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STUDIES ON THE LARVAE OF A FEW DEMERSAL FISHES OF THE SOUTH WEST COAST OF INDIA

BY

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THESIS SUBMITTED TO THE COCHIN UNIVERSITY OF
SCIENCE AND TECHNOLOGY IN PARTIAL
FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DECEMBER 1989.

DECLARATION

I hereby declare that the thesis entitled **Studies on the larvae of a few demersal fishes of the south west coast of India** has not previously formed the basis of the award **of** [redacted] **other similar title or recognition.**

Cochin 16.
December, 1989.

(M.P. DILEEP)

CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Mr. M.P. Dileep under my supervision at the UNDP/FAO/Pelagic Fishery Project, and School of Marine Sciences, Cochin University of Science & Technology and that no part thereof has been presented for any other degree in any University.

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ACKNOWLEDGEMENTS

I am greatly indebted to Prof. (Dr.) C.V. Kurian, D.Sc., Retired Professor and Head of the Department of Marine Sciences, University of Cochin, for his guidance, criticisms and discussions without which this work would not have been possible. I am grateful to Dr. K.C. George, Scientist, CMFRI for the help and encouragement given during the study.

My thanks are due to the authorities of UNDP/FAO/Pelagic Fishery Project Cochin, for making available the materials and laboratory facilities for the work and also to Cochin University of Science and Technology for providing me a Junior Research Fellowship.

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1. INTRODUCTION

1.1. Importance of ichthyoplankton studies

Since the later half of the 19th Century, ichthyoplankton research has played an important role in marine science and its application to fisheries. It has contributed to our knowledge of the life histories of many commercially important species. Delsman (1922-'38) pioneered the ichthyoplankton studied in the Indo-Pacific region and contributed a wealth of information on the taxonomy of eggs and larvae of a number of commercially important species from Java sea. Apart from this, the fishery oriented objective of ichthyoplankton studies considered to be of particular value, include determination of spawning area and season based on the distribution of eggs and larvae, forcasting of year class strength on the basis of the abundance of late larvae and exploration of new resources. Se veral other informations like study of fish population dynamics, estimates of biomass of spawning fish population and their fluctuation, environmental condition and spawning etc, can be derived from such studies. The ichthyoplankton studies lead to obtain information on the distribution and abundance of fish population as in the case of Atlantic mackerel (Sette, 1953) or tunas (Matsumoto, 1966; Richards, 1969, Ueyanagi, 1969) or to an evaluation of fishery resources in general (Ahlstrom, 1965, 1971 and 1972 Richards, 1984 Neilson et al. 1988).

There are several marked advantages in sampling fish during their early life history stages rather than as juveniles or adults. Most marine fishes, both pelagic and demersal have planktonic eggs and larvae. So these stages can be sampled with a single kind of gear, a plankton net. The net collects not only fish eggs and larvae, but part of their potential zooplanktonic food and predators.

Study of ichthyoplankton have always contributed to the study of the Ocean. Fish eggs and larvae can be used in describing short term and long term variations in the marine environment as they are part of theplankton and can be involved in the definition of the indicator communities associated with water masses. With the growing interest in structure and functioning of eco-systems and in man's effects on them, eg. through fisheries and pollution, ichthyoplankton studies gained new importance.

1.2. Quantitative approach to Ichthyoplankton studies

Since most marine fish of commercial importance have extremely high fecundities, mortalities must be correspondingly high in eggs and larval stages to maintain the population in balance. These mortalities are believed to occur mainly during the first few months of the life history of a fish. Hjort was the first to suggest that good and bad year classes were determined during the embryonic and larval phases (Dannevig, 1919). Beverton and Holt (1957) pointed out that density - dependent factors of the fish population may have their greatest effect at the early stages of the stock. Of the early quantitative works on the eggs and larvae of marine fishes, the comprehensive series of surveys to examine the fluctuations in the Pacific sardine, Sardinops caerulea and northern anchovy populations carried out by California Co-operative Oceanic Fisheries Investigations along the Pacific Coast of North America are worth mentioning (Scofield, 1934, Sette and Ahlstrom, 1948, Ahlstrom 1948, 1952, 1954, 1959 a&b. and Marak and Colton 1961, Marak et al 1962, Richards 1969, 1981, 1984.

Other workers have made estimates of mortality in the larval phase of marine fishes, which include the Atlantic mackerel (Sette, 1953), the Japanese sardine and anchovy (Nakai et al, 1962) and the Black Sea anchovy (Dekhnik, 1954). Boonprakob (1963) published the results of fish eggs survey in the gulf of Thailand. A number of studies on eggs and larval abundance have been carried out from Indian waters also. (Bal & Pradhan 1945, 1946, 1947, Panikkar and Nair (1945)

IIOE (1960-65) Ahlstrom 1968, Peter 1967 b, 1969 a,b, 1974, 1977 Mukundan 1971, Nellen (1973) Alikhan (1972) Silas 1974, Premalatha (1988). The UNDP/FAO/Pelagic Fishery Project has also done a comprehensive and systamatic ichthyoplankton survey along the South West Coast ofIndia during 1971-1975 (Anon 1976)

1.3. Ichthyoplankton studies of marine fishes in Indian Waters.

The study of ichthyoplankton, especially those of the economically important marine fishes, has received considerable attention after the discovery of the eggs of the cod, the gurnard and the haddock by G.O. Sars (1864). The study of ichthyoplankton has contributed not only to the knowledge of the life history of important fish species, butalso to the understanding of the spawning season, breeding ground and such other problems relating to the biology of fishes. Though it is well known that a knowledge of these aspects of the biology of food fishes is an essential pre-requisite for the proper management and exploitation of the marine fishery resources, the availble literature on the development of fish are only for about 10% of the total marine fish species (Smith - 1974). While considerable advance has been made in this branch of science in temperate countries, very little is known about the eggs and larvae of tropical marine food fishes. The only exception is the work of Delsman (1922-1938) who elucidated the early life histories of a number of fishes of the Java sea.

Contributions on the subject relating to the early development of marine fishes from Indian waters are comparatively few. The erstwhile Madras Presidency fisheries department pioneered the study on the development of marine fishes in India (Hornell 1922, Nayudu, 1922, Hornell and Nayudu 1923). In late years the same department also gave several contributions on these aspects (John 1939, Devanesan and John 1940, 1941, Devanesan and Varadarajan 1942, Devanesan 1943, Chidambaram 1943,Chidambaram and Venkataraman 1946, Jacob 1949, Chacko 1950, Chacko and Mathew 1955).

Certain Indian Universities like Bombay, Madras and Travancore (erstwhile) and the institutes under them also contributed to the studies on ichthyoplankton taxonomy. (Aiyar 1935, Jones 1937, Panikkar and Aiyar 1939, Gopinath 1942, 1946, 1950, Panikkar and Nair 1945, Menon 1945, Bal and Pradhan, 1945, 1946, 1947, 1951, John 1951, Nair 1952 b,c Vijayaraghavan 1957, and Kuthalingam, 1957, 1959, 1960, 1961 a,b). Contributions on ichthyoplankton studies along the South West Coast of India also resulted from the works at the department of Marine Sciences, University of Cochin. (Balakrishnan, 1961, 1963, 1969, 1971, Balakrishnan and Devi 1974, Devi 1969, 1982, Nair 1961, Dileep 1977, Sreekumari 1977, Premalatha 1977, 1988).

On the East Coast, similar studies on fish eggs and larvae were contributed by Universities of Andhra and Annamalai (Ganapathi and Raju 1961 a,b, 1963, Rao 1963, Raju and Ganapathi 1969, Balasubrahmanyam et al 1967, Venkataramanujam 1975, Venkataramanujam et al 1984, Ramanathan 1977, Ramanathan and Natarajan 1979, Thangarajan and Ramamoorthi - 1982).

Ichthyoplankton studies were also carried out by CMFRI since 1947 (Jones and Menon, 1951, 1953, Pantalu and Jones 1951, Jones and Pantulu 1958, Jones 1958-1967, Jones and Kumaran 1962, 1964, Balakrishnan 1957, Kuthalingam 1957, 1959, 1960, 1961 a,&b. Bapat and Prasad 1952, Bapat 1955, Nair 1948, 1952 a,&b 1959, Rao 1973, Rao& Girijavallabhan - 1973, Balakrishnan and Rao 1971, Bensam 1968, a & b, 1969, 1971 a & b, 1973, Vijayaraghavan 1973 a & b, 1975, Girijavallabhan and Gnanamuthu 1975, 1983, Girijavallabhan 1983, Silas and George 1971 Silas 1975).

The erstwhile Indo-Norwegian Project (The Integrated Fisheries Project, Cochin) in collaboration with CMFRI collected several eggs and larval samples from the shelf waters of South West Coast and the Laccadives Archipelago (Jones 1967 a). These materials have been used by and large for quantitative studies and also to indicate the spawning grounds, mainly of tunas.

Quantitative approach on ichthyoplankton studies were also carried out in India waters. Bal and Pradhan (1945, 1946, 1947) and Panikkar and Nair (1945) reported on the results of investigation on eggs and larval collections in Bombay and Madras waters respectively. During the International Indian Ocean Expedition (IIOE 1960 - '65) collections of ichthyoplankton from open ocean and shelf waters of Indian Ocean were made. But the collections have been made from widely separated stations and so the coverages have been rather limited. However these investigations have resulted in the publication of some general accounts of fish eggs and larvae and their distribution in the Indian Ocean (Ahlstrom 1968, Peter, 1967 b, 1969 a,b, 1974, 1977, Panikkar and Rao 1973)

Nellen (1973) made a detailed study on the kinds and abundance of the fish larvae from the cruise of R.V. Meteor in the Arabian sea and Persian Gulf during 1964-'65. The cruise covered some sections of the shelf waters of the South West Coast of India also.

One of the recent quantitative study of ichthyoplankton from an area of adjacent to Indian Coast was that of Alikhan (1972), who studied the distribution and baundance of fish larvae in the Gulf of Aden and off the coast of Pakistan based on the material collected during 1964-'67 period, in 9 different cruises.

Silas (1974) described in detail the different larval stages of Indian mackerel and mapped their distribution and abundance off the South West Coast of India and the Laccadives sea, based on materials from cruises of R.V. Varuna in 1964.

The most comprehensive and systamatic ichthyoplankton surveys along the West Coast of Indian were carried out by the research vessels of UNDP/FAO/ Pelagic Fishery Projects, Cochin during 1971 - 1975 period (George - 1979). Recently Premalatha (1988) described the distribution and abundance of carangid fish larvae in the above collections along the South West Coast of India.

1.4. Present status of studies on the larvae of Flat fishes, Lizard fishes and Bombay duck.

a. Flat fishes

The various stages in the development of a number of flat fishes have been studied in detail from the temperate seas. Agassiz (1879) pioneered these works and he described different stages of flat fishes like Paralichthys dentatus, P. oblongus, Pseudopleuronectes americanus. Other works worth mentioning are Cunningham (1891, 1892) on Limanda limanda, Pleuronectes platessa, Scopthalmus maximus, Solea valgaris; Raffaele (1888) on Arnoglossus thori, and Scophthalmus rhombus, and Holt (1893) on L. limanda, P. platessa, Arnoglossus thori and A. laterna. Ehrenbaum (1909) described and illustrated the eggs and larval developments of a number of flat fishes from Norwegian waters. Kyle (1913, 1921) contributed valuable information on the larval and post-larval development of fishes such as Hippoglossus platessoides limandoides, P. platessa, A. thori, Bothus podes.

Eggs and early larval stages of a number of Pleuronectid fishes from Japanese waters have been described and illustrated by Mito (1961, 1963). They includes Paralichthys olivaceus, Hippoglossides robustus, Aesopia cornuta, Cynoglossus robustus. Ochiai and Amaoka (1963) described larvae and young of Arnoglossus japonicus, Crossorhombus valderostratus, Bothus myriaster and Bothus sp. Other recent works include Amaoka (1970, 1971) on B. myriaster, Chascanopsetta lugubris.

Pertseva-Ostroumova (1965) figured and described the larval stages of 20 species of flat fishes from the gulf of Tonkin. They include, Pseudorhombus sp., Arnoglossus Spp. Psettina iijimae, P. hainanensis, Engyprosopon grandisquamis, Crossorhombus azureus, Crossorhombus sp., Branchy pleuronovae - zealandiae, Samaris cristatus, Zebrias guagga, Arelia bilineata, Cynoglossus oligolepis, C. sibogae, and Symphurus orientalis. Orsi (1968) described larvae of Parophrys vetulus. Smith (1967) described and illustrated a post larvae of Parabothus thackwrayi. Gutherz (1971) described characteristics of some larval bothid flat fishes and developmental stages of Cyclospsetta fimbriata. Leonard (1971) described the larvae of Hippoglossina oblonga from Western North Atlantic.

Yasnnaga (1971) studied the feeding habit and growth of P. olivaceus, in larval stage. Evseenko (1976) on Bothus ocellatus, Fursa (1978) on Cynoglossus lida, Policansky and Sieswerda (1979) on Platichthys stellatus, Sumida et al (1979) on Pleuronichthys cocnosus, P. decurrens, P. ritteri, P. verticatis, P. ocellatus, Hypsopsetta guttulata, and Hippoglossina stomata and Harding et al (1979) on P. platessa are some other works of larval flat fishes.

Laroche (1980) described the larval development and morphology of Liopsetta puntanami from North West Atlantic. Tucker (1982) described and illustrated the larvae of Citharichthys cornutus, C. gymnorhimus, C. spilopterus and Etropus crossotus from North West Atlantic Le (1982) described the post-larvae of Solea senegalensis from Bay of Biscay. Khodja and Marinaro (1983) illustrated the larval development of Buglossidium luteum. Minami (1983, 1866) described the larval stages of Cynoglossus joyneri, P. cornutus, Hippoglossoides dubius, Kareius bicoloratus, Verasper variegatus and Limanda herzensteini from Japanese waters. Kim et al (1983) described the larval stage of Limanda yokohamae from Japan and Korean waters. Evseyenko and Efremen ko (1986) made a detailed description of the larval development of Mancopsetta maculata from South Atlantic.

Unlike the flat fishes of the temperate waters, very few of the Indian species, with the exception of the 'Malabar Sole', Cynoglossus macrostomus, were studied in detail. Devanesan and Varadarajan (1942) described the eggs of Cynoglossus semifaciatus [= C. macrostomus, Menon- (1970)]. Chidambaram (1945) and

Chidambaran and Venkataraman (1946) studied the spawning time of C. semifaciatus and have mentioned October to March as spawning period of the fish. Panikkar and Nair (1945) reported the occurrence of larvae of Solea sp. from Madras Coast. John (1951) has recorded and illustrated the eggs and larval stages of Psettodes erumei, Arnoglossus tapeinosoma, A. macrolophus & Paraplagusia bilineata from the Madras Coast. Gopinath (1946) recorded post-larval stages of Bothus (Platophrys) Pantherinus, Pseudorhombus arsius, P. triocellatus and P. bilineata from Trivandrum Coast. Nair (1952 a&b) have illustrated and described the eggs, newly hatched and post-larval forms of Cynoglossus sp. from Madras coast.

Jones and Menon (1951) have described the larval stages of Brachirus pan, Cynoglossus lingua and Cynoglossus sp. Eggs and larvae of Cynoglossus sp. and their distribution along the gulf of Mannar and Palk Bay have been studied by Bapat (1955). Detailed studies on the development, biology and distribution of 'Malabar Sole' at Calicut have been carried out by Sheshappa (1965, 1968, 1972, 1973) and Sheshappa and Bhimachar (1951, 1954, 1955). George (1958) also made some observations on the fishery and biology of the 'Malabar Sole'. Sheshappa (1974) described the fishery and biology of Cynoglossus dubius at Calicut. Vijayaraghavan (1957) described and illustrated eggs and larvae of Cynoglossus A & B and post-larvae and juveniles of C. bilineatus and their food and feeding habits, from Madras Coast. Kuthalingam(1957, 1960) described eggs and reared larvae of C. lingua and Solea elongata. Jones and Pantulu (1958) described and illustrated the larval forms of P. erumei, P. arsius, P. oligodon, A. tapeinosoma, Bothus sp., Samaris macrolepis, Solea ovata, Heteromycteris oculus and Cynoglossus sp. I, II & III from Bengal and Orissa Coast. Balakrishnan (1961, 1963) described the larval stages of C. semifaciatus, A. tapeinosoma, Bothus ocellatus, Laeops guentheri, Solea ovalia, and Cynoglossus monopus from South West Coast. Basheeruddin and Nagappan Nair (1962) reported the occurrence of juvenile stages of P. erumei and Bothus pantherinus from the coastal waters off Madras city. Devi (1969) described and illustrated the larvae of Pseudorhombus elevatus. Bensam (1969) illustrated the eggs and larvae of C. semifaciatus. Larval forms of Solea heinii, Cynoglossus puneticeps, C. brevis, C. cynoglossus and C. lida have been described by Balakrishnan and Devi (1972) from Cochin Back water. Venkataramanujam and Ramamoorthi (1977) reported the occurrence of eggs and larvae of Pseudorhombus javanicus, P. arsius, and Cynoglossus sp. from Porto Novo water. Ramanathan and Natarajan (1979) described and illustrated eggs and larval development of Cynoglossus areal, C. monopus and larval forms of P. erumei, B. novaezeelandiae, P. arsius, B. myriaster, Synaptura albomaculata and S. commersoniana from Bay of Bengal. Devi (1982) described the diagnostic characters of the larvae of Psettina breviricits and P. iijimae. Thangaraja and Ramamoorthi (1982) described the eggs and larval development of laboratory reared S. ovata.

b. Lizard fishes:

Very little work has been done on the development of lizard fishes (Family Synodontidae) - Raffaele (1888) has described the eggs of Saurus lacerta. In 1897 Ogilby described a new genus and species, Godella hypozona, which was afterwards redescribed by Waite (1904) as the young of the common Trachinocephalus myops. Weber (1913) described and figures the larvae of Saurida gracilis and Synodus variegatus from Indo-Pacific region. Sanzo in 1915 has described and illustrated complete developmental stages of Synodus saurus from the Meditarranean, ranging from the eggs to post-larval stages. The larval stages of Synodus synodus was identified by Regan (1916) from off the coast of Brazil. Delsman (1929, 1938) described eggs and pro-larvae of S. tumbil and Synodus sp. from Java sea. Gopinath (1946) described and illustrated the post-larvae of Saurus indicus and S. myops from Trivandrum coast. Nair (1952 b) described and figured different stages of the eggs of S. tumbil from Madras plankton. Vijayaraghavan (1957) and Kuthalingam (1959) described and illustrated eggs and reared larvae of S. tumbil.

Gibbs (1959) has illustrated and made a synopsis if the post-larval stage of T. myops, Synodus foetus, S. poeyi, S. synodus, S. saurus, Saurida brasiliensis S. normani, and S. suspicio from Western Atlantic. Mito (1961) described and illustrated the eggs and larvae of S. variegatus, S. tumbil, S. elongata, S. synodus sp. and T. myops from Japanese waters. Zvjagina (1965) has described and illustrated the eggs, larvae and post-larvae of seven species of lizard fishes (T. myops S. tumbil, S. elongata, S. undosquamis, S. variegatus, Synodus sp. and Saurida sp.) from gulf of Tonkin. Anderson et al (1966) illustrated the post larval stages of T. myops, S. saurus, S. synodus, S. foetus, S. suspicio and S. brasiliensis from the Western Atlantic Ocean. Dileep (1977) described and illustrated the larval stages of S. tumbil from South West Coast of India. Venkataramanujam and Ramamoorthi (1977) reported the presence of larvae of S. tumbil and S. gracilis in Porto Novo coastal waters. Venkataramanujam et al (1984) described the laboratory reared larvae of S. gracilis.

c. Bombay duck:

The only available literature on the early developmental stages of the Bombay duck, Harpodon nehereus is a brief description of the egg by Delsman in 1929.

1.5. Importance & Objectives of the present study.

Systematic survey of ichthyoplankton is one of the means available for evaluating fish resources. It also contributes in studying the development, growth, behaviour, food requirements and mortality of the early stages of important fishes and also for clarifying the fish systematics. Besides these, the ichthyoplnkton studies provide detection and appraisal of fishery resources by locating spawning concentration of fish stock, exploration for new resources and monitoring long-term changes in the composition and abundance of resources and spawning times and areas.

The main objectives of the present study has been the collection of the larvae of some of the important and less studied demersal fishes of the South West Coast of India, preparation of their life history series, statistical analysis of the morphometric characters, spatial as well as temporal distribution of the larvae in relation to the chief hydrographic parameters such as temperature, salinity and oxygen, so as to delineate the spawning areas and seasons of these fish populations.

The informations regarding the kind and amount of bottom fish resources along the Indian Coast are scanty. Even though the flat fish resources of Indian waters contributes a singificant share in the total marine fish landings the detailed studies on biology and fishery have been conducted only for 'Malabar Sole' (Cynoglossus macrostomus) while the reminder species of this group are inadequately known. Lizard fishes (order Myctophiphormes) are always present in the miscellaneous catch in all seasons but an adequate knowledge of the potential resources of this group is wanting. The Bombay duck, coming under the same order, is one of the most heavily fished species particularly along the Maharashtra & Gujarat coasts but its early developmental stages are not studied. Hence the present study will contribute to a better understanding of the demersal fishery resources of the South West Coast of India.

1.6. Fishery of flat fishes, lizard fishes and Bombay duck with a list of fishes belonging to the Orders: **Pleuronectiformes** and **Myctophiformes** with special reference to South West Coast of India.

Order Pleuronectiformes (Heterosomata) and Order Myctophiformes are two important groups of demersal fishes found along the inshore waters of the west coast of India.

Order Pleuronectiformes, collectively known as flat fishes, is a group of bottom fishes that is readily recognized by unique appearance in having both eyes on the same side of the head, either to left or right of mouth and one side of the body is pigmented while the other side normally white or very light. The group is distributed throughout the marine waters of the world and are particularly abundant on the continentnal shelf and are of commercial importance. Many species are found in brackish water habitats also while a few are confined to fresh water. Thery are benthic and carnivorous.

Larvae of flat fishes are bilaterally symmetrical and swim upright, but in later stages of development one eye migrates across the top of the skull to lie adjacent to the eye on the other side. They then lie and swim on the blind side.

In the Systema Nuturae (1758) Linnaeus placed all flat fishes known to him in a single genus, Pleuronectes. During the last decade of the eighteenth century and the first part of the nineteenth century eight more genera of flat fishes were described. Recognising the similarities of the forms, Cuvier (1817) established a family for their inlcusion, but grouped them together with the gadoids, gobiesocids, cyclopterids, echineids and ophicephalids in a division of sub-branchial malacoptergians, characterized by the thoracic position of the ventral fins and the absence of spines in the dorsal fins. Muller (1846) restricted the numberof forms associated with the flat fishes in a higher systematics category, but still placed them together with the gadoids and ophidiods in his new order Anacanthini. Cope (1871) finally isolated the flat fishes from other orders and placed them under the order Heterosomata, which is subsequently called the Pleuronectiformes.

Pleuronectiformes comprises about 520 extant species and 117 genera. Various authors have divided the order in to a larger or smaller number of families. The extreme points of view among fairly modern writers are probably those of Jordan (1923), who recognized eleven families, where as Weber and deBeaufort (1929), recognized only four. Regan (1910) presented a classification, founded on considerable anatomical investigation, that divided the order in to five families viz. Psettodidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae. This classification was accepted by Norman (1934). In a most recent classification by Nelson (1976) six families were recognized by him viz. Psettodidae, Citharidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae, and it is this classification that is followed here. Hubbs (1945) Punpoka (1964) and Menon (1977) also dealt with the classification of the order.

All the families except citharidae are represented in Indian Waters. Norman (1927 & 1928) has described about 91 species from the Indian Waters. Saramma (1963) reported thirty species from Kerala coast.

The following list of species embrace flat fishes known from the Indian coasts with special reference to the West Coast of India.

Family **Psettodidae**

Psettodes erumei (Bloch & Schneider)

Family **Bothidae**

Arnoglossus tapeinosoma (Bleeker)

Psettina breviricitis (Alcock)

P. profunda (Weber)

Engyprosopon grandisquamis (Temminck & Schlegel)

E. cocosensis (Bleeker)

E. latifrons (Regan)

E. macrolepis (Regan)

E. mogkii (Bleeker)

Crossorhombus valde-rostratus (Alcock)

C. azureus (Alcock)

Bothus ocellatus (Agassiz)

B. pantherinus (Ruppell)

B. bleekeri (Steindachner)

B. ovalis (Regan)

B. leopardinus (Gunther)

Parabothus polylepis (Alcock)

Grammatobothus polyophthalmus (Bleeker)

Chascanopsetta lugubris Alcock

Laeops guentheri Alcock

L. macrophthalmus (Alcock)

Cephalopsetta ventrocellatus Dutt & Rao

Pseudorhombus arsius (Hamilton)

P. elevatus Ogilby

P. dupliciocellatus Regan

P. javanicus (Bleeker)

P. malayanus Bleeker

P. micrognathus Norman

P. triocellatus (Schlegel)

P. natalensis Gilchrist

Family **Pleuronectidae**

Poecilopsetta colorata Gunther

Nematops grandisquama Weber & deBeaufort

Marleyella bicolorata (Von Bonde)

Samaris cristatus (Gray)

Samariscus inornatus (Lloyd)

S. longimanus Norman

Family **Soleidae**

Aesopia cornuta Kaup

Aseraggodes cyaneus (Alcock)

Brachirus orientalis (Bloch)

Euryglossa orientalis (Schneider)

Heteromycteris oculus (Alcock)

Liachirus melanospilus (Bleeker)

Paradachirus marmoratus (Lacepede)

Solea elongata Day

S. ovata Richardson

Synaptura albomaculta Kaup

S. commersoniana (Lacepede)

S. pan (Hamilton)

Zebrias altipinnis (Alcock)

Z. maculosus Oommen

Z. guagga (Kaup)

Z. zynapturoides (Jenkins)

Z. zebra (Bloch)

Family **Cynoglossidae**

Cynoglossus arel (Schneider)

C. bilineatus (Lacepede)

C. carpenteri Alcock

C. cynoglossus (Hamilton - Buchanan)

C. dispar Day

C. dubius (Day)

C. kopsi (Bleeker)

C. lida (Bleeker)

C. lingua Hamilton-Buchanan

C. macrostomus Norman

C. monopus (Bleeker)

C. puncticeps (Richardson)

C. semifasciatus Day

Paraplagusia bilineata (Bloch)

P. blochi (Bleeker)

Symphurus septemstriatus (Alcock)

S. trifasciatus (Alcock)

Classification of the lizard fishes and other related forms are subjected to much changes. In his classification Regan (1911) included the lizard fishes in the family Synodontidae of the order Iniomi. But according to Berg (1940) these fishes belong to family synodidae in the Scopiliformes. In the recent classification of Nelson (1976) these fishes are inlcuded in the family Synodontidae in the order Myctophiformes and in the super order Scopelomorpha (Iniomi, in part).

The family Synodontidae have four genera, Saurida, Synodus, Trachinocephalus and Xystodus, with about 34 species. The genus, Xystodus is not represented in Indian Waters. Norman (1934) in his revision of the lizard fishes described 26 species in the three genera Saurida, Synodus and Trachinocephalus. Two species of the genus Saurida: Saurida tumbil (Bloch) and S. nebulosa Cuv & Val. synonym S. gracilis (Quoy & Gaimard) were described by Day (1878) from Indian Waters. These two species along with a third one, S. grandisquamis Gunther, were described by Weber & deBeaufort (1913) from the Indo-Aaustralian Archipelago. According to NOrman (1935) S. grandisquamis Gunther is a synonym of S. undosquamis (Richardson). In his revision, the fishes of the genus Saurida, Norman (1935) has described five species, S. gracilis, S. tumbil, S. undosquamis, S. filamentosa and S. elongata from the Indo-Pacific. Three species of the genus Saurida, two species from Synodus and one from Trachinocephalus were recorded from the Indian Waters. Thery are:

1. Saurida tumbil (Bloch)
2. S. undosquamis (Richardson)
3. S. gracilis (Quoy & Gaimard)
4. Synodus variegatus (Lacepede)
5. S. indicus (Day) and
6. Trachinocephalus myops (Schneider)

The Bombay duck, Harpadon nehereus (Hamilton) also belongs to the same order Myctophiformes. The earliest record of this fish was from the mouth of Ganges by Hamilton (1822), who called it nehereus and referred it doubtfully to the genus Osmerus. Le Sueur (1825) proposed the generic name Harpadon for his Salmo microps which is synonymous with Osmerus nehereus Gunther (1864) assigned the species nehereus to the genus Harpadon ~~and also included the genus Harpadon~~ and also included the genus Harpadon under the family Scopelidae. Jordan (1923) created the family Harpodontidae. Day (1889) included the genus Harpadon in the family Synodidae. But in his classification Nelson (1976) included 'Bombay duck' in the family Harpadontidae under the order Myctophiformes. The family Harpodontidae has only one genus Harpodon with four species. They are Harpadon nehereus (Hamilton) H. microchir Gunther, H. squamosus Alcock, and H. mortensoni Hardenburg of which H. nehereus and H. squamosus are from Indian waters. Only H. nehreus is represented in the west coast of India.

Fishery

Soles and other flatfishes constitute an important element in the ground fish resources of the India. They are represented by a large number of genera in our waters. But most of the flat fishes occur in small numbers all along the cost, except the Malabar Sole Cynoglossus macrostomus Norman, which supports an important fishery from Quilon in Kerala to Moolki in South Kanara. The major sole-fishing centres on the West coast are Baikampady, Ullal, Kanhangad, Hosdurg, Cannanore, Tellicherry, Quilandy, Kozhikode, Chowghat, Ponnani, Narakkal and Alleppey-Purakkad. On the East coast important sole-fishing grounds are located south of Visakhpatnam.

The sole fishery begins towards the end of South West monsoon and continues till November. Catches in the early part of the fishing season comprise maturing specimens and during late October and November fully mature forms. Major part of the total landings of the sole is obtained within the first few weeks of the commencement of the season. This sudden appearance of the soles in the surface or sub-surface waters of the isnshore region is phenomenal and is known in Kerala as "Manthayilakom", when they are captured in huge quantities in boat-seines, cast-nets and shore-seines.

Another species that contributes to a small fishery occasionally along the S.W. coast is C. dubius Day which grows to a larger size. Species of Solea and Synaptura members of the family Soleidae occasionally come in small quantities in the miscellaneous inshore catches. The "Indian Halibut", Psettodes erumei (Schn.) occurs in small quantities on both coasts and has been known to occur in deeper waters (Pradhan, 1967). Species such as C. lingua, C. lida, C. puncticeps, C. bilineatus, Paraplagusia spp. and Pseudorhombus spp. are also caught with the malabar sole occasioanally.

The Bombay duck, Harpodon nehereus (Ham.) and Lizard fishes (Saurida and allied genera) together constitute a very significant fishery, especially along the North West coast of India. All these members are treated together as one group because of their taxonomic affinities; this group forming about 8-12% in the total marine landing of India.

Outside India, the Bombay duck occurs on the east coast of Africa, Malaya, Indonesia and China. In India the fish shows a discontinuous distribution, occurring abundantly along with Gujarat coast and Maharashtra region of the west coast and the West Bengal region of the east coast. The abundance dwindles southwards on the west coast and there is very little catch along the Kerala coast. On the east coast also there is no catch in the Tamil Nadu region, but formed in small numbers along the Coromandel coast. Its abundance increases northwards on the east coast.

The distribution of the Bombay duck has been thoroughly studied by various authors like Hora (1934), Raj (1954) Chopra (1939) and Bapat (1967, 1970) and came to the conclusion that the distribution & abundance of the fish is due to (a) peculiarities in the distribution and movements of the choice food organisms of the fish. (b) variation in salinity along the coasts of India and (c) fluctuation in the surface temperature of the sea water.

The fishing season for Bombay duck lasts from September to January - March. The fishing is mainly confined to the South and South-east coasts of Gujarat and Konkan coasts.

The lizard fishes, closely related to Bombay duck, are obtained in the occasional catches all along the coast except in the West Bengal. They include Saurida tumbil, S. undosquamis, S. nebulosa, Synodus variegatus, S. indicus and Trachinocephalus myops. Some other species such as Synodus binotatus Schultz, S. englemani Schultz S. jaculum Russel & Cressey and S. macrops Tanaka were also reported from Indian Coast (Fischer, W, and G. Bianchi (eds) 1984). Most of them' grow over 30cm in length and are caught in trawls operated upto 60 metre depth. The results of the observations of Fishery Survey of India vessels indicated that the lizard fishes were found in the entire shelf area of west coast and their distribution were more concentrated in 100-200m depth zone. Along theSouth-West coast the lizard fishes were found to have extended distribution even to the continental slope (Joseph, K.M. 1980). Along the South West coast of India, a potential fishery for S. undosquamis and S. tumbil is indicated at 75 - 100m depth. The all India landings of lizard fishes show that landings are high in Kerala, Maharashtra, and Tamil Nadu and moderate in Andhra Pradesh, Gujarat, Karnataka and Goa and meagre in other states.

1.7. The Species studied

Order : **PLEURONECTIFORMES (HETEROSOMATA)**

Family : **Bothidae**

Sub family : Paralichthinae

1. Pseudorhombus arsius (Hamilton, 1853)

Sub Family : Bothinae

2. Psettina profunda (Weber, 1913)
3. Engyprosopon grandisquamis (Temminck & Schlegel, 1846)
4. Engyprosopon cocosensis (Bleeker, 1855)
5. Bothus ovalis (Regan, 1908)
6. Grammatobothus polyophthalmus (Bleeker, 1866)
7. Laeops guentheri Alcock, 1890
8. Laeops macrophthalmus (Alcock, 1889)

Family : **Cynoglossidae**

9. Cynoglossus macrostomus, Norman 1928
10. Paraplagussia bilineata (Bloch.1784)

Family : **Soleidae**

11. Aseraggodes cyaneus (Alcock, 1890)

Order : **MYCTOPHIFORMES**

Family : **Synodontidae**

12. Saurida undosquamis (Richardson, 1848)
13. Synodus variegatus (Lacep'ede, 1803
14. Trachinocephalus myops (Forster, 1801)

Family : **Harpadontidae**

15. Harpadon nehereus (Hamilton 1822)

2. MATERIALS AND METHODS

2.1. Area of collection

In the present studies, the area covered include the South West Coast of India from Ratnagiri (17°00'N) to Tuticorin (08° 40'N) approximately 1350 Km. of the coast of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu are encompassed (Fig. 1.). Regular and systematic sampling were made during the period from September 1971 to December 1975 along seven fixed sections strating from north, Ratnagiri, Karwar, Kasaragod, Cochin, Quilon, Cape Comorin and Tuticorin. The sections of Calicut, Coondapur and Vengurla were also worked a few times. Along each section upto 10 stations were worked. Stations were 10 nautical miles apart on the continental shelf and 15 or 30 nautical miles apart beyond the shelf. Majority of all stations worked (68%) were on the continental shelf. The routine programme has been to cover each section atleast once every six weeks.

2.2. Vessels and gear

Two vessels 'R.V."Sardinella" (Length 16.34m, 153HP) and R.V. "Varuna" (Length 28m, 400 HP) were used by the project in 1971 and 1972. From 1973 onwards a larger vessel R.V. "Rastrelliger" (Length 46.5m, 1320 HP) was also in operation.

The principal sampling gear was the 'Bongo' 20 net (Hydrobios type) with nylon neting of 0.5mm mesh size and equipped with calibrated flow meter. The system consists of a pair of net cones of 20cm diameter in the mouth and 90cm long and connected by a yoke. The yoke-bar with the net can swing in a sleeve, connected to the wire rope and takes a horizontal position in tow. Keeping the equilibrium of the net during the tow a heavy cast metal depression is shackled to the sleeve. In some cruises a special plastic collar type 'Bongo'20 and 'Bongo' 60 (ring diameter 60 cm) nets were also used.

Fig: 1. : Area of Sampling.

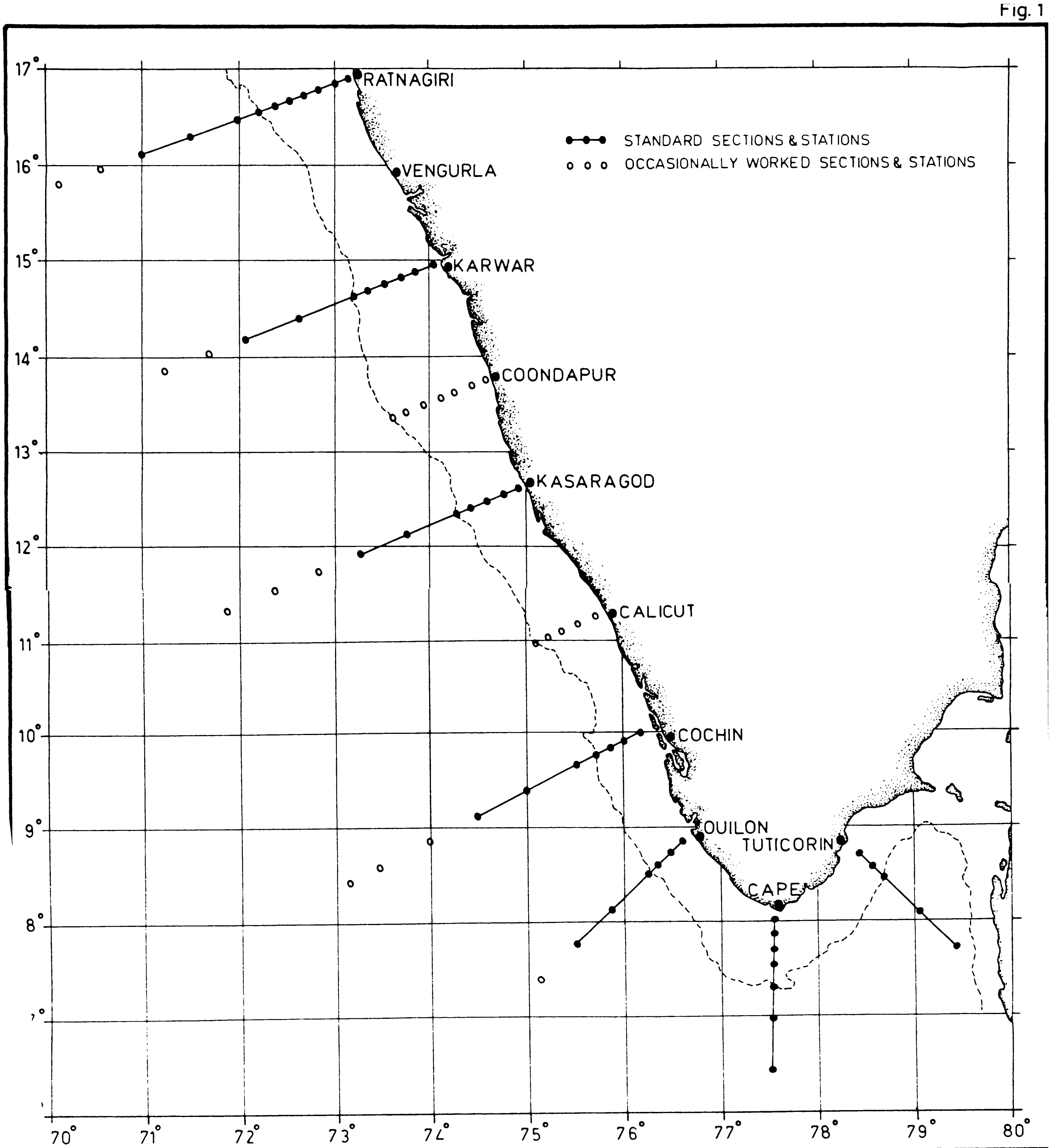
STANDARD SECTIONS & STATIONS
OCCASIONALLY WORKED SECTIONS & STATIONS
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 1

The nets were operated in continuous oblique hauls at minimum winch speed (20 meters per minute) and 2 to 3 knots vessel speed. At the first shore stations of each section, 10m was the usual collection depth. At shallow stations the tows were made from near the bottom. Prior to 1973 the maximum collection depth was limited to 25-50m but later a standard maximum of 100m was adopted and occasionally it was isncreased to 150m to reach deeper thermocline.

The plankton samples were preserved immediately after collection in 4% formaldehyde solution in sea water. In addition to the plankton collections by the research vessels, they were also engaged in a number of pelagic trawls and obtained larged number of juvenile stages of fishes.

Nansen reversing water bottles were used for hydrographical data. The temperature was calculated from the reading of the reversing thermometer, the dissolved oxygen was estimated by Winkler method and the salinity was calculated with the help of a salinometer.

2.3. Materials

The materials for the present study is obtained from the ichthyoplankton collections of UNDP/FAO/Pelagic Fishery Projects vessels, obtained during their regular acoustic survey cruises from Ratnagiri to Tuticorin. During the period from September 1971 to December 1975, 1330 hauls were made from 50 regular stations and 23 occasionally collecting stations fixed along 9 sections viz. Ratnagiri, Karwar, Coondapur, Kasaragod, Calicut, Cochin, Quilon, Cape Comorin and Tuticorin. Samples were taken in duplicate.

Out of these flat fish larvae in 333 samples, lizard fish larvae in 133 samples and Bombayduck larvae in 9 samples were present. Details of stations and sampled, year-wise are given in Tables-1 & -2.

The preserved samples were transferred to the shore laboratory after each cruise for further analysis. From the entire plankton sampled, ichthyoplankton were sorted out and materials for the present study were segregated from these sub-sorted sampled.

2.4. Methods

The present study deals with two parts, qualitative and quantitative. The quantitative study includes spacial as well as temporal distribution and abundance of larvae. For the purpose of standardising the density of larvae under study, an index of their number occurring below on square metre of the surface was computed based on the formula $\frac{N \times D}{V}$, where N is the actual number of the larvae at the Station, V the volume of the water filtered in m^3 and D the depth of the tow. (Dragesund 1970). Since all the nets had periodically calibrated flow meters, the volume of water could be computed.

The qualitative part of the study include sorting of the larvae and their identification. The basic principles for the identification of early stages of fishes have two methods; 1. work from juveniles to larvae to eggs and 2. rear eggs and larvae from known parents to identifiable stages in the laboratory. Both methods require a complete series of specimens and the 2nd method provides materials in the best condition. The first method is followed in the present study. For the larval identification transitory as well as permanent characters were used. Transitory characters include larval pigmentation, elongate fin rays, and body spination. Meristic counts, position and size of the pelvic fin base osteological peculiarities are the permanent characters which are retained after the larvae attain juvenile or adult.

The larval period is divided in to three stages: 'Pre-flexion', 'flexion' and 'post-flexion', based on the flexion of the notochord which occurs during caudal fin formation. (Moser and Ahlstrom 1970; Ahlstrom et al 1976 and Sumida et al 1979). In the pre-flexion stage the notochord is straight, whereas in the flexion stage the notochord is slightly bent upward, but the caudal elements are not yet formed. In the post-flexion stage the flexion is completed and all the caudal elements are formed. In the case of flat fish larvae the transformation from the larval to juvenile stage was marked by the eye migration, development of ossified pectoral fin rays, scales and the lateral line. The larvae of lizard fish and Bombay duck enter juvenile stage when all the fin rays, including pectoral fin rays, get ossified and scales and lateral line formed.

The number of specimens examined varied according to species, depending on their availability and abundance, ranging from several hundred larvae of C. macrostomus, E. cocosensis and E. grandisquamis to few numbers of H. nehreus & P. polyophthalmus. In most case developmental series of larvae through juveniles were assembeled for each species.

Measurements of selected body parts, such as standard length, pre-anal distance, head length, eye diameter, snout length body depth and length of upper jaw were taken to provide descriptive and comparative morphometric data. The total length (T.L) was not taken due to the damaged caudal fin in many specimens. Measurements were made on the right side of each soleid specimen, on the left side of the bothid and cynoglossid specimen and on either side of the synodontid and harpondontid larvae. All the measurements were made using a calibrated ocular micrometer, mounted on the eye piece of a stereomicroscope.

The procedures followed in making measurements and in enumerating meristic counts and also the terminology used in the morphometric tables are as follows: Body length (B.L.) In pre-flexion and flexion stages, horizontal distance from tip of snout to tip of notochord, referred to as notochordal length (NL) in post flexion stage from tip of snout to posterior margin of hypural elements ie. Standard length - (SL)

Head length (H.L.): Tip of snout to posterior edge of cleithrum on a horizontal line through centre of eye on small larvae or tip of snout to origin of dorsal most part of pectoral fin base or tip of snout to posterior most part of the opercle on large larvae.

Snout length (SN): Horizontal distance from tip of snout to anterior margin of pigmented region of eye (In the case of flat fish larvae the SN is taken from the ocular side)

Eye diameter (E.D.): Horizontal distance across the eye.

Body depth (B.D.): Vertical distance across body at pectoral fin base. For flat fish larvae, the dorsal pterygiophore region is also included, when it is formed

Pre-anal distance (PAD): Horizontal distance from tip of snout through mid line of body to vertical through anus (In most of the flat fish larvae the intestinal coil is bulged outside of the body and even uncoiled and the intestine stranded outside as in the case of Laeops sp. So PAD for flat fish larvae have been taken from tip of snout through mid line of the body to first inter-haemal spine)

Upper jaw length (U.J.L): Anterior tip of pre-maxillary to distal edge of maxillary.

The total number of fin rays have been counted in which the basal portion is distinguishable. Pectoral fin counts can not be fully made on larvae since full complements of ossified pectoral rays form at juvenile stage. Gill rakers are not fully formed during larval period in certain species described. The urostyle is also included in the total number of vertebrae. When the vertebrae are not ossified the myotome counts have been taken. For the clarification of meristic counts and other details a certain number of larvae from each species were cleared with KOH solution and stained with Alizarin Red-S by Hollister's method.

After preservation in 4% formaldehyde solution only the black melanophores will persist in the specimens. In order to clearly define the shape and size of colour markings, certain meanings are given for the terms used in the description of pigmentation.

Band - is used to indicate a vertical colour pattern on the body.

Streak - indicates length-wise color marking.

Line - is used when the mark is very narrow

Dot - refers to single andminute mark

Blotch - indicates a concentration of dots at a point

All the drawings of the specimens were made with the aid of a camara lucida attached to a stereomicroscope. The statistical analysis were computed in a 3rd generation Hewlett Packard HP 9825 A desk computer system.

Table: I. Station list showing the number of plankton hauls, number of hauls with flat fish/lizard fish/Bombay duck larvae and different species obtained from different profiles from the area under study during September - 1971 to December - 1975.

Station	Year	Month	Total No. of hauls	No. of hauls with flat fish larvae	*C. macrostomus*	*P. bilineata*	*A. cyaneus*	*P. arsius*	*P. profunda*	*E. grandisquamis*	*E. cocosensis*	*B. ovalis*	*G. polyophthalmus*	*L. guentheri*	*L. macrophthalmus*	No. of hauls with Lizard fish larvae	*S. undosquamis*	*S. variegatus*	*T. myops*	Other lizard fish larvae	No. of hauls with Bombay duck larvae	*H. nehereus*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1971	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1972	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	10	2	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-
		May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	10	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	2	-	1	3
		Sept.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Ratnagiri -	1973	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	12	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
		Mar.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		May	11	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
		June	10	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-
		July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1974	Jan.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	9	1	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-
		Apr.	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
- Ratnagiri -	1974	June	8	1	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-
		July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	10	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	29	-	2	8
		Sept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	10	1	-	-	-	-	-	9	-	-	-	-	-	1	5	-	-	-	-	-
		Dec.	10	1	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
	1975	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	10	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	10	-	-
		Mar.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	10	2	-	-	-	-	-	9	-	-	-	-	-	1	-	-	3	-	-	-
		May	10	3	3	3	-	-	-	-	4	-	-	-	-	1	-	9	-	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	9	4	-	-	-	-	-	3	3	-	2	2	-	2	-	3	6	-	3	9
		Sept	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	9	3	69	-	-	-	-	-	5	-	3	-	-	-	-	-	-	-	-	-
		Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Karwar -	1971	Oct.	5	3	127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1972	Jan.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	6	2	-	-	-	-	-	-	8	4	-	-	-	-	-	-	-	-	-	-
		May	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		July	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	3	1	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-
		Oct.	5	1	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1973	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	10	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	1	-	-

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	1973	Mar.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	11	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-
		May	7	5	1	-	-	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-
		June	8	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
		July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	6	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	8	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1974	Jan.	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	6	2	-	-	-	-	-	13	-	-	-	-	-	1	-	9	-	-	-	-
		Apr.	8	4	-	-	-	-	-	5	18	-	5	-	-	3	-	12	12	-	-	-
		May	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-	-	-	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		July	8	2	-	-	-	-	-	4	-	-	4	-	-	-	-	-	-	-	1	1
		Aug.	5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	12	-	1	10
		Sept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	8	-	-	-	-	-	-	-	-	-	-	-	-	3	3	-	-	7	-	-
		Dec.	8	-	-	-	-	-	-	-	-	-	-	-	-	3	9	-	-	8	-	-
	1975	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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		Apr.	8	3	3	-	-	-	-	6	9	-	-	-	-	1	-	-	3	-	-	-
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		Feb.	7	1	-	-	-	-	-	-	1	-	-	-	-	2	-	-	2	-	-	-
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		Feb.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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		Feb.	10	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	4	-	-	-
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		Apr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		May	5	3	-	-	-	-	-	1	3	-	-	-	-	1	-	-	1	-	-	
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		May	6	1	-	-	-	-	-	3	-	-	-	-	-	1	-	-	9	-	-	
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		Nov.	7	3	148	-	-	-	-	-	-	-	-	-	-	1	6	-	-	-	-	-
		Dec.	7	3	-	-	-	-	-	22	-	6		-	-	6	23	-	-	20	-	-
	1975	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	7	3	-	-	-	-	-	10	4	6	-	-	-	-	-	-	-	-	-	-
		Apr.	7	3	-	-	-	-	-	5	14	-	5	-	-	-	-	-	-	-	-	-
		May	-	1	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
		June	7	6	-	-	-	-	-	51	19	-	3	4	-	3	5	-	6	-	-	-
		July	-	1	-	-	3	-	-	-	-	-	-	-	-	1	-	8	-	-	-	-
		Aug.	6	2	-	-	-	-	-	-	14	-	5	-	-	-	-	-	-	-	-	-
- Kasaragod -		Sept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	7	2	26	-	-	4	-	-	-	-	-	-	-	1	26	-	-	-	-	-
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		July	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	1973	Jan.	5	1	-	-	-	-	-	-	4	-	-	-	-	1	-	-	-	2	-	-
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- Cochin -	1971	Sept.	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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		Nov.	10	5	81	-	-	4	-	-	2	-	-	-	1	5	6	-	1	3	-	-
		Dec.	4	2	-	-	-	-	-	1	1	-	-	-	-	1	-	-	-	1	-	-
	1972	Jan.	4	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
		Feb.	4	1	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-
		Mar.	6	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
		Apr.	6	1	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
		May	6	1	1	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-
		July	4	7	2	-	2	-	-	-	1	-	1	-	-	1	-	-	1	-	-	-
		Aug.	6	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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	1973	Jan.	11	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	9	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-
		Apr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		May	5	15	1	1	-	-	18	8	8	-	1	-	-	1	-	-	1	-	-	-
		June	2	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
		Jul.	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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		Oct.	7	1	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
		Nov.	7	3	-	-	-	-	-	-	8	-	-	-	8	1	4	-	-	-	-	-
		Dec.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1974	Jan.	7	2	30	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-
		Feb.	7	-	-	-	-	-	-	-	-	-	-	-	-	1	-	9	-	-	-	-
		Mar.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	7	3	5	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-

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	1974	May	6	3	3	-	-	-	2	-	5	-	-	-	-	2	-	-	11	-	-	-
		June	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		July	7	3	58	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Aug.	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	6	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Oct.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Nov.	6	-	-	-	-	-	-	-	-	-	-	-	-	7	21	7	5	24	-	-
		Dec.	6	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
	1975	Jan.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Feb.	6	4	-	-	-	-	-	1	4	6	-	-	-	-	-	-	-	-	-	-
- Cochin -		Mar.	6	2	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-
		Apr.	12	8	-	-	-	-	-	12	23	-	3	-	4	1	-	-	1	-	-	-
		May	6	5	-	3	-	-	-	6	20	-	-	-	5	-	-	-	-	-	-	-
		June	6	6	-	-	3	-	-	10	3	-	2	-	4	-	-	-	-	-	-	-
		July	6	9	2	-	7	-	-	-	5	1	4	2	-	-	-	-	-	-	-	-
		Aug.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Sept.	6	3	14	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
		Oct.	6	1	3	-	-	-	-	-	-	-	-	-	-	4	34	-	-	-	-	-
		Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Dec.	5	1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
	1971	Sep	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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		Dec.	4	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	1	1	-	-
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		Feb.	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mar.	5	2	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-
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Table: 2. Showing the number of hauls and details of larvae collected from September 1971 to December 1975.

	1971	1972	1973	1974	1975	Total
Number of hauls taken	56	282	373	344	275	1330
Hauls with flat fish larvae	11	45	78	67	132	333
Flat fish larvae/m^2	220	189	177	556	814	1956
Hauls with Lizard fish larvae	12	16	25	50	30	133
Lizard fish larvae/m^2	18	24	35	341	222	642
Hauls with Bombay duck larvae	-	1	-	4	4	9
Bombay duck larvae/m^2	-	3	-	19	10	32

3. LARVAL STUDIES

3.1. Description of larval stages

3.1.1. PSEUDORHOMBUS ARSIUS (Hamilton 1822)

Larvae of Pseudorhombus spp. are poorly known. However, a few authors have described and illustrated early developmental stages of some of these fishes from Indian Ocean. Gopinath (1946) described and illustrated post-larval stages of P. arsius and P. triocellatus. Jones and Pantulu (1958) illustrated late post-larval stages of P. oligodone and P. arsius from Orissa coast. Pertseva - Ostroumova (1965) illustrated an 8.2mm specimen of Pseudorhombus sp., while Devi(1969) described and illustrated a series of P. elevatus larvae. Ramanathan and Natarajan (1979) described 3 stages (3.6, 4 and 8mm) of P. arsius larvae from Porto Novo waters. A series of larvae from 2.8mm to 8.2mm have been collected in the present study.

2.8mm larva (Fig. 2.a)

Pre-flexion stage. The body of the larva is symmetrical, transparent and laterally compressed. The jaws are devoid of teeth, and the lower jaw is a little prominent than the upper one. The nasal depression is not yet formed. The optic lobe of the brain is large and oval in shape. The round fore-brain is small and occupies above the eye. Otocyst present. The heart is developed and the ventricle is pyriform. Rudiments of gill arches are visible. The liver is small and lies in between first and fourth myotomes. Air bladders is not seen. The intestinal coil is just formed and the anterior descending portion is enlarged. Ten pre-anal and 21 post-anal myotomes are discernible at this stage.

Double rows of melanophores occur along the dorsal and ventral contours of the body (one on either side of the marginal fin folds). On the ventral side this row extends in to the peritonial region internally. Posterior most portion of the caudal region is devoid of pigments. Scattered pigment spots are seen on the outer margin of the dorsal and anal fin folds. Concentration of stellate melanophores are seen on the lateral side, in between 23rd and 28th myotomes. Irregular pigment spots occur on the intestinal coil, outer margin of pectoral fin, opercular flap, isthumus region, ventral side of the lower jaw and rudimentary dorsal tentacular processes.

Vertical fin folds present. At the anterior end of the dorsal fin fold, just above the nape, a pair of tentacular processes are developed, which will later become two of the elongated dorsal fin rays. A pair of larval pectoral fins with fleshy bases have already originated.

About two rows of long and slender spines are seen on the pre-opercular margin. Another set of small and slender spines are developed on the sphenotic region.

3.2mm larva (Fig. 2.b)

Pre-flexion stage. Nasal depression has developed as a round thickening in front of eye. Rudimentary gill filaments are developed on the gill arches. The triangular shaped liver lies in between 1st and 6th myotomes. The vent opens at 10th myomere. The haemal spine of the first caudal vertebra shows ossification at this stage, 10 pre-anal and 23 post-anal myotomes differentiated.

Two more dorsal tentacular process are developed on the head. All other characters are same as in the preceding stage (2.8mm stage). No change is evident in the pattern of pigmentation.

The spination on the pre-opercular region now has two rows; one on the margin of the pre-opercle and the other just in front of it. No chan ge in the sphenotic spination.

4mm larva (Fig. 2.c)

Pre-flexion stage. Five elongated dorsal rays are formed in the place of tentacular processes. The anterior one is not flat and club shaped as in P. elevatus (Devi, 1969). Rudiment of 6th ray is visible behind the 5th one. The dorsal and anal pterygiophore regions first appear at this stage as narrow bands of cell aggregation on the bases of respective fin folds in between 23rd and 28th myotomes, where the lateral band of pigmentation is present. Similarly an aggregation of cells is evident on the posterio-ventral aspect of the straight notochord.

6.4mm larva (Fig. 2.d)

Post-flexion stage. Minute teeth are seen on the jaws. Lower jaw is a little prominent than the upper one. The nasal depression deepens and a flap-like outgrowth has originated at the anterior rim of the nasal depression. About 6 branchiostegal rays are discernible. The optic lobe of the brain is round and large. The hind brain is prominent. The gill filaments are well differentiated at this stage. The dorso-ventrally elongated liver lies in between the cleithrum and intestinal coil. Air bladder is not seen. The vent opens at the 11th myotome.

Seven elongated and 33 small rays are developed at the anterior end of the dorsal fin fold. Fleshy dorsal and anal pterygiophore regions have formed and traces of pterygiophores are seen from the posterior half of this region. From here faint traces of striations can be detected in the dorsal and anal fin folds. These striations are actinotrichia, rather than true rays. Four caudal elements have developed ~~loped~~ on the ventral aspect of the upturned notochord and count of the feebly developed 8 caudal fin rays associated with the caudal elements is 0 + 0 + 3 + 4 + 1 + 0. The ventral fin bud is developed, devoid of rays; 10 pre-anal and 26 post-anal myotomes could be counted at this stage.

The size of the sphenotic and pre-opercular spines are reduced. The stellate chromatophores on the dorsal and ventral body countours get more thickened. The lateral pigments, which are now seen in the myosepta, spread anteriorly. In addition to the pigments described in the previous stages, few irregular spots are also seen at the mouth region.

7.2mm larva (Fig.2.e)

Post-flexion stage. The nostrils developed by the fusion of the flaps. Number of teeth increased in both jaws. The small liver elongated downwards and its ventral portion is chisel shaped. Gill rakers developed as small protuberances on the gill arches. The 'V' shaped pyloric caeca can be seen at this stage.

The anterior 9 dorsal rays enlarged in size. About 75 dorsal and 56 anal pterygiophores are discernible. Feebly developed lepidotrichial rays are also now detected from the posterior half of the dorsal and anal fin folds, 15 caudal fin rays are formed. The posterior end of the upturned notochord is extended beyond the caudal elements; 4 to 5 ventral fin basals are developed.

Spines on the head are rather reduced in size. The myoseptal pigmentation extended forwards and reaches upto the level of pectoral fin. The pigment spots increased in the dorsal and anal fin folds, head and in the ventral portion of the abdomen. The caudal fin is devoid of pigments.

8.2mm larva (Fig. 2.f)

This early transforming stage is bilaterally asymmetrical due to the migration of the right eye upto the dorsal margin of the head. In this case the right eye migrates over the head as in the pleuronectid larvae (Sumida *et al.* 1979). Teeth are small and closely set in upper jaw; but in lower jaw the lateral teeth are strong and wide apart than those of the upper jaw, and 9 to 10 teeth on the blind side of the jaw. Seven branchiostegals are differentiated. About 9 small gill rakers are countable on the lower part of the anterior arch. The shape and size of the liver is same as in the preceding stage. The intestinal coil pushed forward by highly developed interhaemal spine of the first caudal vertebra. The vent opens at 7th myotome; 10 pre-anal and 26 post-anal vertebrae countable.

Full complements of all the fin rays are developed except in the pectoral fin; 76 dorsal and 58 anal fin rays are formed. The anterior 6 to 7 dorsal rays are more or less thin and flat, 17 caudal rays are developed. The ventral fins are short-based, subequal and sub-symmetrical and has 6 rays each. All the fin rays are attached with thin membranes.

The sphenotic and pre-opercular spines are reduced in size with increase in age and not discernible at this stage.

Closely placed pigment spots are seen on the dorsal, anal and ventral fins. Dashes of pigments at the bases of dorsal and anal pterygiophores and also in the myosepta are thickened. Irregular spots are seen on the fleshy pterygiophore regions, bases caudal and pecotral fins, abdomen, opercular and mandibular region.

Changes in body form

Relative pre-anal distance increases slightly during pre-flexion stages, thereafter it shows uniform rate of growth with standard length (Table - 3). Relative head length increases during larval development. Relative snout length and upper jaw length increase in pre-flexion stage and uniformly developed during flexion and post-flexion period. The relative eye diameter shows uniform pattern of development through out the period. The relative body depth increases slightly during pre-flexion stage whereas it increases sharply in flexion and post-flexion period (Table - 3).

The nostrils begin to develop as round thickening in front of the eyes, at 3.2mm SL. Later a depression is formed and at 6.4mm flap-like outgrowth developed on the rim of this depression (Fig-2d). At 7.2mm these flaps are fused together and nostrils developed. Minute teeth are first seen at 6.4mm SL. The number of teeth increases and at 8.2mm closely set small teeth are seen in the upper jaw and widely spaced strong teeth are developed in the lower jaw.

The gill arches are visible even in the smallest larva (2.8mm) and rudimentary gill filaments appear on these gill arches at 3.2mm length. Gill rakers are first seen when the larvae attain 7mm length. The adult complement of gill rakers is achieved at 8.2mm. About six branchiostegal rays are discernible at 6.4mm and fully developed at 7.2mm. Air bladder is absent throughout the larval period.

The heart, brain and liver are already developed in the larvae of 2.8mm SL. The liver is very small when compared to other bothid flat fish larvae. The optic lobe of the brain is round shaped in almost all the stages, whereas its shape is either rectangular or square in larvae belonging to the sub family Bothinae. The hind brain is also prominent in this case.

Fin formation.

In the development P. arsius the pectoral fin is the first to appear and the last to complete its development. The caudal fin completes development first, followed in order by the dorsal, anal and pelvic fins. At 8.2mm the adult complement of fin rays are present in the caudal, dorsal, anal and pelvic fins (Fig. 2.f).

Pectoral fin. The pectoral fin is prepsent as a fan-like structure with fleshy base in the smallest larva (2.8mm) and remain as such in the largest larva (8.2mm) in the collectio ns.

Caudal fin. The fully developed caudal fin has 17 rays associated with 6 caudal elements. The dorsal and ventral most rays are simple and the remaining rays are branched. A ventral thickening has been noticed near the posterior end of the straight notochord at about 4mm SL. This thickened tissue develops in to 4 median hypural plates at about 5.2mm. At 6.4mm SL 8 median rays are seen and during this time the dorsal flexion begins, so that the hypurals and fin rays are arranged parellel to the axis of the body. At about 7.2mm all the rays except the unbranched ones are developed. Full complement of rays are discernible at 8.2mm SL.

Dorsal fin. DorsaL fin rays begin to develop in a thickened area above the nape of specimen of about 2.8mm. At 3.2mm 3 to 4 tentacular processes originate from this thickened portion. These rudimentary rays elongate in size and about 6 rays are visible at 4mm. The fleshy dorsal pterygiophore region first appears at this stage as a narrow band of cell aggregation on the base of dorsal fin fold in between 23rd and 28th myotomes, where the lateral band of pigmentation is present. This region develops forward and backward and at about 6.4mm SL few dorsal pterygiophores are formed, from the same portion where the pterygiophore region first appeared. Striations of actinotrichial rays are also seen from this area. Seven elongated dorsal rays are developed anteriorly at 6.4mm. At about 7mm SL, 9 elongated anterior dorsal rays and 75 dorsal pterygiophores are discernible. Feebly developed true rays (lepedotrichia) also appear at this stage. Number of lepidotrichiae increases rapidly and at 8.2mm SL the adult complement of dorsal fin rays are seen. At this stage all the rays are equal in size except the anterior 6 to 7 rays which are thin and flat as in the adult.

Anal fin. The development of anal fin pterygiophores begin simultaneously with that of the dorsal fin. Anal pterygiophore region appears at 4mm SL between 23rd and

28th myotomes, midventrally. At about 6.4mm SL it is extended further and few pterygiophores are developed. About 56 anal pterygiophores and 40 feeble anal rays are discernible at 7.2mm SL. The number of fin rays increase rapidly, as in the dorsal fin, and the adult complement of fin rays are formed by about 8.2mm. (Fig. 2.f)

Pelvic fin. The pelvic fin is visible as a low bud on the ventral outline, immediately posterior to the cleithrum in 6.4mm larvae; 4 to 5 basals are developed at about 7mm length. Development continues until at 8.2mm SL, 6 rays are visible. The pelvic fins are short based, sub-symmetrical and sub-equal in position.

Larval spination.

A group of sphenotic spines and rows of pre-opercular spines are characteristic features of larvae of Pseudorhombus sp. These spines can be traced from very young stage (2.8mm) to post-flexion stages. Spines are thin and elongated in earlier stagets and do not alter position, but become less conspicuous with increasing size of larvae and completely absent in the metamorphosing stage (8.2mm).

Pigmentation.

