CHAPTER 1.

GENERAL INTRODUCTION
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1.1. Introduction

India is one of the leading fish producing nations in the world with an average annual production of 6.1 million tonnes of fish and shell fish from capture and culture fisheries in 2001 (Ayyappan and Biradar, 2002). Fisheries play a very significant role in the Indian economy by providing employment to nearly 7 million people directly or indirectly, supplying rich protein food and earning valued foreign exchange. For the last one decade the growth of marine fish production is at very slow pace. However, the inland fish production has registered steady increase during the past two decades and the share of inland fisheries sector in the total fish production of the country is about 50% in 1999-2000 (Keremane and Naik, 2001). With a production of over 2.8 million tonnes from the inland sector, India occupies the second position, next to China, in aquaculture (Sankar and Ramachandran, 2002). This spectacular growth was achieved as a result of the overwhelming growth of fresh water aquaculture during the past two decades.

India has a long coastline of about 8118 kilometre (km) with an Exclusive Economic Zone (EEZ) of 2.02 million sq.km for exploration and exploitation of resources therein. Inland fishery resources in India are very rich and varied comprising an extensive network of 45,000 kilometres of rivers, 1,26,334 kilometres of canals, 2.05 million hectares (ha) of man made reservoirs, 2.7 million ha. of estuaries, 1.42 million ha. of brackish waters, 1.3 million ha. of oxbow lakes and derelict water bodies and 2.36 million ha. of
ponds and tanks dispersed over varied geoclimatic situations (Ayyappan and Biradar, 2002).

Globally the per capita fish consumption increased from 13 kg in 1990 to 16kg in 2001 and the demand is still growing (Verdegam, 2005). The current level of marine fish production from the country is about 2.70 million tonnes whereas the estimated potential from the Indian EEZ is 3.92 million tonnes. The production from the pelagic fish resources in India is 1.43 million tonnes in 2003 (CMFRI, 2004). The coastal zone upto a depth of 50m is prone to tremendous fishing pressure by the traditional, small and large mechanized vessels leaving little scope for further exploitation. Increase in marine fish production can be achieved only with the exploitation of deep sea and oceanic regions where the level of exploitation is marginal. A wide variety of fishes, crustaceans, molluscs etc. contribute to the marine and inland fish production. According to Nelson (1994) there are 24,618 species of fishes belonging to 482 families and 4,258 genera. Jayaram (1999) reported that in Indian region alone 2500 species of fishes are present, out of which 930 are freshwater inhabitants and 1570 are marine. Among these, the fishes of the family Hemiramphidae constitute a minor pelagic fishery of the country. They inhabit the marine, brackish and fresh water environments.

Species of the family Hemiramphidae have a very wide distribution. They are distributed in the western and eastern Indian Ocean, African coast including Madagascar and Mauritius, Red Sea, Pakistan, India and Sri Lanka.
They are also found in the Indo-Pacific region, Indo-Australian archipelago and Mediterranean Sea.

Fishes of the family Hemiramphidae are commonly called ‘half beaks’. They are inhabitants of both sea and fresh water. The body is elongated with a prolonged lower jaw and a short triangular upper jaw with minute teeth except in the genus *Oxyporhamphus* where the lower jaw is not noticeably elongated. The half beaks are omnivores, feeding on floating sea grass, algae, crustaceans and small fishes. They are prone to leap and skitter on the surface and one offshore species, *Euleptorhamphus viridis* leaps out of the water and glides like a flying fish. They are generally egg layers except the fishes of the genera *Demogenys*, *Hemiramphodon* and *Nomorhamphus* which are livebearers. In the males of these fishes a part of the anal fin is modified as an intromittent organ known as andropodium. The freshwater species are mostly viviparous in contradiction to the marine species.

The hemiramphids live close to the surface and are protectively coloured for their pelagic mode of life by being green or blue on the back and silvery white laterally and ventrally. The tip of the lower jaw is usually bright red or orange. They are mainly caught with seines and pelagic trawls and dip netted under lights at night.

