STUDIES ON THE FLATFISH DIVERSITY OF INDIA

Thesis submitted to the
Mahatma Gandhi University

in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Zoology

(Faculty of Science)

by

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under the guidance of

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August 2011

Declaration

I hereby declare that the thesis entitled **"Studies on the flatfish diversity of India"** is a bonafide record of original research work carried out by me under the supervision and guidance of Dr. A Gopalakrishnan, Principal Scientist and Scientist-in-Charge, National Bureau of Fish Genetic Resources, Kochi Unit, CMFRI Campus, Ernakulam 682018, Kerala, in partial fulfillment of the requirements for the Degree of Doctor of Philosophy of Mahatma Gandhi University and that no part of this work has been presented for any degree, diploma or any other similar title of any other University.

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To God the Almighty,
I submit my humble work.........

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Rekha J. Nair

Abstract

Fishes constitute slightly more than one half of the total number of approximately 54,711 recognized living vertebrate species of the world. Flatfishes represent an interesting and diverse order of marine, estuarine and to a lesser extent, freshwater euteleostean fishes. They are common species in most marine fish assemblages right from the poles to the tropics. Flatfishes captured in tropical fisheries are often not identified even to genus or family level rather, much of the catch is merely identified as "Pleuronectiformes"; 54-80% of the total landings of tropical flatfishes consist of unidentified species. For flatfishes inhabiting tropical seas, despite recent progress, considerable diversity is still being discovered and the taxonomy of many tropical flatfishes remains especially problematic. Failure to identify species, and erroneous species identifications, still represent serious impediments to collection of meaningful data for many of these smaller species. Work on Indian flatfishes has been scattered over the time period and ample scope exists for a study on the diversity of the group. Based on the present collections from different parts of South India and Andaman Islands during the period 2004 - 2010, 63 species of flatfishes belonging to 8 families and 26 genera have been collected. The most speciose family was Soleidae with 9 genera and 17 species, followed by Bothidae with 9 genera and 14 species and Cynoglossidae with 2 genera and 13 species. Family Bothidae had representations from deep sea. New distributional records were *Aserraggodes kobensis* and *Brachirus annularis* for the Indian waters. *Psettodes erumei* a major resource in the flatfish fishery has virtually been absent in the landings except for stray numbers in large trawlers off Mangalore. The study points out the decline of the resource off South India. This calls for immediate steps to device steps to protect and preserve this species. New emerging resources in the fishery are *Synaptura commersoniana* in the estuarine landings off Kochi. Occurrence of *Pardachirus pavoninus*, *Heteromycteris oculus* and *Paraplagusia bilineata* in the '*rollermadi'* landings at Pamban point to the existence of these ornamental varieties in the Gulf of Mannar.

Key words: Pleuronectiformes, flatfish, taxonomy, diversity, India

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Preface

Fishes constitute slightly more than one half of the total number of approximately 54,711 recognized living vertebrate species of the world (Nelson, 2006). There are descriptions of an estimated 27,977 valid species of fishes compared to 26,734 tetrapods. (Nelson, 2006). Flatfishes represent an interesting and diverse order of marine, estuarine and to a lesser extent, freshwater euteleostean fishes. They are well known organisms as they occur in all the world's oceans, and are represented by a large number of species and genera and in some regions, their populations are sufficiently large to constitute major fishery resources. Gastronomy apart, the layman's curiosity is aroused in flatfishes not only by the unusual flattened shape, presence of both eyes on the same side of the head, but also by the remarkable ability to match the colour and pattern of their background and to bury themselves in the sediment. Fishes have been exploited using a wide variety of gears from various depths and in all sizes leading to heavy recruitment overfishing as well as growth overfishing. As a consequence, man has now realized that conservation of this resource is a needed agenda of this century to preserve the varied species for posterity. Tropical seas are the largest marine biomes of the world and on these waters from a depth of 30 – 100 m subsist a major portion of the coastal population for their livelihood. In this area are found diverse assemblages of marine fish, among them are the flatfishes in a variety of forms and extreme length ranges. In tropical areas, flatfishes occur in a variety of habitats including mangrove estuaries and adjacent mudflats, in seagrass beds and on mud bottoms. The majority of flatfishes inhabiting the Indo-Pacific region, especially species of Bothidae, Samaridae, Poecilopsettidae, Soleidae and Cynoglossidae are relatively small fishes generally not of commercial importance. Other tropical flatfishes, especially larger species (Psettodidae and some Paralichthyidae, Cynoglossidae, Soleidae and Bothidae), are captured on a regular basis in tropical fisheries and for these, better (although still limited) taxonomic and ecological data are available. (Munroe, 2005). For the other groups limited taxonomic information is available. Although tropical flatfishes are frequently caught, are species rich and even sometimes numerically abundant, most are thin bodied, small sized species reaching only to 30-40 cm total length Of the 3.3 million tonnes of marine fishes landed in 2010, flatfishes accounted for 43682 tonnes (1.4%) which was less than the previous year by 1962 tonnes Landings of flatfishes have been on the increase in India due to improvements in gear and craft. (CMFRI, 2011). Flatfishes landed in tropical fisheries are taxonomically different and significantly more diverse than those of temperate areas, a situation typical of tropical demersal fish communities in general (Longhurst & Pauly, 1987). Worldwide, considerable work on flatfishes has been done; starting from 1758 to 2006, a steady increase has been noticed in the number of flatfishes newly reported and described. Views on flatfish diversity have helped to clarify issues and directions where additional research is needed to better understand the diversity, evolution, biology and biogeography of these fishes. With accumulation of new systematic information including species discoveries, improved species diagnoses and phylogenetic hypotheses – the reliability of information regarding species diversity and geographical distributions will also increase. For flatfishes inhabiting tropical seas, despite recent progress, considerable diversity is still being discovered and the taxonomy of many tropical flatfishes remains problematic. Failure to identify species, and erroneous species identifications, still represent serious impediments to collection of meaningful data for many of these smaller species. Though there has been scattered works on Indian flatfishes, a detailed work on the flatfishes and their availability has been lacking in India. Hence work on flatfishes on these lines demand utmost attention in the present world and is taken up in the present study with the objectives.

1) Detailed morpho-meristic studies on flatfishes available in South India.
2) Distribution pattern of flatfishes in the world and in India.
3) Description of new distributional records in India if any.

The work is presented chapter-wise for easy understanding.

Chapter I deals with scope and importance of the work and specific objectives. The first part of the work deals with the present status of the world marine capture fisheries, world flatfish fisheries, importance of the finfish taxonomy and the evolution of the fish taxonomy in India. The importance of the present work in the context of Indian taxonomy and the objectives of the present study are also presented in the chapter.

Review of all previous literature from Peter Artedi (1705-1735 A.D) to the present year is presented in **Chapter II**. Revisions on revisions of certain families and genera, phylogeny of the pleuronectid fishes, classification and larval morphology, intra-relationships of the flatfishes, life history stages of flatfishes, species distribution, distribution pattern of larvae and adults, spawning and fecundity of flatfishes, biology and other aspects of flatfish stock assessment and growth are also presented. A review of methods of interpretation and analysis of morphometric data in relation to phylogeny is also given.

Chapter III deals with **Materials and methods** employed in the present study. Details of survey locations, methods of collection, transport, preservation are explained. Proforma for meristic and morphometric data collection as well as methodology of collection is given in detail. Full details of taxonomic terms used in the text are explained. Details of analysis methods, mode of preparation and presentation of description is also included. Diagrammatic representation of the morphometric characters is also presented.

Results are presented in detail in **Chapter IV**. The Order Pleuronectiformes is classified following Nelson (2006) and results are presented in three major suborders. Discussion is presented familywise with subsections of each genus and species collected. The discussion on the taxonomic review is presented along with the description of each group. The variation in scale morphology among different species of the flatfish families studied is also presented. Details of new distributional records, phylogeny of major families are presented as subsections. A key to the identification of all species collected is provided family wise.

Chapter V deals with the discussion of the results. Present status of flatfish records in India, distribution pattern, changes in the present distribution pattern, reasons for decline of Indian halibut fishery, conservation strategies and results of phylogeny are also discussed.

The last part of the thesis deals with **Conclusion** were highlights and future strategies are presented in bullet points. In **Bibliography** all references cited in the text are mentioned. **List of Tables, Figures** and **Plates, Terms used and Abbreviations** mentioned in the Thesis are also presented. **Publications** from the work are also attached. References cited in the synonym table and distribution are not listed as they are explained in detail in the respective sections.

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Chapter 1

INTRODUCTION

Contents

Fishes constitute slightly more than one half of the total number of approximately 54,711 recognized living vertebrate species of the world (Nelson, 2006). There are descriptions of an estimated 27,977 valid species of fishes compared to 26,734 tetrapods. (Nelson, 2006). Right from the prehistoric era, fishes have been hunted by man for food and sport alike. Fishes have been exploited using a wide variety of gears from various depths and in all sizes leading to heavy recruitment overfishing as well as growth overfishing. As a consequence, man has now realized that conservation of this resource is a needed agenda of this century to preserve the varied species for posterity.

1.1 Capture fisheries

Capture fisheries and aquaculture supplied the world with about 110 million tonnes of food fish in 2006, providing an apparent per capita supply of 16.7 kg (live weight equivalent), which is among the highest on record (FAO, 2008). Of this, aquaculture accounted for 47 percent. Overall, fish provided more than 2.9 billion people with at least 15 percent of their average per capita animal protein intake. The share of fish proteins to the total world animal protein supplies grew from 14.9 percent in 1992 to a peak of 16 percent in 1996, declining to about 15.3 percent in 2005 (FAO, 2008). Global capture fisheries production in 2006 was about 92 million tonnes with an estimated first sale value of US $ 91.2 billion, comprising about 82 million tonnes from marine waters and a record 10 million tonnes from inland waters. Asian countries accounted for 52 percent of the global capture production. Catches in the Western Indian Ocean have increased over the years while it has decreased in the Eastern and Western Central Atlantic. On the whole, proportions of over exploited, depleted and recovering stocks have remained stable over the last 15 years (FAO, 2008). As per FAO (2008), in 2007, about 28 percent of stocks were either over exploited, depleted or recovering from depletion and thus yielding less than their maximum potential owing to excess fishing pressure. Western Indian Ocean was one of the areas showing highest proportions of fully – exploited stocks.

1.2 Flatfishes

Flatfishes represent an interesting and diverse order of marine, estuarine and to a lesser extent, freshwater euteleostean fishes. They are well known organisms as they occur in all the world's oceans, and are represented by a large number of species and genera and in some regions, their populations are sufficiently large to constitute major fishery resources. Gastronomy apart, the layman's curiosity is aroused in flatfishes not only by the unusual flattened shape, presence of both eyes on the same side of the head, but also by the remarkable ability to match the colour and pattern of their background and to bury themselves in the sediment. Their presence was known even from the prehistoric rock carvings (Muus and Nielsen, 1999), their remains are found in ancient middens (Nicholson, 1998, Barrett *et al.*, 1999) and they continue to make up a significant proportion of the world ground fish catch today.

Flatfishes are deep bodied, laterally compressed fishes, easily recognizable by the presence of both eyes on one side in juvenile and post-metamorphic individuals. They are well known organisms as they occur in all of the world's oceans, are represented by large numbers of species and genera. They are common species in most marine fish assemblages right from the poles to the tropics. Taxonomically, the best known fish faunas are those occurring in the areas that support large commercial fisheries. These fisheries are primarily located in the northern hemisphere in both Atlantic and Pacific Oceans. (Munroe, 2005). In 1998, flatfish landings from Atlantic amounted to 0.4 million tonnes or nearly half of the total world flatfish catch, with the northern waters contributing the maximum. In the Northwest Atlantic, there are 51 species of flatfishes divided into 4 families; of these only 8 species (7 pleuronectids and 1 bothid) divided into 28 stocks and two flatfishes complexes (mixed species) are under fisheries management control (Millner and Whiting, 1996). The flatfish fisheries in the Northeast Atlantic are dominated by species from three families, the Pleuronectidae (plaice, Greenland halibut, flounder), the Soleidae (common sole) and Bothidae (turbot, brill and megrim). In the Southwest Atlantic, of the 45 species of flatfishes reported, only the paralichthyids are economically important and have high price in market. In the southwest Atlantic, of the 35 species of seven families reported, only the soleids, bothids and some species of cynoglossids contribute to commercial fishery (Munroe, 2005).

1.2.1 Flatfish fisheries

Of the 300 species known to inhabit the Pacific Ocean (Minami and Tanaka, 1992), nearly 50 species are commercially important as food fishes in the temperate waters alone. People throughout the countries bordering the Pacific Ocean as well as Europe and the eastern USA consume flatfishes from the Pacific Ocean, sometimes as a delicacy, due to their desirable flesh quantities combined with high protein and low fat content (Wilderbuer *et al.*, 2004). In the Pacific region, contribution of flatfish to the total fisheries vary with the geographical area. Flatfishes make up 25 % of the total catch weight in Canada to as little as 2 % in Tasmania and 1.5 % in Japan in 1988 (MAFF, 2000). In the tropics, they occur especially on soft bottom habitats in estuaries and a variety of other substrata on the inner continental shelf. Tropical seas are the largest marine biomes of the world and on these waters from a depth of 30 – 100 m subsist a major portion of the coastal population for their livelihood. In this area are found diverse assemblages of marine fish, among them are the flatfishes in a variety of forms and extreme length ranges. In tropical areas, flatfishes occur in a variety of habitats including mangrove estuaries and adjacent mudflats, in seagrass beds and on mud bottoms. The majority of flatfishes inhabiting the Indo-Pacific region, especially species of Bothidae, Samaridae, Poecilopsettidae, Soleidae and Cynoglossidae are relatively small fishes generally not of commercial importance. Other tropical flatfishes, especially larger species (Psettodidae and some Paralichthyidae, Cynoglossidae, Soleidae and Bothidae), are captured on a regular basis in tropical fisheries and for these, better (although still limited) taxonomic and ecological data are available. (Munroe, 2005). For the other groups, limited taxonomic information is available. Although tropical flatfishes are frequently caught, are species rich and even sometimes numerically abundant, most are thin bodied, small sized species reaching only to 30-40 cm total length (Munroe, 2005). Seldom do flatfishes exceed 5 % of the fish biomass of tropical fish demersal communities. Most landings data reported to FAO from tropical regions do not list statistics for individual flatfishes (except Indian halibut). Flatfishes captured in tropical fisheries are often not identified even to genus or family level, rather, much of the catch is merely identified as "Pleuronectiformes"; 54-80% of the total landings of tropical flatfishes consist of unidentified species. About 70-75% of flatfishes reported from the Eastern Indian Ocean (EIO) and Western Central Pacific (WCP) are now identified to family level. In contrast even 80% of the annual catches from the Western Indian Ocean (WIO) are not identified even to family level. Only when species harvested by fisheries are correctly identified, will it be possible to critically evaluate ecological impacts on individual species or changes in biodiversity within demersal communities exploited by fisheries (Munroe, 2005).

Even though flatfishes make only minor economic contributions to tropical fishery landings, subsistence and artisanal fishers by their sheer numbers and intensity, harvest large numbers of flatfishes; larger numbers of tropical flatfishes are also killed or damaged as byproducts of industrial trawl fisheries operating in these waters, along with pollution and habitat degradation. Only a small proportion of the total diversity of flatfishes taken in regional tropical fisheries has commercial value as species marketed directly for human consumption.

1.2.2 Indian flatfish fisheries

In India, an estimated 3.3 million tonnes of marine fish was landed in 2010 (CMFRI, 2010). During 1989–2010, fishery production did not have a smooth sail, but increased by leap and bounds. However, the period 2005-10 witnessed a meteoric increase in production by over 45 % ie. 1.03 million tonnes compared to 2005. During 2007-2008, marine fisheries production in India grew by 6.3 % to reach 2.8 million tonnes. Of the 3.3 million tonnes of marine fishes landed in 2010, flatfishes accounted for 43682 tonnes (1.4%) which was less than the previous year by 1962 tonnes. Landings of flatfishes have been on the increase in India due to improvements in gear and craft. An estimated 29700 t of flatfishes was landed during 1985-1989 which increased to 43000 t in 2000-2004 and then showed a slight decline to 41,100 t in 2006-2010. Highest landings of flatfishes was recorded during 1992 (63,300 t). Landings of Indian halibut decreased from 6.7 % in 1985 to about 2.0 % of the total flatfish landed during 2010 (CMFRI, 2010); landings of *Psettodes erumei* in the regular trawl fishery has also declined drastically in Kerala during the period under study. However, landing of soles has remained more or less constant contributing 93 – 97.7% of the total flatfish fishery over the time period. Strangely, landing of flounders has remained nearly constant during the period. This has in turn contributed to the increase in the market value of the small sized cynoglossids. Most small sized flatfishes captured in fisheries belong to diverse families such as the Soleidae, Cynoglossidae, Bothidae and Paralichthyidae. Many species in the families Poecilopsettidae, Citharidae and Samaridae are also common by-catch species in industrial fisheries where they are either discarded at sea after capture, or if landed are processed into fish meal or other products. (Munroe, 2005). Larger sized tropical flatfishes marketed for human consumption in India include the Indian halibut (*Psettodes erumei*), (Pradhan, 1969; Hussain, 1990; Mathew *et al*., 1992), few paralichthyids (*Pseudorhombuis arsius, P. javanicus, Paralichthys spp*.,) bothids (especially *Bothus* spp.,), a few soles (*Solea* spp., *Achirus* spp., *Synaptura* spp., *Brachirus* spp.,) tonguefishes (mainly *Cynoglossus* spp., especially Malabar sole). Cynoglossidae is another important family of tropical flatfishes of which only genus *Cynoglossus* is commercially important. Tonguefishes are among the dominant families taken in inshore fisheries throughout most of the Indo-West Pacific region (Chong *et al*.., 1990). For fishes like Malabar sole and spiny turbots, most landings result from by-catch of other fisheries (Rajaguru, 1992; Khan and Nandakumaran, 1993; Jayaprakash and Inasu, 1999; Jayaprakash, 2000). Soles (Soleidae) although taxonomically diverse in shallow tropical marine waters, historically have constituted minor components of fish landing reported from these regions. Soleid species inhabiting shallow, marine, estuarine and mangrove habitats are very important in the subsistence fisheries of these regions, although their landing consists largely of small sized ones. The species dominant in the sole fishery along the Kerala coast is *Cynoglossus macrostomus* commonly called the Malabar sole because of its rich presence in the Malabar area of Kerala (Rekha, 2007). Larger sized soles like *Cynoglossus macrolepidotus* occur in the fishery off the South East coast of India especially along Tamilnadu coast.

1.3 Global distribution of flatfish

Flatfishes that support the large commercial fisheries are taxonomically the best known; they occur mostly in the northern hemisphere in both Atlantic and Pacific Oceans (Families Pleuronectidae, Scopthalmidae, some members of Soleidae and Paralichthyidae) and in the South temperate regions (Rhombosoleidae and Paralichthyidae). Flatfishes landed in tropical fisheries are taxonomically different and significantly more diverse than those of temperate areas, a situation typical of tropical demersal fish communities in general (Longhurst and Pauly, 1987). According to Nelson (2006), 678 extant species of flatfishes are recognized worldwide in approximately 134 genera and 14 families. Of this, about 10 species are thought to occur only in freshwater (six achirids, one soleid, and three cynoglossids). However, according to Munroe's (2005), compilation of all published and personal queries, of the 1339 nominal species of flatfishes described, named or recognized, 716 species are considered valid, while another 670 names are regarded as synonyms for pleuronectiform fishes. A review of Eschmeyer (2010, online) shows that species are also not uniformly distributed among families. Families with low species diversity include the monotypic Paralichthodiidae, Psettodidae (2 species each), Achiropsettidae (6 species), Citharidae (7 species), Scophthalmidae (9 species), with moderate diversity Rhombosoleidae (19 species), Samaridae (28 species), Poecilopsettidae (30), Achiridae (31), Pleuronectidae (60) and with high diversity Paralichthyidae (95), Soleidae (139) and finally Cynoglossidae and Bothidae (145 species each). The Indian halibut which has an extensive geographic range throughout the Indo-West Pacific is one of the most important commercially important species of tropical flatfish.

Worldwide, considerable work on flatfishes has been done; starting from 1758 to 2006, a steady increase has been noticed in the number of flatfishes newly reported and described. During the period

1758-1900, an approximate 315 species were described; during 1901-2005, over 401 species were described. Around 129 species (18%) of flatfishes were discovered only during the last 30 years; this points to the fact that the level of undiscovered diversity in flatfishes is substantial. The habitats of many of these flatfishes are remote tropical waters or deep water habitats; species level taxonomy still remains poorly known. Expanded views on flatfish diversity have helped to clarify issues and directions where additional research is needed to better understand the diversity, evolution, biology and biogeography of these fishes. With accumulation of new systematic information – including species discoveries, improved species diagnoses and improved phylogenetic hypotheses – the reliability of information regarding species diversity and geographical distributions will also increase. (Cotterill and Dangerfield, 1997). In addition to discovering new species, revisions of various groups of flatfishes had also been undertaken; many synonyms have been raised to valid names and many valid species have been synonymised with existing names. Such detailed systematic works may help to discover more new species; delineate confusions and therefore improve the diversity counts.

1.4 Importance of finfish taxonomy

For flatfishes inhabiting tropical seas, despite recent progress, considerable diversity is still being discovered and the taxonomy of many tropical flatfishes remains especially problematic. Failure to identify species, and erroneous species identifications still represent serious impediments to collection of meaningful data for many of these smaller sized species (Gibson, 2005). Inaccurate identifications and lack of recognition of species diversity, in turn compromise reliability of information on geographical and ecological distributions, habitat requirements and trophic and reproductive biology of poorly known flatfishes from tropical regions. Much more systematic work is needed before evolutionary hypotheses can be developed for most tropical flatfishes and their biogeographical history interpreted (Munroe, 2005). This highlights the importance of systematic taxonomy in the present day.

Leaders in many fields of biology have also acknowledged their total dependence on **Taxonomy**

> *"The extent to which progress in ecology depends upon accurate identification, and upon the existence of a sound systematic groundwork for all groups of animals, cannot be too much impressed upon the beginner in ecology. This is the essential basis of the whole thing; without it the ecologist is helpless, and the whole of his work may be considered useless."* (Mayr, 1969: 6)

> *"Taxonomy is at the same time the most elementary and the most inclusive part of zoology, most elementary because animals cannot be discussed or treated in a scientific way until some taxonomy has been achieved, and most inclusive because taxonomy in its various guises and branches eventually gathers together, utilizes, summarizes, and implements everything that is known about animals…"* (Blackwelder, 1967:22).

1.5 Marine finfish taxonomy in India

In India, as on date about 2500 species of fishes are known (Talwar and Jhingran, 1991) of which about 1570 are truly marine. Workers on marine fishes, perforce, refer to either the publication by Day (1878), which needs considerable revision, or various regional studies as those of Munroe (1955); Smith and Heemstra (1986), Randall, (1995), Kuronoma and Abe (1986) etc., which on the other hand do not include all species known from the region till date, resulting in inaccurate identifications. While there is urgent need for comprehensive publications on Indian marine fishes, taxonomic literature published in recent years show that there is considerable scope for work in this area because most of the earlier species descriptions were made on single or few specimens, intraspecific variations were not taken into account leading to cases of recounting of different stages in the life history of certain species as belonging to different species, or creation of new species on the basis of certain abnormal specimens of a species (*Cirrhinus chaudhryi* Srivastava, 1968) and to a lot of confusion on the identity of the species in many instances. There has been very few taxonomic revisions of families or genera of marine fishes of India -- flatfishes of some localities (Norman, 1927, 1928, 1934 and Menon, 1977), Scombridae by Jones and Silas (1962a, 1962b, 1962c) ; Mugilidae by Sarojini (1962a, 1962b) ; Clupeioids by Whitehead (1965, 1973, 1985); Trichiuridae by James (1967); Leiognathidae by James (1978); Chirocentridae by Luther (1968); Mullidae by Thomas (1969); Sphyraenidae by De Sylva (1975); Syngnathidae (genus *Hippichthys*) by Dawson (1976); Scorpaenidae (Choridactylinae) by Eschmeyer (1968); Callionymidae by Ronald (1983); Sciaenidae by Lal Mohan (1972, 1982) and Trewavas (1977); genus *Nemipterus* (Nemipteridae) by Russell (1986); Platycephalidae by Murty (1982); Murty and Manikyan, 2007); Balistidae by Sahayak (2004). Non-availability of comprehensive work incorporating all species described by and discovered subsequent to Day (1878) could help subsequent workers carry out work satisfactory and without difficulty. This problem has to some extent been solved by the works of Weber and de Beaufort (1911-1962) and '*Fish Identification* *sheets'* issued by FAO (Fischer and Whitehead, 1974; Fischer and Bianchi, 1984) but adequate descriptions of families of fishes to sort out nomenclatural issues in many cases are lacking.

Work on Indian flatfishes has been scattered, the only concise work was by Menon (1977) on the Cynoglossids of the British Museum; the others were Norman (1927 & 1928), Rao (1935), Chidambaram (1945), Kuthalingam (1957), Saramma (1963), Balakrishnan (1963), Ramanathan *et al*. (1977, 1979a, 1979 b, 1990) and Radhamanyamma (1988). In addition to their contribution to subsistence fishery, many species of flatfishes command ornamental value in the ornamental trade eg. *Cynoglossus macrostomus, Brachirus orientalis*, (Anna Mercy *et al*., 2007) *Pardachirus pavoninus* and *P. marmoratus*. Though there has been scattered works on Indian flatfishes, a detailed work on the flatfishes and their availability has been lacking in India. Hence work on flatfishes on these lines demand utmost attention in the present world and is taken up in the present study with the following objectives.

1.6 Objectives of the study

1) Detailed morpho-meristic studies on flatfishes available in South India.
2) Distribution pattern of flatfishes in India and in the world.
3) Description of new distributional records in India if any.

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Chapter 2

MATERIALS AND METHODS

Contents

2.1 Study period and locality

The study was undertaken for a period of six years from 2004-2010. The specimens for the present study were collected from different gears all along the coasts. Collections were largely based on trawler landings as well as discards along the coasts. The different collection centres were Karwar, Mangalore, Calicut, Kochi (Fort Kochi, Cochin, Kalamukku and Munambam Fisheries Harbour), Quilon (Neendakara and Sakthikulangara Fisheries Harbour) on the west coast and Tuticorin, Mandapam, Rameswaram, Pambam, Kovalam, Chennai and Vishakapatnam on the east coast. Collections were also made at Andaman Islands. In addition, deep sea samples were obtained from the collections of FORV Sagar Sampada off the East coast and West coast of India. Some samples were also collected from deep sea multiday day trawlers operating for shrimps. Soles were generally collected from cast netters as well as indigenous "*valloms*" operating in the backwaters during monsoon. Attempts were made to collect adequate number of specimens of each species. However, since landings of some of the species are very poor, only a few samples of some could be collected; descriptions of these were made based on the samples collected.

2.2 Collection and preservation

The samples collected were tentatively identified into the three groups as halibuts, flounders or soles in the field itself based on their gross body morphology. Care was taken to minimize the stress to the animals in the case of soles as they were mostly obtained live. Care was taken to see that most of the fishes which were collected were in good condition as trawling was seen to cause loss of fins and scales. The fishes were packed in ice and brought to the lab for further studies. While packing the fish in ice, they were placed in horizontal position to prevent the body shape from changing. Only material in good condition was brought to the lab. Once the fishes were brought to the lab, they were thoroughly cleaned to remove dirt and detritus as well as the mucous which laminates the fishes eg. soles when they are stressed. The fishes were placed on a flat surface with their blind side down. The fins were spread out so as to preserve them in their natural condition and to facilitate easy counts. They were then injected with 1% formalin in the abdominal region and caudal region; dilute formalin was also poured onto the body to stiffen the fins in spread out position. Once ready, they were stored in wide open mouth bottles, tagged with date of collection, gear and locality and used for further studies.

2.3 Measurements

All the 63 species of flatfishes collected were examined carefully for their diagnostic characters, and grouped into one of the three groups

– halibut, flounders and soles. Care was taken to photograph most of these fishes in fresh condition. Colour in fresh as well as prominent external features/markings was also noted immediately. Morphometric (taken on ocular side mainly, except, where mentioned separately) and meristic measurements were taken for each of the group separately based on the Proforma prepared (Figs. 1(a), 1(b)).

2.3.1 Meristic counts

1) **Fin count**: All rays whether branched or unbranched were counted as single rays. (D, A, P_1, P_2, V_1, V_2, C where D stands for dorsal fin, A for anal fin, P_1, P_2, stands for the pectoral fin on ocular and blind side, V_1, V_2 for pelvic fin on the ocular and blind side respectively and C for Caudal fin.
2) **Gill raker**: Count was taken for first gill raker on ocular side.
3) **Lateral line count**: The scales of the middle lateral line represented by pores were counted from the first scale above the angle of the gill opening to the scale at the end of the hypural plate on the caudal peduncle. In case of cynoglossids the scales between the upper and middle lateral lines were also counted in a diagonal line following the natural scale row.
4) **Head scale count**: An oblique row of scales on the head counted posteriorly from the posterior border of the lower eye.

2.3.2 Morphometric measurements

1) **Total length (TL)**: From tip of snout to the posterior margin of caudal fin.
2) **Standard length (SL)**: From tip of snout to posterior tip of caudal peduncle.

3) **Head length (HL)**: From tip of snout to posterior angle of opercular margin.

4) **Head width (HW)**: Greatest width across head at posterior portion of operculum.

5) **Head depth (HD)**: Distance from anterior origin of operculum to the ventral side of head.

6) **Snout length (SNL)**: Distance between tip of snout and middle outer margin of orbit (taken for both the upper (SNL_1) and lower eye (SNL_2)).

7) **Eye diameter (ED)** (upper and lower): Greatest distance across eye measured parallel to body length (does not include fleshy area) – ED_1 for upper eye and ED_2 for lower eye.

8) **Interorbital distance (ID)**: Narrowest width between two orbits measured vertical to body length.

9) **Chin depth (CD)**: Vertical distance between the end of the maxillary and the most ventral aspects of the head.

10) **Pre orbital (PrOU, PrOL)**: Distance from the tip of snout to the middle point of the orbit; taken for both upper and lower eye respectively.

11) **Post orbital (PBU, PBL)**: Distance from posterior point of orbit to the outer angle of opercular margin

12) **Upper jaw length (UJL)**: Distance from tip of upper jaw to outer free end of maxillary.

13) **Lower jaw length (LJL)**: Distance from inner angle of mouth of outer tip of lower jaw.

14) **Upper head lobe width (UHL)**: Distance from dorsal margin of body to dorsal/upper origin of operculum.

15) **Lower head lobe width (LHL)**: Distance from dorsal origin of operculum to most ventral part of operculum.

16) **Body depth (BD_1)**: The vertical distance across body just in front of anal fin.

17) **Body depth (BD_2)**: Distance across the widest part of the body exclusive of fins measured on ocular side.

18) **Dorsal fin length (DFL)**: The distance from base of the n^{th} dorsal fin to its tip. The n^{th} dorsal fin ray will be the longest dorsal fin ray taken near the middle of the body or near the maximum width of the body. In cases where the first few rays of the dorsal fin are longer, their lengths are taken separately.

19) **Anal fin length (AFL)**: The distance from base of the n^{th} anal fin to its tip. The n^{th} anal fin ray will be the longest anal fin ray taken near the middle of the body or near the maximum width of the body.

20) **Pectoral fin length (P_1FLO, P_2FLB)**: The length of the longest pectoral fin ray; measurements are taken for ocular and blind side separately as size of the fins are found to be different.

21) **Pelvic fin length (V_1FLO, V_2FLB)**: The length of the longest pelvic fin ray; measurements are taken for ocular and blind side separately as size of the fins are found to be different.

22) **Caudal fin length (CFL):** Distance from the hind end of the vertebral column to the maximum length of the caudal fin.

23) **Caudal peduncle length (CDL)**: Horizontal distance between last ray of dorsal fin and origin of caudal fin.

24) **Dorsal fin base (DBL)**: Horizontal distance from base of first dorsal fin ray to the last dorsal fin ray. Measurements are taken on blind side when origin of dorsal fin is on blind side.

25) **Anal fin base (ABL)**: Horizontal distance from base of first anal fin ray to the last anal fin ray.

26) **Pectoral fin base (P_1BLO, P_2BLB)**: Vertical distance across the pectoral fin base; measurements are taken for ocular side and blind side.

27) **Pelvic fin base (V_1BLO, V_2BLB)**: Horizontal distance across the pectoral fin base; measurements are taken for ocular side and blind side.

28) **Caudal peduncle depth (CPD)**: Vertical distance from base of last dorsal fin to the base of last anal fin.

29) **Trunk length (TKL)**: Longitudinal distance from posterior angle of operculum to caudal fin base.

30) **Pre dorsal length (PDL)**: Tip of fleshy snout to base of first dorsal ray (measured on ocular/blind side based on position of origin of dorsal fin).

31) **Pre anal length (PAL)**: Tip of fleshy snout to origin of anal fin.

32) **Pre pectoral length (P_1LO, P_2LB)** : Distance from tip of snout to origin of pectoral fin (both ocular and blind)

33) **Pre pelvic length (V_1LO, V_2LB)**: Distance from tip of snout to origin of pelvic fin (both ocular and blind).

2.4 Qualitative characters

1) **Eye**: Relative position of upper (migrating) eye and lower (fixed eye) as well as their position on head.

2) **Jaw position**: Relative position of upper jaw with respect to lower eye. The point of the ending of the upper jaw in front of, behind or just below lower eye is also noted. This denotes the length of the upper and lower jaw.

3) **Dentition on upper and lower jaw on ocular and blind side**: Nature and pattern of teeth on both the jaws on both ocular and blind side are noted.

4) **Fin pigmentation**: Presence/absence of characteristic markings on fins or patterns if any.

5) **Body pigmentation**: Presence/absence of pigmentation on body.

6) **Peritoneum pigmentation:** Relative intensity and coverage of pigmentation on the peritoneum; pigmentation varies with different species.

7) **Opercular pigmentation**: Pattern of pigmentation varies on the surface of the operculum.

8) **Membrane ostia:** Presence /absence of membrane ostia (small pores) in the basal part of the membranes of the dorsal and anal fins.

9) **Ocular/ rostral spines:** Presence/absence of spines near/ around eye and snout.

10) **Dorsal fin origin:** Relative position of the dorsal fin on the body with respect to the migrating eye (upper) varies

between genera. Point of insertion also varies between ocular and blind side.

11) **Scale:** Nature and type of scales on body varies between ocular and blind side in species; in the same species it sometimes varies at different regions of the body.

12) **Squamation on dorsal and finrays:** Scales may be present/ absent on finrays on ocular and blind side.

2.5 Data presentation

The samples collected were carefully studied for their meristic counts and morphometric characters and photographed in fresh condition. Hand drawings were made for further reference giving stress to their external characters. Head region was examined under a Zeiss Stereo Zoom Microscope under 40 X magnification to study the nostrils, eyes, spines in detail. Scales were removed from the lateral line area as well as different regions of the body, washed to remove dirt and examined under a Stereo Zoom Microscope and drawings made. Details was recorded and presented as description of species. The frequency distribution of meristic characters together with estimated values of mean, standard deviation and standard error are given for all species. Certain body proportions were expressed as percent of standard length, some as percent of head length; the range was given, followed by means in parentheses. The relation between certain body lengths and standard length and between certain dimensions in the head and head length were calculated after ascertaining the type of relationship through a scatter diagram, following the least squares method (Snedecor and Cochran, 1967). The results are presented in the figures and calculated values of slope and elevation along with the coefficient of correlation (R^2) are shown in the figure for each species. A study of this nature assumes greater importance since the body proportions vary with growth. Besides, understanding variations in allometric growth will help understand the intraspecific variations better. Colour description was mostly based on fresh specimens, but where the fresh samples were not available, descriptions were based on formalin preserved samples. The original description as well as descriptions by subsequent authors was consulted before finalizing the identification of each species. Additionally, the subsequent descriptions of the nominal species considered as junior synonyms of a valid species was also consulted. Under each species, synonyms, material examined, diagnosis, meristic counts, body measurements as percent of standard length and head length, description of species, colour, scale pattern, sexual dimorphism if any, distribution, relation with other species, taxonomic comments and observations if any were arranged accordingly so as to make comparisons easy. Synonyms are presented as exhaustive as possible with locations as far as possible; the references from India were cited to the extent possible. References cited in the synonyms, distribution are not listed in the Bibliogrpahy.

Drawings were also prepared for as many species as possible. The known distribution of each species in the world is shown in the world map and from different localities in India on the India map. The known distribution was collected from literature. In addition, collection centres for each species was also marked on India map. In the map of India, places marked with capital letter (A, B..) denote localities were samples were collected by earlier workers, places marked with small letter (a,b,..) denote localities from where samples were collected for the present study.

Key to all species listed is also provided. Comprehensive lists of genera with comments by various revisors are provided in table format to provide the evolutionary pattern of the genus. Classification followed was that of Nelson (2006), while for synonyms and validity of species and genera, Eschmeyer (Catalog of Fishes, online) was followed.

2.6 Type definitions

1) **Holotype**: The single specimen taken as the type by the original author of the specimen.

2) **Paratype**: A specimen supplementary to the holotype, used by the original author as the basis of a new species.

3) **Syntype**: One of the several specimens of equal rank upon which a species is based (also called co-type).

4) **Lectotype**: A specimen selected from a syntypic series subsequently to the original description to serve as the holotype.

5) **Neotype**: A specimen selected to replace the holotype when the primary type is lost or destroyed.

6) **Logotype**: Type selected by the "first revisor".

7) **Orthotype**: Type of a genus as individual or distinctly implied by the original author.

8) **Tautotype**: A term used when the genus and species carries the same name.

9) **Topotype**: A specimen from the type locality of the species.

10) **Allotype**: A term for a designated specimen of opposite sex to the holotype.

11) **Haplotype**: Sole species named under a genus, therefore of necessity.

12) **Type genus**: The genus upon which a family is based.

13) **Type species**: A single species upon which a genus is based.

14) **Homonym**: One of the two or more identical but independently proposed names for the same or different taxa.

15) **Type by original description**: The species described at the time of creation of a new genus.

16) **Synonyms**: An annotated list of published scientific names the taxonomists have given a single valid species or genus.

2.7 Analysis of data

For species for which more than one specimen was examined, arithmetic range with mean was provided for meristic and morphometric values. Data is presented as percentage of standard length and head length. Analysis of variance was calculated whenever ranges varied with sex as well as body proportions. Standard deviation was calculated for all measurements. Correlation coefficient as well as slope was calculated for non–meristic characters and presented in Tables. Comparative values for meristic data taken from various synonyms as well as different revisors was prepared in tabular form for as many references available for each species. Comparision with type data was made in as many species as possible. Taxonomic relationships between species of the same genus and between genus in the same family was estimated in as many cases as possible.

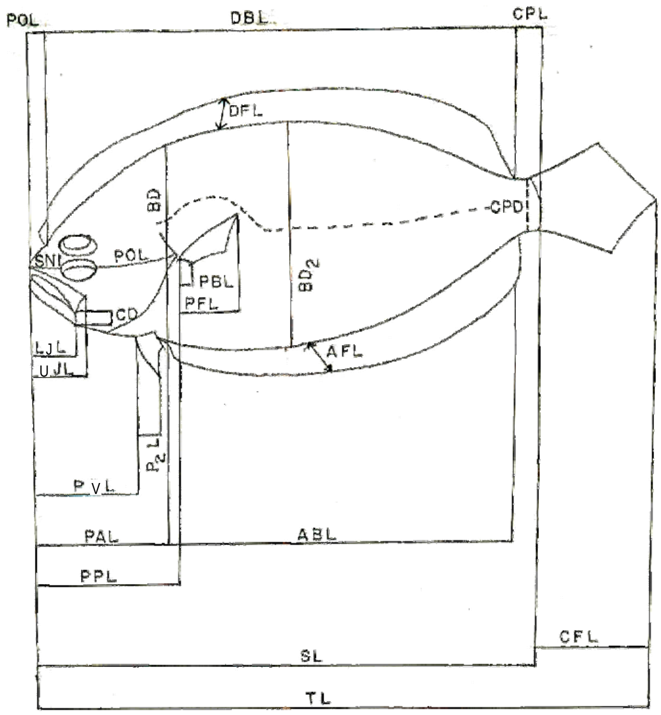
For the statistical analysis, all the characters were used. A correlation coefficient analysis was conducted to elucidate the degree of interference of the characters. The head characters were indexed with reference to the head length (HL); all the other characters were indexed with reference to the standard length (SL). Heterogeneity of the samplings examined was revealed and paired Student's test with statistical significances $p < 0.05$ and $p < 0.001$ were studied. The range of the meristic characters for species in a family was prepared to study the intaspecies variation in a family.

2.7.1 Cluster analysis

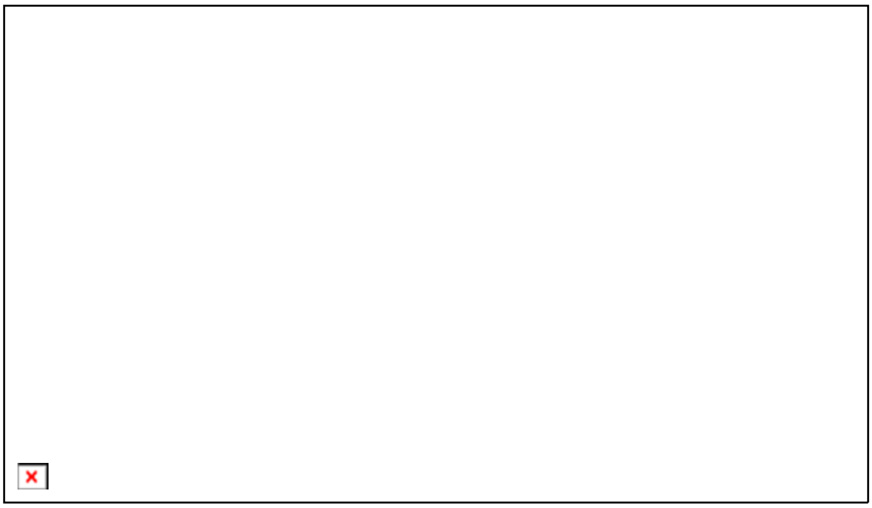
Cluster analysis (CA) is an exploratory data analysis tool for organizing observed data into meaningful taxonomies, groups, or clusters, based on combinations of parameters, which maximizes the similarity of cases within each cluster while maximizing the dissimilarity between groups that are initially unknown. Each cluster thus describes, in terms of the data collected, the class to which its members belong. Items in each cluster are similar in some ways to each other and dissimilar to those in other clusters. For each family with more than six species described, clustering analysis was done. The meristic characters (dorsal, anal, lateral line counts and pectoral fin counts (ocular) were selected as the variables for the study.

Hierarchical cluster analysis: This is used for finding relatively homogeneous clusters of cases based on measured characteristics. It starts with each case as a separate cluster, i.e. there are as many clusters as cases, and then combines the clusters sequentially, reducing the number of clusters at each step until only one cluster is left. The clustering method uses the dissimilarities or distances between objects when forming the clusters. The SPSS programme calculates ‘distances’ between data points in terms of the specified variables. The output in the form of a tree diagram is called a dendrogram. Dendrograms were prepared for three major families.

For this, first *hierarchical cluster analysis* using *Ward’s method* applying *squared Euclidean Distance* as the distance or similarity measure is done. This helps to determine the optimum number of clusters we should work with. In the next stage, the cluster analysis is rerun with the selected number of clusters, which enables us to allocate every case in our sample to a particular cluster. The x-axis gives the measure of the similarity or distance at which clusters join and different programs use different measures on this axis. Dendrograms were prepared for three major families in the present study.



(a)



(b)

Fig. 1 Diagrammatic representation of (a) Halibut (b) Sole with morphometric measurement pattern

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Chapter 3

REVIEW OF LITERATURE

Contents

3.1 Period of Aristotle - Carolus Linnaeus

History of Ichthyology coincides with that of Zoology which dates back to the time of Aristotle (384 - 322 B.C) who is said to be the **Father of Natural History**. His knowledge on the habits of fishes was very accurate, although he adopted the nomenclature of the local fishermen to designate the species. However, his knowledge was limited to 115 species of fishes, all of which were native of Aegian Sea adjacent to Greece. After Aristotle, no proper work on fishes was available for nearly 1800 years, which was a period of regression in the science of Ichthyology and is regarded as a dark age in the history of Ichthyology.

Pierre Belon (1517-1575 A.D) in "*De aquatilibus libri duo"* and his contemporaries Hyppolyto Salviana (1514–1572) in "*Aquatilium animalium historia"*, Qulielmus Rondelet (1506-1566) in "*libri de piscibus marinis*" made original observations of the fishes of Mediterranean Sea in Europe. Guilielmus Riso (1611–1678 A.D) along with his colleagues George Marcgrav (1610-1644) catalogued 420 species including those which were already catalogued. Simultaneously, Guillaume Rondelet published "*De Piscibus Marinis*" in Latin which was later expanded and translated into other languages as well. In this work, 244 different species from Mediterranean was described; however, no classification was given. Peter Artedi (1705-1738 A.D) called the **Father of Ichthyology** studied the interrelationships between various groups of fishes and developed a systematic classification wherein he recognized 47 genera and 230 species. Artedi grouped genus into "*maniples*", similar to the present day family concept. Artedi's work was infact published by Carl von Linnaeus as "*Artedi Ichthyologia* "in 1789 A.D after his death. Fishes were placed under 5 heads – Malacopterygii, Acanthopterygii, Branchiostegii, Chondropterygii and Plagiuri; flatfishes were placed in group *Pleuronectes* in Malacopterygii. Carolus Linnaeus (1707-1778) first reported on fishes in *Systema Naturae;* however, it was in the twelfth edition (1758) that the binomial system of nomenclature was consistently applied to all animals. In all, by 1738, 47 genera with over 230 species of fishes were known from the whole world. The followers of Linnaeus were mostly his students with whom began the science of geographical distribution. Prominent among them were Peterr Osbeck, Fredrik Hasselquist, Otto Fabricius (1744-1822) author of "*Fauna of Greenland*", Martin Brunnich who collected material for his work "*Pisces Massiliensis*" and Petrus Forskal who brought out

"*Descriptio Animalium*" on the fishes of the Red Sea. Far more elaborate was the work of Mark Eliezer Bloch's work "*Ichthyologia*" which was in German and published in two parts. After this publication, Dr. Bloch began a systematic catalogue to include all known species. This work was published after his death by his collaborator Schneider as "*M.E Blochii Systema Ichthyologia*" which contained 1519 species of fishes.

3.2 Period of Lacépède and Cuvier

Lacepede wrote "*Histoire Naturelle des Poissons*" (1798-1803) in five volumes. With Cuvier (1769-1832) and the "*Regne Animal arrangé après son Organisation*" (1817) began a new era of ichthyology. Cuvier's studies on the different species of fishes are contained in "*Histoire Naturelle des Poissons*", the joint work of Cuvier and his pupil Valenciennes. 22 volumes were published during 1794–1865, containing 4514 nominal species. Friedrich Henle and Johann Muller (1841) produced the first authoritative work on sharks in "*Systematische Beschriebungen der Plagiostomen*". Sykes published his work on "*Fishes of the Dukhun*" in the "*Transactions of the Zoological Society of London*" (1848: 340-378) wherein descriptions of 46 species along with 28 figures were given. Louis Agassiz (1850) published a monograph on the fishes of Lake Superior. The local fish fauna of Cuba was studied by Aloy (1799-1891). Temminck (1770-1858) and Schlegel (1804-1844) studied and catalogued the fauna and fishes of the Japanese islands. Duméril (1865-70) published two volumes of the "*Natural History of the Fishes*" covering sharks, ganoids and other fishes not treated by Cuvier. Gunther (1859–1870) gave a systematic study of 6843 species and 1682 doubtful species in the eight volumes of his work "*Catalogue of the Fishes of the British Museum*". This was one of the last attempts to write a series of volumes on the fishes of the world. In 1898, Boulenger brought out a classic work on percoid fishes.

3.3 Fisheries literature in India

Knowledge of fishes in India is comparatively old. The use of fishes is evidenced from the fish engravings and fish remains obtained from the excavations at Mohenjodaro and Harappa of the Indus valley (2500-1500 BC). Somesvara, the son of King Vikramaditya VI has recorded common sport fish in his book "*Manasollasa*" (1127 A.D). The first writer on Indian fishes was Marc Elieser Bloch whose work was published in 1785 as "*Naturgeschichte der auslandischen Fische*". More fishes were described by him in the book "*Systema Ichthyologie*" which was continued later by his co-author Schneider. Bloch in this book described 122 genera of fishes; flatfishes were placed in Genus *Pleuronectes*. Lacèpede (1798 - 1803) in his work "*Histoire naturelle des Poissons*" added to the information given by Bloch. Patrick Russell (1803) described and figured 200 species of fishes from Vizagapatanam in "*Two Hundred Fishes Collected at Vizagapatnam and on the Coast of Coramendel*" using local names. Francis Buchanam's (who subsequently took the name Hamilton) "*Fishes of Ganges*" (1822) contained descriptions of 269 species of fish with 97 figures from the river Ganges and its tributaries. Later on, Cuvier and Valenciennes's "*Histoire Naturelle des Poissons*" (1828-1849) provided a great impetus to the study of Ichthyology. This work published in many volumes gave good scientific account of most fishes. In 1830, Bennett published an illustrated work containing coloured figures of 30 species of fishes found along the coast of Ceylon. Blyth's "*Fishes from Andamans, Fishes from Pegu, Calcutta*" (1838), followed by "*The Cartilaginous Fishes of Lower*

Bengal", "*Fishes of Port Blair*" and "*On some fishes of The Tenasserim Provinces and Lower Bengal*" (1860) are some of the other works of this period. Cantor's work "*Notes respecting some Indian fishes*" (1839) and "*Catalogue of Malayan Fishes*" provided descriptions of 292 species of fishes along with 14 plates with anatomical details. "*Indian Cyprinidae*" published in the second volume of "*Asiatic Researches*" by Mc Clelland (1839) contained descriptions of 138 fishes, 25 plates, with 103 full figures of fishes; however, the figures were copies from Hamilton–Buchanan drawings. Cantor (1849) in his "*Catalogue of Malayan Fishe*s" described Family Pleuronectisidae in Order Anacanthini with 14 species in 7 genera; fishes were grouped based on presence of eye and colour on left/right. Thomas Caverhill (1849) in the first part of his '*Fishes of Southern India*' published in '*Madras Journal of Literature and Science*' Volume XV (1849:139-149) described 22 species of which 3 were new species. In the second part (1849:302-346), 150 species were described of which 55 were new. Pieter Bleeker during 1842-1864, collected over 30,000 fishes and authored numerous papers based on his collections. In 1851, Caverhill authored another paper "*Ichthyological Gleanings in Madras*" in which he mentioned of 391 species obtained during his two years residence in Madras. Bleeker's '*Ichthyologische fauna van Bengalen*' (1853) lists fishes previously described from India together with detailed descriptions of 162 species. In Bleeker's (1856) paper on fishes of Amboina, 348 species of fishes were listed; in the paper on descriptions of "*Species of carps from Ceylon*" (1862) 4 plates of illustrations and 11 coloured plates were given; the samples were subsequently sent to Leiden Museum. '*Atlas Ichthyologique des Indes Orientales Neerlandaises*' published in twelve volumes (1862-1877) is the biggest and perfect contribution to the ichthyological studies of the

Indo-West Pacific. In the "*Memoir sur les Poissons de la Cote de Guinee*, Bleeker (1863) mentions of three families of flatfishes – Pleuronecteoidei with the species *Hemirhombus guineensis*, Family Soleoidei with *Solea triopthalmus* and Family Psettoidei with species *Psettus sebae*. In 1865, Tickell authored a paper on *Asthenurus atripinnis* in '*Journal of the Asiatic Society of Bengal'*. Gunther (1886) describing the '*Fishes of Zanzibar*' placed all flatfishes in Family Pleuronectidae; 6 genera with 6 species were described. Day's *Fishes of India* (1875–1878) and '*Fauna of British India, Burma and Ceylon*' (1889) are the notable contributions of that time. In this, all fishes were figured, the groups being arranged as in Gunther's catalogue. Boulenger (1904) gave a systematic account of Teleostei under the series of "*Cambridge Natural History*". Weber and Beaufort (1911–51) described "*The fishes of Indo-Australian Archipelago"* which covered mostly all groups of fishes from the Indo–Australian Archipelago. Smith and Pope (1906) listed the fishes collected from Japan. In the 20th century, besides Chaudhari's (1912) account of some new species of freshwater fishes of Northern India, the contributions by Hora and others (1920-56) and Shaw and Shebbare (1937) on fishes of North Bengal are highly commendable. Misra (1949) has made a commendable contribution in terms of *Fauna of British India*. Menon (1949–1963) made studies on the '*Fishes of the Indian Museum*' and gave a revised account of the fishes of the genus *Garra* in 1964 and also reported several new fishes. The works of Haig (1950), Silas (1951, 1958) and Menon (1952) have been further steps in this direction. Jayaram (1954) and Jayaram and Dhas (2000) revised the genus *Mystus* and genus *Labeo*. The fishes of Nainital were studied by Chaudhary and Khandewal (1960). Munroe (1955) provided an exhaustive work on the marine and freshwater fishes of Ceylon. Menon's (1977) monumental work on the Cynoglossids of the British Museum in the form of a Monograph is a great step in the history of flatfish ichthyology.

3.4 Flatfish in ichthyology

The first mention of flatfishes in Ichthyology was probably by Willughby and Ray (1686) in *L'Historia piscium* where flatfishes were placed as *Ossei Plani* (Flat bony). However, the oldest flatfish fossils, otoliths dating from the Early Eocene some 53-57 million years ago (Mya) indicate the presence of Pleuronectiformes as far back as the early Tertiary (Schwarzhans, 1999). *Eobothus minimus* (Agassiz, 1834-1842), a representative of the bothoid lineage with uncertain affinities within the group, is the oldest existing skeleton representative of the Pleuronectiformes, dating at least to the Lutetian (some 45 Mya) in the Eocene (Norman, 1934; Chanet, 1997, 1999). The oldest soleids *Eobuglossus eocenicus* and *Turahbhuglossus cuvillierii* both known from single specimens from the Upper Lutetian of Egypt (Chabanaud, 1937; Chanet, 1994, 1997) are also among the first known flatfish fossils and they are identical to skeletons of recent soleids (Munroe, 2005). Jacques Klein (1740-1749) in his "*Missus historioe naturalis piscium promovendae*" has classified flatfishes into 3 groups based on position of eye. Flatfishes were placed in the group *Pleuronectes* in Malacopterygians in Artedi's work along with Stromateus (butterfishes) and Gadus (codfishes). Carolus Linnaeus (1758) in *Systema Naturae* also placed all flatfishes under the group *Pleuronectes* as *Malcopterygians Branchiales*. The characters attributed were thoracic pectoral and single dorsal fin. The group consisted of ten genera – *Achirus*, (*A. trichodactylus, A. lineatus, A. ocellatus, A. lunatus*), *Hippogloffus, Cynogloffus, Plateffa, Rhombus* (*R. maximus*), *Paffer* (*P. papillofus*), *Flefus, Limanda, Solea* and *Linguatula*.

The fishes were said to have a laterally compressed body with the eye placed in lateral pits. Broussonet (1782) described a single flatfish *Pleuronectes mancus* in his work "*Ichthyologia*". Artedi (1792) placed all flatfishes in the one genus *Pleuronectes* in the group *Malacopterygii* based on "*laterally compressed body, single continuous dorsal fin, pelvic fin thoracic in position*". The name "*Pleuronectes*" was introduced in zoology for the first time by Artedi and Linnaeus followed his example. Artedi (1792) in *Genera Piscium* described genus *Pleuronectes* as fish with dextral eyes, oblong body, and included species *P. solea, P. annulatus, P. trichidactylus, P. rhombus, P. maximus, P. paffer, P. glacialis, P. americanus, P. ocellatus, P. limandoides, P. plateffoides, P. zebra, P. hippogloffoides, P. cynogloffus, P. plaginfa, P. papillofus, P. macrolepidotus, P. dentatus, P. punctatus, P. argus, P. mancus, P. lunatus, P. lineatus, P. bilineatus, P. kitt, P. whiff-Tagonis, P. laterna, P. armata* and *P. japonicus.* The followers of Linnaeus also followed Artedi's classification and merely classified the genus in an arbitary way into several sub-genera.

Lacepede (1801) in his '*Histoire Naurelle des Poissons*' placed flatfishes in genus *Pleuronectus* with 4 subgenera without assigning them any names and described 29 species in them including *Pleuronectes hippoglossus, P. limanda, P. solea, P. platessa, P. flesus, P. platessoides, P. cynoglossus, P. linguatula, P. glacialis, P. limanduala, P. sinensis, P. limandoides, P. peguza, P. ocellatus, P. trichodactylis, P. zebra, P. plagiusa, P. argenteus, P turbot, P. rhombus, P. punctatus, P. dentatus, P. passer, P. papillosus, P. argus, P. japonicus, P. calimanda, P. macrolepidotus* and *P. commersonii*. Bloch (1801) placed flatfishes in genus *Pleuronectes* and described 37 species *Pleuronectes platessa, P. platessoides, P. rhombus, P. limanda, P. triocellatus, P. limandoides, P. flesus P. solea, P. hippoglossus, P, trichodactylus, P. ocellatus, P. cynoglossus, P. glacialis, P. americanus,* *P. erumei, P. linguatula, P. chrysopterus, P. zebra, P. plagusia, P. rhombus, P. maximus, P. lunatus, P. punctatus, P. passer, P. macrolepidotus, P. surinamensis, P. dentatus, P. arnoglossus, P. orientalis, P. maculatus, P. nigricans, P. achirus, P. bilineatus, P. albus, P. arel, P. lineatus, P. spinosus.* In addition 5 new species *P. papillosus, P. japonicus, P. kitt, P. plagusia, P. scapha* were also described. Russell (1803) recorded 8 species of flatfish from the Coramendal coast - *Hippoglossus erumei, Rhombus marginatus, R. triocellatus, Synaptura Russellii, Synaptura lata* Blkr (*Solea lata*, Hass) *Synaptura cornuta* Blkr (*Solea cornuta* Cuv), *Plagusia potous* Cuv, *Plagusia Blochii* Blkr. Dumeril (1804) raised flatfishes to family status and gave the name *Heterosomes.*

Quensel (1806) divided the genus *Pleuronectes* into two with the following definition –

a) *Pleuronectes* – "*having complete jaws not covered with scales; the maxillary dilated and free at its extremity; the mandible with cutaneous folds between its limbs at the chin. Gill opening extending above the opercular angle or atleast above the pectoral; the lower eye more anterior than the upper one; nostrils distant from the jaws, that on the blind side being near the dorsal edge*"

b) *Solea* - "*jaws are covered with scales, the superior one not fully developed, and the scaly mandible not showing the usual folds at the chin. Gill openings wholly below the pectorals; inferior eye rather back than the superior one; nostrils on both sides near the jaws, all fin rays divided, no spine in the anal*". (Richardson's Yarrell, Vol. I: 668).

Rafinesque–Schmalz (1810) classified *Pleurostomi* (Class *Pomniodi*, Division *Giugulari*) into two orders, Order *Acherini* (*Symphurus*) and Order *Pleronetti* (*Solea, Scophthalmus* and *Bothus*). Flatfishes were placed along with Gads and Trachinids. Risso (1810) in his "*Ichthyologie de Nice*" arranged the flatfishes into two subgenera according to the side on which the eyes are placed. Pallas (1811) in '*La Zoographie russe*' placed *Pleuronectes* in order *Branchiata* along with *Perca* and *Salmo*.

Rafinesque (1815) in '*Analyse de la nature*' on Tableau de l' universe placed flatfishes in the suborder *Pleuropsia*, Family *Pleuronectia* with two subfamilies *Achirus* (with genera *Achirus*, *Symphurus* and *Monochirus*) and subfamily *Diplochiria* (Genus *Pleuronectes, Scophthalmus, Bothus, and Plagiusa.* Blainville (1816) placed flatfishes as *Pleuronectes* under *Jugulaires* and asymmetrical shape of the body was the main character chosen. Cuvier (1817) in *Regné Animal* placed Flatfishes (*Poissons plats*) along with Gadoids under *Malacopterygiens, Subrachiens* as Family *Pleuronectes*; here an attempt was made to indicate the relationship of various groups of animals. Flatfishes given as a genus *Pleuronectes* were raised to family level (Family *Poisson Flats*, *Des Pleuronectus*) in the division of sub-branchial Malacopterygians based on the characters thoracic position of the pelvic fins and absence of spines in dorsal fin. Flatfishes were grouped into 5 subfamilies Hippoglossinae, Pleuronectinae, Platessinae, Soleinae and Cynoglossinae with species as

a) *Platessa* (which included the plaice (*Platessa platessa*), flounder (*Platessa flesus*) and dab (*Pleuronectes limanda*));

b) *Hippoglossus* (which includes the *P. hippoglossus* and several other Mediterranean species described by other authors such as *La Plie* Large (*Pleuronectes latus), Pleuronectes flesus, Pleuronectes poda*).

c) *Rhombus* (which includes Turbot (*Pleuronectes maximus*), *La Barbue (Pleuronectes rhombus), Le Targeur (P. punctatus), P. laevis* and *P. cardina)*

d) *Solea* (includes the common sole *Pl. solea* Linn, *P. ole* of Belon, the *Solea oculata* of Rondelet, the *Pégouse* of Risso and the *lascaris* and *theophilus* of the same author). The *Monochires* in which the right pectoral fin is very small and the left one is very minute and wanting and the *Achirus* with no pectoral at all are placed as subgenera.

Goldfuss (1820) changed the simple classification of Gmelin (1789) by combining different groups. *Pleuronectes* was placed under *Leptosomata,* Order *Sternopterygii* which was formed by Goldfuss uniting the groups *jugulaires* and *thoraciques* of Gmelin. Hamilton (1822) in his account of the fishes in the River Ganges described two genera *Pleuronectes* and *Achirus* with 4 species *Pleuronectes nauphala, Pleuronecetes arsius, Pleuronectes pan* and *Achirus cynoglossus.* Risso (1827) reclassified fishes using Linnaeus classification as base into *Chondropterygiens* and *Poissons Osseux* (Bony fishes). Flatfish was raised to family level with one family *Pleuronectides* and 4 genera *Hippoglossus, Solea, Rhombus* and *Monochirus.* Agassiz (1842:260) placed the flatfishes near the Family Chaetodontidae and Scorpididae. Richardson (1843), in contributions to the *Ichthyology of Australia*, Vol. XI of '*The Annals and Magazine of Natural History*' described a new species of flatfish *Rhombus lentiginosus*. In 1843, Temminck and Schlegel published "*Fauna Japonica*" wherein 4 species were described. Muller (1846) first made the use of the relation between air bladder and gut for the definition of higher divisions. He removed the sub-branchial *malacopterygians* from the *abdominales* or *physostomes* and placed them nearer the acanthopterygians. A new order *Anacanthini* was erected to include the *Pleuronectids*, *Gadoids* and *Ophidioids.* This association of the Pleuronectoids with the Gadoids was retained in many subsequent classifications. Muller (1846) erected a new order Anacanthinii to include Pleuronectoids and Gadoids and Ophidiods. Cantor (1849) in his *Catalogue of Malayan Fishes* described Family Pleuronectidae in Order Anacanthini with 14 species in 7 genera; fishes were grouped based on presence of eye and colour patterns on right or left side. Bleeker in "*Sur quelque genre de la Famille des Pleuronectoides*" placed flatfishes in genera in the family Pleuronectoides. The main character of differentiation between genus *Psettodes* and the remaining were "*presence/absence of teeth on palatine, presence/absence of anal spine, lateral line with a curve anteriorly and sinistral eyes*". Bleeker (1852) reported 19 species of flatfishes from Java and Amboina, 2 from Madura, 1 from Bali, 6 from Sumatra, 1 from Banka, 6 from Borneo, 2 from Celebes, 1 from Moluccan Islands and 9 from Indo-Archipelago; 3 families were collected from Amboina - Pleuronectoidei, Soleidae and Plagusioidei – *Psettodes* was placed along with *Pseudorhombus* and *Platophrys* in Family Pleuronectoidei. Later in 1853, Bleeker recorded 5 genera and 17 species of *Pleuronecteoidei* from Bengal. Bleeker (1852, 1854, 1855) described three species of flatfishes and placed them in Pleuronecteoidei. In Bleeker's (1856) paper on fishes of Amboina, of the 348 species of fishes listed, six species were flatfishes–*Rhombus mogkii*, *Rhombus pantherinus*, *Solea heterorhinos*, *Synaptura heterolepis*, *Achirus melanospilos* and *Plagusia marmorata*. Bleeker (1860) describing the fishes of Sumatra placed flatfishes in three families Pleuronecteoidei, Soleoidei, Plagusiodei with 13 species. Gunther (1862) placed all flatfishes in Family Pleuronectidae; the family was subdivided into two groups based on development of jaws and dentition on blind side or both sides of head. Gunther (1862) describing the Acanthopterygii in the British Museum, placed 155 flatfishes in 34 genera in Family Pleuronectidae. Later, Gunther (1866) describing the *Fishes of Zanzibar*, placed all flatfishes in Family Pleuronectidae; 6 genera with 6 species were described – *Psettodes erumei*, *Pseudorhombus russellii*, *Rhomboidichthys pantherinus*, *Pardachirus marmoratus* and *Cynoglossus quadrilineatus*. Bleeker (1866) described in detail some species of the genera *Pseudorhombus* and *Platophrys* from the Indo-Archipelago. Cope (1871) recognized flatfishes as a distinct Order Heterosomata. Later works of Bleeker where flatfishes were recorded were those on *Synaptura* from Cap de Bonne (Esperance, 1865), *Citharichthys* from Suriname and Gautimala (1865) and *Ichthyologique Fauna of China* (1873). Gunther (1880) divided Order Anacanthini into two main divisions – Anacanthini Pleuronectoidei and Anacanthini Gadoidei. Later, Gunther (1887), listed collections of *HMS Challenger* in which 19 flatfishes were recorded; of these, 4 were same as other littoral species, 10 were found between 100-200 fathoms, 2 between 200-300 fathoms, 3 between 300-400 fathoms. Species recorded belong to genera *Hippoglossus*, *Hippoglossoides*, *Poecilopsetta*, *Anticitharus*, *Samaris*, *Lepidopsetta*, *Pseudorhombus*, *Rhomboidichthys*, *Monolene*, *Citharichthys*, *Pleuronectes*, *Nematops*, *Solea*, *Aphoristia*. Gill (1887) suggested that "*the Heterosomatous fishes may have branched off from the original stock or progenitors of Taeniosomous fishes*". This idea was however not elaborately followed. Jordan and Goss (1889) like many earlier workers, considered flatfishes as belonging to a single family Pleuronectidae, but subdivided into seven subfamilies Hippoglossinae, Pleuronectinae, Samarinae, Platessinae, Oncopterinae, Soleinae and Cynoglossinae. They distinctly recognized soles from flounders but stated that "*the characters which mark them as a group seem no more important than those which set off one subfamily of flounders from another*". Alcock (1888-89) listed Pleuronectidae from Bay of Bengal wherein 29 species were described; of which 11 were new, 3 were rare. Day (1889) published a vast collection of papers describing many fishes. In his work "*Fauna of British India*" and "*Fishes of India*" flatfishes were included in Family Pleuronectidae with genera *Psettodes, Citharichthys, Pseudorhombus, Platophrys, Solea, Achirus, Synaptura, Plagusia* and *Cynoglossus.* In "*Fishes of Malabar*", Day described 3 genera of flatfishes with 3 species. Alcock (1890) described the deep sea fishes collected by *R.I.M.S Investigator*; flatfishes were placed in one family Pleuronectidae with 17 genera and 63 species; this was 8 genera and 24 species more than that described in the *Fauna of British India*. Collections were made from Ganjam, north of Gopalpur, Orissa and East coast of Ceylon. Depthwise occurrence of species was given. In 20-40 fathoms, *Psettodes erumei*, *Pseudorhombus javanicus*, *Cynoglossus oligolepis*, *Synaptura quagga*, *Brachypleura xanthosticta*, *Arnoglossus macrolophus* and *Laeops guentheri* were recorded. Alcock (1890) systematically described fishes from South East coast of Ceylon, east coast of Andaman Chain and Gulf of Martaban in '*Shore fishes from the Bay of Bengal*'. Gill (1893) regarded Heterosomata as a suborder of Teleocephali, equal in rank to Anacanthini. Later, while describing a collection of bathybial fishes, Alcock (1894) recorded 4 new species of flatfishes from 3 genera, all in family Pleuronectidae. Cunningham (1896:498) was the first to throw doubts on the validity of associating the Flatfishes and Gadoids - "*there can be no doubt that the Gadidae and Pleuronectidae instead of being closely allied are very remote from each other in structure and descent*". Holt (1894) hinted at the affinity of flatfishes with deep-bodied fishes such as *Platax* or *Dascyllus* or even with *Zeus*. Jordan and Evermann (1898:2602) describing the relationship of flatfishes with its sister groups opined "*Its near relationship is probably with the Gadidae, although the developed pseudobranchiae and the thoracic ventral fins indicate an* *early differentiation from the anacanthine fishes*". They raised flatfishes to the suborder Heterosomata with two distinct families: Pleuronectidae and Soleidae. The Pleuronectidae which had three subfamilies Hippoglossinae, Pleuronectinae and Psettinae were characterized by "*a more or less distinct preopercular margin* (ie. *not hidden by the skin and scales of the head*)*, eyes large, well separated, mouth moderate or large, teeth present*". The Soleidae were subdivided into two subfamilies, Soleinae and Cynoglossinae, and were characterized by "*an adnate preopercular margin, hidden by the skin and scales of the head; eyes small, situated close together; mouth very small, much twisted; teeth rudimentary or wanting*" (Jordan and Evermann, 1898). Alcock (1899) in "*A Descriptive Catalogue of the Indian Deep Sea Fishes in the Indian Museum*" collected by "*Investigator*" mentions of 10 species of flatfishes in one family Pleuronectidae. Flatfishes collected were grouped into two – those with jaws and dentition nearly equally developed on both sides and those with jaws and dentition more developed on blind side. Fishes in genera *Psettodes*, *Arnoglossus*, *Pseudorhombus*, *Chascanopsetta*, *Rhomboidichthys*, *Psettylis*, *Citharichthys*, *Samaris* and *Brachypleura* were placed in the former group. Fishes in genera *Laeops*, *Boopsetta*, *Solea*, *Achirus*, *Synaptura*, *Aphoristia*, *Plagusia* and *Cynoglossus* were placed in the second group. The species described were in genera *Chascanopsetta*, *Boopsetta*, *Laeops*, *Solea* and *Aphoristia*. With this collection, 8 genera and 24 species were added to the 8 genera and 39 species recorded in the *Fauna of British India*. Kyle (1900) further divided Heterosomata into two families Pleuronectidae and Soleidae; Pleuronectidae with four subfamilies Hippoglossinae, Pleuronectinae, Hippoglosso–rhombinae, and Rhombinae and Soleidae with three subfamilies Soleinae, Achirinae and Cynoglossinae. Subsequently, describing the fishes from the Island of Formosa, Jordan and Evermann (1902) placed the eight flatfishes collected in Family Pleuronectidae. Boulenger (1902:1) considered the flatfishes as nearly related to Zeidae to which he gave the name *Zeorhombi* with *Amphistium* a fossil fish from upper Eocene in a division of the Acanthopterygii; he also described six flatfishes from Cape Colony of which *Arnoglossus capensis* was a species new to South African coast and to science. Identification characters were also given for the six species described. Gilchrist (1904) in his '*Descriptions of New South African Fishes*' listed 9 species in 7 genera, all of which were new to science. Regan (1905 a, b) described two species of Cynoglossids from Japan, three deep sea flatfishes from Sea of Oman and Persian Gulf from the collections of Gordon Smith deposited in BMNH. In his paper, Regan listed 19 fishes from the Sea of Oman of which 3 were flatfishes–*Laeops macropthalmus*, *Cynoglossus carpenteri* and *Solea umbratilis* from depths 98-243 fathoms. In the list of fishes from Persian Gulf, 35 fishes were listed of which 6 flatfishes recorded were *Psettodes erumei*, *Pseudorhombus arsius*, *Synaptura zebra*, *Rhomboidicthys pantherinus*, *R. grandisquamis* and *R. poecilurus*. Later, Jordan and Starks (1906) reported 11 species of sinistral flounders belonging to five genera and one family from the seas around Japan. Twelve species of flatfishes in two families *Pleuronectidae* and *Soleidae* and 9 genera were described by Smith and Pope (1906) from Japan. Evermann & Seale (1907) described 10 flatfishes in Family Pleuronectidae and Soleidae. Lloyd (1909) based on *R.I.M.S Investigator's* collection along the south coast of Arabia from Muscat to Aden, described 27 fishes in addition to Crustaceans. Among the three new species of new fishes described was a flatfish *Laeops nigrescens*. The other species of flatfishes collected were *Solea umbratilis* and *Cynoglossus carpenteri*. Evermann and Seale (1907) in '*Bulletin of the*

Bureau of Fisheries' placed 10 flatfishes in 6 genera, 2 families Family Pleuronectidae and Family Soleidae. They opined that "*the flounders and soles together constitute the suborder Heterosomata. The relations of this group are uncertain but it is evident that these fishes have no special affinity with the Gadidae or with other forms with jugular ventral fins. Boulenger associates the flounders with the Zeidae and suggests the derivation of both groups from the extinct family Amphistiidae. But there is no positive warrant for this ingenious guess*". Twenty flatfishes were described by Regan (1908) from Gardiner's collections from the Indian Ocean; all the fishes were placed in one family Pleuronectidae. Six new species were described in addition to the earlier described species. In 1908, Jordan and Richardson added 2 more species to Jordan and Evermann's (1902) list, making the list count ten. The fishes added were *Psettodes erumei* and *Scaeops orbicularis*; the latter was made valid under the name *Engyprosopon grandisquama*. Jordan and Starks (1906) placed the flounders and soles together in suborder Heterosomata with the comments "*the relations of this group are uncertain, but it is evident that these fishes have no special affinity with the Gadidae or with other forms with jugular ventral fins*". Boulenger had associated the flounders with the Zeidae, and suggests the derivation of both groups from the extinct family Amphistiidae. Jenkins (1910) described 25 species of flatfishes in 13 genera collected by steam trawler '*Golden Crown*' from Bay of Bengal, those in the Trivandrum Museum from the Indian Marine Survey collection and the flatfishes collected by Annandale on Puri Beach. Franz (1910), Hubbs (1915), Tanaka (1915) and Kamohara (1936) added many species and genera to the Japanese sinistral flounders. Later in 1910, Regan drew attention to the perch like characters of *Psettodes*, which he regarded as the most generalized member of the

Heterosomata and "*simply an asymmetrical Percoid. The mouth, the skull, the pectoral arch and the vertebral column are all quite Percoid*". He also added that the rest of the flatfishes had arisen from a form not unlike *Psettodes*. He disagreed with Thilo (1902) and Boulenger (1902) that the Zeidae are nearly related to the Heterosomata. Regan also added that "*Bothus and Solea were already in existence in the upper Eocene and indeed the whole Upper Eocene fish fauna is strickingly modern, so that there is no reason to regards Amphistium as ancestral to the flatfishes on account of its occurrence in the Upper Eocene*." Regan also proposed a new system of classification that raised the Heterosomata to the level of order with two suborders: Psettodoidea and Pleuronectoides. Within the second suborder, the family Pleuronectidae now contained three subfamilies – Pleuronectinae, Samarinae and Rhombosoleinae. The family was characterized by "*having eyes on right side of head, nerve of left eye always dorsal, olfactory lamellae slightly raised, parallel without central rachis and eggs without oil globules*". Regan in 1913, placed the Heterosomata as a specialized offshoot from the Order Percomorphii; he proposed an entirely new classification of the group based on the study of anatomy and osteology of a number of genera. Two suborders were recognized for Heterosomata namely Psettodoidea and Pleuronectoidea. The only family under Psettodoidea was Psettodidae with one genus. The second suborder Pleuronectoidea was further divided into two main divisions Pleuronectiformes and Solaeiformes which corresponded to the Pleuronectidae and Soleidae of Jordan and Evermann. The main character which separated the two suborders were dorsal fin extension into head/not. The division Pleuronectiformes contained two families Bothidae and Pleuronectidae, each with 3 subfamilies Paralichthinae, Platophrinae and Bothinae under Family Bothidae and Pleuronectinae, Samarinae and Rhombosoleinae under Pleuronectidae. Division Solaeiformes was characterized by small mouth, lower jaw not prominent, strongly curved, convexity of the lower jaw fitting into concavity of upper, preopercular margin not free, pectoral and pelvic fins small or absent. The division contained two families Soleidae and Cynoglossidae. Weber (1913) placed the flatfishes collected from the tropical Indo-Pacific region (Siboga Expedition) in Family Pleuronectidae with 4 subfamilies Psettinae, Hippoglossinae, Pleuronectinae and Soleinae. 33 genera were recognized with over 61 species. Subfamily Psettinae included the genera *Psetyllis*, *Platophrys*, *Scaeops*, *Engyprosopon*, *Arnoglossus*, *Anticitharus* and *Pseudocitharichthys* new genera. Subfamily Hippoglossinae had characters "*ventral fin symmetrical in form and position, placed laterally. Jaw and teeth on both sides nearly symmetrical. Eyes sinistral or dextral*." Subfamily Pleuronectinae included genera *Laeops*, *Nematops* and *Boopsetta*. The characters cited were "*symmetrical ventral fins, large eyes, pectoral fin on eyed side longer, teeth well developed on blind side*". Genus *Psettodes* was placed along with *Samaris* and *Samariscus* in subfamily Hippoglossinae, Family Pleuronectidae. Several new species were also described–*Samariscus huysmani*, *Pseudorhombus argus*, *Pseudorhombus affinis*, *Platophrys microstoma*, *Arnoglossus profundus*, *Arnoglossus elongates*, *Anticitharus annulatus*, *Aserraggodes filiger*. Besides two new genera *Lepidoblepharon* and *Laiopteryx* were also erected to include 2 new species. Ogilby (1916) following Regan's classification described 4 genera of flatfishes from Queensland. In 1920, Regan revised the group flatfishes from Natal; Pleuronectoidea and Soleidea were recognized as equal in rank to the Psettodoidea; 3 suborders were described under the Order Hetrosomata. Under suborder Pleuronectoidea, three families were recognized–Bothidae, Paralichthodidae and Pleuronectidae. Family Bothidae had 3 subfamilies Paralichthinae, Bothinae and Psettinae; the former two with widespread distribution in the tropical and temperate seas and the latter in North Atlantic. Family Pleuronectidae had three subfamilies Pleuronectinae, Samarinae and Rhombosoleinae while Family Paralichthodidae had only one genus. Suborder Soleoidea was further divided into two families–Soleidae and Cynoglossidae. Family Paralichthodes was made the type of the Family Paralichthodidae. Kyle (1921:118) concluded that the origin of the flatfishes is polyphyletic. "*With regard to origin*" he writes that "*the conclusion is reached that the flatfishes are not a homogenous group. Symphurus represents the earliest origin and has sprung from a stock which has given rise, amongst others to the Macrurids and Trachypterids. The Bothus type is related to the Psettidae, the Rhomboids have a near relation in Stromateoides and the Zeus is an advanced relative; the Pleuronectoids are distinct from both. Psettodes, the 'Percoid' appears to have sprung from a distinct line of evolution and is a modern accession to the ranks of the flatfishes.*" Mc Culloch (1922) placed flatfishes in Order Heterosomata with four families Bothidae, Pleuronectidae, Soleidae and Cynoglossidae and 12 genera. The character followed was the margin of preoperculum free/fused. Jordan (1923:167) placed the Heterosomata near the Anacanthini and Allotriognathi (ribbonfish), but remarked that "*flounders and soles, having no spines and the ventral fins thoracic with an increased number of rays, should not be placed far from the percomorphus series*". Till this period, all workers considered Flatfishes as a natural group derived from a single stock whether Gadoid, Zeoid or Percoid. Norman (1926, 1928) studied the flatfishes of the Indian Museum as well as flatfishes of Australia, and revised the subfamily Rhombosoleinae. Oshima (1927) recorded 30 species in his "*List of Flounders and Soles found in the waters of Formosa*" under five families. *Aesopia cornuta* and *Zebrias fasciatus* were placed in Family Synapturidae. Fowler (1928) describing the *Fishes of Oceania*, recognized 4 families in Order Pleuronectiformes. Regan (1929) omitted the suborders and divisions of earlier workers and recognized five families Psettodidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae. The subfamilies of Bothidae and Pleuronectidae were retained but the South African genus *Paralichthodes* was removed from the subfamily Samarinae and placed in a separate subfamily Paralichthodinae. Norman (1931) described some fishes of Family Bothidae in which he clearly separated *Pseudorhombus natalensis* from *P. arsius* as well as described four species. Later, Norman (1934) brought out a *Monograph on Flatfishes* of the world wherein all available systematic information for the flatfishes was summarized. Norman recognized 292 species in 85 genera in this work. However, taxonomic information for Soleidae, Achiridae and Cynoglossidae was not included in the work. Later, Norman (1934) and Sakamoto (1984) recognized five subfamilies in Family Pleuronectidae – Pleuronectinae, Paralichthodinae, Rhombosoleinae, Samarinae and Poecilopsettinae. The classification given by Regan (1910) was adopted by Norman (1934) with minor revisions – another subfamily was erected under Poecilopsettinae to place the dextral Pleuronectidae. Subfamily Pleuronectidae was characterized by Norman (1934) as "*having eyes on the right side; optic chaisma monomorphic, the nerve of the left eye always dorsal, dorsal fin extending forward on the head atleast to above the eye; all the finrays articulated; pelvic of from 3 to 13 rays; mouth usually terminal, with the lower jaw more or less prominent; maxillary without a supplemental bone; palatines toothless*; *lower edge of urohyal deeply emarginated, so that the bone* *appears forked; pre-operculum with free margin; nasal organ of blind side usually near edge of head, but sometimes nearly opposite that of ocular side; vertebrae never fewer than 30; on each side a single post–cleithrum; ribs present; egg without an oil globule in the yolk.*"

Eventhough most workers were of the view that Heterosomata had arisen from a common ancestor, Chabanaud (1934, 1936) agreed with Kyle (1921) in considering that Pleuronectidae cannot be derived from Psettodoidei and that the Pleuronectiformes are of a polyphyletic origin. Subsequently, Fowler (1936) while describing the *Fishes of West Africa*, included flatfishes in Order Heterosomata–three families were included in it namely Psettodidae, Bothidae and Soleidae. Psettodidae was placed as a separate family in suborder Psettodoidea; Family Bothidae had 4 genera–*Citharus*, *Syacium*, *Arnoglossus*, *Platophrys* and *Lepidorhombus*; the main character of differentiation was the position of the septum of the gill cavity. 29 species in 11 genera were described in all. Chabanaud (1939) recognized 551 species in 125 genera from taxonomic information for species of Pleuronectiformes he considered valid, including those in the family not addressed in Norman's study. Berg (1940) recognized Pleuronectiformes as an order under subclass Actinopterygii, Class Teleostomi. He stated that *"there is no reason to apply the 'rule of Priority' to taxonomical units higher than genera*" and followed Goodrich (1906, 1930) and chose the name coined from the most known family of flatfishes and used it to describe the order as "Pleuronectiformes". Berg further divided the order into two suborders Psettodoidei and Pleuronectoidei. The suborder Pleuronectoidei was further divided into two super families Pleuronectoidae including the family Bothidae and family Cynoglossidae. The family Bothidae corresponds to Bothidae and Paralichthidae of Jordan and Scopthalmidae of Chabanaud. The family has three subfamilies–Paralichthyinae (Miocene to Recent); Bothini (Lower Eocene to Recent) and Rhombini (Scopthalmi). Family Pleuronectidae corresponds to Hippoglossidae and Pleuronectidae and Samaridae and Rhombosoleidae of Jordan. Tinker (1944) in his book on *Hawaiian Fishes* placed flatfishes in Family Pleuronectoidei; 15 species were placed in 10 genera. Hubbs (1945) revised the classification of sinistral flounders on the basis of some important characters wherein Family Citharidae was erected by regrouping two genera formerely placed in the Bothidae (sinistral taxa) and Pleuronectidae (dextral taxa). The genera *Brachypleura* and *Lepidoblepharon* were placed in Family Citharidae. Cadenat (1950) listed the *Fishes of the Sea of Senegal* where 29 species of flatfishes were recognized in 5 families. Orcutt (1950) worked out the life history of the Starry Flounder *Platichthys stellatus*. Jones (1951:132) has placed the flatfishes described from India in Order Pleuronectiformes in 2 suborders Psettodoidei and Pleuronectoidei, 4 families with 14 species. Matsubara and Takamuki (1951) studied the flatfishes of the genus *Samariscus* from the Japanese waters; Matsubara (1955) also revised the system of classification of Japanese sinister flounders and referred them into 43 species in 18 genera, eight subfamilies, 2 families and 2 suborders. However, there have been doubts on this classification since it has been based on external characters only. In describing "*The Marine and Freshwater fishes of Ceylon*", Munroe (1955) placed flatfishes in Order Pleuronectiformes. Five families–Psettodidae, Pleuronectidae, Bothidae, Soleidae and Cynoglossidae with 19 genera and 36 species were described. The work was based on compilation of all the marine, brackish and freshwater species of fish that were recorded from Ceylon and the adjacent waters of the Gulf of Mannar. Chen (1956) listed 34 species in his "*Checklist of the Species of Fishes known from Taiwan* (Formosa). This added 7 new species to Oshima's (1927) list. Fowler (1956), while describing the *Fishes of Red Sea and Southern Arabia*, placed flatfishes in Order Pleuronectidae, with 3 suborders Psettodina, Pleuronectina and Soleina and 5 families and 17 genera. Family Bothidae was further classified into two subfamilies–Paralichthyinae and Laeopsinae; the former with 4 genera *Pseudorhombus*, *Arnoglossus*, *Engyprosopon* and *Bothus* and the latter with one genus *Laeops*. 18 species were described in Family Bothidae. Family Pleuronectidae had one genus – Genus *Samariscus* with one species in it. Family Soleidae was further subdivided into two subfamilies – Soleinae and Aseraggodinae with 3 genera and 6 species in the former and two genera and 3 species in the latter. 5 genera and 18 species were described in Family Cynoglossidae. Fourmanoir (1957) while describing the *Fishes of Mozambique Canal*, reported 7 species of flatfishes in 5 genera and 4 families–Psettodides, Bothides, Soleides and Cynoglossides. In the "*Handbook of Hawaiian Fishes*" Gosline and Brock (1960) placed flatfishes in 4 families–Bothidae, Pleuronectidae, Soleidae and Cynoglossidae; 17 species were recorded in all the families together. Based on two intensive surveys on the Coramendal coast of India, Menon (1961) recorded 175 species of fishes of which 10 were flatfishes; they were placed in 3 families–Psettodidae, Bothidae and Cynoglossidae in Order Pleuronectiformes. Smith and Smith (1961) describing "*Sea Fishes of Southern Africa*" placed flatfishes in Order Heterosomata; 5 families described were Psettodidae, Pleuronectidae, Bothidae, Soleidae and Cynoglossidae. The major difference between *Psettodes* and other families were extension of dorsal fin onto head and spinous anterior rays. Genus *Pseudorhombus* continued to be placed in

Family Bothidae, Subfamily Paralichthyinae. Later in 1963, while describing the *Fishes of Seychelles*, Smith and Smith placed flatfishes in 4 families with over 13 species. Amaoka (1963) made a revision of the species of genus *Engyprosopon* found in the waters around Japan. Chen and Weng (1965) in their review of the flatfishes of Taiwan, described 76 species in 28 genera and 5 families which included 40 new records and two newly described species *Laeops tungkongensis* and *Synaptura nebulosa*. In the "*Fishes of Oceania*", Fowler (1967) has described flatfishes in different families Pleuronectidae and Soleidae. Munroe (1967) recorded 33 species of flatfishes under 5 families, 2 subfamilies and 17 genera from New Guinea. Amaoka (1969) opined that the phylogenetic relationship of the Heterosomata has not been properly understood on account of poor osteological studies. He made a comparative study of the cranium, orbital bones, gill rakers, branchial apparatus, urohyal, vertebral and other accessory bones, caudal rays and caudal skeleton and arrived at the conclusion that flatfishes are polyphyletic in origin, a view proposed by Kyle (1913) and supported by Chabanaud (1934, 1936). Amaoka also drew up a phylogenetic scheme for the sinistral flounders and related flatfishes based on the study of the morphology of Japanese flounders. He recognized four large genetic stems *Psettodes* stem, *Citharoides* stem, *Paralichthys* stem and *Bothus* stem; the stems were so distinct in their characters that they were considered as four families namely Psettodidae, Citharidae, Paralichthyidae and Bothidae. He also added that Heterosomata is not a natural group derived from a single stock as a generalized percoid as suggested by Norman and Hubbs, but sprung off from different stocks among the ancestoral percoids much earlier to the percoid group. Amaoka's analysis was eclectic, eg. a combination of phonetic and cladistic methods and did not include *Engyophrys*, *Trichopsetta*, *Grammatobothus*, *Lophonectes* and *Monolene* for which larvae are known. Fowler (1972) in his "*Synopsis of Fishes of China*" recognized 6 families under Order Heterosomata with over 51 species. Lindberg (1974) in "*Fishes of the World*" placed flatfishes in Order Pleuronectiformes – the order was further divided into 2 suborders Psettodoidei and Pleuronectoidei with 6 families in all. Amaoka (1962, 1964, 1969, 1970, 1971, 1972, 1973, 1974, 1976, 1979, 1984) studied in detail the distribution, larval forms, phylogeny, larval morphology of the sinistral flounders of Japan. Jordan & Evermann (1973) describing "*Shore fishes of Hawaii*" placed flatfishes in suborder Heterosomata. Three families of flatfishes Bothidae, Soleidae and Cynoglossidae with 4 species were described by Jones and Kumaran (1980) from Laccadive Archipelago. Evseenko (2004) prepared an annotated checklist of fishes of Family Pleuronectidae. Relyea (1981), while describing the "*Inshore Fishes of the Arabian Gulf*" placed flatfishes in Order Pleuronectiformes with 4 families and 14 species; Hussain and Ali–Khan (1981) recorded 11 species in 2 genera including 3 new records of fishes of family Cynoglossidae of Pakistan. The new species recorded were *Paraplagusia blochii*, *P. bilineata* and *Cynoglossus borneansis*. In a revision of the sole fishes of Taiwan (Shen and Lee, 1981), fourteen species belonging to eight genera was described. Lauder and Lim (1983) presented a cladogram for flatfishes stating that the hypothesis is tentative and interrelationships expressed are problematic. In the "*Treatise on the Deep Sea Fishes of the Atlantic Basin*" by Goode, Tarleton and Bean (1896), flatfishes of Family Pleuronectidae were placed in Order Heterosomata. Nelson (1984) listed the Poecilopsettinae, Rhombosoleinae, Samarinae and Pleuronectinae as subfamilies in Pleuronectidae on the basis of two characters: eyes almost dextral and no oil globule in yolk of egg. Sakamoto's (1984) hypothesis of pleuronectid interrelationships assumed that the Pleuronectinae, Samarinae, Rhombosoleinae, Poecilopsettinae and Paralichthodinae were monophyletic because both eyes were on right side of the body, optic nerve of the left side was always dorsal, preopercle had a free margin and finrays were without spines. However, Hensley and Ahlstrom (1984), in a review of flatfish classification, indicated that the evidence for monophyly of Pleuronectidae (*sensu* Norman, 1934) was not convincing. They concluded that the diagnostic characters reviewed in Norman (1934) were found to be plesiomorphic for the order or had distributions that were unknown for many pleuronectiform taxa. They proposed the "Regan–Norman model and classification" as the detailed hypothesis for pleuronectiform evolution. According to the model proposed by Ahlstrom *et al*. (1984) incorporating works of Regan (1910) and Norman (1934, 1966) with modifications by Hubbs (1945), Amaoka (1969), Hensley (1977) and Futch (1977), Order Pleuronectiformes was divided into three suborders–Psettodoidei, Pleuronectoidei and Soleoidei. The suborder Psettodoidei contains only one family Psettodidae and the members are distributed in the waters of the Indo–Pacific and West African regions. The suborder Pleuronectoidei includes five families - Citharidae, Scopthalmidae, Paralichthyidae, Bothidae and Pleuronectidae. Family Citharidae contains two subfamilies - Subfamily Brachypleurinae found in the waters of the Indo–Pacific region and subfamily Citharinae in the Indo–Pacific, Meditterranean and West African regions. Four genera were included in Family Scopthalmidae–*Lepidorhombus*, *Phrynorhombus*, *Scopthalmus*, *Zeugopterus*; Family Bothidae was further divided into two subfamilies–subfamily Taeniopsettinae distributed along Western

Atlantic, Eastern Pacific and Indo–Pacific and subfamily Bothinae distributed along Indian, Pacific, Atlantic, Mediterranean and Southern Oceans. Four genera were included in the former subfamily while the latter had 18 genera in it. Species in Family Scopthalmidae were distributed in the North Atlantic, Mediterranean and Black Sea while Family Paralichthyidae was reported from Western and Eastern Atlantic, Eastern Pacific and the Indo-Pacific and had 16 genera in it. Family Pleuronectidae was further subdivided into five sub-families-subfamily Pleuronectinae with twenty six genera distributed in the Atlantic, Mediterranean, Pacific and Artic Oceans, subfamily Poecilopsettinae with three genera distributed in the Indo–Pacific and Atlantic Oceans, subfamily Paralichthodinae with one genus distributed in the Indian Ocean off South Africa, subfamily Samarinae with two genera distributed in the Indo-Pacific and subfamily Rhombosoleinae with eight genera distributed along New Zealand, Southern Australia and South America. Suborder Soleoidei has two families Soleidae and Cynoglossidae–the former with two subfamilies–subfamily Soleinae with worldwide distribution from temperate to tropical waters and subfamily Achirinae with distribution along the American coasts; the latter with two subfamilies- subfamily Symphurinae with distribution along the tropical and subtropical American coasts, Mediterranean, West African and Indo–Pacific coasts and subfamily Cynoglossinae with distribution along the Indo–Pacific, Mediterranean, West African and Japanese coasts. Norman (1966) recognized 22 genera in subfamily Soleinae and 9 genera in subfamily Achirinae. Subfamily Symphurinae was represented by one genus *Symphurus*; two genera *Cynoglossus* and *Paraplagusia* represented subfamily Cynoglossinae. Talwar and Kacker (1984) placed flatfishes in Order Pleuronectiformes–three suborders with 5 families were recognized in it. Masuda *et al*. (1984) in "*The Fishes of the Japanese Archipelago*" placed flatfishes in Order Pleuronectiformes; 5 families were described in 2 suborders Pleuronectoidei and Soleoidei. The families described were Paralichthyidae, Bothidae, Pleuronectidae in the first suborder and Soleidae and Cynoglossidae in the second suborder. Smith and Smith (1986) reported 53 species of flatfishes placed in 6 families under Order Heterosomata from Southern Africa. Fishes were placed in Order Heterosomata, families described were Psettodidae, Pleuronectidae, Bothidae, Soleidae and Cynoglossidae. The major difference between *Psettodes* and other families were extension of dorsal fin onto head and spinous anterior rays. Genus *Pseudorhombus* continued to be placed in Family Bothidae, subfamily Paralichthyinae. Fishes were placed in three suborders–Psettodoidae, Pleuronectoidae and Soleoidea with 1, 3 and 2 families respectively. Kuronuma and Abe (1986), describing the "*Fishes of the Arabian Gulf*", grouped flatfishes into five families. 26 species belonging to 14 genera were described in the five families. Later workers (Chapleau and Keast, 1988; Chapleau, 1993) using cladistic analysis of major taxa within the order supported the hypothesis that the Pleuronectidae was not monophyletic and suggested that the subfamilies Pleuronectiane, Samarinae, Rhombosoleinae and Poecilopsettinae should be elevated to family level. This concept was recognized by Hensley (1993) and partly by Nelson (1994). Rajaguru (1987) collected 47 species of flatfishes under 22 genera from India. Hensley (1984, 1986), Hensley and Amaoka (1989), Hensley and Randall (1990, 1993), Hensley and Suzumoto (1990) made a series of publications on different species of *Pseudorhombus* and *Crossorhombus* as well as Bothids of Easter Island and Rass (1996) on taxonomy of Pleuronectidae. A taxonomic re-appraisal of the Atlanto–

Mediterranean soles was given by Ben Tuvia (1990). Larson and Williams (1997) in their checklist of fishes from Darwin's Harbour placed flatfishes in Order Pleuronectiformes - 6 species in Family Bothidae, and 2 in Family Soleidae were described.

3.5 Revision of the flatfish family

Revisions of certain families and genera in Order Pleuronectiformes was done by Amaoka (1963) on Genus *Engyprosopon*, Staunch and Cadenat (1965) on genus *Psettodes*, Anderson and Gutherz (1967) on genus *Trichopsetta*, Amaoka and Yamamoto (1984) and Foroshchuk (1991) on Genus *Chascanopsetta*, Quero (1997) on Soleidae and Cynoglossidae on the Island of Reunion, Clark and George (1979), Cooper and Chapleau (1998) on Family Pleuronectidae, Chapleau and Keast (1988) on Family Soleidae, by Evseenko (1987, 1996) on Genus *Achiropsetta*, Amaoka and Rivaton (1991) on genus *Tosarhombus*, Kim and Youn (1994) on flounders from Korea, on family Cynoglossidae (Kim and Choi, 1994), Chabanaud (1928) on Genus *Heteromycteris*, Munroe and Marsh (1997) on Genus *Symphurus*, Evseenko (2000) on family Achiropsettidae, Orr and Matarese (2000) on genus *Lepidopsetta*, Hensley (2005) on Genus *Asterorhombus*, Randall (2005) and Randall and Gon (2005) on Genus *Aseraggodes*, Randall and Johnson (2007) on Genus *Pardachirus*, Vachon *et al*. (2007) on Genus *Dagetichthys* and *Synaptura* and East Asian *Pleuronichthys* (Suzuki *et al.* 2009). Five species and two subspecies were recognized in genus *Chascanopsetta* by Foroshchuk (1991).

3.5.1 Phylogeny of flatfish

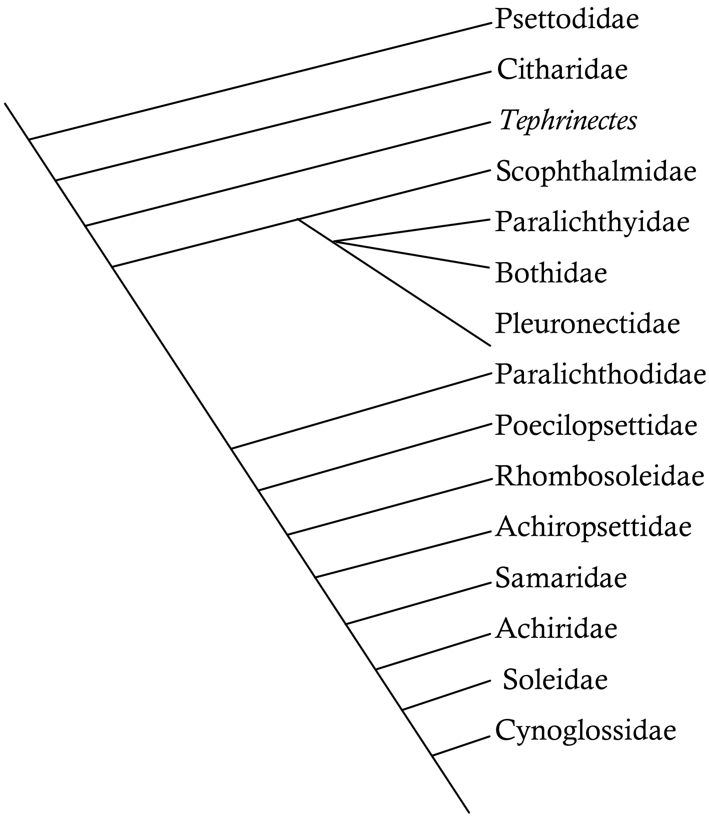
Phylogeny of the pleuronectid fishes have been studied by the works of Regan, (1910, 1929), Norman (1934, 1966), Kuronuma (1938), Hubbs

(1945), Kim (1973), Li (1981), Munroe (2005). Among these workers, except Kim (1973), all the papers discussed the relation among the subfamilies based on several characters including osteology. Kim (1973) studied the inter relationships of 14 species of the Pleuronectinae based on the comparative osteology of the cranium, the urohyal, the vertebrae and the caudal skeleton. The classification of the dextral flounders has been studied since the 19th century. In 1910, Regan treated all dextral flounders as a single family. Since then, classification was based first on subfamilial level (Regan, 1929; Norman, 1934; Berg, 1940; Hubbs, 1945) and some were raised to family status (Regan, 1920; Jordan, 1923). Later, Nelson (1976) divided Pleuronectidae into 4 subfamilies and the Pleuronectinae into two tribes. Family Paralichthyidae was erected by Amaoka (1969) by elevating the subfamily status of Paralichthinae to family status. Interrelationships among flatfishes have not been much resolved. Interrelationships of the Family Pleuronectidae was worked out by Sakamoto (1984) based on as many internal and external characters on dextral flounders. Four subfamilies Pleuronectinae, Poecilopsettinae, Rhombosoleinae and Samarinae were recognized. Cladistic methodology was first used by Lauder and Lim (1983) to study interrelationships between flatfishes. Evseenko (1984) erected the family Achiropsettidae to include the four genera *Achiropsetta*, *Neoachiropsetta*, *Mancopsetta* and *Pseudomancopsetta*. He also hypothesised the Achiropsettidae as the outgroup to a clade comprising the Samaridae, Soleidae and Cynoglossidae. Hensley and Ahlstrom (1984) and Ahlstrom *et al*. (1984) provided a detailed synthesis of knowledge on classification and larval morphology of the Pleuronectiformes. They pointed out the weakness of the earlier classifications, but did not produce a cladogram reflecting their hypotheses of intrarelationships of the flatfishes. First attempts at cladistic hypotheses of relationships were proposed for the Cynoglossidae by Chapleau (1988) and for the Soleidae by Chapleau and Keast (1988). Chapleau (1988) gave a phylogenetic reassessment of the monophyletic status of the family Soleidae. Based on a detailed study of the characters, Pleuronectiformes have been classified into eight families; he also established the monophyly of the Achiridae based on six characters. Chapleau (1993) elevated all subfamilies of Norman (1934) to family status. He also did a cladistic analysis of familial and subfamilial relationships using available ordered and polarized morphological characters. This was the first attempt to incorporate all available information to build a cladogram of interrelationships within the Pleuronectiformes. Based on the study, Chapleau agreed with Hensley and Ahlstrom (1984) in doubting the monophyly of Citharidae. Early ontogeny and systematics of Bothidae was worked out by Fukui (1997) based on larval characters using cladistic analysis. He agreed with Hensley and Ahlstrom (1984) in the conclusion that family Bothidae is monophyletic. He also opined that *Asterorhombus* and *Engyprosopon* except species 2 of subfamily Bothinae are sister groups for the subfamily Taeniopsettinae and added that re-examination of adult systematic is necessary in *Arnoglossus*. Cooper and Chapleau (1998) did a cladistic analysis of interrelationships for 53 pleuronectid species using 106 morphological and osteological characters. Results showed that the Family Pleuronectidae is monophyletic. In addition, he also defined five subfamilies which are Hippoglossinae, Eopsettinae, Lyopsettinae, Hippolgossidinae and Pleuronectinae. The largest subfamily Pleuronectinae was further subdivided into 4 tribes. Ramos (1998) also corroborated the monophyly of the family and proposed a phylogenetic hypothesis of interrelationships. Adam *et al.* (1998) mentions of 6 species of flatfishes in 4 genera and 3 families.

The phylogenetic status of the *Paralichthodes algoensis* was reviewed by Cooper and Chapleau (1998). First attempts at cladistic hypothesis of relationships were proposed for the Cynoglossidae by Chapleau (1988) and for the Soleidae by Chapleau and Keast (1988). They determined that the suborder Pleuronectoidei of Hensley and Ahlstrom (1984) was paraphyletic. Based on their studies, they also recommended that the Pleuronectinae, Poecilopsettinae, Rhombosoleinae and Samarinae be raised to family rank. Evseenko (1996) studying the ontogeny and relationships of the flatfishes of Southern Ocean concluded that achiropsettids are a monophyletic group and morphologically they are a transitional group between *Brachypleura* (Citharidae) on one hand and the Paralichthyidae and Bothidae on the other hand. Four genera and 7–8 species were included in the achiropsettids. Hensley (1997) prepared an overview of the systematics and biogeography of the flatfishes wherein recent changes in flatfish classification was discussed and it further reiterated critical research areas in need of study on systematics and biogeography of pleuronectiform fishes. Early ontogeny and systematics of Bothidae was worked out by Fukui (1997) based on larval characters using cladistic analysis. He agreed with Hensley and Ahlstrom (1984) and Chapleau (1993) in the conclusion that family Bothidae is monophyletic. He also opined that *Asterorhombus* and *Engyprosopon* except species 2 of subfamily Bothinae are sister groups for the subfamily Taeniopsettinae and added that re-examination of adult systematic is necessary in *Arnoglossus*. Hensley and Ahlstrom (1997) and Ahlstrom *et al*. (1984) provided a detailed synthesis of knowledge on classification. Cooper and Chapleau (1998) did a cladistic analysis of interrelationships for 53 pleuronectid species using 106 morphological and osteological characters. Results showed that the Family Pleuronectidae is monophyletic. In addition, he also defined five subfamilies which are Hippoglossinae, Eopsettinae, Lyopsettinae, Hippolgossidinae and Pleuronectinae. The largest subfamily Pleuronectinae was further subdivided into 4 tribes. Later, Hoshino (2000, 2001) after re-examination of the status of five genera and six species in Citharidae, concluded that these fishes did form a monophyletic group that should be recognized at the family level. Chanet (2003) published a cladistic appraisal of the Scophthalmid fishes. Currently two major lineages of flatfishes are recognized: the Psettoidei comprising the family Psettodidae and the Pleuronectoidei containing all the other flatfish groups. Fourteen families are recognized in this group, with *Tephrinectes* also representing a distinct lineage within the Order. (Munroe, 2005). Phylogenetic analysis of 61 species in Order Pleuronectiformes based on sequences of 12S and 16S mitochondrial genes were done (Azevedo *et al.*, 2008). Results showed that most families of flatfish Scopthalmidae, Pleuronectidae, Samaridae, Cynoglossidae, Achiridae, Citharidae and Bothidae are monophyletic, only Family Paralichthyidae was said to be polyphyletic.

3.5.2 Present status of flatfish phylogeny

However, Nelson (2006) concluded that about 678 extant species are recognized in approximately 134 genera and 14 families. Of this some species are thought to occur in freshwater, another few enter estuaries or marine water and another few species are normally marine in nature, but enter freshwater. The Order is now classified into two suborders– Psettodoidei and Pleuronectoidei; the former with one family Psettodidae and the latter with 13 families in three superfamilies Citharoidea, Pleuronectoidea and Soleoidea. This classification is followed in the present work.



(Source: Munroe in Gibson, 2005, Flatfishes: Biology and Exploitation, 391 pp)

Fig. 2 Phylogeny tree of the flatfish families of the world

Taxonomic relations especially within the subfamily Pleuronectinae remain uncertain inspite of numerous investigations into the biology and systematic of the flatfish. (Ninnikov *et al.*, 2007).

3.6 Life history of flatfishes

Immense literature on the life history stages of flatfishes has accumulated since the early work of Cunningham (1887, 1889, 1890, 1891) who described numerous series reared from eggs collected from running ripe females. Other European workers (Holt, 1893; Mc Intosh and Prince, 1890; Petersen, 1904, 1906; Schmidt, 1904; Kyle, 1913) identified early life history series of additional species. By the time of publication of Ehrenbaum's (1905-1909) summary, ontogenic changes of the major groups of eastern North Atlantic fish fauna were already studied. Padoa (1956) summarized ontogenic information on Mediterranean flatfishes; Russell (1976) provided an extensive review of previous European contributions. Martin and Drewry (1978) and Fahay (1983) summarized information on the ontogenetic stages of the western Atlantic fishes. Early life histories of some flatfishes from different areas have been studied–of North Pacific were summarized by Pertseva-Ostroumova (1961) and of Dover sole by Markle *et al*. (1992). Amaoka (1964) described the development and growth of the sinistral flounder *Bothus myriaster* found in the Indian and Pacific Oceans. The other work on the eggs and larvae of flatfishes include those of Orsi (1968), Richardson *et al*. (1980), Crawford (1986), Fukuhara (1986), Oda (1991) and Fukui and Liew (1999) on *Taeniopsetta radula*.

3.7 Distribution of flatfishes

Flatfishes are said to have a global occurrence in marine habitats. Ecological studies demonstrate that flatfish species distributions within regions are modified by responses of species to various ecological factors including water temperature, salinity, depth, sediment type and its spatial distribution, prey distribution and degree of habitat specialization of the species. (Munroe, 2005). The distribution pattern of larvae and adults of some species of flatfishes have been studied by Bonde (1927), Norman (1934), Bowman (1935), Thompson (1936), Thompson and Cleve (1936), Rapson (1940), Gopinath (1946), Raymont (1947); Andriashev (1954), Seshappa and Bhimachar (1955), Bishai (1960, 1961 a,b), Musienko (1961), Pearcy (1962), Pradhan and

Dulked (1962), Riley (1964); Rass (1965); Shuntov (1965), Haertel and Osterberg (1967), Pillay (1967), Yesaki and Wolotira (1968), Edwards and Steele (1968), McIntyre and Eleftheriou (1968), Hognstead (1969), Powles and Kohler (1970), Irvin (1974), Hoss *et al*. (1974), Balakrishnan and Lalithambika Devi (1974), Lalithambika Devi (1969, 1977, 1986, 1989 a, b, 1991, 1993, 2004), Menon (1977), Munroe (1990, 1998), Heemstra (1999), Evseenko (1999, 2000). The greatest diversity of flatfishes occurs in the tropical and subtropical marine waters where approximately 528 species representing nearly 74 % of the total diversity of the Order Pleuronectiformes are found. Many species continue to be discovered from tropical Indo-West Pacific waters; therefore species richness values for the area are only conservative estimates. Species richness estimates are highest for flatfish assemblages occurring in marine waters in the area bordered by northern Australia and New Caledonia to the south and east, Indonesia, Malaysia and the Gulf of Thailand in the west, the Philippines and southern Japan in the northeast and the south China Sea to the north. (Briggs, 1974, 1999; Planes, 1998). Munroe (2005) reports that the South China Sea supports the greatest diversity of flatfish species (125). Other Indo-west Pacific localities with diverse flatfish assemblages include Taiwan (82 species), the Indo-Malay Archipelago (80 species), Philippines (76 species), north-western Australia (82 species), southern Japan (79 species) and Gulf of Thailand (56).

3.8 Spawning and fecundity of flatfishes

Scattered and sparse information on the spawning and fecundity of flatfishes exists. Published literature include those of Buchanan-Wollaston (1924), Yamamoto (1939), Chidambaram (1945), McHugh and Walker (1948), Arora (1951), Simpson (1951), Shellbourne (1953, 1956, 1957, 1962, 1963 a, b, 1964, 1965), Bagenal (1955 a,b, 1956, 1957 a, b, 1958, 1960, 1963 a, b, 1966, 1967), Marr (1956), Kuthalingam (1957), Simpson (1959, 1971), Baxter (1959), Rustad (1961), Pradhan (1962), Torchio (1962), Barr (1963), Railey and Thacker (1963), Pitt (1965), De Groot and Schuy (1967), Holliday and Jones (1967), Kutty (1967), Mirnov (1967), Ryland and Nichols (1967), Nash (1968), Seshappa (1974), Jayaprakash (1999, 2000, 2001), Grace *et al*. (1992), Zimmermann (1997) and Vivekanandan *et al*. (2003).

3.9 Other biological aspects of flatfishes

Information on the biology and other aspects of flatfishes are also scattered. Available information include eye migration and cranial development during flatfish metamorphosis reviewed by Brewster (1987); study on the diurnal activity and feeding habits of plaice by de Groot (1964). Later Braber and De Groot (1973) studied the food of five flatfish species in the Southern Northern Sea–the flatfishes belonging to the five groups Psettodidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae were regrouped into three groups–fish feeders, crustacean feeders and polychaete mollusk feeders. Other reports in this area include those of Zoutendyk (1974 a, b) on the length–weight relationships and age and growth of the Agulhas sole *Austroglossus pectoralis,* Kawamura (1985) on behavior of flounder *Paralichthys olivaceus*, Bawazeer (1987, 1900) on stock assessment and growth, mortality of large toothed flounder *Pseudorhombus arsius* in Kuwait waters, Khan and Hoda (1993) on the food and feeding habits of *Euryglossa orientalis* from Karachi coast, Knust (1996) on the food of Seadab, Terwilliger and Munroe (1998) on age and growth of tonguefish *Symphurus plagiusa*, Chapleau (1988) on the comparative osteology and intergeneric relationships of the tongue soles, Castillo-Rivera *et al*. (2000) on the feeding biology of *Citharichthys spilopterus*, Horwood (2001) on the population biology and ecology of sole, Cabral *et al*. (2003) on feeding habits of *Synaptura lusitanica* and Voronina (2007) on the seismosensory system of *Psettodes erumei*.

3.10 Range extensions of flatfishes

Several papers on reports of new species and extension of distribution areas have been reported over the time period, adding to the total species list of flatfishes. Prominent among those reported from the Western Indian Ocean, Indo–West Archipelago and south east Asia are *Aseraggodes ocellatus* from Ceylon (Weed, 1961), *Mancopsetta milfordi* (Penrith, 1965) from South Africa, *Microstomus shuntovi* from the seamounts of northwestern and Hawaiian ridges (Borets, 1983), *Achiropsetta heterolepis* from Russia (Evseenko, 1988), *Psettina multisquamea* from Saya-de-Malya Bank, *Solea stanalandi* from Persian Gulf (Randall and McCarthy, 1989), *Symphurus callopterus* from eastern Pacific (Munroe and Mahadeva, 1989), *Engyprosopon hensleyi*, *Arnoglossus sayaensis* and *Parabothus malhensis* from Saya de Malha Bank (Amaoka and Imamura, 1990), *Symphurus melasmatotheca* and *S. undecimplerus* from eastern Pacific (Munroe and Nizinski, 1991), *Engyprosopon hensleyi*, *Arnoglossus sayaensis* and *Parabothus malhensis* from Saya de Malha Bank (Amaoka and Imamura, 1990), *Chascanopsetta megagnatha* from Sala-y-Gomez Submarine Ridge (Amaoka and Parin, 1990), *Chascanopsetta elski* from Saya de Malha Bank (Foroshchuk, 1991), *Grammatobothus polyopthalmus* and *Arnoglossus taepinosoma* from Japan (Amaoka *et al*., 1992), *Cynoglossus lida*, *Paraplagusia bilineata* and

Zebrias quagga from Andaman and Nicobar islands (Rao *et al.,* 1993), *Paraplagusia sinerama* from Indo-Pacific region (Chapleau and Renaud, 1993), *Parabothus taiwanensis* from Taiwan (Amaoka and Shen, 1993), *Asterorhombus fijiensis*, (Amaoka *et al*., 1994), *Asterorhombus bleekeri* (Amaoka and Arai, 1994), *Plagiopsetta glossa* (Cooper *et al*., 1994); *Pardachirus balius* from Oman (Randall and Mee, 1994), *Zebrias captivus* from Persian Gulf (Randall, 1995), *Engyprosopon raoulensis* from south-west Pacific Ocean (Amaoka and Mihara, 1995), *Pardachirus diringeri* from Reunion Island (Quero, 1997); *Bothus swio* (Hensley, 1997), *Chascanopsetta kenyaensis* from coasts of Kenya and Somalia (Hensley and Smale, 1997), *Arnoglossus micrommatus* from south west coast of Australia (Amaoka *et al*., 1997), *Symphurus hondoensis* from Suruga Bay, Japan (Munroe and Amaoka, 1998), *Citharichthys gnathus* from Galapagos Islands (Hoshino and Amaoka, 1999), *Samaris macrolepis* from Northwest Australia (Hoshino and Amaoka, 1998); *Arnoglossus debilis* from Hawaii (Fukuii, 1999), *Synaptura annularis* from Japan and India (Gonzales *et al*., 1994; Rekha, 2005), *Citharoides orbitalis* from Western Australia (Hoshino, 2000), *Poecilopsetta praelonga* from northwestern waters of Australia (Hoshino *et al.* 2000), *Monolene helenensis* from eastern tropical Atlantic (Amaoka and Imamura, 2000), *Asterorhombus annulatus* (Amaoka and Mihara, 2001), *Aseraggodes holcomi* from Hawaiian Islands (Randall, 2002), *Soleichthys maculosus* from Northern Australia (Muchchala and Munroe, 2003), *Soleichthys serpenpellis* and *S. oculofasciatus* from Australian waters (Munroe and Menke, 2004), *Asterorhombus filifer* (Hensley and Randall, 2003); *Engyprosopon vanuatuensis* and *Engyprosopon marquisensis* (Amaoka and Séret, 2005 a, b) from South Pacific Island and Marquesas islands respectively; *Heteromycteris normani* (Joglekar, 1973); *Poecilopsetta* *pectoralis* from New Caledonia (Kawai and Amaoka, 2006), *Nematops nanosquama* from Marquesas Islands (Amaoka *et al*., 2006), *Aseraggodes cheni* and *Aseraggodes orientalis* from Taiwan and Japan (Randall and Senou, 2007), *Nematops microsoma* from Tarawa Atoll in Indian Ocean (Voronina and Evseenko, 2008), *Cynoglossus ochiaii* (Yokogawa *et al*., 2008) from Japan. Some tropical species like *Chascanopsetta lugubris* have been recorded from Western Atlantic also (Deubler Jr and Rathjen, 1958).