The pattern of pigmentation on the body of the larvae have not changed in the course of development, though the intesity is more with age. In the preflexion stage double rows of melanophores occur along the dorsal and ventral contours of the body. A lateral band of stellate chromatophores are also seen in the caudal region in between 23rd and 28th myotomes. In addition to these, irregular pigment spots are seen on the margin of dorsal, anal and pectoral fin folds, intestinal coil, opercular flap., isthmus region, ventral side of the lower jaw and on the rudimentary anterior fin rays. During development the lateral band of pigments occupy the myosepta of that region. In the post-flexion stage these myoseptal pigments spread anteriorly along the epaxial and hypaxial regions of all the myotomes and at 8.2mm all the myosepta on both sides have these pigments. At this stage irregular pigment spots are visible all over the body except in the caudal fin.

Migration of eye.

Speciments of 7.2mm are symmetrical; the right eye has not begun to migrate (Fig. 2.e) By about 8.2mm SL the right eye reached the mid-dorsal ridge, anterior to the origin of the dorsal fin. In Pseudorhombus sp. the right eye migrates over the head as in pleuronectids (Sumida et al. 1979) and Scophthalmus sp.(Jones 1972).

Distinguishing characters of **P. arsius** larvae.

Anterior elongated dorsal tentacular processes 7 to 9 in numbers. The dorsal and anal fin rays begin to develop from near the caudal end (near the caudal peduncle). Dorsal 72-80, anal 54-62, pelvic fin base sub equal, myotomes 35-36, 9 small pointed gill rakers on lower part of anterior arch, air bladder absent. Liver small, the optic lobe of brain small and rounded. Right eye migrates over the head.

Spination: Two rows of long and slender spines on pre-opercular region. Set of small and slender spines on sphenotic region. The size of spines reduces with age and completely absent in metamorphosis stage.

Pigmentation: Double row of pigment spots on the dorsal and ventral contours of the body. Scattered pigment spots on the outer margins of dorsal and anal fin folds. Concentration of stellate melanophores on the lateral side, in between 23rd and 28th myotomes. Irregular pigment spots on intestinal coil, opercular flaps, isthumus region, ventral side of lower jaw, and rudimentary dorsal tentacular processes. Posterior end of caudal fin devoid of pigmentation.

Fig. 2. Developmental stages of P. arsius

a. 2.8mm larva

b. 3.2mm larva

c. 4mm larva

d. 6.4mm larva

e. 7.2mm larva

f. 8.2mm larva

Fig. 2

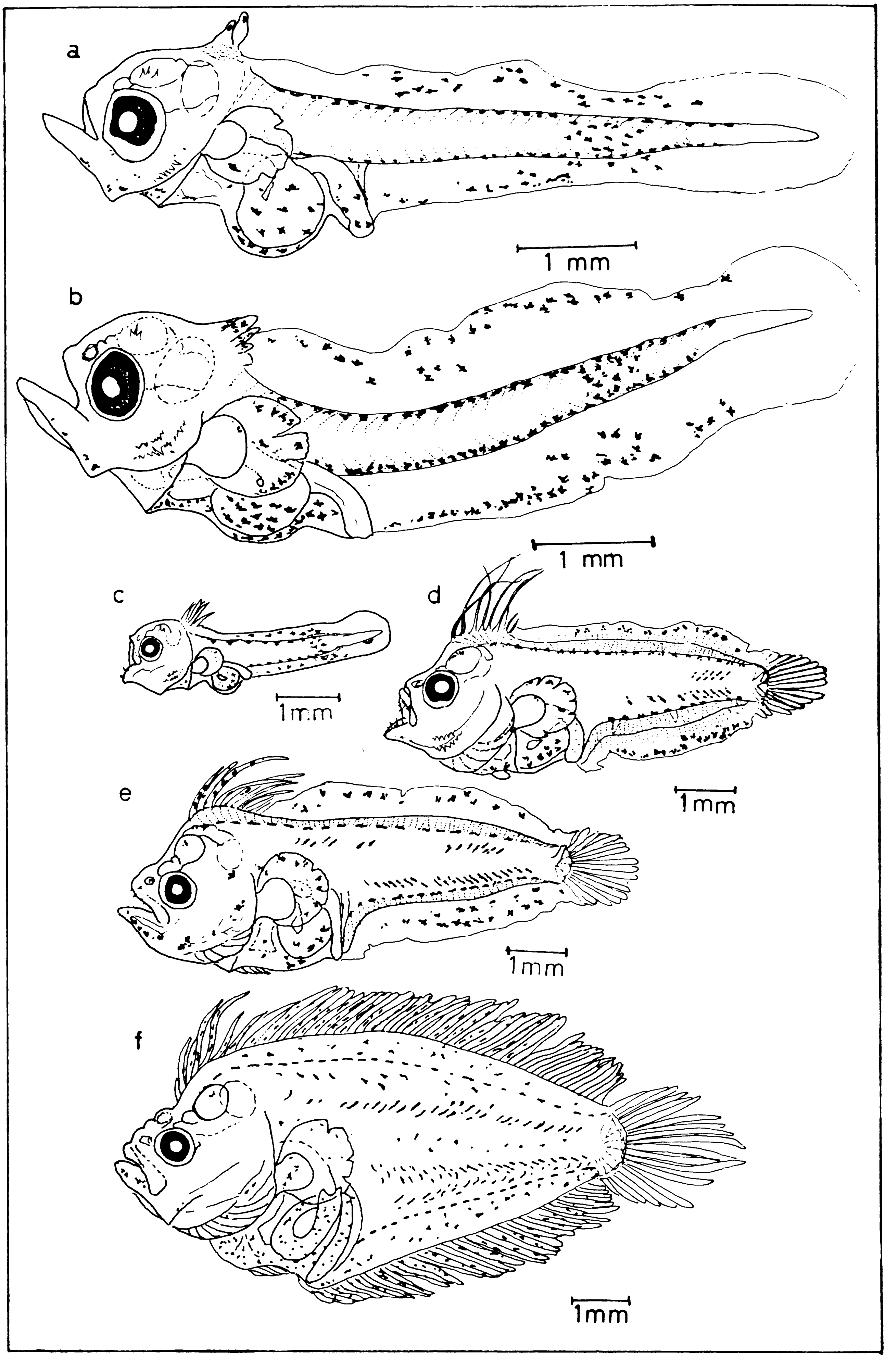


Table: 3. <u>Body proportions of ***P. arsius*** larvae.</u>
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.8	46	20	7	7	-	21
3 - 3.9	3.5	42	25	9	8	14	24
4 - 4.9	4.0	44	25	10	8	13	25
5 - 5.9	5.2	52	30	11	7	13	35
6 - 6.9	6.3	50	32	10	8	13	35
7 - 7.9	7.2	50	32	11	7	14	40
8 - 8.9	8.2	50	33	10	7	15	39

3.1.2. PSETTINA PROFUNDA (Weber 1913)

Larvae of P. profunda have not been described previously. Pertseva - Ostruoumova (1965) described larvae of P. hainanensis and P. iijimai from the gulf of Tonkin. Devi (1981) described development characters of P. brevirictis and P. iijimai. In the present study 10 selected stages of larval P. profunda from pre-flexion stage (2.7mm NL) to late post-flexion stage (15.5mm SL) are described in detail.

2.7mm larva (Fig. 3.a)

Pre-flexion stage. Body laterally compressed and elongated. A hook-like ventral sprout is feebly discernible in the angular region. Mouth very small, the lower jaw prominent. Eyes pigmented. The thickening on the nasal region not evident at this stage. The gill arches are named, devoid of both gill filaments and rakers. Fore-brain small, round and slightly bent downward and seen in front of the eye; mid-brain large, round in shape and occupies above the eye; the hind-brain also developed. The heart feebly discernible and the ventricle pyriform. Liver large, rectangular. The anterio-posterior axis of the liver is greater than the dorso-ventral axis. Air bladder present and lies at the 9th myomere. The intestinal coil not fully formed, the posterior portion not yet emerged out. About 31 myotomes are discernible.

A single dorsal tentacle is seen on the head. The primordial marginal fin and larval pectoral fin with fleshy base present.

Pigmentation confined to the ventral portion of the body. Two pigment spots lies mid-ventrally from angular region to the intestinal coil. A large chromatophore in the peritonial cavity, just above the intestinal coil. Another line of mid ventral pigmentation extending from behind the intestinal coil to near the posterior tip of straight notochord.

3.5mm larva (Fig. 3.b)

Pre-flexion stage. Ventral sprout at the angular region enlarges in size. Jaws well developed and 2 to 3 pairs of canine teeth on the anterior part of both jaws. The upper profile of the snout convex in appearance. A round thickening developed in the nasal region. Rudimentary gill filament formed. Brain, heart and liver well developed. The liver lies in between 4th and 8th myotomes and above the straight portion of the intestinal coil. The intestinal coil fully formed and vent opens at 12th myomere. About 33 myotomes are countable at this stage.

A group of 3-5 melanophores present on the roof of brain. Few spots are also seen at the angular region, ventral sprout, out margin of larval pectoral fin and ventral side of intestinal coil. All other pigments on the mid-ventral side of the body same as in the previous stage.

4.1mm larva (Fig. 3.c)

Pre-flexion stage. Maxilla reaches the anterior margin of the eye. About 4 teeth in the anterior part of each jaw. A round thickening seen at the nasal region. Buds of gill filaments developed on the gill arches. The rectangular-shaped liver lies in between 1st and 8th myotomes. Air bladder large, lies above the straight portion of the intestine and occupies in between 4th and 8th myotomes, vent opens at 11th myomere.

Formation of dorsal and anal pterygiophore regions begin as fleshy thickenings developed in between the find folds and body proper. Dorsal pterygiophore region, begins from the middle portion and anal pterygiophore region formed from the anterior portion of fin folds.

About six pigment spots seen on the cranium. On the ventral side of the body there are 4 spots at the base of ventral sprout, few spots on the ventral side of lower jaw, 5 to 6 spots at the angular region and a continuous line from the angular region to vent. Ventral body margin also pigmented upto the last myomere.

4.5mm larva (Fig. 3.d)

Pre-flexion stage. The upper profile of snout is almost straight at this stage Snout enlarged and lower jaw is prominent. Number of teeth increased in both jaws. The nasal thickening enlarged. Gill filaments developed. Liver lies in between 4th and 9th myotomes and the anterio-posterior axis of the liver is almost equal to that of the dorso-ventral axis. The posterio-ventral tip of the liver is extended further backwards and reaches to the bottom of the intestinal coil. A large air bladder is discernible. The vent opens at 10th myomere level.

About 53 dorsal and 30 anal pterygiophores are developed in the respective fleshy pterygiophore regions. Few feebly developed dorsal fin rays are evident in the middle portion of the dorsal fin fold. Few anal fin rays are also feebly developed in the anterior portion of the anal fin fold. A slight ventral thickening is noticed at the posterior most tip of straight notochord. About 34 myotomes are discernible at this stage.

Pigmentation same as in the preceding stage.

5mm larva (Fig. 3.e)

Pre-flexion stage. Outer margin of nasal thickening more enlarged. Number of teeth increased in jaws, first inter-haemal spine clearly seen at this stage.

Apex of the dorsal tentacle bifurcated. About 76 pterygiopohores and 63 rays developed in the dorsal fin; 40 pterygiophores and 29 rays in the anterior part of anal fin also developed. The ventral thickening at the posterior tip of notochord divided in to two parts. Ventral fin bud developed behind the ventral tip of cleithrum.

5.7mm larva (Fig. 3.f)

Flexion stage. The posterior tip of notochord slightly turned upwards. Branchiostegal rays developed. Gill filaments well formed.

Bifurcated dorsal tentacle present. Dorsal fin has 90 pterygiophores and 76 feeble rays; 65 pterygiophores and 50 feeble rays also developed on the anal fin, 2 hypural elements formed in the caudal region. Pelvic fin bud present.

6.2mm larva (Fig. 3.g)

Late flexion stage. A slight depression has developed in the centre of nasal thickening. Number of teeth in up per and lower jaws increases. Maxillary in front of the anterior edge of eye. Branchiostegal rays well formed and 7 in number. Feebly developed gill rakers are seen. The anterio-posterior axis of liver very much reduced and about half the length of its dorso-ventral axis. Air bladder is vesicular and lies at 8th myomere.

Anterior tip of dorsal fin bends a little downwards. Dorsal and anal fin rays developed except in the posterior region. Dorsal fin has 69 rays and 75 pterygiophores and anal fin has 53 rays and 60 pterygiophores, 3 hypural elements developed and about 7 feebly developed caudal fin rays also discernible. The pelvic fin buds enlarge in size.

Number of pigment spots in the head region reduced.

7.7mm larva (Fig. 3.h)

Post-flexion stage. About 10 minute teeth in up per jaw and 8 in lower jaw. Branchiostegal rays well developed. Gill rakers feebly developed. The ventral sprout reduced in size. The first inter-haemal spine reaches just above the vent, 38 myotomes are discernible.

The anterior part of the dorsal fin bends further downwards, 78 dorsal and 55 anal fin rays are countable. Caudal elements fully developed, but only 7 rays are formed in caudal fin (0 + 0 + 3 + 4 + 0 + 0). No rays on pelvic fin bud.

The head region devoid of pigments. Pigmentation seen on the ventral portion of the intestinal coil and dashes of pigments in between ventral body margin and fleshy anal pterygiophore region.

About 6 spines develeoped at the mid-ventral portion of cartilaginous plate.

9.6mm larva (Fig. 3.i)

Post-flexion stage. The nasal depression more deepened and the margin of it thickened. The ventral sprout very much reduced in size. About 6 gill rakers are seen on the lower part of anterior arch. About 38 vertebrae are seen.

The bending of the anterior part of dorsal fin still continues. About 93 dorsal rays and 70 anal rays are developed, 15 caudal fin rays are formed and arranged with caudal elements (0 + 3 + 5 + 4 + 3 + 0). Four to 5 feeble rays are developed on the pelvic fin fud. The left pelvic fin base is larger than the right one. No rays on pectoral fin.

Pigmentation on the mid-ventral portion of intestinal coil and on the ventral body margin (at the inner margin of the anal pterygiophore region).

Serration on the cartilaginous plate present. In addition another spine is seen on the pubic bar just behind the pelvic fin base.

15.5mm larva (Fig. 3.j)

Late post-flexion stage, but the larvae is still symmetrical. Teeth are small uniserial, and not enlarged anteriorly. Flap-like projection developed in the upper and lower margins of nasal depression, 6 gill rakers are seen on the lower part of anterior arch. The intestinal coil pushed forward by the 1st inter-haemal spine. The 'V' shaped pyloric caeca clearly seen at this stage, 38 vertebrae are discernible

The anterior part of the dorsal fin reaches just above the nasal region. A small dorsal fin developed in front of the reduced dorsal tentacle, 93 dorsal and 71 anal fin rays are countable. The 17 caudal fin rays arranged with caudal elements as 1 + 3 + 5 + 4 + 3 + 1. Pelvic fin has 6 rays. The pelvic fin of the left side broad-based. No rays on pectoral fin.

Pigment spots seen on the mid ventral part of intestinal coil. Dashes of pigments are seen on the dorsal and anal body margin and lie in between body proper and respective pterygiophore regions.

Serration seen on the cartilaginous plate and anterior part of pubic bar.

Changes in body form.

The relative pre-anal distance shows uniform pattern of development in pre-flexion stage, but decreases during post-flexion stage. Relative head length increases in pre-flexion stage and then shows gradual diminution in post-flexion stage.
Snout length shows gradual relative increase in pre-flexion stage and uniform development thereafter. Relative eye diameter and relative upper jaw length decrease gradually throughout the larval development, whereas the relative body depth increases (Table 4).

Dentition first visible in 3.5mm larva where a pair of minute teeth present in the anterior part of each jaw. The teeth in P. profunda are small and uniseral and fully developed teeth are seen in 15.5mm larva. The development of nostril begins as a round thickening in front of eye at 3.3mm NL. At 6.2mm SL a depression is developed in this area and outer margin of this depression gets thickened.

At 15.5mm stage flap-like outgrowths developed on the upper and lower margin of the nasal depression.

The 2.7mm larva possesses only the gill arches and is devoid of both gill filaments and gill rakers. Rudimentary gill filaments are noticed in 3.3mm larva and at about 5mm (flexion stage) the fully developed gill filaments are seen. The rudimetary gill rakers are discernible at 7.7mm stage (post-flexion stage) and about 6 short gill rakers are present in 15.5mm stage.

The massive liver occupies in between 1st and 7th myotomes in almost all the larval stages. At first its anterio-posterior axis is greater than the dorso-ventral axis. But at about 3.5mm stage the anterior-posterior axis of the liver is reduced due to forward movement of the intestinal coil along with the 1st inter-haemal spine and at 4mm the dorso-ventral axis is greater than the anterio-posterior axis .

The air bladder is noticed in all the stages of larvae, which is a large conspicuous organ which lies just above the straight portion of the intestine and occupies in between 4th and 8th myotomes.

Branchiostegal rays are prominent in the early flexion stages and the full count of rays is present in 6.2mm stage. In early larval stages only the anterior most myotomes can be seen. At 2.7mm about 25 myotomes are discernible. The haemal spine of first caudal vertebra poorly visible in 3.5mm stage. An Adult complement of 9 thoracis and 29 caudal vertebrae is present in 7.7mm stage. The first sign of flexion takes places in the 4.6mm larva and at about 6.2mm dorsal flexion is completed.

Fin formation.

The fin formation in P. profunda larvae is similar as in other larvae belonging to the sub-family Bothinae. In the early stages, only the primordial marginal fin, dorsal tentacle and larval pectoral fin are present.

Dorsal fin. The fully formed dorsal fin has 90-95 rays, the fleshy dorsal pterygiophore region begins to develop from the middle region of the body at 4mm stage and about 11 dorsal pterygiophores are feebly discernible at this stage. This fleshy region grows in anterior and posterior directions very rapidly. At 4.6mm few dorsal fin rays are feebly discernible at the middle region of the body, from where the dorsal pterygiophore first formed. The dorsal fin formation accelerates at about 5mm to 63 feebly developed dorsal rays, and 76 dorsal pterygiophores are countable at this stage. The adult complement of dorsal rays are seen in 9.6mm larva. The single dorsal tentacle retained in almost all the stages. During development it gets bifurcated and reduced in size. In the late post-flexion stage (15.5mm) the dorsal tentacle is very much reduced and a small dorsal fin ray is developed in front of the dorsal tentacle.

Anal fin. The formation of anal fin begins simultaneously alongwith the formation of dorsal fin. The fleshy anal pterygiophore region first seen in the anterior part of the anal fin fold in 4mm larva and about 7 number of anal pterygiophores are countable at this stage. About 40 anal pterygiophores and 29 anal fin rays are evident at 4.6mm. Fully formed anal fin with 70-73 rays is seen in 8.3mm larva.

Caudal fin. The fully formed caudal fin has 17 rays associated with the 6 caudal elements (1 + 3 + 5 + 4 + 3 + 1). The caudal fin begins to form at the under side of the body, a short distance anterior to the tip of the notochord in specimen of about 4.5mm. The caudal elements begin to develop in the flexion stage.

At about 5mm two rays initially formed at mid-caudal region. The complement of 17 rays is present in specimen of 8.3mm SL.

Pelvic fin. The pelvic fin is visible as a low bud on the ventral outline immediately posterior to the cleithrum in 4mm larva, 4 feeble rays are discernible at 8.3mm The base of right pelvic fin is short-based and that of the left side elongated, 6 pelvic fin rays are visible in larva of 15.5mm.

Pectoral fin. The larval pectoral fin with a fleshy base and outer membranous structure is present in the smallest larva in the collections (2.7mm) and rays are not yet formed in the largest specimen (15.5mm).

Serration. Spines are formed in P. profunda larvae only in the post-flexion stage. At about 7.7mm, 4 to 5 small pointed spines are developed on the cartilaginous plate mid-ventrally. In 8.3mm stage 2 spines are also developed in the pubic bar, Just behind the pelvic fin base. The number of spines increases with age and about 9 spines on cartilaginous plate and 6 on pubic bar are developed at 15.5mm stage.

A ventral sprout, which is a characterisitic appendage of the larvae belonging to genus Psettina is present in all larvae of P. profunda. The size of the ventral sprout is reduced with age and completely disappeared in 15.5mm larva.

Pigmentation. Pigmentation is mainly confined to the ventral contour of the body of P. profunda larvae. In the early stages pigment spots are seen on the ventral sprout and ventral contour of the pre and post-anal regions of the body. In addition to these, few scattered pigment spots are also seen on the occipital region and angular region of the head. This pigment pattern is seen in the pre-flexion and flexion stages of the larvae. But in the early post-flexion stage the pre-anal pigmentation is very much reduced and confined only below the intestinal coil. During this time the pigment spots on the head region and ventral sprout disappear. In late post-flexion larva (15.5mm SL), in addition to the pigment spots on the ventral contour of the body, dashes of pigmentation are developed in between the fleshy dorsal pterygiophore region and body proper. At this stage the pre-anal pigmetation is limited to the ventral side of the intestinal coil alone.

Distinguishing characters of **P. profunda** larvae.

The dorsal and anal fin begin to develop from the anterior part of caudal region (near the vent) Dorsal 90-95, anal 70-73. Vertebrae - 38.

A ventral sprout present.

Serration: Serration only in post-flexion stage, 5-9 spines on cartilagenous plate, 2-6 spines on pubic bar.

Pigmentation: Line of pigment spots on the ventral contour of the body. Few pigment spots on ventral sprout, occipital and angular region of head.

Fig. 3. : Developmental stages of P. profunda.

a. 2.7mm larva

b. 3.5mm larva

c. 4.1mm larva

d. 4.5mm larva

e. 5mm larva

f. 5.7mm larva

g. 6.2mm larva

h. 7.7mm larva

i. 9.6mm larva

j. 15.5mm larva

Fig. 3

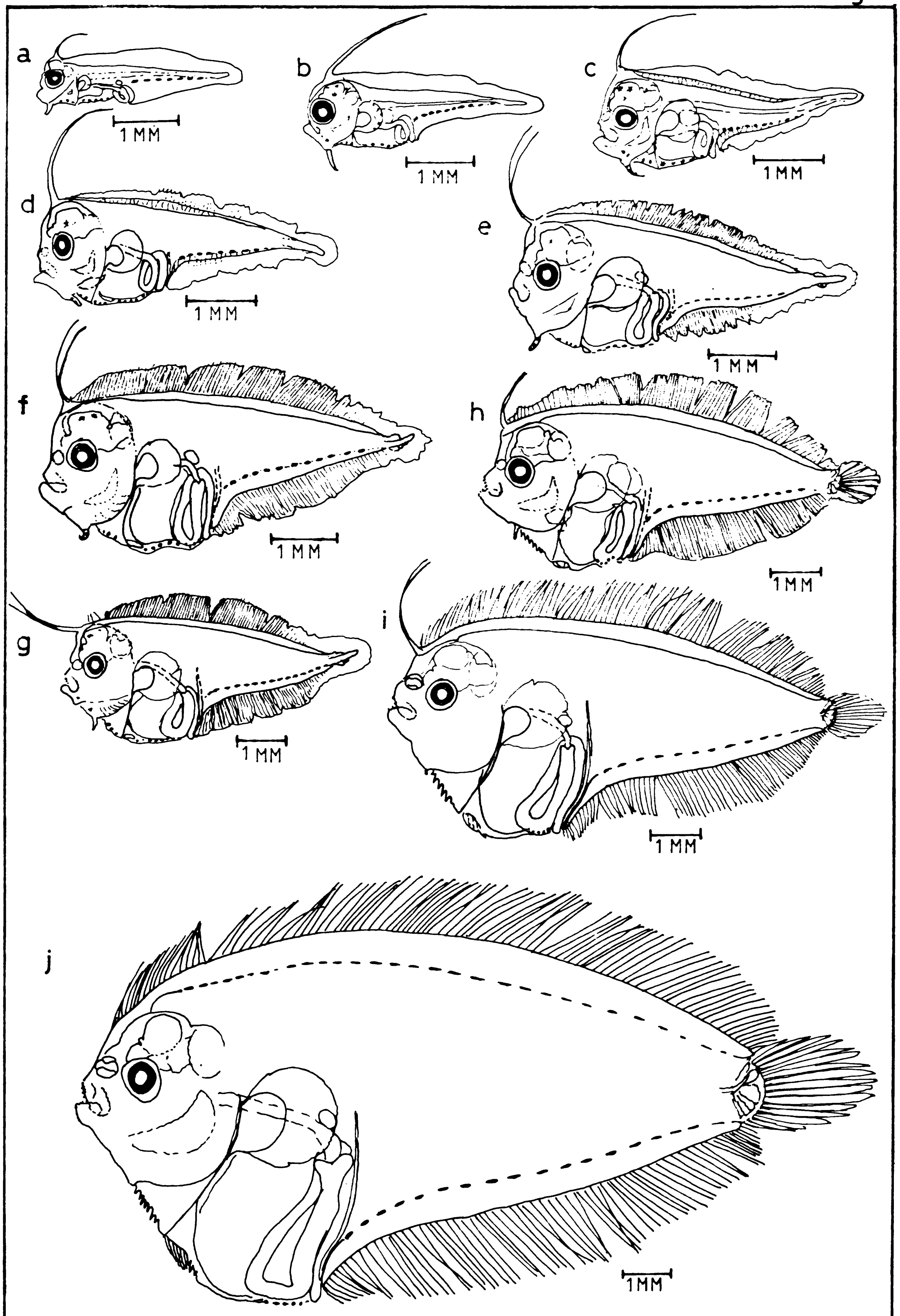


Table: 4. Body proportions of **P. profunda** larvae
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.7	48	19	4	7	-	19
3 - 3.9	3.4	49	24	6	7	7	28
4 - 4.9	4.3	49	27	9	7	7	40
5 - 5.9	5.3	49	28	9	7	7	42
6 - 6.9	6.2	48	26	8	6	7	45
7 - 7.9	7.7	44	27	10	5	7	45
8 - 8.9	8.3	42	28	10	6	7	50
9 - 9.9	9.6	41	26	8	5	7	49
11 - 11.9	11.8	40	26	7	5	6	51
15 - 15.9	15.5	39	24	8	4	6	49

3.1.3. ENGYPROSOPON GRANDISQUAMIS (Temminck & Schlegel, 1846)

Pertseva-ostroumova (1965) described and illustrated three stages of the larvae of E. grandisquamis(3.8, 8.9 & 14.3mm) from the Gulf of Tonkin. No other descriptions are available. However the post-larvae of E. grandisquamis tentatively identified by Ochiai and Amaoka (1963) in the analytical key prepared by them for identifying the post-larval froms of sub family Bothinae, mainly based on the counts of vertebrae, and dorsal, anal and pectoral fin rays. In the present study 8 selected stages of larvae from 2.5mm to 13.4mm are described in detail.

2.5mm larva (Fig. 4.a)

Mouth small and terminal. Maxilla not ossified. Nasal thickening not formed. Opercular flap feebly developed, 3 gill arches feebly developed on each side. Heart lies just in front of cleithrum, ventricle pyriform in shape. Otocyst present. Fore-brain small and bead-like and lies in front of the eye. Mid-brain large and somewhat square in shape and lies above the eye. Hind-brain also differentiated. The liver is large and rectangular in shape; it occupies below the straight portion of the alimentary canal and in between 1st and 8th myotomes. The oval shaped air bladder lies in between 4th and 8th myotomes. The intestinal coil developed and the vent opens at 13th myomere. About 31 myotomes discernible at this stage. Notochord straight. The single dorsal tentacle originated from the anterior tip of the head and bifurcated at its tip. The primordial marginal fin fold present. Larval pectoral fin fan-like with fleshy base. The ventral margin of the cartilaginous plates which lies in front of the cleithrum with 7 minute spines. About 7 minute spines developed on the pubic bar, which supports the intestinal coil ventrally. Patches of pigmentation seen on the dorsal and anal fin folds at about 24th myomere.

3.6mm larva (Fig. 4.b)

Pre-flexion stage. 2-3 minute teeth developed in the anterior part of both jaws. A round thickening has developed in the nasal region. Rudiments of gill filaments formed on the gill arches.

The bases of dorsal and anal fin (fleshy pterygiophore regions) first appear at this stage. The dorsal pterygiophore region froms in between the body proper and inner margin of dorsal fin fold. The formation of this pterygiophore region first begins from the middle of the body, later it extends to anterior and posterior portions of the body. The anal pterygiophore region develops from the anterior portion of the anal fin fold, just behind the vent.

All other characters such as pigmentation & spination same as in the preceding stage.

4.6mm larva (Fig. 4.c)

Pre-flexion stage. Number of teeth in jaws more. The round thickening on the nasal region more prominent. The anterio-posterior axis of the liver greater than its dorso-ventral axis and occupies in between 1st and 9th myotomes. Air bladder small and vesicular in this specimen and lies above the intestinal coil at about 8th myomere. The vent opens at 10th myomere.

About 54 dorsal pterygiophores and 31 anal pterygiophores are developed, 25 faint traces of dorsal fin rays are seen in the middle region of dorsal fin fold, 22 anal fin rays also feebly developed anteriorly. A ventral thickening visible near the posterior end of the straight notochord.

Serration seen on the cleithrum, cartilaginous plate & pubic bar. A single spine-like process is seen at the angular region ventrally. The cartilaginous plate has 21 small spines and pubic bar has 12 groups of small spines.

Pigment patches are seen on the dorsal and anal fin folds at about 25th myomere.

5.5mm larva (Fig. 4.d)

Flexion stage. About 8 teeth present in each jaw. A depression is seen on the round thickening in the nasal region. Gill filaments well developed. The anterio-posterior axis of the liver reduced, whereas the dorso-ventral axis enlarged. Vent opens at 11th myomere, 10 pre-anal and 24 post-anal myotomes are discernible, 3-4 branchiostegal rays are also differentiated.

Posterior tip of notochord slightly flexed upwards. The ventral thickening at the posterior end of notochord divided and form 3 hypural elements. About 3-4 feeble rays are also seen on the caudal fin fold. Anterior tip of dorsal fin slightly bends downward. Dorsal tentacle large. About 72 pterygiophores and 63 feeble rays formed in the dorsal fin. Anal fin has 40 rays and 49 pterygiophores. Pelvic fin bud developed on the anterior part of pubic bar and just behind the ventral tip of cleithrum.

Serration and pigmentation as in the previous stage.

6.6mm larva (Fig. 4.e)

Post-flexion stage, 6 branchiostegal rays differentiated. The anterio-posterior axis of the liver much reduced. This has happened when the 1st inter-haemal spine pushed the intestinal coil to the forward direction. Air bladder present. The size of the intestinal coil reduced and vent opens at the 9th myomere.

The anterior end of the dorsal fin bends further downwards. About 78 dorsal and 60 anal fin rays developed, 13 feeble caudal fin rays formed and associated with six hypural elements in the order 0 + 2 + 5 + 4 + 2 + 0. Pectoral fin fan-like, pelvic fin bud enlarged in size.

Six spines on the cleithrum, 32 on cartilaginous plate, 18 groups of spines on pubic bar and one single spine on the angular region present.

In addition to the pigment patch on the dorsal and anal fin (25th myomere) few spots are seen at the tip of the caudal fin and dorsal tentacle.

8.4mm larva (Fig. 4.f)

Post-flexion stage, 12 teeth in upper jaw and 10 in lower jaw. Nasal depression deepens further. Branchiostegal rays well developed and 6 in number. Gill filaments well formed and small protuberance of gill rakers are visible. The mid brain somewhat round in shape and lies above the eye, 34 vertebrae are discernible.

The dorsal tentacle reduced in size and bifurcated anteriorly. Anterior tip of dorsal fin bent downwards; 78 dorsal rays and 56 anal rays are differentiated. The 17 caudal rays are arranged in the 6 hypural elements. The caudal formula is 1 + 3 + 5 + 4 + 3 + 1. Five basals developed on the pelvic fin bud. The origin of the left pelvic fin bud is more anterior and larger than the right one. No rays in pectoral fin.

11.2mm larva

Minute conical teeth in both jaws. Outer margin of the nasal depression thickened and flap-like out-growths developed. About 5 minute gill rakers are discernible on lower part of the anterior arch. Dorso-ventral axis of the liver is about two times larger than the anterio-posterior axis of the liver and lies in between 1st and 8th vertebra. Vent opens at 8th myotome.

The dorsal tentacle is verymuch reduced in size. The anterior end of the dorsal fin base is attached to the ethmoid region of the cranium ahead of eye. Dorsal rays 89, anal rays 68, and caudal 17. Six feeble rays are developed on each pelvic fin. There are 7 spines on cleithrum, 34 spines on cartilaginous plate and 20 groups of spines on pubic bar.

13.4mm larva

There are 18 minute conical teeth in upper jaw and 16 in lower jaw. On the left side, the nasal flaps fused together to form anterior and posterior nostrils. On the right side the nasal flaps not yet fused together. Six branchiostegal rays are present; the posterior most three are longer and directed posteriorly and anterior most three are directed posterio-ventrally. Six minute gill rakers are seen on the lower part of the anterior arch. Air bladder present, 34 vertebrae formed, 89 dorsal rays and 68 anal rays developed. All other fins are well developed except the fleshy based pectoral fins, which are devoid of rays.

Serration is seen on the cleithrum, cartilaginous plate, and pubic bar.

Pigmentation present on the dorsal and anal fin rays at about 25th to 27th vertebral level. Margin of caudal fin also pigmented.

Changes in body form.

The relative pre-anal length, relative eye diameter and relative upper jaw length decrease during the larval development whereas the relative body depth increases (Table 5). The relative head length increases slightly during pre-flexion and flexion stages, then it decreases gradually during post-flexion period. The relative snout length increases during pre-flexion stage, thereafter it shows uniform pattern of development (table: 5).

The dentition first appears, when the larva attains 3.2mm. Minute conical teeth are seen in the anterior part of the jaws. Even in the pre-flexion stage the larva is having about 8 teeth in upper jaw and 6 to 8 in lower jaw. During development, number of teeth increases and at post-flexion stage it is about 14 to 16 in upper jaw and 12 to 14 in lower jaw. Teeth are conical and uniserial in the larvae.

The nasal thickening is first observed in 2.8mm stage and a depression is developed at 3.6mm. Nasal folding develops in the post-flexion larva of 11.2mm. At about 13.4mm the foldings on the left side fused together to form anterior and posterior nostrils where as on the right side foldings not yet fused together at this stage.

Feebly developed gill arches are seen in 2.5mm larva and at 3.4mm rudiments of gill filaments are seen at flexion stage (5.4mm SL). Gill rakers first appear in 8mm larva as an elevation on the dorsal surface of the ceratobranchial. At about 8.4mm stage 2 to 3 small gill rakers are formed on the lower part of the anterior arches. By about 12.4mm the number of gill rakers on lower part has increased from 4 to 5. The adult complement of 5-7 gill rakers is reached at about 13.4mm.

The branchiostegal rays are first discernible at 5mm. At about 6.3mm, 6 branchiostegal rays are evident. In early stages of larvae the liver is massive and rectangular in shape and it occupies below the straight portion of the intestine. During development the anterio-posterior axis of the liver is reduced due to the forward pushing of the intestinal coil by the inter-haemal spine of the 1st caudal vertebra. In the post-flexion stage the dorso-ventral axis of the liver is greater than the anterio-posterior axis.

The air bladder is noticed in all the stages of the larvae. It is located in between 4th and 8th myotomes and above the straight portion of the intestine. During late post-flexion stage air bladder becomes less conspicuous.

Fin formation

Fin formation in E. grandisquamis is typical as in other larval forms of sub-family Bothinae. In 2.5mm stage only primordial marginal fins and larval pectoral fins are present. In addition to these a long filamentous dorsal tentacle is also seen at the anterior tip of dorsal fin fold.

Pectoral fin. The fleshy based, fan-like larval pectoral fin is without any rays in 2.5mm stage and the condition is same in the largest specimen collected (13.4mm).

Dorsal fin. The formation of the fleshy dorsal pterygiophore region in *E. grandisquamis* larva is first evident from the middle portion of the larva at 3.6mm. The formation of pterygio phore region begins as a narrow strip of tissue concentration just above the dorsal body margin and ~~on the ventral margin of the dorsal body margin and~~ on the ventral margin of the dorsal fin fold at the level of first caudal vertebra, and 6 to 8 feebly developed pterygiophores also seen at this stage. At about 4mm stage this fleshy region extends further forward and backward and about 43 dorsal pterygiophores are discernible. At about 4.6mm actinotrichial rays are formed in the overlying dorsal fin fold. The number of pterygiofores increases gradually. Feebly developed true dorsal rays are seen from the middle of the dorsal fin fold at about 4.9mm stage. The origin of the dorsal fin base moves anteriorly at about 5.5mm stage and the movement continues until the fin base is attached to the ethmoid region of the cranium ahead of eye at 11.2mm stage. The full complement of dorsal fin rays is achieved at about 6.6mm and fully developed rays are seen at 8.4mm. The side of the dorsal tentacle gets reduced in later stages and becomes the same size of the other dorsal fin rays.

Anal fin. The anal pterygiophore region begins to form at the same time of the formation of dorsal pterygiophore region at 3.6mm stage. At about 4mm stage, 28 anal pterygiophores are discernible. About 22 true rays are seen at 4.9mm and adult number of rays are achieved at 8.4mm stage.

Pelvic fin. The pelvic fin bud is noticed in larva of about 4.2mm as a thickening on the ventral edge of the body immediately behind the cleithrum. The left side fin base is larger than the right one. In post-flexion larvae (8.3mm) 3 basals are formed and at 8.9mm 5 basals are seen. Feebly developed fin rays are first evident in 11.2mm larva and 6 rays are clearly visible at 13.4mm stage.

Caudal fin. The fully formed caudal fin has 17 principal rays associated with six hypural elements. The dorsal and ventral most caudal fin rays are simple, the remaining rays are branched.

A ventral thickening near the posterior end of the notochord is seen on specimen of about 4.2mm (pre-flexion stage). This thickened tissue develops in to two mediam hypural plates at the beginning of the flexion stage (5.1mm) and 3 feebly developed rays are also formed at this time. At 5.5mm stage about 3 to 4 caudal rays are developed on 3 hypural elements. They develop at an oblique angle to the notochord. By about 6.6mm stage (post-flexion stage) the hypurals (six in number) and 13 caudal rays are arranged parellel to the axis of the body. The full complement of 17 principal caudal rays in the formula 1 + 3 + 5 + 4 + 3 + 1 is discernible when the larva attains 7.3mm SL.

Pigmentation. Pigmentation in the larvae of E. grandisquamis is restricted to the dorsal and anal fins. Pigment concentrations are seen on the dorsal and anal fins at the level of 24th myomere. In addition, in post-flexion stage irregular pigment spots are also seen at the margin of caudal fin and on the dorsal tentacle.

Serration. In E. grandisquamis larva serration is seen on cleithrum, cartilaginous plate and pubic bar. In addition to these, spine is also present at the angular region of early larval forms.

Serration on the cleithrum first appears on the larvae of 3.4mm. At this stage 1 to 2 backwardly projecting spines are seen. Number of spines increased in later stages and 7 to 9 spines are seen in post-flexion larvae. Serrations are seen on the ventral margin of cartilaginous plate and pubic bar. In the pre-flexion stage about 7 spines are seen on the cartilaginous plate and 7 groups of small spines on pubic bar. During development the number of spines increased and at the post-flexion stages about 32 spines are seen on cartilaginous plate and 18 groups of spines (each group containing one to two small spines) on the pubic bar.

Distinguishing characters of ***E. grandisquamis*** larvae.

Dorsal 79-89, anal 59-68, vertebrae - 34, Liver large, optic lobe of brain large. Gill rakers 5-7 on the lower part of anterior arch.

Serration: Serration seen on cleithrum, cartilaginous plate and pubic bar.

Pigmentation: Pigment patches on the dorsal and anal fins at about 24th myomere. In addition, in late post-flexion larvae irregular pigment spots develop at the margin of caudal fin and on the dorsal tentacle.

Fig.-4. : Developmental stages of *E. grandisquamis*

a. 2.5mm larva

b. 3.6mm larva

c. 4.6mm larva

d. 5.5mm larva

e. 6.6mm larva

f. 8.4mm larva

Fig. 4

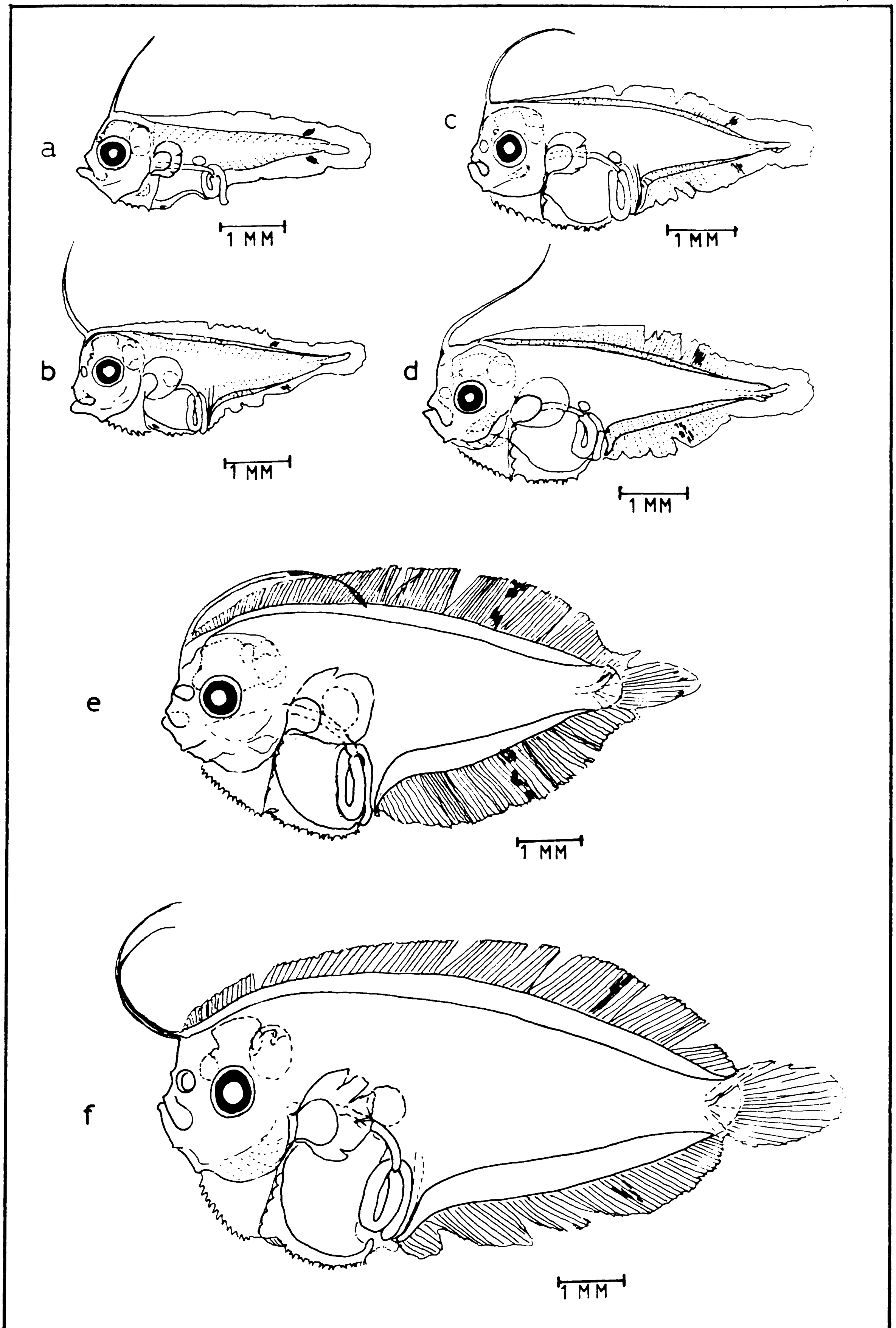


Table: 5. Body proportions of ***E. grandisquamis*** larvae (proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.65	51	24	7	8	-	24
3 - 3.9	3.43	52	26	8	8	8	30
4 - 4.9	4.55	51	27	10	9	9	39
5 - 5.9	5.33	50	27	10	8	8	41
6 - 6.9	6.40	49	27	10	8	8	44
7 - 7.9	7.43	46	26	9	7	7	43
8 - 8.9	8.30	45	26	9	7	7	45
9 - 9.9	9.20	45	26	10	8	7	47
11 - 11.9	11.25	44	26	9	7	6	45
12 - 12.9	12.40	40	25	9	6	6	47
13 - 13.9	13.40	41	27	10	6	6	45

3.1.4 ENGYPROSOPON COCOSENSIS (Bleeker 1855)

Five larval stages from 2.7mm to 19.3mm of E. cocosensis were described and illustrated by Balakrishnan (1963), but incorrectly identified as Arnoglossus tapeinosoma Bleeker. Here 11 larval stages from pre-flexion stage to late post-flexion stage are described.

2.2mm larva (Fig. 5.a)

Pre-flexion stage. Teeth not developed in weakly formed jaw bones. Pre-opercular bones and opercular flaps are feebly developed. Gill arches rudimentary. Heart differentiated, but the ventricle not attained the pyriform shape. Optic lobe of the brain large and lies above the eye. The small bead-like fore-brain just in front of the eye. Hind-brain not yet discernible. Otocyst seen behind the eye. The highly developed liver extends upto the intestinal coil and its antero-posterior axis is about 7 times larger than the dorso-ventral axis. A small, vesicular air bladder is seen just above the straight portion of the intestine. The intestinal coil developed. About 19 myotomes visible. Cleithrum, urohyal bone, cartilaginous plate and pubic bar are feebly seen at this stage.

The dorsal tentacle bifurcated from its base. The dorsal and anal fin folds confluent with the caudal fin fold. The larval pectoral fin is fan-like and has fleshy base.

Two minute spines are seen on the ventral margin of the cartilaginous plate.

3.3mm larva (Fig. 5.b)

Pre-flexion stage. Teeth not yet formed. A round thickening of tissue developed in the nasal region. Rudimentary gill filaments are discernible in the gill arches. Heart is well differentiated. The rectangular shaped liver occupies in between 1st and 9th myotomes. The dorso-ventral axis of the liver is slighly enlarged. Air bladder lies at the 10th myotome level. The vent opens at the 13th myotome, 29 myotomes are countable.

The dorsal and anal pterygiophore regions first appear at this stage from the anterior portion of the caudal region as narrow strips of tissue concentration along the bases of respective fin folds.

The spination has increased, 9 spines are seen on the ventral edge of cartilaginous plate and 6 minute spines on the ventral margin of pubic bar, a single spine is seen in the angular region.

4.2mm larva (Fig. 5.c)

Pre-flexion stage. The body depth increases, 2 to 3 canine teeth are seen from the anterior end of the jaw. The nasal depression developed. The opercular flaps well formed; but branchiostegal rays are not yet developed. Feebly developed gill filaments are seen. The liver enlarged in size and lies in between 1st and 9th myotomes. The dorso-ventral axis of the liver is about equal to the anterio-posterior axis at this stage. Air bladder is very large in this specimen and occupies from 5th to 8th myotomes. The vent opens at 12th myotome. The inter-heamal spine of the 1st caudal vertebra is well developed and reaches just above the anal opening, 32 myotomes differentiated.

Vertical fin folds retain, 14 dorsal and 12 anal pterygiophores.

Number of spines increased in cartilaginous plate and pubic bar. In addition to these, spines are developed in the cleithrum also (two each on either side)

4.7mm larva (Fig. 5.d)

Pre-flexion stage. Minute conical teeth are present in both jaws. The nasal depression well formed. A small bony projection has been noticed in front of the nasal depression.

There are 30 dorsal pterygiophores developed in between 6th and 28th myotomes, 18 anal pterygiophores are also noticed in between 12th and 24th myotomes. Striations of actinotrachial rays are evident in the dorsal and anal fin folds A triangular-shaped thickening has developed at the posterio-ventral aspect of the straight notochord.

Spination noticed in angular, cleithrum, cartilaginous plate and pubic bar.

5.7mm larva (Fig. 5.e)

Flexion stage. The nasal depression more deepends. About 4 branchiostegal rays are feebly developed on either side. The 'V' shaped hepatic caeca is visible. The vent opens at 12th myotome. There are 10 pre-anal and 24 post-anal myotomes.

Origin of dorsal fin base slightly moved anteriorly. True rays (65 in number) begin to develop from the middle part of the dorsal fin fold. Similarly about 40 rays are developed from the anterior part of the anal fin fold. Posterior end of the notochord flexed upwards and 3 hypural elements are formed in the thickened triangular portion. Actinotrachial rays are evident in the caudal fin. Ventral fin buds are developed just above the mid-ventral line and behind the cleithrum.

The spination on the pubic bar are in groups and 2-3 spines in each group.

6.5mm larva (Fig. 5.f)

Post-flexion stage. The outer margin of the nasal depression thickened. 5 branchiostegal rays are discernible on each side. Gill filaments well developed. The anterio-posterior axis of the liver verymuch reduced due to the forward pushing of the intestinal coil by the haemal-spine of 1st caudal vertebra. The optic loble of the brain is large and square-shaped. The vesicular air bladder lies at 9th vertebral level.

The bifurcated dorsal tentacle reduced in size. Though the dorsal as well as the anal pterygiophores are completely developed, the fin rays are not yet formed near the caudal peduncle. Anterior-dorsal rays are similar in size. About 72 dorsal and 52 anal fin rays are developed, 6 caudal elements are discernible and 12 caudal fin rays are arranged in these elements as 0 + 1 + 5 + 4 + 2 + 0. The left pelvic fin bud is larger than the right one.

A pair of angular spines present. Posteriorly directed 5 spines are seen in the cleithrum. There are 19 spines on the ventral margin of the cartilaginous plate. Pubic bar has 16 groups of small spines.

9.5mm larva (Fig. 5.g)

Post-flexion stage. The larva has 16 teeth in upper jaw and 10 in the lower jaw. Flap-like outgrowths developed from upper and lower margins of the nasal depression. A blunt bony projection is seen above the maxillary. Gill filaments and branchiostegal rays are well developed. The optic lobe of the brain is now spherical in shape. The vent opens at 10th myotome level.

Anterior region of the dorsal fin continues to shift forward. Rays of all the fins are developed except in the pectoral fin. There are 79 dorsal, 58 anal and 17 caudal rays. Caudal rays are associated with 6 caudal elements as 1 + 3 + 5 + 4 + 3 + 1. The anterior 3 rays of the elongated left pelvic fin are in advance of the 1st ray of the right pelvic fin.

Spinations are same as in the preceding stage.

10.6mm larva (Fig. 5.h)

Dentition is uniserial in both jaws. The flap-like outgrowths in the nasal depression enlarged in size. The dorso-ventral axis of the liver is about 2 times larger than the anterio-posterior axis. Ten pre-anal and 24 post-anal vertebrae are discernible.

The shifitng of the dorsal fin continues. There are 82 dorsal rays, 60 anal rays and 17 caudal rays. The ventral fin has 6 rays on each side.

Angular spines present, cartilaginous plate has 26 spines at its mid-ventral line, 7 spines are seen on the cleithrum. The pubic bar which supports the liver ventrally, has 21 groups of spines of which the anterior ones are larger.

<u>12.6mm larva</u> (Fig. 5.i)

Post-flexion stage. Nostrils developed on both sides by the fusion of the flap-like outgrowths on the margin of the nasal depression. A blunt spine is seen on the snout. Sprout-like gill rakers are seen on the gill arches. The vent opens at 9th vertebral level.

The origin of the dorsal fin base becomes already attached to the ethmoid region of the cranium ahead of the eye. Tissue between the ventral edge of the anterior portion of the dorsal fin and the frontal region of the cranium has become thin. A slight upward migration of the right eye has been noticed at this stage. The dorsal tentacle reduced in size and occupies just above the nostril. Full complement of dorsal, anal, caudal and pelvic fin rays are developed.

Angular spines become blunt, 9 spines developed on the cleithrum, 24 spines on the cartilaginous plate and 20 groups of spines on the pubic bar.

<u>14.5mm larva</u>

Eyes asymmetrical and the right eye has moved a little upwards. Nostrils well developed. The auricle thin-walled, ventricle thick-walled, has pyriform shape. The spherical mid-brain is about 3 times larger than the fore-brain which lies above the eye. Air bladder vesicular and lies in between 9th and 10th vertebrae. The intestinal coil pushed further forward by 1st inter-haemal spine and vent opens at 8th vertebral level.

The anterior tip of the dorsal fin slightly detached from the ethmoid region The tissue between the ventral edge of the dorsal fin and the frontal region of the cranium becomes more thin and a gap has formed there. The dorsal tentacle reduced to the size of the rays behind it. ~~Dorsal tentacle reduced to the size of the rays behind it.~~ Dorsal and anal fins have 82 and 59 rays respectively.

Spines on the cartilaginous plate and pubic bar reduced in number.

19mm larva

Body elongated, pre-caudal length very much reduced. Teeth uniserial. Otocyst clearly seen, 6 short, pointed gill rakers on lower part of anterior arch. Feebly developed scales present in the lateral line of left side. Anterio-posterior axis of the liver very much reduced by the forward movement of intestinal coil. The vent opens at 7th vertebral level, 10 pre-anal and 24 post-anal vertebrae are discernible.

The anterior part of the dorsal fin detached from the head up to the frontal region of the cranium where the tissues became thin and a gap has formed as in the preceding stage. (Through this gap the right eye will pass over to the left side). The right eye migrates further upwards, but not reaches the upper margin of the head. Dorsal has 78 rays and anal 57 rays. Tip of pelvic bone projects downwards and backwards between the pelvic fins. Left pelvic fin has longer rays and first 3 rays of it are ahead of the 1st ray of the right pelvic fin. No rays are developed in the pectoral fin.

There are 9 to 10 spines on the cleithrum and 14 spines on the cartilaginous plate. Spines disappeared from the posterior part of the pubic bar and 9 to 10 larger spines remain in the anterio-ventral part.

Changes in body form.

Relative pre-anal distance decreases during larval development whereas relative body depth increases (Table: 6.). Relative head length, eye diameter upper jaw length and snout length udergo a uniform pattern of development through out the larval stages (Table: 6.).

Teeth on maxillary appear early at 2.9mm stage and during later stages teeth increase in number regularly with growth of body. The most advanced post-flexion larvae have 18 to 20 teeth in the up per jaw and 14 to 16 teeth in the lower jaw. Anterior teeth are large in size. Development of nostril begins even in the smallest pre-flexion larva (2.2mm) as an aggregation of tissue at the snout region. Nasal depression is visible at 3mm stage. During development this depression enlarges and at 8.7mm, flap-like outgrowths are developed from the anterior and posterior margins of this depression. These flaps enlarge in size and are fused together to form anterior and posterior nostrils at 12.2mm stage.

At 2.2mm the feebly developed gill arches are naked. Rudimentary gill filaments appear in 3.3mm stage. Well developed gill filaments are discernible in 5.9mm larva. Bud-like gill rakers are first evident in 8.7mm larva and adult complement of gill rakers (5-6) are visible in the lower part of anterior arch at 10mm stage. In the early pre-flexion stage the liver is rectangular in shape and occupies in between 1st and 12th myotomes. At this stage the anterio-posterior axis of the liver is about 3 times larger than its dorso-ventral axis. During the flexion stage the anterio-posterior axis of the liver is almost equal to the dorso-ventral axis due to the forward movement of the intestinal coil. In the post flexion larvae the liver lies in between 2nd and 8th myotomes and its dorso-ventral axis is about 2 times larger than the anterio-posterior axis. A vesicular, oval-shaped air bladder is present in all the larval stages and it lies above the straight portion of the intestine.

Fin formation

Fin formation is typical as in other larval forms of sub-family Bothinae. In 2.2mm larva only the primordial marginal fins and larval pectoral fins are present. A long filamentous dorsal tentacle is also present in the head region.

Pectoral fin. The pectoral fin is present as a fan-like ray-less structure with fleshy base in the smallest larva (2.2mm), rays not developed in the largest specimen (19mm) also.

Dorsal fin. The dorsal fin fold and a single dorsal tentacle present in the smallest larva of the collection. The dorsal pterygiophore region first appears at 3.3mm stage as a narrow strip of tissue above the level of 10th myomere and in between the body proper and dorsal fin fold. This pterygiophore region extends further forward and backward and at 3.6mm stage about 3-5 dorsal pterygiophores are developed. During development the number of dorsal pterygiophores increases and at about 4.7mm stage striations of actinotrachial rays are evident in the middle part of the dorsal fin fold. At 5mm stage, true rays are seen at this region. In 5.7mm larva 65 dorsal rays are discernible and full complement of dorsal fin rays are developed at about 7mm.

The origin of the dorsal fin base, along with the dorsal tentacle begins to move anteriorly in the larvae of about 5.5mm and continues to shift anteriorly until it becomes attached to the ethmoid region of the cranium ahead of eye at 12.6mm stage. During development the size of the dorsal tentacle is reduced and reaches the same size of the other dorsal fin rays at about 14.5mm stage.

Anal fin. Anal pterygiophore region is formed at the anterior portion of the anal fin at 3.3mm stage and 2 to 3 pterygiophores are countable at 3.6mm stage. The anal fin rays are evident in the anterior portion of the fin at about 5mm stage. During development the number of fin rays increases rapidly, as in the dorsal fin and adult complements of 56-63 fin rays are developed by about 7mm. In both dorsal and anal fins, the posterior-most rays near the caudal peduncle are developed lastly.

Pelvic fin. The pelvic fin bases develop in the specimen of about 5mm, as a small thickening on the ventral edge of the body immediately behind the ventral end of cleithrum, 4 to 5 pelvic fin basals developed at about 8mm and 4 feeble rays are evident at 8.7mm. Six rays are developed at 9.8mm. The rays on the left pelvic fin are larger and the anterior three are in front of the first ray of the right pelvic fin.

Caudal fin. The fully formed caudal fin of E. cocosensis has 17 principal rays, the outer most ones are unbranched. The rays are supported by six caudal elements in the order 1 + 3 + 5 + 4 + 3 + 1.

Early caudal formation involving thickening in the hypural area of the developing caudal fin occurs in larvae of 4.5mm length. Initiation of the flexion of the notochord begins in the larva of 5mm and 4 to 5 hypural elements are discernible at 5.3mm stage. Simultaneously, feeble rays are formed from the middle portion of the fin and at 5.5mm about 11 rays are developed. Fully formed caudal fin with 17 rays are sen in 8mm larva.

Serration. Serration in E. cocosensis larvae is confined on the outer margin of cleithrum, pubic bar and cartilaginous plate. In the early pre-flexion stage there are 2 to 3 spines on the cleithrum, 10 to 12 on the cartilaginous plate and 10 to 16 on the pubic bar. Number of spines gradually increases on the cleithrum and 8 to 9 spines developed at late post-flexion stage. The number of spines on the cartilaginous plate increases rapidly during early post-flexion stage and reaches upto 24 to 26. Serration on pubic bar is prominent and the anterior spines are more elongated than the posterior ones. At about 2.5mm, 7 minute spines are developed on the pubic bar. The number of spines increases very slowly in pre-flexion stage. About 18 spines are developed in flexion stage and 20 to 22 in post-flexion stage.

Distinguishing characters of *E. cocosensis* larvae.

Dorsal and anal fin rays begin to develop from the anterior part of the caudal region (near the vent). Single dorsal tentacle. Dorsal 77-84, anal 56-63, Vertebrae - 34, liver large, optic lobe of brain large. Five to seven short, pointed gill rakers on the lower part of anterior arch.

Serration: Serration on cleithrum, cartilaginous plate and pubic bar. No pigmentation on body parts.

The larvae of *E. cocosensis* and *E. grandisquamis* are very much similar in various aspects, such as, meristic counts, number of gill rakers on the lower part of anterior arch, and serration on cleithrum, cartilaginous plate and pubic bar. But the number of serration is less in *E. grandisquamis* than in *E. cocosensis*. Pigment patches are seen on the dorsal and anal fins of *E. grandisquamis* but no pigmentation is seen in *E. cocosensis*. A detailed statistical study on the interspecific comparison of the slope of the various body relationships in *E. cocosensis* and *E. grandisquamis* showed that the relationship between pre-anal distance (PAD), upper jaw length (UJL) and body depth (BD) against body length (BL) is the same for both species. But statistically significant differences were observed to exist between head length (HL) eye diameter (ED) and snout length (SN) against body length (BL) (Table - 7).

Fig. 5. : Developmental stages of E. cocosensis

a. 2.2mm larva

b. 3.3mm larva

c. 4.2mm larva

d. 4.7mm larva

e. 5.7mm larva

Fig. 5

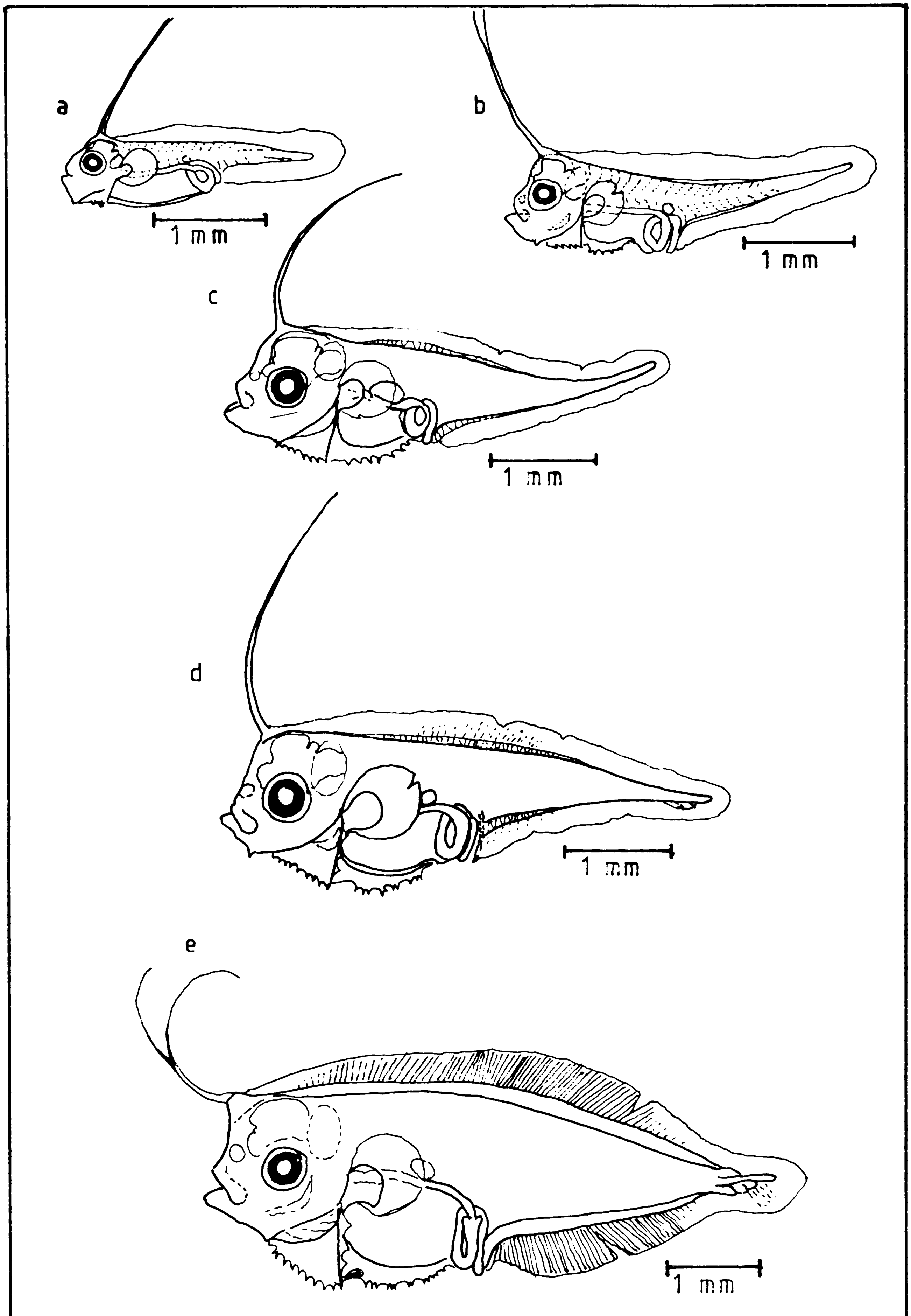


Fig. 5. : Developmental stages of E. cocosensis (Cont:)

f. 6.5mm larva

g. 9.5mm larva

h. 10.6mm larva

i. 12.6mm larva

Fig. 5

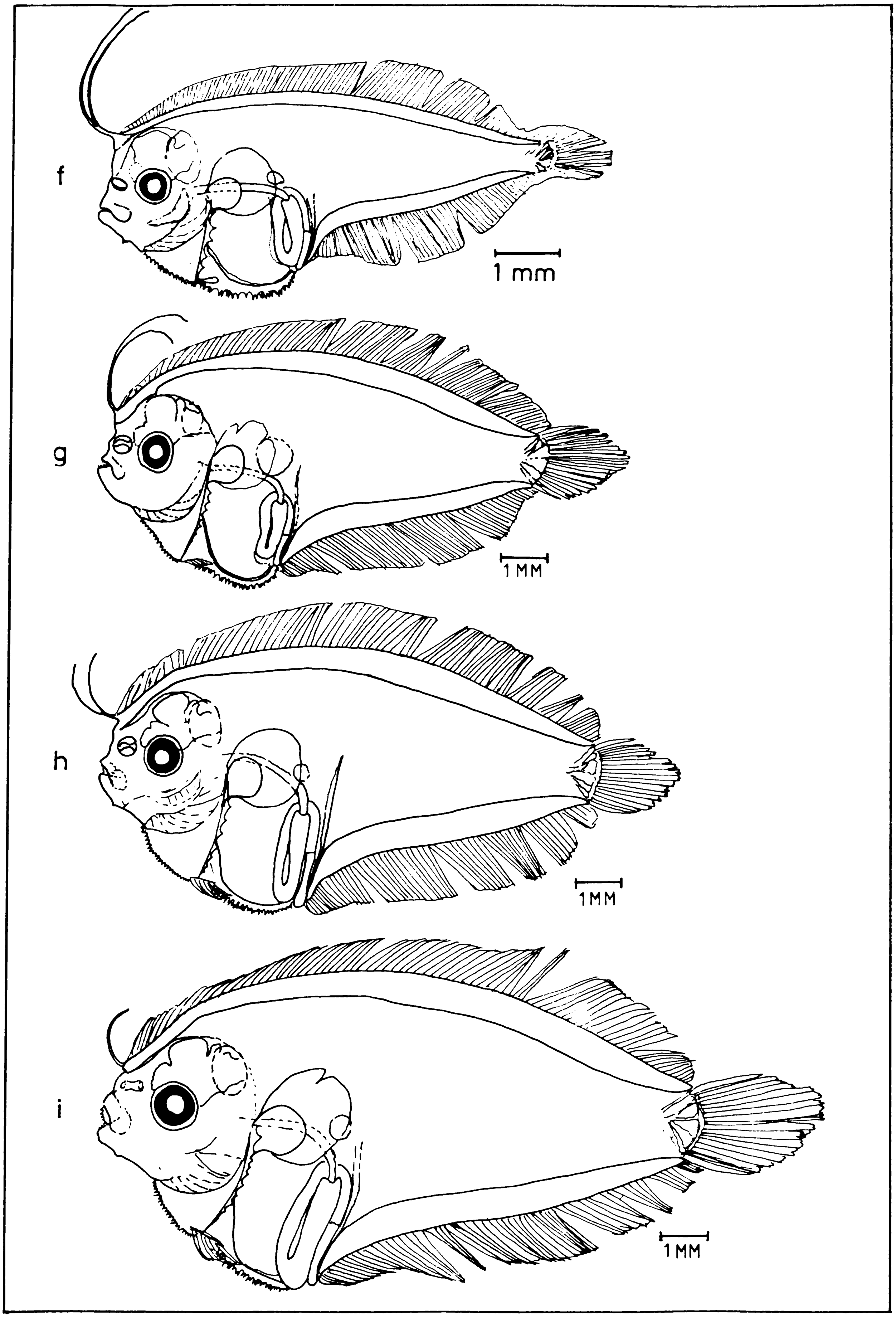


Table: 6. Body proportions of *E. cocosensis* larva.
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.63	59	24	10	8	7	27
3 - 3.9	3.48	55	26	10	8	8	30
4 - 4.9	4.35	53	27	10	8	8	34
5 - 5.9	5.37	52	27	10	8	8	41
6 - 6.9	6.55	49	27	10	8	8	44
7 - 7.9	7.33	48	27	11	8	7	44
8 - 8.9	8.35	46	27	10	7	7	46
9 - 9.9	9.61	42	27	10	7	7	48
10 - 10.9	10.33	40	27	10	7	7	46
11 - 11.9	11.48	41	26	9	7	7	43
12 - 12.9	12.27	41	26	9	7	7	42
13 - 13.9	13.15	39	27	10	7	7	42
14 - 14.9	14.50	37	27	9	6	7	41
19 - 19.9	19.00	24	26	8	6	7	40

Table: 7. Inter specific comparison of the slope of the various body relationships in **E. cocosensis** and **E. grandisquamis** larvae.

