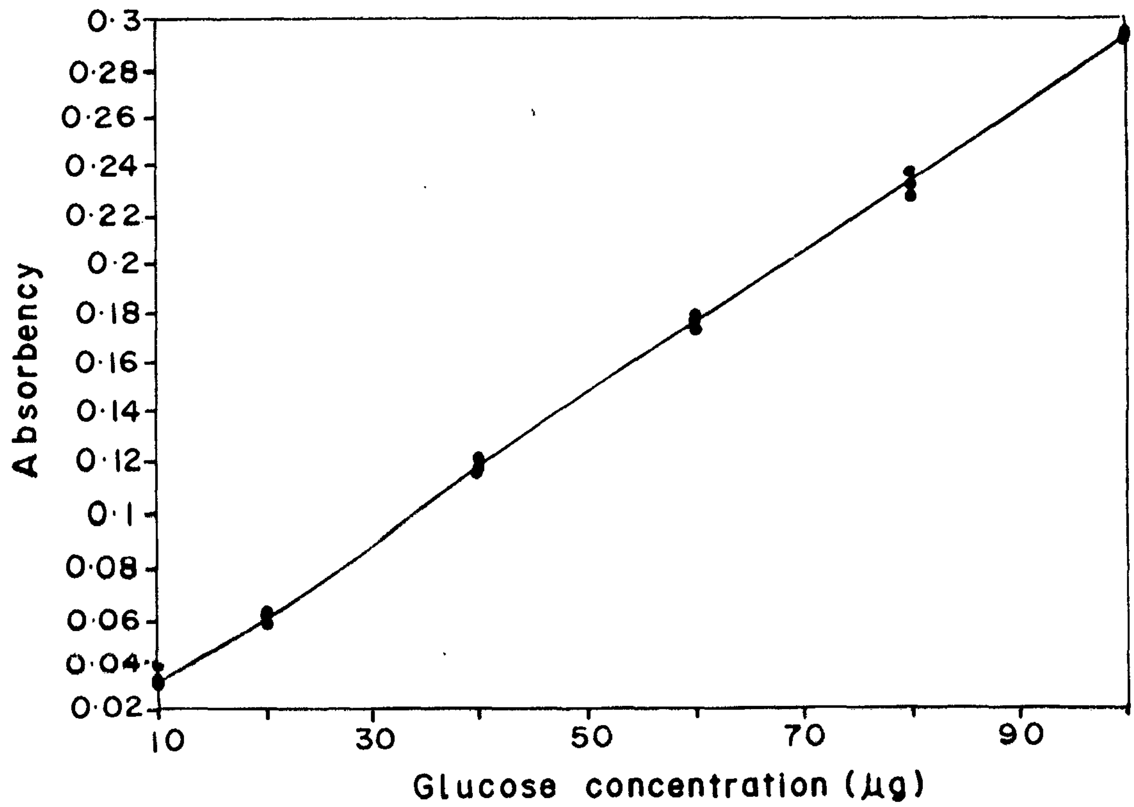



Fig. 7.4 Regression analysis between carbohydrate concentration and absorbency.

chloroform-methanol-distilled water mixture (1:2:0.8 v/v). The extract was filtered through an ignited (450 $^{o}$C for 3 hours) GF/C filter paper, and the filtrate was transferred to a separating funnel. To this, 2 ml of distilled chloroform and 4 ml of distilled were added and the entire mixture was shaken for 10 minutes. The chloroform layer was separated and the procedure repeated with leftover sample. The collected chloroform layer was evaporated to dryness in vacuum. The extracted lipid was treated with 3 ml of 0.15% of potassium dichromate and then kept for boiling in water bath for 15 minutes. To this, 4 ml of distilled water was added and upon cooling the absorbency was read at 440 nm. The blanks were treated similarly alongwith each set of analysis. The standard (stearic acid) was prepared following the same procedure (Fig. 7.5.1). For the analysis of gonad samples the second standard was prepared by taking higher concentration of stearic acid and by increasing the volume of potassium dichromate to 10 ml followed by the dilution with 10 ml of distilled water (Fig. 7.5.2) since the lipid concentration in gonads was higher than the oxidizing capability of 3 ml of dichromate. The concentrations are expressed as mg/g dry sample.

Organic carbon in the sample was determined following the method of El Wakeel and Riley (1957). A known weight (10-12 mg) of the sample was taken in a wide mouth test tube and treated with 10 ml of chromic acid. The samples were then boiled in water bath for two and half hours. After cooling, the content was transferred to a 500 ml conical flask containing 200 ml of distilled water. Four to six drops of ferrous phenanthroline

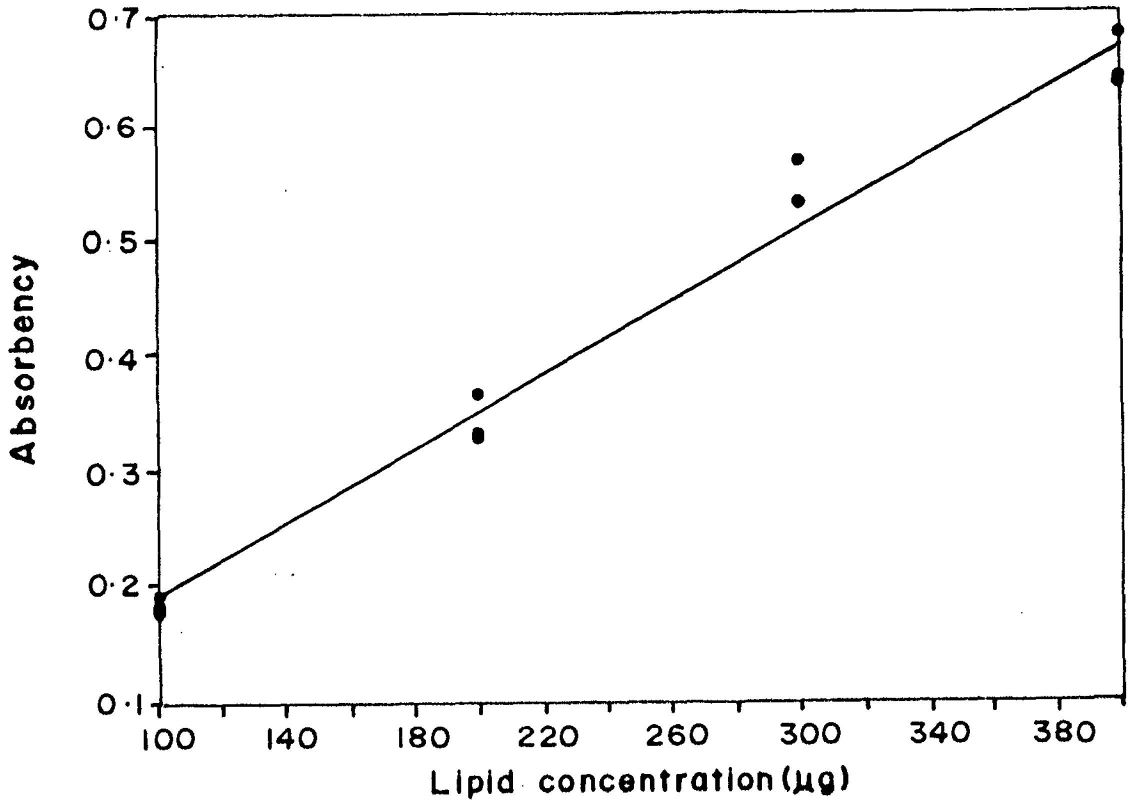



Fig. 7.5.1 Regression analysis between lipid concentration and absorbency.

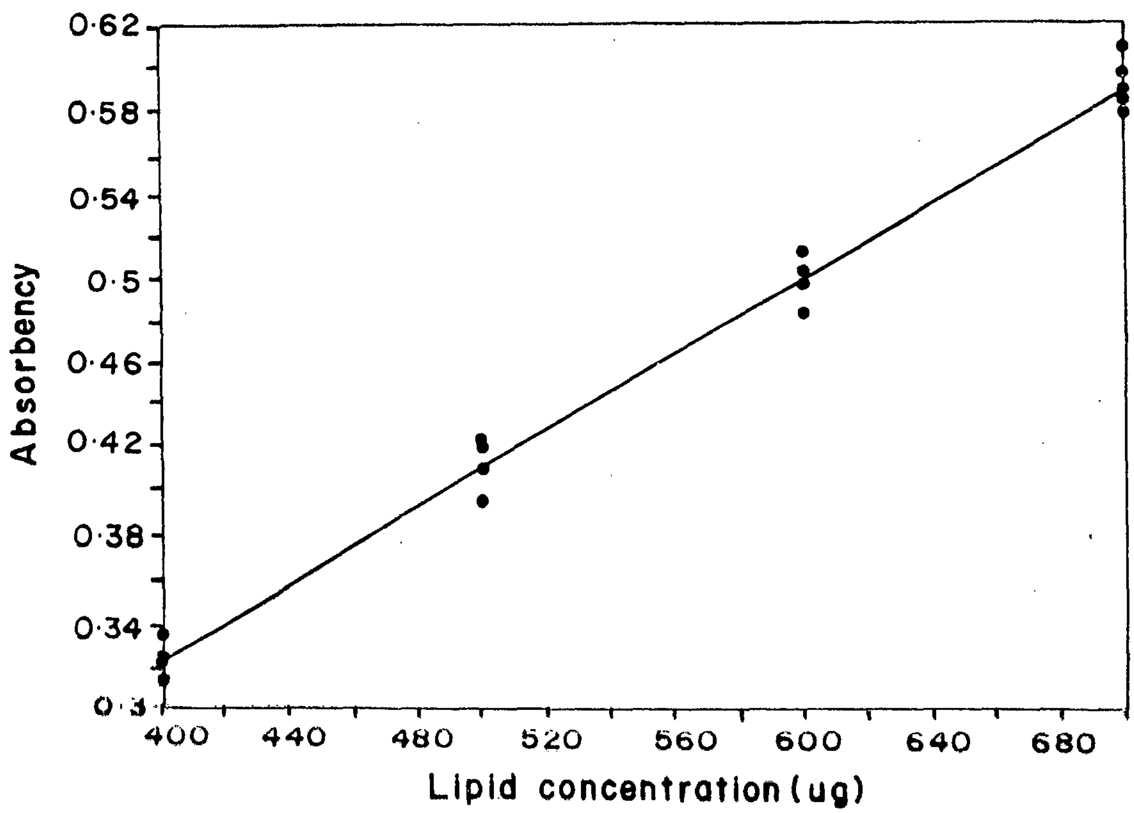



Fig. 7.5.2 Regression analysis between Lipid concentration and absorbency.

indicator were added to the sample and titrated against 0.2N ferrous ammonium sulphate until a pink colour just persisted. Blanks were also carried out in the similar manner with each set of analysis. One ml of 0.2N ferrous ammonium sulphate is equivalent to 1.05 x 0.6 mg of carbon.

The ash content was estimated by ashing the pre-weighed samples (about 500 mg) at 600 $^{o}$C in a muffle furnace for 6 hours. The difference in weight was calculated and the values are expressed as mg/g dry weight.

Calorific content was calculated by multiplying with a factor 5.7 for protein, 4 for carbohydrate and 9.3 for lipid, respectively (Prosser and Brown, 1965).