Hemiramphids are known as ‘kola’ / ‘pookola’ in Kerala, ‘mural’ in Tamil Nadu, ‘mudduru’ / ‘kosalsa’ in Andhra Pradesh, ‘surali kondai’ / ‘konothi’
in Karnataka and 'sumbo' / 'Tol' in Maharashtra. Half beaks and full beaks contribute significantly to the marine landings of Tamil Nadu, Kerala and Andhra Pradesh. It is a very prominent fishery in Tamil Nadu constituted by the marine species. Kerala state stands second in the production of hemiramphids. Considering the importance of this group and lack of detailed information on their biology, histology, and biochemistry the present study was undertaken.

1.2. Review of literature


Van Hasselt (1823) described *Hemiramphus erythrorinchus* and *Euleptoramphus viridis*. Seven species of hemiramphids were reported by Cuvier and Valenciennes (1846) from the Western Indian Ocean. Bleeker, (1858) and Günther (1866) reported *Hemiramphus balinensis, H. capensis*
and *H. affinis* respectively. Weber and de Beaufort (1922) listed thirty two species of hemiramphids from the Indo- Australian Archipelago. South African species of the genus *Hemiramphus* Cuvier was described by Smith (1933,1949). A new species of, *Hyporhamphus patris* from Sinaloa, Mexico was described by Miller (1945); Herre (1944) gave a review of the half beaks of the Philippines and adjacent waters. Miller (1945) used the names *Hyporhamphus roberti* and *Hyporhamphus hilderbrandi* for the same halfbeak fish of Tropical America. Fowler (1950) described the halfbeak, *Hyporhamphus unifasciatus* on the Virginia coast. A new species of hemiramphid from Philippines was recorded by Sarenas and Ronquillo (1952). Munro (1955) reported six species from the Sri Lankan waters. Parin (1961) described a new species of flying half beak, *Oxyporhamphus meristocystis* from the waters of the Indo Malayan Archipelago. Collette (1962) described a new half beak *Hemiramphus bermudensis* from Bermuda. Hemiramphids from tropical West Africa were described by Collette (1965). Classification, geographic variation and distribution of the oceanic hemiramphid *Euleptorhamphus viridis* were given by Parin (1966). A new half beak species *Rhynchorhamphus arabicus* was reported from southern Yemeni waters by Parin and Shcherbachev (1972). Collette (1973) reported a hybrid half beak *Hyporhamphus australis* x *Hy. melanochir* and listed two species from Australian waters.

Two new species, *Rhynchorhamphus malabaricus* and *R. naga* under the subgenus *Rhynchorhamphus* from the Indo-Pacific region were described
by Collette (1976). Five more new species under the genus *Hemiramphus* from Indo-Pacific region were described by Collette (1978). The status of the two names of South African half beaks *Hyporhamphus delagoae* (Bernard) and *Hyporhamphus improvisus* (Smith) was mentioned by Collette (1982).

Two new species of fresh water half beaks *Zenarchopterus roberisi* and *Z. alleni* from New Guinea were described by Collette (1982). A new species of freshwater halfbeak, *Zenarchopterus ornithocephala*, from the Vogelkop Peninsula of New Guinea was reported by Collette (1985). Collette and Su (1986) described the hemiramphids of the Far East. Fishes of the family Hemiramphidae of Africa were reported by Collette (1986). Chen (1988) reported on the flying halfbeaks, *Oxyporhamphus* of Taiwan. Six species of fresh water viviparous half beaks of the genus *Hemirhamphodon* from southern Thailand were reported by Anderson and Collette (1991).

In India, studies on hemiramphids commenced with the work of Day (1878,1889) who recorded thirteen species of hemiramphids from the Indian waters. Talwar and Chakrapany (1970) listed five species from this area. The occurrence and abundance of *Hyporhamphus (Hyporhamphus) xanthopterus* (Valenciennes) in the Vembanad Lake of the south west coast of India was reported by Kurup and Samuel (1980). A rediscovery of *H. (H) xanthopterus* endemic to Vembanad Lake, Kerala was done by Collette (1981). The occurrence of *H. (H) xanthopterus* (Valenciennes) in the lakes of southern Kerala was reported by Nair et al (1983). Talwar and Kacker (1984) reported 13 species and Talwar and Jhingran (1991) reported 10 species of the family
Hemiramphidae from Indian waters. A detailed description of 3 genera of the family Hemiramphidae was done by Jayaram (1999); Shaji and Easa (2001) recorded two species of Hemiramphidae, *Hyporhamphus (Hyporhamphus) limbatus* and *H.(H) xanthopterus* from the freshwaters of the Western Ghats of Kerala.