Name of the species	Comparing characters	t		p
E. cocosensis / E. grandisquamis	BL - PAD	$\frac{0.024}{0.01628}$ =	1.4724	N.S.
	BL - HL	$\frac{0.01}{0.0036}$ =	2.7778	$0.005 < P < 0.01$
	BL - ED	$\frac{0.006}{0.0014}$ =	4.2857	$P < 0.001$
	BL - SN	$\frac{0.008}{0.0028}$ =	2.8571	$0.002 < P < 0.005$
	BL - UJL	$\frac{0.003}{0.0045}$ =	0.6667	N.S.
	BL - BD	$\frac{0.011}{0.0085}$ =	1.2941	N.S.

t = student's t, P = probability, N.S. = Not Significant.

3.1.5. BOTHUS OVALIS (Regan, 1908)

Larvae of B. ovalis have not been described previously. However larval stages of related species have been described by Emery (1883) (B. podar), Gopinath (1946) (B. Platophrys pantherinus), Jones & Panthalu (1958) (Bothus sp.) Ochiai & Amaoka (1963) (Bothus sp) Amaoka (1964) (B. myriaster) and Ramanathan et al (1979) B. myriaster). It has been pointed out that B. myriaster (Temminck & Schlegel, 1846) and B. bleekeri Steindachner 1861, described from the Western Indian Ocean, are probably conspecific with B. ovalis. (Fisher. W. and G. Bianchi (eds) 1984). In the present study, 8 selected stages from 3.15mm to 16.4mm are described in detail. In addition, 23 numbers of post-larvae of 28mm to 35mm range, obtained from pelagic trawl collections, are also included.

3.15mm larva **(Fig. 6.a-1)**

Pre-flexion stage. Maxillaries developed. Both jaws devoid of teeth. Nasal depression seen in front of eye. Brain well differentiated. Otocyst is clearly seen behind the eye. Gill filament feebly developed, but the gill arches are devoid of rakers, branchiostegal rays not developed. The liver is massive, lies in between 1st and 8th myomeres. The dorso-ventral axis of the liver is about twice the length of its anterio-posterior axis. A large air bladder lies above the intestinal coil, vent opens at 10th myomere level. The interhaemal spine of the first caudal vertebra well defined and reaches just above the vent. The notochord is straight and about 28 myotomes are countable.

The dorsal tentacle is large and single, its base slightly bent forward. The fleshy dorsal and anal pterygiophore regions formed. About 48 dorsal pterygiophores are discrenible from the middle portion of the dorsal pterygiophore region. Traces of fin rays are evident in the dorsal fin fold above the developed dorsal pterygiophores. Pterygiophores also developed from the anterior portion of the anal fin. Few feebly developed fin rays are discernible in the anal fin fold. The pelvic fin bud developed mid-ventrally just behind the ventral tip of the cleithrum. The pectoral fin is fan-like and devoid of rays. The notochord is straight and no evidence of caudal fin bud.

A single spine on the angular region is seen. No other serration on the body.

Pigmentation restricted on the dorsal body margin, where there is a single line of pigment spots in between the dorsal body margin and fleshy dorsal pterygiophore region. The terminal portions of this region are devoid of pigment spots.

4mm larva (Fig. 6 a)

Pre-flexion stage. Teeth not developed, nasal depression more prominent. The anterio-posterior axis of the liver much reduced due to the forward pushing of the intestinal coil by the inter-haemal spine of first caudal vertebra. A vesicular air bladder is visible at 8th vertebral level. About 35 myotomes are discernible at this stage.

The anterior portion of the dorsal fin base moved further forward. The anterior tip of the dorsal tentacle bifurcated. There are feebly developed 79 dorsal rays and 57 anal rays. Rays are not formed in the posterior portion of both dorsal and anal fins. Dorsal and ventral congregation of tissues noticed on the poster tip of straight notochord, 6 feebly developed rays are noticed on the ventral fin bud of which the base of the left pelvic fin is elongated.

Pigmentation and other characteristics are same as in the previous stage.

6.4mm larva (Fig. 6 b)

Flexion stage. The gill filaments well developed. The massive liver occupies in between 3rd and 8th myotomes. The vent opens at 10th myomere level, 36 myotomes are discernible at this stage. The anterior part of the dorsal fin, along with the dorsal tentacle bends further downwards. About 70 dorsal and 60 anal fin rays are developed. Rays are not developed in the posterior most portion of both fins, 3 hypural elements are formed in the thickened portion, on the ventral side of the flexed notochord. Pelvic fin rays well developed. Pigmentation seen only on the dorsal margin of the body.

7.3mm larva (Fig. 6 c)

Post-flexion stage. Teeth are developed in both jaws anteriorly. About 6 teeth in upper jaw and 4 teeth in lower jaw are countable. The nasal depression more prominent in this stage. Feebly developed branchiostegal rays are discernible. The well differentiated brain bends along with the bending of the anterior part of the dorsal fin. The mid brain is more prominent. The otocyst seen behind the eye. The liver occupies in between 2nd and 7th vertebrae. The air bladder is seen above the intestinal coil. The pyloric appendages are clearly visible at this stage.

The anterior tip of the dorsal fin reaches above the nasal depression, 89 dorsal rays and 68 anal rays are differentiated. Full complement of caudal elements are formed and 15 rays are developed in the caudal region in the order 0 + 3 + 5 + 4 + 3 + 0.

Spination seen on the angular region and few spines are also developed on the anterio-ventral part of the pubic bar. Pigmentation is same as in the previous stages.

<u>8mm larva</u> (Fig. 6 d)

Post-flexion stage. Number of teeth increased in both jaws. Slight thickenings noticed on the upper and lower margins of the nasal depression. The branchiostegal rays are clearly visible. The anterio-posterior axis of the liver still reduced in size. There are 38 vertebrae, including urostyle.

The size of the dorsal tentacle reduced. There are 87 dorsal rays, 69 anal rays and 17 caudal rays. Pelvic fin has 6 rays and the rays on the left pelvic fin are larger and anterior three rays of the pelvic fin are in advance of the 1st ray on the right side.

Spination on the angular region and pubic bar present. Line of pigment spots are seen on the dorsal and ventral body margins in between the body proper and fleshy pterygiophore regions.

<u>9.8mm larva</u> (Fig. 6 e)

Post-flexion stage. Mouth very small, teeth in both jaws. The branchiostegal rays are well formed. The massive air bladder lies above the intestinal coil. The 'V' shaped pyloric appendages are clearly visible. The intestinal coil pushed forward by the large inter-haemal spine of first caudal vertebra, 38 vertebrae are countable, of which first 10 are pre-anal and 28 are caudal.

There are 90 dorsal and 69 anal fin rays. Caudal fin has 17 rays and arranged as 1 + 3 + 5 + 4 + 3 + 1.

Serration and pigmentations as in the 8mm stage.

<u>14.5mm larva</u>

Post-flexion stage. Maxilla in front of the eye. Fold-like outgrowth developed from the margin of the nasal depression. The right eye shifted a little upwards. Gill filaments well developed, but rakers are not yet formed. Vent opens at 8th myomere level, 38 vertebrae are discernible.

The dorsal tentacle very much reduced in size. All fins, except the pectoral fin are developed. There are 89 dorsal rays, 68 anal rays, 17 caudal rays and 6 rays on each pelvic fin.

The po st-anal pigmentation and serration is same as in previous stage.

16.4mm larva

Post-flexion larva. Single row of minute canine teeth in both jaws. The right eye migrates a little upward. The folding at the upper and lower margins of the nasal depression fused together and nostril formed. Gill rakers are feebly developed, about 5-6 rakers are countable at this stage on the lower part of the anterior arch. The pyloric appendages well defined and has 'V' shape, 38 vertebrae are discernible.

Th anterior portion of the dorsal fin reaches above the nostril. 90 dorsal rays and 69 anal fin rays are formed. No rays in the pectoral fin.

The serration and pigmentation are as in the previous stages.

Twenty three numbers of B. ovalis post-larvae of 28mm to 35mm range were also collected in the pelegic trawl operations. Metamorphosis has been completed; the right eye has migrated to the left side of the body through a cranial cavity. Mouth very small. Scale cycloid on both sides. Gill rakers 6-7. All fins developed, dorsal 87-92, anal 65-71, caudal 17, pectoral 8 and pelvic 6, vertebrae 38.

Changes in body form.

Relative pre-anal distance, relative eye diameter and relative upper jaw length show gradual decrease with the larval development (Table-8). The relative head length, snoutlength and body depth undergo uniform pattern of development through out the period of larval stages. (Table-8).

Mouth is very small and development of dentition starts only at the flexion stage (6.4mm - 6.8mm). Nasal depression is seen in the pre-flexion stage. The upper and lower margins of this depression are thickened at early post-flexion stage (10.7mm) and folding discerned in 12.8mm larva. The flap-like foldings are fused together on the left side at about 14.5mm stage and nostrils developed on both sides at 16.4mm stage. The oval shaped otocyst is visible in all stages of laravae, which occupies just behind the eye.

Gill filaments are well developed in the flexion larvae, (6.4mm - 6.8mm). In the pre-flexion stages rudiments of gill filaments are noticed in the well developed arches. Gill rakers are first observed in late post-flexion larvae of 16.4mm and fully developed at 18.1mm stage. Heart is seen in 3.15mm larva. The ventricle is pyriform and other parts of the heart are also well developed at this stage.

The liver is massive and occupies in between cleithrum and intestinal coil. During development its anterio-posterior axis gets reduced due to the forward movement of the intestinal coil. The round shaped air bladder is seen above the intestinal coil in all stages. The pyloric appendages are prominent in this species and have 'V' shape. The vent opens at 10th myomere level in early stages and the opening advances along with the development of the larva.

Fin Formation.

The developmental sequence of the fin of the B. ovalis larva is same as in the other larvae belonging to the family Bothidae. The adult B. ovalis has 88-92 dorsal, 64-70 anal, 17 caudal, 8-9 pectoral and 6 pelvic fin rays.

Dorsal fin. The dorsal tentacle is single and its anterior tip bifurcated in almost all larvae. The size of the dorsal tentacle diminishes with age and becomes the same size of other dorsal fin rays in late post-flexion stages. The fleshy dorsal pterygiophore regions are well developed in the 3.15mm larva except in the caudal portion, 48 dorsal pterygiophores first appear along the back of the body. Traces of rays are evident in the middle region of the dorsal fin fold at this stage. About 79 feeble dorsal rays are discernible at 4mm stage. Rays are very slowly developed in the posterior most part of the dorsal fin and full complement of dorsal rays attained in the early post-flexion stage (10.7mm).

Anal fin. The pterygiophores in the anal fin first appear from the anterior portion of the anal fin fold and about 39 pterygiophores are countable in 3.15mm larva, 57 anal rays are developed from the anterior portion of the anal fin in 4mm larva and fully developed anal fin is seen in 9.8mm larva.

Caudal fin. The caudal fin begins to form at the under side of the body at a short distance anterior to the tip of the notochord in specimen of 4.0mm. The caudal elements have begun to develop in the flexion stage and about 4 elements are developed in the late flexion stage (6.8mm). Flexion occurs in larvae between 6mm and 7mm. By the time the caudal ray begins to develop and 15 rays are discernible at 7.3mm stage. The complete complement of 17 caudal rays is present in specimen 8.0mm and larger.

Pelvic fin. The pelvic fin is visible as a low bud at the ventral out line immediately posterior to the cleithrum in 3.15mm larva and 6 feeble rays differentiated in the 4mm larva.

The larval pectoral fin is seen in all series of larvae and rays are not developed in 18.1mm larva.

Branchiostegal rays are evident in the late flexion larvae (6.8mm). In larger specimens, six branchiostegal rays are differentiated, the posterior three are longer and directed posteriorly and the anterior most three are directed posterio-ventrally.

Spination. In the early pre-flexion stage a blunt spine is observed in the angular region. In addition to this, pubic bar is also serrated in the early post-flexion stage During development serration on the pubic bar gets reduced in number.

Migration of eye. Flat fish larvae are normally symmetrical with eyes opposite each other on either side of the head during their pre-flexion stages and into post-flexion stages. Some flat fish larvae remain symmetrical with regard to eye placement until attaining quite large sizes, (Hubbs and Chu 1934, Amaoka 1970, 1971 , 1972, 1973). However, in B. ovalis the migration of the right eye begins in the post-flexion stage of 14.5mm. The migration of right eye in B. ovalis is a very slow process and it requires some time to move completely over.

The specimen of 14.1mm is symmetrical, the right eye has not begun to migrate. By about 14.5mm the right eye has moved slightly. This upward migration of the right eye is still continued in the late post-flexion larva. At this stage the tissue between the ventral edge of the anterior portion of the dorsal fin and the frontal region of the cranium become thin. The eye migration is completed only in the post-larvae between 28mm and 30mm (collected in the pelagic trawl operation). The right eye has migrated through an opening developed in between the frontal region of the cranium and the ventral edge of the anterior portion of the dorsal fin.

Distinguishing characters of B. ovalis larvae

Larvae with large body depth. Large single dorsal tentacle. Dorsal and anal fin rays begin to develop from the anterior part of caudal region (near the anal opening) Dorsal 88-92, anal 64-70, elongated left pelvic fin base. Liver large. Optic lobe of brain large. Gill rakers 6-7 on the lower part of anterior arch. Vertebrae - 38.

Eye migration: right eye migrates through an opening in between cranium and dorsal fin.

Spination: a blunt spine in angular region of pre-flexion larvae; and few sp[illegible] pubic bar. Number of spines reduced with age.

Pigmentation: Dash-like pigmentation in between dorsal body margin and fleshy dorsal pteryg iophore region. In the early post-flexion stage another line of dash-like pigmentation developed in between ventral body margin and anal pterygiophore region.

Fig. 6. : Developmental stages of *B. ovalis*

a.1. 3.15mm larva

a. 4mm larva

b. 6.4mm larva

c. 7.3mm larva

d. 8mm larva

e. 9.8mm larva

Fig. 6

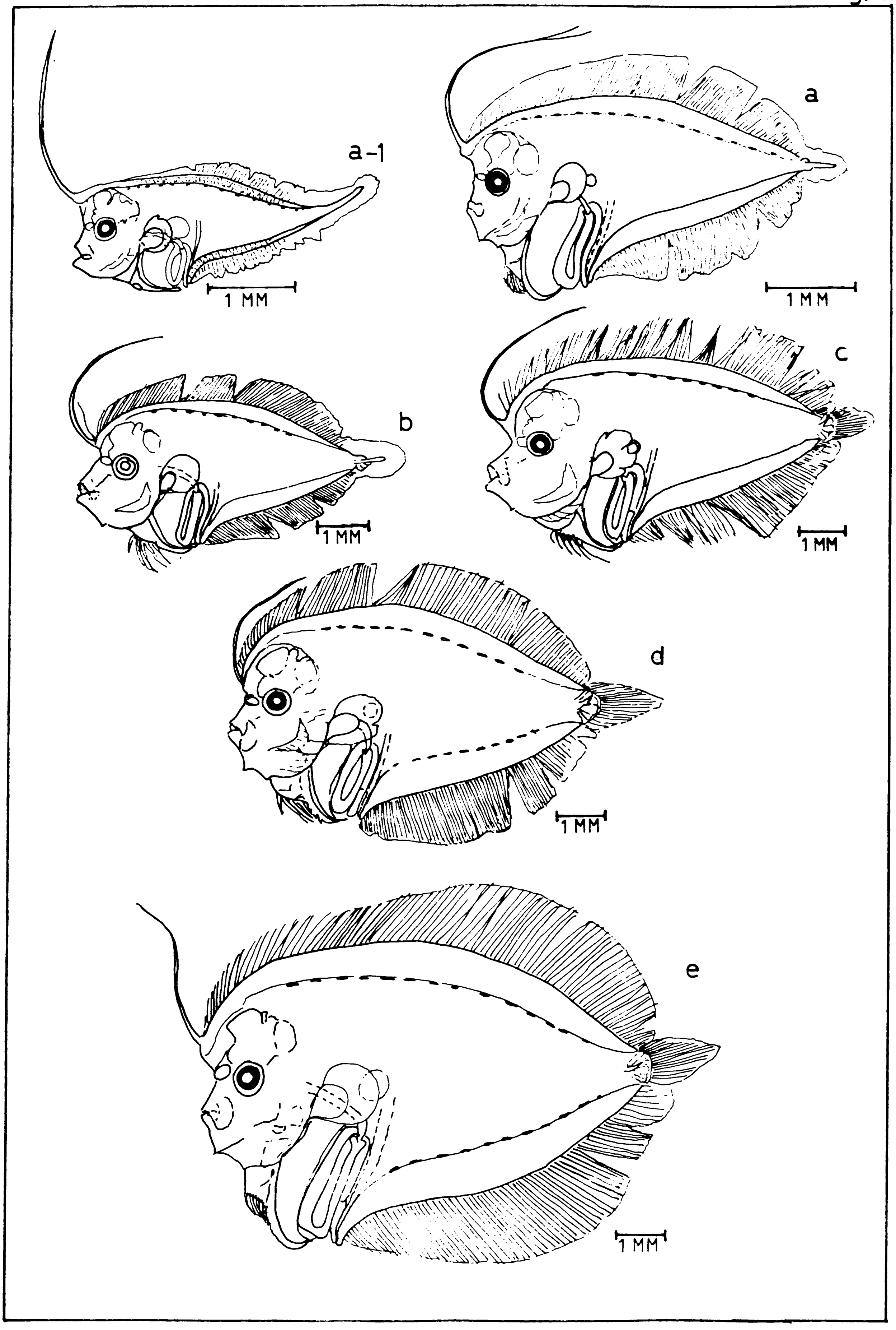


Table: 8. Body proportions of **B. ovalis** larvae
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
3 - 3.9	3.15	48	25	11	8	8	40
4 - 4.9	4.00	47	24	10	8	8	47
6 - 6.9	6.60	46	24	12	5	7	38
7 - 7.9	7.50	45	24	13	5	7	46
8 - 8.9	8.25	44	26	12	6	7	37
9 - 9.9	9.80	45	24	10	5	7	55
10 - 10.9	10.65	44	26	11	5	7	56
12 - 12.9	12.8	42	26	10	5	6	52
13 - 13.9	13.25	42	25	11	5	6	52
14 - 14.9	14.46	42	25	10	5	6	50
15 - 15.9	15.00	42	25	10	5	5	50
16 - 16.9	16.45	42	24	10	5	5	47
17 - 17.9	17.45	41	26	10	5	5	50
18 - 18.9	18.10	41	26	11	5	5	47

3.1.6. GRAMMATOBOTHUS POLYOPHTHALMUS (Bleeker, 1866)

The larvae of this species have not been described previously. Devi (Abstract - 1976) mentioned the presence of post larvae in the Indian Ocean. Here 9 selected stages are described in detail.

3mm larva (Fig. 7.a)

Pre-flexion stage. Jaws are sub-equal and devoid of teeth. The maxillary feebly developed. A round thickening has been developed in the nasal region. The feebly formed opercular flaps do not completely cover the rudimentary gill filaments. The heart is conspicuous and the ventricle is pyriform. Otocyst is discernible just behind the eye. The brain has differentiated; the optic lobe is large and round and occupies above the eye. The small fore-brain is seen in front of the eye. The anterio-posterior axis of the liver is about two times larger than the dorso-ventral axis. The liver occupies in between 1st and 8th myotomes. The large oval shaped air bladder is visible in between 4th and 9th myotomes. The coiling of the intestine is completed and the vent opens at 11th myotome. The urohyal and a cartilaginous bone behind it are weakly developed. The pubic bar, which supports the overlying liver, also discernible; 29 myotomes are countable at this stage.

A single dorsal tentacle has originated over the head. The dorsal and anal fin folds are confluent with caudal fin fold. The fan-like pectoral fins have fleshy bases.

Pigmentation is seen on the head, trunk and tail. A branching chromatophore is seen on the roof of the cranium, internally. Few pigment spots are noticed on the mandibular region and angle of the lower jaw.

A line of pigment spots is visible mid-ventrally from the tip of angular region to the anal opening. Few stellate chromatophores are irregularly placed on the ventral side of the intestinal coil. The air bladder thickly pigmented. Few pigment spots are seen on the outer margin of the larval pectoral fin.

The post-anal pigmentation consists of a line of pigment spots along the mid-ventral line of the body from the 10th to 29th myotome and blotches of pigments on the bases of dorsal and anal fin folds at the level of 23th myotome.

4.4mm larva (Fig. 7.b)

Pre-flexion stage. During this stage the slender bodied larva changes in to deep bodied form. About 6 teeth are developed on the anterior portion of each jaw. The nasal depression is clearly visible in front of the eye. The gill filaments are weakly formed. The optic lobe of the brain changes its shape into rectangular form and slightly bends downwards over the eye. About 33 myotomes are discernible at this stage.

The fleshy dorsal and anal pterygiophore regions are developed from the anterior caudal portion and they extend upto the 30th myotome level. About 50 dorsal and 20 anal pterygiophores are feebly visible in these portions. Few actinotrichial rays are also seen.

The post-anal pigment spots on the mid-ventral line of the body, now seen in between the fleshy anal pterygiophore region and ventral body proper. Few pigment spots are also seen at the base of the dorsal pterygiophore region. Other pigmentations are same as in the preceding stage.

5.8mm larva (Fig. 7.c)

Flexion stage. Lower jaw is little prominent and about 8 teeth in each jaw. The nasal depression gets more deepened. The gill filaments are well formed. The branchiostegal rays are weakly developed. The anterio-posterior axis of the liver is much reduced due to the forward pushing of the intestinal coil by the inter-haemal spine of the first caudal vertebra. The vent opens at 8th myotome. There are 9 pre-anal and 27 post-anal myotomes.

The length of the dorsal tentacle is reduced, and the anterior portion of the dorsal fin moves further downwards and the dorsal tentacle is now seen just above the nasal depression. About 67 dorsal and 46 anal fin rays are feebly developed at this stage. A triangular shaped thickening has formed on the ventral side of the slightly upturned notochord and 3 hypurals are feebly discernible there. Actinotrichial rays can be seen from the thickened caudal portion. Pelvic fin buds are formed behind the cleithrum.

Pigmentation increases on the body. Three blotches are evident at the bases of dorsal fin rays in between 27th to 30th, 37th to 41st and 55th to 57th rays. Similarly two blotches are seen on the anal fin at the bases of 20th to 23rd and 40th to 44th rays. The mid-ventral pigmentation is seen from the tip of lower jaw to the anal opening. On the right side of the body dashes of pigments are present on the bases of dorsal and anal pterygiophore regions. Deep seated melanophorers are also seen on the pre-caudal vertebra. In addition to these, pigment spots are also seen on the dorso-lateral and ventro-lateral aspects of the anterior few myotomes. On the left side of the body pigments are seen on the air bladder.

7mm larva (Fig. 7.d)

Post-flexion stage. The mouth is terminal and about 5 pairs of teeth are developed in each jaw. The nasal depression is enlarged and the dorsal and ventral margins get thickened. A blunt spiny projection is noticed in front of the nasal depression. Branchiostegal rays are feebly developed. The ventral portion of the intestinal coil is pushed forward by the inter-haemal spine of the first caudal vertebra and the vent opens at the level of 5th myotome. 36 myotomes are discernible at this stage. The pubic bar extends posteriorly to the level of the descending portion of the intestinal coil.

The origin of the dorsal fin continues to shift anteriorly and it becomes attached to the ethmoid region of the cranium ahead of eye. The dorsal and anal fins completely developed and attain the adult complement of rays. The size of the elongated dorsal tentacle is now reduced to the size of the other anterior dorsal fin rays, 6 caudal elements and 12 caudal fin rays are differentiated and arragements of these rays to the caudal elements are 0 + 0 + 5 + 4 + 3 + 0. Full complement of pelvic fin rays developed and anterior 3 rays of the left pelvic fin is in advance of the first ray of the right pelvic fin. Pectoral fins are devoid of rays.

Blotches of pigmentation of the base of the dorsal and anal fins increase in number. There are 4 blotches on the dorsal fin bases (at the bases of 15th to 17th, 27th to 30th, 38th to 41st and 56th to 59th rays) and 3 blotches on the anal fin base (at the bases of 10th to 13th, 20th to 23rd and 40th to 43rd rays). In addition to the pigments described in the preceding stage pigment spots are also seen on the bases of few anterior anal fin rays and on the anterior ray of the left pelvic fin. On the right side of the body myoseptal pigments are developed in the anterio-dorsal region and pigments on the mid-lateral, dorso-lateral and ventro-lateral lines extend further backward.

<u>8.8mm larva</u> (Fig. 7.e)

Teeth are uniserially arranged in both jaws; about 12 in upper jaw and 14 in lower jaw. The dorsal and ventral margins of the nasal depression more thickened. Full count of 7 branchiostegal rays per side developed at this stage. Sprout-like gill rakers are seen on the gill arches. The posterio-ventral part of the liver is hook-like and extends under the intestinal coil. The anterio-posterior axis of the liver is much reduced and it lies in between 1st and 8th myotomes. The sac-like air bladder is seen above the intestinal coil.

There are 82 dorsal and 64 anal fin rays, 14 caudal fin rays are discernible from the middle portion of the cuadal fin (0 + 2 + 5 + 4 + 3 + 0).

In addition to the pigments described in the preceding stages the following developments have also been noticed:

a. bases of all anal fin rays are pigmented.

b. a new line of myoseptal pigments originated in the hypaxial region from the caudal peduncle to the 21st myotome.

c. the myoseptal pigmentation on the anterio-dorsal region of the body as well as the dorso-lateral line of pigments extends further backwards.

10mm larva (Fig. 7.f)

Post-flexion stage. Dentition is more or less equally developed in both jaws. Fold-like outgrowths have developed from the thickened portions of the nasal depression, 7 small gill rakers are discernible on the lower part of the anterior arch. The right eye has begun to migrate at this stage. The fore-brain now attains a rectangular shape and lies above the eye. The optic lobe is some what square and seen behind the eye. The vent opens at 4th myotome.

All the fins fully developed except the pectoral fin. Origin of the dorsal is attached to the ethmoid region of the cranium and its point of attachment has shifted on to the right side of the head over the nasal depression. A new small dorsal ray has developed in front of the old dorsal tentacle. There are 84 dorsal, 65 anal and 17 caudal fin rays. The arrangement of caudal fin rays with 6 caudal elements is: 1 + 3 + 5 + 4 + 3 + 1.

Pigmentation is more or less same as in the preceding stage. On the right side of the body few pigment spots are formed in posterior most part of the mid-lateral line, and the fleshy anal pterygiopohore region. Few dash-like myoseptal pigments can be seen above the mid-lateral line at about the mid portion of the body.

12.5mm larva (Fig. 7.g)

The larva is asymmetrical due to the upward migration of the right eye. The tissue between the ventral edge of the anterior portion of the dorsal fin and the frontal region of the cranium has become thin, and the supra-orbital bars slightly shifted on to the left side. The nostril on the left side has already developed, but on the right side the flaps are not completely fused together. Gill rakers are clearly visible and there are 8 on the lower part of the first gill arch. Air bladder is still massive and lies in between 7th and 11th vertebrae. The vent opens at 3rd vertebra. There are 9 pre-anal and 27 post-anal vertebra.

The first dorsal fin rays originates from above the right nostril; 84 dorsal, 66 anal, 17 caudal and 6 pelvic fin rays are discernible. The left pelvic fin is long-based and reaches up to the urohyal. The pectoral fin rays are not yet formed. The caudal fin is pointed.

At this stage the pigmentation on the body increased considerably. On the right side, the dashes of pigments along the inner margin of the pterygiophore regions get more prominent. Other pigments on the right side of the body are; a line of pigments along the mid-lateral line, a dorso-lateral and ventro-lateral starting from the base of the pectoral fin and ending at about the 26th vertebra, myoseptal pigmentation on the epaxial and hypaxial portions of the body, myoseptal pigments on the anterio-dorsal region of the first 17 myotomes, and on the pre-opercular margin. In addition to these, irregular pigment spots are also seen on the opercular flap, over the pterygiophore regions, abdomen and near the air bladder.

Bases of all the dorsal and anal fin rays are pigmented. Few anterior dorsal rays and pelvic fin rays are pigmented. The mid-ventral line from the anterior tip of lower jaw to the vent is heavily pigmented. The 4 blotches on the dorsal fin and 3 on the anal fin are clearly seen. Air bladder is thickely pigmented on the left side.

15.4mm larva.

Teeth are uniserial and about 20 in each jaw. Nostrils developed on both sides and a blunt projection is seen in front of anterior nostril. Migration of the right eye continues. A depression begins to form above the frontal region of the cranium due to the thinning of the tissue there. The posterio-ventral portion of the liver is tapered and lies below the intestinal coil; 36 vertebrae are discernible.

There are 83 dorsal and 64 anal fin rays. The pectoral fin rays are not yet formed. Pigments begin to develop on the left side also; few pigment spots are seen on the maxilla and inner margin of the pterygiophore regions, a mid-lateral line starting from the anterior region of the body and ends at the first caudal vertebra, and a myoseptal pigmentation along the ventro-lateral line. All other pigmentations are same as in the preceding stage.

22mm larva

Metamorphosting stage. The anterior portion of the dorsal fin detached from the ethmoid region of the cranium and the upper edge of the migrating right eye is visible through this detached portion. Blunt prominences are seen above the maxillary and in front of left eye. Scales are developed on both sides, especially on the lateral line. Cteni are visible in scales near the caudal peduncle on the left side. The scale on the right side cycloid.

There are 84 dorsal, 66 anal, 17 caudal and 6 pelvic fin rays. Actinotrachial rays are visible in the larval pectoral fin.

In addition to the pigments described in the preceding stages scattered melanophores are seen on the head and the body.

Changes in body form.

Both relative pre-anal distance and relative eye diameter decrease during three larval phases (Table - 9), whereas the relative head length and relative body depth increase. The relative snout length and upper jaw length show uniform pattern of development throughout the larval period (Table - 9).

The dentition is first formed when the larvae are about 4mm in length; 4 to 6 teeth are seen in the anterior part of the jaw and in the early post-flexion stage the larvae have minute uniserial teeth in both jaws.

In the 3mm long larva, nostrils are seen as round thickening in front of the eye. At about 8mm the dorsal and ventral margins of this thickening get more prominent and the middle portion deepens. Fold-like outgrowths develop from the thickened portions at about 8.8mm stage. The fusion of these foldings first begin on the left side of the larva at 12mm and at 15.5mm fusion is completed on both sides.

Rudimentary gill filaments are seen in the larvae of 3mm and fully developed gill filaments are evident in the flexion stage. The gill rakers begin to develop at about 8.8mm as tiny protuberances on the lower limbs of the gill arches. By 10mm, the number of gill rakers increases and the adult complement of 8 to 9 gill rakers on the lower limb of the anterior arch is reached at 22mm size.

Branchiostegal rays are evident in the flexion larvae at about 5.88mm stage and 5 in numbers. At 6.8mm, 7 branchiostegal rays are discernible; the posterior most four are longer and directed posteriorly and the anterior most three are directed posterio-ventrally.

In early larvae the liver is massive and occupies in between 1st and 8th myotomes. At this stage the anterio-posterior axis of the liver is grerater than the dorso-ventral axis. Later the anterio-posterior axis is reduced due to the forward pushing of the intestinal coil by the inter-haemal spine of the first caudal vertebra and in the post-flexion stage the dorso-ventral axis is greater than the anterio-posterior axis.

The air bladder is noticed in the larva of 3mm, located just above the straight portion of the intstine and lies in between 5th and 7th myotomes. In larva of about 20mm the air bladder becomes less conspicuous due to intensification of the above lying musculature.

Fin formation.

Fin formation follows a definite sequential pattern in G. polyophthalmus larvae as in other larval forms of sub-family Bothinae. In the 3mm stage only the vertical fin folds and larval pectoral fins are present. A long filamentous dorsal tentacle is also seen at the anterior tip of the dorsal fin fold.

Pectoral fin. The larval pectoral fin present in the 3mm larva has a fleshy base and ray-less outer membrane. Actinotrichia are evident at 20mm. True pectoral fin rays are not developed even in the larva of 29mm length.

Dorsal fin. A single dorsal tentacle at the beginning of the dorsal fin fold of early stages is a characteristic feature of larvae belonging to the sub-family Bothinae.

The first sign of fleshy dorsal pterygiophore region is evident at 4.1mm as a narrow strip of tissue concentration above the dorsal body margin at the level of first caudal vertebra. At about 4.4mm this fleshy region extends forward and backward and 58 dorsal pterygio phores are discernible. At about the same time actinotrichial rays are also formed in the overlying dorsal fin fold. Feebly developed true rays are seen from the central portion of the dorsal fin fold at 5.5mm stage. The origin of the dorsal fin base moves anteriorly at about 4.4mm and the movement continues until the fin base it attached to the ethmoid region of the cranium ahead of eye at 8.8mm. The size of the dorsal tentacle is reduced to the size of the other dorsal fin rays. Another small dorsal fin ray is developed in front and slightly on right side of the reduced dorsal tentacle at about 12mm size. Full complement of dorsal fin rays attained in 10mm larva.

Anal fin. The anal pterygioiphore region is also formed at the same time of the formation of dorsal pterygiophore region (4.1mm). This portion has first appeared at the anterior part of the anal fin fold. At about 4.4mm stage, 33 anal pterygiophores are discernible. Lepidotrichial rays are evident at flexion stage and adult number of fin rays reached at 10mm length.

Caudal fin. The fully formed caudal fin of the G. polyophthalmus has 17 rays and supported by six caudal elements.

A ventral thickening can be observed near the posterior end of the straight notochord in the larvae of about 5.5mm length. This thickened portion is divided in to two at 5.8mm and six at 6.3mm stage. Along with this, 10 feeble rays are formed; 17 rays are formed at 10mm stage.

Pelvic fin. The pelvic fin is visible as a low bud on the ventral outline immediately posterior to the cleithrum at 5.5mm. The pelvic fin basals first appear in the long based left pelvic fin bud at about 6.3mm. The left pelvic fin base is longer than the right one and extends to the urohyal and supported by a cartilaginous plate placed in advance of the cleithram. The fin rays are evident at about 7mm (post-flexion stage) and complete set of rays are formed at 8.8mm stage. The anterior three rays of the left pelvic fin are in advance of the anterior most ray of the right pelvic fin.

Pigmentation

In the early stages pigmentation is restricted to the mid-ventral line of head, trunk and tail, outer margin of pectoral fin and operculam, ventral side of the intestinal coil, roof of the cranium and left side of the air bladder. In addition to these a pair of blotches could be seen each on the bases of dorsal and anal fin folds at about 23rd myotome. After the formation of the fleshy anal pterygiophore region (4.4mm stage), the line of pigment spots in the tail region is seen in between the body proper and anal pterygiophore region. At this stage a similar line of pigment spots also occur along the dorsal side, below the dorsal pterygiophore region. In the flexion stage the pigments intensify on the body (Fig. 7.c) Three blotches are seen on the dorsal fin and 2 on the anal fin. On the right side a line of pigment spots are seen over the trunk vertebrae, externally. Parellel to this line a dorso-lateral and a ventro-lateral line also formed and these lines end at about the middle of the body.

In the post-flexion larvae the number of blotches increased to 4 on the dorsal fin and 3 on the anal fin. Pigment spots also are developed on the bases of first ray of the left pelvic fin and anterior 10 anal fin rays. On the right side myoseptal pigments are evident anterio-dorsally. At 8.2mm stage more bases of anal fin rays are pigmented. Similarly bases of few anterior dorsal fin rays are pigmented at this stage. Dashes of myoseptal pigments are developed ventro-laterally in the posterior most part of the body.

Pigmentation is more intenstified on the right side at 10mm stage. New myoseptal pigments originate dorso-ventrally. In the caudal peduncle pigment spots are developed on the mid-lateral line. Few dashes of pigments are seen over the posterior part of anal pterygiophore region. When the larva attains 12.5mm length the bases of all dorsal and anal fin rays get pigmented. Few anterior dorsal rays are also pigmented to this stage. The myoseptal pigments on the epaxial and hypaxial masses extend further forward. The myoseptal pigments on the anterio-dorsal region reach about half of the body length. The myoseptal pigments also occur anterio-ventrally and near the air bladder. The dorso-lateral and ventro-lateral lines of pigments almost reach the level of 26th myotome. Irregular pigment spots are seen on the operculam, trunk and pterygiophore regions. On the left side of the body pigmentation is restricted to the air bladder and a small mid-lateral line of pigments spots above the pectoral fin. Larva of 15.4mm length undergoes little changes in pigment pattern from earlier stages. Few irregular pigment spots are developed on the head and right side of the body. The pattern of pigmentation is same in transforming stage (22mm) as in the 15.4mm, but more densely placed.

Migration of eye.

The specimens of 8.8mm are symmetrical, the right eye has not begun to migrate. The dorsal fin continues to move anteriorly and its origin is over the anterior edge of eye. By about 10mm the right eye has moved slightly and the origin of the dorsal fin is attached to the ethmoid region of the cranium and its point of attachment has shifted to the right of the head. At this time the supra-orbital bars have begun to shift on to the left side, and as a result the tissue between the ventral edge of the anterior portion of the dorsal fin and the frontal region of the cranium has become thin.

By about 12.5mm, the right eye has migrated further upwards and a depression has been created above the left eye due to the shifting of the supra-orbital bars. At 15.4mm the depresion above the left eye is wider and the supra-orbital bars continue their shifting to the left side. At 20mm the upper edge of the right eye is visible through this depression. At 22mm length, origin of the dorsal fin is detached from the ethmoid region and this detachment extends upto the frontal region. The upper half of the migrating right eye can be seen through this detached portion. In the larger specimen the right eye will move to the left side through the area between the dorsal fin and the frontal region of the cranium where there is a depression created by the shifting of supra-orbital bars.

The characters of the present larvae such as the meristic counts, presence of ctenoid scales on the left side, and cycloid scales on right side and number of gill rakers on the lower part of the anterior arch agree with that of adult. G. polyophthalmus.

The present larvae resemble with larva of Bothus ocellatus Agasiz by Balakrishnan (1963), but differ in the number of dorsal and anal fin rays, number of blotches on the dorsal fin and presence of myo-septal pigments.

Distinguishing characters of **G. polyophthalmus** larvae

Dorsal tentacle single. Dorsal and anal fin rays begin to develop from the anterior part of the caudal region (near the vent). Dorsal 80-86, anal 64-67, vertebrae - 36. Gill rakers 8-9 on lower part of anterior arch.

Migration of eye: the right eye migrates through an opening between the dorsal fin base and frontal region of the cranium.

Pigmentation: Four blotches of pigments on the dorsal fin and three blotches on the anal fin. Body thickely pigmented on right side. Dashes of pigments on the dorsal and ventral body margins, mid-lateral line, dorso-lateral and ventro-lateral lines. Myoseptal pigmentation on the body. Pigment spots on the ventral contour of the body present. Bases of dorsal and anal fin rays pigmented. Irregular pigment spots on the body parts.

Fig. 7. : Developmental stages of G. polyophthalmus

a. 3mm larva

b. 4.4mm larva

c. 5.8mm larva

d. 7mm larva

e. 8.8mm larva

f. 10mm larva

g. 12.5mm larva

Fig. 7

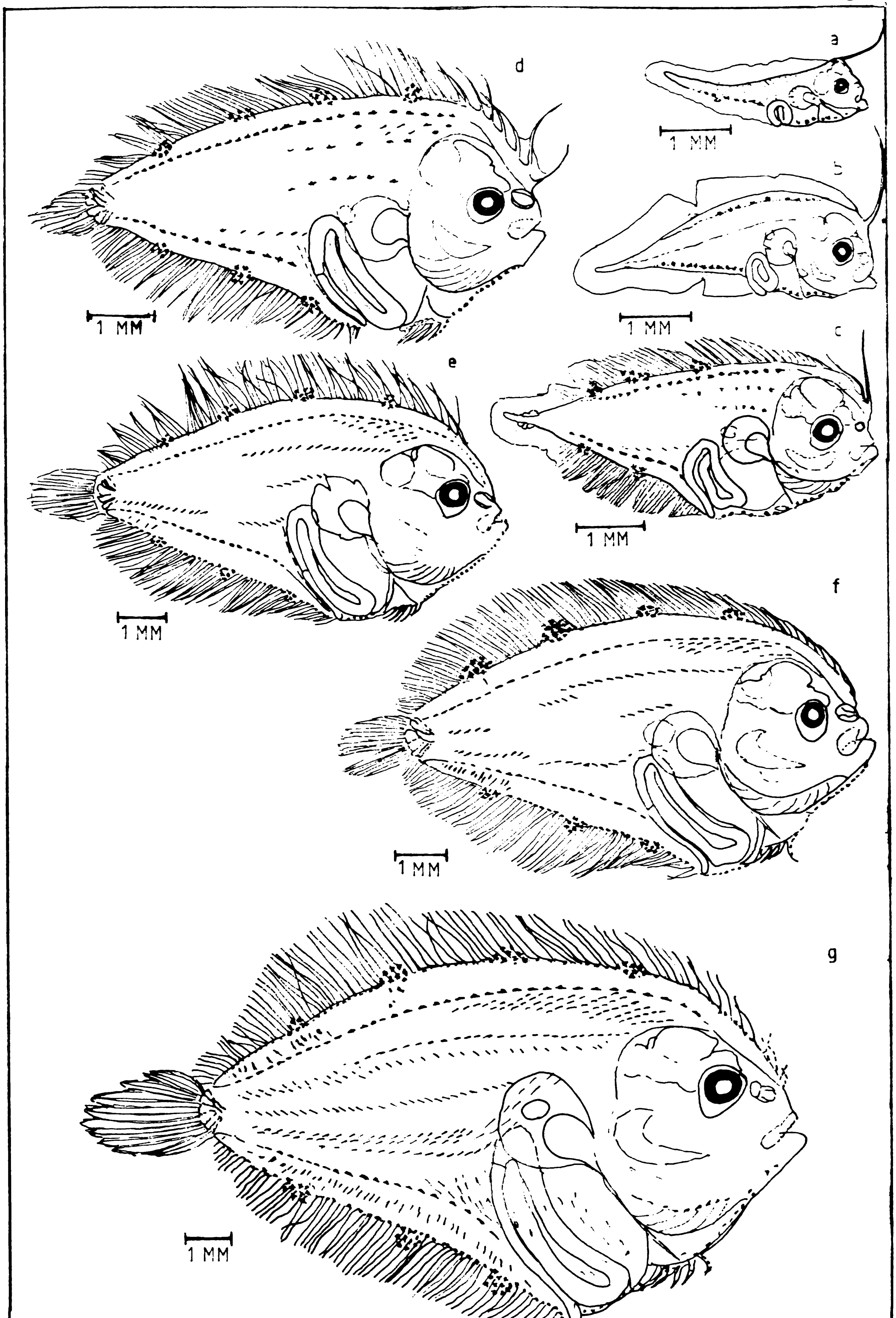


Table: 9. Body proportions of **G. polyophthalmus** larvae
(Proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
3 - 3.9	3.0	47	27	8	7	8	27
4 - 4.9	4.3	43	29	9	7	9	34
5 - 5.9	5.6	43	28	10	6	7	38
6 - 6.9	6.4	42	32	11	6	8	41
7 - 7.9	7.0	40	30	11	6	9	47
8 - 8.9	8.5	41	33	10	6	8	48
10 - 10.9	10.0	38	32	10	5	7	50
11 - 11.9	11.6	36	32	11	5	9	51
12 - 12.9	12.3	35	33	10	5	8	51
14 - 14.9	14.6	37	34	10	5	8	49
15 - 15.9	15.4	36	33	10	5	7	52

3.1.7. LAEOPS GUENTHERI Alcock 1890

A complete series of larval stages from 2.5mm to 48mm length are described here. A 'post-larval' stage of L. guentheri (18.9mm) has been described previously by Balakrishnan (1963).

2.5mm larva (Fig. 8.a)

Pre-flexion stage. Body elongate and lanceolate. About 31 myotomes are countable. The maxillary bones feebly develeoped. Cleithrum well formed. Heart and brain differentiated. Nasal depression not formed. The otocyst seen as an oval-shaped structure behind the eye. The opercular flaps rudimentary and newly formed gill arches are seen through the flap. The gill arches are naked, devoid of gill filaments and rakers. The rectangular shaped liver lies in between 1st and 12th myotomes. The anterio-posterior axis of the liver is 6 times larger than its dorso-ventral axis and supported ventrally by a weakly developed pubic bar. Air bladder is not seen. The intestinal coil formed and vent opens at 15th myomere.

A large single dorsal tentacle originated from the head. The dorsal and anal primordial fin folds confluent with caudal fin fold. Fan-like larval pectoral fin formed.

A single line of pigment spots seen mid-ventrally from angular region to the intestinal coil. Few pigment spots are also concentrated above the intestinal coil.

3.2mm larva (Fig. 8.b)

Pre-flexion stage. An aggregation of tissue is noticed in the nasal region. Rudimentary gill filaments have developed at this stage. The anterio-posterior axis of the liver reduced. The oval-shaped air bladder is seen above the straight portion of the intestine in between 6th and 9th myotomes. The vent opens at 14th myomere, 41 myotomes are countable.

All other characters are same as in the preceding stage.

4.4mm larva (Fig. 8.c)

Pre-flexion stage. Tissue concentration in the nasal region more prominent. Teeth not developed. The dorso-ventral axis of the liver is about half in length to that of its anterio-posterior axis. The intestinal coil partially bulged out, which is a specific character found in the early stages of L. guentheri.

The elongated dorsal tentacle which is about half the length of the NL, has shifted its position from the frontal region to the ethmoid region of the head, and this shifting enables the dorsal tentacle pointing anteriorly. As in other bothid larvae, the dorsal pterygiophore region first appears in the middle portion and extends towards both ends. Here in the mid-dorsal region, a narrow strip of tissue is formed in between the dorsal body margin and dorsal fin fold. The anal pterygiophore region also developed at the same time from the anterior portion, in between the anal fin fold and ventral body margin.

In addition to the abdominal pigmentation described in the preceding stages a large pigment spot is seen on left side medio-laterally at about 23rd myomere. Few irregular spots are also seen on the dorsal tentacle.

5.7mm larva (Fig. 8.d)

Flexion stage. The posterior most part of the notochord slightly flexed. A slight depression is developed in the nasal region. Gill filaments well developed The anterio-posterior axis of the liver very much reduced. The air bladder is vesicular in this specimen and lies in between 7th and 8th myotomes. 45 myotomes differentiated.

The length of the dorsal tentacle is about equal to the length of the larva. Shifting of the anterior portion of the dorsal fin base continuous. 72 dorsal and 46 anal pterygiophores developed in the respective fleshy pterygiophore regions.

Few actinotrichial rays are also visible in the dorsal and anal fin folds. A slight thickening is noticed ventrally at the flexed portion of the notochord. Pelvic fin bud not yet developed. The pectoral fin fan-like and devoid of rays.

Pigment spots on the pubic bar reduced in number and those on the intestinal coil disappear. The air bladder pigmented. Pigmentation on the medio-lateral line and dorsal tentacle present.

11.4mm larva (Fig. 8.e)

Post flexion stage. Jaws are sub-equal and have minute teeth in the anterior part. Branchiostegal rays feebly developed. The liver occupies in between 2nd and 8th myotomes, its dorso-ventral axis greater than the anterio-posterior axis. The pyloric appendages differentiated. Part of the intestinal coil still bulged out. The inter-haemal spine of the first caudal vertebra developed.

The origin of the dorsal fin is attached to the ethmoid region of the cranium ahead of the eye. About 98 dorsal rays and 75 anal rays are discernible, 12 caudal fin rays developed. Six caudal elements are feebly formed. The newly formed caudal rays are supported by the six caudal elements in the order 0 + 0 + 5 + 4 + 3 + 0. Five pelvic fin basals are seen at this stage.

Pigment spot on the pubic bar completely absent. On the left side of the body two blotches of pigments are seen medio-laterally at 25th and 32nd myotomes. Pigments on the air bladder and dorsal tentacle present.

12.7mm larva (Fig. 8.f)

Post-flexion stage. Body more elongated. Nasal depression prominent, 4-5 branchiostegal rays are countable, 46 vertebrae are discernible. First inter-haemal spine more elongated.

Dorsal 98, anal 77, caudal has 14 rays in the order 0 + 2 + 5 + 4 + 3 + 0.

Pelvic fin has 6 basals.

Pigmentation of the air bladder and dorsal tentacle persist. Three blotches of medio-lateral pigments are seen on the left side at 18th, 25th and 33rd myotomes.

16.8mm larva (Fig. 8.g)

Post-flexion stage. The anterior margin of the nasal depression thickened. Six numbers of branchiostegal rays clearly visible. Gill rakers are developed and 6 rakers are seen on the lower part of the anterior arch. The vesicular air bladder is seen above the intestinal coil. There are 45 numbers of vertebrae.

A small ray is developed in front and a little right side of the dorsal tentacle. A wide gap is noticed in between the dorsal tentacle and rest of the rays behind it. Dorsal 102, anal 78, caudal 17 in the order 1 + 3 + 5 + 4 + 3 + 1. The pelvic fin on the right side short based and each fin carries 6 feeble rays.

About 7 blotches of black melanophores are on the dorsal tentacle. Blotches of pigments on the medio-lateral line seen only on the left side of the body, irregular pigment spots are seen on the connecting membrane of the dorsal and anal fin rays and on the inner margin of the dorsal and anal pterygiophore region.

23mm larva

Post-flexion stage. Eyes asymmetrical, eye on the right side slightly moved upwards. Flap-like outgrowths have developed on the upper and lower margins of the nasal depression, 8 small gill rakers on the lower part of the anterior arch. Air bladder lies below the 10th vertebra. The bulged out intestine partially supported by feebly developed pubic bar.

Full complement of all fin rays, except in the pectoral fin developed. Pigmentation on the left side more prominent.

34mm larva.

The eyes migrated further upward. The nasal flaps fused together and nostrils formed. The anterio-posterior axis of the liver very much reduced. Air bladder present.

The small first dorsal fin ray, which is in front of the dorsal tentacle, lies just above the newly formed right nostril. Dorsal 101, anal 80 and caudal 17. Pelvic fin has 6 rays and that on the left side larger. No rays developed in the pectoral fin.

Pigment spots are seen on the ventral part of the opercular, pelvic fin and dorsal tentacle. Rows of pigment spots are seen on the median fins towards their margins and base of the caudal fin. Blotches on the medio-lateral line of the left side and rows of pigments on the base of pterygiophore regions are same as in the preceding stages.

48mm larva

Right eye migrated upto the dorsal margin of the body, in between the dorsal tentacle and 3rd dorsal ray. Dorsal tentacle reduced in length. Nostrils well developed, mouth small. Minute teeth present in both jaws, 8 gill rakers on the lower part of the anterior arch. The ventral portion of the intestinal coil still seen bulged out.

Dorsal tentacle much reduced, but larger than other dorsal rays. As in the adult stage the dorsal tentacle and the small ray in front of it are detached from the remaining dorsal rays. There are 101 dorsal rays and 80 anal rays. All other fins are well developed except the pectoral fin, which has only actinotrichial rays.

Line of pigment spots are seen on the inner margin of both dorsal and anal pterygiophore regions. All the dorsal and anal fins are pigmented towards their margins. Irregularly arranged blotched of pigments are seen on the left side of the body and a few on the dorsal and anal fins. On the right side of the larva a line of pigment spots on the medio-lateral line, myoseptal pigmentation on the hypaxial mass and line of pigment spots in between the dorsal and anal pterygiophores.

Changes in body form.

The relative pre-anal distance decreases during larval developoment whereas relative body depth increases (Table 10). The eye diameter shows uniform pattern of development during pre-flexion and flexion stages and then decreases sharply in post-flexion stage (Table 10). The relative head length, snout length, and upper jaw length show uniform pattern of development duirng the three phases of larval periods.

When the larva attains 6.2mm minute larval teeth are evident in the anterior parts of both jaws. These canine-like teeth are present in all subseaquent stages of the larvae.

The development of nostrils are first discerned in the larvae at 3.2mm, where a round thickening appears in the snout region, in front of the eye. This thickening is much prominent at 4.4mm larva and a depression is developed in the middle of this thickening by about 5.7mm SL. The outer margin of this depression gets thickened and by about 19mm stage flap-like outgrowths have developed from the upper and lower margins. These flaps enlarge in size and fuse together to form nostrils at 34mm stage. Fully formed nostril first appears on the left side of the body.

Gill arches are evident in the 2.5mm larva. Filament buds are developed on these arches at 3.2mm stage and well formed gill filaments discerned in 5.7mm larva. Feebly developed gill rakers can be observed in specimens between 15mm and 16.8mm length. Larvae of 19mm length have fully developed rakers and 6 to 8 in numbers on the lower part of the anterior arch.

The oval-shaped otocyst is visible in all larval stages and lies behind the eye. Brain is well formed even in the smallest larva available (2.5mm NL) and the optic lobe is prominent.

As in other bothid larvae, liver in early stages is having rectangular shape and its anterio-posterior axis is much extended than the dorso-ventral axis. The liver lies in between 1st and 12th myomeres in 2.5mm stage. During development the anterio-posterior axis is very much reduced as the intestinal coil moves anteriorly. Air bladder is present in all stages either in large round shape or in vesicular shape.

Branchiostegal rays are first seen in 6.2mm stage and well developed rays are seen in 16mm larva. The posterior most 3 are longer and directed posteriorly and the anterior most 3 are directed posterio-ventrally.

The intestinal coil has formed in 2.5mm stage. In the subsequent stages the coil becomes more enlarged. The vent is located at the margin of the fin fold and is directed posteriorly. From 4.4mm stage onwards the intestinal coil is partially bulged out. This is an important taxonomic character as it is not met with in any other flat fish larvae except in a post-larva of Parabothus thackwrai reported by J.L.B. Smith (1967). The bulging out of intestinal coil is either due to the weakly developed pubic bar which supports the intestinal coil and liver ventrally or due to the massiveness of the intestinal coil.

In early larvae (2.5mm) 31 myotomes can be seen and are more clearly evident along the middle of the body. At 5.7mm stage about 43 vertebrae are discernile and 45 to 46 number of vertebrae are seen from 6.2mm larva onwards.

Fin formation

Premordial marginal fin, the paired pectoral finbuds and dorsal tentacle are present in the smallest larva collected (2.5mm).

Pectoral fin. The fleshy based, fan-like larval pectoral fin is present in the smallest specimen collected. True pectoral rays are not yet developed in 48mm larva (largest specimen collected).

Dorsal fin. In 2.5mm larva the dorsal fin fold and the tentacle are present. The dorsal tentacle reaches about half of the total length of the larva. Dorsal pterygiophore region first appears in the mid dorsal region when the larva attains a length of 4.4mm (late pre-flexion stage). In the subsequent stages rapid development is noticed towards both anterior and posterior directions and about 72 dorsal pterygiophores are discernible at 5.7mm stage. Along with this development dorsal rays are also formed, first from the middle region and then towards both directions. About 98 rays are seen in 11.4mm stage. The region of the dorsal fin base moves anteriorly on the larvae from 4.4mm onwards and at 11.4mm it it attached to the ethmoid region of the cranium, ahead of eye. A small dorsal ray is developed ahead of dorsal tentacle at 16.8mm stage and lies above the nostril on the right side. This small ray along with the dorsal tentacle is detached from reminder of dorsal fin rays and a wide gap is noticed in between the dorsal tentacle and the ray just behind it (the third dorsal ray).

Anal fin. Formation of anal fin begins along with the dorsal fin. At 4.4mm stage, development of anal pterygiophore starts from the anterior end of anal fin as a streak of tissue in between the anal fin fold and the ventral body margin About 46 anal pterygiophores are countable at 5.7mm. The 6.2mm larva has 30 anal fin rays at the anterior end of anal fin. The adult complement of 77 to 81 anal fin rays are achieved by about 16.8mm.

Caudal fin. Fully formed caudal fin has 17 rays associated with 6 caudal elements. A ventral thickening near the posterior end of the notochord is seen in specimens about 5.7mm and from this thickened tissue, 6 caudal elements developed and about 12 rays are discernible at 11.4mm. All the caudal fin rays are developed by about 15mm and associated with the caudal elements in the order 1 + 3 + 5 + 4 + 3 + 1 (from dorsal to ventral).

Pelvic fin. At 6.2mm length low bud is noticed on the ventral outline immediately posterior to cleithrum, 5 basals are developed on this bud by about 11.4mm. Feebly developed pelvic fin rays are evident in 15.1mm larva and 6 well developed rays are seen at 19mm stage. The left pelvic fin base is elongated.

Pigmentation.

In the early stages pigmentation in L. guentheri larva is mostly confined to pre-anal region. A single line of pigment spot is seen on the ventral contour (on the pubic bar) and few irregular spots on the upper portion of the intestinal coil. This pigment pattern is not altered until the larva attains 4.4mm, during this stage a medio-lateral pigment blotch is seen on the left side at about 24th myomere. Few irregular pigment spots are also seen on the dorsal tentacle. At 5.7mm stage the abdominal pigments are reduced and pigment spots above the intestinal coil totally disappear. At this stage few melanophores develop internally on the air bladder. By about 11.4mm an additional medio-lateral pigment blotch is developed on 32nd myomere and at 12.7mm another blotch is developed on 18th myomere. These three medio-lateral pigment blotches are seen only on the left side.

At about 17mm, 7 blotches are seen on the dorsal tentacle. During this time irregular pigment spots are developed on the dorsal and anal fins, towards their margins and also on the inner margins of the dorsal and anal pterygiophore regions. By about 34mm in addition to these pigmentation few spots are seen on the ventral parts of the operculam, pelvic fin and caudal fin base. At about 48mm stage several irregularly arranged pigment blotches are seen on the left side of the body. On the right side, lines of pigment spots are seen on the medio-lateral line, on the myosepta of the hypaxial mass and in between the dorsal and anal pterygiophores.

Migration of eye.

Specimens of 17mm are symmetrical, the right eye has not begun to migrate. During this time the origin of the dorsal fin continues its movement anteriorly and also a gap is developed in between the dorsal tentacle and 3rd dorsal ray. A slight upward migration of right eye is noticed by about 19mm. This upwards migration of right eye is very slow and at 48mm it reaches on the dorsal margin in between the dorsal tentacle and the 3rd dorsal ray.

Distinguishing characters of **L. guentheri** larva.

First two dorsal rays (the dorsal tentacle and a small ray in front of it) separated by an interspace from reminder of fin. Dorsal fin commences above the nostril of right side. Single dorsal tentacle very large and reaches more than half of the body length. Dorsal 98-101, anal 78-80. Gill rakers 6-8 on the lower part of the anterior arch. The massive intestinal coil bulges between the pelvic fin and anal origin. (A similar instance has been pointed out by Smith(1967) in a post-larva of Parabothus thackwrai, but its last pelvic fin ray is filamentous)

Pigmentation: Three pigment blotches at 18th, 25th and 33rd myotomes on the left side.

Fig. 8. : Developmental stages of L. guentheri

a. 2.5mm larva

b. 3.2mm larva

c. 4.4mm larva

d. 5.7mm larva

e. 11.4mm larva

f. 12.7mm larva

g. 16.8mm larva

Fig. 8

Table: 10. Body proportions of *L. guentheri* larvae
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.5	56	20	8	6	-	16
3 - 3.9	3.6	51	19	6	6	-	16
4 - 4.9	4.4	48	23	5	6	-	23
5 - 5.9	5.7	46	21	5	5	6	26
6 - 6.9	6.2	42	19	5	4	6	23
11 - 11.9	11.4	44	21	5	4	6	30
12 - 12.9	12.7	42	20	4	4	5	28
15 - 15.9	15.1	41	20	5	3	5	30
16 - 16.9	16.8	44	22	5	4	5	28
17 - 17.9	17.0	45	22	6	4	6	35
19 - 19.9	19.0	44	21	8	4	6	36
21 - 21.9	21.0	40	21	8	4	6	34
23 - 23.9	23.0	37	21	7	3	6	37
24 - 24.9	24.5	38	21	8	3	6	40
34 - 34.9	34.0	35	21	6	3	5	35
48 - 48.9	48.0	32	20	5	2	5	35

3.1.8. LAEOPS MACROPHTHALMUS (Alcock 1889)

Larvae of L. macrophthalmus have not been described previously. Five selected stages from 6.9mm to 24.5mm are described here.

6.9mm larva (Fig. 9.a)

Flexion stage. Very minute teeth present in the anterior parts of both jaws. Ossification of the jaw bones completed. The nasal region has a round thickening. Branchiostegal rays not developed. Gill filaments rudimentary. The massive liver occupies in between 2nd and 7th myotomes. Heart developed, ventricle pyriform. Air bladder is vasicular and extends from 8th to 9th myotomes. Brain fully developed. An elongated and slender pubic bar supports the intestinal coil and massive liver ventrally ends in front of the vent. About 39 myotomes are countable at this stage.

The fleshy dorsal pterygiophore region well developed and 85 pterygiophores are discernible. The anteriorly directed dorsal tentacle is elongated and about half the length of the SL, and bifurcated at its apex. A single dorsal pterygiophore is seen in front of the dorsal tentacle, 80 numbers of dorsal rays are feebly developed; 65 numbers of anal pterygiophores and 60 feebly developed rays are seen in the anal fin. Only actinotrichial striations are noticeable in the posterior most portion of both dorsal and anal fins. Four caudal elements have differentiated in the caudal region, below the upturned notochord. Traces of few rays seen in the caudal fin fold. The pelvic fin bud developed on the ventral outline, immediately posterior to cleithrum. The larval pectoral fin fan-like and devoid of any rays.

Few pigment spots are seen on the inner margin of the fleshy dorsal pterygiophore region and on the dorsal tentacle.