Concentration of protein, carbohydrate and lipid was calculated using the following formula :

$$mg/g = \frac{E \times F}{W\ (g)}$$

where,

E = Extinction co-efficient

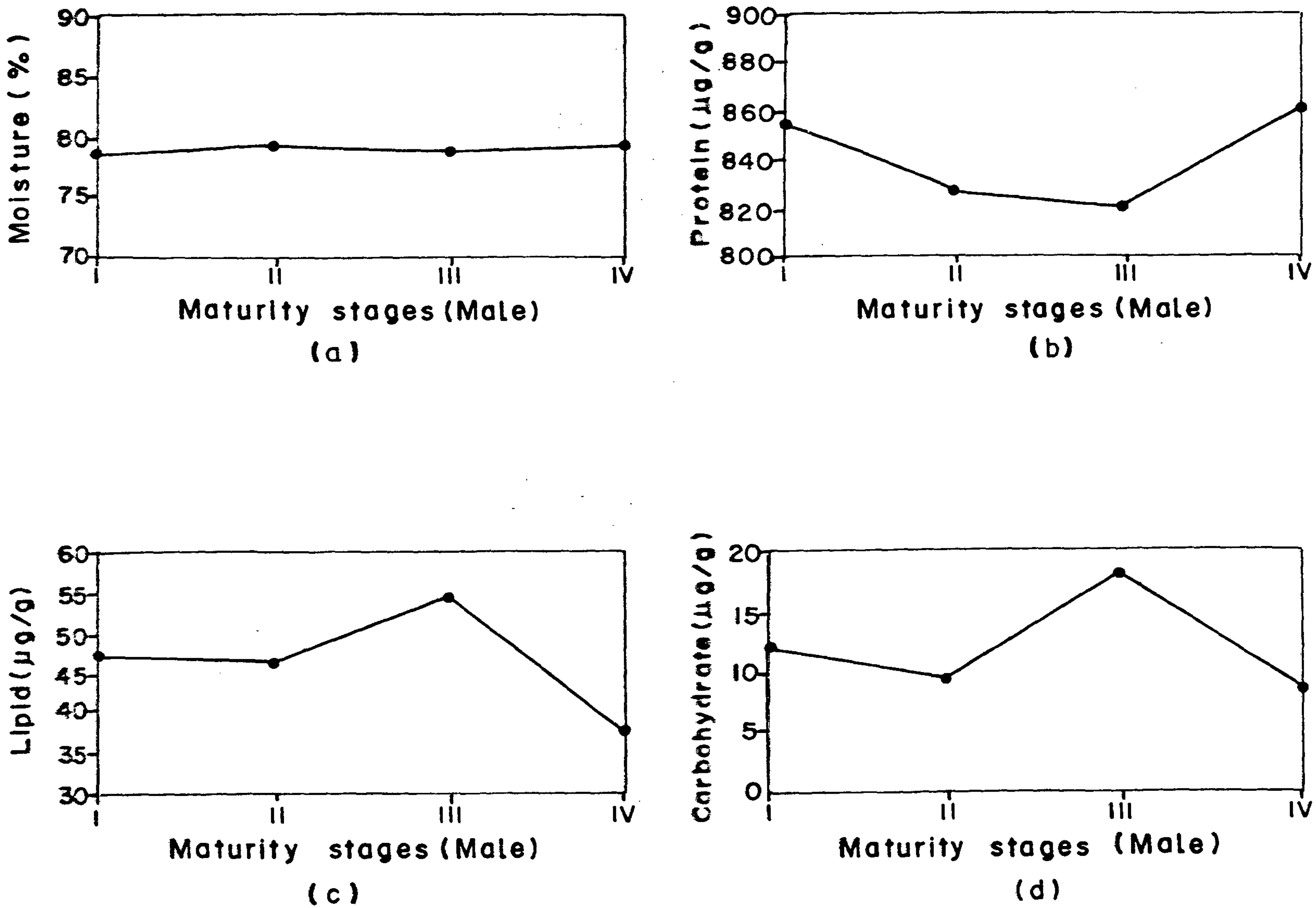
F = Factor derived from standard

W = Weight of sample in g

## 7.3 RESULTS

7.3.1 Variation in Gonadal Maturity Stages: Four maturity stages viz. immature, early maturing, ripe and spent could be distinguished based on morphological characteristics of testes and are referred as stage I, II, III and IV, respectively. Similarly in female, based on ovary morphology and ova diameter six stages i.e. immature, developing virgin, early maturing, late maturing, ripe and spent were defined as stage I, II, III, IV, V and VI, respectively. For male only body muscle while in female both muscle and ovary were analysed for the proximate component analysis .

In muscle tissue of male, moisture content showed small variation during the different gonadal maturity stages (Fig. 7.6a). Protein content gradually decreased from immature stage (854.88 mg/g) to the matured stage (820.66 mg/g) followed by a significant rise in spent spawners (861.86 mg/g) (Fig. 7.6b). Lipid content was almost constant during the first two stages of maturity, but increased to 54.67 mg/g in the matured spawner. This was followed by a distinct fall (38.06 mg/g) in the spent spawners (Fig. 7.6c). Carbohydrate content was maximum (18.49 mg/g) in the matured spawners whereas in other stages it was almost constant with little variation (Fig. 7.6d). Ash content was low in immature and mature spawners but high in maturing and spent spawners (Fig. 7.6e). Organic carbon was high in immature and mature but low in maturing and spent fish (Fig. 7.6f). Calorific content was high in immature specimen (5.36 K cal/g) followed by a decrease (5.18 K cal/g) in matured and then gradually increased till spent phase (5.26 K cal/g) (Fig. 7.6g).



Moisture ( % )
90
85
80
75
70
I
II
III
IV
Maturity stages (Male)
(a)
Protein ( µg/g )
900
880
860
840
820
800
I
II
III
IV
Maturity stages (Male)
(b)
Lipid (µg/g)
60
55
50
45
40
35
30
I
II
III
IV
Maturity stages (Male)
(c)
Carbohydrate (µg/g)
20
15
10
5
0
I
II
III
IV
Maturity stages (Male)
(d)


Fig. 7.6

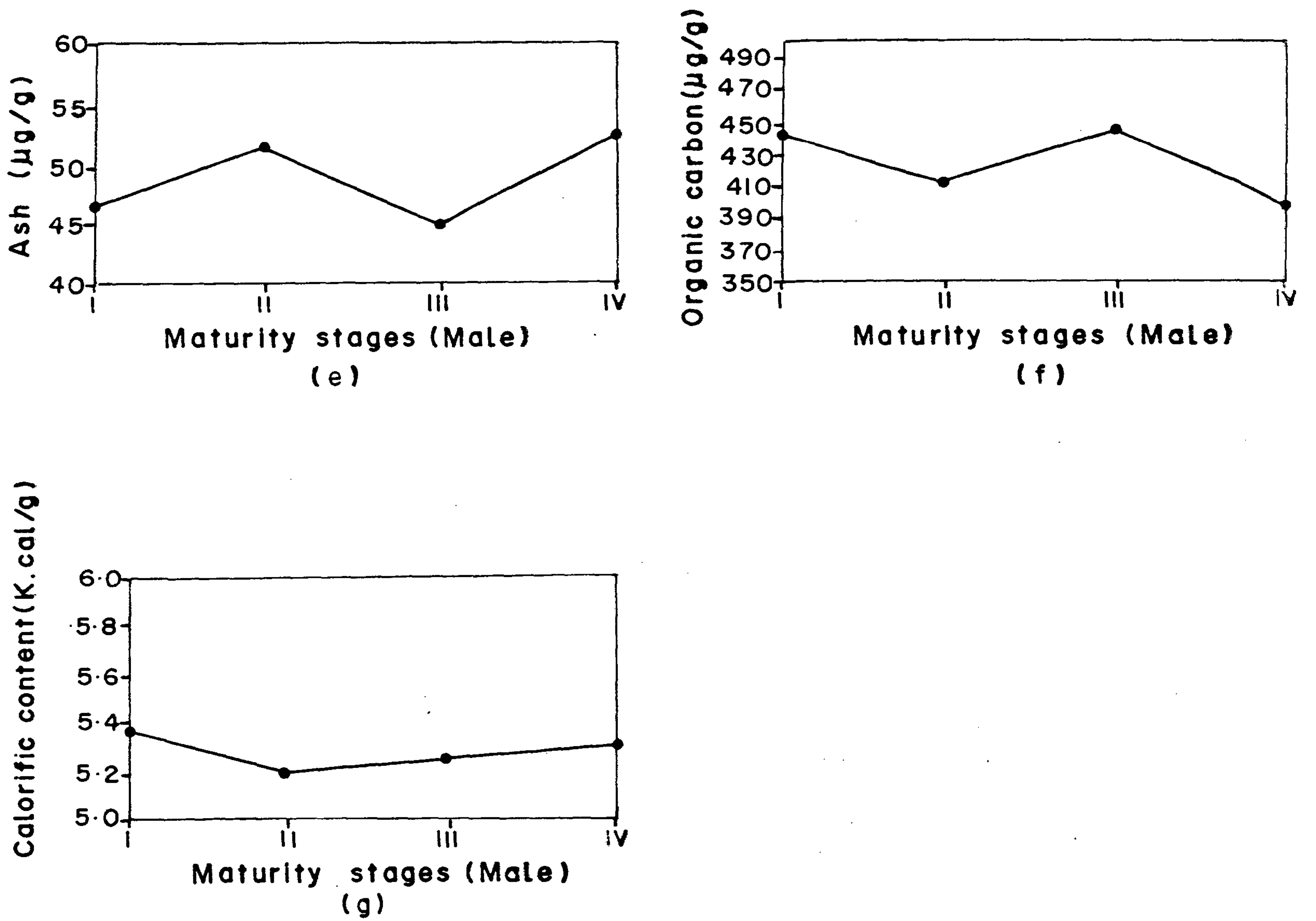
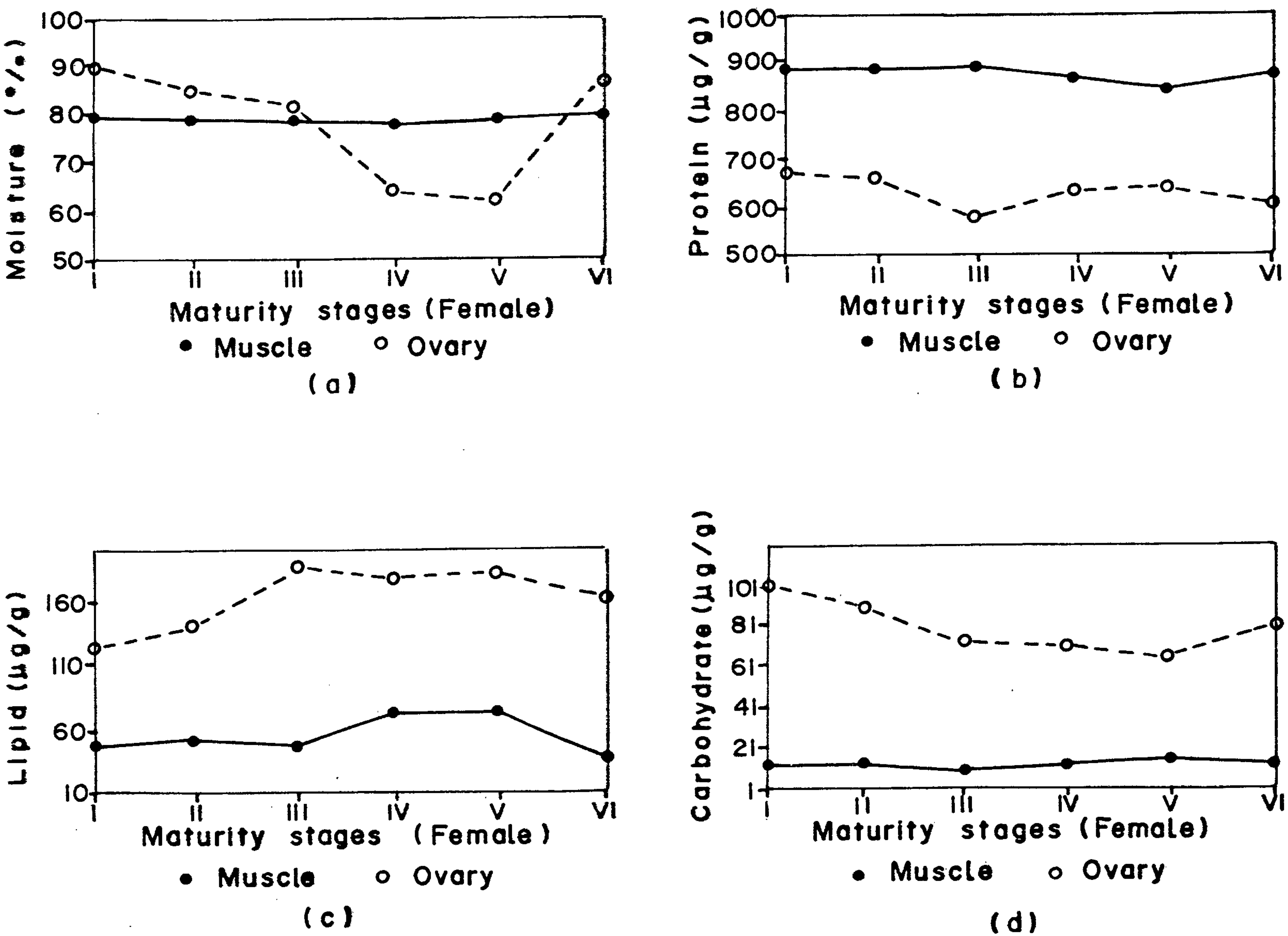



Fig. 7·6 Variation in biochemical constituents of muscle tissue of male <u>E. suratensis</u> with respect to different gondal maturity stages, a) Moisture b) Protein c) Lipid d) Carbohydrate e) Ash f) Organic carbon g) Calorific content.