Attempts were made by several workers to study the biology and fishery of hemiramphids in many areas all over the world. A note on the females and eggs of *Hemiramphus far* was given by Wickstead (1956). Reproduction, development and distribution of the flying half beak *Oxyparhamphus micropterus* were reported by Kovalevskaya (1963). A study of half beak larvae and juveniles from Chesapeake Bay was done by Hardy and Johnson (1974). The biology of two exploited half beaks *Hemiramphus brasiliensis* and *H. balao* of South East Florida coast were investigated by Berkeley and Houde (1978). McBride *et al.* (2003) has studied the spatial and temporal spawning pattern of the above mentioned two species which form a valuable bait fishery along the South Florida coast. The reproductive biology of these two species was studied in detail by McBride and Thurman (2003).

The gut contents of the needlefish *Hyporhamphus knysnaensis* from Rondeveil, Southern Cape was reported by Coetzee (1981). Changes of chemical composition during the early development of egg and larva in *Hemiramphus sajori* was reported by Kimata (1982). Feeding habit of the
Southern Australian garfish *Hyporhamphus melanochir*, a diurnal herbivore and nocturnal carnivore was reported by Robertson and Klumpp (1983). Nutrition of the Southern sea garfish *Hyporhamphus melanochir* was studied by Klumpp and Nichols (1983). They studied the assimilation of two types of food, the sea grass and crustaceans. Changes of chemical composition during the early development of eggs and larvae of the horn fish, *Hemiramphus sajori* (Temminck et Schiegel) were reported by Kim et al. (1984). Montgomery and Saunders (1985) described the functional morphology of the piper *Hyporhamphus ihi* with reference to the role of the lateral line in feeding. They proposed a hypothesis that the piper uses the anterior lateral line system in prey detection. Its elongated body form, swimming behaviour and lack of a specialized visual system are all consistent with this hypothesis. A unique spermatozeugmata in the testes of the genus *Zenarchopterus* wherein the method of sperm packing and morphology of spermatozeugmata are unique was observed by Grier and Collette (1987). They indicate that these fishes practice internal fertilization. Kawamura et al. (1990) described the larval growth and the age and size related variation in the development of sense organs in the half beak *Hemiramphus sajori*. Some aspects of the biology of *Hyporhamphus gaimardi* in Uda Walawe reservoir, in Sri Lanka were reported by Chandrasoma and Wijeratne (1990). Yacapin (1991) described the growth, mortality and recruitment of *Oxyporhampus micropterus* in Bohal Sea, Philippines and also established that the annual recruitment of this species is strongly bimodal.
A study of the host-parasite relationships between copepods and needle fishes was done by Cressey and Collette (1971). Natarajan and Nair (1972) gave a description on the nature of attachment of the copepod *Lernaeenicus hemiramphi* Kirtisingh to the host fish *Hemiramphus xanthopterus*. A new cymathoid isopod, *Glossobius hemiramphi* from the mouth of the Ballyhoo, *Hemiramphus brasiliensis* in the Caribbean Sea was recorded by Williams (1985). A new host record of *Cymathoa indica* (Schiodte and Meinert) from Sundarbans, West Bengal was given by Misra and Nandi (1986). Species of the parasitic isopod genera *Ceratothoa* and *Glossobius* (Crustacea) were recorded by Neil and Thomas (1989) from the mouths of flying fishes and half beaks. Analysis of the carotenoids present in the red coloured integuments of mandible of *Hemiramphus sajori* was done by Maisuno and Ookubo (1981) and opined that it was due to ketocarotenoids.