3.11 Indian work on flatfishes

Scattered work on flatfishes has come from India over the time period. Bleeker (1853) from Bengal, Alcock (1889–1889) from Bay of Bengal, Day (1889), Alcock (1890) on deep sea flatfishes are the initial ones. The first and only comprehensive work on the flatfishes of India was by Norman (1927 & 1928) in which he deals with the specimens from the coast of Southern Asia, from the Persian Gulf to the Mergui Archipelago, from the collections in the Indian Museum and also a few deep sea forms obtained by R.I.M.S. "*Investigator*". Rao (1935) gave an account of the "*Otoliths of Psettodes erumei*". Gopinath (1946) described the larvae of four flatfishes, three from Family Bothidae and one from Family Cynoglossidae from the Trivandrum coast. Chidambaram (1945) and Chidambaram and Venkataraman (1946) worked on and described the spawning season of soles; Jones and Menon (1951) presented the bionomics and developmental stages of some Indian flatfishes. Larval stages and eggs and larvae of certain flatfishes occurring along Madras coast were recorded by John (1944, 1951). Munroe (1955) prepared an exhaustive account of the marine and freshwater fishes of Ceylon; Kuthalingam (1957) gave details of the life history and feeding habits of *Cynoglossus lingua*; Jones and Pantulu (1958) on the juvenile fishes off Bengal and Orissa coast. Life history and feeding habits of *Solea elongata* were described by Kuthalingam (1960). Menon (1961) made a collection from Coramendal coast; of the 174 fishes, 10 flatfishes were recorded. Distribution of *Laeops guentheri* and *Zebrias altipinnis* was mentioned by Pradhan and Dhulkhed (1962) and Talwar and Sen (1966) respectively. Pradhan (1964) gave a preliminary account of the flatfishes found along the Bombay coast. From a collection of bottom fauna from the Kerala coast by R.V. Conch during 1958-63, Saramma (1963) recorded 30 species of flatfishes. The collections were made from the continental shelf within the 100 fathom line as well as deep water stations outside the shelf. The fishes were placed in Order *Heterosomata* in families *Bothidae, Pleuronectidae, Soleidae, Cynoglossidae.* Balakrishnan (1963) gave a detailed account of the fish eggs and larvae collected by *R.V Conch*. Dutt and Rao (1965) described a new bothid fish *Cephalopsetta ventrocellatus* from the Bay of Bengal; Jones and Kumaran (1966) described *Liachirus melanospilus* and *Samaris cristatus*, new records from the Indian Seas. Talwar (1966, 1973) described new records of flatfishes from the Indian seas; *Brachirus panoides* and *Pardachirus marmoratus* were recorded for the first time from Orissa coast by Talwar and Chakrapani (1966), Seshappa (1964, 1970, 1972a, 1972b, 1973) gave accounts of flatfish resources of India, abnormalities in flatfishes as well as details of morphometric studies on five species of flatfishes. Detailed study of the Indian halibut *Psettodes erumei* was given by Pradhan (1969) in three parts where fishery, biology and racial study results on the fish were presented. Joglekar (1973) gave the systematic status of subfamily Heteromycterinae and description of *Heteromycteris normani*; Venkataramanujam and

Ramamoorthi (1973) redescribed *Samaris cristatus* from Porto Novo. Gaps in the studies on the behaviour of Indian Ocean flatfishes were mentioned by De Groot (1973). The inter-relationships between alimentary tract and food and feeding habits of flatfishes of Porto Novo were described by Ramanathan *et al*. (1975). The feeding and breeding habits of the Indian halibut *Psettodes erumei* were detailed by Abraham and Nair (1976) and the "*Biology and fishery of Psettodes erumei*" from Porto Novo was described by Devadoss *et al*. (1977). Menon and Rama Rao (1975) listed the type specimens collected by RIMS *Investigator*. Flatfishes were placed in Order Pleuronectiformes, in which "species were placed in Family *Bothidae*, 5 species in Family *Pleuronectidae*, 4 in Family *Soleidae,* 8 in Family *Cynoglossidae.* Devi (1977) studied the distribution of flatfish larvae in the Indian Ocean. Ramanathan *et al*. (1977, 1979a, 1979b, 1990) gave detailed accounts of the flatfish eggs and larvae and the breeding biology of *Cynoglossus macrolepidotus*, *Psettodes erumei* and *Pseudorhombus triocellatus* from Porto Novo waters. The taxonomic status of the genera *Synaptura* was reviewed by Menon and Joglekar (1978). Thirty two flatfishes of Porto Novo were recorded and depicted by Ramanathan and Natarajan (1980); Jones and Kumaran (1980) recorded 4 species from three families from Laccadive waters. Menezes (1980) depicted observations on the morphometry and biology of *Psettodes erumei* and *Pseudorhombus arsius* from Goa. Length–weight relationships of three species of flatfishes landed at Calicut was studied by Seshappa (1981). Chakrapani and Seshappa (1982) made a morphometric comparision of the Malabar sole from different centres of west coast of India and Talwar and Kacker (1984) recorded 43 species of flatfishes under 25 genera and 5 families from India. The fishes were placed in Order Pleuronectiformes. Apte and Rao (1992) described the morphometric and meristic characters of *Zebrias quagga* and *Pseudorhombus elevates*; *Engyprosopon grandisquama* was reported for the first time from Andaman Islands (Krishnan and Mishra, 1992). Seventeen species belonging to four families and eight genera were described by Venkateshamoorthy *et al*. (1993) from Mangalore. Biology of *Psettodes erumei* and *Pseudorhombus elevatus* from the northern Arabian Sea was studied by Pradhan (1964); anatomy of olfactory organs of *Cynoglossus oligolepis* was studied by Kapoor and Ojha (1973). Other scattered works on flatfishes were those on otoliths of *Psettodes erumei* (Rao, 1935), age and growth, fishery and biology of *Cynoglossus semifasciatus* by Seshappa and Bhimachar (1951, 1954, 1955), bionomics on Indian flatfishes (1951), biology of *Pseudorhombus elevatus* (Pradhan, 1959), growth and mortality of *Cynoglossus macrolepidotus* (Kutty, 1966); biology of *Psettodes erumei* (Abraham and Nair, 1976; Devadoss *et al*., 1977; fecundity of the Indian Halibut *Psettodes erumei* from Bay of Bengal (Shafi *et al*.,1978; Hussain,1990), population dynamics of *Cynoglossus macrolepidotus* (Kutty and Qazim, 1969; Ramanathan *et al*. 1977), from Kuwaiti waters by Baz and Bawazeer (1989), Malabar sole from west coast by Seshappa and Chakrapani (1983, 1984), *Cynoglossus macrolepidotus* from Bombay coast by Rao and Dwivedi (1989), biology of *Cynoglossus arel* and *C. lida* by Rajaguru (1992), population dynamics of *Cynoglossus macrostomus* along Calicut coast (Khan and Nandakumaran, 1993), age and growth of Malabar sole (Jayaprakash and Inasu, 1999), food and feeding habits of *Cynoglossus macrostomus* (Jayaprakash, 2000) and by Rekha (2005) on fishery of *Cynoglossus macrostomus* off Cochin. New records during the last few years were that of Joglekar (1973), Rama–Rao (1967), Rekha (2006), Bijukumar (2009).

Morphometric studies on *Cynoglossus semifasciatus*, *Zebrias quagga* and *Pseudorhombus elevatus* were detailed by Chakrapani & Seshappa (1982) and Apte and Rao (1992). In the checklist of estuarine and marine fishes of Parangipettai coastal waters, Ramaiyan *et al*. (1986-1987) reported 32 species. Radhamanyamma (1988) has given an account of flatfishes of Southwest India with detailed information on the biology of *Cynoglossus punticeps*. Twenty five species were listed from the southwestern coast in this work.

3.12 Species differentiation using morpho-meristics

Morphometric and meristic counts have been used over time for species differentiation and continue to be used. Studies on the species discrimination during eighteenth and early 19th century detailed differences in counts (Bloch, 1794; Cuvier, 1816) and measured differences amongst species became part of standard practice by the mid 19th century (Muller and Troschel, 1845, 1849; Cuvier and Valenciennes, 1850; Gunther, 1864). By the mid 20th century, a set of standard linear measurements were finalized. (Hubbs and Lagler, 1958). Since then differences among species were explored commonly by comparing means and ranges of raw measures or ratios of these measures in head or standard length. With more variables and datasets, multivariate techniques like principal component analysis (PCA; Jolicoeur, 1963) that can summarize variables on a single axis also became common practice in the analysis of linear measurements. Several recent works on species differentiation of different fishes include those on Serranid species (Cavalcanti *et al*., 1999); Mediterranean horse mackerel (Turan, 2004); *Selene* species (Filho *et al*., 2006); three flounder species (Vinnikov *et al*., 2007); *Toxotes* species (Simon *et al*., 2010) Epinepheline species (Imam and Mohammad, 2011); *Leporinus cylindriformis* (Sidlauskas *et al.*, 2011) and *Trachurus* species (Karaoglu and Belduz, 2011).

Though there has been some work on Indian flatfishes, a detailed work on the flatfishes and their availability has been lacking in India. The information available is scattered; taxonomic accounts are few, no concise document is available. With revisions in family and genus, many species have changed their valid status, some synonyms have become valid names and vice versa. Indian flatfish taxonomy has been neglected over the last two decades. With India being a party to the CBD, documentation of its diverse fauna is a must; information of what resources are available and what resources have been lost during the past few years is lacking. Hence this specific work is a step in this direction and it is of utmost relevance in the present day.

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Chapter 4

RESULTS

Contents

4.1 Samples collected

Based on the collections from different parts of South India and Andaman Islands during the period 2004-2010, 63 species of flatfishes belonging to 8 families and 26 genera have been collected.

4.2 Collections

The samples were collected from trawler landings at Karwar, Mangalore, Calicut, Kochi (Fort Kochi, Cochin and Munambam Fisheries Harbour), Quilon (Neendakara and Sakthikulangara Fisheries Harbour) on the west coast and Tuticorin, Mandapam, Rameswaram, Pambam, Kovalam, Chennai, Vishakapatnam on the east coast. Besides these, deep sea samples were collected from trawler vessels operating at 200-400 m depth on the West coast as well as from Fisheries Research Oceanographic Vessel *Sagar Sampada* off Vishakapatanam on the East coast. In addition to these locations, landings by small vessels at Andaman Islands were also observed (Fig.3). The list of flatfishes collected from different locations in India is given family wise and genus wise herewith.

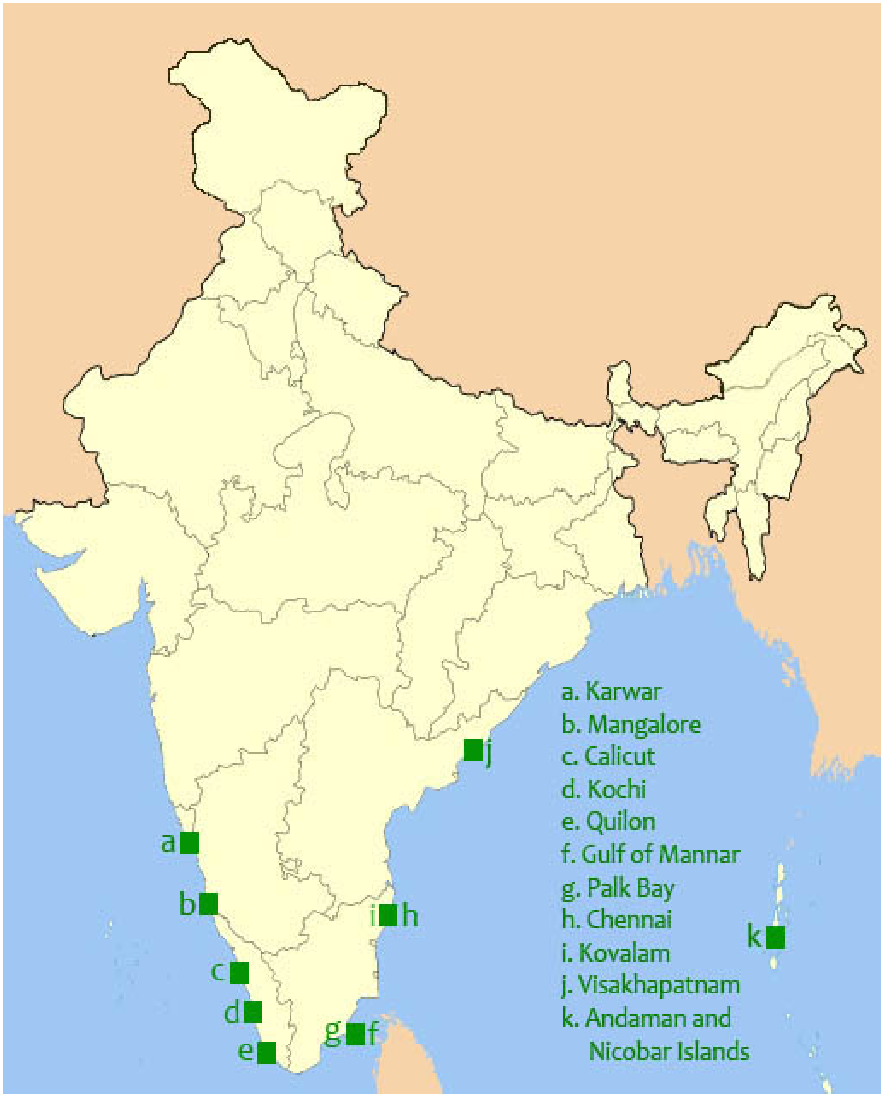


Fig. 3 Sites from where samples were collected for the present study.

4.3 Classification of Order Pleuronectiformes

The Order Pleuronectiformes comprises of a highly distinctive group with bilaterally symmetrical larvae and highly asymmetrical, strongly compressed adults with a flat eyeless or blind side and a convex eyed side. Both eyes are on upper side and protrude above the body surface allowing the fish to see when lying buried in the sand. The upper eye is migratory and moves by torsion as the larvae metamorphose into adult. Adults are either sinistral or dextral. Dorsal and anal fin bases long, mostly with branched or unbranched rays; caudal fin with 17 rays, caudal peduncle region highly reduced; pelvic fins with 6 rays generally, pectoral and pelvic fins sometimes absent, symmetrical, in some, pectoral on blind side reduced; eyes either contiguous or widely spaced, interorbital region scaly or naked, generally concave. Eyed side is pigmented, blind side usually white, unpigmented, in some, coloured patches present. Lateral line sometimes absent on blind side. Body cavity very small, adults without swim bladder. Body covered with scales (cycloid, ctenoid or tuberculate) which are sometimes deciduous. Young flatfish larvae are bilaterally symmetrical and swim upright, but early in their development, between 10-25 mm in length, 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 eyeless side (blind side) (Nelson, 2006). Asymmetry may also be reflected in other characters such as dentition, squamation and paired fins. Most species have both eyes on the right side and lie on the left side. In some species like *Psettodes erumei*, both dextral and sinistral individuals may occur. In the present study, the classification of flatfishes by Nelson (2006) is followed. List of fishes collected family wise is also given. As per this classification, the order is divided into three suborders.

Suborder Psettodoidei

Body elliptical, dorsal fin arising above the maxillary, not extending onto front region of head, anterior rays spinous; first two rays of anal fin spinous; eyes either sinistral or dextral; nostrils placed in front of interorbital space. Mouth large, teeth on jaws barbed, palatine toothed with a single row; anus on mid-ventral line of body. The suborder has only one Family with one genus – Family Psettodidae and Genus *Psettodes.*

4.3.1 Family Psettodidae

The psettodids or toothed flounders are the basal group of flatfishes hypothesized to be the sister group for the Pleuronectoidei. The family is represented by one genus *Psettodes* and three species. The members of this family have widespread distribution throughout the Indo-West Pacific from East Africa to southern China, through Indonesia and northern Australia, and eastward to the Philippines. In the present work only one species was recorded.

4.3.1.1 Genus *Psettodes*

Psettodes erumei (Bloch and Schneider, 1801)

Suborder Pleuronectoidei

Body elliptical, dorsal and anal fins not confluent with caudal. Dorsal origin above eyes, anal fins without spines, palatine without teeth.

The suborder is further divided into three superfamilies; fourteen families are recognized in these superfamilies. Hensley and Ahlstrom (1988) considered this suborder to comprise all fishes except the Psettodidae and soleoid taxa (Cynoglossidae, Achiridae and Soleidae). Chapleau and Keast (1988) suggested the suborder described by Hensley and Ahlstrom (1988) as paraphyletic and also recommended that the

Pleuronectinae, Poecilopsettinae, Rhombosoleinae and Samarinae be raised to family rank.

Superfamily Citharoidea

Pelvic fins with only one spine; rest rays. Pelvic fin base short. Posterior nostril on blind side not prominent.

4.3.2 Family Citharidae

Commonly called large scale flounders, citharids are reported to occur in Mediterranean waters and in the Indo-west Pacific from Japan to Australia. The family is represented by five genera and six species in the world; in the present work, one genus with one species has been obtained.

Body elongate, compressed. Eyes dextral, separated by a narrow interorbital ridge. Scales large, deciduous. Dorsal fin extending onto head atleast to eyes; dorsal origin on blind side. Dorsal and anal fins without spines; palatine without teeth.

Subfamily Brachypleurinae is Indo – Pacific in distribution.

4.3.2.1 Genus: *Brachypleura*

Brachypleura novaezeelandiae Gunther, 1862

Superfamily Pleuronectoidea

4.3.3 Family Paralichthyidae

They are popularly called sand flounders and are seen in marine habitats. Eyes sinistral, pelvic fin bases short, nearly symmetrical, but position of bases variable in species. Pectoral rays branched. Around 16 genera have been reported from over the world, only two genera with 8 species collected in the present study; the genera are *Cephalopsetta* and *Pseudorhombus*.

4.3.3.1 Genus: *Pseudorhombus*

Pseudorhombus argus Weber, 1913

Pseudorhombus arsius Hamilton, 1822

Pseudorhombus diplospilus Norman, 1926

Pseudorhombus dupliciocellatus Regan, 1905

Pseudorhombus elevatus Ogilby, 1912

Pseudorhombus javanicus Bleeker, 1853

Pseudorhombus natalensis Gilchrist, 1905

Pseudorhombus triocellatus (Schneider, 1801)

4.3.3.2 Genus *Cephalopsetta*

Cephalopsetta ventrocellata Dutt and Rao, 1965

4.3.4 Family Bothidae

Subfamily Bothinae:

They are commonly called left eye flounders. Eyes sinistral, pelvic fin base on the ocular side longer than that of the blind side and place on the midventral line of the body, its origin well in front of the pelvic finbase on the blind side. Pectoral and pelvic finrays not branched, all rays, no spine. 23 genera with about 140 species reported worldwide; in the present study, 9 genera with 16 species have been collected.

4.3.4.1 Genus *Arnoglossus*

Arnoglossus aspilos (Bleeker, 1851)

Arnoglossus taepinosoma (Bleeker, 1866)

4.3.4.2 Genus *Bothus*

Bothus myriaster (Temminck and Schlegel, 1846).

Bothus pantherinus (Ruppell, 1821)

4.3.4.3 Genus *Chascanopsetta*

Chascanopsetta lugubris Alcock, 1894

4.3.4.4 Genus *Crossorhombus*

Crossorhombus azureus (Alcock, 1889)

4.3.4.5 Genus *Engyprosopon*

Engyprosopon grandisquama Temminck and Schlegel, 1846
Engyprosopon maldivensis (Regan, 1908)
Engyprosopon mogkii (Bleeker, 1834)

4.3.4.6 Genus *Grammatobothus*

Grammatobothus polyopthalmus (Bleeker, 1865)

4.3.4.7 Genus *Laeops*

Laeops guentheri Alcock, 1890
Laeops macropthalmus (Alcock, 1889)
Laeops natalensis Norman, 1931
Laeops parviceps Gunther, 1880

4.3.4.8 Genus *Neolaeops*

Neolaeops micropthalmus (von Bonde, 1922)

4.3.4.9 Genus *Parabothus*

Parabothus polylepis (Alcock 1889).

Super family Soleoidea

4.3.5 Family Poecilopsettidae

These are commonly called big eye flounders due to their big eyes. Origin of the dorsal fin above the eyes, lateral line rudimentary on blind side, pelvic fins symmetrical. Worldwide 3 genera with 20 species have been reported. In the present study only one genus with 4 species have been collected.

4.3.5.1 Genus *Poecilopsetta*

Poecilopsetta colorata Gunther, 1880
Poecilopsetta inermis (Breder, 1927)
Poecilopsetta natalensis Norman, 1931
Poecilopsetta praelonga Alcock, 1894

4.3.6 Family Samaridae

They are also called crested flounders. Reported from marine tropical and subtropical waters of the Indo – Pacific mainly from deep waters. Dorsal fin origin is in front of the eyes; lateral line well developed, pelvic fins symmetrical. 3 genera with over 20 species reported worldwide, in the present study one genus with one species recorded.

4.3.6.1 Genus *Samaris*

Samaris cristatus Gray, 1831

4.3.7 Family Soleidae

Soles have eyes dextral in position, margin of the preoperculum concealed completely, dorsal and anal fins not contiguous with caudal in some, in some contiguous. Pelvic fins free and not attached to anal fin. According to Eschmeyer (Catalog of Fishes, 2010, online), Family Soleidae is represented by 20 genera and 165 species; the type localities of 12 species is in India. According to Catalogue of Life (2010, online) 27 genera are represented in Family Soleidae. In the present study, 9 genera with 19 species have been reported.

4.3.7.1 Genus *Aseraggodes*

Aseraggodes kobensis (Steindachner, 1896)

Aseraggodes umbratilis (Alcock 1894).

4.3.7.2 Genus *Aesopia*

Aesopia cornuta Kaup, 1858

4.3.7.3 Genus *Brachirus*

Brachirus annularis Fowler, 1934

Brachirus orientalis (Bloch and Schneider, 1801)

Brachirus pan (Hamilton, 1822)

4.3.7.4 Genus *Heteromycteris*

Heteromycteris hartzfeldii (Bleeker, 1853)

Heteromycteris oculus (Alcock, 1889)

4.3.7.5 Genus *Liachirus*

Liachirus melanospilus (Bleeker, 1854)

4.3.7.6 Genus *Pardachirus*

Pardachirus marmoratus (Lacépède, 1802)

Pardachirus pavoninus (Lacépède, 1802)

4.3.7.7 Genus *Solea*

Solea ovata Richardson, 1846

4.3.7.8 Genus *Synaptura*

Synaptura albomaculata Kaup, 1858

Synaptura commersoniana (Lacépède, 1802)

4.3.7.9 Genus *Zebrias*

Zebrias cochinensis, Rama Rao, 1967
Zebrias crossolepis Zheng and Chang 1965
Zebrias japonicus (Bleeker, 1860)
Zebrias synapturoides (Jenkins, 1910)
Zebrias quagga (Kaup, 1858).

4.3.8 Family Cynoglossidae

Commonly called tonguefishes; they have eyes sinistral. Preopercular margin concealed by skin and scales; dorsal and anal fins contiguous with caudal, caudal pointed in most cases. Pelvic fin may/may not be attached to anal fin. Pectoral fin absent; eyes very small, placed close together, mouth assymetrical. The family is divided into two subfamilies – Symphurinae and Cynoglossinae. Three genera with 127 species reported; in the present study, 2 genera with 12 species were collected in subfamily Cynoglossinae.

Subfamily Cynoglossinae

Snout hooked, mouth assymetrical, inferior. Lateral lines well developed on the ocular side. Lips fringed in *Paraplagusia*, plain in *Cynoglossus*. Most of the species occur in sandy beds and are burrowing forms, some are collected from brackish and freshwaters.

4.3.8.1 Genus *Cynoglossus*

Cynoglossus acutirostris Norman, 1939
Cynoglossus arel (Bloch and Schneider, 1801)
Cynoglossus bilineatus (Lacépède, 1803)
Cynoglossus carpenteri Alcock, 1889
Cynoglossus cynoglossus (Hamilton, 1822)

Cynoglossus dubius Day, 1873

Cynoglossus itinus (Snyder, 1909).

Cynoglossus lida (Bleeker, 1851).

Cynoglossus macrolepidotus (Bleeker, 1851)

Cynoglossus macrostomus Norman, 1928

Cynoglossus punticeps (Richardson, 1846)

4.3.8.2 Genus *Paraplagusia*

Paraplagusia bilineata (Bloch 1787)

4.3.1 Family Psettodidae

Psettodids are toothed flounders and a basal group of flatfishes. This family is represented by only one genus–*Psettodes*. These large flatfishes with both sinistral and dextral individuals are characterized by several derived internal features discussed in Chapleau (1993). Externally, these fishes are easily recognized by such pleisomorphic characters as the posterior location of the dorsal fin, which does not advance onto the cranium anterior to the eyes, occurrence of spines in dorsal and anal fins, large mouth with specialized teeth, and nearly rounded bodies without the obvious bilateral symmetry in lateral musculature development evident in other flatfishes (Munroe, 2005).

Two species of *Psettodes* occur in tropical marine waters, the spot tail spiny turbot, *Psettodes belcheri*, found off tropical West Africa and the Indian spiny turbot, *P. erumei* with wide spread distribution throughout the Indo-West Pacific from East Africa to Southern China, through Indonesia and northern Australia and eastward to Philippines. According to Talwar and Kacker (1984), the family contains a single genus with three species of which one species is available in India.

Review of observations done by various workers on Family Psettodidae is given in Table 1.

Table 1: Review of observations done by various workers on Family Psettodidae

Genus	Synonym	Type	Observations			
			Jordan	Bleeker	Norman	Eschmeyer
Psettodes Bennett 1831	***Psettodes*** Bennett 1831	*Psettodes belcheri* Bennett	orthotype		synonym	**VALID**
		Hippoglossus erumei Bleeker	-	type	-	
	Sphagomorus Cope 1867	*Pleuronectes erumei*	-		-	Synonym of *Psettodes*

4.3.1.1 Genus *Psettodes* Bennett, 1831

Psettodes Bennett, 1831, *Proc. Comm. Zool. Soc.*, (12):147 (Type: ***Psettodes belcheri*** **Bennett**); Norman, 1934, *Syst. Monog. Flatfish.*, 1: 57; Ahlstrom *et al*., 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 640; Heemstra, 1986, *Smith. Sea Fish.,*: 853; Lindberg and Fedorov, 1993, *Handbook Iden. Anim.,*:166 : 11; Li and Wang, 1995, *Fauna Sinica*: 100; Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3792; Hoese and Bray, 2006, *Zoo. Cat. Aust.,*: 1804.

Sphagomorus Cope, 1860, *Trans. Amer. Phil. Soc. Philad.*, XIII: 407 (Type: ***Pleuronectes erumei*** **Schneider**).

Dorsal fin arising above the posterior end of maxillary, anterior rays of dorsal fin spinous, others branched. Anal fin and dorsal fin similar in shape. First two rays of anal fin spinous, rest branched. Pectoral fin on eyed side bigger, the first two rays simple, rest branched.

Pelvic fins small, symmetrical in shape with one spine and five short rays. Caudal fin 24 in number, 15 rays branched. Lateral line well developed on both sides, with a slight curve above pectoral fin. Teeth present in two rows, each teeth with an inward curve, sharp and prominent. Gill rakers palmate each with a barbed tip.

Taxonomic remarks

The genus *Psettodes* was erected by Bennett in 1831 based on the species *Psettodes belcheri*. Cantor (1849) placed these fishes in Genus *Hippoglossus* in Order Anacanthini, Family Pleuronectidae. Bleeker (1857) described Genus *Psettodes* with the following characters "*teeth present in uniserial in pattern on vomer, palatine, in biserial in order on maxilla. Dorsal and anal fin rays free. Maxilla ends below posterior portion of eye*". In 1862, Gunther placed Genus *Psettodes* in Family Pleuronectidae which was continued by Day (1889) and Alcock (1889). However, according to Boulenger (1881), the flatfishes have been derived from symmetrical deep bodied fishes with a short body cavity, represented by the Eocene *Amphistium*. Bowers (1906) placed *Psettodes* in Family Pleuronectidae along with *Pseudorhombus*, *Scaeops*. Regan (1910) first drew attention to the perch characters of *Psettodes* which he regarded as the most generalised member of the Heterosomata and simply an "*asymmetrical percoid*". Regan (1910) further compared the osteology of *Psettodes* and Gadoids and clearly pointed out the differences –

1) Spinous rays of the dorsal and spinous first ray of pelvics in *Psettodes* is absent in Gadoids.
2) Direct attachment of the pelvic bones in *Psettodes* compared to attachment with a ligament in Gadoid.

3) 17 rays in caudal, 15 branched in *Psettodes.*

4) Absence of air bladder in adult *Psettodes*.

5) Well developed pseudobranchiae in *Psettodes* which is absent in Gadoids.

6) Small opisthotic bone which is large in Gadoids.

Weber (1913) described *Psettodes* with "*dorsal origin behind eye, both sides of body with ctenoid scales*" and placed the genus in Family Pleuronectidae, subfamily Psettinaae. Ogilby (1916:132) while describing the Queensland Halibut *Psettodes erumei* mentions "*it is probable that this species which exhibit this divergence from the common law in a more marked degree are more directly descended from their percoid ancestory, than those which have developed a more constant dextrality or sinistrality*". Kyle (1921:119) says that "*it is the most recent addition to the ranks of the Heterosomata. Its indeterminate character, sinistral or dextral, as well as the structure of the mouth and cheek muscles, indicate that it is a near relative of some present day genus of normal teleosts, eg. of Lichia among the Carangidae*". According to Tate Regan (1929:214, 324) "*Except for its asymmetry and the long dorsal and anal fins, Psettodes is a typical perch and might almost be placed in the Serranidae….. It may have retained so many percoid features because it has not adopted progression along the bottom by undulatory movements of the body and marginal fins to the same extent as other flatfishes*." Amaoka (1969) considered *Psettodes* as the most "*primitive*" flatfish, but proposed in a polyphyletic origin of the order from an ancestral percoid stem. But as did Chabanaud (1949), Amaoka did not define clearly the "*percoid stem*". Psettodids are hypothesized to be the sister group for the Pleuronectoidei.

4.3.1.1.1 *Psettodes erumei* (Bloch and Schneider, 1801)

Indian halibut

Pleuronectes erumei Bloch and Schneider, 1801, *Syst. Ichth.*,: 150 (Tranquebar, India); Bleeker, 1857, *Act. Soc. Sc. Indo-Neerl.,* II: 9 (Amboina); Bleeker, 1858, *Act. Soc. Sc Indo-Neerl.*, III: 28 (Trussan, Padang, Priaman Sumatra).

"*Adalah*" *Nooree Nalaka*" Russell, 1803, *Descr. Fish. Vizag.*, I: 54, 60, pls. lxix, lxxi (Coramendal coast).

Hippoglossus erumei Ruppell, 1828, *Atl. Reise Nordl. Africa*:121 (Massaua); Ruppell, 1835-1840, *Neue Wirb. Abyss. Fische*: 84; Bleeker, 1852, *Verh. Bat. Gen.,* XXIV:13 (Batavia); Cantor, 1849, *J. Asiat. Soc. Bengal*, XVIII: 1198, 1200 (Sea of Penang, Malayan Peninsula, Coramendal, Bay of Bengal, Ganges estuaries, Massauah); Duméril, 1859, *Arch. Mus. Hist. Nat. Paris.*, X: 264 (West Africa).

Pleuronectes nalaka Cuvier 1829, *Regne Animal,* II: 340 (type locality: Vizagapatam, India).

Hippoglossus dentex Richardson 1845, *Voy. Sulph. Fish.*,: 102, pl. 47 (Southern coast of China); Richardson, 1846, *Rept. Brit. Assoc.*, 15 : 278.

Hippoglossus goniographicus Richardson 1846, *Rep. Brit. Ass. Adv. Sci.*,: 279 (Canton, China, coast of China).

Psettodes erumei Gunther, 1862, *Cat. Brit. Mus.*, IV: 402 (Red Sea, British India, Pinang); Gunther, 1866, *Fish. Zanzibar*, 112 (Red Sea); Bleeker, 1866-1872, *Atl. Ichth.,* VI: 4; Capello, 1872, *J. Sci. Math. Phys. Nat. Acad. Lisboa*: 86 (Bissau, West Africa); Klunzinger, 1870, *Fische Rothen Meeres*: 570 (Koseir, Red Sea); Boulenger, 1887, *Proc. Zool. Soc.*

London: 665 (Muscat); Day, 1878 -1888, *Fish. India*: 422, pl.91, fig. 4 (Indian Seas); Day, 1889, *Fauna Brit. India, Fish,* 2 : 439, fig. 155 (Indian seas); Alcock, 1889, *J. Asiatic Soc. Bengal,* 58 (2) : 280 (False Point to Ganjam, 10-23 fathoms); Regan, 1905, *J. Bombay Nat. Hist. Soc.,* 16(2) : 330 (Persian Gulf); Evermann and Seale, 1907, *Bull. Bur. Fish.*, 26:106 (San Fabian); Bowers, 1907, *Bull. Bur. Fish.*, XXVI: 45 (Cavite); Steindachner, 1907, *Denk. Ak. Wien,* 71 (1): 166 (E. Arabia); Jenkins, 1909, *Rec. Ind. Mus.*, 3:24 (Elephant point, Santapalii, Gopalpur); Jordan and Richardson, 1910, *Checklist. Phillipine Fish.,* : 53; Weber, 1913, *Die Fische der Siboga Exped.*, LVII : 420 (Rothen Mer); Regan, 1915, *Ann. Mag. Nat. Hist.*, *London* (8) XV: 129 (Lagos); Norman, 1927, *Rec. Ind. Mus.*, 29, pt. 1: 8, fig. 1 (Persian Gulf, Muscat, Gulf of Oman, Andaman Sea, Orissa, Madras); Weber and Beaufort, 1929, *Fish. Indo-Austr. Arch.,* V: 97, fig. 24 (Malay, Batavia); Norman, 1934, *Syst. Monog. Flatfish.*, 1: 37, fig. 30 (Muscat); Tortonese, 1935-36. *Bull. Mus. Zool. Anat. Comp. Un. Torino*, 45, ser.3, 63: 20 (Red Sea; Massaua); Fowler, 1936, *Bull. Amer. Mus. Nat. Hist.*, LXX: 495 (Senegambia, Cape Blanco); Okada and Matsubara, 1938, *Key. Fish. Japan*: 415 (Formosa, East Africa, Red Sea); Blegvad, 1944, *Danish Sci. Invest. Iran*, III: 197 (Jask, Iranian Gulf); Liang, 1951, *Taiwan Fish. Res. Inst. Rep.*, 3: 35; Herre, 1953, *Checklist Philippine Fish.*,: 176 (Red Sea, East Africa, Japan); Blegvad, 1944. *Danish Sci. Invest. Iran*, pt. 3: 197, fig. 121 (Jask); Smith, 1949, *Sea Fish. S. Africa*: 15 (Kalankan, East Indies); Matsubara, 1955, *Fish. Morph. Hierar.*, II: 1248, fig. 477 (Formosa, China Sea, Red Sea, East Africa); Munroe, 1955, *Fishes of Ceylon*: 256, pl. 49, fig.741; Chen, 1956, *Synop. Vert. Taiwan*: 96 (Formosa); Fowler, 1956, *Fish. Red Sea and Southern Arabia*, I: 59 (Sumatra, Hong Kong, Manila); Fourmanoir, 1957, *Mem. de l'institute*

Scientifique de Madagascar, Tome I: 42 (Mozambique); Menon, 1961, *Rec. Ind. Mus*., 59(3): 399 (Tranquebar); Smith, 1961, *Sea Fish. S. Africa*: 155 (Indo–Pacific, Delagoa Bay); Smith and Smith, 1963, *Fish. Seychelles*: 11 (South Africa) pl. 7, fig. 1; Marshall, 1964, *Fish. Great Barrier Reef*: 451, pl. 62, fig. 439 (Pacific Ocean, Queensland); Chen and Weng, 1965, *Biol. Bull. Tunghai Univ*., 25: 5, fig. 2; Amaoka, 1969, *J. Shimonoseki Univ. Fish*, 18(2): 72, fig. 1 (Tonking Bay); Fowler, 1972, *Fish. China*: 165 (China, Canton); Relyea, 1981, *Inshore Fish. Arab. Gulf*: 122, (Arabian Gulf); Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 842, fig. 346 (Bombay, Madras); Allen and Swainston, 1988, *Marine Fish F.W Australia*: 46; Krishnan and Menon, 1993, *Rec. Ind. Mus*., 93 (1-2): 210 (Kakinada, Gopalpur); Li and Wang, 1995, *Fauna Sinica*: 101; Randall, 1995, *Coastal Fish. Oman*: 354; Evseenko, 1996, *J. Ichth*., 36 (9): 57 (Southern Ocean); Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 584 (Malaysia); Allen, 1997, *Marine Fish. Austr.,*: 234; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide*: 228; Chen *et al*., 1997, *Fish. Nansha Island.,*: 174 (South China); Fricke, 1999, *Fish. Mascarene Islands*: 569; Mishra and Sreenivasan, 1999, *Rec. Zoo. Surv. India*, 97 (2): 253; Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl*., 8: 644 (South China Sea); Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (1): S121; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India. Occ. Paper*, 216: 45 (Pondicherry, Karaikal).

Material examined: N=2, TL 126.2 mm and 180.25 mm from Kochi and Chennai Fisheries Harbours.

Diagnosis: Upper eye on dorsal surface of head, mouth with sharp pointed teeth. Preopercular margin easily seen, not hidden by skin or scales; pelvic fins with one spine and 5 soft rays.

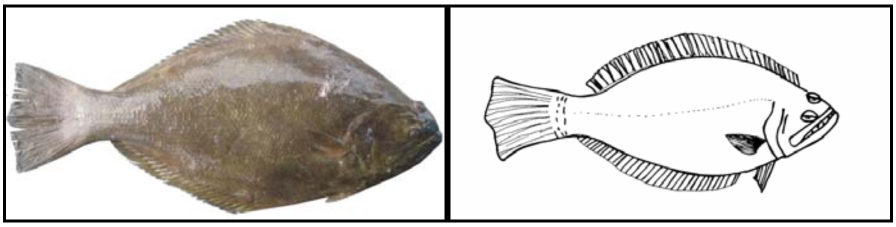


Plate I *Psettodes erumei* (Bloch and Schneider, 1801)

Meristic counts: D 51 - 55 (53); A 37 - 39 (38); P_1 14 – 15 (15); C 16.

Body proportions as percent of SL (mean in parentheses): HL 29.96 - 31.5 (30.7); HW 33.2 – 40 (36.6); HD 19.7 – 23.98 (21.9); ED_1 4.9 – 6.7 (5.8); ED_2 3.8 - 6.3 (5.1); ID 1.9–2.8 (2.3); $PrOU_1$ 6.1 – 6.9 (6.5); PrOL 3.8 – 8.97 (6.4); PBU 17.4 – 20.4 (18.9); PBL 17.03; BD_1 29.6 – 42.8 (36.2); BD_2 42.8; UJL 21.1-23.1 (22.1); LJL 17.3 – 21.8 (19.5); CD 5.5 - 6.8 (6.2); DFL 10.9 – 13.5 (12.2); AFL 9.1 – 11.1(10.1); P_1FLO 12.3 – 12.8 (12.5); P_2FLB 13.3 – 14.4 (13.9); V_1FLO 7.8 – 9.2 (8.5); V_2FLB 9.44; CFL 16.9 – 20.1 (18.5); DFL 57.99 – 69.2 (63.6); ABL 54 -56 (55); P_1BLO 3.02 – 3.1 (3.04); P_2BLB 3.6; V_1BLO 2.9 - 3.01 (2.95); V_2BLB 1.7; CBL 12.6; CPD 10.86; PDL 18.8 -38.95; PAL 40.2 – 41.7 (40.98); P_1LO 29.8 – 33 (31.4); P_2LB 29.6; V_1LO 29.8 – 32.5 (30.4); V_2LB 30.4.

As percent of HL (mean in parentheses): HW 110.7 - 125.4 (118.1); HD 80 – 100 (90); ED_1 16.4 – 31.5 (23.9); ED_2 12.7 – 40 (26.4); ID 6.2 - 19.7 (12.97); P_rOU 6.7 - 23.2 (14.9); P_rOL 6.3 – 12.8 (9.6).

Description: Body oval in outline, not deeply compressed. Body depth 2.9 times in standard length. Prominent head, eyes placed apart, separated by a flat, scaled area of moderate width; the upper eye placed nearly on the dorsal profile; lower eye slightly smaller than upper eye, placed posterior to upper eye, upper eye diameter 1.3 times the lower eye, 2.7 times the interorbital width; post orbital contained 4.8 times in head length. A comparative statement of the meristic characters of *Psettodes erumei* is given in Table 2.

Table 2: A comparative statement of the meristic characters of *Psettodes erumei*

Meristic Characters	Earlier workers														Present study 2004-2010	
	Bloch 1801	Cantor 1850	Bleeker 1852	Gunther 1862	Day 1877, 1889	Weber & Beaufort 1929	Norman 1934	Blegvad 1944	Munroe 1955	Fowler 1956	Fourmanoir 1957	Smith 1961	Amaoka 1969	Smith 1986	(N = 2)	Mean ± SD
Dorsal rays	59	48-53	16-17/36 - 19/34	47-53	47-56	49-54	50-56	47	50-56	50-53	48-54	50-56	52-56	38-45	51 - 55	53 ± 2.8
Anal rays	45	35-39	9/29-9/30	35-41	34-41	36-44	34-43	37	34-43	37-43	34-43	34-43	37- 43	33-42	37 - 39	38 ± 1.4
Pectoral	14	14-15	2/12-3/11	*	16	14/15	14-16	16	*	*	*	*	14(0)/ 14(13)	14-16	14 -15	15 ± 0.71
Caudal	16	*	16-18	*	17		17	*	*	*	*	*	*	*	16	16 ± 1
Lateral line scales	*	*	*	75	70-75	72-77	68-76	*	68-76	*	*	68-76	65-72	68-75	68	68
Gill rakers	*	*	*	*	*	*	*	*	*	*	*	*	18-20	*	*	*

*Data not available

Teeth biserial on upper jaw, outer row of teeth curved inside. Teeth on lower jaw biserial, more closely placed than that of upper jaw. Body covered with ctenoid scales on ocular side. Each scale oval in structure with 12–15 lines radiating from centre to tip. Tiny ctenii present on pigmented portion of each scale. Maxillary ends well behind the posterior margin of lower eye, 1.4–1.7 times in head length and 4.3–4.7 times in SL. Nostrils close together, the lower one in front of the interorbital space. Lateral line continuous, arising from the upper free end of the operculum and extending upto caudal fin origin, 68 scales placed on the lateral line. Single dorsal fin not extending onto head with 51–55 rays, anal with 37–39 rays, pectoral with 14–15 rays, caudal fin double truncate with 15 branched and 2 unbranched rays.

Colour: Body brownish – grey with faint four transverse bands; dorsal and anal fins and posterior part near caudal fin darker brownish black.

Distribution:

World: Reported from Red Sea, British India, Pinang (Gunther, 1862, 1866); Malayan Peninsula, Madagascar, Comores, L'ile Europa (Fourmanoir, 1957); Massaua (Ruppell, 1828); Red Sea (Klunzinger, 1870); Muscat, Gulf of Oman (Boulenger, 1887, Norman, 1927); Persian Gulf (Regan, 1905); East Arabia (Steindachner, 1907); Red Sea, Massaua (Tortonese, 1935-36); Persian Gulf (Regan, 1905); Lagos (Regan, 1915); Malay, Batavia (Weber and Beaufort, 1929); Senegambia, Cape Blanco (Fowler, 1936); Tonking Bay (Amaoka, 1969); Arabian Gulf (Relyea, 1981); South China Sea (Randall and Lim, 2000); South China (Chen *et al.*, 1997); Malaysia (Mohsin and Ambak, 1996); Southern Ocean (Evseenko, 1996). (Localities were *Psettodes erumei* has been recorded in the world are given in Fig.4).

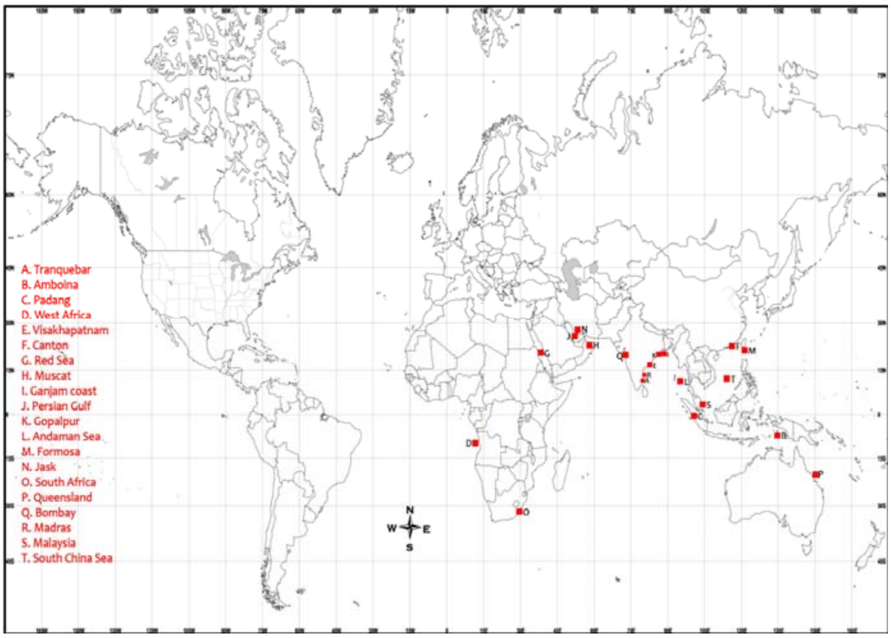


Fig. 4: Map showing localities were *Psettodes erumei* has been recorded in the world.

India: Reported from False Point to Ganjam (Alcock, 1889); Andaman Sea, Orissa, Madras (Norman, 1927); Bombay, Madras (Talwar and Kacker, 1984); Tranquebar (Menon, 1961); Kakinada, Gopalpur (Krishnan and Menon, 1993); Parangipetta (Ramanathan, 1977; Rajguru, 1998), Neendakara (present work). (Localities were *Psettodes erumei* has been recorded in India are given in Fig.5).

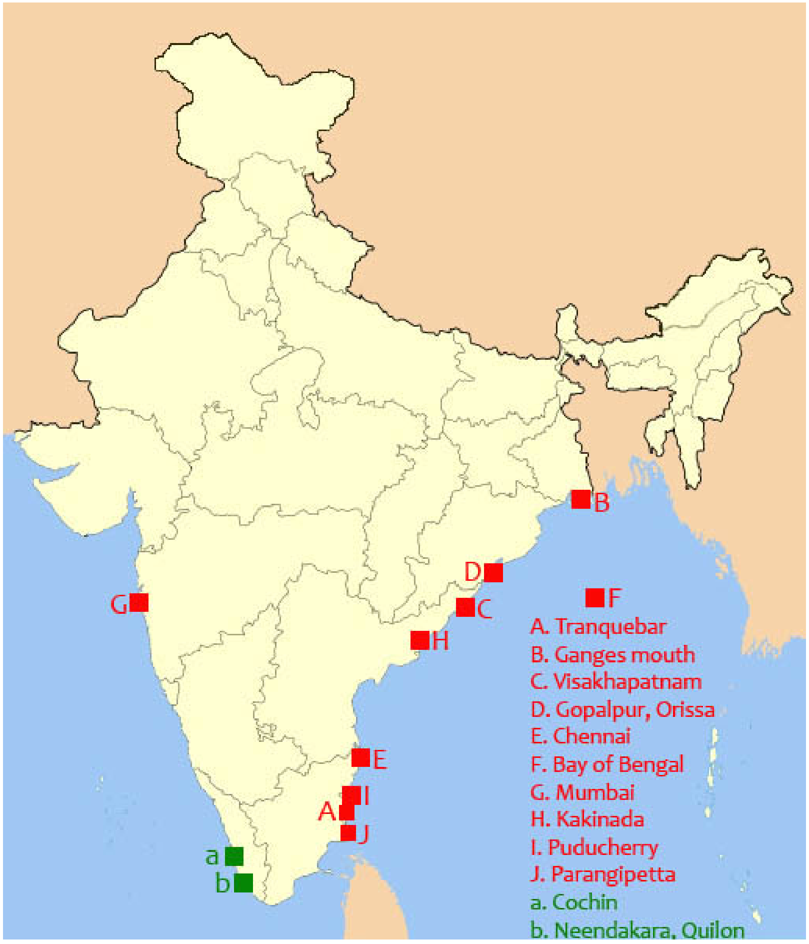


Fig. 5: Map showing localities were *Psettodes erumei* has been recorded in India.

Fishery: Formed a good fishery till 2000 in India, but landings have drastically declined to a 900 tonnes in 2007 and 1000 tonnes in 2008. Reports of landings in Kerala show that the fishery stock has been depleted (CMFRI, 2008-09).

Taxonomic comments: The species *Psettodes erumei* was first described as *Pleuronectes erumei* by Bloch and Schneider in 1801 based on a sample collected from Tranquebar, India (ZMB 7404, right skin). Russell (1803) in his '*Descriptions of the fishes of Vizagapatnam*' named it "*Nooree Nalaka*". The fish was placed in genus *Hippoglossus* and described as *Hippoglossus erumei* by Ruppell (1828). Subsequently, the fish was described as *Pleuronectes nalaka* by Cuvier based on a sample from Vishakapatnam. Descriptions are not available but only a footnote as "*Pleuronectes erumei*, Bl. Schn., *ou adalah*, Russel, 1, 69; *Pl. nalaka*, N., ou *Norée nalaka*, Russel, 77. Gunther (1862) placed this fish in Genus *Psettodes* and synonymised *Pleuronectes nalaka, Hippoglossus goniographicus* and *Hippoglossus dentex* with *Psettodes erumei*. Regan (1910) placed *Psettodes erumei* in Order Heterosomata, suborder Psettodoidea. The species according to Regan "*has no gill rakers, and the strongly toothed mouth is larger than in any other flatfish; this is evidently a predaceous fish, which probably lies on the bottom, concealed from its prey, and then darts out, swimming rapidly for a short distance by lateral movements of the tail. Probably it has retained so many Percoid features because it has not adopted progression by undulating movements of the body and marginal fins to the same extent as other fishes of this order.*" Weber and Beaufort (1929) comments that "*P. belcheri Bennett from the West coast of Africa, which has been united with this species, differs in having smaller species*".

Observations: Bloch in his work has described *Psettodes erumei* with 59 dorsal fins, but in the work of Weber and Beaufort (1929) the fincount was in the range 49 - 54. Lower fincounts were observed by Smith (1986) and Blegvad (1944) from African waters for both dorsal and anal fin rays. The counts given by Gunther (1862) and Day (1877, 1889) match well with that of the descriptions by Cantor (1850). Results of the correlation coefficient analysis done on non-meristic characters of *Psettodes erumei* is given in Table 3. The ratio of the body depth and head length to SL for the present specimens matches well with that of Randall (1955) (2.3 - 2.5; 3.2 –3.6).

Table 3: Results of the correlation coefficient analysis on non-meristic characters of *Psettodes erumei*

Characters	Ratio/ Range in SL	Mean	SD
Head length	3.2 - 3.3	3.26	0.11
Head depth	4.2 - 5.1	2.76	0.64
Eye diameter (U)	20.4 - 23.6	17.70	2.3
Interorbital width	35.8 - 53.8	44.79	12.68
Body depth	2.3 - 3.4	2.86	0.74
Upper jaw length	4.3 - 4.7	4.53	0.29
Lower jaw length	4.6 - 5.8	5.19	0.85
Chin depth	14.6 -18.3	16.46	2.58
Dorsal fin length	7.4 - 9.2	8.28	1.26
Anal fin length	9.1 - 11	10.04	1.4
Pectoral fin length (O)	6.99 - 8.2	7.99	0.83
Pectoral fin length (B)	7.5 - 12.9	7.23	3.79
Pectoral base length (O)	32.6 - 33.1	32.87	0.35
Pectoral base length (B)	33.2 - 34.7	33.95	1.08
Pre dorsal length	2.6 - 5.3	3.95	1.95
Pre anal	2.4 - 2.5	2.44	0.06
Pre pectoral length (O)	3.03 - 3.4	3.19	0.23
Pre pelvic length (O)	3.1 - 3.4	3.22	0.2
Characters	**Ratio/Range in HL**	**Mean**	**SD**
Head width	0.8 - 0.9	0.85	0.08
Head depth	1.3 - 1.6	1.42	0.24
Eye diameter (U)	4.7 - 6.1	5.42	0.97
Interorbital width	11.3 - 16.1	13.69	3.42
Post orbital	4.3 - 5.2	4.75	0.61
Body depth	0.7 - 1.0	0.87	0.20
Upper jaw length	1.36 - 1.4	1.39	0.04
Lower jaw length	1.4 - 1.7	1.59	0.20
Chin depth	4.6 - 5.5	5.04	0.62
Dorsal fin length	2.3 - 2.8	2.54	0.30
Anal fin length	2.9 - 3.3	3.08	0.32
Pectoral finlength (O)	2.4 - 2.5	2.45	0.01
Pectoral finlength (B)	2.2 - 2.3	2.22	0.05
Caudal finlength	1.6 - 1.8	1.67	0.15
Anal fin length	0.55 - 0.6	0.56	0.01

4.3.2 Family Citharidae

Species in this family are commonly called large scale flounders. World over, 5 genera and 6 species have been reported (Nelson, 2006), in the present study, however, only 1 genus with 1 species has been collected. Citharids are flatfishes with pelvic fins with one flexible spine and five soft rays; their gill membranes are more widely separated. These two characters make this family similar to the Psettodids. Body elliptical, deeply compressed; eyes placed close together with a narrow interorbital ridge. Mouth large; posterior nostril on blind side not prominent. Teeth is present on the vomer. Eyes sinistral or dextral, dextral in genus *Brachypleura.* The anus is present on the eyed side of the midventral edge, rather than on the blind side. Pelvic fins equally developed, finbase short. Dorsal fin origin is anterior to eyes. Pectoral fins well developed.

Citharids are said to be distributed in temperate and subtropical seas of Europe and West Africa (*Citharus*); South Africa, throughout the Indian Ocean, the Philippines, Japan and western Australia (*Citharoides*), central and northern Indian Ocean eastward to the Philippines and Australia (*Brachypleura*, *Lepidoblepharon*) in the western Central Pacific.

Taxonomic comments: Hubbs (1945) erected this family by regrouping two genera formerly placed in the Bothidae (sinistral taxa) and Pleuronectidae (dextral taxa). Inclusion of genera featuring opposite ocular asymmetries in the same family deviated radically from earlier traditional hypotheses that had grouped flatfish taxa heavily weighted on ocular symmetry. (Munroe, 2005). Hensley and Chapleau (1984) doubted the monopoly of the family. Chaplaeu's (1993) cladistic analysis of the Order

Pleuronectiformes also confirmed the findings of Hensley and Chapleau (1984). Cooper and Chapleau (1998) suggested that the dextral genus *Lepidoblepharon* is sister to all remaining pleuronectiformes. The sinistral *Citharus* was not shown on the cladogram, but the dextral *Brachypleura* was sister to a clade comprising the four families Scophtalmidae, Paralichthyidae, Bothidae and Pleuronectidae; this clade along with *Brachypleura* was sister to all known Pleuronectiformes. Hoshino (2000, 2001) re-examined the status of five genera and six species placed in the family Citharide and concluded that the fishes form a monophyletic group that should be recognised at family level. Review of observations done by various workers on Family Citharidae is given in Table 4. The family consists of five genera *Brachypleura*, *Citharoides*, *Citharus*, *Lepidoblepharon* and *Paracitharus* of which a species in the genus *Brachypleura* was obtained in the present study.

Table 4: Review of observations done by various workers on Family Citharidae

Genus	Synonym	Type	Observations				
			Jordan	Alcock	Heemstra and Gon	Lindberg and Fedorov	Eschmeyer
Brachypleura Günther 1862		Fem. *Brachypleura novaezeelandiae* Günther 1862	-	-	Valid	Valid	VALID
	Laiopteryx Weber, 1913	*Brachypleura xanthosticta* Alcock 1889	Misspelled *Liopteryx* by Jordan 1920	Type by monotypy	-	-	Synonym

4.3.2.1 Genus *Brachypleura* Gunther, 1862

Brachypleura Gunther, 1862, *Cat. Brit. Mus.*, 4: 419 (type: *Brachypleura novaezeelandiae* Gunther 1862, New Zealand); Hector, 1872, *Fish. New Zealand*: 50 (New Zealand); Weber, 1913, *Siboga Exped.*, 57:

414; Norman, 1934, *Syst. Monog. Flatfish.*, I: 400; Ahlstrom *et al*., 1984, *Am. Soc. Ichth. Herp. Sp. Publ. No.* 1: 640; Li and Wang, 1995, *Fauna Sinica*: 108; Hoshino, 2001, *Ichth. Res*., 48 (3): 391; Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 391; Hoese and Bray, 2006, *Zool. Cat. Australia*: 1808.

Laiopteryx Weber, 1913, *Die Fisch. der Siboga Exped*., LVII: 423 (type: *Brachypleura xanthosticta* Alcock 1889.

Diagnostic character: Scales deciduous, less than 35 in lateral line; snout, jaws, interorbital space and upper parts of orbit not scaled.

Description: Body elliptical, compressed, eyes dextral, place close together separated by a narrow ridge. Head scaled except the snout, jaws and interorbital. Mouth large, gape wide; maxillary ending below the mid-half of the lower eye or a little beyond. Eyes dextral. Gill rakers lanceolate. Teeth sharp, cananiform at the anterior part, well developed in both jaws, biserial, outer row more larger. Dorsal fin origin on blind side, well in front of eye on snout; sheath covering basal part of dorsal fin. In males, first few rays are slightly elongated, filamentous. Anal similar to dorsal. Tip of interhaemal spine does not project in front of anal fin. Pectoral fins equally developed on both sides, rays in the middle branched. Pelvic finrays short on both sides, asymmetrical, ocular well placed in advance of blind side fin. Caudal peduncle short, caudal fin with highly convex ends, middle row branched. Lateral line with less than 35 scales, with a prominent curve above pectoral fin; supra temporal branch absent. Body scales on ocular side ctenoid, those on blind side cycloid with feeble denticulatons. Lateral line straight.

Remarks: Regan (1910) listed *Brachypleura* along with *Paralichthodes* and *Samaris* in subfamily Samarinae in Family Pleuronectidae. Weber (1913) placed *Brachypleura* in subfamily Hippoglossinae along with *Psettodes*, *Samaris* etc. Characters ascribed where "*straight lateral line, vomer with teeth, eyes dextral*". *Brachypleura* was listed by Norman (1927, 1934) as a genus in subfamily Samarinae along with *Lepidoblepharon*, *Samaris* and *Samariscus*, the difference being the large mouth, large denticulated gill rakers and well developed pectorals. The dextral flounder genus *Brachypleura* has only one species *Brachypleura novaezeelandie* which inhabits the deep waters of the Indo–Pacific region. This genus had been recognized as a member of the subfamily Samarinae of the family Pleuronectidae (Regan, 1910; Norman, 1927, 1934).

Laiopteryx was described as a new genus by Weber (1913) to include *Laiopteryx xanthosticta*. Characters assigned were oblique and wide mouth, maxilla about half of the head length, teeth sharp pointed, anterior slightly larger. Amaoka (1972) studied the osteology and relationships of *Brachypleura novaezeelandie* and remarked that "*certain important characters of the genus Brachypleura, however, were found to be different from those of the Japanese citharids. It might be necessary to erect a new subfamily or family for Brachypleura*." However, at present it is placed as a genus in Family Citharidae.

4.3.2.1.1 *Brachypleura novaezeelandiae* Gunther, 1862
Yellow dabbled flounder

Brachypleura novaezeelandie Gunther, 1862, *Cat. Brit. Mus.,* 4: 419 (New Zealand); Hector, 1872, *Fish. New Zealand*: 50 (New Zealand); Gunther, 1880, *Rep. Sci. Res. Expl. Voy. H.M.S "Challenger" Zool*., 1(6): 49 (Arafura Sea in 35 to 49 fathoms, off New Zealand, River Mary, Queensland); Norman, 1927, *Rec. Ind. Mus.,* XXIX: 43, fig. 12 (Ganjam Coast, Maldive Islands, Hugli mouth); Fowler, 1928, *Mem. B. P. Bishop Mus.*, XII, 2: 93 (New Zealand, East Indies); Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.*, V: 145 (Java Sea, Timor Sea); Norman, 1934, *Syst. Monog. Flatfish*: 400, fig. 289 (Maldives, Burmese Coast, Andaman, off Ganjam Coast); Herre, 1941, *Mem. Ind. Mus.*,:13 (3): 319; Hubbs, 1945, *Misc. Publ. Mus. Zool. Univ. Michigan*, 63:34; Punpoka, 1964, *Kasetstart Univ. Fish. Res. Bull.*, (1): 29, fig. 7 (Gulf of Thailand); Shih – Chieh, 1966, *Quar. J. Taiwan Mus.*, 20 (1, 2): 194, figs. 81- 84; Fowler, 1967, *Mem. B. P. Bishop Mus.*, XI: 320 (Oceania); Amaoka, 1971, *J. Shimonoseki Univ. Fish.*, 20 (1): 20, pl. I, fig. B (South China Sea); Kuronuma and Abe, 1986, *Fish. Arabian Gulf*: 241 (Arabian Gulf); Anderson *et al.*, 1998: 28; Li and Wang, 1995, *Fauna Sinica*: 108; Randall, 1995, *Coastal Fish. Oman*: 354 (Oman); Mohsin and Ambak, 1996, *Marine Fish. Malaysia*, 587; Carpenter *et al.*, 1997, *FAO Sp. Iden. Guide*: 228; Evseenko, 1998, *Russ. Acad. Sci.*, 57; Hensley, 2001, *FAO Sp. Iden. Guide*: 3797; Hutchins, 2001, *Rec. W. Aust. Mus.*,: 46 (Australia); Manilo and Bogorodsky, 2003, *J. Ichth.*, :S122; Hoese and Bray, 2006, *Zool. Cat. Australia*: 1808.

Brachypleura xanthosticta Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII: 281, pl. xvii, fig. 3 (S.W of Puri, South of Ganjam); Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV: 327, Alcock, 1898, *Illust. Zool. "Investigator", Fish.,* pl. xxii, fig. 2; Regan, 1908, *Trans. Linn. Soc. London, Zool.*, 12 (3): 232 (Maldives, Suvadiva, 44 fathoms, Malaku, 27 fathoms); Jenkins, 1910, *Mem. Ind. Mus.*, iii: 27 (Ganjam coast, Eastern Channel at mouth of Hoogli River); Borodin, 1930, *Bull. Vand. Mar. Mus.*, I (2): 46.

Liaopteryx xanthosticta Weber, 1913, *Siboga-Exped. Fisch.,*: 423 (Timor Sea).

Material examined: N = 1, TL = 102.51 mm from Chennai.

Diagnosis: An elliptical shaped flatfish with dextral eyes closely placed, with ctenoid scales on ocular side and cycloid scales with feeble denticulations on blind side.

Plate II *Brachypleura novaezeelandiae* Gunther, 1862

Meristic characters: D 78; A 47; P_1 12; V_1 6; Ll. 32.

Body proportions as percent of SL: HL 30.2; HD 20.7; ED_1 8.3; ID 1.2; PrOU 7.4; PrOL 10.95; PBU 24.8;PBL 20.8; BD_1 40.9; BD_2 41.4; DFL 9.6; AFL 10.6; P_1FL 20.78; V_1FL 12.3; CFL 20.5; ABL 72.5; P_1BLO 5.3; V_1BLO 3.78; PDL 18.5; PAL 39.68; P_1LO 29.75; V_1LO 2.4; UJL 15.4; LJL 17.6; CD 4.7.

As percent of HL: HD 68.5; ED_1 27.5; ED_2 25.5; ID 3.9; PrOU 24.5; PrOL 36.2; PBU 82.1; PBL 68.7; BD_1 135.1; BD_2 137.03; DFL 31.7; AFL 35.1; P_1FL 68.7; V_1FL 40.7; CFL 67.6; DBL 277.8; ABL 239.8; P_1BL 17.6; V_1BL 17.6; PDL 61.2; PAL 131.2; P_1LO 98.4; V_1LO 8.02; UJL 50.7; LJL 58.1; CD 15.6.

Description: Body elliptical, compressed. Eyes dextral, separated by a narrow bony ridge, upper a little in advance of lower. Eye diameter 3.7 – 3.9 times in HL. Mouth large, gape wide, oblique in position, maxillary ending below the midhalf of the lower eye or a little beyond. Snout and lower jaw very prominent. Nostrils placed close together, below anterior part of upper eye, the upper nostril is a longitudinal slit, the lower one is rounded; nasal organ of blind side above first ray of dorsal fin very small, inconspicuous. Teeth sharp, cananiform at the anterior part, well developed in both jaws, biserial; anterior teeth of upper jaw enlarged; teeth in lower jaw biserial almost throughout, those of the outer series larger. A patch of conical teeth on vomer. Gill - membranes more or less united below the throat; gill - rakers rather long, slender, denticulated, not numerous. Preopercular margin free. Dorsal fin origin on snout on blind side, in front of eyes. Anterior dorsal fin filamentous in males, of shorter length in female; most of the rays simple, not scaled, those on middle part longer. Sheath covering basal part of dorsal fin. Anal origin behind a vertical drawn from the origin of the pectoral. Anal similar to dorsal; middle rays branched; last few rays longer than the first few. Tip of first interhaemal spine not projecting in front of fin. Dorsal and anal fins free from caudal. Caudal fin rhomboidal, with the middle rays branched. Pectoral fins equally developed on both sides. Pelvic fin on ocular side inserted in front of pelvic base on blind side; that on blind side larger. Body scales on ocular side ctenoid, those on blind side cycloid with feeble denticulations. Scales deciduous. Caudal fin branched; caudal peduncle very short. Scales rather large, deciduous, imbricated, ctenoid or cycloid, absent on eyes, interorbital, jaws, snout and on fins; less than 35 scales in lateral line. Lateral line with a distinct curve above the pectoral fin; no supratemporal branch. A comparative statement of the meristic characters of *Brachypleura novaezeelandie* is given in Table 5. Results of the correlation coefficient analysis done on non-meristic characters of *Brachypleura novaezeelandie* is given in Table 6.

Table 5 : A comparative statement of the meristic characters of *Brachypleura novaezeelandie*

Meristic Characters	Earlier workers									Present work 2004 - 2010
	Gunther 1862	Alcock 1889 (*B. xanthosticta*)	Weber 1913	Norman 1927, 1934	Fowler 1928	Punpoka 1964	Amaoka 1971	Kuronuma and Abe 1986	Randall 1995	N = 1
Dorsal rays	72	68 - 69	70 -72	65 – 74	72	65 -74	68 -72	64 -72	65 -74	78
Anal rays	48	44 - 46	47	43 – 49	48	43 - 49	45 – 49	42 - 47	41 – 49	47
Pectoral (O/B)	*	*	11	10 - 12	*	10 - 12	12 – 13	10 - 12/10 -11	17 – 19	12
Lateral line	30	30	32 – 33	29 - 32	30	29 - 33	28 – 32	28 - 30	29 – 32	31
Caudal	*	*	*	17 – 19	*	17 - 19	*	17 - 18	*	17
Pelvic	*	*	6	6	*	6	*	*	*	6
Gill rakers	*	*	*	8 - 10	*	*	8 -9	7 - 9	8 -10	8

* Data not available

Table 6: Results of the correlation coefficient analysis on non-meristic characters of *Brachypleura novaezeelandie*

Characters	Range in SL	Range in HL
Head length	3.31	
Head depth	4.83	1.5
Eye diameter (U)	12.3	3.7
Eye diameter (L)	12.95	3.9
Interorbital width	85.1	25.7
Preorbital (U)	13.5	4.1
Preorbital (L)	9.1	2.8
Post orbital (U)	4.03	1.2
Post orbital (L)	4.8	1.5
Body depth I	2.5	0.7
Body depth II	2.4	0.7
Dorsal fin length	10.4	3.2
Anal fin length	9.4	2.9
Pectoral fin length (O)	4.8	1.5
Pelvic fin length (O)	8.1	2.5
Dorsal base length	1.2	0.4
Anal base length	1.4	0.4
Pectoral fin base length (O)	18.8	5.7
Pelvic fin base length (O)	26.4	8.00
Pre dorsal length	5.4	1.6
Pre anal length	2.5	0.8
Pre pectoral length	3.4	1.02
Pre pelvic length	41.3	12.5
Upper jaw length	6.5	1.97
Lower jaw length	5.7	1.7
Chin depth	21.3	6.4

Colour: In fresh condition, ocular side is yellowish brown, sometimes with some indistinct darker margins; vertical fins often with small dark spots. Blind side is whitish. When preserved the colour changes to light yellow.

Distribution

World: New Zealand, Java Sea, Timor Sea, Indian Ocean, Arafura Sea, coast of New Guinea, New Zealand (Gunther, 1862; Norman, 1927; Weber and Beaufort, 1929); Maldives (Norman, 1934); Gulf of Thailand (Punpoka, 1964); Arabian Gulf (Kuronuma and Abe, 1986); Oman (Mohsin and Ambak, 1996); Australia (Hutchins, 2001). Map map showing localities were *Brachypleura novaezeelandie* has been recorded in the world is given in Fig. 6.

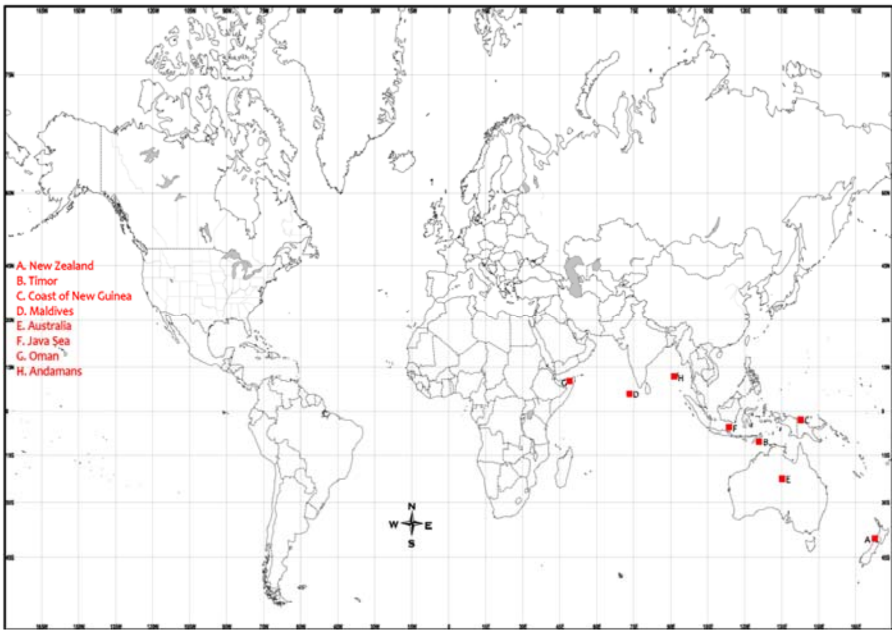


Fig. 6: Map showing localities were *Brachypleura novaezeelandie* has been recorded in the world.

India: Andamans, off Ganjam Coast (Norman, 1934); Porto Novo (Rajguru, 1987); Chennai (present study). Map showing localities were *Brachypleura novaezeelandie* has been recorded in the world is given in Fig. 7.

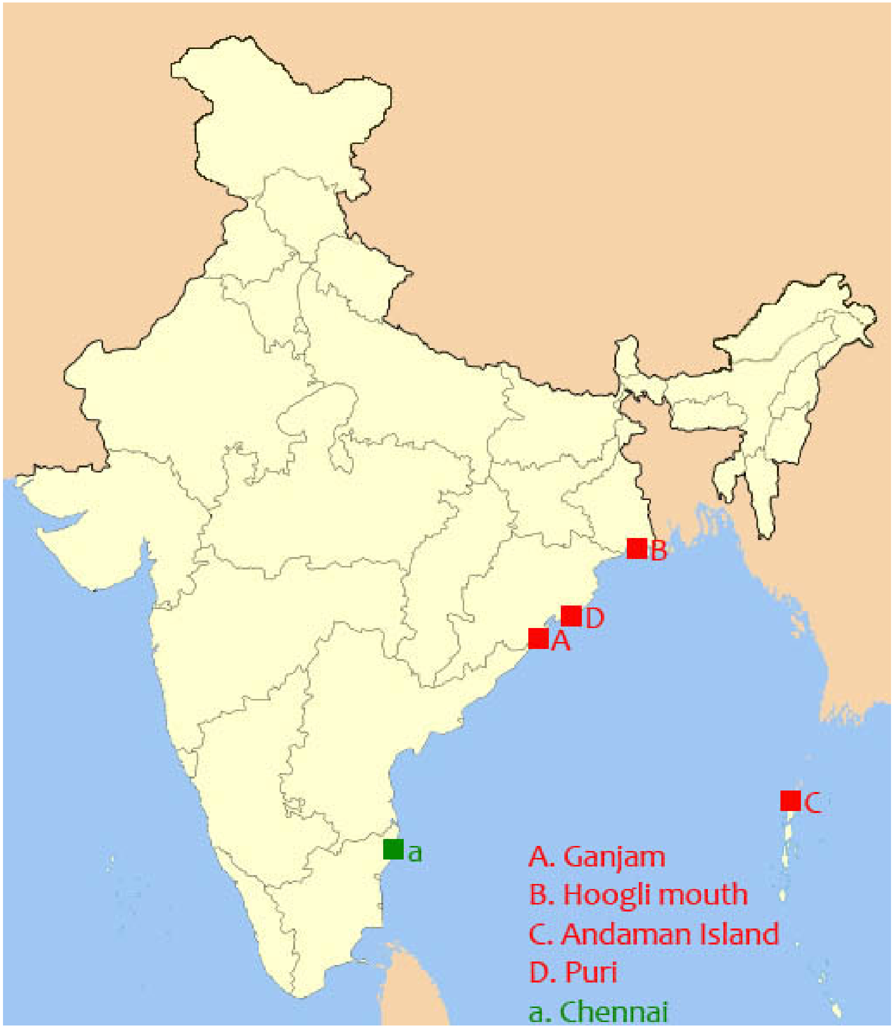


Fig. 7: Map showing localities were *Brachypleura novaezeelandie* has been recorded in India

Taxonomic comments: The fish was first described by Gunther (1862) based on two samples in the collections in the British Museum. Alcock (1889) described the fish under the name *Brachypleura xanthosticta* based on samples of length 3.75 – 4.2 inches from south west of Puri and 5 miles South of Ganjam from 25 fathoms on clean sandy bottom.

Weber (1913) placed the fish in a new genus as *Laiopteryx xanthosticta* based on differences pointed by Alcock and those he noticed. According to Norman (1927) "*Brachypleura xanthosticta was said to differ from Brachypleura novaezeelandie in the presence of an anterior curve to the lateral line and in having a double row of teeth in the lower jaw, differences which led Weber to erect the genus Laiopteryx for its reception. Examination of the types of B. novaezeelandie shows that Gunther's description was inaccurate, and that teeth of the lower jaw are distinctly biserial. The scales of the specimen are entirely wanting and the anterior curve of the lateral line is not apparent; Gunther clearly mistook the septum between the myotomes for the lateral line*." The dorsal fin counts of *L. xanthosticta* (70 - 72) described by Weber and very much in agreement with that of *B. novaezeelandie* described by Weber and Beaufort (65 - 72). Fowler (1928) placed the fish in family Samarinae, though now it is placed in Citharidae. Later, Fowler placed the species in Family Pleuronectidae along with *Pseudorhombus* and *Arnoglossus*.

Observations: Except for the slightly higher dorsal fin count, the meristic counts of the present specimen are similar to that of the earlier workers; the meristic measurements of the present specimen are in agreement with that given by Gunther (1862). The present work also agrees with Norman (1924) in the presence of biserial teeth in the lower jaw.

4.3.3 Family Paralichthyidae

Species in this family are commonly called sand flounders. About 16 genera and 105 species of paralichthyid flounders are distributed worldwide in tropical, subtropical and temperate seas (Munroe, 2006). McCulloch (1922) listed all sinistral flounders with margin of free preopercle in Family Bothidae. Genus *Pseudorhombus* was represented by three species from New South Wales; in the Pacific, family members extend from about 45^0N to about 35^0S (Norman, 1934); in the Western Atlantic, 9 genera occur in the Gulf of Maine (Bigelow and Schroeder, 1953). The genus was also recorded from southern Argentina (Diaz de Astarloa and Munroe, 1998). Of the 16 genera reported worldwide, only two genera *Pseudorhombus* with 23 valid species and *Tarphops* with 2 species are reported from the Indo–west Pacific with species ranging from East Africa and the Red Sea throughout the Indian Ocean and Indo–Australian Archipelago to the Western Pacific including Korea and Japan (Amaoka, 1969). A third genus *Paralichthys* is represented in the western Pacific by a single species (Japanese flounder *P. olivaceus*).

Paralichthyidae was regarded as a subfamily of the Bothidae by Norman (1934) and others. Hensley and Ahlstrom (1984) thoroughly discussed changes in composition of this taxon since Norman (1934). Family Paralichthyidae was erected by Amaoka (1969) while working on the sinistral flounders of Japan by elevating the subfamily status of the Paralichthinae to family rank. The principal difference from the Bothidae is in the structure of the pelvic fin. Chapleau (1993) recognized *Pseudorhombus* and *Tarphops* along with *Cephalopsetta* as the *Pseudorhombus* group, a possible monophyletic lineage among paralichthyids. Paralichthyidae with about 16 genera and 105 species has been recognized as a paraphyletic group. (Hensley and Ahlstrom, 1984; Chapleau, 1993; Pardo *et al*., 2005; Berendzen and Dimminck, 2005; Nelson, 2006). Chapleau (1993) also was unable to establish the monophyly of this family and concluded that further work was needed to clarify relationships of these fishes. Review of observations done by various workers on Family Paralichthyidae is given in Table 7.

Table 7: Review of observations by various workers on Family Paralichthyidae

Genus	Synonym	Type	Observations					
			Jordan	Norman	Amaoka	Ahlstrom	Munroe	Eschmeyer
Cephalopsetta Dutt & Rao 1965		*Cephalopsetta ventrocellatus* Dutt & Rao 1965				**VALID**		**VALID**
Pseudorhombus Bleeker 1862		*Rhombus polyspilos* Bleeker 1853	Includes *Rhombiscus* Jordan & Snyder	**VALID**	**VALID**	**VALID**		**VALID**
	Neorhombus Castelnau 1875	*Neorhombus unicolor* Castelnau 1875	**VALID**	Questionably a **synonym** of *Pseudorhombus* Bleeker 1862				**VALID**
	Rhombiscus Jordan & Snyder 1900	*Rhombus cinnamoneus* Temminck & Schlegel 1846		Synonym of *Pseudorhombus* Bleeker 1862	Synonym			Synonym
	Spinirhombus Oshima 1927	*Spinirhombus ctenosquamis* Oshima 1927		Synonym of *Pseudorhombus* Bleeker 1862	Synonym			Synonym
	Teratorhombus Macleay 1881	*Teratorhombus excisiceps* Macleay 1881	Synonym of *Pseudorhombus* Bleeker 1862	Synonym of *Pseudorhombus* Bleeker 1862				Synonym
Parabothus Norman 1931		*Arnoglossus polylepis* Alcock 1889			**VALID** Type by original designation		**VALID**	

The greatest diversity of genera and species of paralichthyids occurs in the seas of the New World especially the Caribbean Sea and tropical eastern Pacific (Munroe, 2005).

Subfamily Paralichthyinae was placed in family Bothidae by Fowler (1972) while describing the *Fishes of China* with the characters "*Ventral fins alike; eyes separated by ridge; mouth moderate or large*"; three genera *Tephritis*, *Pseudorhombus* and *Paralichthys* were placed in the subfamily. Paralichthyids have a dorsoventrally flattened, ovate body with sinistral eyes. Mouth protractile, asymmetrical, lower jaw prominent, teeth canine like in some, absent on vomer. Posterior margin of preopercular margin free. Dorsal and anal fin free from caudal; pelvic fin bases short, nearly symmetrical, that on the blind side placed a little behind the ocular one, with variation in the position of the bases between species. Pectoral fin rays branched. Lateral line with a prominent arch above the pectoral fin. At present, sixteen genera with 105 species are included in the family (Eschmeyer, 2011) of which only one genus was obtained in the present study – Genus ***Pseudorhombus***.

Habitat: Sand flounders are predominantly marine, though few are seen rarely in freshwater.

4.3.3.1 Genus *Pseudorhombus* Bleeker, 1862

Pseudorhombus Bleeker, 1862, *Versl. Akad. Wet. Amsterdam*, xiii: 426. (type: ***Rhombus polyspilos*** Bleeker); Hector, 1872, *Fish. New Zealand*: 50; Day, 1877, *Fish. India*: 422; Regan, 1920, *Ann. Durban Mus*., II: 207; Weber and Beaufort, 1929, *Fish. Indo–Austr. Arch*., V: 99; Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) VIII: 597; Wu, 1932, *Thès. Fac. Sci. Univ. Paris,* A. 244 (268): 79; Norman, 1934, *Syst. Monog. Flatfish*: 89;

Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 88; Ahlstrom *et al.,* 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 642; Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 347; Desoutter, 1986, *Checklist Fish. Africa*: 428; Hensley, 1986, *Smith. Sea Fish.*,:861; Rahman, 1989, *Freshwater Fish. Bangladesh*: 29; Pan *et al*., 1991, *Freshwater fish. Guangdong*: 526; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166: 22; Gomon *et al.,* 1994, *Fish. Aust.,*: 848; Li and Wang, 1995, *Fauna Sinica*: 123; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3843; Nakabo, 2000, *Fish. Japan*: 1827.

Neorhombus Castelnau, 1875, *Res. Fish. Aust. Vict. Off. Rec. Philad. Exhib*.,: 45 (type: ***Neorhombus unicolor*** Castelnau 1875).

Teratorhombus Macleay, 1881, *Proc. Linn. Soc. N. S. W*., VI: 126 (type: ***Teratorhombus excisiceps*** Macleay 1881).

Rhombiscus Jordan and Snyder, 1900, *Proc. U.S Nat. Mus*., XXIII: 379. (type: ***Rhombus cinnamoneus*** Temminck and Schlegel 1846).

Spinirhombus Oshima, 1927, *Japan J. Zoo. Trans. Abst.,* 1(5): 187 (type: ***Spinirhombus ctenosquamis*** Oshima 1927)

Istiorhombus Whitley, 1931, *Aust. Zoo.,* VI: 322 (type: ***Pseudorhombus spinosus*** McCulloch).

Description: Common in the Indo–Pacific region, species in this genus has an ovoid body, deep and compressed; dorsal profile more or less similar in both sexes; head comparatively large. Eyes sinistral, placed close, separated by a bony inter-orbital ridge which is naked. Spines absent in the rostral, orbital and mandibular region. Two nostrils present on either side, one tubular in structure with a flap and the other oval without a flap. Mouth oblique, gently arched anteriorly, maxillary extends to below the middle of the lower eye or a little beyond. Teeth well developed on both jaws, placed in a single row, the teeth in the front part of mouth larger and more prominent, tapering in size as it progresses inwards. Teeth on lower jaw stronger, larger and more widely spaced than that of upper jaw. Gill rakers well developed, palmate, with serrations on its inner margin. Scales small in size, not deciduous, either ctenoid or cycloid on the sides, mostly cycloid on blind side. Lateral line present on ocular side, prominent, a supratemporal branch running upwards towards the dorsal side of head and to the anterior portion of the dorsal fin. Dorsal fin origin on blind side on a vertical above the middle of the upper eye, all rays simple. Anal fin origin nearly on a vertical down from hind end of operculum or base of pectoral fin, nearly resembling dorsal, all rays simple. Pectoral fins unequal, that on ocular side longer than on blind side; first 2-3 rays on ocular side long, simple, rest branched; on blind side all short and simple, not branched. Pelvic fins inserted on nearly a vertical from posterior end of pre-opercle. Caudal fin pointed, or double truncate, with two outer simple rays and inner rays branched.

In the present study, eight species of *Pseudorhombus* have been recorded.

Pseudorhombus argus
Pseudorhombus arsius
Pseudorhombus diplospilus
Pseudorhombus dupliciocellatus
Pseudorhombus elevatus
Pseudorhombus javanicus
Pseudorhombus natalensis
Pseudorhombus triocellatus

Taxonomic comments: Genus *Pseudorhombus* was described by Bleeker (1866) with sinistral eyes, lateral line with a deep convex curve anteriorly, dorsal origin in front of the eyes and no anal spine. *Pseudorhombus* as a genus was placed one among the nine genera under family Pleuronectidae by Day (1889) following Gunther (1877). The same classification was continued by Jordan and Starks (1907), Jordan, Tanaka and Snyder (1913) and Jordan and Thompson (1914) while describing the fishes obtained from Japan. This classification was changed by Regan (1920), Norman (1928, 1934) where two subfamilies were recognized in Family Bothidae – *Paralichthinae* and *Bothinae*; Genus *Pseudorhombus* was placed in subfamily Paralichthinae. Regan (1920) described *Pseudorhombus* with the characters "*pelvic fin symmetrical, teeth uniserial*". Two species *Pseudorhombus russelli* and *P. natalensis* were described by Regan from Natal. Eight species of genus *Pseudorhombus* were recorded by Norman (1927) from Indian coast, of which, 7 species were recorded in the present work. Norman (1931) comments that "*Spinirhombus Oshima cannot be maintained as a separate genus; the absence/presence of the pre-anal spine may be a variable feature*". Blegvad (1944) while describing the *Fishes of the Iranian Gulf* placed genus *Pseudorhombus* in Family Bothidae. This was followed by Munroe (1955) in the *Marine and Freshwater Fishes of Ceylon* where 10 genera were placed in Family Bothidae. Three species of *Pseudorhombus* were collected from the Ceylonese and adjacent waters of Gulf of Mannar – *P. triocellatus*, *P. arsius* and *P. javanicus*. Subsequently, Amaoka (1969) in his work on the sinistral flounders of Japan erected a new family Paralichthyidae in which he included genus *Pseudorhombus* along with the two genera *Tarphops* and *Paralichthys*. According to Talwar and Kacker (1984), eight species of *Pseudorhombus* have been recorded from Indian Ocean of which *P. natalensis* is rare in the landings.

Observations: Of the 14 species of *Pseudorhombus* described by Gunther (1862), locality of only two species is India. Day (1878) reported three species of *Pseudorhombus* species from India. Five species of *Pseudorhombus* - *P. cinnamomeus*, *P. misakius*, *P. oligodon, P. dupliocellatus*, *P. ocellifer* and *P. oligolepis* were recorded from Japan by Jordan and Starks (1907). McCulloch (1919) reported three species of *Pseudorhombus* from New South Wales – *P. arsius*, *P. multimaculatus* and *P. tenuirastrum*. Norman (1927) in his work on flatfishes of India, recognised 2 subfamilies in Family Bothidae and 2 genera *Pseudorhombus* and *Taeniopsetta* in subfamily Paralichthinae. According to Norman (1934), world over, 24 species of *Pseudorhombus* have been recorded of which eight species are said to occur in India – *Pseudorhombus dupliocellatus*, *P. triocellatus*, *P. annulatus*, *P. malayanus*, *P. arsius*, *P. elevatus*, *P. micrognathus* and *P. javanicus*. Munroe (1955) reported 3 species of this genus from Ceylonese waters. Smith (1961) placed genus *Pseudorhombus* in Family Bothidae while describing the *Fishes of South Africa*. Fowler (1972) placed *Pseudorhombus* in Family Bothidae and described four species from China – *Pseudorhombus cinnamomeus*, *P. arsius*, *P. pentopthalmus* and *P. oligolepis*. Ramanathan (1977) reported 5 species of *Pseudorhombus* from Porto Novo coast, all of which have been recorded in the present work. Rajguru (1987) in his study reported 7 species of *Pseudorhombus* of which 2 were not represented in the present work. Radhamanyamma (1988) reported only four species in her work from southwest India. Eight species were recognised in genus *Pseudorhombus* in the present work of which the presence of *P. argus* and *P. natalensis* are new records to south-west Indian waters.

New Record 1

4.3.3.1.1 *Pseudorhombus argus* Weber, 1913

Peacock flounder

Pseudorhombus argus Weber, 1913, *Die Fisch. Siboga Exped.,* LVII: 425, pl. 11, fig. 6, (Jeden Island, Aru Islands, Indonesia, Siboga station 273, depth 13 meters); Weber and Beaufort, 1929, *Fish. Indo - Austr. Arch.*, V: 113, fig. 27; Marshall, 1964, *Fish. Great Barrier Reef*: 455 (North west of Hervey Bay, Queensland, 9 – 11 fathoms); Allen and Swainston, 1988, *Marine Fish F. W Australia*: 146; Mohsin and Ambak, 1996, *Mar. Fish. Malaysia*: 591; Allen, 1997, *Marine Fish. Aust.,*: 234; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3846; Hutchins, 2001, *Rec. W. Aust. Mus.*, 63: 46; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1827.

Material examined: N= 1; TL 252.86 mm from Tuticorin.

Diagnosis: Body with five double ocellii on ocular side, 4 in a square point and the fifth a faded one on the posterior part of the lateral line near the caudal peduncle. Dorsal fin origin behind posterior nostril on blind side; upper profile of head with a distinct notch; 16 gillrakers on lower part of anterior arch.

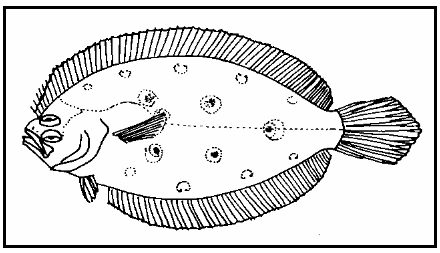


Plate III *Pseudorhombus argus* Weber, 1913

Meristic counts: D 71; A 53, P_1 10; P_2 9; V_1 6; V_2 6, Ll 68.

Body proportions as percent of SL: HL 27.99; HW 38.1; HD 18.96; BD_1 44.3; BD_2 38.2; ED_1 9.43; ED_2 6.3; ID 1.5; PrOU 6.1; PrOL 5.4; PBU 16.3; PBL 15.9; UJL 10.4; LJL 10.04; CD 2.8; DFL 9.4; AFL 9.8; P_1FLO 13.7; P_2FLO 10.5; V_1FLO 6.03; V_2FLB 8.5; CFL 18.5; DBL 91.7; ABL 70.97; P_1BLO 4.2; P_2BLB 3.7; V_1BLO 4.3; V_1BLB 3.9; PDL 8.87; PAL 29.2; P_1LO 28.3; P_2LB 28.1;V_1LO 23.12; V_2LB 22.4.

As percent of HL: HW 136.2; HD 67.7; BD_1 158.2; BD_2 136.5; ED_1 33.7; ED_2 22.4; ID 5.3; PrOU 21.6; PrOL 19.4; PBU 58.04; PBL 56.9; UJL 37.1; LJL 35.86; CD 10.01; DFL 33.5; AFL 35.1; P_1FLO 49.01; P_2FLO 37.4; V_1FLO 21.5; V_2FLB 30.2.

Description: Body oval with a prominent notch in front of the eyes. Body depth contained 2.3 times and head depth contained 3.6 times in length. Upper eye placed a little in front of the lower eye, its diameter contained 2.9 times in head length. Interorbital space narrow with a ridge, the distance contained 6.3 times in upper eye diameter. Preorbital distance is a little shorter than eye diameter. Two nostrils present on ocular side, the first one tubular near the lower eye, the second one oval in outline with tiny sensory papillae on its lower border. Maxillary ending to a little beyond the middle point of the lower eye; upper jaw nearly equal to eye diameter. Teeth very small, closely placed, with the anterior ones very slightly enlarged. 17 teeth on blind side of lower jaw. Gill rakers slender, moderately long, 16 gill rakers on lower branch of the first gill arch. Body covered with ctenoid scales on its ocular side and cycloid scales on the blind side. Lateral line origin from behind the upper free margin of the opercle; proceeds with a distinct curve in the pectoral fin area to the caudal fin base. A supratemporal branch proceeds upto the dorsal profile to the base of the eighth dorsal fin ray; the second branch proceeds behind the upper eye to the lower eye. Dorsal fin origin on the blind side just behind the nostril on the blind side; it appears in front of the upper eye on the ocular side. Anal fin origin just in front of a vertical below the free end of operculum. Pelvic fin on ocular side inserted on a vertical below the preoperculum. Tip of the interhaemal spine feeble, not projecting. Pectoral on eyed side longer than blind side pectoral and dorsal fin ray. and inserted a little below the free upper end of operculum. Caudal fin double truncate. A comparative statement of the meristic characters of *Pseudorhombus argus* is given in Table 8.

Table 8: A comparative statement of the meristic characters of *Pseudorhombus argus*

Meristic Characters	Earlier workers				Present Study 2004 - 2010 (N = 1)
	Weber 1913	Norman 1934	Weber and Beaufort 1929	Amaoka and Hensley 2001	
Dorsal	69	68 - 69	69	67 - 72	71
Anal	52	51 - 54	53	51 – 55	53
Pectoral (O)	*	*	2.8.1	12 – 13	12
Pectoral (B)	*	12 -13	10	*	10
Pelvic	*	*	2.4	*	6
Caudal	*	*	*	*	18
Lateral line count	68	76 -79	72	70 -78	73
Gill rakers	*	*	*	2 - 6 + 10 - 16	16

*Data not available

Colour: In fresh condition, brownish with four double ocellii at square end tips on ocular profile and a fifth ocellii near the posterior part of the lateral line near caudal. Black spots seen on vertical fins also. Four paired ocellii seen on the outer ends of the dorsal and ventral profiles. Faded black marks seen on the pectoral and caudal fins also. Blind side whitish.

In formalin preserved specimens, the dots are retained but in faded condition on ocular side; blind side whitish.

Distribution

World: Jeden Island, Aru Islands, Indonesia, (Weber, 1913); Australia (Swainston, 1988); Hervey Bay, southern Queensland (Norman, 1934; Marshall, 1964). Map showing localities were *Pseudorhombus argus* has been recorded in the world is given in Fig.8.

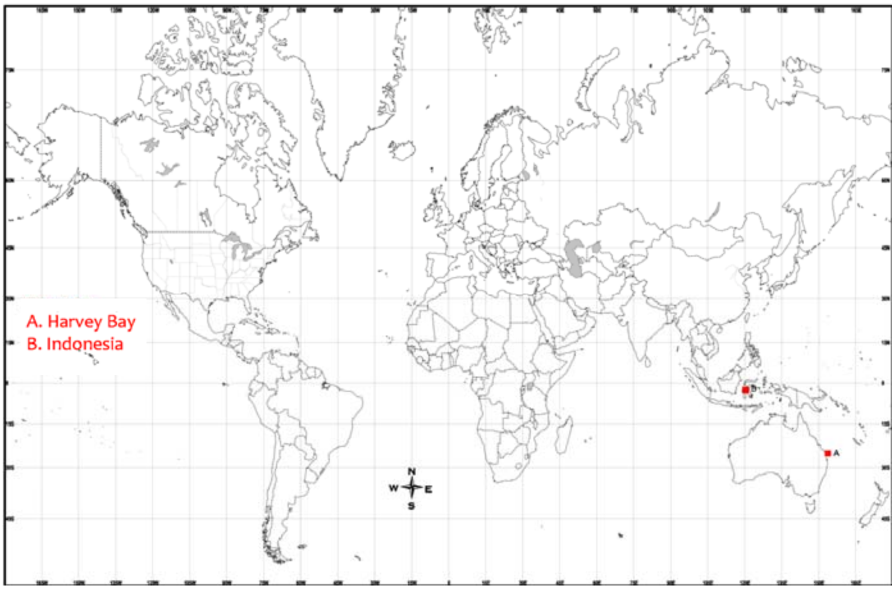


Fig 8: Map showing localities were *Pseudorhombus argus* has been recorded in the world.

India: This is the first report from the Indian waters. Map showing locality were *Pseudorhombus argus* has been recorded in the world is given in Fig.9.

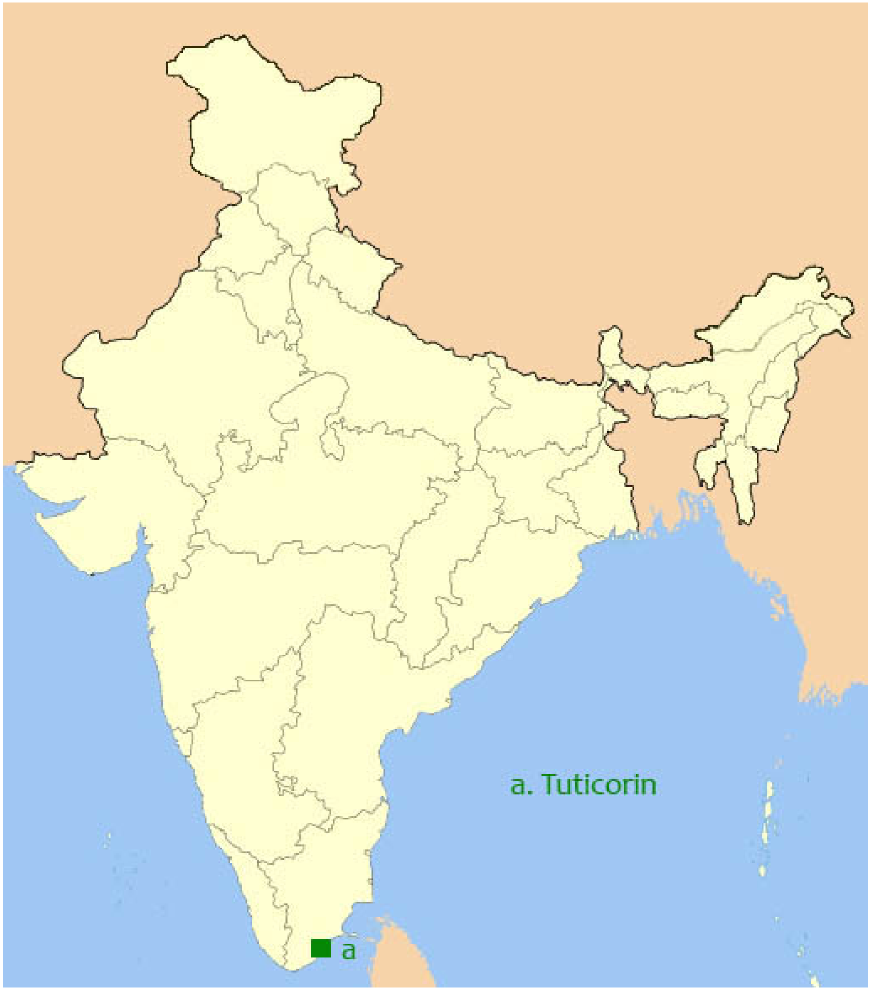


Fig 9: Map showing localities were *Pseudorhombus argus* has been recorded in India.

Habitat: The species is reported to live at depths of 15 to 25 m on muddy and sandy bottoms.

Taxonomic comments: The species was first described by Weber (1913) based on collections at depths of 13 meters at Siboga station 273 from Aru islands from the Indo – Australian Archipelago. Later on, one sample of the species was again collected in the "*Endeavour*" expedition from southern Queensland. Norman (1934) comments that "*this species is very closely related to P. jenynsii (Bleeker), but may be distinguished by the more numerous gill rakers*". *Le Pleuronecte argus* described by Lacepede (1801, *Hist. Nat. Poiss*., 3: 599) mentions of small scales on body as well as brown dots with blue centre. He may be referring to the ocellii on the ocular side. But the counts differ very much.

Observations: This species has not been reported during the earlier works on flatfishes in Indian waters. The present specimen matches well this description of Weber (1913) and Amaoka and Hensley (2001). *P. argus* can be distinguished from its closely related species *Pseudorhombus dupliocellatus* in the presence of pointed gillrakers in the former.

4.3.3.1.2 *Pseudorhombus arsius* (Hamilton, 1822)

Large toothed flounder

Pleuronectes arsius Hamilton Buchanan, 1822, *Fish. Ganges*: 128 (estuary below Calcutta, Bay of Bengal); Hora, 1929, *Mem. Ind. Mus*., IX: 86, pl. xvii, fig. 1, 2.

Pleuronectes chrysopterus Bloch and Schneider, 1801, *Syst. Ichth*., 151 (Chinese seas).

Platessa russellii Gray, 1830-1835, *Illust. Ind. Zoo.,* pl. 94, fig. 2; Cantor, *J. Asiat. Soc. Bengal*, XVIII (2): 1196 (Sea of Pinang, Malayan Peninsula, Singapore).

Rhombus lentiginosus Richardson, 1843, *Ann. Mag. Nat. Hist*., XI: 495 (Port Essington, Cobourg, Australia); Bleeker, 1852, *Verh. Bat. Gen.,* XXIV, Pleuron.,: 15.

Platessa balteata Richardson, 1846, *Rep. British Ass. Adv. Sci.*,: 278 (Canton, China).

Rhombus arsius Bleeker, 1853, *Verh. Bat. Gen.,* XXV: 76.

Rhombus polyspilus Bleeker, 1855, *Nat. Tijd. Ned. Ind.,* 4: 503.

Teratorhombus excisiceps Macleay, 1881, *Proc. Linn. Soc. N.S.W.,* 6: 126, pl. 2 (Port Jackson, New South Wales, Australia).

Pleuronectes maculosus Cuvier, 1829, *Regne Animal,* 2: 341 (Vishakapatnam, India).

Pleuronectes mortoniensis De Vis, 1882, *Proc. Linn. Soc. N.S.W.,* 7 (pt. 3): 370 (Moreton Bay, Queensland).

Neorhombus ocellatus De Vis, 1886, *Ann. Rep. Qd. Mus.,*: 5

Pseudorhombus lentiginosus Bleeker, 1865, *Ned. Tijds. Dierk.,* II : 184.

Pseudorhombus russellii Gunther, 1862, *Cat. Brit. Mus.*, IV: 424 (Umbilo River, Port Natal, China, Borneo, Bengal, Pinang, East Indian Archipelago, Port Essington); Kner, 1865-1867, *Novara Exp. Fisch.,* I: 283; Day,1865, *Fish. Malabar*: 172 (Malabar, India); Bleeker, 1866-72, *Atl. Ichth.*,: 6, pl.2, fig. 2; Gunther, 1866, *Fish. Zanzibar*: 112 (Aden); Macleay, 1878, *Proc. Linn. Soc. N.S.W.*, II: 362; Boulenger, 1887, *Proc. Zoo. Soc. London*: 665 (Muscat); Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII, pt. 3: 282 (Bay of Bengal); Sauvage, 1891, *Hist. Nat. Madagascar*, xvi, *Poiss.*,: 473; Steindachner, 1907, *Denk. Ak. Wien,* 71(1): 166 (East Arabia); Zugmayer, 1913, *Abh. Bayer. Ak. Wiss.,* 26 (6): 15 (Oman); Gilchrist and Thompson, 1917, *Ann. Durban Mus.,* I: 399; Regan, 1920, *Ann. Durban Mus.*, ii: 208, fig. 1 (as *P. russelli*) (Natal); Von

Bonde, 1922, *Rep. Fish. Mar. Biol. Sur. S. Afr.*, II, *Spec. Rep.* I: 15; Fowler, 1926, *Proc. Acad. Nat. Sci. Philad.*, LXXVII: 204; Oshima, 1927, *Japan J. Zoo. Trans. Abst.,*1(5): 183; Reeves, 1927, *J. Pan-Pac. Res. Inst.*, 2(3):14 (Chefoo); Gunther, 1963, *Voy. Challenger* : 46 (Arafura Sea).

Pseudorhombus andersonii Gilchrist, 1904, *Mar. Invest. S. Africa* 3: 9, pl. 26 (Durban Harbour, South Africa)

Pseudorhombus arsius Gunther, 1862, *Cat. Brit. Mus.*, IV: 426 (Ganges); Day, 1878 -1888, *Fish. India*, 4^0: 423, pl. XCI, fig.5 (Andamans); Rutter, 1897, *Proc. Acad. Nat. Sc. Philadelphia*: 87 (Swatow); Regan, 1905, *J. Bombay Nat. Hist. Soc.*, 16 (2): 330 (Persian Gulf); Bowers, 1906, *Bull. Bur. Fish.*, XXVI: 45 (Cavite); Jordan and Seale, 1907, *Bull. U.S. Bur. Fish.,*: 45; Jenkins, 1910, *Mem. Ind. Mus.,* III, I: 24 (Arakan coast, Puri Beach, Balasore Bay); Snyder, 1912, *Proc. U.S. Nat. Mus.,* LXII: 439; Jordan, Tanaka and Snyder, 1913, *Cat. Fish. Japan*, XXXIII, Art. 1: 315 (Shimidzu, Kagoshima); Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci., Imp. Univ. Tokyo,* 33 (1): 315; Mc Culloch, 1919, *Checklist N.S Wales*, II: 35 (New South Wales); Hora, 1923, *Mem. Ind. Mus.,* XXI: 388; Norman, 1926, *Biol. Res. "Endeavour"*, V: 231; Norman, 1927, *Rec. Ind. Mus.,* XXIX, pt. 1: 13 (Muscat, Gulf of Oman); Fowler, 1928, *Mem. B. P. Bishop Mus.,* XI: 320; Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch.,* V: 105 (East coast of India, Andamans, Cochin, Java, Sumatra); Mc Culloch, 1929, *Mem. Aust. Mus.*, V: 279; Wu, 1932, *Cont. Morph. Biol. Poiss. Heterosomes*: 86; Herre, 1933, *J. Pan-Pac. Res. Inst.*, 8: 5; Herre, 1934, *Fish. Herre Phil. Exp.,*: 104; Norman, 1934, *Syst. Monog. Flatfish.*, I: 101, fig. 62 (Muscat); Fowler, 1934, *Hong Kong Nat*., 5: 57; Fowler, 1938, *Fish. Malaya*, 88: 80; Norman, 1939, *Murray Exped. Rep*.,7 (1): 98 (Gulf of Aden, 18-22 metres); Blegvad, 1944, *Danish Sci. Invest. Iran*, III:199 (W. of Bushire; Bushire Harbour); Smith, 1949, *Sea Fish. S. Africa*:156, pl. 10, fig. 304; Munroe, 1955, *Fish. Ceylon*: 259, fig.747 (Ceylonese waters, Pearl banks); Matsubara, 1955, *Fish. Morph. Hier*.,:1253; Fowler, 1956, *Fish. Red Sea S. Arabia,* I:162 (Kovshak); Smith, 1961, *Sea Fish. S. Africa*: 156, pl. 10, fig. 304 (Knysna, Natal); Khalat, 1961, *Mar. F.W Fish. Iraq*: 143; Marshall, 1964, *Fish. Great Barrier Reef*: 454, pl.62, fig. 440 (Australia); Punpoka, 1964, *Fish. Res. Bull. Kasetsart Univ*.,:20; Fowler, 1967, *Mem. B. P. Bishop Mus*., XI:320 (Oceania); Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2):99; Masuda *et al*.,1975, *Fish. S. Japan*:344, pl. 148 B (Shizuoka Prefecture southward); Dor, 1984, *Checklist Fish. Red Sea*: 269; Amaoka in Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 347; Matsuura in Okamura *et al*., 1985, *Jap. Fish. Res. Conserv. Tokyo* 2: 609, 734; Kuronuma and Abe, 1986, *Fish. Arabian Gulf*: 242, pl. 27; Desoutter, 1986, *Checklist Fish. Africa*: 428; Hensley, 1986, *Smith. Sea Fish.,*: 861; Allen and Swainston, 1988, *Mar. Fish F.W Australia:* 146; Quero and Mauge, 1989, *Cybium*: 389; Rahman, 1989, *Freshwater Fish. Bangladesh*: 29; Kawanabe and Mizuno, 1989, *Freshwater Fish. Japan*: 668; Talwar and Jhingran, 1991, *Inland Fish. India*, 2:1039; Lindberg and Fedorov,1993, *Fish. Sea. Japan*, pt. 6: 24; Kottelat *et al*. 1993, *Freshwater Fish W. Indonesia*: 68; Kuiter,1993, *Coastal Fish S.E Australia*:382; Gomon *et al.,* 1994, *Fish. Aust.,*:849; Poll and Gosse, 1995. *Gen. Poiss. Afrique*: 79; Goren and Dor, 1994, CLOFRES II: 71; Li and Wang, 1995, *Fauna Sinica*:137; Randall,1995, *Coastal fish. Oman*: 358; Evseenko, 1996, *J.*

Ichth., 36 (9): 726; Allen, 1997, *Marine Fish. Aust.,*:234; Larson and Williams, 1997, *Proc. Sixth Intl. Marine Biol. Workshop*: 373; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide*: 230; Kuiter, 1997, *Guide Sea Fish. Australia*:383; Mishra *et al*., 1999, *Rec. Zool. Surv. India,* 93 (3): 89; Johnson, 1999, *Mem. Qd Mus.,* 43 (2): 752; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8:644; Nakabo, 2000, *Fish. Japan*: 1357; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3847; Sakai *et al*., 2001, *Bull. Nat. Sci. Mus., Ser. A*. 27(2):123; Hutchins, 2001, *Rec. W. Australian Mus., Suppl*., 63:46; Shinohara *et al*., 2001. *Mem. Nat. Sci. Mus*.,: 335; Nakabo, 2002, *Fish Japan*. 2º ed:1357; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (suppl.1):S122; Khan, 2003, *Rec. Zool. Surv. India*, *Occ. Paper* 209: 11; Heemstra and Heemstra, 2004, *Coastal Fish S. Africa*: 433; Randall, 1995, *Coastal fish. Oman*: 616; Hoese and Bray, 2006, *Zool. Cat. Aust.,:* 1827, Gomon, 2008, *Mem. Mus. Victoria*, 65: 807.

Pseudorhombus polyspilus Bleeker, 1866-1872, *Atl. Ichth*., VI:7; Jordan and Seale, 1907:45; Bowers, 1906, *Bull. Bur. Fish*., XXVI: 45 (Cavite); Weber, 1913, *Siboga Exp.*,:424 (Makassar Fish Market); Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch*.: 106, fig. 26; Schmidt, 1930, *Proc. 4th Pac. Sci. Congress, Java*, 1929, 3: 112.

Platophrys russellii Evermann and Seale, 1906, *Fish Philippine Island*: 105 (Bulan).

Material examined: N= 5; TL 73.1–290 mm from Neendakara and Cochin Fisheries Harbours; one specimen TL 290mm (F149/420) from CMFRI Marine Museum, Mandapam; 1 specimen TL 121.56 mm from Karwar, 1 specimen TL 120.3 mm from Chennai.

Diagnosis: Flatfish with a slender oval body with sharp teeth on lower jaw. Dorsal fin with 70 – 80 rays, anterior teeth in jaws, much enlarged or canine like, maxilla ends at posterior half of lower eye, upper eye slightly in advance of lower.

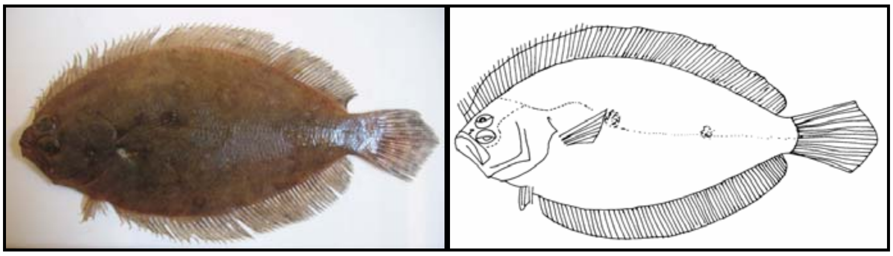


Plate IV *Pseudorhombus arsius* (Hamilton, 1822)

Meristic counts: D 72 - 78; A 52 - 57; P_1 9 -11, P_2 9 - 13; V_1 5 - 6; V_2 5 - 6; C 17; Ll 70 – 81 (73).

Body proportions as percent of SL (mean in parentheses): HL 26.4–30.5 (28.3), HW 33.5–41.7 (39.5); HD 21.1–26.5 (24.3); ED_1 5.3–9.7 (6.8), ED_2 4.7–7.8 (5.9); ID 0.8 –1.5 (1.12); UJL 10.4–17.6 (12.9); LJL 9.1–15.1 (10.7); P_rOU 3.2–4.7 (4.01); P_rOL 9.1–15.1 (10.7); PBU 15.2–17.1(16.3); PBL 15.1–16.6 (15.9); SNL_1 5.4–6.6 (5.9); SNL_2 5.4 – 6.1 (5.7); DFL 9.5–12.4 (11.2); AFL 9.5–13.3 (11.2); P_1FLO 14.3–17.8 (16.2); P_2FLB 10.4–13.7 (12.2); V_1FLO 6.8–11 (9.5); V_2FLB 5.1–12.1 (9.3); CFL 15.5– 21.2 (19.4); DBL 87.6–91.3 (89.4); ABL 64.8–70.8 (68.04); P_1BLO 3.6–4.3 (3.9); P_2BLB 2.2–4.3 (3.02); V_1BLO 2.9–5.5 (3.9); V_2BLB 2.7–4.4 (3.3); CBL 9.6–16.4 (11.6); PDL 4.4–5.4, PAL 31.96–35.1 (33.6); P_1LO 27.8–29.8 (28.4); P_2LB 27.9–30.7 (28.95); V_1LO 23.8–27.3 (24.9); V_2LB 23.8–28.2 (25.6).

As percent of HL (mean in parentheses): HW 331.3–421.2 (355.3); HD 201.3–278.5 (219); ED_1 44–58.4 (52.02), ED_2 43.4–81.7 (53.7);

ID 6.3–16.2 (10.4); UJL 93.4–106.9 (101.2); LJL 79.1–89.6 (82.8); P_rOU 30.6–42.4 (36.04); P_rOL 49.5–73.4 (56.1); PBU 127.6–162.4 (146.96); PBL 130.4–158.5 (143.4); SNL_1 43.7–66.5 (53.6); SNL_2 45.4–63.8 (51.5); PDL 13.1–56.5 (37.6).

Description: Body oval, flattened, upper profile straight, with a slight notch near snout, in front of eyes; both profiles equally convex. Body depth less than half total length. Eyes small, separated by a bony interorbital ridge; upper eye placed slightly in front of lower eye; placed closer to outer profile by a distance lesser than half its diameter. Ocular length a little more than half head length, blind one nearly half head length. A pair of nostrils present on both sides – on ocular side two nostrils seen in pre-orbital space, anterior one tubular with a fleshy flap, the second oval in outline without a flap. Nostrils on the blind side placed in front of the dorsal fin origin. Mouth large, strongly arched; maxillary ends at posterior half of lower eye; length 1.7 - 2.5 times in HL, lower jaw not projecting, placed 2.7 times in HL. Upper jaw with sharp, close set teeth in a single row on both sides; lower jaw with stronger and more widely spaced teeth on both sides, 6 -13 on blind side. Teeth villiform and not with barbed ends. Gill rakers moderate in length, strongly serrate, well developed on both limbs; 7 - 9 gill rakers on lower limb, 4 on upper limb. A comparative statement of the meristic characters of *Pseudorhombus arsius* is given in Table 9. Results of the correlation coefficient analysis done on non-meristic characters of *Pseudorhombus arsius* is given in Table 10.