10mm larva (Fig. 9.b)

Post-flexion stage. Nasal depression developed and lies in front of eye and above the maxillary; gill filaments well developed. Anterio-posterior axis of liver greatly reduced and lies in between 2nd and 8th myotomes. A vesicular air bladder is seen above the intestinal coil. Branchiostegal rays are feebly discernible.

The large intestinal coil is partially supported by pubic bar. The 'V' shaped pyloric appendages seen in the anterior part of the intestinal coil. In general the intestinal coil in the larval forms of Laeops spp. are large and in some instances the coil bulges out as in L. guentheri.

In most of the larvae the elongated dorsal tentacle is particularly supported by a membrane which reaches from the base to the middle of the tentacle. The anterior portion of the dorsal fin moves forward and reaches up to the ethmoid region of the head. A small ray has developed in front and on the right side of the dorsal tentacle. The first two rays are detached from reminder of dorsal fin rays, 86 dorsal and 64 anal rays are differentiated, 13 caudal fin rays are arranged in the 6 caudal elements in the order 0 + 2 + 5 + 4 + 2 + 0. The ventral fin buds enlarged in size.

Pigmentation same as in the previous stage.

11.4mm larva(Fig. 9.c)

Post-flexion stage. The outer margin of nasal depression gets thickened. Rudiments of gill rakers visible on the gill arches. The anterio-posterior axis of liver reduced further due to the forward pushing of the intestinal coil by the inter-haemaal spine of first caudal vertebra. About 40 vertebrae are countable at this stage.

The first dorsal ray originates above the nasal depression on the right side.

The dorsal fin has 90 rays, 70 rays developed in the anal fin. Full complement of 17 rays differentiated in the caudal fin and arranged with the caudal elements in the order 1 + 3 + 5 + 4 + 3 + 1. The pelvic fin rays feebly developed and the base of the left fin is larger than the right one.

Pigment spots are present in the inner margin of both dorsal and anal pterygiophore regions. Irregular pigment spots are seen on the dorsal tentacle.

16mm larva (Fig. 9.d)

Flap-like outgrowths have developed on the upper and lower margins of the nasal depression. The tissue between the ventral edge of anterior portion of the dorsal fin and the frontal region of the cranium is becoming thin. The larva becomes asymmetrical due to a slight upward migration of the right eye. About 6-7 small gill rakers are countable at the lower part of anterior arch.

Full complement of all the fin rays, except in the pectoral fin,. have developed at this stage. Dorsal 86, anal 70, caudal 17 and pelvic 6.

Pigment spots are less prominent than in the previous stages.

24.5mm larva.

Larva asymmetrical. The right eye migrates further upwards. The tissue above the frontal region more thinned. The nostrils on the left side developed by the fusion of the upper and lower flaps, whereas on the right side thery are not yet fused together. Minute teeth are seen in both jaws, 8 numbers of small gill rakers are discernible on the lower arm of the anterior arch. Liver lies in between 5th and 9th vertebrae. Air bladder not seen clearly due to the overlying tissues. The vent opens at the level of 9th vertebra, 41 vertebrae are countable.

First dorsal fin ray originates above the nostril of the right side. The size of the dorsal tentacle reduced a little. First two dorsal rays detached from the reminder of rays. There are 90 dorsal, 69 anal, 17 caudal and 6 pelvic fin rays. The left pelvic fin base elongated than the right one. The fleshy based pectoral fin has no rays.

Pigment spots are seen on the inner margin of dorsal and anal pterygiophore regions, and on the dorsal tentacle.

Change in body form.

Relative pre-anal distance decreases moderately. The relative head length snout length, upper jaw length and body depth show uniform pattern of development throughout the larval stage whereas the relative eye diameter shows slight decrease during post-flexion stage.(Table - 11).

Dentition is noticed in all the specimens collected. Canine-like teeth are present in the anterior part of the jaws, at 6.9mm stage. Formation of the nostril is typical. A round thickening is noticed in the nasal region of 6.7mm larva. Further, a depression is formed in this region and at 12.3mm length ridges are developed on the upper and lower margins of this depression. These ridges enlarge in size and are flap-like in 16mm stage. In 24.5mm larva these flaps are fused together on the left side and formed the nostril, whereas on the right side these are not fused together.

Bud-like gill filaments are evident in the 6.9mm larva but at 8.3mm stage the filaments are well developed. Traces of gill rakers first appear in 10mm larva and at 15.5mm stage, 6 feebly developed rakers are noticed on the lower arm of anterior arch, 8 rakers are clearly visible in 24.5mm larva.

Brain is well formed in very early stages. The optic lobe is prominent, the fore brain and hindbrain are also well developed. Fully developed heart is noticed in the 6.9mm larva itself. The ventricle is pyriform.

The liver is massive as in other bothid fish larvae and in early stages it lies in between 3rd and 7th vertebrae. During development the dorso-ventral axis of the liver is more enlarged than the anterio-posterior axis. In later stages the posterio-ventral tip of the liver tapers and has a hook-like appearance and this portion lies below the intestinal coil.

The air bladder is conspicuous and present in almost all the larvae and lie above the straight portion of the intestine. The branchiostegal rays first seen in 10mm larva and full complement of six rays are seen in 12.3mm stage. An adult complement of 40 to 41 vertebrae are achieved in 15.5mm larva.

Fin formation

All the fins begin to develop in the smallest larva of L. macrophthalmus, collected (6.9mm).

Pectoral fin. The fleshy based ray-less larval pectoral fin is present in 6.9mm larva and not developed any fin rays in the pectoral fin of the largest specimen collected (24.5mm).

Dorsal fin. As in other bothid larvae the dorsal tentacle is first to form and subsequent development of rays first begins from the middle region of the dorsal fin. In 6.9mm larva rays on the middle portion are more advanced than the anterior and posterior portions of the dorsal fin, whereas for the caudal peduncle only actinotrichial striations are seen. The fleshy dorsal pterygiopohore region is fully developed at this stage and about 85 pterygio phores are countable. The larvae of 6.9mm has 80 feebly developed dorsal rays and the number of rays increased to 86 at 8.3mm stage. Full complement of dorsal fin rays are noticed in the 10mm larva. During this time a small ray is developed in front and on the right side of the dorsal tentacle. This ray along with the dorsal tentacle is detached from the reminder of the dorsal fin. This is a specific character of genus Laeops.

The dorsal tentacle is elongated, reaches about half of its body length. In early stages the dorsal tentacle is partially supported by a membrane which reaches from the base of the tentacle to the middle of it.

At the time when dorsal fin rays begin to develop, the origin of the dorsal fin base moves anteriorly on the larva until the fin base is over the eye. The anterior portion of the dorsal fin continues to shift forward until it becomes attached to the ethmoid region of the cranium ahead of eye. The anterior most ray originates from above the posterior nostril of right side (24.5mm stage).

Anal fin. At 6.9mm larva 65 pterygiophores are observed in the anal region. During this time 60 anal fin rays have developed anteriorly and only actinotrichial rays are seen near the caudal fin. The number of anal fin rays increased rapidly, as in the dorsal fin, and the adult complement of 67 to 70 rays are developed by about 11.4mm SL.

Caudal fin. The fully formed caudal fin has 17 rays associated with 6 caudal elements in the order 1 + 3 + 5 + 4 + 3 + 1 (from upper to lower). At 6.9mm stage the ventral thickening near the posterior end of the upturned notochord is divided and formed four median caudal plates and traces of rays are seen in the caudal fin. By about 8.3mm SL, 10 rays are discernible and it increases to 13 at 11.4mm length. Fully developed caudal fin is seen at 16mm stage.

Pelvic fin. The pelvic fin is visible as a low bud on the ventral outline immediately posterior to the cleithrum in 6.9mm larva. Development continues and at 11.4mm six rays are feebly visible. Well developed pelvic fin is seen at 16mm. The fin on the right side is short-based and on the left side it is elongated.

Pigmentation.

In the early stages pigmentation is confined to the inner margin of the dorsal pterygiophore region and in the dorsal tentacle. At 6.9mm stage a line of pigment spots is seen along the inner margin of dorsal pterygiophore region and few irregular pigment spots are seen on the dorsal tentacle. By about 11.4mm in addition to above mentioned pigmentation, a line of pigment spots is also seen on the inner margin of anal pterygiophore region. During development no change has been noticed in the pattern of pigmentation.

Migration of eye.

Up to 16mm stage the larvae are symmetrical. A slight upward migration of right eye is noticed at 16mm SL. During this time the tissue between the ventral edge of the anterior portion of the dorsal fin and frontal region of the cranium is thin. Upward migration of the right eye continues and it reaches near the margin of the head at 24.5mm SL.

Distinguishing characters of *L. macrophthalmus* larvae.

Single dorsal tentacle, very large and reaches about half of body length. First two dorsal rays detached from reminder of dorsal fin. Origin of dorsal fin above the nostril of right side. Dorsal 86-90, anal .67-70. Gill rakers 6-8 on lower part of anterior arch. Vertebrae 40 - 41. Intestinal coil massive, but supported by a prominent pubic bar.

Pigmentation: Pigmentation limited to the inner margin of dorsal and anl pterygiophore regions and dorsal tentacle.

The interspecific comparison of different body parameters of *L. guentheri* and *L. macrophthalmus* showed that the slope of the PAD, HL, and UJL against BL, relationship are statistically different. But in the case of ED, SN and BD against BL, no specific difference was found to exist. (Table 12).

Fig. 9. : Developmental stages of L. macrophthalmus

a. 6.9mm larva

b. 10mm larva

c. 11.4mm larva

d. 16mm larva

Fig. 9

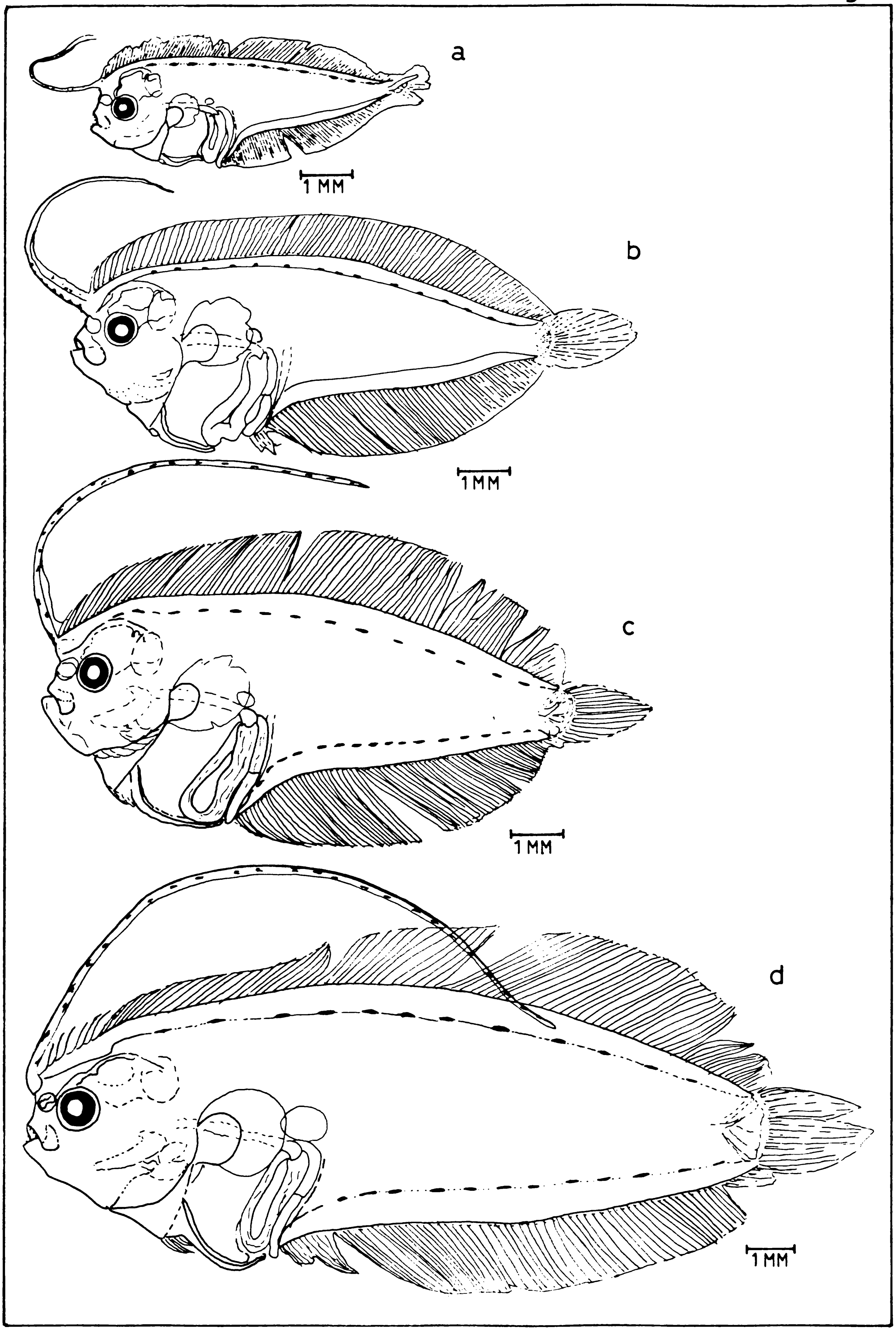


Table: 11. Body proportions of ***L. macrophthalmus*** larvae
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
6 - 6.9	6.9	48	25	7	6	6	32
7 - 7.9	7.2	49	25	7	6	7	33
8 - 8.9	8.3	47	23	8	5	6	36
9 - 9.9	9.2	46	25	8	5	7	35
10 - 10.9	10.0	45	24	8	5	7	35
11 - 11.9	11.6	42	24	8	5	6	36
12 - 12.9	12.3	41	24	8	5	6	37
15 - 15.9	15.5	42	22	6	5	5	35
16 - 16.9	16.0	43	24	7	4	6	39
24 - 24.9	24.5	42	25	8	4	6	33

Table: 12. Inter specific comparison of the slope of the various body relationships in **L. guentheri** and **L. macrophthalmus** larvae

Name of species	Comparing characters	t		p
L. guentheri / L. macrophthalmus	BL - PAD	$\frac{0.041}{0.0163}$	= 2.5153	0.01∠P∠0.02
	BL - HL	$\frac{0.14}{0.0136}$	= 2.9412	0.005∠P∠0.01
	BL - ED	$\frac{0.003}{0.0036}$	= 0.8333	N.S.
	BL - SN	$\frac{0.001}{0.0103}$	= 0.0978	N.S.
	BL - UJL	$\frac{0.027}{0.0067}$	= 4.0299	∠0.001
	BL - BD	$\frac{0.038}{0.0565}$	= 0.6726	N.S.

3.1.9. CYNOGLOSSUS MACROSTOMUS (Norman 1928)

C. macrostomus -which forms an important commercial fishery on the west coast of India and popularly known as the 'Malabar sole', - has been confused with C. semifaciatus by many authors (Menon, 1971). Seshappa & Bhimachar (1955 and Balakrishnan (1961) described and illustrated a series of larval stage of 'Malabar sole' which they mistakenly identified as C. semifaciatus. Here six selected stages from pre-flexion (2mm NL) to metamorphosing stage (9.7mm SL) are described in detail.

2mm larva (Fig. 10.a)

Pre-flexion stage. Body thin, transparent, laterally compressed and symmetrical. Head round, snout small, eye pigmented, otocyst developed, nostrils not formed. Mouth developed but no indication of teeth in jaws. Heart thin-walled. The gill arches feebly discernible. Air bladder present at the level of 9th myomere. Mid brain prominent. A very prominent bulge seen ventrally containing the intestinal coil. Vent opens at the level of 12th myomere, 32 myotomes are visible.

Notochord straight. The primordial marginal fin present and extends from the nape of head to the posterior margin of intestinal coil. A bifurcated dorsal tentacle originates above the head. Fan-like pectoral fins with fleshy base present.

Black chromatophore seen at the ventral surface of the intestinal coil, dorsal tentacle, roof of air bladder and on the outer margin of the fan-like pectoral fin. A double line of pigmentation on the dorsal and ventral body countour, which lies on either side of dorsal and anal fin folds, The pigmentation on the base of dorsal fin fold interrupted to form 5 to 6 dashes of pigments, where as it is continuous on the base of anal fin fold. A few irregular pigment spots are also seen on the anal fin fold.

3mm larva (Fig. 10.b)

Pre-flexion stage. Head prominent. Maxilla feebly developed. Rudiments of nostril developed as a round thickening at the snout region in front of eyes. The opercular flap differentiated. Branchiostegal rays not seen. Gill filaments feebly formed. The liver visible in front of intestinal coil.

The dorsal tentacle and fin folds present. Pigmentation same as in the preceding stage.

4.8mm larva (Fig. 10.c)

Flexion stage. 2-3 minute conical teeth in both jaws. Nasal depression deep and foldings developed on the upper and lower margins of nasal depression. The anterior tip of rostral cartilage grows downwards and reaches the snout region The maxilla reaches the posterior margin of eye. Gill filaments developed, 6 branchiostegal rays are visible at this stage. Air bladder seen in between 6th & 9th myotome. About 42 myotomes are discernible.

Fleshy dorsal and anal pterygiophore regions develops. About 90 dorsal and 60 anal pterygiophores are seen, 4 hypurals are formed on the ventral side of the slightly flexed notochord. Pelvic fin-bud developed in front of the intestinal coil.

Few pigment spots are formed on the roof of the cranium. Air bladder and intestinal coils pigmented. The 7 dashes of pigments seen at the inner margin of the dorsal pterygiophore region is continuous, but more concentrated at 6 to 7 places. A line of pigment spots is seen at the outer margin of the anal pterygiophore region. Irregularly placed pigment spots are seen on the anal fin folds, and pectoral fin fold. In addition, a discontinuous line of pigment spots is seen on the mid lateral line.

6.5mm larva (Fig. 10.d)

Post-flexion stage. Body more elongated. Dentition in both jaws.

The rostral cartilage grows further downwards and a notch is developed in between the anterior tip of rostral cartilage and snout. The anterior tip of rostral cartilage slightly detached from the body proper; thinning of tissue is also noticed in between the rostral cartilage and head region. Head enlarges in size. The intestinal coil still bulges out and vent opens on the right side of the body.

There are about 96 feeble dorsal rays, of which the first few are separated and remaining rays are united together with fin fold; 74 anal fin rays are also seen; 5 - 6 hypural elements developed in the caudal region and 3 feeble caudal rays are visible. In the ventral fin bud about 4 rays are feebly differentiated.

Irregular pigment spots are seen on the opercular flap. All other pigmentation same as in the preceding stage.

8mm larva (Fig. 10.e)

The larva is assymmetrical as the right eye slightly migrated upwards. At this stage the larva shows the sign of metamorphosis as the rostral cartilage is detached from the ethmoid region of the cranium and encloses a small space between itself and inter-orbital region of the head. The nasal flaps not fused together. The bulging of the intestinal coil less pronounced. Air bladder still present. Vertebrae 49 in number.

The dorsal tentacle reduced in length. About 102 dorsal rays, 82 anal rays and 10 caudal rays are developed.

9.7mm larva (Fig. 10.f)

Minute teeth on the right side of the jaws. Nostrils formed, the anterior one is tubular and posterior slit-like. Branchiostegal rays 6 in number. Maxillary reaches verymuch behind the left eye. The right eye migrated to the margin of the slit, formed in between the cranium and rostral cartilage which is partially detached from the anterior portion. Gill opening narrow. The gill membrane united. The gill filaments and minute gill rakers are seen. Air bladder still exists. The size of intestinal coil reduced. Vent opens at right side of the body.

The dorsal tentacle not present; 100 dorsal rays, 79 anal rays and 10 caudal fin rays formed. Four rays in pelvic fin. The ray-less, fan-like larval pectoral fin still present.

The pigmentation on left side more prominent. The 9 dashes of pigmentation on the inner margin of dorsal pterygiophore region and 7 to 8 dashes of pigmentation on the inner margin of anal pterygiophore region spread to the body proper, and form irregular cross bands on the left side of the body. Few irregular pigment spots are also seen on the vertical fins. Pigmentation on the ventral portion of intestinal coil, air bladder and on the head region are still present.

Changes in body form.

The relative pre-anal distance and relative eye diameter decrease during larval development whereas the relative head length and relative body depth increase (Table 13). Throughout the larval stages the relative snout length and relative upper jaw length show uniform pattern of development (Table 13).

The nostril begins to develop as round thickening in the snout region, in front of eye. It first seen when the larva is about 2.5mm in length. Upper and lower margins of the nasal depression get more thickened at about 4.8mm and flap-like projections formed. These flap-like projections are fused together to from anterior and posterior nostrils at about 8.2mm length.

Gill arches present in 2mm larvae, bud of gill filaments noticed in 3.15mm stage. At about 4mm stage the filaments are well formed. but gill rakers are seen only in 8.2mm stage. Air bladder present in all larval stages.

Fin formation.

Larval pectoral fin present in all stages of larvae which will later shed off from the body and lack in adult.

Dorsal fin. From the very early stage of development a pair of dorsal tentacle is present in the head region. At about 4mm stage, 64 dorsal pterygiophores are developed posteriorly. Feeble rays are developed in the fin fold posteriorly and about 101 rays are countable in 5.5mm larva. Fully developed rays are seen from 6.7mm larva onwards. The fully formed dorsal fin has 100 - 106 fin rays. During development the dorsal tentacle is reduced in size and forms the anterior dorsal ray. During metamorphosis the dorsal tentacle is partially absorbed in the body and partially decayed and dropped off (Seshappa & Bhimachar - 1955).

Anal fin. Anal fin forms as in the case of dorsal fin. Fully formed anal fin has 78 - 84 rays. At 4mm stage 48 anal pterygioiphores developed. About 73 feeble rays are seen at 5.5mm stage and fully formed rays are seen in 7.5mm larvae.

Caudal fin. The fully formed caudal fin has 10 rays. A ventral thickening is noticed at the posterior end of the straight notochord in 4mm larva, 4 hypurals are seen in 4.8mm larva. About 3 feeble rays are formed in 6.5mm larva and at 7.5mm full complement of caudal rays are seen.

Pelvic fin. The pelvic fin-bud first appears in the larva having a length of 4mm; feebly developed 4 rays are seen in 6.7mm larva.

Pigmentation.

In the early stage the pigmentation is confirmed to the dorsal and ventral body margins and ventral side of intestinal coil. Outer margin of the larval pectoral fin is also having scattered pigment spots. There are 6 to 7 dashes of pigmentation on the dorsal body margin and continuous line of pigment spot on ventral body margin. At about 4.8mm stage thick concentration of pigment spots are seen on the ventral margin at 5 to 6 places. At about 4.8mm stage another line of pigment spots developed in between fleshy anal pterygiophore region and anal fin. In addition, pigmentation is also formed on the mid lateral line, opercular flap, ventral fins, roof of air bladder and cranium. During early metamorphosis stage, irregular bands of pigments develop on the left side of the body.

Migration of eye.

In 4.8mm larva a notch is developed on the snout, just above the eye. The anterior tip of rostral cartilage reaches just above the notch and begins to detach from the body at about 6.5mm stage. During further development the tissue in between the cranium and rostral cartilage get thinned and a slit-like opening is developed in 8mm larva. In 9.7mm larva the upper edge of the right eye is visible through the slit.

Distinguishing characters of **C. macrostomus** larvae.

A pair of dorsal tentacles on the head. Dorsal and anal fin rays begin to develop from the posterior end of caudal portion (near the caudal fin). Dorsal 100 - 106, anal 78-84, vertebrae 47-51, liver and optic lobe of brain small.
The right eye migrates to left side through a slit formed by the detachment of rostral cartilage from the head.
Pigmentation: There are 6 to 7 dashes of pigmentation on the dorsal body margin and continuous line of pigment spots on the ventral body margin. On ventral side another line of pigment spots seen in between fleshy anal pterygiophore region and anal fin. Pigmentation also seen in the mid-lateral line, opercular flap, vertical fins, roof of the air bladder and cranium. In late post-flexion stage, irregular bands of pigments develop on the left side of the body.

Fig. 10. : Developmental stages of C. macrostomus

a. 2mm larva

b. 3mm larva

c. 4.8mm larva

d. 6.5mm larva

e. 8mm larva

f. 9.7mm larva

Fig.10

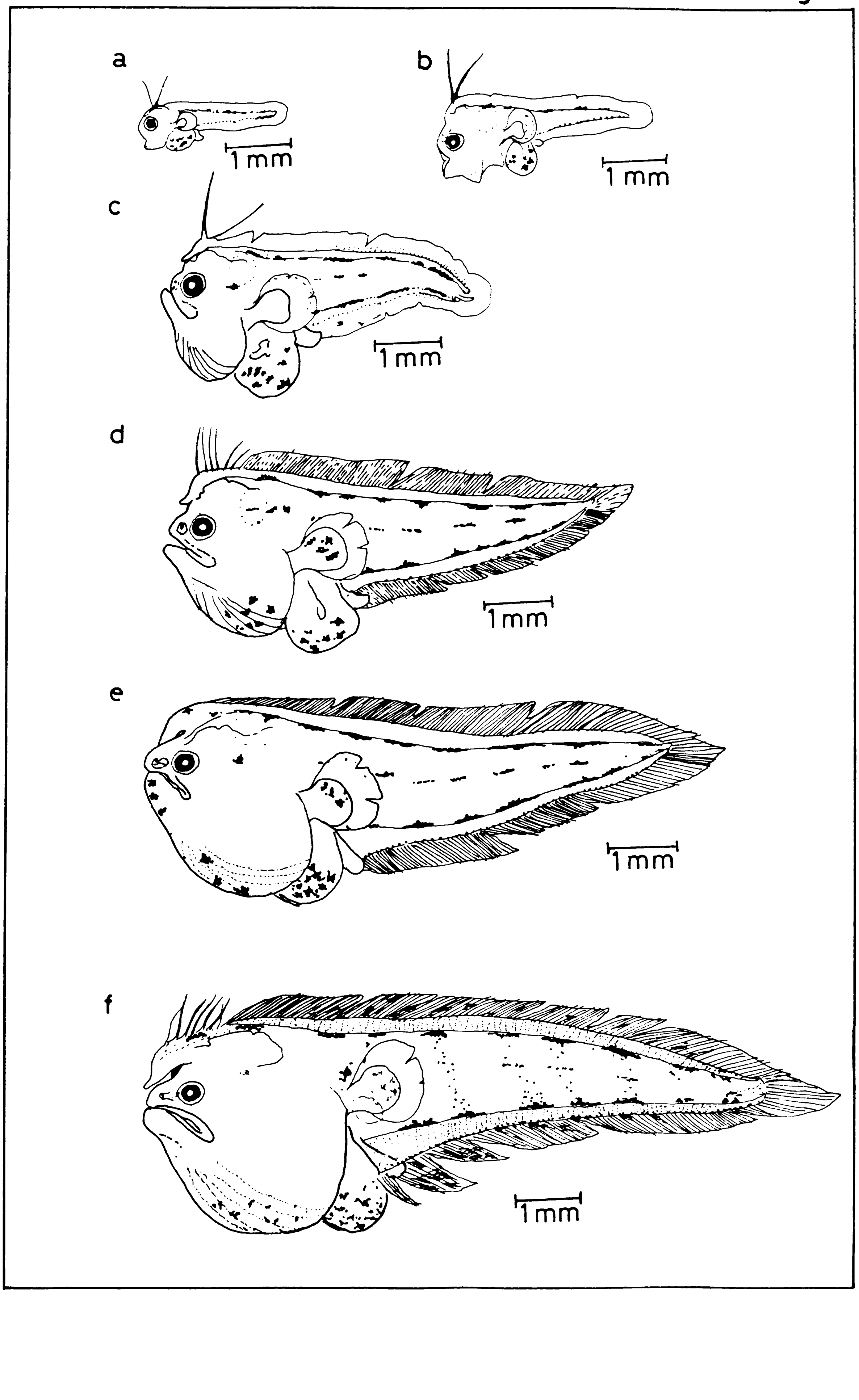


Table: 13. <u>Body proportions of ***C. macrostomus*** larvae</u>
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.42	43	26	4	8	-	12
3 - 3.9	3.52	42	28	7	6	11	17
4 - 4.9	4.46	40	28	7	5	11	22
5 - 5.9	5.34	41	28	6	5	11	23
6 - 6.9	6.39	40	29	6	5	11	25
7 - 7.9	7.25	40	29	6	4	11	25
8 - 8.9	8.38	38	32	7	4	11	24
9 - 9.9	9.65	38	31	6	4	12	23

3.1.10. PARAPLAGUSIA BILINEATA (Bloch 1784)

Gopinath (1946) described a larva of P. bilineata having a length of 10mm from Trivandrum coast. John (1951) described and illustrated a matamorphosed stage (18mm) from Madras coast. In the present study six selected stages from 3.5mm to 17.5mm are described in detail.

3.5mm larva

Body lanceolate, mouth large, maxillary well formed. Nasal depression developed in front of eye. Brain well developed and optic lobe more prominent. Opercular flaps differentiated. Gill arches formed. Branchiostegal rays not developed. Heart and liver discernible. Intestinal coil developed and vent opens on the right side of the body. About 40 myotomes are discernible.

A pair of dorsal tentacle seen above the occipital region of the head. The upper median fin fold originates from the nape of the head and backwards and the lower median fin from behind the intestinal coil and both confluent posteriorly with caudal fin fold. Larval pectoral fin fan-like with a fleshy base.

Dashes of pigments seen at three places on the dorsal body contour and in the mid-lateral line. A line of post-anal pigmentation is seen on the ventral contour of the body, where aggregation of chromatophores are seen at six places. Pigment spots also seen on the outer margin of pectoral and anal fin folds posterior tip of straight notochord, air bladder and isthmus region.

4.5mm larva (Fig. 11.a)

Pre-flexion stage. Rostral cartilage not developed. An oval-shaped nasal depresion seen in front of the eye. Protuberances of gill filaments evident on the gill arches. Air bladder enlagerd and lies in between 3rd and 7th myotomes. About 47 myotomes are countable at this stage.

'V' shaped dorsal tentacle seen on the head. Formation of caudal fin is evident as a slight thickening on the posterio-ventral part of the straight notochord. Vertical fin folds devoid of any rays.

Pigmentation more or less same as in the preceding stage. Few pigment spots are seen on the dorsal fin fold posteriorly.

6.9mm larva (Fig. 11.b)

Flexion stage. Marked changes have been noticed at this stage. The well developed rostral cartilage runs forward and downward and its anterior tip at the level of fore-brain. Nasal depression deepens. Gill filaments well developed. Six number of feebly formed branchiostegal rays are seen and 49 myotomes (9 + 40) are discernible.

The paired dorsal tentacles large in size and each tentacle is having two strands united at the base and detached at the distal end. The anterior tentacle is directed forward and the posterior one upward. Dorsal and anal pterygiophores have develeoped as thin layer of tissue in between respective fin folds and body proper. Three hypural elements are noticed below the flexed portion of the notochord. Ventral fin bud developed in front of the intestinal coil, mid ventrally. About 90 dorsal pterygiophores and 80 anal pterygiophores have developed from the posterior parts of the thick pterygiophore regions. Formation of pterygiophores from the posterior part is an unique character of family Cynoglossidae. Fan-like pectoral fin reduced in size.

Dashes of pigments seen on the inner margins of the dorsal and anal pterygiophore regions; 8 on the dorsal and 6 on the ventral margins. Mid lateral line has 3 dashes. The last two dashes of the dorsal and ventral rows are larger in size. In addition to ventral row a continuous line of pigment spots present at the base of anal fin fold. Pigmentation on air bladder, intestinal coil, isthmus region, and outer margin of pectoral fin present. Few irregular spots are also seen at the ventral part of the operculam.

11.3mm larva (Fig. 11.c)

Post-flexion stage. Rostral cartilage enlarges in size and reaches just above the nasal depression. Outer margin of nasal depression thickened. Opercular flaps well formed and fused together. The six branchiostegal rays clearly visible; the anterior two are directed downward and the other 4 directed backward Air bladder small in this specimen and lies in between 6th to 9th vertebrae. Intestinal coil reduced in size. All the fins, except pectoral, have developed. Dorsal fin has 112 rays, the first two are larger. Anal 87, caudal 8,. Caudal elements well developed, 4 feebly developed rays seen in the median ventral fin. The rayless pectoral fin further reduced in size, 51 vertebrae are discernible.

Pigmentation increases, 9 dashes at the inner margin of dorsal pterygiophore region, 7 dashes at the inner margin of anal pterygiopohore region are connected by continuous row of pigment spots. Base of the anal fin rays are also pigmented Mid-lateral line has 4 dashes of pigments. Two stellate melanophores are seen on the roof of the cranium. Both dorsal and anal pterygiophore regions pigmented at about 42nd vertebrae. Pigmentation also seen on air bladder, ventral side of intestinal coil, operculam and anal fin rays.

13mm larva (Fig. 11.d)

Post-flexion stage. Epicranial bony system well developoed. The erisma, feebly developed, prolonged anteriorly. Strongly developed rostral cartilage reaches further downward. Maxillary reaches the middle of eye. Teeth not developed. Flaps developed on the outer margin of nasal depression. The size of intestinal coil much reduced.

Fin rays well formed. First two dorsal rays still larger. Dorsal with 107, anal 87, caudal 8 and median ventral fin 4 rays. Dorsal and anal fin confluent with caudal.

Pigmentation more prominent, 9-10 dashes at the inner margin of dorsal pterygiophore region. Pigmentation at the inner margin of anal pterygioophore region more or less continuous and thickened at 7-8 places. Mid lateral line has 7 dashes. Bases of all anal fin rays pigmented. Few irregularly placed spots on dorsal, anal and caudal fins posteriorly. Pigmentation on other parts of the body as in the preceding stage.

17.5mm larva

Early metamorphosis stage. Body asymmetrical. The right eye migrates a little upwards and a slit-like opening formed in between the cranium and upper lying epicranial bony systems, through which the right eye migrates to left side during development. Scales developed. Cteni feebly formed on the scales, particularly on the ocular side. Fringed tentacles appeared on the lips of left side. Nostrils developed by the fusion of the flaps in the nasal depression which is single and tubular on left side. A small rostral hook developed. Jaws weakly formed and devoid of teeth. Intestinal coil very much reduced in size. Rudimentary pectoral fin not yet shed off from the body. Dorsal with 103, Anal 77, Caudal 8 and median ventral fin 4 rays.

On the left side stellate chromatophores seen all over the body and vertical fins, except in the caudal fin and on the snout. Margin of the roastral hook free of pigments. On the right side, longitudinal rows of pigments are seen on the inner margins of dorsal and anal pterygiophore regions. Branching chromatophores are seen in the myosepta. Pigmentation on the vertical fins as on the left side. Irregular pigment spots seen on the ventral side of the intestinal coil.

Operculam is not pigmented on right side.

Changes in body form.

The relative body depth increases whereas relative upper jaw length undergoes a moderate diminution during the larval development (Ta ble 14). All other characters such as relative pre-anal length, head length, snout length and eye diameter show uniform pattern of development throughout the larval stages (Table 14).

Dentition is not seen even in the largest larva collected, (17.5mm SL). Nostril developed as a round thickening on the snout of 3.5mm larva. A depression is formed at the middle of this thickening at 7.8mm stage and the outer margin gets thickened in 11.3mm larvae. Flap-like outgrowths seen on the outer margin of the nasal thickeneing at 13.1mm stage and in the 16mm larva these outgrowths get fused together to form nasal tubes. Oval shaped otocyst present in all the stages of larvae collected.

Rudimentary gill filaments discernible in 3.5mm larva and fully developed ones are evident in 6.9mm larva. As in other cynoglossid larvae liver is very small in larvae of P. bilineata and well developed liver is evident in 3.5mm larva. Air bladder is present in all the larval forms and lies above the peritonial cavity. The intestinal coil is develeoped in the smallest larva itself. About 40 myotomes are countable at 3.5mm stage and in 65mm larva the number of myotomes increases to about 50; 51 to 53 vertebrae are seen from 7mm stage onwards.

Fin formation.

Primordial marginal fins and a pair of dorsal tentacle are present in the early stages of larval development. The larval pectoral fin is present in all the stages of larvae collected. The caudal fin elements are the first to develop, followed by dorsal, anal and pelvic fins.

Pectoral fin. During metamorphosis the fan-like, fleshy based larval pectoral fin is reduced in size and finally shed off from the body. At 17.5mm stage (the largest larva in the collection) though the size of the fin is reduced, it exists as a pair of small structure.

Dorsal fin. As in other fishes of Family Cynoglossidae the dorsal fin of *P. bilineatus* is first developed from the posterior part. At about 5mm a thin layer of dorsal pterygiophore region appears near the caudal end, 55 numbers of pterygioophores discernible at 6.5mm stage. In the early flexion stage (6.9mm SL) the number increases to 90. Feebly developed actinotrachial rays are seen in 7mm; larvae at 7.8mm length 109 dorsal rays are clear and well formed rays are seen at 11.3mm stage (post-flexion stage).

Anal fin. Anal fin also developed at the same time of the dorsal fin's development. At 3.5mm only anal fin fold is present. At 5mm anal pterygiophore region is developed at the posterior end of anal fin fold, 45 anal pterygiophores are evident at 6.5mm stage. Traces of feeble rays are first evident at 7mm and full complement of anal fin rays reached at 11.3mm stage.

Caudal fin. At 4.5mm a slight thickening is noticed on the posterio-ventral aspect of the straight notochord. During development the thickening enlarges in size and at 6.5mm it is divided in to 3 caudal elements. Feebly developed caudal rays are also noticed at this stage. Fully developed caudal rays seen at 11.3mm stage.

Pelvic fin. A median pelvic fin bud is seen at 6.5mm stage. At 7.8mm two rays are formed on the bud and adult number of 4 rays are achieved at post-flexion stage (11.3mm).

Pigmentation.

In the pre-flexion stage, pigmentation is seen on the dorsal and ventral contours of the body, and mid-lateralline. Dashes of pigmentation seen, three each on the dorsal countour and on mid-lateral line. Though the pigmentation is continuous on the ventral contour, concentration of pigment spots is seen at six places. In addition, pigment spots are also seen on the outer margin of the larval pectoralfin fold, anal fin fold, posterior tip of straight notochord, air bladder and isthmus region of the head.

Pigmentation in the flexion larvae is similar to that described for the pre-flexion stage, except in the additional concentration of pigment spots on the dorsal and ventral body margin. On the dorsal body margin the number of dashes increases to eight and the last two dashes of both dorsal and ventral body margins are larger in size. In addition to ventral row, a continuous line of pigment spots are present at the base of anal fin. Few irregularly arranged spots are also developed at the ventral part of operculam.

During further development, the number of dashes on dorsal and ventral body margins increases. In the post-flexion stage the dorsal pterygiophore region has 9 to 10 dashes and anal pterygiophore region has 7 to 8 dashes. Mid-lateral line has 7 dashes of pigments. Few irregular spots are seen on the dorsal, anal and caudal fins posteriorly. In early metamorphosis stage stellate chromatophores are developed all over the body and ventral fin on the left side. Caudal fin and snout regions are free of pigments. Margin of rostral hook is also devoid of pigments. On the right side longitudinal rows of pigments are seen on the inner margin of dorsal and anal pterygiophore regions and branching chromatophores in the myosepta. Pigementation on the vertical fins is as on the left side.

Migration of eye.

At 17.5mm stage the right eye migrates a little upwards. A slit-like opening is developed in between the cranium and upper lying epicranial body system, through which the right eye migrates to left side during development.

Distinguishing characters of **P. bilineata** larva.

A pair of dorsal tentacles on the head. Dorsal and anal fins begin to develop from the posterior portion of the caudal region (near the caudal fin). Dorsal 100-114, anal 72-89. Single median pelvic fin with 4 rays. Vertebrae 45-52. Ctenoid scales on both sides. In late post-flexion stage lip on the left side fringed.

Eye migration: The anterior portion of the rostral cartilage detached from the head and a slit-like opening developed above the cranium through which the right eye migrates to left side.

Pigmentation: During pre-flexion stage dashes of pigmentation on the dorsal and ventral contours of the body and on the mid-lateral line. Pigment spots are also seen on the outer margin of larval pectoral fin fold, anal fin fold, posterior tip of straight notochord, air bladder etc. During development the number of dashes increases. In early metamorphosis stage stellate chromatophores are developed all over the body on the left side.

Fig. 11. : Developmental stages of *P. bilineata*

a. 4.5mm larva

b. 6.9mm larva

c. 11.3mm larva

d. 13mm larva

Fig. 11

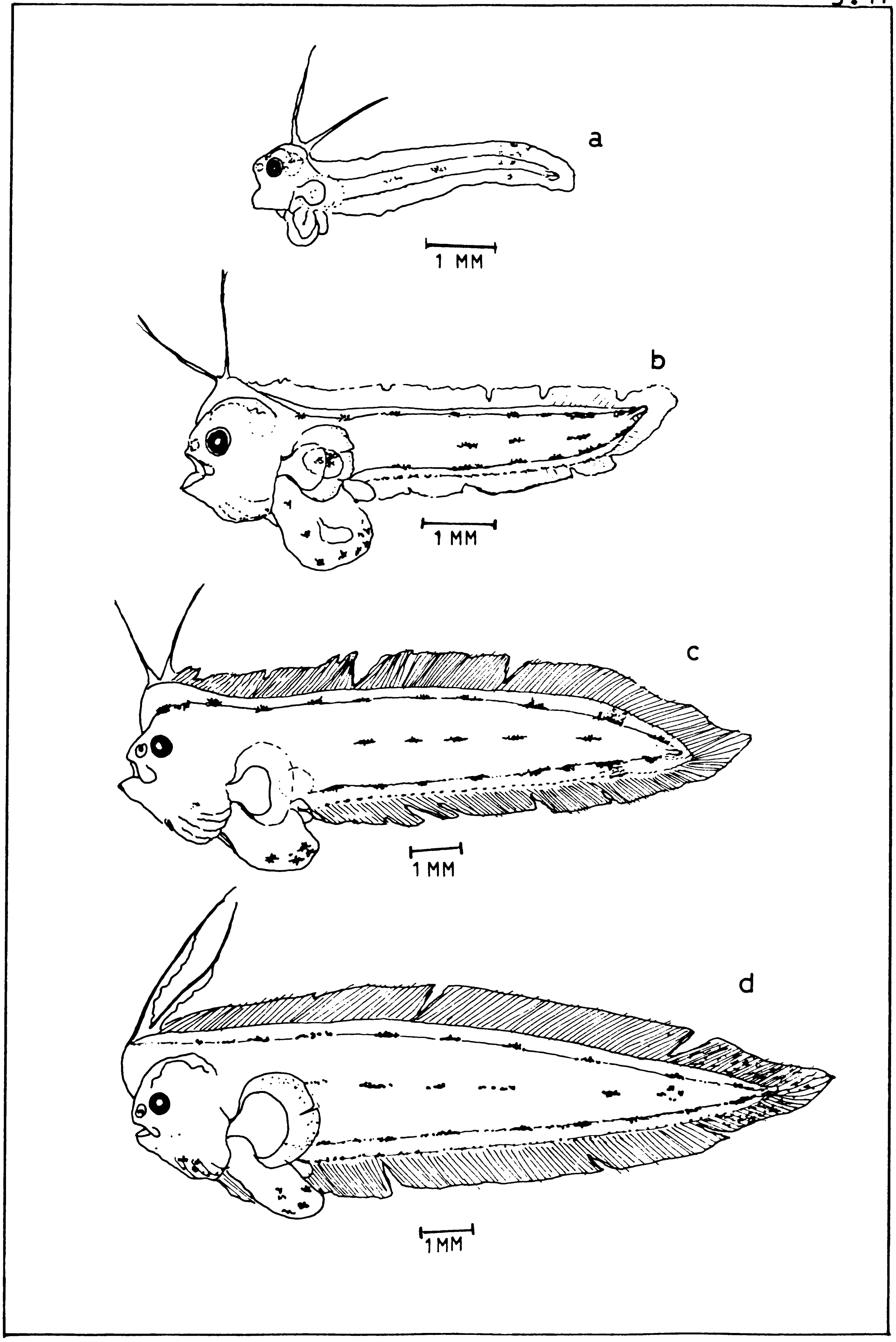


Table: 14. Body proportions of **P. bilineata** larvae
(Propotions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
4 - 4.9	4.80	29	19	4	5	8	8
5 - 5.9	5.34	31	19	4	5	9	9
6 - 6.9	6.42	33	19	5	5	8	12
7 - 7.9	7.20	32	21	4	5	7	13
8 - 8.9	8.23	30	19	4	5	6	16
10 - 10.9	10.20	29	20	3	5	5	15
11 - 11.9	11.30	34	22	4	4	7	20
13 - 13.9	13.00	29	19	4	5	5	22
17 - 17.9	17.50	29	23	4	4	6	29

3.1.11. ASERAGGODES CYANEUS (Alcock, 1890)

Larvae of A. cyaneus have not been described previously. In the present study 9 selected stages from 3.8mm to 14.2mm are described in detail.

3.8mm larva (Fig. 12.a)

Pre-flexion stage. Body symmetrical and broad anteriorly. Lower jaw little prominent. A round thickening is noticed in the nasal region. Branchiostegal rays not developed. Gill filaments well formed. Heart and brain differentiated. Hind brain more prominent. An oval shaped otocyst seen behind the eye. Air bladder is small and vesicular, lies in between 6th and 8th myomeres. The intestinal coil developed and backwardly directed vent opens at 15th myomere level, 34 myotomes discernible at this stage.

Primordial marginal fin folds present. Dorsal fin fold originates from the occipital region of the head. The pterygiophore regions developed from the anterior part of both dorsal and anal fin folds. About 48 dorsal pterygiophores developed in the fleshy dorsal pterygiophore regional anteriorly. Few actinotrichial rays visible in the anterior part of the dorsal fin, 35 anal pterygiophores developed in the anterior part of the anal pterygiophore region. There are 2 epurals and 7 hypurals in the caudal region. Striations of actinotrichial rays are also visible in the caudal fin fold. The fan-like pectoral fin has fleshy base. Pelvic fin-bud not developed. Formation of the scales are seen as a pair of scale platelets on either side of caudal peduncle.

The larva is heavily pigmented on the ventral half of the body and pectoral fin base. Branched chromatophores are seen on the head and over the intestinal coil. Few pigment spots are also seen on the caudal fin fold. The ventrolateral region heavily pigmented and it spreads upwards to form five bands. The bands are tapering towards the dorsal side except and last band on the caudal peduncle, where it spreads towards the dorsal and anal fin folds. A small band is also formed from the sphenotic region of the head and ends at the anterior tip of dorsal fin fold.

4.9mm larva (Fig. 12.b)

Post-flexion stage. Lower jaw little prominent. Outer margin of the nasal depression gets thickened, 4 branchiostegal rays feebly discernible. Gill filaments well developed. Liver very small. Brain well differentiated and small in size. The vent opens at 10th myomere.

Fin folds present, 66 dorsal and 41 anal pterygiophores differentiated. The caudal fin has 14 feebly developed rays. Caudal elements clearly seen. Ventral fin bud formed behind the ventral tip of the cleithrum. On the left side thin cutaneous flaps (dermal keels) are developed on the lateral line system, on the operculam and on the anterior end of the dorsal pterygiophore region. Pigment pattern is same as in the preceding stage.

5.6mm larva (Fig. 12.c)

Post-flexion stage. Nostril well developed. The anterior nostril tubular and the posterior one is slit-like. Branchiostegal rays clearly formed. A large air bladdr lies in between 5th and 9th vertebrae. Vent opens at 10th vertebral level. Vertebrae 37 (vertebrae are not easily countable as in other flat fish larva due to the heavy pigmentation and thickness of the body wall and so cleared and alizarine stained specimens were used for taking mertistic counts).

The dorsal and anal fin folds not yet completely separated from the caudal fin. About 59 actinotrachial rays are discernible in the dorsal fin and 48 in the anal fin, 18 feeble caudal rays developed. **There** are 2 epurals and 7 hypurals. Pelvic fin base developed as a thickening mid-ventrally, behind the operculam.

Two pairs of scale plate-lets are developed on either side of caudal peduncle. Dermal keels increased in number. Dorso-lateral line reaches upto the level of pectoral fin base. Lines on the operculam as in the previous stages.

Pigmentation increased on the body. About six vertical bands are developed on both sides; the posterior most one is larger and extends to dorsal and anal fins. Branched chromatophores are seen on the snout, opercular region, over the intestinal coil and on the pectoral fin base. Anterior end of the dorsal fin and base of the caudal fin pigmented. Few irregular spots are seen on the dorsal and anal fins. Pigmentation more prominent on right side.

6mm larva (Fig. 12.d)

Inwardly directed teeth at the anterior tips of jaws. Nostrils on both sides well differentiated, 6 branchiostegal rays are discerned. The intestinal coil much reduced in size, 37 vertebrae are prominent.

Three pairs of scale plate-lets have developed on the caudal peduncle. The dermal keels on the dorso-lateral line reaches to about 12th vertebral level.

Constrictions have developed at the joining junctions of caudal fin with that of dorsal and anal fins. Vertical fins are membareneous. Dorsal 62, anal 48 and caudal 18 feebly developed rays. Pectoral fin-bud clearly visible on the ventral contour just in front of the intestinal coil. The pigment pattern same as in the preceding stage.

6.8mm larva (Fig. 12.e)

A notch has developed above the snout. On the right side, the anterior nostril tubular and posterior one is slit-like, where as on the left side nostrils are not completely formed. Opercular flaps fused together ventrally. Air bladder persists. The ventral bulging of the intestinal coil reduced in size.

The origin of the dorsal fin bends downwards and reaches just above the newly formed notch on the snout region. Dorsal 66, anal 46. The dorsal and anal fins completely separated from caudal fin. The caudal fin has 18 rays. All the fin rays of the vertical fins are inter-connected by thin membranes. The pelvic fin-bud enlarges in size.

The number of sensory dermal keels increases. The dorso-lateral line reaches upto the 34th dorsal ray. The mandioopercular line well developed and reaches the base of the larval pectoral fin. The supra-orbital line united with medio-lateral line, which is extended up to the caudal fin. More number of scale plate-lets are evident in the caudal region.

Pigmentation is same as in the previous stage.

8.2mm larva (Fig. 12.f)

A fissure developed in the notch above the snout. The left eye migrates a little upward, The upper jaw reaches the level of the posterior margin of fixed eye. The tubular anterior nostril on the right side larger than that of the left side. The gill opening extends upto the upper part of the larval pectoral fin base. The opercular flap completely covered with skin.

Dorsal 67, anal 46 and caudal 18. Pectoral fin rays feebly developed. Number of scales increased in the caudal region.

11.3mm larva (Fig. 12.g)

Fissure above the snout enlarged inwardly. The left eye migrated further upwards and reached very near to the fissure. The tubular anterior nostril downwardly directed.

Dorsal fin originates above the fissure and has 69 rays; 49 anal rays developed. Pelvic fin has 5 simple rays. The pelvic fin on the right side more median in position. The caudal fin, where it is free from dorsal and anal fins has 18 rays, of which median 14 rays are slightly branched.

The dermal keels, which are associated with the lateral line system are prominent on the left side and obscure on the right side. The general arrangement of lateral line system on the left side is as follows: (Fig. 12.i) the cephalo-dorsal line begins at the tip of snout region and runs posteriorly along the dorsal contour of the head and united with dorso-lateral line at the occipit. The dorso-lateral line runs posteriorly along dorsal contour of the body and ends near middle of the body. The supra-orbital line begins near the anterior end of the snout, extending posteriorly on the mid-lateral side of the head in a curved line to the temporal region. The medio-lateral line begins from the conjuction of supra-orbital line and runs posteriorly in a straight line on the median axis of the body and further extends to three caudal fin rays. The pre-opercular line, which is not fully formed in this specimen due to the migration of the left eye, originates from supra-orbital line and runs downward and forward and ends at the mouth cleft. The mandioopercular line is a double line and on the ventral side of the operculam and the line begins near the tip of the lower jaw, runs backward along the ventral contour of the head, ending at the rear area of the opercle. The temporal commissure absent. On right side medio-lateral line only present.

More scales developed in the caudal region.

12mm larva (Fig. 12.h)

Left eye migrated to the margin of the fissure and can be seen through the opening. Teeth not seen. About 4 to 6 rows of scales, parallel to mid lateral line developed in the caudal region. The scales are strongly ctenoid and mostly unbranched. Numbers of scales decreased towards anterior region.

Dorsal fin originates just above the snout. Dorsal has 71 rays and anal 50. Caudal fin has 18 rays, the mid 14 are branched. The caudal fin is associated with the last three vertebrae. There are only 3 dorsal supporting structures lying above the urostyle. The first 2 epurals originating from the penultimate vertebra, support two rays and other epural supports next two caudal rays. There are 7 hypural elements, all but 3 of which are associated with the urostyle 9 caudal rays are supported by hypural elements adjacent to the urostyle, 4 by the hypurals originating from the penultimate vertbra and last one by the element originating from ante-penultimate vertebra.

Pelvic fins have 5 rays each and sub-symmetrical.

The lateralline system and the pigmentation are same as in the preceding stage.

14.2mm larva

Left eye not completely migrated to right side. Two nostrils on each side; anterior nostril on right side tubular and posterior nostril slit-like; on the left side both nostrils tubular.

Scales, serrated with strong cteni seen on the caudal peduncle and 7 to 8 longitudinal rows of ctenoid scales on the entire length of the body (these rows of scales mainly confined towards the mid-lateral line of both sides). Lateral line system as in 11.3mm stage.

Dorsal with 70 simple rays, first ray in front of right eye. Anal 50 rays; dorsal and anal fins free from caudal. Caudal fin rounded, the median 14 rays branched, but the rest ones simple. Pelvic fins short-based and sub-symmetrical in size.

In addition to the typical pigmentation on both sides of the body, on the right side, few dark brown blotches are also developed. These blotches as seen in the adult are arranged on the mid lateral line and near the dorsal and ventral margins of the body.

Changes in body form.

Relative body depth increases moderately during larval development (Table 15). The pre-anal distance and eye diameter shows gradual diminution during development where as head length, snout length show uniform rate of growth (Table - 15)

The larval dentition is more or less very feeble in development, 2 to 3 pairs of teeth present in the anterior part of both jaws in the post-flexion stage from about 5.9mm length onwards. In the members of the dextral soles of family soleidae, the lateral line system on blind side is detected by the arrangement of the cutaneous flaps or dermal keels developed on or near the system. Here dermal keels first appear in the flexion larva of about 4.6mm length and clearly discernible in later stages. The following lateral line system is present on the left side of the post-flexion larvae;-cephalo-dorsal line, dorso-lateral line, supra-orbital line, pre-opercular line and mandio-opercular line. Temporal commissure is absent.

Nasal thickening is noticed in the smallest larva collected (3.9mm). Folding developed in the periphery of this round thickening in the flexion larva of 4.9mm length. Fully formed nostrils evident in 5.6mm larva. On the right side the anterior nostril is tubular and posterior one is slit-like, where as on the left side both are tubular. In all the larvae collected, gill filaments well developed and devoid of any gill rakers. Heart and liver formed in the 3.9mm larva. In all specimens liver is very small in size in contrast to that in the larvae of family Bothidae. Opercular flaps are thick and confluent with each other ventrally. Branchiostegal rays developed in pre-flexion larvae and 7 in number. Full complement of 37 vertebrae discerned at 5.6mm stage.

Fin formation.

In the development of A. cyaneus, the caudal fin completes development first, followed in order by the dorsal, anal and pelvic fins. The larval pectoral fin is present in all stages of the larvae as a vestigial organ and it may shed off during development.

Dorsal fin. Development of dorsal fin ray is an important taxonomic character in larval flat fish. Here, the origin of dorsal fin ray first begins from the anterior part of the dorsal fin fold. At 3.9mm stage 8 to 10 feeble rays are developed anteriorly. Along with this development about 48 dorsal pterygiophores are also formed. When the larva attains 5.6mm length about 60 feeble rays are developed in the dorsal fin and 65 to 70 dorsal pterygiophores are also discernible. Fully developed dorsal fin is seen in 9.5mm larva.

Anala fin. There are 35 anal pterygiophores in 3.9mm specimen. Anal fin rays begin to develop from the anterior end of anal fin fold. The number of pterygiophores increased rapidly in the fleshy anal pterygiophore region and by about 5.6mm lenth, 48 feeble rays are developed. An adult complement of 47 to 50 rays was achived in the larva of about 9.5mm length.

Caudal fin. The fully formed caudal fin has 18 principal fin rays associated with 10 caudal elements in the order 1 + 1 + 2 + 3 + 2 + 2 + 2 + 3 + 1 + 1. Larvae of 3.9mm length has 2 epurals and 7 hypurals. Actinotrachial rays are also seen on the caudal fin fold; 13 feeble rays are discernible at 4.6mm stage. Adult complement of rays are achieved at 5.6mm stage.

Pelvic fin. Pelvic fin base developed at 5.6mm as a low bud below and behind cleithrum. This bud enlarged during development and 3 feeble rays are evident at 9.5mm stage and 5 rays developed at 11.3mm stage. The pelvic fins short-based and sub-symmetrical in size.

Migration of eye.

The upward migration of left eye is first noticed in 8.2mm larva. But the development of fissure, for the migration of left eye to right side, has started in the 6.8mm stage itself, as a slight notch above the snout. The depth of the notch increased and a fissure developed in 8.2mm larva. At 11.3mm stage the fissure enlarged in size and separated the 'orsal cartilage from the snout region. At 12mm stage the upper part of the left eye reached the margin of the fissure.

Distinguishing characters of ***A. cyaneus*** larvae.

No dorsal tentacle present. Opercular flaps confluent ventrally. Liver and intestinal coil very small in size. Dorsal pterygiophore region develops from the anterior part of the dorsal fin fold. Dorsal fin originates from just above the snout. The rays of the vertical fins are inter-connected by thin membranes. The round caudal fin free from dorsal and anal fins.

Dorsal fin: 67 - 82 rays, Anal fin 45 - 57 rays, pelvic fin - 5 rays.

Vertebrae 37 - 38.

Formation of scales: Scale platelets are seen on either side of caudal peduncle from very early stages - scales ctenoid.

Lateral line system: lateral line system on blind side associated with series of fine dermal keels.

Eye migration: the left eye migrates to right side through a fissure developed above the snout.

Pigmentation: Ventro-lateral region of the larvae heavily pigmented and 5 to 6 bands formed; the last band, near the caudal peduncle spreads towards the dorsal and anal fins. Pigmentation also seen on the sphenotic region of the head and vertical fins.

Fig. 12. : Developmental stages of *A. cyaneus*

a. 3.8mm larva

b. 4.9mm larva

c. 5.6mm larva

d. 6mm larva

e. 6.8mm larva

f. 8.2mm larva

Fig. 12

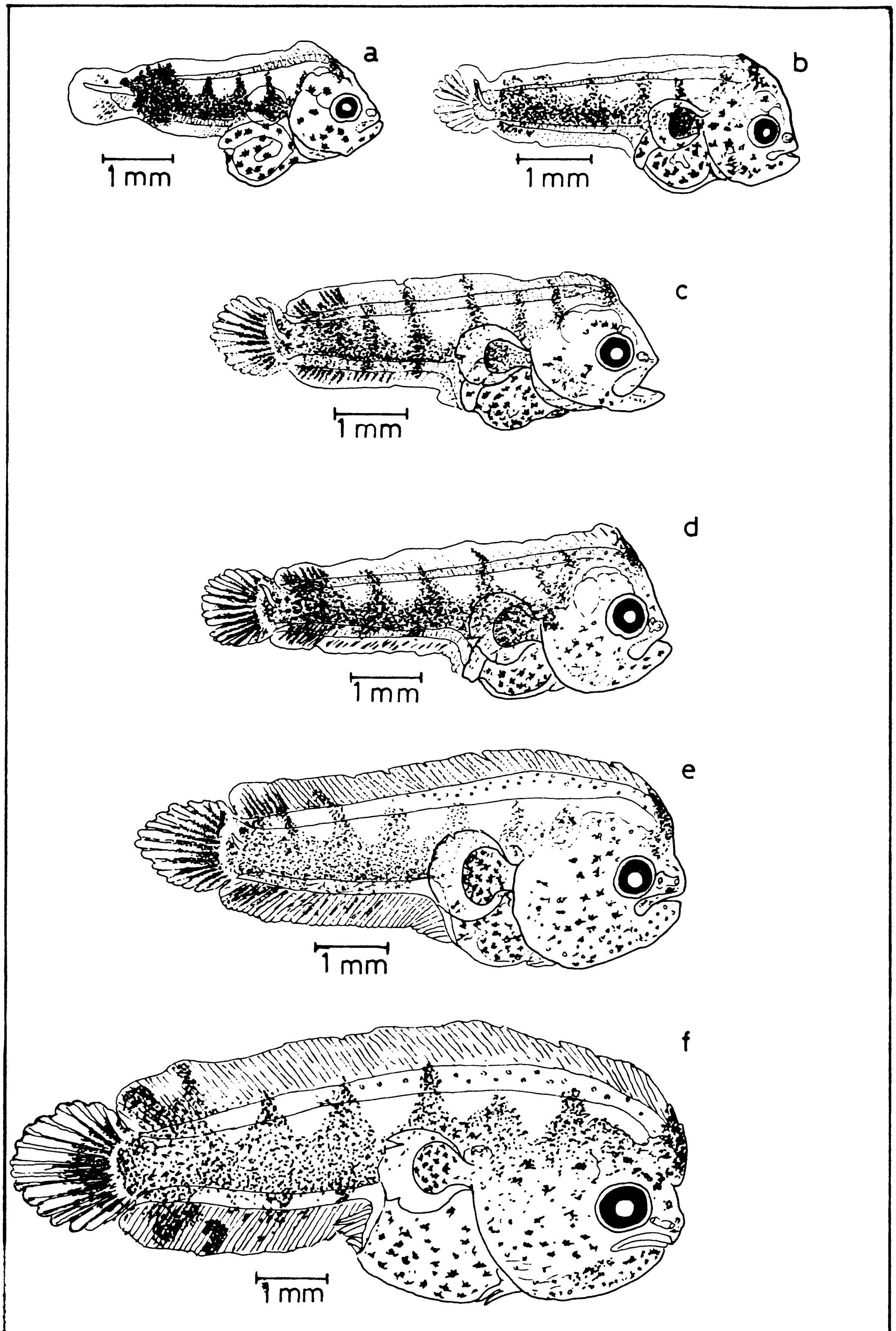


Fig. 12. : Developmental stages of A. cyaneus (Cont.)

g. 11.3mm larva

h. 12mm larva

i. 11.3mm larva - Showing the arrangement of lateral line system of left side of the body.

Fig. 12

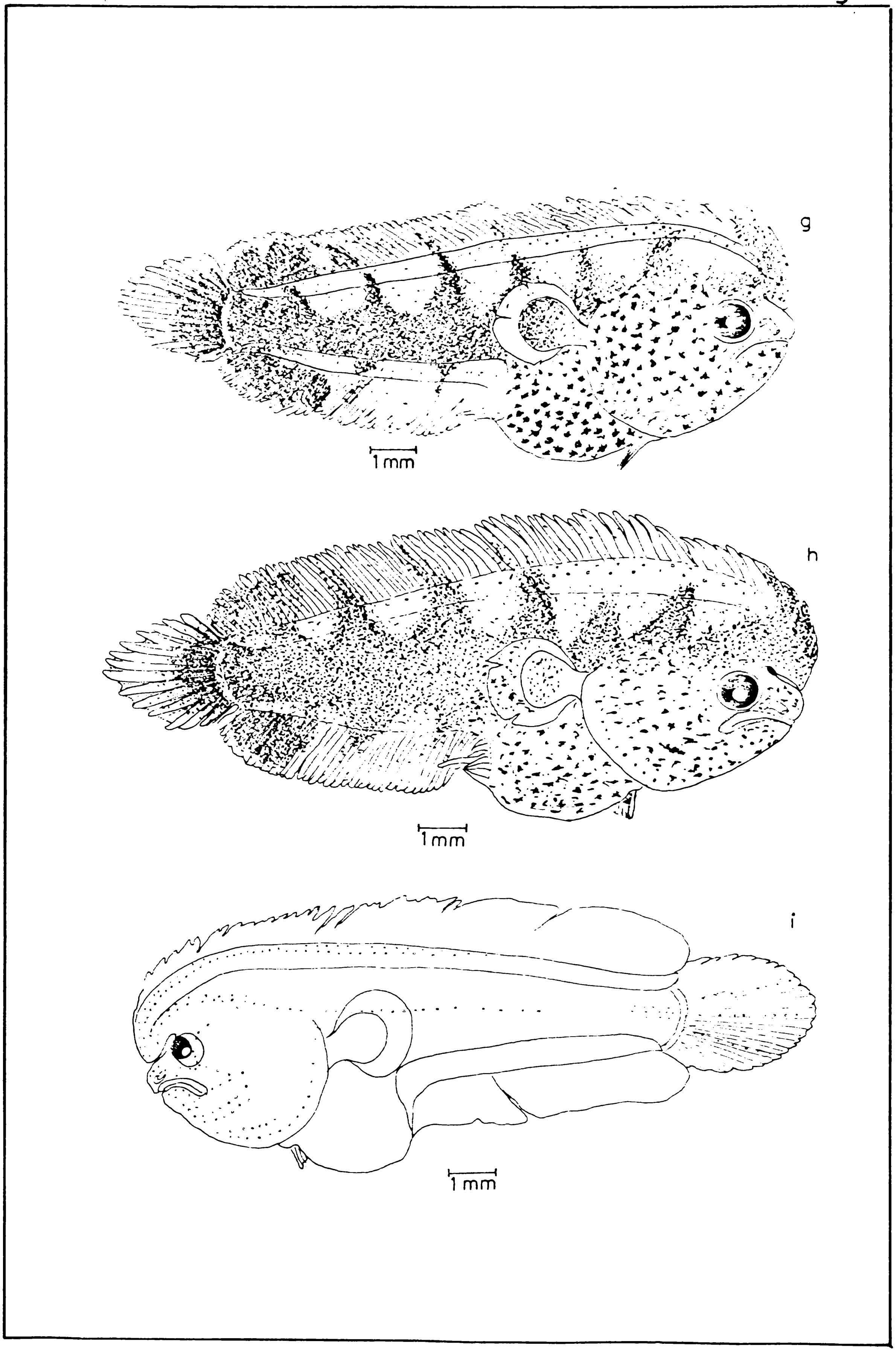


Table: 15. Body proportions of ***A. cyaneus*** larvae
(proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
3 - 3.9	3.8	58	32	8	8	8	34
4 - 4.9	4.75	49	31	5	7	11	32
5 - 5.9	5.43	52	33	6	8	11	34
6 - 6.9	6.53	51	33	6	7	12	36
7 - 7.9	7.55	50	32	6	7	12	38
8 - 8.9	8.2	54	34	6	7	12	39
9 - 9.9	9.5	47	36	5	6	11	37
11 - 11.9	11.15	49	34	7	6	11	39
12 - 12.9	12.0	49	33	7	5	11	38
14 - 14.9	14.2	44	33	6	5	11	41

3.1.12. SAURIDA UNDOSQUAMIS (Richardson, 1848)

Zvjagina (1965) has described a 4.9mm larva as S. undosquamis from Gulf of Tonkin. In the present study 11 selected stages from 2.55mm to 19.8mm stages are described in detail.