In female muscle the moisture content did not show much variation (78.0 to 79.28%) with reference to gonadal maturity (Fig. 7.7a). Protein content gradually decreased through immature (884.36 mg/g) to ripe stage (839.25 mg/g) followed by an increase in the spent spawners (878.10 mg/g) (Fig. 7.7b). Lipid content was almost stable in the first three maturity stages, later increased gradually till ripe stage (71.35 mg/g) which was followed by a sudden decrease to the minimum in spent spawners (36.02 mg/g). This concentration was even lower than that observed for the first three stages of maturity (Fig. 7.7c). Carbohydrate content almost showed a steady state (9.22 - 12.66 mg/g) throughout the maturity cycle (Fig. 7.7d). The ash content was also stable in the first four maturity stages. Thereafter, it decreased to the minimum (46.15 mg/g) in ripe spawner and showed the highest content (59.60 mg/g) in the spent spawner (Fig. 7.7e). Organic carbon did not vary much in the first three stages of maturity and gradually increased to 490.99 mg/g in the ripe stage followed by a fall (431.88 mg/g) with a minimum concentration in the spent stage (Fig. 7.7f). Calorific content also showed similar trend up to third stage followed by an increase (5.61 K cal/g) in the late maturing stage, and later decreased to its minimum (5.39 K cal/g) in spent stage (Fig. 7.7g).

The moisture content showed wide fluctuations during the various stages of gonadal maturity, with maximum value (89.33%) in immature and the minimum value (61.28%) in ripe ovary. The moisture content decreased gradually till third stage (81.08%)



Moisture (%)
100
90
80
70
60
50
I
II
III
IV
V
VI
Maturity stages (Female)
Muscle
Ovary
(a)
Protein (µg/g)
1000
900
800
700
600
500
I
II
III
IV
V
VI
Maturity stages (Female)
Muscle
Ovary
(b)
Lipid (µg/g)
160
110
60
10
I
II
III
IV
V
VI
Maturity stages (Female)
Muscle
Ovary
(c)
Carbohydrate (µg/g)
101
81
61
41
21
1
I
II
III
IV
V
VI
Maturity stages (Female)
Muscle
Ovary
(d)


Fig. 7.7

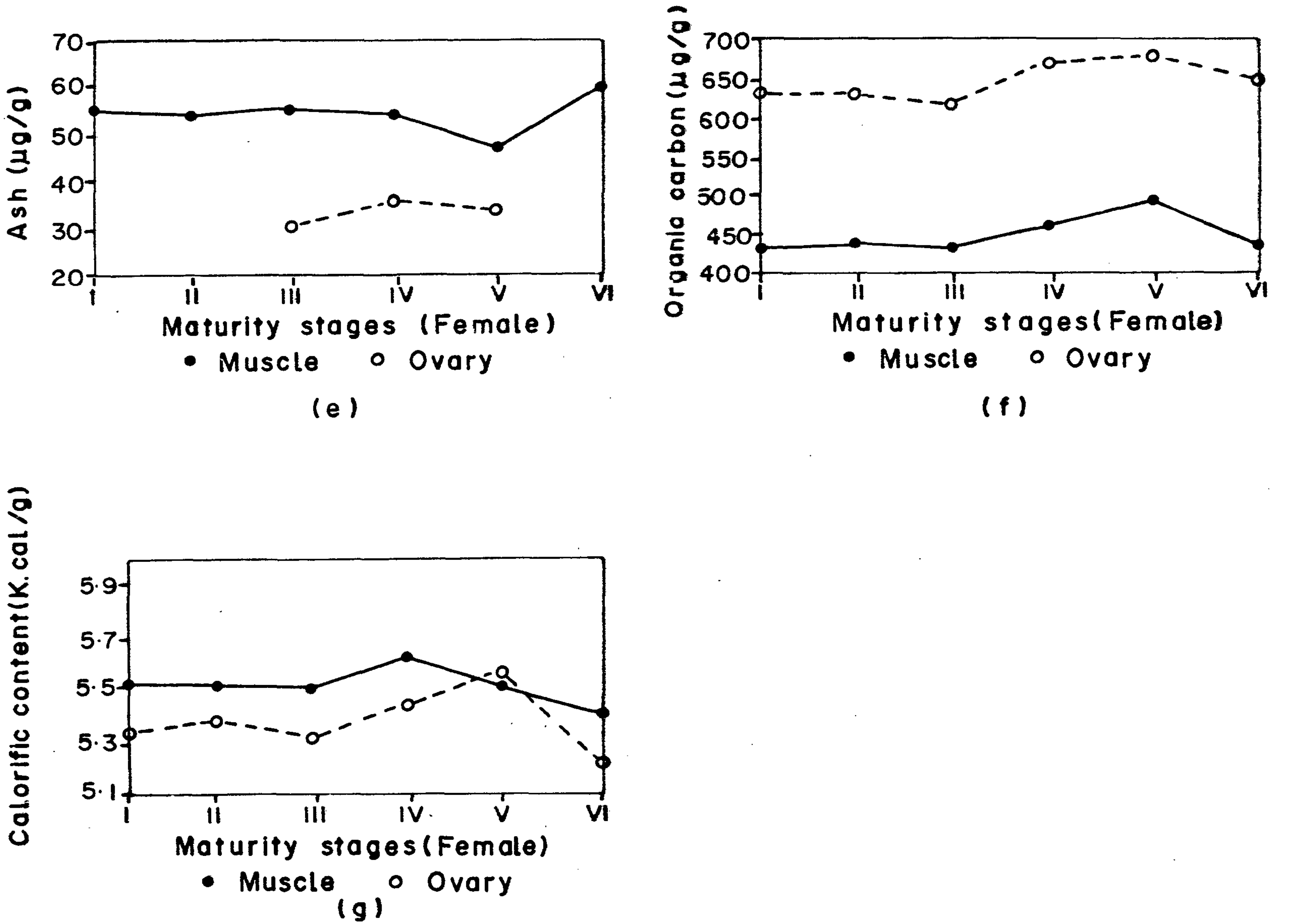
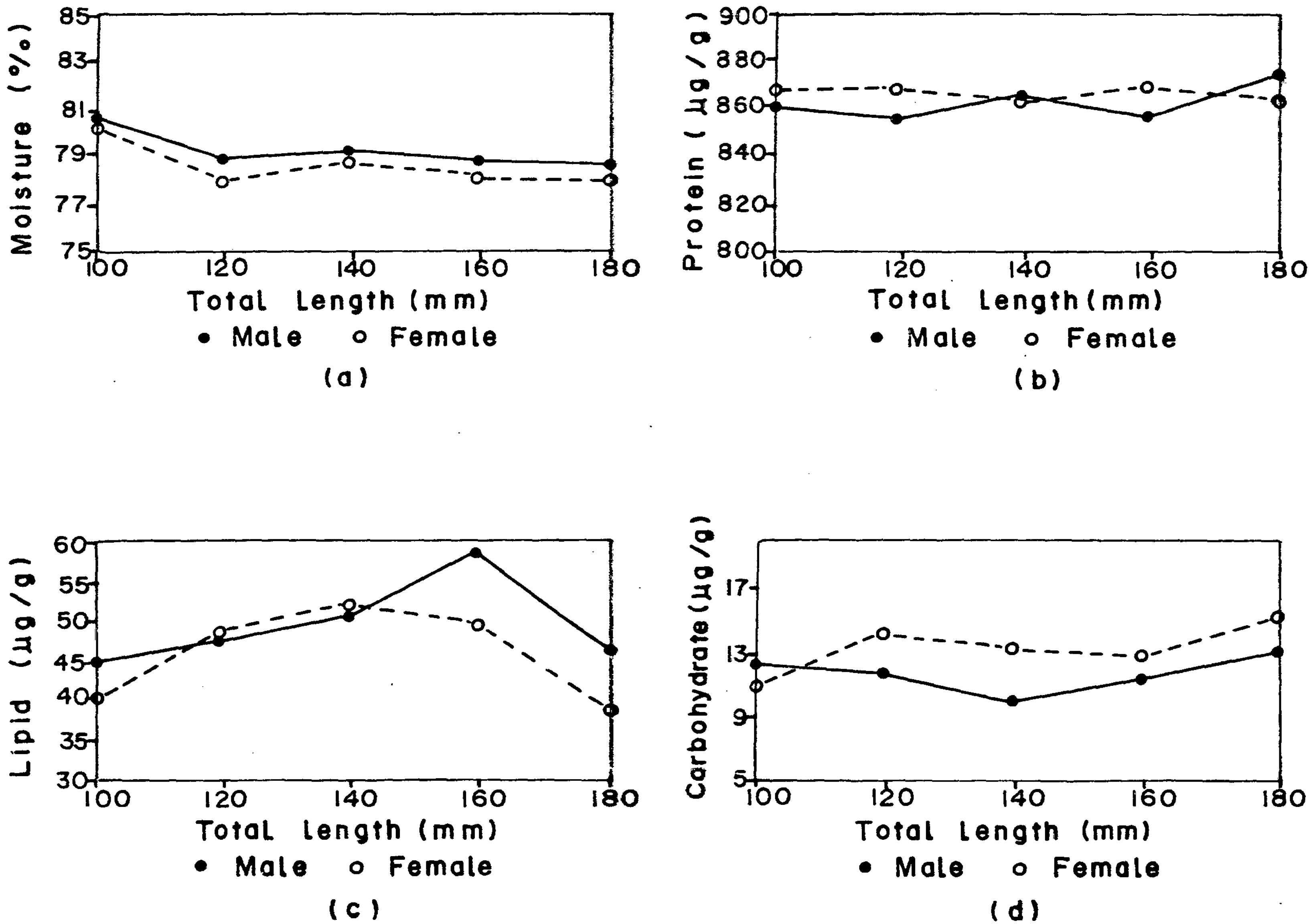



Fig. 7.7 Variation in biochemical constituents of muscle tissue and ovary of female *E. suratensis* with respect to different gonadal maturity stages, a) Moisture b) Protein c) Lipid d) Carbohydrate e) Ash f) Organic carbon g) Calorific content.

which was followed by a sudden fall (64.28%) in IV stage, afterwards the values stabilized (61.28%) in the V stage (Fig. 7.7a). The value increased to 86.09% in spent spawner which is at par with the developing virgin. The protein content was high (673.17 mg/g) in the ovary of immature virgin and then gradually decreased (573.37 mg/g) till stage III. The value increased in the late maturing stage (622.39 mg/g) and remained stable throughout spent stage (Fig. 7.7b). The protein level of ovaries was relatively less than the muscle on dry weight basis, whereas, on wet weight basis it was higher than the muscle content in late maturing and ripe stage. The lipid content was minimum in immature ovary (118.29 mg/g), which gradually increased (188.50 mg/g) till stage III and thereafter, almost remained stable till ripe stage. The lipid content in spent ovary was higher (159.43 mg/g) than the virgin maturing (140.37 mg/g) (Fig. 7.7c). The carbohydrate content in the ovary was maximum (100.28 mg/g) in immature stage and gradually decreased to the minimum (64.98 mg/g) in the ripe stage, followed by marginal increase (79.09 mg/g) in spent ovary (Fig. 7.7d). The carbohydrate content of ovaries was always higher than the body muscle. Ash content was estimated only in III, IV and V stages due to lack of sufficient sample and its value were found to be almost stable (Fig. 7.7e). The organic carbon was almost stable (616.67 - 630.82 mg/g) during the first three maturity stages, but increased (666.66 - 671.88 mg/g) in late maturing and ripe stage (Fig. 7.7f). The organic carbon decreased to 641.43 mg/g in the spent ovaries, though it was marginally higher than the first three maturity stages of ovary . The organic carbon of ovary was always higher than the muscle values. Calorific content was stable (5.31 - 5.39 K cal/g) in first three maturity stages with some marginal variations, however, it gradually increased to its peak value (5.56 K cal/g) in the ripe ovary (Fig. 7.7g). The calorific content was minimum (5.22 K cal/g) in the spent ovary.