Table 9: A comparative statement of the meristic characters of *Pseudorhombus arsius*

Meristic Characters	Earlier workers															
	Hamilton 1822	Gunther 1862	Day 1889	Bowers 1906	Jenkins 1910	Weber and Beaufort 1929	Norman 1931, 1934	Blegvad 1941	Khalat 1961	Saramma 1963	Marshall 1964	Punpoka 1964	Chen and Weng 1965	Munroe 1967	Amaoka 1969	Fowler 1972
Dorsal	81	81	71 – 79	72	71 - 76	71 -76	72 - 80	76	72 – 80	73 – 74	72 -79	71 – 81	76 – 78	70 – 80	74 -78	71 – 80
Anal	55	55	54 – 61	57	*	54 -56	54 - 62	60	56 – 61	57 – 60	54 - 62	54 – 62	58 – 60	51 – 62	57 - 60	54 – 61
Pectoral (o)	*	*	11	*	*	2.8.2	11 – 13	12	11 -13	2.8.2	*	*	12	*	11 -12	*
Pectoral (B)	*	*	12	*	*		*	*	*	11	*	*	11	*	10 -12	*
Pelvic	*	*	6	*	6	2 +4/ 2.3.1	*	6	6	*	*	*	6	*	*	*
Caudal	16	*	17	*	*		*	*	*	*	2+13+2	*	18	*	*	*
Lateral line count	*	*	75 -85	77	*	75 - 80	69 - 80	*	*	86	70 - 80	67 - 80	*	67 - 80	70 - 80	67 - 80

Meristic Characters	Masuda *et al.*, 1975	Earlier workers						Present Study 2004-2010	
		Ramanathan 1977	Masuda *et al.*, 1984	Kuronuma & Abe 1986	Radhamanyamma 1988	Weber 1913 *P. polyspilus*	Regan 1920 *P. russelli*	N = 6	Mean + SD
Dorsal	74 -78	68 - 74	74 -78	70 - 81	74 – 78	70 - 76	70 – 81	72 - 78	73 + 3.96
Anal	56 - 59	51 - 58	57 - 60	54 – 61	58 – 60	53 – 57	54 – 61	52 - 57	54 + 1.78
Pectoral (o)	*	11 -13	11 -12	11 -12	11	2.7.2 or 1.8.2	*	9 -11	10 + 0.8
Pectoral (B)	*	10 -12	*	10 - 12	*	10 – 12	*	9 - 13	10 + 1.5
Pelvic	*	6	*	*	6	2.3.1	*	5-6 /5-6	6 + 0.5
Caudal	*	17	*	*	17	*	*	2 +13+2	6 + 0.5
Lateral line count	75 -79	66 - 80	70 - 80	71 - 82	*	70 - 82	74 - 85	70 - 81	17 + 9

*Data not available

Table 10: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus arsius*

Characters	Ratio / Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.3 - 3.8	3.54	0.19	0.998	0.25
Head Width	2.4 - 2.99	2.55	0.25	0.98	0.3
Head Depth	3.8 - 4.7	4.15	0.36	1.0	0.19
Eye Diameter (U)	10.3 - 18.8	15.53	3.48	0.92	0.04
Eye Diameter (L)	12.8 - 21.2	17.46	3.12	0.98	0.04
Inter orbital	64.8 - 132.1	96.88	29.66	0.88	0.02
Upper jaw	5.7 - 9.6	8	1.45	0.98	0.08
Lower jaw	6.6 - 11.1	9.69	1.79	0.96	0.07
Pre orbital (U)	21.3 - 31.4	25.34	3.83	0.98	0.05
Pre orbital (L)	14.2 - 17.2	16.25	1.22	1	0.05
Post orbital (U)	5.9 - 6.57	6.14	0.3	1	0.17
Post orbital (L)	6.03 - 6.6	6.29	0.23	1	0.16
Snout to upper eye	15.3 - 18.6	17.13	1.54	0.98	0.07
Snout to lower eye	16.5 - 18.7	17.63	0.96	1.00	0.05
Dorsal fin length	8.1 - 10.5	9.04	1.09	0.96	0.1
Anal fin length	7.54 - 10.6	9.03	1.13	0.96	0.11
Pectoral fin length (O)	5.6 - 6.98	6.19	0.54	0.98	0.16
Pre dorsal	18.6 - 22.6	20.45	2.08	0.86	0.04
Pre anal	2.9 - 3.13	2.98	0.12	0.98	0.35
Pre pectoral(O)	3.4 - 3.6	3.53	0.11	1.00	0.26
Pre pectoral(B)	2.3 - 3.6	3.46	0.15	1.00	0.26
Pre pelvic (O)	3.7 - 4.2	4.03	0.26	0.94	0.26
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head Width	0.7 - 0.8	0.72	0.052	0.98	1.2
Head Depth	1.09 - 1.3	1.17	0.056	1.00	0.76
Eye Diameter (U)	3.2 - 5.4	4.37	0.893	0.90	0.17
Eye Diameter (L)	3.9 - 5.6	4.91	0.673	0.98	0.15
Inter orbital	18.5 -37.9	27.44	8.609	0.86	0.06
Upper jaw	1.7 - 2.5	2.25	0.305	0.98	0.33
Lower jaw	2.01 -3.1	2.73	0.422	0.96	0.3
Pre orbital (U)	6.1 - 9.56	7.2	1.405	0.98	0.18
Pre orbital (L)	4.3 - 4.9	4.59	0.23	1.00	0.22
Post orbital (U)	1.6 - 2	1.74	0.152	1.00	0.66
Post orbital (L)	1.7 - 2.02	1.78	0.137	1.00	0.62
Snout to upper eye	4.03 - 5.4	4.85	0.498	0.98	0.28
Snout to lower eye	4.8 - 5.4	4.98	0.222	1.00	0.21

Scales moderately ctenoid on ocular side, cycloid on blind side; head scaled, interorbital area, snout and tip of jaws naked. Base of each fin ray scaled, scales extend onto fin rays. Lateral line tubular, arising from above the operculum, with a strong curve around pectoral fin, then proceeding straight to caudal. Supratemporal branch enters dorsal fin on 11^{th} ray; the other branch curves below the upper eye to the lower half of the lower eye. Single lateral line seen on blind side. Dorsal fin origin on the blind side, above nostril on blind side; first ray free. Inter haemal spine projecting out of body profile a little. Pectoral fin origin on ocular side in a straight line above the anal fin; outer three rays simple, inner ones branched. Pelvic fin bases together, origin together. Caudal fin rhomboid, outer two rays simple, inner branched. Anus opens on the blind side, above anal fin origin.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs: 10,11,13); the linear regression equations obtained were

Head width on SL	: $y = 0.2985\ x + 11.15$; $R^2 = 0.97$; $p < 0.001$
Head depth on SL	: $y = 0.19\ x + 5.9$; $R^2 = 0.995$; $p < 0.001$
Eye diameter (upper) on SL	: $y = 0.04\ x + 2.5$; $R^2 = 0.91$; $p < 0.001$
Eye diameter (lower) on SL	: $y = 0.038\ x + 2.26$; $R^2 = 0.975$; $p < 0.001$
Snout length (SNL_1) on SL	: $y = 0.06\ x - 1.22$; $R^2 = 0.\ 98$; $p < 0.001$
Snout length (SNL_2) on SL	: $y = 0.05\ x + 0.55$; $R^2 = 0.995$; $p < 0.001$
Dorsal fin length on SL	: $y = 0.96\ x + 1.92$; $R^2 = 0.96$; $p < 0.001$
Snout length (SNL_1) on HL	: $y = 0.28\ x – 2.2$; $R^2 = 0.\ 98$; $p < 0.001$
Snout length (SNL_2) on HL	: $y = 0.2\ x – 0.189$; $R^2 = 0.99$; $p < 0.05$
Postorbital (upper) on HL	: $y = 0.665\ x – 2.7$; $R2 = 0.999$; $p < 0.001$
Postorbital (lower) on HL	: $y = 0.62\ x – 1.77$; $R2 = 0.997$; $p < 0.001$

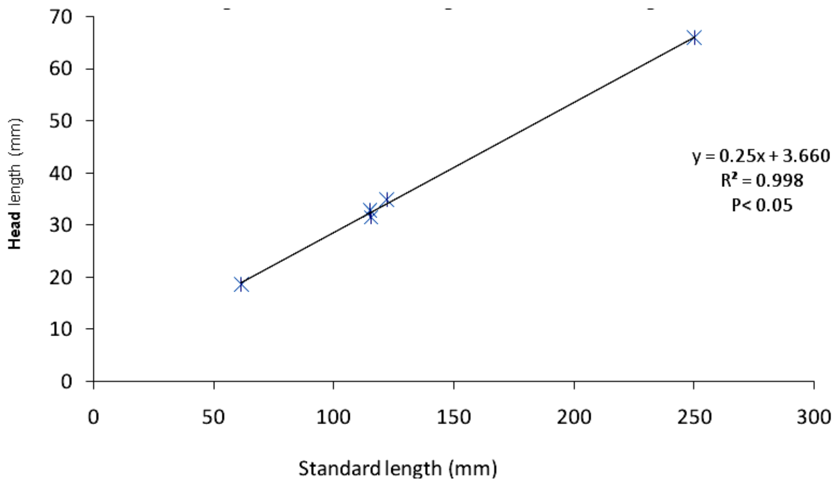


Fig.10: Regression of Headlength on Standard length

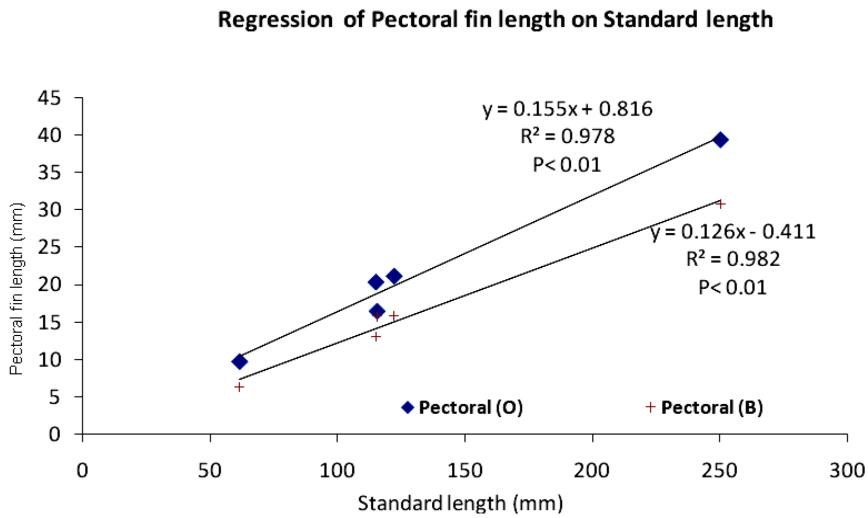


Fig.11: Regression of Pectoral fin length on Standard length

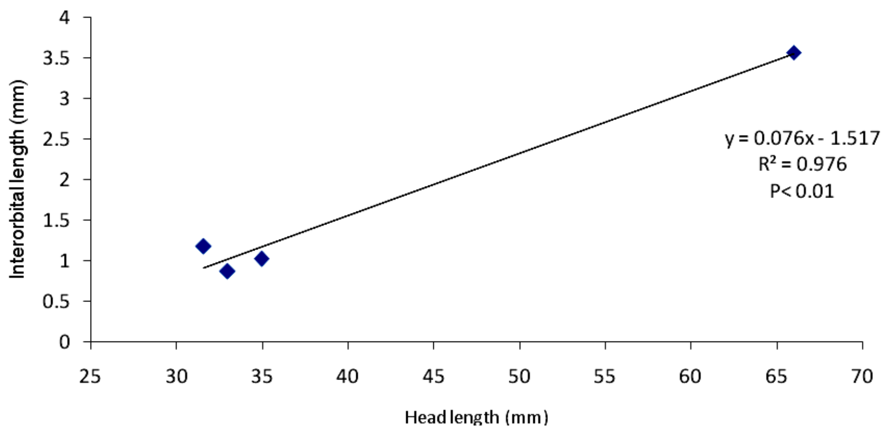


Fig.12: Regression of Inter orbital on Head length

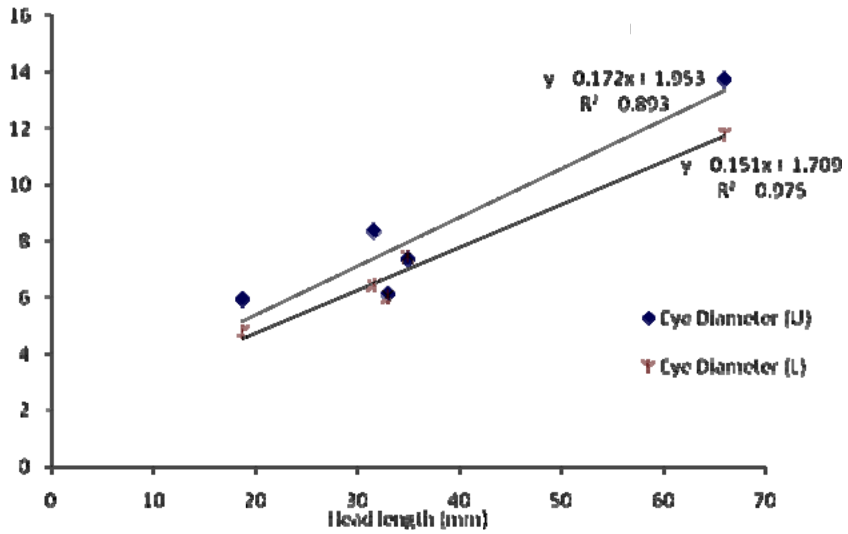


Fig.13: Regression of Eye diameter on Head length

Colour: Body brownish in colour with two distinct spots, one at junction of straight and curved lateral line, the second near posterior half of lateral line; several indistinct spots present on the body and fins. Blind side whitish.

Distribution:

World: Persian Gulf (Regan, 1905); East Arabia (Steindachner, 1907); Oman (Zugmayer, 1913); Aden (Gunther, 1866); Muscat (Boulenger, 1887); Moreton Bay, Queensland (De Vis, 1882, Norman, 1934); Port Essington, Cobourg, Australia (Richardson, 1843); Durban Harbour, South Africa (Gilchrist, 1904); Shimidzu, Kagoshima (Jordan *et al.*, 1913); Mergui Archipelago, Muscat, Gulf of Aden, Gulf of Oman (Norman, 1927, 1934, 1939); Java, Sumatra (Weber and Beaufort, 1929); New South Wales (Norman, 1934); West of Bushire; Bushire Harbour (Blegvad, 1944); Gulf of Siam, Delagoa Bay, Philippines, Kovshak (Fowler, 1956). Map showing localities were *Pseudorhombus arsius* has been recorded in the world is given in Fig. 14.

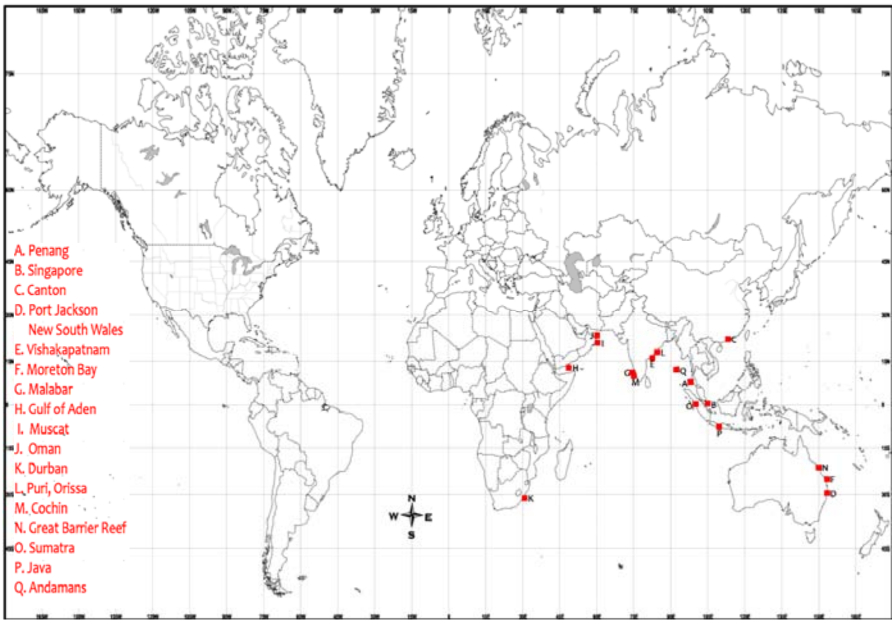


Fig 14: Map showing localities were *Pseudorhombus arsius* has been recorded in the world.

India: Estuary below Calcutta, Bay of Bengal (Hamilton Buchanan, 1822); Vishakapatnam (Cuvier, 1829); Arakan coast, Puri Beach, Balasore Bay (Jenkins, 1909); East coast of India, Andamans, Bombay, (Fowler, 1956); Cochin (Weber and Beaufort, 1929), Kochi, Karwar, Chennai (present study). Map showing localities were *Pseudorhombus arsius* has been recorded in the world is given in Fig. 15.

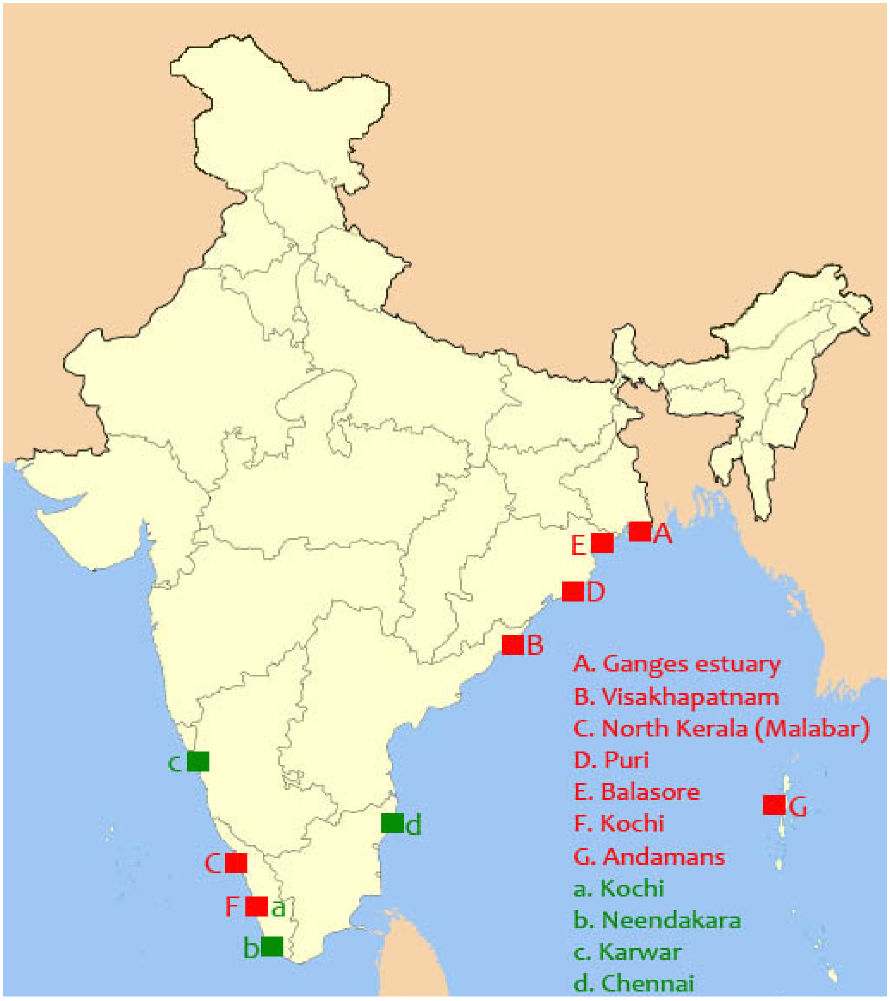


Fig. 15: Map showing localities were *Pseudorhombus arsius* has been recorded in India

Habitat: Common species from shallow estuaries to 100 m (Randall, 1995).

Taxonomic comments: The species was first described by Hamilton as *Pleuronectes arsius* based on collections from Gangetic belt. Hamilton described it as "*a pleuronectes with the eyes on the left*". He also added that "*this species has a strong affinity with P. nauphala as well as with the Noree nalaka of Dr. Russell (Indian Fishes, Vol. II, No. 77). It is said to differ from Dr. Russell's fish in the absence of three eye like spots*". Day comments that "*Pleuronectes Russell, Fish. Vizag. I, p. 58 and Noree nalaka, pl. 75 or Rhombus maculosus, Cuv. Reg. Anim. And Jerdon, M.J.L and Sc., is probably this species*". *Pseudorhombus russellii* described by Gunther (1862) had 70 –77 dorsal rays, 56–60 anal fin rays and 75 lateral line scales. Day mentions that "*Dr. Bleeker distinguishes P. russellii = P. arsius as having lateral line 85, seven to nine teeth in the left side of the lower jaw and nine to fourteen on the right; the body in comparision with P. polyspilus is said to be more elevated". Pseudorhombus polyspilus* was synonymised by Day with *P. arsius* with the comment that none of the characters mentioned for *P. polyspilus* appears to be constant, hence its identity as a separate species was not recognized. Day (1897) also differentiated *Pseudorhombus oligodon* Bleeker from this species more by its possessing ctenoid scales on both sides of the body. The description given for *P. andersoni* by Gilchrist (1904) does not match with that of *P. arsius* in the nature of body scales, Gilchrist mentions of ctenoid scales on both sides of the body, while the present specimen has cycloid scales on the blind side of the body. Hence P. *andersoni* cannot be synonymised with *P. arsius*. Regan (1920) synonymised *P. andersoni* with *P. russelli* with the comment "*P. andersoni is evidently based on an ambicolorate example of this species*". Complete ambicoloration in flatfishes is usually correlated with other variations towards symmetry such as delayed or arrested migration of the eye which interrupts the extension forward of the dorsal fin and the similar structure of the scales on both sides of the fish. However, the description of *Platessa russelli* given by Cantor (1849) matches exactly with the description given by Jenkins (1910) who differentiates *P. russelli* from *P. arsius* in having minute teeth and longest dorsal rays at commencement of posterior half of fin. The dorsal fin counts of *P. russelli* given by Jenkins (1910) as 69, showed much variation with the counts of *P. arsius* recorded by him. However, the description of *P. russelli* given by Gunther (1862) matches with that of the *P. arsius* and hence can be synonymised with it. Hence, *P. russelli* Norman (1934) as well as the samples obtained in the present study and hence can be synonymised with *P.arsius*. In *P. polyspilus*, the ridge separating the eyes is nearly horizontal, the eyes being above each other, in *P. arsius* the ridge is perpendicular and the upper eye is somewhat in advance of the lower. The upper profile is also much more arched in typical *P. arsius*, but there is a certain variability in this character and some specimens of *P. polyspilus* are much more elevated than the rest. The teeth in the lower jaw of *P. polyspilus* is shorter and more crowded than in *P. arsius*. With the differences clearly noticed, *P. polyspilus* and *P. andersoni* need not be reckoned as synonyms of *P. arsius*. However, Norman (1927) concluded that *P. polyspilus* cannot be recognized as a distinct species. The reasons cited were "*more slender body, less convex dorsal profile, anterior margins of the eyes level, fewer teeth on blind side of lower jaw*". Barnard (1925) had united *P. natalensis* with *P. arsius*. However, Norman (1931) examining the single co-type in the British Museum distinguished the two species as separate. Eschmeyer (2010, online) was distinguished *P. russelli* as a separate species.

Norman (1934) comments on the synonymy of *Pleuronectes maculosus* as "*Pleuronectes maculosus* Cuvier is based on the figure of "*Nooree Nalakka* A" in Russell's '*Descriptions of the Fishes of Vishakapatanam*, vol. I: 58, pl. LXXV (1803) which may represent this species. *Teratorhombus excisiceps* Macleay and *Pseudorhombus andersoni* Gilchrist were ambicolorate examples. The identity of *P. arsius* and *P. russellii* seems fairly certain, but the former is based on a drawing of a young specimen and the latter on a poorly stuffed skin. *P. polyspilus* should perhaps rank as a distinct variety or subspecies". The description of *P. polyspilus* given by Weber and Beaufort (1929) is very similar to the present specimen of *P. arsius* except in the position of eyes. Weber and Beaufort (1929:108) in a note opines "*even after all what has been written on the relation of this species and P. arsius… it is difficult to come to a conclusion on the validity of the two species. The chief difference between the two species is the position of the eyes*". According to Punpoka (1964), "*Pseudorhombus arsius is similar to P. malayanus, but the latter has ctenoid scales on both sides of the body*".

Observations: Wide variation is noted in the dorsal fincounts reported by various workers. Hamilton and Gunther reported 81, while the range was 71–80. Ramanathan (1977) reported the lower range for *P. arsius* studied from Porto Novo as 68, which was not reported by any other worker. The same feature was reported in the lateral line count also with Ramanthan reporting 66 and the range for others being 70–80. However, Day (1889) and Saramma (1963) reported lateral line count as 85/86 for their samples collected from Andaman and off Kerala respectively. Dorsal fin counts reported by Weber and Beaufort (71–76) match with that of Amaoka (74 - 78), while lower values are reported for anal fin by Weber and Beaufort (54 - 56) compared to 57–60 for Amaoka. Ratio of ED in HL are in a lower range (4 – 4.2) in the collections of Weber and Beaufort compared to Amaoka's values (4.7–5.5). Presence of deciduous scales on the maxillary reported by Weber are not reported in the present study.

P. arsius is seen occasionally in the markets; large ones are sold locally and used fresh for meat.

New Record 2

4.3.3.1.3 *Pseudorhombus diplospilus* Norman, 1926

Four twin spot flounder

Pseudorhombus sp., Ogilby, 1912, *Mem. Qd. Mus.*, i: 44;

Pseudorhombus diplospilus Norman, 1926, *Biol. Res. "Endeavour"*,V: 226, fig. 1 (Queensland); McCulloch, 1929, *Mem. Aust. Mus.*, V: 280; Norman, 1934, *Syst. Monog. Flatfish*: 93, fig. 54 (Queensland); Marshall, 1964, *Fish. Great Barrier Reef*: 455, (East coast of Queensland, 9–35 fathoms); Allen and Swaintson, 1988, *Mar. Fish. N.W Aust.*,: 146; Allen, 1997, *Mar. Fish. Trop. Aust.,*: 234; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3849; Hutchins, 2001, *Rec. West. Aust. Mus. Supp*., 63: 46; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (Suppl. 1) S. 122; Hoese and Bray, 2006, *Zool. Cat. Aust.,* 35: 1828.

Pseudorhombus condorensis Chabanaud, 1929, *Bull. Mus. Hist. nat. Paris*, (2) I: 370 (Poulo Condor); Desoutter *et al*., 2001, *Cybium*, 25 (4): 301.

Material examined: N = 6, TL 196.62 - 283 mm from Neendakara Fisheries Harbour.

Diagnosis: Body ovoid, brown with a pair of double overlapping ocelli on ocular side, plain white on ventral side.

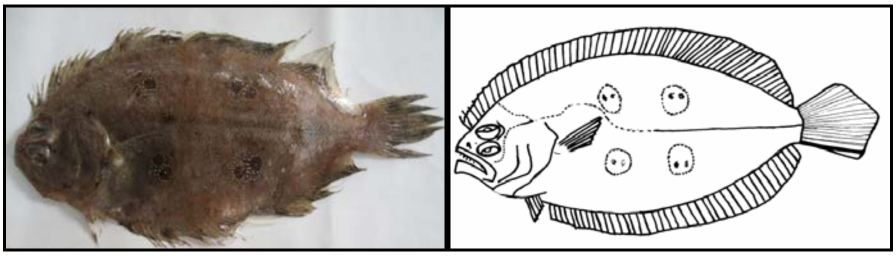


Plate V: *Pseudorhombus diplospilus* Norman, 1926

Meristic characters: D 70 – 74; A 60 – 63; P_1 10 – 11; P_2 10, V_1, V_2 6, C 2 - 4+13 - 20; Ll 94.

Body proportions as percent of SL (mean in parentheses): HL 25-29.2 (27.4); BD_1 37.1–42.3 (39.9); HD 20.3–23.4 (21.7); HW 31.2–34.96 (32.9); CD 1.7–2.6 (2.1); ED_1 7.1–8.7 (7.95); ID 0.3–0.9 (0.6); PrOU 5.3–5.95 (5.6); PBU 14.4–16.6 (15.9); UJL 9.7–11.9(10.6); LJL 12.04–14.6 (13.3); DFL 8.1–12.9 (9.7); P_1FLO 13.6–15.9 (14.7); P_2FLB 9.6; V_1FLO 7.2–9.5 (8.3); AFL 8.2–11.3 (9.6); CFL 16.4–20.3 (18.2); DBL 84.1–85.7 (84.8); P_1BLO 3.02–3.7 (3.4); P_2BLB 3.05–3.3 (3.2); V_1BLO 2.6–3.6 (3.3); V_2BLB 2.6–3.3 (2.9); ABL 58.7–67.7 (65.1); CBL 9.4–13.3 (10.8); CPD 7.5–8.9 (8.4); PDL 5.1–9.2 (7.4); PAL 26.5–34.3 (29.96); P_1LO 25.96–29.5 (27.6); P_2LB 25.8–29.4 (27.6); V_1LO 20.8–24.9 (23.3); V_2LB 21.9–26.6 (23.8).

As percent of HL (mean in parentheses): HD 76.8–82.9 (79.1); HW 112.8–124.7 (120.0); CD 6.7–9.5 (7.8); ED_1 24.2–33.7 (29.1); ID 1–3.1 (2.1); PrOU 19.6–21.6 (20.6); PBU 55.8–59.1 (58.1); UJL 36.5–40.9 (38.6); LJL 45.8–51.6 (48.4); DFL 28.7–44.1 (35.4); P_1FLO 49.8–57.7 (53.7); P_2FLB 38.3 ; V_1FLO 27.1–36.8 (30.3); AFL 29.2–45.1 (35.1); CFL 62.1–72 (66.5); DFB 290.9–335.6 (310.2); P_1BLO 10.7–13.6 (12.6); P_2BLB 11–12.2 (11.6); V_1BLO 9.2–13.2 (11.9); V_2BLB 9.3–13.1 (10.9); CBL 34.8–47.2 (39.2); ABL 213.6–265.7 (238.1); CPD 28.5–35.6 (30.8);

PDL 17.4 –32.7 (27); PAL 100.3–124.5 (109.3); P_1LO 98.1–103.7 (100.8); P_2LB 97.3–103 (100.7); V_1LO 80.8–88.2 (85); V_2LB 83.2–91 (86.6); BD 140–152.4 (145.5).

Description: Upper profile convex, with a notch in front of the upper eye. Dorsal fin arising halfway above eye on blind side. Eyes big, bulging out, placed close with a narrow interorbital width lesser than eye diameter; upper eye placed a little in front of the lower eye. Maxillary ends at middle or little beyond middle of lower eye; lower jaw projecting just a little more than upper jaw. Strong knob at symphysis. Teeth present in both jaws; those on upper jaw small, close set laterally, a pair of strong canines seen anteriorly, visible clearly even when mouth is closed. Teeth on lower jaw stronger, wider apart than that of the upper jaw, blind side with 5 villiform teeth. Gill rakers palmate, 7 seen on upper lobe. A comparative statement of the meristic characters of *Pseudorhombus diplospilus* is given in Table 11.

Table 11 : A comparative statement of the meristic characters of *Pseudorhombus diplospilus*

Meristic Characters	Earlier workers		Present Study 2004-2010	
	Norman 1927	FAO	N = 6	Mean ± SD
Dorsal	75 -79	75 - 81	70 – 74	70 ±1.6
Anal fin count	61 - 64	61 – 64	60 - 63	61 ± 1.2
Pectoral (O)	11 -12	*	10 - 11/10	10 ± 0.4
Lateral line count	88 - 95	83 - 89	94	95 ± 0.1

*Data not available

Body covered with scales, on ocular side feebly ctenoid, on blind side cycloid. Lateral line tubular, arising from outer free end of operculum, curves around pectoral fin area, ends at outer tip of caudal peduncle. Supra-temporal branch ends at base of 9th dorsal ray, has numerous branchlets entering scales in upper head region. Lateral lines pattern same on blind side also. Tip of haemal spine not projecting. Pectoral fin on ocular side inserted a little behind anal fin origin with 10 – 11 rays. Pelvic inserted below the outer free end of preoperculum. Origin of the pelvic fin on blind side origin is at the 6th fin ray of pelvic on ocular side. Caudal fin double truncate. All fins except caudal covered with a membrane, body scale extends into dorsal and anal rays also.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 18,19,20,21); the linear regression equations obtained were

Head width on SL	: $y = 0.32\,x + 1.67$; $R^2 = 0.94$; $p< 0.001$
Head depth on SL	: $y = 0.18\,x + 6.71$; $R^2 = 0.86$; $p < 0.001$
Eye diameter on SL	: $y = 0.09\,x – 1.54$; $R^2 = 0.81$; $p < 0.05$
Head width on HL	: $y = 0.78\,x + 0.418$; $R^2 = 0.94$; $p < 0.001$
Head depth on HL	: $y = 1.33\,x - 6.54$; $R^2 = 0.96$; $p < 0.001$
Perorbital on HL	: $y = 0.23\,x – 1.13$; $R^2 = 0.94$; $p < 0.001$
Postorbital on HL	: $y = 0.62\,x – 1.77$; $R^2 = 0.98$; $p < 0.001$
Upper jaw length on HL	: $y = 0.27\,x + 5.78$; $R^2 = 0.91$; $p < 0.001$

Results of regression analysis showed that the variation of various body parameters in relation to standard length is highly significant. However the variation of dorsal and anal fin length on standard length and interorbital length on head length and standard length was not found to be significant. Results of the correlation coefficient analysis done on non-meristic characters of *Pseudorhombus diplospilus* is given in Table 12

Table 12: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus diplospilus*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.4 - 4.0	3.7	0.2	0.77	0.23
Head depth	4.3 - 4.9	4.6	0.3	0.72	0.18
Head width	2.9 -3.2	3	0.1	0.88	0.32
Chin depth	38.1 - 57.4	47.9	7.2	0.34	0.02
Eye diameter	11.5 -14.1	12.7	1.2	0.66	0.09
Interorbital	110.6 - 353.4	203.1	95.7	0.17	-0.01
Preorbital	16.8 - 19	17.7	0.8	0.88	0.06
Post orbital	6 - 6.9	6.3	0.4	0.77	0.14
Upper jaw	8.4 -10.3	9.5	0.7	0.74	0.06
Lower jaw	6.8 - 8.3	7.6	0.6	0.66	0.08
Dorsal (20)	7.8 - 12.3	10.5	1.5	0.07	0.05
Pectoral (O)	6.3 -7.3	6.8	0.4	0.69	0.12
Anal	8.8 - 12.1	10.6	1.3	0.24	0.04
Caudal	4.9 - 6.1	5.5	0.5	0.12	0.04
Predorsal	10.8 - 19.6	14	3	0.55	0.1
Preanal	2.9 - 3.8	3.4	0.3	0.27	0.09
Prepectoral (O)/(B)	3.4 - 3.9	3.6	0.2	0.59	0.27
Prepelvic (O)	4.0 - 4.8	4.3	0.3	0.58	0.16
Prepelvic (B)	3.8 - 4.6	4.2	0.3	0.72	0.17
Length of pre opercle	4.9 -5.6	5.2	0.3	0.77	0.13
Body depth	2.4 -2.7	2.5	0.1	0.88	0.43
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	1.21 - 1.3	0.04	1.27	0.88	0.78
Head width	0.8 -0.89	0.03	0.83	0.92	1.33
Chin depth	10.5 - 14.95	1.96	13.11	0.30	0.1
Eye diameter	2.96 - 4.13	0.46	3.48	0.41	0.32
Interorbital	32.3 - 99.8	26.54	55.53	0.18	-0.03
Preorbital	4.62 -5.12	0.21	4.86	0.88	0.23
Post orbital	1.7 - 1.8	0.04	1.72	0.96	0.62
Upper jaw	2.5 - 2.7	0.13	2.59	0.81	0.27
Lower jaw	1.9 - 2.2	0.1	2.07	0.88	0.34
Dorsal (20)	2.3 - 3.5	0.4	2.87	0.10	0.22
Pectoral (O)	1.7 -2.01	0.12	1.87	0.69	0.49
Pelvic (O)	2.7 -3.7	0.41	3.34	0.07	0.13
Predorsal	3.1 - 5.7	0.96	3.85	0.24	0.34
Preanal	0.8 - 1.00	0.07	0.92	0.66	1.15
Prepectoral (O)/(B)	0.96 - 1.02	0.02	0.99	0.96	0.93
Length of pre opercle	1.4 - 1.5	0.05	1.42	0.92	0.58
Body depth	0.7 - 0.7	0.02	0.69	0.96	1.8

Colour: Body brownish with 2 pairs of double ocelli, 2 above lateral line, 2 below. The last pair is seen well behind maximum depth of body. Each ocelli has a brown centre, lined with yellow spots. Faint spots seen on median fins. A series of rings present on dorsal and anal fin.

Distribution:

World: Reported from Indo–Australian Archipelago, Queensland, off Australia, South China Sea (FAO). Map showing localities were *Pseudorhombus diplospilus* has been recorded in the world is given in Fig. 16.

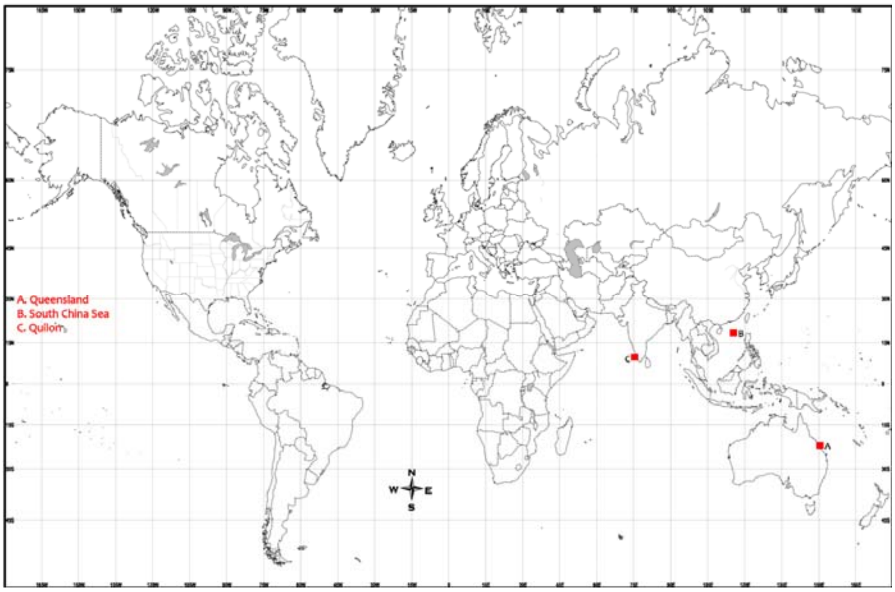


Fig 16: Map showing localities were *Pseudorhombus diplospilus* has been recorded in the world.

India: This present work extends the distribution of this species to Indian waters to the South west coast of India. Map showing localities were *Pseudorhombus diplospilus* has been recorded in the world is given in Fig. 17.

Fig. 17: Map showing localities were *Pseudorhombus diplospilus* has been recorded in India

Taxonomic remarks: The fish was first described as *Pseudorhombus diplospilus* by Norman (1926). The taxonomic name was followed by several subsequent workers. *Pseudorhombus condorensis* described by Chabanaud (1929) is now a junior synonym with *P. diplospilus.*

Observation: Ratio of body depth and head length to standard length matches with that reported by Norman (1934) (2.2 – 2.6 and 3.4 – 3.6).

Fin counts of the present specimen are similar to that reported by Norman. A fish with TL 283 mm was female with ripe ova and an ovary length of 114.18 mm.

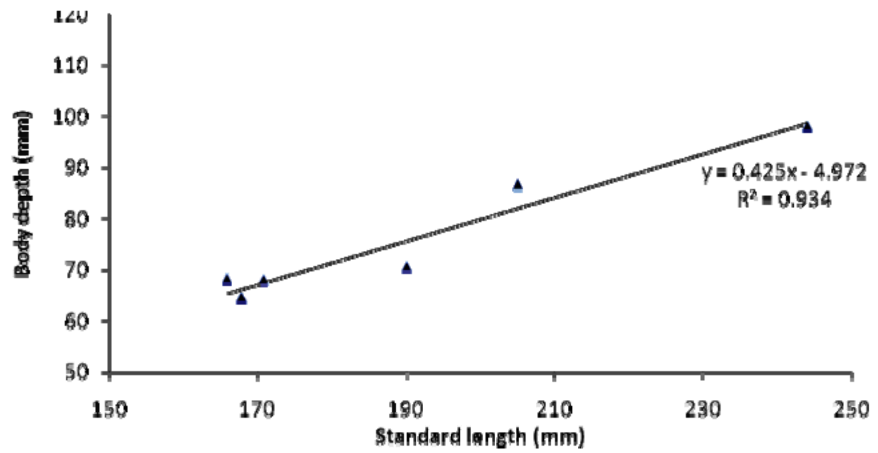


Fig. 18: Regression of Body depth on Standard length

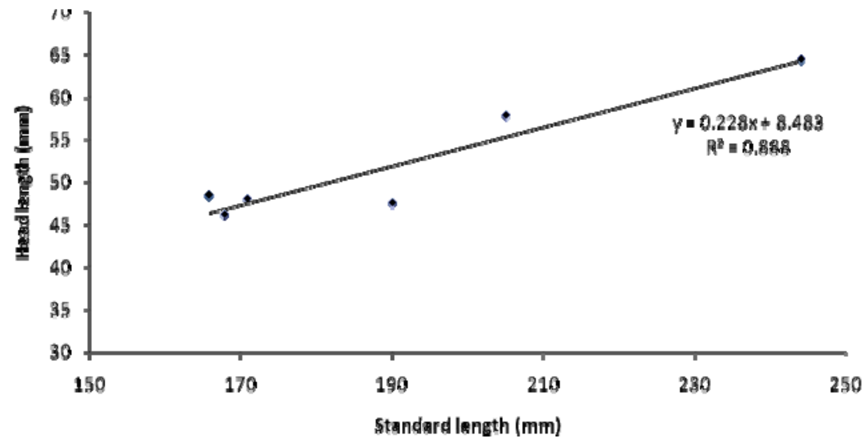


Fig. 19: Regression of Head length on Standard length

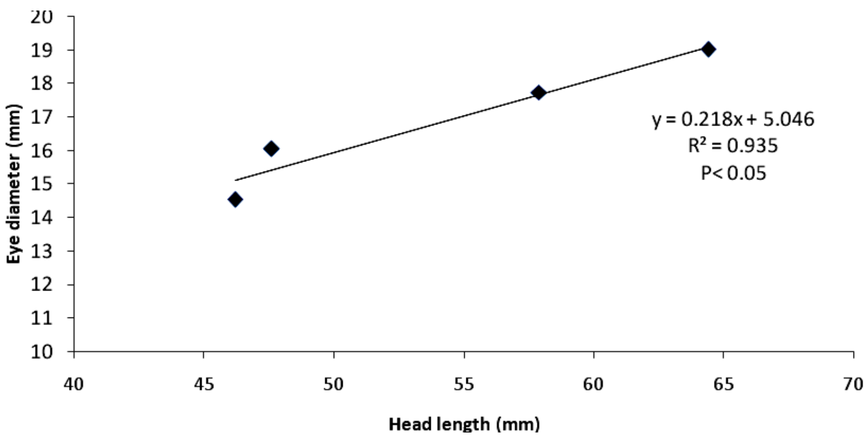


Fig. 20: Regression of Eye diameter on Head length

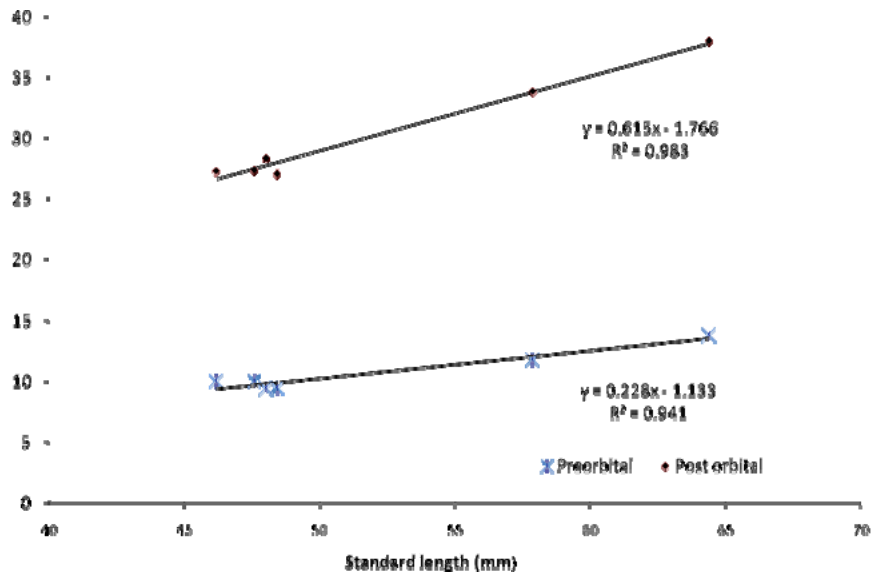


Fig. 21: Regression of pre – orbital and post orbital on Standard length

4.3.3.1.4 *Pseudorhombus dupliciocellatus* Regan, 1905

Ocellated flounder

Pseudorhombus dupliciocellatus Regan, 1905, *Ann. Mag. Nat. Hist.*,(7), XV: 25 (type locality: Kobe, Inland Sea, Japan); Gunther *et al*., 1905, *Ann. Mag. Nat. Hist*., 16 (7): 25 (Japan); Jordan and Starks, 1906, *Proc. U.S. Nat. Mus*., 31: 177 (Japan Sea); Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci. Tokyo*, 33 (1): 316 (Inland sea of Japan); Norman, 1926, *Biol. Res. "Endeavour"*, V: 228, fig. 21 (Japan, Phillipines, Australia); Norman, 1927, *Rec. Ind. Mus*., XXIX:10 (Nicobar); McCulloch, 1929, *Mem. Aust. Mus.,* V: 278; Weber and Beaufort, 1929, *Fish. Indo - Aust. Arch*., V: 102 (Java Sea); Schmidt, 1931, *Trans. Pac. Com. Acad. Sci*., USSR, ii: 124; Norman, 1934, *Syst. Monog. Flatfish.,* I: 94, fig.55 (Nicobar Island); Okada and Matsubara, 1939, *Keys Fish. Japan*: 417 (Japan, Formosa); Matsubara, 1955, *Fish. Morph. Hierar*., II: 1252, fig. 478 B (Japan, Formosa, Malay); Marshall, 1964, *Fish. Great Barrier Reef*: 455 (east coast of Queensland, 9 – 33 fathoms); Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 90, fig. 11 (Yahatahama, Ehime Prefecture, Myazaki, Pref.); Kyushin *et al.,* 1982, *Fishes S. China Sea*: 259; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 347, pl. 311-D (Southern Japan, S. China Sea, morthwest Australia); Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 852, fig.350 (Nicobar islands); Allen and Swainston, 1988, *Mar. Fish F.W Australia*: 146; Lindberg and Fedorov, 1993, *Fish. Sea. Japan*, pt. 6: 23; Li and Wang, 1995, *Fauna Sinica*: 125; Allen, 1997, *Marine fish Australia*: 234 as *dupliocellatus*; Amoaka in Randall and Lim, 2000, *Raffles Bull. Zoo Suppl*., 8: 644; Nakabo, 2000, *Fish Japan*, 2 ed: 1356; Hutchins, 2001, *Rec. Western Austr.*

Mus., Suppl., 63: 46; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide,* IV (6): 3850; Nakabo, 2002, *Fish Japan.* 2^0 ed.:1356; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (1): S122; Adrim *et al* ., 2004, *Raffles Bull. Zool. Suppl.*, 11: 127; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1828.

Platophrys palad Evermann and Seale, 1907, *Bull. Bur. Fish.*, XXVI: 105, fig. 21 (Bulan, Sorsogon, Luzon Island, Philippines); Oshima, 1927, *Japan J. Zool.,* I (5): 185 (Taiwan).

Pseudorhombus cartwrighti**,** Ogilby, 1912. *Mem. Qd. Mus.*, I: 47.

Type: BMNH Reg no. 1905. 6.6. 243

Material examined: N = 1; TL 207.91 mm from Cochin Fisheries Harbour.

Diagnosis: A large flounder with four large double ocellii two on either side of lateral line; with palmate gill rakers which are as broad as long. Maxilla reaching just below middle of lower eye.

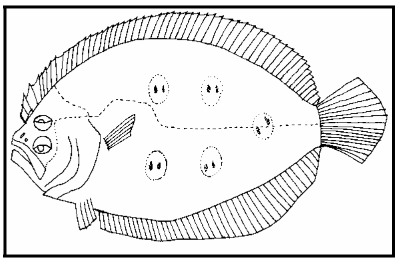


Plate VI: *Pseudorhombus dupliciocellatus* Regan, 1905

Meristic counts: D 74, A 63, P_1 12, $P_2$10; V_1 V_2 5; C 10 + 2; Ll 83.

Body proportions as percent of SL: HL 27.3; HD 12.2; ED 6.52; ED_2 6.2; ID 0.83; SNL_1 6.88, SNL_2 5.8; P_1FLO 18.6; P_2FLB 11.9; V_1FLO

9.50; DBL 87.44, P_1BLO 4.8, P_2BLB 4.7, V_1BLO 2.5, V_2BLB 2.12 ; CPD 12.74; PDL 6.5; V_1LO 21.57; V_2LB 23.02; PAL 28.1.

As percent of HL: HD 44.6; ED_1 23.9, ED_2 22.5, ID 3.04, SNL_1 25.2, SNL_2 21.13.

Description: Body ovoid; broad at the middle region, convex upper profile, deeply notched after snout in front of upper eye; depth nearly half of its length, head moderate, snout large, protruded, equal to or a little larger than eye diameter. Dorsal and anal profile uniformly convex except for snout region. Eyes placed close with a narrow interorbital region; lower eye a little smaller in diameter than the upper one; the upper eye placed a little behind the lower eye. Eye diameter nearly as half as the maxillary. A pair of nostrils placed in front of the interorbital region on ocular side; anterior one tubular with a short fleshy flap, the posterior one without flap. Nostril on blind side without flap placed in front of the dorsal fin origin. Mouth oblique, large, maxilla ending below midpoint of lower eye. Teeth on both jaws uniserial, more widely spaced and stronger on the lower jaw. Teeth on upper jaw small and close set laterally. Gill rakers palmate, well developed on upper and lower limb, as broad as long, 7 on lower limb. A comparative statement of the meristic characters of *Pseudorhombus dupliciocellatus* is given in Table 13. Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus dupliciocellatus* are given in Table 14.

Table 13: A comparative statement of the meristic characters of *Pseudorhombus dupliciocellatus*

Meristic Characters	Earlier workers									Present Study 2004-2010	
	Jordan & Seale 1907 (as *Platophrys palad*)	Jordan & Starks 1907	Weber & Beaufort 1929	Norman 1934	Punpoka 1964	Cheng and Weng 1965	Amaoka 1969	Amaoka 1971	Masuda *et al.*, 1984	N = 2	Mean ± SD
Dorsal	77	74	72-75	74-78	74 – 78	75	72-73	72 – 76	72 - 78	60	60
Anal	60	56	53-61	56-63	63	58	57	56 – 58	56 - 63	50 - 51	51 ± 0.7
Pectoral O/B	*	*	2+8+2 /12	10-12	11/12	11	12/11-12	11 - 12 (0)/ 10 - 11	10 – 12 (0)	11 / 12	11
Lateral line scutes	83	98	75-84	73-84	83	*	76	*	73 - 84	76	76
Caudal	*	*	*	*	4 + 16	18	*	20	*	20	20

*Data not available

Table 14: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus dupliciocellatus*.

Characters	Ratio in SL	Characters	Ratio in HL
Head length	3.7		
Head depth	8.2	Head depth	2.24
Eye diameter (U)	15.3	Eye diameter (U)	4.19
Eye diameter (L)	16.3	Eye diameter (U)	4.45
Interorbital width	120.5	Interorbital width	32.93
Snout to upper eye	14.5	Snout to upper eye	3.97
Snout to lower eye	17.3	Snout to lower eye	4.73
Caudal fin length	5.2	Caudal finlength	1.42
Pectoral fin length (O)	5.4	Pectoral fin length (O)	1.47
Pelvic fin length (B)	8.4	Pelvic fin length (B)	2.29
Pelvic fin length (O)	10.5	Pelvic fin length (O)	2.88
Dorsal base length	1.1	Dorsal base length	0.31
Pectoral base length (O)	20.9	Pectoral base length (O)	5.73
Pectoral base length (B)	21.5	Pectoral base length (B)	5.88
Pelvic base length (O)	40.1	Pelvic base length (O)	10.95
Pelvic base length (B)	46.4	Pelvic base length (B)	12.68
Caudal peduncle depth	7.8	Caudal peduncle depth	2.15
Predorsal length	15.4	Predorsal length	4.21
Pre pelvic (O)	4.6	Pre pelvic (O)	1.27
Pre pelvic (B)	4.3	Pre pelvic (B)	1.19
Pre anal	3.6	Pre anal	0.97

Lateral line origin on head, a supratemporal branch extending to base of 9th dorsal ray, the second branch curving behind both eyes and ending a little below the lower eye; the straight branch arising at the junction of meeting point of the earlier branches, mostly on the 36^{th} scale, strongly arched above pectoral fin anteriorly, then continues in a straight line to caudal fin origin. Lateral line seen on blind side, also in the same pattern. Lateral line scales tubular. Dorsal fin origin straight above the nostril on blind side in front of upper eye. All rays simple. Anal fin origin a little in front of pectoral fin origin on eyed side. Pectoral fins unequal in length, eyed side longer, outer two rays of pectoral (ocular) unbranched, rest branched; pectoral fin on blind side with unbranched rays. Pelvic fin placed well in front of pectoral; pelvic fin on ocular side inserted in front of pelvic fin on blind side. Caudal fin pointed posteriorly, outermost 2 rays unbranched, rest branched. Anal opening on blind side in front of anal fin origin. Tip of first haemal spine not projecting. Scales feebly ctenoid on ocular side, cycloid on blind side; interorbital ridge, jaws and snout naked. Body scale extends into fin ray.

Colour: In fresh condition, body brownish with 2 pairs of double ocelli, one above lateral line, one below, slightly behind, the other two behind maximum body depth. The ocelli are placed close together with a brown center and lined by outer yellow. The four ocelli are placed as if in the corner of a square box. Fins with small brown spots covered with membrane. In formalin preserved specimens, body colour on ocular side is brown, ocellii brown, blind side whitish.

Distribution:

World: Reported in the Indo-Pacific region from Nicobar Islands, northward to Japan and southward to northeastern Australia. This species has been trawled by "*Endeavour*" at various points along the

Queensland west at depths ranging from 19 to 33 fathoms. Also reported from Kobe, Inland Sea of Japan (Regan, 1905, Jordan and Starks, 1919); Java Sea (Weber and Beaufort, 1929); Japan, Formosa (Okada and Matsubara, 1939); Japan, Formosa, Malay (Matsubara, 1955); Yahatahama, Ehime Prefecture, Myazaki, Pref (Amaoka, 1969); Bulan, Sorsogon, Luzon Island, Philippines (Evermann and Seale, 1907); Taiwan (Oshima, 1927). Map showing localities were *Pseudorhombus dupliciocellatus* has been recorded in the world is given in Fig. 22.

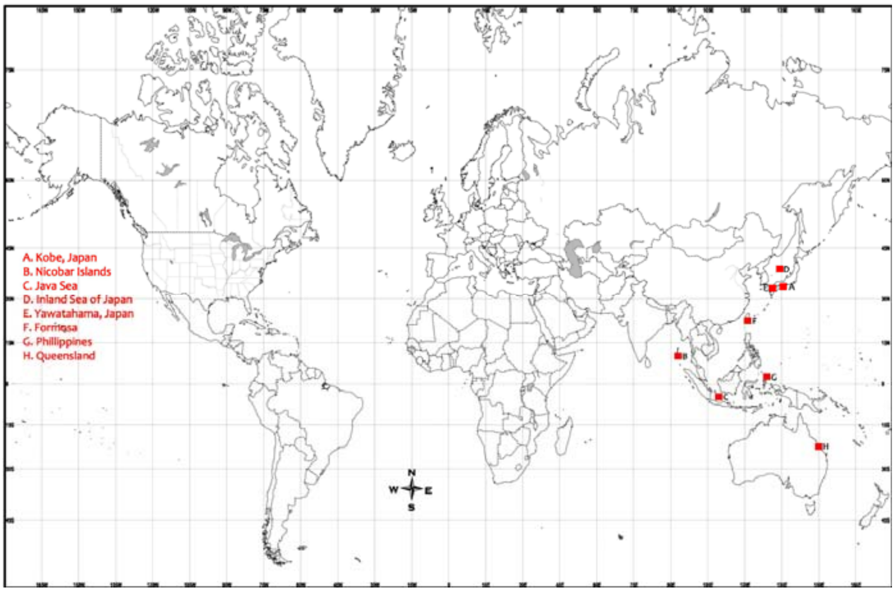


Fig. 22: Map showing localities were *Pseudorhombus dupliciocellatus* has been recorded in the world.

India: This is the first record from Indian subcontinent; reported earlier only from Nicobar islands. (Norman, 1927). Map showing localities were *Pseudorhombus dupliciocellatus* has been recorded in India is given in Fig. 23.

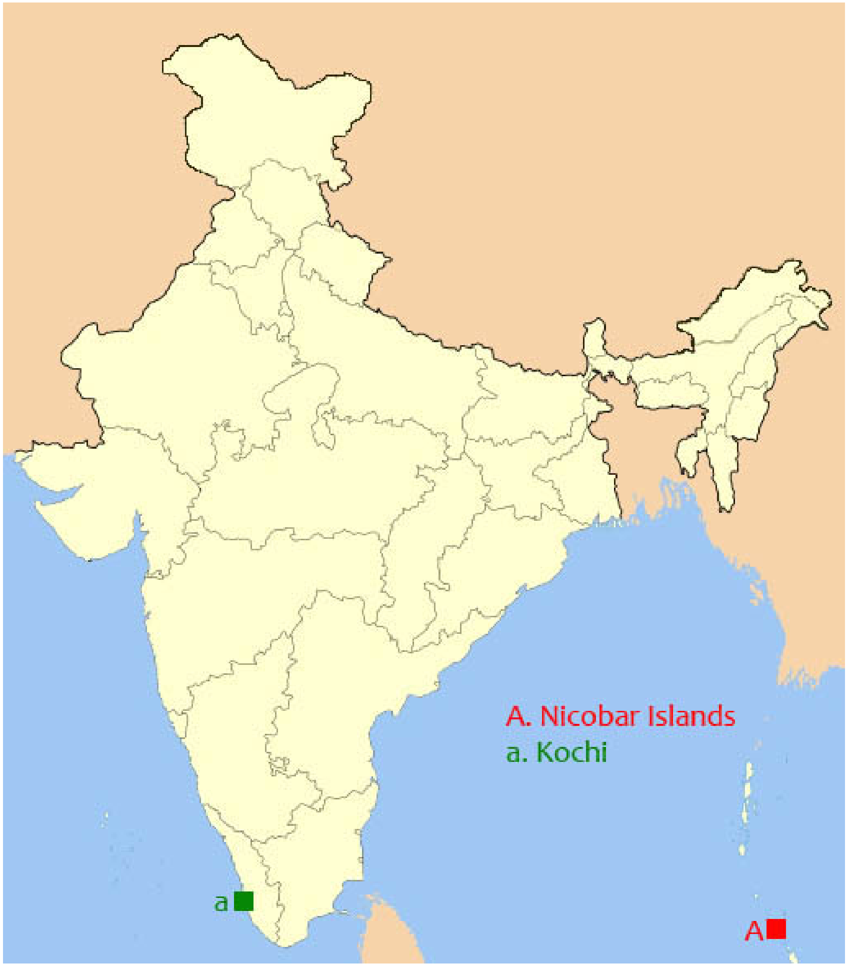


Fig. 23: Map showing localities were *Pseudorhombus dupliciocellatus* has been recorded in India.

Habitat: Sandy and muddy bottom.

Taxonomic note: This species was first described by Regan (1905) based on a sample from Kobe off Japan. Simultaneously Evermann and Seale (1907) described a fish *Platophrys palad* from Bulan, Philippines. The description of the fish was similar to that of Regan and hence was synonymised with *Pseudorhombus dupliocellatus*.

Observations: Lateral line count of Weber and Beaufort's (1929) specimens are slightly less than the present work; present results match with that of Norman (1934) and Punpoka (1964). However, lateral line counts of Jordan and Starks (1907) are very high compared to the earlier workers as well as to the present specimen.

This specimen differs from *P. triocellatus* in the presence of 4 ocelli on the ocular side compared to three in the latter.

4.3.3.1.5 *Pseudorhombus elevatus* Ogilby, 1912

Deep flounder

Pseudorhombus elevatus Ogilby, 1912, *Mem. Qd. Mus*., I: 45 (Bulwer, Moreton Bay, Queensland); Norman, 1926, *Biol. Res. "Endeavour*", V (5): 234, fig.3; Norman, 1927, *Rec. Indian Mus*., 29(1): 15 (Persian Gulf, 13 fathoms); Mc Culloch, 1929, *Mem. Aust. Mus.,* 5 (2): 279; Norman, 1934, *Syst. Monog. Flatfish*, I: 108, fig. 66 (Persian Gulf, 13 fathoms, Australia); Blegvad, 1944, *Danish Sci., Invest. Iran*, pt. 3: 200 (West of Bushire; Jask; Res el Mutaf); Fowler, 1956, *Fish. Red Sea S. Arabia*., I: 164, fig. 83; Marshall, 1964, *Fish. Great Barrier Reef*: 455 (Bowen, Harvey Bay, 9 – 25 fathoms), Chen and Weng, 1965, *Biol. Bull.,* 25 (*Ichth. Ser.*, 5): 34, fig. 21 (Tungkong); Munroe, 1967, *Fish. New Guinea*: 129, fig. 201 (New Guinea); Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 853, fig. 351; Hensley, 1986, *Smith. Sea Fish.,*: 862; Kuronuma and Abe, 1986, *Fish. Arabian Gulf*: 243 (Gulf); Allen and Swainston, 1988, *Marine Fish. Aust.,*: 146; Krishnan and Mishra, 1993, *Rec. Zool. Surv*., 94 (2 - 4): 234 (Danavaipetta); Goren and Dor, 1994, *Fish. Red Sea*, CLOFRES: 71; Li and Wang, 1995, *Fauna Sinica*: 141; Randall, 1995, *Coastal Fish. Oman*: 359; Evseenko, 1996, *J. Ichth*., 36 (9): 726; Mohsin and Ambak, 1996, *Mar. Fish. Malaysia*:

592; Allen, 1997, *Marine Fish. Aust.,*: 234; Larson and Williams, 1997, *Proc. Sixth Intl. Marine Biol. Workshop*: 373; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide*: 230; Johnson, 1999, *Mem. Qd Mus.,* 43 (2): 752; Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 644; Bijukumar and Sushama, 2000, *J. Mar. Biol. Ass. India,* 42 (1-2): 187; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide*, IV (6): 3851; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl.,* 63 :46; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1): S122; Khan, 2003, *Rec. Zool. Surv. India*, *Occ. Pap*er, 209: 11; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India. Occ. Paper*, 216: 46 (Pondicherry, Karaikal); Heemstra and Heemstra, 2004, *Coastal Fish S. Africa*: 434; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1828.

Pseudorhombus javanicus (part) Day, 1877, *Fish. India*: 424, pl. xcii, fig. 2 (Madras); Jenkins, 1910, *Mem. Ind. Mus*., :24.

Pseudorhombus affinis Weber, 1913, *Die Fisch. Siboga Exped.,* LVII: 426, pl. xi. fig I (Saleyer); Weber and Beaufort, 1929, *Fish. Indo-Aust. Archip.*, V: 110, fig. 25 (Saleyer, Malacca Strait).

? ***Pseudorhombus oligodon*** Schmidt and Lindberg, 1930, *Bull. Acad. Leningrad*: 1147.

Material examined: N = 24; TL = 51.4 – 140.08 mm from Neendakara.

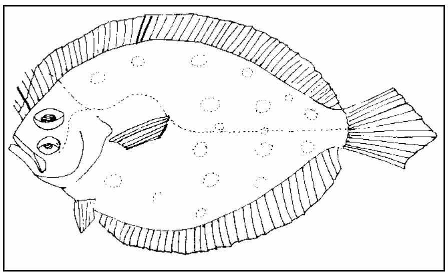



Plate VII: *Pseudorhombus elevatus* Ogilby, 1912

Diagnosis: An elongate-oval shaped flounder with about five rows of faint dark rings on the dorsal surface with a brownish ocelii with or without a ring of small white spots at the junction of the curved and straight lateral line.

Meristic counts: D 67–71 (69); A 50 - 61 (55); P_1 9 - 11 (10); P_2 7–10 (9); V_1 (O), (B) 5 - 6 (6); C 4 + 10 -15 (13); Ll. 63 - 81 (75).

Body proportions as percent of SL (mean in parentheses): HL 27.3 – 32.5 (30.5); HD 20.91–46.9 (27); BD_1 46.7–98.7 (53.9); P_1FLO 15.8–20 (18); P_2FLB 8.2–18 (12.9); V_1FLO 4.3–14.7 (9.3); V_2FLB 3.8–16.3 (10.6); CFL 16.3–26.1 (21.5); DFL 7.3–14.9 (9.79); AFL 10.3–19 (12.7); P_1BLO 3.7–9.8 (4.8); P_2BLB 2.9– 4.7 (3.7); V_1BO 3.3–6.1 (4.7); V_2BB 1.9–4.9 (3.2); CPD 9.4 -11.6 (10.3).

As percent of HL: (mean in parentheses): HD 64.9–153.2 (88.6); ED_1 25.96–36.26 (32.3); ED_2 23.9 - 31.9 (28.3); SNL_1 7.89 - 21.6 (13); SNL_2 3.2– 21 (8.44).

Description: Body profile oval, deeply flattened; head small, dorsal profile notched in front of eyes, highly convex. Eyes placed close, separated by a bony interorbital ridge, interorbital space very little. Lower eye placed slightly in front of the upper eye. Two nostrils present on ocular side, the first placed in the middle of the interorbital space just a little above the middle point of the lower eye is a tubular structure with a fleshy flap of tissue at its end. Second nasal opening is oval in outline with five fine sensory papillae at its lower origin. Mouth placed obliquely, upper jaw prominent, lower jaw with a prominent notch on the ventral profile below the inner end of the maxillary. A comparative statement of the meristic characters of *Pseudorhombus elevatus* is given in Table 15.

Table 15: A comparative statement of the meristic characters of *Pseudorhombus elevatus*

Meristic characters	Earlier workers										
	Day 1877	Weber 1913	Weber and Beaufort 1929 (as *affinis*)	Norman 1934	Blegvad 1944	Fowler 1956	Saramma 1963	Chen and Weng 1965	Munroe 1967	Amaoka 1971	Ramanathan 1977
Dorsal	69	68	66 – 76	67 -74	68	67 – 71	68	70	67 – 72	69	64 – 74
Anal	52 – 53	53	51 – 54	52 -58	52	52 – 55	52	58	52 – 58	52	47 – 58
Pectoral (o)	*	*	2.9.1	11 -12	12	11- 12	2.7.2	12	11 – 12	12	11 - 12
Pectoral (B)	*	*	11	*	*	*	9	*	*	11	10 – 12
Pelvic	6	*	2. 4	*	6	*	2.4	6	*	*	6
Caudal	18	*	*	*	*	*	*	18	59 - 67	*	17 – 18
Lateral line	70 - 75	73	70 -76	65 -74	75	59 - 67	*	*	*	66	64 - 75

Meristic characters	Earlier workers				Present Study 2004-2010	
	Type detail	Kuronuma & Abe 1986	Heemstra 1986	Randall 1995	N = 24	Mean$\pm$ SD
Dorsal	72	70	68 – 74	67 – 74	57- 71	66 $\pm$ 2.7
Anal	55	58	53 – 57	52 – 58	47 - 61	52 $\pm$ 2.7
Pectoral (o)	12	12	10 – 12	11 – 19	9 -11	10 $\pm$ 0.6
Pectoral (B)	12	11	11 – 12	*	7 - 10	9 $\pm$ 0.1
Pelvic	6	*	*	*	5 - 6	6 $\pm$ 0.3
Caudal	6	68	61 - 71	*	4 + 10 -15	13 $\pm$ 0.9
Lateral line	72		65 - 74		53 - 91	75 $\pm$ 9.6

* Data not available

Maxillary ending half way or a little beyond the middle of the lower eye. Teeth small, villiform, curved inwards, present in both jaws; closely set in the upper jaw, but set a little apart in the lower jaw. 32 teeth present on the upper jaw, and 31 teeth on lower jaw on blind side. Gill rakers long, slender, 12 numbers on lower arch and 3 on the upper arch, margins serrated. Dorsal fin origin is below the notch, above the anterior nostril on the blind side; a membranous fold runs downward from the first dorsal ray down to the nostrils on the blind side. Pectoral fin on blind side placed ahead of that on ocular side. Finlength of pectoral on ocular side longer than that on blind side. Pelvic fin on ocular inserted below the opercular flap, in front of the origin of pectoral (O) and pelvic (B). Caudal fin double truncate.

Body covered with ctenoid scales on the ocular side and cycloid scales on the blind side. Fine sharp ctenii arise from the pigmented part of the scale. Lateral line present on both sides; the lateral line is tubular in nature on the ocular side and arches above the pectoral fin. From the junction of the operculum on the ocular side, it proceeds forward in a curved manner as supratemporal branch and ends near the dorsal ray between the 8^{th} and 9^{th} ray. Each lateral line scale has a tubular part which gives off a branch to the adjoining scale. Lateral line scale is also ctenoid. Scales seen on the dorsal and anal finrays in a single row. Tip of the haemal spine projects on the ventral side just before the anal fin.

Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus elevatus* are given in Table 16.

Table 16: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus elevatus*

Characters	Ratio/ Range in SL	Mean	SD	R^2 on SL	Slope
Head length	27.3 - 32.5	30.5	1.4	0.96	0.3
Head depth	20.9 - 46.9	27.1	7.97	0.3	0.1
Eye diameter (U)	7.9 - 11.4	9.9	0.96	0.9	0.06
Eye diameter (L)	7.1 -10.2	8.6	0.8	0.9	0.06
Snout to upper eye	2.4 - 6.97	3.95	1.1	0.6	0.06
Snout to lower eye	0.97 - 6.5	2.58	1.4	0.6	0.06
Body depth	46.7 - 98.7	53.9	9.8	0.9	0.5
Pectoral fin length (O)	15.8 - 20.0	18.1	1.1	0.9	0.2
Pectoral fin length (B)	8.2 -18.0	12.9	1.7	0.8	0.12
Pelvic fin length (O)	4.3 -14.7	9.3	2.02	0.8	0.11
Pelvic fin length (B)	3.8 - 16.2	10.6	2.7	0.8	0.12
Caudal fin length	16.7 - 26.1	21.5	2.5	0.7	0.14
Dorsal height	7.3 - 14.9	9.8	1.9	0.7	0.14
Anal height	10.3 - 19.0	12.7	1.9	0.5	0.13
Pectoral base length (O)	3.7 - 9.8	4.8	1.2	0.5	0.04
Pectoral base length (B)	2.9 - 4.7	3.7	0.6	0.8	0.04
Pelvic base length (O)	3.3 - 6.1	4.7	0.8	0.8	0.05
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	64.9 - 153.2	24.72	88.6	0.25	0.5
Eye diameter (U)	26.0 - 36.3	2.65	32.26	0.81	1.4
Eye diameter (L)	23.9 - 31.9	2.47	28.26	1.0	0.1
Snout to upper eye	7.9 - 21.6	3.45	12.96	1.0	0.9
Snout to lower eye	3.2 - 21.1	4.52	8.443	0.64	0.9
Body depth	49.2 - 69.9	4.46	59.43	0.64	1.0
Pre dorsal	15.3 - 31.4	3.38	20.63	0.49	0.5
Pre anal	88.3 - 121.2	8.74	108	1.0	1.8
Pre pelvic (O)	67.6 - 103.8	7.98	82.5	0.81	0.6
Pre pelvic (B)	63.0 - 99.4	7.75	83.71	1.0	2.5

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 26, 27, 28); the linear regression equations obtained were

Head depth on SL	: $y = 0.14x + 7.87$; $R^2 = 0.28$; $p < 0.001$
Body depth on SL	: $y = 0.5x + 2.05$; $R^2 = 0.71$; $p < 0.01$
Eye diameter (ocular) on SL	: $y = 0.06x + 2.08$; $R^2 = 0.87$; $p < 0.001$
Eye diameter (blind) on SL	: $y = 0.06x + 1.55$; $R^2 = 0.92$; $p < 0.001$
Dorsal fin length on SL	: $y = 0.14x - 1.14$; $R^2 = 0.71$; $p < 0.001$
Anal fin length on SL	: $y = 0.13x - 0.144$; $R^2 = 0.81$; $p < 0.001$
Predorsal fin length on SL	: $y = 0.067x - 0.203$; $R^2 = 0.73$; $p < 0.001$
Pectoral fin length (O) on SL	: $y = 0.17x + 0.989$; $R^2 = 0.94$; $p < 0.001$
Head width on HL	: $y = 0.48x + 7.54$; $R^2 = 0.30$; $p < 0.05$
Snout length (SNL_1) on HL	: $y = 0.19x - 1.22$; $R^2 = 0.62$; $p < 0.001$
Snout length (SNL_2) on HL	: $y = 0.21x - 2.39$; $R^2 = 0.63$; $p < 0.001$

Results of regression analysis showed that the variation of various body parameters in relation to standard length and head length is highly significant.(Figs. 26, 27, 28).

Colour in fresh condition: Body (ocular) in fresh condition is pale brownish with a series of faint circular markings, with three conspicuous markings on the lateral line, one at the bottom of the curve, one at the middle of the body and one at the caudal fin origin. Blotches on the body are more or less speckled with white. Faint markings extend onto dorsal side of all fins. Caudal fin has no markings. Blind side pale white in colour. The colour is not lost in preserved specimens.

Distribution:

World: Reported from Persian Gulf, throughout the Indian Ocean and on coasts of India, Burma, east coast of Queensland, throughout Indo–

Australian Archipelago, Queensland (Ogilby, 1912); Saleyer (Weber, 1913); Malacca Strait, Persian Gulf (Norman 1927, 1934); Malacca Strait (Weber and Beaufort, 1929); Bulwer, Moreton Bay, West of Bushire; Jask; Res el Mutaf (Blegvad, 1944); Iranian Gulf (Blegvad, 1944); Tungkong (Chen and Weng, 1965); Thailand (Punpoka, 1964) and northern Australia (Sainsbury *et al*., 1985). Map showing localities were *Pseudorhombus elevatus* has been recorded in the world is given in Fig. 24.

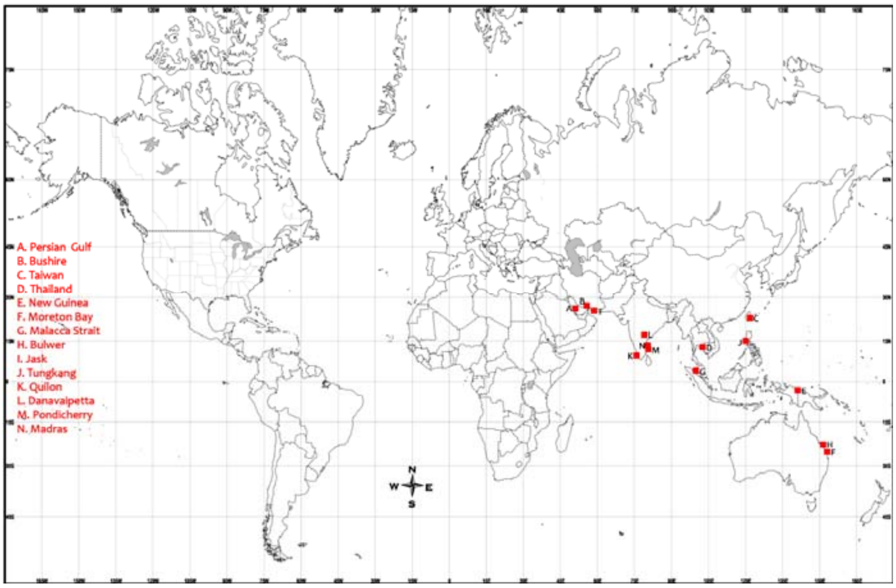


Fig. 24: Map showing localities were *Pseudorhombus elevatus* has been recorded in the world.

India: Recorded from Quilon on west coast of India, Danavaipetta (Krishnan and Mishra, 1993) Pondicherry, Karaikal (Mishra and Krishnan, 2003) and Madras (Day, 1877) on the East coast. Map showing localities were *Pseudorhombus elevatus* has been recorded in the world is given in Fig. 25.

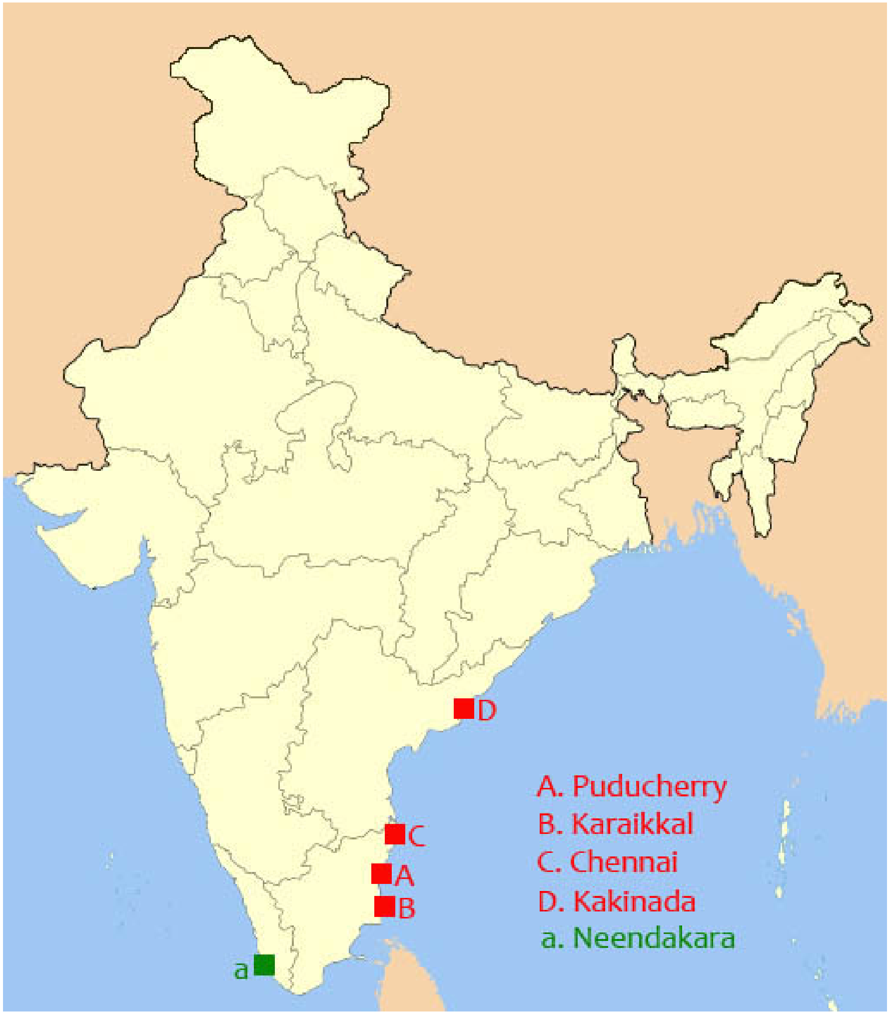


Fig. 25: Map showing localities were *Pseudorhombus elevatus* has been recorded in India

Taxonomic comments: The species was originally described as *Pseudorhombus javanicus* by Day which was followed by Jenkins (1910). In 1913, Weber described the same fish as *P. affinis*. The meristic counts given by Weber (1913) and Weber and Beaufort (1929) match well with that of Day (1879) and hence can be synonymised with *P. javanicus* of Day, of Blegvad (1944). Counts and description given by Norman

(1934) are the same as that of the earlier workers for the species and hence they can be synonymised as junior synonyms of *P. elevatus*. *P. javanicus* of Day (1889) is actually another species and not the species mentioned here as seen from the difference in fin counts.

Observations: Results of the present study match with that of Weber (1913) and Norman (1934), but the lower ranges were seen in a few specimens. Pectoral fin counts (ocular) given by Randall (1995) are higher than that reported by earlier workers. However, in the present study, few specimens with lower pectoral fin counts were also obtained. Slight variation was noticed in the lateral line counts of the present work compared to the earlier workers. Results are closer to that of Norman (1934) and Randall (1985). However, Fowler (1956) reported very low range (59 – 67). The counts given by Ramanathan (1977) and Radhamanyamma (1988) match well with that of the present work. Hensley in Smith and Heemstra (1986) noted that specimens from the Arabian Gulf and South Africa had more gillrakers on lower arch (15 – 19) than elsewhere (10 – 15). Randall (1995) mentions that the fish attains 18 cm TL; however the samples in the present study had a maximum length of only 14 cm. Blegvad mentions of a sample weighing 1.5 kg, but the samples collected in the present study were relatively smaller in size. Pectoral fin counts (ocular) given by Randall (1995) were higher than that reported by earlier workers. However, in the present study, two specimens with lower pectoral fin counts were also obtained. Slight variation was noted in lateral line counts of the present work in relation to earlier workers, but results are closer to that of Norman (1934), Randall (1985). However, Fowler (1956) reported very low range (59 - 67) for lateral line counts.

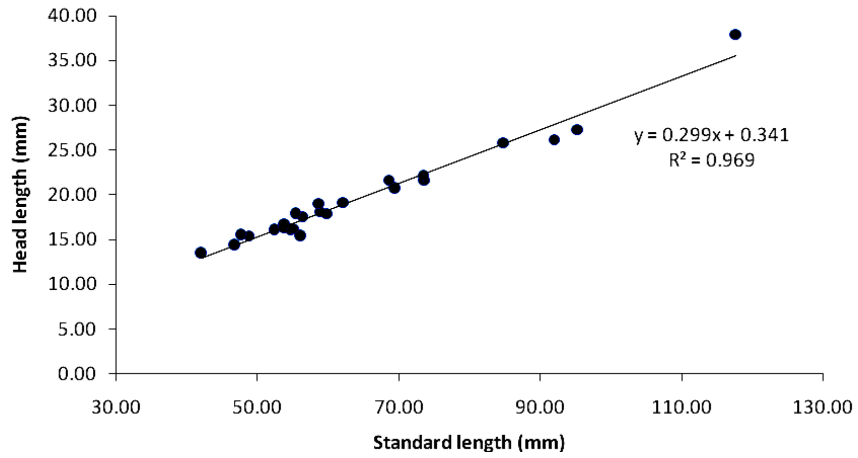


Fig. 26: Regression of Head length on Standard length

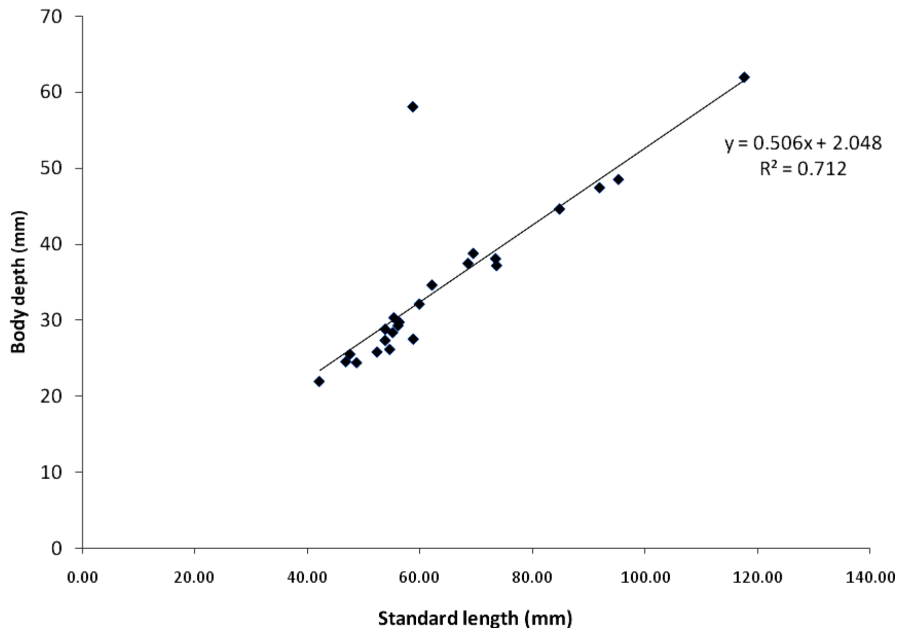


Fig. 27: Regression of Body depth on Standard length

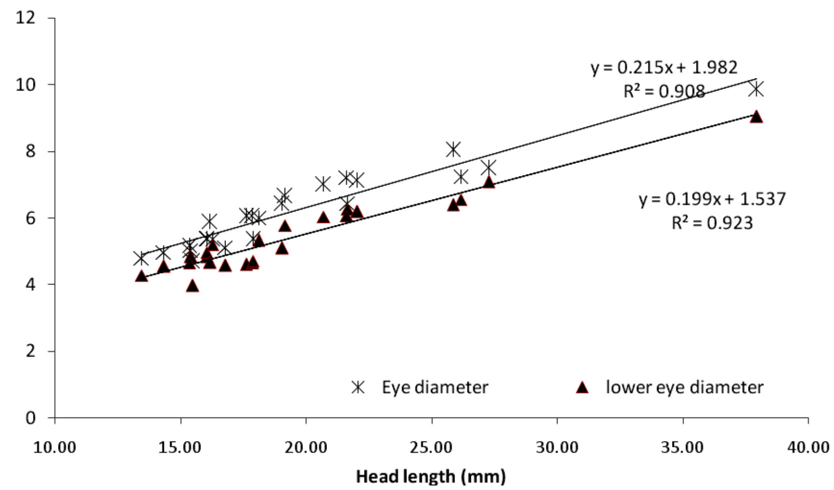


Fig. 28: Regression of eye diameter on Head length

4.3.3.1.6 *Pseudorhombus javanicus* (Bleeker,1853)

Javanese flounder

Rhombus javanicus Bleeker 1853, *Nat. Tijd. Ned. Indië*, 4: 502 (type locality: Jakarta, Batavia, Java, Indonesia).

Platophrys javanicus Evermann and Seale, 1907, *Bull. U.S Bur. Fish.*, XXVI, (1906): 105.

Pseudorhombus javanicus Gunther, 1862, *Cat. Brit. Mus.*, IV: 427 (Java); Bleeker, 1866 -1872, *Atl. Ichth.*, VI: 8; Day, 1878 - 1888, *Fish. India*, 4^0: 424; Alcock, 1889*, J. Asiat. Soc. Bengal*, LVIII, pt. 2 (3): 282 (Bay of Bengal); Jordan *et al.*, 1907, *Bull. Bur. Fish.*,:281 (Philippines); Jenkins, 1910, *Mem. Ind. Mus.,* III, I: 24 (Elephant point, Puri Beach); Weber, 1913, *Siboga–Exp. Fische*: 424 (Makascar); Norman, 1927, *Rec. Ind. Mus.*, XXIX: 16 (Puri Beach); Weber and Beaufort, 1929, *Fish. Indo–Aust. Archip.*,: 109, (Malaya); Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) viii: 598; Wu, 1932, *Thes. Fac. Sci. Univ. Paris,* A. 244 (268): 82; Norman, 1934, *Syst. Monog. Flatfish*: 109, fig. 67 (Singapore, Nahtram Bay); Blegvad, 1944, *Danish Sci. Invest. Iran*, III: 201, pl.12, fig. 1 (South of Bushire; Chahbar); Fowler, 1956, *Fish. Red Sea,* I: 164 (Iran, East Indies); Menon, 1961, *Rec. Ind. Mus.*, 59 (3):399 (Coramendal coast, Porto Novo); Kyushin *et al.,* 1982, *Fish. South China Sea*: 261; Li and Wang 1995, *Fauna Sinica*: 131; Randall, 1995, *Coastal Fish. Oman*: 358, Mohsin and Ambak, 1996, *Mar. Fish. Malaysia*: 593; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide*: 231; Mishra *et al*., 1999, *Rec. Zool. Surv. India*, 93(3): 89; Amaoka and Hensley, 2001, *FAO Sp. Iden. Guide*,: 3852; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (suppl. 1): S122; Mishra and Krishnan 2003, *Rec. Zool. Surv. India Misc. Publ. Occ. Paper*, 216: 47.

Platophrys javanicus Evermann and Seale, 1906, *Bull. Bur. Fish.,* XXVI: 105.

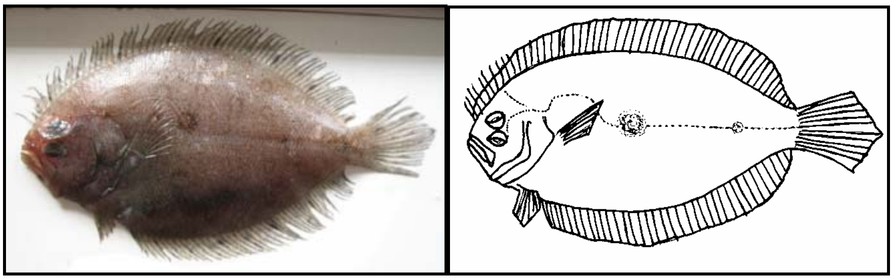


Plate VIII: *Pseudorhombus javanicus* (Bleeker, 1853)

Material examined: N = 1; TL 178.16 mm.

Diagnosis: Head evenly curved on dorsal profile; body scales on ocular side ctenoid anteriorly, cycloid posteriorly, with a strip of ctenoid scales at the edges of the body.

Meristic counts: D 69; A 51; P_1/P_2 10/10; V_1/V_2 6/5; C 15; Ll. 79.

Body proportions as percent of SL: HL 34.5; HW 48.3; HD 29.4; ED_1 9.3, ED_2 8.3; ID 0.9; UJL 14.3; LJL 13.3; P_rOU 2.8; P_rOL 6.9; PBU 18.7; PBL 19.7; SNL_1 8.5; SNL_2 6.1; DFL 11.5; AFL 12.2; P_1FLO 19.9; P_2FLB 12.5; V_1FLO 14.6; V_2FLB 10.4; CFL 18.5; DBL 85.9; ABL 57.9; P_1BLO 3.8; P_2BLB 3.8; V_1BLO 4.3; V_2BLB 2.7; CBL 13.3; P_1LO 33.3; P_2LB 33.7; V_1LO 29.5; V_2LB 30.2.

As percent of HL: HW 140.1; HD 85.2; ED_1 27.1; ED_2 24.2; ID 2.6; UJL 41.5; LJL 38.7; P_rOU 8.1; P_rOL 20.01; PBU 54.2; PBL 57.3; SNL_1 24.8; SNL_2 17.6; DFL 33.3.

Description: Body oblong, oval, flattened, upper profile uniformly convex, with a very slight notch in front of interorbital space. Upper eye placed a little in front of the lower eye; preorbital length contained nearly 3 times in upper eye diameter; eye diameter contained 3.6 - 4 times in HL. Two nostrils present in front of the interorbital space, both round in outline, anterior one with an elongated tubular fleshy covering, the other without any flap. Mouth large, maxillary ending a little more than middle of lower eye. Lower jaw longer; teeth present on both jaws, small at the inner end, a little enlarged anteriorly; 12 teeth on lower jaw on blind side. Gill rakers spiny, those on lower limb longer.

Dorsal fin origin on blind side, above the nostrils, in front of upper eye; first two rays of dorsal fin free, all the other rays connected by a membrane at the base. Pelvic fin origin on both ocular and blind side together. Pelvic fin on blind side smaller. A comparative statement of the meristic characters of *Pseudorhombus javanicus* is given in Table 17. Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus javanicus* are given in Table 18.

Table 17: A comparative statement of the meristic characters of *Pseudorhombus javanicus*

Meristic Characters	Earlier workers									Present Study 2004-2010
	Gunther 1862	Day 1889	Weber 1913	Norman 1927	Weber and Beaufort 1929	Norman 1934	Munroe 1955	Fowler 1956	Amaoka 1969	N = 1
Dorsal	69 - 74	69	71	69 -72	71 -76	69 -76	69 - 72	69 - 76	74 -78	73
Anal fin count	51 -56	52 – 53	51	54 – 55	54 -56	51 -56	54 - 55	51 - 56	57 -60	55
Pectoral (O)	*	10	*	11	2.8.2	11 -12	*	11 - 12	11 -12	11
Pectoral (B)	*	*	*	*	*	*	*	*	10 -12	11
Pelvic	*	6	*	*	2 +4/ 2.3.1	*	*	*	*	5 /5
Caudal	*	18	*	*	*	*	*	*	*	2 +13+2
Lateral line count	75	70 - 75	73	68 -72	75 - 80	67 -74	68 -72	67 - 74	70 - 80	65

*Data not available

Table 18: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus javanicus*

Characters	In SL	SD	In HL	SD
Head width	2.07	67.2	0.7	14.6
Head depth	3.4	53.04	1.17	5.4
Eye diameter (U)	10.7	38.02	3.7	26.6
Eye diameter (L)	12.02	37.3	4.14	27.7
Inter orbital	112.7	31.7	38.8	35.6
Upper jaw length	7.00	41.8	2.4	21.4
Lower jaw length	7.50	41.03	2.6	22.4
Pre orbital (U)	36.02	33.12	12.4	33.6
Pre orbital (L)	14.5	36.2	5.00	29.2
Post orbital (U)	5.4	45.02	1.9	16.7
Post orbital (L)	5.1	45.83	1.8	15.6
Snout to upper eye	11.7	37.44	4.03	27.5
Snout to lower eye	16.5	35.6	5.7	30.1
Dorsal fin length	8.7	39.7	2.99	24.3
Anal fin length	8.2	40.14	2.8	23.6
Pectoral fin length (O)	5.04	45.9	1.7	15.5
Pelvic fin length (B)	8.03	40.4	2.8	23.3
Pelvic fin length (O)	6.9	41.97	2.4	21.04
Pelvic fin length (B)	9.6	38.9	3.30	25.5
Caudal fin length	5.4	44.9	1.86	16.9

Pectoral fin origin on blind side in front of anal fin; pectoral fin origin (ocular) behind pelvic (ocular). Well developed caudal peduncle present. Lateral line origin just above free tip of operculum, supratemporal branch enters dorsal fin base at 10-11th ray, the other branch moves downwards, a subbranch entering upper eye, the other curves around lower eye and enters it. The other main branch curves around pectoral fin as a plateau and proceeds towards caudal fin as a straight line. Scales on ocular side ctenoid except at base of dorsal and anal fins and area near caudal peduncle; ctenoid scales round in outline with fine radiating ctenii on proximal end. Blind side covered with cycloid scales. Interhaemal spine slightly visible on ventral profile. Caudal double truncate.

Colour: Body brownish, covered with feeble round patterns, continued on the fins also. Two dark spots present on body, one at junction of curved and straight lateral line, second at middle of straight lateral line.

Distribution:

World: Jakarta, Batavia, Java, Indonesia (Bleeker, 1853); Malaya (Weber and Beaufort, 1929); South of Bushire; Malaya Peninsula, Indo–west Archipelago, southern China, Singapore, Nahtram Bay (Norman, 1934); Chahbar (Blegvad, 1944); Iran, East Indies (Fowler, 1956). Map showing localities were *Pseudorhombus javanicus* has been recorded in the world is given in Fig. 29.

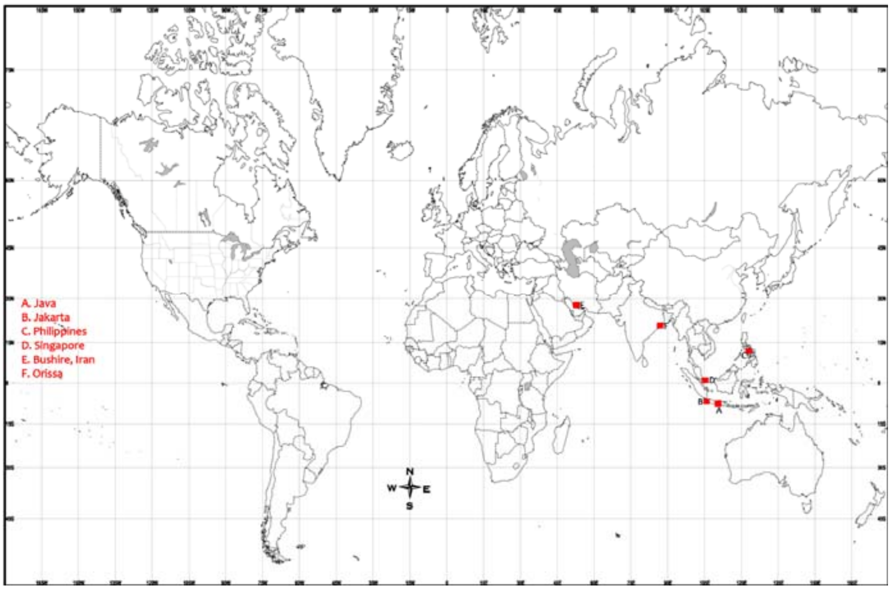


Fig. 29: Map showing localities were *Pseudorhombus javanicus* has been recorded in the world.

India: Puri Beach, East coast of India (Jenkins, 1910, Norman, 1927, 1934), Quilon, Kochi (present work). Map showing localities were *Pseudorhombus javanicus* has been recorded in the world is given in Fig. 30.

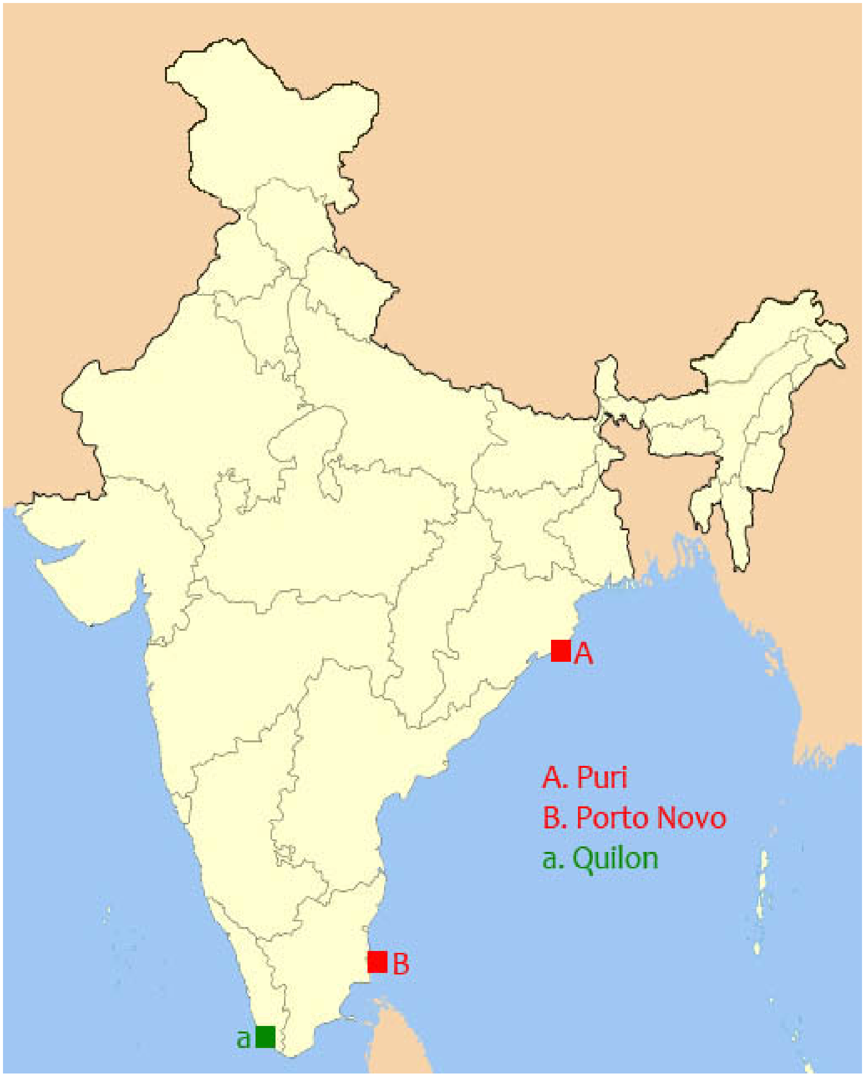


Fig. 30: Map showing localities were *Pseudorhombus javanicus* has been recorded in India

Taxonomic comments: The fish was first described by Bleeker (1853) based on a sample from Java. Descriptions and counts given by subsequent workers are very similar to the present results. Jordan *et al*. (1907) mentions of six specimens collected from Cavite described as *Pseudorhombus polyspilus* by Jordan and Seale which were later redescribed as *P. javanicus*. Norman (1931) compared this species to Oshima's description of *Spinirhombus levisquamis* and suggested that they are synonyms.

Observations: *P. javanicus* differs from *P. arsius* in greater number of teeth (Fischer and Bianchi, 1984). Weber (1913) mentions that the meristic counts are more closely related to Gunther than to that of Day. Norman (1927) mentions of the supratemporal branch entering the 9th – 10th ray of the dorsal, however, in the present work, it enters the dorsal ray at the 10th – 11th ray base.

New Record 3

4.3.3.1.7 *Pseudorhombus natalensis* Gilchrist 1905

Natal flounder

Pseudorhombus natalensis Gilchrist 1905, *Mar. Invest. S. Afr.*, III: 8, pl. xxv (Cape Natal); Gilchrist and Thompson, 1917, *Ann. Durban. Mus.*, I: 399; Regan, 1920, *Ann. Durban Mus.*, II: 209 (Cape Natal, 54 fathoms); von Bonde, 1925, *Trans. Roy. Soc. S. Afr.*, XII: 290; Fowler, 1926, *Proc. Acad. Nat. Sci. Philad.*, LXXVII: 203; Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) VIII: 508; Norman, 1934, *Syst. Monog. Flatfish*: 104, fig. 63 (Natal); Hensley, 1986, *Smith. Sea Fish.,*: 5669 (Durban and Tugela River); Mohsin and Ambak, 1996, *Mar. Fish. Malaysia*: 593; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43: S122; Heemstra and Heemstra, 2004, *Coastal Fish. S. Africa*: 434.

Pseudorhombus russellii (part) Barnard, 1925, *Ann. S. Afr. Mus.*, xxi: 388, pl. xvii, fig.2.

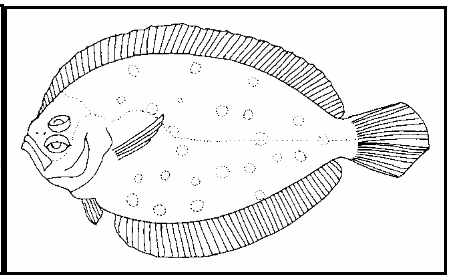



Plate IX: *Pseudorhombus natalensis* Gilchrist 1905

Material examined: N = 3; TL 186.11–289 mm from Neendakara Fishing Harbour.

Diagnosis: A *Pseudorhombus* fish with the last two dorsal finrays and last three anal rays branched.

Meristic counts: D 68 - 71 (69); A 48–51 (49); P (O/B) 9–10; V 6/5- 6; C 16–17; Ll. 66–77.

Body proportions as percent of SL (mean in parentheses): HL 27.8–28.9 (28.2); HW 23.1–24.9 (23.9); HD 39.6–43.1 (41.4); ED_1 6.3–6.8 (6.5); ED_2 6.1–6.5 (6.3); SNL_1 7.3 –7.7 (7.5); SNL_2 5.98–6.3 (6.2); ID 0.6–0.9 (0.7); UJL 10.7–11.3 (10.98); LJL 8.5–9.9 (9.2); CD 2.3–3.3 (2.7); BD_1 10.4–41.9 (29.2); BD_2 49.3–49.6 (49.4); DFL 10.3–11.1 (10.7); AFL 12.7–14.3 (13.4); P_1FLO 16.7–17.9 (17.2); P_2FLB 11.4–13.12 (12.2); V_1FLO 9.4–10.8 (9.97); V_2FLB 8.7–11.2 (10); CFL 18.03–20.8 (19.6); DBL 89.97–92.3 (91.3); ABL 66.7–70.4 (68.6); P_1BLO 4.02–4.4 (4.2); P_2BLB 2.9–4.4 (3.6);

V_1BO 4.0–4.9 (4.3); V_2BB 2.98–4.04 (3.4); CFL 11.6–12.8 (12.3); PDL 4.1–4.4 (4.2); P_1LO 27.3–28.8 (27.98); P_2LO 27.3–29.9 (28.5); V_1LO 22.2–23.8; V_2LB 22. 6–23.2.

As percent of HL (mean in parenthesis): HW 83.1–86.2 (84.97); HD 137.1–155.2 (147.2); ED_1 22.4–24.6 (23.2); ED_2 21.9–22.5 (22.3); SNL_1 26.3–26.8 (26.6); SNL_2 21.5–22.7 (21.9); PBU 52.2–56.4 (54.5); PBL 55.7–57.9 (56.5); UJL 37.8–40.8 (38.99); LJL 30.7 –35.7 (32.5); CD 8.1–11.5 (9.5); BD_1 37.4–150.6 (110.4); BD_2 170.8 –178.6 (175.9); DFL 35.8–39.88 (38.1); P_1FLO 57.7–64.5 (61.03).

Description: Body deeply ovoid, more deep than long. Eyes placed close together, separated by a bony interorbital ridge; lower eye placed a little in front of upper eye. Snout shorter than eye diameter. Two nostrils seen in front of lower eye, just above upper jaw, the outer one with a flap, the other oval. Mouth oblique, convex in outline with the maxillary ending just below the middle point of the lower eye. Lower jaw not projecting. Teeth small, villiform, close set, not enlarged anteriorly, seen on ocular side. Gill rakers very short, 10–11 on lower arm. Pectoral fin placed just behind lower eye on a straight line, just below outer opercular tip. Dorsal fin origin above the snout at the notch on blind side, in front of lower eye. All fin rays except the last two are unbranched, last two fin rays are bifurcated. Interray membrane prominent. Anal fin rays unbranched except the last three. Lateral line originates from above the operculum, curves in a semi-circular pattern over the pectoral fin and proceeds straight to the caudal fin base; the branch in front separates into a supra-temporal branch which enters the dorsal fin at the base of the 10^{th} ray; the other branch traverses the base of the upper eye and proceeds around the base of the lower eye. The supra-temporal branch and the lateral line is clearly visible on the blind side also. Interhaemal spine visible, projecting beyond body contour. Caudal fin double truncate. Body covered with weekly ctenoid scales on ocular side and cycloid scales on blind side; scales extend into dorsal and anal fin rays. A comparative statement of the meristic characters of *Pseudorhombus natalensis* is given in Table 19.

Table 19: A comparative statement of the meristic characters of *Pseudorhombus natalensis*

Meristic characters	Earlier workers					Present work 2004 - 2010	
	Gilchrist 1905	Norman, 1931, 1934	Regan 1920	Cheng and Weng 1967	Heemstra 1986	N = 3	Mean $\pm$ SD
Dorsal	67	70	70	64	68 – 72	68 - 71	69 ± 1.7
Anal	52	52	52	54	52 – 55	48 -51	49 ± 1.5
Pectoral (O/B)	*	11	*	9/8	11 – 12 (O) / 9 – 11 (B)	9 -10	9.3 ± 0.6
Lateral line	62	*	60	*	51 - 63	66 - 77	73 ± 6.1
Caudal	*	*	*	18	*	16 - 17	16.7 ± 0.6
Pelvic	*	*	*	6	*	6/5 - 6	

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus natalensis* are given in Table 20.

Table 20: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus natalensis*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.47 - 3.6	3.56	0.08	0.94	0.37
Head Width	4.02 - 4.3	4.19	0.16	0.98	1.07
Head Depth	2.32 - 2.53	2.42	0.1	0.42	0.55
Eye Diameter (U)	14.63 - 15.9	15.34	0.65	0.35	-0.02
Eye Diameter (L)	15.5 - 16.4	15.96	0.49	0.83	1.94
Snout to upper eye	12.96 - 13.7	13.36	0.37	0.98	1.26
Snout to lower eye	15.89 - 16.7	16.23	0.43	0.96	0.74
Post orbital (U)	6.2 - 6.9	6.54	0.38	0.66	2.14
Post orbital (L)	6.2 - 6.4	6.3	0.13	1	0.59
Body $depth_1$	2.4 - 9.6	4.81	4.17	0.96	0.34
Body $depth_2$	2.02 - 2.03	2.02	0.01	1	0.48
Dorsal fin length	9 - 9.7	9.36	0.33	0.87	0.08
Anal fin length	7.01 - 7.9	7.49	0.44	0.95	6.09
Pectoral finlength (O)	5.6 - 6	5.83	0.22	0.62	0.47
Pectoral finlength (B)	7.6 - 8.8	8.24	0.57	0.66	0.34
Pelvic fin length (O)	9.3 - 10.6	10.15	0.75	0.41	0.05
Pelvic fin length (B)	8.9 - 11.5	10.08	1.31	0.74	1.58
Caudal finlength	4.8 - 5.6	5.1	0.39	0.11	-0.17
Dorsal base length	1.1 - 1.1	1.09	0.02	1	1.03
Pre dorsal	22.99 - 24.1	23.67	0.6	0.79	0.35
Pre pectoral (O)	3.5 - 3.7	3.58	0.1	0.90	5.65
Pre pectoral (B)	3.4 - 3.7	3.52	0.16	0.77	1.21
Pre pelvic (O)	4.2 - 4.5	4.33	0.15	0.72	0.61
Pre pelvic (B)	4.3 - 4.4	4.37	0.05	0.96	0.64
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	1.16 - 1.2	1.18	0.02	1	1.07
Head depth	0.6 - 0.7	0.68	0.04	0.21	0.51
Eye diameter (U)	4.1 - 4.5	4.32	0.22	0.58	0.08
Eye diameter (L)	4.5 - 4.6	4.49	0.06	0.96	0.22
Snout to upper eye	3.7 - 3.8	3.76	0.04	1	0.3
Snout to lower eye	4.4 - 4.6	4.56	0.13	0.85	0.21
Post orbital (U)	1.8 - 1.9	1.84	0.07	0.85	0.67
Post orbital (L)	1.7 - 1.8	1.77	0.04	0.90	0.54
Upper jaw length	2.5 - 2.7	2.57	0.1	0.69	0.33
Lower jaw length	2.8 - 3.3	3.1	0.25	0.38	0.31
Chin depth	8.7 - 12.3	10.79	1.88	0.94	0.34

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 33, 34); the linear regression equations obtained were

Head width on SL	: $y = 0.4x - 27.08$; $R^2 = 0.98$
Head depth on SL	: $y = 0.28x + 22.63$; $R^2 = 0.42$
Body depth (BD_1) on SL	: $y = 0.34x + 10$; $R^2 = 0.13$
Dorsal fin length on SL	: $y = 0.04x + 11.8$; $R^2 = 0.87$
Anal fin length on SL	: $y = 0.28x - 23.5$; $R^2 = 0.94$
Eye diameter (upper) on HL	: $y = 0.08x + 7.19$; $R^2 = 0.57$
Eye diameter (lower) on HL	: $y = 2.22x - 0.01$; $R^2 = 0.96$
Snout length (SNL_1) on SL	: $y = 0.297x - 1.4$; $R^2 = 0.995$
Snout length (SNL_2) on SL	: $y = 0.22x + 0.2$; $R^2 = 0.84$
Postorbital length on SL	: $y = 0.54x + 1.04$; $R^2 = 0.91$

Regression of body depth BD_2 (ie. maximum depth of body) on SL and snout length (to upper eye) was found to be significant at 5% level. All the other parameters were found to be non – significant.

Colour: Brownish body with a number of distinct rings arranged all over the body on ocular side, three black ocelli seen one at the junction of curved and straight lateral line, one at posterior 2/3[rd] of lateral line and the last at the junction of caudal peduncle. Two black spots seen on caudal fin rays, black spots seen on dorsal and anal rays also. A conspicuous spot seen on pelvic fin tip.

Distribution:

World: Reported from Cape Natal (Gilchrist, 1905; Fowler, 1926; Heemstra and Heemstra, 2004). Map showing localities were *Pseudorhombus natalensis* has been recorded in the world is given in Fig. 31.

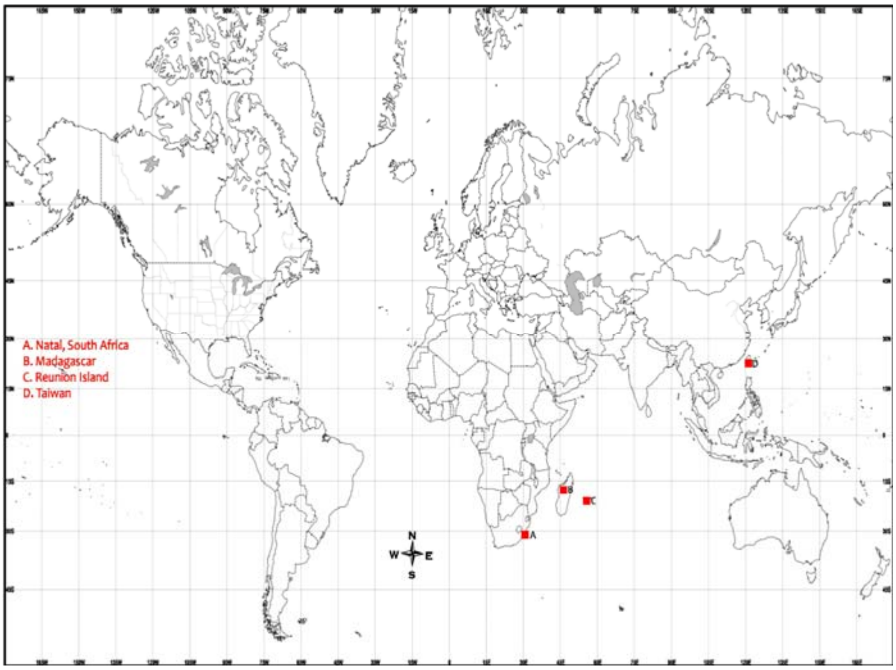


Fig. 31: Map showing localities were *Pseudorhombus natalensis* has been recorded in the world.

India: Not reported from India earlier; this is the first report from Indian waters. Map showing localities were *Pseudorhombus natalensis* has been recorded in India is given in Fig. 32.

Fig. 32: Map showing localities were *Pseudorhombus natalensis* has been recorded in India.

Taxonomic comments: The fish was first described as *Pseudorhombus natalensis* based on a sample collected by Gilchrist (1904) from Cape Natal. Barnard (1925) united *P. arsius* with *P. natalensis*. However, Norman (1931) differentiated *P. natalensis* from *P. arsius* in eye diameter being 3.5 in HL (4.6- in HL in *P. arsius*), maxillary not reaching middle of the eye (reaching middle of eye in *P. arsius*) and 58 scales in lateral line compared to 69 – 80 in *P. arsius*.

Observations: In the descriptions given by both Gilchrist (1905) and Regan (1905), the supra-temporal branch of the lateral line is said to not reach upto base of dorsal fin; however, in the present sample it is seen to touch the dorsal fin base. The counts and description of the present specimen match well with that of the descriptions given by the earlier workers.

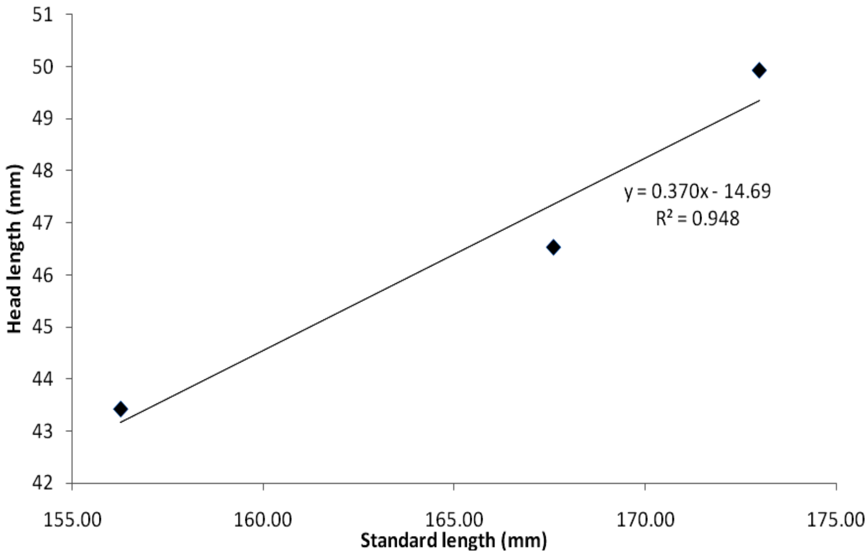


Fig. 33: Regression of Head length on Standard length

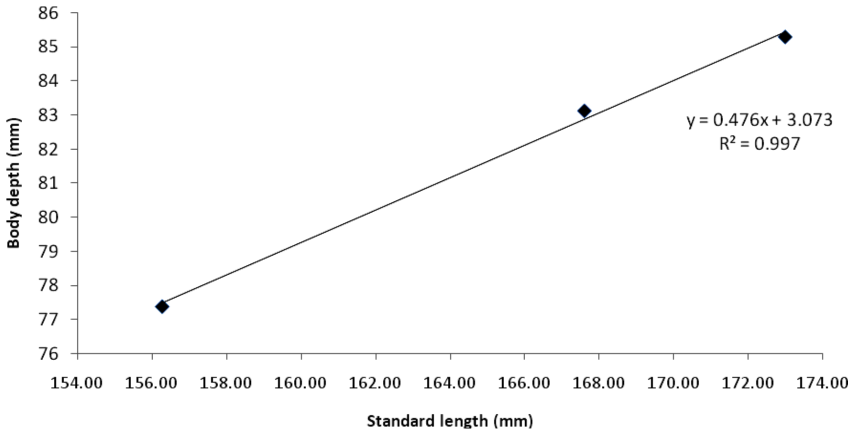


Fig. 34: Regression of Body depth on Standard length

4.3.2.1.8 *Pseudorhombus triocellatus* (Bloch and Schneider)

Three spotted flounder

Pleuronectes triocellatus Bloch and Schneider, 1801, *Syst. Ichth.,*: 145 (type locality: Tranquebar).

Rhombus triocellatus Valenciennes in Cuvier, 1836-1846, *Régne Animal,* IV. *Poissons*, in note I: 304; Bleeker, 1853, *Nat. Tijd. Ned. Indië,* V : 528 (Coramendal coast); Russell, 1803, *Pisces Coromandeliani*, pl. 76 (Vizagapatnam); Bleeker, 1853, *Verh. Bat. Gen. Bengal*, XXV: 59.

Pseudorhombus triocellatus Gunther, 1862, *Cat. Fish.,* IV: 428 (East Indian Seas); Kner, 1865, *Reise Novara Fisch.,* 1, pt. 5 : 284 (Tahiti); Bleeker, 1866–1872, *Atl. Ichth.*, vi : 9, Pleuron., pl. viii, fig. I; Day, 1877, *Fish. India*: 424, pl. xcii, fig. 1 (Madras); Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII, pt.2: 283, pl xvi, fig.3; Day, 1889, *Fauna Br. India, Fish.*, 2: 442; Gunther, 1909, *Fish. Sudsee*, VIII: 341 (Indian Ocean, Tahiti); Norman, 1927, *Rec. Ind. Mus.*, XXIX: 11 (Ceylon, Madras, East coast); Fowler, 1928, *Mem. B. P.*

Bishop Mus., 10: 93 (India, East Indies); Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.,* V: 108 (Ceylon, British India, East Indies, Sumatra, Moluccas); Norman, 1934, *Syst. Monog. Flatfish,* I: 96, fig.57 (Madras, Orissa coast); Blegvad, 1944, *Danish Sci. Invest. Iran*: 198 (Arabian Gulf, Chahbar); Jones, 1951, *J. Zool. Soc. India*, 3(1): 132; Munroe, 1955, *Fish. Ceylon*: 259, fig.746 (Pearl banks); Fowler, 1956, *Fish. Red Sea,* I: 161 (India, Ceylon, Burma, East Indies); Menon, 1961, *Rec. Ind. Mus.*, 59(3): 399 (Pondicherry, Karaikkal); Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 857 (East coast of India); Bianchi, 1985, *FAO Sp. Iden. IV*: 110 (Pakistan); Krishnan and Mishra, 1993, *Rec. Zool. Surv. India*, 93 (1-2): 234 (Uppada, Baruva); Randall, 1995, *Coastal Fish. Oman*: 359, fig. 1023 (Oman).

Paralichthys triocellatus Fowler, 1904, *J. Acad. Nat. Sci. Philad*., (2) 12: 555.

"***Nooree Nalaka***" Russell, 1803, *Descr. Fish. Visag.*, I: 59, pl. lxxvi. (Vishakapatnam)

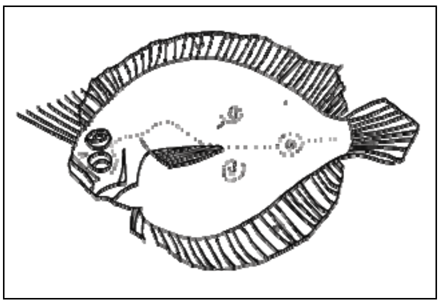



Plate X: *Pseudorhombus triocellatus* (Bloch and Schneider)

Material examined: N=10; TL 92.46 – 121.55 mm from Neendakara, Tuticorin, Mandapam.

Diagnosis: Scales cycloid on blind side, except forward at edges of body, three conspicuous ocelli on body.

Meristic characters: D 56–68, A 45–52, P_1 10–11; P_2 9–11; V_1, V_2 5–6; Ll 58 –70, Gr (lower) 24.

Body proportions as percent of SL (mean in parentheses): HL 28–31 (29), HW 26–32.5 (28), ED_1 6.6–9.4 (8.2), ED_2 7.01–10.1 (8.6), PrOU 3–3.9 (3.4), PrOL 6.4–7.7 (6.9), ID 1.2–2.8 (1.9), PBU 14.2–19.6 (16), PBL 13.3–17 (15), SNL_1 6.3–8.5 (7.1), SNL_2 5.6–7.4 (6.4), BD_1 43.2–54.6 (49.6), BD_2 60.8–65.2 (62.9), TKL 68.5–79 (72.7), UJL 11.4–15.1 (12.9), LJL 8.4–11.5 (10), CD 2.7–5.2 (3.4), DFL first finray 15.3–19.8 (16.9), DFL other finrays 12.9–16.8 (14.9), AFL 13.03–18.2 (15.7), P_1FLO 14.5–21.2 (18.9), P_2FLB 5.2–15.9 (13.2), V_1FLO 9.3–12.6 (11.1), V_2FLB 9.7–30.4 (13.2), CFL18.1–22.9 (20.7), DBL 86.2–91.8 (88.96), ABL 66.5–70.8 (68.2), P_1BLO 4.5–5.7 (5.1), P_2BLB 3.8–5.8 (4.9), V_1BLO 2.1–5.6 (3.8), V_2BLB 2.1–4.3 (2.9), CBL 8.02–14.54 (11.6), CPD 10.6–13.04 (11.8), PDL 2.7–6.12 (4.4), PAL 30.4–38.8 (35.4), P_1LO 26.6–32.2 (29.02), P_2LB 27.8–32.8 (29.95), V_1LO 24.9–28.1 (26.4), V_2LB 17.3–26.73 (23.2).