2.55mm larva (Fig. 13.a)

Pre-flexion stage. Lower jaw prominent, teeth absent in both jaws, otocyst present. Eye pigmented. Brain well developed; fore-brain very small and in front of eye; the massive mid-brain above the eye and hind-brain behind the eye. Liver and heart developed. About 40 myotomes develeoped. Notochord straight.

Fin fold present. Pectoral fin fleshy-based, fan-like and devoid of any rays.

Pigmentation confined to the ventral portion of the body, 6 pairs of peritonial pigments, the 2nd 4th and 6th pairs are very small. A branching chromatophore seen midventrally at 38th myomere.

3.1mm larva (Fig. 13.b)

Pre-flexion stage. Teeth not developed. Opercular flap formed. Gill arches discernible but no gill filaments. Heart and brain developed. Mid-brain prominent, 45 myotomes countable.

Fin fold present. Formation of the caudal elements begun as a ventral thickening on the posterior end of straight notochord.

Pigmentation as in the preceding stage.

4.4mm larva (Fig. 13.c)

Pre-flexion stage. Minute teeth in upper jaw. Rudimentary gill filaments formed. Myotomes 46, (pre-anal 31, post-anal 14).

Fin fold present. Fan-like pectoral fin has no rays. Thickening on the caudal region more prominent.

Pigmentation as in the preceding stage, the first, third and sixth pairs of peritonial pigments larger.

5.5mm larva (Fig. 13.d)

Flexion stage. The posterior end of notochord flexed slightly upwards. Nasal depression begins to develop in the snout region in front of the eye. Small teeth present in the anterior portion of both jaws. Gill filaments well developed, gill rakers not seen. Branchiostegal rays not seen. Myotomes 47 numbers. Three hypural elements developed in the caudal portion, fin-fold fringed at the position of 2nd dorsal. Pigmentation as in the previous stage.

7.6mm stage (Fig. 13.e)

Post-flexion stage. Slight thickening noticed in the anterior margin of the nasal depression. Branchiostegal rays developed, 47 myotomes developed. Posterior end of the notochord projects outside of the caudal portion.

Anal fin base developed and 3 anal fin basals clearly visible. Caudal fin has 7 hypurals and slight thickening noticed in the epural portion. Lepidortrachial rays visible in caudal fin. Pelvic fin bases not developed.

Peritonial and anal pigmentation same as in preceding stages. Single branching chromatophore seen on each side of caudal elements.

8.8mm larva (Fig. 13.f)

Post-flexion stage. Teeth in both jaws. Maxillary reaches to the anterior margin of the eye. Gill filaments well developed, 48 myotomes clearly discernible.

Dorsal fin fold fringed at the adipose fin area. Anal fin fold with 8 basals. Caudal fin has 8 hypural elements. About 18 principal caudal fin rays feebly developed. Pectoral fan-like.

No change in pigment pattern.

11.9mm larva (Fig. 13.g)

Post-flexion stage. Flap-like projection developed in the margin of nasal depression. Maxillary reaches to the middle of eye. Gill filaments well formed, but gill rakers not seen. Vertebrae 31 + 17.

Anal fin has 9 basals, few rays feebly developed, 19 caudal fin rays formed, 4 basals developed in the upper portion of the fleshy base of pectoral fin. Pelvic fin bud developed mid-ventrally at about 12th myomere.

In addition to the well formed six pairs of peritonial pigment spots, an additional small pair is seen just above the vent. Branching chromatophore behind the anal fin enlarged in size. In the caudal region the number of chromatophores increases.

12.8mm larva (Fig. 13.h)

Post-flexion stage. Flaps in the nasal region enlarges. Canine teeth in both jaws. Branchiostegal rays developed, about 48 vertebrae are formed.

Bases of the dorsal developed in between 16th and 22nd myomere, 10 anal fin rays discernible, another ray feebly developed from the basal of anterior anal ray. Caudal fin rays well developed, 2 to 3 secondary rays are also developed on either side of caudal fin. Pectoral fin has 7 basals and feebly developed rays are seen in the upper portion of the pectoral fin. Pelvic fin bud enlarged in size.

Seven pairs of peritonial pigmentation including the small spots above the vent, 2 branching chromatophores behind the anal fin, 3 spots at the base of caudal fin.

16.7mm larva (Fig. 13.i)

Teeth well formed. Nasal flaps not fused together. Branchiostegal rays well developed, gill rakers not seen. Otocyst present. Vertebrae 48.

Dorsal fin bud with 5 feeble rays. Anal fin has 11 rays and lie in between 35th and 44th myomeres. Caudal fully developed. Pectoral fin has 10 feeble rays, 2 to 3 basals are also developed ventrally, pelvic fin bud enlarged in size.

Pigmentation as in the previous stage, the pigments behind the anal fin extended further backwards.

18.2mm larva **(Fig. 13.j)**

Nostril developed by the fusion of flaps. Maxillary reaches to about the posterior margin of eye. Opercular flaps well defined. Vertebrae 31 + 17.

Dorsal fin well formed and has 10 rays. Adipose fin differentiated. Anal fin has 11 rays. Well developed caudal fin forked; pectoral fin has 12 feebly developed rays, few basals are also developed on the ventral side. Pelvic fin has 5 feeble rays.

Seven pairs of peritonial pigment patches, 2 branching chromatophores in the ventral contour, just behind the anal fin, 2 branching chromatophores at the base of caudal fin.

19.8mm larva (Fig. 13.k)

Nostrils well developed. Canine teeth in both jaws. Gill rakers not seen. Vertebrae 47. Dorsal fin has 11 rays. Adipose fin at the level of anal fin, which has 11 rays, 19 principal caudal fin rays. Pectoral fin rays not fully developed and about 13 rays are discernible, 6 feebly developed rays are seen on the pelvic fin bud. The position of the pelvic fin base is in advance of dorsal fin base.

Four branching chromatophores seen at the base of caudal fin. Other pigmentation as in the preceding stage.

Changes in body form.

The relative pre anal distance, and eye diameter decrease slightly during development (Table 16). The relative head length, snout length and body depth show uniform growth rate throughout the period whereas the relative upper jaw length increases (Table 16).

A pair of canine teeth form in the anterior portion of jaws at about 3.4mm length. The number of teeth increases gradually and at 19.2mm length the jaws are fully occupies by the canine-like teeth. The nostril begins to develop as a round thickening on the snout, in front of eye at about 4mm length. During pre-flexion and flexion stages a depression is formed at this area and at late post-flexion stage (8.8mm) the margin of this depression gets thickened. Folding developed from this thickening and at about 16.5mm stage foldings fused together and nostrils formed. Rudimentary gill filaments appear in the pre-flexion stage (3.4mm and during flexion stage (5.5mm) these gill filaments are well developed. Gill rakers are not yet developed in 19.8mm larva. The branchiostegal rays are present at about 12.8mm length. Heart, brain and liver are already developed in larvae of 2.5mm length. The optic lobe of the brain is more prominent in all stages.

Fin formation

The caudal fin completes development first, followed by anal and dorsal fins. The pectoral fin and pelvic fins are not yet completely developed in 19.8mm larva which is the largest larva of S. undosquamis in the collection.

Pectoral fin. The pectoral fin is present as fan-like, with fleshy base in the smallest specimen (2.5mm). As in usual in pectoral fin development the rays at the dorsal portion first appear at about 11.9mm. At this stage about 4 basals are developed on the dorsal margin of the pectoral fin base. The number of basals increases and 9 feebly developed rays are discernible in 15.2mm larva. At 19.8mm stage, only 13 pectoral fin rays are discernible (adult has 14-15 pectoral fin rays).

Caudal Fin. The fully formed caudal fin of the *S. undosquamis* has 19 principal rays. The caudal fin forms as a ventral thickening observed near the posterior end of the straight notochord in larva about 3.1mm lenth. Hypural elements begin to develop from this thickening at 4.9mm stage and the number of hypurals increases at flexion stage (5.8mm). Eight hypural elements are countable at 9.2mm stage. Few feebly developed caudal fin rays are first discernible at 7mm stage and full complement of 19 rays is seen in 8.4mm larva.

Dorsal Fin. The base of dorsal fin appears in between 16th and 22nd myomeres in larvae of 12.8mm length. About 9 feebly developed rays are noticed at 16.4mm and 10 rays are discernible at 18.2mm. The adipose fin also developed along with the dorsal fin development.

Anal Fin. The base of the anal fin can be observed in between 24th and 39th myomeres mid-ventrally at about 6.4mm stage; 6 basals are countable at 7mm, 10 feeble rays are discernible when the larva attains 12.8mm length.

Pelvic fin. Tiny pelvic fin buds are first visible in 11.9mm larva, 5 rays are discernible at 15.2mm length and 6 feeble rays are countable at 19.8mm length. The adult complement of pelvic fin rays is 9 in number.

Pigmentation.

The paired peritoneal pigment patches of larval lizard fishes are considered to be of taxonomic importance.

In the larva of S. undosquamis six pairs of peritoneal pigment patches are seen from very early stages. But in certain specimens the 2nd, 4th and 6th pairs are very small or incompletely developed. The first pair of peritoneal pigment is just below the end of opercular flap and the last pair is in front of the vent. In addition to six pairs of peritoneal pigment patches a pair of small dots are also developed just above the vent in 12.8mm stage.

A branching melanophores is seen in the ventral contour, just behind the anal fin base. This pigment spot is visible from the very early stages of larvae. It extends further backwards (towards the caudal fin) at 12.8mm stage. In addition to these pigmentation a branching melanophore is present at the caudal element from 5.9mm onwards. During the development the number of pigment spots at the caudal base increases to three.

The pigmentation is an important taxonomic character in larval lizard fishes. A very similar pattern of pigmentation is seen in the larvae of S. tumbil (Dileep - 1977) but it differs in the number of meristic counts such as dorsal fin rays, anal fin rays and number of vertebrae. The 7th pair of peritoneal pigment patches appears very early (9.9mm) in S. tumbil larvae where as in S. undosquamis larvae it appears only in 12.8mm stage. Zvjagina (1965) described a larva of S. undosquamis having a length of 4.9mm but it differs from the present collection of larvae in the number of peritoneal pigment patches. The larvae described by Zvjagina has only 3 pairs of peritoneal pigment patches where as the larvae described here have 6 pairs in the early stage. But here also in certain specimens the 2nd, 4th and 6th pairs of patches are either poorly developed or completely absent. The branching chromatophores present in the anal and caudal regions are similar in both cases.

Distinguishing characters of ***S. undosquamis*** larvae.

Pigmentation: Six pairs of peritoneal pigment patches in the pre-flexion, ~~and early post-~~flexion and early post-flexion stages, 7 pairs in late post-flexion stage. Anal and caudal pigmentation also present from very early stage.

Meristic Counts: Dorsal 11-12, Anal 10-11, Pectoral 14-15.

Number of Vertebrae: 47 - 48.

Fig. 13. : Developmental stages of S. undosquamis

a. 2.55mm larva

b. 3.1mm larva

c. 4.4mm larva

d. 5.5mm larva

e. 7.6mm larva

f. 8.8mm larva

g. 11.9mm larva

Fig. 13

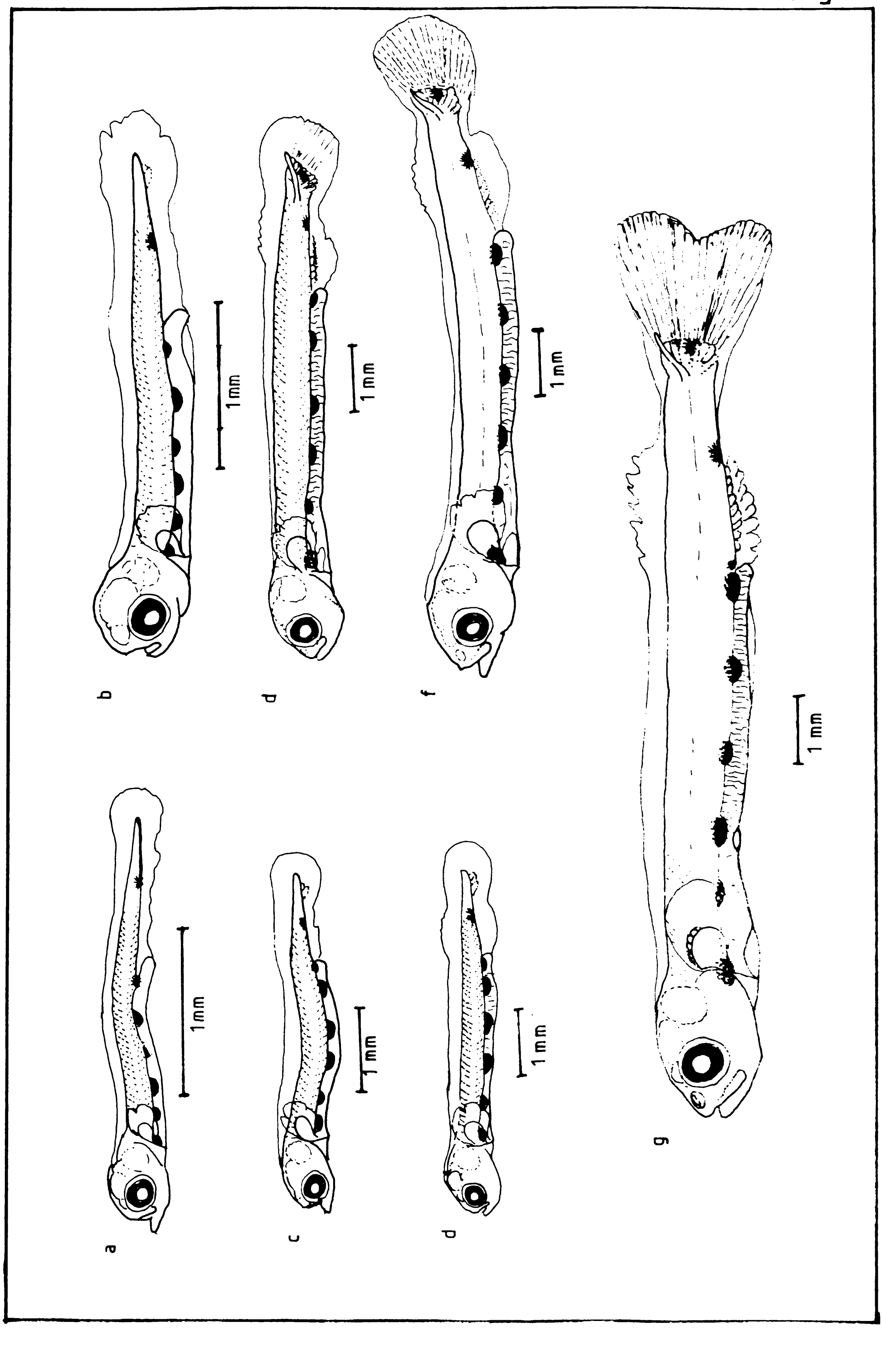


Fig. 13 : Developmental stages of S. undosquamis (Cont.)

h. 12.8mm larva

i. 16.7mm larva

j. 18.2mm larva

k. 19.8mm larva

Fig.13

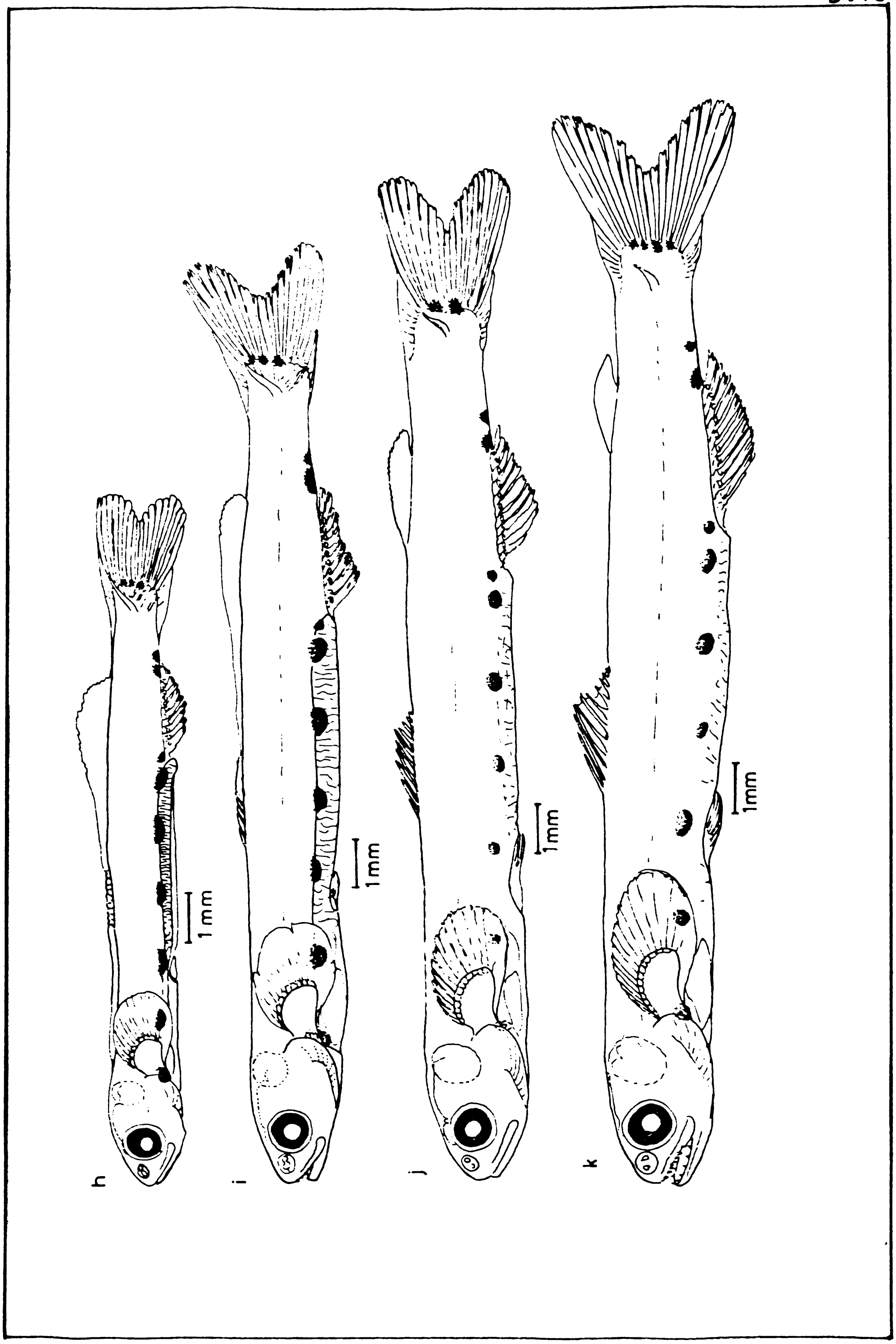


Table: 16. Body proportions of ***S. undosquamis*** larvae
(Proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
2 - 2.9	2.75	68	24	4	7	-	10
3 - 3.9	3.36	72	22	4	7	6	12
4 - 4.9	4.49	75	21	4	7	5	12
5 - 5.9	5.46	77	21	4	6	5	10
6 - 6.9	6.45	76	20	4	6	6	9
7 - 7.9	7.44	76	21	6	6	7	10
8 - 8.9	8.40	78	21	5	6	7	10
9 - 9.9	9.30	73	22	5	5	7	11
11 - 11.9	11.90	73	22	5	5	8	11
12 - 12.9	12.80	73	21	5	5	7	11
15 - 15.9	15.20	73	24	5	5	9	11
16 - 16.9	16.50	71	23	4	5	8	11
18 - 18.9	18.20	70	22	4	5	8	12
19 - 19.9	19.80	69	23	5	5	9	12

3.1.13. SYNODUS VARIEGATUS (Lac'epede, 1803)

Weber (1913) described the late larva of S. variegatus (45mm). Mito (1961) described the eggs and newly hatched larva of S. variegatus. Zvjagina (1965) described and illustrated egg and larva (5.25mm) of S. variegatus from the Gulf of Tonkin. Here, 7 selected stages from pre-flexion stage to late post-flexion stage (5.4mm - 24.5mm SL) are described in detail.

5.4mm larva (Fig. 14.a)

Pre-flexion stage. A round thickening developed in the nasal region. Teeth not seen, lower jaw a little prominent than the upper one. Rudimentary gill filaments are seen on the arches. Opercular flap feebly developed. Heart and liver developed. Otocyst present. Small fore-brain above the eye; the large oval shaped mid brain behind the eye and hind brain developed. There are 43 pre-anal and 10 post-anal myotomes.

Primordial marginal fin present. The end of the notochord straight and on the ventral side of it a triangular thickening developed which forms the rudiment of hypural elements. The ray-less, fan-like pectoral fin present.

Pigmentation is confined to the ventral and caudal portions of the body, 11 pairs of peritoneal pigment patches present along the ventro-lateral side of the gut, the first on the posterior border of the gill cleft, below the pectoral fin base and the last pair in front of the anal opening. A branching melanophore is seen in the ventral margin, behing the vent and below the 49th myomere. In the caudal region a branching chromatophore is seen on the triangular thickening and a number of pigment spots are spread towards the margin of the caudal fin fold.

6.3mm larva (Fig. 14.b)

Teeth present in the anterior part of both jaws, a pair of teeth in upper jaw and two pairs in the lower jaw. Gill filaments rudimentary, 54 myotomes are discernible (43 pre-anal and 11 post-anal)

Eleven pairs of peritoneal pigment patches. Two to three closely placed branching chromatophores in the anal portion. A long dash of pigments on the caudal thickening. The pigment spots more concentrated in the ventral half of the caudal fin-fold.

<u>8.9mm larva</u> (Fig. 14.c)

Pre-flexion larva. Nasal depression more deepend, 43 pre-anal and 13 post anal myotomes are countable. A slight thickening at the base of anal fin fold is seen. One hypural element feebly differentiated. The caudal fin fold fringed. Pigmentation same as in the preceding stages.

<u>13.7mm larva</u> (Fig. 14.d)

Flexion stage. Outer margin of the nasal depression thickened. Gill filaments bud-like. Otocyst present, 58 myotomes developed, notochord flexed upwards.

Dorsal fin fold present, a fringed appearance at the place of adipose fin, 9 basals developed in the anal fin, feebly developed anal fin rays are also discernible. Caudal fin has 7 hypurals and 19 feebly developed rays. Pectoral ray-less.

Eleven pairs of peritoneal pigment patches. Mid-ventral pigmentation at the base of last anal fin ray and behind it. Caudal pigmentation on the hypural elements. Ventral half of the caudal rays radially pigmented from the base to half of its length.

<u>18.9mm larva</u> (Fig. 14.e)

Post-flexion stage. Nasal flap well developed, but not fused together, conical teeth in both jaws; 57 vertebrae differentiated.

Dorsal fin base developed mid-dorsally in between 18th and 22nd myotomes. Adipose fin formed. Anal fin has 10 rays. A few secondary ray also developed in the caudal fin. Pelvic fin bud developed mid-ventrally at the level of 12th myomere. No rays in pectoral fin.

Caudal and peritoneal pigmentation same as in the preceding stage. Base of the last 4 anal fin rays pigmented. A narrow dash of pigments also seen behind the anal fin mid-ventrally.

20.7mm larva (Fig. 14.f)

Post-flexion stage. Nostril developed by the fusion of the flaps. Branchiostegal rays feebly developed. Gill filaments well developed. Vertebrae 57.

Dorsal fin basals developed in between 18th and 25th myotomes, but no rays. Anal 9 rays. Pectoral fin has 7 basals on the dorsal margin of the fleshy base. Pelvic fin bud with fin fold developed at 12th myomere.

Pigmentation as in the previous stage.

24.5mm larva (Fig. 14.g)

Late post-flexion stage. Upper jaw prominent. Maxillary reaches up to the middle of eye. Canine teeth in both jaws. Nostrils well developed. About 12 branchiostegal rays are countable. Otocyst present.

Dorsal fin has 12 feebly developed rays in between 18th and 26th myotomes mid-ventrally. Adipose fin well developed. Anal has 10 rays. Caudal fin well formed. Pectoral fin has 10 feeble rays and 2-3 more basals formed ventrally. Pelvic fin has 6 feeble rays, below the 12th myomere.

Eleven pairs of peritoneal pigmentation. Bases of last 6 anal fin rays pigmented. A long dash of pigments reaches from the base of anal fin to the 10th post-anal myomere, mid-ventrally. Posterio-dorsal portion of the caudal peduncle pigmented. Middle and ventral portion of the caudal fin base thickly pigmented.

Changes in the body form.

The body of larval S. variegatus elongated and slender, and this form retained through out its developemental stages.

Relative pre-anal distance, head length, snout length and eye diameter, show uniform pattern of development during the three phases, whereas the relative jaw length and body depth increase during post-flexion stage. (Table 17)

The nasal development is very slow in the larvae. A round thickening is seen on the snout region in front of the eye in 5.1mm stage. At 6.3mm stage a small depression is formed on this thickening and during flexion stage (13.7mm) the outer margin of the nasal depression get thickened. Flap-like projections developed on this margin at 17.8mm and these flaps fused together to form nostrils at 20.7mm stage.

A pair of small canine teeth present in both jaws in 5.9mm larva and number increases during the development. The oval otocyst is visible in all stages and it lies behind the eye. The branchiostegal rays are evident in very late post-flexion stage (20.7mm) and about 12 numbers are formed at 24.5mm stage. The gill for--mation is also very slow. Rudimentary gill filaments are seen at 5.4mm stage and bud-like filaments are evident in 12.5mm larva.

The 5.1mm larva has 53 (43 + 10) myotomes and adult complement of 55 to 60 vertebrae are seen in 13.7mm larva.

Fin formation

Caudal fin. A ventral thickening can be observed near the posterior end of the straight notochord in larvae of about 5.4mm and 4 hypurals are discernible in 7.7mm larva. The number increases and 7 hypurals are formed in 10.8mm larva.

Feebly developed rays are seen in 10.8mm larva and full complement of rays is seen in 13mm stage.

Dorsal fin. The fully formed dorsal fin of S. variegatus has 10-13 rays. The base of the dorsal fin can be seen in between 18th and 22nd myotomes in larvae of about 17.8mm (post-flexion stage). Feeble rays are evident in specimen of about 24.5mm length.

The posterior fleshy adipose fin in S. variegatus forms before the formation of dorsal fin. At about 13.7mm stage a fringed appearance is developed on the dorsal fin fold above the anal fin fold and adipose fin is formed at 18.9 stage.

Anal fin. Fully formed anal fin of S. variegatus has 8 - 10 rays. The base of anal fin can be observed in some larvae at about 8.9mm in length. About 9 basals are differentiated at 10.8mm. Feeble rays first appear in the anal fin fold at about 13.7mm stage and 9 rays are discernible at 17.8mm.

Pectoral fin. The larval pectoral fin is present in the smallest larva in the collection, but it is not fully developed in the largest specimen (24.5mm). As is usual in pectoral fin development, the dorsal (top) rays first appear and then rays are added ventrally. At 20.7mm length 7 basals are formed dorsally and 10 feeble rays are countable at 24.5mm.

Pelvic fin. Pelvic fin base develops in late post-flexion stage. The fin bud is first noticed in specimen of about 17.8mm as a thickening on the ventral edge of the body at the 12th myomre. At 24.5mm, 6 feeble rays are discernible.

Pigmentation

Pigmentation in S. variegatus larva is confined to peritoneal, anal and caudal regions, 11 pairs of peritoneal pigmentation is clearly visible from the very early stages of larval development. Weber (1913) described larvae of S. variegatus with 11 pairs of peritoneal pigment patches. Mito (1961) also described different stages of larvae of Synodus variegatus but it differs in number of peritoneal pigment patches and number of myotomes. Gopinath (1946) described a larva of Saurus indicus Day, with 11 pairs of peritoneal pigment patches, but it differs from the larvae of S. variegatus in the presence of pigmentation on the occipital region and in the meristic counts. Zvjagina (1965) also described a larva of S. variegatus (5.25mm)which agrees in all respects with the present larvae.

In the early stages a single branching melanophore is seen on the anal region. At about 10.8mm the number of branching chromatophores increases and during further development dashes of pigment developed towards caudal fin. At 24.5mm the bases of last 4 anal fin rays are also pigmented. In the caudal region, a branching chromatophore is seen on the hypural elements (5.4mm). In addition, radially placed pigment spots also occur on the caudal fin fold. In 6.3mm stage, the pigmentation on the caudal fin fold is more concentrated in the ventral half. In later stages, these pigment spots spread over to the dorsal half of the hypural elements (18.9mm stage).

Distinguishing characters of larvae of **S. variegatus.**

Small head and elongated body. Meristic counts: dorsal 10-13, anal 8-10, pectoral 12-13, Vertebrae 55-60.

Pigmentation: 11 pairs of peritoneal pigment patches. Anal and caudal pigmentation present.

Fig. 14. : Developmental stages of _S. variegatus_

a. 5.4mm larva

b. 6.3mm larva

c. 8.9mm larva

d. 13.7mm larva

e. 18.9mm larva

f. 20.7mm larva

g. 24.5mm larva

Fig. 14

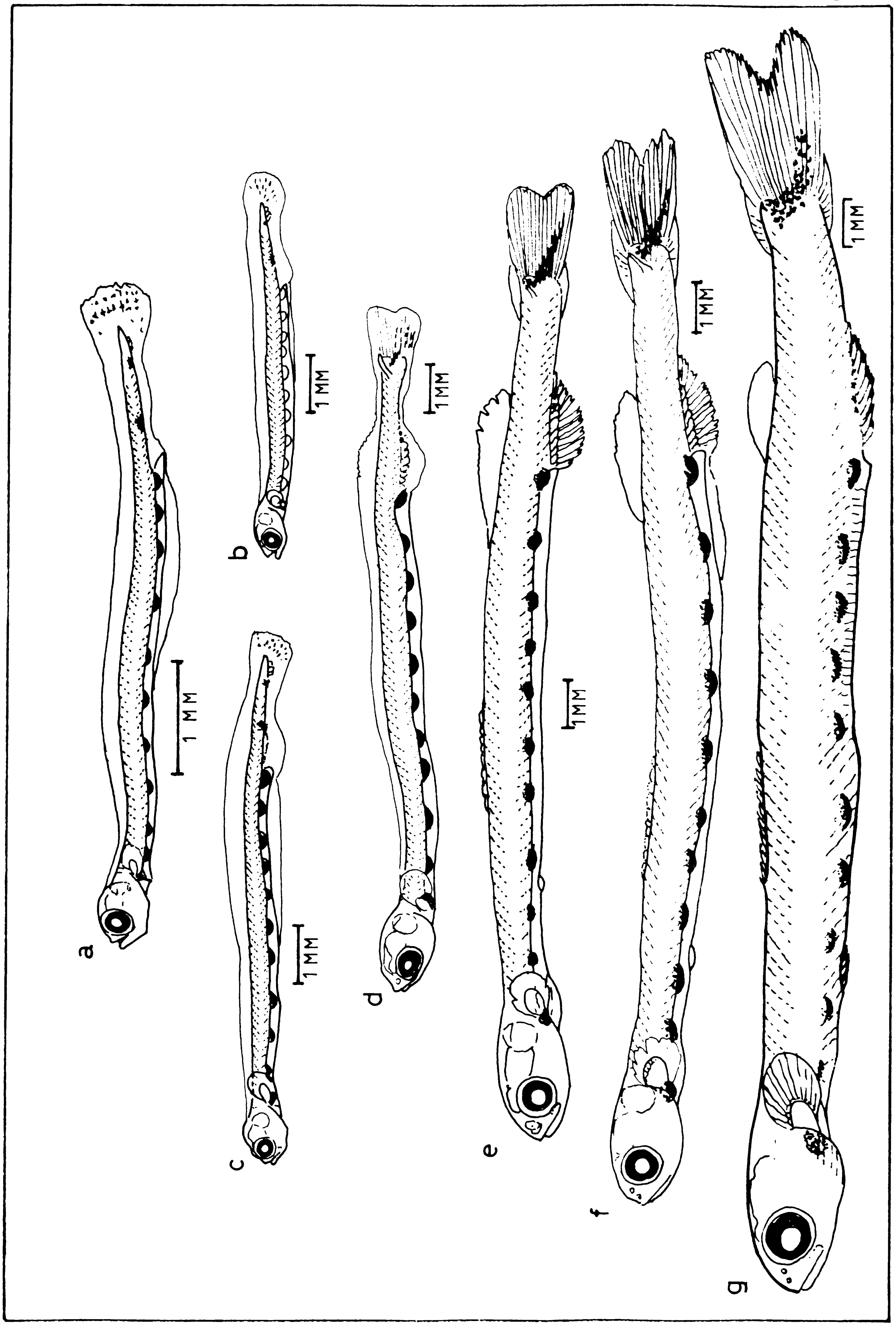


Table: 17. Body proportions of **S. variegatus** larvae

(Proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
5 - 5.9	5.5	79	14	3	4	-	7
6 - 6.9	6.4	77	13	3	4	5	6
7 - 7.9	7.8	76	15	3	4	4	5
8 - 8.9	8.5	78	14	3	4	4	5
9 - 9.9	9.55	78	13	3	4	4	5
10 - 10.9	10.8	79	12	3	4	4	5
12 - 12.9	12.5	80	10	3	3	4	4
13 - 13.9	13.36	79	13	3	4	4	5
17 - 17.9	17.8	79	13	3	4	6	6
18 - 18.9	18.9	77	15	3	4	5	6
19 - 19.9	19.0	80	15	3	4	5	5
20 - 20.9	20.7	78	14	2	4	5	6
22 - 22.9	22.6	78	13	3	4	5	6
24 - 24.9	24.5	78	13	3	4	5	6
26 - 26.9	26.0	77	12	3	4	6	6

3.1.14. TRACHINOCEPHALUS MYOPS (Forster, 1801)

Ogilby (1897) described a new genus and species Godella hypozona which was afterwards redescribed by Waite(1904) as the young of T. myops. Gopinath (1946), Mito (1961) and Zvjagina (1965) also described different stages of larval T. myops. Here, 9 stages from 4.4mm to 33mm are described in detail.

4.4mm larva (Fig. 15.a.)

Pre-flexion stage. Nostril and teeth not developed. Opercular flap feebly developed. No trace of gill filaments. Otocyst present. Heart, liver and brain visible, myotomes 50 (38 + 12). Notochord straight.

Primordial marginal fin present. Pectoral fin fan-like with fleshy base.

Six pairs of peritoneal pigment patches, first pair below the pectoral fin base and last pair in front of the vent. A branching melanophore is mid-ventrally in between 46th and 47th myotomes. Upper and lower edges of the posterior end of the notochord pigmented. On the caudal fin fold, pigment spots are radially placed.

7.1mm larva (Fig. 15.b)

A pair of minute teeth in the lower jaw. No teeth in upper jaw. A round thickening developed in front of the eye. Opercular flap developed.

Fin folds present. A slight ventral thickening noticed at the posterior end of the notochord, which later forms the hypural elements of the caudal fin.

Pigmentation same as in the preceding stage.

9.6mm larva (Fig. 15.c)

Pre-flexion stage. Nasal depression formed. Teeth in both jaws, 39 pre-anal and 13 post-anal myotomes discernible.

Dorsal fin fold fringed at the position of adipose fin. Anal fin fold also prominent, but not traces of rays, 3 hypural elements differentiated. Few actinotrichial rays also formed in the caudal fin fold.

Pigmentation as in the previous stage.

11.6mm larva (Fig. 15.d)

Flexion stage. Nasal depression more prominent. Gill filament rudimentary, 39 pre-anal and 16 post-anal myotomes are discernible.

The posterior end of notochord flexed a little upwards. Six hypural elements differentiated, 10 feeble rays developed in caudal fin. A slight longitudinal thickening is noticed in between the anal fin fold and body proper. Dorsal fin fold fringed at the position of adipose fin.

The caudal pigmentation more prominent.

12.9mm larva (Fig. 15.e)

Post-flexion stage. Flap-like projection developed in the nasal depression. Gill filament rudimentary, 54 myotomes discernible.

Dorsal fin fold present, fringed at the place of adipose fin, 9 anal fin basals formed, but rays not developed. Caudal fin has 19 feebly developed principal rays, 7 hypurals developed. No rays in pectoral fin.

The peritoneal and anal pigmentation enlarged in size. Upper half of the caudal peduncle thickly pigmented. Inter space between few middle caudal rays are also pigmented.

17.2mm larva (Fig. 15.f)

Post-flexion stage. Nostrils developed by the fusion of the flaps. Branchiostegal rays feebly developed. About 53 vertebrae visible.

Dorsal fin not developed, 12 anal fin basals formed. Caudal fin fully formed, there are 17 branched rays.

A pair of branching chromatophores developed in the occipital region. All other pigmentation same as in the preceding stage.

20mm larva (Fig. 15.g.)

Late post-flexion stage. Nostrils well developed. Gill filaments well formed but no gill rakers, teeth present in both jaws, vertebrae - 55.

About 11 dorsal fin basals developed in between 16th and 23rd myotomes; 15 branched anal fin rays visible. Caudal fin rays well formed, few secondary rays are also seen. Pectoral fin has 7 basals in the upper (dorsal) portion. Pelvic fin-bud developed mid-ventrally at 12th myomere.

A pair of branching chromatophores in the occipital region. A branching chromatophore seen behind the pectoral fin base on either side; 6 pairs of peritoneal pigmentation. A large branching chromatophore mid-ventrally behind the anal fin. Pigment spots are seen on either side of adipose fin base. A row of medio-lateral pigment spots seen in between adipose fin and anal fin. Caudal peduncle pigmented in an oblique fashion; inter-spaces of few caudal fin rays also pigmented.

29mm larva

The dorsal fin developed in between 17th and 26th myotomes and has 12 rays, the last ray branched. Adipose fin formed in between 43rd and 48th myotomes. Anal fin has 15 rays; 19 principal caudal fin rays and about 12 secondary rays also developed on either side of the caudal fin. Pectoral has 12 feebly developed rays. Pelvic fin not fully formed and about 6 rudimentary rays are seen.

The occipital region has 2 pairs of branching chromatophores. A pair of branching chromatophores also seen at the base of pectoral fin. Six pairs of peritoneal pigment patches clearly seen. A single line of pigment spots on the lateral line, starting from the level of pelvic fin and up to the posterior end of anal fin. A line of closely placed ventro-lateral pigment spots is seen just above the anal fin base.

The mid-ventral pigmentation, seen behind anal fin, is partially embeded inside the body. The base of last few anal fin rays also pigmented. The base of adipose fin pigmented. A line of pigment spots also seen in between dorsal fin and adipose fin. The upper end of caudal peduncle thickly pigmented. The interspaces of few central caudal rays pigmented.

33mm larva

All the fins well developed. Dorsal 13 rays, anal 15 rays, caudal 19 rays, pectoral 13 rays and pelvic 8 rays.

Pigmentation same as in the preceding stage.

Changes in body form.

Relative pre-anal distance increases slightly during pre-flexion stage, however it grows uniformly during flexion and post-flexion stages (Table 18). The relative head length, relative snout length and relative eye diameter show uniform pattern of development throughout the larval stages (Table-18). The relative upper jaw length and relative body depth show moderate development during pre-flexion and flexion stages, whereas they increase only slightly during late post-flexion stage.

Nostrils developed as a round thickenging on the snout of 7.1mm larva. This thickening enlarges in size at 11mm length and a depression is formed.

At 12.9mm flap-like outgrowths develop on the outer margins of this depression and at about 17mm these flaps are fused together to form the nostril.

Teeth first evident in 7.1mm larva, as a pair of conical teeth in lower jaw. At about 9.6mm stage teeth are developed in both jaws. Gill filament seen in 11.6mm larva and well developed filaments are seen in 15.5mm larva. Branchiostegal rays are seen in post-flexion stage (17.2mm). Heart, liver and brain are developed from very early stages (4.4mm).

Fin formation

Dorsal fin. The soft adipose fin in T. myops forms before the formation of dorsal fin. The formation of adipose fin is seen in 9.6mm larva as fin fold fringed at the position of adipose fin and clearly formed in 18mm stage. Formation of dorsal fin first seen in 20mm larva, about 11 basals developed at mid-ventral region in between 16th and 23rd myotomes.

Full complement of dorsal rays (12-13) develops only in late post-flexion stage (33mm stage).

Anal fin. The base of anal fin can be observed in some larvae at about 11.6mm in length and 8 basals are developed at 11.8mm stage. Rays first appear in the developing anal fin in 20mm larva. The adult complement of 14 to 15 rays is usually attained at about 21mm stage.

Caudal fin. The fully formed caudal fin has 19 principal rays. The dorsal and ventral-most rays are simple; the remaining rays are branched. The caudal fin develops in much the same manner as the caudal fin of most fish larvae. A ventral thickening near the posterior end of the notochord is seen in specimen about 7mm. This thickened tissue develops in to 7 hypural elements and associated rays The first 8 caudal rays are seen in 9.8mm stage. They develop at an oblique angle to the slightly flexed notochord. By about 11.8mm length, all principal caudal rays are feebly developed.

Pectoral fin. In the development of pectoral fin, the top rays first appear, and then the rays are added ventrally. About 3 pectoral fin basals are developed in 18mm larva. At about 20mm, 7 basals are developed. Full complement of 13 feeble rays is seen at 27mm stages.

Pelvic fin. Pelvic fins develop only in very late post-flexion stage. Pelvic fin-bud formed in 18mm stage. About 6 rudimentary rays are visible when the larva attains 29mm. Fully developed pelvic fin with 8 rays are seen in 33mm stage.

Pigmentation.

As in other fishes of family Synodontidae, the pigmentation in T. myops is considered to be of taxonomic importance. In T. myops from the very early stages of developed (4.4mm) six pairs of peritoneal pigment patches are present. In addition, branching melanophores are seen in the anal and caudal regions. When the larva attains about 11.8mm length, a pair of branching chromatophores develop in the occipital region. Lateral line pigmentation begins at 18mm stage as three pigment spots seen on the lateral line in between adipose fin and anal fin fold. During development the lateral line pigments extend further forward and at 29mm it reaches up to the level of pelvic fin base. At 20mm a single branching chromatophore is developed just behind the pectoral fin base and base of adipose fin. At 27mm stage 2 rows of pigment spots are developed on the dorsal body contour in between dorsal fin base and adipose fin.

Six pairs of peritoneal pigment patches are common in some other lizard fish larvae such as, Saurida undosquamis and early stage of S. tumbil. But pigmentation in the occipital region, lateral line, behind the pectoral fin base, around the adipose fin base, and dorsal body contour in between dorsal fin and adipose fin are found only in T. myops larvae.

Distinguishing characters of *T. myops* larvae.

Snout smaller than eye, body elongated, anal fin base larger than dorsal fin base.

Meristic counts: dorsal 12-13, anal 14-15, pectoral 13, pelvic-8, vertebrae 52-55

Pigmentation: Six pairs of peritoneal pigment patches. Pigmentation also seen on the occipital region, lateral line, behind pectoral fin base, around adipose fin base, and between dorsal fin and adipose fin.

Fig. 15. : Developmental stages of *T. myops*

a. 4.4mm larva

b. 7.1mm larva

c. 9.6mm larva

d. 11.6mm larva

e. 12.9mm larva

f. 17.2mm larva

g. 20mm larva

Fig. 15

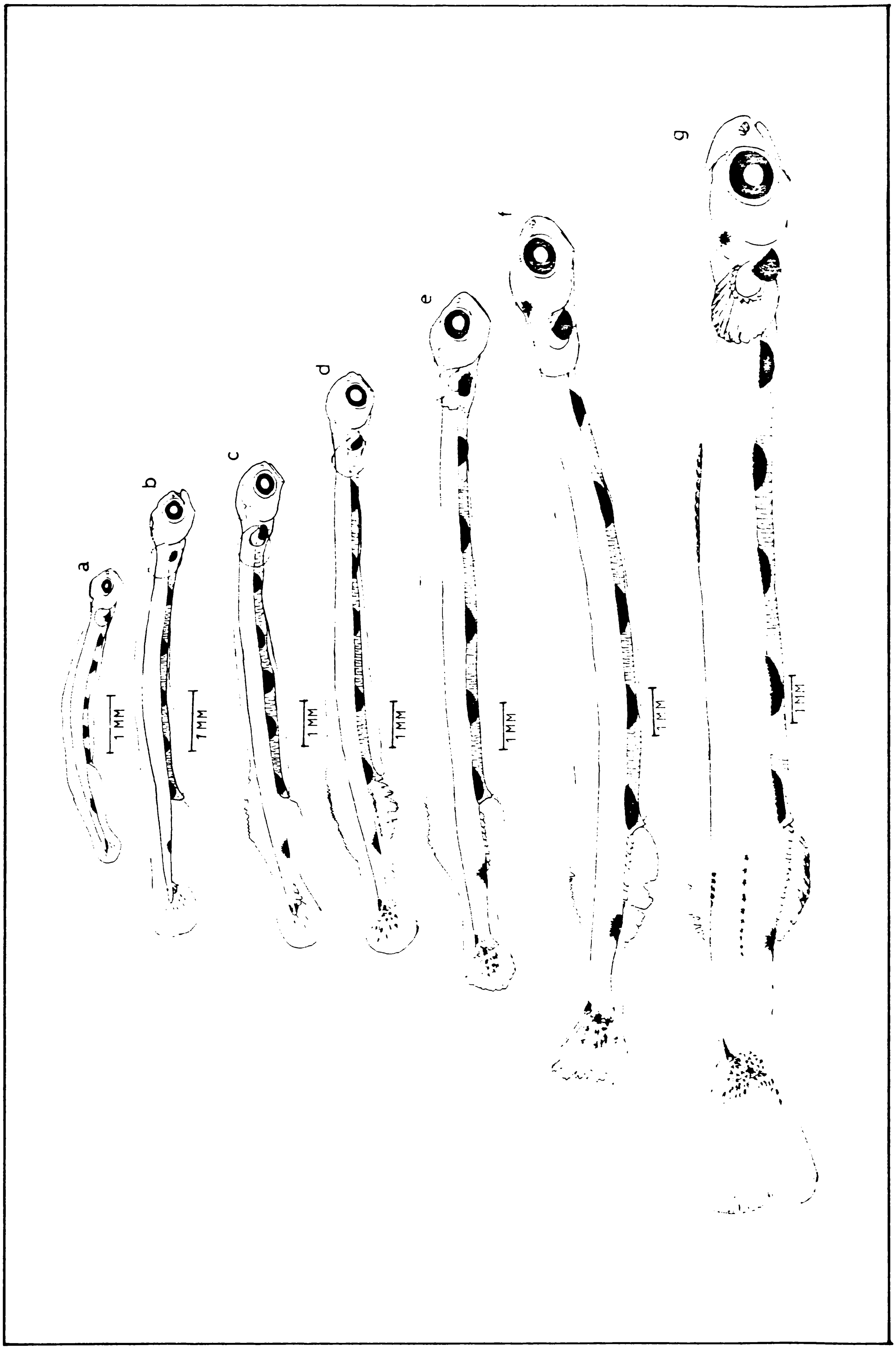


Table: 18. Body proportions of **T. Myops** larvae
(Proportions expressed as percentaged of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
4 - 4.9	4.6	71	13	2	4	6	7
5 - 5.9	5.6	71	13	2	5	6	6
6 - 6.9	6.4	74	12	2	5	5	6
7 - 7.9	7.3	73	11	2	4	6	5
8 - 8.9	8.2	73	11	2	4	6	5
9 - 9.9	9.8	73	12	2	4	6	6
10 - 10.9	10.5	75	11	2	5	6	5
11 - 11.9	11.8	75	13	2	4	6	6
12 - 12.9	12.8	75	12	2	4	6	5
13 - 13.9	13.5	75	13	2	4	7	6
15 - 15.9	15.5	77	13	2	4	6	6
17 - 17.9	17.2	75	11	2	4	6	5
18 - 18.9	18.2	77	13	2	4	6	6
20 - 20.9	20.2	74	13	3	4	7	6
21 - 21.9	21.3	75	14	2	4	7	6
22 - 22.9	22.4	76	12	2	4	8	6
23 - 23.9	23.5	68	12	2	3	7	5
27 - 27.9	27.0	70	10	2	4	8	7
29 - 29.9	29.0	72	13	2	4	8	7
33 - 33.9	33.0	75	13	3	4	8	7

3.1.15. HARPADON NEHEREUS (Hamilton 1822)

Larvae of H. nehereus have not been described previously. Here, 8 stages from 10mm to 29mm in length are described in detail.

10mm larva (Fig. 16.a)

Post-flexion stage. The body long and cylindrical, jaws devoid of teeth. Eye pigmented. The nasal depression is formed and its posterior margin slightly thickened. Snout small. Branchiostegal rays feebly developed. Gill filaments well formed. Heart, liver and brain also well developed, 42 myotomes are discernible at this stage.

Dorsal and anal fin folds present, 13 anal fin basals developed, 7 hypurals and few feeble rays have originated in the caudal region. The pelvic fin base feebly developed in between 17th and 18th myotomes. The pectorals fan-like.

Pigmentation is confined to the ventral portion of the body. Seven pairs of peritoneal pigment spots along the ventro-lateral side of the gut; the first pair below the end of opercular flap and last pair in front of anal opening. A branching chromatophores is seen behind the anal basals and another one at the middle of caudal fin base.

10.7mm larva (Fig. 16.b)

Post-flexion stage, minute teeth in both jaws. Outer margin of nasal depression thickened. Branchiostegal rays feebly developed.

Dorsal fin not developed, but a fringed appearance is seen in the fin fold of second dorsal. Anal has 14 basals and actinotracheal rays are seen on the fin fold. Caudal fin has 19 feeble rays. Pelvic fin buds developed, 6 basals are seen on the upper portion of fleshy pectoral fin base.

Pigmentation same as in the previous stage (10mm).

<u>11.5mm larva</u> (Fig. 16.c)

Mouth wide, lower jaw prominent, gill filaments well formed, small protuberances of gill rakers are also seen; 31 pre-anal and 12 post-anal myotomes are clear.

Dorsal fin not developed, 13 anal fin rays feebly formed. Caudal has 19 rays. Few secondary rays also formed on the upper and lower parts of the cauadal fin. Six feeble rays on the upper portion of the pectoral fin; 4 basals also seen at the lower portion of the pectoral fin base. Pelvic fin bud seen in between 3rd and 4th pairs of peritoneal pigment spots.

<u>12.4mm larva</u> (Fig. 16.d)

Margin of nasal depression more thickened. Branchiostegal rays well formed, 43 myotomes discernible.

Dorsal not formed. Anal fin lies in between 31st and 40th myotomes and has 14 rays, the middle ones are larger. The caudal fin developed. The pelvic fin bud developed ventrally in between 15th and 18th myotomes and has 2 basals. The pectoral fin has 7 feeble rays and 2 more basals are also seen ventrally. Pigmentation as in previous stage.

<u>14.3mm larva</u> (Fig. 16.e)

Eyes small, the outer margins of the nasal depression curved inwards, but not fused together. The well developed heart seen behind the pectoral fin base. The liver well formed and extended upto the second pair of peritoneal pigment spots. Otocyst present. The intestine has a striated appearance.

Anal fin has 14 rays, caudal fin developed, 5 to 6 rays present in pelvic fin fold. The pectoral fin has 8 feeble rays.

Seven pairs of peritoneal pigment spots, the last pair is the smallest. A branching chromatophore behind the anal fin and a pair of branching chromatophores on either side of caudal base.

15.7mm larva (Fig. 16.f)

Teeth in both jaws, the inner ones are larger. Nostrils partially developed by the fusion of the nasal flaps.

Dorsals not developed. Anal has 15 rays. Six rays developed on the pelvic fin bud, 8 rays in pectoral fin.

Pigmentation as in the previous stage, except in the post-anal region. Three chromatophores are seen mid-ventrally just behind the anal fin.

22.5mm larva

Teeth in both jaws, about 18 branchiostegal rays seen. Gill rakers pointed. Nostril well formed, feebly developed. First dorsal has 13 rays, the first ray small and other 3-4 anterior rays larger. The small 2nd dorsal is adipose fin and seen above the anal fin, 14 rays seen in the anal fin and 9 rays in pelvic fin.

Five branching chromatophores are seen mid-ventrally, just behind the anal fin, of which the first two are on the bases of the last two anal fin rays.

Four dots are seen at the caudal fin base, peritoneal pigmentation as in previous stage.

29mm larva

Teeth completely filled in jaws, poster teeth larger in size. Lower jaw prominent. Nostrils well developed, gill rakers well formed, 43 vertebrae are prominent.

Twelve rays in the 1st dorsal, 2nd dorsal adipose. Anal has 14 rays, base of which is larger than the base of 1st dorsal fin. Pelvic has 9 rays and 12 rays in pectoral fin. Caudal has 19 rays and 9 secondary rays on either side of caudal fin rays.

A thickening is noticed at the middle portion of the bifurcated caudal fin. The thickening begins from the base of the caudal fin, which will later develop in to the median lobe of the caudal fin. Pigmentation as in the previous stage.

Changes in body form.

The relative pre-anal length and relative eye diameter decrease moderately during larval development. The relative head length, relative snout length and relative body depth show uniform rate of growth through out the larval stages. The relative upper jaw length shows slight increase during development.(Table 19)

The nasal depression is seen in 10mm larva and its posterior portion has got thickened. Flap-like outgrowths developed in 11.7mm larva. These flaps are enlarged in size and partially fused together at 15.7mm stage. Fully developed nostrils are present in 22.5mm larva. Minute conical shaped teeth are seen in all the stages.

Gill arches with feebly developed filaments are seen in 10mm larva. Gill filaments are well formed at 10.7mm stage. Pointed gill rakers begin to develop when the larvae are about 11.4mm and well formed gill rakers are seen at 15.7mm stage. Branchiostegal rays are seen in 10mm stage and full complement of branchiostegal rays is seen when the larva attains 12.4mm length.

The brain, liver, and heart are developed in larva of 10mm length.

Fin formation.

Pectoral fin: The fan-like pectoral fin with fleshy base and devoid of any rays are seen in 10mm larva. At 10.7mm, six basals are seen in the upper portion of the fleshy bases of the pectoral fin. Six feeble rays are first evident at 11.5mm stage and full complement of 11-12 rays is obtained in 24.8mm larva.

Caudal fin: The fully formed caudal fin has 19 principal rays. The 10mm larva (post-flexion stage) has 7 hypural elements. About 19 feeble rays are seen in 10.7mm larva. The formation of the median lobe of the caudal fin is seen in 29mm larva. A thickening is noticed at the middle portion of the bifurcated caudal fin. This thickening begins from the base of caudal fin, which will later develop as the median lobe of the caudal fin.

Dorsal fin. The dorsal fin formation is very slow in the larvae of H. nehereus. The 1st dorsal is seen in the middle of the body with 12-14 rays and narrow adipose fin opposite to the middle of the anal. Dorsal fin-fold present in 10mm larva and 13 feebly developed dorsal rays are seen only in the 22.5mm larva.

Anal fin. Fully developed anal fin has 14-15 rays; 10mm larva has 13 basals, 14 basals are seen in 10.7mm larva and at this stage a few feeble rays are also formed, 13 feeble rays are seen at 11.5mm stage and 15 rays are seen at 11.7mm stage. Fully developed anal fin rays are seen in 22.5mm larva.

Pelvic fin. Pelvic fin base develops early. At 10mm a slight thickening is seen mid-ventrally at about 18th myomere. Two basals are evident at 12.4mm stage and 4 feeble rays are seen at 12.9mm; 9 rays ar formed in 22.5mm larva.

Pigmentation.

The pattern of pigmentation in the larva of H. nehereus is very much similar to that of the larvae of lizard fishes (Family Synodontidae). There are seven pairs of peritoneal pigmentation, the last pair is small and lies above the vent. No change has been noticed in the number and position of peritoneal pigmentation during the larval development. In addition to this, pigmentation seen on post-anal region and caudal fin base. The pigment spots increased in number along with the larval development. At 10mm, single branching chromatophore is seen behind anal fin base. The number increased to 3 at 15.7mm and 5 at 22.5mm. In early stage the caudal fin base has a single branching chromatophore on either side. The number increased in to two at 11.7mm and 4 at 22.5mm stage.

Distinguishing characters of **H. nehereus** larvae.

Meristic counts: dorsal 12-13, anal 14, pelvic 9, vertebrae 43, caudal fin trilobed.

Pigmentation: Seven pairs of peritoneal pigment patches. Pigmentation also seen on the anal fin base and base of caudal fin.

Fig. 16. : Developmental stages of *H. nehereus*

a. 10mm larva

b. 10.7mm larva

c. 11.5mm larva

d. 12.4mm larva

e. 14.3mm larva

f. 15.7mm larva

Fig. 16

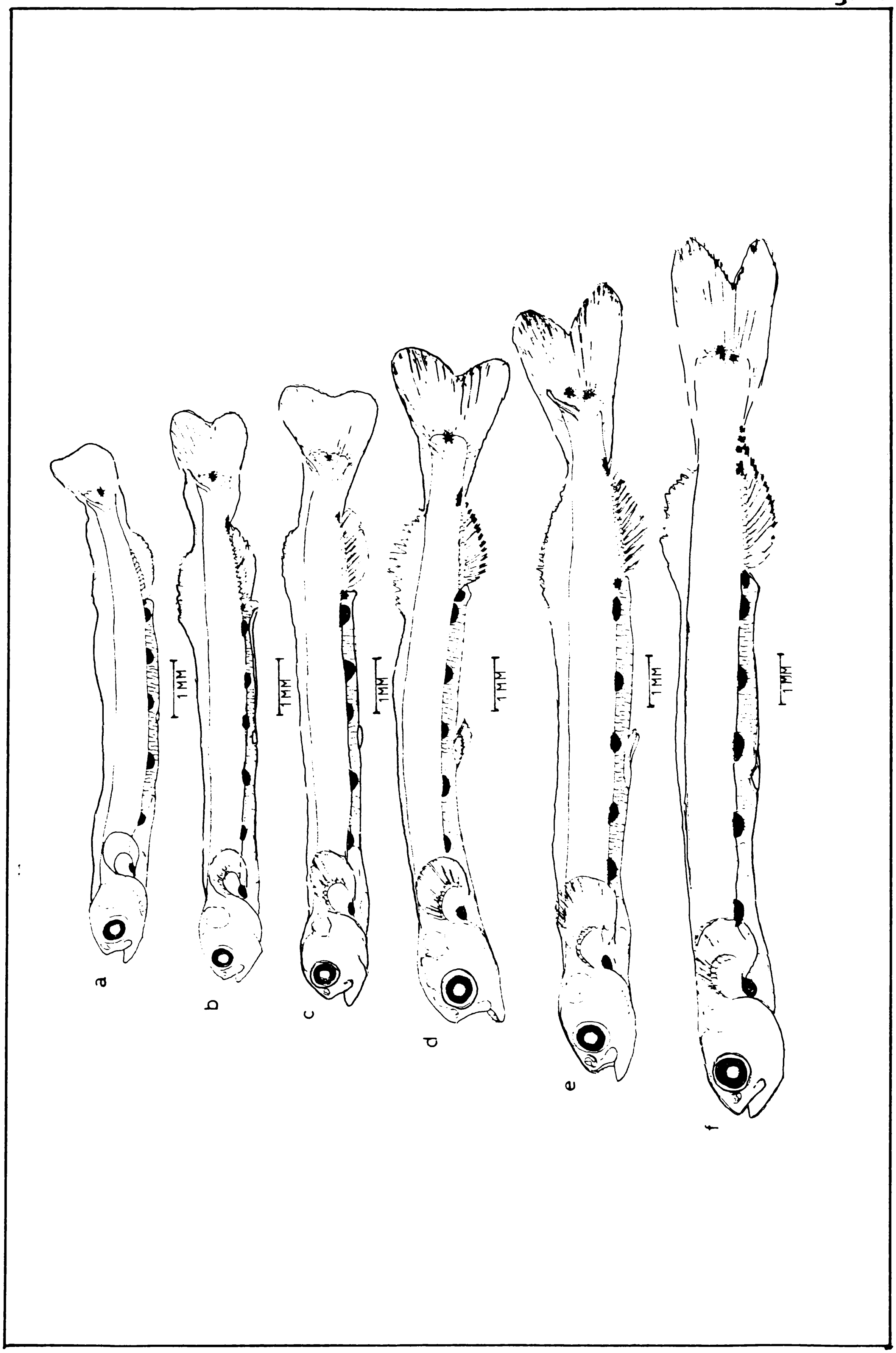


Table: 19.

Boody proportions of **H. nehereus** larvae

(Proportions expressed as percentage of body length)

Body length (mm) Range	mean	PAD	HL	SN	ED	UJL	BD
10 - 10.9	10.35	77	19	3	5	6	10
11 - 11.9	11.53	75	19	4	4	7	9
12 - 12.9	12.65	74	19	4	5	6	10
13 - 13.9	13.00	74	20	4	4	7	11
14 - 14.9	14.30	75	18	4	4	6	10
15 - 15.9	15.70	73	19	4	4	6	10
22 - 22.9	22.50	73	19	4	3	7	10
24 - 24.9	24.80	73	20	4	3	8	10
29 - 29.9	29.00	72	19	4	3	8	10

4. TOPOGRAPHY AND HYDROGRAPHY OF THE SOUTH WEST COST OF INDIA

The area of present study includes the S.W. coast of India, from Ratnagiri to Tuticorin covering the continental shelf and part of the slope about 60 nautical miles on an average from the continental edge along the standard sections, ie. off Ratnagiri, Karwar, Kasaragod, Cochin, Quilon, Cape Comorin and Tuticorin.

The shelf area of S.W. coast of India is wide in the north and narrow in the south. Off Ratnagiri, the 200 metre depth line is about 80 nautical miles from the coast, while off Quilon it is only about 30 n. miles. The Angria Bank off Ratnagiri, the Quilon Bank, the Wadge Bank off Cape Comorin are some of the shallow offshore areas in the S.W. coast of India.

The bottom is hard or rocky south of Quilon, while north of this the inshore belt is generally sandy and the bottom has a chain of rocky outgrowth in the deeper waters around 100 m. depth. On the north of Calicut and off Ratnagiri some rocky stretches of shore-line are also seen.

The hydrographic conditions of S.W. coast of India are largely influenced by monsoons particularly S.W. monsoon. During May - October, the surface current flows southwards, causing a lifting of the isolines for different oceanographic parameters near the coast. This lifting generates upwelling of intermediate water of low oxygen content. The upwelling is more pronounced north of Quilon than in the area around Cape Comorin in the south. Several investigations were carried out on the hydrography of the S.W. coast of India. The annual fluctuations in the physical conditions have been discussed by Ramamirtham and Jayaraman (1960), Murthy (1965), Sharma (1967), Darbyshire (1967), Rao (1967) and Banse (1968). The effect of S.W. monsoon on the hydrographical condition has been studied by Ramasastry and Myrland (1960), and Patil et al (1964). The UNDP/FAO

Pelagic Fishery project, worked along the S.W. coast from 1971-'75 and published technical reports on the Oceanography of the region (Anon 1973, 1976).

Along the S.W. coast of India the surface temperature conditions show a double oscillation during an year with maximum in April and in November and minimum in July/August and in December/January (Sharma 1967). In general, the low temperatures are often spread over a longer period in the northern area than in the south. The maximum thermocline depth in the area is about 150m in the winter months and very much shallow in monsoon months, due to the upwelling water reaching near surface level (Sharma 1967., Anon, 1973).

Due to the discharge of the large amount of fresh water during the S.W. monsoon a sharp decline of salinity is noticed off Cochin and northwards in the surface layer (30%o or less), whereas at the same time it is only slightly less than 34%o off Cape Comorin and Tuticorin (Anon 1976). Generally the shelf waters of the area are well aerated during most part of the year, with 4 to 5 ml/L of dissolved oxygen at the surface, except during the upwelling period. Dissolved oxygen values showed an increase in seasonal amplitude from South to North (Anon 1976). It is believed that the upwelling process which brings nutrient rich water towards the surface as well as spreading of oxygen deficient water over shelf area is very important both for fishery development and fish distribution in the area.