7.3.2 Variation due to size group: Biochemical composition was also estimated in the samples of various size groups viz. 100, 120, 140, 160 and 180 mm which corresponds to the relative age of 7 - 8, 9 - 10, 12 - 13, 16 - 17 and 23- 24 months, respectively. In both the sexes, the moisture content was high (80.4%) in 100 mm size group (Fig. 7.8a), but was almost stable (77.65 -79.10%) in other size groups. There was no distinct variations in protein content (854.88 - 873.94 mg/g) of the muscle as the fish grows in size (Fig. 7.8b). Lipid content increased in both the sexes with increase in size till 160 mm and thereafter decreased in 180 mm group and the values were on par with 100 mm size (Fig. 7.8c). The lipid content of female was either equal or less than the male. Carbohydrate content was almost stable up to 160 mm but increased to its maximum in 180 mm. The carbohydrate levels were comparatively higher in females than the males except in 100 mm size group (Fig. 7.8d). The ash content in male was observed to increase marginally (46.61 - 56.62 mg/g) with increase in size. In female it was less (51.18 mg/g) in 100 mm group, then marginally increased in 120 and 140 mm groups, but again reduced and remained stable in higher size groups (Fig. 7.8e). Overall variation in ash content was insignificant. The value of organic carbon was stable up to 120 mm group in male but gradually



Moisture (%)
85
83
81
79
77
75
100
120
140
160
180
Total Length (mm)
• Male o Female
(a)
Protein (μg/g)
900
880
860
840
820
800
100
120
140
160
180
Total Length (mm)
• Male o Female
(b)
Lipid (μg/g)
60
55
50
45
40
35
30
100
120
140
160
180
Total Length (mm)
• Male o Female
(c)
Carbohydrate (μg/g)
17
13
9
5
100
120
140
160
180
Total Length (mm)
• Male o Female
(d)


Fig. 7.8

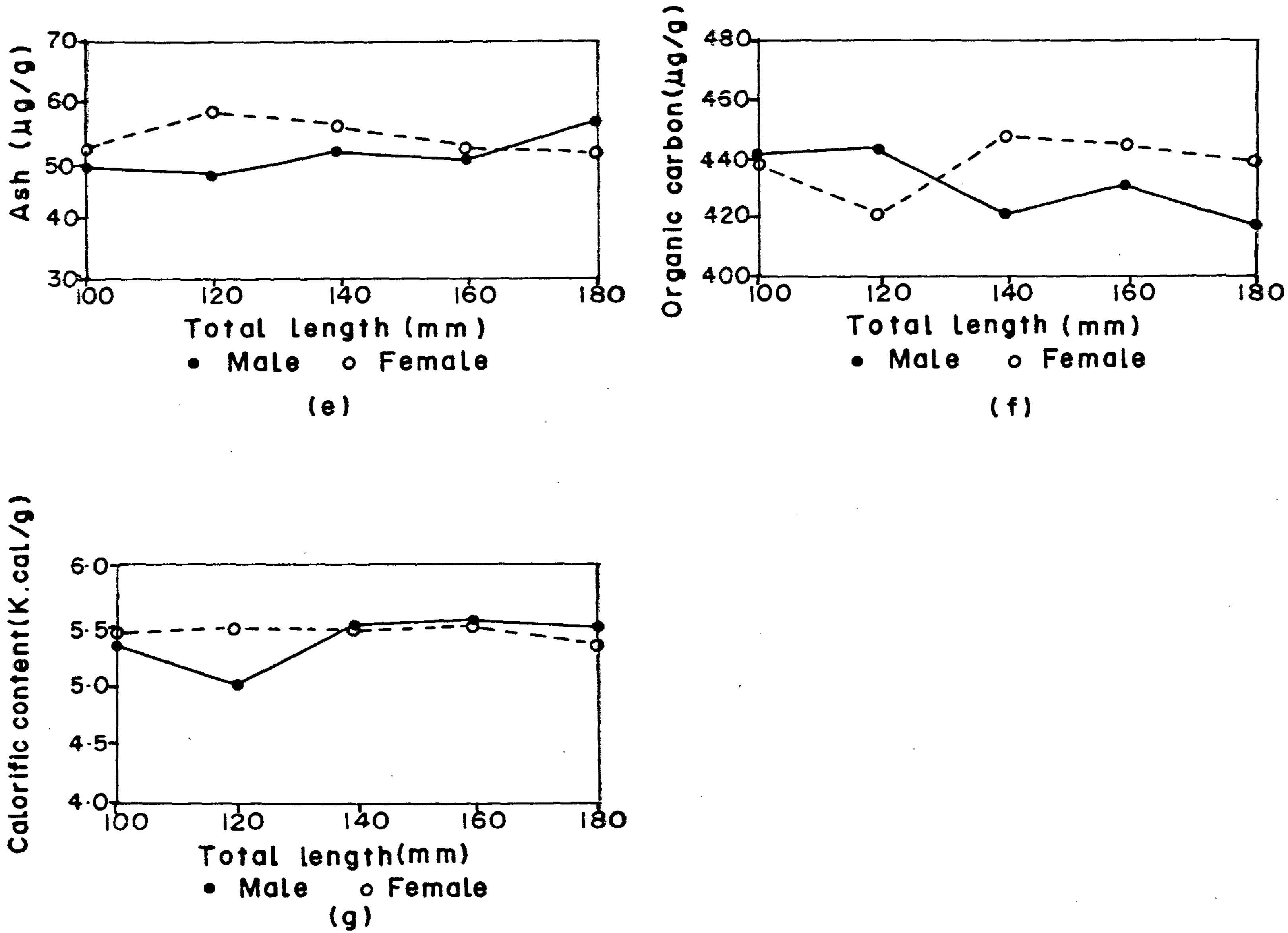



Fig. 7.8 Variation in biochemical constituents of muscle tissue of male and female *E. suratensis* with reference to different size groups/age, a) Moisture b) Protein c) Lipid d) Carbohydrate e) Ash f) Organic carbon g) Calorific content.

decreased with increase in size, though it was not so conspicuous (Fig. 7.8f). In female also it was almost stable except in 120 mm group. Similarly, calorific content did not show much variation in different size groups studied (Fig. 7.8g).

7.3.3 Seasonal Variation: Monthly variation in proximate biochemical constituents on wet weight and ash free weight basis of male and female E. suratensis is given in Tables 7.1 to 7.4.

Moisture: The moisture content varied from 76.2 to 79.9% and from 76.86 to 80.40% in male and female, respectively. The minimum* and the maximum values were in January and August respectively. The magnitude of variation in male and female was not much different i.e. 3.70% and 3.54%, respectively. The fluctuation in moisture was similar in both the sexes (Fig. 7.9). The moisture content decreased from February to May and then increased again during south-west monsoon (June - August). Subsequently, September onwards decreasing trend was evident with little variation in November until the minimum was recorded. A second peak was observed in February. The highest percentage of moisture coincided with the south-west monsoon when the salinity was minimum in the natural habitat.

Protein: The protein content in the muscle of male varied from 818.11 to 881.57 mg/g, and in female from 801.37 to 875.66 mg/g. The magnitude of variation was 63.46 mg/g and 74.29 mg/g in male and female, respectively. The calculated protein percentage on wet weight basis varied from 17.23 to 20.18 and 16.77 to 19.55 in male and female, respectively (Tables 7.1 and 7.3). On ash free

Table 7.1 Monthly variation in proximate biochemical constituents (wet wt.) of muscle tissue in male *E. suratensis*.

| Sr. No. | Months | Protein (%) | Carbohydrate (%) | Lipid (%) | Organic Carbon (%) | Ash (%) |
|---|---|---|---|---|---|---|
| 1 | Feb. | 18.83 | 0.28 | 0.98 | 8.99 | 1.22 |
| 2 | Mar. | 17.22 | 0.28 | 0.93 | 7.90 | 1.26 |
| 3 | Apr. | 19.17 | 0.29 | 0.88 | 8.66 | 1.28 |
| 4 | May | 20.05 | 0.26 | 1.20 | 9.84 | 1.24 |
| 5 | Jun. | 18.32 | 0.26 | 0.97 | 9.36 | 1.14 |
| 6 | Jul. | 17.55 | 0.24 | 1.20 | 8.94 | 1.17 |
| 7 | Aug. | 17.61 | 0.23 | 1.04 | 8.42 | 1.07 |
| 8 | Sep. | 17.94 | 0.23 | 0.82 | 8.30 | 1.11 |
| 9 | Oct. | 18.66 | 0.24 | 1.16 | 9.07 | 1.08 |
| 10 | Nov. | 17.41 | 0.16 | 0.97 | 8.46 | 1.07 |
| 11 | Dec. | 18.39 | 0.24 | 1.25 | 9.24 | 1.05 |
| 12 | Jan. | 20.17 | 0.31 | 1.20 | 11.20 | 1.12 |
| 13 | Feb. | 18.57 | 0.28 | 1.14 | 9.11 | 1.10 |
| 14 | Mar. | 19.11 | 0.22 | 0.72 | 9.08 | 1.07 |
| 15 | Apr. | 18.69 | 0.23 | 0.75 | 8.53 | 1.32 |
| 16 | May | 18.96 | 0.22 | 0.74 | 9.04 | 1.12 |

Table 7.2 Monthly variation in proximate biochemical constituents (ash free wt.) of muscle tissue in male *E. suratensis*.

| Sr. | Months | Protein (%) | Carbohydrate (%) | Lipid (%) | Organic carbon (%) |
|---|---|---|---|---|---|
| 1 | Feb. | 92.64 | 1.37 | 4.84 | 44.21 |
| 2 | Mar. | 88.39 | 1.44 | 4.78 | 40.58 |
| 3 | Apr. | 92.32 | 1.42 | 4.27 | 41.71 |
| 4 | May | 92.20 | 1.23 | 5.55 | 45.24 |
| 5 | Jun. | 86.22 | 1.26 | 4.56 | 44.04 |
| 6 | Jul. | 88.96 | 1.25 | 6.12 | 45.33 |
| 7 | Aug. | 92.56 | 1.21 | 5.47 | 44.24 |
| 8 | Sep. | 93.28 | 1.21 | 4.30 | 43.15 |
| 9 | Oct. | 91.41 | 1.20 | 5.69 | 44.44 |
| 10 | Nov. | 90.63 | 0.86 | 5.09 | 44.04 |
| 11 | Dec. | 90.06 | 1.20 | 6.14 | 45.24 |
| 12 | Jan. | 88.99 | 1.38 | 5.30 | 49.43 |
| 13 | Feb. | 92.33 | 1.43 | 5.68 | 45.29 |
| 14 | Mar. | 91.50 | 1.07 | 3.48 | 43.47 |
| 15 | Apr. | 91.54 | 1.17 | 3.67 | 41.77 |
| 16 | May | 91.71 | 1.09 | 3.60 | 43.70 |

Table 7.3 Monthly variation in proximate biochemical constituents (wet wt.) of muscle tissue in female *E. suratensis*.

| Sr. No. | Months | Protein (%) | Carbohydrate (%) | Lipid (%) | Organic carbon (%) | Ash (%) |
|---|---|---|---|---|---|---|
| 1 | Feb. | 17.40 | 0.40 | 0.86 | 9.27 | 1.11 |
| 2 | Mar. | 17.74 | 0.28 | 1.00 | 9.16 | 1.20 |
| 3 | Apr. | 19.02 | 0.33 | 0.84 | 9.63 | 1.13 |
| 4 | May | 19.55 | 0.30 | 1.06 | 10.08 | 1.20 |
| 5 | Jun. | 19.37 | 0.31 | 1.07 | 9.39 | 1.29 |
| 6 | Jul. | 16.90 | 0.26 | 0.90 | 9.17 | 1.16 |
| 7 | Aug. | 16.98 | 0.21 | 0.77 | 8.56 | 1.00 |
| 8 | Sep. | 16.76 | 0.23 | 0.85 | 8.97 | 1.09 |
| 9 | Oct. | 18.60 | 0.24 | 1.09 | 9.40 | 1.04 |
| 10 | Nov. | 17.97 | 0.27 | 1.12 | 9.42 | 1.13 |
| 11 | Dec. | 17.80 | 0.27 | 1.15 | 9.65 | 1.16 |
| 12 | Jan. | 18.54 | 0.30 | 1.87 | 11.07 | 1.15 |
| 13 | Feb. | 17.79 | 0.27 | 0.93 | 9.04 | 1.16 |
| 14 | Mar. | 18.48 | 0.29 | 1.05 | 9.49 | 1.22 |
| 15 | Apr. | 18.51 | 0.27 | 0.76 | 9.17 | 1.42 |
| 16 | May | 18.24 | 0.30 | 1.08 | 9.84 | 1.19 |

Table 7.4 Monthly variation in proximate biochemical constituents (ash free wt.) of muscle tissue in female *E. suratensis*.

| Sr. | Months | Protein (%) | Carbohydrate (%) | Lipid (%) | Organic carbon (%) |
|---|---|---|---|---|---|
| 1 | Feb. | 87.93 | 2.04 | 4.36 | 46.93 |
| 2 | Mar. | 89.45 | 1.42 | 5.05 | 46.16 |
| 3 | Apr. | 90.96 | 1.61 | 4.06 | 46.05 |
| 4 | May | 91.17 | 1.42 | 4.97 | 47.03 |
| 5 | Jun. | 92.08 | 1.51 | 5.13 | 44.67 |
| 6 | Jul. | 87.86 | 1.37 | 4.72 | 47.70 |
| 7 | Aug. | 91.34 | 1.14 | 4.16 | 46.17 |
| 8 | Sep. | 87.86 | 1.37 | 4.72 | 46.61 |
| 9 | Oct. | 92.09 | 1.23 | 5.40 | 46.57 |
| 10 | Nov. | 90.05 | 1.36 | 5.63 | 47.21 |
| 11 | Dec. | 88.24 | 1.33 | 5.72 | 47.82 |
| 12 | Jan. | 84.36 | 1.37 | 8.52 | 50.39 |
| 13 | Feb. | 91.37 | 1.42 | 4.79 | 46.43 |
| 14 | Mar. | 92.46 | 1.46 | 5.28 | 47.50 |
| 15 | Apr. | 92.23 | 1.37 | 3.79 | 45.71 |
| 16 | May | 88.94 | 1.46 | 5.30 | 48.00 |