As percent of HL (mean in parentheses): HW 101.1-167.38 (149.82), HD 93.1–104.8 (96.9), ED_1 22.6–31.6 (28.2), ED_2 24.9–34 (29.4), PrOU 10–13.9 (11.8), PrOB 22.7–27 (23.9), ID 4.1–9.5 (6.6), PBU 49.4–63.3 (55), PBL 49.4–63.3 (51.3), SNL_1 22.4–29.6 (24.2), SNL_2 20–25.7 (21.9).

Description: Body deeply ovoid, head large with a slight notch on snout; head length nearly equal to head width; eyes large, sinistral, separated by a narrow naked interorbital ridge, upper and lower eye diameter nearly equal; lower eye a little in advance of the upper eye; maxillary scaly extending up to anterior $1/3^{rd}$ of the lower eye. Nostrils two on ocular side, placed in front of the interorbital space; first one circular in outline, with a long fleshy tubercle, thick fleshy wall and a small fleshy lobe covering the outer periphery; the second nostril is ovoid in outline with six fine ciliated structure on the wall at the entrance. Single row of villiform teeth seen on upper and lower jaw on ocular side; close set in front and widely spaced inside. Gill rakers very long, with slight serrations on their inner end and closely set with 24 on lower part of first gill arch.

Lateral line arises from above the opercular region, rising to a prominent curve above pectoral fin and then extending straight backward. The supratemporal branch reaches the base of 12-13th dorsal fin ray, the other branch passing below upper eye to about half of lower eye; extensions from the lateral line extend into skin. Lateral line scale has a tubular groove through which the canal runs.

Dorsal fin origin is on blind side at the notch well in front of upper eye, anterior rays (first 12) longer than rest, free and not joined by membrane. Pectoral finlength (ocular) 1.5 times in head length. Pre-anal spine very strong. Origin of pelvics (on ocular and blind side) in front of pectoral fin, bases together. Dorsal and anal fin bases end at origin of caudal peduncle, not confluent with the caudal. Caudal fin slightly rounded or double truncate. Body width maximum after the point of the anus. Scales weekly ctenoid on ocular side and cycloid on blind side. A comparative statement of the meristic characters of *Pseudorhombus triocellatus* is given in Table 21. Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus triocellatus* are given in Table 22.

Table 21: A comparative statement of the meristic characters of *Pseudorhombus javanicus*

Meristic Characters	Earlier workers									Present Study 2004-2010
	Gunther 1862	Day 1889	Weber 1913	Norman 1927	Weber and Beaufort 1929	Norman 1934	Munroe 1955	Fowler 1956	Amaoka 1969	N = 1
Dorsal	69 - 74	69	71	69 -72	71 -76	69 -76	69 - 72	69 - 76	74 -78	73
Anal fin count	51 -56	52 – 53	51	54 – 55	54 -56	51 -56	54 - 55	51 - 56	57 -60	55
Pectoral (O)	*	10	*	11	2.8.2	11 -12	*	11 - 12	11 -12	11
Pectoral (B)	*	*	*	*	*	*	*	*	10 -12	11
Pelvic	*	6	*	*	2 +4/ 2.3.1	*	*	*	*	5 /5
Caudal	*	18	*	*	*	*	*	*	*	2 +13+2
Lateral line count	75	70 - 75	73	68 -72	75 - 80	67 -74	68 -72	67 - 74	70 - 80	65

*Data not available

Table 21: Results of the correlation coefficient analysis on non-meristic characters of *Pseudorhombus triocellatus*

Characters	**Ratio/Range in SL**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head length	3.2 - 3.6	3.44	0.1	0.9	0.3
Head Width	1.9 - 3.5	2.34	0.4	0.5	0.6
Head Depth	3.1 - 3.8	3.56	0.2	0.6	0.2
Eye Diameter (U)	10.6 - 15.1	12.3	1.5	0.1	0.03
Eye Diameter (L)	9.9 - 14.3	11.8	1.4	0.01	0
Pre orbital (U)	25.5 - 33.96	29.6	3.04	0.5	0.04
Pre orbital (L)	12.9 - 15.6	14.4	0.8	0.7	0.05
Inter orbital	35.9 - 82.5	54.9	13.9	0.3	0.03
Post orbital (U)	5.1 -7.1	6.29	0.5	0.5	0.13
Post orbital (L)	5.9 -7.5	6.7	0.6	0.6	0.2
Snout to upper eye	11.7 - 15.8	14.3	1.5	0.3	0.1
Snout to lower eye	13.6 - 17.7	15.8	1.3	0.3	0.04
Body depth I	1.8 - 2.3	2.02	0.14	0.5	0.3
Body depth II	1.5 - 1.6	1.6	0.03	0.96	0.6
Pre dorsal	16.3 - 37.3	23.9	5.7	0.04	0.02
Pre anal	2.6 - 3.2	2.8	0.2	0.5	0.3
Prepectoral (O)	3.1 - 3.8	3.5	0.2	0.7	0.3
Prepectoral (B)	3.1 - 3.6	3.4	0.2	0.7	0.24
Prepelvic (O)	3.6 - 4.02	3.8	0.14	0.9	0.3
Prepelvic (B)	3.7 - 5.8	4.4	0.8	0.7	0.5
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head Width	0.6 - 0.99	0.68	0.113	0.79	2.30
Head Depth	0.95 - 1.1	1.03	0.039	0.91	0.89
Eye Diameter (U)	3.2 - 4.4	3.59	0.377	0.48	0.15
Eye Diameter (L)	2.9 - 4.02	3.44	0.340	0.26	0.05
Pre orbital (U)	7.2 - 10	8.62	1.026	0.57	0.11
Pre orbital (L)	3.71 - 4.4	4.20	0.249	0.78	0.17
Inter orbital	10.5 - 24.2	15.98	4.092	0.48	0.09
Post orbital (U)	1.6 - 2.03	1.83	0.118	0.82	0.58
Post orbital (L)	1.7 - 2.1	1.96	0.123	0.91	0.70
Snout to Upper eye	3.4 - 4.5	4.17	0.377	0.63	0.24

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 37, 38); the linear regression equations obtained were

Head width on SL	: $y = 0.55\ x - 10.19$; $R^2 = 0.47$; $p < 0.05$
Head depth on SL	: $y = 0.21\ x + 6.64$; $R^2 = 0.60$; $p < 0.001$
Body depth on SL	: $y = 0.31\ x + 16.46$; $R^2 = 0.53$; $p < 0.05$
Body depth (max) on SL	: $y = 0.57\ x + 4.898$; $R^2 = 0.97$; $p < 0.05$
Dorsal finlength on SL	: $y = 0.09\ x + 5.54$; $R^2 = 0.3$
Anal finlength on SL	: $y = 0.03\ x + 10.88$; $R^2 = 0.06$
Head width on HL	: $y = 2.3\ x - 20.81$; $R^2 = 0.62$; $p < 0.001$
Lower eye diamter on HL	: $y = 0.05\ x - 6.16$; $R^2 = 0.07$
Preorbital (upper) on HL	: $y = 0.11\ x + 0.213$; $R^2 = 0.33$
Preorbital (lower) on HL	: $y = 0.17\ x + 1.7$; $R^2 = 0.60$; $p < 0.05$
Snout length (SNL_1) on HL	: $y = 0.24\ x + 0.09$; $R^2 = 0.\ 4$
Snout length (SNL_2) on HL	: $y = 0.12\ x + 2.59$; $R^2 = 0.22$

Results show that regression of head depth on SL and head width on HL is significant at 1 % level, regression of head width, body depth on SL and preorbital on HL is significant at 5 % level.

Scale: Ocular side ctenoid with fine ctenii at the outer tips; blind side cycloid scales, ctenoid scales present at the dorsal and anal anterior base. Scales on the lateral line have a tubular structure upto half of scale for enclosing the canal. Long ctenii are present at the outer ends.

Colour: Body brownish with three prominent ocelli, one each on either side of lateral line and one on the lateral line just in front of caudal peduncle forming a triangular design. Small indistinct spots seen scattered on body and dorsal, anal and caudal fins on ocular side.

Distribution:

World: As per FAO, the species is reported from Pakistan waters, from Bombay on West coast of India to Sri Lanka, throughout the Indo-Australian Archipelago upto northwestern Australia. It is also reported from Tahiti (Kner, 1865); Ceylon, British India, East Indies, Sumatra, Moluccas (Weber and Beaufort, 1929); Chahbar (Blegvad, 1944); India, Ceylon, Burma, East Indies (Fowler, 1956); Pakistan (Bianchi, 1985). Map showing localities were *Pseudorhombus triocellatus* has been recorded in the world is given in Fig. 35.

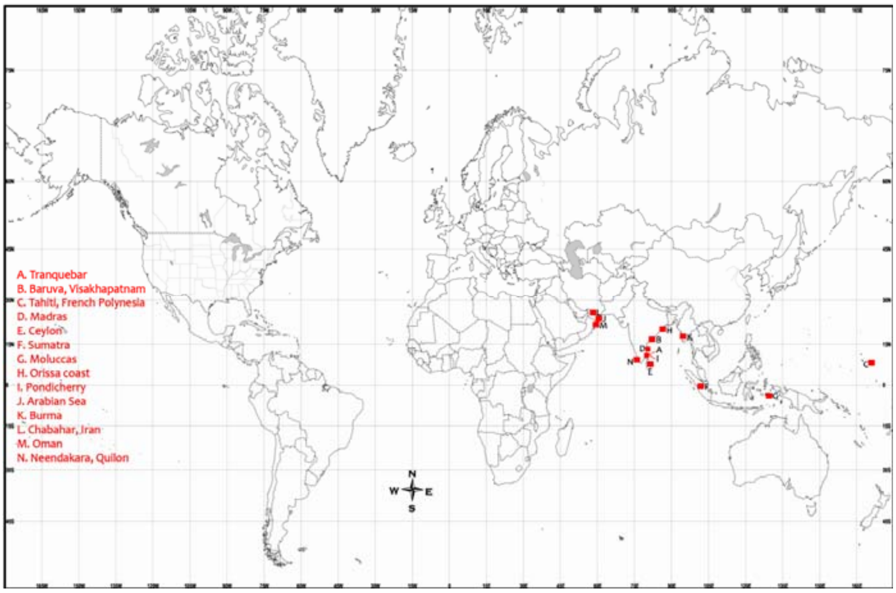


Fig. 35: Map showing localities were *Pseudorhombus triocellatus* has been recorded in the world.

India: Reported from Tranquebar (Bloch, 1801); Vishakapatnam (Russell, 1803); Coramendal coast (Bleeker, 1853); East Indian Seas (Gunther, 1862); Madras (Day, 1877); Ceylon, Madras, East coast (Norman, 1927); Madras, Orissa coast (Norman, 1934); Pondicherry, Karaikkal, (Menon, 1961); Parangipetta (Ramanathan, 1977; Rajguru,1987); Uppada, Baruva (Krishnan and Mishra, 1993); Neendakara (Radhamanyamma, 1988; present work, 2010). Map showing localities were *Pseudorhombus triocellatus* has been recorded in the world is given in Fig. 36.

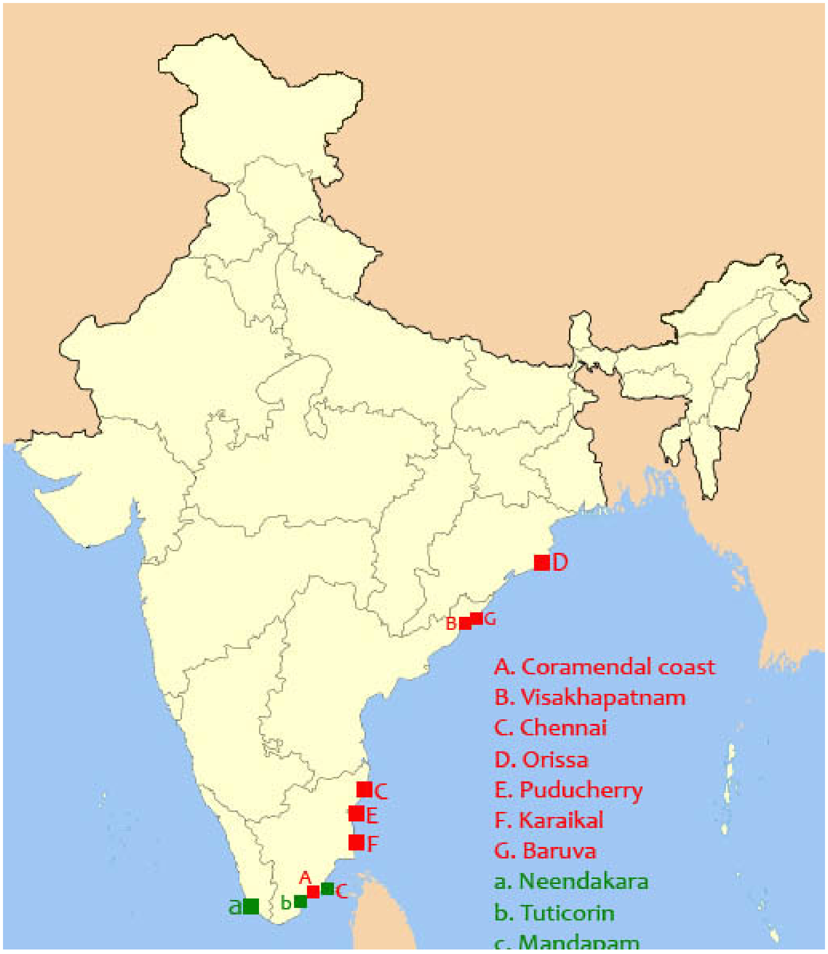


Fig. 36: Map showing localities were *Pseudorhombus triocellatus* has been recorded in India.

Fishery: Rarely seen in trawls; caught in mini trawls and vessels operating in shallow inshore waters.

Habitat: Seen to inhabit shallow waters on mud and sandy bottoms of the continental shelf.

Taxonomic note: The species was first described by Schneider (1801) in genus *Pleuronectes* based on a sample from Tranquebar, India. Subsequently, Cuvier described the species as *Rhombus triocellatus*; this was followed by Bleeker (1853) based on samples from Vishakapatnam. Gunther (1862) synonymised *Pleuronectes triocellatus* and *Rhombus triocellatus* with *Pseudorhombus triocellatus*. Russell (1803) had listed the species in his book "*Fishes of Vishakapatnam*".

Observations: The number of gillrakers on the first arch as described by Weber and Beaufort (1929) is fifteen, while in the present study it is 24. Blegvad (1924) had reported high dorsal fin ray and lateral line scale count in his samples. The dorsal fin ray count in the present study has its lower limit much less than those reported earlier. Anal fin ray and lateral line scale counts match with those of Ramanathan (1977), while those reported by Blegvad (1944) and Krishnan and Misra (1993) are in a higher range. Pectoral fin size is also unequal, that on ocular side is much larger than that of blind side.

This species differs from other *Pseudorhombus* species in the presence of the three ocellii in a triangular pattern and the enlarged anterior dorsal finrays. *P. triocellatus* differs from other sinistral flounders in having equal pelvic finbases, while it is asymmetrical in others. Munroe (1955) reports of a dorsal profile without a notch near the snout; however in the present samples, a slight notch is noticed. The same feature was reported by Radhamanyamma (1988). The meristic counts of the present specimen are well within the range reported by earlier workers.

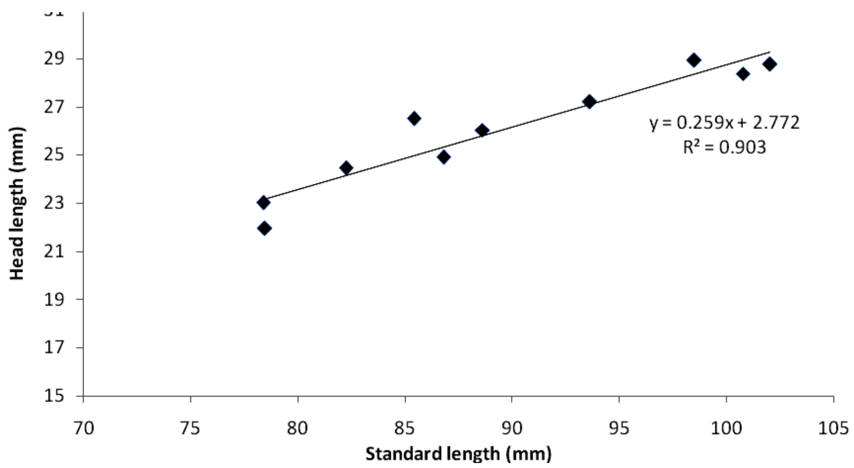


Fig. 37: Regression Head length on Standard length

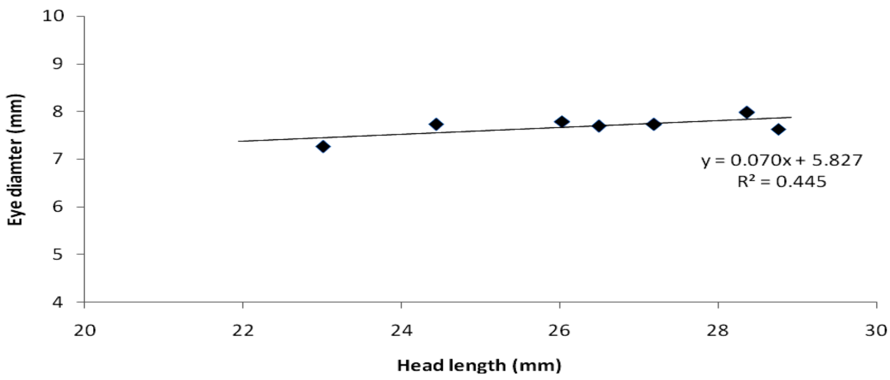


Fig. 38: Regression Upper eye diameter on Head length

4.3.3.2 Genus *Cephalopsetta*

The genus was erected by Dutt and Hanumanta Rao (1965) to include a species collected by them from Vishakapatnam. Body shape resembles *Pseudorhombus*. Head 2.3 - 2.7 in SL, body large in size compared to other Paralichthyds, with large eyes. Scales weakly ctenoid on the ocular side, cycloid on head and blind side. Gill rakers elongated and pointed. Lateral line well developed on both sides with a curve above the pectoral fin; supra temporal branch not reaching dorsal fin.

4.3.3.2.1 *Cephalopsetta ventrocellata* Dutt and Rao, 1965

Cephalopsetta ventrocellata Dutt and Rao, 1965, *Proc. Ind. Acad. Sci.* B, 62 (4):180, fig. 1 (Vishakapatnam); Talwar, 1973, *Proc. Zool. Soc. Calcutta*, 26:11 (Quilon).

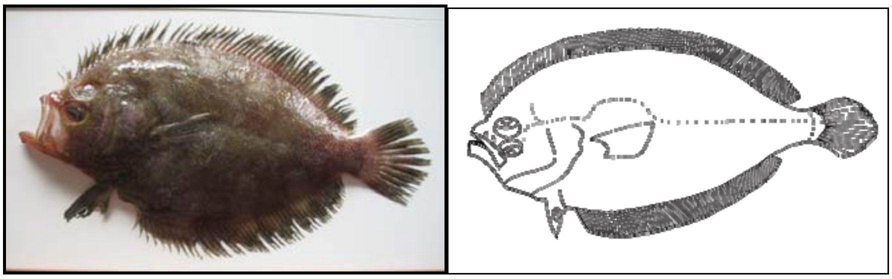


Plate XI: *Cephalopsetta ventrocellata* Dutt and Rao, 1965

Material examined: N = 6; TL 150.77 - 235 mm collected from trawler vessels operating off Cochin. Samples were obtained only once during the study period.

Diagnosis: A bothid with clear marked ocelli on the pelvic fin on the ocular side; ocular side with ctenoid scales and blind side with cycloid scales.

Meristic counts: D 64–69 (66.2); A 47- 50 (49); P_1 10–12 (10.4); P_2 6; C 4–6 +10–16; Ll 69.

Body proportions as percentage of SL (mean in parentheses): HL 32.03 –37.9 (34.3); HW 43.1–50.4 (47.86); HD 28.8–32.8 (30.04); ED_1 7.9–10.1 (9.3); ED_2 7.9–10.1 (9.3); ID 0.8–1.5 (1.12); PrOU 3.9–7.9 (6.4); PrOL 6.4–7.3 (6.7); PBU 12.3–20.1 (16.5); PBL 18.4–19.2 (18.8);

CD 2.6–4.1 (3.4); UJL 12.5-14.9 (13.7); LJL 11.43–17.92 (13.9); BD_1 48.9–55.9 (52.9); DFL (30^{th} ray); AFL (12^{th} ray) 7.9–14.04 (11.64); P_1FLO 18.5-22.1 (20.6); P_2FLB 11.6-14.9 (12.9); V_1FLO 13.6-18.2 (15.9); V_2FLB 4.2–13.5 (10.7); CFL 17.2–20.9 (19.4); DBL 82.2–86.5 (83.3); ABL 58.6–63.5 (60.9); P_1BLO 3.7–5.1 (4.5); P_2BLB 3.4–4.1 (3.7); V_1BLO 3.6–6.5 (4.6); V_2BLB 3.1–12.3 (5.4); CBL 13.4–13.9 (13.7); CPD 9.3–10.9 (10.1); PDL 5.8–7.8 (6.6); PAL 36.3–43.6 (38.9); P_1LO 31.6–36.2 (33.8); P_2LB 28.6–37.6 (33.9); V_1LO 26.1-30.7 (28.1); lateral line 20.04–53.3 (41.5); lateral line curved 19.7–52.9 (33.4).

As percentage of HL (mean in parentheses): HW 130-146.6 (139.7); HD 82–94.6 (87.7); ED_1 20.8–30.4 (27.1); ED_2 21.1–29.7 (24.3); ID 2.2–4.4 (3.3); PrOU 10.3–24.8 (18.8); PrOL 18.5–19.5 (19.1); PBU 54.7 –59.9 (56.4); CD 7.7–12.9 (10.3); UJL 39–43.1 (40.9); LJL 35.7–51.8 (41.1); BD_1 147.7–166.9 (155.4).

Description: Body broad, oval, deeply flattened with a distinct caudal peduncle and a sharp notch just in front of the upper eye. Eyes large, eye diameter 3.7 times in HL; eyes placed close, one above the other, interorbital space very small, bony. Upper jaw protrudes a little ahead of lower jaw in front region; maxillary ending midway below the lower eye. Five close set villiform teeth on upper jaw on ocular side, teeth set a little far apart on blind side of upper jaw; 23 – 31 teeth present on lower jaw on the blind side; teeth closely spaced, large canines absent. Dorsal fin origin on notch on blind side, in front of upper eye, pectoral origin on a horizontal line behind lower eye, just below the outer free end of the operculum. Pelvic fin inserted in front of pectoral fin below the pre opercle; anal origin behind the pectoral fin; dorsal and anal fins end at the origin of caudal peduncle. Caudal fin truncate. Lateral line origin behind the upper eye middle portion; lateral line curves around the pectoral fin and proceeds backwards. Scales on the ocular side appear to be cycloid, some on close examination have feeble ctenii proximal to the outer exposed portion, blind side with cycloid scale. Interhaemal spine prominent.

Proportionate increase in pelvic fin compared to increase in body length absent in this fish; pelvic fin decreases in size as body length increases. A comparative statement of the meristic characters of *Cephalopsetta ventrocellata* is given in Table 23.

Table 23: A comparative statement of the meristic characters of *Cephalopsetta ventrocellata*

Meristic characters	Earlier workers		Present work 2004 - 2010	
	Dutt and Rao 1965	Talwar 1973	N = 9	Mean ± SD
Dorsal	65 - 68	66 - 68	64 - 69	65.9 ± 4.7
Anal	47 - 50	46 - 48	47 - 50	49.4 ± 1.3
LL scales	67 -70	69 - 71	65 - 69	69 ± 11.2
Pectoral	12/11	12 / 11	10 -12	10.9 ± 0.9
Pelvic	6/6	*	5- 6	6 ± 0.8
GR	7 -10 + 17 -20	7 – 8 +18 - 19	*	*
Caudal	17	17	4 - 6 +10 -16	*

* Data not available

Results of regression analysis showed that the variation of various body parts in relation to standard length is highly insignificant in the case of pectoral fin length on blind side, but highly significant for head length, pectoral fin length and pelvic fin on standard length Results of the correlation coefficient analysis on non-meristic characters of *Cephalopsetta ventrocellata* is given in Table 24.

Table 24: Results of the correlation coefficient analysis on non-meristic characters of *Cephalopsetta ventrocellata*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	2.6 - 3.12	2.9	0.16	0.95	0.27
Head Width	1.98 - 2.32	2.1	0.11	0.94	0.40
Head Depth	3.05 - 3.7	3.4	0.17	0.96	0.23
Preorbital (U)	12.6 - 38.7	20.9	9.78	0.73	0.12
Preorbital (L)	13.8 -17.3	15.4	1.30	0.89	0.04
Post orbital (U)	4.9 - 8.12	5.95	1.27	0.58	0.23
Post orbital (L)	4.8 - 5.5	5.18	0.29	0.87	0.19
Body depth	1.8 - 2.04	1.9	0.09	0.99	0.40
Dorsal fin length	7.1 - 11.4	8.9	1.31	0.41	0.02
Anal fin length	7.05 - 12.6	8.7	1.77	0.25	0.03
Pectoral fin length (O)	4.4 - 5.4	4.9	0.35	0.90	0.13
Pectoral fin length (B)	5.9 - 8.6	7.5	1.00	0.61	0.08
Pelvic fin length (O)	5.4 - 7.4	6.5	0.60	0.85	0.08
Pelvic fin length (B)	7.4 - 23.7	9.8	5.59	0.18	0.04
Caudal fin length	4.8 - 5.8	5.2	0.34	0.91	0.15
Pre dorsal	11.2 - 17.6	15.4	2.21	0.59	0.06
Pre anal	2.3 - 2.8	2.6	0.16	0.94	0.29
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head length	0.68 - 0.77	0.	0.04	0.92	1.40
Head Width	1.05 - 1.23	1.2	0.06	0.91	0.52
Head Depth	2.45 - 3.8	3.4	0.4	0.48	0.12
Eye Diameter (U)	2.57 - 4.6	3.8	0.6	0.26	1.23
Eye Diameter (L)	22.96 - 44.9	31.4	7.78	0.61	0.01
Inter orbital	4.03 - 13.5	7.2	3.6	0.55	4.02
Upper jaw length	1.9 - 2.8	2.5	0.4	-0.15	0.05
Lower jaw length	0.6 - 0.7	0.7	0.03	0.94	-2.43
Body depth	2.45 - 3.8	3.01	0.4	0.28	0.06
Pre dorsal	0.8 - 1.0	0.9	0.1	0.89	1.79
Pre anal	0.96 - 1.1	1.0	0.03	0.97	0.75
Prepectoral (O)	0.92 - 1.2	1.0	0.07	0.83	0.84
Prepectoral (B)	1.2 - 1.3	1.2	0.05	0.95	0.67
Prepelvic (O)	1.1 - 1.3	1.2	0.06	0.91	1.02
Prepelvic (B)	0.6 - 1.9	0.95	0.6	0.99	4.11

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph; the linear regression equations obtained were

Head length on SL	:	$y = 12.5 + 0.27\ x$; $R^2 = 0.91$; $p< 0.001$
Pectoral fin (O) length on SL	:	$y = 0.13\ x+13.00$; $R^2 = 0.80$; $p < 0.01$
Pectoral fin (B) length on SL	:	$y = 0.07\ x + 11.6$; $R^2 = 0.46$; $p >0.01$
Pelvic fin (O) length on SL	:	$y = 0.08\ x+13.2$; $R^2 = 0.72$; $p < 0.01$

Colour: Body brownish on ocular side with a patch of dark brownish–blue on the dorsal side and with a few scattered faint spots on the body. A prominent ocelli present between 3rd and 5th pelvic fin ray; ocelli with outer black ring and inner yellow blotch enclosed in a white border. Pectoral fin on ocular side with faint white marks in a vertical pattern. Outer membrane tips of caudal, dorsal and anal fin black. On the blind side, pectoral and pelvic fins are white in colour. Scales on ocular side dark with a light speck in the centre.

Distribution:

World: Reported by Kotthaus (1977) from Pakistan and Hensley and Amaoka (1989) from Andaman Sea, eastern Arabian Sea and Gulf of Oman. Map showing localities were *Cephalopsetta ventrocellata* has been recorded in the world is given in Fig. 39.

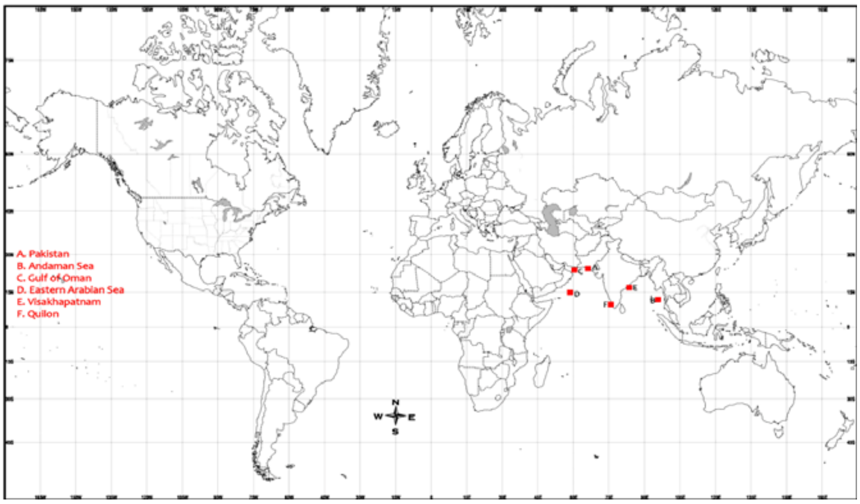


Fig. 39: Map showing localities were *Cephalopsetta ventrocellata* has been recorded in the world.

India: Recorded from Vishakapatanam on the east coast of India by Dutt and Rao (1965); Quilon (Talwar, 1973). Map showing localities were *Cephalopsetta ventrocellata* has been recorded in India is given in Fig. 40.

Fig. 40: Map showing localities were *Cephalopsetta ventrocellata* has been recorded in India.

Taxonomic comments: Dutt and Rao (1965) followed Norman (1934:61) and included *Cephalopsetta* with *Ancylopsetta* Gill and *Gastropsetta* Bean in Group II of the subfamily Paralichthinae of the family Bothidae. They concluded that *Cephalopsetta* takes "an *intermediate position*" between the two genera, "*the origin of the dorsal is in front of the eyes as in Gastropsetta, yet there is a concavity as in Ancylopsetta. In fact the first ray of the dorsal originates from the base of the broad V shaped concavity*". The V shaped urohyal of *Cephalopsetta* had broad wings; this was also taken to be an intermediate character between the two genera. The name *Cephalopsetta ventrocellata* given by Dutt and Rao (1965) was due to the presence of its large head and the presence of the ocelli on the ventral fin. Dutt and Rao (1965) stated that ocular side of the fish "*has a few irregular spots*".

Hensley and Ahlstrom (1984) recognized a subgroup within the Family Paralichthyidae erected by Amaoka (1969) composed of *Pseudorhombus*, *Tarphops* and *Cephalopsetta* and called it the *Pseudorhombus* group; thereby excluding it from the genera *Ancylopsetta* and *Gastropsetta*. However, Guntherz (1966) Ahlstrom *et al*. (1984) as well as Hensley and Ahlstrom (1984) have also pointed out the presence of an elongate pelvic fin in young ones of the genera *Ancylopsetta* and *Gastropsetta* and a reduced pelvic fin in adult stages is similar to that reported in *Cephalopsetta*. Hence, the inclusion of *Cephalopsetta* along with *Ancylopsetta* and *Gastropsetta* is most apt compared to the present position. Saramma (1969) recorded this species at Quilon; however, it was assigned the name *Lioglossina punctata* and placed in the monotypic genus *Lioglossina* established by Gilbert (1891) for the reception of *L. tetropthalmus* from the Gulf of California. Talwar remarks that "*the topotypes of L. punctata agree very well with the original description and a paratype of Cephalopsetta ventrocellatus. These two species are evidently conspecific though L. punctata is said to have only 8 (against 18 – 19) gill rakers in the lower arm of the first arch*". Talwar comments that the difference in counts could probably be due to "topographical error" and "*erroneous observation*".

Observations: The species resembles *Pseudorhombus megalops* in the presence of the ocelli on the pelvic fin. The difference noted is that in *P. megalops*, the ocelli is present between the 4^{th} - 5^{th} ray; while in *C. ventrocellata*, it is present between the 3^{rd} - 5^{th} ray.

The description given by Kotthaus (1977) on the dorsal fin origin as being immedietly above the posterior nostril on the blind side match well with that of the present specimen. Kotthaus (1977) describes the Hensley and Amaoka (1984) mentions that the point of the dorsal fin origin is variable in their samples, the base of the first dorsal fin ray being above either the nostril or the space between them. The present specimens match well with that of Hensley and Amaoka (1984). Body scale on ocular side have feeble ctenii, while on blind side scales are cycloid. This matches well with the remarks of Dutt and Rao (1965). Kotthaus (1977) and Hensley and Amaoka (1984) added that "*the scales are covered by skin*". However, in the present study such a feature was not noticed.

4.3.4 Family Bothidae

Body oval, dorsoventrally flattened. Eyes sinistral in most species, preopercle margin free and distinct, mouth terminal with lower jaw more or less prominent. Nasal organ on blind side near dorsal profile. Spines absent in fins; dorsal fin origin above or anterior to upper eye. Dorsal and anal fins separate from caudal fin. Branchiostegal membranes united. Anus placed on blind side.

According to Regan (1910), Family Bothidae is sinistral, except for reversed samples in certain species; right eye nerve always dorsal, olfactory laminae arranged transversly from a central rachis. Family Bothidae was further classified into three subfamilies–Paralichthinae, Platophrinae and

Bothinae with 18, 12 and 4 genera respectively. The main difference noticed was in the length of the pelvic fin and size of mouth. Regan further (1920) described Family Bothidae as sinistral with 5 genera reported from Natal waters in 2 subfamilies Paralichthinae and Bothinae. Oshima (1927) when describing "*Flounders and Soles of Formosa*" placed them in five families–Family Bothidae with genus *Platophrys* and Family Paralichthyidae with genera *Pseudorhombus, Spinirhombus* and *Tephrinectes*. According to Norman (1927), family Bothidae consists of 2 subfamilies Paralichthinae and Bothinae, the former with 2 genera in Indian waters *Pseudorhombus* and *Taeniopsetta* and the latter with eight genera in Indian waters–*Arnoglossus, Crossolepis, Engyprosopon, Crossorhombus, Bothus, Grammatobothus, Chascanopsetta* and *Laeops*. While describing the marine fishes of West Africa, Fowler (1936) mentioned of five genera in Family Bothidae-*Citharus*, *Syacium*, *Arnoglossus*, *Platophrys* and *Lepidorhombus*. Seven genera with 11 species were described by Munroe (1955) while describing left hand flounders of Family Bothidae from Ceylonese waters. The genera placed in the family included *Pseudorhombus*, *Chascanopsetta*, *Grammatobothus*, *Arnoglossus*, *Bothus*, *Engyprosopon* and *Crossorhombus*. Later, Fowler (1956) placed Family Bothidae in suborder Pleuronectinae along with Family Pleuronectidae. Suborder Pleuronectinae was characterized with free preopercle edge, prominent mandible, nasal organ on blind side usually near edge of head, Family Bothidae was characterized by sinistral fishes with single globule in yolk of egg. Five genera *Pseudorhombus*, *Arnoglossus*, *Engyprosopon*, *Bothus* and *Laeops* were placed in Family Bothidae.

Amaoka (1969) raised subfamily Paralichthinae to family status by erecting a new family Paralichthyidae which included three genera *Paralichthys*, *Pseudorhombus* and *Tarphops*. Family Bothidae has two subfamilies Taeniopsettinae and Bothinae, the former with one genus *Taeniopsetta* and the latter with 13 genera–*Parabothus, Tosarhombus, Crossorhombus, Engyprosopon, Bothus, Asterorhombus, Psettina, Arnoglossus, Japonolaeops, Laeops, Neolaeops, Kamoharia* and *Chascanopsetta*. Chen and Weng (1965) placed genus *Bothus* in Family Bothidae, subfamily Bothinae along with 6 other genera – *Arnoglossus, Psettina, Engyprosopon, Crossorhombus, Chascanopsetta* and *Laeops*. As per FAO sheets for the Western Indian Ocean, Family Bothidae consists of two subfamilies – Paralichthinae and Bothinae with three and nine genera in them respectively with 49 species. Twelve genera of bothids were reported from India by Talwar and Kacker (1984), of which, six are not commercially important; three genera *Taeniopsetta*, *Grammatobothus* and *Parabothus* are likely to occur in Indian seas as they are reported from adjacent seas. Fourteen genera were recognized by Hensley (1986) from South African waters–*Mancopsetta, Syacium, Citharichthys*, *Pseudorhombus, Monolene, Chascanopsetta, Laeops, Neolaeops, Psettina*, Arnoglossus, *Bothus, Crossorhombus, Engyprosopon* and *Asterorhombus*. The monophyletic nature of Bothidae was proposed by Hensley and Ahlstrom (1984) and Chapleau (1993) and corroborated in an extensive study conducted by Fukui (1997) where the author listed five synamorphies for the family. According to Munroe (2005), 25 genera and 145 species of bothid flatfishes occur worldwide, primarily in tropical and subtropical waters with the majority of species occurring in relatively shallow marine waters. A few species in a smaller number of genera (eg. *Parabothus*, *Chascanopsetta*) occur on the outer continental shelf and upper continental slope. Nelson (2006) reported the family to have 20 genera and about 140 species. Review of observations done by various workers on Family Bothidae is presented in Table 25.

Table 25 : Review of observations by various workers on Family Bothidae

Family	Genus	Synonym	Type	Observations				
				Jordan	Bleeker	Norman	Amaoka	Eschmeyer
Bothidae		***Arnoglossus*** Bleeker 1862	*Pleuronectes arnoglossus* Bloch & Schneider 1801	**Tautotype** = *Pleuronectes laterna* Walbaum	Synonym		**VALID**	**VALID**
		Bascanius Schiodte 1868	*Bascanius taedifer* Schiodte 1868	Orthotype based on a larvae, name preoccupied as *Bascanion*		Synonym		Synonym
		Caulopsetta Gill 1893	*Pleuronectes scaphus*	**orthotype**	Synonym	Synonym	Synonym	Synonym
		Charybdia Facciolà 1885	*Peloria ruppellii*	**orthotype** ; based on a larval flounder, perhaps young of *Platophrys*				Synonym, type by subsequent designation.
		Dollfusetta Whitley 1950	*Peloria rueppelii* Cocco 1844					Synonym
		Dollfusina Chabanaud 1933	*Peloria rueppelii* Cocco 1844			Synonym		Synonym
		Kyleia Chabanaud 1931	*Arnoglossus thori* Kyle 1913			Synonym		Synonym
		Scidorhombus Tanaka 1915	*Scidorhombus pallidus* Tanaka 1915				Synonym	Synonym
	Bothus Rafinesque 1810	***Bothus*** Rafinesque 1810	*Bothus rumolo* Rafinesque 1810	Equivalent to *Rhombus* Klein of earlier date.			**VALID**	**VALID**
		Platophrys Swainson 1839	*Pleuronectes ocellatus*	Haplotype; replaces *Rhomboidichthys*		Synonym		Synonym
		Platotichthys Nichols 1921	*Platotichthys chartes* Nichols 1921			Synonym		Synonym
		Psettyllis Alcock 1890	*Psettyllis pellucida* Alcock 1890	First designation in 1920. Spelled *Psettylis* by Jordan 1920		Synonym	Synonym	Synonym of *Bothus* Rafinesque 1810

Family	Genus	Synonym	Type	Observations				
				Jordan	Bleeker	Norman	Amaoka	Eschmeyer
		Pseudocitharichthys Weber 1913	*Citharichthys aureus* Day 1877			Doubtful synonym of *Bothus*		Synonym of *Bothus* Rafinesque 1810
		Rhomboidichthys Bleeker 1856	*Rhombus myriaster* Temminck & Schlegel 1846	A synonym of *Platophrys*		Synonym	Synonym	Synonym of *Bothus* Rafinesque 1810
		Symboulichthys Chabanaud 1927	*Platophrys maculifer* of Jordan & Goss 1889	Type designated by		Synonym	Synonym	Species treated as *Symboulichthys maculifer* (Jordan & Goss) with Poey's species questionably in synonymy, but *maculifer* Jordan & Goss is not an original description
	Chascanopsetta Alcock 1894	***Chascanopsetta*** Alcock 1894	*Chascanopsetta lugubris* Alcock 1894;			**VALID** Type by monotypy	**VALID**	**VALID**
		Pelecanichthys Gilbert & Cramer 1897	*Pelecanichthys crumenalis* Gilbert & Cramer 1897			**VALID**	Synonym	Synonym of *Chascanopsetta* Alcock 1894
		Trachypterophrys Franz 1910	*Trichopsetta* Gill 1889	Omitted			Synonym of *Chascanopsetta* Alcock 1894	Synonym
Bothidae	***Crossorhombus*** Regan 1920		*Platophrys dimorphus*			**VALID**	**VALID**	**VALID** Type by original designation
	Engyprosopon Günther 1862	***Engyprosopon*** Günther 1862	*Rhombus mogkii* Bleeker 1854	Type designated			**VALID**	**VALID**
		Scaeops Jordan & Starks 1904	*Rhombus grandisquama* Temminck & Schlegel 1846			Synonym of *Engyprosopon* Günther 1862	Synonym of *Engyprosopon* Günther 1862	Synonym of *Engyprosopon* Günther 1862
	Grammatobothus Norman 1926		*Platophrys (Platophrys) polyophthalmus* Bleeker 1866	**VALID**		**VALID**		**VALID** Type by original designation

Family	Genus	Synonym	Type	Observations				
				Jordan	Bleeker	Norman	Amaoka	Eschmeyer
	Laeops Günther 1880	***Laeops*** Günther 1880	*Laeops parviceps* Günther 1880			**VALID**	**VALID**	**VALID**
		Laeoptichthys Hubbs 1915	*Laeoptichthys fragilis* Hubbs 1915			Synonym	Synonym	Synonym
		Lambdopsetta Smith & Pope 1906	*Lambdopsetta kitaharae* Smith & Pope 1906			Synonym	Synonym	Synonym
		Leptolaeops Fowler 1934	*Laeops clarus* Fowler 1934					Synonym Type by original designation
		Scianectes Alcock 1889	*Scianectes macrophthalmus* Alcock 1889			Synonym of *Laeops* Günther 1880	Synonym of *Laeops*	Synonym of *Laeops*
	Neolaeops Amaoka 1969		*Laeops microphthalmus* von Bonde 1922				**VALID** Type by original designation	**VALID**
	Parabothus Norman 1931		*Arnoglossus polylepis* Alcock 1889			**VALID** Type by original designation		**VALID**

Bothid fishes are most diverse in the tropical Indo-west Pacific, where species occur from the east coast of Africa and Red Sea throughout the Indian Ocean and the Indo – Australian Archipelago, Japan, Australia and New Zealand and across the Central Pacific (Norman, 1934). In the Western Atlantic, bothids were recorded from seas off Long Island to Rio de Janerio, Brazil. From the eastern Atlantic, bothids were recorded from Southern Scotland, the Kattegat, Christiana Fjord, Mediterranean, Black Sea, West African coast to South Africa. This species rich family is among the most diverse of the Pleuronectiformes and many new bothids continue to be discovered in Indo – Pacific waters (Amaoka *et al*., 1993; 1997; Amaoka and Mihara, 2000).

4.3.4.1 Genus *Arnoglossus* Bleeker, 1862

Arnoglossus Bleeker, 1862, *Versl. Akad. Wet. Amsterdam*, XIII: 427 (type: ***Pleuronectes arnoglossus*** Schneider); Norman, 1927, *Rec. Ind. Mus*., XXIX: 19; Norman, 1931, *Ann. Mag. Nat. Hist*., (10) VIII: 599; Norman, 1934, *Syst. Monog. Flatfish*: 173; Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 185; Nielsen, 1973, CLOFNAM: 621; Ahlstrom *et al.,* 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 642; Amaoka in Masuda *et al.,* 1984, *Fish. Jap. Arch.,*: 349; *Nielsen in Whitehead et al*., *1986, Fish N.E Atl. Medit.,***:** 1294; Hensley 1986, *Smith Sea Fish*.,: 855; 941; Lindberg and Fedorov, 1993, *Fish. Sea. Japan*, VI: 55; Gomon *et al.,* 1994, *Fish. Austr.,*: 844; Li and Wang, 1995, *Fauna Sinica*: 150; Arai and Amaoka, 1996, *Ichth. Res*.,: 360; Amaoka *et al.,* 1997, *Ichth. Res*., 44 (2): 131; Amaoka and Mihara, 2000, *Mem. Mus. Nat. Hist. Nat*., 184: 785; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide*, IV (6): 3803, 3805; Evseenko, 2003, *Vopr. Ikht*., 43 (Suppl. 1): S59; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 812; Gomon, 2008, *Fish. Aust. South. Coast*: 808.

Peloria Cocco, 1844, in *Kroh. Glorn. Gabin. Messina Ann.*, iii, XXV: 21 (type: ***Peloria heckeli*, Cocco**).

Bascanius Schïodte, 1868, *Nat. Tijd.*, 3 (V): 275 (type: ***Bascanius taedifer*, Schïodte**)

Anticitharus Gunther, 1880, *Shore Fish."Challenger"*:47 (type: ***Anticitharus polyspilus* Gunther**).

Charybdia Facciola, 1885, *Nat. Sicil.*, IV: 265 (type: *Peloria ruppelii* Cocco 1844).

Caulopsetta Gill, 1893, *Mem. Nat. Acad. Sci. Washington*, VI: 124 (type: ***Pleuronectes scaphus*** (Forster) Schneider).

Scidorhombus Tanaka, 1915, *Zool. Mag. Tokyo*, 27 (325): 567 (type: ***Scidorhombus pallidus***)

Kyleia Chabanaud, 1931, *Bull. Soc. Zool. Fr.*, LVI: 393; Chabanaud, 1933, *Mem. Soc. Sci. Nat. Maroc*, XXXV: 49 (type: ***Arnoglossus thori*** Kyle).

Dollfusina Chabanaud, 1933, *Mem. Soc. Sci. Nat. Maroc.*, XXXV: 31, 44 (type: ***Peloria rueppellii*, Cocco**).

Dollfusetta Whitley, 1950: 44 (type: *Peloria rueppelii* Cocco 1844).

Description: Body elongate, deeply compressed, with a slight thickness only in the central part. Eyes sinistral separated by a narrow interorbital space, no variation in different sexes. Spines absent on orbit and nostril. Mouth small, oblique in opening, the maxillary ending on a vertical in front of the lower eye. Dentition in jaws equally developed on both sides. Teeth small, slender, sharply pointed, placed in a uniserial pattern. Vomer toothless. Dorsal fin origin on snout, above the nostrils on the blind side, all rays simple, scaled on the ocular side. Anal fin origin in front of a vertical from the pectoral. Tip of the first interhaemal spine not projecting infront of the anal spine. Pectoral fin on ocular side longer than that of the blind side. Body covered with scales, deciduous; ctenoid on ocular, cycloid on blind side. Small scales seen on the rays of the pelvic and median fins. Lateral line present only on ocular side of body; supratemporal branch absent. Vent present on blind side of body a little above the origin of the anal fin.

Taxonomic remarks: The genus *Arnoglossus* was erected by Bleeker in 1862 based on a specimen *Pleuronectes arnoglossus***.** The characters assigned were lateral line with an anterior curve, dextral eyes and two preanal spines. The genus *Peloria* erected by Cocco (1844) based on the type *Peloria heckeli***,** Cocco was later synonymised with *Arnoglossus*. Weber (1913) placed *Arnoglossus* in subfamily Psettinae along with *Psettylis* and *Engyprosopon* with the characters "*interorbital space narrow, scales deciduous, teeth similar in both jaws, gill rakers slender*." Different genera *Bascanius, Anticitharus* erected on similar species in different names were later synonymised with *Arnoglossus.*

Observations: *Arnoglossus* is a speciose genus with members distributed from off the Atlantic coast of Europe and Africa, in the Mediterranean and Black Seas, throughout the Indo–west and South Central Pacific to the Nazca Submarine Ridge in the Southeastern Pacific (Fowler, 1936; Marshall, 1964; Parin, 1991). Five species of *Arnoglossus* were recorded from Indian waters by Norman (1927)–*Arnoglossus annulatus*, *A. polyspilus*, *A. malhensis*, *A. intermedius* and *A. macrolophus*. *A. macrolophus* has been subsequently made a synonym of *A. taepinosoma*. However, Arai and Amaoka (1996) re-examined the holotype of *Arnoglossus taepinosomus* and found it to bear none of the diagnostic characters ascribed by many authors to the species and hence designated it as a valid species distinct from *A.*

taepinosomus. Norman (1934) recorded 16 species of *Arnoglossus* species from the Indo–Pacific. The genus is represented by three species on the west African coast (Fowler, 1936; Smith, 1961), one from Ceylonese waters (Munroe, 1955), six species in Australian waters and three in Queensland waters (*A. waitei*, *A. fisoni*, *A. intermedius*) (Marshall, 1964). Talwar (1973) added one more species to the Indian records–*Arnoglossus arabicus*; 12 samples were collected off Quilon at a depth of 300 m. Two species have been recorded in the present study both from the deep water trawler samples from Kochi–*Arnoglossus aspilos* and *Arnoglossus taepinosoma*. Saramma (1963) reported *A. taepinosoma* from the west coast of India off Kerala and Norman (1934) reported the locality of *A. aspilos* in the British Museum as Malay Peninsula and Archipelago. Hence the presence of *Arnoglossus aspilos* is a new record to Indian waters.

New Record 4

4.3.4.1.1 *Arnoglossus aspilos* (Bleeker, 1851)

Spotless eye flounder

Rhombus aspilos Bleeker, 1851, *Nat. Tijd. Ned. Ind.,* 1:408 (Jakarta [Batavia], Java, Indonesia).

Arnoglossus aspilus Gunther, 1862, *Cat. Brit. Mus.*, IV: 417 (Java, Bali, Sumatra); Capello, 1872, *J. Sci. Math. Phys. Nat. Acad. Lisboa*: 85 (Angola); Weber, 1913, *Fish. Siboga Exped*.,: 430 (Makassar); Gunther, 1877, *Shore Fish. "Challenger"*: 47 (Arafura Sea); Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 645.

Platophrys (Arnoglossus) aspilus Bleeker, 1866-72, *Atl. Ichth*., VI: 15, Pleuron. Pl. vi, fig. 2.

Bothus (Arnoglossus) aspilus Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch*., V: 132.

Arnoglossus aspilos Fowler, 1928, *Mem. B.P. Bishop Mus*., X: 89; Fowler, 1936, *Bull. Amer. Mus. Nat. Hist*., LXX: 505 (Angola); Blegvad, 1944, *Fish. Iran Gulf*: 202, fig. 122 (Iran Gulf); Fowler, 1956, *Fish. Red Sea S. Arabia*, I: 165 (Iran, Malaya, East Indies); Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull*., 1:15 (Gulf of Thailand, Malay Peninsula); Chen and Weng, 1965, *Biol. Bull*., 27: 3, fig. 26; Randall, 1995, *Coastal Fish Oman*: 356 (Oman); Li and Wang, 1995, *Fauna Sinica*: 153; Larson and Williams, 1997, *Proc. Sixth Intl. Marine Biol. Workshop*: 373; Carpenter *et al.,* 1997, *FAO Sp. Iden. Guide,* IV (6): 228 (as *aspilus*); Randall and Lim, 2000, *Raffles Bull. Zool*., 8: 645 (South China Sea); Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV(6): 3825; Hutchins, 2001, *Rec. W. Aust. Mus. Supp.,* 63: 46; Adrim *et al*., 2004, *Raffles Bull. Zool. Suppl*., 11: 127; Randall, 2005, *Reef Fish. S. Pacific*: 356; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1812.

Arnoglossus aspilos praeteritus Whitley, 1950, *Proc. R. Zoo. Soc. N.S. Wales*: 32, fig. 1 (Between Cape Jaubert and Wallal, Western Australia).

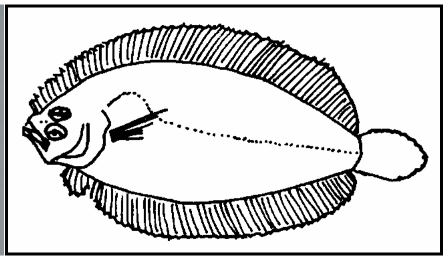


Plate XII *Arnoglossus aspilos* (Bleeker, 1851)

Material examined: N =1, TL 107.41 mm from Neendakara Fishing Harbour.

Diagnosis: A slender bothid with very little interorbital space and oblique mouth and deciduous scales.

Meristic characters: D 80, A 63; C 15; P_1 12, V_1/V_2 5, Ll. 45

Body measurements as percent of SL: HL 24.5; HD 22.5; BD 32.6; ED_1 7.4; ED_2 5.98; ID 0.82; PBU 13.6; SNL_1 6.1; SNL_2 4.01; UJL 6.1; LJL 8.8; DFL 8.9; AFL 10.03; CFL 20.4; P_1FLO 21.8; DBL 97; ABL 74.6; P_1BLO 4; P_2BLB 3.4; PDL 42; PAL 27.

As percent of HL: HW 146.7; HD 92.2; BD1 133.4; ED_1 30.1; ED_2 24.4; ID 3.4; PBU 55.7; SNL_1 24.8; SNL_2 16.4; UJL 26.95; LJL 36.1; DFL 36.5 AFL 41.01; CFL 83.3; PDL 17.3; PAL 110.5.

Description: Body oval in outline, compressed, elongated, profile of head not prominent, with a convex slope. Head moderate, eyes sinistral, separated by a narrow interorbital space which is less than the snout length, lower eye a little in front of upper eye. Notch present, not very prominent. Mouth small, terminal, curved downwards. Sharp pointed inwardly pointed teeth closely set uniserially on both jaws upto the junction of both jaws. Teeth not enlarged anteriorly. Lower jaw is prominent. Maxillary ends beyond the anterior portion of the lower eye. Dorsal fin origin on snout on blind side and on a horizontal from the lower portion of upper jaw. Anal fin origin on a vertical through outer free tip of operculum. Dorsal and anal rays do not join with the caudal, rays simple. Caudal fin obtusely pointed. Lateral line well developed on ocular side alone, with a curve above the pectoral fin. Supratemporal branch absent. Small openings seen on the blind side on the preopercular area. Body covered with scales, deciduous; ctenoid on ocular, cycloid on blind side. Small scales seen on the rays of the pelvic and median fins. Gill rakers on first arch seven, slender. A comparative statement of the meristic characters of *Arnoglossus aspilos* is given in Table 26. Results of the correlation coefficient analysis on non-meristic characters of *Arnoglossus aspilos* is given in Table 27.

Table 26: A comparative statement of the meristic characters of *Arnoglossus aspilos*

Meristic characters	Earlier workers											Present work 2004 -2010 (N = 1)
	Bleeker 1852	Bleeker 1866, 1875	Gunther 1862	Weber and Beaufort 1929	Norman 1934	Fowler 1936, 1956	Blegvad 1944	Punpoka 1964	Chen and Weng 1965	Kuronuma and Abe 1986	Randall 1995	
Dorsal	80 – 82	80 – 84	80 - 82	80 – 84	80 – 84	80 – 82	80	80 - 84	90	84 - 95	80 – 84	80
Anal	61 – 63	61 - 63	61 – 63	62 – 64	61 – 64	61 – 73	64	61 – 64	68	63 – 76	59 - 64	63
Lateral line	*	*	45	46 - 48	40 - 48	45	*	45 - 48	48	*	46 - 48	45
Pectoral (O)	11 – 12	*	*	*	*	11-12	12	*	*	*	11 -12	12
Caudal	18	*	*	*	*	*	*	*	*	*	*	17
Pelvic	5 - 6	*	*	*	*	*	6	*	*	*	*	5

*Data not available

Table 27: Results of the correlation coefficient analysis on non-meristic characters of *Arnoglossus aspilos*

Characters	Ratio in SL	Characters	Ratio in HL
Head length	1.4	Head Width	0.68
Head Width	4.1	Head Depth	1.08
Head Depth	2.8	Body depth	0.75
Body depth	4.4	Eye Diameter (U)	3.32
Eye Diameter (U)	3.1	Eye Diameter (L)	4.09
Eye Diameter (L)	13.6	Inter orbital	29.69
Inter orbital	16.7	Postorbital length	1.80
Postorbital length	121.4	Snout to upper eye	4.04
Snout to upper eye	7.3	Snout to lower eye	6.10
Snout to lower eye	16.5	Upper jaw length	3.71
Upper jaw length	25.0	Lower jaw length	2.77
Lower jaw length	15.2	Dorsal fin length	2.74
Dorsal fin length	11.3	Pre dorsal length	5.80
Anal fin length	11.2	Pre anal length	0.90
Caudal fin length	10.0		
Pectoral fin length (O)	4.9		
Pectoral fin length (B)	4.6		
Pelvic fin length (B)	16.1		

Colour: In fresh condition, body brownish coloured with small black spots on finrays. In preserved condition, colour is uniform light yellow as the scales were lost.

Distribution:

World: Reported from Java, Indonesia (Bleeker, 1851; Gunther, 1862); Jakarta [Batavia], East Indies, Angola (Capello, 1872, Fowler, 1936); Singapore, Malacca Strait, Sumatra, Celebes (Weber and Beaufort, 1929); Arabian Sea (Blegvad, 1944; Kuronuma and Abe, 1986); Thailand (Punpoka, 1964). Map showing localities were *Arnoglossus aspilos* has been recorded in the world is given in Fig. 41.

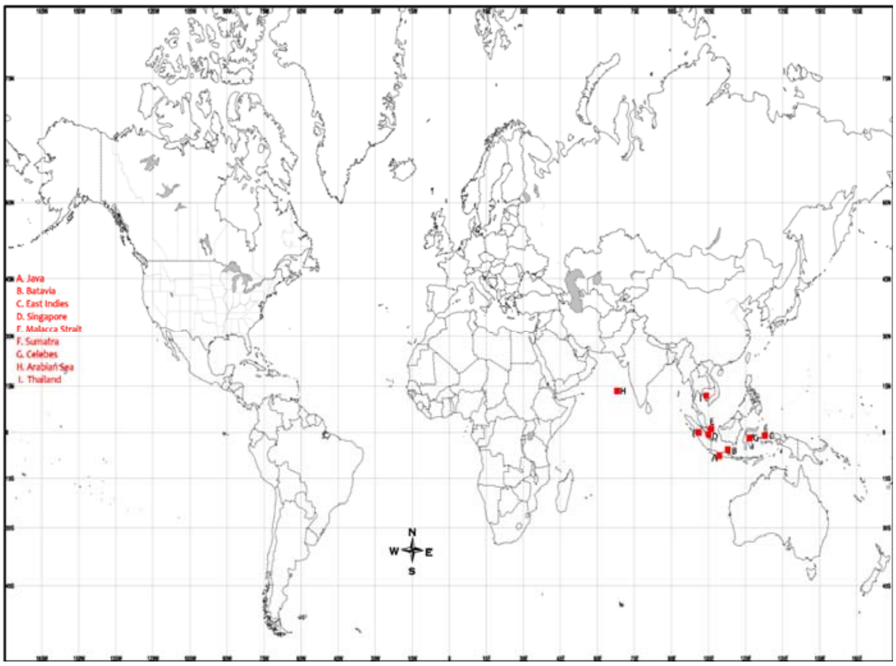


Fig. 41: Map showing localities were *Arnoglossus aspilos* has been recorded in the world.

India: Not previously reported from India. This is the first report from Indian waters. Map showing localities were *Arnoglossus aspilos* has been recorded in the world is given in Fig. 42.

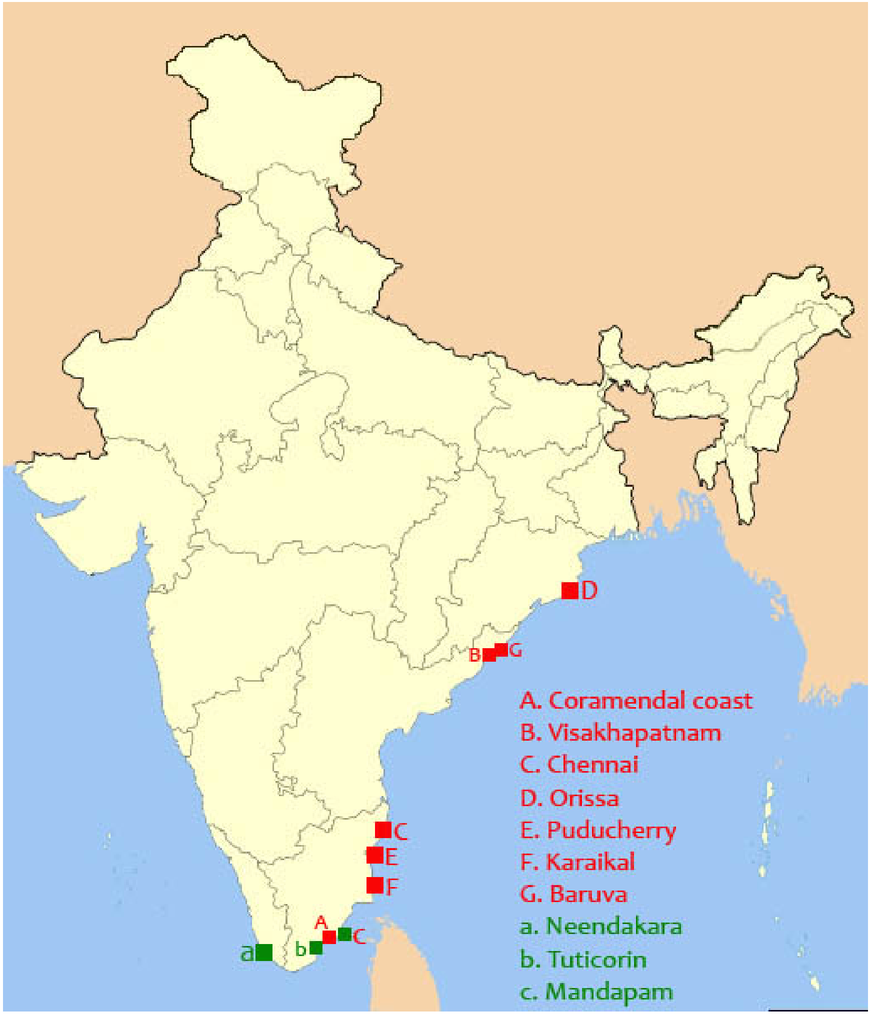


Fig. 42: Map showing localities were *Arnoglossus aspilos* has been recorded in India.

Taxonomic remarks: The species was first described by Bleeker as *Rhombus aspilos* based on collections from Sumatra. The diagnostic characters were sinistral eyes with the lower eye placed a little in front of upper eye; dorsal and anal fins simple with 80 and 60 rays respectively. Subsequently, Bleeker (1866) placed the species in genus *Platophrys*. Gunther (1862) described *Arnoglossus aspilus* based on

Bleeker's collections. Fowler (1928) placed *Arnoglossus aspilos* as the species name and this was followed by later workers also.

Remarks: Bleeker (1875) gave the dorsal ray counts as 80 – 84 and the anal ray count as 61–63. Norman (1927) recorded five species of *Arnoglossus* from Indian waters–*A. annulatus*, *A. polyspilus*, *A. malhensis*, *A. intermedius* and *A. macrolophus*. Saramma (1963) recorded one more species of *Arnoglossus* (*A. taepinosoma*) off Kerala. The present species is said to be of rare occurrence in Arabian Gulf (Kuronuma and Abe, 1986) and differs from the above six species in having 80 dorsal and 63 anal fin rays. However in the collections of Chen and Weng (1965) from Taiwan the dorsal and anal fin counts were much higher (90 and 68 respectively). Similar higher counts were also reported by Kuronuma and Abe from Arabian Gulf (dorsal 84 -95 and anal 63-76). According to Randall (1995), the sample from Indonesia had only 80 dorsal fin rays and 59 anal fin rays and hence he opined that "*the identification of the Gulf specimens, therefore, may be regarded as provisional*". Meristic counts in the present study are also similar to that reported by the earlier workers excluding that of Chen and Weng and Kuronuka and Abe. The maximum length reported as per Randall (1995) is 8.5 cm while the present specimen is 10.74 cm.

4.3.4.1.2 *Arnoglossus taepinosoma* (Bleeker, 1865)

Crested Flounder

Platophrys (Arnoglossus) taepinosoma Bleeker, 1866, *Ned. Tijd. Dierk.*, iii: 49 (type locality: Padang, Sumatra); Bleeker, 1866 – 72, *Atl. Icth.*, vi: 13, Pleuron, pl. iv, fig, 4.

Arnoglossus macrolophus Alcock, 1889, *J. Asiat. Soc. Bengal*, lviii (2): 280, pl. xviii, fig. 2 (Ganjam); Alcock, 1890, *Ann. Mag. Nat. Hist.*, (6), VI: 433; Alcock, 1898, *Illust. Zool. "Investigator", Fish.*, pl. xxiii, fig. 3; Johnstone, 1904, *Ceylon Pearl Oyster Fish. Suppl. Rep.*, XV: 211; Weber, 1913, "*Siboga" Exped. Fisch.*: 432; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 21, fig. 3 (Ganjam, Andaman Islands); Fowler, 1928, *Mem. B.P Bishop Mus.*, X: 90; Munroe, 1955, *Fish. Ceylon*: 260, fig. 751 (coastal waters of Ceylon, 30 fathoms).

Bothus (Arnoglossus) taepinosoma Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.*, V: 127.

Arnoglossus taepinosoma Reeves, 1927, *J. Pan Pac. Res. Inst.*, 2 (3): 14 (Hong Kong); Norman, 1934, *Syst. Monog. Flatfish.*,: 185, fig. 131; Fowler, 1934, *Proc. Acad. Nat. Sci. Philad.*, 85 (for 1933): 63, fig. 18; Norman, 1939, *Sci. Rep. Murray Exped.*, viii (I): 99 (Gulf of Oman, 106 m, 68–71 mm TL); Jones, 1951, *J. Zoo. Soc. India*, 3 (1): 132; Fowler, 1956, *Fish. Red Sea S. Arabia,* I: 166 (Chinese specimens); Munroe, 1967, *Fish. New Guinea*: pl. 13, fig. 206; Fowler, 1967, *Mem. B.P Bishop Mus.,* XI: 320 (Oceania); Chu, 1913, *Biol. Bull. St. John's Univ.*, 1: 90 (Hong Kong); Amaoka, 1971, *J. Shimonoseki Univ. Fish.*, 20 (1): 28, pl. III, A; Dor, 1984, CLOFRES: 267; Li and Wang, 1995, *Fauna Sinica*: 151; Randall, 1995, *Coastal Fish. Oman*: 356; Arai and Amaoka, 1996: 360 (as *tapeinosoma*); Mohsin and Ambak, 1996, *Marine fish. Malaysia*: 589; Carpenter *et al.*, 1997: 229; Amaoka in Randall and Lim, 2000: *Raffles Bull. Zool.*, 8: 645 (South China Sea); Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide*, IV (6): 3828 (as *taepinosomaus*).

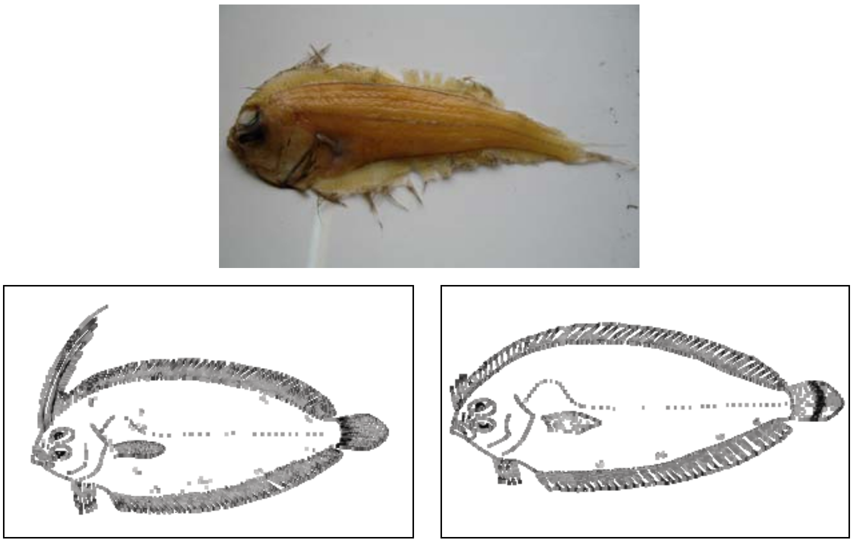


Plate XIII: *Arnoglossus taepinosoma* (Bleeker, 1865)

Material examined: N = 1, TL 101.34 mm from Neendakara Fishing Harbour.

Diagnosis: A dwarf, slender bothid flatfish with 4 anteriormost dorsal rays slightly elongated.

Meristic counts: D 92, A 67 (female); P_1 13; P_2 9; Ll 56.

Body proportions as percent of SL: HL 28.5; HW 34.8; HD 22.6; ED_1/ED_2 8.73; ID 1.49; SNL_1 6.3; SNL_2 4.7; BD 37.37; DFL 13.7; CFL 19.9; AFL 13.1; CD 3.9; UJL 7.03; LJL 8.6; DBL 98.2; ABL 73.58; CBL 5.5

Body proportions as percent of HL: HW 122.4; HD 79.4; ED_1/ED_2 30.7; ID 5.2; SNL_1 22; SNL_2 16.5; CD 13.6; UJL 24.7; LJL 30.1.

Description: Body highly elongated, elliptical, depth more than one–third SL. Maximum body depth at opercular region. A comparative statement of the meristic characters of *Arnoglossus taepinosoma* is given in Table 28.

Table 28 : A comparative statement of the meristic characters of *Arnoglossus taepinosoma*

Meristic characters	Earlier workers											Present work 2004-2010 (N = 1)
	Bleeker 1866	Alcock 1889 (*A.macrol ophus*)	Norman 1934	Weber and Beaufort 1929	Munroe 1955 (*A.macrol ophus*)	Saramma 1963	Munroe 1967	Amaoka 1971	Fowler 1972	Amaoka *et al.*,1992	Randall 1995	
Dorsal	90	88 – 90	89 – 98	83 – 90	89 – 98	93	83 – 98	96 – 97	83 – 98	93 - 98	89 – 98	92
Anal	68	67	67 – 72	65 – 70	67 – 72	71	65 – 72	75 – 76	65 – 72	72 – 77	67 – 72	70
Lateral line	54 - 59	55	*	54 - 60	48 - 55	*	54 - 60	55 – 57	48 - 60	54 - 59	48 - 55	56
Pectoral O/B	11/9	9	11 - 12	10 -13/ 7-10	*	11/8	11- 12	13 – 14/10	*	13 -14/9-12	*	13/9
Caudal	*	17	*	*	*	*	*	*	*	17	*	14
Pelvic	*	6	*	6	*	*	*	*	*		*	5

*Data not available

Upper profile of head with a slight notch in front of the upper eye, snout very short, shorter than eye diameter. Eyes placed close together separated by a bony ridge, lower eye placed a little in front of upper eye. Mouth moderate, oblique, maxillary ending at anterior part of lower eye. Teeth small, uniserial, closely set in both jaws, well developed on blind side of both jaws, no enlarged anterior teeth. Gill rakers slender, well developed only on lower jaw (8 -12) without any serrations. Dorsal fin origin on blind side above nostril, the first six rays slightly elongated. Anal fin also well developed; dorsal and anal free from caudal. Pectoral fin on ocular side short; pelvic fin origin on ocular side on a vertical below lower eye, origin on blind side at the fourth ray of ocular side. Caudal fin pointed, outer two rays simple, rest branched. Results of the correlation coefficient analysis on non-meristic characters of *Arnoglossus taepinosoma* is given in Table 29.

Table 29: Results of the correlation coefficient analysis on non-meristic characters of *Arnoglossus taepinosoma*

Characters	Ratio in SL	Ratio in HL
Head length	3.51	
Head Width	2.87	0.817
Head Depth	4.43	1.260
Eye Diameter (U)	11.45	3.259
Eye Diameter (L)	11.45	3.259
Inter orbital	67.31	19.154
Snout to Upper eye	15.98	4.548
Snout to lower eye	21.28	6.057
Chin depth	25.79	7.340
Body depth $_1$	2.68	0.761
Dorsal finlength	7.32	2.083
Anal finlength	7.64	2.175
Caudal finlength	5.02	1.430
Dorsal base length	1.02	0.290
Anal base length	1.36	0.387
Caudal peduncle depth	18.16	5.167
Upper jaw	14.23	4.048
Lower jaw	11.69	3.328

Lateral line origin at the upper outer end of operculum, supra temporal branch absent; mild curve above pectoral fin. Preopercle rhomboidal, operculum semicircular. Scales small, feebly ctenoid on ocular side, cycloid on blind side.

Colour: In fresh condition, body brownish with a series of indistinct blotches along dorsal and ventral profile of body. A dark spot on distal part of pectoral, distal end of pelvics blackish. Samples preserved in formalin are yellowish, spots absent. Blind side white.

Distribution:

World: Reported from Arabian Gulf, Gulf of Oman to the Malay Peninsula and Archipelago (Norman, 1934); Sumatra (Bleeker, 1866); Malacca Strait, Java Sea, China, Indonesia (Randall, 1995). Map showing localities were *Arnoglossus taepinosoma* has been recorded in the world is given in Fig. 43.

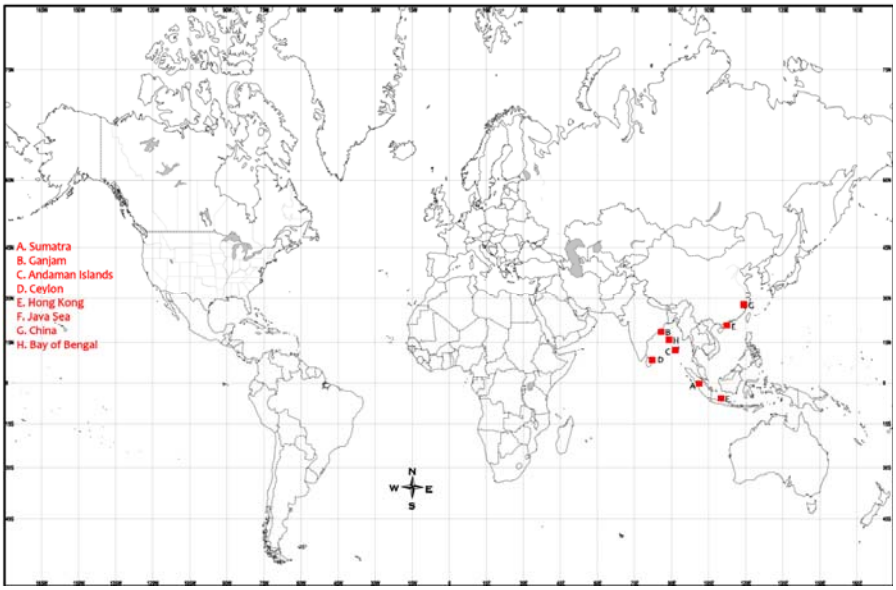


Fig. 43: Map showing localities were *Arnoglossus taepinosoma* has been recorded in the world.

India: Bay of Bengal, off Ceylon (Munroe, 1955); Ganjam (Alcock, 1889); Bengal and Orissa (Jones and Pantulu, 1958). Map showing localities were *Arnoglossus taepinosoma* has been recorded in the world is given in Fig. 44.

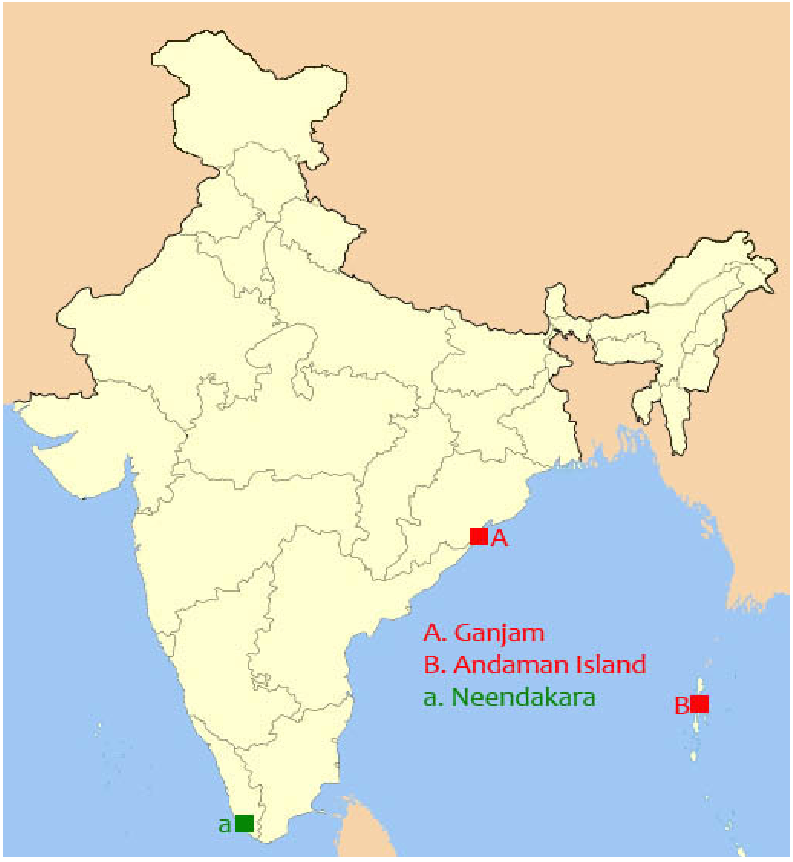


Fig. 44: Map showing localities were *Arnoglossus taepinosoma* has been recorded in India.

Taxonomic comments: *Arnoglossus macrolophus* was described by Alcock (1889) based on a sample of 3.15 inches TL from 5 miles south of Ganjam at 25 fathoms. Bleeker in his description mentions "*the species has an elongated body just like the other Arnoglossus species*". Fowler (1967) synonymised *A. taepinosoma* as valid name over *A. macrolophus* with "*I follow Weber and Beaufort in using the above name to replace the latter*

Arnoglossus macrolophus Alcock". *Arnoglossus taepinosomus* (Bleeker, 1866) has been characterized by many authors as having anterior dorsal fin rays greatly elongated in males and a large dark spot on the posterior dorsal and anal finbases (Weber and de Beaufort, 1929; Fowler, 1934, 1956; Norman, 1934; Baoshan, 1962; Abraham, 1963; Shen, 1966, 1983; Munro, 1967; Dor, 1970; Amaoka, 1971; Kotthaus, 1977; Amaoka et al., 1972). An examination of the holotype of *A. taepinosomus* by Arai and Amaoka (1996) revealed, however the absence of such diagnostic characters leading them to conclude that " *it is now evident that Bleeker's A. taepinosomus is a rare or infrequently caught species, since most of the records of A. taepinosomus are apparently of A. macrolophus"*. The species *Arnoglossus macrolophus* was hence made a valid species distinct from *A. tapeinosomus* by Arai and Amaoka (1996).

Observation: *A. macrolophus* described by Munroe (1955) resembles the description of Norman (1934). Anal fin counts given by Norman (1934), Munroe (1955, 1967) (67–72), Randall (1995) are on the lower side compared to that reported by Amaoka (1971) and Amaoka *et al.* (1992). The same feature was noted in the pectoral fin counts on ocular side. The present specimen has lateral line counts (56) higher than that reported by Randall (1995), but similar to that reported by Amaoka *et al.* (1992), Munroe (1967) and Amaoka (1971). The lateral line count of *A. macrolophus* given by Munroe (1955) are also similar to that of the present specimen. The maximum length reported for the species is 12.7 cm.

4.3.4.2 Genus *Bothus* Rafinesque

Bothus *Rafinesque,* 1810, *Carr. Nuov. Animal Sicilo*: 23 (Type: ***Bothus rumolo*** Rafinesque, type species by subsequent designation); Bonaparte, 1833, *Icon. Faun. Ital. Fasc.*, IV: 24; Bonaparte, 1846, *Cat. Method. Pesci. Europ*., 49; Kyle, 1913, *Rep. Danish Ocean. Exped*., 1908-1910, ii, A, I: 94; Regan, 1920, *Ann. Durban Mus*., II: 212; Norman, 1934, *Syst. Monog. Flatfish*: 220; Fowler, 1934, *Fish. China* V: 187; Chen and Weng, 1965, *Biol. Bull*., 27:14 (Taiwan); Gutherz, 1967, *U. S. Dept. Int. Circ.,*: 40; Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 161; Nielsen in Hureau and Monod, 1973, *Checklist Fish N.E Atlantic Medit*., V, 1: 620; Ahlstrom *et al.,* 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 642; Amaoka in Masuda *et al*., 1984, *Fish. Jap. Arch.,* 1984:349; Nielsen in Whitehead *et al.,* 1986, *Fish N.E Atl. Medit.,*: 1297; Hensley, 1986, *Smith. Sea Fish.,*: 855, 941; Lindberg and Fedorov, 1993, *Handbook Ident. Anim.,* 166 : 44; Li and Wang, 1995, *Fauna Sinica*: 206; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6): 3804; Munroe 2003, *FAO Sp. Iden. Sheet, West. Central Atlantic*, III: 1887; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1815.

Solea (non Quensel, 1806), Rafinesque, 1810, *Ind. Itt. Sicil*.,: 14, 52 (Type: ***Solea rhomboide*** Rafinesque).

Platophrys (subgenus of *Psetta*) Swainson, 1839, *Nat. Hist. Fish*., ii: 187, 302 (Type: ***Rhombus ocellatus*** Agassiz 1831. Type by monotypy); Jordan and Evermann, 1898, *Bull. U.S Nat. Mus*., XLVII (3): 2660; Jordan and Starks, 1907, *Proc. U.S Nat. Mus*., 31: 165.

Coccolus Cocco 1844, *Giorn. Gabin. Messina, Ann*.,:21; Bonaparte, 1846, *Cat. Method. Pesci Europ*.,: 47 (Type: ***Coccolus annectens*** (Cocco) Bonaparte).

Peloria Cocco 1844, in Krohn, *Giorn. Gabin. Messina, Ann*., iii, v (xxv): 21 (Type: ***Peloria heckeli***, Cocco).

Rhomboidichthys Bleeker, 1856, *Act. Soc. Sc. Indo–Neerl.,* I, Manado: 67 (type: ***Rhombus myriaster*** Bleeker).

Citharichthys (non Bleeker, 1862), Day, 1877, *Fish. India*: 422.

Psettyllis Alcock 1890, *Ann. Mag. Nat. Hist.,* (6) VI: 437 (Type: ***Psettyllis pellucida*** Alcock 1890).

Pseudocitharichthys Weber 1913, "*Siboga" Exped., Fisch.,*: 413. (Type: ***Citharichthys aureus*** Day 1877. Type by monotypy**.**

Platotichthys Nichols 1921, *Bull. Amer. Mus. Nat. Hist*., XLIV: 21 (Type: ***Platotichthys chartes*** Nichols 1921. Type by original designation (also monotypic)**.**

Symboulichthys Chabanaud, 1927, *Bull. Soc. Zool. Fr.*, III: 76 (Type: ***Platophrys maculifer*** Jordan and Goss).

Description: Body ovoid in outline, moderately compressed. Eyes sinistral, separated by a flat or concave space, broader in male; lower eye placed in advance of upper. Fishes show sexual dimorphism in the nature of interorbital space and position of eyes and fins.Male fishes have spines on snout, and sometimes on the orbital margin, at the tip of the symphysis of the lower jaw. Pectoral fin is elongate in males; some flaps are seen on the posterior margin of each eye. Mouth small to moderate in size. Teeth present in jaws in uniserial/biserial pattern depending on the species. Canine teeth present in some. Body covered with scales, generally cycloid on ocular and blind side. Dorsal fin origin on snout, the anterior few rays elongated in males. Lateral line with a strong curve anteriorly at the pectoral fin region which then proceeds in a straight line to caudal peduncle end. Pelvic fin bases of different sizes, ocular fin base is larger; pectoral fin length increases as filaments on ocular side in some species. Gill rakers small, thick in nature. Anal fin more or less the same shape as dorsal fin. Tip of first inter haemal spine not projecting in front of anal fin.

Taxonomic note: *Platophrys* as a genus was described by Bleeker. The characters described are sinistral eye, interorbital distance width. Later in 1815, he placed genus *Bothus* in suborder Pleuropsia, Family *Pleuronectia* in subfamily Diplochiria along with Genus *Pleuronectes, Scophthalmus, Bothus*, and *Plagusia*. Genus *Bothus* was first described by Rafinesque (1910) based on the type specimen *Bothus rumolo* and placed under Order Pleronetti along with genera *Solea* and *Scopthalmus*. Weber (1913) placed *Platophrys* in subfamily Psettinae with the characters "*teeth in 1- 2 rows, eyed side with ctenoid scales, gill rakers short, thick*". A new genus *Pseudocitharichthys* was described by Weber (1913). Regan (1920) mentions that Genus *Bothus* differs from *Crossorhombus* in smaller scales and in having the membrane joining the operculum to the pectoral arch scaleless. Fowler (1936) mentions of the genus *Platophrys* with the characters "*interorbital area more or less broad, deeply concave, scales ctenoid, adherent*".

Observation: Weber and Beaufort (1929) described 12 species of *Bothus* from the Indo–Australian Archipelago. Norman (1927) described four species of *Bothus* from Indian waters and 14 species of *Bothus* in his *Monograph of Flatfish* (1934) which 8 species are from Indo–Pacific area. However, only three species were recorded from Japanese waters. Fowler (1934) recorded three species from Chinese waters–*Bothus assimilis*, *B. mancus* and *B. myriaster*. Four species were reported by Amaoka (1964) from the Pacific coast of Japan–*Bothus mancus*, *Bothus pantherinus*, *B. ovalis* and *B. myriaster*. Of these the former two are easily separable from the latter on the basis of the meristic characters and coloration of the fish. As per Nielsen (1973) in the FAO sheets for Western Indian Ocean, genus *Bothus* is represented by seven species. Four species of *Bothus* were recorded by Munroe (1955) from the Ceylonese waters–*Bothus polylepis*, *Bothus ovalis*, *Bothus pellucida* and *Bothus pantherinus*. Talwar and Kacker

(1984) reports of four species from India–*Bothus mancus, Bothus myriaster, Bothus leopardinus* and *Bothus pantherinus*, of which *B. mancus* and *B. leopardinus* are said to be of rare occurrence. Three species in this genus– the flowery flounder *Bothus mancus*, the Indo–oval founder *Bothus myriaster* and the leopard flounder *Bothus pantherinus* have nearly circumglobal distribution throughout the tropical waters.

In the present work both *Bothus myriaster* and *Bothus pantherinus* has been recorded from genus *Bothus*.

4.3.4.2.1 *Bothus myriaster* (Temminck and Schlegel, 1846)
Panther flounder

Rhombus myriaster Temminck and Schlegel, 1846, *Fauna Japon. Poiss.,*: 181, pl xcii, fig. 2 (Japan); Bleeker, 1853, *Verh. Bat. Gen.* XXV (7): 37; Boeseman, 1947, *Rev. Fish. Burger and Von Siebold*: 181, pl. XCII, fig. 2 (Japan).

Rhomboidichthys myriaster Bleeker, 1856, *Act. Soc. Sc. Ind. Neerl.*, I, *Besc. visch. Menado :* 67 (Menado); Gunther, 1862, *Cat. Brit. Mus.*, IV: 436 (Japan, Celebes).

Platophrys* (*Platophrys*) *myriaster Bleeker, 1866-1872, *Atl. Ichth.*, VI: 10; Bleeker, 1874, *Nederl. Tjls. Dierk.*, 4: 436.

Platophrys circularis Regan, 1908, *Trans. Linn. Soc. London. Zool.*, 12 (pt. 3): 233, pl. 26, fig. 3 (Amirante, Seychelles, Indian Ocean).

Platophrys ovalis Regan, 1908, *Trans. Linn. Soc. London. Zool.*, 12 (pt. 3): 232, pl. 27, fig. 6. (Amirante, Seychelles, Indian Ocean).

Platophrys myriaster Jordan and Snyder, 1901, *Checklist Fish. Japan*: 122; Jordan and Evermann, 1902, *Proc. U.S. Nat. Mus.,* XXV: 365

(Keerum, Formosa); Jordan and Starks, 1906, *Proc. U.S. Nat. Mus.*, XXXI: 167; Steindachner, 1907, *Denk. Ak. Wien,* 71(1): 152, 166 (Gischis, S. Arabia); Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci. Tokyo,* 33 (1): 312 (Southern Japan, southward to China, Formosa); Weber, 1913, *Siboga-Exped. Fisch.,*: 428 (larval stage) (Celebes, Ambon, Japan, China); Hubbs, 1915, *Proc. U.S. Nat. Mus.*, XLVIII: 457; Steindachner, 1902, *Denk. Akad. Wein* LXXI: 152; Reeves, 1927, *J. Pan. Pac.Res. Inst.*, 2(3): 14 (South China); Fowler, 1929, *Proc. Acad. Nat. Sci. Philadel.,*: 615 (Hong Kong); Chu, 1931, *Biol. Bull. St. John Univ.*, 1:90; Kamohara, 1931, *Zool. Mag.*, 43 (514): 542.

Bothus* (*Platophrys*) *myriaster Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.,* 5: 120 (Sumatra, Java, S. Japan, China, Formosa).

Bothus myriaster Steindachner, 1861, *Ichth. Mitth. III. Verh. zool. bot. Ges. Wien* XI :179; Chabanaud, 1929, *Bull. Mus. Hist. Nat. Paris*, (2) I: 379; Wu, 1932, *Thès. Fac. Sci. Univ. Paris,* A. 244 (268): 95; Norman, 1934, *Syst. Monog. Flatfish.,* 1: 236, fig. 179. (Indo-China, Formosa, Japan); Okada and Matsubara, 1938, *Fish. Fishlike Animals*: 422 (Japan); Smith, 1949, *Fish. South. Africa*: 160, fig. 316 (Natal); Kamohara, 1950, *Fish. Tosa Kishu*: 241; Mori, 1952, *Mem. Hyogo Univ. Agri.*, 1(3):172; Matsubaara, 1955, *Mem. College Agri. Kyoto Univ.*, (68): 1260, fig. 491 (Japan, Formosa, Indo–China); Fowler, 1956, *Fish. Red Sea S. Arabia*, I: 171 (Japan, China, Hong Kong); Mori, 1956, *Mem. Hyogo Univ. Agri.*, 2(3):172; Smith, 1961, *Sea Fish S. Africa*:160 (Knysna); Amaoka, 1964, *Bull. Misaki Mar. Biol. Inst. Kyoto Univ.*, (5): 12, figs. 1-2; Chen and Weng, 1965, *Biol. Bull.*, 27:16, fig. 36 (Pescadores, Kaohsuing, South China Sea); Amaoka, 1969, *J. Shimonoseki Univ. Fish.*, 18(2): 162, fig. 57 (Japan); Amaoka in Masuda *et al.*,1984, *Fish. Jap. Arch.,*: 349; Li and Wang, 1995, *Fauna Sinica*: 209; Hensley, 1986, *Smith Sea Fish.*, 856, fig. 259.4 (Inhambane, South Africa); Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad.,* 166: 45; Francis, 1993, *Pac. Sci.,* 47 (2):167; Kim and Youn, 1994, *J. Ichth.*, 6 (2): 109; Goren and Dor, 1994, *Fish. Red Sea,* CLOFRES II: 71; Li and Wang, 1995, *Fauna Sinica*: 208; Evseenko, 1996, *J. Ichth.*, 36 (9):727; Evseenko, 1998, *Russian Acad. Science*: 59; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.,* 8: 645; Nakabo, 2000, *Fish. Japan*, 2^0:1365; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide* :3818; Nakabo, 2002, *Fish Japan,* 2:1365; Youn, 2002, *Fish. Korea*: 429, 680; Manilo and Bogorodsky, 2003, *J. Ichth.,* 43 (suppl. 1): S122; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India. Misc. Publ. Occ. Paper,* 216: 45; Heemstra *et al*., 2004, *J. Nat. Hist.*, 38: 3331; Hoese and Bray, 2006, *Zool. Cat. Aust.,* 35: 1816 (Australia).

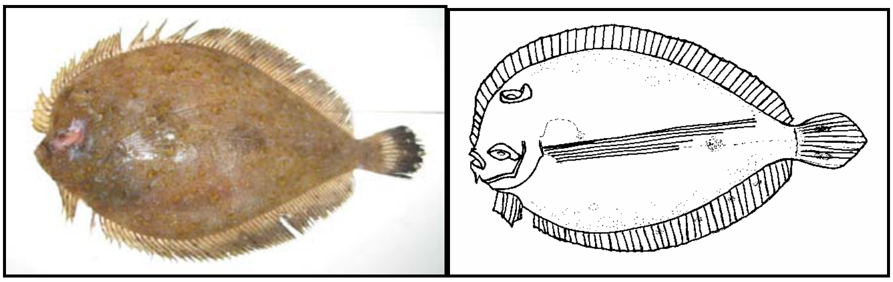


Plate XIV: *Bothus myriaster* (Temminck and Schlegel, 1846)

Material examined: N =17, TL 79.4 -179.54 mm from Neendakara Fisheries Harbour.

Diagnosis: A *Bothus* with cycloid scales on its body except for marginal area of body and lower jaw.

Meristic counts

Males: D 84 -102; A. 60 - 69 (65); P_1 7 - 9 (8); P_2 6 – 8; V_1, V_2 6; C. 17-21;

Females: D 82–86, A. 62–67 (64), P_1 8–9; P_2 8; V_1, V_2 6; C 17–18.

Body measurements as percent of SL (combined) (means in parentheses): HL 25.02–29.56 (27.13), TKL 71.1–76.3 (64.7), HW 44.4–52.4 (48.6), HD 23.9–32.4 (28.6), BD_1 41.3–53.3 (44.5), BD_2 53.6–68.3 (50.3), ED_1 7.5–11.2 (9.4), ED_2 7.4–10.6 (8.7), ID 5.4–12.5 (9.2), SNL_1 12.1–20.8 (14.9), SNL_2 3.7–6.7 (4.6), UHL 19.8–29.1 (20.6), LHL 27.1–35.4 (12.5), PrOU 3.6–11.5 (5.3), PrOL 4.1–6.3 (5.4), PBU 3.3–7.8 (5.5), PBL 9.7–13.03, (11.8), UJL 5.95–7.8 (6.9), LJL 3.7–6.9 (5.7), DFL 9.7–12.4 (10.8), AFL 8.7–15.7 (11.5), CFL 14.2–20.6 (17.7), P_1FLO 23.7–66.5 (47.5), P_2FLB 10.8–17.1 (15.1), V_1FLO 8.5–15.7 (11.4), V_2FLB 8.8–13.9 (11.1), DBL 89.1–97.1 (94.1), ABL 74.5–81.4 (78.6), P_1BLO 2.6–4.7 (3.8), P_2BLB 2.2–4.7 (3.04), V_1BLO 6.1–10.8 (8.6), V_2BLB 3.9–8.2 (6.2), CPD 7.6 –10.3 (9.14), PDL 3.2–5.1 (4.2), V_1LO 9.5–15.04 (12.04), V_2LO 11.1–19.3 (16.04), P_1LO 24.1–30.5 (27.3), P_2LB 24.6–30.7 (26.2), PAL 22.4–27.97 (25.3).

As percent of HL (mean in parentheses): TKL 240.7–301.5 (271.2), HW 170.6–193.6 (181.1), HD 92.5–122.01 (105.4), BD_2 148.7–195.4 (173.3), ED_1 26.1–40.8 (34.3), ED_2 25.7–37.6 (32.3), ID 20.8–43.6 (33.7), SNL_1 41.4 - 73.9 (62.5), SNL_2 13.2–25.1 (19.3), UHL 69.1–112.7 (86.2), LHL 104.1–123.4 (109.8), PrOU 14.2–43.4 (19.97), PrOL 13.9–23.8 (19.4), PBU 12.2–28.9 (19.8), PBL 38.2–47.2 (43.3), UJL 20.6–28.3 (25.5), LJL 14.2–24.5 (20.5), DFL 36.7–45.04 (40.3), AFL 32.8–55.8 (42.9), CFL 56.7–77.04 (65.7), P_1FLO 95.6–247.5 (183.1), P_2FLB 40.3–64.1 (55.7), V_1FLO 32.9–58.97 (42.23), V_2FLB 33.01 - 51.4 (39.8), DFB 317.7 – 378. (348.8), AFB 270.5 - 317.75 (291.1), P_1BLO 9.5–18.5 (13.9), P_2BLB 8.1–16.3 (11.2), V_1BLO 22.4–38.7 (31.7), V_1BLB 13.3–30.1 (22.7), CPD 28.8–36.9 (34.03), PDL 11.8–18.98 (15.4), V_1LO 34.8 –55.4 (43.8), V_2LB 40.9–67.1 (58.9), P_1LO 89.7–106.2 (100.4), P_2LO 85.2–111.7 (102.5).

As percent of SL (mean in parentheses) (males): HL 25–28.7 (26.6), TKL 71.7–76.3 (73.8), HW 43.4–51.9 (48.5), HD 23.9–32.4 (28.8), BD_1 42.9–53.3 (47.8), BD_2 55.5–65.5 (60.1), ED_1 7.6–11.2 (9.3), ED_2 7.7–10.6 (8.95), ID 7.7–12.5 (10), SNL_1 15.6–20.9 (17.8), SNL_2 3.7–6.7 (5.3), UHL 19.8–27.9 (22.4), LHL 27.9–35.4 (30.5), PrOU 4.4–11.5 (5.8), PrOL 4.3–6.3 (5.4), PBU 3.3–6.99 (5.3), PBL 9.7–12.7 (11.5), UJL 6.2–7.5 (6.9), LJL 4.8–6.5 (5.7), DFL 10.2–11.73 (10.77), AFL 8.7–14.8 (11.5), CFL 14.2–19.4 (17.4), P_1FL 49.9–66.5 (57.6), P_2FL 10.8–16.2 (14.7), V_1FLO 8.6–15.7 (11.13), V_2FLB 8.8–12.9 (10.3); DBL 91.4–97.1 (94.7), ABL 74.5–80.3 (78.6), P_1BLO 3.1–4.7 (3.8), P_2BLB 2.6–3.7 (3.1), V_1BLO 6.1–10.8 (8.8), V_2BLB 4.6–7.5 (6.01), CPD 8.4–10.3 (9.2), PDL 3.4–5.1 (4.3), V_1LO 9.5–13.7 (11.7), V_2LB 12.2–18.1 (16.1), P_1LO 24.1–30.7 (27.9), P_2LB 25.4–30.7 (27.9), PAL 22.4–27.1 (24.8).

As percent of SL (mean in parentheses) (females): HL 27.2–29.6 (28.6), TKL 71.1–74.3 (72.3), HW 49–52.4 (50.4), HD 27.97–29.2 (28.8), BD_1 43.3–47.6 (44.8), BD_2 62.8–68.3 (65), ED_1 9.2–10.9 (9.9), ED_2 7.8–9.4 (8.8), ID 6.6–9 (7.9), SNL_1 12.1–16.2 (14.7), SNL_2 4.5–5.3 (4.95), UHL 20.4–25.9 (22.7), LHL 29.3–31.4 (30.4), PrOU 4.4–5.7 (4.8), PrOL 4.1–5.4 (4.9), PBU 4.2–7.8 (5.5), PBL 11.9–13 (12.5), UJ 6.9–7.8 (7.5), LJ 4.95–6.9 (5.96), DFL 10.7–12.4 (11.5), AFL 9.5–15.6 (11.98), CFL 17.5–20.6 (19.2), P_1FLO 28.6–36.7 (32.6), P_2FLB 15.4 –17.1 (16.3), V_1FLO 12.1–12.8 (12.6), V_2FLB 11.5 - 13.5 (12.4), DBL 92.8–94.2 (93.7), ABL 78.9 - 81.4 (80.1), P_1BLO 2.6–3.5 (3.2), P_2BLB 2.2 - 3.2 (2.6), V_1BLO 6.9 - 8.9 (7.8), V_2BLB 3.9 - 8.2 (6.4), CPD 8.5–9.8 (9.2), PDL 3.4 - 4.7 (4.2), V_1LO 12.2–15 (13.4), V_2LB 11.1–19.3 (15.9), P_1LO 27.6–29.8 (28.99), P_2LB 28.6–28.9 (28.8), PAL 26.8–27.97 (27.5). A comparative statement of the meristic characters of *Bothus myriaster* is given in Table 30. Results of the correlation coefficient analysis on non-meristic characters of *Bothus myriaster* is given in Table 31

Table 30: A comparative statement of the meristic characters of *Bothus myriaster*

Meristic Characters	Earlier workers										Present Study 2004-2010	
	Norman 1934	Temminck & Schlegel 1846	Gunther 1862	Weber 1913	Weber & Beaufort 1929	Cheng & Weng 1965	Amaoka 1969	Ramanathan & Natarajan, 1980	Radhamanyamma 1988	Randall 1995	N = 17	Mean ± SD
Dorsal rays	93-95	95	88 -95	88	88-89	92	87 - 97	88 -95	84 – 88	85 – 95	84 -102	89.4 ± 6.3
Anal rays	67-71	67	65	70	65	66	61 -73	65 – 71	64 – 66	66 – 72	60 -69	64 ± 4.5
Pectoral (O)	8 - 9	8	*	9	B 7-9 (O) 8-9	8/8	8 -10 (O) 7 - 10 (B)	8 – 10 (O) 9 – 10 (B)	*	9 – 11	7-9 (O) 6 – 8 (B)	8.1 ± 0.6
Lateral line	104	*	*	*	120	*	74 -108	72 -108	90 - 94	80 - 92	83	88.5 ± 5.5
Pelvic	*	6	*	6/6	6	17	*	*	*	*	6	*

*Data not available

Table 31: Results of the correlation coefficient analysis on non-meristic characters of *Bothus myriaster*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.4 - 4	3.7	0.2	0.96	0.27
Head width	1.9 - 2.3	2.1	0.1	0.96	0.42
Head depth	3.1 - 4.2	3.5	0.4	0.88	0.29
Body depth I	1.9 - 2.42	2.13	0.17	0.92	0.54
Body depth II	1.5 -1.9	2.1	0.18	0.92	0.46
Dorsal FL	8.1 -10.3	9.3	0.7	0.96	0.09
Anal FL	6.4 -11.5	8.9	1.4	0.71	0.08
Caudal FL	4.9 - 7.1	7.1	5.7	0.81	0.15
Pectoral (O) FL	1.5 - 4.2	2.3	0.9	0.34	0.43
Pectoral (B) FL	5.8 – 9.3	6.7	0.9	0.85	0.13
Pelvic (O) FL	6.4 -11.8	9.1	1.8	0.61	0.1
Pelvic (B) FL	7.2 - 11.3	9.2	1.3	0.86	0.15
Pre dorsal	19.6 – 31.5	24.6	4.2	0.74	0.05
Pre pelvic (O)	6.7 – 10.5	8.4	1.2	0.88	0.15
Pre pelvic (B)	5.2 – 9.01	6.4	1.1	0.83	0.18
Prepectoral (O)	3.3 – 4.2	3.7	0.3	0.94	0.29
Prepectoral (B)	3.3 – 4.1	3.6	0.2	0.96	0.31
Pre anal	3.6 – 4.5	3.97	0.3	0.94	0.26
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	0.5 - 0.6	0.56	0.03	0.96	1.53
Head depth	0.8 -1.1	0.96	0.08	0.92	1.08
Body depth I	0.4 - 0.5	0.58	0.04	0.94	1.96
Eye diam (U)	2.45 - 3.8	2.93	0.33	0.90	0.4
Eye diam (L)	2.6 - 3.9	3.14	0.34	0.88	0.35
Inter orbital length	2.3 - 4.8	3.09	0.71	0.81	0.45
Snout-> U eye	1.4 - 2.4	1.63	0.26	0.81	0.76
Snout-> L eye	3.99 - 7.6	5.39	1.09	0.37	0.14
Upper head length	0.89 - 1.5	1.18	0.16	0.56	0.5
Lower head length	0.8 - 0.96	0.91	0.06	0.44	1.21
Pre orbital (U)	2.3 - 7.1	5.42	1.09	0.31	0.13
Pre orbital (L)	4.2 - 7.2	5.15	0.73	0.92	0.27
Post orbital (U)	3.5 - 8.2	5.24	1.38	0.71	0.27
Post orbital (L)	2.1 - 2.6	2.30	0.15	0.96	0.47
Upper jaw	3.5 - 4.8	3.96	0.33	0.94	0.28
Lower jaw	4.1 - 7.94	4.91	0.78	0.94	0.28

Description: Body deeply elliptical, strongly compressed, head rather small contained 3.7 times in SL, body widest at the middle part, dorsal profile more convex than ventral profile in the head region, rising sharply from lower eye upwards. Snout very narrow, distance from snout to lower eye less than half the eye diameter. Eyes large, both nearly equal in diameter, diameter nearly equal to length of maxillary; interorbital space broad, concave, scales cycloid; upper eye placed a little behind the lower. In males, five big spines and three small spines present in the front orbital portion of upper eye and lower eye respectively. In front of the lower eye, in the concave interorbital space, a thick fleshy horn is present which carries the nostril at its tip; a small oval opening present just at the base of the fleshy horn is the second nostril. Interorbital space is more in males. Mouth very small, curved in a concave pattern towards the ventral profile, maxillary ends at anterior 1/3 of lower eye, lower jaw projecting slightly in front of the upper jaw. Fine villiform, sharp biserial teeth present on the upper jaw, those on the outer end more stronger and wider apart than in the inner end; teeth on lower jaw biserial in anterior half, uniserial on the latter half; outer set stronger with inwardly curved teeth, widely set, inner set closely placed, sharp, villiform and not so strong. Gill rakers on the lower limb of first arch small and pointed, not serrate, none present on upper limb.

Upper eye surrounded by a canal system which arises from the anterior branch of the lateral line and is a part of it; a supratemporal branch enters into the dorsal profile; the main lateral line arises from behind the interorbital space, forms a plateau around the pectoral fin and extends to the tip of the caudal peduncle till the caudal rays. The lateral line is canal like with extensions into the neighbouring scale, the curve is at the 18^{th} - 20^{th} scale; the curved portion of lateral line contained two times in head length. Lateral line absent on blind side.

Body covered with cycloid scales which are deciduous except at the extremities which have ctenoid scales; those on blind side cycloid. The anterior region of head in front of the interorbital, jaws, snout and base of pectoral fin naked. Anal opening is on the blind side, in front of the pelvic fin. Dorsal fin origin on blind side, at the junction of snout and body, before a horizontal through upper margin of lower eye. Three finrays present on the blind side, finlength increasing gradually from the front to the middle portion of the body, then decreasing towards the caudal peduncle. Caudal peduncle very narrow. Pelvic fin placed below head region, origin at the outer ventral profile of head; pectoral origin behind anal origin on the ocular side of body. Interhaemal spine projects in front of anal opening.

Sexual dimorphism: Very clear sexual dimorphism seen in adult fishes; males are generally bigger in size compared to females. Rostral spine prominent in males and interorbital area is more concave. Pectoral fin is longer in males with the first fin highly elongated; length of the fin is nearly 2.18 and 1.6 times head length in males and females respectively. Interorbital space is very wide in males, contained 2.6 times in head length; in females it is contained 3.5 times. Males have a prominent spine on the snout, another at the junction of lower and upper jaw, several small spines around orbit; a membraneous flap is present at the hind end of the orbit. Spines and membraneous flaps are absent in females. Brown spots present on the middle portion of the pectoral fins. Orange white vertical bands present in the middle area on the ventral blind region in males with the other areas deep blackish; in females blind side is white with no markings. Males have two rows of blue spots in the region between snout and upper eye which is absent in females.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 47, 48, 49, 50); the linear regression equations obtained were

For **males**

Head width on SL	:	$y = 0.43\,x + 5.89$; $R^2 = 0.92$
Head depth on SL	:	$y = 0.28\,x + 1.01$; $R^2 = 0.62$
Body depth (BD_1) on SL	:	$y = 0.45\,x + 2.59$; $R^2 = 0.77$
Body depth (BD_2) on SL	:	$y = 9.7\,x + 0.51$; $R^2 = 0.77$
Dorsal fin length on SL	:	$y = 0.095\,x + 1.26$; $R^2 = 0.92$
Anal fin length on SL	:	$y = 0.027\,x + 8.77$; $R^2 = 0.13$
Pectoral finlength on SL	:	$y = 0.82\,x - 24.12$; $R^2 = 0.83$
Head width on HL	:	$y = 1.47\,x + 9.5$; $R^2 = 0.94$
Head depth on HL	:	$y = 1.06\,x + 0.37$; $R^2 = 0.78$
Eye diameter (upper) on HL	:	$y = 0.43\,x - 2.11$; $R^2 = 0.79$
Eye diameter (lower) on HL	:	$y = 0.35\,x - 0.4$; $R^2 = 0.77$
Interorbital distance on HL	:	$y = 0.62\,x - 6.4$; $R^2 = 0.92$
Preorbital (lower) on HL	:	$y = 0.28\,x - 2.04$; $R^2 = 0.8$
Postorbital length (upper) on SL	:	$y = 0.32\,x - 3.4$; $R^2 = 0.64$
Postorbital length (lower) on SL	:	$y = 0.41\,x + 0.58$; $R^2 = 0.90$

Regression of anal finlength on SL was found to be non-significant while all the other parameters were found to be significant at 5 % level.

For **females**

Head width on SL	: $y = 0.52\,x - 0.74$; $R^2 = 0.98$
Head depth on SL	: $y = 0.31\,x - 1.98$; $R^2 = 0.99$
Body depth (BD_1) on SL	: $y = 0.51\,x - 4.8$; $R^2 = 0.97$
Body depth (BD_2) on SL	: $y = 0.56\,x - 8.23$; $R^2 = 0.99$
Dorsal fin length on SL	: $y = 0.09\,x - 1.97$; $R^2 = 0.94$
Anal fin length on SL	: $y = 0.01\,x + 8.98$; $R^2 = 0.16$
Pectoral fin length on SL	: $y = 0.43\,x - 9.26$; $R^2 = 0.95$
Head width on HL	: $y = 1.84\,x - 1.67$; $R^2 = 0.99$
Head depth on HL	: $y = 1.07\,x - 1.68$; $R^2 = 0.96$
Eye diameter (upper) on HL	: $y = 0.42\,x - 1.87$; $R^2 = 0.99$
Eye diameter (lower) on HL	: $y = 0.4\,x - 2.4$; $R^2 = 0.94$
Interorbital distance on HL	: $y = 0.42\,x - 3.64$; $R^2 = 0.99$
Preorbital (upper) on HL	: $y = 0.24\,x - 1.82$; $R^2 = 0.95$
Preorbital (lower) on HL	: $y = 0.26\,x - 2.14$; $R^2 = 0.79$
Postorbital length (lower) on SL	: $y = 0.05\,x + 11.12$; $R^2 = 0.93$

Regression of body depth 2 (ie maximum depth of body) and head depth on SL and head width and interorbital on HL was found to be significant at 5 % level. All the other parameters were found to be non – significant.

Males and females combined

Head length on SL	: $y = 0.27\,x + 0.15$; $R^2 = 0.96$
Head width on SL	: $y = 0.42\,x + 6.46$; $R^2 = 0.96$
Body depth (BD_1) on SL	: $y = 0.54\,x - 6.1$; $R^2 = 0.93$
Body depth (BD_2) on SL	: $y = 0.46\,x + 15.3$; $R^2 = 0.92$

Dorsal fin length on SL	: $y = 0.09\ x + 1.37$; $R^2 = 0.96$
Pectoral fin length on SL	: $y = 0.43\ x + 4.87$; $R^2 = 0.34$
Head width on HL	: $y = 1.53\ x + 6.89$; $R^2 = 0.97$
Head depth on HL	: $y = 1.08\ x - 0.7$; $R^2 = 0.92$
Eye diameter (upper) on HL	: $y = 0.4\ x - 1.46$; $R^2 = 0.90$
Eye diameter (lower) on HL	: $y = 0.35\ x - 0.64$; $R^2 = 0.89$
Interorbital distance on HL	: $y = 0.45\ x - 2.96$; $R^2 = 0.81$

Except regression of pectoral fin length on SL, regression of body parameters on SL and HL mentioned above was found to be highly significant.

t test on pectoral fin (ocular) in males and females show that the difference noted externally is highly significant ($P < 0.05$).

Colour: In fresh condition, both males and female fishes have reddish brown body, with brown spots ringed with diffuse brown; a small ocelli present at the junction of the straight and curved portion of the lateral line, a second ocelli seen in the widest portion of the body on the straight lateral line. A series of blackish – brown spots seen on anal fin; black spot on the pectoral fin seen as bands when fin is folded, outer free end of caudal fin blackish.

Distribution:

World: Reported from Japan (Temminck and Schlegel, 1846; Okada and Matsubara, 1938; Boeseman, 1947; Amaoka, 1969); Menado (Bleeker, 1856*)*, Saudi Arabia (Steindachner, 1907) Celebes, Amirante, Seychelles, Indian Ocean (Regan, 1908); Southern Japan, southward to China, Formosa (Jordan, Tanaka and Snyder, 1913); Celebes, Ambon, Japan, China (Weber, 1913); South China (Reeves, 1927); Hong Kong (Fowler, 1929, 1956); Sumatra (Weber and Beaufort, 1929); Indo-China, Formosa, Japan (Norman, 1934); Cape St. Blaize, Southeast Africa to Taiwan and Japan (Smith, 1986); Natal, Australia (Hoese and Bray, 2006). Map showing localities were *Bothus myriaster* has been recorded in the world is given in Fig. 45.

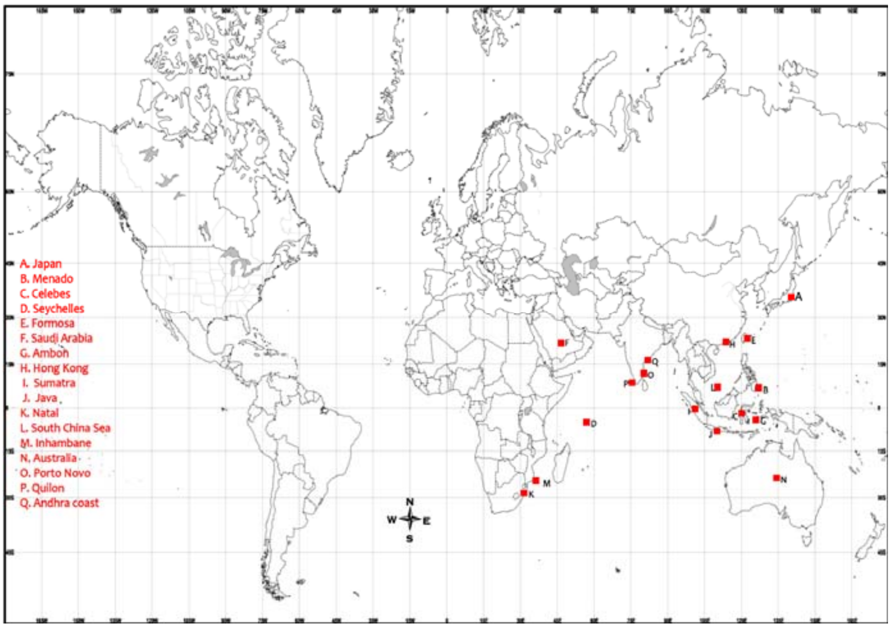


Fig. 45: Map showing localities were *Bothus myriaster* has been recorded in the world.

India: From India it has been reported from Porto Novo waters (Ramanathan and Natarajan, 1980), Quilon (Radhamanyamma, 1988) and Andhra Coast (Talwar and Kacker, 1984). Map showing localities were *Bothus myriaster* has been recorded in India is given in Fig. 46.

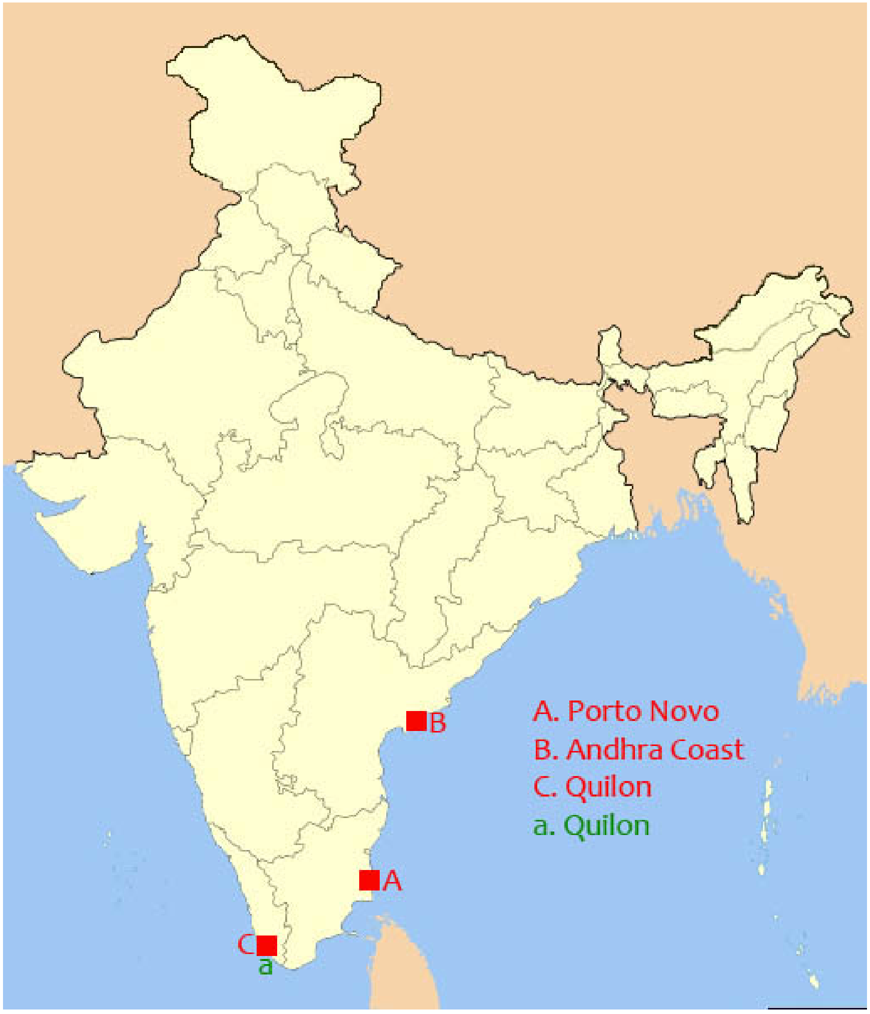


Fig. 46: Map showing localities were *Bothus myriaster* has been recorded in India.