5. DISTRIBUTION AND ABUNDANCE OF LARVAE

5.1. Larvae of flat fishes

5.1.1. Seasonal distribution and abundance

5.1.1.1. Distribution and abundance during 1971 to 1975

1971: The plankton collections were started from September 1971 onwards and flat fish larvae were obtained in all the months of the year. The abundance of larvae was maximum in the month of October (95%) (Table: 20)

1972: Larvae were obtained throughout the year except in the month of December. Higher number of larvae was obtained in September (35%) and fairly moderate abundance was also noticed during April, October and November (Table: 20). The larval occurrence gradually increased during the pre-monsoon period (September). The abundance was steady during the early part of the post-monsoon period, and thereafter it diminished and became practically nil in the last part of the post-monsoon period (December - January) (Table:20).

1973: The larval occurrence was noticed in all the months of the year except in December. Maximum abundance was in May (28%) and there was good representation in January (15%). March, October and November showed moderate occurence (Table: 20). A gradual increase in abundance was noticed in pre-monsoon months and peak in May. The abundance was poor in monsoon months (June to September) and steady in postmonsoon months (Table: 20).

1974: The larvae occurred throughout the year. About 50% of the larvae was collected in the post-monsoon months and remaining months showed great fluctuations (Table:20). Maximum abundance occurred in November and April. July and December showed moderate occurrence.

1975: The larvae were present in all the months except in January. Maximum abundance was observed from February to June with a peak in June (19%). The remaining months of monsoon period showed gradual reduction in abundance (Table 20). A secondary peak was seen in October and there after a steep reduction in abundance was noticed during November - December period (Table:20).

5.1.1.2. Species-wise distribution and abundance during 1971 - 1975 period.

During 1971 larvae of C. macrostomus dominated in the distribution (96%). Larvae of P. arsius (2%), E. cocosensis (1%). E. grandisquamis and L. macrophthalmus were also presented in the collection (Table: 21). In 1972 C. macrostomus larvae formed about 51% and E. cocosensis 24%. Other larvae which showed moderate occurrence were P. arsius (5%), P. profunda (5%), L. guentheri (5%), E. grandisquamis (3%), B. ovalis (2%), L. macrophthalmus (2%) P. bilineata (1%), A. cyaneus (1%) and G. polyophthalmus (1%) (Table: 21).

In 19 73 larvae of E. cocosensis formed 33%, E. grandisquamis 22%, C. macrostomus 21%, and P. profunda 11%. Other species obtained were L. macroph thalmus (6%) L. guentheri (3%) P. bilineata (3%) and G. polyophthalmus (1%). In the year 1974 C. macrostomus showed better density (48%), E. grandisquamis formed 21%, E. cocosensis 18%, B. ovalis 4%, L. macrophthalmus 3%, G. polyophthalmus 2%, P. profunda 2%. P. arsius 1%, P. bilineata 5% ., and A. cyaneus 5% (Table: 21). E. cocosensis (36%) dominated in the year 1975. E. grandisquamis obtained 20%, C. macrostomus 17%, G. polyophthalmus 7%, A. cyaneus 5%, B. ovalis 4%, L. macrophthalmus 3%, P. bilineata 2%, P. arsius 2%, P. profunda 2%, and L. guentheri 2% (Table: 21.)

5.1.1.3. Month-wise distribution and abundance (pooled data of different years)

The seasonal variation of the physical parameters causes variation in plankton production which closely related to the ichthyopkankton distribution. The general treand of zooplankton production showed similarly in all the sections under study (Anon -1976). Low zooplankton biomass was noticed in all the sections from January to April. Afterwards, closely following the upwelling during the south west monsoon, plankton biomass increased to reach a peak usually during the July - September period. A secondary peak of production was noticed around November (Anon - 1976).

Though the larvae of flat fishes were present throughout the year the highest peak was noticed in the early part of the post-monsoon period (October - November). Another secondary peak was observed from April to June. Other months showed much variations and January, February and December showed very low in larval occurrence (Fig. 17.a and Table: 22).

5.1.1.4. Species-wise distribution and abundance during different months (pooled data of different years)

The larvae of C. macrostomus occurred in all months, July to November, showed the maximum abundance, with a peak in October (34%). Occurrence of larvae was less in February to June and in December. The distribution pattern showed that even though the species had a protracted/prolonged breeding period, it bred mainly in monsoon and post-monsoon periods (Table: 22).

The larvae of P. bilineata occurred in May to July and in December. Maximum abundance was noticed in May (54%) (Table : 22).

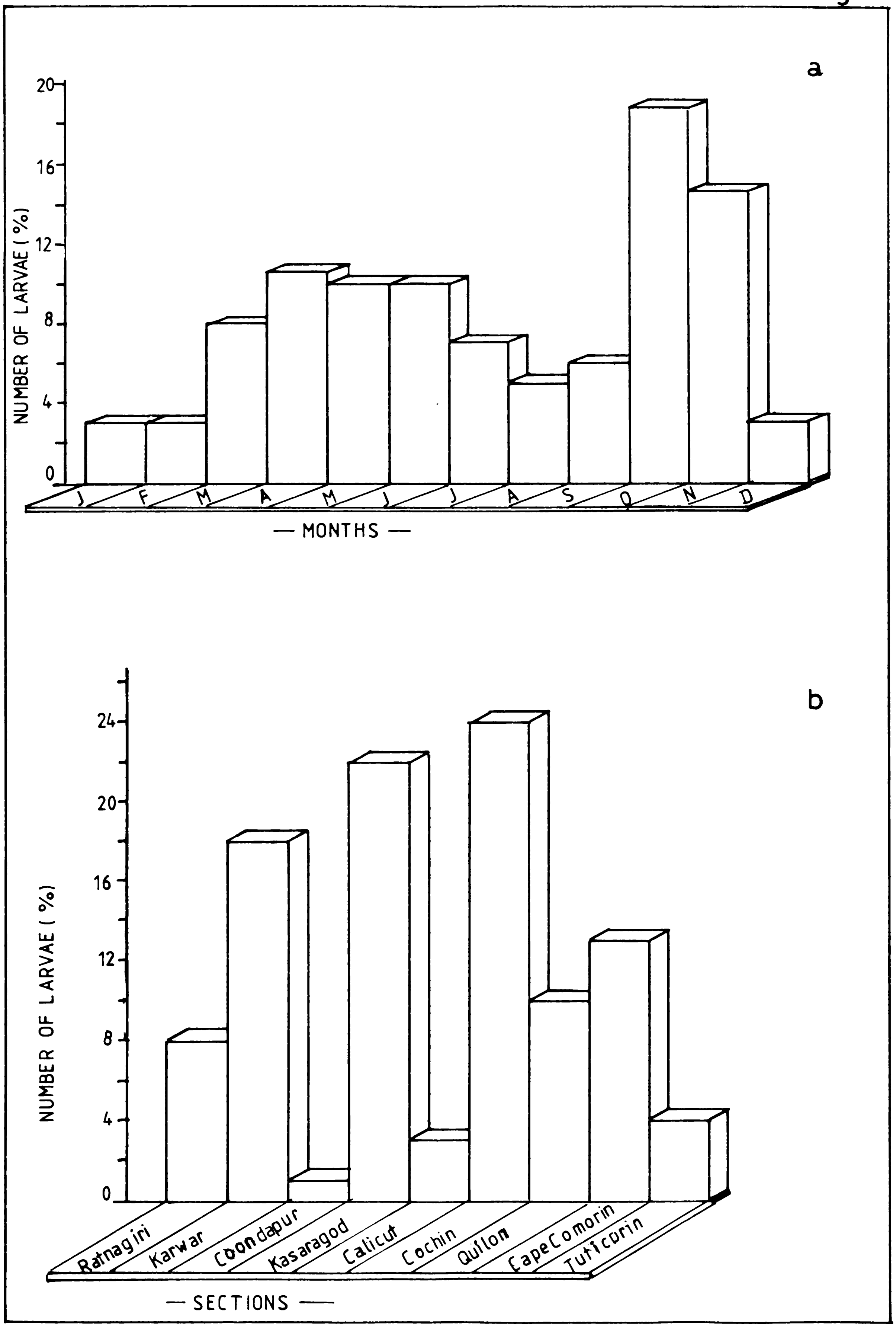
The larval abundance of A. cyaneus showed the maximum in July (47%) and less in June (20%), occurrence of larvae was also noticed in September (Table: 22).

Fig. 17. : Distribution and abundance of flat fish larvae

a. Month-wise abundance of flat fish larvae from 1971 to 1975.

b. Abundance of flat fish larvae in different profiles.

Fig. 17


a
NUMBER OF LARVAE (%)
0
4
8
12
16
20
J
F
M
A
M
J
J
A
S
O
N
D
— MONTHS —
b
NUMBER OF LARVAE (%)
0
4
8
12
16
20
24
Ratnagiri
Karwar
Coondapur
Kasaragod
Calicut
Cochin
Quilon
Cape Comorin
Tuticorin
— SECTIONS —

The P. arsius larvae were obtained in June, October and November. Maximum abundance was noticed in November (69%) (Table: 22).

In the case of P. profunda larvae, there was an increase in abundance from March onwards and reaching the peak in May (53%). There after it reduced to 3% in June. Other months of larval occurrence were August and November (Table:22).

The larvae of E. grandisquamis occurred throughout the year except in September. Maximum number of larvae occurred from March to June with a peak in June (23%). A secondary peak was also noticed in November (17%)(Table: 22).

Though the larvae of E. cocosensis occurred throughout the year, maximum number was present from March to June, with a peak in March (19%). During monsoon and post-monsoon months the abundance was very low (Table: 22).

The occurrence of larvae of B. ovalis highly fluctuated and showed three periods, one in February to April, next one from July - August and the third one from October to December. The maximum number of larvae occurred in December (38%) (Table: 22).

The larvae of G. polyophthalmus occurred in pre-monsoon and monsoon months. Its distribution and abundance mainly concentrated from February to August and a gradual increase in abundance was noticed from April onwards with a peak in July (22%) (Tabale: 22).

The larvae of L. guentheri were obtained from February to August with maximum in April (24%). A fairly moderate distribution was also seen in June. Stray occurrence was noticed in November (Table: 22).

The larvae of L. macrophthalmus not occurred in the months January, February, July and October. The larvae were more abundant during May and August and less in March and December (Table: 22).

5.1.2. Effect of of hydrographic features on the larval distribution.

The oceanographical conditions of the S.W. Coast of India are largely influenced by the monsoons, the associated currents and the upwelling phenomenon. The Oceanographic condition and biology of the area north of Quilon are mainly influenced by S.W. Monsoon and north Arabian Sea, while the area south of it is more influenced by the N.E. monsoon and Bay of Bengal condition.

Surface temperature conditions along the S.W. Coast show a double oscillation during an year with two peaks, one in April and a secondary one in November. Corresponding minima occurred during July/August and December/January (Sharma, 1967). The temperature at the top of the thermocline depth ranges from 26° to 29° C during the monsoon season and the range is slightly less during winter (Murthy 1965).

Very low salinities of less than 30‰ are observed during the S.W. monsoon from Cochin and northwards in the surface layer, due to discharge of large amount of fresh water, while off Cape Comorin and Tuticorin, surface salinity is only slightly less than 34‰. Salinity and its seasonal amplitude increase north of Kasaragod (Anon, 1976).

Dissolved oxygen values show an increase in seasonal amplitude from south to north of the area. The shelf water of the area are generally well aerated during most part of the year, with 4-5 ml/L of dissolved oxygen at the surface except during the S.W. monsoon and upwelling period. There is a slow decrease in oxygen content towards and during the S.W. monsoon season, with an abrubt rise afterwards (Anon, 1976).

The effect of hydrological condition on the distribution of flat fish larvae was observed and it was seen that in general, the larvae preferred warm water within the range of 27° - 29°C, 34 - 35‰ salinity and Ca 4ml/L of Oxygen.

Fig. 18. : Distribution of flat fish larvae in relation to temperature.

a. all flat fish larva

b. *C. macrostomus*

c. *P. bilineata*

d. *A. cyaneus*

e. *P. arsius*

f. *P. profunda*

g. *E. grandisquamis*

h. *E. cocosensis*

i. *B. ovalis*

j. *G. polyophthalmus*

k. *L. guentheri*

l. *L. macrophthalmus*

Fig.18

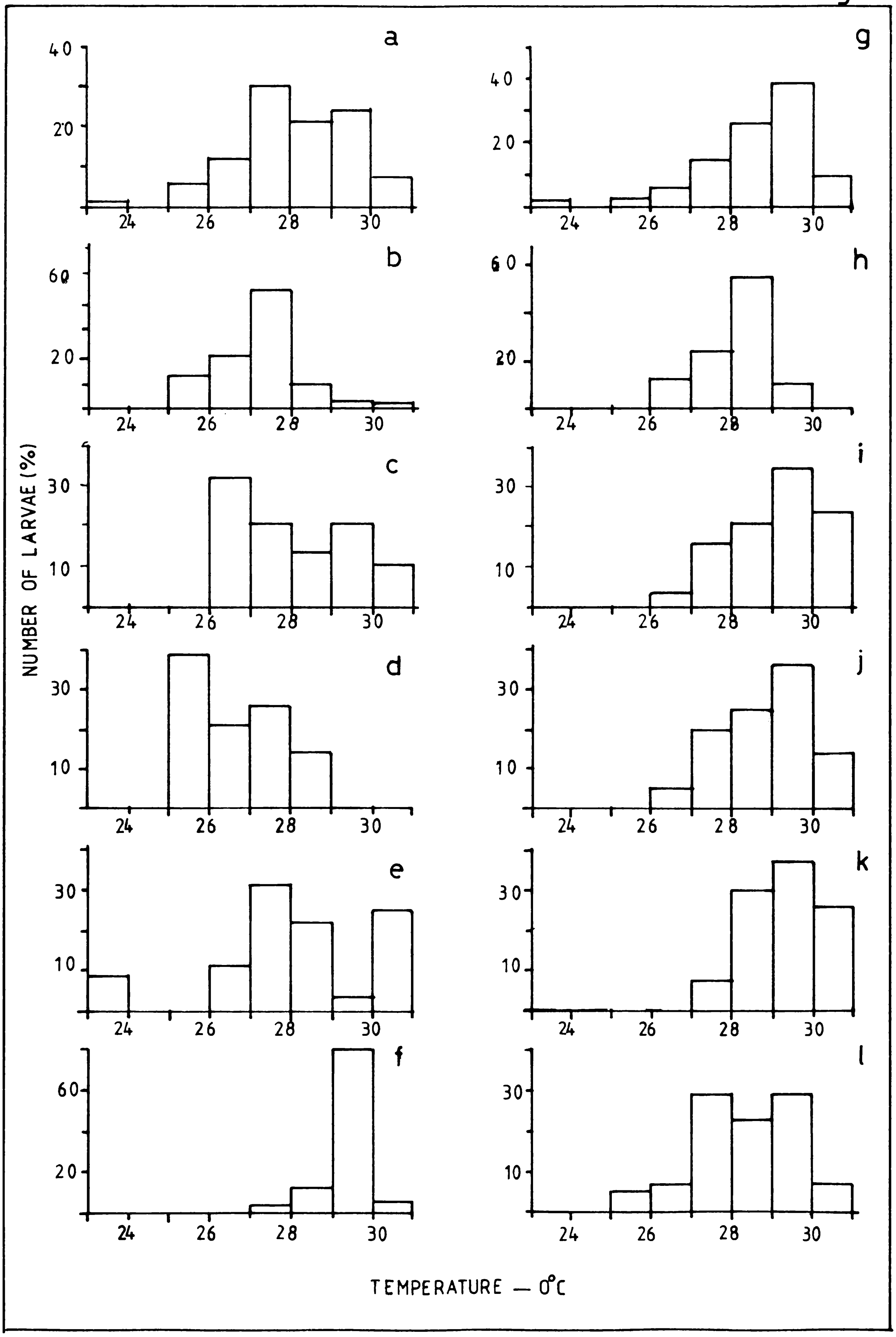


Fig. 19. : Distribution of flat fish larvae in relation to salinity

a. all flat fish larva

b. _C. macrostomus_

c. _P. bilineata_

d. _A. cyaneus_

e. _P. arsius_

f. _P. profunda_

g. _E. grandisquamis_

h. _E. cocosensis_

i. _B. ovalis_

j. _G. polyophthalmus_

k. _L. guentheri_

l. _L. macrophthalmus_

Fig. 19

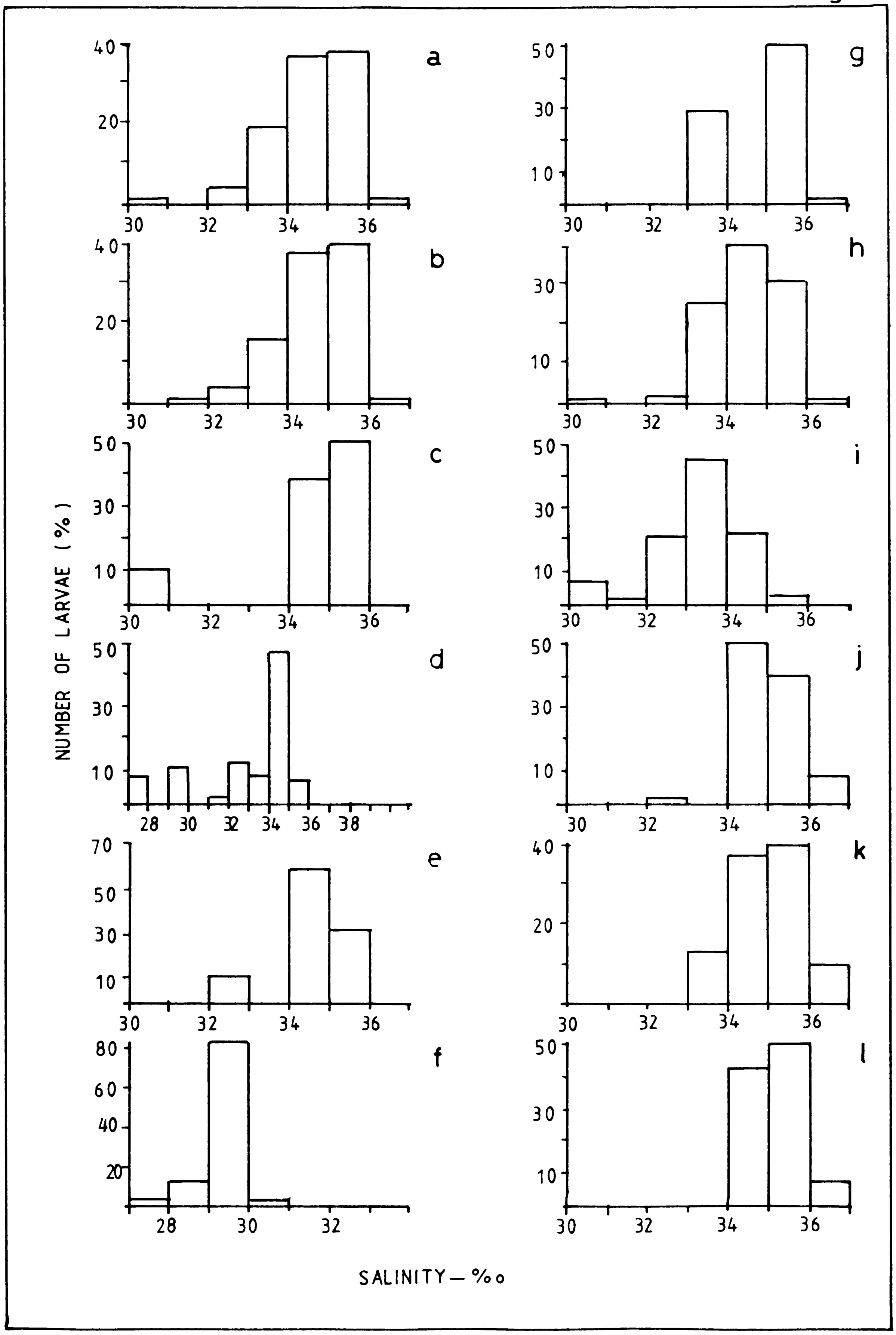


fig. 20. : Distribution of flat fish larvae in relation to Oxygen.

a. all flat fish larva

b. *C. macrostomus*

c. *P. bilineata*

d. *A. cyaneus*

e. *P. arsius*

f. *P. profunda*

g. *E. grandisquamis*

h. *E. cocosensis*

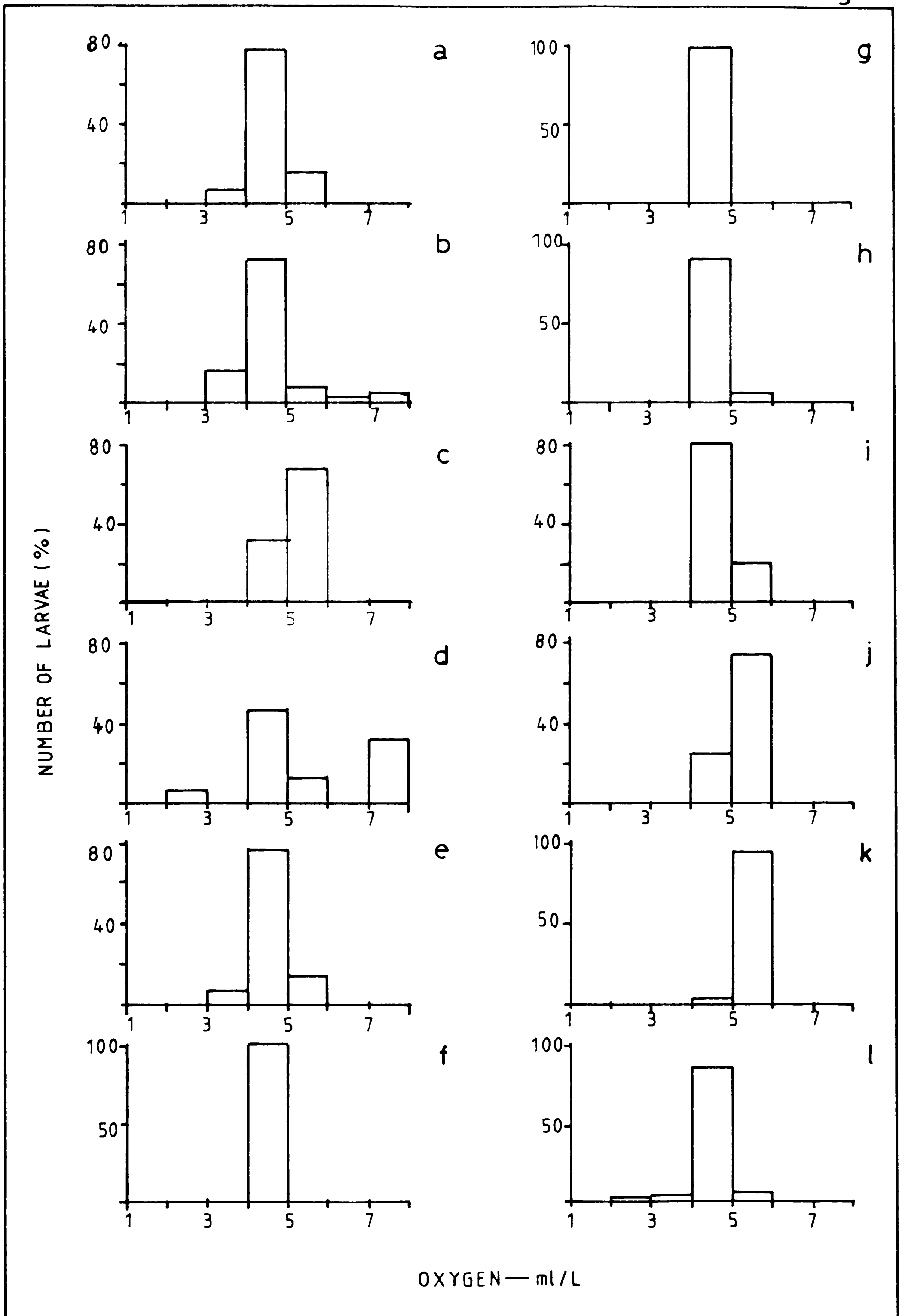
i. *B. ovalis*

j. *G. polyophthalmus*

k. *L. guentheri*

l. *L. macrophthalmus*

Fig 20



Different species, selected for the study also showed much variation in their distribution. Maximum abundance of larvae of C. macrostomus was observed in the temperature range of 26° - 27°C, salinity 34 - 35‰ and oxygen 3-4ml/L.

Maximum abundance of P. bilineata larvae was observed when the temperature reached about 26 - 27°C with salinity 35‰ and oxygen content 5ml/L. Larvae of A. cyaneus was maximum at 25°C with a salinity of 35‰ and oxygen 4ml/L. The larvae of P. arsius were found to occur maximum in a temperature of 27°C with 34‰ salinity and 4ml/L oxygen.

The larvae of P. profunda, E. grandisquamis and E. cocosensis occurred maximum when the temperature ranged between 28°-29°C, Salinity at 34 - 35‰ and oxygen about 4ml/L.

The larvae of B. ovalis occurred maximum at a temperature of 28°C with salinity and oxygen at 33‰ and 4ml/L respectively. Larvae of G. polyophthalmus and L. guentheri were found to occur maximum in the temperature range between 28° - 29°C, with a salinity range between 33 - 34‰ and oxygen 4 - 5 ml/L, whereas the L. macrophthalmus larvae occurred maximum in 27 - 29°C range and 34 - 35‰ salinity with 4ml/L Oxygen content.(Fig.18 to 20).

5.1.3. Spacial distribution and abundance

Though the flat fish larvae were presented in all sections, they were most abundant in between Cochin and Karwar. Maximum abundance was observed in Cochin (24%) and in Kasaragod (22%). Karwar was the next section of abundance (16%), followed by Cape Comorin (13%), Quilon (10%), Ratnagiri (8%), Tuticorin (4%), Calicut (3%) and Coondapur (1%) (Table:23 & Fig.17.b)

5.1.3.1. Year-wise spacial distribution and abundance during 1971 to 1975.

During 1971 maximum abundance was observed from Karwar section (58%). The second most abundant area was Cochin (41%). Kasaragod also showed the occurrence of larvae. In 1972 maximum abuandance was recorded from Kasaragod (25%), Karwar (20%) being the next section of abundance, followed by Calicut (17%), Quilon (17%), Cochin (16%) and Ratnagiri (5%) (Table: 24.).

During 1973 the flat fish larvae were represented at every section except in Ratnagiri, 37% of larvae were obtained from Cochin, followed by Quilon 20%, Cape Comorin 15%, Tuticorin 8%. Karwar 7%, Calicut 6%, Kasaragod 5% and Coondapur 2%.

In 1974 maximum abundance was observed in Kasaragod (35%), and followed by Cochin (23%), Cape Comorin (17%), Karwar (9%), Quilon (8%), Ratnagiri (6%) and Tuticorin (2%). During 1975 larvae occurred in all sections but Coondapur and maximum was recorded from Kasaragod (22%). Cochin represented second in abundance (20%) followed by Cape Comorin (16%), Ratnagiri (13%), Karwar (11%), Quilon (11%), Tuticorin (6%) and Calicut (1%) (Table: 24).

5.1.3.2. Month-wise spacial distribution and abundance.
(Pooled data of different years)

In Ratnagiri section maximum abundance of larvae was observed in October (52%). April also showed moderate occurrence (12%) followed by March (8%), May (7%), August (7%), November (6%), June (6%) and December (2%). No larvae were observed during January, February, July and September (Table: 25.).

In Karwar section, larvae were present in all the months except in January and December. In October 57% larvae occurred, followed by April (18%), June (10%) August (9%), March (7%), July (3%), September (3%), May (2%) November

(1%) and February (1%) (Table: 25). Larvae were obtained from Coondapur only in February and March.

Larvae were most abundant in Kasaragod during November (35%) and June (18%). Moderate occurrence was also noticed in September (11%), March (9%) and October (5%) and rare in April, May and July. (Table: 25). In Calicut section the larvae were observed only in January (8%), April (23%), June (25%), July (12%), September (20%) and November (12%).

In Cochin section larvae were observed in every month of the year and was most abundant in November (21%), July (19%). During May (18%) and April (14%) also got fairly good number of larvae. Less number of larvae were observed during December (8%), June (5%), February (4%), September (4%), January (2%), August (2%), October (2%) and November (1%) (Table: 25).

Larvae occurred throughout the year in Quilon section also. . Maximum abundance was noticed in May (17%) followed by November (15%), February (13%) July (13%), September (13%) and March (12%). Occurrence of larvae was rare in January (2%), April (2%), June (4%), August (2%), October (3%) and December (4%) (Table: 25).

In Cape Comorin, maximum abundance of larvae was observed in November (25%). May (19%), March (13%), April (11%) and August (11%) showed moderate occurrence and in January (5%), February (5%), July (5%), October (3%) and December (3%) only less number of larvae were obtained. In Tuticorin section larvae were obtained in March (36%), June (23%), October (9%), November (24%) and in December (8%) (Table: 25).

5.1.3.3. Species-wise spacial distribution and abundance of larvae.

C. macrostomus was represented at every section and was the most numerous species of larvae. Relatively high density of larvae was observed in Cochin-Karwar area and less in southern sections (Quilon - Tuticorin). Larval abundance was maximum in Kasaragod section (30%) and Cochin being the next area of abundance (29%). Karwar (20%) and Ratnagiøri (10%) showed moderate occurrence. The percentages of occurrence were very less in Coondapur (0.5%), Calicut (2%), Quilon (5%), Cape Comorin (3%) and Tuticorin (0.5%). (Table: 23).

P. bilineata larvae were recorded from Cochin to Cape Comorin and in Ratnagiri. Maximum number of larvae were obtained from Quilon (43%) followed by Cochin (25%), Cape Comorin (21%) and Ratnagiri (11%). A. cyaneus larvae were abundant only from Quilon to Kasaragod sections. Larval abundance was maximum towards southern side, Quilon being the most abundant area (44%) followed by Cochin (35%), Calicut (14%) and Kasaragod (7%) (Table: 23).

Larvae of P. arsius occurred only from Kasaragod in the north to Tuticorin in the south. Larval abundance was maximum in Cape Comorin (39%) and Quilon (28%). The larvae were obtained from Kasaragod (11%), Cochin (11%) and Tuticorin (11%) (Table: 23).

P. profunda larvae were distributed from Kasaragod to Cape Comorin and most abundant in Cochin (45%), Cape Comorin being the next area of high occurrence (23%), followed by Quilon (15%), Calicut (8%) and Kasaragod (8%).

E. grandisquamis larvae were obtained at all sectiosns except in Coondapur. Maximum number was obtained from Kasaragod (28%) and Cape Comorin being the next (17%). Larval occurrence was moderate in Cochin (16%), Tuticorin (11%) Ratnagiri (9%), Karwar (9%) and Quilon (8%) and less in Calicut (2%) (Table:23).

Larvae of E. cocosensis were the second most abundant in the collections and obtained from all the sections. Maximum abundance of larvae was found in

Cochin (23%) and Karwar(20%). Larval occurrence was moderate in Cape Comorin (19%) Kasaragod (14%) and Quilon (11%) and less in Ratnagiri (7%), Tuticorin (4%) and Calicut (2%), Coondapur showed the value less than 1%. (Table: 23).

B. ovalis larvae were found in scattered locations. Larval abundance was maximum in Cape Comorin (33%), followed by Kasaragod (28%), Cochin (17%), Quilon (16%) and Karwar (7%).

Larvae of G. polyophthalmus occurred at all sections except in Coondapur. The abundance of larvae was maximum towards the south. Maximum number of larvae was obtained from Kasaragod (19%) followed by Cape Comorin (18%), Karwar (18%), Cochin (16%) and Quilon (15%). Comparatively less number of larvae were obtained from Ratnagiri (7%) Calicut (3%) and Tuticorin (4%) (Table: 23.).

Larvae of L. guentheri were not obtained from Coondapur, Cape Comorin and Tuticorin. Maximum abundance of larvae was obtained from Calicut (30%) and Quilon (30%) sections. Moderate occurrence was noticed in Kasaragod (17%). Karwar (10%) Ratnagiri (7%) and Cochin (7%) showed less in abundance (Table: 23.).

L. macrophthalmus larvae showed a discontinuous distribution and found in Ratnagiri and Karwar in north and Cochin to Cape Coimorin in south. Maximum abundance of larvae occurred in Cochin (39%) and Cape Comorin (39%). The percentage of occurrence was low in Quilon (9%) Karwar (7%) and Ratnagiri (5%).

5.1.4. Horizontal distribution and abundance.

In general the larvae of flat fishes were more concentrated in near-shore waters of the area and density gradient towards offshore was gradually lighter.

The concentration has been highest in the area between 10 to 20 miles away from shore. Occurrence in moderate level was noticed upto 70 miles and thereafter it diminished. The larvae were present in the offshore area of Ratnagiri, Karwar and Cape Comorin (Fig:21.)..

5.1.4.1.Year-wise horizontal distribution and abundance

In 1971, the sampling was covered only to shelf waters from Karwar to Quilon. The area lying at about 20 miles off Kasaragod showed very high core values (118/m^2). Moderate level of larval occurrence was noticed in Cochin section also.

During 1972 the survey extended further seaward, as well as to the north up to Ratnagiri. The larval concentration was high in the inshore waters from Karwar to Quilon and moderate in the mid-shelf area. From 1973 onwards the area from Ratnagiri in the north to Tuticorin in the south were covered by the research vessels. The inshore shelf, from Karwar to Tuticorin showed moderate densities in larvae, while the offshore regions of the area except from Cochin to Cape Comorin was very poor in larval occurrence.

During 1974 the entire shelf area up to 70 miles except in Calicut and Tuticorin sections showed moderate larval densities, the nearshore waters off Kasaragod and Cochin had high core values (60 - 74/m^2). In Ratnagiri and Tuticorin the nearshore areas upto 30 miles were devoid of larvae.

In 1975 the trend of larval densities has the same pattern as noticed in the previous year. The entire shelf areas of Karwar, Kasaragod, Cochin and Cape Comorin showed moderte density values. A dense patch of larvae (69/m^2) was observed within 10 miles off Ratnagiri. Small concentrations of larvae were observed in the offshore waters north of Kasaragod and upto Ratnagiri.

5.1.4.2. Species-wise horizontal distribution and abundance.

The distribution of C. macrostomus larvae showed good denisty values and localised concentration from Ratnagiri to Cape Comorin area with high density values of about $144/m^2$ in the inner-shelf of Karwar, $147/m^2$ in 10 miles area off Kasaragod and $141/m^2$ in 20 miles are off Cochin. A dense patch of $69/m^2$ was observed within 10 miles area off Ratnagiri. Much of the mid-shelf and off-shore areas had very poor larval density whereas the inner-shelf within 30 miles showed high core values. (Fig: 22.).

Larvae of P.. bilineata were found in the inshore area from Cochin to Cape Comorin and all other areas were devoid of larvae, except a small concentration at about 60 miles off Ratnagiri. The larval densities were more in the 20 - 30 miles stations (Fig. 23).

A. cyaneus larvae were obtained in the area between Kasaragod and Quilon Moderate density values were obtained within 20 - 50 miles stations and the best concentration of larvae ($16/m^2$) was osbserved in an area about 40 miles off Quilon. The areas north of Kasaragod and south of Quilon were found to be devoid of the larvae (Fig. 24.).

The concentration of the P. arsius larvae was found in the inner-shelf area, from Kasaragod to Tuticorin. Relatively high core densities ($10/m^2$) were located in the 20 miles station off Cape Comorin. The mid-shelf area off Cochin also showed a moderate density gradient (Fig.25.). About 40% of the P. profunda larvae were found in 20 miles statiosns from Calicut to Quilon. In off Cochin and Cape Comorin, larvae were observed at a distance of about 70 miles from the shore (Fig. 26.). The larvae of P. profunda were absent in the collection from Tuticorirn as well as from north of Kasaragod.

E. grandisquamis larvae occurred in all the sections. The larvae were frequently caught off Cochin, followed by Karwar, Kasaragod and Tuticorin. The larval abundance was maximum in the 20 - 50 miles stations. High core of larval density ($24/m^2$) was obtained in an area about 50 miles off Kasaragod and at Tuticorin some 20 miles away from shore. High density value was also obtained in Cape Comorin area (Fig: 27.).

E. cocosensis larva was distributed all over the shelf area from Ratnagiri to Tuticorin. High core density values were obtained in the stations between 20 - 60 miles. The nearshore belt of about 10 miles of the entire coast was very poor in larval density. High density value of $46/m^2$ was observed in an area about 40 miles off Cochin. Moderate level of concentration occurred in the mid-shelf in Karwar, Kasaragod and Cape Comorin sections. An offshore concentration of $27/m^2$ was observed about 80 miles off Cape Comorin (Fig. 28.).

The larvae of B. ovalis were found mainly in mid-shelf waters and occurred in all sections, except Ratnagiri and Tuticorin. The larval concentrations were high in between 40-50 miles away from shore. The best concentration of larvae was obtained off Cape Comorin at about 40 miles station ($9/m^2$) (Fig: 29).

The larvae of G. polyophthlmus were distributed in the mid-shelf and offshore areas from Ratnagiri to Tuticorirn and the entire nearshore belt of an average width of about 10 miles was devoid of larvae. High concentrations of larval density occurred in the mid-shelf areas of Karwar, Quilon and Cape Comorin (Fig.30).

As in the case of G. polyophthalmus, larvae of L. guentheri were not observed in the inshore belt of an average width of 10 miles in the entire areas from Ratnagiri to Tuticorin. Maximum abundance was noticed in the mid-shelf waters from Karwar to Quilon area. One patch of high density ($9/m^2$) off Calicut and another of slightly lesser density in Quilon section have been observed. The larvae was absent in the collections from Cape Comorin and Tuticorin. (Fig: 31).

The larvae of L. macrophthalmus were absent from Kasaragod, Calicut and Tuticorin sections. The inner shelf of the entire area was very poor in larval density. Maximum larval density was seen in the Cochin and Cape Comorin areas and a high core value ($14/m^2$) was observed in the outer shelf area off Cape Comorin (Fig: 32).

5.1.5. Vertical distribution and abundance

The present study also dealt with any possibility of relation between the distribution and abundance of ichthyoplankton in relation to day/night variation. It was seen that the larvae of flat fishes in general doest not show much response to the day/night variation (Table - 26). About 46% of the larvae were collected in day and 54% in night.

Slight variations have been noticed in species-wise study. The C. macrostomus occurred about equally in day and night collections. During day time it occurred 52% and in night 48%. The larvae of P. bilineata were more in night (68%) than in day (32%). A. cyaneus larvae showed same pattern of abundance and obtained 37% in day and 73% in night collections . Maximum abundance of larvae of P. arsius was osbtained during day (61%) than in night (39%). The larvae of P. profunda were obtained equally in day and night collections (50% each).

The larvae of E. grandisquamis were obtained less in day collections (33%) as in the case of E. cocosensis larvae (41%). Maximum abundance of B. ovalis larvae were obtained in day collections (60%) than in night (40%). The larvae of G. polyophthalmus showed about same pattern of occurrence and obtained 56% during day and 44% at night. No variation was noticed in the collection of L. guentheri larvae and obtained equal number of larvae in day and night collections. Larvae of L. macrophthalmus were more abundant in day (57%) than in night (43%) (Table: 26).

Fig. 21. : Horizontal distribution of total flat fish larva.

Fig . 21

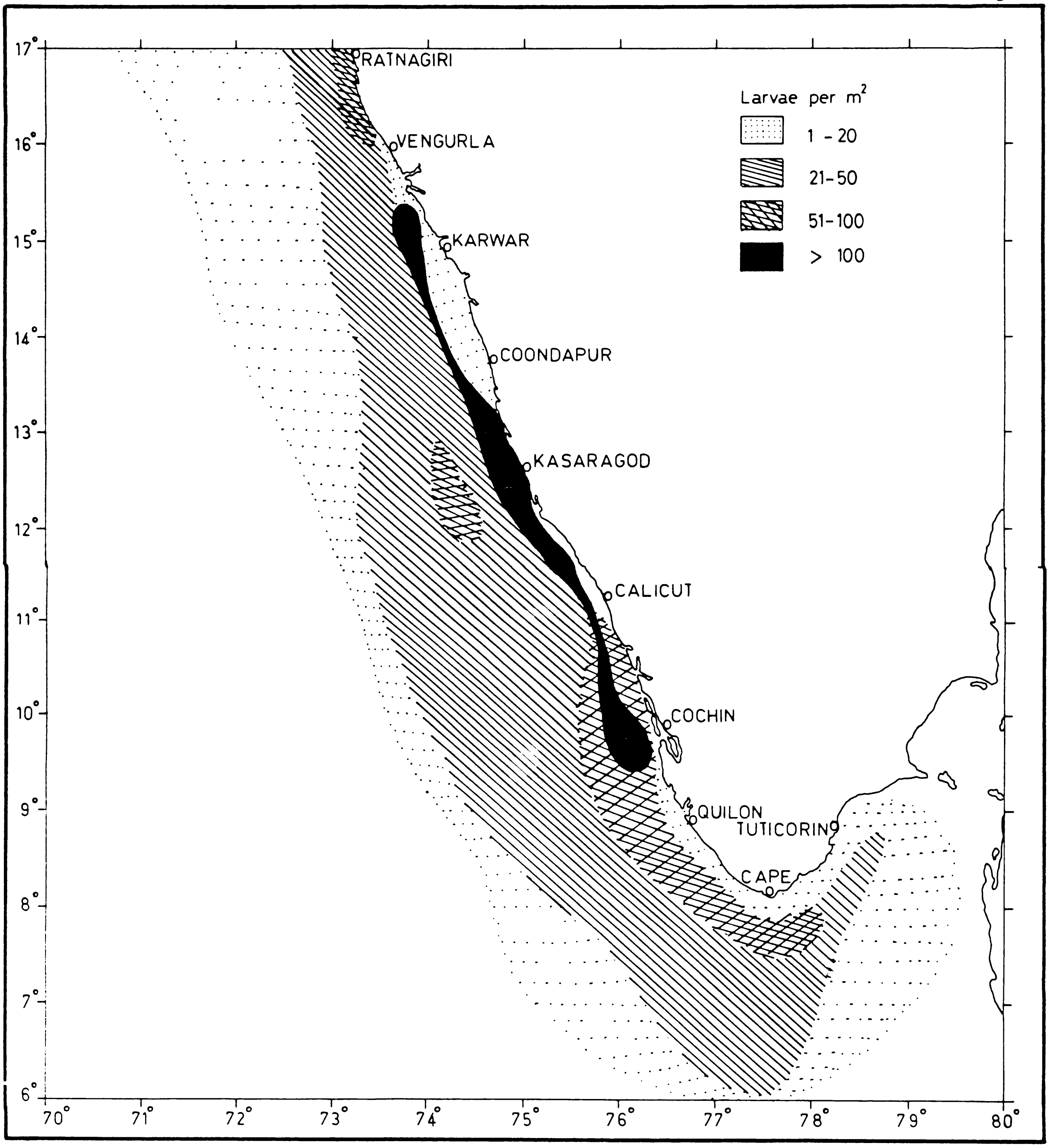
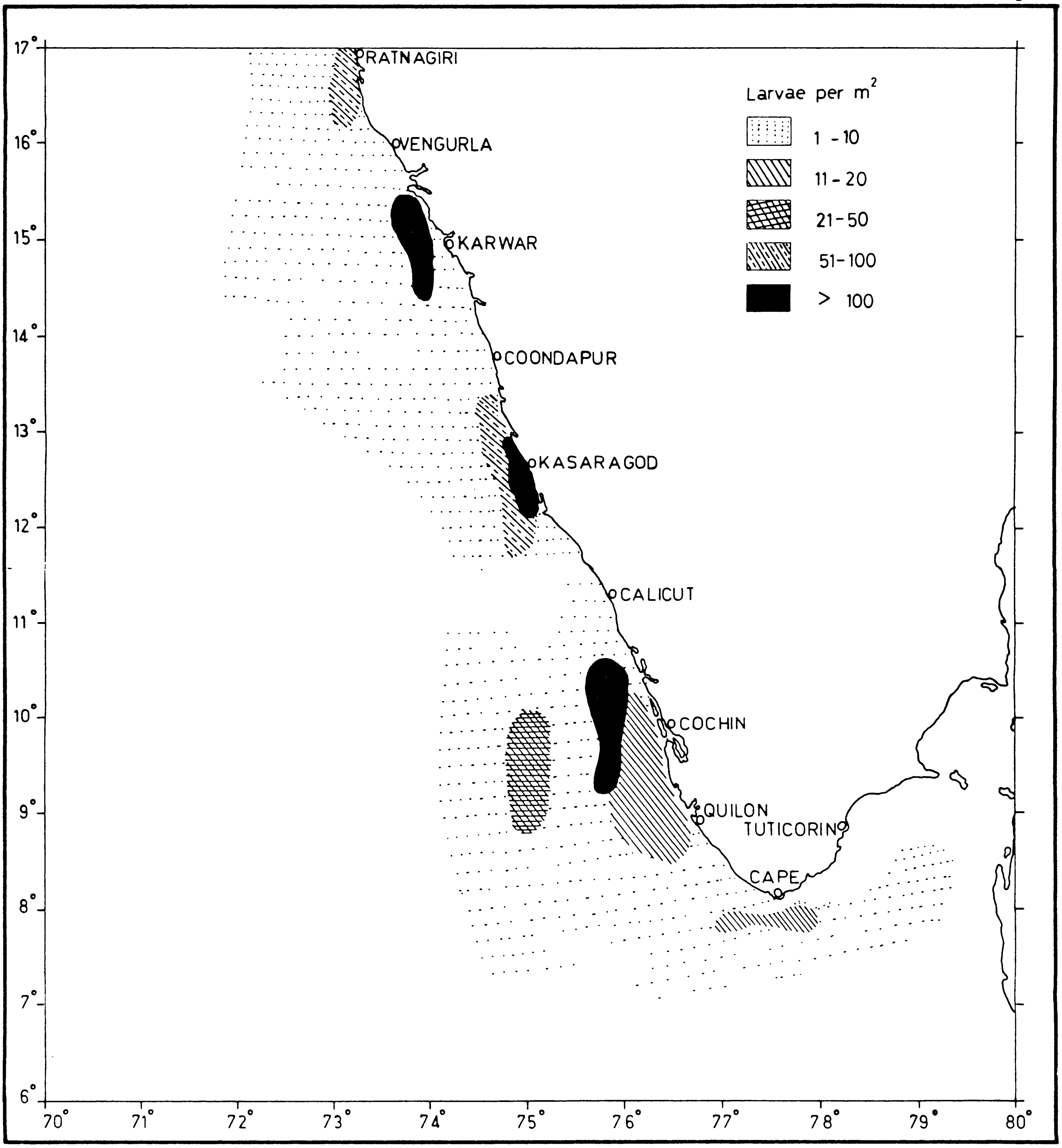

Larvae per m2
1 - 20
21-50
51-100
> 100
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 22. : Horizontal distribution of the larvae of C. macrostomus

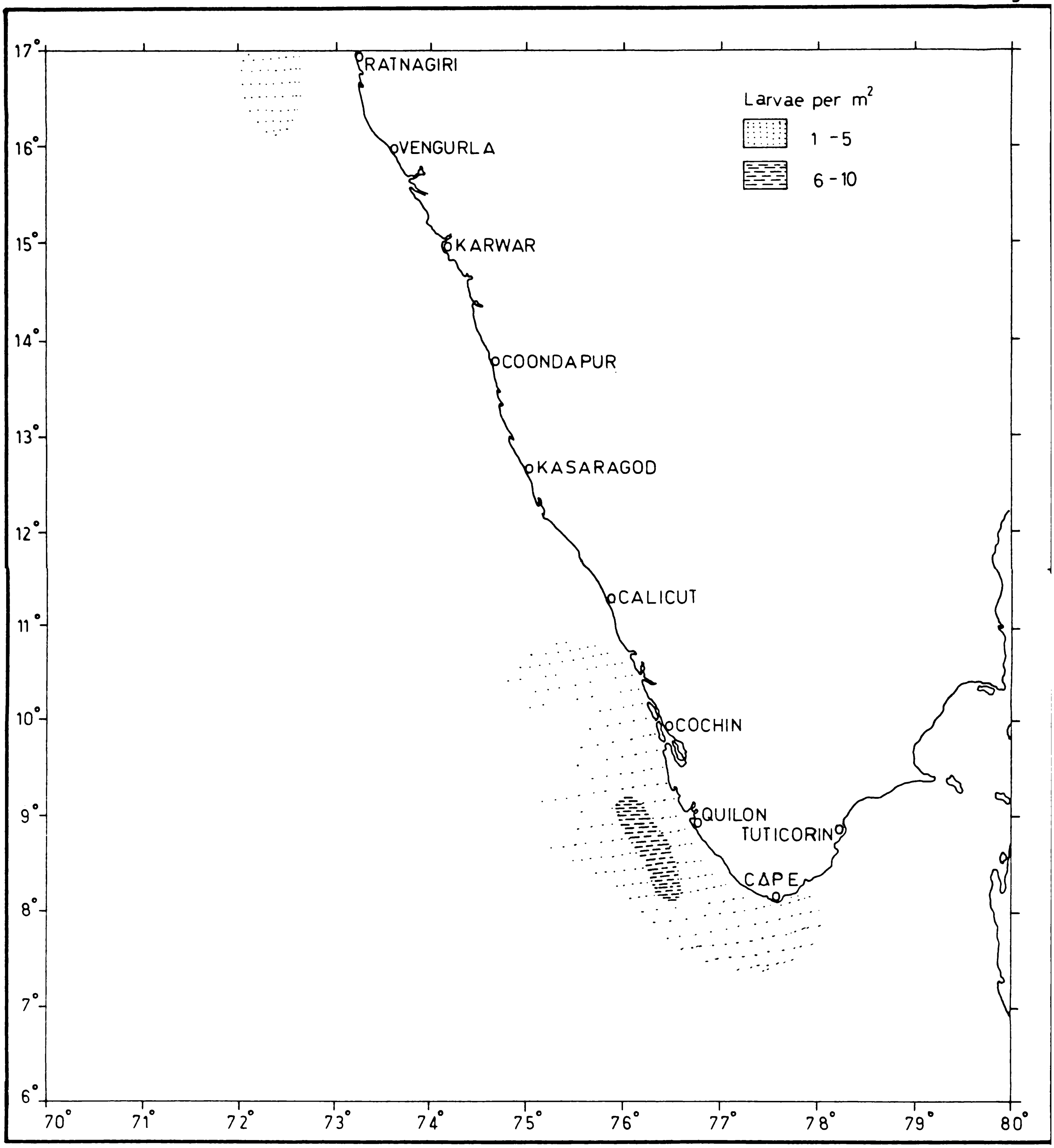
Fig. 22



Larvae per m²
1 - 10
11 - 20
21 - 50
51 - 100
> 100
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 23. : Horizontal distribution of the larvae of P. bilineata

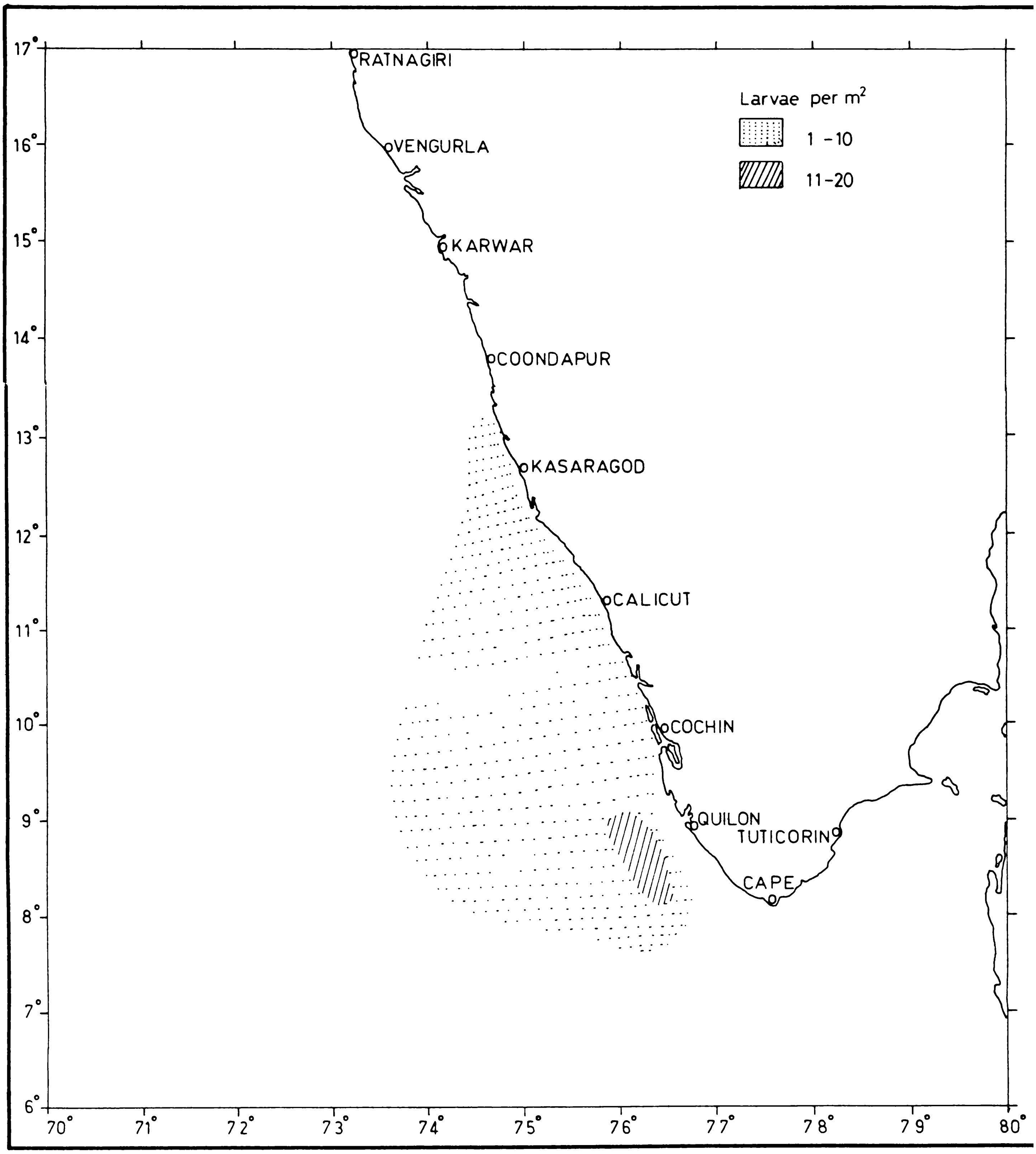
Fig.23



RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
Larvae per m²
1 - 5
6 - 10
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 24. : Horizontal distribution of the larvae of A. cyaneus

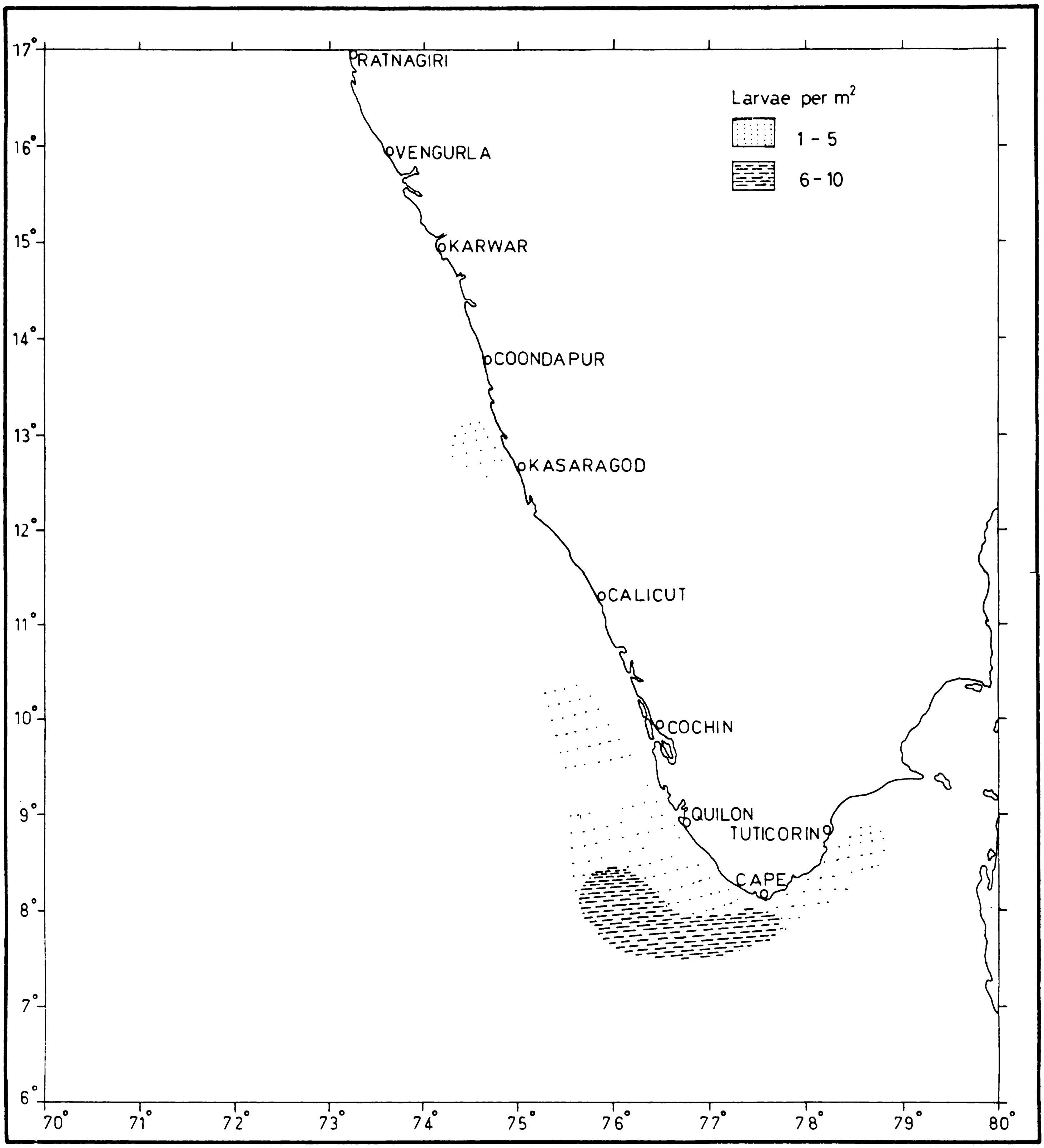
Fig . 2



Larvae per m²
1 -10
11-20
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 25. : Horizontal distribution of the larvae of P. arsius

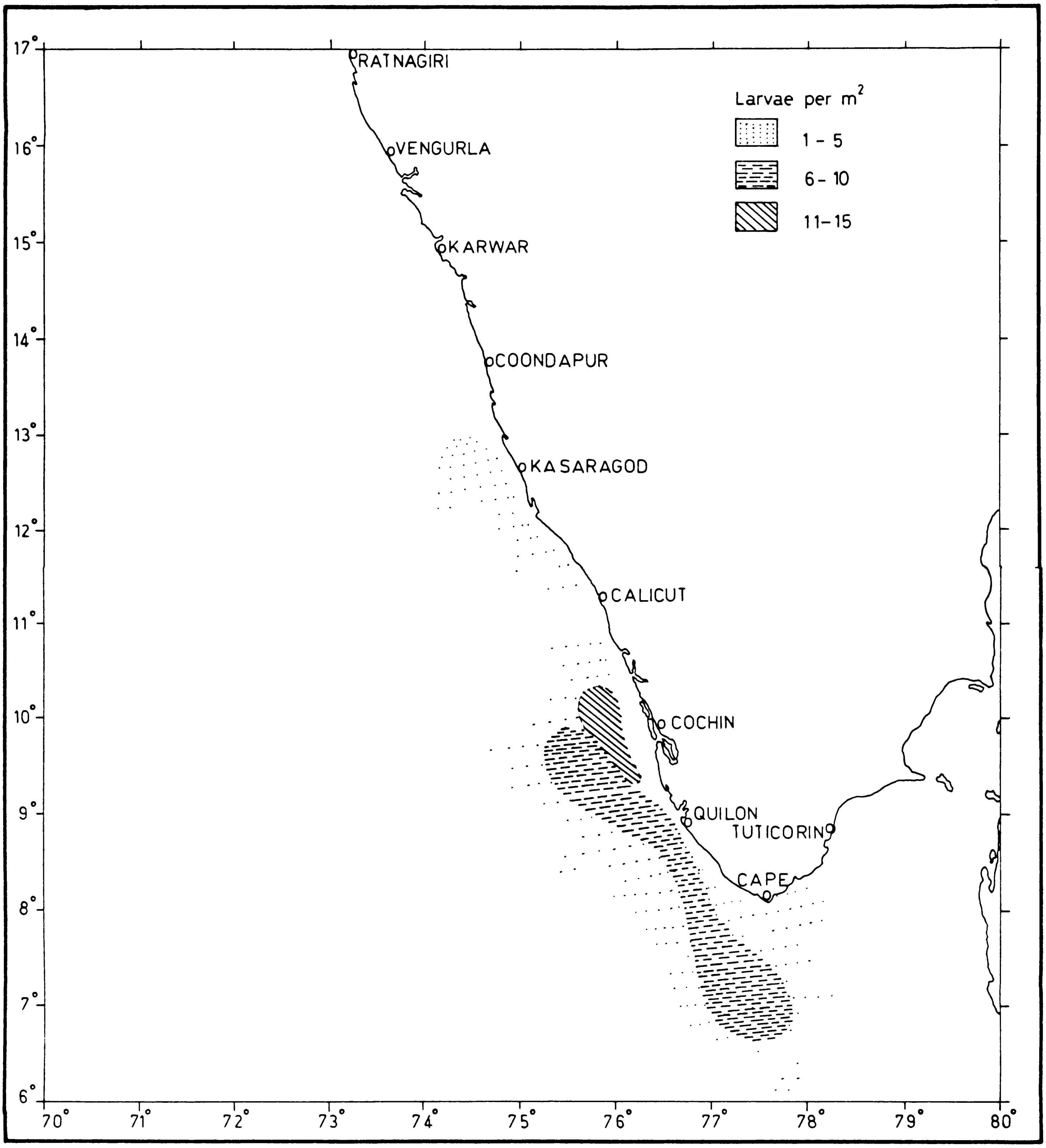
Fig . 25



Larvae per m²
1 - 5
6 - 10
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 26. : Horizontal distribution of the larvae of *P. profunda*

Fig. 26



Larvae per m^2
1 - 5
6 - 10
11-15
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 27. : Horizontal distribution of the larvae of *E. grandisquamis*

Fig. 27

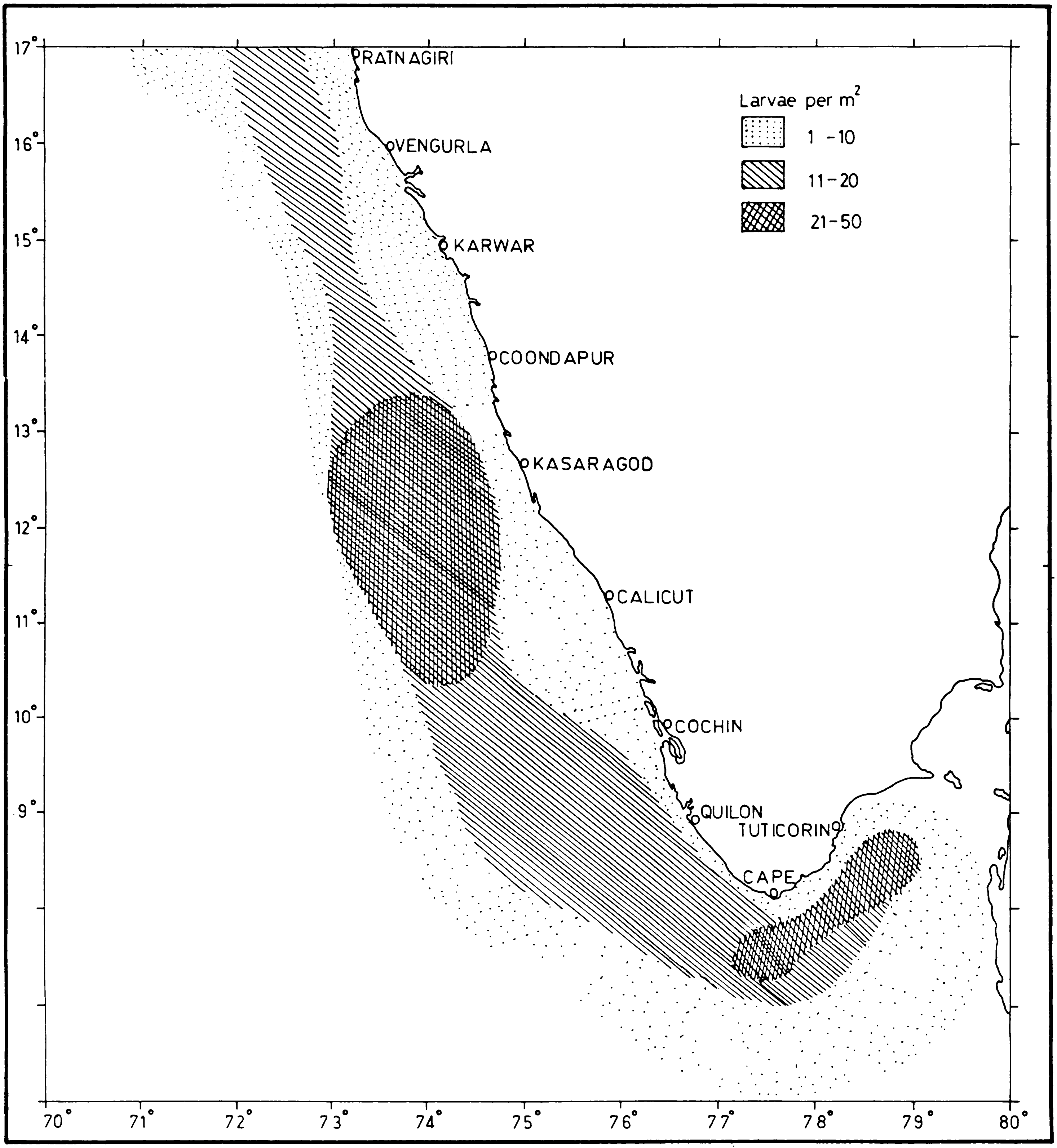

Larvae per m²
1 -10
11-20
21-50
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 28. : Horizontal distribution of the larvae of E. cocosensis