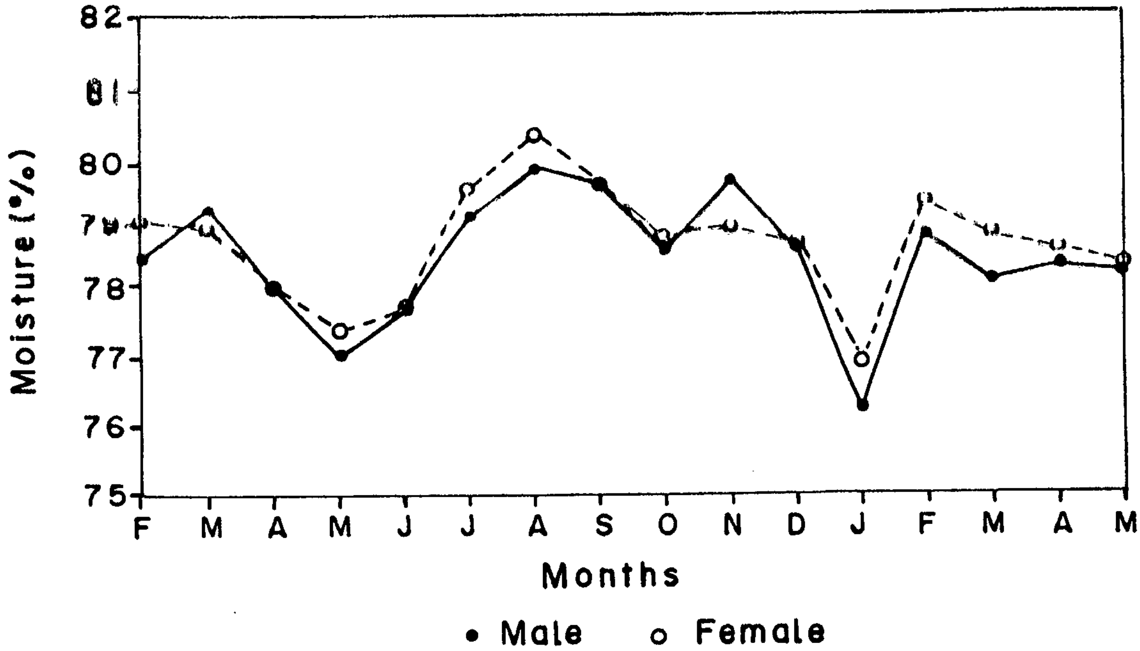



Fig. 7.9 Monthly variation in moisture of muscle tissue of *E. suratensis*.

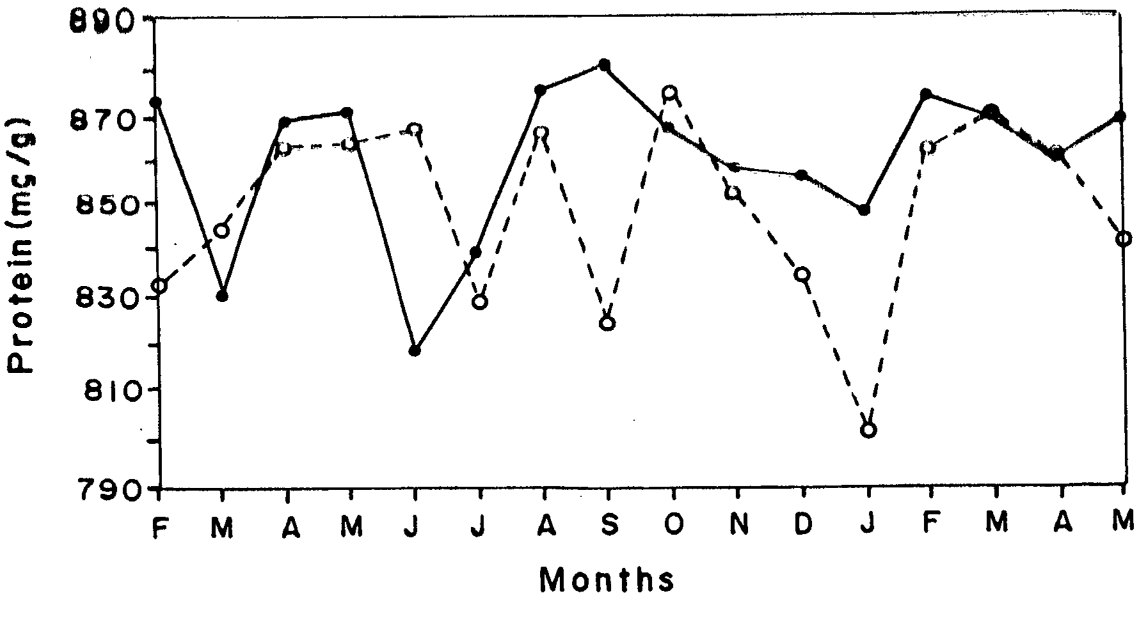



Fig. 7.10 Monthly variation in protein content of muscle tissue of *E. suratensis*

weight basis, the protein content in male varied from 86.22 to 93.29% and in female 84.36 to 92.46% (Tables 7.2 and 7.4). The protein content decreased marginally (873.94 - 871.97 mg/g) from February to May in male, but fell significantly in June (818.11 mg/g). The values increased gradually till September (881.57 mg/g). From October onwards the protein content showed decreasing trend till January (847.88 mg/g) and then suddenly increased in February (875.06 mg/g) (Fig. 7.10). In female, there was no distinct pattern except wide fluctuation during June to October (823.98 - 875.66 mg/g) and showed a gradual decrease from November to January (852.04 - 801.37 mg/g). It suddenly increased in February (862.36 mg/g), with little fluctuation till May.

<u>Lipid</u>: Lipid content in male varied from 33.14 - 58.43 mg/g, 3.48 - 6.14% and 0.72 - 1.25% on dry weight, ash free weight and wet weight basis, respectively. There was no distinct pattern, however, the lipid content increased in harmonic progression till July (57.78 mg/g) and then gradually decreased till September (40.64 mg/g) followed by harmonic progression till December (58.43 mg/g). January onwards it started decreasing till March (33.14 mg/g) and then remained almost stable (Fig. 7.11). However, two distinct peaks (July and December) and troughs (March, April, May) could be distinguished.

In female, the lipid content fluctuated widely from 35.47 - 80.95 mg/g, 3.79 - 8.52%, 0.76 - 1.87% on dry weight, ash free dry weight and wet weight basis, respectively. It showed a distinct seasonal pattern with fluctuation from February to April (38.52 - 47.65 mg/g) followed by a gradual increase till

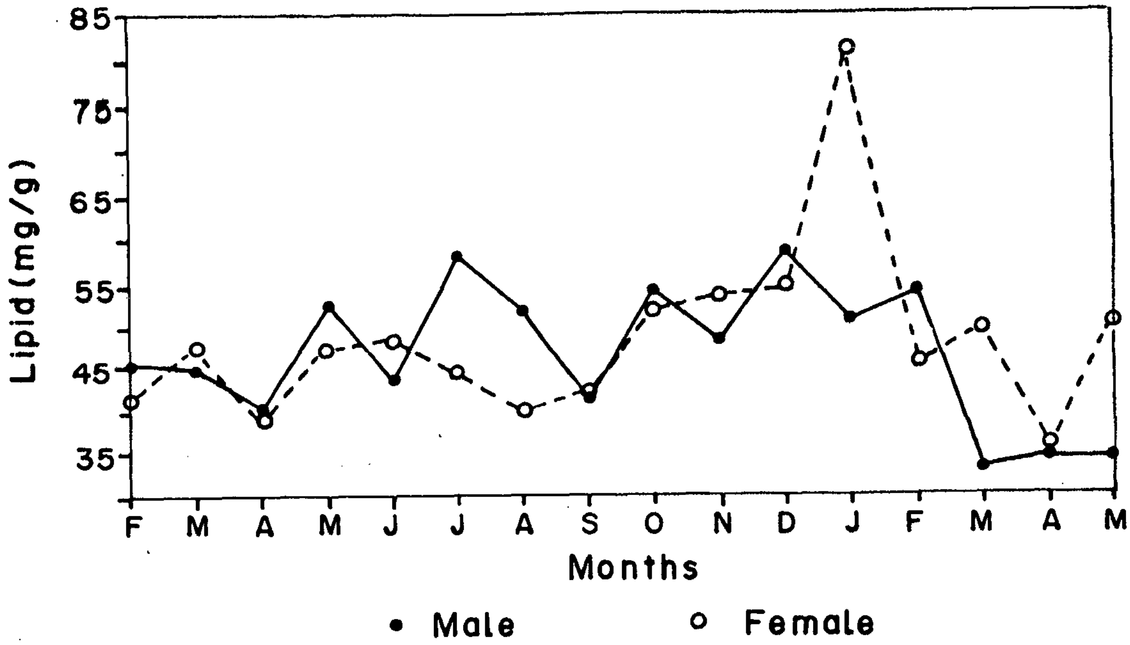



Fig. 7.11 Monthly variation in lipid content of muscle tissue of *E. suratensis*.

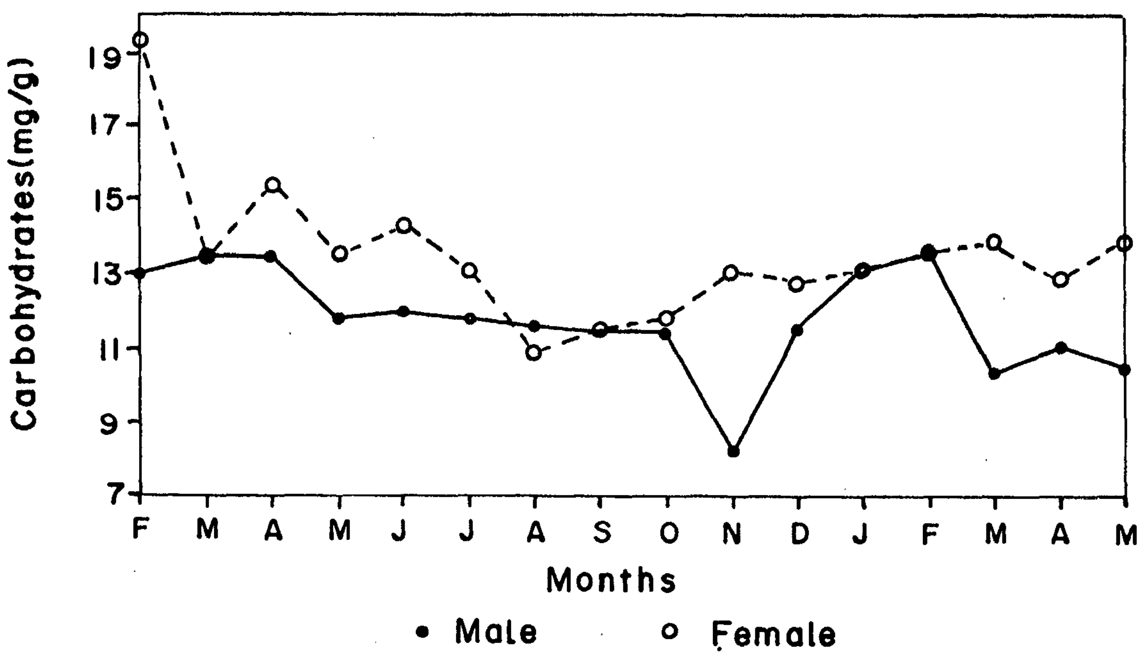



Fig. 7.12 Monthly variation in carbohydrate content of muscle tissue of *E. suratensis*.

June (48.34 mg/g). The lipid content decreased gradually till August (38.47 mg/g) and then went on increasing up to January when the maximum value (80.95 mg/g) was observed . Thereafter, it again decreased in pulses till May. Relatively, lower values were recorded during April and August.

<u>Carbohydrate</u>: Carbohydrate content in male varied from 8.17 - 13.54 mg/g, 0.86 - 1.44%, 0.16 - 0.31% on dry weight, ash free dry weight and wet weight basis, respectively. Similarly, in females it varied from 10.88 - 19.39 mg/g, 1.14 - 2.04%, 0.21 - 0.40%, respectively, on dry weight, ash free weight and wet weight basis. In male, it followed an almost constant trend from February to April (12.93 - 13.54 mg/g) and then marginally decreased in May. The values remained stable during June till October (11.43 - 11.99 mg/g). There was a sharp decrease in November (8.17 mg/g) followed by gradual increase till February (13.58 mg/g). Further decrease in March (10.26 mg/g) was followed by almost constant level till May.