Taxonomic remarks: This species was first described in genus *Rhombus* by Temminck and Schlegel based on a sample from Japan. Later on in 1856, Bleeker described it in *Rhomboidichthys* using the same species name '*myriaster*'. Later on Bleeker (1866) placed it in genus *Platophrys*, and the species name was retained. Steindachner in 1861 placed the species in Genus *Bothus*. This was followed by Chabanaud (1929) and many others and is now considered a valid name. Jordan and Starks (1907) described a female specimen of TL 16 cm from Formosa as *Platophrys myriaster*. The description of the present specimen matches well with that of *Platophrys myriaster* described by Jordan and Starks. *Platophrys ovalis* described as a new species by Regan (1908) from Seychelles is similar in dorsal fin, anal fin and lateral line counts to that of Weber and Beaufort (1929) and Amaoka (1969). Regan (1908) has also mentioned "*allied to P. myriaster*". Norman (1934) pointed out that if a number of specimens of the fish were to be precisely examined, *B. ovalis* (Regan) might prove to be the same as *B. myriaster*, though he did describe the present species as if it were two different ones. Matsubaara (1955) agreed with Norman's view. Kamohara (1958) who recognized *B. myriaster* and *B. ovalis* as one and the same species, gave no ground reasons for it. There is a divergence of opinion among the investigators of the fish on this point. The holotype of *B. ovalis* which was established by Regan (1908) is a young fish of 95 mm in total length. Amaoka (1964) concluded that *B. ovalis* recorded by Regan was a young fish and *B. myriaster* recorded by Temminck and Schlegel was an adult one. Such being the case, *B. myriaster* takes priority of nomenclature and consequently *B. ovalis* (Regan) is nothing but a synonym of *B. myriaster*. *Platophrys circularis* described as a new species from Amirante at 22 – 85 fathoms also has dorsal and anal fincounts very similar to *Rhomboidichthys myriaster* of Gunther (1862). Amaoka (1964, 1969) has pointed out that *Platophrys ovalis* and *Platophrys circularis* described by Regan (1908) are synonyms of *Bothus myriaster*, this was also supported by Lindberg and Fedorov (1993:45). Weber (1913) in the footmark remarks that "*the genus Psettyllis is closely allied to Rhomboidichthys and Psettylis ocellata to Rhomboidichthys ocellatus Agassiz. Psettyllis however seems* *to differ in the following characters: (1) cycloid scales on the general surface of the body except for several rows along the skin margins on the ocular side which are strongly ctenoid and (2) asymmetrical jaws and dentition.*" Weber treated *Rhombus* as a synonym of *Platophrys*. Gunther (1862) described the species as *Rhomboidichthys myriaster* and did not highlight any sexual dimorphism. However, the mention that "*sometimes the pectoral fin is seen to be elongated*" might be a reference to male fishes.

Observations: Dorsal fincounts by Radhamanyamma (1988) (84 - 88) do not match with those of Norman (93 - 95) and Ramanathan and Natarajan (88 - 85). Results of the present study however, match with all the earlier revisors since a wide range is noticed in dorsal fin counts. Variation is noticed in all fincounts except ventral (pelvic) fin counts. Lateral line counts of the present study also match with the results of earlier workers. Lateral line counts given by Weber and Beaufort (1929) are on the higher side and have not been recorded by any workers; the present results match only with those of Gunther from Celebes, Ramanathan and Natarajan from Porto Novo and Amaoka from Japan.

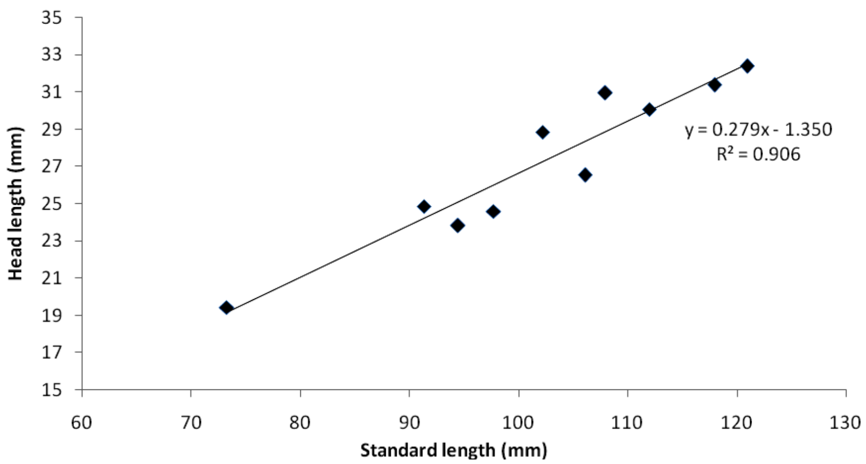


Fig. 47: Regression of Head length Standard length (males)

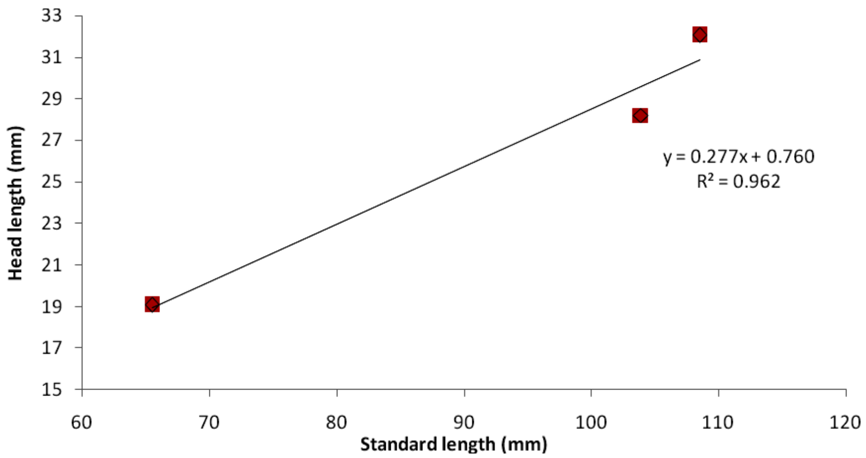


Fig. 48: Regression of Head length Standard length (females)

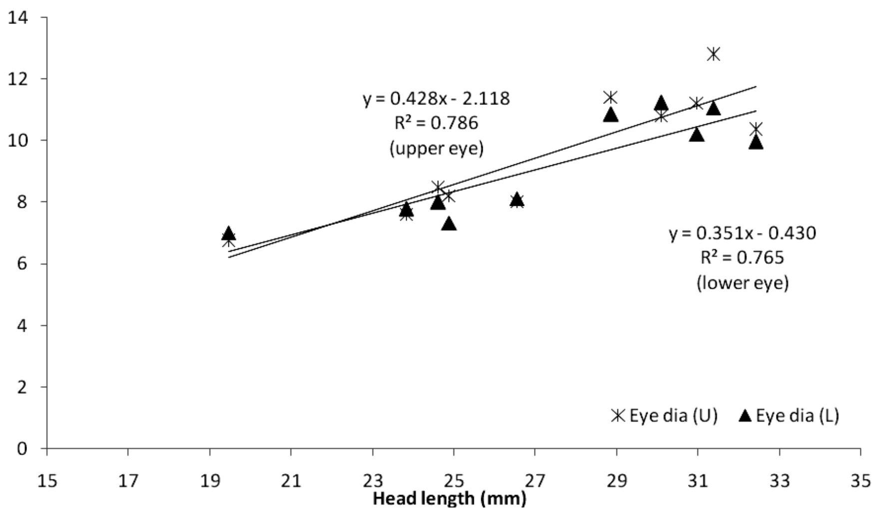


Fig. 49: Regression of eye diameter on Head length in males

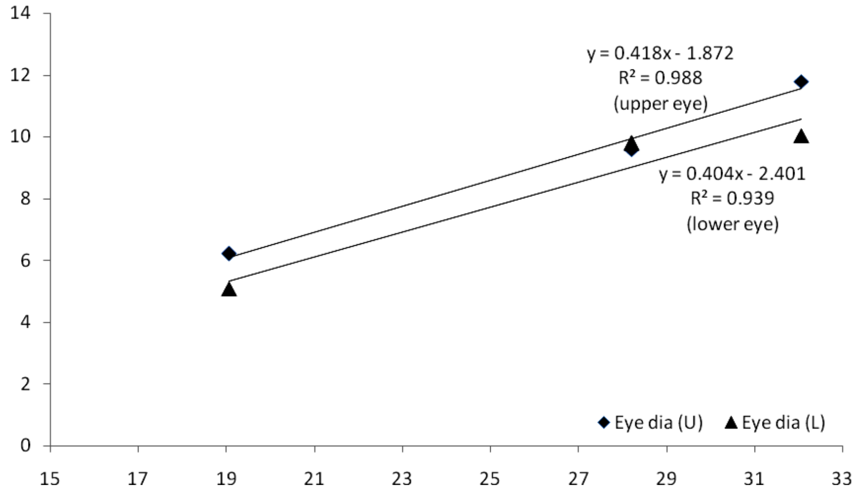


Fig. 50: Regression of eye diameter on Head length in females

4.3.4.2.2 *Bothus pantherinus* (Ruppell, 1821)

Leopard Flounder

Rhombus pantherinus Ruppell, 1821, *Atl. Reise Nord. Afrika, Fisch.,*: 121, pl. 31, fig. 1 (Mohila, Red Sea).

Rhombus parvimanus Bennett, 1832, *Proc. Comm. Sci. Zool. Soc. London* (14): 168.

Rhombus sumatranus Bleeker, 1851, *Nat. Tijd. Ned. Ind.,* I: 409.

Passer marchionessarum Valenciennes, 1846, *Voy. Aut. Années* 1836-39: no p., Pl.9 (Marquesas Islands).

Psetta pantherina Ruppell, 1852, *Verz. Samml. Senk. Mus.*, IV, *Fische*: 19.

Pleuronectes lunulatus Jouan, 1961, *Mem. Soc. Cherbourg*, viii: 256.

Rhomboidichthys pantherinus Gunther, 1862, *Cat. Brit. Mus.*, IV: 436; Playfair and Gunther, 1866, *Fish. Zanzibar*: 112 (Aden, Zanzibar, Red Sea and east coast of Africa to the Feejee Islands); Klunzinger, 1871, *Verh. zool – bot. Ges. Wien, Bd*. XXI: 571; Gunther, 1909, *Fisch. Sudsee*, viii: 342; Schmeltz, 1879, *Mus. Godeffroy, Cat*., 7: 56 (Samoa).

Pseudorhombus pantherinus Bleeker, 1862, *Versl. Akad. Wet. Amsterdam*, xiv: 103.

Platophrys (Platophrys) pantherinus Bleeker, 1866, *Atl. Ichth*., VI: 11, Pleuron, pl. ii, fig. 3.

Platophrys pantherina Day, 1879, *Fish. India* 4: 425; Day, 1889, *Fauna Br. India* II: 443 (Red Sea, Africa, Malaya Archipelago).

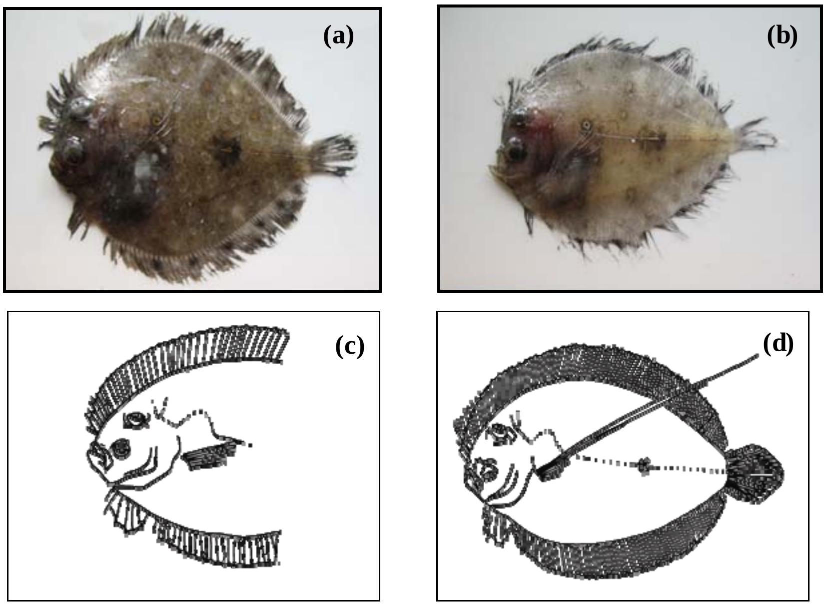
Platophrys pantherinus Waite, 1899, *Mem. Aust. Mus.,* III, 9: 546; Steindachner, 1900, *Denk. Akad. Wien,* LXX: 511; Steindachner, 1902, *Denk. Ak. Wien.,* LXXI: 153; Jordan and Evermann, 1905, *Bull. U.S Comm. Fish*., xxiii: 512; Regan, 1905, *J. Bombay Nat. Hist. Soc*., XVI: 332; Jordan and Seale, 1906, *Bull. U.S. Bur. Fish*., XXV: 412; Steindachner, 1907, *Denk. Ak. Wien,* 7(1): 153 (Kalansiye, Socotra); Evermann and Seale, 1907, *Bull. Bur. Fish*., 26: 105 (Baron); Jordan and Richardson, 1908, *Bull. Bur. Fish*., 28: 280; Regan, 1908, *Trans. Linn. Soc. London Zool*., 12(3): 232 (Maldives, Suvadiva, 43 fathoms, S. Nilandu, 30 and 36 fathoms, Seychelles Group, Amirante, 30 fathoms); Jenkins, 1909, *Mem. Ind. Mus*., III: 26 (Arakan coast); Kendall and Goldsborough, 1911, *Mem. Mus. Comp. Zool*., XXVI: 332; Weber, 1913, *"Siboga" Exped. Fisch.,*: 427 (Menado, Saleyer); Ogilby, 1913, *Mem. Qd. Mus*., II: 90; Gilchrist and Thompson, 1917, *Ann. Durban Mus*., I: 400; Bamber, 1915, *J. Linn. Soc. London, Zool*., XXXI,: 485 (Sudanese Red Sea); Jordan and Jordan, 1922, *Mem. Carnegie Mus*., 10(2): 24; Mc Culloch, 1922, *Mem. Qd. Mus*., vii: 244

(Murray Island); Von Bonde, 1925, *Trans. Roy. Soc. S. Afr.*, XII: 287; Fowler, 1926, *Proc. Acad. Nat. Sci. Philad.*, LXXVII: 204; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 33 (Madras, Andaman Islands, Horsburgh Atoll, Maldives); Fowler, 1928, *Mem. B.P. Bishop Mus.*, X: 91; Schmidt, 1930, *Trans. Pac. Comm. Acad. Sci. U.S.S.R*, I: 111; Fowler, 1931, *Mem. B.P. Bishop. Mus.*, xi: 320 (Honolulu, Queensland); Herre, 1934, *Fish. Herre Phillippine Exped.*,: 104; Tortonese, 1935, *Bull. Mus. Zool. Anat. Comp. Un. Torino*, 45(3), 63:20 (Eritrea); Seale, 1935, *Calif. Acad. Sci. Proc. Ser.*, 4, 21: 351 (Matema, Pago Pago); Herre, 1936, *Field. Mus. Pub.*, 353, *Zool. Ser.*, 21: 58; Munroe, 1958, *Papua and New Guinea Agri. J.*,10 (4): 282; Fowler, 1967, *Mem. B. P. Bishop Mus.,* XI: 320 (Honolulu).

Bothus pantherinus Regan, 1920, *Ann. Durban Mus.*, II: 212, fig. 3 (Natal); Barnard, 1925, *Ann. S. Afr. Mus.*, XXI: 385; Norman, 1926, *Biol. Res. "Endeavour*" V: 252; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 33; Fowler, 1928, *Mem. B. P. Bishop Mus.,* XII (2): 27 (Muscat, Gulf of Oman, Karachi); McCulloch, 1929, *Mem. Aust. Mus.*,V: 276; Borodin, 1932, *Bull. Vand. Mar. Mus.,* 1(3):74; Norman, 1934, *Syst. Monog. Flatfish.*,: 234, fig. 177 (Persian Gulf, Muscat); Fowler, 1938, *Fish. Bull. Singapore*, 1: 272; Okada and Matsubara, 1938, *Key. Fish Japan*: 423; Norman, 1939, *Sci. Rep., Brit. Mus.* (*Nat. Hist.*): 100 (Gulf of Aden, 18 – 22 m); Tortonese, 1941, *Atti. Acad. Ligur. Sc. Lett.*, 1, fasc. 1: 5 (Italian Somali); Smith, 1949, *Sea Fish. South. Africa*: 160, fig. 317; Fowler, 1949, *Mem. B. P. Bishop Mus.,* 12(2): 61; Ben Tuvia and Steinitz, 1952, *Israel Dep. F. Sea. F. Res. Stn. Bull.*, 2: 11 (Eilat); Munroe, 1955, *Fish. Ceylon*: 261, pl. 50, fig. 755 (Coastal waters of Ceylon); Jones and Kumaran, 1959, *Indian J. Fish.*, 6: 49; Marshall, 1964, *Fish. Great Barrier Reef.* 459; Chen and Weng, 1967, *Biol. Bull.,* 27: 15, fig. 35 (Pescadores); Jones, 1969, *Bull. Cent. Mar. Fish. Res. Inst.*, 8: 29; Amaoka 1969, *J. Shimonoseki Univ. Fish.*, 18(2):170 (Japan); Nielsen, 1973, *Checklist Fish. N.E Atlantic Medit.,* CLOFNAM: 620; Amaoka in Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 349, pl. 313-I (Japan); Dor, 1984, *Checklist Fish. Red Sea*: 268; Hensley, 1986, *Smith. Sea Fish.,*: 856, fig. 259.5 (Port Alfred, South Africa); Allen and Swainston, 1988, *Marine Fish. Aust.,*: 146; Winterbottom *et al*., 1989, *Royal Ontario Museum Life Sci. Cont.,* 145: 66 ; Randall *et al.,* 1990, *Fish. Great Barrier Reef* : 450; Baranes and Golani, 1993, *Israel J. Zoo.,* 39: 312 ; Lindberg and Fedorov 1993, *Zool. Inst. Russian Acad.*,166: 45; Kuiter, 1993, *Coastal Fish. S.E Australia*: 385; Francis, 1993, *Pac. Sci.,* 47 (2):168; Goren and Dor, 1994, *CLOFRES* II: 71; Li and Wang, 1995, *Fauna Sinica*: 212; Randall, 1995, *Coastal fish. Oman:* 356; Amaoka and Kishimoto, 1996, *I. O. P. Diving News*, 7(10): 3; Hensley, 1997, *J.L.B. Smith Inst. Ichth. Sp. Publ.* 58: 5; Allen, 1997, *Marine Fish. Trop. Aust,*: 234; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide,* Kuwait: 229; Kuiter, 1997, *Sea Fish. Austr.,*: 380; Randall *et al.*, 1997*, Fish. Great Barrier Reef,* i-xx: 450; Evseenko, 1998, *J. Ichth*., 38 (9): 59; Myers, 1999, *Micronesian Reef Fish.,:* 279; Fricke 1999, *Fish. Mascarene Islands*: 571; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.,* 8: 645; Nakabo, 2000, *Fish. Japan*, 2^0: 1366; Laboute and Grandperrin, 2000, *Poiss. Nouv. Calédonie*: 450; Randall and Earle, 2000, *Occ. Pap. Bernice P. Bishop Mus.*,:21; Matsuura and Peristiwady, 2000, *Fish. Ikan*: 301; Sakai *et. al.*, 2001, *Bull. Nat. Sci. Mus. (Tokyo) Ser.* A, 27(2): 123; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV(6): 3819; Hutchins, 2001, *Rec. W. Aust. Mus. Supp.,* 63: 46; Bilecenoglu *et al.*, 2002, *Zootaxa*, 113: 179 ; Nakabo, 2002, *Fish. Japan*: 1366; Allen and

Adrim, 2003, *Zool. Stud*., 42(1): 63; Manilo and Bogorodsky, 2003, *J. Ichth.,* 43 (suppl. 1): S122; Myers and Donaldson, 2003, *Micronesica*, 35-36: 649; Matsuura *et al*., in Kimura and Matsuura, 2003, *Fish. Bitung*: 214 ; Lobel and Lobel, 2004, *Pac. Sci.*, 58(1): 77; Randall *et al.*, 2004, *Atoll Res. Bull*., 502: 31; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India. Misc. Publ. Occ. Paper,* 216: 45 ; Heemstra *et al*., 2004, *J. Nat. Hist*., 38: 3331; Heemstra and Heemstra, 2004, *Coastal Fish. S. Africa*: 432; Randall, 2005, *Reef Fish. S. Pacific*: 614; Mundy, 2005, *Bishop Mus. Bull. Zoo.,* 6:517; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1816; Randall, 2007, *Reef Shore fish. Hawaii Island.,*: 458; Fricke *et al*., 2009, *Stutt. Beit. zur Natur. A, Neue Serie*., 2:114.

Bothus (Platophrys) pantherinus Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.,* 5: 123 (Waigiu).



(a) Adult (b) Young (c) Female (d) Male

Plate XV: *Bothus pantherinus* (Ruppell, 1821)

Material examined: N= 2, TL 50.6 mm from Neendakara Fisheries Harbour.

Diagnosis: An oval *Bothus* with dark scattered spots on the vertical fins and two prominent spots one at the junction of curved and straight lateral line and the second at the hinder end of the straight lateral line. Scales ctenoid on ocular side, interorbital width not very broad.

Meristic counts: D 87; A 62; P_1 10; P_2 9; V_1 6; Ll. 76.

Body proportions as percent of SL: HL 27.5; HW 51.2; HD 24.3; ED_1 10.2; ED_2 4.3; ID 2.9; PrOU 17.6; PrOL 6.2; PBU 17.1; PBL 14; CD 3.76; BD1 66.5; BD2 53; DFL 12.9; AFL 14.9; P_1FLO 32.2; P_2FLB 16.3; V_1FLO 12.7; V_2FLB 10.2; CFL 17.9; DBL 96.6; ABL 73.6; P_1BLO 3.3; V_1BLO 9.8; V_2BLB 7.6; PDL 4.1; PAL 35.4; P_1LO 31.1; V_1LO 15.7; V_2LB 21.8; UJL 8.95; LJL 6.8.

As percent of HL: HW 186.3; HD 88.5; ED_1 37.1; ID 25.3; PrOU 64.04; PrOL 22.6; PBU 62.1; PBL 50.95; CD 13.7; BD1 242.1; BD2 192.9; DFL 47.2; AFL 54.3; P_1FLO 117.2; P_2FLB 59.4; V_1FLO 46.3; V_2FLB 37.3; CFL 65.1; DBL 351.4; ABL 267.8; P_1BLO 12.1; V_1BLO 35.8; V_2BLB 27.6; PDL 14.9; PAL 128.9; P_1LO 113.3; V_1LO 57.1; V_2LB 79.5; UJL 32.6; LJL 24.6.

Description: Body ovate, moderately compressed with the maximum depth at the centre. Body profile equally convex on both sides. Head large with big eyes, the upper placed a little behind the lower eye; the anterior portion of upper eye on a vertical through middle point of lower eye. Two very small fleshy tubercles on hind end of eyelid. Interorbital space prominent, concave. Nostrils placed close together, first one on ocular side tubular with a flap at outer tip, the second one round, smaller in size without a flap. Nostrils on blind side very small. Mouth large, terminal, oblique, the lower jaw projecting a little in front of upper jaw; maxillary ending just in front of lower eye. Teeth small, closely set, about equally developed on both sides. Teeth on upper jaw biserial, a little enlarged at the anterior half, teeth on lower jaw uniserial, more stronger than that of upper jaw. Lateral line arises from behind eye, at the outer free end of the operculum. Lateral line with a plateau curve in front, just behind operculum proceeding straight to caudal. Dorsal fin inserted on blind side on a horizontal passing through upper margin of lower eye; the fin rays increasing in length till maximum depth of body. Anal fin inserted just behind pelvic fin on dorsal side. Pectoral fins asymmetrical, fin on ocular side with 1 - 4 elongated filaments; pectoral fin on blind side smaller. Pelvic fin small; on ocular side inserted just below middle of lower eye; pelvic fin on blind side inserted at the fourth ray of pelvic fin on ocular side. Caudal obtusely pointed. Anus on blind side above the origin of anal fin. Lateral line tubular in structure with split ends into which the single tubular end fits. A comparative statement of the meristic characters of *Bothus pantherinus* is given in Table 32. Results of the correlation coefficient analysis on non-meristic characters of *Bothus pantherinus* is given in Table 33.

Table 32 : A comparative statement of the meristic characters of *Bothus pantherinus*

Meristic Characters	Earlier workers											
	Day, 1889	Gunther18 62	Jordan & Evermann 1905 (Hawaii)	Gunther 1909	Regan 1920 (Natal)	Norman 1927 – 28 (India)	Fowler 1928 (Oceania)	Weber & Beaufort, 1929	Schmidt 1930 Ryuku	Norman 1934 (Indo – Pacific)	Munroe 1955	Fourmanoir 1957 (Mozambique)
Dorsal rays	85 - 91	92	92	89 – 96	85 - 93	85 - 93	85 – 93	86 - 93	92	85 – 95	86 – 93	90 – 95
Anal rays	65 - 70	69	69	68 - 72	65 - 70	65 - 70	65 - 70	65 - 70	68	64 – 71	65 – 70	70
Pectoral (O/B)	10	*	*	*	*	*	*	11 – 10(0) / 10 – 9 (B)	*	9 – 11 (0)	*	*
Lateral line	75 - 85	85	*	85	*	*	*	82 - 87	*	80 - 92	82 - 87	*
Pelvic	6	*	*	*	*	*	*	6	*	*	*	*

*Data not available

Table 33: Results of the correlation coefficient analysis on non-meristic characters of *Bothus pantherinus*

Characters	In SL	In HL
Head length	3.64	
Head width	1.95	0.54
Head depth	4.11	1.13
Eye diameter (U)	9.81	2.70
Eye diameter (L)	9.81	2.70
Inter orbital length	14.38	3.95
Pre orbital (U)	5.68	1.56
Pre orbital (L)	16.09	4.42
Post orbital (U)	5.87	1.61
Post orbital (L)	7.14	1.96
Chin depth	26.58	7.30
Body depth $_1$	1.50	0.41
Body depth $_2$	1.89	0.52
Dorsal fin length	7.71	2.12
Anal fin length	6.71	1.84
Pectoral fin length (O)	3.10	0.85
Pectoral fin length (B)	6.13	1.68
Pelvic fin length(O)	7.87	2.16
Pelvic fin length (B)	9.77	2.68
Caudal fin length	5.59	1.54
Caudal peduncle depth	11.80	3.24
Dorsal fin base	1.04	0.28
Anal fin base	1.36	0.37
Pectoral fin base (O)	30.00	8.24
Pectoral fin base (B)	30.00	8.24
Pelvic fin base (O)	10.17	2.79
Pelvic fin base (B)	13.17	3.62
Pre dorsal	24.42	6.71
Pre anal	2.82	0.78
Pre pectoral (O)	3.21	0.88
Pre pectoral (B)	3.21	0.88
Pre pelvic (O)	6.37	1.75
Pre pelvic (B)	4.58	1.26
Upper jaw length	11.17	3.07
Lower jaw length	14.79	4.06
Chin depth	26.58	7.30

Body scale marks show moderately ctenoid on ocular side, cycloid on blind side. Gill rakers short, slender, smooth, not serrate. Scales absent in the smaller sample. Present specimen is a female due to presence of 1 - 4 elongated filaments.

Colour: Body brownish green in colour with numerous yellow or white coloured dots or blackish markings on body. Yellow spots are seen on vertical fins also. Two prominent spots seen - one just at the junction of curved and straight part of lateral line and the second at latter part of the straight lateral line. A vertical row of small white spots seen in the preorbital area in front of eyes. Pectoral fin pale with blackish bars.

In formalin preserved specimens the body colour changes to dark brown and the ocellii and markings take a brown colour.

Distribution:

World: Reported from Red Sea (Klunzinger, 1866; Pellegrin, 1913; Bamber, 1915), Aden, Zanzibar east coast of Africa to the Feejee Islands (Gunther, 1866; Day, 1889, Smith, 1961); Maldives, Suvadiva, S. Nilandu, Seychelles Group, Amirante (Regan, 1908); Java, Amboina and East Indies, Mascarenes east to Hawaiian Islands (Jordan and Evermann, 1905; Tinker, 1978); Arakan coast (Jenkins, 1909); Natal (Regan, 1920); Murray Island, Darnley Island, Torres Strait (Mc Culloch, 1922), Oceania (Fowler, 1928); Ryuku Islands (Schmidt, 1930); Port Sudan (Fowler, 1931); Indo–Pacific, Ogasawara Islands, south to New Caledonia, New Britian, Lord Howe Island, Honolulu, Savaii, Fiji, Tahiti, Ponape (Norman, 1934); Marquesas Islands and Society Islands, north to southern Japan, Fanning, Takaroa (Fowler, 1938); Nauru (Whiteley and

Colefax, 1938); Samao (Schultz, 1943); Guam, Honolulu, Samao (Fowler, 1956); Archipelago des Comores, Mozambique (Fourmanoir, 1957); Queensland (Marshall, 1964; Munroe, 1957); Taiwan (Chen and Weng, 1965); Mariana (Woods, 1966); Japan (Amaoka, 1969); Arabian Gulf (Sivasubramaniam and Ibrahim, 1982; Kuronuma and Abe, 1986; Masuda *et al*., 1984). Map showing localities were *Bothus pantherinus* has been recorded in the world is given in Fig. 51.

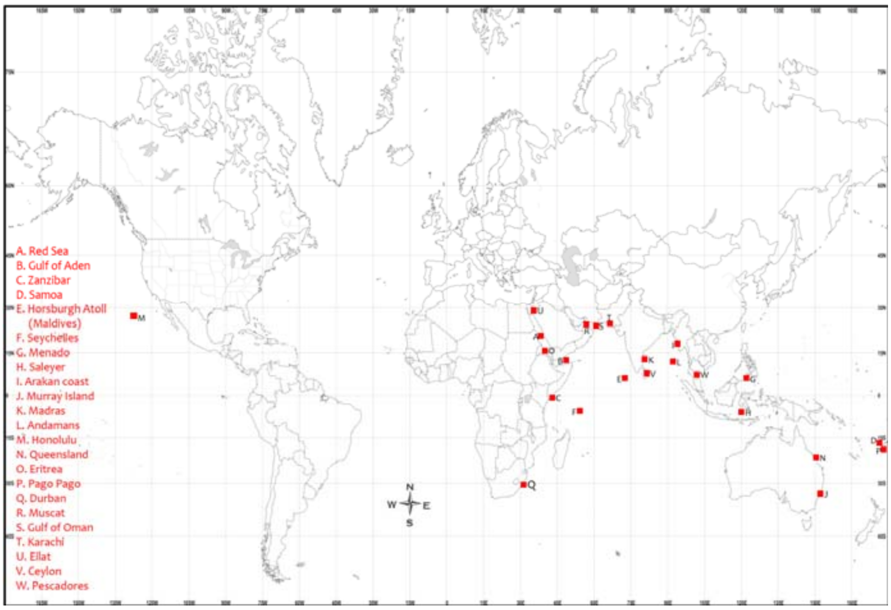


Fig. 51: Map showing localities were *Bothus pantherinus* has been recorded in the world.

India: Madras, Andamans, Nicobar Islands (Norman, 1927), Laccadives (Jones and Kumaran, 1980). Map showing localities were *Bothus pantherinus* has been recorded in the world is given in Fig. 52.

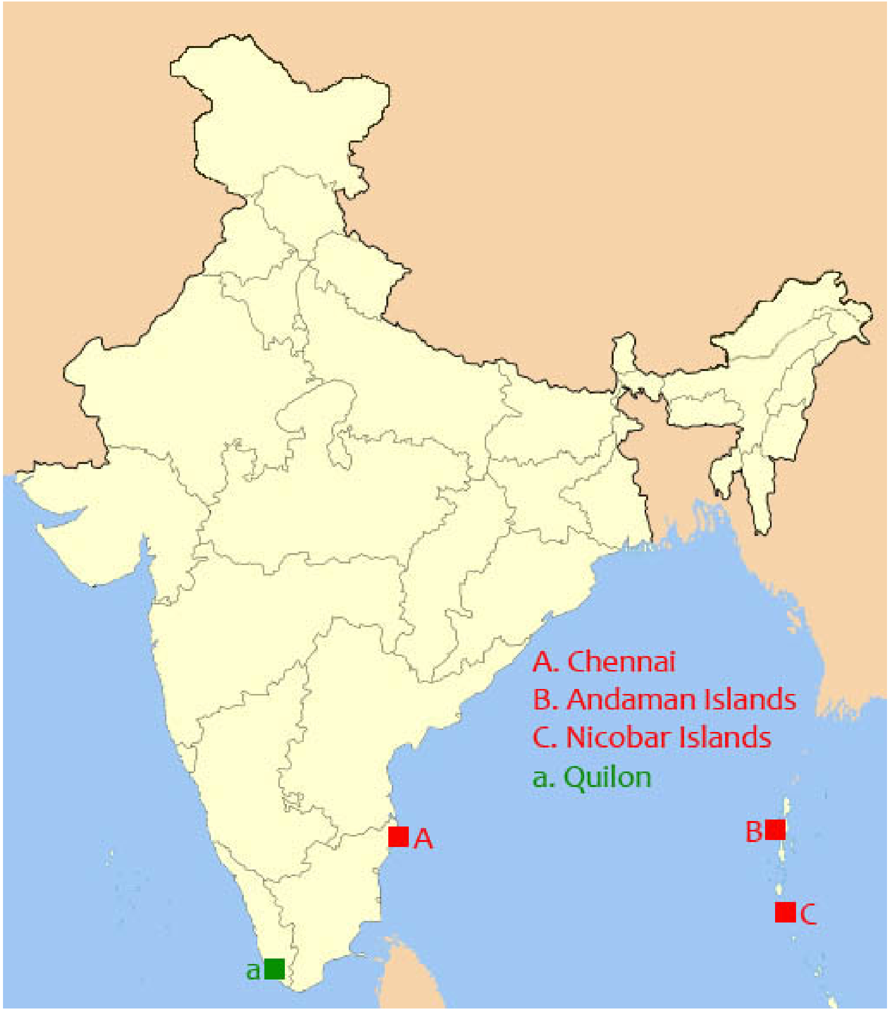


Fig. 52: Map showing localities were *Bothus pantherinus* has been recorded in India.

Taxonomic comments: The species was first described as *Rhombus pantherinus* by Ruppell based on collections from the Red Sea. Gunther (1862) placed the fish in the genus *Rhomboidichthys* erected by Bleeker with the type *R. myriaster*, the characters mentioned for the genus being "*scales very small*". Subsequently, Bleeker (1866) placed the fish in genus *Platophrys*, another genus erected by Bleeker (1862) the characters being "*scales of moderate size and deciduous*". Later, Regan (1920) placed the fish in genus *Bothus* erected by Rafinesque (1910). All the other genera are now considered synonyms of this genus *Bothus*.

Observations: Jones and Kumaran (1980) give higher counts (87–98 for dorsal, 64-71 anal) for samples from Laccadives compared to Kuronuma and Abe (dorsal 77–87, anal 58–64). The present results are closer to that of Kuronuma and Abe, but fall within the range specified by earlier workers.

4.3.4.3 Genus *Chascanopsetta* Alcock, 1894

Chascanopsetta Alcock, 1894, *J. Asiat. Soc. Bengal,* 58(2): 128 (type species by original description ***Chascanopsetta lugubris*** Alcock); Norman 1934, *Syst. Monog. Flatfish*: 249; Matsuura in Uyeno *et al.*, 1983, *Fish. Surinam French Guiana*: 460; Amaoka and Yamamoto, 1984, *Bull. Fac. Fish. Hokkaido Univ.*, 35 (4): 201; Ahlstrom *et al.*, 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 642; Amaoka in Masuda *et al.*, 1984, *Fish. Jap. Arch.,*: 350; Hensley, 1986, *Smith. Sea Fish.,*: 856; Amaoka and Parin, 1990, *Copeia* (3): 717.

Trachypterophrys, Franz, 1910, *Klasse der K. Bayer Akad. Der Wiss.*, 4: 60 (type species by original designation: ***Trachypterophrys raptator*** Franz).

Pelecanichthys, Gilbert and Cramer, 1897, *Proc. U.S Nat. Mus.*, 19 (1114): 432 (type species by original designation: ***Pelecanichthys crumenalis*** Gilbert and Cramer).

Description: Body elongate, elliptical, strongly compressed, highly flexible. Caudal peduncle very narrow in depth. Anterior dorsal profile similar in both sexes. Tip of isthmus ends far behind posterior end of lower eye. Head small, less than ¼ standard length with extremely large mouth. Eyes separated by a narrow bony ridge, eyes placed nearly vertical. Rostral, orbital and mandibular spines absent. Two nostrils on each side; on the ocular side, one nostril is tubular with a flap, second one nearly oval in outline. Mouth gape wide, oblique in outline; maxillary extending to a vertical from the lower eye or to a little beyond it; length a little more than half the head length. Lower jaw protruding a little beyond upper jaw, front end of maxillary not protruding beyond snout tip. Uniserial teeth present on upper jaw, those on lower jaw well curved towards inner side and depressible; canines absent. Gill rakers rudimentary, not serrated, none on upper limb. Scales very small, cycloid, embedded in skin. Lateral line equally developed on both sides, with a plateau curve above pectoral fin.

Dorsal fin originating on blind side, anterior rays slightly elongate, connected by membrane at their bases; all rays simple. Dorsal and anal fin not joined with caudal. Pectoral fin on ocular side longer than that of blind side, all rays simple. Pelvic on ocular side placed in front of pelvic on blind side, origin on blind side at the second – third ray position of that on ocular side. Caudal fin outer tip nearly rounded, outer two rays simple, rest branched.

Distribution: A species of bothid flounder living in the deep waters of the Indian Pacific and Atlantic Oceans.

Taxonomic remarks: Genus *Chascanopsetta* was placed by Weber (1913) in subfamily Hippoglossinae, Family Pleuronectidae along with *Samaris* and *Psettodes*. The characters stated were "*teeth in 1–2 rows, finrays of dorsal and anal unbranched, cycloid scales on body*".

The genus *Pelecanichthys* established by *P. crumenalis* has been synonymised with genus *Chascanopsetta*. *Pelecanichthys* is characterized by having both jaws longer than head, a distinct gular pouch formed by the mandibular membrane (Gilbert and Cramer, 1897; Norman, 1934). According to Amaoka (1984)

> "*these characters were probably very useful as generic characters before C. prognathus was described by Norman (1939). But on a comparative examination between holotypes of both 'crumenalis' and 'prognathus', and specimens of 'lugubris', it was found that 'prognathus' is intermediate between 'crumenalis' and 'lugubris' in the lengths of both jaws, and also 'prognathus' has a gular pouch which is similar to that of 'crumenalis' in structure, though Norman (1939) pointed out that C. prognathus does not have a gular poach, while Kuronuma (1940) stated that C. normani (synonym of C. prognathus) has a gular pouch*."

Thus based on the above conclusion, it was decided by Amaoka that the characters mentioned have no value as generic characters. Hubbs (1915) and Norman (1931) synonymised genus *Trachypterophrys* with genus *Chascanopsetta*. Norman (1931) synonymised it on the basis of examination of 3 co-types from Japan. Thus *Trachypterophrys* is now considered a synonym of *Chascanopsetta*.

Genus *Chascanopsetta* was first described by Alcock (1894) with *Chascanopsetta lugubris* as type species. Chen and Weng (1965) recorded two species in the genus from Taiwan – *C. lugubris* and *C. megastoma*. Presently Amaoka and Yamamoto (1984) in their review of genus *Chascanopsetta* has recognized 5 species and 2 subspecies in this genus - *C. prorigera* Gilbert, 1905, from the central and western Pacific; *C. micrognathus* from the Kyushu–Palau Ridge, *C. lugubris lugubris* Alcock, 1894, *C. lugubris danae* Bruun, 1937, from the Atlantic, *C. prognathus* Norman, 1939 from the Indian and western Pacific and *C. crumenalis* (Gilbert and Cramer, 1879) from near the Hawaiian islands.

4.3.4.3.1 *Chascanopsetta lugubris* Alcock,1894

Pelican flounder.

Chascanopsetta lugubris Alcock, 1894, *J. Asiat. Soc. Bengal*, 63 (2): 129, pl. 6, fig. 4 (original description, type locality: Bay of Bengal); Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV, pt. 2: 327; Alcock, 1899, *Cat. Indian Deep Sea Fish.,*: 125 (Bay of Bengal 145 – 250 fathoms, Gulf of Mannar, 143 fathoms); Brauer, 1906, *Wiss. Ergebn."Valdivia'*, 15 (1): 295; Norman, 1927, *Rec. Ind. Mus.*,: 35, fig. 9; Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) 8: 601; Norman, 1934, *Syst. Monog. Flatfish*: 250, fig. 191 (south–east Africa, Gulf of Mannar, Japan); Kamohara, 1934, *Bot. and Zool.*, 2(7): 1201; Kamohara, 1938, *Offshore bottom fish. Japan*: 59; Okada and Matsubara, 1938, *Key Fish. Japan*: 421, pl. 105, fig.1; Kuronuma, 1940, *Suisan Kenkyushi* 35 (8):213; Kuronuma, 1940, *Bull. Biogeogr. Soc. Jap.*, 10 (3): 43 (South Japan, Africa, Bay of Bengal); Smith, 1949, *Fish. South. Africa*: 157, fig. 306; Kamohara, 1950, *Fish. Tosa Japan*: 241, fig. 182; Kuroda, 1951, *Jap. J. Ichth.,* 1(6): 389; Munroe, 1955, *Fish. Ceylon*: 259, pl. 49, fig. 749; Matsubara, 1955, *Fish. Morph. Hier.*,: 1262 (Japan, Africa); Kamohara, 1958, *Rep. Usa Mar. Biol. St.*, 5 (1): 62; Nielsen, 1961, *Atlantide Rep.*,(6):122; Smith, 1961, *Sea Fish. S. Africa*: 122 (Africa, Atlantic Ocean); Kamohara, 1964, *Rep. Usa Mar. Biol. St.*, 11(1): 82; Chen and Weng, 1965, *Biol. Bull.*, 27: 23, fig. 39 (Tungkong); Shen, 1967, *Quart. J. Taiwan Mus.*, 20 (1, 2): 186, figs. 62 - 65; Amaoka 1969, *J. Shimonoseki Univ. Fish.*, 18 (2): 221; Amaoka and Yamamoto, 1984, *Bull. Fac. Fish. Hokkaido Univ.*, 35 (4): 210; Amaoka in Okamura *et al.*, 1982, *Fish. Kyushu-Palau Ridge Tosa Bay*: 407; Matsuura in Uyeno *et al.*, 1983, *Fish. Surinam French Guiana*:

460; Amaoka in Masuda *et al.*, 1984, *Fish. Jap. Arch.,*:350; Amaoka and Yamamoto, 1984, *Bull. Fac. Fish. Hokkaido Univ.,* 35 (4): 209; Matsuura in Okamura *et al.*, 1985, *Fish. Kyushu-Palau Ridge Tosa Bay*: 613, 736; Hensley, 1986, *Smith. Sea Fish.,*: 857, fig. 259.6 (Natal, Delagoa Bay); Robins and Ray, 1986, *Field guide Atl. coast fish. North America*: 289; Aldebert *et al.*, 1990, CLOFETA, 2:1033; Foroshchuk, 1991, *J. Ichth.*, 31 (3): 81; Bianchi and Carpenter in Bianchi *et al.,* 1993, *FAO Sp. Iden. Guide, Namibia*: 178; Li and Wang, 1995, *Fauna Sinica*: 218; Evseenko, 1996, *J. Ichth.*, 36 (9): 727; Hensley and Smale, 1998, *J. L. B. Smith Inst. Ichth. Sp. Publ.,* 59: 9; Evseenko, 1998, *Russian Acad. Sci.*,: 59, Amaoka in Randall and Lim 2000, *Raffles Bull. Zool. Suppl.*, 8: 645, Hutchins, 2001, *Rec. W. Aust. Mus. Supp.,* 63: 46, McEachran and Fechhelm, 2005, *Fish. Gulf of Mexico*, 2: 826; Nakabo, 2000, *Fish. Japan*, 2 ed.: 1358; Fukui *et al*., 2001, *Ichth. Res.,* 48 (1): 100; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6): 3829; Shinohara *et al.,* 2001, *Mem. Nat. Sci. Mus. Tokyo,* 20: 334; Nakabo, 2002, *Fish. Japan*: 1358; Munroe, 2003, *FAO Sp. Iden. Guide, W. C. Atl.,* 3: 1892; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (Suppl.1): S122; Shinohara *et al*., 2005, *Mem. Nat. Sci. Mus. Tokyo,* 29: 441; Trunov, 2006, *J. Ichth*., 46 (7): 476; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1816

Trachypterophrys raptator Franz, 1910, *Abh. Bayer. Ak. Wiss.,* IV: 60, pl.7, fig.54 (type loc. Fukuura, Japan.); Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci. Tokyo,* 33 (1): 315; Kamohara, 1931, *Zool. Mag.*, 43 (508, 509): 93.

Chascanopsetta raptator Hubbs, 1915, *Proc. U.S. Nat. Mus.*, XLVIII: 452.

Chascanopsetta gilchristi von Bonde, 1922, *Rep. Fish. Mar. Biol. Surv. S. Africa 2, Spec. Rep.* I: 7; Barnard, 1920, *Ann. S. Africa Mus.*, XXI: 390.

Chascanopsetta maculata von Bonde, 1922, *Rep. Fish. Mar. Biol. Surv. S. Africa 2, Spec. Rep.,* I: 8 (Natal, South Africa); Barnard, 1925, *Ann. S. African Mus.*, 21, pt I: 390.

Chascanopsetta lugubris danae Bruun, 1937, *Viden. Medd. Dansk Nat. Foren,* 101: 126, pl .1, fig. 1.

Chascanopsetta microstoma Kuronuma, 1940, *Bull. Biogeogr. Soc. Japan,* 10 (3): 51, fig. 7 (type locality: Off Heta, Suruga Bay, Japan, depth about 300 meters).

Chascanopsetta normani Kuronuma, 1940, *Bull. Biogeogr. Soc. Jap.*, 10 (3): 40, figs. 3-4; Matsubara, 1955, *Fish. Morph. Hierar.*, II: 1262.

Chascanopsetta galatheae Nielsen, 1961, *Galathea Report,* 4: 220, fig. 1, pl.14 (Natal, South Africa).

Chascanopsetta blumenalia Shen, 1967, *Quart. J. Taiwan Mus.,* 20 (1-2): 187 (off Hong Kong).

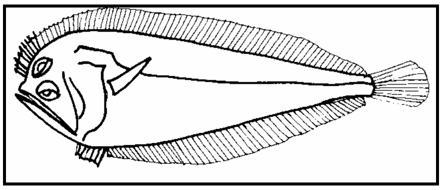



Plate XVI: *Chascanopsetta lugubris* Alcock,1894

Material examined: N =12 specimens, TL 147.64 - 245.76 (mean: 185.2) from the three localities of Cochin, Quilon, and 350 m depth off Vishakapatnam. (**New record from the west coast of India**).

Diagnosis: A species of *Chascanopsetta* with the lower jaw shorter than head, tip projecting slightly beyond upper jaw, lower jaw contained 1.2 times in head, upper jaw contained 1.4 times in head.

Meristic characters: D 110 - 115 (104); A 70 - 85 (76); C 14 -19 (16); P_1 9 -14 (12); P_2 10 -15 (12); V_1 5; V_2 4 - 6 (5); Ll 140 – 180 (170).

Body proportions as percent of SL (mean in parentheses): TKL 72.1 - 98.8 (81.9); HL 21.3 - 31.2 (24.1); HW 19.8 - 37.96 (26.99); BD_1 17.8 - 31.3 (25.3); ED_1 5.7 -9.6 (6.8); ED_2 4.6 - 7.7 (6.04); ID 0.97 - 1.82 (1.3); SNL_1 2.4 - 6.2 (4.7); SNL_2 2.9 - 4.9 (3.8); UHL 4.8 - 13.8 (9.1); LHL 8.5 -23.5 (16.8); P_rOL 1.7 -5.3 (3.1); POL 7.4 - 17.2 (13); DFL 5.7 - 10.9 (7.6); AFL 6.8 -9.96 (8.01); CFL 11.3 -16.5(13.7); P_1FLO 9.23 - 13.8 (10.1); P_2FLB 6.7 - 8.3 (3.6); V_1FLO 3 - 7.4 (4.7); V_2FLB 5.8 - 7.8 (3.9); DBL 85.4 - 114.4 (94.13); CBL 2.3 - 5.7 (4.8); P_1BLO 1.5 - 2.99 (2.23); P_2BLB 1.4 - 2.4 (1.9); V_2BLB 2.2 - 4.4 (3); lateral line straight part 69.8 - 90.8 (62.4); lateral line curved part 10.8 - 19.7 (12.2); CPD 3.2 - 4.6 (3.3); PDL 1.97 - 5.6 (2.9); V_1LO 19.5 - 27.6 (23.03); V_2LB 21.6 - 25.04 (23.4); P_1LO 21.96 - 24.98 (23.8); UJL 15.1 - 20.75 (16.84); LJL 17.3 - 26.78 (20.5); CD 4.83.

As percent of HL (mean in parentheses): HW 93.2 - 164.3 (112.6);ED_1 22.6 - 34.8 (28.2); ED_2 18.6 - 32.3 (25.3); ID 4.2 - 6.9 (5.5); SNL_1 9.7 - 26.8 (19.5); SNL_2 11.7 - 18.4 (15.7); UHL 20.5 - 57.3 (37.6); LHL 39.7 - 100.11 (69.8); P_rOU 6.6 - 21.3 (13.2); PBU 29.97 - 58.89 (54.2); UJL 61.9 - 86.4 (70.4); LJL 73.9 - 95.7 (85.4); CD 20.2.

Description: Body elongate, elliptical, strongly compressed and flexible, widest at midregion at the origin of anal fin, body depth equal to 1.2 head depth; dorsal and ventral profile convex, then horizontal and tapering to caudal peduncle; caudal peduncle very narrow, clearly defined, contained 6.8 times in SL. Head small, less than ¼ standard length with extremely large mouth. Eyes large separated by a narrow bony ridge, eyes placed nearly vertical. Rostral, orbital and mandibular spines absent. Two nostrils on each side; on the ocular side, one nostril is tubular with a flap, second one nearly oval in outline. Mouth gape wide, oblique in outline; well developed on both sides; maxillary extending to a vertical from the lower eye or to a little beyond it; length a little more than half the head length. Lower jaw protruding a little beyond upper jaw when closed, front end of maxillary not protruding beyond snout tip. Uniserial teeth present on upper jaw, teeth size progressively reduced towards inside; those on lower jaw well curved towards inner side and depressible; canines absent. Tongue large, free, with a strong point. Gill rakers rudimentary, not serrated, disc like, none on upper limb.

Scales very small, cycloid, embedded in skin. Scales near the lateral line are larger in size. Lateral line equally developed on both sides, with a plateau curve above pectoral fin. Finrays weak in structure. Dorsal fin origin on blind side, in front of eye, anterior rays slightly elongate, connected by membrane at their bases; all rays simple. Anal fin origin towards rear end of pectoral fin. Dorsal and anal fin not joined with caudal. Pectoral fin on ocular side longer than that of blind side, all rays simple. Pelvic on ocular side placed in front of pelvic on blind side, origin on blind side at the second – third ray position of that on ocular side. Last ray of pelvic connected to first ray of anal by a low membrane. Caudal peduncle narrow at tip, but expands at point of insertion of caudal fin. Caudal fin outer tip nearly rounded, outer two rays simple, rest branched. Anal opening on blind side between the last pelvic ray and first anal ray. A comparative statement of the meristic characters of *Chascanopssetta lugubris* is given in Table 34. Results of the correlation coefficient analysis on non-meristic characters of *Chascanopssetta lugubris* is given in Table 35.

Table 34 : A comparative statement of the meristic characters of *Chascanopsetta lugubris*

Meristic characters	Earlier work					Present work 2004 - 2010	
	Alcock 1894, 1899	Smith 1961	Cheng and Weng 1965	Masuda *et al.*, 1984	Smith 1986	N = 12	Mean ± SD
Dorsal	115	120	118 - 120	111 - 127	122 - 128	110 – 115	106 ± 4.9
Anal	80	85	80	76 - 88	84 - 89	70 – 85	75 ± 4.4
LL scales	*	140	158 - 180	152 - 205	*	140 - 180	152 ± 6.8
Pectoral (O/B)	*	*	15 - 17	13 -17	14 – 17/ 12 -16	9-14/ 10 - 15	12 ± 1.4
Caudal	16	*	17	*	*	14 – 19	15 ± 0.53

Table 35: Results of the correlation coefficient analysis on non-meristic characters of *Chascanopssetta lugubris*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Trunk length	1.13 - 1.4	1.25	0.08	0.77	0.77
Head length	3.97 - 4.7	4.26	0.25	0.87	0.27
Head width	2.6 -5.1	3.87	0.58	0.35	0.30
Body depth	3.3 - 5.6	4.14	0.74	0.53	0.35
Eye diameter (Upper)	12.9 - 17.7	15.24	1.42	0.41	0.05
Eye diameter (Lower)	13.9 - 21.7	17.17	2.34	0.22	0.04
Inter orbital length	60.5 - 102.7	78.42	12.29	0.58	0.02
Snout to upper eye	16.1 - 41.5	23.54	8.02	0.14	0.05
Snout to lower eye	23.4 - 34.5	27.53	3.74	0.32	0.03
Dorsal fin length	9.2 - 17.5	13.79	2.24	0.38	0.10
Anal fin length	9.2 - 17.5	12.85	1.22	0.82	0.11
Caudal fin length	6.4 - 8.9	7.5	0.69	0.61	0.14
Pectoral fin length (O)	7.3 -10.8	9.2	1.01	0.32	0.07
Pectoral fin length (B)	13.3 -14.9	14.35	0.63	0.91	0.06
Pelvic fin length (B)	12.9 - 17.1	15.42	1.43	0.93	0.11
Pre pelvic (O)	4.1 - 5.1	4.44	0.28	0.75	0.16
Pre pelvic (B)	3.99 - 4.6	4.28	0.22	0.81	0.19
Pre pectoral	4 - 4.6	4.21	0.3	0.74	0.15
Upper jaw	5.4 -6.6	6.08	0.37	0.77	0.16
Lower jaw	4.5 -5.8	5.00	0.36	0.73	0.20
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	0.6 - 1.1	0.91	0.13	0.33	1.0
Body depth	0.8 - 1.3	0.97	0.14	0.56	1.3
Eye diameter (U)	2.9 - 4.4	3.59	0.39	0.40	0.2
Eye diameter (L)	3.1 - 5.4	4.05	0.64	0.18	0.1
Inter orbital length	14.5 - 23.7	18.41	2.68	0.61	0.1
Snout to upper eye	3.7 -10.3	5.53	1.88	0.16	0.2
Snout to lower eye	5.4 - 8.5	6.48	0.92	0.34	0.1
Upper head length	1.8 - 4.9	2.97	1.04	0.13	0.5
Lower head length	1 -2.5	1.53	0.43	0.17	0.7
Pre orbital length	4.7 -15.2	8.51	3.14	0.01	0.1
Post orbital length	1.7 - 3.3	1.91	0.46	0.45	0.6
Pelvic fin length (O)	1.7 -2.7	2.16	0.3	0.20	0.2
Pectoral fin length (B)	2.96 - 3.8	3.41	0.36	0.66	0.2
Pre pelvic (O)	0.9 - 1.2	1.05	0.1	0.70	0.6
Pre pelvic (B)	0.9 - 1.2	1.02	0.09	0.63	0.6
Pre pectoral	0.96 - 1.1	1.02	0.1	0.69	0.5
Upper jaw	1.2 - 1.6	1.43	0.13	0.62	0.5
Lower jaw	1.04 - 1.4	1.18	0.1	0.70	0.7

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 55, 56); the linear regression equations obtained were

Head width on SL	:	$y = 0.29\ x – 5.12$; $R^2 = 0.934$; $p < 0.05$
Body depth on SL	:	$y = 0.35\ x – 15.5$; $R^2 = 0.73$; $p < 0.001$
Head width on HL	:	$y = 1.05\ x + 2.83$; $R^2 = 0.57$; $p < 0.05$
Eye diameter (upper) on SL	:	$y = 0.17\ x + 4.26$; $R^2 = 0.63$; $p < 0.05$
Eye diameter (lower) on SL	:	$y = 0.13\ x + 4.59$; $R^2 = 0.42$; $p < 0.05$
Interorbital distance on HL	:	$y = 0.07\ x – 0.55$; $R^2 = 0.78$; $p < 0.001$
Snout length (SNL_1) on HL	:	$y = 0.197\ x – 0.06$; $R^2 = 0.399$; $p < 0.05$
Snout length (SNL_2) on HL	:	$y = 0.12\ x + 1.68$; $R^2 = 0.59$; $p < 0.05$
Postorbital on HL	:	$y = 0.58\ x – 1.54$; $R^2 = 0.67$; $p = 0.001$

Results of regression analysis showed that the variation of various body parameters in relation to standard length and head length is highly significant.

Colour: Body brown tan coloured on ocular side with few dark spots on body, bluish at peritoneum area; vertical fins light brown, paired fins darker than body. Blind side of body pale brownish, with the area below the operculum bluish in colour. In formalin, colour of body remains the same.

Distribution:

World: Hong Kong, South China Sea, Fukura, Japan (Franz, 1910); Western Pacific, Indian Ocean and both sides of the Atlantic Ocean

(Gutherz, 1967; Amaoka and Yamamoto, 1984) at depths of 270 - 595 m. Map showing localities were *Chascanopsetta lugubris* has been recorded in the world is given in Fig. 53.

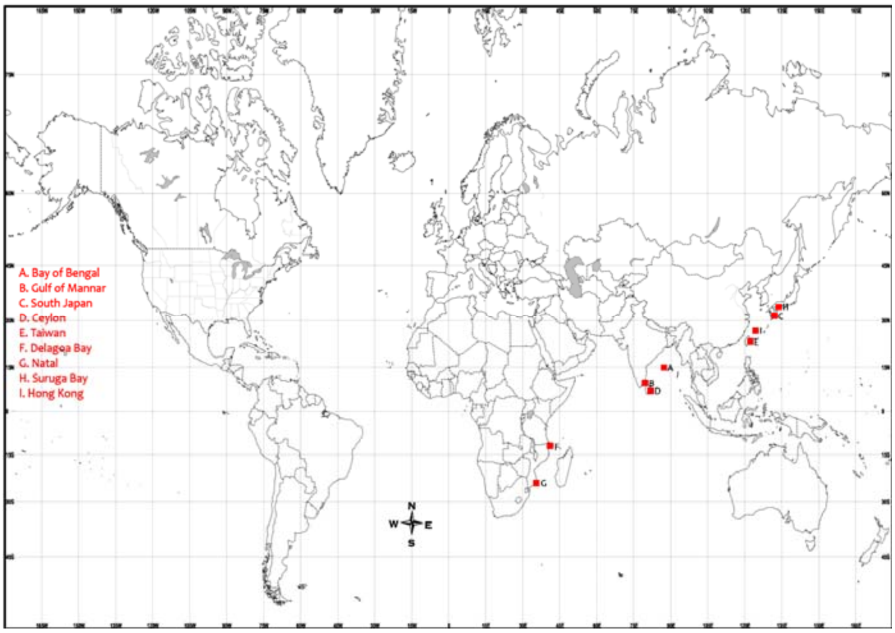


Fig. 53: Map showing localities were *Chascanopsetta lugubris* has been recorded in the world.

India: Bay of Bengal (Alcock, 1894); off Vishakapatnam; Cochin, Neendakara Fishing Harbour (present study). Map showing localities were *Chascanopsetta lugubris* has been recorded in the world is given in Fig. 54.

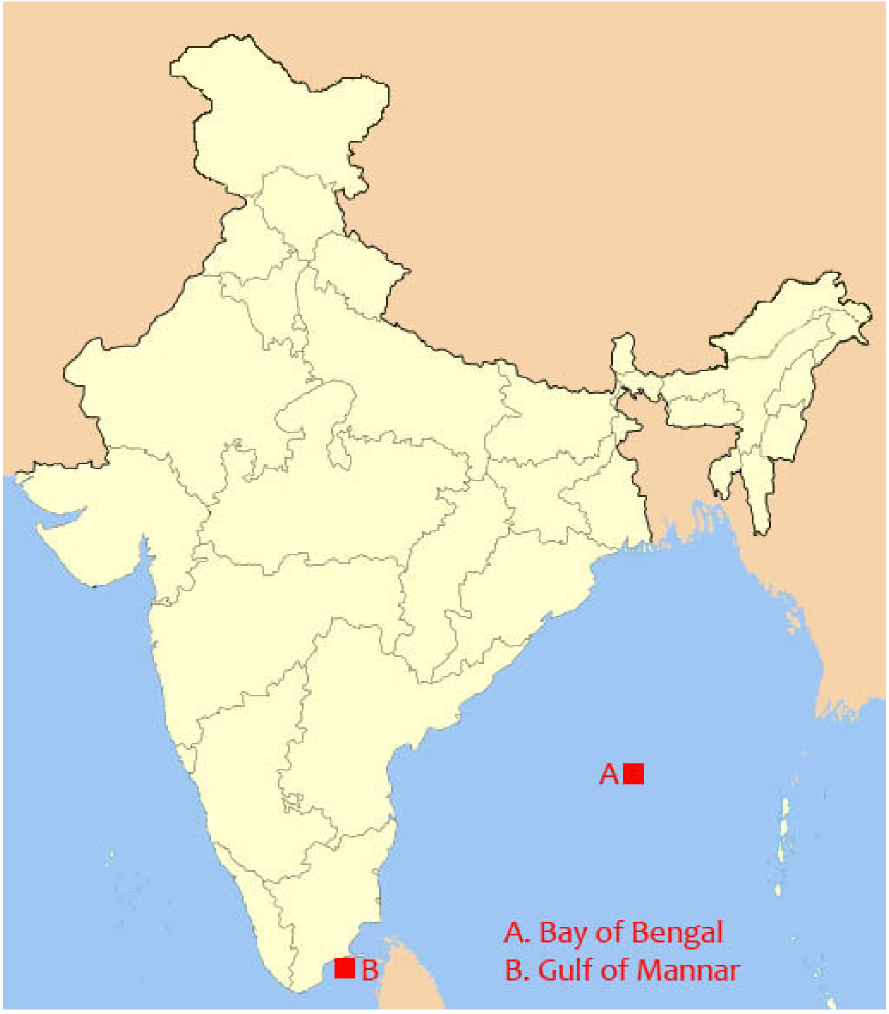


Fig. 54: Map showing localities were *Chascanopsetta lugubris* has been recorded in India.

Taxonomic remarks: The species was first described by Alcock, (1894) based on sample from "*Investigator*" Expedition from Bay of Bengal from a depth of 145 to 250 fathoms. *Trachypterophrys raptator* Franz, 1910 and *Chascanopsetta gilchristii* von Bonde is distinguished from *C. lugubris* in having a flat topped curve of the lateral line (Hubbs, 1915; von Bonde, 1922). Norman (1934) comments that "*the* *curve of a sharp angle as shown in Alcock's figure of the type of C. lugubris is clearly an abnormal condition, since the curve in the type is normally flat–topped on the blind side of the body*". In their review of genus *Chascanopsetta*, Amaoka and Yamamoto (1984) comments that their specimens exhibit the variation of absence and presence of spots on the body. This feature was noted in the present collection also. Kuronuma (1940) described *C. microstoma* based on a single specimen from Sagami Bay, Japan. The species is said to differ from *C. lugubris* in having a very small mouth; however it resembles *C. lugubris* in its meristic counts. According to Amaoka, (1971) "*the mouth is still fully undeveloped at a size less than about 140 mm in SL and hence at this stage resemble C. microstoma".* Therefore, it can be concluded that *C. microstoma* described by Kuronuma is a young specimen of *C. lugubris*. *C. normani* described by Kuronuma again from Sagami Bay has also been synonymised with *C. lugubris* by Amaoka and Yamamoto (1984) since the counts of the co-type match well with that of *C. lugubris*. Similarly, the species *C. blumenalia* described by Shen (1967) based on a single specimen collected off Hong Kong had a transparent body, small number of teeth on both jaws, short head, narrow body and a small number of scales on the lateral line.

Observations: The ratio of upper jaw in standard length decreases as the standard length of the specimen increases. This fish has not been previously recorded from the west coast of India by earlier workers and hence is a new record to the west coast of India.

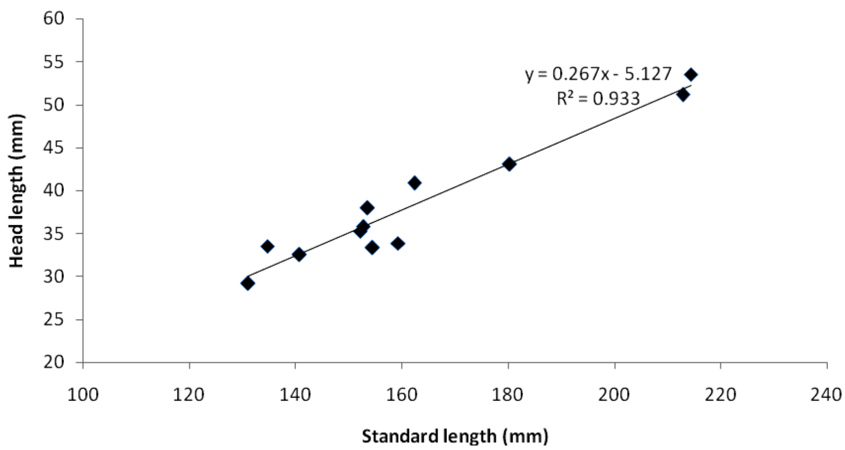


Fig. 55: Regression of Head length on Standard length

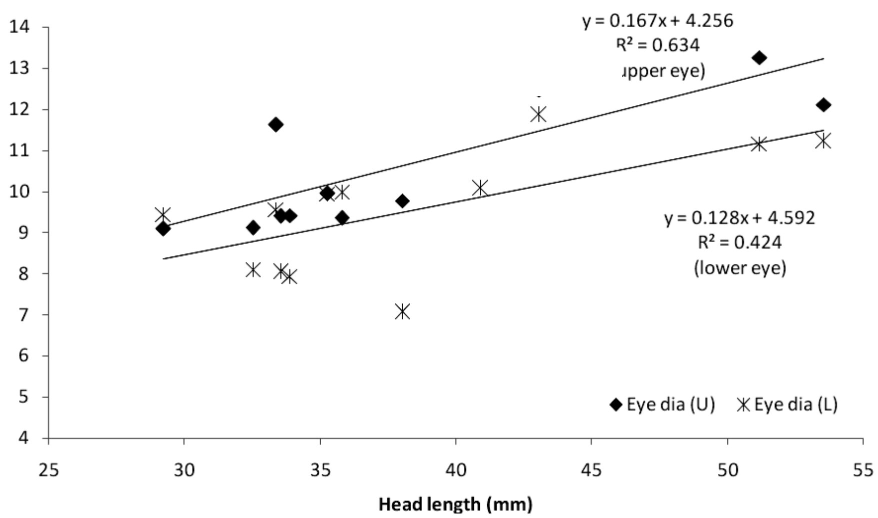


Fig. 56: Regression of Eye dimeter on Head length

4.3.4.4 Genus *Crossorhombus* Regan, 1920

Crossorhombus Regan, 1920, *Ann. Durban Mus*., II: 211 (type: ***Platophrys dimorphus*** Gilchrist); Norman, 1934, *Syst. Monog. Flatfish.,* I:217; Amaoka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 132; Ahlstrom *et al.,* 1984, *Am. Soc. Ichth. Herp. Sp. Publ., 1*: 642; Amaoka in Masuda *et al.*, 1984, *Fish. Jap. Arch.,*: 348; Hensley, 1986, *Smith. Sea Fish.,*: 857, 941; Hensley and Randall, 1993, *Copeia* (4): 1125; Lindberg and Fedorov, 1993, *Handbook Iden. Anim.,* 166: 36; Li and Wang, 1995, *Fauna Sinica*: 185; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6): 3804; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1817.

Body ovate, deep, dorsoventrally compressed. Dorsal profile more convex in males. Eyes sinistral, separated by a scaly interorbital space which is broader in males. In males, rostral spine present on snout, few spines present on margin of snout also. Two nostrils present on either side; on ocular side anterior nostril is tubular with a flap at its tip, the second semi-oval in outline. Mouth small. Teeth biserial in jaws; gill rakers short, few in number. Body scales very small, not deciduous, ctenoid on ocular side, cycloid on blind side. Snout and area in front of interorbital space naked. Upper free end of the gill opening a short distance above the pectoral fin origin. Dorsal fin origin on blind side, above nostril, fin rays simple. Anal fin rays simple. Pelvic on blind side originates on a vertical from the 4th ray of pelvic on ocular side.

Five species of *Crossorhombus* were recognized worldwide– *Crossorhombus azureus* from Bay of Bengal, northwestern Australia, South China Sea, Taiwan and Aru Islands; *C. valderostratus* from

South Africa to India, Sri Lanka, *C. kanekonis* from Hong Kong, China, Taiwan and Japan; *C. kobensis* from Japan, Formosa Strait and South China Sea and *C. howensis* from Howe Island and Taiwan. Of these species, *C. kanekonis* has been synonymised with *C. azureus* by Hensley and Randall (1993). Two species reported from Indian waters are *Crossorhombus azureus* and *C. valderostratus* (Norman, 1927) of which only one species *Crossorhombus azureus* is recorded in the present study.

Remarks: Regan (1920) erected the genus based on the type *Platophrys dimorphus* of Gilchrist renaming it as *Crossorhombus dimorphus*. Two specimens 40 and 120 mm were examined based on collections from Natal at a depth of 22 – 26 fathoms. Further, he adds that *Scaeops kobensis* Jordan and Starks from Japan and *Engyprosopon xenandrus* Gilbert from Hawaii belong to this genus.

4.3.4.4.1 *Crossorhombus azureus* (Alcock, 1889)

Blue spotted Flounder

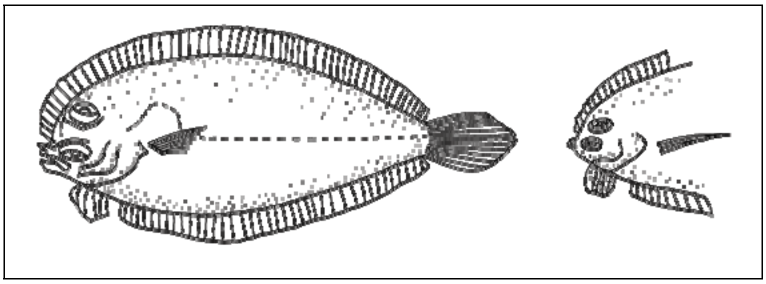
Rhomboidichthys azureus Alcock, 1889, *J. Asiat. Soc. Bengal,* LVIII, 2: 283, pl. xvi, fig. 3 (type locality: Devi River, Mahanadi delta, Bay of Bengal); Alcock, 1890, *Ann. Mag. Nat. Hist. Ser.*, 6, VI: 435 (South east coast of Ceylon); Alcock, 1896, *J. Asiat. Soc. Bengal,* LXV (2): 328; Alcock, 1898, *Illust. Zool. "Investigator" Fish.* pl. xxiv, fig.3; Johnstone, 1904, *Ceylon Pearl Oyster Fish. Supp. Rep.*, XV: 210, Jenkins, 1910, *Mem. Ind. Mus.*, III: 27 (Arakan coast).

Platophrys microstoma Weber, 1913, *"Siboga" Exped., Fisch.,* : 427, pl vii, fig. 3.

Crossorhombus azureus Norman, 1927, *Rec. Ind. Mus.*, XXIX: 30 (S.E India, Burma and Nicobar Islands); Wu, 1932, *Thès. Fac. Sci. Univ. Paris,* A. 244 (268): 93 (Hainan, Hong Kong); Norman, 1931, *Ann. Mag. Nat. Hist.,* (10) VIII: 600; Norman, 1934, *Syst. Monog. Flatfish.*, I: 219, fig. 167; (South eastern India, Ceylon, Indo–China, China); Liang, 1948, *Quart. J. Taiwan Mus.*, I, 2:20 (Pescadores); Matsubara, 1955, *Fish. Morp. Hier.,* II : 1259 (Formosa, China, Ceylon); Munro, 1955, *Fish. Ceylon* : 261, fig. 758; Chen and Weng, 1965, *Biol. Bull.,* 27: 25 - 27, fig. 34; Hensley and Randall, 1993, *Copeia* (4): 1125, Krishnan and Mishra, 1993, *Rec. Ind. Mus.*, 93(1-2): 234 (Kakinada, Gopalpur); Li and Wang, 1995, *Fauna Sinica*: 186; Chen *et al.,* 1997, *Fish.Nansha Island,*: 175; Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl.*, 8: 645; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide* IV (6): 3820; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl.*, 63: 46, Manilo and Bogorodsky, 2003, *J. Ichth.*, 43(1) : S122; Mishra and Krishnan, 2003, *Rec. Zool. Sur. Occ. Pap.*, 219: 46; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1817.

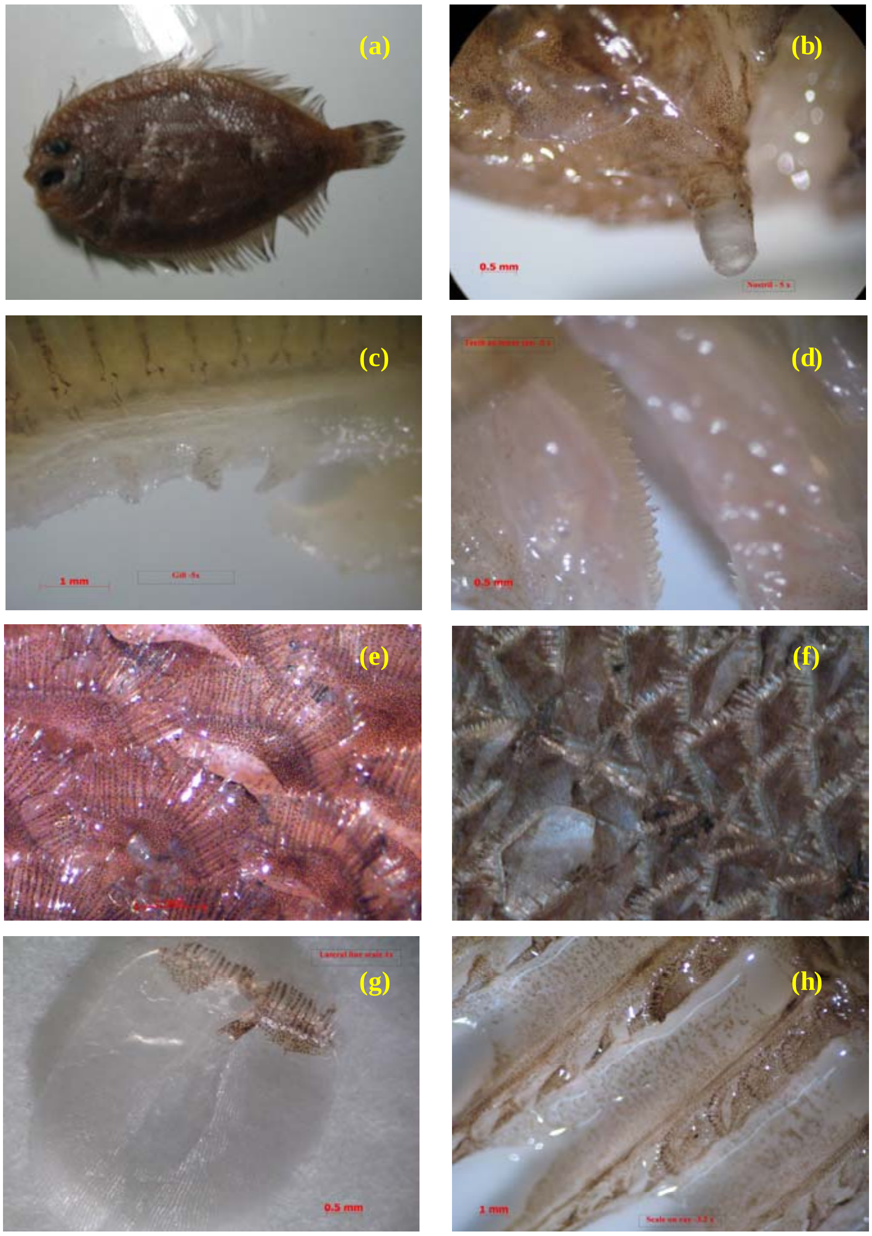
Bothus (Arnoglossus) microstoma Weber and Beaufort, 1929, *Fish. Indo Aust. Arch.,* V: 126 (Jedan Island, off Aru islands).

Bothus microstoma Chabanaud, 1929, *Bull. Mus. Hist. Nat. Paris*, (2) 1: 379.



(A)

Plate XVII: *Crossorhombus azureus* (Alcock, 1889)



(a) Female fish (b) Anterior nostril (c) Gill rakers (d) Teath on lower jaw
(e) Body scale (Ocular) (f) Lateral line) (g) Lateral line scale)
(h) Scale on dorsal fin ray

(B)

Plate XVII: *Crossorhombus azureus* (Alcock, 1889)

Material examined: N = 57; TL 75.71 – 131 mm from Neendakara, Quilon

Diagnosis: Broad, oval body with 5 pairs of blue dots on the snout, a broad blackish band across caudal fin on hinder part a narrower one at caudal fin base.

Meristic characters (Females): D 77 - 92 (85); A 59 – 77 (66); P_1 9 -12 (10); P_2 7 -11 (9); V_1/ V_2 6; C 2 - 6 (5) + 11 -14 (12); Ll 50 - 69 (62); GR 6 -7.

Body proportions as percent of SL (mean in parentheses): HL 23.5 - 25.9 (24.9); HD 20.8 - 26.2 (22.96); ED_1 7.03 - 10.04 (8.5); ID 6.1 - 9.3 (7.8); SNL_1 4.4 -10.6 (6.9); SNL_2 0.9 - 4.8 (2.2); BD_1 47.3 -54.3 (50.95); P_1FLO 14.9-18.7 (17.2); P_2FLB 10.3 - 14.3 (11.7); V_1FLO 7.8 - 12.6 (10.2); V_2FLB 7.7 - 13.2 (11.3); CFL 14.4 - 21.3 (18.89); DBL 88.6 - 94.1 (91.6), ABL 69.4 -78.4 (73.9); P_1BLO 3.1 - 4.7 (3.9); P_2BLB 2.3 - 3.9 (2.9); V_1BO 8.2 -11.6 (10.04); V_2BB 2.4 -5.9 (3.9); CPD 10.5 - 12.8 (11.7).

As percent of HL (mean in parentheses): HD 82.7-103.5 (92.2); ED_1 28.7 - 40.6 (34.3); ED_2 24.1 -36.5 (31.23); ID 6.9 -18.7 (12.9); SNL_1 17.3 - 42.5 (27.5); SNL_2 3.6 -18.9 (8.7)

Meristic characters (Males): D 77-91 (86); A 57-71 (66); P_1 8-12 (10); P_2 8 -10 (9); V_1, V_2 6; C 2 -6 (5) + 10 -13 (12); Ll 54 -71 (61); GR 7

Body proportions as percent of SL (mean in parentheses):HL 23.1 - 26.4 (24.5); HD 21.3 - 26.6 (23.9); ED_1 7.5 - 9.9 (8.6); ED_2 6.9 - 9.1 (7.9); ID 2.8 - 8.1 (6.2); SNL_1 6.2 - 13.1 (9.8); SNL_2 0.9 - 4.4 (2.3); BD_1 47.8 - 55.2 (51.4); P_1FL 15.2 - 19.2 (17.8); P_2FL 10.2 - 14.4 (12.3); V_1FLO 7.3 - 12.9 (10.1); V_2FLB 3.4 -15.1 (11.2); CFL 17.6 -22.95 (19.8); DBL 87.7 - 94.2 (90.8); ABL 67.7 - 76.7 (73.2); P_1BLO 3.1 - 6.02 (4.11); P_2BLB 2.54 -3.6 (3.1); V_1BO 7.3 -12.2 (9.83); V_2BB 2.9 - 5.1 (3.9); CPD 10.93 - 12.5 (11.9).

As percent of HL (mean in parentheses): HD 85.4 - 107 (97.7); ED_1 30.6 - 40.4 (34.97); ED_2 28.6 - 35.93 (32.2); ID 11.9 - 31.97 (25.2); SNL_1 26.1 - 54.82 (40.2); SNL_2 3.3 - 18.4 (9.4).

Description: Body roundish–oval, head small, eyes large. Anterior profile of head nearly vertical, a bony ridge present in front of orbit. Upper eye placed half way behind compared to lower eye. Males present with ocular flaps. Snout projects out and bears the short orbital spine in males; shorter than eye diameter. Inner margins of orbit very sharp; interorbital area deeply concave and wider in males. Two nostrils on ocular side, one tubular, the other oval; nostrils on the blind side very minute, placed toward dorsal origin. Fleshy cover seen for the jaws. Palate is also fleshy in nature. Cleft of mouth is nearly vertical. Maxillary ends below anterior edge of eye or a little beyond; upper jaw with a closely set inward pointing teeth in two rows like a comb. A single row of teeth in lower jaw. Origin of dorsal on blind side of snout behind mouth. Dorsal fin rays connected with a membrane, scales extend onto rays. A small pore found at the base of each inter-ray membrane. Origin of anal in vertical through hind border of operculum, its rays shorter than dorsal. Pectoral fin longer on ocular side; pelvics nearly equal in length. Anal origin little behind base of pelvic fin on blind side. Gill rakers short, fleshy and thick; six present on the first arch. Colour light brown, pigmented. Lateral line on ocular side strongly curved and flattened at the pectoral fin region; each made up of prominent tubes, the tube opens onto next scale at its split end. Lateral line on blind side with no supra-pectoral curve, but rises simply to the post–temporal region. Body covered with ctenoid scales on ocular side, pigmented brownish–grey and cycloid scales on blind side. A comparative statement of the meristic characters of *Crossorhombus azureus* is given in Table 36. Results of the correlation coefficient analysis on non-meristic characters of *Crossorhombus azureus* is given in Table 37.

Table 36 : A comparative statement of the meristic characters of *Crossorhombus azureus*

Meristic Characters	Earlier workers										Present work 2004-2010	
	Alcock 1889	Alcock 1890	Weber 1913	Norman 1927	Weber and Beaufort 1929	Norman 1934	Chen and Weng 1965	Amaoka 1971	Ramanathan 1977	Radhamanyamma 1988	N = 57	Mean ± SD
Dorsal	84	84 – 90	90	84 – 88	90	84 -90	88 - 90	89	85 - 93	77 - 81	77 – 92 (86)	86 ± 3.3
Anal fin count	64	64 – 70	72	68 – 73	72	64 -73	68	70	64 - 72	61 - 64	59 – 77 (66)	66 ± 3.4
Pectoral (O)	10	*	11	11 – 12	11	11 -12	12	13	11 - 13	11	8 – 12 (10)	10 ± 0.8
Pectoral (B)	9	*	10	11 – 12	10	*	11	11	9 - 13	*	7 – 11 (9)	9 ± 0.8
Pelvic	6	*	5	*	6	*	6	*	6	6		6
Caudal	17	17	17	*	*	*	17	*	15 - 18	17	5 + 11 – 14 (12)	12 +5 ±1
Lateral line count	55	55	55 -57	53 – 57	55 -57	52 -57	58 - 62	57	52 - 59	*	50 - 69 (61)	62 ± 3.7

*Data not available

Table 37 : Results of the correlation coefficient analysis on non-meristic characters of *Crossorhombus azureus*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.8 - 4.3	4.06	0.13	0.88	0.26
Head ht.	3.8 - 4.8	4.3	0.25	0.74	0.29
Eye diameter (U)	10.0 - 14.2	11.78	0.92	0.48	0.08
Eye diameter (L)	10.8 - 16.4	12.87	0.97	0.58	0.08
Inter orbital	12.4 - 57.2	24.61	10.79	0.44	0.15
Snout to upper eye	7.6 - 22.8	12.66	3.41	0.31	0.16
Snout to lower eye	21.1 - 118.3	52.34	22.8	0.02	0.03
Body depth	1.8 - 2.1	1.96	0.06	0.88	0.52
Pectoral (O)	5.2 - 6.7	5.73	0.34	0.69	0.18
Pectoral (B)	6.9 -9.8	8.35	0.64	0.62	0.15
Pelvic (O)	7.8 - 13.7	10.01	1.17	0.21	0.09
Pelvic (B)	6.6 - 29.5	9.3	2.96	0.25	0.14
Caudal	4.4 - 6.9	5.19	0.38	0.69	0.23
Dorsal	1.1 - 1.14	1.1	0.02	0.96	0.88
Anal	1.3 - 1.5	1.36	0.04	0.88	0.73
Pectoral (O)	16.6 - 32.3	25.29	2.84	0.19	0.03
Pectoral(B)	25.5 - 43.1	33.71	3.9	0.45	0.04
Pelvic (O)	8.21 - 13.8	10.16	1.01	0.37	0.1
Pelvic (B)	17.1 - 41.2	26.2	3.99	0.25	0.05
Caudal peduncle depth	7.9 - 9.5	8.49	0.38	0.81	0.13
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head height	0.9 -1.2	1.06	0.07	0.40	1.06
Eye diameter (U)	2.5 - 3.5	2.91	0.23	0.22	0.29
Eye diameter (L)	2.7 - 4.2	3.18	0.24	0.32	0.3
Inter orbital	3.13 - 14.4	6.17	2.7	0.12	0.53
Snout to upper eye	1.8 - 5.8	3.15	0.86	0.05	0.56
Snout to lower eye	5.3 - 30.7	13.11	5.8	0.00	0.1
Body depth	0.45 - 0.5	0.48	0.02	0.66	1.89

Digestive system: Small coiled tube, intestine short, showing its mixed feeding behaviour. Pyloric caecae 6 in number; whitish in colour, branched in nature.

Colour: In fresh condition, head and body on ocular side brownish black; dorsal, and anal fins blackish, caudal black with a white band in the centre. Blind side whitish with a conspicuous bluish black colour pattern in males.

Sexual dimorphism: *Crossorhombus azureus* shows sexual dimorphism. T test was performed for comparing the means for the male and female population. Results of the *t* test were highly significant ($P< 0.01$), for the parameters interorbital distance, length of pectoral fin on ocular side, snout length (SNL_1), body depth, upper and lower eye diameter. However, it is not significant for snout length (SNL_2), head length and length of pelvic fin on ocular side. The results show that sexual dimorphism is very clear in this species and the significant characters can be taken as characters for sexual dimorphism. In males, five rows of dark blue azure spots seen on ocular side between eye and snout on the head region. Males with a strong rostral spine on snout and two orbital spines, one on each orbit. Inter orbital space is more in males. Pectoral fin on ocular side is longer than of blind side. Males have a characteristic pattern on the blind side, the size of which depends on the maturity stage of the animal.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Fig. 59,60); the linear regression equations obtained were

For males

Head length on SL : $y = 0.29 – 3.73\ x$; $R^2 = 0.94$

Body depth (BD_1) on SL : $y = 0.53\ x – 1.75$; $R^2 = 0.94$

Eye diameter (ED_1) on SL : $y = 0.008 + 0.09\ x$; $R^2 = 0.72$

Interorbital length on SL : $y = 0.14\ x – 6.75$; $R^2 = 0.77$

Eye diameter (upper) on HL : $y = 1.2 + 0.294\ x$; $R^2 = 0.74$

Eye diameter (lower) on HL : $y = 0.53 + 0.297\ x$; $R^2 = 0.8$

Interorbital distance on HL : $y = 0.47\ x – 4.7$; $R^2 = 0.78$

Snout length (upper) on HL : $y = 0.43\ x – 0.7$; $R^2 = 0.5$

Regression of all the above parameters on SL and HL were found to be significant at 5 % level.

For females

Head length on SL : $y = 0.26\ x - 0.795$; $R^2 = 0.96$

Body depth (BD_1) on SL : $y = 1.62 + 0.49\ x$; $R^2 = 0.92$

Pectoral fin length on SL : $y = 0.42 + 0.17x$; $R^2 = 0.76$

Head width on HL : $y = 1.06\ x – 2.7$; $R^2 = 0.86$

Eye diameter (upper) on HL : $y = 1.9 + 0.25\ x$; $R^2 = 0.54$

Eye diameter (lower) on HL : $y = 0.92 + 0.27\ x$; $R^2 = 0.66$

Interorbital distance on HL : $y = 0.33\ x – 4.02$; $R^2 = 0.84$

Snout length (SNL_1) on HL : $y = 0.43\ x – 3.2$; $R^2 = 0.52$

Snout length (SNL_1) on HL : $y = 0.22\ x – 2.83$; $R^2 = 0.43$

Regression of all the above parameters on SL and HL respectively were found to be significant at 5 % level.

Combined for males and females

Head length on SL : $y = 0.26\ x – 1.46$; $R^2 = 0.94$

Body depth (BD_1) on SL : $y = 0.52\ x -0.77$; $R^2 = 0.94$

Pectoral fin length on SL : $y = 0.17\ x – 0.24$; $R^2 = 0.83$

Eye diameter (upper) on SL : $y = 0.58 + 0.07\,x$; $R^2 = 0.68$

Head depth on HL : $y = 1.03\,x - 1.59$; $R^2 = 0.85$

Eye diameter (upper) on HL : $y = 1.17 + 0.29\,x$; $R^2 = 0.69$

Eye diameter (lower) on HL : $y = 0.42 + 0.30\,x$; $R^2 = 0.76$

Regression of all the above parameters on SL and HL respectively were found to be significant at 5 % level.

Distribution:

World: South east coast of Ceylon, Formosa, China, Jedan Island (Alcock, 1890; Johnstone, 1904; Weber and Beaufort, 1929; Matsubara, 1955); Burma (Norman, 1927). Map showing localities were *Crossorhombus azureus* has been recorded in the world is given in Fig. 57

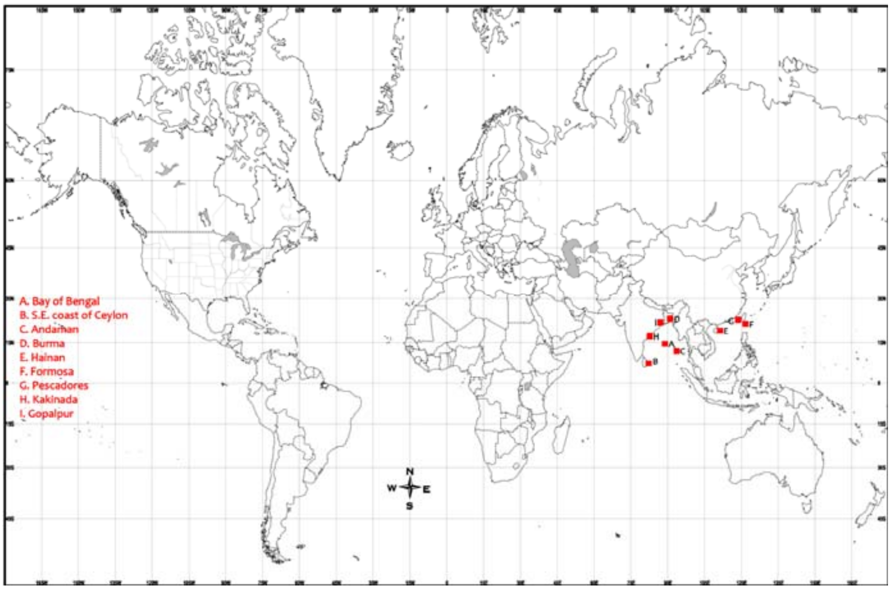


Fig. 57: Map showing localities were *Crossorhombus azureus* has been recorded in the world.

India: Devi River, Mahanadi Delta, Bay of Bengal (Alcock, 1889), South east India, Burma and Nicobar Islands (Norman, 1927), Kakinada, Gopalpur (Krishnan and Mishra, 1993). Map showing localities were *Crossorhombus azureus* has been recorded in India is given in Fig. 58.

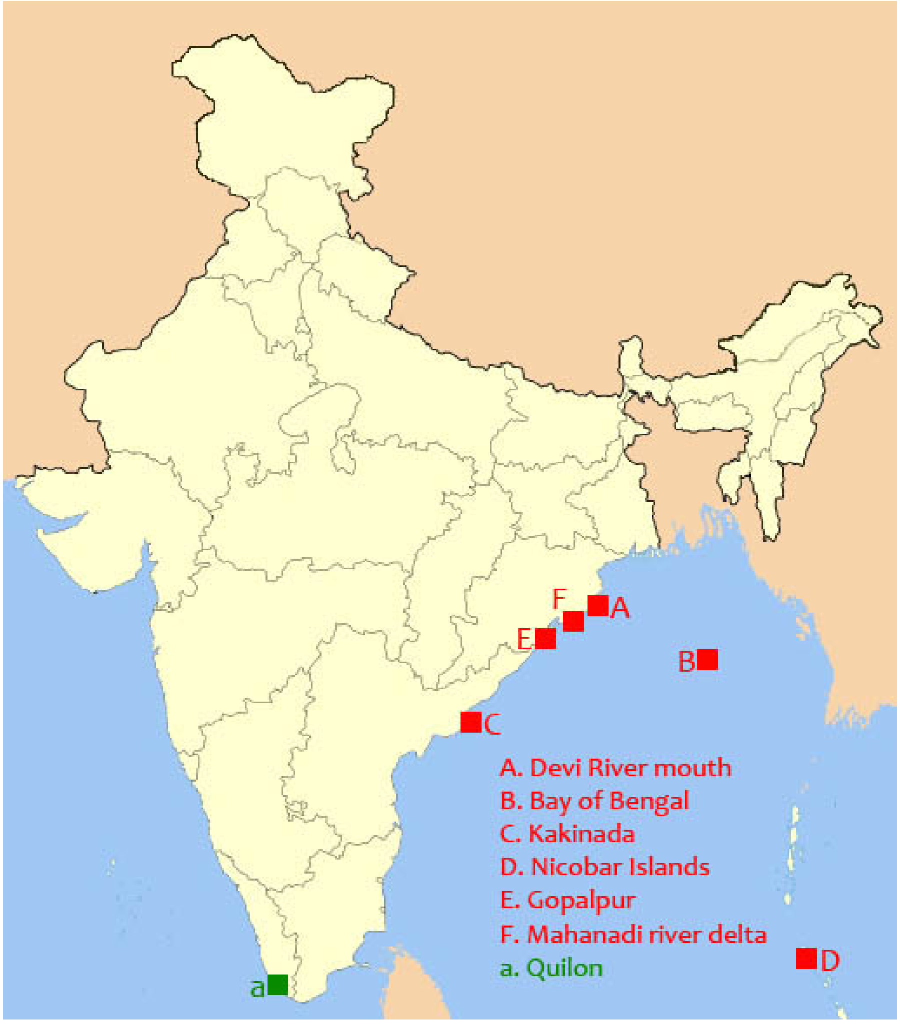


Fig. 58: Map showing localities were *Crossorhombus azureus* has been recorded in India.

Taxonomic comments: The species was first described by Alcock as *Rhomboidicthys azureus* based on his collections from Devi River, Mahanadi delta as well as from other areas of the Bay of Bengal. This was followed by Jenkins in 1910. Weber (1913) based on his Siboga collections described the fish as a new species *Platophrys microstoma*. Variations were noticed only in the anal fin counts. Weber and Beaufort (1929) described the species as *Bothus (Arnoglossus) microstoma* based on samples from Jedan island, off Aru islands, synonymising the species with *Platophrys microstoma* described by him earlier. Later studies by Chen and Weng (1965) from Taiwan waters also point to the same counts. Amaoka (1969) distinguished *C. azureus* and *C. kanekonis* based on dentition, presence/absence of ocular flaps in males, number of lateral line scales and lower limb gill rakers. He had used Norman's (1934) description of *C. azureus* for comparision with *C. kanekonis*. However, Hensley and Randall (1993) synonymised *C. kanekonis* with *C. azureus.* Later workers, Randall and Lim (2000); Nakabo (2000) Shinohara *et al*. (2001) concluded that they are two distinct species.

Observations: Dorsal fin counts given by Alcock (1889, 1890) from Bay of Bengal, Weber (1913) and Ramanathan (1977) from Porto Novo are on the higher range. However, Radhamanyamma reports of 77- 81 for dorsal fin counts ; the lower range reported in the present study is in agreement with that of Radhamanyamma, while higher range given are in agreement with the other workers. However, there is clear distinction in the ray count of pectoral fin on the blind side and that of the ocular side. The caudal fin count given by Alcock (1890) could be the sum total of the branched and unbranched rays. A higher value is seen for the lateral line scale count in the present samples. The differences could possibly be due to difference in geographical area studied. Mention of the colour pattern on the blind side of *C. azureus* is limited to Alcock (1890), Amaoka (1969), Chen and Weng (1965), Chilvers and Chan

(1973) and Shen (1983). The colour pattern is very prominent in relation to the sex and maturity of the animal.

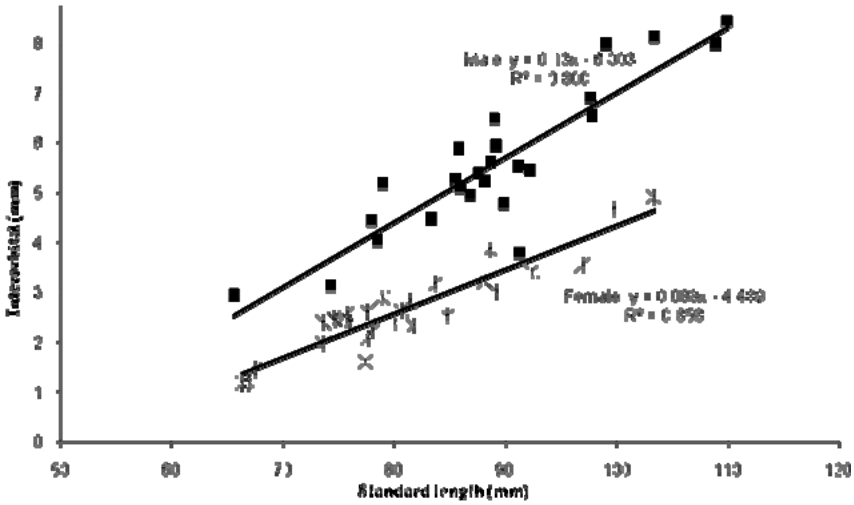


Fig. 59: Regression of interorbital on Standard length

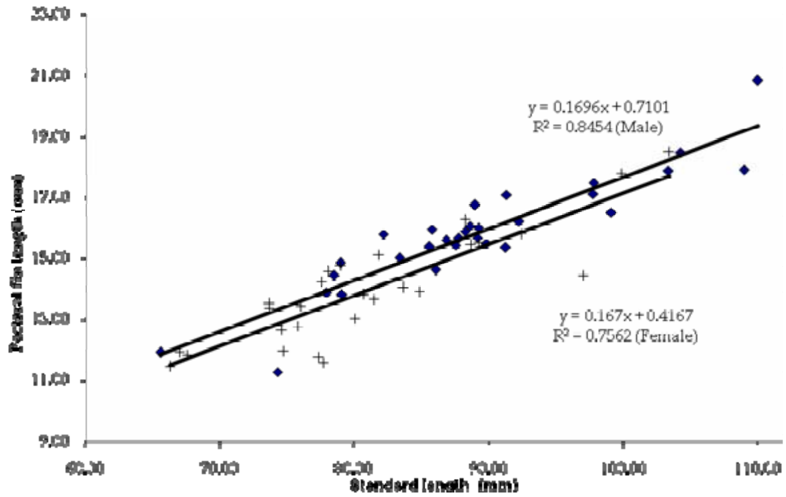


Fig. 60: Regression of pectoralfin length (ocular) on Standard length

4.3.4.5 Genus *Engyprosopon* Gunther, 1862

Engyprosopon Gunther, 1862, *Cat. Fish*., IV: 431 (type: ***Rhombus mogkii***, Bleeker); Jordan and Starks, 1907, *Proc. U.S Nat. Mus*., 31:171; Weber, 1913, *Siboga Exped*.,: 413; Regan, 1920, *Ann. Durban Mus*., II:210; Norman, 1934, *Syst. Monog. Flatfish*.,: 203; Amaoka, 1969, *J. Shimonoseki Univ. Fish*, 18(2); Ahlstrom *et al.,* 1984, *Am. Soc. Ichth. Herp. Sp. Publ.,* 1: 642; Hensley, 1986, *Smith. Sea Fish.*,: 858; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166: 39; Amaoka *et al*., 1993, *Mem. Mus. Nat. Hist. Nat. Zool*., 158: 377; Li and Wang, 1995, *Fauna Sinica*: 193; Hensley and Amaoka, 2001*, FAO Sp. Iden. Guide,* IV (6): 3804; Amaoka and Seret, 2005, *Ichth. Res.,* 52(1): 18, 373; Amaoka *et al*., 2008, *Nat. Mus. Nat. Hist. Suppl*., 2: 107.

Scaeops Jordan and Starks, 1904, *Bull. U.S. Comm. Fish*., XXII: 627 (***Rhombus grandisquama***, Schlegel), Jordan and Starks, 1907, *Proc. U.S Nat. Mus*., 31:168.

Diagnosis: Bothid flounders of the genus *Engyprosopon* occur in the shallow waters of the Indian and Western Pacific Oceans. They are characterized by the presence of a highly branched caudal skeleton, ctenoid scales with short spines and appearance of secondary sexual characters. (Amaoka, 1969; Amaoka *et al*., 1993). Species in the genus has ctenoid scales with short ctenii on the ocular side of the body.

Description: Body small, ovate, deeply compressed. Eyes sinistral, separated by a flat or concave space; the interorbital space varies depending on species and sex. Male fishes have one or more spines on the orbital margins. Mouth very small, maxillary scarcely reaching to a vertical line below middle point of eye. Teeth present, small in size, mostly uniserial laterally and biserial in the anterior portion. Vomer toothless. Opercular membrane free, the upper outer end is just in front of the lateral line origin. Head scaled. Dorsal fin single, origin on blind side above the nostril, well ahead or just above migratory eye. Finrays simple, body scales extend into finrays. Pectoral fin of unequal sizes; that on blind side smaller and shorter. Uppermost two rays of pectoral fin elongated in males of some species. Pelvic fin bases of different sizes – ocular one with longer base, point of insertion of pelvic fin of ocular side well in front of pelvic fin of blind side. Tip of interhaemal spine not projecting. Caudal rounded or truncate. Body covered with scales, scale size varies from moderate to large, feebly ctenoid on ocular side, cycloid on blind. Lateral line well developed on ocular side, arising just behind upper outer end of opercular membrane, forming a curve or plateau in the pectoral fin region and continuing backwards, extending into caudal origin. Supratemporal branch absent. Gill rakers unserrated. Secondary sexual characters noted are interorbital width, pigmentation of the blind side and presence of a rostral spine and orbital spine.

Engyprosopon is a bothid genus with about 30 nominal species of small sized flatfishes which has members distributed throughout the Indo-Pacific from South Africa; northern Indian Ocean and Red Sea to the Indo–Australian Archipelago and Japan, the Hawaiian Islands and with a larva also found at the Sala-y-Gomez Submarian Ridge.

Taxonomic comments: The genus *Engyprosopon* was placed in subfamily Psettinae, Family Pleuronectidae by Weber (1913) while describing the Siboga collections. The characters mentioned were small interorbital, ctenoid scales on ocular side. Weber (1913) stated the characters "*interorbital space narrow, ocular side ctenoid, teeth in two rows*".

Scaeops described by Jordan and Starks (1902) is said to resemble *Platophrys* but differing in the presence of large scales, finrays produced in males, uniserial teeth.

Observations: Eight species of *Engyprosopon* were recorded from Indian waters by Norman (1927) – *E. cocosensis*, *E. grandisquama*, *E. latifrons*, *E. macrolepis*, *E. filimanus*, *E. sechellensis*, *E. maldivensis* and *E. mogki*. Fifteen species of *Engyprosopon* species recorded by Norman (1934) in his "*Monograph on Flatfishes*", from Indo-Pacific of which 2 species are said to be from Indian waters – *E. cocosensis* and *E. grandisquama*. Talwar and Kacker (1984) points to the presence of these two species of *Engyprosopon* from India; he however adds that *E. cocosensis* is of no fishery importance. Hensley (1986) reported two species *E. grandisquama* and *E. natalensis* from South African waters. Though Norman (1927) described that eight species known from India are *E. cocosensis* (Travancore coast, Nicobar Islands), *E. grandisquama* (Nicobar Islands), *E. latifrons*, *E. macrolepis*, *E. filimanus*, *E. sechellensis*, *E. maldivensis*, *E. mogkii*; except *E. cocosensis*, *E. grandisquama* collection location of none were in India, but in Indian Ocean. Three species of *Engyprosopon* were recorded from South African waters–*E. valderostratus*, *E. grandisquama* and *E. natalensis*. Two species of *Engyprosopon* - *E. bleekeri* and *E. grandisquama* have been recorded from Queensland (Marshall, 1964), *E. xystrias* and *E. multisquama* from Arabian Gulf (Kuronuma and Abe, 1986), *E. iijimae* from Japan (Jordan and Starks, 1907). Ramanathan recorded only one species *E. grandisquama*, while Rajguru (1987) recorded both the species reported earlier. In the present study three species of *Engyprosopon* have been recorded - *E. grandisquama, E. mogkii* and *E. maldivensis*. Of the three fishes, the first one is very common in the trawler discards during the postmonsoon period. *E. mogkii* was earlier reported from Indian Ocean, Malay Peninsula, but not anywhere near shoreline. *E. maldivensis* was reported earlier only from Maldives. Hence both *E. mogkii* and *E. maldivensis* are new records to Indian waters.

4.3.4.5.1 *Engyprosopon grandisquama* Temminck and Schlegel, 1846

Large scale flounder

Rhombus grandisquama Temminck and Schlegel, 1846, *Fauna Japan* (Pisces):183, pl. x cii, figs, 3, 4. (Nagasaki, Japan); Boeseman, 1947, *Zool. Med. Ingen.,* (Leiden), 28: 183, figs. 3,4; Bleeker, 1860, *Act. Soc. Sc. Indo. Neerl*., VIII: 18 (Japan).

Rhombus poecilurus Bleeker, 1852, *Nat. Tijd. Ned. Ind.,* III: 293 (Ambon Island, Moluccas Islands, Indonesia).

Rhomboidichthys grandisquama (part) Gunther, 1862, *Cat. Brit. Mus*., IV: 437 (Chinese and Japanese seas, Gulf of Forseca); Ishikawa and Matsuura, 1897, *Cat. Nat. Hist. Dept. Imp. Mus*.,: 25 (Japan); Regan, 1905, *J. Bombay Nat. Hist. Soc*., 16 (2): 332 (Muscat).

Platophrys (Arnoglossus) poecilurus Bleeker, 1866-72, *Atl. Ichth*., vi: 13, Pleuron., pl. V, fig. I.

Pseudorhombus poecilurus Bleeker, 1873, *Ned. Tijds. Dierk*., 4: 274 (Amboina).

Rhomboidichthys spilurus Gunther, 1880, *Challenger Rep. Zool.,*: 47, 53, pl. xxi, fig. A. (South of New Guinea, Cebu).

Rhomboidichthys spiniceps Macleay, 1882, *Proc. Linn. Soc. N.S.* Wales, VI: 127 (type locality: Port Jackson, New South Wales, Australia); Ogilby, 1887, *Cat. Fish. N.S. Wales*: 32.

Rhomboidchthys poecilurus Regan, 1902, in Gardiner, *Fauna. Maldive Laccadive Arch*., I: 277; Regan, 1905, *J. Bombay Nat. Hist. Soc*., XVI (2): 332 (Muscat).

Arnoglossus spilurus Johnstone, 1904, *Ceylon Pearl Oyster Fish, Suppl. Rep*., XV: 211.

Scaeops grandisquama Jordan and Starks, 1904, *Bull. U. S. Com. Fish*., XXII (1902): 627, pl. viii, fig. 2; Jordan and Starks, 1907, *Bull. U.S. Nat. Mus*., XXXI: 168, fig. I (sandy coast of Japan, northward to Misaki); Snyder, 1912, *Proc. U.S. Nat. Mus*., 42: 438; Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci. Tokyo,* 33 (1): 311 (Japan); Izuka and Matsuura, 1920, *Cat. Nat. Hist. Dept. Tokyo Imp. Mus*.,: 116; Fowler and Bean, 1922, *Proc. U.S Nat. Mus*., LXII (2): 67 (Takao); Von Bonde, 1922, *Trans. Roy. Soc. Afr*., XII: 287; Barnard, 1925, *Ann. S. Afr. Mus*., XXI: 387; Uchida, 1927, *Fish. Kagoshima Pref.,*: 41; Ui,1929, *Fish. Kisyu, Wakayama*: 271; Tanaka and Abe, 1955, *Descr. Thousand Fish*., :218 (South Japan).

Scaeops poecilurus Jordan and Starks, 1905, *Proc. U.S. Nat. Mus*., XXVIII: 803; Regan, 1908, *Trans. Linn. Soc. London, Zool*., XII: 233 (Maldives, Savadiva, 34 – 44 fathoms); Weber,1913, "*Siboga" Exped. Fisch*.,: 429; Fowler, 1928, *Mem. B. P. Bishop Mus.,* X: 92 (West New Guinea);

Scaeops spilura Jordan and Seale, 1906, *Bull. Bur. Fish*., 25: 412; Bamber, 1915, *J. Linn. Soc. London, 31, Zool*.,: 485 (Sudanese Red Sea); Fowler, 1928, *Mem. B. P. Bishop Mus.,* 10: 92.

Scaeops orbicularis Jordan and Scale, 1907, *Bull. Bur. Fish.*, 26: 45; Jordan and Richardson, 1909, *Mem. Carnegie Mus.*, 4(4): 201 (Cavite, Luzon Island, Philippines); Oshima, 1927, *Jap. J. Zool.*, 1(5): 179.

Arnoglossus grandisquama Fowler, 1934, *Fish. China,* V: 56, fig. 17 (China, Canton)

Engyprosopon grandisquama Jordan and Snyder, 1901, *Fish. Japan, Annot. Zool. Jap. Checklist*, 190:122 (Nagasaki); Norman, 1926, *Biol. F.I.S. "Endeavour"* 1909–14, 5(5): 250; Norman, 1927, *Rec. Ind. Mus.,* 29(1):25, fig. 25 (Muscat, Gulf of Oman, Mekran Coast); Mc Culloch, 1929, *Mem. Aust. Mus.,* 5 (2): 276; Wu, 1932, *These Fac. Sci. Univ. Paris*, A. 244 (268): 91 (China); Norman, 1934, *Syst. Monog. Flatfish*., I :209, fig.156 (Arakan coast, Mekran coast, Burma, Nicobar Islands, Queensland); Kamohara, 1936, *Suisan Kenkyushi*, 31(3):3; Kamohara, 1938, *Prov. Tosa. Shikoku*, Japan: 57; Okada and Matsubara, 1938, *Fish. Japan*: 422 (Japan, Formosa, East Africa); Norman, 1939, *Sci. Rep. Murray Exped.,* 7(1): 100 (Gulf of Aden, 18-22 m); Kuronoma, 1939, *Suisan Kenkyushi*, 34(2): 85; Kuronuma, 1940, *Suisan Kenkyushi*, 35(8): 213; Blegvad, 1944, *Danish Sci. Invest. Iran*, 3: 202, fig. 123 (Chahbar); Liang, 1948, *Quart. J. Taiwan Mus*., 1(2): 19; Smith, 1949, *Fish. S. Africa*: 159; Kamohara, 1950, *Desc. Fish Province Tosa Kishu Japan*: 240; Kuroda, 1951, *Jap. J. Ichth*., 1(6): 389; Okada, 1955, *Fish. Japan*: 371, fig. 338 (Japan, China Sea); Munroe, 1955, *Fish. Ceylon*: 756, pl. 50; Matsubara, 1955, *Fish. Morph. Hierar*., II: 1259 (Formosa, Japan, China, East Africa); Fowler, 1956, *Fish.*

Red Sea S. Arabia, I:167 (Philippines, Japan); Chen, 1956, *Synop. Vert. Taiwan*: 99 (Kaohsiung); Mori, 1956, *Mem. Hyogo Univ. Agri.*, 2(3): 31; Munroe, 1958, *Papua and New Guinea Agri. J.*, 10(4): 284; Kamohara, 1958, *Rep. Usa Mar. Biol. St.*, 5(1): 62; Smith, 1961, *Sea Fish. S. Africa*: 159 (Natal to Delagon Bay); Amaoka, 1963, *Bull. Misaki Mar. Biol. Inst., Kyoto Univ.*, (4): 108; Marshall, 1964, *Fish. Great Barrier Reef*: 458, pl. 60, fig. 444 (Queensland coast, 5 - 30 fathoms); Kamohara, 1964, *Rep. Usa Mar. Biol. St.*, 11(1): 82; Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull.*, (1): 16, fig. 3; Chen and Weng, 1965, *Biol. Bull.*, 27:10, fig. 32 (Tungkong, Tainan); Amaoka, 1969, *J. Shimonoseki Univ. Fish.*, 18(2): 79, fig. 44 (Nobeoka, Japan); Masuda *et al.*, 1975, *Coastal Fish. South. Japan*: 345 (Japan); Kyushin *et al.*, 1982, *Fish. S. China Sea*: 263; Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 848, fig. 348; Dor, 1984, *Checklist Fish. Red Sea*: 268; Kuronuma and Abe, 1986, *Fish. Arabian Gulf* :45; Hensley, 1986, *Smith. Sea Fish.,*: 858, fig. 259.8 (Durban Indo–Pacific, Japan); Krishnan and Mishra, 1992, *J. Andaman Sci. Ass.*, 8(1): 83 (Hut Bay, Little Andaman); Lindberg and Fedorov, 1993, *Handbook Iden. Anim.,* 166: 40; Amaoka *et al.*, 1993, *Mem. Mus. Nat. Hist. Nat. Zool.*, 158: 381; Krishnan and Mishra, 1994, *Rec. Zool. Surv.*, 94 (2-4): 300; Goren and Dor, 1994, *Checklist Fish. Red Sea*: 71; Masuda *et al.*, 1984, *Fish. Jap. Arch.*,:194; Randall, 1995, *Coastal Fish. Oman*: 357; Mohsin and Ambak, 1996, *Mar. fish. Malaysia*:590 (as *grandisquamis*); Allen, 1997, *Mar. Fish. Aust.,*: 234; Randall *et al.*, 1997, *Fish. Great Barrier Reef*: 539; Johnson 1999, *Mem. Qd. Mus.*, 43: 752; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.*, 8: 645; Nakabo, 2000, *Fish.*

Japan, 2: 1364; Iwatsuki *et al*., 2000, *Bull. Fac. Agric. Miyazaki Uty*, 47: 105; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide* IV (6): 3823; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl*., 63: 46; Nakabo, 2002, *Fish. Japan*, 2^0, 2:1364; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1): S.122; Mishra and Krishnan, 2003, *Rec. Zool. Surv. Occ. Pap*., 219 :46; Adrim *et al*., 2004, *Raffles Bull. Zool. Suppl*., 11: 127; Randall, 2005, *Reef Shore Fish Pacific*: 614; Amaoka *et al*., 2008, *Nat. Sci. Supp*., 2: 112.

Bothus (Arnoglossus) poecilurus Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.,* 5: 131 (Sumatra, Java, Red Sea, Indian Ocean).

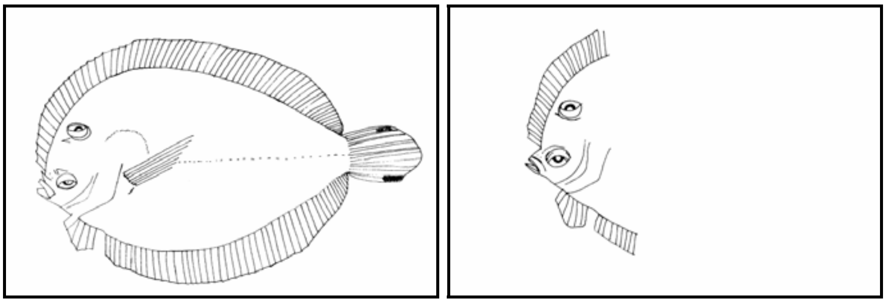


Plate XVIII: *Engyprosopon grandisquama* Temminck and Schlegel, 1846

Materials examined: N= 25; TL 48.6-110.3 TL mm from Kochi, Neendakara.

Diagnosis: Caudal fin with a pair of large dark spots, gill rakers on lower arch 5 - 7

Meristic characters: D 60 - 83 (75); A 54 - 62 (58); P_1 9 - 11; P_2 7 - 10; V_1 5, C 16.

Body proportions as percent of SL (mean in parentheses): HL 23.1 – 29.2 (25.4); HW 25.4 - 42.2 (38); HD 22.1 -35.2 (26.03); ED_1 6.9 - 10.2

(8.1); ED_2 6.5 -9.2 (7.7); ID 2.3 – 6.5 (4.3); PrOU 2.3 - 5.5 (3.4); PrOL 4.7 -7.5 (5.8); PBU 8.9 -14.4 (12.5); PBL 11.1-14.2 (12.8); SNL_1 8.7-12.9 (10.5); SNL_2 4.6-12.9 (5.7); CD 1.2– 4.3 (2.8); UJL 7.1 -12.3 (9.02); LJL 5.7 - 9.6 (7.3); DFL 10.3 - 14.5 (12); AFL 9.4 - 13.5 (11.5); P_1FLO 18.5-32.3 (23.3); P_2FLB 11.1-27.9 (13.6); V_1FLO 7.2-14.5 (10.4); V_2FLB 2.1- 20.7 (10.97); CFL 9.6 - 22.1 (13.1); CPD 10.9 - 13.4 (12.1); PDL 2.89 - 5.3 (3.8); PAL 22.3 - 33.6 (27.6); P_1LO 24.1 - 27.1 (22.5); P_2LB 11.9 - 22.2 (16.02); V_1LO 16.7 - 25.9 (19.5); inter pelvic 2.9 - 20 (6.7); BD_1 37.6 - 51.95 (42.6).