Fig. 28

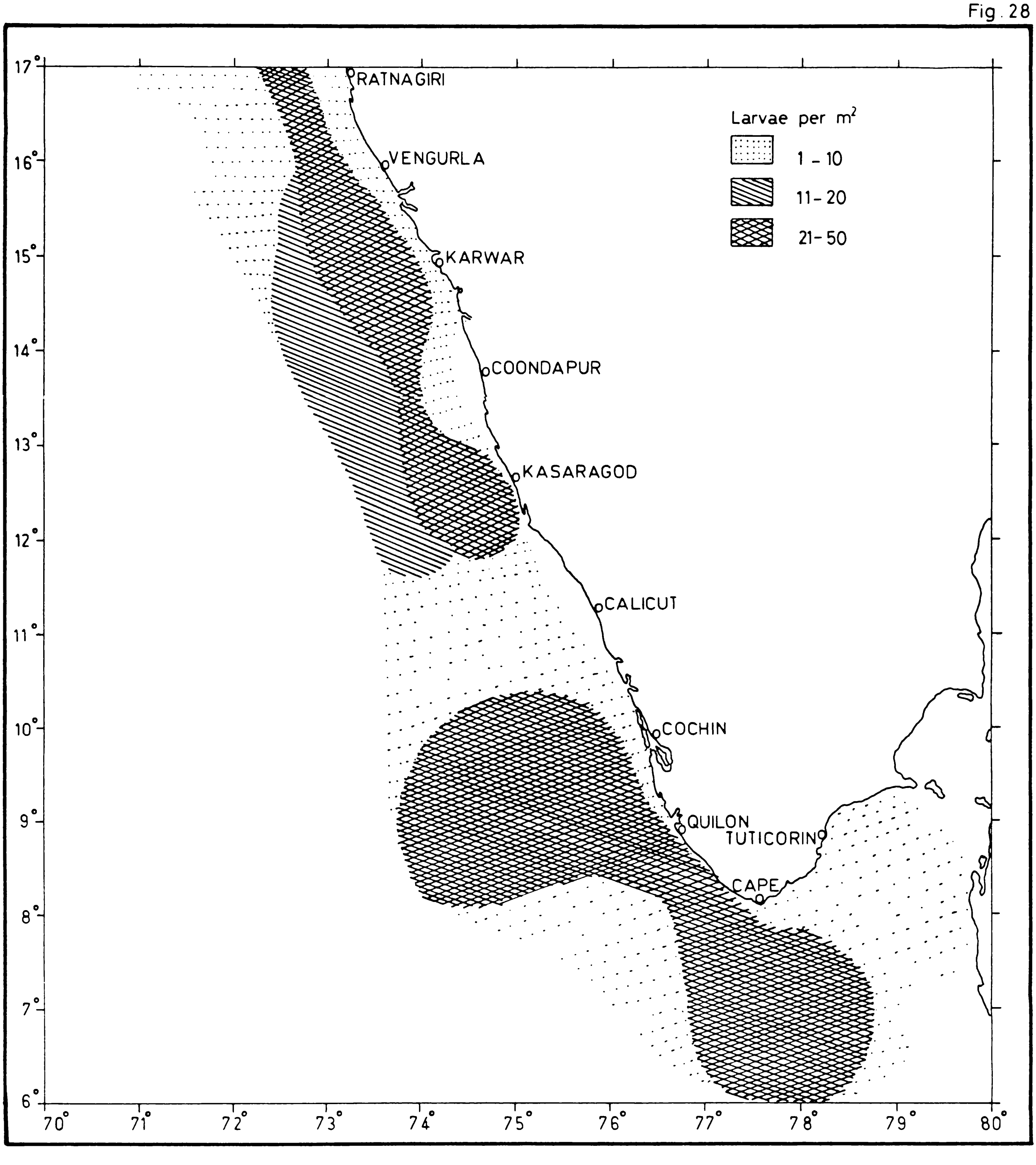
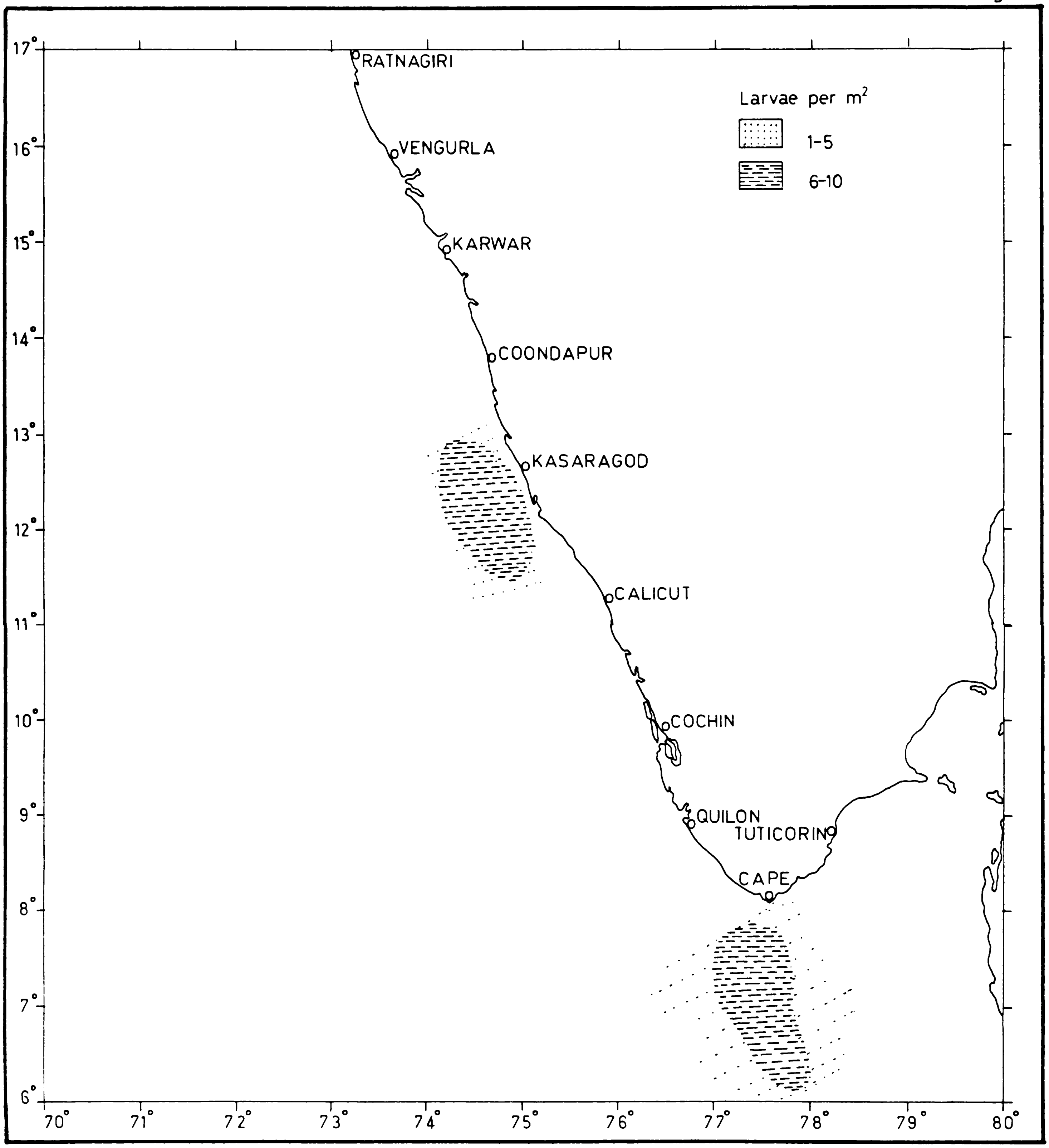

Larvae per m²
1 - 10
11 - 20
21 - 50
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 29. : Horizontal distribution of the larvae of B. ovalis

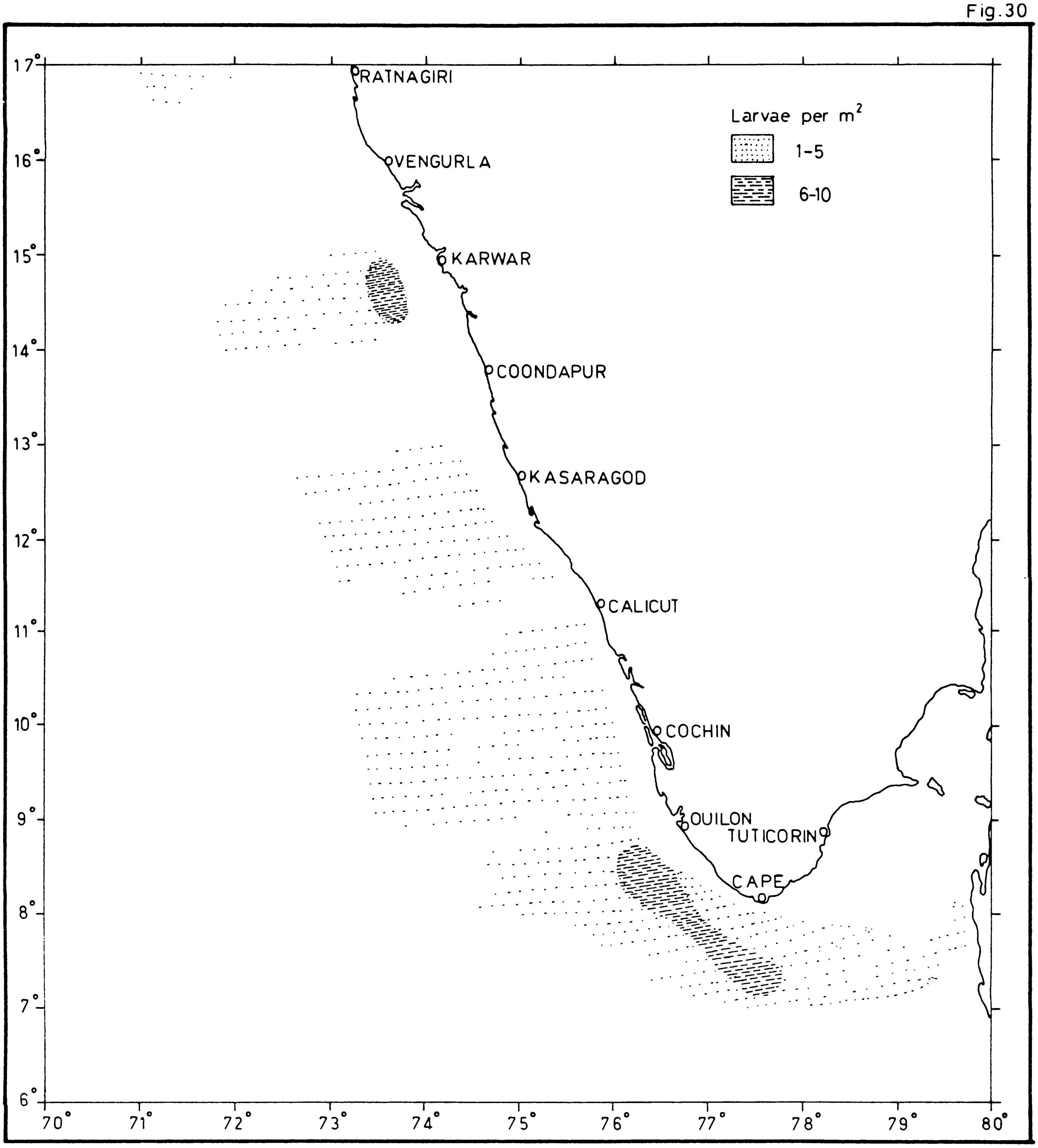
Fig. 29



Larvae per m²
1-5
6-10
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 30. : Horizontal distribution of the larvae of G. polyophthalmus

Fig.30



17°
16°
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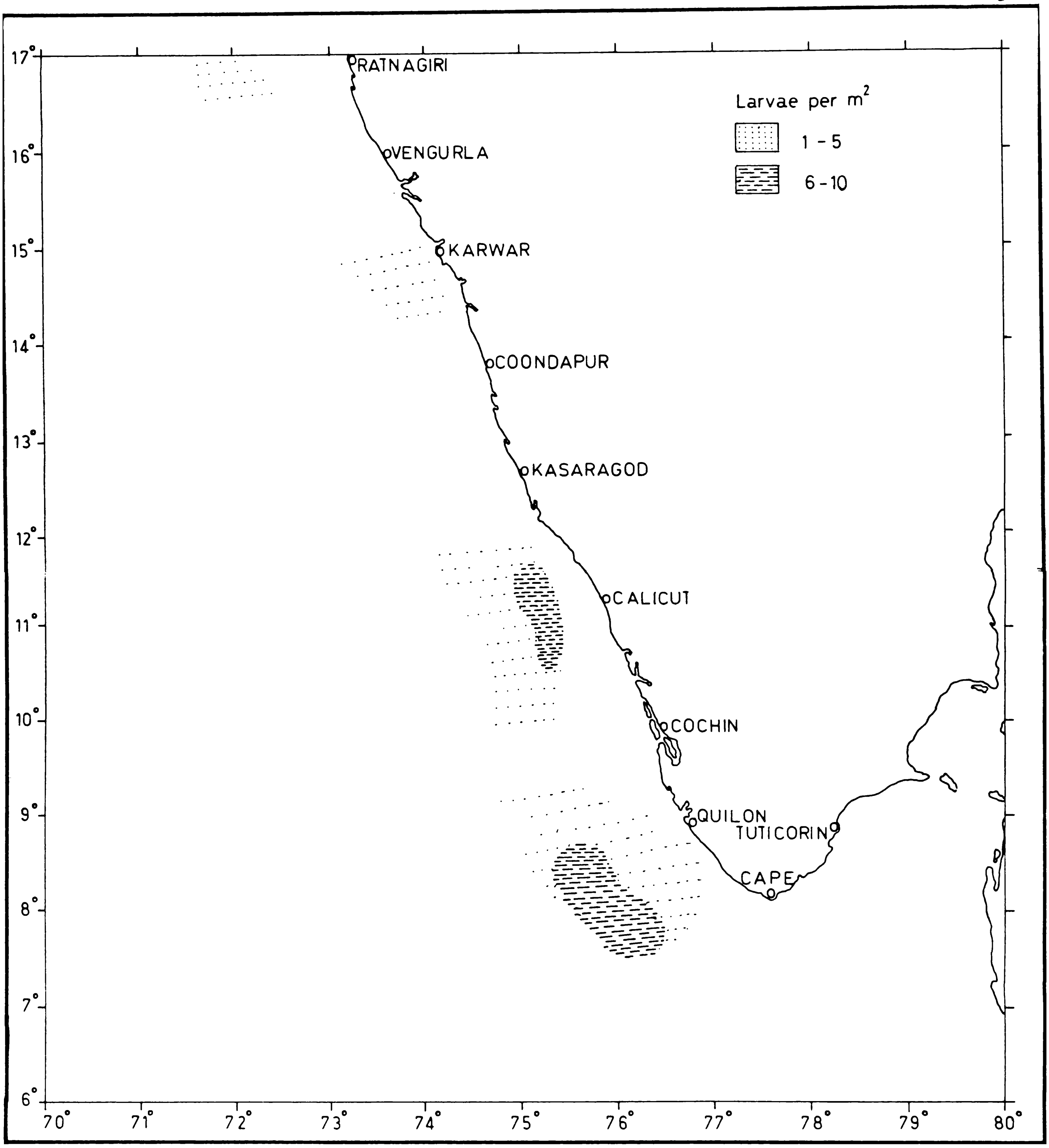
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
Larvae per m²
1-5
6-10

Fig. 31. : Horizontal distribution of the larvae of L. guentheri

Fig .31



Larvae per m²
1 - 5
6 - 10
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 32. : Horizontal distribution of the larvae of L. macrophthalmus

Fig.32

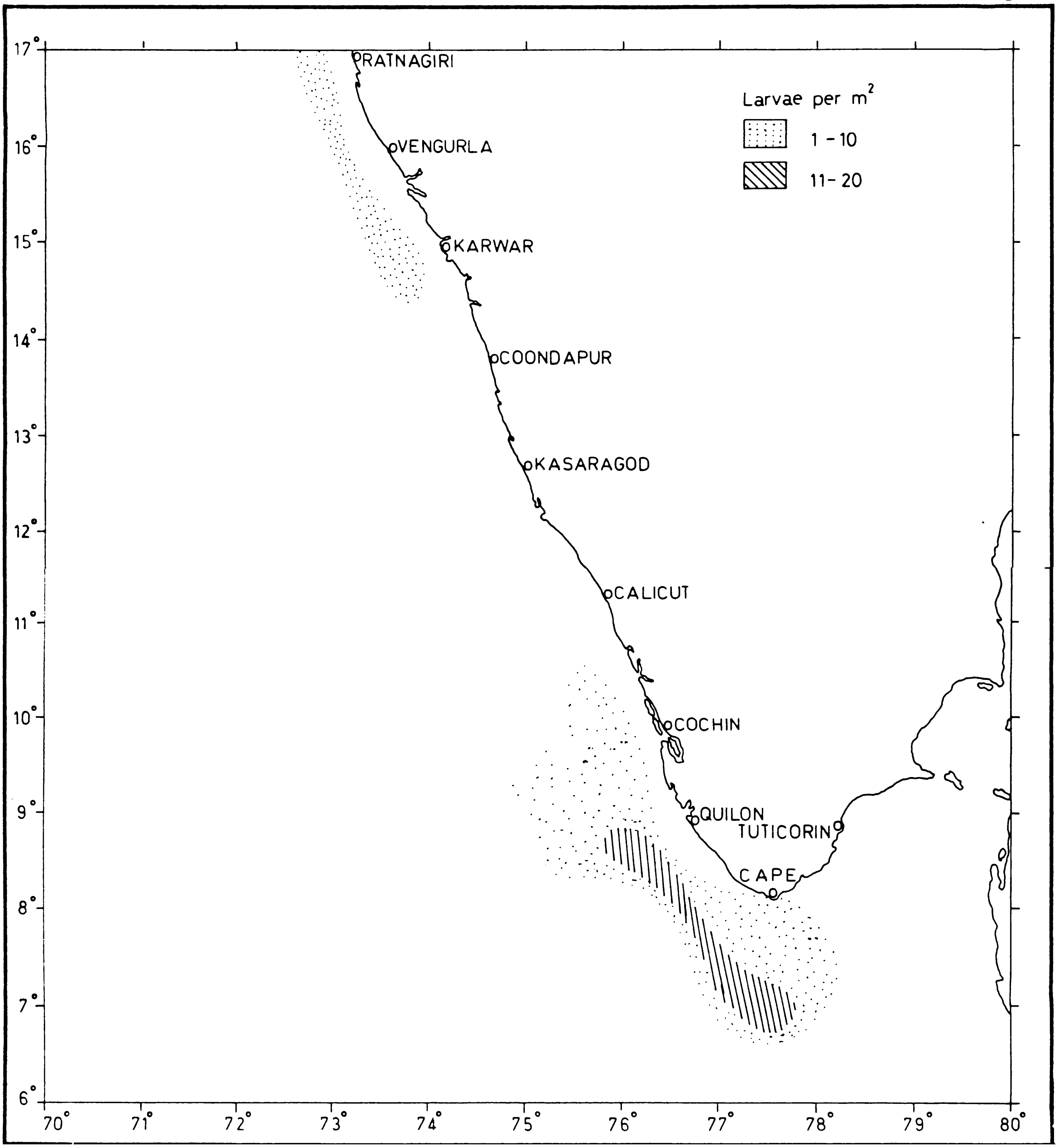

Larvae per m^2
1 - 10
11 - 20
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Table: 20. **Showing the number of larvae of flat fishes obtained during different months from 1971 to 1975**

Year	Month	C. macrostomus	P. bilineata	A. cyaneus	P. arsius	P. profunda	E. grandisquamis	E. cocosensis	B. ovalis	G. polyophthalmus	L. guentheri	L. macrophthalmus	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1971	Sept.	3	-	-	-	-	-	-	-	-	-	-	3
	Octo.	208	-	-	-	-	-	-	-	-	-	-	208
	Nov.	-	-	-	4	-	-	2	-	-	-	1	7
	Dec.	-	-	-	-	-	1	1	-	-	-	-	2
1972	Jan.	-	-	-	-	-	-	2	-	-	-	-	2
	Feb.	1	-	-	-	-	-	10	-	-	-	-	11
	Mar.	-	-	-	-	-	-	6	-	-	-	-	6
	Apr.	-	-	-	-	9	-	17	4	-	6	-	36
	May	2	2	-	-	1	-	-	-	-	1	-	6
	June	-	-	-	-	-	-	3	-	1	2	-	6
	July	2	-	2	-	-	-	2	-	1	-	-	7
	Aug.	6	-	-	-	-	-	-	-	-	-	-	6
	Sept.	62	-	-	-	-	-	-	-	-	-	4	66
	Oct.	21	-	-	-	-	-	-	-	-	-	-	21
	Nov.	2	-	-	10	-	5	4	-	-	1	-	22
	Dec.	-	-	-	-	-	-	-	-	-	-	-	-
1973	Jan.	10	-	-	-	-	4	13	-	-	-	-	27
	Feb.	-	-	-	-	-	-	1	-	-	-	-	1

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1973	Mar.	2	-	-	-	-	10	7	-	-	1	3	23
	Apr.	-	-	-	-	-	3	1	-	-	1	-	5
	May	2	4	-	-	18	10	11	-	1	3	-	49
	June	3	1	-	-	2	2	8	-	1	-	-	17
	July	1	-	-	-	-	5	3	-	-	-	-	9
	Aug.	-	-	-	-	-	1	-	-	-	-	-	1
	Sep.	5	-	-	-	-	-	-	-	-	-	-	5
	Oct.	9	-	-	-	-	4	6	-	-	-	-	19
	Nov.	5	-	-	-	-	-	8	-	-	-	8	21
	Dec.	-	-	-	-	-	-	-	-	-	-	-	-
1974	Jan.	30	-	-	-	-	-	4	-	-	-	-	34
	Feb.	-	-	-	-	-	-	5	-	-	-	-	5
	Mar.	1	-	-	-	-	13	37	-	-	-	-	51
	Apr.	5	-	-	-	-	33	28	-	5	-	-	71
	May	11	3	-	-	2	13	5	-	-	-	-	34
	June	-	-	-	-	-	8	-	-	-	-	-	8
	July	58	-	-	-	-	4	-	-	4	-	-	69
	Aug.	5	-	3	-	7	4	-	4	1	-	14	35
	Sep	3	-	-	-	-	-	-	-	-	-	-	3
	Oct.	1	-	-	3	-	3	1	1	-	-	-	9
	Nov.	148	-	-	4	4	14	9	-	-	-	-	179
	Dec.	1	-	-	-	-	22	13	19	-	-	3	58

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1975	Jan.	-	-	-	-	-	-	-	-	-	-	-	-
	Feb.	4	-	-	-	-	6	19	9	4	4	-	46
	Mar.	4	-	-	-	6	13	47	6	3	3	-	82
	Apr.	3	-	-	-	-	32	46	-	8	-	4	93
	May	3	6	-	-	6	11	47	-	11	-	15	99
	June	-	-	3	4	5	65	61	-	8	4	4	154
	July	6	9	21	-	-	-	5	7	10	2	-	60
	Aug.	-	-	-	-	-	3	44	-	7	2	-	56
	Sept.	19	-	14	-	-	-	6	-	-	-	-	39
	Oct.	98	-	-	4	-	-	4	-	3	-	-	109
	Nov.	5	3	-	7	-	36	17	5	-	-	-	73
	Dec.	-	-	-	-	-	-	-	3	-	-	-	3

Table: 21. Showing total number of flat fish larvae (Species wise) obtained during different years from 1971 to 1975

Year	C. macrostomus	P. bilineata	A. cyaneus	P. arsius	P. profunda	E. grandisquamis	E. cocosensis	B. ovalis	G. polyophthalmus	L. guentheri	L. macrophthalmus	Total
1971	211	-	-	4	-	1	3	-	-	-	1	220
1972	96	2	2	10	10	5	44	4	2	10	4	189
1973	37	5	-	-	20	39	58	-	2	5	11	177
1974	263	3	3	7	13	114	102	24	10	-	17	556
1975	142	18	38	15	17	166	296	30	54	15	23	814

Table: 22. Showing the number of larvae of flat fishes obtained during different months from September 1971 to December 1975. (Pooled data of different years)

Month	C. macrostomus	P. bilineata	A. cyaneus	P. arsius	P. profunda	E. grandisquamis	E. cocosensis	B. ovalis	G. polyophthalmus	L. guentheri	L. macrophthalmus	Total
Jan.	40	-	-	-	-	4	19	-	-	-	-	63
Feb.	5	-	-	-	-	6	35	9	4	4	-	63
Mar.	7	-	-	-	6	36	97	6	3	4	3	162
Apr.	8	-	-	-	9	68	92	4	13	7	4	205
May	18	15	-	-	32	34	63	-	12	4	15	193
June	3	1	9	4	2	75	72	-	10	6	4	186
July	67	9	20	-	-	9	10	7	15	2	-	139
Aug.	11	-	-	-	7	8	44	4	8	2	14	98
Sept.	92	-	14	-	-	-	6	-	-	-	4	116
Oct.	256	-	-	7	-	7	11	1	3	-	-	285
Nov.	241	3	-	25	4	55	40	5	-	1	9	383
Dec.	1	-	-	-	-	23	14	22	-	-	3	63

Table: 23. Showing the total number of flat fish larvae obtained from different profiles during the period 1971 to 1975.

Section	C. macrostomus	P. bilineata	A. cyaneus	P. arsius	P. profunda	E. grandisquamis	E. cocosensis	B. ovalis	G. polyophthalmus	L. guentheri	L. macrophthalmus	Total
Ratnagiri	72	3	-	-	-	29	33	-	5	2	3	147
Karwar	160	-	-	-	-	29	101	4	12	3	4	313
Coondapur	1	-	-	-	-	-	1	-	-	-	-	2
Kasaragod	226	-	3	4	5	92	70	16	13	5	-	434
Calicut	12	-	6	-	5	5	10	-	2	9	-	49
Cochin	214	7	15	4	27	51	114	10	11	2	22	477
Quilon	41	12	19	10	9	26	56	9	10	9	5	206
Cape Comorin	19	6	-	14	14	56	96	19	12	-	22	256
Tuticorin	4	-	-	4	-	37	22	-	3	-	-	70

Table: 24. Showing total number of flat fish larvae obtained from different profiles during different years from 1971 to 1975.

Section	1971	1972	1973	1974	1975	Total
Ratnagiri	-	9	-	32	106	147
Karwar	127	38	12	49	87	313
Coondapur	-	-	2	-	-	2
Kasaragod	3	45	9	199	178	434
Calicut	-	33	10	6	-	49
Cochin	90	30	69	126	162	477
Quilon	-	33	36	46	92	206
Cape Comorin	-	-	26	95	137	256
Tuticorin	-	-	14	9	47	70

Table: 25. Showing total number of flat fish larvae obtained from different profiles during different months from 1971 to 1978 (pooled data of different years)

Month	Ratnagiri	Karwar	Coondapur	Kasaragod	Calicut	Cochin	Quilon	Cape Comorin	Tuticorin	Total
Jan.	-	-	-	-	4	41	4	14	-	63
Feb.	-	1	1	-	-	21	27	13	-	63
Mar.	12	21	1	38	-	7	25	33	25	162
Apr.	18	58	-	24	11	61	5	28	-	205
May	10	5	-	12	-	85	33	48	-	193
June	8	34	-	77	18	24	9	-	16	186
July	-	8	-	3	-	89	26	13	-	139
Aug.	10	27	-	23	-	6	5	27	-	98
Sept.	-	9	-	48	10	23	26	-	-	116
Oct.	76	148	-	30	-	9	7	9	6	285
Nov.	9	2	-	151	6	104	30	64	17	383
Dec.	3	-	-	28	-	8	9	9	6	63

Table: 26. Showing the day and night collections of flat fish larvae.

Species	Number of larvae		Total
	day	night	
C. macrostomus	391	358	749
P. bilineata	9	19	28
A. cyaneus	16	27	43
P. arsius	22	14	36
P. profunda	30	30	60
E. grandisquamis	108	217	325
E. cocosensis	206	297	503
B. ovalis	35	23	58
G. polyophthalmus	38	30	68
L. guentheri	15	15	30
L. macrophthalmus	32	24	56
TOTAL	902	1054	1956

5.2. Larvae of lizard fishes

5.2.1. Seasonal distribution and abundance

5.2.1.1. Distribution and abundance during 1971 to 1975.

During 1971, the lizard fish larvae were obtained only in November - December period. The maximum abundance of larvae was recorded in November (78%) (Table.27). In 1972, larvae were not obtained from January to March and in September. August showed maximum abundance (22%) and October to December showed fairly moderate occurrence (Table: 27).

In 1973, larvae occurred from January to June and November and in February the larvae were most abundant (26%). From march onwards a gradual decrease in abundance was noticed and from July to October and in December no larva was obtained.(Table: 27).

During 1974, the larvae were obtained throughout the year, except in the months of June and September (Table: 27). The maximum abundance was noticed in November - December period with a peak in November (34%). During 1975, the October - November period showed maximum abundance and larvae were obtained in all the months of the year except in July, September and December (Table: 27).

5.2.1.2. Species-wise distribution and abundance during 1971 - 1975.

Larvae of S. undosquamis dominated (50%) during 1971, T. myops formed about 11% and rest consisted of other lizard fishes, mainly S. tumbil. In 1972, S. undosquamis is formed 30%, T. myops 22%, S. variegatus 7% and rest other lizard fishes. In 1973, T. myops dominated (49%). Other speices were S. variegatus (17%), S. undosquamis (11%) and other lizard fishes (23%). In 1974 also T. myops dominated (30%) and the rest obtained were S. undosquamis (28%) S. variegatus (17%) and other lizard fishes (25%). In 1975, S. undosquamis formed about 62%, S. variegatus 18%, T. myops 10% and rest were other lizard fishes. (Table: 28).

5.2.1.3. Distribution and abundance during different months (pooled data of different years)

Larvae of lizard fishes were present throughout the year except in September. Highest peak was noticed in November (32%). October (14%) and December (13%) showed moderate occurrence. A uniform pattern of distribution was noticed from February to June. During January and July occurrence of larvae was very low. (Table:29 & Fig. 33.a).

5.2.1.4. Species-wise distribution and abundance during different months. (pooled data of different years)

Maximum occurrence of S. undosquamis larvae was noticed from October to December with a peak in November (44%) and it may abe presumed that the main breeding period of the species is in post-monsoon season. February to March and May to June also showed less degree of occurrence, but they were not collected in January, April and July to September.

The larvae of S. variegatus occurred from January to June, August and from November to December. Maximum occurrence was noticed in March (19%) and in June (17%).

The T. myops larvae occurred throughout the year except in September. Maximum abundance was noticed in August (32%); April, May and November showed moderate occurrence (Table: 29.).

5.2.2. Effect of hydrographic features on the larval distribution.

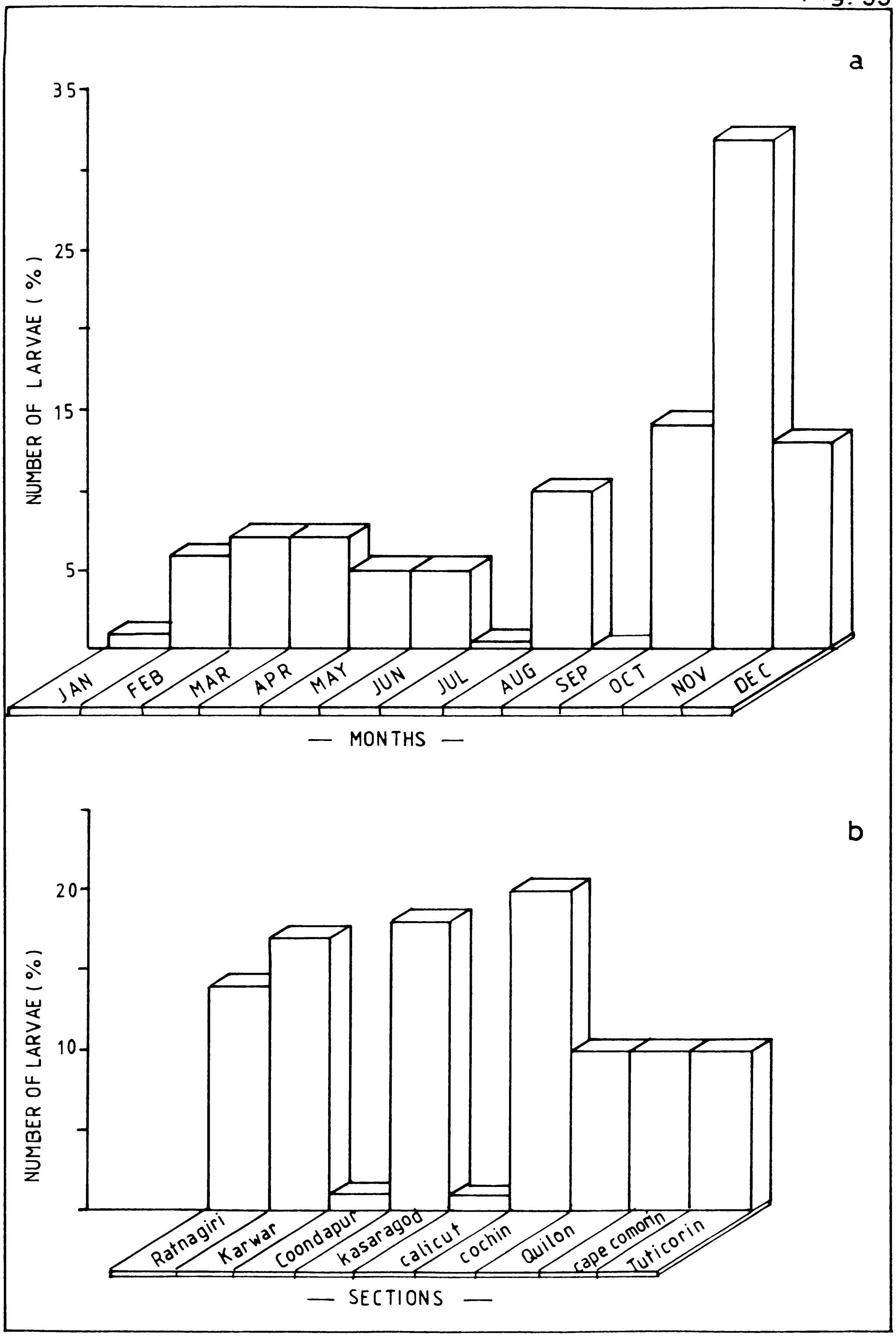
In general the larvae of lizard fishes preferred warm water within the range of 27° to 28°C, 33 to 35%o salinity and 4ml/L Oxygen.

Fig. 33. : Distribution and abundance of lizard fish larvae

a. Month-wise abundance of lizard fish larvae from 1971 to 1975.

b. Abundance of lizard fish larvae in different profiles.

Fig. 33



a
NUMBER OF LARVAE (%)
35
25
15
5
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
— MONTHS —
b
NUMBER OF LARVAE (%)
20
10
Ratnagiri
Karwar
Coondapur
kasaragod
calicut
cochin
Quilon
cape comorin
Tuticorin
— SECTIONS —

Fig. 34. : Distribution of lizard fish larvae in relation to temperature and salinity.

a. Effect of temperature in the distribution of all lizard fish larvae

b. Effect of temperature in the distribution of the larvae of _S. undosquamis_

c. Effect of temperature in the distribution of the larvae of _S. variegatus_

d. Effect of temperature in the distribution of the larvae of _T. myops_

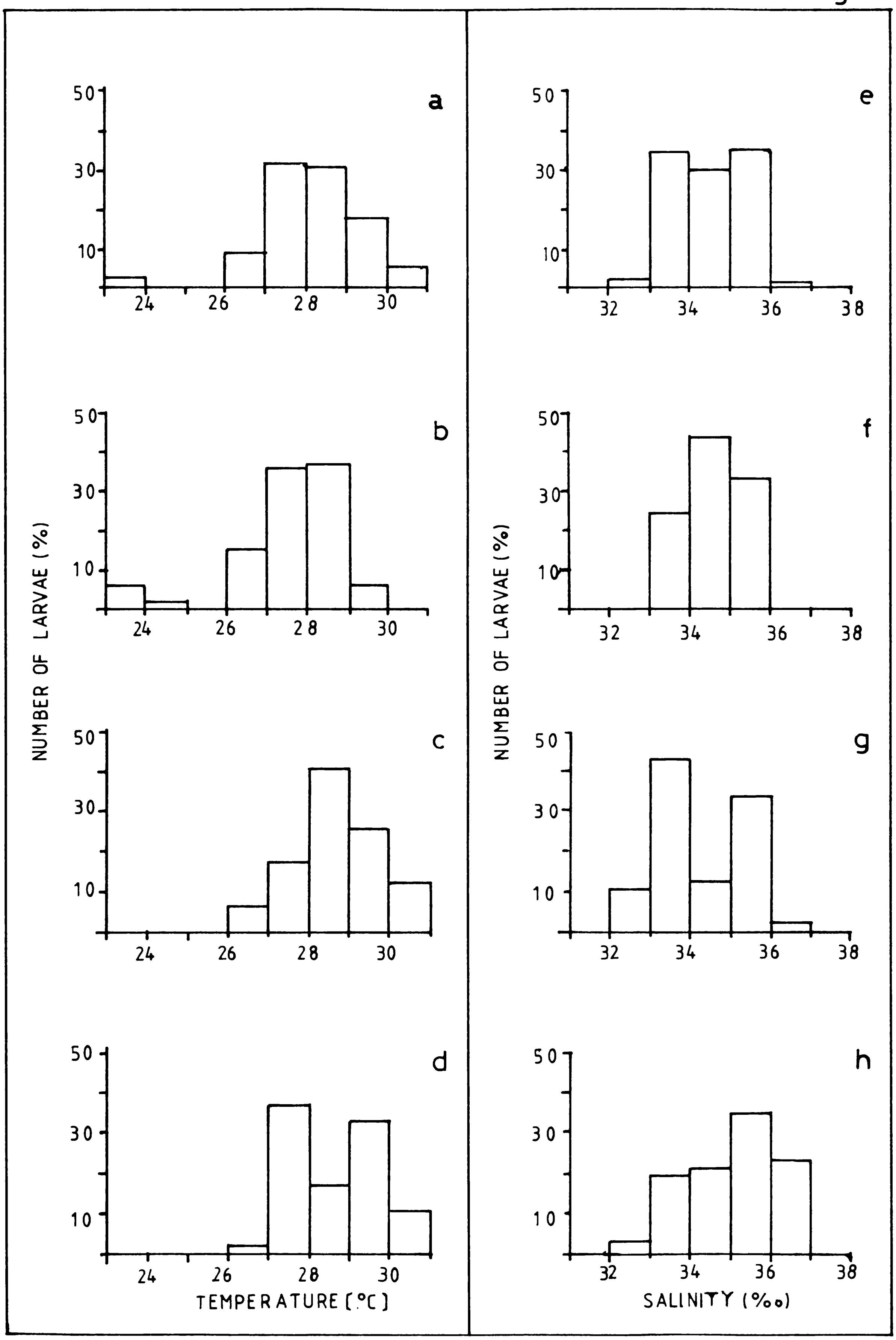
e. Effect of salinity in the distribution of all lizard fish larvae

f. Effect of salinity in the distribution of the larvae of _S. undosquamis_

g. Effect of salinity in the distribution of the larvae of _S. variegatus_

h. Effect of salinity in the distribution of the larvae of _T. myops_

Fig.34



a
b
c
d
e
f
g
h
50
30
10
24
26
28
30
32
34
36
38
NUMBER OF LARVAE (%)
TEMPERATURE (°C)
SALINITY (‰)

Fig. 35. : Distribution of lizard fish and Bombay duck larvae in relation to hydrographical parameters.

a. Effect of oxygen in the distribution of all lizard fish larvae

b. Effect of oxygen in the distribution of larvae of S. undosquamis

c. Effect of oxygen in the distribution of the larvae of S. variegatus

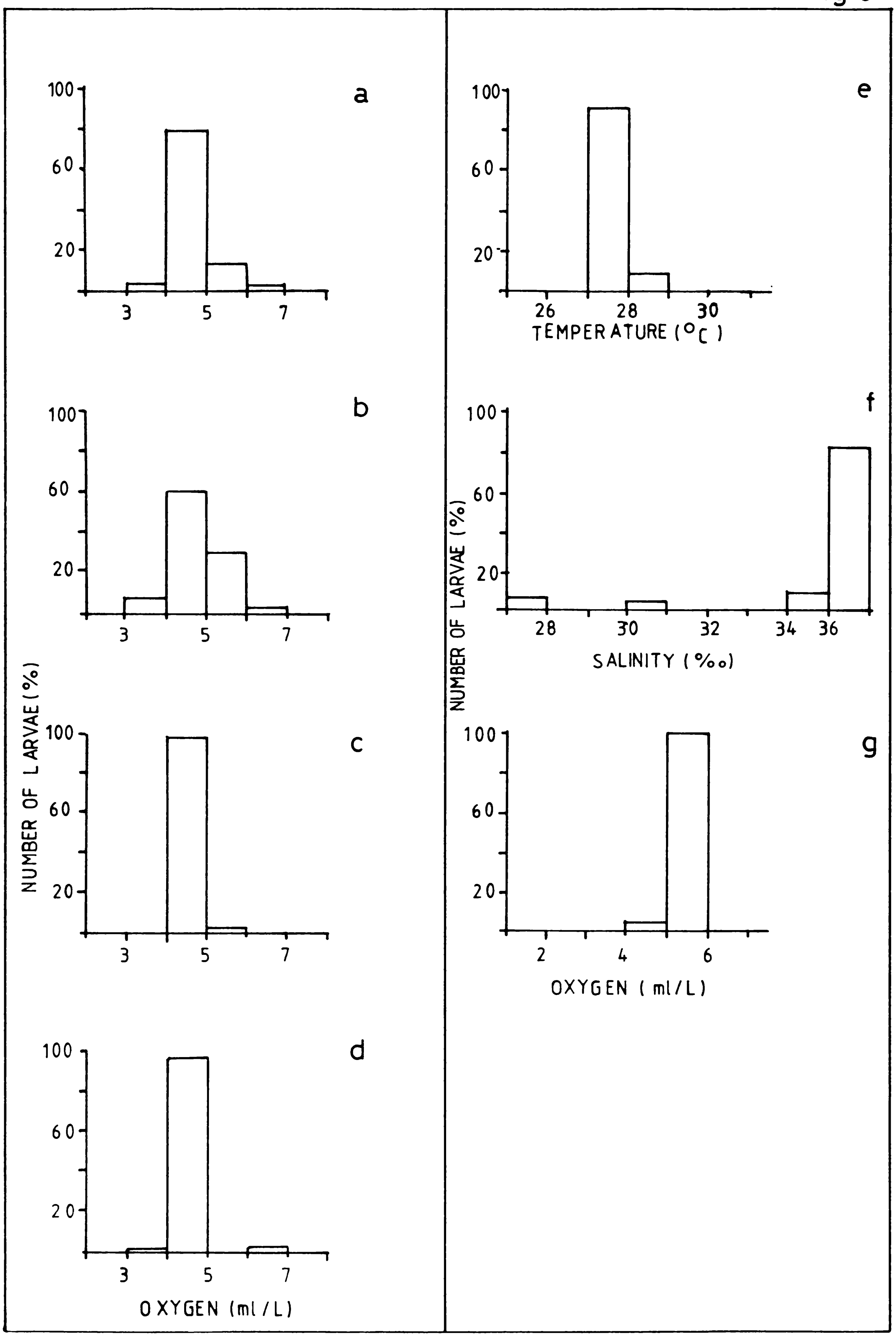
d. Effect of oxygen in the distrirbution of the larvae of T. myops

e. Effect of temperature in the distribution Bombay duck larvae

f. Effect of salinity in the distribution of Bombay duck larvae

g. Effect of oxygen in the distribution of Bombay duck larvae

Fig.35


a
b
c
d
e
f
g
NUMBER OF LARVAE (%)
OXYGEN (ml/L)
TEMPERATURE (°C)
SALINITY (‰)
OXYGEN (ml/L)
100
60
20
3
5
7
26
28
30
28
30
32
34
36
2
4
6

Maximum abundance of S. undosquamis larvae was observed between the temperature range of 27° to 28°C. Salinity 34 - 35‰ and 4ml/L Oxygen. Larvae of S. variegatus showed much abundance in 28°C, 33‰ salinity and 4ml/L Oxygen.

Maximum abundance of T. myops larvae was observed when the temperature was at 27°C, Salinity at 35‰ and Oxygen at 4ml/L. (Fig. 34 & 35).

5.2.3. Spacial distribution and abundance during 1971 to 1975.

Larvae of lizard fishes were found throughout the area. The larvae represented maximum in Cochin Section (20%) and Kasaragod being the second in abundance (18%). Moderately high occurrence was noticed in Karwar (17%) and Ratnagiri (14%). A uniform pattern of abundance was noticed in Quilon(10%), Cape Comorin (10%) and Tuticorin (10%). The larvae occurred rarely in Calicut (1%) and Coondapur (1%) (Table 30 & Fig. 33.b).

5.2.3.1. Year-wise spacial distribution and abundance during 1971 to 1975.

During 1971 larvae were obtained only from Kasaragod, Cochin and Quilon. Maximum abundance of larvae was recorded from Cochin (61%) followed by Kasaragod (22%) and Quilon (17%). In 1972 Kasaragod showed maximum in abundance (29%) and Cochin was the second in abundance (26%), Ratnagiri showed moderate occurrence (22%) followed by Calicut (15%) and Quilon (7%) (Table: 31).

In 1973 larvae were obtained in all the sections from north to south. Area of maximum abundance was from Cochin to Karwar and other sections showed moderate occurrence. Maximum number of larvae was obtained from Kasaragod (20%), followed by Cochin (17%), Karwar (14%), Ratnagiri (11%), Tuticorin (11%), Quilon (9%), Coondapur (6%), Calicut (6%) and Cape Comorin (6%) (Table: 31).

During 1974 larvae were maximum in abundance and occurred at all but two stations. Maximum number of larvae occurred in Karwar (23%), Cochin (21%) Moderately high occurrence was noticed in Cape Comorin (13%), Ratnagiri (12%) and Quilon (10%), Tuticorin being the lowest in abundance (5%).

In 1975 larvae were obtained from all the stations except Calicut and Coondapur sections. The percentage of occurrence was high in Kasaragod (20%), Tuticorin (19%) and Ratnagiri (17%). Moderate occurrence was noticed in Cochin (15%), Karwar (11%), Quilon (11%) and Cape Comorin (7%).

5.2.3.2. Month-wise spacial distribution and abundance (pooled data of different years)

August showed the maximum abundance in Ratnagiri (63%). During February (12%) and May (11%) larvae occurred moderately. Low number of larvae was also obtained in November (6%) April (3%) July (3%) and June (2%). (Table: 32).

In Karwar maximum number of larvae was obtained during April (25%) and August being the second in abundance (20%). Moderate occurrence was obtained in March (18%) and December (15%) and less in November (9%), February (2%) and June (1%). Occurrence of larvae at Coondapur was only in February (Table:32).

Maximum abundance of larvae from Kasaragod was obtained in December (39%) followed by October (22%). All other months except August and September showed moderate or low occurrence (Table: 32). In Calicut larvae were obtained only in February (33%), June (33%) and November (34%) (Table: 32).

In Cochin section maximum abundance was observed in November (52%) followed by October (29%), May (9%) and February (7%). During March, April, July and December larval abundance were very low and about 1% each. No larva was obtained during January, June, August and September (Table: 32).

In Quilon section maximum number of larvae was obtained in November (88%) and very low in abundance during February (4%), March (4%) and December (4%). No larva was obtained during the remaining months (Table: 32).

The larvae occurred in Cape Comorin in all the months except in July and September. Maximum abundance was observed in October (35%) followed by March (15%), Aapril (12%), February (11%), December (8%) and very low in January, May, June, August and November (Table: 32).

In Tuticorin larvae were obtained maximum in November (65%), moderate in December (12%) and August (8%) and low in January (5%). No larva occurred in the remaining months. (Table: 32.).

5.2.3.3. Species-wise spacial distribution and abundance.

Larvae of S. undosquamis were more abundant in Cochin (26%) and Kasaragod (24%). Quilon showed moderate occurrence (14%). Uniform occurrence of larvae was noticed in Cape comorin and Tuticorin (12% each). Low occurrence of larva wass obtained from Karwar (10%) and Ratnagiri (2%). No larva occurred in Calicut and Coondapur (Table: 30).

The larvae of S. variegatus was also found in almost all the sections except in Calicut and Coondapur. The larval abundance was maximum in Karwar (27% followed by Tuticorin (18%), Cochin (15%), Cape Comorin (13%), Ratnagiri (12%), Kasaragod (7%) and Quilon (7%).

T. myops larvae were represented at all but one section (Calicut). The larvae were more abundant in northern sections than in south. Maximum abundance was sobtained in Ratnagiri (27%) followed by Karwar (19%), Kasaragod (15%), Cochin (14%), Cape Comorin (10%), Quilon (9%), Tuticorin (5%) and Coondapur (1%).

5.2.4. Horizontal distribution and abundance

The distribution of lizard fish larvae showed a shoreward concentration. The concentration has been highest from Karwar to Tuticorin. The density gradient was highest in the near shore belt between 20 and 30 miles area, and gradually lighter towards offshore. But moderate level of occurrence was noticed upto 80 miles and thereafter the abundance was very poor. The inshore belt within 10 miles area was poor in larval abundance (Fig.: 36.).

5.2.4.1. Year-wise horizontal distribution and abundance.

D uring 1971 larval concentration had low values and occurred in the mid shelf water from Kasaragod to Quilon area. Moderate value of $6/m^2$ was observed off Cochin. During 1972 larvae were observed in the inshore area of Kasaragod, Cochin and Quilon sectiosns as well as the offshore area of Ratnagiri.

During 1973 moderate level of larval occurrence was noticed over the entire shelf area from Ratnagiri to Tuticorin. But very little larval concentration had been observed in the areas upto 20 miles from the shore. In 1974 larval concentrations were observed in the inshore and mid-shelf areas from Kasaragod to Tuticorin and offshore areas of Ratnagiri and Karwar. High core value of concentration was noticed off Cape Comorin ($18/m^2$), moderate level of larval concentration was observed off Cochin and in the offshore areas of Karwar.

The mid-shelf areas of Kasaragod and Cape Comorin showed high values (12-$16/m^2$).

In 1975, the high core value was observed in the inshore waters off Tuticorin ($37/m^2$). Moderate level of density values were seen in Cochin and Kasaragod sections. The outer shelf areas off Ratnagiri also showed moderate level of larval concentration.

5.2.4.2. Species-wise horizontal distribution and abundance.

The concentration of S. undosquamis larvae was maximum in near-shore waters upto 30 miles area. High density value occurred off Kasaragod ($34/m^2$). The near-shore area off Cochin, Quilon and Tuticorin showed still higher concentrations of larvae. Ratnagiri and Karwar area showed poor in abundance. No larva was observed in Calicut section (Fig: 37).

The larvae of S. variegatus were not observed in the entire near-shore areas from Ratnagiri to Tuticorin except one or two patches of light density off Tuticorin and Cape Comorin. A strip of moderate density extending from Karwar to Tuticorin was seen in mid-shelf area. High density value occurred in Tuticorin area ($13/m^2$) (Fig: 38).

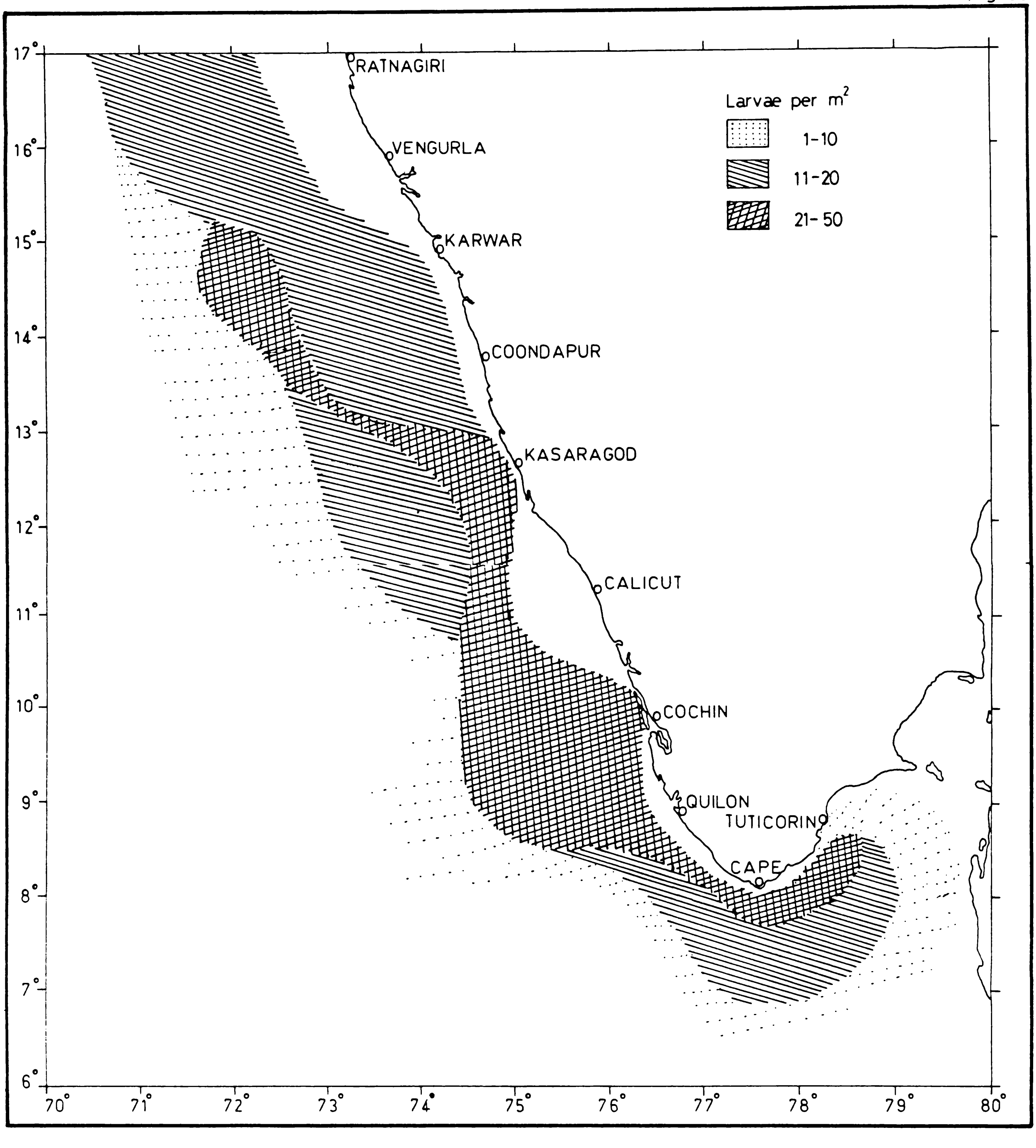
The larvae of T. myops occurred in the mid-sehlf area, larval abundance was more in 50 - 60 mile stations all along the area. High density value occurred in offshore area of Ratnagiri ($20/m^2$). Moderate density gradient was observed in Kasaragod and Cochin sections. Larval abundance was poor in Cape Comorin and Tuticorin and no larva was observed in Calicut section (Fig. 39).

5.2.5. Vertical distribution and abundance

Maximum number of lizard fish larvae was obtained in night collections (57%) (Table: 33). The larvae of S. undosquamis were more abundant during night (66%) and in the case of S. variegatus 65% of larvae were obtained during the night collections where as the larvae of T. myops were more abundant in day collections (54%) (Table: 33.).

Fig. 36. : Horizontal distribution of total lizard fish larvae

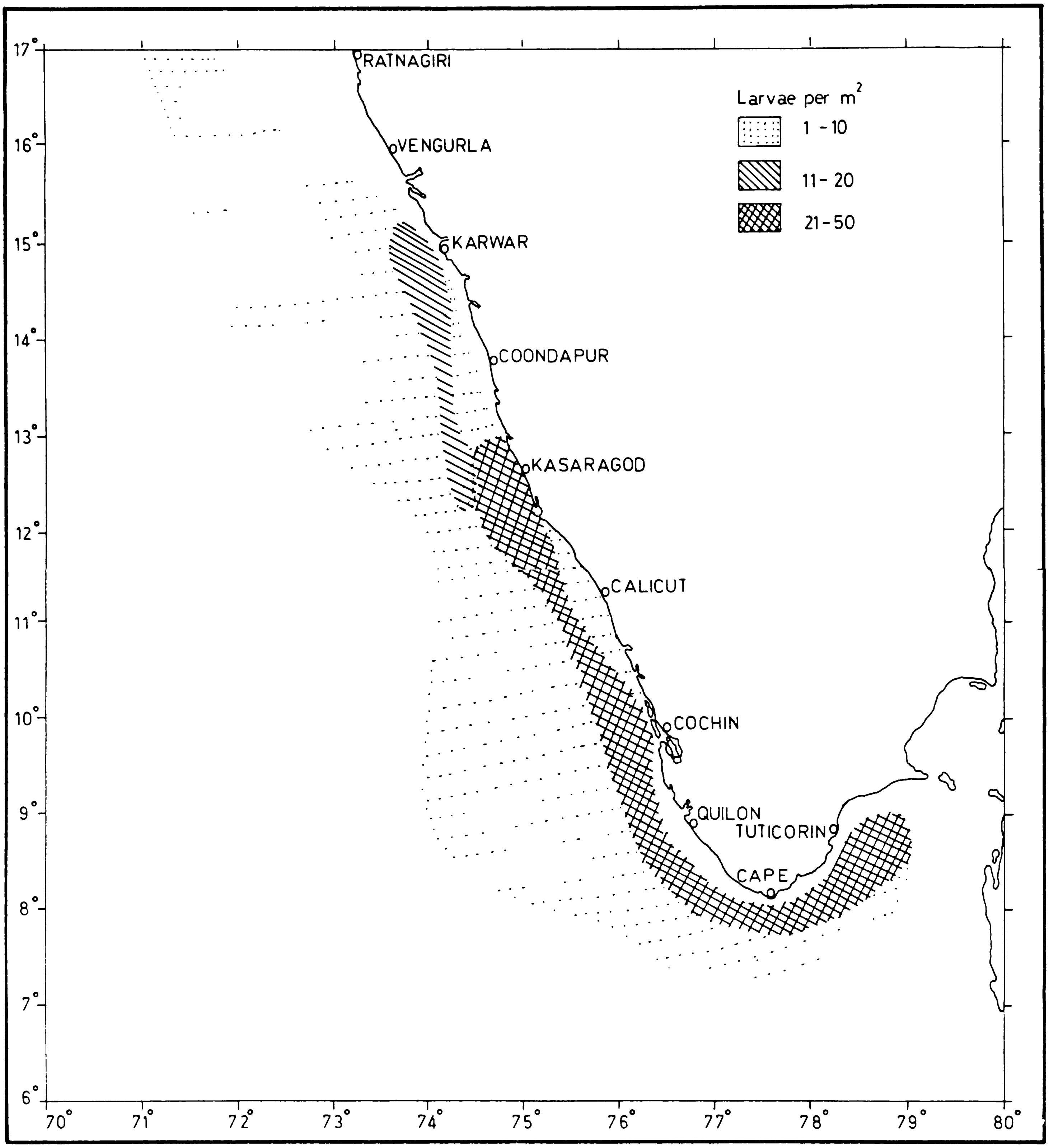
Fig. 36



Larvae per m²
1-10
11-20
21-50
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 37. : Horizontal distribution of the larvae of S. undosquamis

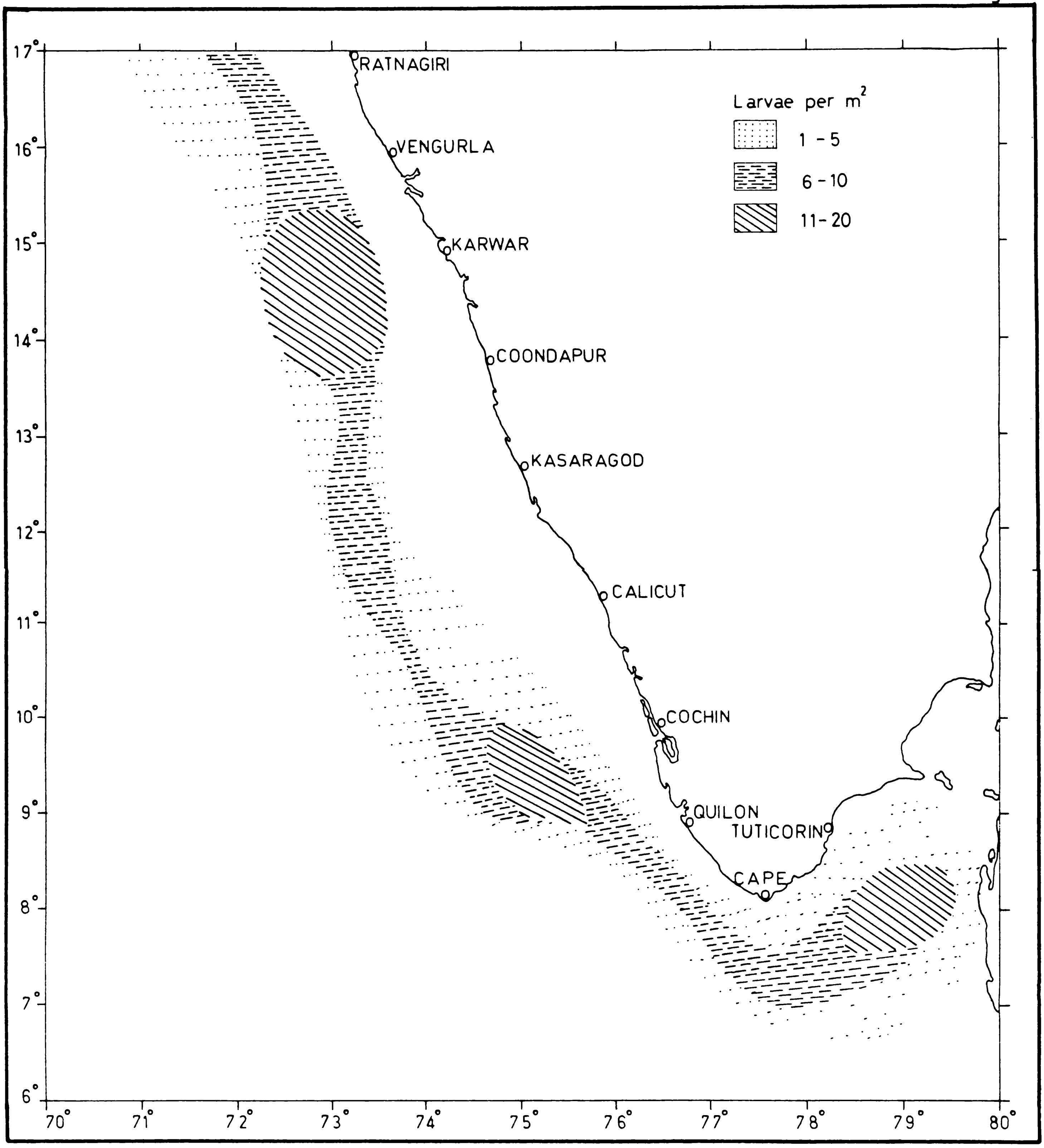
Fig. 37



Larvae per m²
1 - 10
11 - 20
21 - 50
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 38. : Horizontal distribution of the larvae of S. variegatus

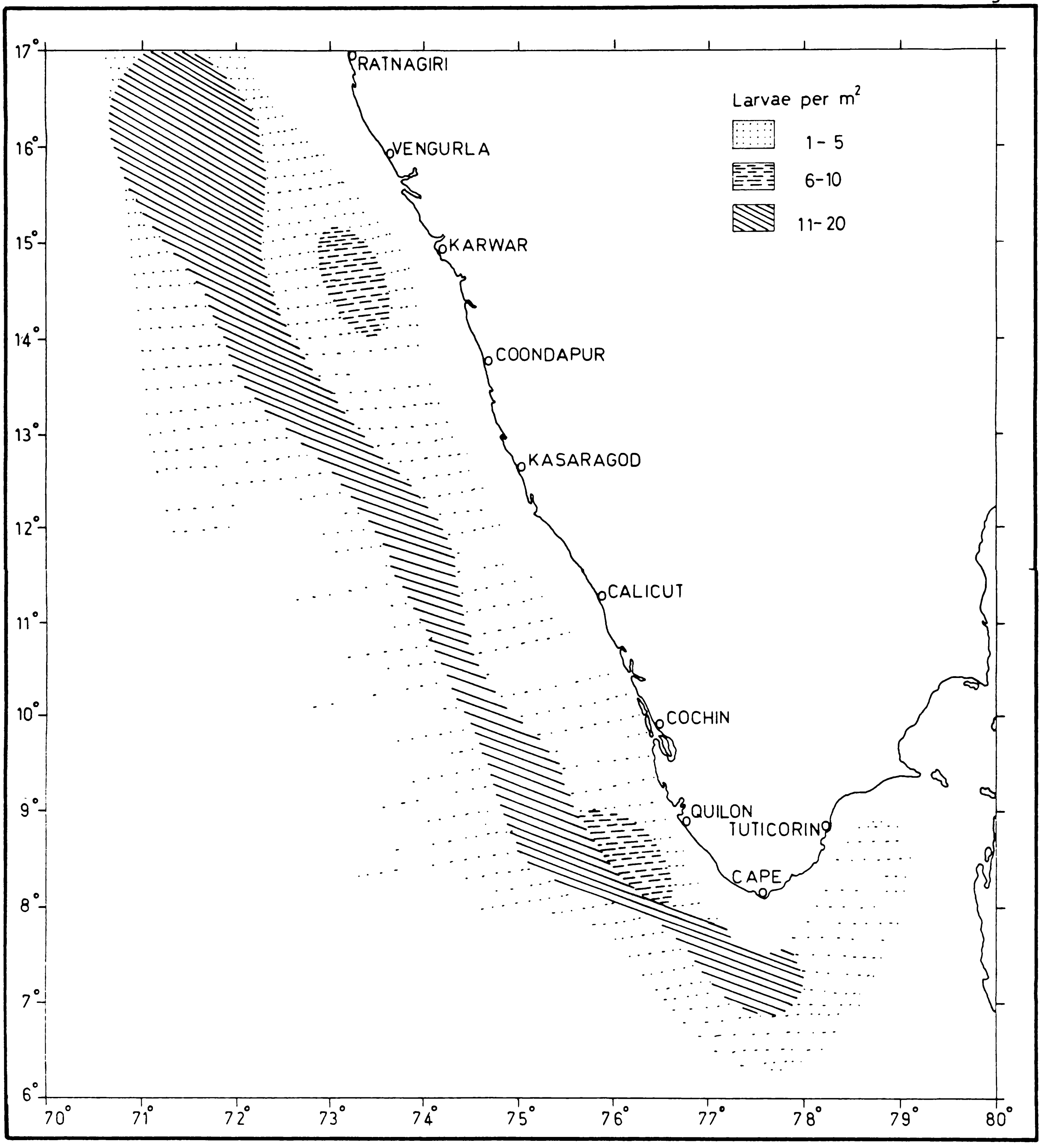
Fig.38



RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
Larvae per m²
1 - 5
6 - 10
11 - 20
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Fig. 39. Horizontal distribution of the larvae of _T. myops_

Fig. 39



Larvae per m²
1- 5
6-10
11- 20
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12°
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Table: 27. Showing the number of larvae of lizard fishes/Bombay duck obtained during different months from September 1971 to December 1975.