In female the carbohydrate content was high from February to July (12.98 - 19.39 mg/g) and low during August to October (10.88 - 11.74 mg/g) followed by high values (12.66 - 13.88 mg/g) from November to May (Fig. 7.12).

<u>Ash</u>: Ash content in male varied from 47.27 - 60.87 mg/g, 1.05 - 1.32% on dry weight and wet weight basis, respectively. The ash content followed a harmonic pattern of peaks and troughs with minimum in December and January, and maximum in March and April. In female, it varied from 50.07 - 66.15 mg/g, 1.00 - 1.42%,

respectively on dry and wet weight basis. The seasonal pattern is almost similar in both of the sexes (Fig. 7.13) with minimum being in January and the maximum in April.

<u>Organic carbon</u> : Organic carbon in male varied from 381.16 - 470.94 mg/g, 7.09 - 11.20% on dry and wet weight basis, respectively (Fig. 7.14 and Table 7.1). Organic carbon is almost stable between May to November followed by a peak in January (470.94 mg/g) and the through in March April (413.43 - 393.29 mg/g). In female, the organic carbon ranged from 420.90 to 478.71 mg/g, 8.58 - 11.07% on dry and wet weight basis respectively. The organic carbon trend was almost constant with a peak in January (478.71 mg/g) and a trough in February to April.

<u>Calorific content</u> - Calculated calorific content in male varied from 5.11 - 5.54 K cal/g, 5.38 - 5.84 K cal/g and 1.07 - 1.27 K cal/g on dry, ash free and wet weight basis, respectively. There was no specific seasonal trend except a probable error in June. In female the calorific content varied from 5.13 - 5.51 K cal/g, 5.42 - 5.82 K cal/g and 1.04 - 1.24 K cal/g on dry, ash free and wet weight basis, respectively. The high values were recorded during May-June, October-November, January-February and low during July to September (Fig. 7.15).

## 7.4 DISCUSSION

The protein and moisture content of the muscle tissue

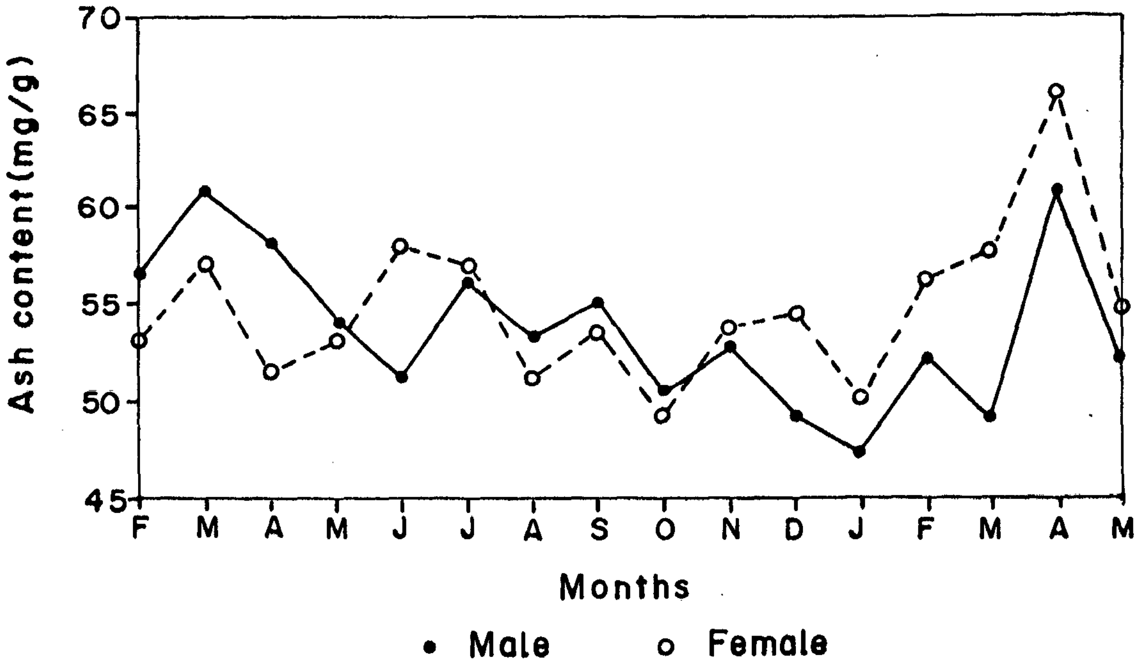



Fig. 7.13 Monthly variation in ash content of muscle tissue of E. suratensis

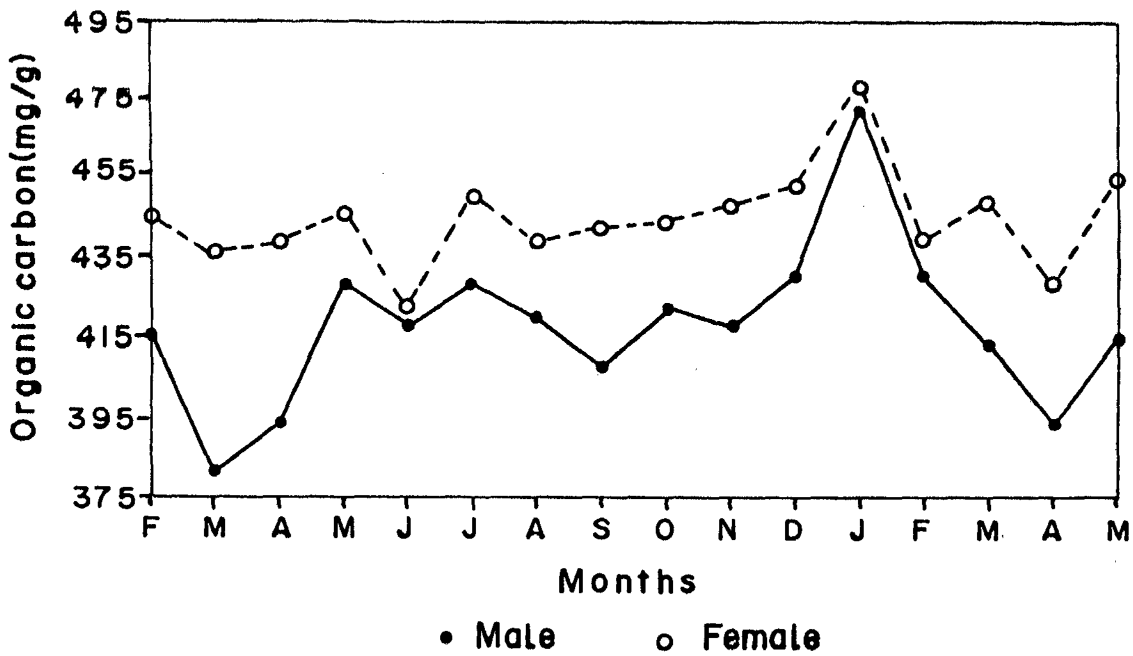



Fig. 7.14 Monthly variation in organic carbon of muscle tissue of E. suratensis

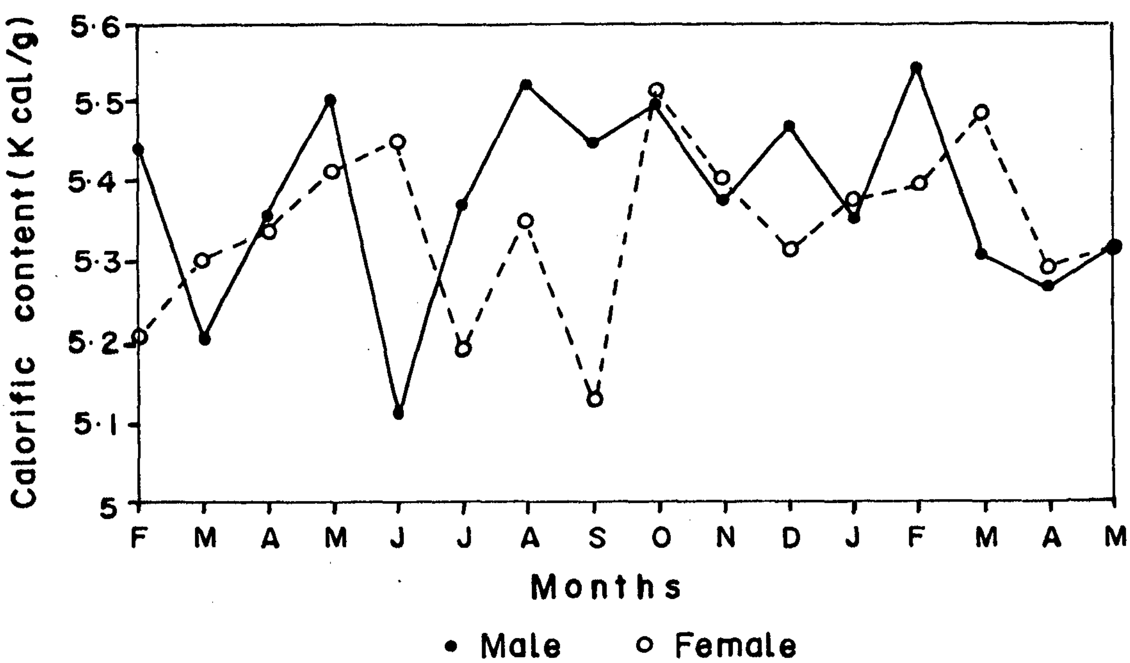



Fig. 7.15 Monthly variation in calorific content of muscle tissue of _E. suratensis_

gradually decreased as the gonadal maturity in female approached the ripe and mature stage in male which corresponds to the cessation of feeding in the ripe and mature stage, respectively. It has been reported that lean fish upon starving (Groves,1970) mobilize the body protein as an endogenous source of energy. Thus, the decrease in protein level in both the sexes could be compared to the starving condition (Groves, 1970). Salmonids have been reported to mobilize protein from the muscle in response to low feed intake during spawning migration (Mommsen *et al.*, 1980; Konagaya, 1982). A drop in muscle protein of *Oncorhynchus mykiss* in mature fish was associated with decreased feed availability and prolonged physical activity (Kiessling *et al.*, 1991). Thus the present observation corroborates earlier findings.

In contrast, the lipid levels were high in late maturing and ripe fish in females and mature males. The increase in rainbow trout muscle fat was reported in immature fish and the maturing males, but no increase in female towards the spawning. This indicates that maturing female spent maximum energy in the development of gonad in the later part of maturation, thus less surplus energy is deposited as muscle fat. It appears that the fish rely on the energy reserves from the body and viscera during the period which results in decreased body fat. Male, as compared to female does not produce sex products in large quantity and as a consequence, sexual maturation seems to be less energy demanding than the female, thus enabling them to store surplus energy as fat in the musculature (Tveranger, 1985).

Male and female of Sockeye salmon (Oncorhynchus nerka) used fat reserves for spawning migration. Female gonads grew much faster than males, as a consequence, female spent more energy on gonadal growth (Idler and Bitners, 1959). The females therefore, use higher amount of fat and protein than males. In northern pike (Esox lucius), the food uptake reduced before and during spawning and the fish had to use endogenous energy reserve for gonadal growth. The liver is used as a storage house of large amount of lipid, which are used for maturation of gonad and spawning activity (Janagaard, 1967).