As percent of HL (mean in parentheses): HW 110 - 163.8 (150); HD 88.9 - 152.6 (103); TKL 260.2 -335.2 (284.8); ED_1 27.8 - 38 (31.8); ED_2 26.4 – 36.4 (30.4); ID 8.4 - 26 (17); PrOU 8.7 - 20.3 (13.6); PrOL 19.4 - 30.5 (23); PBU 36.6 - 58 (49.2); PBL 41.5 - 57.8 (50.7); SNL_1 29.7 – 51.1 (41.4); SNL_2 17.4 - 52.7 (22.5); CD 5.1 - 17.4 (11.1); UJL 26.9 - 48 (35.5); LJL 22 - 37.6 (28.7); PDL 10.9 - 20.2 (15.7); PAL 86.6 -131.1 (109.2); P_1LO 90 - 116.8 (102.3); P_2LB 93.8 - 111.2 (101.9); V_1LO 49.3 – 84.7 (63.3); V_2LB 64.6 -100.8 (77.4); inter pelvic 11.3-78.1 (26.4); BD_1 147.4 - 211.6 (166.8).

Description: Body oval in outline, with a prominent notch behind the snout. Mouth oblique. Upper eye slightly behind lower eye in origin; interorbital space concave; maxillary ends at the anterior region of the lower eye. Upper jaw biserial anteriorly, uniserial laterally; lower jaw uniserial in front, biserial posteriorly. Teeth sharp, spaced slightly apart on upper and lower jaws. Mouth oblique, leads to a short thick tube the stomach, followed by the intestine; pyloric caeca absent. Nostril two on ocular side, the first one above the upper jaw tubular with a hole at its tip; the second oval in outline; nostril on blind side just down under the dorsal origin on blind side. Gill rakers 5 - 6 on lower arm, strong spinous, bulb like on upper arm. Rostral and orbital spines present in front of eye in males; very small or absent in females. Single continuous dorsal fin and anal fin with unbranched fin rays. Dorsal origin on blind side, just above the migratory eye, finlength increases from origin to centre and then decreases in a similar pattern. Pectoral fin origin behind lower eye in a straight line; pelvic origin on blind side behind pelvic on ocular side. Caudal fin rounded at tip, finrays at outer end branched, rest unbranched. Anus opens on blind side. Lateral line well developed on ocular side, on the blind side it is depressed.

Scales: Body weakly ctenoid on ocular side, cycloid on blind side. Scales on body semi oval in outline with a pigmented outer portion with weak ctenii. Lateral line scale semi-oval in outline, with a narrow pigmented part, a lateral striated part and a central grooved part. Cycloid scales in the interorbital area.

A comparative statement of the meristic characters of *Engyprosopon grandisquama* is given in Table 38. Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon grandisquama* is given in Table 39.

Table 38 : A comparative statement of the meristic characters of *Engyprosopon grandisquamis*

Meristic characters	Earlier workers											
	Temmnick & Schlegel 1846	Gunther 1862	Gunther 1880	Bleeker 1844	Jordan & Starks 1906	Norman 1927	Weber & Beaufort 1929 (East Indies)	Norman 1934	Munroe 1957	Smith, 1961	Amaoka 1963, 1969	Marshall 1964
Dorsal rays	76	76 – 83	90	83	79	81 – 88	80 – 90	79 - 89	82 – 87	80 - 90	79 – 87	79 - 89
Anal rays	58	58 - 62	60	61	60	59 – 68	59 – 68	59 – 68	60 – 66	60 - 68	59 – 65	59 - 68
Lateral line scales	*	40	47	*	36		40 - 48	*	39 – 43	36 - 45	37 - 43	
Pectoral	11	*	*	11	*	10 - 12	9 – 11/ 8 - 9	*	*	*	11 -12/ 9 -10	10 - 12
Ventral	6	*	*	6	*	*	6	6	*	*	*	
Gillrakers	*	*	*	*	*	*	*	*	5 - 6	5-7	*	
Caudal	16	*	*	*	*	*	*	*	*	*	*	

Meristic characters	Earlier workers				Present study, 2004-2010	
	Cheng and Weng, 1965	Masuda 1975	Ramanathan 1977	Randall 1995	N = 25	Mean ± SD
Dorsal rays	85 - 92	79-87	77 – 90	79 – 89	60 - 83	75 ± 11
Anal rays	62 -70	59-66	58 – 69	59 – 68	54 – 62	58 ± 4
Lateral line scales	42 - 46	42-43	37 - 45	36 - 46	37 - 45	38 ± 5
Pectoral	*	*	9 – 12/ 9 - 11	11 - 12	9 – 11/ 7 -10	10 ± 1
Ventral	*	*	6		5	5
Gillrakers	6 - 7	*	*		*	*
Caudal	*	v	16 -17		16 - 17	16 ± 1

*Data not available

Table 39 : Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon grandisquama*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.4 -4.3	3.95	0.22	0.96	0.22
Head Width	3.9 - 2.7	2.65	0.29	0.85	0.36
Head Depth	4.5 -3.9	3.87	0.33	0.81	0.26
TKL	1.2 -1.4	1.33	0.04	0.98	0.74
Eye Diameter (U)	9.8 -14.6	12.51	1.22	0.81	0.07
Eye Diameter (L)	10.9 -15.4	13.07	1.04	0.90	0.07
Pre orbital (U)	18.3 -44.4	30.03	5.28	0.59	0.03
Pre orbital (L)	13.4 -21.2	17.42	1.98	0.76	0.05
Post orbital (U)	6.9 -11.3	8.14	1.1	0.77	0.12
Post orbital (L)	7.1 -9.04	7.82	0.49	0.94	0.13
SNL_1	7.8 - 11.6	9.67	1.01	0.94	0.14
SNL_2	7.8 -21.7	18.32	2.79	0.45	0.07
UJL	8.14 - 14.1	11.3	1.57	0.69	0.07
LJL	10.4 -17.6	14.05	2.13	0.62	0.06
Pre dorsal	18.95 -34.6	25.59	3.69	0.66	0.03
Pre anal	2.98 -4.5	3.65	0.35	0.86	0.23
Pre pectoral (O)	3.3 - 4.2	3.88	0.23	0.92	0.24
Pre pectoral (B)	3.7 - 4.2	3.91	0.14	0.96	0.24
Pre pelvic (O)	4.5 - 8.4	6.4	1	0.71	0.16
Pre pelvic (B)	3.9 - 6.01	5.17	0.47	0.85	0.2
Inter pelvic	5 - 34.4	16.95	5.84	0.08	0.03
Body depth	1.9 - 2.7	2.36	0.16	0.92	0.47
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head Width	0.6 - 0.9	0.67	0.06	0.88	1.59
Head Depth	0.7 - 1.2	0.98	0.09	0.74	1.07
Eye Diameter (U)	2.6 - 3.6	3.16	0.26	0.85	0.32
Eye Diameter (L)	2.8 - 3.8	3.31	0.25	0.88	0.28
Inter orbital	3.8 - 11.9	6.51	2.29	0.64	0.3
Pre orbital (U)	4.9 - 11.4	7.61	1.41	0.53	0.11
Pre orbital (L)	3.3 - 5.2	4.41	0.5	0.72	0.2
Post orbital (U)	1.7 - 2.7	2.06	0.26	0.81	0.55
Post orbital (L)	1.7 - 2.4	1.98	0.16	0.90	0.55
SNL_1	2.0 -3.4	2.46	0.35	0.88	0.57
SNL_2	1.9 - 5.8	4.65	0.76	0.42	0.3
Chin depth	5.8 -19.6	9.64	2.87	0.56	0.15
Upper jaw	2.1 - 3.7	2.86	0.38	0.72	0.29
Lower jaw	2.7 - 4.5	3.56	0.51	0.64	0.28

Colour: Body brownish in colour, on ocular side slight brownish, on blind side with nearly transparent fins. Caudal fin with a pair of black spots at its lower and upper margin. In some specimens, pectoral fin on ocular side has brown bands.

Sexual dimorphism: The fish shows sexual dimorphism with greater concave interorbital space in males and head a little elongated in females. Rostral and orbital spines present in males. Pectoral falcate, nearly as long as head in males, equal to post orbital part of head in females. Males have body stained with bluish grey in centre, grey with white on blind side, in females, the blind side is fully in females whitish. In bigger sized female fishes, small spines are present at the symphysis of the lower jaw.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 63, 64); the linear regression equations obtained were

For male fishes

Head width on SL	: $y = 0.36\ x + 2.5$; $R^2 = 0.89$; $p < 0.001$
Head depth on SL	: $y = 0.25\ x + 0.98$; $R^2 = 0.77$; $p < 0.001$
Eye diameter (upper) on SL	: $y = 0.09\ x - 0.97$; $R^2 = 0.85$; $p < 0.001$
Eye diameter (lower) on SL	: $y = 0.064\ x + 0.89$; $R^2 = 0.83$; $p < 0.001$
Dorsal fin length on SL	: $y = 0.12\ x + 0.11$; $R^2 = 0.73$; $p < 0.05$
Head width on HL	: $y = 1.5\ x + 1.5$; $R^2 = 0.93$; $p < 0.001$
Head depth on HL	: $y = 1.02\ x + 0.81$; $R^2 = 0.76$; $p < 0.05$
Eye diameter (upper) on HL	: $y = 0.38\ x - 1.13$; $R^2 = 0.87$; $p < 0.001$
Eye diameter (lower) on HL	: $y = 0.25\ x + 1.2$; $R^2 = 0.72$; $p < 0.001$
Interorbital on HL	: $y = 0.36\ x - 2.59$; $R^2 = 0.98$; $p < 0.001$

For female fishes

Head length on SL	: $y = 0.23\ x + 1.89$; $R^2 = 0.94$; $p< 0.001$
Head width on SL	: $y = 0.33\ x + 2.85$; $R^2 = 0.79$; $p < 0.001$
Head depth on SL	: $y = 0.26\ x + 0.08$; $R^2 = 0.77$; $p < 0.001$
Body depth (BD_1) on SL	: $y = 0.43\ x – 0.34$; $R^2 = 0.98$; $p < 0.001$
Body depth (BD_2) on SL	: $y = 0.52\ x – 1.3$; $R^2 = 0.99$; $p < 0.001$
Eye diameter (upper) on SL	: $y = 0.06\ x + 1.09$; $R^2 = 0.75$; $p < 0.001$
Dorsal fin length on SL	: $y = 0.12\ x + 0.11$; $R^2 = 0.73$; $p < 0.05$
Head width on HL	: $y = 1.5\ x – 0.13$; $R^2 = 0.86$; $p< 0.001$
Head depth on HL	: $y = 1.03\ x - 0.29$; $R^2 = 0.68$; $p < 0.001$
Eye diameter (upper) on HL	: $y = 0.29\ x + 0.49$; $R^2 = 0.83$; $p < 0.001$
Eye diameter (lower) on HL	: $y = 0.28\ x + 0.34$; $R^2 = 0.92$; $p < 0.001$
Interorbital on HL	: $y = 0.19\ x – 0.77$; $R^2 = 0.\ 57$; $p < 0.001$
Preorbital (U) on HL	: $y = 0.094 + 0.63$; $R^2 = 0.\ 47$; $p < 0.001$
Preorbital (L) on HL	: $y = 0.2 + 0.39$; $R^2 = 0.\ 78$; $p < 0.001$

Results of regression analysis showed that the variation of various body parameters in relation to standard length and head length is highly significant. However, regression of preorbital (upper eye and lower eye) on head length in males is not significant.

t test was performed on certain body characters; interorbital space and pectoral fin length on ocular side was found to be highly significant in males and females.

Distribution:

World: Amboina (Bleeker, 1873); Nobeoka, Japan (Bleeker, 1860; Schlegel, 1842; Bleeker, 1860; Ishikawa and Matsuura, 1897; Jordan and Starks, 1906; Tanaka and Snyder, 1913; Amaoka, 1963, 1969); South of New Guinea, Cebu (Gunther, 1880); Port Jackson, New South Wales, Australia (Macleay, 1882); Ambon Island, Moluccas Islands, Indonesia (Bleeker, 1852); Muscat (Regan, 1905);Cavite, Luzon Island, Philippines (Jordan and Richardson, 1909; Norman, 1934); Sudanese Red Sea (Bamber, 1915); Muscat, Gulf of Oman, Mekran Coast (Norman, 1927); West New Guinea (Fowler, 1928); East Indies (Weber and Beaufort, 1929); China, Canton (Fowler, 1934); Gulf of Aden, 18 - 22 m (Norman, 1939); Leiden (Boeseman, 1947); Leiden (Boeseman, 1947); Natal to Delagoa Bay, Africa (Smith, 1961); Taiwan (Chen and Weng, 1965); Thailand (Punpoka, 1964); Red Sea (Dor, 1984); Arabian Gulf (Kuronuma and Abe, 1986; Blegvad, 1944). Map showing localities were *Engyprosopon grandisquamis* has been recorded in the world is given in Fig. 61.

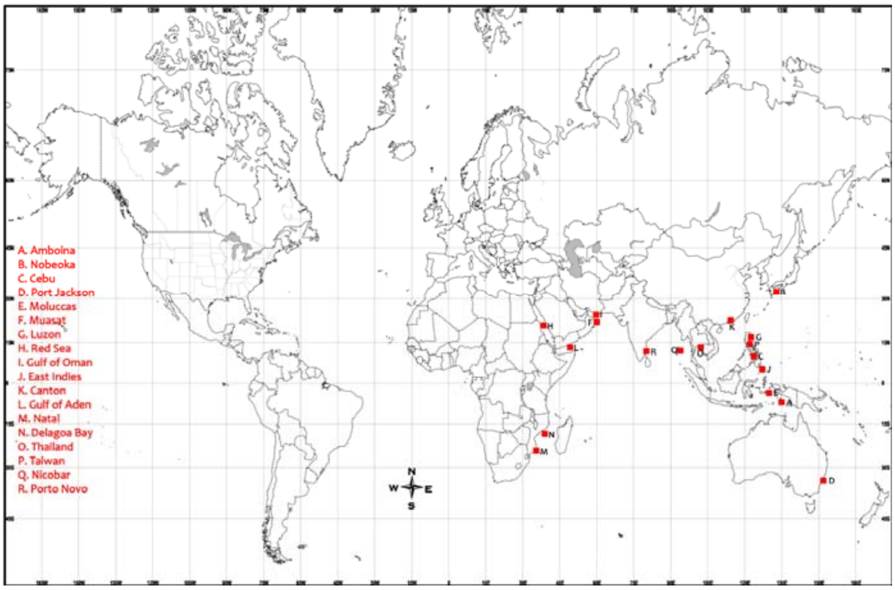


Fig. 61: Map showing localities were *Engyprosopon grandisquamis* has been recorded in the world.

In India: Reported from India (Norman, 1927); Nicobar islands (Norman, 1934); Porto Novo (Ramanathan, 1977), Quilon and Kochi (present work). Map showing localities were *Engyprosopon grandisquamis* has been recorded in India is given in Fig. 62.

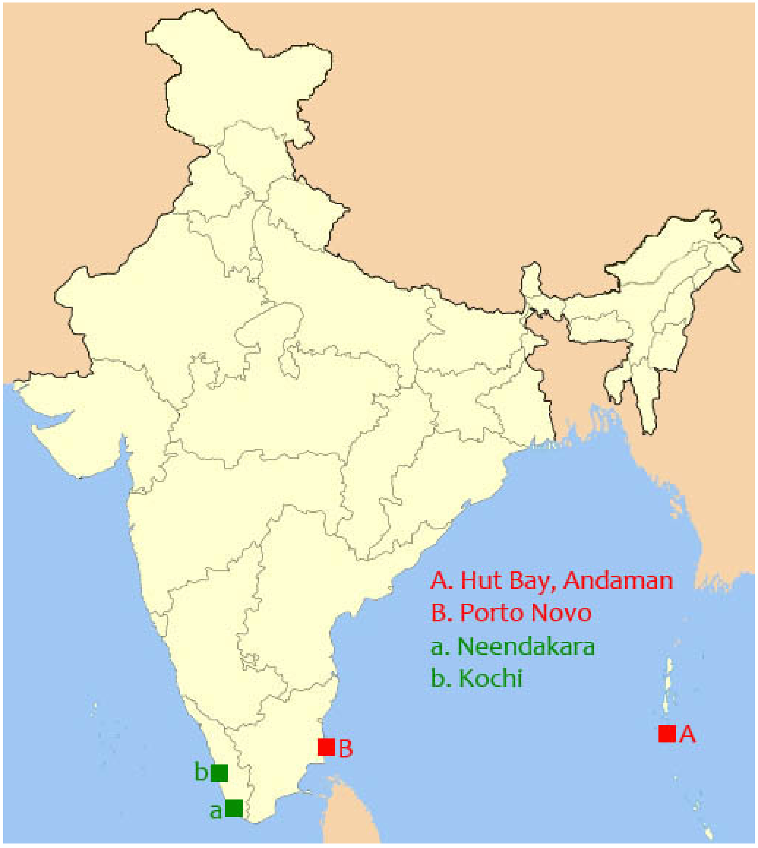


Fig. 62: Map showing localities were *Engyprosopon grandisquamis* has been recorded in India.

Remarks: Small fishes which are landed along with non-target species in discards.

Taxonomic remarks: The fish was first described by Temmnick and Schlegel (1846) based on a sample from Japan. Subsequently, it was redescribed as *Rhomboidicthys grandisquama* by Gunther (1862). Fowler (1934) described the fish in genus *Arnoglossus* as *A. grandisquama* along with other *Arnoglossus* species based on the characters large scales and sinistral shape. However, subsequent workers did not follow the idea of Fowler. *Rhomboidichthys spiniceps* described by Macleay, 1881 from Port Jackson and *R. spilurus* of Gunther, 1880 was synonymised with *E. grandisquama* by Amaoka *et al*. (1993:382) and Lindberg and Fedorov (1993: 40). The fish was then placed in a variety of genera including *Arnoglossus*, *Platophrys*, *Scaeops* and finally *Engyprosopon* in which it is placed now.

Observations: The meristic counts of *E. grandisquama* show a wide range in the present and earlier studies. They however match with that of the earlier workers.

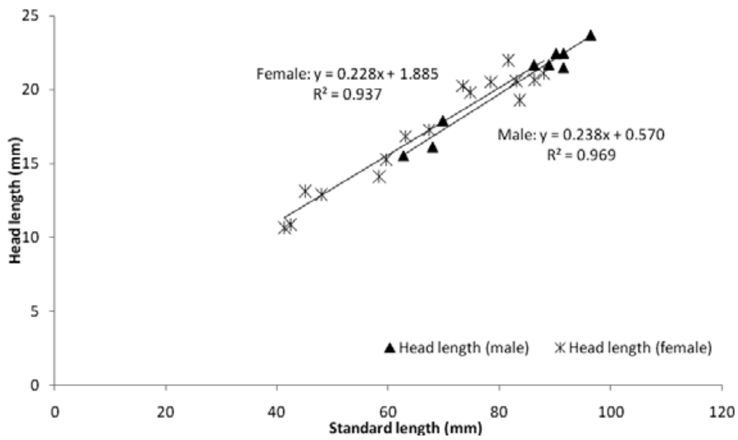


Fig. 63: Regression of Head length on Standard length

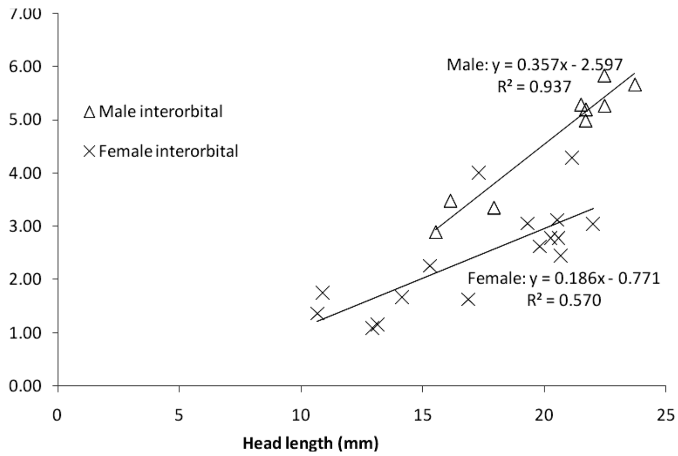


Fig. 64: Regression of Interorbital length on Head length

New Record 5

4.3.4.5.2 *Engyprosopon maldivensis* (Regan, 1908)

Olive wide eyed flounder

Scaeops maldivensis Regan, 1908, *Trans. Linn. Soc. London, Zool*., XII: 234, pl. xxv, fig.1 (Maldives, Indian Ocean, 27 – 44 fathoms).

Engyprosopon maldivensis Norman, 1927, *Rec. Ind. Mus*., XXIX: 27 (Maldives); Norman, 1934, *Syst. Monog. Flatfish*: 216, fig. 165 (Maldive Islands); Dor, 1984, *Checklist Fish. Red Sea,* CLOFRES: 269; Amaoka *et al*., 1993, *Mem. Mus. Nat. Hist*.,: 393; Goren and Dor, 1994, *Checklist Fish. Red Sea*, CLOFRES II: 71; Amaoka and Mihara, 1995, *N. Zealand J. Mar. F.W Res*., 29: 56; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl.*, 8: 645; Hensley and Amaoka, 2001, *Proc. Biol. Soc. Wash.*, 102(3): 3832; Hutchins, 2001, *Rec. West. Aust. Mus. Suppl*., 63: 46; Shinohara *et al*., 2005, *Mem. Nat. Sci. Mus. Tokyo* 29: 442; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1819; Amaoka *et al*., 2008, *Nat. Mus. Nat. Sci Publ. Suppl*., 2: 113.

Engyprosopon borneensis Chabanaud, 1948, *Bull. Mus. Nat. Hist. Nat*., (Ser. 2), 20 (1): 64, figs. 1, 2 (North east of Datoe Point, N. coast of Borneo).

Engyprosopon macroptera Amaoka, 1963, *Bull. Misaki Mar. Biol. Inst. Kyoto Univ*.,4: 115, fig. 5 (Mimase, Kochi Prefecture, Japan); Lindberg and Fedorov, 1993, *Handbook Iden. Anim.,* 166: 40; Amaoka *et al*., 1993, *Mem. Mus. Nat. Hist. (Series A), Zool.*, 158: 380; Li and Wang, 1995, *Fauna Sinica*: 199; Nakabo, 2000, *Fish Japan*, 2 ed: 1363; Nakabo, 2002, *Fish Japan*, 2° ed.: 1363.

Arnoglossus maculipinnis Fowler, 1934, *Proc. Acad. Nat. Sci. Philadel.*,, 85: 329, fig. 84 (vicinty of Jalo, Sulu Province, Philippines).

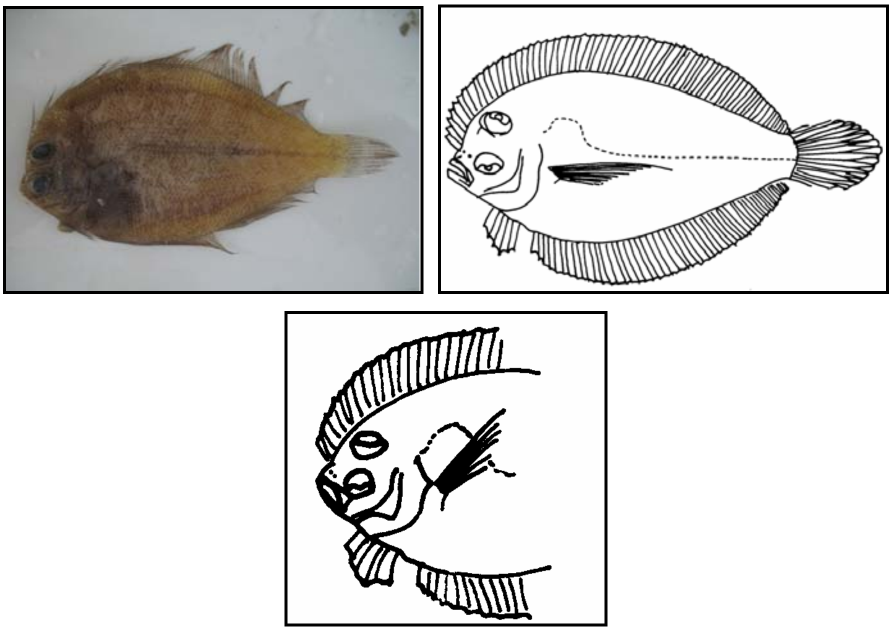


Plate XIX: *Engyprosopon maldivensis* (Regan, 1908)

Material examined: N =1; TL 63.1 mm from Neendakara.

Meristic counts: D 70; A 54; P_1 11; Ll 41

Diagnosis: Pectoral fin on both sides longer than the head length.

Body proportions as percent of SL: HL 29.6; HW 15.8; HD 26.8; ED_1 10.3; ED_2 9.6; ID 6.8; SNL_1 12.1; SNL_2 5.8; CD 3.6; UJL 10.7; LF 15.3; DFL 12.6; AFL 16.3; P_1FL 17.4; P_2FL 13.9; V_1FL 12.6; V_2FL 11.13; CFL 18.9; DBL 92.3; ABL 63.9; P_1BLO 3.8; P_2BLB 2.3; V_1BLO 7.4; V_2BLB 3.6; CBL 9.7; BD_1 38.2; BD_2 43.6.

As percent of HL: HW 125.5; HD 90.46; ED_1 34.77; ED_2 32.3; ID 23.14; SNL_1 40.8; SNL_2 19.6; CD 12.1; UJL 36.03; LJL 51.8; DFL

42.4; AFL 54.93; P_1FLO 58.7; P_2FLB 47.1; V_1FLO 42.4; V_2FLB 37.6; CFL 63.8; DBL 311.95; ABL 215.8; P_1BLO 12.96; P_1BLB 7.8; V_1BLO 24.9; V_2BLB 12.3; CBL 32.7; BD_1 129.2 ; BD_2 147.3.

Description: Body depth 2.3 times in SL; HL 3.3 times in SL; snout shorter than eye, ED_1 2.9 and ED_2 3.1 times in HL. Interorbital space concave, wide. Upper eye placed a little behind lower eye; maxillary ends below middle of lower eye. A spine present on snout in the male specimen, spines absent elsewhere on head. 8 gillrakers of moderate length on the lower gill arch. Teeth villiform on blind side. Lateral line tubular with 41 scales. Dorsal origin on blind side at notch, fin rays stiff, strong, scaled. Dorsal and anal fins end just in front of caudal fin. Caudal nearly rounded. Fins on pectoral on ocular side 11; upper most slightly produced touching the lateral line in males. Body covered with deciduous feebly ctenoid scales on dorsal side and cycloid scales on blind side.

A comparative statement of the meristic characters of *Engyprosopon maldivensis* is given in Table 40. Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon maldivensis* is given in Table 41.

Table 40: A comparative statement of the meristic characters of *Engyprosopon maldivensis*

Meristic characters	Earlier workers		Present 2004-2010 N = 1
	Regan 1908	Amaoka *et al.*, 1993	
Dorsal rays	70 - 76	77 – 91	70
Anal rays	53 - 58	55 - 68	54
Lateral line	*	41 - 50	41
Pectoral	11	*	11
Gill rakers	8 - 9	0 – 2+ 7 - 11	9

*Data not available

Table 41: Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon maldivensis*

Characters	Ratio In SL	Ratio in HL
Head Width	2.69	0.80
Head Depth	1.11	1.39
Eye Diameter (U)	3.61	2.60
Eye Diameter (L)	2.80	1.08
Inter orbital	1.50	1.40
Snout to upper eye	0.79	0.57
Snout to lower eye	1.18	2.08
Chin depth	3.36	1.61
Upper jaw length	0.54	0.34
Lower jaw length	0.23	0.70
Dorsal fin length	0.85	1.22
Anal fin length	0.94	0.77
Pectoral fin length (O)	0.72	0.94
Pectoral fin length (B)	1.17	1.25
Pelvic fin length (O)	1.38	1.11
Pelvic fin length (B)	1.25	1.13
Caudal fin length	0.66	0.59
Dorsal base length	0.12	0.20
Anal base length	0.30	1.45
Pectoral base length (O)	24.07	16.65
Pectoral base length (B)	27.76	1.67
Pelvic base length (O)	0.52	0.31
Pelvic base length (B)	0.63	2.03
Caudal base length	0.76	0.38
Body depth I	0.09	0.25
Body depth II	0.22	0.88

Colour: In fresh condition, body pale brown, dark on operculum; caudal fin with numerous dark spots and markings. When preserved, the body colour remains brown and the markings on the body become pale.

Distribution:

World: Reported from Maldives, Indian Ocean (Regan, 1908; Norman, 1934); vicinty of Jalo, Sulu Province, Philippines (Fowler, 1934); North east of Datoe Point, North coast of Borneo (Chabanaud, 1948); Mimase, Kochi Prefecture, Japan (Amaoka, 1963). Map showing localities were *Engyprosopon maldivensis*has been recorded in the world is given in Fig. 65

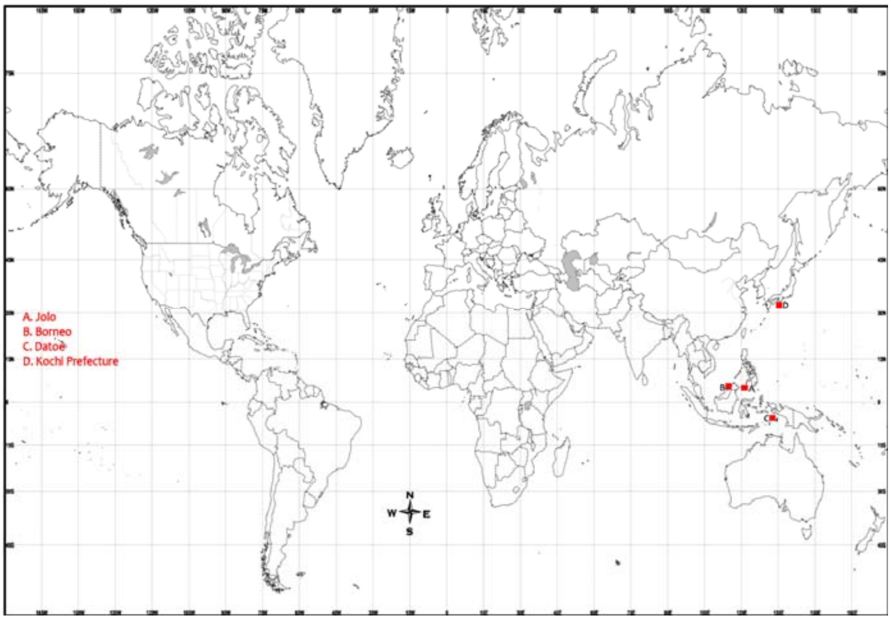


Fig. 65: Map showing localities were *Engyprosopon maldivensis* has been recorded in the world.

India: Present report only from Neendakara. This is a new record to the Indian waters. Map showing localities were *Engyprosopon maldivensis* has been recorded in India is given in Fig. 66.

Fig. 66: Map showing localities were *Engyprosopon maldivensis* has been recorded in India.

Taxonomic comments: Regan (1908) described the species based on three specimens of total length 70 mm collected from Maldives at a depth of 27–44 fathoms. Fowler (1934:329) described *Arnoglossus maculipinnis* based on a collection from the vicinity of Jolo, Sulu Province, Philippines (6°08'45"N, 121°03'E, Albatross station 5140, depth 20-76 fathoms); however this was synonymised with *E. maldivensis* by Dor (1984). According to Eschmeyer (2010 online) *"Norman apparently established the lectotype by referring to the type as 1901.12.31.94 coupled with a* *footnote stating, 'A male of 63 mm. is selected as the holotype', 'the lectotype was designated by Amaoka et al. (1993); 5 paralectotypes were mentioned, the original description was based on 3 specimens'.*

Observations: The dorsal fin counts, lateral line counts and description of the present specimen (male) match well with that of the description of Regan than to Amaoka's sample. This fish could be a stray sample of larval transport.

New Record 6

4.3.4.5.3 *Engyprosopon mogkii* (Bleeker, 1834)

Rhombus mogkii Bleeker, 1834, *Nat. Tijd. Ned. Ind.,* vii: 256 (Manado in sea); Bleeker, 1856, *Act. Soc. Sc. Indo-Neerl.*, I: 8 (Amboina); Bleeker, 1857, *Act. Soc. Sc. Indo –Neerl.*, II : 19 (Ternate).

Achirus mogkii, Bleeker, 1860, *Nat. Tijd. Ned. Ind.,* XXII: 101.

Rhomboidichthys mogkii Gunther, 1862, *Cat. Brit. Mus.*, IV: 438 (Bali, Celebes, Amboina).

Pseudorhombus mogkii Bleeker, 1863, *Nat. Tijds. Dierk.*, I: 230.

Platophrys (Arnoglossus) mogkii Bleeker, 1866-72, *Atl. Ichth.*, vi: 14, Pleuron, pl. ii, fig. 1.

Engyprosopon mogkii Weber, 1913, *Siboga–Exp. Fisch.,*: 429 (Kawa, Ceram, 120 mm TL); Norman, 1927, *Rec. Ind. Mus.*, XXIV: 27, plate V (Malay Archipelago, Indian Ocean); Norman, 1934, *Syst. Monog. Flatfish.,*: 207, fig. 154; Fowler, 1939, *Proc. Acad. Nat. Sci. Philadel.,*, 91: 80 (Sorong); Fowler, 1967, *Mem. B. P. Bishop Mus.*, XII, 2: 61; Li and Wang, 2000, *Fauna Sinica*: 203; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6): 3832.

Bothus (Arnoglossus) mogkii, Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.,* V: 128, fig. 30.

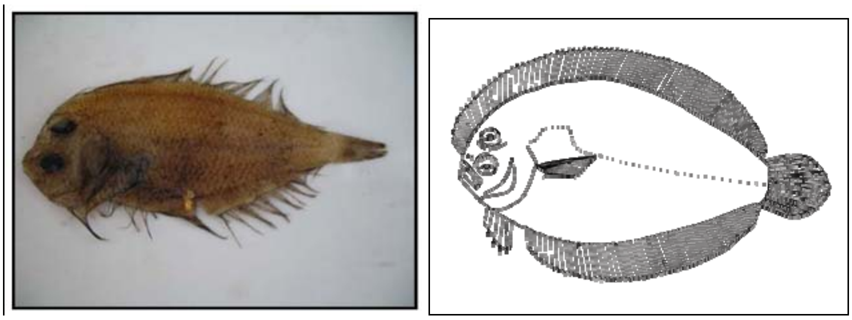


Plate XX: *Engyprosopon mogkii* (Bleeker, 1834)

Material examined: N = 3; TL 96.61 – 102.27 mm from Neendakara.

Diagnosis: Body width 3.1 in total length; maxillary ends at anterior one-third of eye.

Meristic counts: D 77 – 84; A 62– 66; P_1 11-12; P_2 6- 9; V_1/V_2 5/5; C 4-6 + 11-12; lateral line 60.

Body measurements as percent of SL: HL 24.9 – 27.8; HW 32 – 40.5; HD 22.7 – 25.3; ED_1 8.8 – 9.9; ED_2 8.5 – 8.98; ID 2.3 – 3.2; SNL_1 7.1 – 9.4; SNL_2 3.6 – 4.7; CD 2.4 – 3.1; UJL 7.2 – 8.2; LJL 7.4 – 9.2; DFL 11.4 – 12.3; AFL 13 – 13.6; P_1FL 16.9 – 19.2; P_2FL 8.2 – 11.9; V_1FLO 8.5 – 11.1; V_2FLB 8.7 – 10.4; CFL 17.6 – 19.6; DBL 91.7 – 94.8; ABL 73.1 – 75.2; P_1BLO 2.95- 4.1; P_2BLB 2.2 – 3.11; V_1BLO 4.2 – 8.1; V_2BLB 3.6 – 4.1; CBL 9.7 – 12.8; PDL 3.7 – 4.9; PAL 25.4 – 27.2; P_1LO 24.9 – 27.7; P_2LB 24.8 – 27.7; V_1LO 14.6 – 21.2; V_2LB 18.4 – 21.7; BD_1 31.6 – 43.2; BD_2 39.2 – 53.4.

As percent of HL: HW 120.5 – 162.7; HD 85.4 – 101.6; ED_1 34.7 – 35.6; ED_2 32.3 – 34.2; ID 8.1 – 12.99; SNL_1 26.7 – 33.6; SNL_2 13.6 – 16.8; CD 9.01 – 12.4; UJL 27.1 – 29.4; LJL 26.5 - 37; DFL 41.02 – 49.34; AFL 48.7 – 52.4; P_1FLO 63.4 – 75.7; P_2FLB 30.8 – 47.7; V_1FL

31.98 – 44.7; V_2FL 31.2 – 41.8; CFL 69.2 – 70.6; DBL 335.2 – 368.5; ABL 262.7- 298.92; P_1BLO 10.6 – 16.2; P_2BLB 7.8 – 12.3; V_1BLO 15.1 – 30.4; V_2BLB 12.8 – 16.5; CBL 34.99 – 51.4; PDL 13.3 – 18.4; PAL 97.1 – 102.4; P_1LO 99.6 – 100.2; P_2LB 97.03 – 99.5; V_1LO 58.8 – 76.4; V_2LB 73.8 – 79.8; BD_1 118.96 – 173.4 ; BD_2 145.8 – 214.4.

Description: Body elongate, ovoid both profiles convex in the post orbital area; the area from the snout to postorbital region sharply convex. Body width 3.1 in total length. Head width greater than head length; the eye diameter of upper and lower eye more or less same, lower eye slightly in front of upper eye. Maxillary ends below anterior one-third of eye, 3.7 in head. Gill rakers nil on upper arm, 6 – 7 on lower arm. Snout hook like. Eyes placed high up on head, a little apart (in females) with a concave interorbital space covered with scales. Upper eye a little behind the lower eye. Lateral line arising from behind upper outer free end of operculum with a plateau projection, proceeding straight backward; lateral line with tubular scales. Dorsal fin origin on snout on blind side. Anal origin slightly before hind border of operculum. Pectoral (ocular) origin at outermost point of operculum, the origin of pectoral (blind) in front of ocular one on blind side. Pectoral fin on ocular side very short in females; very long crossing the straight part of the lateral line after the projection in males. Subposterior rays of dorsal and anal longest; all rays of dorsal and anal fins simple. A comparative statement of the meristic characters of *Engyprosopon mogkii* is given in Table 42. Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon mogkii* is given in Table 43.

Table 42 : A comparative statement of the meristic characters of *Engyprosopon mogkii*

Meristic characters	Earlier workers						Present 2004-2010	
	Bleeker 1854	Gunther 1862	Norman 1927	Weber & Beaufort 1929	Norman 1934	Devi 1999	N=2	Mean ± SD
Dorsal rays	78	78 – 82	83 – 86 (78)	78 – 84	83 – 86 (78)	80 – 87	77 – 84	80 ± 3.8
Anal rays	58	58 – 62	61 – 62 (58)	58 - 62	61 – 62 (58)	58 - 62	62 – 66	63 ± 2.3
Lateral line	*	52	*	52 - 55	51 - 53	*	60	59 ± 1.4
Pectoral	10	*	11	11 – 13	11	*	11 - 12	11 ± 0.6
Pectoral (B)	8	*	*	7 - 9	*	*	6 - 9	8 ± 2.1
Ventral	6	*	*	6	*	*	5/5	5
Gillrakers	*	*	6	*	6	*	6	6
Caudal	3 + 11+3	*	*	*	*	*	4 – 6 + 11 - 12	

*Data not available

Table 43: Results of the correlation coefficient analysis on non-meristic characters of *Engyprosopon mogkii*

Characters	Range in SL	Mean	SD	R^2 in SL	Slope
Head length	3.6 - 4.02	3.79	0.21	0.98	0.96
Head Width	2.5 - 3.12	2.79	0.33	-0.16	-0.75
Eye Diameter (U)	10.1 - 11.4	10.77	0.64	1.00	-0.01
Eye Diameter (L)	11.1 - 11.8	11.47	0.31	1.00	0.55
Inter orbital	30.9 - 44.5	37.72	9.60	-1.00	-1.09
Snout to upper eye	10.7 - 14.1	12.67	1.77	0.90	-2.39
Upper jaw length	12.2 -13.97	13.36	0.99	0.98	0.48
Dorsal finlength	8.1 - 8.8	8.52	0.33	-0.49	0.27
Anal finlength	7.4 - 7.7	7.49	0.16	0.93	-1.35
Pectoral (O) finlength	5.2 - 5.9	5.49	0.39	0.58	0.69
Pectoral (B) finlength	8.4 - 12.2	10.50	1.93	-0.44	0.59
Pelvic (O) finlength	8.98 - 11.8	10.61	1.45	-0.49	0.71
Pelvic (B) finlength	9.6 -11.5	10.47	0.98	-1.00	0.30
Caudal finlength	5.1 - 5.7	5.41	0.29	1.00	-2.03
Dorsal base length	1.1 - 5.7	1.07	0.02	0.84	1.75
Anal base length	1.3 - 1.4	1.35	0.02	0.70	0.37
Pre dorsal	20.5 - 27.1	24.44	3.49	-0.26	-0.18
Pre anal	3.7 - 3.9	3.77	0.14	0.85	0.62
Pre pectoral (O)	3.6 - 4.01	3.81	0.28	1.00	1.47
Pre pectoral B	3.6 - 4.04	3.85	0.21	1.00	1.03
Pre pelvic O	4.71 - 6.8	5.64	1.09	0.96	1.76
BD1	2.3 -3.2	2.73	0.42	-0.21	-1.67
BD2	1.9 -2.6	2.30	0.37	-0.61	1.18
Characters	**Range in HL**	**Mean**	**SD**	**R^2 in HL**	**Slope**
Head Width	0.6 - 0.8	0.74	0.11	-0.37	-0.75
Head Depth	0.98 - 1.4	1.19	0.21	-0.18	1.00
Eye Diameter (U)	2.5 - 2.8	2.70	0.21	0.99	3.23
Eye Diameter (L)	1.1 -3.1	2.36	1.13	0.98	-1.13
Inter orbital	7.7 - 12.4	10.04	3.31	-1.00	-1.80
Snout to Upper eye	2.98 - 3.3	3.13	0.22	0.79	3.45
Snout to Lower eye	1.97 - 6.4	4.76	2.43	0.76	0.84
Chin depth	1.5 - 9.8	6.47	4.39	-0.20	2.07
Upper jaw length	0.3 - 3.5	2.40	1.79	0.91	11.47
Lower jaw length	2.7 - 3.8	3.23	0.75	-1.00	0.25
Dorsal finlength	2.03 -2.4	2.23	0.29	-0.67	2.02
Anal finlength	0.9 - 2.05	1.61	0.66	0.99	12.59

In males, spine seen on snout, none in interorbital area. Pelvic origin of blind side from the fifth ray of pelvic on blind side. Pelvic (ocular) origin just below outer most free tip of operculum. Caudal rounded, separate from dorsal and anal finrays. Body covered with feebly deciduous ctenoid scales on ocular side and cycloid scales on blind side. Gill rakers 6 - 7 on lower arch. Lateral line arising from behind outer free end of operculum, proceeding backward to form a plateau above the pectoral fin and then proceeding as a straight line upto caudal fin.

Colour: Body colour brown on ocular side, white on blind side. Colour remains the same in formalin.

Distribution:

World: Manado in sea (Bleeker, 1834); Amboina (Bleeker, 1856); Sorong (Fowler, 1939), Celebes, Bali (Gunther, 1862). Map showing localities were *Engyprosopon mogkii* has been recorded in the world is given in Fig. 67.

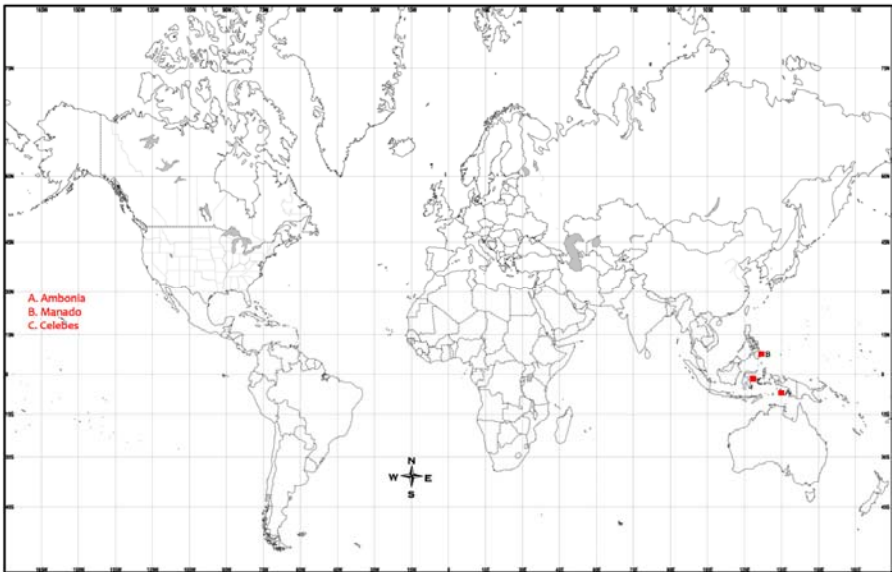


Fig. 67: Map showing localities were *Engyprosopon mogkii* has been recorded in the world.

India: Reported from Neendakara Map showing localities were *Engyprosopon mogkii* has been recorded in India is given in Fig. 68.

Fig. 68: Map showing localities were *Engyprosopon mogkii* has been recorded in India.

Taxonomic comments: The fish was first described by Bleeker in 1834 based on a sample from Manado and placed in genus *Rhombus*. Similar samples were collected from Amboina and Ternate also by Bleeker. However, in 1863, Bleeker described a new species *Achirus mogkii.* Weber and Beaufort in a footnote comments that "*with Achirus Mogkii, Nat. Tijdschr. Ned. Indie XXII, 1860, p. 101, named from Singapore, Bleeker* *certainly meant this species, as there is no Achirus of that name*". It was Weber (1913) who based on Siboga collections placed the species in genus *Engyprosopon* in which it continues to date.

Observations: Bleeker's original description gave the dorsal fin ocunts as 78; Norman (1927, 1934) gave on the higher side with 83 - 86. The present study has dorsal fincounts in the range 77 – 84, much in agreement with the earlier workers. The same holds true for the other fincounts also. Lateral line count of the present sample is slightly higher than the values reported by Weber and Beaufort (1929). Lalithambika Devi (1999) comments that the larvae of this species is very rare in the Indian Ocean and has been collected from Andaman Sea and Gulf of Aden. The present specimens were collected from trawler discards at Neendakara Fisheries Harbour. Earlier studies on flatfishes in India did not report of this species; this is the first report from Indian coast.

4.3.4.6 Genus *Grammatobothus* Norman, 1926

Grammatobothus Norman, 1926, *Biol. Res. Endeavour,* V: 253. (Type: ***Grammatobothus polyopthalmus*** Bleeker).

1) Body quite similar to *Bothus*; interorbital space very narrow, concave, similar in both sexes. Teeth uniserial in both jaws, teeth on front end not very large compared to teeth placed inside. First few dorsal fin rays (anterior) enlarged in both sexes. Ocular side with small ctenoid scales, cycloid scales on blind side. Lateral line developed on both sides of body.

2) Three species have been recorded from Indo – Pacific of which two *Grammatobothus polyopthalmus* and *G. pennatus* have been recorded from Queensland (Marshall, 1964). Only one species reported in the present study – *Grammatobothus polyopthalmus.*

4.3.4.6.1 *Grammatobothus polyopthalmus* Bleeker, 1866; Many eyed flounder

Platophrys (Platophrys) polyopthalmus Bleeker, 1865, *Ned. Tijd. Dierk.*, III: 46 (Sumatra, Indonesia); Bleeker, 1866-1872, *Atl. Ichth.*, VI :12, pl. ii, fig. 3; Mc Culloch, 1922, *Mem. Qd. Mus.*, VII (4): 244 (Queensland).

Rhomboidichthys angustifrons Gunther, 1880, *Shore Fish. Challenger,* I (6): 46, pl. xxi, fig. B (Arafura Sea, depth 30 fathoms); Alcock, 1890, *Ann. Mag. Nat. Hist.*, 6 (36): 435 (S.E coast of Ceylon); *J. Asiat. Soc. Bengal*, 1896, LXV, pt. 2: 328.

Psettylis ocellata, Jenkins, 1910, *Mem. Ind. Mus.*, 3: 27.

Grammatobothus polyopthalmus Norman, 1926, *Biol. Res. "Endeavour",* v: 253; Norman 1927, *Rec. Ind. Mus.,* XXIX: 35, fig. 8 (South coast of Ceylon, Burma); Mcculloch, 1929, *Mem. Aust. Mus.*, V: 276; Norman, 1934, *Syst. Monog. Flatfish.*, I: 245, fig. 187 (Burma, Ceylon, Queensland, Gulf of Martaban, Java Sea, Arafura Sea); Munroe, 1955, *Fish. Ceylon*: 260, pl. 49, fig. 750 (Ceylon); Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull.*, I: 18, fig. 4 (Gulf of Thailand); Kyushin *et al.*, 1982, *Fish China Sea*: 264; Kuronuma and Abe, 1986, *Fish. Arabian Gulf*: 248 (Arabian Gulf); Allen and Swainston, 1988, *Marine Fish. Aust.,*: 146; Amoaka *et al*., 1992, *Jap. J. Ichth*., 39 (3): 259 (Ryukyu Islands, Okinawa Islands); Li and Wang, 1995, *Fauna Sinica*: 215; Randall, 1995, *Coastal fish. Oman*: 357; Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 590; Allen, 1997, *Marine Fish. N. W. Aust.,*: 234; Carpenter *et al.*, 1997, *FAO Sp. Iden. Guide*: 229; Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.*, 8: 645; Nakabo, 2000, *Fish. Japan*: 1365; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* 6: 3824; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl.*, 63: 46; Nakabo, 2002, *Fish. Japan*, 2º ed.:1365.

Bothus* (*Platophrys*) *polyopthalmus Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.,* V: 119 (Sumatra, Java Sea).

Material examined: N = 2; TL 92.6 - 100.1 mm from Neendakara, Quilon.

Diagnosis: Dorsal with 80 – 86 rays, second to sixth rays prolonged and anal with 64 – 67 rays.

Meristic characters: D 80 - 86; A 50 - 66; P (O) 11; P_1 9 - 10; P_2 5 - 6; C 4 - 6+ 11 -14; Ll 65 – 66.

Body measurements as percent of SL (means in parentheses): HL 27. 4 - 28.3 (27.9); HD 51.7 – 52.8 (52.3); ED_1 8.4 - 9.1 (8.75); ED_2 7.8 – 8.6 (8.2); ID 0.3 - 0.6 (0.5); SNL_1 3.5 -3.7 (3.6), SNL_2 2.3 - 2.8 (2.5); P_1FLO 19.01 - 19.4 (19.2); P_2FLB 12.1 - 12.4 (12.3); V_1FLO 10.2 - 11.8 (10.98); V_2FLB 9.3 - 10.8 (10); CFL 23.3 - 23.5 (23.4); P_1BLO 4.4 - 4.5 (4.5); P_2BLB 4.1 - 4.5 (4.3); V_1BLO 2.7 ; V_2BLB 2.5 - 3.1 (2.8); DBL 89.05 -89.2 (89.11); ABL 65.9 - 67.2 (66.5); BD_2 61.8 -63.8 (62.8); anal height (at 20th ray) 14.2 – 15.9 (15); CD 11.7 - 12.8 (12.2); PDL 4.8 -5.4 (5.1); PAL 33.5 - 34.2 (33.8); V_1LO 23.8 - 25.6 (24.7); V_2LO 23.3 - 26.97 (25.12).

As percent of Head Length (means in parentheses): HD 186.9 - 188.6 (187.7); ED_1 30.6 - 32.23 (31.4); ED_2 28.4 - 30.6 (29.5); ID 1.2 - 2.2 (1.7); SNL_1 12.5 - 13.3 (12.9); SNL_2 8.3 – 9.8 (9.04); P_1BLO 67.3 - 70.6 (68.9); P_2BLB 43.8- 44.2 (43.98); V_1FLO 36.04 - 42.9 (39.5); V_2FLB 32.9 - 39.3 (36.1).

Description: Body deeply ovate in profile, dorsoventrally flattened, nearly circular in outline, body depth at 28th dorsal ray a little more than half the SL. Deep notch present on the dorsal profile of head in front of the interorbital space. Head length contained three times in SL; snout length less than half the eye diameter; interorbital space very narrow, concave; lower eye placed a little in front of the upper eye. Gill rakers short, 8 – 9 on lower limb. Mouth small, oblique and gently curved; maxillary ending a little beyond the anterior margin of the lower eye. Two small spines seen just above the maxillary in front of lower jaw. Uniserial teeth placed in both jaws, those on upper jaw larger at the front end, decreasing in size towards the inner area; those on lower jaw equal in size in the front and becoming smaller towards the inside. Gill rakers short, without serrations.

Head totally scaled; scales on ocular side ctenoid with fine short ctenii at the apical margin; cycloid on blind side. Lateral line present on both sides, origin at the outer free end of the operculum, proceeding with a short curve above pectoral finbasse and further as a straight line. Each scale with tubular structure and opens into each alternate scale at the side in a branch like manner. First five dorsal finrays elongated. Dorsal fin origin on blind side on a horizontal from lower margin of the upper eye, second to tenth dorsal fin rays more prolonged than the rest, the fin rays not free but attached by deeply incised interdorsal membrane. Second ray of pectoral fin on ocular side elongated in males extending to nearly middle region of body; elongation of pectoral rays not seen in females. Pelvic fin origin on ocular side on a vertical from the middle of the lower eye; pelvic fin ray on blind side origin at the third ray of ocular side. Last 4 rays of anal fin forked at tip. Outer 4 - 6 rays of caudal fin unbranched, rest branced. Interhaemal spine projects in front of anal fin origin on ocular side. A comparative statement of the meristic characters of *G. polyopthalmus* is given in Table 44. Results of the correlation coefficient analysis on non-meristic characters of *G. polyopthalmus* is given in Table 45.

Table 44 : A comparative statement of the meristic characters of *Grammatobothus polyopthalmus*

Meristic characters	Earlier workers											Present Study 2004 - 2010	
	Bleeker 1867	Gunther (as *P. polyopthalmus*) 1880	Weber & Beaufort 1929	Norman, 1934	Munroe 1955	Punpoka 1964	Ramanathan 1977	Kuronuma & Abe 1986	Amaoka 1992	Radhaman yamma 1988	Randall 1995	N = 2	Mean ±SD
Dorsal	83	83	77-85	80 – 86	77- 85	77- 86	79 – 85	75 – 85	84 - 86	74 – 76	80 – 86	76 – 77	76.5±2.1
Anal	65	62	61-68	64 – 67	61- 68	61- 68	65 – 68	61 - 66	65 - 68	62 – 65	64 – 67	62 – 65	63.5 ± 2.1
Pectoral (O)	14	*	17-13	13 – 15	*	*	14 – 15	*	15 - 17	13	13 - 15	11 -- 13	12 ± 1.4
Pectoral (B)	13	*	11-14	*	*	*	11 - 13	*	12 - 14		*	9 - 10	9.5 ± 0.7
Lateral line	*	80	77-83	77 – 82	77-83	61-68	62 - 68	*	75 - 77	71 - 79	77 – 82	65 - 66	66.5 ± 0.71
Gill rakers	*	*	*	8 - 9	*	*	2 – 3 + 7	*	0-3+7-8		8 - 9	2 – 3 + 7	*

*Data not available

Table 45: Results of the correlation coefficient analysis on non-meristic characters of *Grammatobothus polyopthalmus*

Characters	Range in SL	Mean	SD
Head length	3.5 - 3.6	3.59	0.08
Head depth	1.89 - 1.9	1.91	0.03
Eye diameter (Upper)	10.98 - 11.9	11.45	0.66
Eye diameter (Lower)	11.6 - 12.9	12.21	0.90
Snout to upper eye	27.3 - 28.3	27.79	0.66
Snout to lower eye	36.2 - 43.96	40.06	5.51
Pectoral fin length (O)	5.2 - 5.3	5.21	0.07
Pectoral fin length (B)	8.1 - 8.3	8.17	0.11
Pelvic fin length(O)	8.5 - 9.8	9.16	0.93
Pelvic fin length (B)	9.3 - 10.8	10.01	1.05
Caudal fin length	4.25 - 4.3	4.28	0.03
Pre dorsal	18.6 - 20.8	19.73	1.54
Pre anal	2.92 - 2.99	2.96	0.05
Pre pelvic (O)	3.9 - 4.2	4.05	0.21
Pre pelvic(B)	3.7 - 4.3	4.00	0.42
Characters	**Range in HL**	**SD**	**Mean**
Eye Diameter (U)	3.1 - 3.3	0.12	3.19
Eye Diameter (L)	3.3 - 3.5	0.18	3.40
Inter orbital length	44.8 - 82.5	26.65	63.67
Snout to upper eye	7.5 - 7.99	0.35	7.74
Snout to lower eye	10.2 -12.2	1.30	11.1
Pectoral fin base (O)	1.4 -1.5	0.05	1.45

Colour: Pale brownish on ocular side with three large prominent ocelli two on either side of the pectoral fin and one on the middle area on the lateral line; head and body covered with small brownish spots which extend onto finrays; outer ends of caudal finrays in the middle portion have brown markings. Pectoral fin at its outer ends has pale transverse bars. Head and body covered with small distinct dark spots. Anal fin with small dusky spots.

Sexual dimorphism: The species exhibits sexual dimorphism. The third to seventh dorsal fin rays in male are highly elongated and the interfin membrane greatly expanded in males. The second ray of the pectoral fin is also elongated in males.

Distribution:

World:

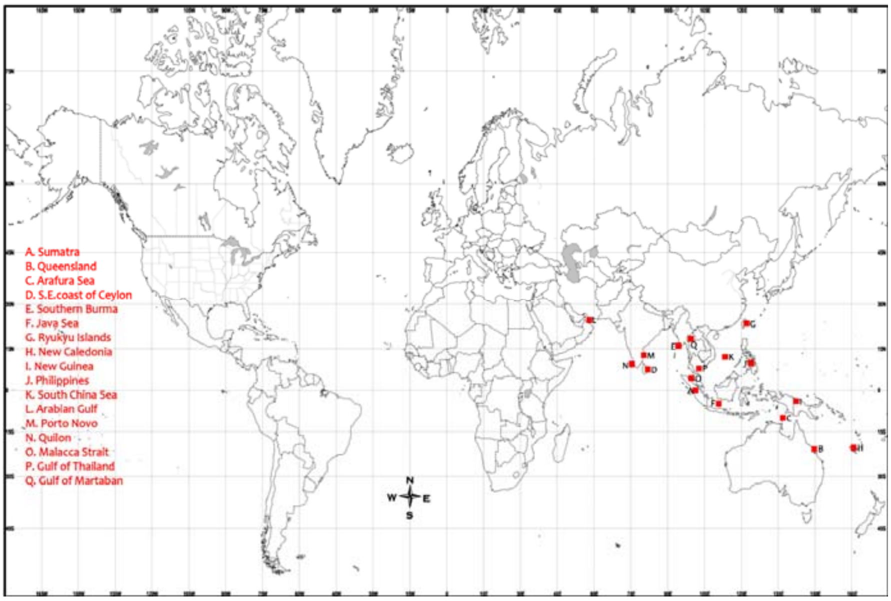


Fig. 69: Map showing localities were *Grammatobothus polyopthalmus* has been recorded in the world.

Reported from Sumatra, Indonesia (Bleeker, 1865); Arafura Sea (Gunther, 1880); different localities of the Indo–Australian Archipelago, off Coast of Negrais, Arabian Gulf, Burma, Gulf off Martaban, Java Sea, Malacca Strait, Arafura Sea, (Bleeker, 1866); Burma, Ceylon, Queensland, Gulf of Martaban, Java Sea, Arafura Sea (Norman, 1927, 1934); Ceylon (Munroe, 1955); Gulf of Thailand (Punpoka, 1964); Sumatra, Java Sea (Weber and Beaufort, 1929); Queensland, Gulf of Thailand, Ceylon, South China Sea, Japan, Malaya Peninsula, Okinawa Island, Japan, New Caledonia, Papua

New Guinea, Phillippines to Australia, Sumatra, Indonesia. (Bleeker, 1866; Norman, 1934, Kyushin *et al*., 1982, Gloerfelt –Tarp and Kailola, 1984, Sainsbury *et al*., 1985). Map showing localities were *Grammatobothus polyopthalmus* has been recorded in the world is given in Fig. 69.

India: Reported from Porto Novo on East coast (Ramanathan, 1977) and Neendakara on the West coast. The present report is from Quilon, Cochin, off the south west coast of India. Map showing localities were *Grammatobothus polyopthalmus* has been recorded in India is given in Fig. 70.

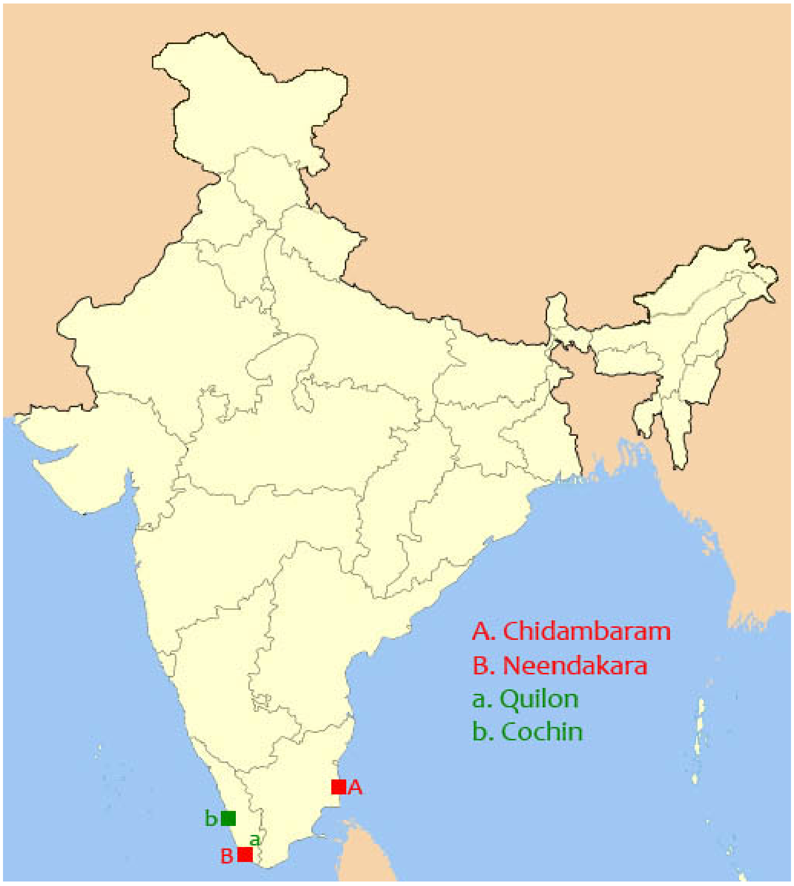


Fig. 70: Map showing localities were *Grammatobothus polyopthalmus* has been recorded in India.

Habitat: Reported from shallow waters with sandy bottom covered with shells and broken coral pieces and from depths of 35 – 55 m.

Taxonomic comments: The fish was first described by Bleeker based on collections from Sumatra as *Platophrys* (*Platophrys*) *polyopthalmus*. Mc Culloch (1922) recorded the fish from Queensland, but commented that the specimen "*differs from Bleeker's description and figure only in having the rostro–frontal border a little more convex. The elongated pectoral fin reaches nearly to end of dorsal*". Gunther (1862) described a new species of fish during the "*Challenger Voyages*" as *Rhomboidichthys angustifrons* based on a sample from Arafura Sea at a depth of 30 fathoms. The description was based on a single fish. Gunther mentions of three large black ocelli edged with white placed in the form of a triangle on the body as well as "*the anterior dorsal rays are nearly detached and produced*".

Observations: Norman (1934) described the fish based on samples from Ceylon. Munroe (1955) described the fish as *Grammatobothus polyopthalmus* based on collections from coastal waters in 32 fathoms off Ceylon. In the description no mention is made about the pectoral fin elongation. However, the meristic counts given by Gunther (1880) for *Rhomboidicthys angustifrons* relate more closely to that of Norman (1934) and hence *Rhomboidicthys angustifrons* can be considered as a synonym of *G. polyopthalmus* described by Norman. Meristic counts agree more with the work of Punpoka (1964).

The species resembles *Pseudorhombus triocellatus* in the presence of the three ocelli on the ocular surface, but differs in the presence of numerous spots in addition to the 3 ocelli. The first six rays of the dorsal fin are elongated in *G. polyopthalmus*, the fourth being the longest; in *P. triocellatus*, the first eight rays are elongated, the length decreasing from the first to the eighth. Dorsal fin count reported by earlier workers show wide range (74 – 86). Norman (1934) mentions higher counts (80 – 86). However the present collection had lower counts for dorsal fin. The lateral line counts of the present study match with that of Punpoka (1964) from Thailand and Ramanathan (1977) from Porto Novo. The ratio of HL in SL for the present specimen agrees well with that of Randall (1995) (3.5 – 4 in SL).

4.3.4.7 *Laeops* Gunther, 1880.

Laeops Gunther, 1880, *Shore Fishes "Challenger"*:29 (Type: ***Laeops parviceps*** Gunther); Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) VIII: 601; Mc Culloch, 1919, *Checklist N.S Wales,* II: 36; Chen and Weng, 1965, *Biol. Bull.*, 27: 24.

Scianectes Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII (2): 284; Alcock, 1890, *Ann. Mag. Nat. Hist.*, (6): VI: 216 (***Scianectes macropthalmus*** Alcock).

Lambdopsetta Smith and Pope, 1906, *Proc. U.S. Nat. Mus.*, XXXI: 496 (***Lambdopsetta kitaharae***).

Laeoptichthys Hubbs, 1915, *Proc. U.S Nat. Mus.*, XLVIII: 460 (***Laeoptichthys fragilis***).

Description: Body elongate, strongly compressed, broad just behind eyes, with a very narrow caudal peduncle. Eyes large, sinistral, separated by a narrow bony interorbital ridge, the lower a little in advance of the upper. Upper profile of head convex above and behind eyes. Interorbital is same in both sexes. Spines absent on rostrum and snout. Nostrils present on both sides, two each - an anterior tubular one with a flap at its outer tip, and a round posterior one without a flap. Small mouth, cleft narrow, oblique in pattern, curved towards the blind side, protractile, nearly well developed on both jaws. Maxillary extending below anterior margin of lower eye, in some a little beyond. Teeth very sharp, present in jaws in narrow villiform band, uniserial on upper jaw, appearing biserial on lower jaw. Dentition well developed on blind side compared to ocular side. Teeth pattern varies in different species. Vomer toothless. Gill rakers are few, small, slender, with no serrations on its posterior part. Body scales deciduous, when present cycloid on both sides. Both the jaws as well as base of pectoral fin naked.

Dorsal fin origin on snout, on a horizontal in front of the upper eye; first two rays separated from the rest by a space. In some, the first ray has a skin like fold. Anal fin origin on a vertical below the base of the pectoral fin, fin rays simple, scaled on ocular side, increasing in size towards the centre and then decreasing towards the caudal peduncle. Pectoral fin lengths unequal, ocular one longer than the blind one. Pelvic bases not symmetrical, the blind one origin at the fourth ray of the ocular. All rays simple. Caudal fin rounded at tip, inner 9 rays branched, outer simple and unbranched. Lateral line origin from upper free end of the operculum, proceeding backward with a slight hump above the pectoral fin on ocular side, ending at the caudal peduncle base. Body covered with small scales, cycloid on blind side, mostly cycloid on ocular side also. Vent on blind side above the anal fin origin.

Distribution: Gulf of Aden, Sea of Oman, Arabian Sea, Bay of Bengal, Japan, Arafura Sea, coasts of Australia.

Taxonomic comments: The genus *Scianectes* was erected by Alcock (1889) to describe a new species *Scianectes lophoptera* collected at 60 fathoms from Devi River, Mahanadi delta of Bay of Bengal. The characters mentioned are similar to that used for *Laeops*. Norman (1931) comments that "*Scianectes and Lambdopsetta are synonyms of Laeops, the type species of which (L. parviceps) has the first two dorsal rays detached from the remainder of the fin*". *Laeoptichthys* Hubbs is said to differ in having the teeth in a "*single even row*". Genus *Laeops* was established to include two Indian species (*S. lophoptera* and *S. macropthalmus*) taken in 68 to 100 fathoms by the "*Investigator*". Alcock (1890) opines that *"I beg now to amend that diagnosis and to place Scianectes is what now appears to me to be its position, near Laeops Gunther".*

Observations: Of the several species reported from the Indo-Pacific, four were reported from India by Norman (1927) – *Laeops guentheri*, *L. nigrescens*, *L. macropthalmus* and *L. lophoptera*. Ten species were described by Norman (1934) in '*Monograph of Flatfishes*', this was seven more in addition to the earlier list. Species described were – *L. nigromaculatus*, *L. parviceps*, *L. natalensis*, *L. kitaharae*, *L. lanceolata*, *L. variegata* and *L. pectoralis*. Norman (1934) opines that *Scianectes* and *Lambdopsetta* are clearly synonyms of *Laeops* and there seems to be no valid reason for retaining *Laeoptichthys* as a distinct genus. In *Laeops nigromaculatus* the first two rays are continuous with the remainder of the dorsal fin, but in other respects this species is a typical *Laeops*. Smith (1961) reports that they are seen in fairly deep waters of the Indo–Pacific. Of the 10 species recorded worldwide, three were recorded from South African waters–*Laeops pectoralis*, *L. kitaharae* and *L. nigromaculatus*. Later, Hensley (1986) recorded one more species of *Laeops* from South African waters – *Laeops natalensis*. In the present study, four species of *Laeops* were recorded from Indian waters – *Laeops guentheri*, *Laeops macropthalmus*, *Laeops natalensis* and *Laeops parviceps.*

4.3.4.7.1 *Laeops guentheri* Alcock, 1890

Gunther's flounder

Laeops guentheri Alcock, 1890, *Ann. Mag. Nat. Hist.*, VI: 438 (Gulf of Martaban, 20 fathoms, off Ganjam and Vishakapatanam, 15–30 fathoms); Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV (2): 328; Alcock, 1898, *Illust. Zool. "Investigator", Fish.*,: pl. xxii, fig. 4; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 37 (north end of Persian Gulf, 15 fathoms); Norman, 1934, *Syst. Monog. Flatfish.*, I: 257, fig. 198 (Persian Gulf, East coast of India, Ganjam and Vishakhapatnam coasts, Gulf of Martaban); Blegvad, 1944, *Danish Sci. Invest. Iran*, pt.3: 203, fig.124 (West of Bushire); Fowler, 1956, *Fish. Red Sea S. Arabia*: 172, fig. 92; Pradhan and Dhulked, 1962, *J. Mar. Biol. Ass. India*, 4(2): 240 (Mysore coast, Tuticorin); Saramma, 1963, *Bull. Dept. Mar. Biol.*, I: 70 (off Alleppey); Chen and Weng, 1965, *Biol. Bull. Tunghai Univ.*, 27: 28, fig. 45; White and Barwani, 1971, *Truc. States Counc. Dubai*, I: 52 (Arabian Gulf); Randall, 1995, *Coastal Fish Oman*: 357; Carpenter *et al.*, 1997, *FAO Sp. Iden. Guide, Kuwait*: 230; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide*, IV (6): 3835; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (suppl. 1): S122.

Scianectes macropthalmus (part) Jenkins, 1910, *Mem. Ind. Mus.*, III: 27.

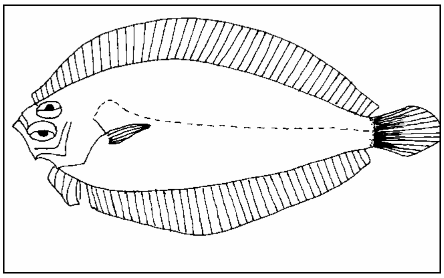


Plate XXI: *Laeops sguentheri* Alcock, 1890

Material examined: N = 1, TL 120.84 - 128.42 mm from Munambam.

Diagnosis: Dorsal profile slightly convex behind eye; teeth in villiform bands; maxillary hardly reaching anterior edge of eye.

Meristic counts: D 98 - 102; A 80 - 81; P_1 9 – 12; Ll 100; C 3+12+2

Body proportions as percent of SL (mean in parentheses): HL 20.7-21.5 (21.1); HW 29.23; HD 17.02 -18.58 (17.8); ED_1 6.69; ED_2 7.13; ID 1.68; UJL 5.65; LJL 7.8; BD_1 29.7 – 32.9 (31.3); BD_2 41.57 – 41.58 (41.57); DFL 8.6 – 10.6 (9.6); AFL 9.4 – 11.1 (10.3); P_1FLO 11.3 – 13.5 (12.4); P_2FLB 8.3; V_1FLO 5.2 – 6.8 (5.9); V_2FLB 6.8 – 7.5 (7.1); CFL 14.6; DBL 92.6 – 93.4 (92.99); ABL 79.6 - 83.8 (81.7); P_1BLO 2.5 – 3.3 (2.9); P_2BLB 2.15; V_1BLO 4.02 – 4.3 (4.2); V_2BLB 2.91; CBL 7.16; PrOL 7.5; PBU 11.6; PBL 11.3.

Body proportions as percent of HL (mean in parentheses): HW 135.8; HD 79.1 – 89.88 (84.5); ED_1 31.1; ED_2 33.1; ID 7.8; UJL 26.2; LJL 36.2; BD_1 137.9 – 159.2 (148.6); BD_2 193.1 – 201.1; DFL 40.1 – 51 (45.6); AFL 45.6 -51.1 (48.5); P1FLO 54.8 – 62.7 (58.8); P_2FLB 38.7; V_1FLO 24.03 – 32.6 (28.3); V_2FLB 32.6 – 35 (33.8); CFL 68; DBL 430 – 451.8 (446.9); ABL 369.7 – 405.4 (387.6); P_1BLO 11.7 – 15.9 (13.8); P_2BLB 10; V_1BLO 19.5 – 19.8 (19.6); V_2BLB 13.5; CBLO 33.3; PrOL36.3; PBU 56.4; PBL 54.7.

Description: Body profile on the dorsal and ventral side convex. Snout pointed, body broadest at outer opercular area, tapering to tail. Eyes placed on left side, close together, lower a little in front of the upper, separated by a narrow interorbital ridge. Upper eye bulges onto the dorsal profile. Two nostrils, the first placed in the concave interorbital space in the front. Orbital spines seen on the lower eye. Teeth in villiform bands in each jaw, mostly on blind side. Maxillary scarcely reaching a vertical below anterior margin of eye. Mouth small, protractile, opening upward; fine villiform teeth in bands on each jaw on blind side. Gill cleft very narrow, gill membranes united throughout. First ray of dorsal fin above posterior nostril of blind side, first two dorsal fin rays detached from remainder of fin rays, no elongated rays in dorsal fin. Anal fin origin on a vertical behind free end of the operculum. Pectoral rays almost equally developed, left side longer than right. Pelvic fin origin at the ventral end of operculum. Interhaemal spine prominent. Lateral line origin from upper outer free end of operculum, with a small elevated narrow plateau above pectoral fin, proceeding straight to caudal fin base. Lateral line developed on ocular side only. Scales cycloid on both sides of body, deciduous. Caudal obtusely pointed. A comparative statement of the meristic characters of *Laeops guentheri* is given in Table 46. Results of the correlation coefficient analysis on non-meristic characters of *Laeops guentheri* is given in Table 47.

Table 46: A comparative statement of the meristic characters of *Laeops guentheri*

Meristic characters	Earlier workers			Present work 2004 - 2010
	Alcock 1890	Pradhan 1977	Chen and Weng, 1967	N = 1
Dorsal rays	94 - 98	96 - 102	64	59
Anal rays	79 - 80	76 - 80	54	49
Pectoral (O)/(B)	13	*	9/8	9/8
Lateral line	*	*	*	68
Ventral	6	*	6	6
Caudal	16	*	18	17

*Data not available

Table 47: Results of the correlation coefficient analysis on non-meristic characters of *Laeops guentheri*

Characters	Range in SL	Mean	Slope
Head length	4.7 - 4.8	4.74	0.11
Head Depth	5.4 - 5.9	5.63	0.36
Body depth$_1$	3.04 - 3.4	3.20	0.69
Dorsal FL	9.5 - 11.6	10.53	0.32
Anal FL	9.02 - 10.6	9.82	-0.09
Pectoral (O) FL	7.4 - 8.8	8.12	-0.13
Pelvic (O) FL	14.8 -19.3	17.08	0.24
Pelvic (B) FL	13.3 - 14.8	14.05	-0.02
Anal BL	1.19 - 1.26	1.22	1.31
Pectoral (O) BL	30.4 - 39.6	35.01	0.12
Pelvic (O) BL	23.4 - 24.9	24.14	0.01
Characters	**Range in HL**	**Mean**	**Slope**
Head Depth	1.1 - 1.26	1.19	3.27
Body depth$_1$	0.6 - 0.7	0.68	6.26
Dorsal FL	2 - 2.5	2.23	2.91
Anal FL	1.9 - 2.2	2.07	-0.84
Pectoral (O) FL	1.6 - 1.8	1.71	-1.18
Pelvic (O) FL	3.1 - 4.2	3.61	2.21
Pelvic (B) FL	2.9 - 3.1	2.96	-0.19
Anal BL	0.2 - 0.3	0.26	11.87
Pectoral (O) BL	6.3 - 8.5	7.41	1.08
Pelvic (O) BL	5 - 5.1	10.00	0.12

Colour: Ocular side brownish, dorsal and anal fin rays dark in colur, black towards tips.

Distribution:

World: South east coast of Ceylon, 20 – 40 fathoms (Alcock, 1890); Persian Gulf, Gulf of Martaban (Norman, 1927). Map showing localities were *Laeops guentheri* has been recorded in the world is given in Fig. 71.

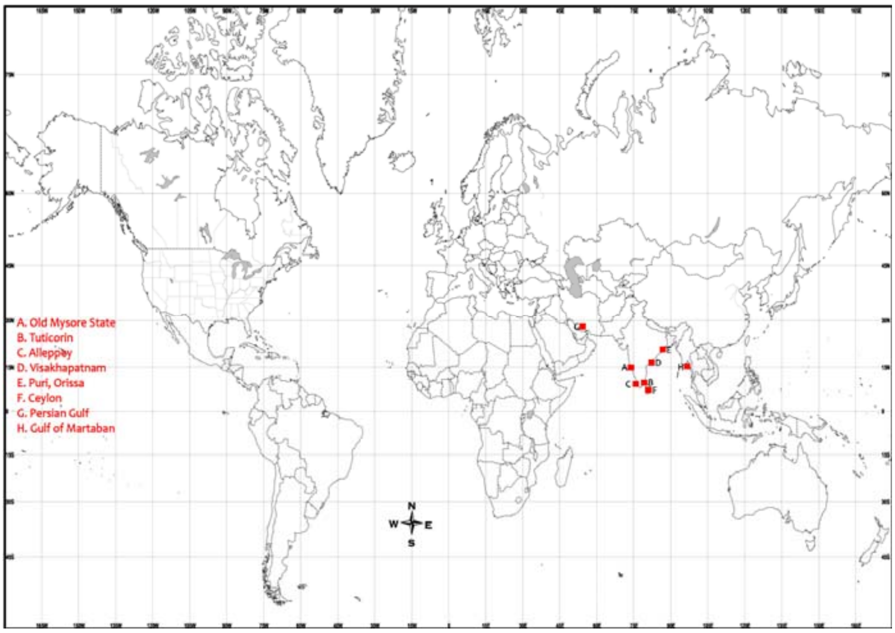


Fig. 71: Map showing localities were *Laeops guentheri* has been recorded in the world.

India: Reported from East coast of India, Mysore, Tuticorin (Pradhan and Dhulked, 1962); Alleppey (Saramma, 1963); Vishakapatnam coast, Ganjam Coast, Puri, Orissa Coast. Map showing localities were *Laeops guentheri* has been recorded in the world is given in Fig. 72.

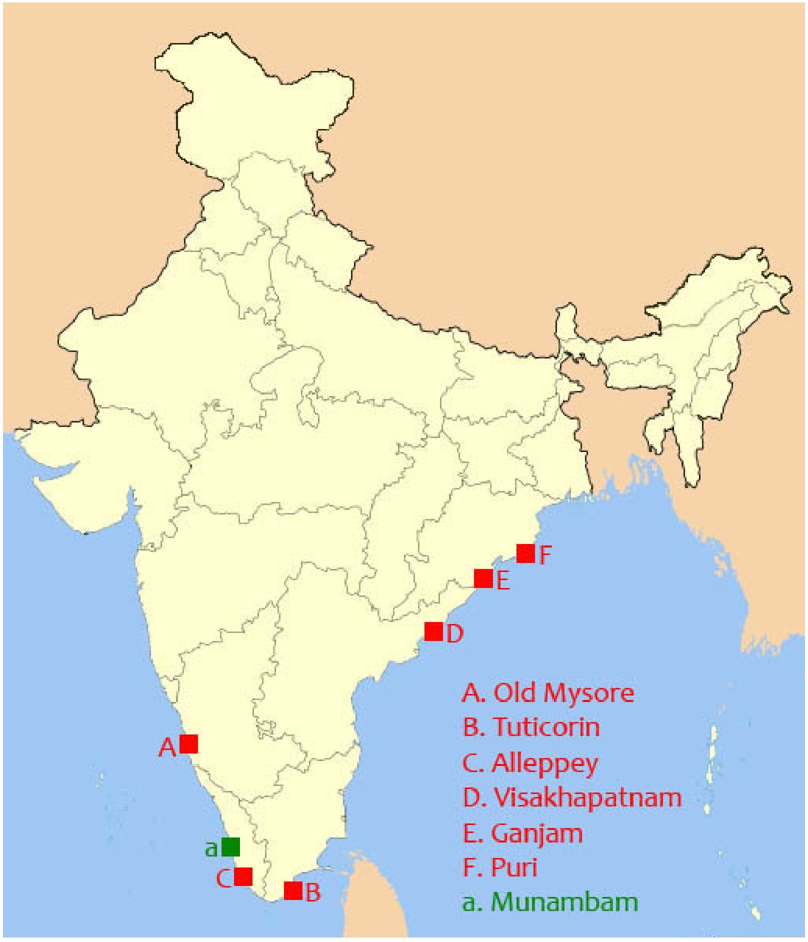


Fig. 72: Map showing localities were *Laeops guentheri* has been recorded in India.

Habitat: Reported upto 20 fathoms.

Taxonomic comments: The species was first described by Alcock (1890) as *Laeops guentheri* in 1890. He mentions that "*this species is very similar to Laeops parviceps Gunther, but the character which distinguishes it are so constant throughout a number of individuals that one is oblidged to recognize their specific value*". A similar species described in genus *Scianectes* as *S. macropthalmus* by Jenkins was later synonymised with *L. guentheri*.

Observations: Alcock (1890) reported the largest specimen to be 45 inches. Norman (1927) comments that "*this species is perhaps identical with L. parviceps Gunther, from the Arafura Sea which has however a slightly smaller head, with less arched dorsal profile, and a somewhat larger number of dorsal (104) and anal (86) rays*".Values of HL in SL in the present study is similar to that reported by Alcock (4.5 – 4.8).

4.3.4.7.2 *Laeops macropthalmus* (Alcock, 1889)

Scianectes macropthalmus Alcock, 1889, *J. Asiat. Soc. Bengal*, lviii, pt. ii: 292, pl .xvi, fig. 4 (Southwest of Akyab, 40 miles, 100 fathoms); Alcock, 1889, *Ann. Mag. Nat. Hist.*, 6 (4): 398; Alcock, 1889, *Ann. Mag. Nat. Hist*., 6 (6): 216; Alcock, 1896, *J. Asiat. Soc. Bengal* LXV, pt. 2: 329; Alcock, 1905, *Illust. Zool. "Investigator" Fishes*, pl. xxiii, fig. 1.

Scianectes lophoptera Alcock, 1889, *J. Asiat. Soc. Bengal*, lviii (2): 284, pl. xvi, fig.2.

Laeops macropthalmus Alcock, 1899, *Cat. Indian Deep Sea Fish*.,: 128; Regan, 1905, *J. Bombay Nat. Hist. Soc*., XVI: 329 (South of Oman, 180 fathoms); Norman, 1934, *Syst. Monog. Flatfish*: 254, fig. 195; Fowler, 1956, *Fish. Red Sea*, I: 171, fig. 90.

Laeops lophoptera Norman, 1927, *Rec. Ind. Mus*., XXIX: 38.

Plate XXII: *Laeops macropthalmus* (Alcock, 1889)

Material examined: N = 20; TL 118.71 – 159.96 mm (Sagar Sampada collection, St. 7. Cruise No. 250, EXPO Gear) at 256.1 m depth off Diglipur (Andaman Islands), dt. 5.11.06, Lat. 11. 20. 29, Long. 74. 49.41).

Diagnosis: Dorsal fin origin above posterior nostril on blind side; head 3 – 3.6, ED 3.75 – 4.2 in HL.

Meristic characters: D 80 – 85; A 60 – 70; Ll 72 -83, P1 10 -13; P2 9 – 13; V_1 6; V_2 6; C 15 – 18.

Body proportions as percent of SL (mean in parentheses): HL 25.7 – 31.9 (29.5); HW 30.6 – 39.02 (35.7); HD 16.1 – 30.2 (21.4); ED_1 7.3 – 8.1 (7.8); ED_2 6.04 – 8.6 (7.5); ID 0.5 – 1.5 (1.01); SNL_1 5.5 – 8.1 (6.3); SNL_2 3.8 – 5.3 (4.4); PrOU 0.6 – 2.2 (1.4); PrOL 3.4 – 5.1 (4.3); PBU 15.7 -18.7 (17.3); PBL 17.2 – 20.6 (18.4); BD_1 32.5 – 40.3 (36.7); BD_2 33.3 – 42.2 (39.7); DFL 8.95 – 15.5 (12.01); AFL 11.8 – 18 (13.5); P_1FLO 11.8 – 21.3 (17.9); P_2FLB 9.5 – 13.1 (11.4); V_1FLO 4.4 – 13.02 (7.03); V_2FLB 5.4 – 10.3 (7.1); CFL 12.7 -21.6 (18.6); DBL 91.95 – 95.85 (93.7); ABL 67.9 – 80.5 (75.4); P_1BLO 2.4 – 3.2 (2.7); P_2BLB 1.2 -3.1(1.8); V_1BLO 2.5 – 8.7 (6.1); V_2BLB 2 – 5.2 (3.5); CPD 4.6 – 7.9 (6.7); Interpelvic 3.1 - 6.2 (4.3); PDL 3.4 – 7.13 (4.9); P_1LO 27.4 – 29.6 (28.6); P_2LB 26.5 – 30.04 (27.9); V_1LO 19.2 – 23.5 (20.9); V_2LB 19.6 – 24.2 (22.02); UJL 6.1 – 8 (6.9); LJL 5.4 – 7.8 (6.4); CD 3.2 – 6.8 (4.13).

Body proportions as percent of HL (mean in parentheses): HW 106.3 – 135; HD 55.9 - 84.4; ED_1 24.7 - 29.1; ED_2 21 - 28.9; ID 1.7 - 5.8; SNL_1 18.4 - 25.1; SNL_2 12.8 - 17.6; PROU 2.1 - 7.6; PROL 11.2 - 18.4; PBU 53.3 - 67.6; PBL 57.8 - 68.8; BD_1 112.3 - 144.1; BD_1 115.7 - 157.3; DFL 29.6 - 53.9; AFL 39.1 - 63.6; P_1FLO 42.8 - 77.1; P_2FLB 32.5 - 43.4; V_1FLO 15.3 – 46; V_2FLB 16.9 - 36.4; CFL 43.3 -

83.2; DBL 297.4 - 367.6; ABL 229.3 - 303.6; P_1BLO 8 - 11.4 P_2BLB 4 - 10.8; CPD 19.6 - 26.3; Inter pelvic 9.3 - 21.3; PDL 11.8 - 20.5; PAL 86.6 - 104.5; P_1LO 92.1 - 101.5; P_2LB 91 - 100.7; V_1LO 64.9 - 78.7 V_2LB 67.4 - 83.8; UJL 20.7 - 26.3; LJL 18.2 - 25.9; CD 10.3 - 15.8.

Description: Body oblong, broadest just behind outer free end of operculum, tapering to tail; upper profile of head more or less convex above and behind eyes. Eyes sinistral, placed close together separated by a bony interorbital ridge; the lower eye a little in front of upper, the upper touching the dorsal profile. Snout pointed, mouth terminal, lower jaw projecting a little in front of upper jaw. Two nostrils one in front of the interorbital region, the other a little below. A small spine present at the base of operculum just behind pelvic base (ocular). Dorsal fin origin on snout on the blind side above the posterior nostril. First ray has a skin like extension on the inner side. Maxillary extending beyond anterior edge of eye. Teeth curved, uniserial in upper jaw, 17 in number, close set, double on lower jaw (27). Teeth placed widely set on blind side. Lower gill rakers 6 – 8. Lateral line origin from upper end of operculum, followed by a small inverted cup curve proceeding straight to caudal peduncle. Caudal fin tip obtusely pointed. Pectoral fin on ocular side long; pelvic fin on ocular side is placed in advance of that on blind side. Caudal fin obtusely pointed. A comparative statement of the meristic characters of *Laeops macropthalmus* is given in Table 48. Results of the correlation coefficient analysis on non-meristic characters of *Laeops macropthalmus* is given in Table 49.

Table 48 : A comparative statement of the meristic characters of *Laeops macropthalmus*

Meristic characters	Earlier workers				Present work 2004 - 2010	
	Alcock 1889	Norman 1934	Shen and Lee 1981	Ochiai 1963	N = 20	Mean ± SD
Dorsal	85 - 88	85 – 90	70 – 78	64 - 74	80 - 85	83 ± 2.3
Anal	68	65 – 70	51 - 55	45 – 55	60 - 70	67 ± 2.13
Pectoral (O/B)	11/12	13 – 15 (O)	*	*	10 -13/ 9 -13	12 ± 0.99/ 11 ± 1.3
Lateral line	95	93	69 – 77	53 - 71	72 - 83	76 ± 2.4
Caudal	17	*	18	*	15 – 18	16 ± 0.7
Ventral	*	*	5/5	*	6/6	6

*Data not available

Table 49: Results of the correlation coefficient analysis on non-meristic characters of *Laeops macropthalmus*

Characters	Range	Mean	SD	R^2 on SL	Slope
Head length	3.1 - 3.9	3.4	0.15	0.64	2.8
BD_1	2.5 - 3.1	2.7	0.14	0.79	1.68
Max. body depth	2.4 - 3.0	2.5	0.15	0.85	1.52
Dorsal FL	6.4 - 11.2	8.5	1.19	0.002	0.23
Anal FL	5.6 - 8.5	7.5	0.68	0.14	1.76
Pectoral (O) FL	4.7 - 8.3	5.6	0.77	0.11	1.08
Pectoral(B) FL	7.98 - 10.5	8.9	0.77	0.31	2.56
Caudal FL	4.6 - 7.9	5.5	1.05	0.26	1.05
Pectoral (O) BL	31.1 – 41.95	36.8	2.94	0.42	15.06
Pectoral (B) BL	32.7 - 85.2	59.3	13.57	0.29	7.28
Pelvic (O) BL	11.5 - 25.6	17	4.43	0.44	2.77
Pelvic (B) BL	19.3 - 43.7	29.5	7.17	0.35	4.32
Caudal peduncle depth	12.6 - 16	14.7	1	0.69	7.09
Characters in HL	**Range**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head Width	0.7 - 0.9	0.83	0.05	0.79	0.49
Head Depth	1.2 - 1.8	1.42	0.19	0.62	0.44
Eye Diameter (U)	3.4 - 4.04	3.79	0.16	0.64	2.95
Eye Diameter (L)	3.5 - 4.8	3.98	0.39	0.58	1.54
Inter orbital	17.3 - 57.4	32.97	12.33	0.02	0.69
SNL_1	3.99 - 5.4	4.73	0.39	0.51	1.87
SNL_2	5.7 - 7.8	6.78	0.57	0.37	2.45
Preorbital (U)	13.2 – 47.97	23.67	9.63	0.02	-0.64
Preorbital (L)	5.4 - 8.97	7.04	0.89	0.2	1.47
Post orbital (U)	1.5 - 1.9	1.71	0.09	0.58	1.13
Post orbital (L)	1.5 - 1.7	1.6	0.08	0.67	1.07
BD_1	0.7 - 0.9	0.8	0.05	0.65	0.44
Pectoral (O) FL	1.3 - 2.3	1.64	0.22	0.1	0.3
Pelvic (O) FL	2.2 - 6.5	4.36	0.83	0	0.03
Pectoral (O) BL	8.8 - 12.5	10.83	0.99	0.26	3.4
Pelvic (O) BL	3.3 - 8.2	5.04	1.41	0.29	0.63
Inter pelvic	4.7 - 110.75	7.33	1.86	0	0.02
Prepectoral (O)	0.99 - 1.09	1.02	0.03	0.59	0.57
Pre pectoral (B)	0.99 - 1.1	1.05	0.04	0.33	0.51
Pre pelvic (O)	1.27 - 1.54	1.41	0.09	0.14	0.25
Pre pelvic (B)	1.19 - 1.5	1.34	0.09	0.29	0.3
Upper jaw length	3.8 - 4.8	4.29	0.33	0.18	1.57
Lower jaw length	3.85 - 5.5	4.67	0.49	0.31	1.3
Chin depth	6.3 - 9.67	7.66	1.16	0.35	2.04

*Scale***:** Body covered with deciduous scales. Scales are roundish with circular radii arising from basal grey spotted area.

Colour: Body off white to grayish. Fin rays brittle like, blackish in colour. Dorsal and anal fins outer end dark in colour, middle rays of caudal and distal part of pectoral dark brown or blackish in colour. Edge of gill cover dusky.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 75, 76); the linear regression equations obtained were

Head length on SL	:	$y = 0.23\ x + 8.00$; $R^2 = 0.64$; $p < 0.001$
Body depth (BD_1) on SL	:	$y = 0.47\ x – 12.8$; $R^2 = 0.79$; $p < 0.001$
Body depth (BD_2) on SL	:	$y = 0.56\ x - 20.1$; $R^2 = 0.85$; $p < 0.001$
Eye diameter (upper) on HL	:	$y = 0.21\ x + 1.7$; $R^2 = 0.64$; $p < 0.001$
Eye diameter (lower) on HL	:	$y = 0.38\ x – 4.6$; $R^2 = 0.58$; $p < 0.001$
Snout length (SNL_1) on SL	:	$y = 0.15\ x - 0.04$; $R^2 = 0.37$; $p < 0.001$

Results of regression analysis showed that the variation of various body parameters in relation to standard length and head length is highly significant.

Distribution:

World: Reported from Sea of Oman, Burma (Norman, 1934). Map showing localities were *Laeops macropthalmus* has been recorded in the world is given in Fig. 73.

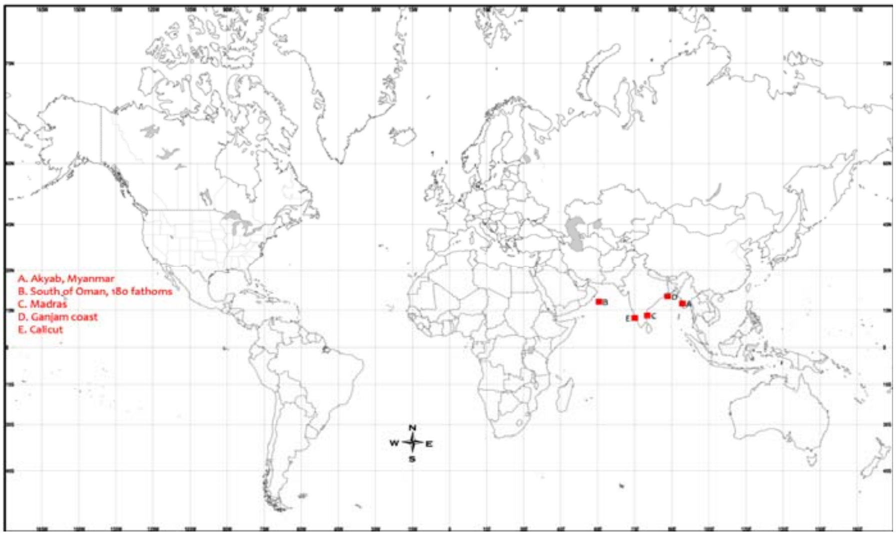


Fig. 73: Map showing localities were *Laeops macropthalmus* has been recorded in the world.

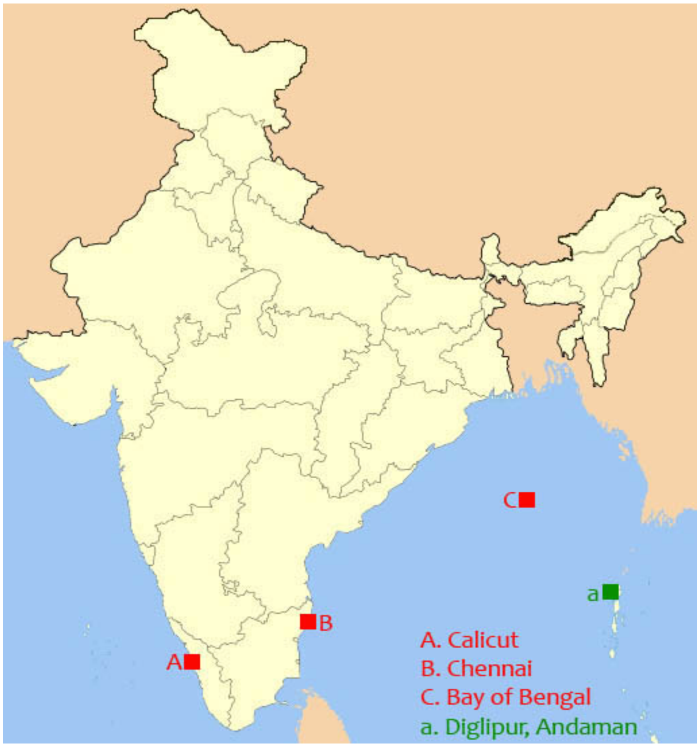


Fig. 74: Map showing localities were *Laeops macropthalmus* has been recorded in India.

India: Reported from Calicut, Madras, off Ganjam coast, Bay of Bengal (98 – 102 fathoms) (Norman, 1934). Map showing localities were *Laeops macropthalmus* has been recorded in the world is given in Fig. 74.

Taxonomic comments: The species was first recorded by Alcock (1889) as *Scianectes macropthalmus* based on a sample from Southwest of Akyab. Later another species was described by Alcock as *Scianectes lophoptera*. The latter has been synonymised with *Scianectes macropthalmus* as synonyms of *Laeops macropthalmus*.

Observations: Norman (1934) has opined that "*examination of the types of L. lophoptera leaves little doubt that this is the young of L. macropthalmus*."Although the original specimen was collected at a depth of 100 fathoms, later, the same was obtained in much shallower water off Puri.

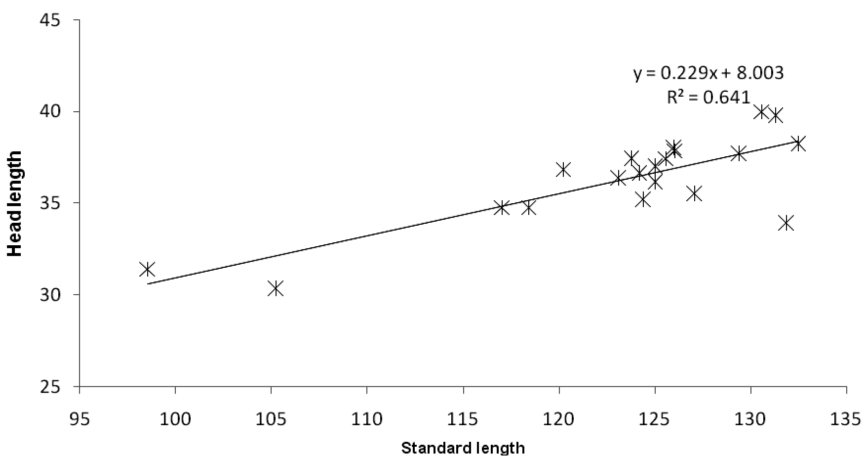


Fig. 75: Regression Head length on Standard length

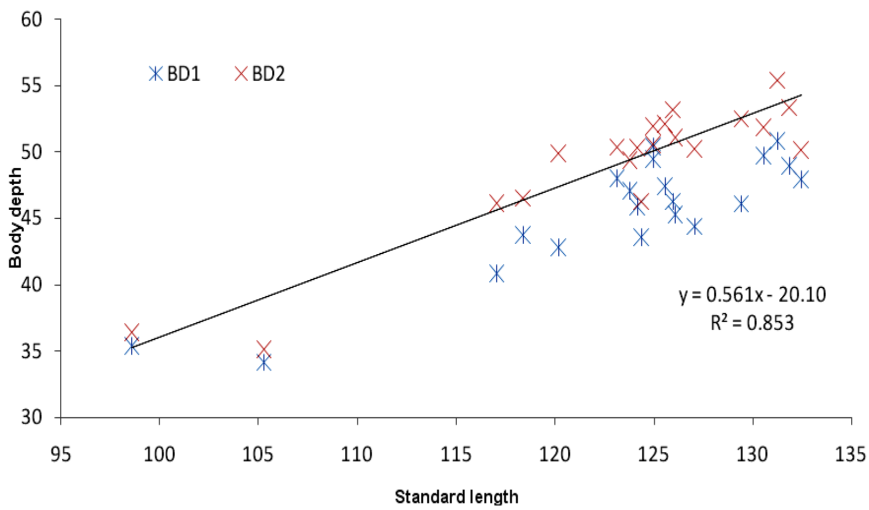


Fig. 76: Regression of Body depth on Standard length

New Record 7

4.3.4.7.3 *Laeops natalensis* Norman, 1931

Khaki flounder

Laeops natalensis Norman, 1931, *Ann. Mag. Nat. Hist.,* (10), VIII: 510 (Coast of Natal, South Africa, depth 180-230 fathoms); Hensley, 1986, *Smith. Sea Fish.*,: 859.

Material examined: N = 1, TL 123 mm from Munambam.

Diagnosis: Pectoral shorter than head; upper profile of head deeply convex above and behind eyes.

Meristic counts: D 99; A 77; P_1 14.

Body proportions as percent of SL: DFL 11.4; AFL 15.2; CFL 9.5; ED_1 24.2; BD_1 42.9

Body proportions as percent of HL: DFL 36.4; AFL 48.5; CFL 30.3; ED_1 24.2; BD_1 136.4

Description: Body oblong, fully flattened on the sides with a broad head region and tapering tail. Upper profile of head and body markedely convex above and behind eyes. Eyes placed close together, lower eye a little in advance of upper. Upper eye nearly touching the upper profile of head. Maxillary extending to below anterior edge of eye. Teeth small, placed in narrow bands, more on the blind side of jaws. Gill rakers 5 - 6 on lower arch of first gill arch. Dorsal origin on blind side above posterior nostril, first two rays detached from the rest of the finrays, ray length increases from first to central part of the body, then decreasing in length towards tail. Anal fin origin on a vertical below the free end of the operculum. Caudal fin rounded. A comparative statement of the meristic characters of *Poecilopsetta natalensis* is given in Table 50. Results of the correlation coefficient analysis on non-meristic characters of *Laeops natalensis* is given in Table 51.

Table 50: A comparative statement of the meristic characters of *Laeops natalensis*

Meristic characters	Earlier work	Present study 2004 – 2010
	Hensley 1986	N = 1
Dorsal rays	98	99
Anal rays	76 - 77	77
Pectoral (O/B)	14 - 15	14

*Data not available

Table 51: Results of the correlation coefficient analysis on non-meristic characters of *Laeops natalensis*

Characters	Range in SL	Range in HL
Head length	4.4 - 4.8	
Head Depth	5.6 - 6.3	1.2 - 1.4
Eye Diameter (U)	14.5 - 21.1	3.29 - 4.4
Eye Diameter (L)	15.6 - 16.3	3.4 - 3.5
Inter orbital	82.2 - 82.5	17.2 - 18.8
Upper jaw length	17.6 - 21.1	4 - 4.41
Lower jaw length	18.6 - 22.8	4.2 - 4.76
Post orbital (U)	7.97 - 9.1	1.7 - 2.1
Post orbital (L)	8.3 - 9.5	1.73 - 2.2
Body depth$_1$	2.8 - 2.98	0.62 - 0.63
Body depth $_2$	2.3 - 2.4	0.5 - 0.6
Dorsal FL	10.2 - 10.5	2.13 - 2.4
Anal FL	7.6 - 9.4	1.72 - 1.96
Pectoral (O)FL	7.7 - 8.8	1.6 - 2.01
Pelvic (O)	11.7 - 13.2	2.5 - 3
Pelvic (B)	10.9 - 13.8	2.3 - 3.1
Caudal FL	6.95 - 8.3	1.5 -1.9
Anal BL	1.24 - 1.27	0.26 - 0.29
Pectoral(B) BL	37.96 - 47.4	7.9 - 10.8
Pelvic (O) BL	18.14 - 20.98	3.8 - 4.78
Pelvic (B) BL	42.2 - 56.94	9.59 - 11.9

Colour: Body yellowish brown. Median fins dusky towards their margins.

Distribution:

World: Natal, South Africa (Von Bonde, 1922). Map showing localities were *Laeops natalensis* has been recorded in the world is given in Fig. 77.

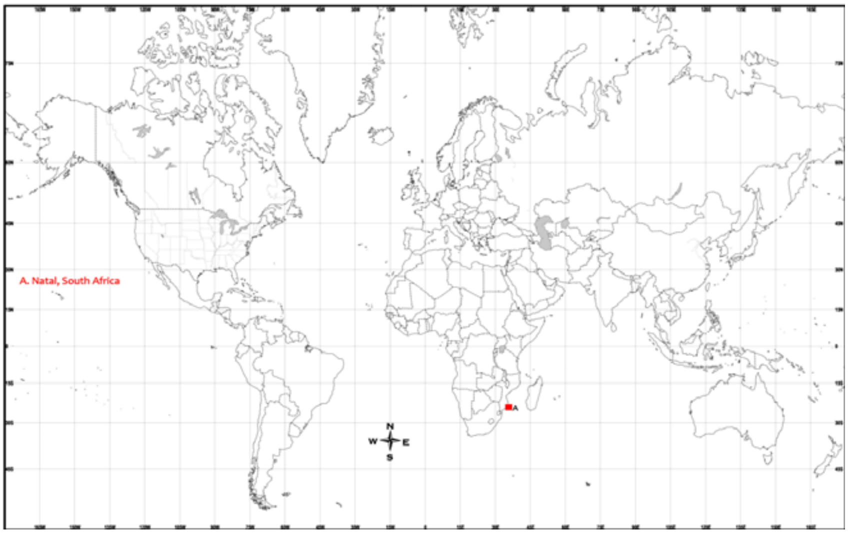


Fig. 77: Map showing localities were *Laeops natalensis* has been recorded in the world

India: Munambam (present study). Map showing localities were *Laeops natalensis* has been recorded in India is given in Fig. 78.

Fig. 78: Map showing localities were *Laeops natalensis* has been recorded in India

Taxonomic comments: The fish was originally described as *Laeops natalensis* by Norman (1931) based on collections off Natal, South Africa.

Observations: Norman (1934) in a note adds that "*readily distinguished from L. kitahare by the deeper body, larger head, more convex profile etc*."

New Record 8

4.3.4.7.4 *Laeops parviceps* Gunther, 1880

Small head flounder

Laeops parviceps Gunther, 1880, *Shore Fish. Challenger*. 29, pl. XV, fig. A (Station 190; Arafura Sea, S.E Australia, Two Fold Bay35 – 49 fathoms); Mc Culloch, 1919, *Checklist Fish and Fishlike animals N.S Wales*, II:36 (Two Fold Bay, 120 fathoms); Fowler, 1928, *Mem. B.P Bishop Mus*., X: 92; Weber and Beaufort, 1929, *Fish. Indo–Austr. Arch*., V: 116, fig. 28 (Arafura Sea, S.E Australia); Norman, 1934, *Syst. Monog. Flatfish* I: 256, fig. 197; Chen and Weng, 1965, *Biol. Bull*., 27:24; Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl*., 8:645.

Laeoptichthys fragilis Hubbs, 1915, *Proc. U.S Nat. Mus*., 48 (2082): 460, pl. 26, fig. 4 (Suruga Gulf, Japan, Albatross station 5074, depth 47 fathoms).

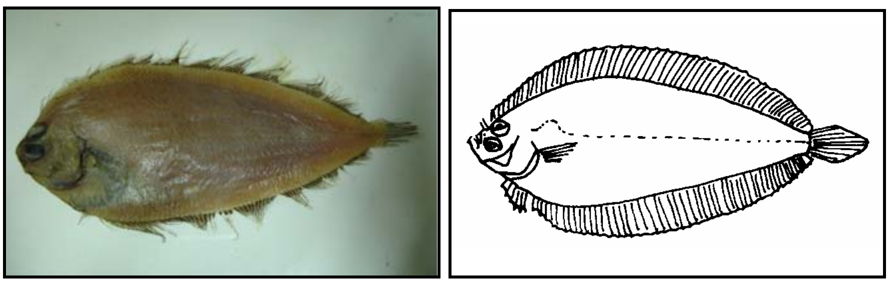


Plate XXIII: *Laeops parviceps* Gunther, 1880

Material examined: N=2, TL 110.57 – 135.54 mm from Neendakara Fisheries Harbour.

Diagnosis: Dorsal fin counts 103 - 106; pectoral fin a little longer than half head length.

Meristic characters: D 103 -106; A 86; $P_1$12; P_2 11; V_1 6; C 3 +8 +3, Gr 7, Ll. 93

Body proportions as percent of SL (mean in parentheses): HL 20.9 - 22.8 (21.84); HW 29.6 - 32.01 (30.78); HD 17.9 - 15.96 (16.91); ED_1 4.8 - 6.95 (5.83); ED_2 6.1 - 6.4 (6.28); ID 1.21 - 1.22 (1.21); UJL 4.7 - 5.7 (5.21); LJL 4.4 - 5.4 (4.89); PBU 11.03 - 12.1 (11.79); PBL 10.6 - 12.1 (11.34); BD_1 33.6 - 36.1 (34.83); BD_2 41.6 - 42.95 (42.29); DFL 9.6 - 9.8 (9.70); AFL 10.7 - 13.2 (11.96); V_1FLO 7.6 - 8.6 (8.07); V_2FLB 7.3 - 9.2 (8.23); CFL 12.1 - 14.4 (13.24) DBL 94.4 - 94.8 (94.60); ABL 78.8 - 80.4 (79.58); P_2BLB 2.1 - 2.63 (2.37); V_1BLO 4.8 - 5.5 (5.14); V_2BLB 1.8 - 2.4 (2.06).

Body proportions as percent of HL (mean in parentheses): HW 140.6 - 141.3 (140.93); HD 70.1 - 85.4 (77.74); ED_1 22.7 - 30.4 (26.54); ED_2 28.2 - 29.3 (28.77); ID 5.3 - 5.8 (5.57); UJL 22.65 - 24.98 (23.81); LJL 20.99 - 23.65 (22.32); PBU 48.4 - 59.98 (54.21).

Description: Body deeply oval with a narrow head region. Body broadest behind free tip of the pectoral fin. Eyes placed close together separated by a narrow interorbital ridge; upper eye placed a little behind lower eye. Mouth small, protractile, opening upwards; maxillary ends nearly on a vertical below anterior edge of eye. Teeth seen on jaw on blind side in narrow bands. Dorsal fin origin on blind side above the posterior nostril, on a horizontal to front margin of upper eye, first two fin rays detached from rest of fin, none of the rays elongated. Pectoral fin a little longer than half head length, right pectoral shorter than left. Caudal fin slightly rhomboid, elongated and pointed. Lateral line developed on ocular side only, supra temporal branch absent; a short semicircular curve present on the anterior part, proceeding straight backwards. A comparative statement of the meristic characters of *Laeops parviceps* is given in Table 52

Table 52 : A comparative statement of the meristic characters of *Laeops parviceps*

Meristic characters	Earlier work	Present study 2004 – 2010
	Hensley 1986	**N = 1**
Dorsal rays	98	99
Anal rays	76 - 77	77
Pectoral (O/B)	14 - 15	14

Colour: Body yellowish brown with slight darker markings. Vertical fins darker towards the outer edges.

Distribution:

World: Reported from Arafura Sea (Amaoka, 1964); South China Sea, Taiwan part of China. Map showing localities were *Laeops parviceps* has been recorded in the world is given in Fig. 79.

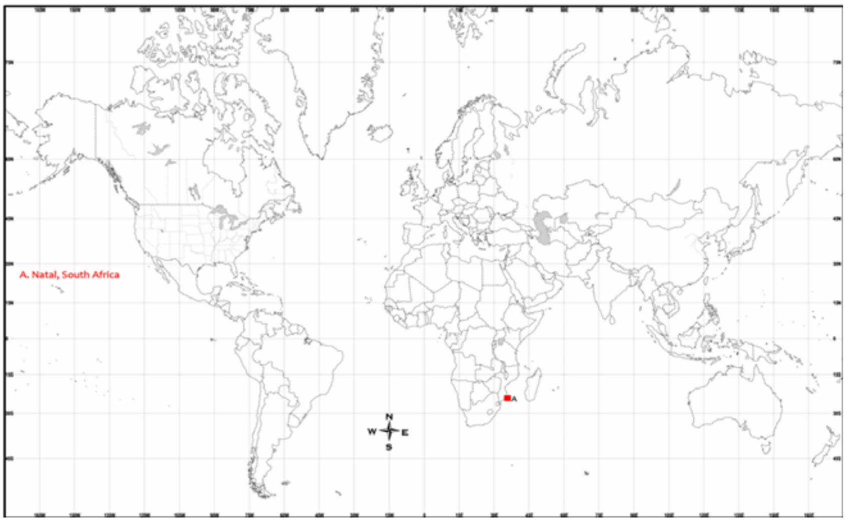


Fig. 79: Map showing localities were *Laeops parviceps* has been recorded in the world.

India: Neendakara, Quilon (first record from Indian waters). Map showing localities were *Laeops parviceps* has been recorded in India is given in Fig. 80.

Fig. 80: Map showing localities were *Laeops parviceps* has been recorded in India.

Taxonomic comments: The species was first described by Gunther (1880) based on his collections of Shore Fishes in the Challenger Expedition from South East Australia from a depth of 35 – 49 fathoms. The fish was of TL 2.6 – 5.5 inches.

Observations: The description and counts of the present specimen match well with that of the original description by Gunther.

4.3.4.8 Genus *Neolaeops* Amaoka, 1969

Neolaeops Amaoka, 1969:148 (Type: ***Laeops microphthalmus*** von Bonde, 1922); Amaoka in Masuda *et al*., 1984, *Fish Jap. Arch*., : 350; Ahlstrom *et al*., 1984, *Am. Soc. Ichth. Herp. Sp. Publ*., 1: 643; Hensley, 1986, *Indo-Pac. Fish Biol*.,: 860; Hensley, 1986, *Smith. Sea Fish*.,: 941; Li and Wang 1995, *Fauna Sinica*: 162; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6): 3803.

Description: Body oval, elliptical, strongly compressed. Snout prominent, hooked. Dorsal profile behind snout deeply convex. Head small, eyes sinistral, small separated by a narrow interorbital ridge. Rostral and orbital spines absent. Nostrils on pairs on both sides – anterior one tubular with a flap, posterior one also tubular without flap. Mouth oblique, moderate in size, maxillary ending below anterior edge of lower eye. Lower jaw ends below middle part of lower eye. Teeth uniserial on both sides with a canine teeth enlarged anteriorly. Teeth on lateral side of lower jaw stronger and more widely spaced than teeth on upper jaw. Gill rakers slender, moderate in size, pointed and smooth walled; serrations absent on the posterior margin of gill rakers. Body covered with cycloid scales on both sides with snout, interobital and jaws naked. Dorsal fin origin above the posterior nostril on blind side, all rays simple, the first two rays separate from the rest of dorsal fin. Anal fin origin on a vertical behind free end of pectoral fin, end at caudal peduncle end. Pectoral fin on ocular side longer than blind side. Caudal fin rounded in centre, elongate and feeble at the tip.

Taxonomic comments: The new genus was erected by Amaoka (1969) while working on the sinistral flounders of Japan. He mentions that "*the present new genus closely resembles Arnoglossus in the arrangement of the teeth, but is easily dintinguished from it in many osteological features*". On the other hand, Amaoka mentions that the genus is "*closely related to Laeops and Japonolaeops in some important characters*" but differs from it "*in having teeth well developed on both sides, the first two rays of the dorsal fin touched the remaining of the fin and the large mouth, and from the latter genus in having uniserial teeth on both sides*".

Remarks: Amaoka described one species *Neolaeops micropthalmus* from Tokushima and later Hensley (1986) recorded one species from South African waters.

New Record 8

4.3.4.8.1 ***Neolaeops micropthalmus* (von Bonde, 1922)**

Cross eyed flounder

Laeops micropthalmus von Bonde, 1922, *Rep. Fish. Mar. Biol. Surv. Rep.*, 2 (Art. 1):11(Natal, South Africa); Barnard, 1925, *Ann. S. African Mus.*, 21 (1,2): 392; Kamohara, 1935, *Zool. Mag.*, 48(1): 21

Arnoglossus micropthalmus Norman, 1931, *Ann. Mag. Nat. Hist.*, 10 (8):508; Norman, 1934, *Syst. Monog. Flatfish*: 197, fig. 145; Okada and Matsubara, 1938, *Key Fish. Japan*: 421; Smith, 1949, *Fish. South Africa*: 159, fig. 312; Matsubaara, 1955, *Fish Morph.*, II: 1258; Kamohara, 1958, *Rep. Usa Mar. Biol. Stn.*, 5 (1): 62.

Neolaeops microphthalmus Amaoka, 1969, *J. Shimonoseki Univ. Fish.*, 18 (2):213; Amaoka in Masuda *et al.*, 1984, *Fish. Jap. Arch.*,:350; Hensley, 1986, *Fish. Jap. Arch.*,: 860; Li and Wang, 1995, *Fauna*

Sinica:162; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl.,* 8:645; Nakabo, 2000, *Fish. Japan*: 1370; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide* IV (6): 3837; Shinohara *et al*., 2001, *Monograph. Nat. Sci. Mus. Tokyo*, 20:334 ; Nakabo, 2002, *Fish. Japan*: 1370.