In the Indian waters more work was carried out along the Tamil Nadu coast especially in the Gulf of Mannar and Palk Bay. Studies on the food and feeding relationships of the hemiramphids from the Gulf of Mannar and Palk Bay were done by Talwar (1962 a). A contribution to the biology of *Hyporhamphus georgii* of the Gulf of Mannar and Palk Bay was done by Talwar (1962 b). The biology of *Hemiramphus marginatus* in the Mandapam area has been discussed by Talwar (1967). The biology of *Hemiramphus gaimardi* of the Pulicat Lake was studied in detail by Sultana et al. (1980). The breeding biology of *Hyporhamphus unifasciatus* from coastal waters of Parangipettai, east coast of India was explained by Durai et al. (1988). The
length-weight relationship of *Hemiramphus marginatus* of the Gulf of Mannar caught by drift gill net was studied by Kasim *et al.* (1996). Though landing of half beaks has been recorded from the backwaters of Kerala no significant work has so far been made on the biological aspects of these species.

### 1.3. Fishery

Half beaks and full beaks constitute a very significant portion in the marine fish landings of Tamil Nadu, Kerala and Andhra Pradesh. The exact landing figures of this group are not available as many states have no separate landing data of hemiramphids. This group might have been included under half beaks and full beaks together or under the miscellaneous category. The estimated half beaks and full beaks landings in India is 7316 tonnes in 2000, 4378 tonnes in 2001, 5922 tonnes in 2002 and 5649 tonnes in 2003, respectively (CMFRI 2002; 2004). Kurup *et al.* (1993) estimated that the percentage contribution of half beaks is 1.16% (84.25 tonnes) towards the fishery of the Vembanad Lake, Kerala. However, Kasim *et al.* (1996) estimated that Tamil Nadu and Kerala contributed 42.6 and 25.6 percent respectively of the total landings of hemiramphids. The contribution of other maritime states are nominal. *Zenarchopterus dispar, Hemiramphus archipelagicus, H. lutkei, Hyporhamphus (H) limbatus H.(H) xanthopterus, Rhynchorhamphus georgii*, and *R. malabaricus* constitute the landings from Kerala, especially from the Cochin coast.
A diversified type of fishing crafts and gears were employed prior to the introduction of mechanized fishing in our country. The traditional dug-out canoes varying from 3 to 8mts. length and plank built canoes (kettuvallam) were employed in the back waters of Kerala. These crafts employed all types of indigenous fishing gears such as long lines, gill nets, boat seines, shore seines etc. Because of the body shape and pelagic habitat of the species most of the indigenous fishing gears are not exactly suitable for capturing the hemiramphids. The type of gear that is operated exclusively for half beaks is ‘murasu vala’ with length 80-140 m; width 40-104 cm; and mesh size 7x5 cm (Kurup and Samuel, 1984).

1.4. Description of the study area

Monthly samples of fishes were collected from fish landing centre like Munambam, markets of Cochin coast like Ernakulam and some fishing grounds in Vembanad Lake like Eloor, Varapuzha, Mulavukadu, Arookutty, South Parur and Murinjapuzha. The locations of collection are shown in the map. (Fig. 1.1). A brief description of the study area is given below.

The study area, which is part of Cochin coast is located between Lat. 9°28’ and 10° N and Long. 76° 13’ and 76° 31 E. Lying parallel to it is an estuary which is commonly called the Cochin backwaters which has a total area of about 200 sq.miles. To the north and south it is continuous with shallow brackish water lagoons which stretch for the most part parallel to the coast line, separated from the sea on the west belts of sand. On the western
side, between Fort Cochin and Vypeen it is permanently connected with the Arabian Sea by a narrow channel of about 450 meters width. Two large rivers, the Periyar on the north and the Pampa on the south, flow into the backwaters. Fringed by the mainland and many thickly populated islands, the backwaters also receives a complex system of canals, rainwater and sewage drains, semi-perennial and seasonal rivers and their tributaries. Some of these maintain permanent connections with the sea while others develop only seasonal contacts during the monsoon months (June to September). The inflow of freshwater from several sources particularly during the monsoon months, is considerable and it is in the backwaters that the mixing of salt and fresh water occurs. The continual discharge of freshwater on the one hand and the inward influx of seawater on the other, bring out highly dynamic conditions reflecting the balance of forces associated with each. These conditions make the backwaters an extremely interesting environment.