Feeding activity ceases during spawning in E. suratensis and after the hatching of larvae the parents are involved in brood care. Thus, for a considerable period there is no regular feeding by the fish. In present study, although male do not spend much energy during the maturation of gonad as compared to female, they indeed equally participate in pairing, courtship, selection of spawning site, nest building and finally the brood care. Thus, the exogenous energy deficit period is prolonged unlike other reported species, which might be influencing intensive feeding activity during the post spawning period. The average lipid content of E. suratensis is about 5% and thus it can be classified as a lean fish. Such fishes upon starvation mobilize body protein as an endogenous source of energy. Therefore, E. suratensis may be utilising the body protein, and the lipid stored around the coiled intestine (Plate 7.1) during the initial phase of cessation of feeding. Since the former was found to

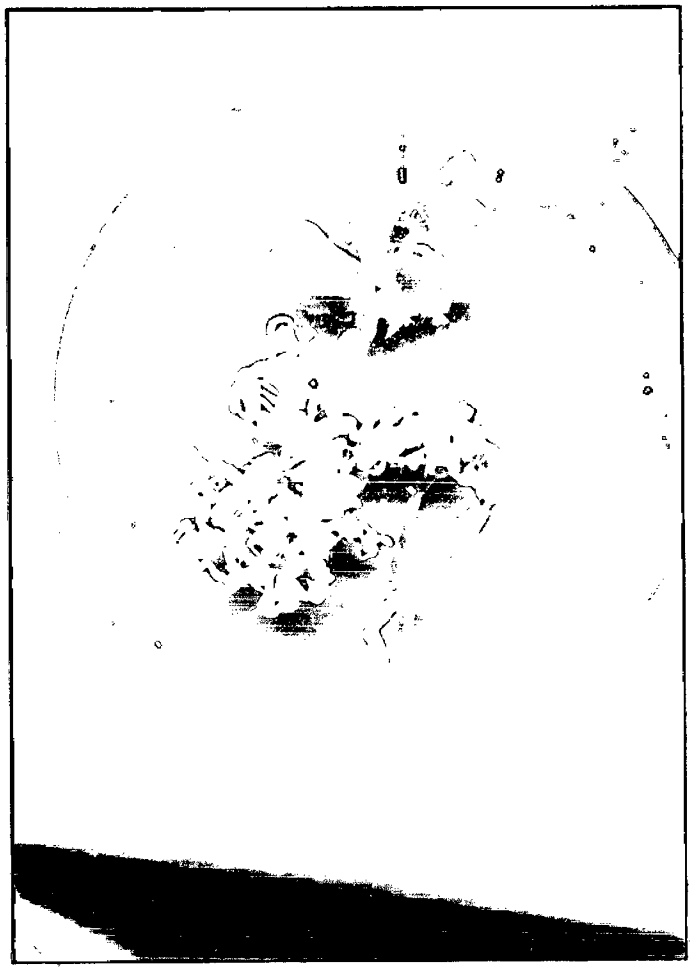


Plate 7.1

decrease gradually as the gonadal maturity approached mature stage and the later were never observed in the ripe and spent fish. In Oreochromis niloticus, excess energy derived from the food is deposited as fat in both carcass and viscera, and the later act as a "sink" for fat storing deposits long after the flesh has been loaded to capacity (Hanley, 1991). Therefore, the visceral lipid may be utilised earlier than the muscle. Being the the accessory fat, early utilisation provide space in the visceral cavity for the growing ovary and digestive tract to accommodate consumed food. The present findings of higher level of lipid in the muscle of ripe stage corroborates the earlier findings (Bruce, 1924; Chanon and Saby, 1932; Apparao, 1967). Thus, in E. suratensis, the protein and visceral lipid reserve may be utilised in the pre-spawning period and the muscle reserve in the post-spawning period. Therefore, the sequence of mobilisation of endogenous source of energy could be the possible reason of high level of lipid content in the mature spawners.

The marginal decrease in ash content and the simultaneous increase in organic carbon in ripe stage could be attributed to the elevated levels of lipid, since the latter displayed linear relationship with the former ($r = 0.8739$; $n = 6$; $p < 0.05$; Table 7.5). The calorific content did not show much variation in female, but decreased in ripe spawner in comparison to late maturing stage. This indicates that the fish cease to feed before attaining ripe stage and starts utilising endogenous source of energy. This continues till the spent stage when the minimum value of calorific content is recorded.

Table 7.5 Correlation matrix of biochemical constituents in muscle tissue of female in different gonadal maturity stages.(n=6)

| | Moist. | Prot. | Carb. | Lip. | Ash | Org.C. | Cal.Con. |
|---|---|---|---|---|---|---|---|
| Moist. | 1.0000 | | | | | | |
| Prot. | .4224 | 1.0000 | | | | | |
| Carb. | .3779 | -.5874 | 1.0000 | | | | |
| Lip. | -.7465 | -.8511 | .2032 | 1.0000 | | | |
| Ash | .5297 | .8223 | -.3043 | -.7805 | 1.0000 | | |
| Org.C. | .4729 | -.9894 | .5158 | .8739 | -.8924 | 1.0000 | |
| Cal.Con. | .0380 | -.2295 | -.1173 | .1804 | .0149 | .2061 | 1.0000 |

DF = 4

Table 7.6 Correlation matrix of biochemical constituents in female gonads at different gonadal maturity stages.(n=6).

| | Moist. | Prot. | Carb. | Lip. | Org.C. | Cal.Con. |
|---|---|---|---|---|---|---|
| Moist. | 1.0000 | | | | | |
| Prot. | .1041 | 1.0000 | | | | |
| Carb. | .8229 | .6258 | 1.0000 | | | |
| Lip. | -.6631 | -.7921 | -.9561 | 1.0000 | | |
| Org.C. | -.8660 | .1677 | -.5933 | .3373 | 1.0000 | |
| Cal.Con. | -.8194 | .3790 | -.4415 | .2620 | .7212 | 1.0000 |

DF = 4

Significant at 0.1 = 0.7293
0.05 = 0.8114
0.02 = 0.8822
0.01 = 0.9172
0.001 = 0.9740

The moisture content was the lowest in the highest class group (180 mm.). There was no variation in protein level as the fish grew in size or age. The lipid levels were low in the 100 mm class, since most of the energy was diverted towards growth. The lipid level increased in higher class (120- 160 mm), and then decreased in the largest class. The increased level at 120 - 140 mm size coincide with the first maturity while the decreased level in the largest class could be attributed to the gradual deteriorating condition of the spawners. *E. suratensis* is a continuous spawner, and may not be getting sufficient food and time for restoration of energy between the successive spawnings, at least, in Goa waters. There appears to be no distinct change in the ash, organic carbon and calorific content with respect to fish size and age.

There was a progressive decrease in moisture and carbohydrate content of ovary and analogous increase in lipid as the fish approached ripe stage. However, during the spent phase the lipid content fell significantly, and the moisture and carbohydrate levels shot up. The moisture content was positively correlated with carbohydrate ($r = 0.8229$; $n = 6$; $p < 0.05$) and inversely related to organic carbon ($r = -0.866$; $n = 6$; $p < 0.05$) and calorific content ($r = -0.956$; $n = 6$; $p < 0.05$; Table 7.6). Therefore, it can be said that the concentration of carbohydrate decreased probably due to its preferential utilization in the early stages of gametogenesis, whereas, the concentration of other constituents increased as a result of decrease in moisture and associated increase in ovary size. The observed reduction in moisture content could be attributed to the accumulation of maximum energy in minimum possible volume of ova as a yolk reserve for the early ontogenic stages. In spent stage, all the components except moisture and ash were observed to decrease and were at par with II and III stage, which also coincide with the gonadal maturity stages in terms of gonad morphology and ova size.

There are very few studies (Apparao, 1967; Medford and Mackay, 1978; Craik and Harvey, 1984; Devauchelle et al.,1988) on the biochemical composition of matured ovary or egg. Unfortunately most studies are restricted to the estimation of moisture, lipid and protein. In the present study carbohydrates were observed to be present in considerable quantity (64.98 - 100.28 mg/g). At this stage it is merely a speculation to say that carbohydrate reserve in ovary may be an energy store for the brief period of early developmental stages of egg, whereas lipid as a reserve for the post-hatching period. The role of glycogen in fish muscle has been described as energy reserve for brief emergency burst moment (Kiessling et al., 1991).

The increased levels of moisture during July-September could be attributed to low level of salinity (0.18%.) resulting from heavy precipitation during south-west monsoon. Thus, in order to maintain osmotic balance, the moisture content might have increased during this period. On the contrary, the low moisture content in April-June could be attributed to higher salinity. The percentage of moisture in body muscle and ion composition of the tissue fluid are known to change according to the ambient salinity as an adaptive measure to maintain the osmotic balance with the medium. In Sebasticus marmovatus, the moisture content of the blood was reported to decrease with the increase in chlorinity (Yamashita, 1967). He reported that in euryhaline fish, specific gravity of blood is positively correlated to the salinity of the environment. The moisture content in Atlantic salmon increased during its spawning migration to freshwater systems (Cowey et al., 1962). While rearing the mullet (Mugil cephalus) in freshwater medium similar pattern was observed (Perera and De Silva, 1978). A similar behaviour of increasing and decreasing body moisture has been reported for natural and cultured green mussel (Galtsoff, 1964; Parulekar et al., 1982).

The low percentage of moisture during January in female could be attributed to the high levels of lipid during this period. The correlation matrix ($r = -0.555$; $p < 0.05$; Table 7.7) revealed that the moisture and lipid were inversely related. This inverse relationship has been documented by various workers for different fish species (Idler and Bitners, 1959; Groves, 1970; Reintz, 1983; Weatherley and Gill, 1983; Tveranger, 1985; Aasgaard, 1987). In male the low level of moisture in January could be assigned to the concomitant impact of protein and lipid, since lipid alone did not exhibited any relationship. The organic carbon was observed to show inverse relationship ($r = -0.4787$; $p < 0.1$). Such relationship has been reported earlier (Geiger and Borgstrom, 1962). Furthermore, the low level of moisture during May-June and January also coincides with breeding seasons when matured specimens were predominant.

Table 7.7 Correlation matrix of biochemical constituents in muscle tissue of female during different months.(n=16)

| | Moist. | Prot. | Carb. | Lip. | Ash | Org.C. | Cal.Con. |
|---|---|---|---|---|---|---|---|
| Moist. | 1.0000 | | | | | | |
| Prot. | .1175 | 1.0000 | | | | | |
| Carb. | -.2300 | -.1034 | 1.0000 | | | | |
| Lip. | -.5551 | -.5219 | -.1319 | 1.0000 | | | |
| Ash | .0618 | .1740 | .0259 | -.3960 | 1.0000 | | |
| Org.C. | .2881 | -.6770 | -.0398 | .7937 | -.4984 | 1.0000 | |
| Cal.Con. | -.3894 | .6450 | -.1640 | .3123 | -.1624 | -.0436 | 1.0000 |

DF = 14

Table 7.8 Correlation matrix of biochemical constituents in muscle tissue of male during different months.(n = 16)

| | Moist. | Prot. | Carb. | Lip. | Ash | Org.C. | Cal.Con. |
|---|---|---|---|---|---|---|---|
| Moist. | 1.0000 | | | | | | |
| Prot. | .1846 | 1.0000 | | | | | |
| Carb. | -.2914 | -.1479 | 1.0000 | | | | |
| Lip. | .0983 | -.1156 | .2156 | 1.0000 | | | |
| Ash | .3436 | -.0621 | .2401 | -.2586 | 1.0000 | | |
| Org.C. | -.4787 | .0018 | .0426 | .5342 | -.7697 | 1.0000 | |
| Cal.Con. | .2051 | .7672 | .0586 | .5466 | -.2054 | .3425 | 1.0000 |

DF = 14

Significant at 0.1 = 0.4259 0.01 = 0.6276
0.05 = 0.4973 0.001 = 0.7420
0.02 = 0.5742

Protein content was at its low level in male during June and January and could be attributed to the breeding season, when the lipid content was comparatively high, though it showed an insignificant relationship. During non-breeding season (April-May and August), the high protein was associated with low lipid content. In female too, the low level of protein was accompanied by analogous high lipid content in January which again coincided with the breeding season. While studying body composition of rainbow trout in relation to first sexual maturity Tveranger (1985) observed that with increase in fat content the protein content is reduced with a simultaneous increase in dry matter. In female, the protein showed a significant inverse relationship with lipid ($r = -0.522$; $p < 0.05$) and organic carbon ($r = -0.677$; $p < 0.01$), and positive relationship with calorific content ($r = 0.645$; $p < 0.02$). Similarly in male, the protein was directly related to calorific content ($r = 0.767$; $p < 0.001$; Table 7.8). These observations revealed that protein content decreases with increase in the lipid content, but the increase in dry matter may not respond to increase in lipid content in brackishwater species, where the moisture content/dry matter also depends upon the density of the aquatic medium. A positive and significant relationship between calorific content and protein suggest that it is a major source of energy in _E. suratensis_.

In both the sexes, the lipid content was high during the breeding season (June July and December-January) and the seasonality was evident in case of female. Lipids are the depot of energy, which the fish utilises during adverse feeding conditions. Overall variations in lipid content in the muscle was not high, since they were also observed to be stored around the coiled intestine (Plate 7.1). Hails (1983) reported the storage of lipid around the intestine in Trichogaster pectoralis. At spawning, the rainbow trout has been reported to retain higher amount of lipid in ovaries and gastro-intestinal tract (Washburn et al, 1990).

In male E. suratensis, increase in lipid was directly proportional to increase in organic carbon ($r = 0.534$; $p < 0.05$) and calorific content ($r = 0.546$; $p < 0.05$). Similarly, in female, the lipid was directly related to organic carbon ($r = 0.794$; $p < 0.001$) but inversely related to moisture ($r = -0.555$; $p < 0.05$) and protein ($r = -0.522$; $p < 0.05$). Thus, in male the lipid content is independent of other components, though protein and ash do have some inverse impact on its concentration. E. suratensis ceases or rarely feed during breeding, since it is deeply involved in pairing, courtship and spawning followed by prolonged parental care. Thus, the lipid stored in body muscle and around the coiled intestine are used as energy reserve during spawning. This could be the possible reason of higher levels of lipids during May-July and December-January.