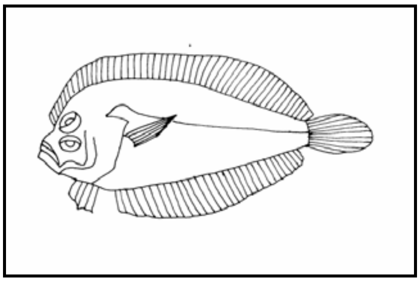


Plate XXIV: *Neolaeops micropthalmus* (von Bonde, 1922)

Material examined: N =1; TL 111.09 mm from Munambam Fisheries Harbour.

Diagnosis: A sinistral flounder with a deep concavity in front of the upper eye, very small eye, deciduous scales.

Meristic characters: D 108; A 83; P_1 10; P_2 7; C 18; V_1 5; V_2 5.

Body measurements as percent of SL: HL 30.8; HD 22.8; HW 36.3; BD_1 37.6; BD_2 42.5; DFL 11.5; AFL 13.1; CFL 18; P_1FLO 13.5; V_1FLO 10; Interpelvic 5.1; DBL 93.3; ABL 75.8; CBL 10.9; P_1BLO 3.9; P_2BLB 2.03; V_1BLO 6.95; V_2BLB 40.2; PrOU 2.42; PrOL 4.8; ED_1 10.12; ED_2 8.6; ID 1.01; UJL 8.2; LJL 7.4.

Body measurements as percent of HL: HD 74.2; HW 117.97; BD_1 121.99; BD_2 138.02; DFL 37.2; AFL 42.7; CFL 58.5; P_1FLO 43.9; V_1FLO 32.5; Interpelvic 16.5; DBL 303.1; ABL 246.1; CBL 35.5;

P_1BLO 12.5; P_2BLB 6.6; V_1BLO 22.6; V_2BLB 13.1; PrOU 7.86; PrOL 15.7; ED_1 32.9; ED_2 28.01; ID 3.3; UJL 26.6; LJL 24.1.

Description: Body deeply oval in shape, stongly compressed with a strongly notched snout and a deep concavity at its hind end. Dorsal profile behind the upper eye deeply convex followed by a nearly sloping profile. Head small, nearly half the body depth. Snout short, prominent. Eyes big, upper eye diameter nearly equal to lower eye diameter, separated by a narrow interorbital ridge; lower a little in front of the upper eye. Nostrils in a pair placed close in front of interorbital ridge; anterior one tubular with a flap, posterior one also tubular without a flap. On blind side, nostrils placed below origin of dorsal, similar in size and shape to that of ocular one. Mouth moderate in size, oblique, symmetrical jaws; maxillary extending to below anterior part of lower eye. Upper jaw with canines enlarged anteriorly; lateral teeth small, close set. Lower jaw with canines enlarged anteriorly, lateral teeth stronger and more widely spaced than anterior; teeth becomes smaller inwards. Gill rakers slender, pointed without any serrations.

Scales small, deciduous, cycloid on both ocular and blind side except on snout, jaws, interorbital area and pectoral fin. Dorsal fin origin on blind side, endins at origin of caudal peduncle. Anal fin origin behind ventral fin base. Pelvic fin bases not together, fourth ray of pelvic fin ocular opposite blind side pelvic fin origin. Caudal fin rounded at central part, rays feeble, inner 11 rays branched, outer three unbranched. Vent opens on blind side above anal fin origin. A comparative statement of the meristic characters of *Neolaeops micropthalmus* is given in Table 53. Results of the correlation coefficient analysis on non-meristic characters of *Neolaeops micropthalmus* is given in Table 54.

Table 53 : A comparative statement of the meristic characters of *Neolaeops micropthalmus*

Meristic characters	Earlier work	Present study 2004 – 2010
	Hensley 1986	**N = 1**
Dorsal rays	108 -110	108
Anal rays	83 - 87	83
Pectoral (O/B)	*	10/7
Caudal	*	18

*Data not available

Table 54: Results of the correlation coefficient analysis on non-meristic characters of *Neolaeops micropthalmus*

Characters	Range in SL	Range in HL
Head length	3.25	
Head Depth	4.38	1.35
Head Width	2.75	0.63
Boby depth $_1$	2.66	0.97
Max body depth	2.35	0.88
Dorsal FL	8.72	3.71
Anal FL	7.61	0.87
Caudal FL	5.56	0.73
Pectoral (O) FL	7.40	1.33
Dorsal BL	1.07	0.05
Anal BL	1.32	1.23
Caudal BL	9.14	6.92
Pectoral (O) BL	25.97	2.84
Pectoral (B) BL	49.30	1.90
Pelvic (O) BL	14.38	0.29
Pelvic (B) BL	24.85	1.73
Pre orbital (U)	41.34	1.66
Pre orbital (L)	20.76	0.50
Eye Diameter (U)	9.88	0.48
Eye Diameter (L)	11.60	1.17
Inter orbital	99.13	8.55
Upper jaw length	12.21	0.12
Lower jaw length	13.50	1.11

Colour: Body colour grayish red on ocular side, blind side yellowish white. Fins brownish with traces of black. In formalin preserved specimens, body colour becomes yellowish and fins blackish yellow.

Habitat: Bathydemersal, 275 – 400 m deep.

Distribution:

World: Natal, South Africa. Map showing localities were *Neolaeops micropthalmus* has been recorded in India is given in Fig. 81.

Fig. 81: Map showing localities were *Neolaeops micropthalmus* has been recorded in India.

Taxonomic comments: The species was first described as *Laeops micropthalmus by* von Bonde (1922); Norman (1931) placed the species in genus *Arnoglossus* as *Arnoglossus micropthalmus*. However, Amaoka

(1969) while describing the sinistral flounders of Japan erected a new genus *Neolaeops* and placed it in the genus as *Neolaeops micropthalmus*.

Observations: Amaoka (1969) comments that the species "*is allied to Japonolaeops dentatus in the number of dorsal and anal fin rays and of vertebrae, but easily separable from it in having a smaller eye, a larger mouth and the dorsal profile steeply rised above the pectoral fin*". The fish is rarely landed in the commercial trawlers.

4.3.4.9 Genus *Parabothus* Norman, 1931

Parabothus Norman, 1931; 600 (Type: ***Arnoglossus polylepis*** Alcock, type species by original designation); Norman, 1934, *Syst. Monog. Flatfish*: 240; Amoaka, 1969, *J. Shimonoseki Univ. Fish*., 18(2): 120; Ahlstrom *et al*., 1984, *Amer. Soc. Ichth. Herp. Sp. Publ.,* 1: 643; Amaoka in Masuda *et al.,* 1984, *Fish. Jap. Arch.,*:348; Hensley, 1986, *Smith. Sea Fish*.,: 941; Amaoka and Shen, 1993, *Bull. Mar. Sci*., 53 (3):1042; Li and Wang, 1995, *Fauna Sinica*: 181; Amaoka *et al*., 1997, *Mem. Mus. Nat. Hist. Nat. Zool.,* 174:157; Hensley and Amaoka, 2001, *FAO Sp. Iden. Guide,* IV (6):3804; Hoese and Bray, 2006, *Zool. Cat. Aust.,*:1822.

Description: Body elliptical, not strongly compressed, not deeply broadened. Eyes sinistral separated by a concave interorbital space which is broader in males than females. Rostral and orbital spines absent in males. A pair of nostrils on both sides places in front of the interorbital area, the anterior one tubular with a flap; the posterior one slightly tubular with a small flap. Mouth moderate, the maxillary ending just below the anterior border of lower eye. Teeth present in both jaws, uniserial with slightly enlarged teeth in anterior part. Gill rakers moderate in size and pointed at tip. Scales on body small, slightly ctenoid with elongate spines. Blind side with cycloid scales, snout tip, jaws and pectoral finbase naked. Dorsal fin origin on blind side above the nostrils, all fin rays simple. Anal fin rays similar to dorsal fin rays in shape. Pectoral fin on ocular side longer than on blind side. Pelvic fin on ocular side placed in front of pelvic fin on blind side, fourth ray of ocular fin in line with first ray of blind side fin. Caudal fin roundes at centre, outer 2 -3 rays simple, rest branched.

Of the eight species reported worldwide (Amaoka and Shen, 1993), five species of adults were reported from the Indo-Pacific region (Norman, 1934) and two from the Japanese waters (Amaoka, 1969) and one from Southern Taiwan (Amaoka and Shen, 1993). Only one post larvae of *Parabothus polylepis* has been reported from the Indo-Pacific region (Lalithambika Devi, 1986). The species *Parabothus polylepis* was recorded in the present study from Neendakara Fisheries Harbour.

4.3.4.9.1 *Parabothus polylepis* (Alcock 1889)

Many scaled flounder

Arnoglossus polylepis Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII, pt. 2 (3): 290, pl. 16, fig. 1. (Off east coast of Sri Lanka, Investigator station 59, depth 32 fathoms).

Rhomboidichthys polylepis Alcock, 1890, *Ann. Mag. Nat. Hist.*, VI: 434; Alcock, 1898, *Illust. Zool.,"Investigator" Fish.*, pl. 24, figs. 4, 5.

Bothus polylepis Norman, 1927, *Rec. Ind. Mus.*, XXIX: 31.

Parabothus polylepis Norman, 1931, *Ann. Mag. Nat. Hist.*, (10) VIII: 600; Norman, 1934, *Syst. Monog. Fish.*,:241, fig.182;Amaoka and Shen, 1993, *Bull. Mar. Sci.*, 53 (3):1045; Amaoka *et al.*, 1997, *Mem. Mus. Nat. Hist. Nat. Zool.,* 174:161; Manilo and Bogorodsky, 2003, *J. Ichth.,* 43 (suppl. 1): S122.

Plate XXV: *Parabothus polylepis* (Alcock 1889)

Material examined: N=2; TL 98.08 - 98.54 mm from Munambam Fisheries Harbour.

Diagnosis: Species characterized by wide and concave interorbital space.

Meristic characters: D 86 – 87; A 64 – 66; P_1 9 -11; P_2 8; V_1/V_2 5; C 2 +12+2

Body measurements as percent of SL (mean in parentheses): HL 27.1 – 28.8 (27.96); HW 37.3 – 38.2 (37.8); HD 22.9 – 24.1 (23.5); ED_1 9.4 – 9.7 (9.6); ED_2 7.6 – 8.95 (8.3); ID 1.6 – 2.2 (1.9); UJL 7.4 – 7.8 (7.6); SNL_1 6.7 – 7.8 (7.2); SNL_2 6.5 – 7.6 (7.1); CD 2.8 – 2.9; DFL 9.8 – 11.8 (10.8); AFL 10.6 – 11.7 (11.1); P_1FLO 18.4 – 18.6 (18.5); P_2FLB 9.5 – 9.6 (9.5); V_1FLO 6.2 – 6.9 (6.5); V_2FLB 3.1 – 5.2 (4.1); CPD 10.2 – 10.3 (10.2); PDL 2.5 – 3.2 (2.8); PAL 27.8 - 28.1 (27.98); P_1LO 26.4 – 28.9 (27.6); P_2LB 25.6 – 27.3 (26.5); P_1VLO 17.7 – 17.9 (17.8); P_2VLB 20.5 – 21.3 (20.9).

As percent of HL (mean in parentheses): HW 129.7 – 140.9 (135.3); HD 83.7 – 84.2 (83.95); ED_1 33.8 – 34.5 (34.2); ED_2 28.1 – 31.1 (29.6); ID 5.9 – 7.6 (6.7); UJL 26.98 – 27.2 (27.1); SNL_1 24.7 – 26.98 (25.8); SNL_2 22.5 – 28.1 (25.3); CD 10.02 – 10.4 (10.2); DFL 36.1 – 41.02 (38.6); AFL 38.9 – 40.6 (39.7); P_1FLO 63.9 – 68.4 (66.2); P_2FLB 33.2 -34.9 (34.1); V_1FLO 27.8 – 37.3 (32.5); V_2FLB 26.6 – 29.6 (28.13); CFL 68.99 – 73.9 (71.4); DBL 315.9 – 355.5 (335.7); ABL 256.7 – 270.7 (263.7); P_1BLO 10.9 –

11.96 (11.4); P_2BLB 6.03 – 8.3 (7.2); V_1BLO 21.5 – 25.2 (23.4); V_2BLB 11.3 – 17.9 (14.6); CPD 35.7 – 37.5 (36.6); PDL 8.8 – 11.6 (10.2); PAL 97.7 – 102.6 (100.2); P_1LO 97.3 – 100.3 (98.8); P_2LB 94.4 – 94.9 (94.6); V_1LO 61.6 – 66.04 (63.8); V_2LB 74.2 – 75.4 (74.8).

Description: Body elongated ovoid, deeply flattened, with a prominent hook like snout; maximum depth of body just behind free tip of the pectoral fin on ocular side. Dorsal profile of body convex just after the upper eye. Upper eye placed a little behind the lower eye, separated by a bony interorbital ridge. Mouth oblique, fine villiform teeth on jaws. Maxillary ending a little beyond the anterior edge of lower eye. An orbital spine present just above the upper jaw. Outer free end of operculum deeply convex; pectoral fin placed at outer free end. Dorsal fin origin on a straight line in front of upper eye, all rays simple, scaled on ocular side. Anal fin origin behind pectoral fin origin. Lateral line origin from outer free end of operculum proceeding backward with a flat plateau like region above the pectoral fin and ending at tip of caudal peduncle. Caudal fin pointed, outer end convex. Body covered with ctenoid scales on ocular side.

A comparative statement of the meristic characters of *Parabothus polylepis* is given in Table 55.

Table 55 : A comparative statement of the meristic characters of *Parabothus polylepis*

Meristic characters	**Earlier workers**		**Present study 2004 – 2010**	
	Norman 1934	**De Bruin *et al.*, 1995**	**N = 2**	**Mean ± SD**
Dorsal rays	83 -86	83 - 90	86 - 87	86.5 ± 0.71
Anal rays	63 – 66	63 - 71	64 - 66	65 ± 1.4
Pectoral (O/B)	11	*	9 - 11/8	10 ± 1.4
Caudal	*	*	2 +12 +2	-
Lateral line scales	82 - 85	*	84	

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Parabothus polylepis* is given in Table 56.

Table 56: Results of the correlation coefficient analysis on non-meristic characters of *Parabothus polylepis*

Characters	Range in SL	Mean	R^2 on SL	Slope
Head length	3.4 - 3.7	3.58	1	3.76
Head Width	2.6 - 2.7	2.65	1	-1.57
Head Depth	4.2 - 4.4	4.26	1	2.83
Eye Diameter (U)	10.3 - 10.7	10.48	1	0.85
Eye Diameter (L)	11.2 - 13.1	12.15	1	2.93
Dorsal fin length	8.5 - 10.2	9.33	1	4.37
Anal fin length	8.6 - 9.5	9.02	1	2.5
Pectoral (O) FL	5.38 - 5.4	5.41	1	-0.22
Pectoral (B) FL	10.5 - 10.6	10.52	1	0.28
Pelvic (O) Fl	9.3 - 13.3	11.29	1	6.93
Pelvic (B) FL	11.7 - 13.8	12.78	1	2.85
Dorsal fin BL	1.04 - 1.1	1.07	1	-11.04
Anal fin BL	1.35 - 1.36	1.36	1	1.57
Pectoral (O) BL	29.1 - 33.9	31.5	1	1.09
Pectoral (B) BL	44.4 - 57.6	51	1	-1.09
Pelvic (O) BL	14.6 - 16.2	15.39	1	-1.37
Pelvic (B) BL	19.4 - 32.6	26.01	1	4.48
Caudal peduncle depth	9.7 - 9.8	9.78	1	0.28
Predorsal	31.7 - 39.4	35.58	1	-1.28
Preanal	3.56 - 3.59	3.57	1	0.89
Prepectoral(O)	3.5 - 3.8	3.63	1	5.52
Prepectoral(B)	3.7 - 3.9	3.78	1	3.89
Prepelvic (O)	5.6 - 5.7	5.61	1	-0.28
Prepelvic (B)	4.7 - 4.9	4.79	1	2.04
Characters	**Range**	**Mean**	**R^2 on HL**	**Slope**
Head Width	0.71 - 0.77	0.74	1	-0.42
Head Depth	1.19 - 1.2	1.19	1	0.75
Eye Diameter (U)	2.9 - 2.96	2.93	1	0.23
Eye Diameter (L)	3.2 - 3.6	3.39	1	0.78
Inter orbital	13.3 - 16.9	15.05	1	0.32
Upper jaw	3.68 - 3.71	3.69	1	0.24
Lower jaw	4.4 - 4.8	4.62	1	0.49
Snout to U eye	3.7 - 4.1	3.88	1	0.62
Snout to L eye	3.56 - 4.44	4.00	1	-0.62
Chin depth	9.58 - 9.98	9.78	1	0.03

Colour: Body brownish on ocular side, white on blind side, fin rays blackish brown. Pectoral fin on ocular side with slight black marks.

Distribution:

World: Off Ceylon (Norman, 1934); Indo-Pacific region (Lalithambika Devi, 1986). Map showing localities were ***Parabothus polylepis*** has been recorded in the world is given in Fig. 82.

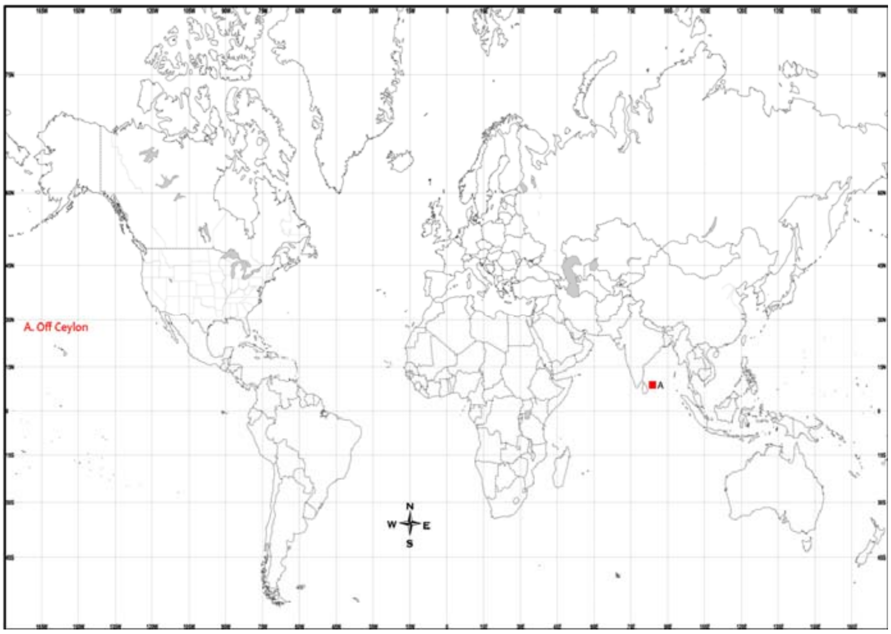


Fig. 82: Map showing localities were *Parabothus polylepis* has been recorded in the world.

India: Munambam (present study). Map showing localities were ***Parabothus polylepis*** has been recorded in the world is given in Fig. 83.

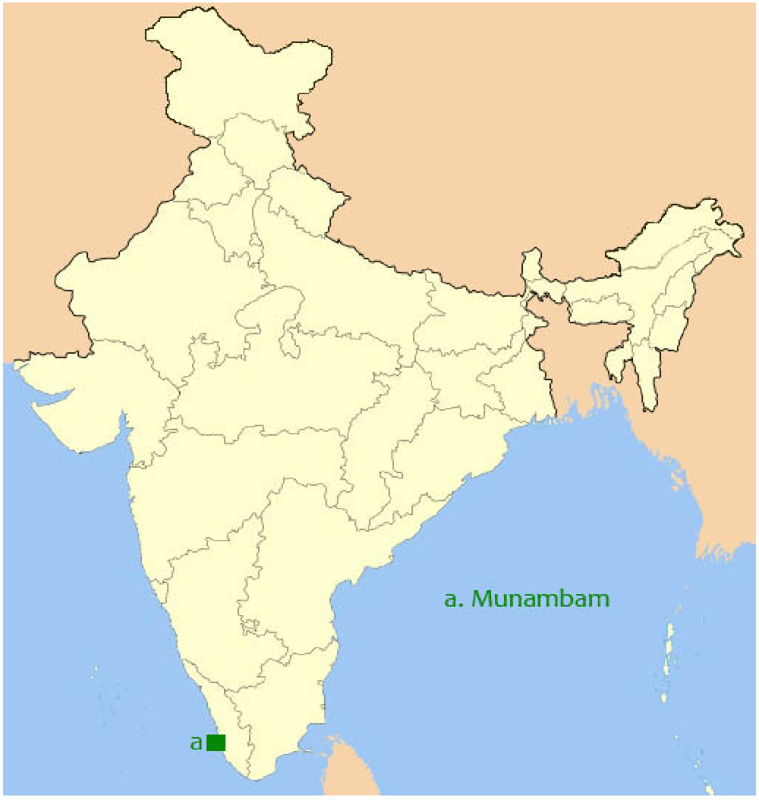


Fig. 83: Map showing localities were *Parabothus polylepis* has been recorded in India.

Habitat: Reported from 32 – 34 fathoms (Norman, 1934).

Taxonomic comments: The species was originally described by Alcock (1889) as *Arnoglossus polylepis* based on Investigator collections off Sri Lanka. Subsequently Alcock (1890) placed the species in genus *Rhomboidichthys*. Norman (1927) described a species *Bothus polylepis* which was later synonymised with the present name.

Observations: *Parabothus polylepis* differs from the other species in having lesser number of dorsal and anal fin rays. It closely resembles *P. budkeri* from which it differs in greater number of lateral line scales (82 – 93) compared to 78–80 in latter.

4.3.5 Family Poecilopsettidae

Commonly called the big eye flounders, the family (sensu Chapleau and Keast, 1988) consists of 3 genera, *Poecilopsetta* Gunther,1880; *Nematops* Gunther,1880 and *Marleyella* Fowler,1925 with 30 species and includes small sized deep water species. (Munroe, 2005). The family is characterized by the origin of the dorsal fin above the eyes, lateral line rudimentary on blind side and symmetrical pelvic fins. *Poecilopsetta* differs from *Marleyella* in lacking the prolonged anterior rays of the dorsal and pelvic fins that are present in the latter genus (eg. Norman,1934; Hoshino *et al*., 2001). Most ichthyologists had separated *Poecilopsetta* from *Nematops* primarily because *Poecilopsetta* species lack tentacles on their eyes (vs. having a tentacle on both eyes or only on the lower eye in *Nematops*) (eg., Norman, 1934; Sakamoto,1984, 1993; Hoshino *et al.*, 2001). Guibord and Chapleau (2004), however, reported specimens of *Nematops macrochirus* Norman (1931) that lacked tentacles on the eyes, and distinguished *Poecilopsetta* from *Nematops* by the absence of an ocular-side nasal bone, and by the presence of two proximal pterygiophores between the first anal fin pterygiophore and the haemal spine of the first caudal vertebrae (vs. ocular side nasal bone present and three proximal pterygiophores between the first anal fin pterygiophore and the haemal spine of first caudal vertebrae in *Nematops*. (Kawai *et al*., 2009).

Members of the genus *Poecilopsetta* are characterized by a narrow mouth, tooth bands present on all jaws, the absence of vomerine and palatine teeth, the location of the dorsal fin origin at the vertical through the middle of the upper eye, and moderate or small scales that are either ctenoid or cycloid on the ocular side and cycloid on the blind side (Gunther, 1880; Norman, 1934). The genus contains 14 species (Quero *et al*., 1988; Hoshino, 2000; Guibord and Chapleau, 2001, 2002; Hoshino *et al.,* 2001; Kawai and Amaoka, 2006) that inhabit deep waters in the Indian, western and central Pacific and the western Atlantic oceans. (Kawai *et al*., 2009).

In the present study only one genus with 4 species have been collected. Regan (1910) placed *Poecilopsetta* in Subfamily Pleuronectinae along with *Boopsetta* and *Nematops* from the Indo–Pacific; the character assigned to the group was small asymmetrical mouth and jaws and with dentition well developed on blind side. In '*Flatfishes of India*', Norman (1927) mentions of 2 subfamilies Pleuronectinae and Samarinae with 4 genera *Poecilopsetta*, *Brachypleura*, *Samaris*, *Samriscus* and 9 species. *Poecilopsetta* was one of the six genera along with *Nematops, Samaris, Samariscus, Lepidoblepharon* and *Brachypleura* recognized by Weber and Beaufort (1929) in the family Pleuronectidae. Five subfamilies were recognized by Norman (1934) in this family – Pleuronectinae, Poecilopsettinae, Paralichthodinae, Samarinae and Rhombosoleinae. However, a review of phylogenetic studies by Chapleau (1993) showed that these groups form a monophyletic assemblage and should be ranked at family level. Review of observations done by various workers on Family Poecilopsettidae is given in Table 57.

Table 57: Review of observations done by various workers on Family Poecilopsettidae

Genus	Synonym	Type	Observations				
			Jordan	Norman	Ahlstrom	Evseenko	Eschmeyer
Nematops Günther 1880		*Nematops microstoma* Günther 1880	Placed in Family Bothidae	VALID	VALID	VALID	VALID
Poecilopsetta Günther 1880		*Poecilopsetta colorata* Günther 1880		VALID	VALID	VALID	VALID
	Alaeops Jordan & Starks 1904	*Alaeops plinthus* Jordan & Starks 1904		Synonym		Synonym	Synonym
	Boopsetta Alcock 1896	*Boopsetta umbrarum* Alcock 1896		Synonym		Synonym	Synonym
	Paralimanda Breder 1927	*Paralimanda inermis* Breder 1927		Synonym		Synonym	Synonym

Among the bottom fishes collected by the Research vessel "*Conch*" off the Kerala coast (Saramma, 1965), 4 species of Pleuronectids - *Poecilopsetta colorata*, *Nematops grandisquama*, *Marleyella bicolorata* and *Samariscus inornatus* were collected. Collections were made at 100-180 fathoms. The species is reported to have worldwide distribution except in the tropical eastern Pacific.

In the present work, four species of *Poecilopsetta* - *Poecilopsetta inermis*, *P. colorata*, *P. natalensis* and *P. praelonga* were collected from deep sea from east and west coast of India.

4.3.5.1 Genus *Poecilopsetta* Gunther, 1880

Poecilopsetta Gunther, 1880, *Shore Fish. "Challenger"*: 48 (Type: ***Poecilopsetta colorata*** Gunther); Hubbs, 1919, *Proc. Biol. Soc. Wash.*, XXXII: 163; Norman, 1913, *Treubia*, XII: 423; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 40;

Boopsetta Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV (2): 305; Alcock, 1899, *Cat. Deep. Sea Fish.*,: 126 (Type: ***Boopsetta umbrarum* Alcock**).

Alaeops Jordan and Starks, 1902, *Bull. U.S Comm. Fish.*, XXII: 623; Jordan and Starks, 1906, *Proc. U.S Nat. Mus.*, XXXI: 198. (Type: ***Alaeops plinthus* Jordan and Starks**).

Paralimanda Breder, 1927, *Bull. Bingham Ocean. Coll.*, I (1): 86 (Type: ***Paralimanda inermis* Breder**).

Diagnosis: Short tentacles absent on eye.

Description: Body ovate to elongate, deeply compressed, fragile. Eyes dextral, nearly contiguous separated by a narrow bony ridge. Mouth very small, nearly symmetrical; maxillary very short, shorter than half head length. Teeth small, villiform, in 1-2 rows in jaws; teeth more developed on blind side. Teeth absent on vomer. Gill rakers short, pointed, few in number. Dorsal fin origin above eye on blind side, behind nostrils, rays simple, 56 to 68, scales absent, a scaly sheath covering the basal part of dorsal fin on ocular side in some species, anterior rays not prolonged. Anal fin similar to dorsal in shape, 45 to 58 rays, tip of interhaemal spine not projecting in front of fin. Pectoral fins unequal, that on ocular side longer with 7 to 12 rays. Pelvic fin with 6 rays, base short, nearly equal but asymmetrical; fin on ocular side more in front in front that that of blind side. Lateral line well developed on ocular side, single, without branches, arising from the outer free end of operculum proceeding to tip of caudal fin with a flat plateau above the pectoral fin. Lateral line on blind side rudimentary or absent.

Distribution: The genus is distributed in the tropical and temperate areas of the Indo – Pacific from Natal to India, off western Australia, Honshu Island, Japan, New Caledonia, continental shelf off south eastern Australia to about off Sydney and in the Hawaiian Archipelago and in the Atlantic Oceans from off New England to Brazil in the western Atlantic.

Taxonomic comments: A new genera *Poecilopsetta* was erected by Gunther (1862) to include the new species *Poecilopsetta colorata*, with the following characters "*mouth rather narrow, the length of the maxillary being one –third of that of the head. Each jaw with a narrow band of villiform teeth. Vomerine and palatine teeth none. The dorsal fin commences above the middle of the eye. Scales very small. Gill membranes united below the throat*."

Observations: Fifteen species of *Poecilopsetta* have been recorded worldwide (Kawai *et al*., 2010). Nielsen (1973) recorded three species from the Western Indian Ocean – *Poecilopsetta albomaculata*, *P. natalensis* and *P. zanzibarensis*. Two species recorded from Indian waters by Norman (1927) are *Poecilopsetta praelonga* and *P. colorata*. Saramma (1967) recorded *P. colorata* off Quilon at a depth of 180 m. Four species has been recorded in the present study – *Poecilopsetta colorata*, *P. inermis P. natalensis* and *P. praelonga.*

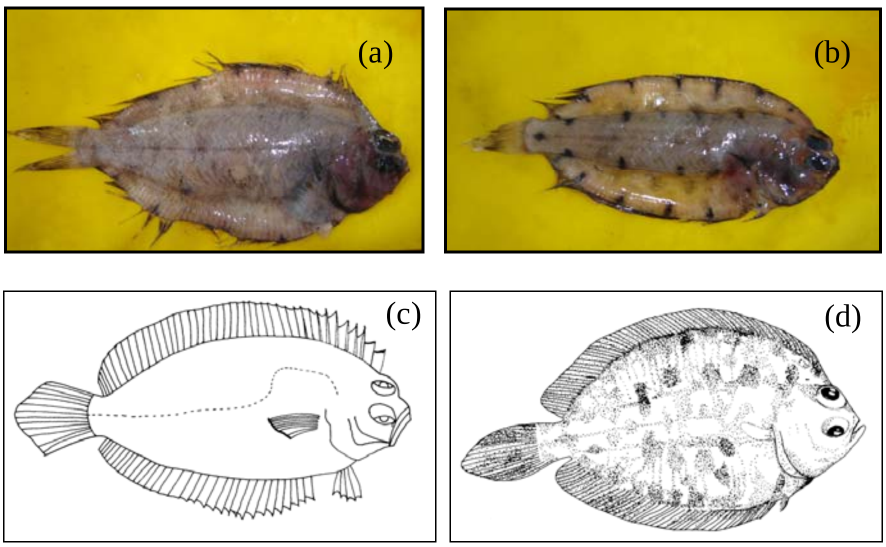
4.3.5.1.1 *Poecilopsetta colorata* Gunther, 1880

Large Spot Flounder

Poecilopsetta colorata Gunther, 1880, *Shore Fish. "Challenger"*: 48, pl. xxii, fig. B; Norman, 1927, *Rec. Ind. Mus*., XXIX: 41 (Colombo, Andaman Sea); Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.*, V: 136 (Kei Islands); Norman, 1934, *Syst. Monog. Fish.*, I: 390; fig. 279 (Gulf of Mannar, Kei Islands); Saramma, 1967, *Bull. Dept. Mar. Biol. Ocean.*, 1:71 (Quilon at a depth of 180 m).

Poecilopsetta maculosa Alcock, 1894, *J. Asiat. Soc. Bengal*, LXII, pt.2:130, pl.vii, fig.1; Alcock, 1896, *Illust. Zool. "Investigator", Fish.*,: pl. xv, fig. 1; Alcock, 1896, *J. Asiat. Soc. Bengal*, LXII, pt. 2: 328; Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch.*, V: 137, fig. 33 (North west of Sumatra, North of Bali, Timor Sea, Kei Islands, Bay of Bengal, Andaman Sea).

Boopsetta maculosa Alcock, 1899, *Cat. Indian Deep Sea Fish.*,: 127.
Boopsetta praelonga Brauer, 1906, *"Valdivia"Tiej. Fisch.*,: 295.
Boopsetta praelonga (part) Sewell, 1912, *Rec. Ind. Mus.*, VII: 10.
Boopsetta maculosa Weber, 1913, *"Siboga" Exped. Monog.*, 57:434.



(a),(c) : Adult (b),(d) : Young

Plate XXVI: *Poecilopsetta colorata* Gunther,1880

Material examined: N=2, TL 88.16-94.51 mm from deep sea trawler landings off Kochi, Kerala.

Diagnosis: Teeth in narrow bands, 90-109 scales in lateral line; eyes separated by a narrow ridge; two rays of the right pectoral branched.

Meristic characters: D 55–56 (56); A 45–46 (46); P_1 10; P_2 8; C 16; Ll. 99

Body proportions as percent of SL (mean in parentheses): HL 24.04 – 25.2 (24.6); HW 26.6 – 42.2 (34.4); HD 14.9 – 20.1 (17.5); BD_1 31.1 – 42.7 (36.9); ED_1 8.8 – 10.1 (9.4); ED_2 8.02 – 9.4 (8.7); ID 0.98 – 1.3 (1.1); SNL_1 5.2 – 6.4 (5.8); SNL_2 2.7 – 3.2 (2.9); UHL 14.7 – 22.6 (18.7); PBU 13.9 – 14 (13.9); UJL 5.97 – 7.97 (6.97); LJL 8.2 – 8.3 (8.3); DFL 10.7 – 13.1 (11.9); AFL 11.6 – 16.6 (14.1); CFL 20.2 – 26.4 (23.3); P_1FLO 7.4 – 9.7 (8.6); P_2FLO 6.6; V_1FLO 8.4 – 11.3 (9.8); V_2FLO 11.4; DBL 82.8 – 85.5 (84.2); ABL 66.4 – 68.3 (67.3); P_1BLO 2.5 – 2.8 (2.6); P_2BLO 2.4; CPD 8.5 – 10.6 (9.5); PDL 13.8 – 14.7 (14.2); P_1LO 23.6 – 26.9; P_2BL 24.6; PAL 27.4 – 33.1 (30.3); V_1LO 24 – 24.4 (24.2).

As percent of HL (mean in parentheses): HW 110.6 – 167.2 (138.9); HD 61.8 – 79.6 (70.7); BD_1 129.6 -169.3 (149.4); ED_1 34.9 – 41.9 (38.4); ED_2 33.4 – 37.4 (35.4); ID 3.9 – 5.3 (4.6); SNL_1 20.6 – 26.7 (23.7); SNL_2 11.1 – 12.6 (11.9); UHL 61.3 – 89.6 (75.4); PBU 54.9 – 58.2 (56.6); UJL 24.8 – 31.6 (28.2); LJL 32.96 – 34.2 (33.6); DFL 44.5 – 51.8 (48.2); AFL 48.2 – 65.8 (57.02); CFL 80.1 – 109.7 (94.9); P_1FLO 30.9 – 38.7 (34.8); P_2FLB 26.2; V_1FLO 34.8 – 44.6 (39.7); V_2FLB 45.1; DBL 339 – 344.5 (341.8); ABL 263.3 – 283.9 (273.6); P_1BLO 10.5 -10.9 (10.7); P_2BLB 9.4; V_1BLO 6.6 – 11.4 (9.01); V_2BLB 9.4; CPD 35.3 – 42 (38.7); PDL 54.6 – 60.9 (57.7); P_1LO 98.1 – 106.8 (102.4); P_2LB 97.5; PAL 113.9 – 131.3 (122.6); V_1LO 96.5 – 99.9 (98.2).

Description: Body deeply ovate with a broad head region and narrow thick caudal peduncle. Eyes dextral, placed close separated by a narrow bony ridge slightly scaled; upper eye placed high on the dorsal profile, slightly behind the lower eye. Mouth curved slightly downward, maxillary ending a little beyond the anterior portion of the lower eye. Teeth in narrow bands; 10 – 11 gill rakers on the anterior part of the lower gill arch. Gill rakers highly elongated in young ones. Dorsal fin origin behind the hump like projection on the blind side; anal origin below the pectoral fin on ocular side. Pectoral fin origin on ocular side behind the pelvic on ocular side; middle rays branched. Caudal peduncle short, thick; caudal fin rhomboidal. Scales on ocular side feebly ctenoid, cycloid and deciduous in young ones. Lateral line origin from behind upper eye followed by a plateau above the pectoral fin, proceeding straight towards the caudal fin. In young ones, plateau of the lateral line is very big and ends halfway down the body.

***Colour*:** Ocular side is pale brownish with numerous pale spots on the head and body and greater part of the fins on the ocular side. Pectoral fin on ocular side has a large black spot; caudal fin has a pair of big black spots one each on the upper and lower part. Blind side is whitish in colour with traces of small black spots. Young ones of the fish had transparent body or whitish with black spots along the outer periphery of the body and outer periphery of the central thich area. Pectoral fin on the ocular side was blackish. On the blind side, five pairs of black marks were seen along the upper and lower periphery; small black spots were seen scattered on the central portion. Opercular membrane on the ocular side were very transparent. A comparative statement of the meristic characters of *Poecilopsetta colorata* is given in Table 57(a)

Table 57(a): A comparative statement of the meristic characters of *Poecilopsetta colorata*

Meristic characters	Earlier workers							Present work 2004-2010	
	Gunther 1862	**Alcock 1894**	**Norman 1927, 1934**	**Weber and Beaufort 1929**	**Weber and Beaufort 1929 (as *P. maculosa*)**	**Munroe 1955**	**Saramma 1967**	**N = 2**	**Mean ± SD**
Dorsal rays	61	56	56 – 61	61	56 – 65	56 – 61	57 – 58	55 – 56 (56)	55.5 ± 0.71
Anal rays	50	46	46 – 50	50	44 – 54	46 – 50	47 – 48	45 – 46 (46)	46 ± 0.71
Pectoral (O)/(B)	*	*	11 - 12	12/ 9	10/ 9	*	11 / 11	10 / 8	10 + 8
Lateral line	*	*	90 - 95	100	80 - 100	*	*	99	99
Ventral	*	5	*	6	6	*	*	6/5	6/5
Caudal	*	18	*	*	*	*	19	16	16

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of *Poecilopsetta colorata* is given in in Table 58

Table 58: Results of the correlation coefficient analysis on non-meristic characters of *Poecilopsetta colorata*

Characters	Ratio/ Range in SL	Mean	Ratio/ Range in HL	Mean
Trunk length	1.3 - 1.34	1.33		
Head length	3.97 - 4.2	4.06		
Head width	2.4 - 3.8	3.07	0.75	0.6 - 0.9
Head depth	4.98 - 6.73	5.86	1.44	1.3 - 1.6
Body depth	2.3 - 3.2	2.78	0.68	0.6 - 0.8
Eye diameter (U)	9.94 - 11.4	10.65	2.63	2.4 - 2.9
Eye diameter (L)	10.6 - 12.5	11.54	2.84	2.7 - 3
Inter orbital length	78.99 - 101.6	90.28	22.30	18.99 - 25.6
SNL_1	15.6 - 19.3	17.42	4.30	3.7 - 4.9
SNL_2	31.5 - 37.5	34.49	8.48	7.9 - 9.02
Upper head length	4.4 - 6.8	5.61	1.37	1.12 - 1.6
Post orbital length	7.2 - 7.22	7.18	1.77	1.7 - 1.8
Upper jaw	12.6 - 16.8	14.66	3.60	3.2 - 4.03
Lower jaw	12.03 - 12.2	12.11	2.98	2.9 - 3.03
Dorsal FL	7.7 - 9.34	8.50	2.09	1.9 - 2.3
Anal FL	6.03 - 8.63	7.33	1.80	1.5 - 2.1
Caudal FL	3.8 - 4.95	4.37	1.08	0.9 - 1.3
Pectoral FL(O)	10.2 - 13.5	11.85	2.91	2.6 - 3.2
Pelvic FL (O)	8.9 - 11.95	10.42	2.56	2.2 - 2.87
Dorsal BL	1.2 - 1.21	1.19	0.29	0.29 - 0.3
Anal BL	1.5 - 1.51	1.49	0.37	0.35 - 0.38
Pectoral BL(O)	36.3 - 39.5	37.89	9.32	9.15 - 9.49
Pelvic BL (O)	34.7 - 63.1	48.87	11.95	8.8 - 15.2
Caudal peduncle depth	9.44 - 11.8	10.61	2.61	2.4 - 2.83
Pre dorsal	6.8 - 7.3	7.05	1.74	1.6 - 1.8
Prepectoral (O)	3.7 - 4.2	3.98	0.98	0.94 - 1.02
Pre anal	3.02 - 3.7	3.34	0.82	0.76 - 0.88
Pre pelvic (O)	4.11 - 4.2	4.14	1.02	1.0 - 1.04

Distribution:

World: Andaman Sea, Kei Islands, North West of Sumatra (Norman, 1934); Colombo (Norman, 1927). Map showing localities were *Poecilopsetta colorata* has been recorded in the world is given in Fig. 84.

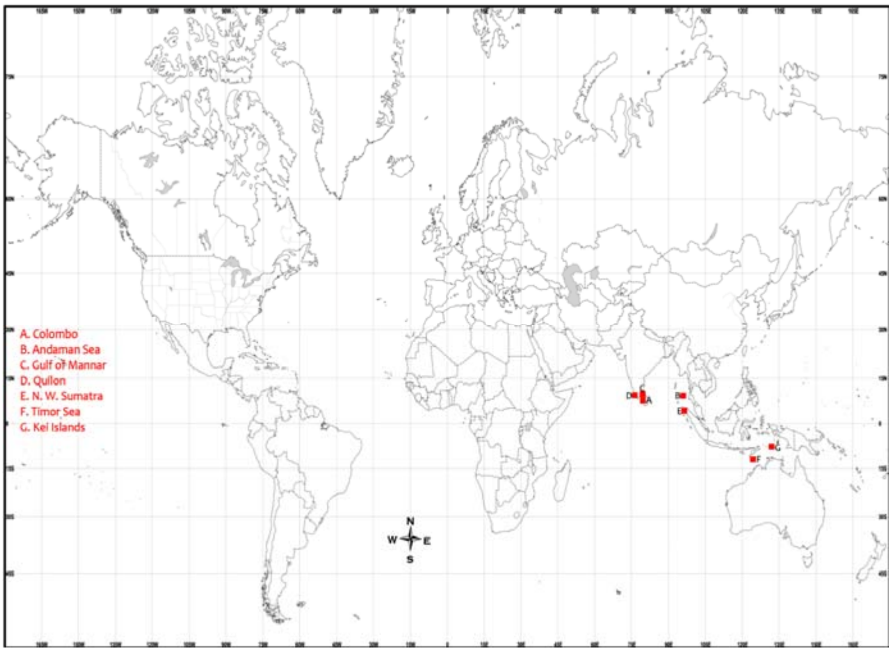


Fig. 84: Map showing localities were *Poecilopsetta colorata* has been recorded in the world.

India: Reported from Gulf of Mannar (Norman, 1934); Quilon at a depth of 180 m (Saramma; 1967); present work (Kochi). Map showing localities were *Poecilopsetta colorata* has been recorded in India is given in Fig. 85.

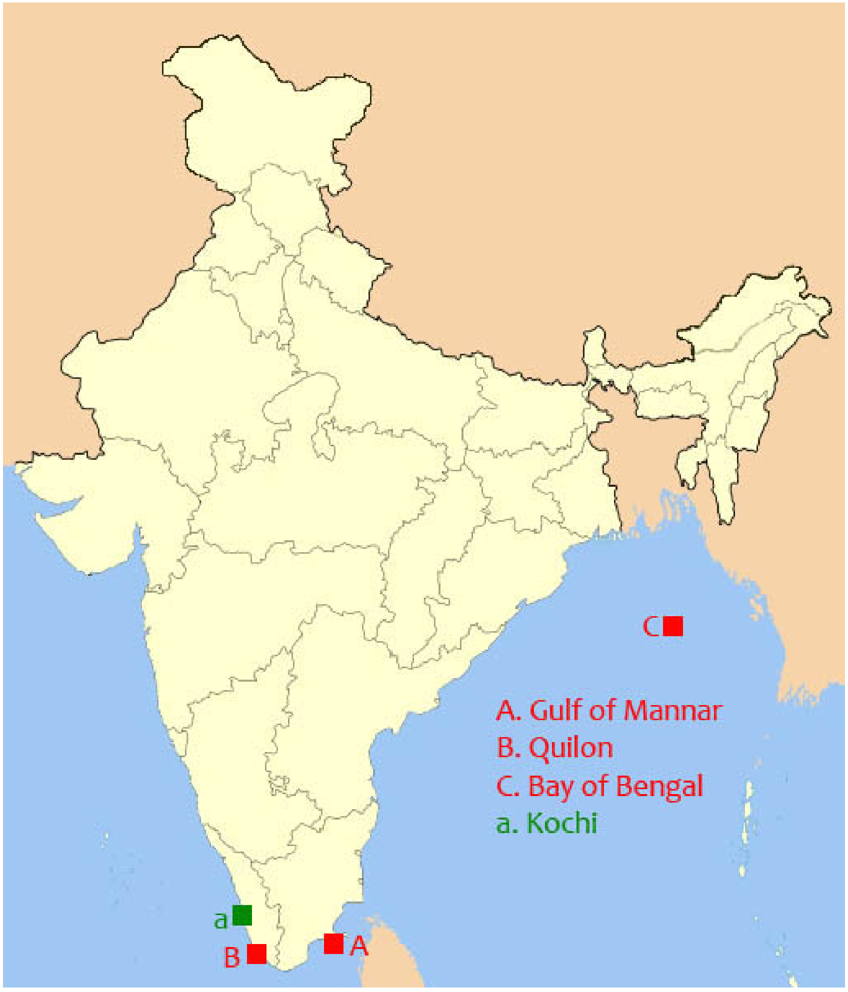


Fig. 85: Map showing localities were *Poecilopsetta colorata* has been recorded in India.

Habitat: Saramma (1967) mentions that the species is a deep water form collected at 180 fathoms from a bottom formed of fine grey sand mixed with a small percentage of silt and shell fragments.

Taxonomic comments: The fish was first described by Gunther (1880) based on Challenger collections from Kai Islands, Challenger station 192, Indonesia, Arafura Sea at a depth 129 fathoms. Later, *Poecilopsetta* *maculosa* was described by Alcock (1894) from collections at 145–250 fathoms in Bay of Bengal during '*Investigator*' collections. Norman (1927) mentioned that the species is closely related to *P. praelonga* as the young one of the species resembles the adult *P. praelonga*. However with regard to the synonymy of *P. maculosa* with *P. colorata*, Norman (1927) mentions "*Examination of a series of examples leaves little doubt that Poecilopsetta maculosa is the young of P. colorata. Brauer* (1906) *expressed some doubt as to the distinction between P. maculosa and P. praelonga; Sewell* (1912) *and Weber* (1913) *concluded that the two species were synonymous. After studying a fair number of specimens, including the types of both species, I conclude that they are quite different*". Later, Guibord & Chapleau (2001:1081) again synonymised *P. maculosa* with *P. praelonga.*

Observations: A lot of confusion in the identity of the species is due to the differential colouration pattern of the adult and young one. Gunther (1862) reported very high values for dorsal and anal fin counts; the values recorded in the present study are closer to the results of the later workers, with the lower range recorded slightly less. Caudal fin counts of the present specimen were also slightly less than that recorded by Alcock (1894).

New Record 9

4.3.5.1.2 *Poecilopsetta inermis* (Breder, 1927)

Paralimanda inermis Breder, 1927, *Bull. Bingham Oceanogr. Coll. Yale Univ*., 1 (1):87, fig. 36 (North of Glovers Reef, Belize, depth 484 fathoms).

Poecilopsetta albomarginata Reisd, 1934, *Smiths. Misc. Coll.*, 91 (15):10, pl. 1.

Poecilopsetta inermis Norman, 1931, *Treubia*, 13: 425; Norman, 1934, *Syst. Monog. Fish*., 389, fig. 278; Sakamoto, 1984, *Mem. Fac. Fish.*

Hokkaido Univ., 31 (1-2):210; Hoshino, 2000, *Ichth. Res*.,45 :95; Uyeda & Sasaki, 2001, *Ichth. Res*., 48 (4): 417; Guibord and Chapleau, 2001, *Copeia* (4):1081; Munroe, 2003, *FAO Sp. Iden. Guide, W.C Pac*ific,: 1924; Evseenko, 2004, *Calif. Acad. Sci. Annot. Checklist. Fish*., 37: 17; Kawai and Amaoka, 2006, *Ichth. Res*., 53: 266; McEachran and Fechhelm, 2005, *Fish. Gulf Mexico*, 2: 863; Kawai *et al*., 2010, *Ichth. Res*., 57 (2): 196.

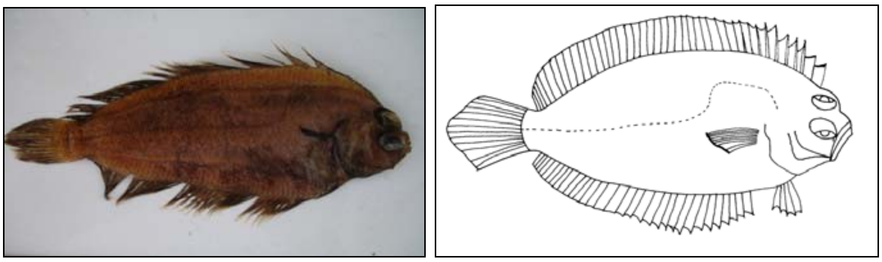


Plate XXVII: *Poecilopsetta inermis* (Breder, 1927)

Material examined: N = 1; 170.99 mm TL from deep sea trawlers at depths of 200 m off Munambam.

Diagnosis: Body covered with cycloid scales on its ocular side.

Meristic characters: D 59; A 49; C 2+13+2; Ll 68; P_1 9; P_2 8.

Body proportions as percent of SL: HL 26.1; HW 32.96; HD 17.7; ED_1 8.3; ED_2 7.99; ID 1.8; UJL 6.2; LJL 4.4; PrOU 3.3; PrOL 2.8; PBU 14.6; PBL 13.6; BD_1 37.4; BD_2 39; DFL 13.8; AFL 12.6; P_1FLO 10.9; P_2FLB 11.9; V_1FLO 9.98; V_2FLB 9.9; CFL 21.4; DBL 88.7; ABL 67.7; P_1BLO 2.3; P_2BLB 1.7; V_1BLO 0.9; V_2BLB 1.8; CBL 10.2.

As percent of HL: HW 126.4; HD 68; ED_1 31.6; ED_2 30.6; ID 7; UJL 23.9; LJL 16.9; PrOU 12.8; PrOL 10.9; PBU 55.9; PBL 52.1; BD_1 143.5; BD_2 149.6.

Description: Body elongate, oval compressed, head small, compressed. Eyes dextral, prominent, upper eye on the dorsal profile, lower placed under, the anterior margins nearly at same level. Tentacles absent on eye; the eyes covered by a thick movable membrane. Snout hooked. Nostrils in pairs, anterior nostril on each side opens at the end of a short tube; tube on blind side shorter. Posterior nostril also placed on tip of nostril. Mouth small, oblique, symmetrical on both sides. Teeth small, sharp, slightly curved inward, present on both jaws, uniserial, well developed on blind side of head. Maxillary ends at anterior one-third of eye. Dorsal origin on blind side just after projection of eye. Pectoral fin origin at the outer projection of operculum on ocular side. Dorsal and anal fin ends at the origin of the caudal peduncle. Caudal fin oval to rounded at its free end. Lateral line arises from upper outer end of operculum, raises into a plateau like area above the pectoral fin region and proceeds straight into the caudal peduncle along the middle of the body. Lateral line absent on blind side. Body covered with cycloid scales on ocular and blind side. A comparative statement of the meristic characters of *Poecilopsetta inermis* is given in Table 59.

Table 59: A comparative statement of the meristic characters of *Poecilopsetta inermis*

Meristic characters	Earlier workers		Present work 2004-2010
	Norman 1934	Hoshino, 2000	N = 1
Dorsal rays	62	58 – 64	52 - 57
Anal rays	53	49 – 55	42 - 47
Pectoral (O)/(B)	9	*	10 - 12
Lateral line	68	63 - 74	65 - 69
Ventral	*	*	5 - 6
Caudal	*	20	16

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of *Poecilopsetta inermis*is given in Table 60

Table 60: Results of the correlation coefficient analysis on non-meristic characters of *Poecilopsetta inermis*

Characters	In SL	In HL
Head length	3.83	
Head Width	3.03	0.79
Head Depth	5.64	1.47
Eye Diameter (U)	12.12	3.16
Eye Diameter (L)	12.52	3.27
Inter orbital	54.50	14.22
Upper jaw	16.07	4.19
Lower jaw	22.68	5.92
Pre orbital (U)	29.98	7.82
Pre orbital (L)	35.24	9.19
Post orbital (U)	6.86	1.79
Post orbital (L)	7.36	1.92
BD_1	2.67	0.70
BD_2	2.56	0.67
Dorsal fin	7.26	1.89
Anal fin	7.97	2.08
Pectoral (O)	9.16	2.39
Pectoral (B)	8.42	2.20
Pelvic (O)	10.02	2.61
Pelvic (B)	10.06	2.62
Caudal	4.67	1.22
Dorsal finbase	1.13	0.29
Anal fin	1.48	0.39
Pectoral (O)	42.74	11.15
Pectoral (B)	58.84	15.35
Pelvic (O)	119.17	31.08
Pelvic (B)	54.29	14.16
Caudal fin	9.85	2.57
Predorsal	8.03	2.09
Preanal	3.27	0.85
Prepectoral(O)	4.13	1.08
Prepectoral(B)	4.02	1.05
Prepelvic (O)	4.15	1.08
Prepelvic (B)	4.31	1.12
Chindepth	49.51	12.92

Colour: Body uniformly black on ocular side, pectoral fin outer tip blackish; two faint dots on outer central portion of caudal fin. Blind side whitish with scattered faint blackish dots.

Distribution: Reported from Atlantic Ocean off Hawai, Bristish Honduras (Norman, 1934), tropical Western Atlantic (Hoshino, 2000). Map showing localities were *Poecilopsetta inermis* has been recorded in the world is given in Fig. 86.

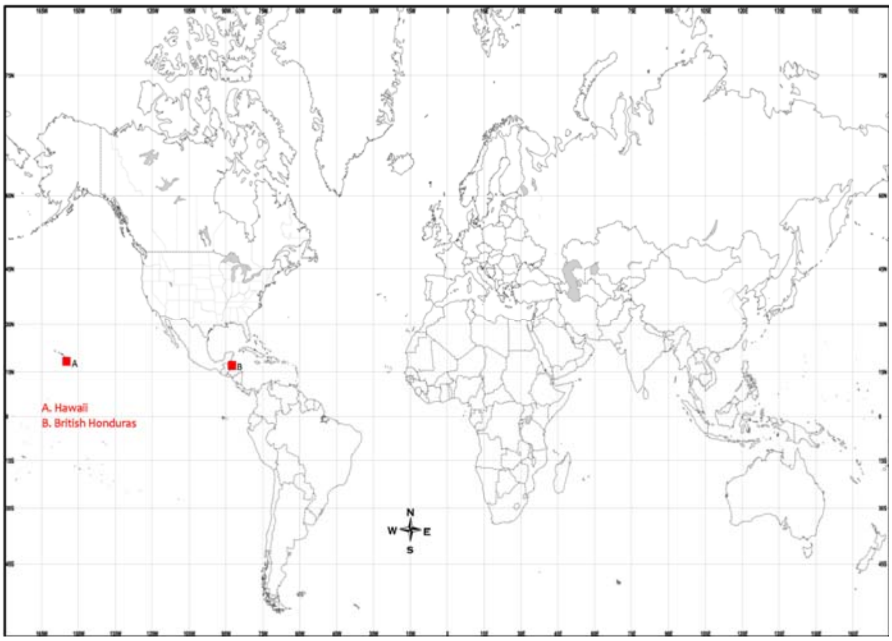


Fig. 86: Map showing localities were *Poecilopsetta inermis* has been recorded in the world.

Map showing localities were *Poecilopsetta inermis* has been recorded in India is given in Fig. 87.

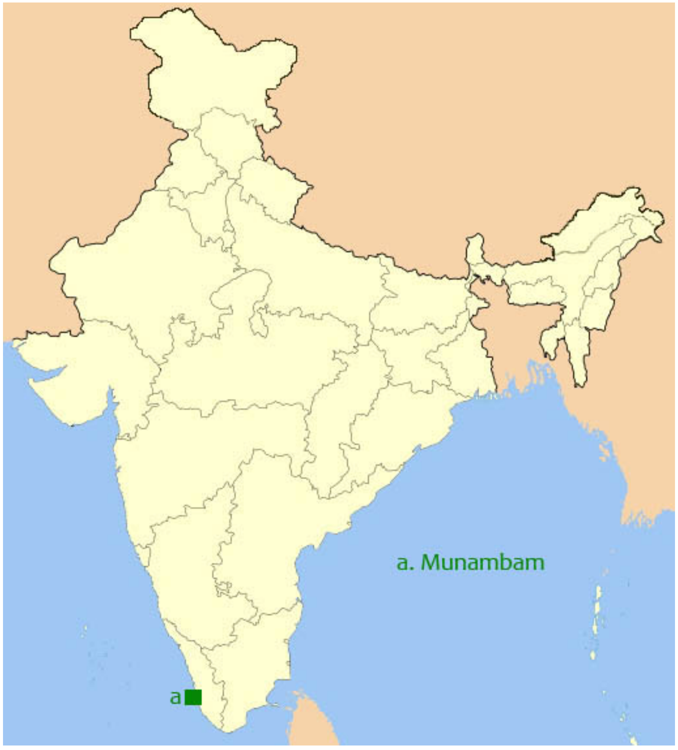


Fig. 87: Map showing localities were *Poecilopsetta inermis* has been recorded in India

Taxonomic comments: The fish was originally described in genus *Paralimanda* as *Paralimanda inermis.* Norman (1931) placed the fish in genus *Poecilopsetta* as *P. inermis* Reid (1934) considered the species to be distinguishable from *P. albomarginata*; however, Hoshino (2000) synonymised *Poecilopsetta albomarginata* Reid as junior synonym of *P. inermis* with the comment that "*Reid (1934) probably did not examine the holotype of P. inermis*".

Observations: This fish has not been previously recorded from Indian Coast or from Western Indian Ocean. However, the recording of this species in Surinam points to the possible occurrence in these waters; this may be a rare occurrence of this species in these waters. Norman

(1934) mentions that the body scales on the ocular side are cycloid; the same is seen in the present specimen also. However, Hoshino (2000) mentions of ctenoid scales on the ocular side. The spots on the body mentioned by Hoshino (2010) in his description are also not present in the present specimen; it could probably due to preservation in ice or even wide changes in geographical distribution.

4.3.5.1.3 *Poecilopsetta natalensis* Norman, 1931

African right eye flounder

Limanda beanie (non Goode) Von Bonde, 1921, *Rep. Fish. Mar. Biol. Surv. S. Africa Sp. Rep.*, I: 16.

Poecilopsetta natalensis Norman, 1931, *Treubia*, XIII: 426 (Off Natal, South Africa, depth 188 fathoms); Norman, 1934, *Syst. Monog. Flatfish.*, I: 393, fig. 283 (Off Natal and Delagoa Bay); Smith, 1961, *Sea Fish. S. Africa*: 155, fig. 301 (Natal); Chen and Weng, 1967, *Biol. Bull.*, 25: 16, fig. 8 (Tungkong, Taiwan); Amaoka in Okamura *et al.*, 1982, *Fish. Kyushu-Palau Ridge Tosa Bay*: 301; Sakamoto, 1984, *Mem. Fac. Fish. Hokkaido Univ.*, 31 (1-2):210; Heemstra, 1986, *Smith. Sea Fish.*,: 864; Quéro *et al.*, 1988, *Cybium*, 12(4):322; Adam *et al.*, 1998, *Ichth. Bull. J. L. B. Smith Inst. Ichth.*, 67:15; Fricke, 1999, *Fish. Mascarene Island*: 572; Hoshino, 2000, *Ichth. Res.*, 47(1): 98; Hoshino *et al.*, 2000, *Ichth. Res.*, 47(3):268; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.,* 8: 645; Hensley, 2001, *FAO Sp. Iden. Guide*, IV (6): 3873; Hoshino *et al.*, 2001, *Species Diversity*, 6: 80; Guibord and Chapleau, 2001, *Copeia*, 2001(4):1081; Evseenko, 2004, *Calif. Acad. Sci. Annot. Checklist. Fish.*, 37:17; Kawai & Amaoka, 2006, *Ichth. Res.*, 53:266; Hoese and Bray 2006, *Zool. Cat. Aust.,* 35: 1835; Fricke *et al.*, 2009, *Stutt. Beit. Natur. A, Neue Serie*. 2:114 ; Kawai *et al*., 2010, *Ichth. Res.*, 57 (2):196.

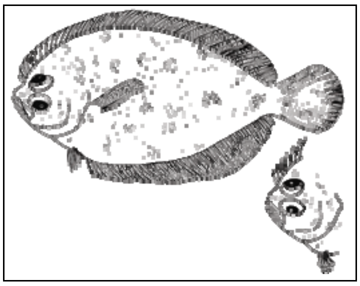


Plate XXVIII: *Poecilopsetta natalensis* Norman, 1931

Material examined: N=4, TL 112.11 – 130.92 from deep sea multiday vessels operating off Munambam at depths over 250 m.

Diagnosis: Teeth in narrow bands; less than 90 scales in lateral line.

Meristic characters: D 47 – 56; A 42 – 46;P_1/P_2 10/10; V_1/V_2 5/5; Ll 75 – 87

Body proportions as percent of SL (mean in parentheses): HL 23.2 – 27.02 (24.97); HW 33.9 – 39.9 (36.7); HD 14.1 – 21.2 (18); ED2 3.4 – 8.9 (7.4); ED_1 8.6 – 10.5 (9.7); ID 1.2 – 2.5 (1.5); SNL_1 6.4 – 8.7 (7.5); PrOU 2.7 – 3.6 (3.2); PBU 9.7 – 16.6 (14.1); BD_1 35.3 – 43.01 (38.6); BD_2 38.7 – 44.7 (42.6); DFL 9.3 – 14.3 (11.4); AFL 9.4 – 15.1 (11.5); P_1FLO 12.9 – 16.6 (14.3); P_2FLO 7.3 – 9 (8.1); CFL 14.8 – 23.6 (21.1); CPD 8.7 – 11.2 (9.9); DBL 71.4 – 85.3 (79.4); ABL 51.4 – 66.7 (61.01); P_1BLO 2.9 – 3.7 (3.1); P_2BLB 1.6 – 3.9 (2.75); V_1BLO 1.7 – 3.2 (2.6); V_2BLB 2.5 – 2.99 (2.7); PDL 12.4 – 13.9 (13.2); PAL 28.5 – 35.6 (32.5); UJL 5.4 – 7.04 (6.3); LJL 3.8 – 7.3 (5.1); CD 1.2 – 3.4 (1.9).

As percent of HL (mean in parentheses): HW 140.4 – 152.7 (147); HD 60.1 – 82.8 (72.2); ED_2 36.4 – 42.2 (39); ED_1 36.4 – 41.2 (39.1); ID 4.3 – 9.4 (6.1); SNL_1 24.3 – 37.3 (30.1); PrOL 11.4 – 13.2 (12.7); PBU 35.7 – 70.4 (57.1); PBL 49.9 – 56.9 (53.2); BD1 144.6 – 164.6 (154.5).

Description: Body deeply oval, laterally compressed but thick and fleshy in the centre. Eyes large, nearly contiguous separated by a narrow interorbital space. Eyes prominent, with the upper eye bulging over the dorsal profile, lower eye a little in front of the upper eye; snout short, shorter than rostral hook prominent. Mouth small, oblique, maxillary ending in front of the lower eye. Fine villiform teeth in bands in both jaws, teeth widely spaced on both jaws on the ocular side, two rows of closely placed teeth on the blind side. Eyes covered by a flap of coloured skin; the lower end of the flap extends beyond orbit and covers posterior part of the eye. Dorsal fin origin just behind the upper eye on blind side; first five dorsal fin rays free and not connected with interfin membrane. Pectoral fin on ocular side a little longer than that of blind side, inserted behind middle portion of the lower eye. Pelvic fin inserted in front of pectoral; asymmetrical, that on blind side inserted slightly behind that on ocular side. Lateral line tubular. Lateral line origin from behind the central portion of the interorbital, forming a plateau like curve above the pectoral fin and then proceeding back to the edge of the caudal peduncle. Each lateral line scale has a central groove with a bulbous portion leading to a tubular portion through which the lateral line canal is connected. Lateral line scales has tiny short six ctenii at its end. Body covered with ctenoid scales on ocular side with six short stumpy ctenii at its free end. Blind side with cycloid scales. A comparative statement of the meristic characters of ***Poecilopsetta natalensis*** is given in Table 61.

Table 61: A comparative statement of the meristic characters of *Poecilopsetta natalensis*

Meristic characters	Earlier workers		Present study 2004 – 2010	
	Norman 1931	Heemstra 1986	N = 4	Mean ± SD
Dorsal rays	65 – 68	60 – 62	47 – 56	55 ± 2.2
Anal rays	54 – 58	51 – 54	42 – 46	45.5 ± 0.58
Lateral line	*	*	75 – 87	82.5 ± 5.5
Pectoral (O/B)	7 - 8/ 7- 10	7 - 8/ 7 -10	10/10	*

Results of the correlation coefficient analysis on non-meristic characters of ***Poecilopsetta natalensis*** is given in Table 62.

Table 62: Results of the correlation coefficient analysis on non-meristic characters of *Poecilopsetta natalensis*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.6 - 4.1	3.78	0.21	0.73	0.33
Headwidth	2.5 - 2.7	2.57	0.10	0.89	0.44
Head depth	4.7 - 5.9	5.31	0.60	0.93	0.10
Eye diameter (U)	9.4 - 9.8	9.68	0.19	0.92	0.09
Eye diameter (L)	9.5 - 9.95	9.70	0.20	0.41	0.06
BD_1	2.3 - 2.6	2.45	0.12	0.28	-0.03
BD_2	2.2 - 2.3	2.21	0.04	0.70	0.43
Dorsal FL	7.02 - 9.4	8.40	1.03	0.97	0.37
Anal FL	6.6 - 9.4	8.41	1.23	0.35	0.15
Pectoral FL (O)	6.02 - 7.3	6.63	0.54	0.14	0.11
Pectoral FL (B)	8.2 - 8.9	8.45	0.40	0.59	0.20
Pelvic FL (O)	10.5 - 12.8	11.77	0.94	1.00	0.18
Pelvic FL (B)	11.1 - 11.8	11.44	0.36	0.64	0.12
Caudal FL	3.7 - 6.8	4.67	1.42	0.91	0.10
Caudal peduncle depth	8.96 - 10.7	9.58	0.81	0.01	0.06
Dorsal fin BL	1.2 - 1.22	1.19	0.02	0.68	0.15
Anal fin BL	1.5 - 1.6	1.55	0.06	0.94	0.82
Pectoral BL (O)	25.3 - 34.9	30.64	4.70	0.96	0.91
Pectoral BL (B)	23.9 - 63.6	39.34	21.27	0.01	0.01
Pelvic BL(O)	25.9 - 58.8	39.24	13.90	0.12	-0.05
Pelvic BL (B)	27.9 - 40.02	35.05	6.37	0.10	-0.03
Pre dorsal	6.3 - 7.6	7.15	0.61	0.91	-0.03
Pre anal	2.8 - 3.1	2.91	0.11	0.04	-0.01
Prepectoral (O)	3.5 - 3.8	3.62	0.14	0.85	0.40
Prepectoral (B)	3.6 - 3.8	3.68	0.06	0.71	0.20
Pre pelvic (O)	3.3 - 3.9	3.66	0.25	0.97	0.25
Pre pelvic (B)	3.6 - 3.8	3.62	0.11	0.55	0.30
Characters	**Range in SL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Headwidth	0.7 - 0.7	0.68	0.68	0.73	1.68
Head depth	1.2 - 1.7	1.37	1.37	0.27	1.22
Eye diameter (U)	2.4 - 2.8	2.54	2.54	0.60	0.42
Eye diameter (L)	2.4 - 2.8	2.51	2.51	0.35	0.29
Inter orbital length	10.6 - 23.2	17.96	17.96	0.57	0.36
SNL1	2.7 - 4.11	3.22	3.22	0.24	-0.40

Colour: Body brownish – grey on ocular side, blind side whitish. Outer free edge of the pectoral fin black; caudal fin with two blackish brown patches, one at either end of the central portion.

Habitat: Deep sea.

Distribution:

World: East Africa (Norman, 1931, 1934); South Africa, Madagascar and Réunion (western Mascarenes) east to Maldives, Taiwan (Chen and Weng, 1967). Map showing localities were ***Poecilopsetta natalensis*** has been recorded in the world is given in Fig. 88

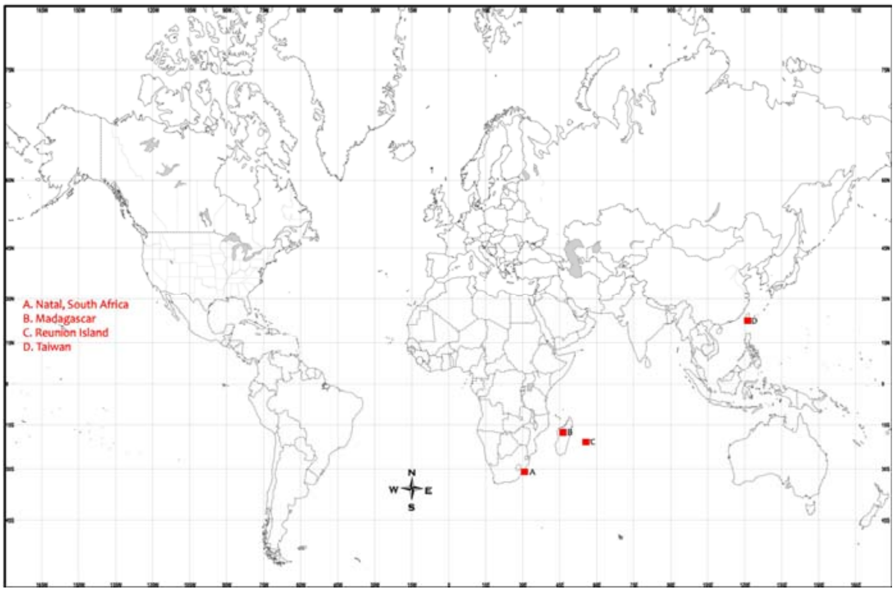


Fig. 88: Map showing localities were *Poecilopsetta natalensis* has been recorded in the world.

India: Munambam (Kerala); this is the first report from the Indian waters. Map showing localities were ***Poecilopsetta natalensis*** has been recorded in India is given in Fig. 89

Fig. 89: Map showing localities were *Poecilopsetta natalensis* has been recorded in India

Taxonomic comments: The species was first described as *Limanda beanie* by Von Bonde (1921) based on samples from South Africa. Later, Norman (1931) described the species as *Poecilopsetta natalensis* based on samples from Natal.

Observations: Not many revisions have come in this species probably due to its distribution in South African region only. Only four numbers of this species was collected during the entire period of study from the Indian coast.

4.3.5.1.4 *Poecilopsetta praelonga* Alcock, 1894

Alcock's crested flounder

Poecilopsetta praelonga Alcock, 1894, *J. Asiat. Soc. Bengal*, LXIII (2):139, pl. VII, fig. 2; Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV (2): 328; Alcock, 1898, *Ann. Mag. Nat. Hist.*, (7) ii: 156; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 40, fig. 11; Norman, 1931, *Treubia*, XIII: 425; Norman, 1934, *Syst. Monog. Flatfish.*,: 391, fig. 281 (Bay of Bengal, Andaman Sea, Timor Sea); Munroe, 1955, *Fish. Ceylon*: 257, fig. 742 (180 – 250 fathoms, Ceylon); Chen and Weng, 1967, *Biol. Bull.*, 25: 13, fig. 6 (Tungkong); Guibord & Chapleau, 2001, *Copeia*, 2001(4):108; Evseenko, 2004, *California Acad. Sci. Annot. Checklist. Fish.*, 37:18.

Boopsetta umbrarum Alcock, 1896, *J. Proc. Asiat. Soc. Bengal*, LXV (2; 3): 305 (Off Colombo, Sri Lanka, Investigator station 204, depth 180 - 217 fathoms.); Alcock, 1897, *Illust. Zool. Investigator*, pl. xvii, fig. 5, pl. 49.

Boopsetta praelonga Alcock, 1899, *Cat. Deep Sea Fish.*,: 126.

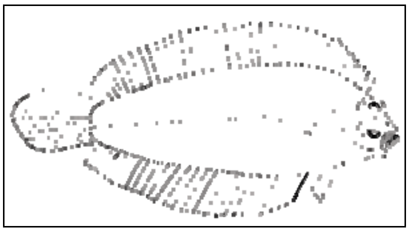


Plate XXIX: *Poecilopsetta praelonga* Alcock, 1894

Material examined: N= 4; TL 11.39-140.61 mm from deep sea trawlers operating off Munambam.

Diagnosis: 95 – 99 scales in the lateral line on ocular side.

Meristic characters: D 52 – 57; A 42 – 47; P_1 10 – 12; P_2 10 - 12, V_1, V_2 5 - 6; C 15 – 16.

Body proportions as percent of SL (mean in parentheses): HL 25.1 – 27.1 (26.1); HW 31.6 – 40.7 (34.8); HD 16.2 – 20.9 (19.4); BD_1 34.8 – 44.7 (41.5); ED2 3.4 – 8.9 (7.4); ED_1 5.9 – 10.3 (8.7); ID 1.1 – 1.4 (1.3); SNL_1 4.5 – 5.7 (4.96); SNL_2 2.5 -4.6 (3.3); UHL 18.3 – 19.3 (18.8); PBL 9.7 – 13.5 (11.7); UJL 5.5 – 7.5 (6.7); LJL 5.6 – 8.2 (6.96); DFL 10.9 – 13.6 (12.3); AFL 10 – 16.5 (12); CFL 21.7 -28.2 (24.9); P_1FLO 11.4 – 15.6 (14.5); P_2FLB 10.1 – 12.7 (11.7); V_1FLO 7.7 – 9.9 (8.5); V_2FLB 7.1 – 8.97 (8.2); DBL 83.3 – 87.1 (85.6); ABL 65.6 – 67.4 (66.7); P_1BLO 1.3 – 3.4 (2.5); P_2BLB 2.5 – 3.8 (3.3); V_1BLO 1.1 – 2.6 (2.1); V_2BLB 1.8 – 2.8 (2.2); CPD 9.8 – 11.1 (10.5); PDL 11.9 – 14.8 (13.3); V_1LO 25.5 – 27.2 (26.1); V_2LB 25.6 – 25.96 (25.8); PAL 31.3 – 33.97 (32.9).

As percent of HL (mean in parentheses): HW 123.3 – 158.4 (133.6); HD 59.8 – 80.1 (74.7); ED2 12.7 – 34.8 (28.7); ED_1 21.9 – 40.4 (33.6); ID 3.95 – 5.5 (4.96); SNL_1 17.5 – 21.7 (19.1); SNL_2 9.4 – 17.9 (12.7); UHL 71.2 – 72.7 (72.1); UJL 21.1 – 29.1 (25.6); LJL 21.3 – 32.1 (26.7); DFL 43.2 – 50.3 (47.3); AFL 38.1 – 64.1 (46.3).

Description: Body rather elongate, compressed with a thick fleshy central portion and a deep caudal peduncle. Head moderate, eyes large, nearly contiguous, upper placed high on dorsal profile, inside a fleshy hump like area; both eyes placed one below the other. Lower eye close to the maxillary. Snout very prominent, with a notch in front of the lower eye. Gill rakers short, pointed, 9 – 11 in lower part of arch. Nostrils two in front of the lower eye; the posterior one placed close to the anterior margin of the lower eye. Teeth narrow, pointed, villiform, in narrow bands in both jaws, more developed on blind side; vomer toothless. Pectoral fin covered by a sheath of skin. A comparative statement of the meristic characters of ***Poecilopsetta praelonga*** is given in Table 63.

Table 63 : A comparative statement of the meristic characters of *Poecilopsetta praelonga*

Meristic characters		Earlier workers				Present work 2004-2010	
	Alcock 1894	**Alcock 1899**	**Norman 1927, 1934**	**Munroe 1955**	**Chen and Weng 1965**	**N = 4**	**Mean ± SD**
Dorsal rays	58 - 60	60	59 - 65	59 - 65	59 – 62	52 - 57	53 ± 2.5
Anal rays	45 - 47	51	50 - 54	50 - 54	50	42 - 47	44 ± 2.2
Pectoral (O)/(B)	*	8/6	8 - 10	8 - 10	8 - 10	10 - 12	10.6 ± 1.1
Lateral line	*	110	90 - 95	90 - 95	95 - 98	95 - 99	96.7 ± 1.7
Ventral	6	6	*	*	5 - 6	5 - 6	5.3 ± 0.5
Caudal	18	18	*	*	18	16	15.7 ± 0.5

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of ***Poecilopsetta praelonga*** is given in Table 64.

Table 64: Results of the correlation coefficient analysis on non-meristic characters of *Poecilopsetta praelonga*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.7 - 3.98	3.84	0.12	0.90	0.23
Head width	2.5 - 3.2	2.90	0.31	0.50	0.42
Head depth	4.8 - 6.2	5.21	0.65	0.97	0.39
Body depth	2.2 - 2.9	2.44	0.29	0.97	0.83
Eye Diameter (U)	9.7 - 16.9	12.06	3.33	0.58	0.19
Eye Diameter (L)	11.2 - 29.2	15.88	8.85	0.83	0.29
Inter orbital length	72.4 - 93.3	78.45	9.95	0.87	0.02
Dorsal fin length	7.3 - 9.2	8.17	0.78	0.40	0.09
Anal fin length	6.1 - 9.99	8.64	1.76	0.17	0.15
Caudal fin length	3.6 - 4.6	4.05	0.45	0.30	0.16
Pectoral fin length (O)	6.4 - 8.8	7.02	1.17	0.41	0.17
Pectoral fin length (B)	7.9 - 9.9	8.67	1.10	0.63	0.15
Pelvic fin length (O)	10.13 - 13	11.90	1.38	0.15	0.04
Pelvic fin length (B)	11.2 - 14.1	12.33	1.55	0.65	0.11
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	0.6 - 0.8	3.03	0.08	0.44	1.63
Head depth	1.3 - 1.7	5.44	0.21	0.76	1.43
Body depth	0.6 - 0.8	2.54	0.10	0.78	3.08
Eye Diameter (U)	2.5 - 4.6	12.65	0.98	0.27	0.55
Eye Diameter (L)	2.9 - 7.9	16.74	2.48	0.54	0.97
Inter orbital length	18.2 - 25.3	81.96	3.26	0.60	0.08
Upper head length	1.37 - 1.4	5.55	0.01	0.99	0.77
Post orbital length	1.9 - 2.6	8.98	0.28	0.54	0.66
Upper jaw length	3.4 - 4.7	15.87	0.55	0.00	0.00
Lower jaw length	3.1 - 4.7	15.44	0.78	0.56	-0.29

A pair of nostrils on the blind side at the tip of the snout. Lateral line prominent on the ocular side, with a prominent plateau above the pectoral fin on ocular side. Lateral line rudimentary on blind side. Dorsal origin behind the posterior part of the eye. Pectoral fin placed behind the lower eye at the outer free end of the operculum. Caudal fin developed, well rounded at the tip. Scales present on the head region above and around mouth; ctenoid scales with small ctenii on ocular side, cycloid scales on blind side. All rays of dorsal, anal, pectoral, pelvic and anal fins simple, caudal fin rays branched.

Colour: Ocular side blackish brown, fins black, caudal fin dark greyish brown, pectoral paler in colour. Blind side with dark black diffuse round spots scattered. In young specimens, six black blotches seen along the lateral lines of both sides of the specimens. The young one of this species resembles the adult of *P. colorata*.

Distribution

World: Reported from Timor Sea, Andaman Sea (Norman, 1927; 1934); Ceylonese waters, (Munroe, 1955); Taiwan (Chen and Weng, 1967). Map showing localities were ***Poecilopsetta praelonga*** has been recorded in the world is given in Fig. 90.

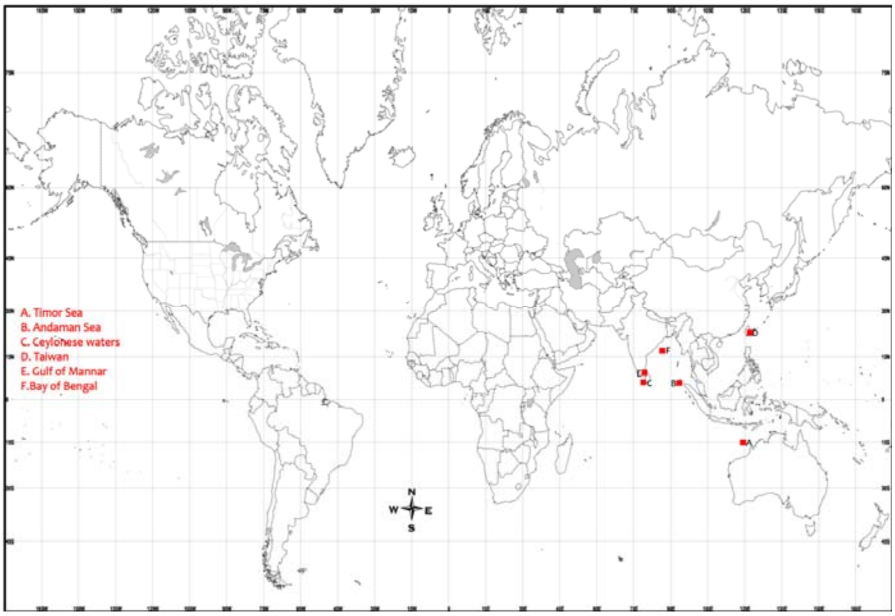


Fig. 90: Map showing localities were *Poecilopsetta praelonga* has been recorded in the world.

India: Reported from Gulf of Mannar, Bay of Bengal (Norman, 1927; 1934). Map showing localities were ***Poecilopsetta praelonga*** has been recorded in India is given in Fig. 91.

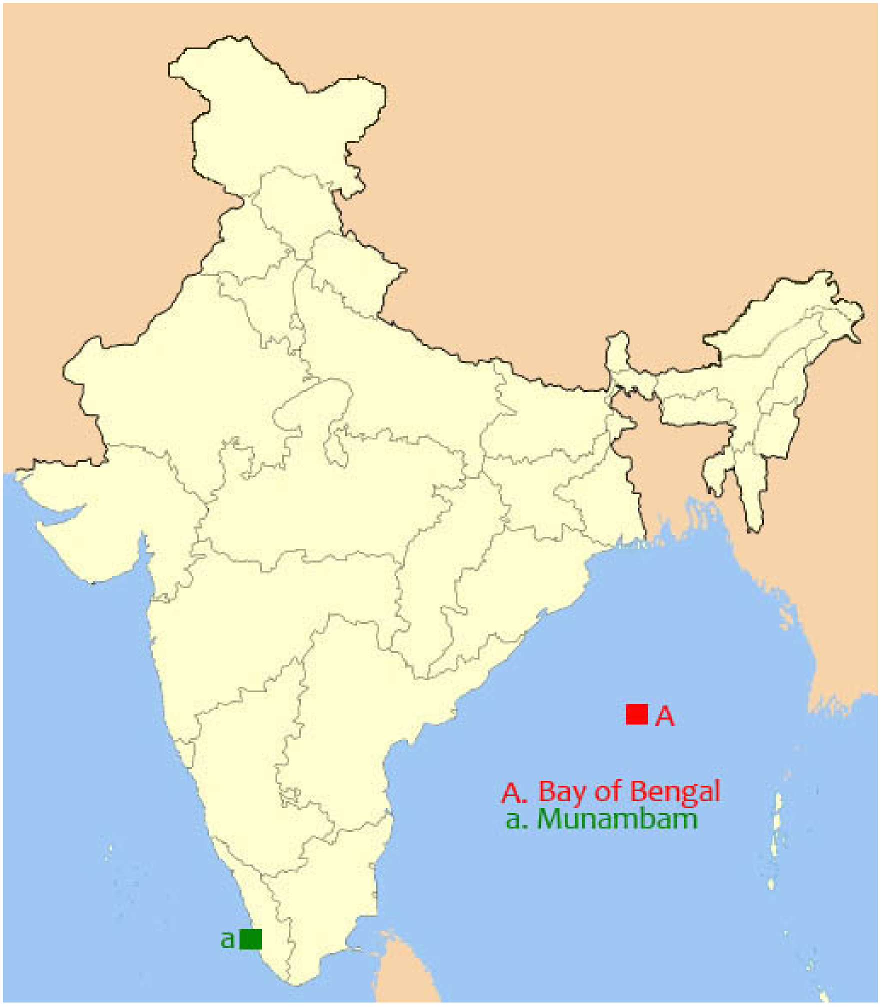


Fig. 91: Map showing localities were *Poecilopsetta praelonga* has been recorded in India

Habitat: Deep sea species.

Taxonomic comments: The species was first described as *Poecilopsetta praelonga* by Alcock in 1894 from the collection of the bathybial fishes from Bay of Bengal from a depth of 142 – 400 fathoms. In his description, he clearly differentiated the species from *Poecilopsetta maculosa*. Later, Alcock in 1896 described a species *Boopsetta umbrarum* during the collections of "*Investigator*". Norman (1927) examined the types of *Poecilopsetta praelonga* and *Boopsetta umbrarum* and concluded that they are synonyms; the description was based on both types together. This was later also confirmed by Guibord & Chapleau (2001) and Evseenko (2004).

Brauer (1906) expressed some doubt as to the distinction between *P. praelonga* and *P. maculosa*; Sewell (1912) and Weber (1913) concluded that they are synonyms. Alcock was very clear in differentiating the two specimens; the only resemblance he mentioned was that of the colour on the blind side. However, though in 1927, Norman concluded that both species are distinct; later in 1934, he placed *Boopsetta maculosa* Weber, 1913 as well as *Poecilopsetta maculosa* Weber and Beaufort, 1929 as synonyms of *P. praelonga*. He also added that "*this species which has an almost exactly similar distribution, may prove to be identical with P. colorata*".

Observations: The meristic counts of the present specimen are in agreement with that given by the earlier workers except for a high value in the lateral line scale count of Alcock (1899). Alcock (1894) mentions of the largest specimen recorded as 3.75 inches collected off Colombo at a depth of 142 – 400 fathoms. The present specimens are much bigger than these specimens.

4.3.6 Family Samaridae

Family Samaridae is a tropical Indo–Pacific group with three genera and 20 species in the family. (Nelson, 2006). Samarinae was erected as a subfamily of Pleuronectidae by Jordan and Goss (1889) with the genera *Samarinae*, *Lophonectes*, *Poecilopsetta* and *Nematops*. Regan (1920) removed *Paralichthodes* from the Samarinae by erecting the new family Paralichthodidae and included four genera in the Samarinae; *Brachypleura*, *Lepidoblepharon*, *Samaris* and *Samriscus*, including *Plagiopsetta glossa* as a doubtful *Samariscus glossa*. Regan mentions that it is "*well distinguished externally from the Pleuronectinae with symmetrical mouth by their form, the absence of a distinct caudal peduncle, the extension forward of the dorsal nearly to the end of the snout, and the asymmetrically placed pelvic fins*". *Paralichthodes* had nostrils below the anterior part of the dorsal fin, *Samaris* had more extended bases of the pelvic fins. Chabanaud (1937) erected the subfamily Brachypleurinae including *Brachypleura* and *Lepidoblepharon* as a subfamily of the Samaridae. Later (1939), he elevated the Samarinae to the family level, listing 15 species and omitting *Brachypleura* and *Lepidoblepharon*. Hubbs (1945) erected Family Citharidae and placed the two genera in it. The monophyly of Samarinae was proposed by Sakamoto (1984) and confirmed by Chapleau (1993). These results permitted Nelson (2006) to raise the subfamily Samarinae to the family level. Molecular level studies confirmed the monophyly status of this family (Berendzen and Dimmick, 2002; Pardo *et al.*, 2005; Azevedo *et al.*, 2008).

Family Samaridae can be distinguished from other Pleuronectoidei by their lack of pectoral fin on blind side, a straight lateral line, small mouth, short gill rakers, pelvic fin asymmetrical, small scales, minute nostrils on blind side.

4.3.6.1 Genus *Samaris* Gray, 1831

Samaris Gray, 1831, *Zool. Misc.,* I: 4 (Type: ***Samaris cristatus*** Gray 1831); Norman, 1934, *Syst. Monog. Flatfish*: 402; Ahlstrom *et al*., 1984, *Am. Soc. Ichth. Herp. Sp. Publ*., 1:643; Sakamoto 1984, *Mem. Fac. Fish. Hokkaido Univ*., 31 (1-2): 211; Sakamoto in Masuda et al. 1984, *Fish. Jap. Arch*.,:354; Heemstra 1986, *Smith Sea Fish*., :864; Quéro et al., 1989, *Cybium* 13(2); Feng in Pan *et al*., 1991, *Freshwater fish. Guangdong Province*: 527; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166: 65; Li and Wang, 1995, *Fauna Sinica*: 269; Hensley 2001, *FAO Sp. Iden. Guide* IV (6):3965; Sasaki and Uyeda 2002, *Ichth. Res*., 49(4):390; Mihara and Amaoka, 2004, *Mem. Mus. Nat. Hist. Nat. Zool*., 191: 619; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1839.

Body elliptical, compressed. Dextral eyes placed close together, nearly contiguous. Narrow mouth with small, equal sized teeth in narrow bands in both jaws, well developed on blind side. Dorsal origin on snout, with the first few rays elongated, filament like, with a bulbous tip. Pectoral fin on ocular side well developed, elongate, placed in front of that on blind side. Dorsal and anal rays free from caudal. Anal fin origin a little behind vertical from pectoral fin origin. Scales ctenoid on ocular side and blind side. Lateral line origin from behind upper eye with a slight raise above pectoral fin followed by a straight line towards caudal peduncle. Gill rakers rudimentary.

Taxonomic comments:

Weber (1913) placed *Samaris* in Family Pleuronectidae, subfamily Hippoglossidae along with *Psettodes*, *Poecilopsetta* and *Pseudorhombus*.

Characters assigned were dorsal origin in front of eyes, eyed side only with ctenoid scales, lateral line straight, pelvic fins unequal, first few dorsal fin rays long and free at its end. Five species are recognized in genus *Samaris* by Norman (1927) – *S. cristatus*, Gray, *S. ornatus* von Bonde, *S. delagoensis* von Bonde, *S. cacatuae* (Ogilby) and *S. macrolepis* Norman. Smith (1961) suggested that of the five species from the Indo – Pacific, probably only two are valid and synonymised *S. delagoensis* and *S. ornatus* with *S. cristatus*. He considered *S. cristatus* and *S. macrolepis* as valid species. Eschmeyer (2010, online) listed 5 species in this genus – *Samaris cristatus*, *Samaris chesterfieldensis*, *Samaris costae, Samaris macrolepis* and *Samaris spinea*. Of this only *Samrais cristatus* was collected from South India in this study.

4.3.6.1.1 *Samaris cristatus* Gray, 1831

Cockatoo right eye flounder

Samaris cristatus Gray, 1831, *Zool. Miscell.*,: 5 (China, Western North Pacific); Richardson, 1846, *Ichth. China Japan*: 279 (Canton); Gunther, 1862, *Cat. Brit. Mus.*, IV: 420 (Chinese Seas); Alcock, 1889, *J. Asiat. Soc. Bengal,* LVIII (pt. 2): 291, pl. xvii; Alcock, 1896, *J. Asiat. Soc. Bengal,* LXV (pt. 2): 327; Alcock, 1898, *Illust. Zool. "Investigator" Fish.*, pl. xxiii, fig. 2; Dunker, 1903, *Natur. Mus. Hamburg, Mitteil*, 21: 164; Norman, 1927, *Rec. Ind. Mus.*, XXIX: 44 (Ceylon, Andaman); Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.*, I: 138, fig. 34 (Bay of Bengal, Singapore, Java Sea, Chinese seas, Ceylon); Chu, 1931, *Index Pisc. Sinen.*,: 92 (Canton); Wu, 1932, *These Fac. Sci. Univ. Paris*, A. 244 (268): 119 (Hongkong); Norman, 1934, *Syst. Monog. Flatfish.*, I: 403, fig. 291 (Indian Ocean, Archipelago, Chinese Seas); Kamohara, 1952, *Rept. Kochi Univ. No* .3: 82 (China); Herre, 1953, *Checklist Philippines Fishes*: 185 (India, Phillipines, China); Matsubara, 1955, *Fish. Morph. Hierar.*, II: 1279 (Japan, China Sea); Munroe, 1955, *Fish. Ceylon*: 257, fig. 744; Chen, 1956, *Synop. Vert. Taiwan*: 108 (Taiwan); Smith, 1961, *Sea Fish S. Africa*: 156, fig. 303 (Natal, Delagoa); Chen and Weng, 1965, *Biol. Bull.*, 25: 18, fig.10 (Tainan, Masa Groove); Venkataramanujan and Ramamoorthi, 1973, *J. mar. biol. Ass. India*, 15 (2): 875; Kuthalingam *et al.*, 1973, *J. mar. biol. Ass. India*, 15 (2): 878; Ramanathan and Natarajan, 1980, *Bull. Zool. Mus. Univ. Amstr.*, 7 (10): 97, fig. 17; Kyushin *et al.*, 1982, *Fish. South China Sea*: 265; Dor, 1984, *Checklist Red Sea*, 269; Sakamoto in Masuda *et al.*, 1984, *Fish. Jap. Arch.*, 354, pl. 318-J; Heemstra, 1986, *Smith's Sea Fish.*,: 864, pl. 133, fig. 260.4; Allen and Swainston, 1988, *Mar. Fish. N. W Australia*: 146; Quero *et al.*, 1989, *Cybium,* 12 (4): 108; Feng in Pan *et al.*, 1991, *Freshwater fish. Guangdong*: 528; Goren and Dor, 1994, *Checklist Fish. Red Sea*: 71; Li and Wang, 1995, *Fauna Sinica*: 270; Evseenko, 1996, *J. Ichth.*, 36 (9): 730; Mohsin and Ambak, *1996, Mar. Fish. Malaysia*: 595; Allen, 1997, *Western Australian Mus.*,: 234; Chen *et al.*, 1997, *Fish. Nasha Islands*: 176; Amaoka in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.*, 8: 645; Nakabo, 2000, *Fish. Japan*: 1381; Hensley, 2001, *FAO Sp. Iden. Guide*, VI (4):3870; Hutchins, 2001, *Rec. W. Australian Mus. Suppl.,* 63: 46; Shinohara *et al.*, 2001, *Mem. Nat. Sci. Mus.*,: 336; Nakabo, 2002, *Fish Japan*. 2º ed: 1381; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (Suppl. 1): 47; Mihara and Amaoka, 2004, *Mem. Mus. Nat. Hist. Nat. Zool.*, 191: 620; Randall 2005, *Reef Fish. South Pacific*: 615; Hoese and Bray, 2006, *Zool. Cat. Aust.,* :1839 (Australia)

Arnoglossus cacatuae Ogilby, 1910, *Endeavour Series*, 1 (Cape Gloucester, Queensland, Australia).

Samaris delagoensis von Bonde, 1925, *Trans. Royal Soc. South Africa*, 12 (pt. 4): (Delagoa Bay, southeastern Mozambique).

Samaris cristatus erythraeus natio Chabanaud, 1969, *Bull. Mus. Nat. Hist. Nat*. (Serie 2), 40 (5):874, figs. 1- 4. (Gulf of Suez).

Samaris ornatus von Bonde, 1922, *Rep. Fish. Mar. Biol. Sur. Union S. Africa Rep*. 2 (art. 1): 13, pl.6 (Natal, South Africa, Pickle station).

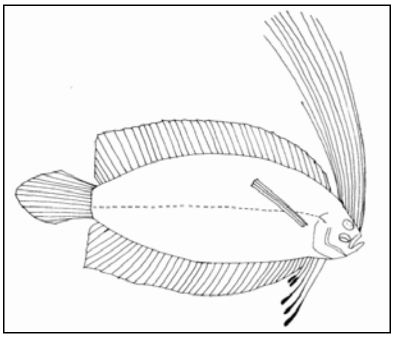


Plate XXX: *Samaris cristatus* Gray, 1831

Material examined: N= 41; TL 68.4 - 188.4 mm (143.8 mm) from Cochin, Munambam and Neendakara harbours.

Diagnosis: Eyes on right side of head; pelvic fins without spines; mouth small, not reaching to middle of lower eye. Anterior dorsal-fin rays and rays of pevic fin on eyed side greatly elongate.

Meristic counts: D 64 – 84 (74); A 42 – 58 (50); P_1 4; V_1/V_2 5 - 8 (5.2); C 13 – 17 (16); Ll. 42 – 76 (58).

Body proportions as percent of SL (mean in parentheses): HL 18.8 – 31.8 (22.2); HW 25.1 – 36.8 (28.8); HD 13 - 22 (16); UJL 4.98 – 9.8

(6.4); LJL 4.7 -10.3 (6.1); CD 1.02 -5.8 (2.3); DFL 57.9 -105.7 (84.5); AFL 13.4 – 11.8 (14.6); P_1LO 17.5 -30.5 (23); V_1LO 15.6 -35.1 (26.6); V_2LO 5.9 – 6.74 (9.8); CFL 11.7 – 41.8 (30.3); DBL 74.8 -116.6 (92.3); ABL 67.3 – 94.9 (73); P_1BLO 1.01 – 3.9 (2.03); V_1BLO 4.4 -9.7 (6.8); V_2BLB 4.2 -9.3 (5.8); CBL 9.6 -13.4 (11.5); ED_1 5.1 -10.1 (6.8); ED_2 4.95 -9.2 (6.4); ID 0.4 - 2.2 (0.9); PrOU 1.5 -5.1 (3); PrOL 2.7 -6.5 (4.6); PBU 9.8 -16.3 (11.9); E –UJ 1.3 -5.95; PDL 3.2 – 13.3; PAL 16.7- 33.3; P_1LO 19.8 -31.3 (22.6); V_1LO 13.2 -22.4 (16.6); BD_1 81.2 – 106.8 (85.7); BD_2 26.4 – 35.7 (30.5); TKL 29.8 – 46.1 (34.3); CPD 71.5 – 94.6 (77.99).

As percent of HL (mean in parentheses): HW 115.5 – 146.8 (129.6); HD 61.2 -84.3 (71.9); UJ 24 -41 (29); CD 5.2 -22.7 (10.4); DFL (longest) 244.2 - 464.4 (383.5); DFL 38.7- 84.9 (62.2); AFL 49.6 -89.3 (65.7); P_1FL 84.3 - 126.4 (104); V_1FLO 23.8 - 75.2 (45.3); V_2FLB 27.3 – 68.6 (46.4); CFL 51.3 – 165.4 (136.8); DBL 329.1 - 475.7 (417.6); ABL 265.7 - 417 (330.4); P_1BLO 4.5 - 14.6 (9.1); V_1BLO 19.2 - 44.4 (30.9); V_2BLB 16.7 - 42.8 (26.1); CBL 38.2 - 63.5 (51.9); ED_1 23.1 -39.4 (30.3); ED_2 23 – 34.6 (28.7); ID 1.7 - 8.7 (4.1); PrOL 12.6 - 26.85 (20.9); PrOU 5.8 - 19.2 (13.5); PBU 39.8 - 58.7 (49.8); PBL 43.9 -63.7 (53.2); E–UJ 5.95 -18.7 (9.8); PDL 13.6 - 58.9 (24.1); PAL 88.99 - 136.2 (114.7); P_1LO 91.75 - 131.3 (101.8); BD_1 325 - 456.2 (388.1); BD_2 107.9 -161.3 (137.8).

Description: Body elongate, compressed, with small head, small eyes, not contiguous, but very close, separated by a narrow naked ridge. Lower eye a little in front of upper; pre orbital area scaleless, area below the eye with scales. Snout prominent, with a clear notch; mouth small, oblique, maxillary ending just below anterior portion of lower eye. Lower jaw placed a little in front of upper eye below the snout; diameter of lower eye a little smaller than upper. Notch on head becomes prominent as fish grows. Eight teeth present on each half of the upper jaw with a prominent cleft; uniform in size on both sides of the jaws; lower jaw with widely spaced teeth. Two nostrils on ocular side, an anterior tubular one placed in front of lower eye; a posterior oval one slightly larger than tubular one. Gill rakers short, bud like with 5 on lower limb and three on upper. Lateral line origin from middle of upper eye, bifurcated at origin end, proceeding in a straight line upto middle caudal ray tip; supra temporal branch absent. In one sample a branch of the lateral line proceeded to the first caudal fin ray. Body depth greater than head width. Dorsal fin origin in front of the upper eye, at the notch, first 10 rays highly elongated with a filamentous tip. Pelvic rays on the ocular side long –first and second long with a small flattened skin like tip, third ray still shorter, 4 and 5 smaller; pelvic ray on blind side very short. A membrane connects the pelvic fin (ocular) base to infront of the anal; first three rays are free. Origin of the pelvics is together; pelvic fin rays on blind side same in length. Pectoral fin on ocular side is long, absent on blind side. Last three finrays of anal free. Caudal fin oval with a slight pointed tip, free from the dorsal and anal.

A comparative statement of the meristic characters of *Samaris cristatus* is given in Table 65.

Table 65 : A comparative statement of the meristic characters of *Samaris cristatus*

	Earlier workers											Present work 2004 - 2010	
Meristic characters	Norman 1927, 1934	Weber & Beaufort 1929	Munroe 1955	Smith 1961	Chen & Weng 1965	Venkataramaiyan & Ramamoorthi 1973	Kuthalingam 1972	Ramanathan 1977	Masuda *et al.*, 1984	Smith 1986	Radhamanyamma 1988	N =41	Mean ± SD
Dorsal rays	77 – 79	73 -81	77 – 79	73 – 86	75 – 76	77 – 85	80	12 – 15 +61 – 71	73 – 86	80 – 86	70 -78	64 – 84	73 ± 5.6
Anal rays	50 -53	51 – 57	50 - 53	50 – 57	50	52 – 58	55	49 -60	49 - 60	54 – 57	43 – 51	42 – 58	50.3 ± 3.36
P1/P2	4	4	4	*	4	*	4	4 -5	4	4	4	4	4
Caudal	*	*	*	*	16	*	*	15 – 17	*	*	16	13 – 17	15.98 ± 0.52
Ventral	*	*	*	*	5	*	5	5	5	*	4	5	5.2 ± 0.56
Lateral line scales	67 – 72	68 -77	67 – 72	70 – 80	72	*	76	68 -78	*	80 - 94	62 – 79	62 – 76	57.8 ± 8.45
Gill rakers	*	*	*	*	*	*	*	4+5 -7	2 -5 +7	*	*	5 +3	5 ± 3

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of *Samaris cristatus* is given in Table 66

Table 66: Results of the correlation coefficient analysis on non-meristic characters of *Samaris cristatus*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.1 -5.3	4.53	0.39	0.924	0.18
Head width	2.7 - 3.99	3.5	0.29	0.904	0.24
Head depth	4.5 -7.8	6.34	0.73	0.791	0.13
Upper jaw length	10.2 - 20.1	15.84	1.96	0.736	0.05
Lower jaw length	1.5 - 21.1	16.22	3.33	0.015	-0.02
Dorsal FL (longest)	0.95 -1.7	1.2	0.16	0.859	0.92
Dorsal FL (20 ray)	5.7 - 9.99	7.4	0.97	0.813	0.14
Anal FL	4.9 -8.5	6.98	0.9	0.698	0.13
Pectoral (O) FL	3.3 - 5.7	4.38	0.4	0.864	0.22
Pelvic longest	2.9 - 6.4	3.85	0.66	0.799	0.25
Pelvic (O)FL	5.97 - 18.5	10.44	2.26	0.473	0.09
Pelvic (B)FL	6.1 - 16.9	10.16	2.2	0.492	0.09
Caudal FL	2.4 -8.6	3.42	0.9	0.678	0.29
Dorsal BL	0.9 -1.3	1.09	0.06	0.976	0.90
Anal BL	1.1 -1.5	1.38	0.08	0.948	0.71
Pelvic (O)BL	10.4 - 22.9	15.31	3.26	0.602	0.07
Pelvic (B)BL	10.8 - 23.7	17.85	3	0.586	0.05
Caudal BL	7.5 -10.4	8.77	0.65	0.919	0.12
Eye Diameter 1	9.9 - 19.4	15.19	2.35	0.689	0.04
Eye Diameter 2	10.9 - 20.2	15.94	1.89	0.783	0.05
Preanal length	3 - 5.97	3.99	0.49	0.800	0.24
Body depth I	2.8 - 3.8	3.29	0.22	0.922	0.28
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	0.7 - 0.9	0.77	0.05	0.96	1.31
Head depth	1.2 - 1.6	1.4	0.11	0.93	0.74
Upper jaw length	2.5 - 4.2	3.5	0.37	0.87	0.25
Lower jaw length	0.4 - 4.7	3.57	0.7	-0.12	-0.12
Eye Diameter 1	2.5 - 4.3	3.35	0.39	0.85	0.23
Eye Diameter 2	2.9 - 4.4	3.52	0.36	0.88	0.26

Body covered with ctenoid scales; preorbital area naked. Cycloid scales seen behind eye on operculum. Body scales petalloid in shape with fine ctenii at tip. A patch of ctenoid scales seen on blind side of the head on the upper side. Head region on the blind side has white soft bulbous like structures which may have a sensory function. They have a bulbous base with a fine tip. In mature male specimens, a crescentic bulbous portion is seen on the blind side of head.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 94, 95); the linear regression equations obtained were

Head length on SL	: $y = 0.18\ x + 4.58$; $R^2 = 0.92$; $p<0.001$
Body depth on SL	: $y = 0.3\ x + 2.1$; $R^2 = 0.92$; $p< 0.001$
Eye diameter (O) on HL	: $y = 0.23\ x + 1.6$; $R^2 = 0.72$; $p< 0.001$
Eye diameter (B) on HL	: $y = 0.23\ x + 1.6$; $R^2 = 0.72$; $p< 0.001$
Upper jaw length on HL	: $y = 0.25\ x + 0.83$; $R^2 = 0.75$; $p < 0.001$
Lower jaw length on HL	: $y = 10.4 - 0.116\ x$; $R^2 = 0.014$; $p > 0.01$.

Regression of preorbital and lower jaw length on HL was found to be non-significant while all the other parameters were found to be highly significant ($P < 0.001$)

Colour: Body coloured brownish on ocular side with a series of dark spots; pectoral and pelvic fins on ocular side black, anterior prolonged tip of dorsal whitish. Blind side whitish.

Distribution:

World: China, western North Pacific (Gray, 1831); Canton (Richardson, 1846); Chinese Seas (Gunther, 1862); Ceylon, (Norman, 1927); Singapore, Java Sea, Chinese seas, Ceylon (Weber and Beaufort, 1929); Hongkong (Wu, 1932); Indian Ocean and Archipelago, Chinese seas (Norman, 1934); China (Kamohara, 1952); Japan, China Sea (Matsubara, 1955); Tainan, Masa Groove (Chen and Weng, 1965); Australia (Hoese and Bray, 2006). Map showing localities were *Samaris cristatus* has been recorded in the world is given in Fig. 92.

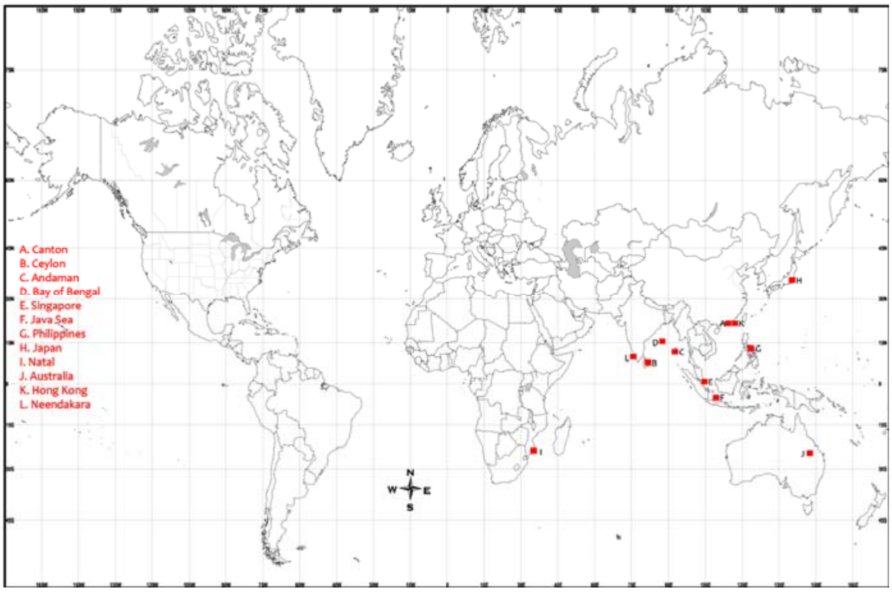


Fig. 92: Map showing localities were *Samaris cristatus* has been recorded in the world.

India: Andaman (Norman, 1927); Bay of Bengal (Weber and Beaufort, 1929); Neendakara (Radhamanyamma, 1988).

Map showing localities were *Samaris cristatus* has been recorded in India is given in Fig. 93.

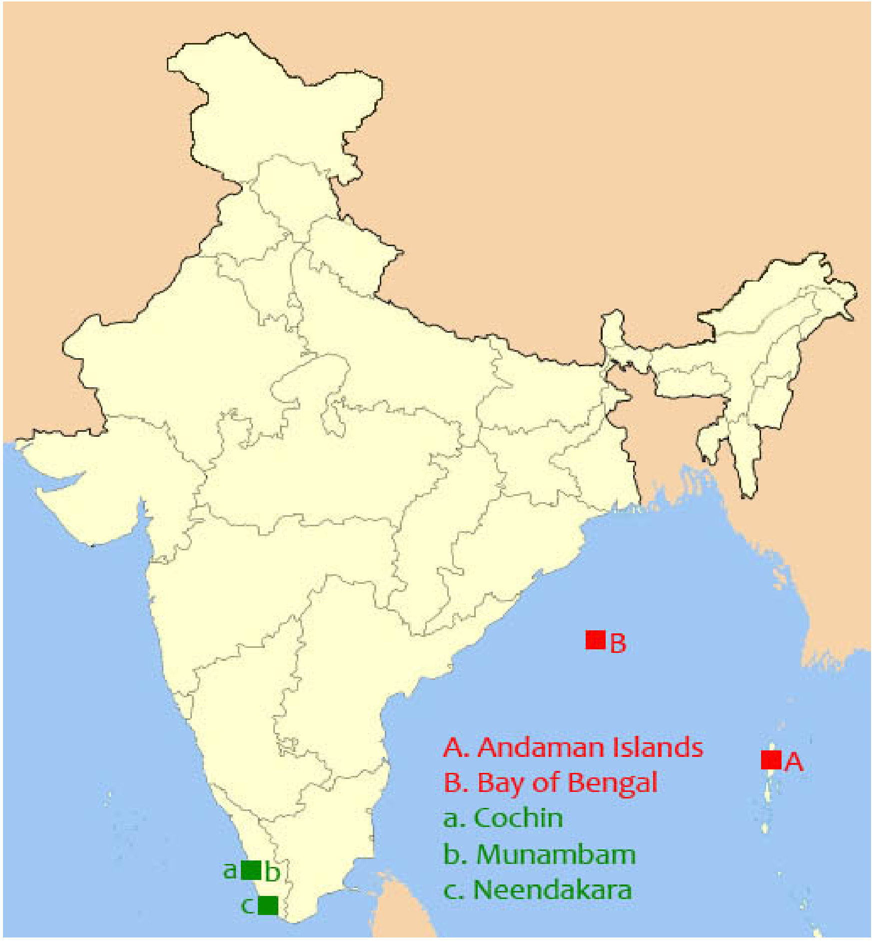


Fig. 93: Map showing localities were *Samaris cristatus* has been recorded in India

Habitat: Recorded from 20 – 120 m depth.

Taxonomic comments: *Samaris cristatus* was originally described by Gray (1831). Norman (1927) in his monograph on flatfishes recognized five species of *Samaris* namely *S. cristatus* Gray, *S. ornatus* Von Bonde, *S. delagoensis* Von Bonde, *S. cacatuae* (Ogilby) and *S. macrolepis* Norman. Smith (1961) has suggested that out of the five species from the Indo-Pacific probably only two are valid and has synonymised *S. delagoensis* and *S. ornatus* with *S. cristatus*. He therefore considers *S. cristatus* and *S. macrplepis* as valid species. Norman (1927) mentions *Samaris ornatus* Von Bonde and *S. delagoensis* Von Bonde, from South east Africa are very close to this species, but appear to have a larger number of scales in a longitudinal series; *S. cacatuae* Ogilby from Queensland has a larger number of dorsal and anal rays and a different colouration. Norman (1934) differentiated the different species of *Samaris* based on the lateral line scale counts and dorsal and anal fin ray counts. However, these were found to be intra specific variation within the species as per Venkataramanujam and Ramanathan (1973).

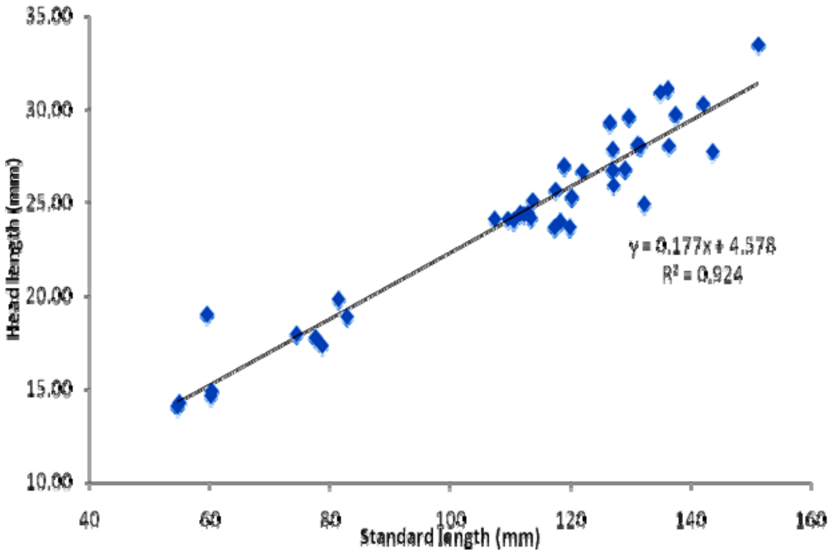


Fig. 94: Regression of Head length on Standard length

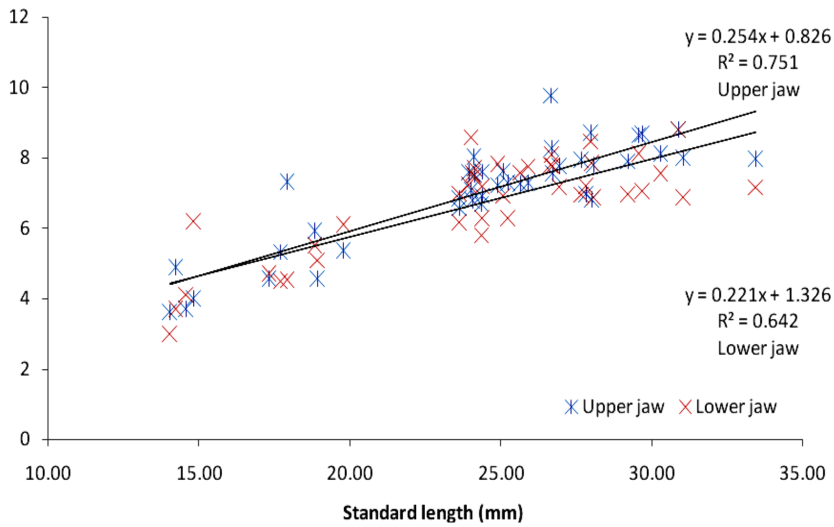


Fig. 95: Regression law length on Headlength

Observations: The counts in the present species ranges from 64 - 84 (mean 73); the lower range was recorded only in one small specimen. A wide range is noted in the dorsal finray count in the earlier reports with the range between 73 and 86. Hence the present work is in agreement with that of earlier workers. The anal fin ray count shows a wide range in the present work (42 - 58), but the lower range is recorded only in the one small specimen with lower dorsal fin ray count. The results are in accordance to that of the earlier workers (49 - 60). The lateral line scale counts of the earlier workers were in the range 63 - 82; in the present work it is 62 -76, well within the range reported by earlier workers.

4.3.7 Family Soleidae

This is one of the largest families in the Order Pleuronectiformes with 35 genera and over 130 species (Nelson, 2006). Species of Soleidae are found in tropical to temperate seas around the world, from nearshore to deep sea; some even in freshwater (Gibson, 2004). Species are characterized by a combination of characters - an oblong or elongated body, coloured on ocular side, head round at anterior region, eyes placed close together, dextral, with or without a bony ridge in between; snout not prolonged into a rostral hook. Mouth slightly curved to strongly convex, contorted; teeth in villiform bands, very small or obsolete. Preopercle adnate, covered by skin and scales; gill openings very narrow. Dorsal rays not reaching upto snout tip, origin above or in front of eye; pectoral fins rudimentary, mostly absent on blind side; if present, fin on ocular side is longer. Pelvic fins symmetrical or asymmetrical; fins very small, not attached to the anal fin, sometimes absent. Dorsal and anal fins not confluent with caudal. Body covered with either cycloid or ctenoid scales which are sometimes modified into cutaneous flaps fringed with filaments. Lateral line single and straight but on head may be arched or have short accessory branches. Species are easily distinguished from other flatfishes by the characters - eyes on the right side, the right pelvic fin not attached to the anal fin, a contorted mouth, no free margin of the preopercle, and a long tubular anterior nostril.

Soleid species inhabiting shallow, marine estuarine and mangrove habitats are probably very important in subsistence fisheries, although there landing are largely unreported (Munroe, 2004). They are distributed throughout the Indo-Pacific with maximum diversity occurring in the Indo-Malayan Archipelago and off northern Australia. Soleids also occur at oceanic islands throughout the Central Pacific extending eastward as far as Hawaii, Easter Islands and the Galapagos

Archipelago, where this family is represented only by Herre's sole, *Aseraggodes herrei* (Grove and Lavenberg, 1997).