Year	Month	*S. undosquamis*	*S. variegatus*	*T. myops*	Other lizard fishes	*H. nehereus*	Total
1	2	3	4	5	6	7	8
1971	Sept.	-	-	-	-	-	-
	Oct.	-	-	-	-	-	-
	Nov.	8	-	1	5	-	14
	Dec.	1	-	1	2	-	4
1972	Jan.	-	-	-	-	-	-
	Feb.	-	-	-	-	-	-
	Mar.	-	-	-	-	-	-
	Apr.	-	-	2	-	-	2
	May	-	1	-	-	-	1
	June	-	-	-	2	-	2
	July	-	-	2	-	-	2
	Aug.	-	-	-	-	-	-
	Sep.	-	1	2	-	3	6
	Oct.	5	-	-	-	-	5
	Nov.	1	-	-	3	-	4
	Dec.	2	-	-	3	-	5

1	2	3	4	5	6	7	8
1973	Jan.	-	3	1	2	-	6
	Feb.	-	-	7	2	-	9
	Mar.	-	1	4	2	-	7
	Apr.	-	-	-	2	-	2
	May	-	1	2	-	-	3
	June	-	1	3	-	-	4
	July	-	-	-	-	-	-
	Aug.	-	-	-	-	-	-
	Sept.	-	-	-	-	-	-
	Oct.	-	-	-	-	-	-
	Nov.	4	-	-	-	-	4
	Dec.	-	-	-	-	-	-
1974	Jan.	-	-	-	-	-	-
	Feb.	-	11	-	-	-	11
	Mar.	-	9	-	-	-	9
	Apr.	-	12	20	-	-	32
	May	-	-	20	-	-	20
	JUne	-	-	-	-	-	-
	July	-	-	-	-	1	1
	Aug.	-	5	41	4	18	68
	Sept.	-	-	-	-	-	-
	Oct.	20	-	3	-	-	23
	Nov.	48	15	20	41	-	124
	Dec.	32	11	3	28	-	74

1	2	3	4	5	6	7	8
1975	Jan.	-	-	-	-	-	-
	Feb.	5	-	-	13	-	18
	Mar.	16	12	-	-	-	28
	Apr.	-	-	7	-	-	7
	May	2	9	-	-	. -	11
	June	5	18	6	-	-	29
	July	-	-	-	-	-	-
	Aug.	-	3	6	-	10	19
	Sept.	-	-	-	-	-	-
	Oct.	60	-	-	-	-	60
	Nov.	56	-	4	-	-	60
	Dec.	-	-	-	-	-	-

Table: 28. Showing total number of lizard fish larvae obtained during different years from 1971 to 1975.

Year	*S. undosquamis*	*S. variegatus*	*T. myops*	Other lizard fish larvae	Total
1971	9	-	2	7	18
1972	8	2	6	8	24
1973	4	6	17	8	35
1974	100	63	107	73	343
1975	144	42	23	13	222

Table: 29. Showing the number of larvae of lizard fishes/Bombay duck obtained during different months from September 1971 to December 1975 (Pooled data of different years)

Month	*S. undosquamis*	*S. variegatus*	*T. myops*	Other lizard fishes	*H. nehereus*	Total
Jan.	-	3	1	2	-	6
Feb.	5	11	7	15	-	38
Mar.	16	22	4	2	-	44
Apr.	-	12	29	2	-	43
May	2	11	22	-	-	35
JUne	5	11	9	2	-	27
July	-	8	2	-	1	11
Aug.	-	9	49	4	31	93
Sep.	-	-	-	-	-	-
Oct.	85	-	3	-	-	88
Nov.	117	15	25	49	-	206
Dec.	35	11	4	33	-	83

Table: 30. Showing the total number of Lizard fish/Bombay duck larvae obtained from different profiles during the period 1971 - 1975.

Section	S. undosquamis	S. variegatus	T. myops	Other lizard fishes	Bombay duck	Total
Ratnagiri	5	14	42	11	20	92
Karwar	24	31	29	18	12	114
Coondapur	-	-	2	-	-	2
Kasaragod	64	8	24	26	-	122
Calicut	-	-	-	6	-	6
Cochin	70	17	21	28	-	136
Quilon	38	8	14	10	-	70
Cape Comorin	31	15	16	4	-	66
Tuticorin	33	20	7	6	-	66

Table: 31. Showing total number of lizard fish larvae obtained from different profiles during different years from 1971 to 1975

Section	1971	1972	1973	1974	1975	Total
Ratnagiri	-	3	4	34	31	72
Karwar	-	-	5	72	25	102
Coondapur	-	-	2	-	-	2
Kasaragod	4	8	7	58	45	122
Calicut	-	4	2	-	-	6
Cochin	11	7	6	77	35	136
Quilon	3	2	3	36	26	70
Cape Comorin	-	-	2	47	17	66
Tuticorin	-	-	4	19	43	66

Table: 32. Showing total number of lizard fish larvae obtained from different profiles during different month from 1971 to 1975.

(Pooled data of different years)

Month	Ratnagiri	Karwar	Coondapur	Kasaragod	Calicut	Cochin	Quilon	Cape Comorin	Tuticorin	Total
Jan.	-	-	-	-	2	-	-	1	3	6
Feb.	11	2	2	4	-	9	3	7	-	38
Mar.	-	21	-	2	-	1	3	10	7	44
Apr.	3	29	-	2	-	1	-	8	-	43
May	10	-	-	10	-	13	-	2	-	35
June	2	11	-	11	2	-	-	1	-	27
July	-	1	-	9	-	-	-	-	-	10
Aug.	41	11	-	-	-	1	-	4	5	62
Sept.	-	-	-	-	-	-	-	-	-	-
Oct.	-	-	-	26	-	39	-	23	-	88
Nov.	5	10	-	10	2	71	61	4	43	206
Dec.	-	17	-	48	-	1	3	6	8	83

Table: 33. Showing the day and night collections of lizard fish larvae.

Species	Number of larvae		Total
	day	night	
S. undosquamis	89	176	265
S. variegatus	39	74	113
T. myops	84	71	155
Total	212	321	533

5.3. Larvae of Bombay duck.

5.3..1. Seasonal distribution and abundance

5.3.1.1. Distribution and abundance during 1971 to 1975

In 1971 and 1973 no larva of H. nehereus was observed in the collections. In 1972 larvae were present only in the month of August. During 1974 larvae were obtained in July and August (95%). Again in 1975, larvae were reported only in the month of August (Table: 27).

Bapat et al (1951) in a study of the biology of H. nehereus, suggested that though the fish is a continuous breeder, there are two peak breeding seasons, the first one between April - July and the second one during November - December. So it may be presumed that the larvae obtained in the present study were from the first peak season (April - July).

5.3.1.2. Month-wise distribution and abundance of **H. nehereus** larvae. (pooled data of different years)

The larvae of H. nehereus were obtained only in July and August. The maximum abundance was noticed in August (97%) and during July only 3% larvae were obtained (Table: 29 & Fig. 40.a).

5.3.2. Effect of hydrographic features on the larval distribution

The larvae of H. nehereus preferred warm water with a temperature of 27°C and 35%o Salinity and 5ml/L Oxygen. (Fig. 35).

5.3.3. Spacial distribution and abundance during 1971 to 1975.

Larvae of Bombay duck were obtained only from northern most sections viz. Ratnagiri and Karwar. The maximum number of larvae were obtained from Ratnagiri (63%) (Table: 30 & Fig. 40.b).

5.3.3.1. Year-wise spacial distribution and abundance during 1971 to 1975.

No larva was obtained during 1971 and 1973. During 1972 larvae were obtained only from Ratnagiri. In 1974, 42% of larvae occurred in Ratnagiri and 58% in Karwar. During 1975, 90% of the larvae were obtained from Ratnagiri and remaining 10% from Karwar section (Table: 34).

5.3.3.2. Month-wise spacial distribution and abundance (pooled data of different years)

Larvae of H. nehereus were obtained from Ratnagiri in August alone. In Karwar maximum abundance of larvae was obtained in the month of August (92%) and the remaining numbers of larvae occurred in July (8%) (Table: 35.).

5.3.4. Horizontal distribution and abundance.

The larvae of H. nehereus were obtained only from Ratnagiri and Karwar sections. Most of the larvae occurred in the near-shore waters upto 30 miles area (Fig: 41).

In 1971 and 1973 no larvae were obtained in the collections. A small concentration of larvae was observed during 1972 from off Ratnagiri at about 20 miles off area. During 1974 larvae were obtained from Ratnagiri and Karwar sections with a high core value ($7/m^2$) from 30 miles off Ratnagiri. Moderate level of larval occurrence was alsos noticed from offshore area of Karwar.
During 1975 larvae mainly occurred along the inner shelf area off Ratnagiri and a light concentration of larvae was observed off Karwar at about 70 miles from the shore.

5.3.5. Vertical distribution and abundance.

All the larvae of H. nehereus were obtained in the day collections only.

Fig. 40. : Distribution and abundance of Bombay duck larvae

a. Month-wise abundance of Bombay duck larvae

b. Abundance of Bombay duck larvae in different profiles.

Fig. 40

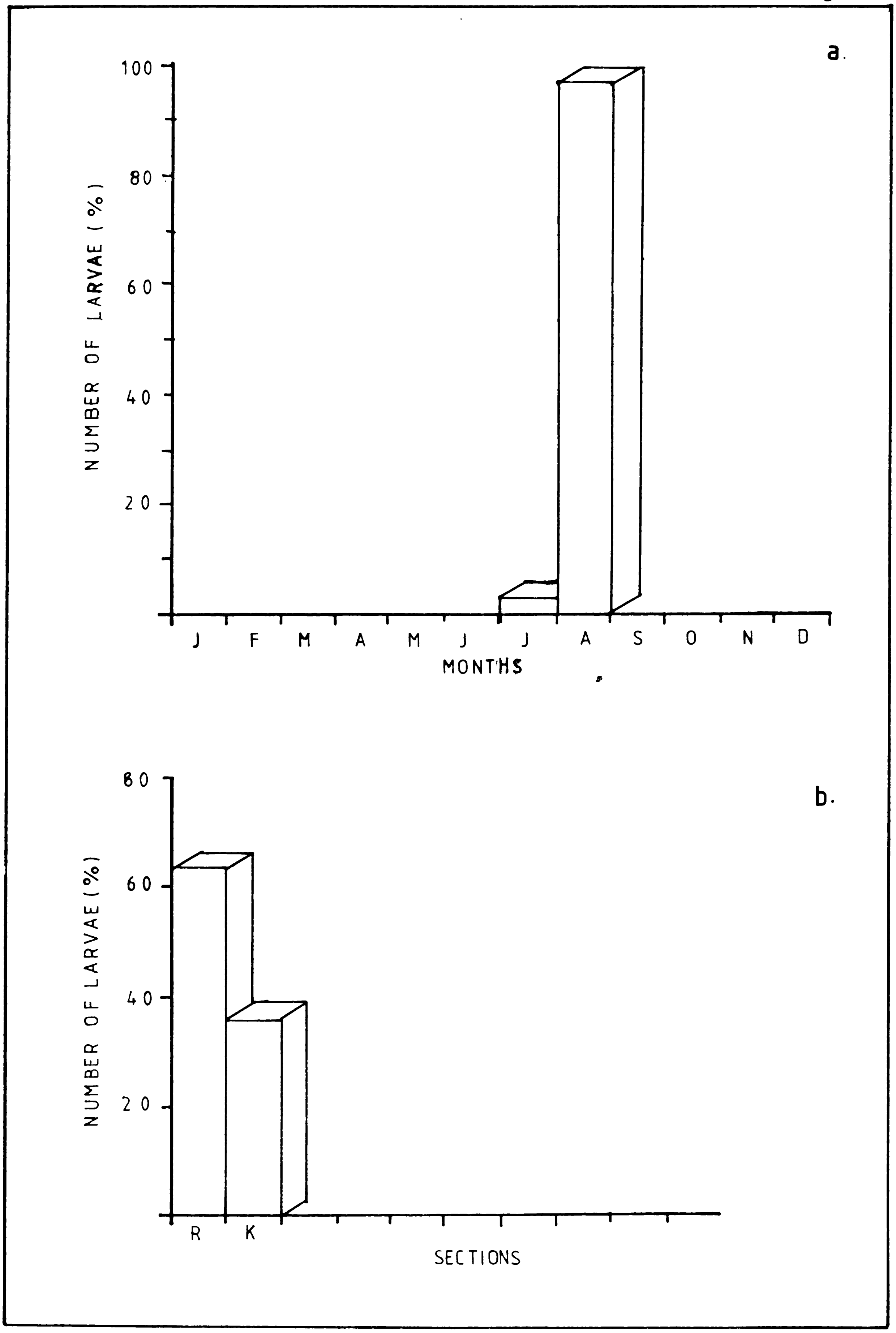

a.
100
80
60
40
20
NUMBER OF LARVAE (%)
J F M A M J J A S O N D
MONTHS
b.
80
60
40
20
NUMBER OF LARVAE (%)
R K
SECTIONS

Fig. 41. : Horizontal distribution of the larvae of H. nehereus

Fig.41

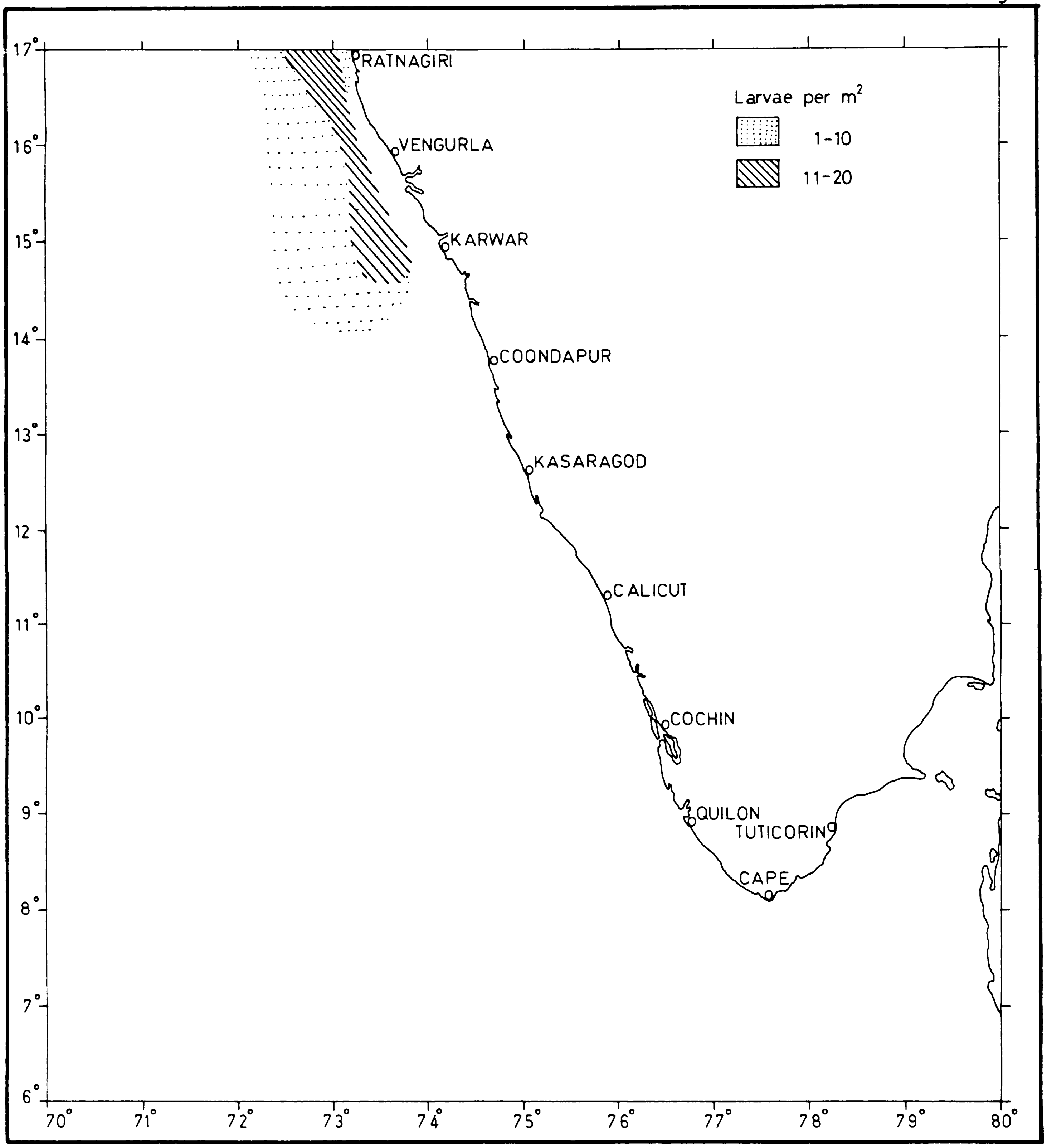

Larvae per m²
1-10
11-20
RATNAGIRI
VENGURLA
KARWAR
COONDAPUR
KASARAGOD
CALICUT
COCHIN
QUILON
TUTICORIN
CAPE
17°
16°
15°
14°
13°
12
11°
10°
9°
8°
7°
6°
70°
71°
72°
73°
74°
75°
76°
77°
78°
79°
80°

Table: 34. Showing total number of Bombay duck larvae obtained from different profiles during different year from 1971 to 1975.

Section	1971	1972	1973	1974	1975	Total
Ratnagiri	-	3	-	8	9	20
Karwar	-	-	-	11	1	12

Table: 35. Showing total number of Bombay duck larvae obtained from different profiles during different months from 1971 to 1975.

(pooled data of different years)

Month	Ratnagiri	Karwar	Total
July	-	1	1
August	20	11	31

6. DISCUSSION

The ichtyoplankton surveys contribute to several fields of marine research such as systematics, life history and ecology of fish. Besides these, the fishery-oriented targets of ichthyoplankton surveys which are considered of particular value include exploration for potential fishery resources, location of spawning concentration of fish stocks, evaluation of relative abundance of such stocks and monitoring of long term changes in the composition and abundance of resources and spawning times and areas. One of the most important advantages in sampling fish during their early life history stages is that these stages can be sampled with a single kind of gear, a plankton net, which collects not only fish eggs and larvae but part of their potential zooplanktonic food and predators.

Earlier works on the ichtyoplankton of the Indian ocean region were confined to certain isolated areas particularly of the coastal waters. The international Indian Ocean Expedition (110E-1960-'65) has made valuable contributions to our knowledge of ichthyoplankton of Indian ocean. But systematic fish eggs and larval surveys in an area, covering all the seasons have not been carried out in Indian waters till recently. The most comprehensive and systematic ichthyoplankton surveys along the West coast of India from Rathnagiri (17°N Lat.) to Cape Comorin (6°N Lat.) and to Tuticorin (7°40'N Lat.) were carried out by the UNDP/FAO/Pelagic Fishery Project, Cochin during 1971-'75 period.

The main objective of the present work was to study the early developmental stages of some of the important and less studied demersal fishes of the S.W. coast of India and spatial as well as temporal distribution of their larvae in relation to the chief hydrographic parameters such as temperature, salinity and oxygen, so as to delineate the spawning areas and seasons of these fish populations.

The study mainly deals with the larvae of eleven species of flat fishes, four species of lizard fishes and also the larvae of Bombay duck. Among flat fishes, major species contributing to the fishery is Cynoglossus macrostomus (Malabar sole) whose larvae were plenty in the collections. Over 90 flat fishes are recorded from Indian waters, of which about 70 are found in waters off the S.W. and S.E. coasts of India. The flat fish fishery of the area is sustained mainly by C. macro stomus, C. dubius, S. punticeps, C. lingua, Paraplagusia bilineata, Solea ovata, Pseudorhombus arsius, P. elevatus and Psettodes erumei.

The pleuronectid larval material in the present collection consists mainly of C. macrostomus followed by those of E. cocosensis and E. grandisquamis. The larvae of G. polyophthalmus, P. profunda, B. ovalis, L. macrophthalmus and A. cyaneus were in moderate abundance and P. arsius, L. guentheri and P. bilineata were in lesser numbers. The general picture of distribution of all flat fish larvae showed that the larvae occurred in the entire area from Ratnagiri to Tuticorin, but more concentrated towards the inshore region. The concentration has been higher ($100/m^2$) in a belt of 10 to 20 miles from Karwar to Cochin (15° 13'N to 9° 30'N). Moderately high core value occurred in the near shore area of Ratnagiri, on the continental slope off Kasaragod and also in the inshore areas from Calicut to Cape Comorin.

Though the larvae of flat fishes were present through out the year, the highest peak was noticed in the early part of the post-monsoon period from October to November. Another secondary peak was noticed from April to June. Other months showed much variation and January, February and December showed low concentrations. The effect of hydrographical conditions on the distribution of flat fish larvae was observed and it was seen that in general, the larvae preferred warm water in the range of 27° - 20°C, 34 - 35%o surface salinity and ca 4ml/L of oxygen. It was seen that about 46% of the larvae were obtained in day collections and 54% in night. Gopinath (1946) observed large numbers of advanced larval stages of flat fishes in shoreseine catches along the Trivandrum coast in the December to March period. Eggs and post-larvae assigned to Cynoglossus semifaciatus well illustrated by Seshappa and Bhimachar (1955), collected from Off Calicut and also indicated its spawning period from October to May. Devi (1967) found that the flat-fish larvae were more abundant in the northern half of the Bay of Bengal, than in other areas in Indian Ocean and concentration in the the neritic region, having relatively low salinity. It was also observed that the larvae were more abundant in April and least in October. Mukundan (1971) from his studies on the inshore plankton at Calicut, found significant abundance of fish eggs and larvae, including those of soles, from August to December.

Identification of P. arsius was based on certain transitory characters such as 7 to 9 elongated dorsal fin rays, pigmentation and spination on sphenotic and pre-opercular regions and also on certain permanent characters such as meristic counts, shape and size of brain and liver and position of the pelvic fins.

Dorsal fin ray development is an important taxonomic character in larval flat fish. Many of the bothid genera in the Western North Atlantic and Pacific have elongated dorsal fin rays in the larval stages. [Paralichthys (Hilderbrand and Cable, 1930), Syacium (Aboussouan, 1968), Cyclopsetta (Goode and Bean, 1896), Cyclopsetta fimbriata (Gutheriz, 1970) and Paralichthys olivaceus (Mito, 1966 and Okiyamma, 1967).] Among the Indian bothid flat fishes, the presence of 9 to 10 elongated anterior dorsal rays are reported only in the larvae of Pseudorhombus sp. (Devi, 1969). The elongation of the anterior dorsal rays in larval stages is also noted in some other groups of flat fishes: Psettodes erumei (Ramanathan and Natarajan, 1979), Symphurus orientalis (Pertseva-Ostroumova, 1965) and Samaris macrolepis (Jones and Pantulu, 1958).

Formation of dorsal and anal pterygiophores is also peculiar in P. arsius. In this group the pterygiophores first appear near the caudal end, whereas in larva belonging to sub-family Bothinae these portions develop from the anterior caudal portion. Formation of pterygiophores from the posterior portion of caudal region is also met with in Cynoglossidae.

Though many bothid larvae have spines, the sphenotic as well as pre-opercular spines are unique characters of Pseudorhombus sp. in our waters. The P.-arsius larva has two rows of pre-opercular spines, whereas in P. elevates (Devi 1969) there are 3 rows of spines.

In P. arsius the migrating eye moves over the mid-dorsal ridge anterior to the origin of the dorsal fin, but in sub-family Bothinae or family Cynoglossidae the eye migrates through the head between the dorsal fin and supra-orbital bars of the cranium. Gopinath (1946) also described the eye migration over the head in P. arsius and P. triocellatus. The present P. arsius larva of 8.2mm agrees with that described by Gopinath (1946) as P. arsius (9.5mm) in the nature of pigmentation and fin counts. Unfortunately he did not describe any other parts of the larvae. Pertseva-Ostroumova (1965) has described a single specimen of Pseudorhombus sp. measuring 8.2mm, collected from the Gulf of Tonkin. The present larva (8.2mm) agrees with it in the general body form, but differs in the presence of air bladder and pattern of pigmentation. In their description of P. arsius larvae, Jones and Pantulu (1958) did not mention the larval characters but gave only the body measurements and fin counts. The 3 larval stages obtained from Porto novo waters (Ramanathan & Natarajan (1979) have 3 dorsal tentacles, and lack pigmentation. The authors did not mention about the spination on the body. The distribution study showed that the larvae of P. arsius were present in the inner shelf area, from Kasaragod to Tuticorin only. High core density was obtained in the 20 miles station off Cape and maximum abundance was during November.

Gopinath (1940) also mentioned that maximum number of larvae obtained along the Trivandrum coast was during November. The larvae were seen maximum at a moderate temperature of 27°C with 30%o salinity and 4ml/L O_2. P. arsius larvae were present more in day samples than in night collections.

The larva of P. profunda has not been described previously. Ten selected stages from pre-flexion to post-flexion stages (2.7 - 15.5mm) are described in the present study. The gill arches are present in 2.7mm larva, and gill filaments and gill rakers are developed at 3.3mm and 7.7mm stages respectively. At first the anterio-posterior axis of the massive liver is greater than its dorso-ventral axis, but at about 4mm stage the dorso-ventral axis is much more greater than the anterio-posterior axis. The base of dorsal and anal fins begin to develop at 4mm stage. The adult complement of dorsal rays are seen in the 9.6mm larva. Fully formed anal fin with 70-73 rays is seen in 8.3mm larva. The pelvic fin bud is formed in 4mm larva and fin with 6 rays are visible in 15.5mm larva. Pelvic fin of right side is short based. Serration hasdeveloped only in the post-flexion stage. At 8.3mm stage, 2 spines are developed on the ventral side of pubic bar. The number of spines increased and at 15.5mm stage about 9 spines on cartilaginous plate and 6 on pubic bar are developed. A ventral sprout on the angular region, which is a characteristic appendage of the larva belonging to genus Psettina is present in almost all the larvae. The sprout is reduced with larval development and completely disappeared in the 15.5mm larva. Pigmentation is mainly confined to the ventral contour of the body. In late post-flexion stage dashes of pigments are developed on the dorsal body margin.

In the present study the larvae of P. profunda were collected from March onwards and reached peak in May; June showed a decline in abundance. Other months of larval occurrence were August and November. The larvae were distribvuted from Kasaragod to Cape Comorin and most abundant off Cochin.

Cape Comorin was the next area of high occurrence followed by Quilon, Calicut and Kasaragod. The larvae of P. profunda were absent in the collections from Tuticorin as well as from north of Kasaragod. So it may be presumed that P. profunda breeds in the inshore area between 6° 30'N to 10°30' N. The larvae occurred maximum when the temperature ranged between 28° - 29°C, and with salinity at 34-35‰ and oxygen about 4ml/L. No significant day-night variation in the catches was noticed.

Pertseva-Ostroumova (1965) illustrated 3 stages (3.8, 8.9 & 14.3mm) of E. grandisquamis larvae from the Gulf of Tonkin. No other descriptions are available. The larvae of E. grandisquamis has a single dorsal tentacle. Dorsal and anal fin rays begin to develop from the anterior part of the caudal region at about 3.6mm. The full complement of vertical fin rays are seen at about 8.4mm stage. The pelvic fin base was noticed in the larva of 4.2mm and fully developed fins were seen at 13.4mm. In E. grandisquamis serration is seen on cleithrum, cartilaginous plate and pubic bar. The serration first appeared on the cleithrum when the larva attained 3.4mm length. The pigmentation in the larvae of E. grandisquamis is restricted to the dorsal and anal fins at the level of 24th myomere. At 6.6mm stage few pigment spots are also developed on the outer margin of caudal fin and dorsal tentacle.

Distribution study showed that the concentration of the larvae of E. grandisquamis was more in the mid-shelf area of the entire S.W. coast with high core value in between 10°N to 13°N and another patch in 7°30' N to 9°N. Though the larvae occurred throughout the year, maximum abundace was noticed in March to June with a peak in June. A secondary peak was also noticed in November. The larvae preferred the temperature range between 28° - 29°C and 34-35‰ salinity. The larvae of E. grandisquamis were obtained less in day collections (33%).

The larvae of E. cocosensis are very much similar to the larvae of E. grandisquamis in various aspects, such as, meristic counts, number of gill rakers on the lower part of anterior arch and serration on cleithrum, cartilaginous plate and pubic bar. But the number of serration is less in E. grandisquamis than in E. cocosensis. No pigmentation is seen in E. cocosensis larvae, but pigment patches are seen on the dorsal and anal fins of E. grandisquamis larvae. The statistical study on the inter-specific comparison of the various body relationship in both the species showed that statistically significant differences were observed in H.L., E.D. and S.N. against B.L.

Larvae of E. cocosensis occurred in 29% of the positive hauls for the flat fish larvae and they were only next in abundance to larvae of C. macrostomus. E. cocosensis larvae were distributed all over the shelf area from Ratnagiri to Tuticorin. High core density values were obtained in the stations between 20-60 miles with maximum concentration observed in an area about 40 miles off Cochin. The larvae of E. cocosensis occurred throughout the year and maximum number was present from March to June, with a peak in March. The E. cocosensis larvae showed a marginal increase in catches at night. The more favourable surface temperature range for the larvae was found to be 28° - 29°C with a salinity range 34-35‰ and oxygen about 4ml/L.

Larvae of B. ovalis have not been described previously. In the present study, 8 selected stages from 3.15mm to 16.4mm are described. The larvae illustrated here have large body depth, less pigmentation and small mouth, which are the characteristic features of larvae belonging to the genus Bothus (Amaoka 1964). In the present study the dorsal pterygiophore are well developed, except in the caudal portion in the 3.15mm and fully developed anal fin is seen in 9.8mm larva. The pelvic fin buds are also developed early and about 6 feeble rays are differentiated in 4mm larva. In pre-flexion stage a blunt spine is seen in the angular region. Pubic bar is serrated only in the early post-flexion stage. The pigmentation is confined only on the left side of thebody, few dash-like pigmentations are evident on the dorsal and ventral body margins. The eye migration agrees as in other larvae belonging to the sub-family Bothinae. The right eye migrated at 28mm through an opening in between the frontal region of the cranium and the ventral edge of the anterior portion of the dorsal fin.

The distribution study showed that the larvae of B. ovalis were found mainly in mid-shelf waters from Karwar to Cape Comorin. The larval concentration was high in between 40-50 miles away from shore. The best concentration of larvae was obtained off Cape Comorin at about 40 mile station. Kasaragod also showed moderate abundance. The periods of occurrence were February to April, July to August and October to December with a peak in December. The larvae of B. ovalis occurred maximumat a temperature of 28°C with 33‰ salinity and about 4ml/L Oxygen and 60% larvae were caught in day hauls.

The larvae of G. polyophthalmus have not been described previously. Devi (1976) mentioned the presence of the post-larvae in the Indian Ocean. In the present study 9 selected stages from 3mm to 22mm are described in detail. The larvae of G. polyophthalmus are thickly pigmented on the right side. In the early pre-flexion stage, a single blotch on the dorsal fin and another one on the anal fin are seen. The blotches of pigments increased and at post-flexion stage 4 blotches on the dorsal fin and 3 on anal fin are developed. Myoseptal pigmentation is also seen on the right side. Pigmentation on the ventral contour of the body, bases of dorsal and anal fin rays are irregular pigment spots on the body help in the identification of the G. polyophthalmus larvae. Dorsal and anal fin begin to develop at 4.1mm stage. Fully formed dorsal and anal fins are seen in 10mm larva. The larvae of G. polyophthalmus was distributed in the mid-shelf and offshore areas from Ratnagiri to Tuticorin. An inshore belt, about 10 miles wide along the surveyed area was devoid of larvae. High concentration of larval density occurred in the mid-shelf areas of Karwar and Quilon to Cape Comorin. The larvae of G. polyophthalmus occurred in pre-monsoon and monsoon months with a peak in June. They were found to occur maximum in a temperature range between 28° - 29°C and salinity 27-29%o. G. polyophthalmus larvae were obtained more in day collections (56%).

A series of larvae of L. guentheri from 2.5mm to 48mm length (metamorphosing stage) are described in the present study. An 18.9mm stage has been described by Balakrishnan (1963) previously. The larvae of L. guentheri are elongated and lanceolate. The single dorsal tentacle is about equal in length of the body. The intestinal coil is large and bulges between the pelvic fin and anal origin. Dorsal and anal fin begin to develop at 4.4mm and full complement of dorsal and anal rays achieved at 16.8mm stage. The anterior two dorsal rays are detached from the reminder of rays. On the left side 3 pigment blotches are seen mid-ventrally. Dorsal and anal fins are also pigmented. The larvae of L. guentheri were collected in the present study from February to August with maximum in April. A fairly moderate distribution was also seen in June. Stray occurrence was noticed in November. The larvae of L. guentheri did not occur in the inshore belt of an average width of 10 miles in the entire area from Ratnagiri to Tuticorin. Maximum abundance was noticed in the mid-shelf waters from 8°N to 15°N. One patch of high density of larvae in off Calicut and another one in Quilon were observed. Area from Cape to Tuticorin were devoid of larvae The larvae were found in surface temperature range of 28° - 29°C and salinity range between 33 - 34%o with 4-5ml/L oxygen content. No singificant day-night variation in the catches was noticed.

Larva of L. macrophthalmus has not been described earlier. Five selected stages from 6.9mm to 24.5mm are described in the present study. The larvae of L. macrophthalmus and L. guentheri are similar in various characters such as, single elongated dorsal tentacle, detached first two dorsal rays from reminder of dorsal fin, origin of dorsal fin above the nostril of right side and massive intestinal coil. But they differ in the meristic counts and pigmentation and also statistical differences were observed in the inter-specific comparison of different body parts such as PAD, HL, and UJL against BL.

The distribution pattern of L. macrophthalmus larvae showed that the larvae were absent from 14°N to 10.30'N Lat. Maximum larval density was seen in Cochin and Cape Comorin areas with a high core value in the outer shelf off Cape Comorin. The larvae were most abundant during May and August and less in March and December. No larvae were recorded in the months of January, February, July and October. The larvae of L. macrophthalmus occurred maximum in a surface temperature range of 27°- 29°C and 34 - 35‰ salinity and about 4ml/L oxygen.

The larvae of C. macrostomus (Malabar sole) the most abundant of all flat fish larvae (38%) were found over most part of the shelf, except in the nearshore area of Tuticorin section. Seshappa & Bhimachar (1955) and Balakrishnan (1961) described larval stages of 'Malabar sole' which they mistakenly identified as C. semifaciatus (Menon, 1971). In the present study pre-flexion stage (2mm) to metamorphosing stage (9.7mm) are described. The larvae of C. macrostomus has a pair of dorsal tentacles above the head. The dorsal and anal fins begin to develop from near the caudal peduncle at about 4mm stage. Fully formed dorsal and anal fins are seen in 7.5mm larva. The right eye migrates to left side through a slit in between the cranium and rostral cartilage. Dorsal and ventral body margins are pigmented. In the late post-flexion stage irregular cross bands developed on the left side. The distribution of C. macrostomus larvae showed good density value and localised concentration from Ratnagiri to Cape Comorin, with high density value in Karwar, Kasaragod and Off Cochin. Moderate density also occurred in Ratnagiri, Quilon and Cape. The inner-shelf area within 30 miles showed high core values whereas much of the mid-shelf and offshore areas had very poor larval density. The larvae of C. macrostomus occurred in all months, July to November showed the maximum abundance with a peak in October. The distribution pattern showed that the species had a protracted breeding period, it bred mainly in monsoon and post-monsoon periods. Maximum abundance of larvae was observed in the temperature range of 26° - 27°C, salinity 34-35‰ and oxygen 3-4ml/L. No significant variation was noticed in day-night collections.

The larvae of P. bilineata are rather long and lanceolate and have paired dorsal tentacles. The dorsal and anal fins begin to develop from the posterior end at about 4mm, and well formed rays are seen in 11.3mm larva. A slit-like opening has developed above the cranium for the migration of right eye. In the late post-flexion stage dashes of pigmentation are seen on the dorsal and ventral contours of the body. During development, dashes of pigments increased. In early metamorphosis stage stellate chromatophores are developed all over the body on the left side. The larvae of P. bilineata were the least abundant of all flat fish larvae, occurring in relatively restricted area from 7°N to 11°N Lat. and a small patch was seen in Ratnagiri area. A high core value was obtained off Quilon region. The larvae occurred in May to July and in December with a peak in May. The larvae were maximum when the temperature reached about 26 - 27°C with salinity 35‰, and oxygen content 5ml/L. The larvae were more in night collections (68%) than in day collections.

The larvae of A. cyaneus have not been described previously. In the present study 9 stages from 3.8mm to 14.2mm are described. The larva has no dorsal tentacle; liver and intestinal coils are very small. The dorsal pterygiophore region begins to develop from the anterior part of the dorsal fin fold. The dorsal fin originates from just above the snout. Scale plate-lets are seen on either side of the caudal peduncle in 3.8mm stage. Ctenoid scales are developed on the caudal peduncle in 5.6mm larva, the lateral line system on blind side is associated with a series of fine dermal keels. The left eye migrates to right side through a fissure developed above the snout. The larvae are heavily pigmented and 5 to 6 bands are developed on the body. A. cyaneus larvae were obtained in the area between Kasaragod and Quilon and moderate density values were obtained within 20-50 miles stations and the best concentration of larvae was observed in the area about 40 miles off Quilon. The larval abundance of A. cyaneus showed the maximum in July and less in June. The occurrence of larvae was noticed in September also. The larvae preferred cool water and maximum abundance was noticed in the surface temperature of 25°C with salinity 35‰ and 4ml/L oxygen. Day and night variation for this species showed that more larvae were present in the night samples.

It has been observed from the present study that certain characters of the larval flat fishes such as number of dorsal tentacles, position of dorsal fin etc. help them to be separated into family or sub-family level:

a. Dorsal tentacle

Single tentacle	-	Larvae of sub-family Bothinae (eg: P. profunda, B. ovalis)
Two dorsal tentacles	-	Family Cynoglossidae (Eg. C. macrostomus, P. bilineata)
More than 3 and about 6 to 9 dorsal tentacles	-	Sub-family Paralichthinae (eg. P. arsius, P. elevatus)
No dorsal tentacle	-	Family Soleidae (eg: A. cyaneus)

The larvae of genus Laeops is having elongated dorsal tentacle which reaches more than 2/3 of the larval length.

b. Origin of dorsal fin.

From the anterior position (near the head)	- Family Soleidae
Near the first caudal vertebra (near the vent)	- Sub-family BOthinae
Near the last caudal vertebra (near the caudal peduncle)	- Family Cynoglossidae Sub-family Paralichthinae

It is found that the larva belonging to sub-family Bothinae has a massive liver and its optic lobe of the brain is large. In Paralichthinae, the right eye migrates over the head. In Bothinae the right eye migrates to left side through an opening formed in between the cranium and base of the dorsal fin, except in the case of genus Laeops, in which the eye migrates over the head, in between the dorsal tentacle and the ray behind it. In Cynoglossidae the right eye migrates to left side through a slit formed by the detachment of rostral cartilage from the cranium. In Soleidae the left eye migrates to right side through a fissure developed above the snout.

The studies on the early life history of the lizard fishes are rather scanty in Indian waters. Gopinath (1946) described post-larvae of Saurus indicus, S. myops and Saurida tumbil and he pointed out their distribution along the Trivandrum coast as during Janaury-February period. Other works on the development of lizard fishes from Indian waters are by Nair (1952), Bapat (1955), Vijayaraghavan (1957), Kuthalingum (1959), Raju & Ganapathi (1967), Venkataramanujam & Ramamoorthi (1974) and Dileep (1977). Vijayaraghavan (1957) collected eggs of S. tumbil during October-December period from Madras Coast. Venkataramanujam & Ramamoorthy (1977) reported that the eggs of S. tumbil were abundant during September-November period in Portonovo waters.

They also obtained eggs of S. gracilis from the same area during January-Februar y and April-May period and suggested that the species spawn around the year with a peak in post-monsoon period. Dileep (1977) reported that larvae of S. tumbil are seen relatively in more numbers in the plankton in November and December along the S.W. coast of India. Annigeri (1963) mentioned that the spent specimens of S. tumbil first appeared in the catches at Mangalore in December and the percentage increased subsequently, indicating spawning of the fish around December. On the east coast of India Basheeruddin & Nair (1962) observed large number of juveniles of S. tumbil off Madras during March and April.

The present study dealt with the early developmental stages of S. undosquamis, S. variegatus and T. myops and also could project a detailed picture of their distribution and abundance along the S.W. coast of India. The distribution study showed that the concentration of larvae has been highest from Kasaragod to Tuticorin. The density gradient was highest in the nearshore belt between 20 and 30 miles area, and gradually lighter towards offshore. The larval occurrence was noticed upto 80 miles and thereafter the abundance was very poor. The inshore belt within 10 miles also was poorin larval abundance. The larvae of lizard fishes were present throughout the year except in September along the coast. Highest peak was noticed in November. August and December showed modered occurrence. During January and July the larval occurrence was very low. In general the larvae of lizard fishes preferred warm water within the range of 27° - 28°C, 33-35‰ salinity and 4ml/L oxygen. Maximum number of larvae was obtained in night collections (57%).

Only a single stage of S. undosquamis (4.9mm) has been described previously by Zvjagina (1965) from the Gulf of Tonkin. Here, 11 selected stages from 2.55m to 19.8mm are described in detail. The basals of dorsal fin begin to appear in

12.8mm larva, 10 rays are developed in 18.2mm stage. The basals of anal fin are devedloped earlier than the dorsal fin origin and at 6.4mm, 6 basals are found. Full complement of 10 rays are seen in 12.8mm larva. The number of vertebra varied from 47-48.

The paired peritoneal pigment patches of larval lizard fishes are considered to be of taxonomic importance. In S. undosquamis larvae 6 pairs of peritoneal pigment patches are developed in the pre-flexion and post-flexion stages; 7 pairs in late post-flexion stage. Anal and caudal pigmentation was also present from very early stage.

The distribution study showed that S. undosquamis larvae was maximum in nearshore waters upto 30 miles area. High density value occurred off Kasaragod. Moderate occurrence was noticed in Cochin, Quilon & Tuticorin. Maximum occurrence of S. undosquamis larvae was noticed from October to December with a peak in November, indicating the spawning of the fish in post-monsoon season. Maximum abundance of S. undosquamis larvae was observed in the surface temperature range of 27° - 28°C, salinity 34-35%o and 4ml/L oxygen.

Weber (1913) described a post-larva (45mm) of S. variegatus. Mito (1961) described the eggs and newly hatched larva of S. variegatus from Japanese waters ZVjagina (1965) illustrated eggs and 5.25mm larva from the Gulf of Tonkin. Seven selected stages from pre-flexion to post-flexion (5.4mm - 24.5mm) have been described in the present study. The larva of S. variegatus has a small head and elongated body. The larva has 11 pairs of peritoneal pigment patches; dorsal begins to develop in 17.8mm stage and adult number of 10-13 rays are developed in 24.5mm larva. The anal fin base is evident in 8.9mm stage, full complement of rays are seen in 17.8mm larva. Vertebrae 55-60 in numbers.

The larvae of S. variegatus occurred in the mid-shelf area from Karwar to Tuticorin with high core value in Tuticorin section. The entire nearshore areas from Ratnagiri to Cape Comorin were devoid of larvae. Maximum abundance of larvae was noticed in the months of March and June. The surface temperature in which the maximum number of larvae occurred was 28°C with 33‰ salinity and 4ml/L oxygen, 65% of the S. variegatus larvae were obtained in the night hauls.

Nine stages of T. myops larvae (4.4mm to 33mm) are described in the present study. Previous works on the development of T. myops are of Gopinath (1946), Mito (1961) and Zvjagina (1965). The larvae of T. myops can easily be identified by its 6 pairs of peritoneal pigment patches and meristic counts. Pigmentation was also seen on the occipital region, lateral line, behind the pectoral fin base and between dorsal and adipose fins. The larvae of T. myops occurred throughout the year except in September and maximum abundance was noticed in August. Moderate occurrence was noticed in April, May and November. The larvae of T. myops occurred in the mid-shelf area, all along the coast. Abundance was more in 50-60 miles stations. High denisty value occurred in the offshore area of Ratnagiri. Moderate density was noticed in off Cochin and Kasaragod sections. More larvae were caught in day hauls (54%). The larval density was more in the surface temperature of 27°C, salinity 35‰ and oxygen 4ml/L.

The early developmental stages of H. nehereus have not been described so far. Eight stages from 10mm to 29mm in length are described in the present study. As in lizard fish larvae, seven pairs of peritoneal pigment patches are present in the larvae of H. nehereus. Pigmentation is also seen on the anal fin base and base of caudal fin. The dorsal fin begins to develop in 13mm larva and feebly developed 13 rays are seen in 22.5mm larva. The 10mm larva has 13 anal basals and fully developed anal fin is seen in 22.5mm larva. The median lobe of the caudal fin begins to develop in 29mm larva.

The distribution study showed that the larvae of H. nehereus were obtained from Ratnagiri (63%) and Karwar (37%). The larvae occurred only in July and August with a peak in August (97%). Bapat et al (1951) suggested that though the fish is a continuous breeder, there are two peak breeding seasons, one in April - July and another in November - December. So it may be presumed that the larvae obtained in the present study were from the April - July season. The larvae of H. nehereus preferred warm water with a temperature of 27°C and 35‰ salinity and 5ml/L of oxygen.

The ichthyoplankton larval intesity varies from year to year. The abundance of flat fish larvae was maximum in 1975 followed by 1974, 1971, 1972 and 1973. During 1971, the plankton collections were begun from September onwards, and maximum number of larvae was obtained in October. In 1972 the larval abundance was maximum in September whereas in 1973 the larvae were obtained maximum during May. During the year 1974 the flat fish larvae were most abundunt in November and April. In 1975 two peaks were observed, first one in June and the second in October. C. macrostomus larvae were obtained maximum in 1971, 1972, and 1974. In 1973 and 1975 larvae of E. cocosensis dominated. E. grandisqauamis larvae occurred moderately from 1973 to 1975.

Maximum number of lizard fish larvae was obtained in the year 1974 followed by 1975. Intensity of larval occurrence was poor from 1971 to 1973. In 1971, 1972 and 1975 S. undosquamis larvae showed maximum in the collections, whereas in 1973 and 1974 the larvae of T. myops dominated. In 1971, 1974 and 1975 larvae of lizard fishes were obtained maximum in the month of November. In 1972, August showed maximum abundance and in 1973 February was the dominant month. The larvae of Bombay duck were obtained only in 1972, 1974 and 1975 and maximum number of larvae was collected in 1974. The larvae of H. nehereus were obtained only in the months of July and August and about 97% of larvae were obtained in August alone.

In tropical waters, most fish eggs are known to hatch out in to larvae within a day and presence of a large congregation of such young larvae any where, could reasonably be indicated as the spawning area of the fish. On the contarary to fairly well defined spawning grounds and seasons often seen in temperate waters, many species in tropics appear to be continuous breeders with prolonged spawning period. In the past, indication of spawning seasons and spawning grounds of fishes in Indian waters, have been based mainly on the occassional collections of eggs and larvae from the coastal areas. Delineation of spawning ground and season could not be possible by occasional collection of eggs and larvae as the fish has a prolonged spawning time and space. It can be done only by a comprehensive survey of eggs and larvae covering the whole are at regular intervals as is done in the present investigation. From the present studies it is found that the larvae of both flat fishes and lizard fishes were more concentrated in near shore waters of the area and density gradient towards offshore was graduallay lighter. In the case of flat fish larvae, the concentration has been highest in thearea between 10-20 miles away from shore, whereas it is 20-30 miles in the case of lizard fish larvae.

The larvae of Bombay duck were obtained only from the near-shore waters of Ratnagiri and Karwar area. From the present study the delineation of the most probabale spawning time and area of the species could be noted as follows:

Species	Most probable spawning areas	Most probable spawning time
C. macrostomus	Throughout the surveyed area in near shore waters off Karwar, Kasaragod and Cochin.	Throughout the year. Peak in October.
P. bilineata	Cochin to Cape Comorin and off Ratnagiri	Monsoon & Post-monsoon, Peak in May.

Species	Most probable spawning areas	Most probable spawning time
A. cyaneus	Kasaragod to Quilon. Best concentration 40 niles off Quilon	Monsoon Peak - July
P. arsius	From Kasaragod to Tuticorin, 20 miles off Cape Comorin	Monsoon Peak - November
P. profunda	Kasaragod to Cape Comorin. Maximum - Off Cochin to Cape Comorin	March to June August & November. Peak - May
E. grandisquamis	Throughout the area, more beyond 20 miles, maximum - Kasaragod to Calicut area and Cape to Tuticorin area.	Throughout the year except September Peak - June & November
E. cocosensis	Throughout the area, maximum from Ratnagiri to Kasaragod and Cochin to Cape 20 - 60 miles.	Throughout the year Maximum March - June. Peak - June
B. ovalis	Mid-shelf waters from Karwar to Cape Comorin; maximum Kasaragod & Cape Comorin	February - April, July - August October - December Peak - December
G. polyophthalmus	Mid-shelf area from Ratnagiri to Tuticorin; maximum Karwar, Quilon and Cape Comorin	Pre-monsoon & Monsoon. Peak - June
L. guéntheri	Mid-shelf waters from Karwar to Quilon, maximum off Calicut.	Pre-monsoon to monsoon Peak - April
L. macrophthalmus	Mid-shelf area of Ratnagiri to Karwar and Cochin to Cape Comorin, maximum outer shelf, off Cape Comorin.	March - June August - November Peak - May & August.
S. undosquamis	Near shore waters of entire area except Calicut, maximum Kasaragod.	Post-monsoon Peak - November

Species	Most probable spawning areas	Most probable spawning time
S. variegatus	Entire mid-shelf area from Ratnagiri to Tuticorin, maximum Karwar, Cochin and Tuticorin	March & June
T. myops	Entire mid-shelf area from Ratnagiri to Cape Comorin, maximum - Karwar, Quilon.	Through the year except September Peak - August
H. nehereus	Nearshore waters from Ratnagiri to Karwar	July - August Peak - August

Observations on day and night collections showed that flat fish larvae were present more in night collections (54%). In the case of lizard fish larvae, a marginal increase in number of larvae caught in night than in day was observed, whereas all the larvae of Bombay duck collected were obtained in day collections only. However, Alikhan (1972), Silas (1974) and Peter (1977) noted increased catches of fish larvae at night in the Indian ocean.

The present study has in a reasonable measure achieved in the identification of certain underscribed or poorly described species and delineation of their spawning seasons and areas. The study also dealt with the chief hydrographical parameters, such as temperature, salinity and oxygen of the area during the time of investigation and their probable influence on larval distribution.

7. SUMMARY

1. The main objective of the present work was to study the early develop mental stages of some of the important and less studied demersal fishes of the S.W. coast of India and their distribution and abundance along the area in relation to environmental parameters so as to delineate their spawning areas and seasons.

2. The materials for the study were obtained from ichthyoplankton collections of UNDP/FAO/Pelagic Project's vessels, obtained during their regular acoustic survey cruises from Ratnagiri to Tuticorin during 1971 - 1975. The plankton collections were made with standard sampling gears viz. Bongo-20 and Bongo-60 (ring diameter 20cm and 60cm respectively with same mesh size 0.505mm). The hydrographic data such as temperature, salinity and oxygen were also collected from all the stations. Few juvenile fishes, collected through pelagic trawl operations by the research vessels were also made use of in the present study for identification puposes.

3. Along 9 sections viz. Ratnagiri, Karwar, Coondapur, Kasaragod, Calicut, Cochin, Quilon, Cape Comorin and Tuticorin, 50 regular standard stations and 23 occasionally collected stations were fixed and a total of 1330 hauls were made from these stations. Samples were taken in duplicates.

4. Out of the total ichthyoplankton collected, a total of 1956 flat fish larvae, 642 lizard fish larvae and 32 Bombay duck larvae obtained from 333, 133, and 9 hauls respectively.

5. Developmental stages of 11 species of flat fishes belonging to 3 families viz. P. arsius, P. profunda, E. grandisquamis, E. cocosensis, B. ovalis,

G. polyophthalmus, L. guentheri, L. macrophthalmus, C. macrostomus, P. bilineata, and A. cyaneus were studied in detail. Among these, larvae of 5 species viz. P. profunda, B. ovalis, G. polyophthlamus, L. macrophthalmus, A. cyaneus are described for the first time. Five stage of P. arsius larvae were described previously. Here, 6 stages from pre-flexion stage (2.8mm) to 13.4mm are described and illustrated for the first time from Indian waters. Five stages of E. cocosensis larvae were described previously as that of Arnoglossus tapeinosoma. In the present study, 11 stages from 2.2mm to 19mm are described. A single post-larvae of L. guentheri was described previously. Here, 10 stages from 2.5mm to 48mm (metamorphosing stage) are described. Six stages of C. macrostomus from 2mm to 9.7mm (Metamorphosing stage) are described. Two stages of P. bilineata were described earlier. Here, 6 stages from 3.5mm to 17.5mm are described.

6. Developmental stages of 3 species of lizard fishes viz. S. undosquamis, S. variegatus and T. myops belonging to 3 genera are studied. Only a single stage of S. undosquamis was illustrated previously from Gulf of Tonkin. Here 11 stages from 2.55mm to 19.8mm are described. Seven stages of S. variegatus from 5.4mm to 24.5mm are described. Nine stages of T. myops from 4.4mm to 33mm are described.

7. Developmental stage of Bombay duck, H. nehereus are described for the first time. Eight stages from 10mm to 29mm are dealt with in detail.

8. Certain general characters, such as number of dorsal tentacle, position of dorsal fin origin, and eye migration, which are helpful in the identification of flat fish larvae were studied.

9. The distribution and abundance of larvae in rerlation to hydrographical parameters are studied in detail. Though the larvae of flat fishes were present throughout the year, the highest spawning activities were seen just prior to and after the S.W. monsoon with a peak in October-November period. The larval flat fishes were prsent in all sections, but were more abundant from Karwar to Cochin. The concentration has been highest in the area between 10 to 20 miles stations, in moderate level from 20 to 70 miles and thereafter it diminished.

10 C. macrostomus larvae, the most abundant of all flat fish larvae were met with in all the months, but more from July to November, with a peak in October and less in February to June. The larvae were present at every section and relatively high density occurred in Cochin - Karwar area. Larval abundance was maximum in Kasaragod section and Cochin was the next in abundance. High core value occurred in the inshore belt within 30 miles. Maximum abundance of C. macrostomus larvae was observed in a temperature range of 26° - 27°, salinity 34 - 35%o and oxygen 3-4ml/L. No significant variation was noticed in the day/night collections.

11. P. bilineata larvae occurred in May toJuly and in December with peak in May. The larvae occurred from Cochin to Cape Comorin and Ratnagiri sections. Maximum abundance was in Quilon followed by Cochin and Cape. The larval density was more in 20-30 miles stations. Maximum abundance was noticed in a temperature range of 26° - 27°C, salinity 35%o and oxygen 5ml/L. The larvae of P. bilineata were more in night collections.

12. The larvae of A. cyaneus, showed maximum abundance in July and less in June. Occurrence of larvae was also noticed in September. The larvae

were present only from Quilon to Kasaragod. Moderate density value occurred within 20-50 miles stations and the best concentration was obtained in an area about 40 miles off Quilon. The A. cyaneus larva was maximum at 25°C with a salinity of 35‰ and oxygen 4ml/L. More larvae were obtained in night collections.

13. The P. arsius larvae were obtained in June, October and November with a peak in November. The larvae were caught in the innershelf area, from Kasaragod to Tuticorin, with high core density in Cape Comorin. The larvae were found to occur maximum in a temperature of 27°C, with 34‰ salinity and 4ml/L oxygen. About 61% larvae were obtained in day collections.

14. The larvae of P. profunda occurred from March to June with a peak in May. Other months of larval occurrence were August and November. The larvae showed a relatively more southern concentration from Kasaragod to Cape Comorin, and most abundant in Cochin section. About 40% of the larvae were found in 20 miles stations from Calicut to Quilon. The larvae were absent in the off-shore areas of Cochin and Cape. The larvae occurred maximum in a temperature range between 28° - 29°C and salinity of 34-35‰ and oxygen about 4ml/L. No significant variation in abundance was noticed in the day/night collectiosns.

15. The larvae of E. grandisquamis were found throughout the year, except in September. Maximum number of larvae occurred from March to June with a peak in June. A secondary peak was noticed in November. The larvae occurred in all the sections and were more frequently caught off Cochin, followed by Karwar, Kasaragod and Tuticorin. The larval abundance was maximum in the 40-50 miles stations. The larvae were obtained maximum in a temperature range between 28° - 29°C, salinity 34-35‰ and 4ml/L oxygen

67% of the larvae were caught in night collections.

16. The larvae of E. cocosensis, second in order of abundance among the flat fish larvae, were found through out the year. The maximum number was present from March to June, with a peak in March. During the monsoon and post-monsoon periods the abundance was very low. The larvae were obtained all over the shelf area from Ratnagiri to Tuticorin. High core values were obtained in the stations between 20-60 miles. The near shore belt of about 10 miles of the entire coast was very poor in abundance. Maximum abundance of larvae was found in Cochin and Karwar, moderate values from Cape, Kasaragod, Quilon and low in Tuticorin and Calicut. The larvae were obtained maximum in a temperature range from 28° to 29°C, salinity 34-35%o and about4ml/L oxygen. About 60% of the larvae were obtained from night collections.

17. B. ovalis larvae occurred in small numbers, more frequently in February - April, July - August and October - December periods. The maximum number of larvae occurred in December. The larvae were found mainly in mid-shelf waters and occurred in all sections, except Ratnagiri and Tuticorin. The concentration of larvae was high in 40-50 miles stations and high core value was obtained at about 40 miles station off Cape Comorin. The larvae were maximum at a temperature of 28°C with salinity 33%o and oxygen 4ml/L About 60% of the larvae were obtained in day collections.

18. The larvae of G. polyophthalmus occurred in pre-monsoon and monsoon months with a peak in June. The larvae were distributed in the mid-shelf and offshore areas from Ratnagiri to Tuticorin, with high core density in Karwar, Quilon and Cape Comorin areas. The entire nearshore belt of an average

width of 10 miles was devoid of larvae. The larvae were maximum in the temperature range between 28° - 29°C, with salinity 33-34%o and oxygen 4-5ml/L.

19. *L. guentheri* larvae were obtained from February to August with maximum in April and moderate in June. Maximum abundance was noticed in the mid-shelf waters from Karwar to Quilon and high core value has obtained off Calicut. The larvae were not found in Cape Comorin and Tuticorin sections and also in the near shore belt of about 10 miles width along the entire coast line. No significant variation was found in day/night collections of the larvae. The larvae were found more in a temperature range between 28° - 29°C, with 33-34%o salinity and 4-5ml/L oxygen.

20. The larvae of *L. macrophthalmus* were maximum in May and August, moderate in November and less in March and December. No larvae were obtained in the months of January, February July and October. The larvae were absent in Kasaragod, Calicut and Tuticorin sections. The inner-shelf area was poor in abundance. The maximum larval density was seen in the Cochin and Cape Comorin sections. The larvae occurred maximum in 27-29°C range of temperature, 34-35%o salinity and 4ml/L oxygen.

21. The larvae of lizard fishes were present throughout the year except in September. Highest peak was noticed in November, moderate in August and December and lowest in January and July. Larvae were found throughout the area. Maximum abundance was noticed in Cochin and Kasaragod areas. Moderately high value occurred in Karwar and Ratnagiri areas. The density gradient was highest in the near shore belt between 20 and 30 miles stations. Moderate level of occurrence was noticed upto 80 miles and thereafter the abundance was very low as in the case within the 10 miles area. In general

the larvae of lizard fishes preferred warm water within the range fof 27°C - 28°C, 33-35%o salinity and about 4ml/L oxygen. The larvae were obtained more in night collections.

22. The larvae of S. undosquamis occurred maximum in October - December period with a peak in November. Larvae were not obtained in January, April and July to September. Larvae were more abundant in Cochin and Kasaragod, moderate in Quilon and low in Karwar and Ratnagiri. The larvae were maximum in nearshore waters upto 30 miles area. The larvae were obtained maximum in the temperature range between 27° - 28°C, salinity 34-35% and 4ml/L oxygen. About 66% larvae were obtained in night collections.

23. Maximum number of S. variegatus larvae were obtained in March and June. They did not occur in the months of July, September and October. The larvae were obtained in all sections except in Calicut. The larval abundance was maximum in Karwar, moderate in Tuticorin and Cochin and less in Kasaragod and Quilon. They were not observed in the entire nearshore areas from Ratnagiri to Tuticorin, except one or two small patches near Cape Comorin and Tuticorin. About 65% of larvae were obtained in the night collections. The larvae showed much abundance in 28°C temperature, 33%o salinity and 4ml/L oxygen.

24. The T. myops larvae occurred throughout the year except in September. Maximum abundance was noticed in August, moderate in April, May and November. The larvae were more abundant in northern sections. Maximum abundance was noticed in the mid-shelf waters. High density value occurred in the off-shore area of Ratnagiri and moderate density gradient was observed in Kasaragod and Cochin. The larvae were present more in a temperature

of 27°C, salinity 35%o and oxygen 4ml/L. The larvae were obtained more in day collections.

25. The larvae of H. nehereus were obtained only in July and August with a peak in August. The larvae were collected only from Ratnagiri and Karwar sections. Most of the larvae occurred in the nearshore waters upto 30 miles area. The larvae were obtained only in day collections and occurred more at a temperature of 27°C and 35%0 salinity with 5ml/L oxygen.

26. The present study revealed the developmental stages of some of the undescribed or under described species of demersal fishes found along the S.W. Coast of India. In addition, the study has in a reasonable measure achieved the delineation of their spawning seasons and areas on the bases of their larval distribution in time and space.

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