Carbohydrates contribute a minor part of the muscle, though its role is similar to that of lipid as the main fuel (Walton and Cowey, 1982). There is no distinct pattern in the concentration of carbohydrate, which were observed to change invariably. Carbohydrate was observed to have absolutely no relationship with any of the other biochemical components. It has been referred that lactic acid is produced during the breakdown of glycogen, and the overall elevation in lactate level and fall in glycogen concentration in lateral muscles following exercise has been observed in various fish species (Black _et al_., 1961). For example, in rainbow trout a fall of 50 -88% in glycogen content in muscle after a few minutes of exercise has been observed (Miller _et al._, 1959; Black _et al._, 1962). The glycogen content was reported to fall by 50% after moderate and by 80% after high speed exercises for 30 minutes in Atlantic cod _Gadus morhua_ (Beamish, 1968). The muscle glycogen depletion and analogous lactate build-up with increasing speed of exercise was also recorded by Broughton and Goldspink (1978) in roach (_Rutilus rutilus_). Hochachka (1961) reported that after 5 minutes exercise, the glycogen content in trout fell by 65 - 70% in trained fish but by only 40% in untrained, and suggested that stamina was not limited by the amount of food reserve but by the ability of blood to tolerate high levels of lactate. Perera and De silva (1978) reported that in _Mugil cephalus_, the major portion of carbohydrate is utilised for energy and the fraction estimated is derived from blood glucose and structural sources such as glyco-protein and glyco-lipid, indicating that it does not store carbohydrate. Carbohydrate are utilised for energy in trout, thus sparing protein for building of the body (Phillips _et al_., 1966).

The decrease in muscle glycogen has been reported to be associated with change in salinity from freshwater to seawater in case of *Oncorhynchus kisutch* and *O. mykiss* (Sheridon *et al*.,1985; Kiessling *et al*., 1991). The latter author emphasised the importance of glycogen as energy store, reserved for brief emergency burst moments. Thus, in the present case the erratic variation in carbohydrate content could be assigned to daily tidal currents, seasonal changes in salinity during monsoon and the capture stress .

Ash content varied in a narrow range (47.27 - 66.15 mg/g) and is inversely related to organic carbon in both the sexes (male, $r = -0.768$; $n = 16$; $p < 0.001$; female, $r = -0.498$; $n = 16$; $p < 0.05$). Organic carbon represents the major total carbon of the biochemical constituents viz protein, lipid and carbohydrate, which may vary according to the conditions. The organic carbon is also high during May and January which corresponds to spawning period. This increase was associated with the increase in lipid levels, since the corresponding protein concentration is low during this period. In male, the organic carbon is positively correlated ($r = 0.534$; $n = 16$; $p < 0.05$) with lipid and inversely related with the moisture ($r = -0.4787$; $p < 0.1$). and ash ($r = -0.7679$; $n = 16$; $p < 0.001$) whereas, in female, the organic carbon is directly related ($r = 0.794$; $n = 16$; $p < 0.001$) with lipid and inversely ($r = -0.677$; $n = 16$; $p < 0.01$) with protein and ash ($r = -0.498$; $p < 0.05$).

In male, the calorific content was positively related with protein ($r = 0.7672$; $n = 16$; $p < 0.001$) and lipid ($r = 0.546$; $n = 16$; $p < 0.05$), thus the collective concentration of both the components was responsible for higher calorific content during

February and May. In female, the calorific content was directly related with protein ($r = 0.645$; $p < 0.02$). Thus, the low calorific content during the breeding season can be attributed to decrease in protein content, which in turn is related to poor feeding conditions. In lean starving fish, body protein serves as an endogenous energy source, if body fat is present, some protein is still degraded to allow catabolic utilization of fat (Groves, 1970). Further, it has been reported that the protein increased more rapidly than water in lean growing fish. In starving fish, both water and protein are lost preferentially and protein disappears more rapidly than water.

The proximate composition of _E. suratensis_, revealed that it is rich in protein content and low in lipid. From nutritional point of view, based on biochemical analysis it can be placed in category `A' (as described by Stansby, 1962). The protein levels of _E. suratensis_ are far higher than that of other reported fish species such as _Mugil cephalus_ (Perera and De Silva, 1978), _Tilapia mossambica_ (Pandian and Raghuraman, 1972), _Oreochromis niloticus_ (Hanley, 1991),and _Chanos chanos_ (Hung _et al._, 1980) cultivable in brackishwater environment. On the contrary it is low in lipid and perhaps is a suitable diet where protein rich and low lipid food is to be supplemented.

# CHAPTER VIII

# SUMMARY

The present study describes a taxonomic fin formula for the identification of <u>E. suratensis</u>, that differs from the earlier reports. The attachment of the inner margins of the ventral fins to the main body with thin membrane, four vertical bands in the head region, number of vertebrae are the additional information reported. A modified truss morphometric method has been adopted to compare the body configuration between the sexes and the stocks. Body configuration of both the sexes is alike, however, the stock of Goa differs from the Chilka lagoon. The diploid number of 48 acrocentric chromosomes corroborates with the earlier reports from Chilka lagoon and Vellar estuary. The RL% of chromosomes is quite apart from the Chilka lagoon stock, indicating submicroscopic differences between the two stocks on genic level. Though, based on truss morphometric and karyotype, the stocks of Goa and Chilka lagoon could be distinguished in two different strains, electrophoretic studies are felt necessary for further confirmation.

Hydrobiological characteristics of the brackishwater fish farm pond and the backwater are influenced by the south-west monsoon, resulting in a rhythmic seasonal pattern. In the natural habitat in Goa, <u>E. suratensis</u> is regularly subjected to variable degree of water salinity ranging from freshwater during monsoon to almost marine condition during pre-monsoon. Thus, indicating its culture possibilities in freshwater. The present study also infers that intensive brackishwater farming needs to be suspended during monsoon when freshwater condition prevails. However, in case of euryhaline cultivable species, the water exchange in the farm needs to be minimal to avoid sudden drop in salinity.

The pH of the backwater dropped to slightly acidic and the total alkalinity below the optimum limit desired for aquaculture during monsoon. This could be due to the concomitant impact of freshwater flux of south-west monsoon precipitation and subsequent leachate from the iron mines located along the bank of Mandovi river. Thus, the application of lime to the culture ponds before the onset of south west monsoon is suggested. Low level of dissolved oxygen in the pond during March - April 1991 could be due to increased respiration over photosynthesis, whereas in June 1991 due to cloudy weather. Therefore, in semi-intensive culture systems it is desirable and in intensive it is essential to operate paddle wheel aerators especially during monsoon. Chlorophyll-*a* registered numerous peaks in backwaters, which could be due to stratification of periphyton and sediment resulting from tidal current.

Length-weight relationship in both the sexes revealed isometric growth in weight, that means weight grows to the cube of length. The asymptotic length ($L\infty$) and weight ($W\infty$) for the population of Goa were computed to be 226 mm and 400 g, respectively. Brody growth co-efficient (K) for the population of Goa, computed through ELEFAN programme was 0.84. Growth parameters revealed that *E. suratensis* attains a size of 130 mm, 185 mm and 210 mm in Ist, IInd and IIIrd years, respectively. The maximum growth increment was observed between the age of 0.5 to 1.5 years, indicating the ideal age for commercial cultivation. The growth performance index '$\phi$' in natural population in Goa is

2.632.

The natural mortality and the fishing mortality were computed to be 1.77 $year^{-1}$ and 2.066 $Year^{-1}$ with an exploitation rate of 0.54. Therefore, the higher rate of exploitation needs immediate measures to manage the limited resources of E. suratenis.

Blue green algae Oscillatoria, Phormidium, Lyngbya and green algae Enteromorpha and Spirogyra were recorded as the predominant food items in the gut of E. suratensis besides the major contribution of detritus. The gut content of juveniles was mainly comprised of epiphyton like blue green algae. The common animal material recorded in the food item were sponges, hydroides, nematodes, polychaete egg mass and the bivalve Modiolus sp.. The present observation delineate that pearl spot prefer plant material in its diet, especially the filamentous algae. Based on the feeding apparatus and the food items recorded in the gut it can be concluded that E. suratensis is basically an herbivorous species, however, depending on the availability of preferred food item it shifts to detrivorous or omnivorous habit. The fish was observed to move in a shoal of 6 - 20 numbers and is involved in group feeding habit. Thus, from aquaculture point of view, additional substratum should be provided in the pond to encourage epiphyton growth.

Fin rot is a frequently occurring disease in E. suratensis in captivity. Injury, transportation and handling stress are the primary causes paving way to the secondary infection of microbes.

Nitrofurazone at the rate of 0.4 to 0.5 mg/l for three successive doses on alternate days was found to be a successful therapeutic agent. Epizootic ulcerative syndrome seems to be a temporary seasonal infection, and probably in due course of time the local fish fauna gets immune to the causative agent. A monogenean parasite Ancyrocephalus sp. recorded from the gills was observed to be a menace in culture chambers, and may lead to mass mortality if timely therapeutic measures are not taken. The other parasites whose damage causing intensity could not be ascertained were Trichodina sp. and Caligus sp.. Cymothoa krishnai an isopod parasite harbouring the buccal cavity is a new record to the host and the Goa waters.

In matured specimens, the sexes can be easily distinguished based on the degree of protrusion and swelling of the urino-genital papilla, which is comparatively more pronounced in female. Ten developing stages of intra-ovarian ova could be distinguished based on the size and the external morphological characters. Six stages of developing ovary based on morphology and frequency occurrence of different ova could be ascertained. In male only four stages of developing testes were identified. The sex ratio of male to female in general was 54.50:45.50, indicating that both the sexes are almost in equal proportion. Sex ratio of male to female up to a size of 150 mm was 51.28:48.72. However, in upper range i.e. above 151 mm size males dominated the population, indicating the differential growth in sexes after attaining first maturity.

The smallest size of the ripe female and male was recorded to be 110 mm and 125 mm, respectively. Most of the population attain first maturity at a size of 141-150 mm in both the sexes. E. suratensis is a protracted breeder and spawns throughout the year with peak during June, November - January and March-April. The ripe virgin spawn twice in a year and thereafter in subsequent years more than twice overlapping over an annual cycle. The total fecundity varied from 757 to 3715 ova/clutch/fish and was directly related to fish length, weight, and ovary weight. The spawning efforts varied from 0.486 to 2.763g/clutch/fish. It showed linear relationship with fish length, weight and ovary weight. Probably, this could be the possible reason for the slow growth in female after attaining first maturity.

The female lay adhesive eggs on hard substratum especially submerged wooden twigs. Hatching takes place after 60-75 hours of post fertilization. The eleuthroembryos are transferred to one among the nests built in the soft sediment. After a period of about 8 days of post hatching the yolk sac is observed and the spawn begin feeding. About 12 days old spawn, leave the nest and start swimming in the water under the protection of parents. During the post hatching period of 8-12 days, parents may shift the eleuthroembryos from one nest to the other. The juveniles are guarded by the parents until they attain a size of 2-3 cm.

The spawn (6.7-7.22 mm) attained a size of about 15 mm and weight of about 62 mg during the rearing period of one month, when fed with decapsulated Artemia cysts. No significant mortality was observed during the rearing period. However, the developmental period (37 $\pm$ 1 - 48 $\pm$ 1 hour stage of post fertilization) was observed to be the most susceptible for microbial infection and infestation of epifauna and parasites due to prolonged developmental period. Therefore, it is necessary to develop suitable hatching techniques in order to improve the hatching percentage and seed production under controlled conditions.

The protein and the moisture content of the muscle tissue gradually decreased as gonadal maturity in female approached the ripe stage and the mature stage in male. This can be attributed to the mobilization of protein as endogenous source of energy, since the spawners cease to feed during spawning.. The energy reserves for the spawning period are stored in the form of lipid in the muscle and viscera around the coiled intestine. The protein and the visceral lipid are utilized during pre-spawning and the muscle lipid during post spawning. The lipid and the carbohydrate content was higher in the ovary than the muscle tissue. In contrast, the moisture and the protein levels were lower than the muscle tissue.

The moisture in the muscle tissue was observed to vary with change in ambient salinity and the reproductive cycle. It established inverse relationship with lipid, which in turn was related to reproductive cycle. Protein was observed to be the major source of energy and showed linear relationship with calorific content. Carbohydrate contribute a minor part of the muscle, but serve as a main source of energy reserve for the emergency burst movements. E. suratensis is rich in protein and low in lipid, and forms a suitable diet where protein rich and low lipid food is to be supplemented.

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