The depth of the Cochin backwaters varies from 10 to 15m in the upper reaches close to the sea. The lower reaches of the estuary, which are close to the fresh water zone, are relatively shallower, with depths ranging from 5 to 7m. The bottom of the estuary is generally muddy. The tidal amplitude is about 1m in the coast area, decreasing to less than 1m in the central zone. It is very little in the lower reaches.
To acquaint with the conditions of the environment from where the samples of fishes were collected, a brief outline of the general hydrographic conditions are given below.

The temperature of the study area is maximum in April (32°C) and minimum in September (26°C). In the post-monsoon months the temperature difference from the surface to the bottom is only about 1°C, but in the monsoon months, June to September, normal variation is about 3-4°C. From June to September, the temperature gradually decreases and from October to April and May, it shows a progressive increase.

The study area is subjected to wide variations in salinity from place to place, season and surface to bottom. Seasonal changes in salinity are very well marked. From October onwards the salinity begins to rise, reaching its maximum in May. In the upper reaches, during April and May, the conditions are predominantly marine. In June, with the onset of monsoon, a sharp fall in the salinity occurs. The differences in salinity from the upper reaches to the lower are more pronounced at the surface than at deeper layers. Maximum salinity values range from 28 to 35‰ and minimum from 1.5 to 14‰. During the period of high salinity there is little difference in values from the surface to the bottom in the upper reaches of the study area whereas during the monsoon months the differences in the vertical profile are more pronounced.
The pH shows a seasonal cycle. Maximum values are obtained when the salinity is high and the minimum during the monsoon months when the salinity is low. The general increase in the pH is found from the freshwater zone to the marine and from the surface to the bottom, which corresponds to the increase in salinity. The values range between 6.2 and 8.2.

Seasonal changes in the oxygen values at the sub-surface level show two distinct phases. The phase of high dissolved oxygen values during monsoon months, (June to September) and the phase of low dissolved oxygen values during the period of pre monsoon months (February to May) In the post-monsoon months (October to January) the values progressively decline. The changes in the oxygen values seem inversely related to the changes in salinity. The vertical distribution of oxygen is also interesting. In the pre-monsoon months, minimum values are observed at the surface and maximum values at the bottom. During the monsoon months, maximum values occur at the surface and minimum at the bottom.

Seston values were generally very high. During the monsoon months, the values at the surface ranged from 7mg/litre, to 65 mg/litre. There was a progressive increase in the seston values from the surface to the bottom. In the post-monsoon months, the values decreased considerably.

Phytoplankton organisms showed a high level of abundance and diversity. The organisms which constituted the main crop were diatoms and
dinoflagellates belonging to Bacillariophyceae, Dinophyceae, Chlorophyceae, Myxophyceae. During the monsoon months there was considerable degree of fluctuation in the abundance of these forms. In the post-monsoon months, however, the organisms became more abundant and consistent. Maximum counts of these organisms were recorded in the pre-monsoon months.

The organisms of common occurrence in the study area are copepods, decapods, barnacles, nauplii and cyprids, brachyuran zoeas, lamellibrachs larvae and gastropod veligers, medusae, ctenophores, mysids, chaetognaths and fish eggs and larvae.

During the monsoon months a considerable decline occurs in the abundance of zooplankton in the study area. The only forms present in substantial numbers from June to September were copepods and molluscan larvae. With the increase in salinity during the post-monsoon months, more and more organisms appear in the backwater and in the pre-monsoon months (February to May), when the salinity is at its maximum, almost all forms mentioned above, are abundantly seen. The total volume of the zooplankton has a direct correlation with the salinity changes.

The fishes inhabiting the study area regions are such species that can tolerate considerable variations in salinity. The most important among these fishes are the mullets, cat fishes, jew fishes, thread fins, perches and the carangids. There are also half beaks, gar fishes, silver bellies, eels, sharks,
and rays but they are not very abundant. The salinity is subjected to regular seasonal and daily fluctuations. During the period of heavy rainfall, the inflow of water from the rivers lowers the salinity. Similarly, when the tide is high, the influx of sea water increases the salinity and the migrants from the sea are not adversely affected, whereas, the migrants from the fresh water if any, have to either adapt themselves to changing salinity or move on to such regions of the estuary where fluctuations are not so intense. When the salinity is lowered, the migrants from the fresh water easily adapt themselves, whereas, those migrants from the sea will have to either adapt themselves to the conditions of lowered salinity or return to the sea.

The microfauna of these area includes bivalves, polychaetes and gastropods. Foraminifera and nematodes formed the dominant groups of the meiofauna. The abundance of foraminiferans progressively decreased from marine to freshwater zone, suggesting that these are restricted to higher salinity areas only. Nematodes on the other hand, were most common in the study area.

1.5. Objectives of the study

The hemiramphids constitute a minor pelagic fishery of Cochin coast. Detailed information on the biology of these fishes is an essential prerequisite for their proper exploitation, management and conservation of the resources. Any information on the biochemical composition of fishes will be of immense use in assessing their nutritive value. The importance of understanding the
body composition during growth is essential in production studies. Considering the importance of this group and the lack of detailed information, a comprehensive study was undertaken on the systematics of hemiramphids available along the Cochin coast with special emphasis on the biology, histology and biochemical aspects of *Hyporhamphus* (H) *limbatus* and *H.* (H) *xanthepterus*, two estuarine species. *H.* (H) *limbatus* is a co-existing species of *H.* (H) *xanthepterus*. Though *H.* (H) *xanthepterus* is described to be a rare species, it is abundant in the coastal waters of Cochin (Kurup and Samuel 1980). Collette (1981) reported that *H.* (H) *xanthepterus* is endemic to Vembanad Lake. Nair *et al.* (1983) reported the occurrence of *H.* (H) *xanthepterus* in the lakes of southern Kerala. The studies on the biological, histological and biochemical aspects of hemiramphid species are scarce and not properly known. The present investigation was undertaken to study these aspects in detail.

1.6. Research approach

The available literature reveals that biological, histological and biochemical studies on hemiramphid species are scarce and incomplete. In the present investigation attempts are made to inquire about the biological, histological and biochemical aspects of *H.*(H) *limbatus* and *H.* (H) *xanthepterus*, the two half beak species which are contributing to the half beak fishery Cochin coast. The results are presented in nine chapters.
The first chapter is a general introduction including the review of previous works done on this genus. It also contains an account of the distribution of hemiramphid species and their fishery along the Indian coast in general during the period of investigation. The second chapter deals with the systematics of the hemiramphids collected from Cochin coast. Altogether seven species were collected during the study and their detailed descriptions are given. The qualitative and quantitative analysis of the food items, feeding behaviour and feeding intensity in relation to season, size, sex and stages of maturity of H. (H) limbatus and H. (H) xanthopterus are dealt with in the third chapter. The fourth chapter incorporates the findings on the breeding biology of the two species covering details on the spawning season, spawning frequency, size and age at first maturity, seasonal variation in condition factor, sex ratio and fecundity. Histological studies of ovary and testes of the two species are included in the fifth chapter.

The sixth chapter incorporates the finding on the length-weight relationship and relative condition factor of H. (H) limbatus and H. (H) xanthopterus. In the seventh chapter age and growth of the two species are described. The growth parameters are described using ELEFAN -1 programme and von Bertalanffy's growth equation (VBGE). The eighth chapter includes the results of the proximate composition of muscles and liver of H. (H) limbatus and H. (H) xanthopterus. Summary of the study is given in the ninth chapter followed by the references.
Fig 1.1
MAP SHOWING LOCATION OF THE STUDY AREA

SOUTH INDIA

10°N

MUNAMBAM

10°N

ERNAKULAM

50°N

VARAPUZHA

AROOKUTTY

MUVATTUPUZHA RIVER

ARABIAN SEA

ALLEPPEY