Linnaeus (1758) erected *Pleuronectes solea* as a species in genus *Pleuronectes* with characters "*eyes dextral, elongated body, with dorsal 91, pectoral 9, pelvic 5, anal 74 and caudal 14 rays*." Cuvier has defined *Solea* as "*their peculiar character is that the mouth is twisted and as it were monstrous on the side opposite to the eyes, and furnished on that side only with slender teeth closely crowded together like the pile of velvet, while the side were the eyes are has no teeth. Their form is oblong, their snout round and always projecting beyond the mouth; the dorsal fin commencing over the mouth and extending like the anal upto the caudal. Their lateral line is straight; the side of the head opposite to the eyes is generally furnished with a sort of villosity. Their intestine is long, with several convolutions and without caecae*". Cunninghman (1890) opines that "*Cuvier obviously meant Monochires, Achires and Plagusia to be mere subgenera indicating the grouping of the various species*". Quensel (1806) first divided the group flatfishes into 2 groups *Pleuronectes* and *Solea*. In Solea "*jaws are covered with scales, the superior one not fully developed, and the sealy mandible not showing the folds at the chin. Gill openings wholly below the pectorals. The inferior eye farther back than the superior one. Nostrils on both sides near the jaws. All the finrays divided, no spine in the anal*" (Richardson's Yarell, Vol. I: 608). Bleeker (1852) placed all flatfishes as Pleuronecteoiden. The generic names used were *Solea*, *Achirus*, *Achiroiides* and *Plagusia*. Species in Genus *Plagusia* were sinistral, while species in genera *Achirus*, *Achiroiides* were distinguished by the presence/absence of confluent fins of caudal and anal. Genus *Solea* was dextral. Bleeker described 14 species of soleids of which 3 were in genus *Solea*, 2 in *Achirus* and 10 in *Achiroiides*. Gunther (1862) included soles in the Family Pleuronectidae along with the other flatfish genera. Day (1877) also followed Gunther (1862) and included flatfishes in one family

Pleuronectidae, with soles in different genera. The definition of Solea was "*eyes on the right side, the upper being more or less in advance of the lower. Cleft of mouth narrow, twisted round to the left side. Teeth on the blind side only, where they are villiform, forming bands; no vomerine or palatine teeth. The dorsal fin commences on the snout, and is not confluent with the caudal. Scales very small, ctenoid. Lateral line straight*". Alcock (1889) mentions of a separate group with jaws and dentition well developed on the blind side, soles were included in this group. Two subgroups were recognised based on whether caudal fin was free or confluent with vertical fins. Evermann and Seale (1907) divided flatfishes into 2 families Pleuronectidae and Soleidae. Later, Fowler (1928) placed 3 species of flatfishes in the 3 genera in Family Soleidae. According to Norman (1928), eight genera of Soleidae are represented in Indian waters – *Solea, Brachirus, Soleichthys, Zebrias, Aesopia, Pardachirus, Aseraggodes* and *Heteromycteris*; he further adds that the classification is tentative. Weber and Beaufort (1929) included soles in the family Soleidae with 10 genera and 63 species. Genus *Cynoglossus* was also included in the family. Munroe (1955) in his *Fishes of Ceylon* describes 6 species of soles in Family Soleidae. In the *Review of Flatfishes of Taiwan*, Chen and Weng (1965) reported 6 genera with 9 species in Family Soleidae. According to Jordan (1967), 27 genera have been placed in this family. Heemstra and Gon (1986) mentioned that Family Soleidae consists of 30 genera and about 120 species worldwide and that "*the taxonomy of the family needs revision; the genera and species are not at all well differentiated*". Munroe (2005) mentions that about 29 genera with 139+ species as currently recognized. According to Nelson (2006), about 35 genera with about 130 species are recognized in the family. Randall and Desoutter (2007) mentions that 31 genera are placed in Family Soleidae. Review of observations done by various workers on Family Soleidae is given in Table 67

Table 67: Review of observations done by various workers on Family Soleidae

Genus	Synonym	Type	Observations						
			Jordan	Others	Heemstra and Gon, 1986	Li and Wang	Gunther	Lindberg & Fedorov, 1993	Eschmeyer
Aesopia Kaup 1858		*Aesopia cornuta* Kaup 1858	Valid genus in Family Synapturidae				Type designated by Günther 1862: 487	**VALID**	**VALID**
	Coryphaesopia Chabanaud 1930	*Aesopia cornuta* Kaup 1858 Type by original designation (also monotypic)						**Synonym**	**Synonym**
Aseraggodes Kaup 1858		*Aseraggodes guttulatus* Type by subsequent designation.	Type designated by Jordan & Evermann 1898						**VALID**
	Beaufortella Chabanaud 1943	*Aserragodes abnormis* Weber & de Beaufort 1929 Type by original designation (also monotypic)						Correct spelling for genus of type species is *Aseraggodes* **Synonym**	**Synonym**
	Coryphillus Chabanaud 1931	*Aseraggodes filiger* Weber 1913; type by monotypy		**Valid as** *Coryphillus* Chabanaud 1931(Munroe 2001); Synonym of *Aseraggodes* Kaup 1858, based on placement of type species -- (Randall 2002					**Synonym of** *Aseraggodes*
	Parachirus Matsubara & Ochiai 1963				**Valid** as ***Parachirus***			**Synonym of** *Aseraggodes*	**Synonym of** *Aseraggodes*

Genus	Synonym	Type	Observations					
			Jordan	Others	Heemstra and Gon, 1986	Li and Wang	Gunther	Lindberg & Fedorov, 1993	Eschmeyer
Brachirus Swainson, 1839		*Pleuronectes orientalis* Bloch & Schneider ; Type by subsequent designation by Swain 1882:281	Valid genus in Family Synapturidae	Regarded as preoccupied by *Brachirus* Swainson, replaced by *Synaptura* Cantor 1849; **Synonym** of *Synaptura* Cantor 1849 (Desoutter 1986:431)		Valid as ***Brachirus***			Valid as ***Brachirus***
	Euryglossa Kaup 1858	*Pleuronectes orientalis* Bloch & Schneider 1801		Objectively invalid,preoccupied by *Euryglossa* Smith 1853 in Hymenoptera (**Kottelat *et al*.** 1993)		**Synonym**			**Synonym**
	Chabanaudetta Whitley 1931	*Synaptura panoides* Bleeker 1851; type is a replacement name							**Synonym** of *Euryglossa* Kaup 1858; and synonym of *Brachirus* Swainson 1838
	Synaptura Cantor, 1849	*Pleuronectes commersonianus* Lacepede; **logotype**	Valid genus in Family Synapturidae						
Heteromycteris Kaup 1858		*Heteromycteris capensis* Kaup 1858; type by monotypy	**VALID**		**VALID**	**VALID**		**VALID**	**VALID**
	Monodichthys Chabanaud 1925	*Monodichthys proboscideus* Chabanaud 1925				**Synonym**		**Synonym**	**Synonym**
Liachirus Günther 1862		*Liachirus nitidus* Günther 1862				**VALID**		**VALID**	**VALID**

Genus	Synonym	Type	Observations						
			Jordan	Others	Heemstra and Gon, 1986	Li and Wang	Gunther	Lindberg & Fedorov, 1993	Eschmeyer
Pardachirus Günther 1862		*Achirus marmoratus* Lacepède 1802. Type by subsequent designation	Type designated by Jordan 1919		**VALID**		**VALID**	**VALID**	**VALID**
Solea Quensel									
	Barnadichthys Chabanaud, 1927	*Solea fulvomarginata* Gilchrist, 1904		Type by original designation (also monotypic)	**Synonym**				**Synonym**
	Microbuglossus (subgenus of *Solea*) Günther 1862	*Solea humilis* Cantor 1849	Type designated by Jordan			**Synonym**			**Synonym**
Zebrias Jordan & Snyder 1900									
	Haplozebrias Chabanaud 1943	*Synaptura fasciata* Macleay 1882							**Synonym**
	Holonodus (subgenus of *Zebrias*) Chabanaud 1936	*Solea synapturoides* Jenkins 1910; type by original designation							**Synonym**
	Nematozebrias Chabanaud 1943	*Aesopia quagga* Kaup 1858; type by original designation				**Synonym**		**Synonym**	**Synonym**

According to Eschmeyer (*Catalog of Fishes*, 2010, online), Family Soleidae is represented by 20 genera and 165 species; the type localities of 12 species is in India. However, according to Catalogue of Life (2010, online) 27 genera are represented in Family Soleidae. The frequent classification of the family implies that the list is still inconclusive. Of the 31 genera reported in the world, 18 species in 9 genera *Aesopia*, *Aseraggodes*, *Brachirus*, *Heteromycteris*, *Liachirus*, *Solea*, *Synaptura*, *Pardachirus* and *Zebrias* were collected in the present study.

4.3.7.1 Genus *Aesopia* Kaup, 1858

Aesopia Kaup, 1858, *Ann. Mag. Nat. Hist*. (Ser. 3) 11: 134 – 140 (type: *Aesopia cornuta*); Gunther, 1862, *Cat. Fish*., IV: 487; Regan, 1920, *Ann. Durban Mus*., II: 218; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Archip*.,: 355; Heemstra and Gon, 1986, *Smith. Sea Fish*.,: 869; Lindberg and Fedorov, 1993, *Handbook Zool. Inst. Russian Acad*., 166: 203; Li and Wang, 1995, *Fauna Sinica*: 322; Munroe, 2001, *FAO Sp. Iden. Guide,* IV(6): 3880; Hoese and Bray, 2006, *Zool. Cat. Aust.,:* 1842; Gunther, 1862, *Anac. Brit. Mus*., 487; Fowler, 1931, *Syn. Fish. China*: 152.

Coryphaesopia Chabanaud, 1930, *Bull. Inst. Ocean*., 555: 17 (*Aesopia cornuta*).

Diagnosis: First dorsal fin ray free enlarged, longer, body covered with cycloid scales, coloured on dextral side with vertical band pattern. Caudal united with dorsal and anal.

Description: Body ovoid, not deeply compressed, head small, dextral eyes, coloured with vertical band patterns on dextral side. Mouth small, subterminal, ending just in front of lower eye, convex in outline; teeth present on blind side; preopercle not free, concealed by scales. Nostrils two on coloured side. On blind side of head, scales produced into papillae like structures. Dorsal fin origin on snout. First dorsal ray elongated, free from the rest. Eyes small, placed close. Caudal united at base with dorsal and anal. Pectoral on ocular side tiny, on blind side seen as an extension of operculum. Pelvic small, free from anal. Body covered with cycloid scales.

Remarks: Monotypic with one species – *Aesopia cornuta*.

Taxonomic comments: According to Gunther (1862), "*according to the rules of nomenclature, the name of Aesopia ought not to be retained for the following single species, but for five other species which Hr. Kaup has referred to that genus. But as we are inclined to consider those five species as belonging properly to the genus Synaptura, we rather prefer to apply a name once used, than to introduce a new one for a species so little known as the following*."

4.3.7.1.1 *Aesopia cornuta* Kaup, 1858

Unicorn sole

Aesopia cornuta Kaup, 1858, *Archiv. Nat.,* :95; Gunther, 1862, *Cat. Brit. Mus*., IV: 487 (British India); Day, 1873, *Proc. Zool. Soc*.,:238; Jordan and Starks, 1906, *Proc. U.S. Nat. Mus*., XXXI: 235, fig. 27 (India, Nagasaki); Hubbs, 1906, *Proc. U.S. Nat. Mus*., XLVIII: 493; Jordan, Tanaka and Snyder, *J. Coll. Sci. Tokyo*, 1913, XXXIII (1): 336, fig. 285 (India, Nagasaki); Hubbs, 1915, *Proc. U.S Nat. Mus*., 48: 493 (Swatow); Regan, 1920, *Ann. Durban Mus*., II: 218; Oshima, 1927, *Jap. J. Zool*., I (5): 196 (Taiwan); Barnard, 1925, *Ann. S. Africa Mus*., XXI: 409; Norman, 1928, *Rec. Ind. Mus*., XXX: 185, fig. 5 (Ganjam coast); Chu, 1931, *Index Pisc. Sinen*: 93 (Seatow); Wu, 1932, *Thès. Fac. Sci. Univ. Paris*, A. 244 (4268): 131;

Fowler, 1934, *Fish. China*, III: 153, fig. 25 (Swatow, Portugese East Africa); Okada and Matsubara, 1938, *Key. Fish. Japan*: 435 (S. Japan); Kamohara, 1952, *Rep. Kochi. Univ*, 3: 84 (British India); Matsuubara, 1955, *Fish. Morph. Hier*., II: 1283 (Pacific Ocean, Formosa, S. Africa); Munro, 1955, *Fish. Ceylon*: 263, fig, 764; Chen, 1956, *Synop. Vert. Taiwan*: 104 (Tainan), Menon, 1961, *Rec. Ind. Mus*., 59: 399; Saramma, 1964, *Bull. Dept. Mar. Biol*., 1: 73; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 355; Heemstra and Gon, 1986, *Smith. Sea Fish.,*: 869; Allen and Swainston, 1988, *Marine fish. N.W Australia*: 146; Quero and Desoutter, 1990, *Cybium,* 14 (2): 105; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad.,* 166: 204; Goren and Dor, 1994, CLOFRES II: 71; Li and Wang, 1995, *Fauna Sinica*: 322; Allen, 1997, *Mar. Fish. Aust.,*: 234; Chen *et al*., 1997, *Fish. Nasha Islands to South China waters*: 177; Evseenko, 1998, *Russian Acad. Sci*.,: 61; Munroe in Randall and Lim, 2000, *Raffles Bull. Zoo Suppl*., 8: 645; Nakabo, 2000, *Fish Japan*, (2 ed): 1386; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl*., 63: 47; Munroe, 2001, *FAO Sp. Iden. Guide*, VI: 3881; Shinohara *et al*., 2001, *Mem. Nat. Sci. Mus*.,: 336; Nakabo, 2002, *Fish Japan*. 2º ed.,:1386; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (Supp. 1): S122; Shinohara *et al*., 2005, *Mem. Nat. Sci. Mus. Tokyo,* 29: 443; Hoese and Bray, 2006, *Zool. Cat. Aust.,* :1842.

Coryphaesopia cornuta Kamohara, 1955, *Color. Illust. Fish. Japan*, No.I: 56; Smith, 1961, *Sea Fish. S. Africa* : 161, fig. 319 (Indo–Pacific).

Synaptura potoo Bleeker, 1853, *Verh. Bat. Gen*., XXV: 76 (Bengal, Coromandelia).

Synaptura cornuta Day, 1877, *Fish. India*: 430, pl. xciv, fig. 4; Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII, pt. 2: 287; Johnstone, 1904, *Ceylon. Pearl. Oyster Fish., Supp. Rep.*, XV:206; Jenkins, 1910, *Mem. Ind. Mus.*, III: 29; Day, 1889, *Fauna Br. India Fishes*, 2:450; Munro, 1955, *Fish. Ceylon*: 263, pl. 50, fig. 764; Kuronuma, 1961, *Checklist Fish. Vietnam*: 32; Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull.*, 1: 48 (Gulf of Thailand)

"***Jerree Potoo***" Russell, 1803, *Descr. Fish. Vizag.,* I : 56, pl. lxxii.

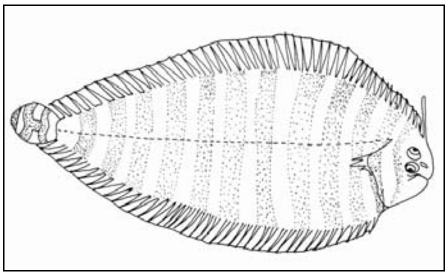



Plate XXXI: *Aesopia cornuta* Kaup, 1858

Material examined: N = 5; TL 129.23 – 158.4 from Cochin, Munambam, Kalamukku Fishing Harbours

Diagnosis: First dorsal fin ray stout like, elongated and white in colour. Body with 12-13 brown bands on body, bands seen across eye in the interorbital region also.

Meristic counts: D 63 – 71 (66); A 56 – 60 (58); C 12 – 17 (15); P_1 12.

Body measurements as percent of SL (means in parentheses): HD 12.1 – 19.8 (16.2); HL 19.1 - 24.3 (21.4); HW 29.4 – 38 (33.2); ED_1 3.4 - 4.2 (3.8); ED_2 3.2 – 4 (3.6); ID 0.7 – 2.7 (1.99); UHL 10.4 – 15.7 (12.6); LHL 18 – 24.6 (20.95); PBU 11.98 – 14.5 (12.8) ; UJL 5.9 – 9 (7.3) ; LJL 5.1 – 7.6 (6.1); CD 5.3 -9.5 (7.9); PDL 6.4 – 12.04 (8.6); PAL 18.9

– 25.9 (22.2); DFL 9.2 – 11.9 (11.1); AFL 8.5 – 12.7(11.1); CFL 12.6 – 15.4 (13.8); V_1FL 4 – 6.4 (5.4); P_1FLO 3.7 – 5.1 (4.5); DBL 98.2 – 120.8 (109.2); ABL 82.1 -102.3 (93.5); P_1BLO 6.1 – 7.5 (6.8); V_1BLO 1.9 – 4.5 (2.8); P_1LO 19.7 – 24.1 (21.8); P_2LB 20.1 -24.1 (22.9); V_1LO 15.1 – 20.9 (18.4); V_2LB 16.4 – 22.4 (18.4).

As percent of HL (mean in parentheses): HW 153.8 – 199 (173.9); ED_1 17.99 – 21.97 (19.9); ED_2 16.7 – 21.02 (18.8); ID 3.6 – 13.9(10.4); UHL 54.5 – 82.2 (65.95); LHL 94.2 – 128.9 (109.6); PBU 62.7 – 75.8 (66.9); PBL 53.7 – 74.3 (62.9); UJL 31.1 – 47.3 (38.3); LJL 26.7 – 39.7 (32.1); CD 27.8 – 48.6 (41.1); PDL 33.5 – 63.02 (45.2); PAL 98.82 – 135.7 (116.4); DFL 48.2 – 62.4 (58.1); AFL 44.4 – 66.3 (57.99), CFL 65.8 – 80.5 (72.3).

Description: Body ovoid, broad at head end, tapering towards caudal fin; not deeply compressed. Head, small, nearly semi–circle like on head region, eyes placed close, contiguous protruding from body surface. Mouth blunt, hind end of mouth ending below the anterior portion of lower eye. Teeth present on lower jaw only, no teeth on upper jaw. Migratory eye a little in advance of lower eye. Nasal opening two on ocular side, anterior one tubular, the second roundish – oval in outline. Tubular nostril placed well in front of eye above upper jaw. Dorsal origin on head, a little in front of upper eye, first finray free, fleshy and longer than the rest. Dorsal and anal confluent with caudal. Pectoral fin seen on ocular side, small, covered by a flap of skin of operculum on ocular and blind side. Pelvic fin origin just behind origin of lateral line. A comparative statement of the meristic characters of *Aesopia cornuta* is given in Table 68.

Table 68: A comparative statement of the meristic characters of *Aesopia cornuta*

Meristic characters	Earlier workers												Present study	
	Gunther 1862	Jordan & Starks 1906	Regan 1920	Norman 1928	Fowler 1934	Munroe 1955	Smith 1961	Punpoka 1964	Chen & Weng 1965	Ramanathan 1977	Shen & Lee 1981	Radhamanyamma 1988	N = 5	Mean ± SD
Dorsal	72	79	69 – 79	69 – 79	69 – 79	69 – 79	75	67 – 79	70 - 78	66 - 79	69 -78	65 – 74	63 – 71	66 ± 4.2
Anal	62	66	61 – 66	61 – 66	60 -66	61 – 66	65	61 - 66	60 - 64	53 - 66	57 - 64	56 – 64	56 – 60	58 ± 1.5
Caudal	17	*	*	15 -17	*	*	*	*	16	15 -17	*	14	14 - 17	15 ± 2.7
Ventral	3 - 4	*	*	*	*	*	*	*	4	4	4	3 - 4	5	*
Pectoral	10	*	*	*	*	*	*	*	*	*	11 – 15 (O/B)	13 – 16	12	
Lateral line scutes	*	94	90 - 100	87 – 98	*	87 - 98	90 - 100	87 -100	*	80 - 100	88 - 96	102 – 110	80 - 87	88 ± 2.5
Bands	12 - 13	*	*	13	14 - 16	13	*	*	13 -14	*	15 - 16	13	12 - 13	12

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Aesopia cornuta* is given in Table 69.

Table 69: Results of the correlation coefficient analysis on non-meristic characters of *Aesopia cornuta*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head depth	5.1 - 8.3	6.85	1.28	0.21	0.07
Head length	4.3 - 5.5	5.09	0.49	0.43	0.09
Head width	2.9 - 3.6	3.28	0.31	0.55	0.21
Eye Diameter (U)	24.6 - 30.2	28.57	2.28	0.56	0.02
Eye Diameter (L)	25.7 - 36.1	30.26	4.01	-0.11	0.00
Dorsal fin length	8.5 - 10.97	9.80	0.95	0.53	0.06
Anal fin length	8.2 - 11.8	9.91	1.51	0.22	0.03
Caudal fin length	7.5 - 8.1	7.84	0.25	0.94	0.12
Pelvic fin length	16.3 - 24.95	20.48	3.11	0.56	0.05
Pect fin length	21.8 - 27.3	24.38	2.11	0.82	0.05
Pre-pelvic(O)	4.9 - 6.7	5.92	0.64	0.53	0.13
Pre-pelvic(B)	4.9 - 6.3	5.47	0.68	0.30	0.07
Pre-pect (O)	4.3 - 5.5	4.98	0.44	0.39	0.07
Pre-pect (B)	4.7 -5.1	4.93	0.23	0.89	0.19
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	3.4 - 5.7	4.31	1.01	0.83	1.43
Eye Diameter (U)	3.5 - 5.4	4.51	0.80	0.94	0.15
Eye Diameter (L)	4.6 - 29.01	11.23	10.09	0.70	0.10
Inter orbital length	0.9 - 1.9	1.32	0.39	0.36	0.12
UHL	0.6 - 1.03	0.78	0.15	0.91	0.82
LHL	1.01 - 1.7	1.28	0.30	0.72	0.84
Post-orbital	1.03 - 1.9	1.38	0.39	0.61	0.31
Upper jaw length	1.9 - 3.9	2.73	0.81	0.78	0.44
Lower Jaw length	1.5 - 2.5	2.12	0.44	0.92	0.47
Chin depth	1.34 - 2.7	2.01	0.68	0.74	0.54
Predorsal length	0.6 - 0.99	0.74	0.18	0.68	0.77
Preanal length	1.3 - 1.7	1.45	0.16	0.84	1.17
Dorsal fin length	1.3 - 2.1	1.70	0.41	0.31	0.16

Body covered with cycloid scales on ocular and blind side. Scales oval in outline with inner part pigmented. Scales extend into finrays, all finrays connected by pigmented membrane. Body with 12-13 brown bands on body, bands seen across eye in the interorbital region also. Caudal fin has a colour pattern, with a grey coloured forked patch at the origin of the tail with two crescent shaped yellow patches at the outer middle portion; the hind end of body has a band. In some fishes, caudal fin is characterised by three white slender dots with three yellow dots in the interspaces, the base portion is black.

Distribution:

World: Persian Gulf (Norman 1928); Gulf of Thailand (Punpoka 1964), Ceylon (Munro, 1955). Map showing localities were *Aesopia cornuta* has been recorded in the world is given in Fig. 96.

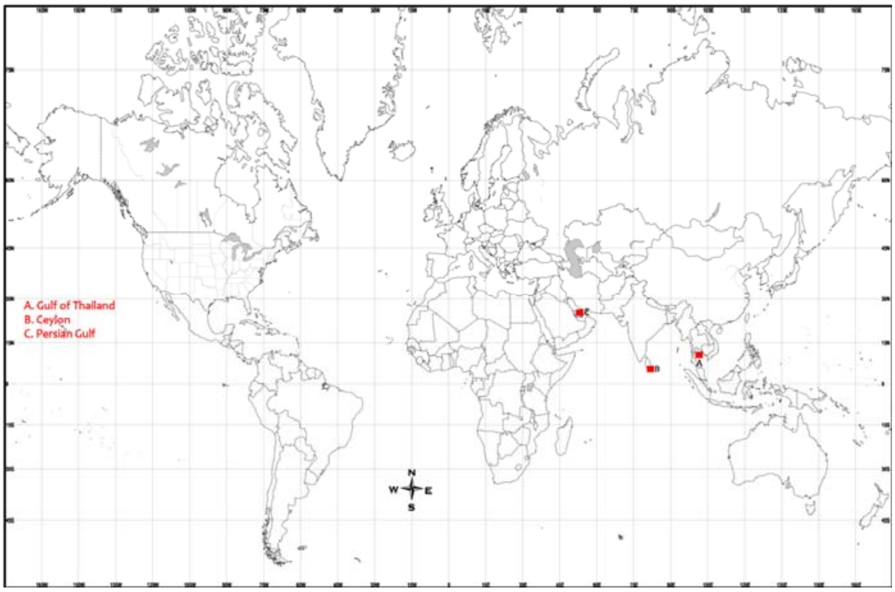


Fig. 96: Map showing localities were *Aesopia cornuta* has been recorded in the world.

India: Reported from Bombay (Kaup 1858). Map showing localities were *Aesopia cornuta* has been recorded in India is given in Fig. 97.

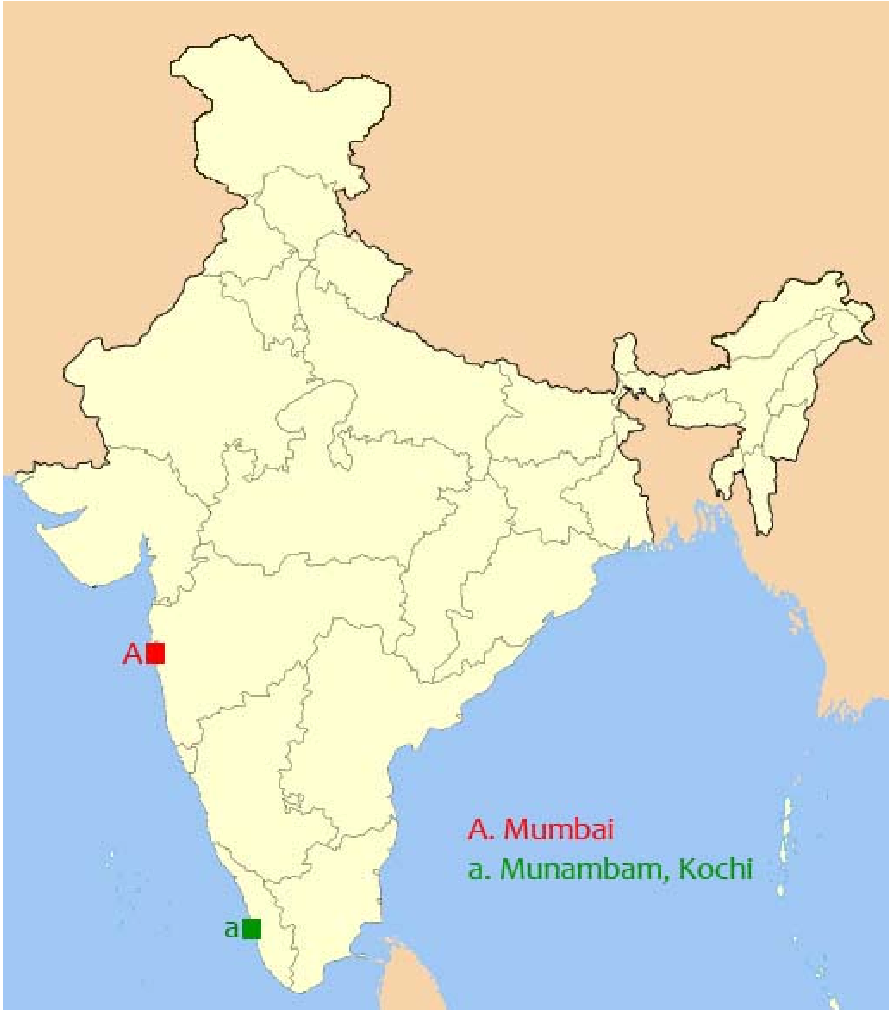


Fig. 97: Map showing localities were *Aesopia cornuta* has been recorded in India

Taxonomic remarks: Gunther (1862) mentions of *Solea cornuta* Cuvier in Cuvier's *Le Regne Animal*, but in the present work, it was not noted. Norman (1928) also comments that he was not able to find any *Solea cornuta* Cuvier in *Règne Animal*. However, in the second edition of the *Règne Animalium* Vol. II he lists "*la sole cornue*" in a footnote on page 343 and refers to Russell's figure but does not give a specific name".

Norman further states that "*the name Solea cornuta Cuvier, is not to be found in Sherbon's "Index Animalium" and probably does not exist*".

Observations: 14 caudal finrays are present in Radhamanyamma's specimen, while in all the other workers it ranges from 15 – 17; in the present work the caudal fin range is 14 – 17; only one sample from Neendakara harbour had 14 caudal finrays. Lateral line counts of earlier workers match well with the present work;

however those by Radhamanyamma were very high. Gunther mentions of only 12-13 vertical bands across body while Fowler mentions of 14 - 16 bands. In the present study, only 12 – 13 bands were noticed. However, 15 -16 bands were seen in the samples collected by Heemstra and Gon off South Africa.

Aesopia cornuta resembles *Zebrais quagga* and *Zebrias synapturoides*, but differs in the presence of the first elongated dorsal finray.

4.3.7.2 Genus *Aseraggodes* Kaup, 1858

Aseraggodes Kaup, 1858, *Arch. Natur.*, 24 (1):103 (Type: ***Aseraggodes guttulatus*** Kaup, 1858); Ochiai in Masuda *et al.*, 1984, *Bull. U. S. Nat. Mus.*, 47: 354; Randall and Meléndez, 1987, *Occ. Pap. B. P. Bishop Mus. Nat. Hist.,*; Chapleau and Keast, 1988, *Canadian J. Zoo.*, 66: 2799; Allen, 1991, *Freshwater Fish. New Guinea*: 206; Lindberg and Fedorov 1993, *Fish. Sea Japan*: 188; Gomon *et al.*, 1994, *Fish. Australia South Coast*: 860; Li and Wang, 1995, *Fauna Sinica*: 293; Munroe, 2001, *FAO Sp. Iden. Guide,* IV (6): 3880; Randall, 2002, *Pac. Sci.*, 56 (3):252; Randall and Bartsch, 2005, *Micronesica*, 380(1):125; Randall, 2005, *Mem. Mus. Victoria*, 62(2):193; Randall and Gon, 2006, *Israel J. Zoo.*, 51(3):165; Hoese and Bray, 2006, *Zoo. Cat. Australia*, 35: 1842; Randall and Senou, 2007, *Zoo. Stud*., 46(3): 303; Park *et al*., 2007, *Korean J. Ichth*., 19 (1):77; Randall and Bartsch, 2007, *Mitt. Mus. Nat. Berlin*, 83(2):105; Randall and Allen, 2007, *Rec. W. Aust. Mus*., 24 (1):109; Randall and Desoutter-Meniger, 2007, *Cybium*, 31(3): 303.

Beaufortella Chabanaud, 1943, *Bull. Mus. Nat. Hist. Nat*., (*Sér*.2), 15(5):291 (Type: ***Achirus abnormis*** Weber and de Beaufort, 1929).

Coryphillus Chabanaud, 1931, *Bull. Mus. Nat. Hist. Nat. (Série* 2), 15 (5):302 (Type: ***Aseraggodes filiger*** Weber 1913).

Parachirus Matsubara and Ochiai, 1963, *Bull. Misaki Mar. Biol. Inst. Kyoto Univ*., 4: 93. (Type: ***Parachirus xenicus*** Matsubara and Ochiai, 1963**).**

Aseraggodes is one of the largest genera in Soleidae with the distribution is confined to the Indo–Pacific region except for two species, *A. haackeanus* from Southern Australia and *A. herrei* from eastern Pacific. Randall (2005) reported twelve species from eastern Australia and the islands of Oceania. Froese and Pauly (2010) reported 52 species of *Aseraggodes*, of which 11 are seen in the Western Indian Ocean, 6 from the Eastern Indian Ocean, 9 in Eastern Central Pacific and 21 in the Western Central Pacific. Species added to the list were *Aseraggodes firmisquamis* and *A. smithi* from Palau and Micronesia.

Description: Body thick, dorsal rays 58 – 79; anal rays 39 – 61; caudal rays usually 18; pectoral fin rays absent, pelvic fin normally 5, gill rakers absent. Body elongate, oval, thin. Two nostrils on both sides, the anterior elongated, tubular not more than one eye diameter in length; posterior nostril of ocular side a narrow opening in labial groove before lower eye, covered dorsally by a skin or membrane. Scales small, ctenoid, (except lateral line scales); lateral line placed mid laterally on both sides of the body. Supra temporal branch of lateral line from front of snout along base of dorsal fin generally the most evident; a small sensory pore usually at the end of the small papilla, on snout above base of the anterior nostril in front of the ventral profile of upper eye. Mouth placed ventrally, small, jaws strongly curved; a band of villiform teeth on the blind side only. Gill membranes united, free from isthmus. Lower part of head scaled over from ocular to blind side. Dorsal fin originate anteriorly on snout, the first ray not prolonged; pores absent on base of dorsal and anal fin ray; pelvic fins on ventral edge of body, close together anteriorly, the origins adjacent or with ocular side fin slightly anterior; anus in front of first anal ray.

Taxonomic remarks: This genus was first described by Kaup (1858) for his new species *Aseraggodes guttulatus*. Though the type locality was not mentioned, Desoutter *et al.* (2001) later identified it as Island of Reunion. Gunther (1862) placed *Aseraggodes* in the synonymy of *Solea*. Upto seven species were known in the genus upto 1913. Weber (1913) described 3 species from the Indonesian waters. Chabanaud (1930) recognized *Aseraggodes* and included 15 species in the genus. Matsubara and Ochiai (1963) described *Parachirus xenicus* as a new genus and species of sole from Japan. In a review of the Soleidae and Cynoglossidae of Japanese waters, Ochiai (1963) separated *Pardachirus* from *Aseraggodes* by having the dorsal, anal and pelvic fins slightly branched (not branched in *Aseraggodes*). By 1965, four more new species were added to the *Aseraggodes* group. Heemstra and Gon in Smith and Heemstra (1986) reviewed the soles of southern Africa. Randall and Bartsch (2005) described two new species from Micronesia. Randall (2005) placed *Parachirus* Matsubara and Ochiai, type species *P. xenicus* Matsubara ad Ochiai, in the synonymy of *Aseraggodes* and reclassified *Aseraggodes macleayanus* (Ramsay) in *Synclidopus* Chabanaud, referred *Aseraggodes permisilis* (Gunther) and *A. ocellatus* Weed to the genus *Pardachirus* Gunther, and described seven new species from the South Pacific region. Randall and Gon (2005) reviewed the genus *Aseraggodes* of the Western Indian Ocean, describing three as new. In the review of the soles of the *Aseraggodes* from the Indo – Malayan region, 16 soles were described. Genus *Aseraggodes* seems mostly related to *Pardachirus*, and species have at times been misplaced in one or the other. The main difference between the two genera is the presence of the prominent pore at the base of most dorsal and anal rays in the species of *Pardachirus* (Randall and Desoutter, 2007). Randall (2007) also comments that "*the listing of A. herrei Seale from the Western Central Pacific by Munroe in Carpenter and Niem (2001) is an error*." Clark and George (1979) opined that "*a powerful toxin is released through these pores from underlying glands when a sole of this genus is threatened*."

Genus *Aseraggodes* is distinct in lacking pectoral fins; having ctenoid scales, no second lateral line on the ocular side of head continuing anterodorsally on body, 10 + 23 - 30 vertebrae, villiform teeth in a band only on blind side of jaws, caudal fin of 18 rays not broadly joined with dorsal and anal fins and base of dorsal and anal rays lacking a pore (as found in species of the genus *Pardachirus*) (Randall and Bartsch, 2005) for the release of a strong toxin when under stress (Clark and George, 1979). At least two species of *Aseraggodes* have a skin toxin (Randall and Melendez, 1987; Randall, 2002) but not from a series of large glands, each leading to a prominent pore.

Eschmeyer's Catalog of Fishes (online) lists 38 species as valid for the genus *Aseraggodes*. The genus *Aseraggodes* is represented by eight species in the Western Indian Ocean and Red Sea – *Aseraggodes brevirostris*, described from Comoro Islands, *A. guttulatus*, *A. diringeri* from Reunion Islands, *A. heemstrai* from Kwa Zulu, Natal, *A. jenny* from Mauritius, *A. sinusarabici* from Gulf of Suez, *A. steinitzi* from southern Red Sea, *A. cyaneus* from Porto Novo (Ramanathan, 1977; Rajguru, 1987) and *A. umbratilis* from South west coast of India (Biju and Deepti, 2009), Bay of Bengal and Arabian Sea (Randall, 2005). In the present study, *Aseraggodes kobensis* has been recorded from the West coast of India along with *A. umbratilis* from Neendakara; thus raising the total number from Western Indian Ocean to 10.

New Record 10

4.3.7.2.1 *Aseraggodes kobensis* (Steindachner, 1896)

Milky spotted sole

Solea kobensis Steindachner, 1896 *Ann. Hofmus. Wien,* XI : 218 (Kobe, Japan).

Aseraggodes kobensis Jordan and Snyder, 1901, *Annot. Zool. Japan*: 122; Jordan and Starks 1906, *Proc. U.S Nat. Mus.*, XXXI: 230, fig. 24 (Kobe); Smith and Pope, 1906, *Proc. U.S. Nat. Mus.*, XXXI: 498; Snyder, 1912, *Proc. U.S. Nat. Mus.*, XXXI: 440; Jordan, Tanaka and Snyder 1913, *J. Coll. Sci. Tokyo*, XXXIII (1): 333, fig. 282 (Nagasaki, Kobe); Jordan and Hubbs, 1925, *Mem. Carng. Mus.*, X: 301; Masuda *et al*., 1984, *Fishes Jap. Arch*.,: 354, pl. 319 E (South China Sea, Chiba, Niigata Pref.); Lindberg and Fedorov, 1993: 192; Li and Wang 1995, *Fauna Sinica* : 294; Chen *et al.*,1997, *Fish. Nasha Islands South*

China.,:177; Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 645; Nakabo, 2002, *Fish Japan*: 1385; Shinohara *et al*., 2001, *Mem. Nat. Sci. Mus*.,: 336; Randall, 2002, *Pac. Sci*., 56 (3): 252; Youn, 2002, *Fish. Korea*: 440, 687.

Aseraggodes melanostictus Norman, 1926. *Biol. Resul. "Endeavour*", V (5): 290, fig. 12. (Solomon Island).

Aseraggodes cyaneus Fowler, 1956, *Fish. Red. Sea S. Arabia*, I: 179, fig. 95

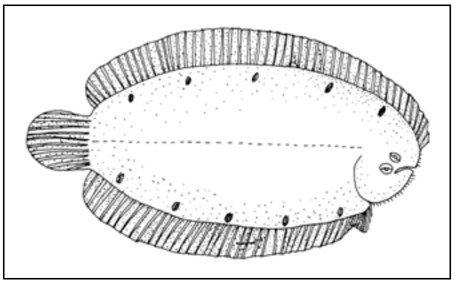


Plate XXXII: *Aseraggodes kobensis* (Steindachner, 1896)

Material examined: N =1, TL = 88.61 from Station 5, Cruise 165 on the West coast of India.

Diagnosis: An oval shaped soleid, dextral with brown spots in pairs, one each on the dorsal and ventral profile.

Meristic characteristics: D 67; A 48; P 5; C 2+14 +2

Body measurements as percent of standard length: HL 28.3; HW 37.4; HD 19.8; ED_1 3.9; ED_2 3.9; SNL_1 6.8; SNL_2 9.2; ID 3.4; CD 4.5; UJL 9.1; LJL 8.2; DFL 8.8; AFL 9.4; V_1FLO 7.3; V_2FLB 9.2; CFL 18.3; DBL 93.4; ABL 67.1; V_1BLO 2; V_2BLB 2; CPD 12.3; BD_1 39.5; BD_2 39.9; PDL 7.9; PAL 36.3; V_1LO 28.5; V_2LB 28.5.

As percent of head length: HW 132.2; HD 69.9; ED_1 13.8; ED_2 13.8; SNL_1 24; SNL_2 32.7; ID 12; CD 21; UJL 32.1; LJL 28.9.

Description: Body oval, fleshy, laterally compressed, the depth 2.5 in SL. Head small with small eyes separated by a scaly interspace which is not concave, head length 3.5 in SL. Upper eye a little in advance of the lower eye which is placed at the posterior margin of the mouth, eye diameter 7.2 in HL. Snout slightly hooked, ending slightly in advance of tip of mandible and on the same level as lower eye; snout length 4.2 in HL. Nostril two on ocular side, first one with round aperture, the second tubular with a flap at its outer end. Mouth small, curved downwards, ending at the middle point of lower eye; fine villiform teeth in a broad band on both jaws on blind side only. Upper jaw 3 times in HL, lower jaw 3.5 times in HL. Gill rakers rudimentary. Dorsal fin origin anteriorly on snout, first ray not prolonged, fin length shorter than anal; pelvic (ocular) slightly longer than pelvic fin on blind side; caudal fin free, not connected to dorsal and anal by skin; pelvic fins placed on ventral side of body, close together, not joined to anal. Pectoral fin absent on ocular and blind side. Lateral line straight from operculum, with 65 scales, no lateral branches. Scales on body small, thin ctenoid on both sides; ctenii on scales more on ocular side.

Table 70: A comparative statement of the meristic characters of *Aseraggodes kobensis*

Meristic characters	Earlier workers					Present work 2004 - 2010
	Jordan and Starks 1906	Snyder 1912	Shen and Lee 1981	Ochiai 1963	Masuda *et al.*, 1984	N = 1
Dorsal	70	70	70 – 78	64 - 74	64 - 74	67 - 69
Anal	51	51	51 - 55	45 – 55	45 – 55	48 – 49
Lateral line	61	76	69 – 77	53 - 71	53 - 71	
Caudal	*	*	18	*	17 - 19	2 + 14 + 2
Ventral	*	*	5/5	*	*	5 - 6

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Aseraggodes kobensis* is given in Table 68.

Table 71: Results of the correlation coefficient analysis on non-meristic characters of *Aseraggodes kobensis*

Characters	In SL	In HL
Head length	3.53	
Head width	2.67	0.8
Head depth	5.05	1.4
Eye diameter (U)	25.58	7.2
Eye diameter (L)	25.58	7.2
Snout to upper eye	14.69	4.2
Snout to lower eye	10.81	3.1
Interorbital	29.43	8.3
Chin depth	16.83	4.8
Upper jaw length	10.98	3.1
Lower jaw length	12.22	3.5
Dorsal fin length	11.39	3.2
Anal fin length	10.62	3.0
Pelvic fin length (O)	13.71	3.9
Pelvic fin length (B)	10.81	3.1
Caudal fin length	5.46	1.5
Dorsal fin base length	1.07	0.3
Anal fin base length	1.49	0.4
Pelvic (O) fin base length	50.48	14.3
Pelvic (B) fin base length	50.48	14.3
Caudal peduncle	8.11	2.3
Body depth $_1$	2.53	0.7
Body depth $_2$	2.51	0.7
Pre dorsal	12.62	3.6
Preanal	2.75	0.8
Pre pelvic (O)	3.51	1.0
Pre pelvic (B)	3.51	1.0

Colour: Brownish on ocular side with three symmetrical pair of brown dots on either profile of body on ocular side. Caudal fin brownish yellow; dorsal and anal fins tips yellowish.

Distribution:

World: *Aseraggodes kobensis* has been previously recorded only from the areas around Japan, Solomon Islands, Korea, China Sea, Tungkong, Taiwan. Map showing localities were *Aseraggodes kobensis* has been recorded in the world is given in Fig. 98.

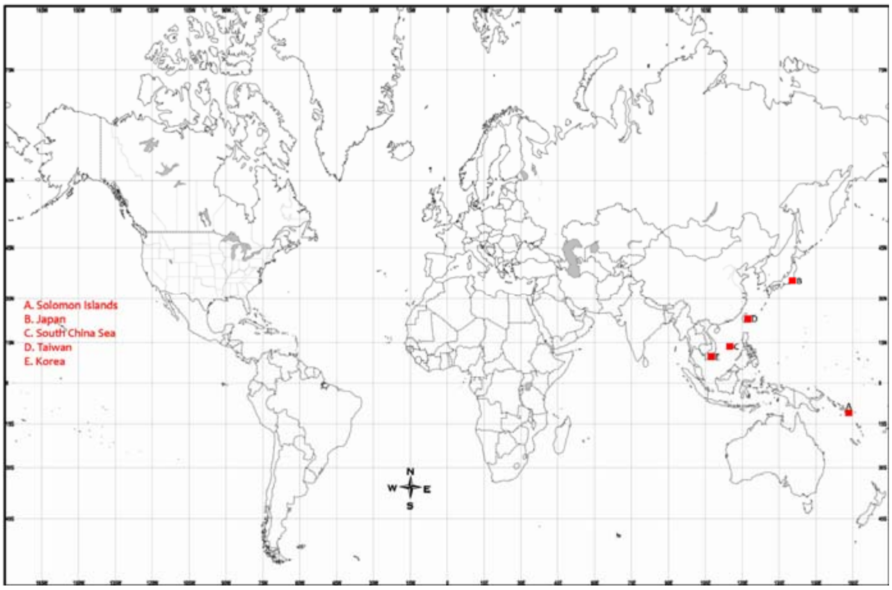


Fig. 98: Map showing localities were *Aseraggodes kobensis* has been recorded in the world.

India: This is the first record from the Indian Ocean. Map showing localities were *Aseraggodes kobensis* has been recorded in India is given in Fig. 99.

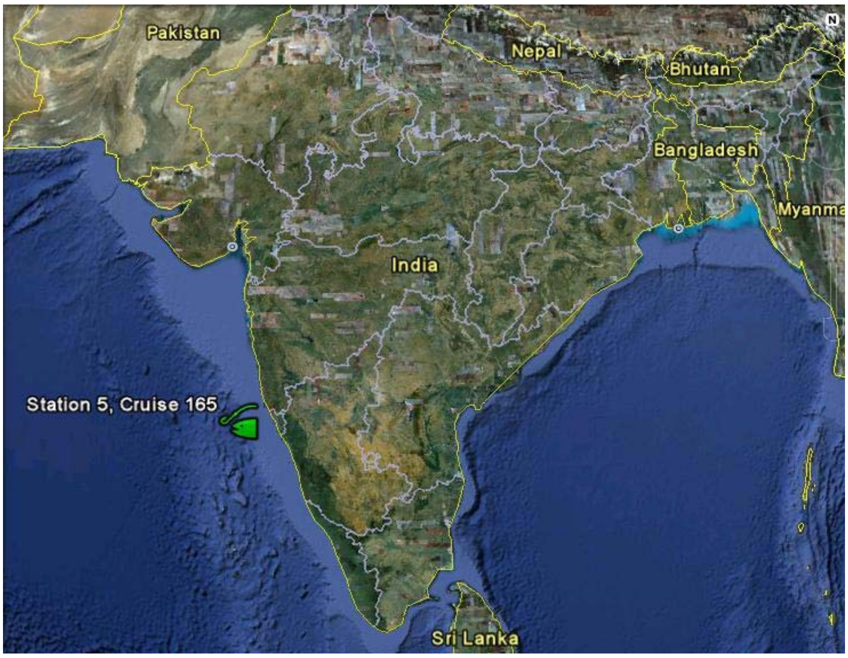


Fig. 99: Map showing localities were *Aseraggodes kobensis* has been recorded in India

Taxonomic remarks: The fish was first described by Steindachner (1896) based on a sample 6.5 cm TL from Kobe, Japan as *Solea (Achirus) kobensis*. Meristic counts of the specimen match well with that reported by Masuda *et al*. (1984).

Observations: The measurements and counts of this species agree with the descriptions given by Jordan and Starks (1906), Chabanaud (1931), Ochiai (1963) from Japan, Chen and Weng (1965) from Taiwan. Descriptions of this fish from elsewhere are absent. *A. kobensis* can be clearly distinguished from *A. umbratilis* in having smaller eyes, no cirri on front of snout, longer caudal peduncle length, smaller caudal fin length. Body pigmentation of *A. kobensis* also shows much variation from *A. umbratilis* – the latter has three series of dots on the body compared to two series in the former.

4.3.7.2.2 *Aseraggodes umbratilis* (Alcock, 1894)

Solea umbratilis Alcock, 1894, *J. Proc. Asiat. Soc. Bengal*, 63 (2): 11, pl. 7, fig. 31 (Bay of Bengal).

Aseragoddes umbratilis Randall and Gon, 2006, *Israel J. Zoo*., 51 (3):188; fig. 11, tables 1 – 3; Biju and Deepti, 2009, *Indian J. Fish*.,: 56(3): 211-214 (Kerala).

Plate XXXIII: *Aseraggodes umbratilis* (Alcock, 1894)

Material examined: N =1, TL 78 mm from Neendakara.

Diagnosis: Dorsal rays 67 - 73, anal rays 47 – 51; all fin rays unbranched. Lateral line scales 76 – 84; 14 in front of the gill opening; lateral line on ocular side of body projecting well above upper eye.

Meristic characters: D 71; A 40; Ll. 79; V_1 6.

Body measurements as percent of SL: HL 27.6; HW 36.9; HD 15.4; ED_1 3.6; ID 2.5; CD 8.5; DFL 8.9; AFL 7.1; V_1FLO 10; CFL 14; DBL 96.2; AFL 56.5; V_1BLO 4.7; CPD 9.9; BD_1 39; BD_2 38.6; PDL 4.9; PV_1LO 35.1; PrOL 6.5; PBU 19.2.

As percent of HL: HW 133.8; HD 55.7; ED_1 13.2; ID 9.1; CD 30.7; UJL 30.7

Description: Body oval, eyes small, interorbital space very narrow; anterior nostril tubular, very short, not reaching lower eye. Thin slender cirri seen on end of snout along ventral side of head on the edge of operculum on the blind side. Maxilla extending to or a little beyond a vertical at rear edge of lower eye. Upper end of gill opening on a horizontal passing slightly below lower eye. Anterior tubular nostril very short, barely reaching the edge of lower orbit. Dorsal and anal fin rays connected by a membrane. Pelvic fin reaching base of second anal ray. Caudal peduncle very short.

A comparative statement of the meristic characters of *Aseraggodes umbratilis* is given in Table 72.

Table 72: A comparative statement of the meristic characters of *Aseraggodes umbratilis*

Meristic characters	Alcock, 1894	Present study N = 1
Dorsal	67 – 73	71
Anal	47 - 51	40
Pectoral	6	6
Lateral line scales	76 - 84	76

Colour: Body brownish red with three rows of dark brown blotches nearly twice the eye diameter seen; the first well below the dorsal fin base, the second nearly in the centre and the third ventral. Interfin membranes dark brown, fin rays lighter.

Distribution:

World: Western Indian Ocean (Alcock, 1899)

India: The species has been recorded from Kattiwar coast and off Malabar coast (Alcock, 1899); Bay of Bengal (Randall and Gon, 2005);

Neendakara (Biju Kumar and Deepthi, 2010 and present study). Map showing localities were *Aseraggodes umbratilis* has been recorded in India is given in Fig. 100.

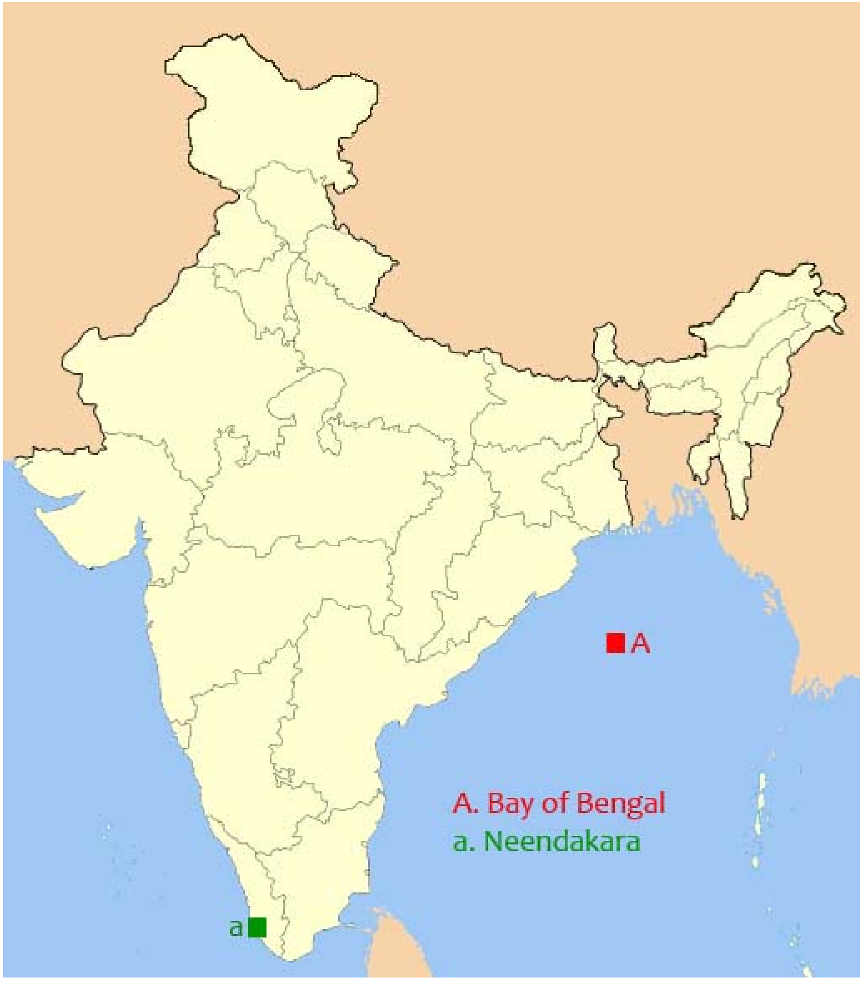


Fig. 100: Map showing localities were *Aseraggodes umbratilis* has been recorded in India

Taxonomic remarks: The species was first described by Alcock (1899) from depths of 124 – 271 m as *Solea umbratilis*; it was subsequently placed in the genus *Aseraggodes.*

Observations: The specimen differs from its closely allied species *A. diringeri* in the presence of the large head, maxilla reaching below rear end of lower eye; absence of cirri along the membraneous edge of dorsal and anal fin and opercular membrane extending upto eye diameter in the former (Randall and Gon, 2005). It differs from *A. kobensis* in the presence of three rows of spots on the body compared to two rows in the latter.

4.3.7.3 Genus *Brachirus* Swainson, 1839

Anisochirus Gunther, 1862, *Cat. Brit. Mus.*, IV: 480, 486 (Type: ***Synaptura panoides*** Bleeker 1851).

Brachirus (subgenus of *Solea*) Swainson, 1838, *Nat. Hist. Class. Fish.,*:303 (Type: ***Pleuronectes orientalis*** Bloch and Schneider, 1801); Li and Wang, 1995, *Fauna Sinica*: 304; Kottelat, 1998, *Ichth. Expl. Freshwater.,* 9 (1): 120; Munroe, 2001, *FAO Sp. Iden. Guide*, IV (6): 3880; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1844;

Heterobuglossus Chabanaud, 1931, *Bull. Soc. Zool. Fr.*, 56: 293.

Chabanaudetta Whitley, 1931, *Aust. Zool.*, VI: 322; (Type: ***Synaptura panoides*** Bleeker, 1851).

Euryglossa Kaup, 1858, *Arch. Nat.*, 24(1): 79 (Type: ***Pleuronectes orientalis*** Bloch); Menon and Joglekar, 1983, *J. Mar. Biol. Ass. India*, 20:14; Kottelat, 1985, *Hydrobiologia*, 121: 274; Kottelat, 1989, *F.W West. Indonesia*: 20.

Trichobrachirus Chabanaud, 1943, *Bull. Mus. Nat. Hist.*,: 292 (Type: ***Synaptura villosa*** Weber 1907).

Synaptura Cantor, 1849, *J. Asiat. Soc. Bengal* XVIII (2): 1204 (Type: ***Pleuronectes orientalis*** Swainson, 1839 = *Pleuronectes orientalis*

Bloch and Schneider, 1801); Torchio 1973, *Checklist fish. N.E Atlantic Mediterranean,* CLOFNAM: 634; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Arch*.,:354 ; Heemstra and Gon, 1986, *Smith. Sea Fish.,*: 873; Quéro *et al*., in Whitehead *et al*., 1986, *Fish. N.E Atlantic Mediterranean*, III: 1323; Desoutter, 1986, *Checklist Fish. Africa*: 431; Kottelat, 1989, *Bull. Zoöl. Mus., Univ. Amsterdam*: 20; Rahman, 1989, *Freshwater Fish Bangladesh*: 27; Desoutter in Leveque *et al*., 1992, *Collection Fauna tropicale,* XXVIII: 864; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad.,* 166:187; Gomon *et al*., 1994, *Fish. Australia South coast*: 861; Munroe, 2001, *FAO Sp. Iden. Guide*, IV (6): 3880.

Description: Body oval with head region broader, tail tapering. Eyes dextral, mouth convex ending at anterior half of lower eye; snout overhanging mouth like a hook. Teeth minute present on blind side. Two nostrils on eyed side; the anterior tubular with opening at tip, the other oval to round in outline covered by a flap. Nostrils on blind side hidden by a flap. Gill membranes united. Scales ctenoid on eyed side, cycloid/ctenoid on blind side. Lateral line straight, extending from behind head to tail, in front in some it extends onto head. On blind side, scales on head produced into bulbous papillae probably sensory in function. Lower lip of eyed side has finger like papillae which nearly covers upper lip. Dorsal fin origin on snout, first few rays very short. Dorsal and anal confluent with caudal, rays simple/bifid branched at tip. Pectoral (ocular) rays well developed with short base and oblong; pectoral (base) smaller than pectoral (ocular). Pelvics with broad base, free from each other and anal. Anus placed closed to pelvic (ocular).

Taxonomic comments: A great deal of confusion exists in the taxonomic status of the soleid fish of the genus *Brachirus* Swainson, 1839, *Synaptura* Cantor, 1850 and *Euryglossa* Kaup, 1853. (Day 1877; Norman 1928; Weber and Beaufort 1929; Smith 1949). Cantor (1849) created *Synaptura* as a replacement name for *Brachirus* Swainson 1839, which he described as a homonym of *Brachyurus* a generic name for mammals. Cantor (1850) recognising this suggested the name *Synaptura* as a substitute, describing *commersoniana* and *zebra* under the proposed genus. Bleeker (1853, 1875) recognised the name *Synaptura* and described *commersoniana* as a sole species under genus *Synaptura* referring *heterolepis*, *macrolepis*, *sundaicus*, *pan*, *panoides* and *zebra* in *Brachirus*. Later, Bleeker (1875) made distinctions between *Synaptura* and *Brachirus*, but did not designate a type species. Kaup (1858) erected a new genus *Euryglossa* for *orientalis*; however, Gunther (1862) restricted this as a subgenus of *Synaptura*. Chabanaud (1928) agreed with the distinction mentioned and designated *Pleuronectes commersonii* Lacepede (1802) as the type species for *Synaptura*. Day (1887) classified Family Pleuronectidae into 9 genera; *Synaptur*a was characterized by dextral eyes, pectorals rudimentary, vertical fins confluent with caudal and body scales ctenoid or cycloid. Those with small and simple nasal organs came under genus *Synaptura* while those with bifid nasal organs came under *Euryglossa*. Fowler (1934) in "*Fishes of China*" designated *Brachirus* Swainson as the valid genus; 2 species *Brachirus orientalis* and *Brachirus swinhonis* were recognized. Fowler (1956) however designated Genus *Synaptura* as valid as "*Brachirus* Swainson (1839) is preoccupied by *Brachyrus* Swainson, it is also spelled *Brachirus* (71, which is identifiable as *Pterois zebra* Cuvier = Scorpaenidae). The four genera viz. *Heterobuglossus* Chabanaud, *Chabanaudetta* Whitley, *Dexillus* Chabanaud and *Euryglossa* Kaup are characterised by either well developed pectorals or reduced and minute pectorals. Since this was the only major character, Menon and Joglekar (1978) synonymised the three genera *Heterobuglossus* Chabanaud, *Chabanaudetta* Whitley and *Dexillus* Chabanaud with *Euryglossa* Kaup. Talwar and Kacker (1984) in the classification of Soleidae separated the genera *Synaptura* and *Euryglossa* on the basis of body (elongate/oblong) and presence/absence of bony process on snout. Kottelat *et al*. (1993) concluded that *Euryglossa* Kaup is preoccupied by *Euryglossa* Smith 1853 in *Hymenoptera* and hence it is objectively invalid. Li and Wang (1995), Kottelat (1998), Desoutter *et al*. (2001) synonymised *Euryglossa* as a junior synonym of *Brachirus* Swainson 1838. Chen and Weng (1995) treated *Brachirus* as the senior synonym of *Synaptura.* Two species were described by them – *S. orientalis* and *S. nebulosa*. Later, *Synaptura nebulosa* was synonymised with *Brachirus annularis*. Desoutter and Munro *et al*. (2001) have reduced *Euryglossa* to an invalid name. Vachon *et al*. (2007) revised the taxonomique and phylogenetic position of *Dagetichthys* and *Synaptura*. They concluded that in the best interest of nomenclature of the species, *Synaptura* is reassigned to *Dagetichthys*. They concluded that the change will stabilize the nomenclatural issues of the species concerned; species *Synaptura albomaculatus*, *S. marginatus, S. commersonii, S. lusitanicus* and *S. cadenati* were placed in genus *Dagetichthys*. However, Eschmeyer (2010, online) concludes that "*current usuage of Synaptura will be maintained as for now*".

Observations: Norman (1928) recorded five species of *Brachirus* Swainson – *B. commersoni, B. albomaculatus, B. orientalis, B. pan* and *B. macrolepis* from Indian waters. Later, Talwar and Chakrapany (1966) added one more species – *B. panoides*.

New Record 11

4.3.7.3.1 ***Brachirus annularis*** Fowler, 1934

Annular sole

Brachirus annularis Fowler, 1934, *Proc. Acad. Nat. Sci. Philadelphia* 85:346, fig. 99 (China Sea, vicinity of Taiwan); Li and Wang, 1995, *Fauna Sinica*: 309; Munroe in Randall and Lim, 2000, *Raffles Bull. Zoo Suppl.*, 8: 646, Nakabo, 2002, *Fish. Japan,* 2:1387, Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1844.

Synaptura annularis Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sin*: 35, fig. 11(Taiwan); Keith *et al*., 1985: 292; Gonzales *et al*., 1994, *Jap. J. Ichth*., 40 (4): 491, fig.1; Nakabo, 2000, *Fish. Japan*: 1387; Nair, 2006, *J. Mar. Biol. Ass. India,* 48 (1): 118 (Kochi).

Zebrias annularis Hutchins, 2001, *Rec. W. Aust. Mus. Suppl*., 63: 47.

Synaptura filamentosa Sauvage, 1878, *Bull. Soc. Phil.*, 2: 93 (Laos, Cambodgien).

Synaptura nebulosa Chen and Weng, 1965, *Biol. Bull. Tunghai Univ. Ichth.*, 5, 25, 27: 76, fig. 52 (Tungkong, Taiwan).

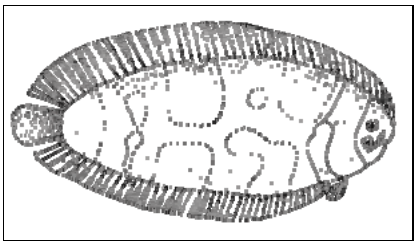


Plate XXXIV: *Brachirus annularis* Fowler, 1934

Material examined: N = 1, TL 147.5 mm from Munambam.

Diagnosis: A sole with large clear annular patches on the body and an unbranched pectoral fin.

Meristic characters: D 76; A 56; P_1 6; P_2 7; V_1/V_2 5; Caudal 13; scales on lateral line 106; SAL 33; SBL 28.

Body measurements as percent of SL: HL 22.7; ED_1 2.3; ED_2 1.8; HW 20.8; ID 3.7; SNL1 6.5; SNL2 5.5; UJL(O) 4.4; UJL (B) 5.6; LJL (O) 4.9; LJL (B) 4.3; BD_1 47.9; DFB 93.8; V_1BL 3.4; V_2BL 3.4; P_1BLO 5.3; P_2BLB 5.8; CPD 6.3; DFL 11.3; AFL 7.4; P_1FLO 3.1; CFL 9.4.

As percent of HL: ED_1 10.3; ED_2 7.97; HW 91.7; ID 16.3; SNL_1 28.4; SNL_2 24.3; UJL (O) 24.7; UJL (B) 24.7; LJL (O) 21.7; LJL (B) 19.1; BD_1 210.9; DFL 50.

Description: Body depth 2.7 in SL; head length 4.4 in SL; snout 2.7 in HL; snout to lower orbit 8.65, snout to upper orbit 7.42; upper eye diameter 3.14; lower eye diameter 2.43, interorbital width 4.97; upper jaw 5.84 on ocular side; 7.53 on blind side; lower jaw 6.65 on ocular and 5.83 on blind side; pectoral fin P_1 11.2 on ocular, 11.35 on blind side, pelvic fin V_1 5.08 on ocular, 4.9 on blind side; longest dorsal fin ray 15.24; longest anal fin ray 9.9; longest caudal fin ray 12.6; longest pectoral finray (O) 4.6, and 4.2 (B). Eyes on the right side, separated by a wide, scaly interorbital space with ctenoid scales in 9 rows. Upper eye slightly in advance of the lower. Anterior nostril is elongated, tubular, immedietly above upper jaw, posterior nostril slit like, covered by a fleshy pappillae in front of the lower eye. Four rows of fleshy papillae seen on blind side, below the lower jaw extending upto base of head and onto ocular side margin; dermal papillae are white on blind side and dark brown on ocular side. A comparative statement of the meristic characters of *Brachirus annularis* is given in Table 73.

Table 73: A comparative statement of the meristic characters of *Brachirus annularis*

Meristic characters	Earlier workers							Present
	Fowler 1933		Chen & Weng 1965	Shen and Lee (1981)		Keith *et al.* 1985	Gonzales *et al.* 1994	2004-2010
	USNM 93095	USNM 93206	THUP 02768	NTUM 05173	THUP 02768	AMS 462014	BSKU 81384	N = 1
Dorsal	70	*	71	70	71	*	70	76
Anal	57	*	59	57	59	*	57	56
Pectoral (O)	9	9	6	6	6	*	9	9
Pectoral (B)	8	9	6	7	7	*	10	8
Pelvic (O)/(B)	5/5	5/5	5/5	5/5	5/5	*	5/5	5/5
Caudal	*	*	18	18	18	*	18	13
Lateral lines	104	105	85	85	89	*	100	206
Scales above LL	29	*	*	*	*	*	32	28
Scales below LL	37	*	*	*	*	*	35	39
Vertebrae	*	*	*	42	*	*	43	-
Patches	7	*	5	5	6-7	6 - 7	6	6

Pectoral fin on blind side small with 7 rays, covered by a membrane, fused with opercular membrane on blind side to form a pocket like structure. Lateral line straight, extends from base of first annular ring to base of caudal on ocular side; on blind side a straight line. Caudal fin rounded, confluent with dorsal and anal rays. Pelvic fin origin on ocular side at junction of head and operculum. Five rays on pelvic fins joined by a flap of skin; pelvic fin on blind side slightly smaller than ocular. Finbases scaled, all finrays joined by flap of skin.

Results of the correlation coefficient analysis done on non-meristic characters of ***Brachirus annularis*** is given in Table 74

Table 74: Results of the correlation coefficient analysis on non-meristic characters of *Brachirus annularis*

Characters	Range in SL	Range in HL
Headlength	4.4	
Head width	4.8	1.1
Eye Diameter (U)	42.7	9.7
Eye Diameter (L)	55.23	12.54
Snout to upper eye	15.51	3.52
Snout to lower eye	18.09	4.11
Upper jaw length	22.98	5.22
Upper jaw length (B)	17.82	4.05
Lower jaw length (O)	20.33	4.62
Lower jaw length (B)	23.02	5.23
Body depth $_1$	2.09	0.47
Dorsal finbase	1.07	0.24
Pelvic fin base length (O)	29.17	6.63
Pelvic fin base length (B)	29.69	6.74
Pectoral fin length $_1$	18.98	4.31
Pectoral fin length $_2$	17.16	3.90
Caudal peduncle length	15.94	3.62
Dorsal fin length	8.81	2.00
Anal fin length	13.58	3.09
Pectoral fin length (O)	29.11	6.61
Pectoral fin length (B)	31.95	7.26
Caudal fin length	10.62	2.41

Scales: On lateral line tubular; on head, interorbital region ctenoid with 6 ctenii, central on longest.

Colour: Body dull reddish brown with distinct annular patches on the ocular side.

Distribution:

World: China Sea, vicinity of Taiwan (Fowler, 1934); Taiwan (Chen and Weng, 1965; Shen and Lee, 1981); Moreton Bay, Queensland, Australia (De Vis, 1883); Laos Cambodgien (Sauvage, 1878). Map showing localities were ***Brachirus annularis*** has been recorded in the world is given in Fig. 101.

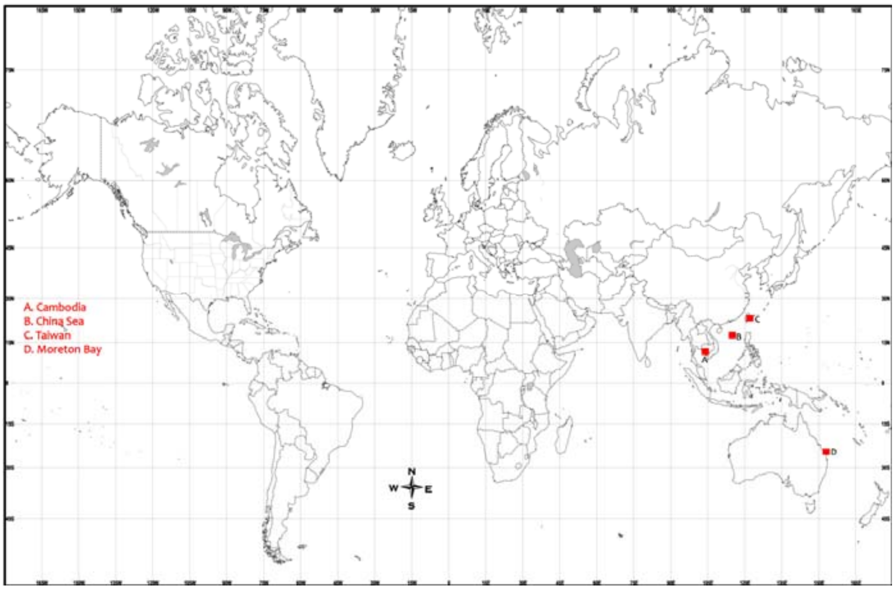


Fig. 101: Map showing localities were *Brachirus annularis* has been recorded in the world.

India: Kochi (Nair, 2006). Map showing localities were ***Brachirus annularis*** has been recorded in India is given in Fig. 102.

Fig. 102: Map showing localities were *Brachirus annularis* has been recorded in India

Taxonomic comments: The species was first described by Fowler (1933). Fowler collected the specimen from Station D. 5315, China Sea, vicinity of Formosa in 148 fathoms. The length of the holotype was 151 mm. Shen and Lee (1981) placed the fish in Genus *Synaptura*; thereafter the fish was placed in different genera and as different species. Eschmeyer (Catalog, online) synonymised all the species under *Brachirus annularis*.

Observations: In his original description, Fowler noted that the sample had no pectoral fin on the left side. In the present specimen, 9 rays are found on the pectoral fin (O) and 8 on blind side. Dr. Kunio Sasaki, who re-examined the holotype of *Synaptura annularis* USNM 93095 and one paratype USNM 93206 noted 9 pectoral fin rays on the ocular side and 8 on the blind side for the holotype and 9 rays on both sides for the paratype. The counts of the present specimen matches with that of the holotype. The meristic counts of the present specimen match well with that of earlier workers.

This is the first record of the species from Western Indian Ocean. This species is distinguished from other congeneric species occurring in this area (*S. commersoniana* and *S. albomaculata*) by the presence of large annular patches on the body and an unbranched pectoral fin. This specimen represents the first record of the annular sole from India.

4.3.7.3.2 *Brachirus orientalis* (Bloch and Schneider, 1801)
Oriental sole

Pleuronectes orientalis Bloch Schneider, 1801, *Syst. Ichth.*, : 157 (Tranquebar); Seale, 1914, *Phillipine J. Sci.*, 9:78.

Brachirus orientalis Swainson, 1839, *Nat. Hist. Fish.*, II: 303; Norman, 1926, *Biol. Results "Endeavour"*: 293; Norman, 1929, *Rec. Ind. Mus.*, XXX: 179, fig. 3 (Kerala, Madras, Chilka); Menon, 1961, *Rec. Ind. Mus.*, 59: 399 (Vellar, Porto Novo); Saramma, 1964, *Bull. Dept. Mar. Biol.*, 1: 72; Lu and Wu in Kuang *et al.*, 1986, *F. W Estuarine fish. Hainan Island*: 334; Li and Wang, 1995, *Fauna Sinica*: 305; Munroe in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl.*, 8: 646; Desoutter *et al.*, 2001, *Marine F. W Res.*, 53(2): 325;

Munroe, 2001, *FAO Sp. Iden. Guide,* IV(6): 3883; Nakabo, 2002, *Fish Japan,* 2: 1387; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1): S122; Hoese and Bray, 2006, *Zool. Cat. Aust.,:* 1845.

Solea foliacea Richardson, 1846, *Rep. 15th Meeting British Ass. Ichth. China*: 279 (coasts of China, Canton).

Solea pan Bleeker, 1851, *Nat. Tijd. Ned. Indie*: 410.

Synaptura pan (Cantor) Bleeker, 1852, *Verh. Bat. Gen*., XXIV: 30.

Solea trichodactylus Kaup, 1858, *Arch. Nat.,* XXIV, I: 481.

Euryglossa orientalis Kaup, 1858, *Arch. Nat.,* XXIV, I: 99; Talwar and Jhingran, 1991, *Comm. Fish India*: 1047; Coad, 1991. *Syllogeus*, 68: 27; Kottelat *et al*., 1993, *F.W Fish. Western Indonesia Sulawesi*: 171; Goren and Dor, 1994, *Fish. Red Sea*, CLOFRES: 72; Randall, 1995, *Coastal fish. Oman*: 360; Rainboth, 1996, *FAO Sp. Sheet*: 222; Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 596; Rema Devi *et al*., 1996, *Rec. Zool. Surv. India*, 95 (3-4): 144; Carpenter *et al*., 1997, *FAO Sp. Iden. Guide*: 233; Bijukumar and Sushama, 2000, *J. Mar. Biol. Ass. India,* 42 (1-2): 188.

Synaptura foliacea Gunther, 1862, *Cat. Brit. Mus*., IV: 481 (China); Day, 1865, *Fish. Malabar*: 173.

Brachirus sundaicus Bleeker, 1866, *Atl. Ichth*.,: 20, pleuron, pl. v, fig. 4, pl. viii, fig. 2.

Brachirus foliaceus Bleeker, 1873, *Ned. Tijds. Dierk*., 4: 130 (reference).

Synaptura orientalis Gunther, 1862, *Cat. Brit. Mus*., IV: 484 (East Indies); Day, 1879, *Fish. India* 4 ^{ed}., :429 (China); Jordan and Evermann, 1902, *Proc. U.S. Nat. Mus*., XXV: 366; Jenkins, 1910, *Mem. Ind. Mus.*, III: 29; Hora, 1923, *Mem. Indian Mus.*,: 759; Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.*, V: 175 (Singapore); Ochiai in Masuda *et al.*, 1984, *Fish. Jap. Arch.*,: 355; Desoutter, 1986, *Checklist F.W Fish. Africa*, CLOFFA: 431; Rahman, 1989, *F.W Fish. Bangladesh*: 28; Poll and Gosse, 1995, *Gen. Poiss. Afrique*: 79; Nakabo, 2000, *Fish Japan*, 2 ed: 1387.

Synaptura (Synaptura) filamentosa Sauvage, 1878, *Bull. Soc. Phil. Paris* (7th Serie), 2: 93 (Laos Cambodgien).

Synaptura nigra Macleay, 1881, *Proc. Linn. Soc. N.S Wales*, V: 49.

Synaptura cinerea De Vis, 1883, *Proc. Linn. Soc. N.S.Wales*, 8 (2): 288. (Moreton Bay, Queensland).

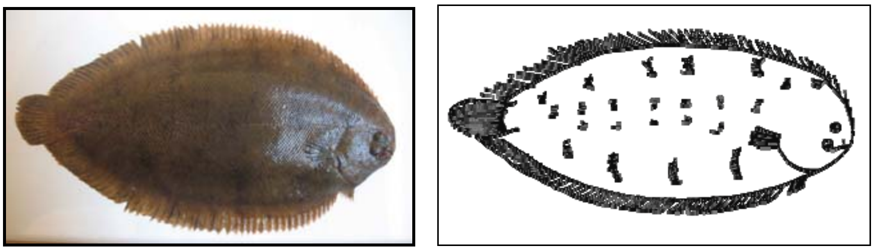


Plate XXXV: *Brachirus orientalis* (Bloch and Schneider, 1801)

Material examined: One specimen of TL 111.31 from Fort Kochi, Ernakulam.

Diagnosis: Body deeply oval; body greenish – black with filaments on the bands blackish. Sometimes irregular faint blotches seen.

Meristic characters: D 64; A 50; C 16; Ll 83.

Body measurements as percent of SL: HL 22.23; HW 36.2; HD 18.1; ED_1 4.1; ED_2 4.6; UJL 6.9; LJL 6.5; ID 1.7; P_rOU 4.7; PrOL 6.8;

PBU12.2; PBL 11.4; SNL_1 5.6; SNL_2 6.8; AFL 6.02; DFL 7.4; V_1FLO 4.9; V_2FLB 4.7; CFL 18.1; DBL 100.9; ABL 81.3; P_1BLO 2.7; P_2BLB 2.2; V_1BLO 2.04; V_2BLB 1.6; CBL 8.6.

As percent of HL : HW 162.95; HD 81.3; ED_1 18.4; ED_2 20.6; UJL 31.2; LJL 29.2; ID 7.5; P_rOU 21.2; PrOL 30.5; PBU 54.8; PBL 51.1; SNL_1 25.2; SNL_2 30.5.

Description: Body deeply oval, 2.5 in SL; head small. Eyes small, separated by a wide interspace, scaly; upper eye in advance of lower eye, slightly smaller than lower eye. Mouth cleft curved, reaching to below middle of eye; four fringes on lower lip pointing upwards. Two nostrils present in front of lower eye, tubular. On the blind side above the cleft of the mouth is a small hole like area surrounded by thick skin in circular pattern. Fine white papillae seen on the outer opercular tip on the blind side. Scales on the blind side have nearly 20 white soft thread like ctenii at its outer tip. Dorsal and anal fin rays joined by a membrane, the posterior rays of both fins joined with caudal fin. Caudal fin oval at outer free end. Pectoral fin on ocular side small with 8 - 9 rays; reduced on blind side. Body covered with ctenoid scales on ocular and blind side; scales do not extend onto fins; scales uniformly shaped on all sides of body. Scales oval in shape, with a light brown spotted part with 13 spines and a strip of radiating grooves from the spotted part to the inner smooth end. On either side of the scales are two semicircular areas with thin radiations. Lateral line scale is grooved in centre. Spotted part of the lateral line scale and body scale varies in the patterns on them. Vertical filamentous bands found on body on ocular side in patches; bands cross lateral line. A comparative statement of the meristic characters of ***Brachirus orientalis*** is given in Table 75.

Table 75: A comparative statement of the meristic characters of *Brachirus orientalis*

Meristic characters	Bloch & Schneider 1801	Norman 1928	Day, 1865 (Malabar)	Gunther1 862	Gunther 1862 (foliacea)	Munroe 1955	Weber & Beaufort 1929	Fowler 1956	Marshall 1964	Cheng & Weng 1965	Ramanathan 1977
Dorsal + Anal+ Caudal	140	62 -72+ 47 - 57+ 16	62 +46 +15	66+ 48+19	62 +46 +16	62 – 72 + 47 – 57 - 16	61 – 65+ 44 -48	61 – 70 + 44 – 48	61 -65+44 - 48	61+44+15	65 -69+ 50 - 53+17 -18
Pectoral (O)/(B)	6	8 - 9	7	9	7	8 - 9	7 -8/5	7- 9	7 -8/5	6-7/4 - 7	7- 8
LL scales	*	63 - 74	75	*	82	*	75 - 85	75 - 85	75 - 85	*	82 – 87
Ventral	4		6	*	*	*	*	*	*	5	5

Meristic characters	Menon & Joglekar 1978	Shen & Lee 1981	Talwar & Kacker 1984	Kuronuma & Abe 1986	Radhamanyamma 1988	Randall 1995	Present 2004 – 2010 N = 1
Dorsal + Anal+ Caudal	59 -73+ 46 -56+ 18 -20	61 + 44- 45+18	62 -72	65 - 67	63 – 68+46 -50+ 17- 19	61 – 65	64 + 50 + 16
Pectoral (O)/(B)	7 -10	6 -7/4- 7	47 - 57	6-7/6-7	8	7- 8	8
LL scales	64 – 83	76 - 80	*	49 - 51	*	75 – 85	83
Ventral	*	5	*	*	5	*	5

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Brachirus orientalis*** is given in Table 76

Table 76: Results of the correlation coefficient analysis on non-meristic characters of *Brachirus orientalis*

Meristic characters	Ratio in SL	Ratio in HL
Head Width	2.76	0.61
Head Depth	5.53	1.23
Eye Diameter (U)	24.53	5.45
Eye Diameter (L)	21.89	4.87
Upper jaw length	14.40	3.20
Lower jaw length	15.42	3.43
Inter orbital	59.94	13.33
Pre orbital (U)	21.26	4.73
Pre orbital (L)	14.73	3.27
Post orbital (U)	8.20	1.82
Post orbital (L)	8.81	1.96
Snout-> U eye	17.83	3.96
Snout-> L eye	14.73	3.27
Dorsal FL	13.53	3.01
Anal FL	16.62	3.69
Pectoral FL(O)	13.23	2.94
Pectoral FL (B)	15.37	3.42
Pelvic FL (O)	20.49	4.56
Pelvic FL (B)	21.41	4.76
Caudal FL	5.54	1.23
Dorsal BL	0.99	0.22
Anal BL	1.23	0.27
Pectoral BL (O)	37.17	8.26
Pectoral BL (B)	46.55	10.35
Pelvic BL (O)	48.93	10.88
Pelvic BL (B)	63.51	14.12
Caudal BL	11.65	2.59

Colour: Greenish – black with filaments on the bands blackish. Sometimes irregular faint blotches seen. Pectoral on ocular side dusky. Fins light coloured.

Distribution:

World: Coasts of China, Canton (Richardson, 1846; Gunther, 1862; Day, 1879); East Indies (Gunther, 1862); Indonesia (Kottelat *et al*., 1993); Laos, Cambodgien (Sauvage, 1878); Moreton Bay, Queensland (De Vis, 1883); Singapore (Weber and Beaufort, 1929); Australia, Egypt, Brunei, Djibouti, Iran, Israel, Bahrain (Menon, 1984); Red Sea and Persian Gulf (Desoutter, 1986); Cambodia (Rainboth, 1996); Taeipei (Shen, 1993); Vietnam (Nguyen and Nguyen, 2006).

Map showing localities were ***Brachirus*** *orientalis* has been recorded in the world is given in Fig. 103

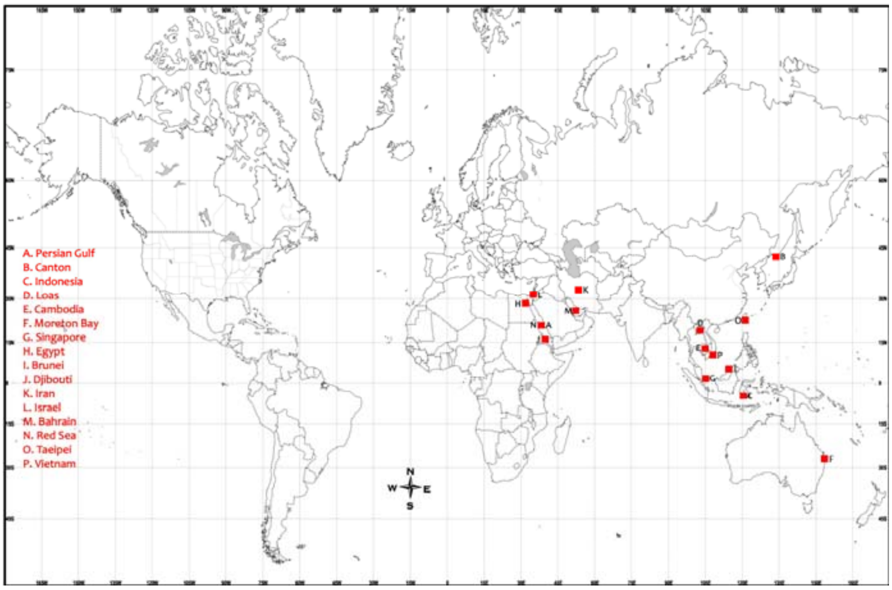


Fig. 103: Map showing localities were *Brachirus orientalis* has been recorded in the world.

India: Tranquebar (Bloch and Schneider, 1801); Kerala, Madras, Chilka (Norman, 1929); Vellar, Porto Novo (Menon, 1961); Madras, Ennore (Day, 1878).

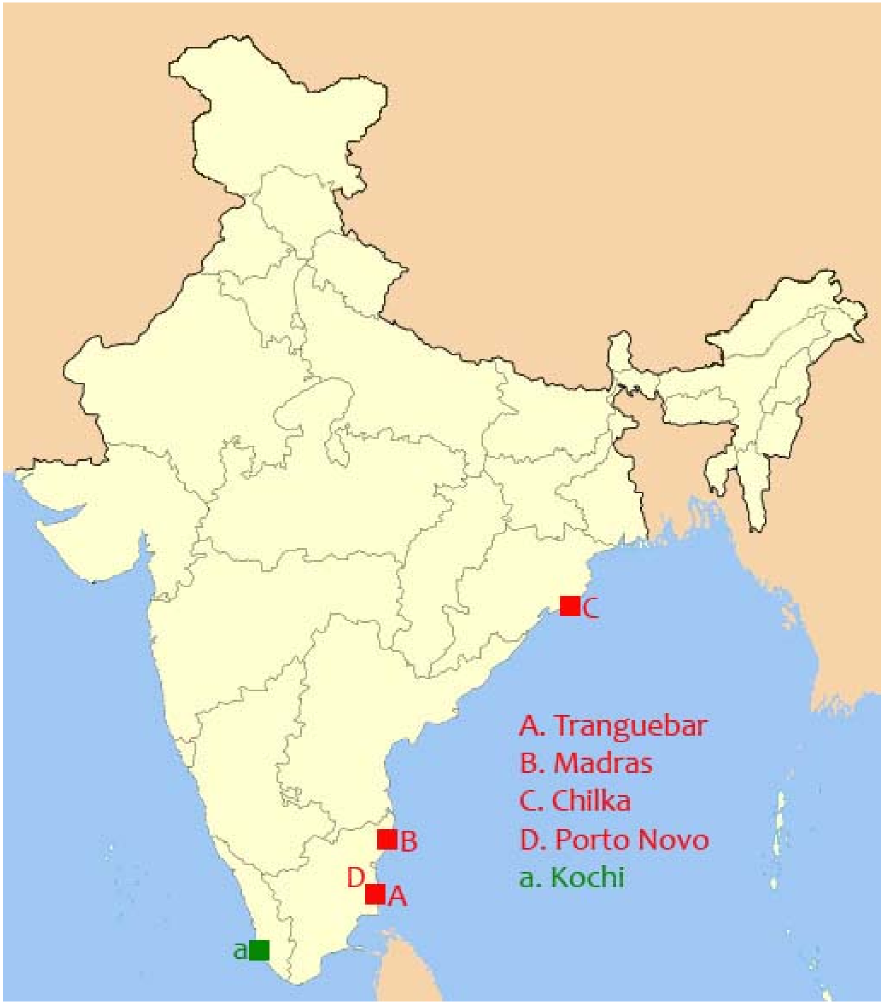


Fig. 104: Map showing localities were *Brachirus orientalis* has been recorded in India

Taxonomic remarks: Bloch (1801) described the specimen as *Pleuronectes orientalis* based on a sample from Tranquebar on the east coast of India. Swainson in 1839 described the fish as *Brachirus* *orientalis*. Kaup (1858) described it in the genus *Euryglossus* as *Euryglossus orientalis* and placed *Pleuronectes orientalis* as the orthotype. *Euryglossa* was said to differ from *Brachirus* in having the nasal tube bifid. Day (1878) described the fish in genus *Synaptura* as *Synaptura orientalis*; Day's classification was followed by many laters workers. However, Norman (1928) mentions that Chabanaud had examined Kaup's type in the Paris Museum and "*kindly informs me that this condition is clearly abnormal, and that the specimen is in all other respects a typical Brachirus orientalis*." Munroe (1955) also placed the fish in genus *Brachirus* following Swainson. Li and Wang (1995: 304), Kottelat (1998: 120), Desoutter *et al*. (2001) synonymised *Euryglossa* as a junior synonym of *Brachirus* Swainson (1838) and hence the name *Brachirus orientalis* is the valid name for the species.

Observations: Body seen to excude slime when caught live from estuarine waters. The fin and scale counts of the present specimen match well with that of earlier workers of both *B. orientalis* as well as *E. orientalis*. However, lateral line counts of Norman (1928) and Menon and Joglekar (1978) show a wide range with very low lower range. The lateral line counts in the present work are on the higher end compared to the reports of Norman (1928) as well as Menon and Joglekar (1978); but are in the range specified by other workers.

4.3.7.3.3 *Brachirus pan* (Hamilton, 1822)

Pan sole

Pleuronectes pan Hamilton, 1822, *Fish. Ganges*: 130, 373, pl.24, fig. 42 (Eastern Ganges).

Brachirus pan Swainson, 1839, *Nat. Hist. Fish.*, II: 303; Bleeker, 1866, *Atl. Ichth.*, VI: 21, Pleuron, pl. ix, fig.1; Norman, 1928, *Rec. Ind. Mus.*, XXX: 181 (Calcutta Bazar); Li and Wang, 1995, *Fauna Sinica*: 307; Munroe in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl., 8*: 646; Munroe, 2001, FAO *Sp. Iden. Guide,* IV (6): 3881.

Synaptura pan Bleeker, 1852, *Verh. Batv. Gen.,* xxiv: 30 (Biliton in sea); Gunther, 1862, *Cat. Brit. Mus.*, IV: 481 (Singapore); Day, 1878-1888, *Fish. India* 4º**:**429; Weber and Beaufort, 1929, *Fish. Indo - Aust. Arch*., IV: 177 (Singapore, Orissa, Ganges delta); Punpoka, 1964, *Fish. Res. Bull. Kasetsart Univ*.,:52(Thailand); Rahman, 1989, *Freshwater Fish. Bangladesh*: 27; Kottelat *et al*., 1993, *F.W Fish. W. Indonesia*:171; Cheng and Weng (1965), *Flatfish Taiwan*: 10.

Euryglossa pan, Talwar and Jhingran, 1991, *Inland Fish. India*: 1046.

Pleuronectes canus Gray, 1854, *Cat. Fish. Gronow* : 91.

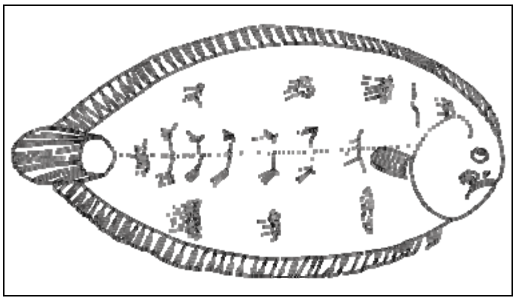


Plate XXXVI: *Brachirus pan* (Hamilton, 1822)

Materials examined: N = 16, TL 125.58 – 182.52 mm from Fort Kochi, Kalamukku, Kochi, Kerala.

Diagnosis: Body deeply oval, with caudal partially joined to dorsal and anal. Scales of the nape and upper part of head enlarged.

Meristic characters: D 59 – 68 (64); A 44 – 51 (47); C 16 – 18 (17); P_1 7/P_2 8; V 5; Ll 65 – 79 (68).

Body measurements as percent of SL (means in parentheses): HL 20.9 - 25.5 (23.13), HD 13.1 – 28.14 (17.2), BD_1 48.7 – 58.5 (52.6), HW 25.7 – 44.6 (35.8), ED_1 3.1-4.93 (3.9), ED_2 2.9 - 4.6 (3.7), ID 1.8 -3.6 (2.8), SNL_1 4.9 - 7.0 (5.9), SNL_2 5.9 – 8.2 (7.1), DFL (20th ray) 5.7 - 10.01 (7.9), AFL 5.8 -10.23 (8.1), CFL 12.5 – 18.8 (15.5), P_1FLO 8.5 – 10.5 (9.5), P_2FLB 5.9 -8.6 (7.5), V_1FLO 5.5 – 8.4 (7.2), V_2FLB 5.4 – 8.3 (6), DBL 96.1 – 102.12 (98.7), ABL 77.8 – 85.9 (81.6), CBL 9.99 – 13.24 (11.3), P_1BLO 1.7 – 3.7 (2.8), P_2BLB 2 -3.2 (2.6), V_1BLO 1.6 – 5.8 (3.5), V_2BLB 0.98 – 3.6 (2.2), PDL 1.5 – 6.9 (3.9), PAL 19.5 - 25.7 (22.1), eye – dorsal fin origin length 4.7 - 6.2 (5.6), mouth 6.2, V_1LO 15.8 – 21.54 (16.89), P_1LO 20.3 - 24.3 (22.3), P_1LB 20.1 - 24.1 (22.2).

As percent of HL (means in parentheses): HD 62.4 -119.2 (76.2), HW 115.6 - 183.8 (163.3), ED_1 12.4 – 20.2 (16.8), ED_2 12.4 -17.99 (15.7), ID 8.12 - 15.97 (12), UJL 26.1 - 39.3 (32.9), LJL 22.2 – 34.8 (28.3), SNL_1 23.1 - 28.4 (25.3), SNL_2 26.8 - 36.5 (30.9), eye to dorsal fin origin 19.95 – 27.1 (23.9), mouth 26.3.

Description: Body deeply oval, with caudal partially joined to dorsal and anal. Eyes placed close together with a scaly interspace. Black fine thick vertical hair marks across body. Two nostrils just above upper region of mouth; the first thick tubular with hole at tip, the second oval in outline with flap. Lips with fine papillae on its edges, giving it a fringed appearance. Mouth with fleshy lips. Cleft of mouth ends in the half of the lower eye just below the anterior part. On blind side, upper and lower jaws are fleshy, joined in a curved pattern. Teeth present on lower jaw only. Pectoral outer free tip portion black, fin tips yellow. Blind surface is white in colour, area around mouth, skin with fine feathery papillae with a thick fleshy stalk. Upper area of head is without scales. Fine hair like structures seen at the outer free end of operculum. Dorsal and anal fins branched. Pelvic with broad base, free and not fused with anal. Pectoral fin seen on ocular and blind side. Lower jaw on blind side has fine teeth. Teeth villiform and in a band. Dorsal fin origin infront of lower margin of upper eye, just few rays smaller than the latter.

Body scales ctenoid, oval in outline, with longer spines on central part. Spines arise on the spotted area. Scale radii arise from the centre and proceed outward. Scales extend from the body covering onto the fin membrane coverings. Scales of the nape and upper part of head enlarged. Digestive system is a long straight tube; anus opens just in front of the anal fin. Lateral line straight, arising from behind operculum, ending at origin of tail. Lateral line canal is tubular, arranged in between scales. Blind side scales with fine hair like ctenii projecting out with 20 ctenii in one scale.

A comparative statement of the meristic characters of *Brachirus pan* is given in Table 77.

Table 77: A comparative statement of the meristic characters of *Brachirus pan*

Meristic characters	Earlier workers					Present work 2004 – 2010
	Bleeker 1852	**Norman 1928**	**Day 1877**	**Gunther 1862**	**Weber & Beaufort 1929**	**N = 1**
Dorsal	65	57 – 61	57 -60	59	57 - 60	63
Anal	48	43 – 46	43 – 45	45	43 – 45	45
Pectoral (O)/(B)	7 / 5	5 – 6	7	5	5 – 6/ 4 -5	8
LL scales	70 - 85	66 - 72	80	75	80	70
Ventral	5 / 4	4	6	*	4	5
Caudal	12	*	14	14	*	17

Results of the correlation coefficient analysis done on non-meristic characters of ***Brachirus pan*** is given in Table 78

Table 78: Results of the correlation coefficient analysis on non-meristic characters of *Brachirus pan*

Meristic characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.9 - 4.8	4.33	0.24	0.84	0.19
Head depth	3.6 - 7.7	6.03	1.01		0.24
Body depth	1.7 - 2.1	1.91	0.09	0.87	0.45
Head width	2.2 - 3.9	2.66	0.39	0.25	0.10
Eye Diameter (U)	20.3 -32.4	26.19	3.83	0.40	0.02
Eye Diameter (L)	21.8 -34.6	27.77	3.32	0.06	0.01
Inter orbital length	28.1 -55.8	37.30	7.56	0.38	0.02
Snout-> U eye	14.3 -20.4	17.17	1.52	0.61	0.03
Snout-> L eye	12.2 -17.1	14.17	1.58	0.05	0.06
Dorsal (20th)	9.99 - 17.6	13.07	2.25	0.27	0.09
Anal	9.8 - 17.2	12.57	2.07	0.18	0.07
Caudal	5.3 - 8.01	6.53	0.65	-0.04	0.08
Pectoral (O)	9.5 - 11.7	10.60	0.74	0.37	0.07
Meristic characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	0.8 - 1.6	1.37	0.22	0.51	1.1
Body depth	0.4 - 0.5	0.44	0.02	0.90	2.1
Head width	0.5 - 0.9	0.62	0.07	0.51	0.9
Eye Diameter (U)	4.9 - 8.1	6.10	0.89	0.40	0.1
Eye Diameter (L)	5.6 - 8.04	6.45	0.71	0.37	0.1
Inter orbital length	6.3 – 12.3	8.70	1.78	0.26	0.1
Snout-> U eye	3.5 - 4.3	3.96	0.24	0.79	0.2
Snout-> L eye	2.7 - 3.7	3.27	0.31	0.73	0.3
Dorsal (20th)	2.3 - 4.3	3.05	0.55	0.50	0.4

Colour: Body brownish with black thin stripes occasionally.

Distribution:

World: Singapore (Gunther, 1862; Weber and Beaufort, 1929); Thailand (Punpoka, 1964). (Fig. 105)

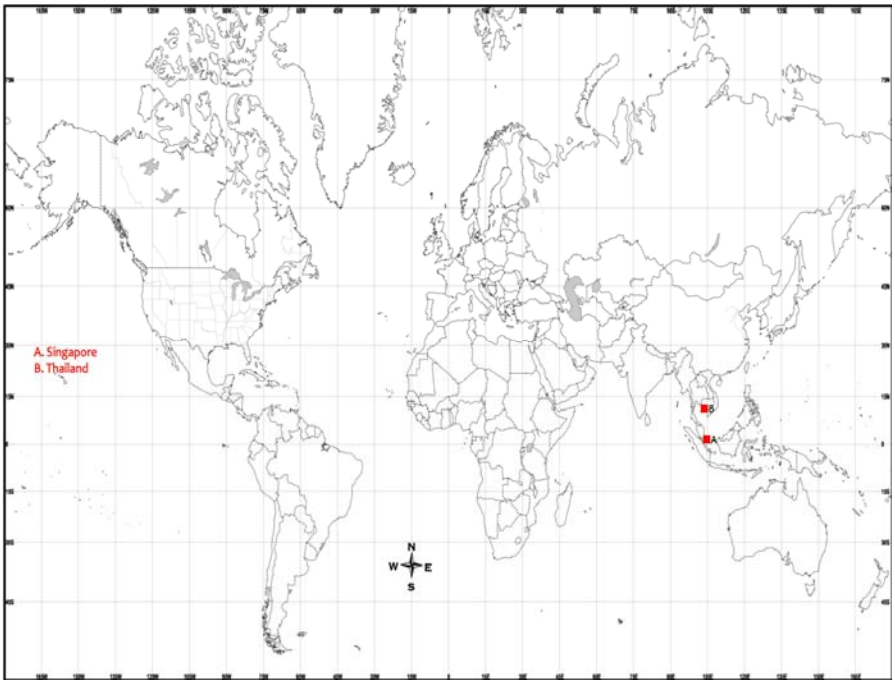


Fig. 105: Map showing localities were *Brachirus pan* has been recorded in the world.

India: Eastern Ganges (Hamilton, 1822); Calcutta Bazar (Norman, 1928); Orissa, Ganges delta (Weber and Beaufort, 1929).(Fig. 106)

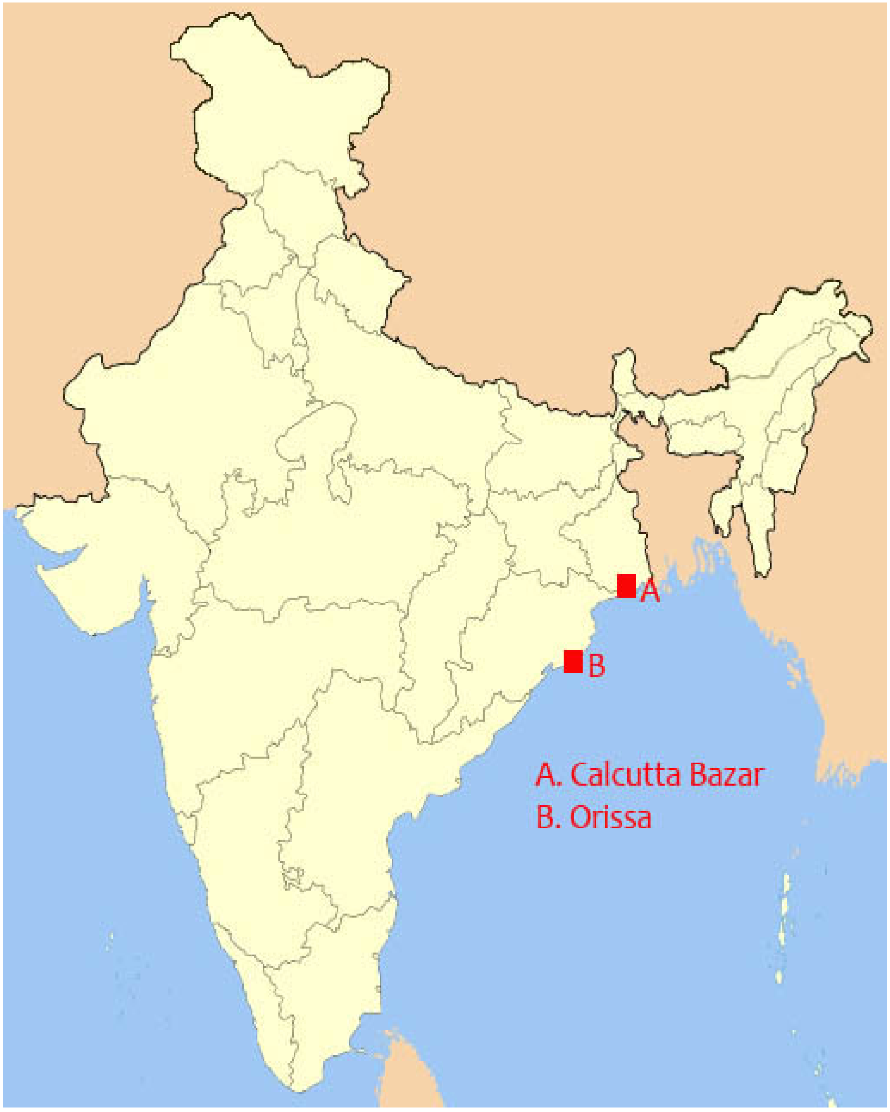


Fig. 106: Map showing localities were *Brachirus pan* has been recorded in India

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph (Figs. 107,108,109,110); the linear regression equations obtained were

Head length on SL : $y = 0.19x + 4.4$; $R^2 = 0.91$

Head width on SL : $y = 0.27x + 2.9$; $R^2 = 0.39$

Head depth on SL : $y = 18.2 - 0.03x$; $R^2 = 0.84$

Body depth (BD_1) on SL : $y = 0.45x + 10.7$; $R^2 = 0.76$

Regression of head length on SL was found to be highly significant while all the other parameters were found to be non - significant.

Taxonomic remarks: The species was first described as *Pleuronectes pan* by Hamilton. In the description he mentions that the jaws are fleshy and contains no teeth. In the present sample fine teeth are present on the lower jaw. Another difference noted is the presence of nostrils in the present specimen compared to the type where Hamilton says "*I can observe no nostrils*". Bleeker (1852) described the fish as *Synaptura pan* based on a sample from Biliton; the range for meristic counts is quite broad, the latter workers did not show much variation from Bleeker in these counts. In 1853, Bleeker synonymised the species *Pleuronectes pan* Bucchanan, *Solea pan* Cuvier and *Brachirus pan* Swainson with *Synaptura pan*. As per Eschmeyer (2010), *Synaptura* and *Euryglossa* are considered synonyms of *Brachirus.*

Observations: Talwar and Kacker (1984) describes the specimen with scales on the upper part of the head and nape distinctly enlarged, caudal fin with 16- 17 rays. Punpoka (1964) mentions of eight black lines across the lateral line instead of six and seven lines in earlier specimens.The present specimen agrees in meristic and morphometric counts with the works of Norman and Bleeker.

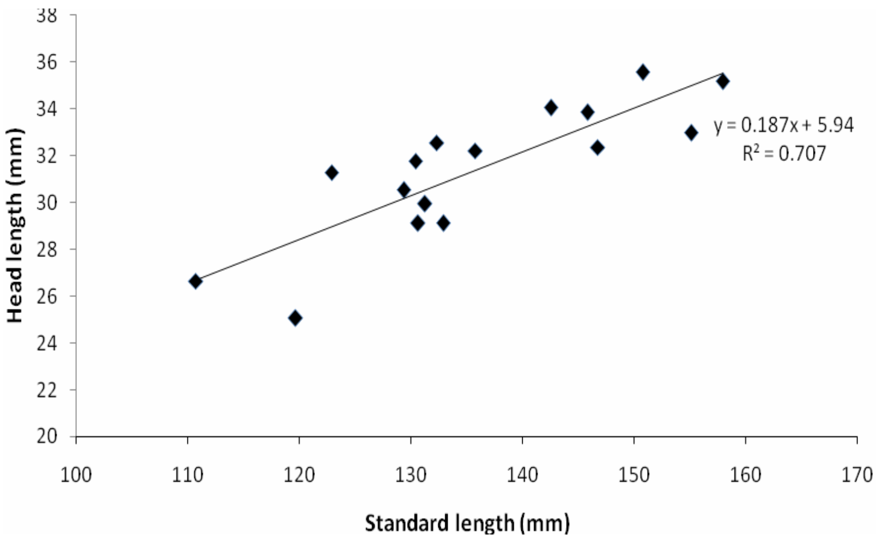


Fig. 107: Regression of Head length on Standard length

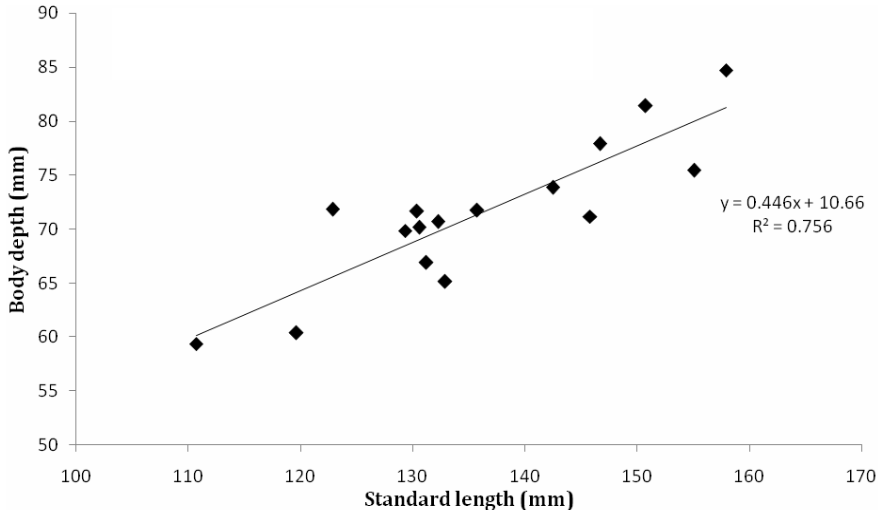


Fig. 108: Regression of depth on Standard length

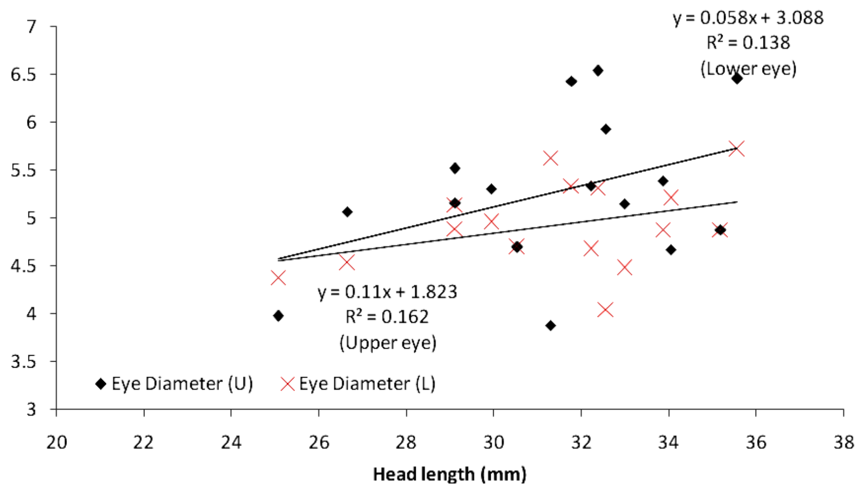


Fig. 109: Regression of Eye diameter on Head length

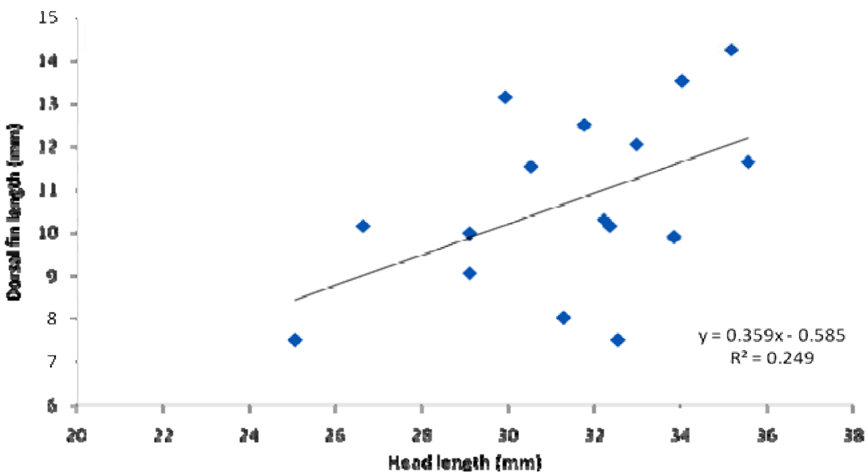


Fig. 110: Regression of Dorsal finlength on Head length

Taxonomic remarks: The species was first described as *Pleuronectes pan* by Hamilton. In the description he mentions that the jaws are fleshy and contains no teeth. In the present sample fine teeth are present on the lower jaw. Another difference noted is the presence of nostrils in the present specimen compared to the type where Hamilton says "*I can observe no nostrils*". Bleeker (1852) described the fish as *Synaptura pan* based on a sample from Biliton; the range for meristic counts is quite broad, the latter workers did not show much variation from Bleeker in these counts. In 1853, Bleeker synonymised the species *Pleuronectes pan* Bucchanan, *Solea pan* Cuvier and *Brachirus pan* Swainson with *Synaptura pan*. Talwar and Kacker (1984) describes the specimen with scales on the upper part of the head and nape distinctly enlarged, caudal fin with 16-17 rays. Punpoka (1964) mentions of eight black lines across the lateral line instead of six and seven lines in earlier specimens.The present specimen agrees in meristic and morphometric counts with the works of Norman and Bleeker. As per Eschmeyer (2010), *Synaptura* and *Euryglossa* are considered synonyms of *Brachirus.*

4.3.7.4 Genus *Heteromycteris* Kaup, 1858

Heteromycteris Kaup, 1858, *Arch. Natur.*, 24(1):103 (Type: ***Heteromycteris capensis*** Kaup, 1858); Ochiai in Masuda *et al.,* 1984, *Fish. Jap. Arch.,*: 354; Heemstra and Gon, 1986, *Smith. Sea Fish.,*: 870; Desoutter, 1986, *Checklist Fish. Africa*: 430; Desoutter in Lévêque *et al.,* 1992, *Collection Faune tropicale,* XXVIII, 2: 861; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*.,:187; Li and Wang, 1995, *Fauna Sinica*: 300; Munroe, 2001, FAO *Sp. Ident. Guide*, IV (6): 3879; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1847.

Monodichthys Chabanaud, 1925:356 (Type: ***Monodichthys proboscideus*** Chabanaud 1925).

Amate Jordan and Starks, 1906:228 (Type: ***Achirus japonicus*** Temminck and Schlegel, 1846).

Seven species of *Heteromycteris* genus have been recorded the world over - *Heteromycteris capensis* from Southeastern Atlantic to southwestern Indian Ocean, *Heteromycteris japonica* from China, *Heteromycteris hartzfeldii* from Western Pacific, *Heteromycteris matsubarai* from Tanegashima, Kagoshima Prefecture, Japan, *Heteromycteris oculus* from Puri and *Heteromycteris proboscideus* from Southeastern Atlantic. Of the different species recorded worldwide, two species have been recorded in the present study, both from east coast of India – *H. oculus* and *H. hartzfeldii.*

4.3.7.4.1 *Heteromycteris hartzfeldii* (Bleeker, 1853)

Hook –nosed sole

Achirus hartzfeldii Bleeker, 1853, *Nat. Tijds. Ned. Indië*, IV: 123 (Ambon Island, Moluccas Islands, Indonesia); Bleeker, 1886 – 1872, *Atl. Icth.*, 6:25, pl.246, fig.1; Evermann and Seale, 1907, *Bull. U.S Bur. Fish.*, 26 (1906): 106 (Philippine Islands); Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch.*, 5:160, fig. 45; Herre, 1953, *Rep. U.S. Fish Wild. Ser.*, 20: 186;

Aseraggodes hartzfeldi Kaup, 1858, *Arch. Nat.*, 24: 103.

Solea hartzfeldii Gunther, 1862, *Cat. Brit. Mus.*, 4:471 (Amboyna).

Solea oculus Alcock, 1889, *J. Asiat. Soc. Bengal*, 58 (3):285

Heteromycteris hartzfeldii Suvatti, 1950, *Fauna Thailand*: 323; Alcala and Cabanban, 1986, *Silliman*: 17; Kailola, 1991, *Res. Bull. 41, Res. Stn, Papua N. Guinea*; Monkolprasit *et al.*, 1997, *Checklist Fish*: 266; Munroe in Randall and Lim, 2000, *Raffles. Bull. Zool. Suppl.*, 8: 646; Munroe 2001, *FAO Sp. Iden. Guide*: 3881; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1847.

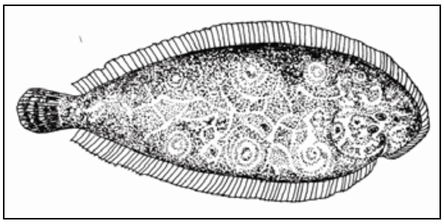


Plate XXXVII: *Heteromycteris hartzfeldii* (Bleeker, 1853)

Material examined: N = 2; TL 138.88mm from Tuticorin Fisheries Harbour and sample T140/245 from CMFRI Museum, Mandapam. (TL 95.09 mm).

Diagnosis: A sole with hazy patterns on its ocular side.

Meristic counts: D 92; A 64; V_1/V_2 6; Ll 58

Body measurements as percent of SL: HL 25.5; HW 34.5; HD 17.3; BD_1 37.4; BD_2 28.3; ED_1 3.3; ED_2 3.6; ID 2.2; PrOU 9.3; PrOL 11.3; PBU 13.2; PBL 10.9; UJL 10.2; LJL 6.7; CD 5.6; DFL 9.96; AFL 7.4; V_1FLO 5.6; V_2FLB 4.8; CFL 11.4; DBL 115.4; ABL 82.4; V_1BLO 9.4; V_2BLB 10.6; PAL 24.2; P_1LO 14.99; P_2LB 15.3.

Body measurements as percent of HL: HW 135.04; HD 67.8; BD_1 146.3; BD_2 110.9; ED_1 13.02; ED_2 14.1; ID 8.8; PrOU $\frac{1}{3}$ 36.5; PrOL 36.5; PBU 44.1; P1LB 51.8; UJL 39.9; LJL 26.2; CD 21.9; DFL 39.01; AFL 29.01; V_1FLO 22.1; V_2FLB 18.7; CFL 44.7.

Description: Body ovate with the rostral hook well on the ventral profile. Eyes separated by a flat scaly interorbital space. Upper eye placed well in front of the lower eye, the posterior part of upper eye ends at anterior of lower eye. Mouth strongly curved; lower jaw ends below middle of lower eye. Two nostrils placed above the jaw in front of the lower eye, the anterior one tubular, the end of the tube ending above the jaw. Rostral hook pronounced ending below a vertical from the upper jaw. Maxillary teeth very small in rows. No fringes below lower jaw. Dorsal fin origin on hook of snout. Dorsal and anal fin rays simple; fins not joined to caudal. Caudal fin rays divided, scaly. Pectoral fin absent on ocular and blind side. Pelvic fin on ocular side continuous with anal. Lateral line origin from behind the upper eye, proceeding straight to caudal fin. An anterior branch arches above the eye and transverses the snout.

Anterior nostril on ocular side a wide short tube; on the blind side, the tubular nostril consists of a thick fleshy sucker like papilla. The posterior nostril is a short simple tube.

A comparative statement of the meristic characters of ***Heteromycteris hartzfeldii*** is given in Table 79.

Table 79: A comparative statement of the meristic characters of *Heteromycteris hartzfeldii*

Meristic characters	Earlier workers				Present work 2004-2010
	Gunther 1862	Kaup 1858	Warren and Seale 1906	Weber and Beaufort 1929	N = 1
Dorsal rays	94 – 101	93	*	88 – 101	92
Anal rays	63 – 65	64	63	61 – 65	64
Lateral line	100	94	98	97 – 102	85
Ventral	*	*	*	*	6

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Heteromycteris hartzfeldii*** is given in Table 80

Table 80: Results of the correlation coefficient analysis on non-meristic characters of *Heteromycteris hartzfeldii*

Characters	In SL	In HL
Head length	3.92	
Head Width	2.90	0.74
Head Depth	5.78	1.48
Bodydepth $_1$	2.68	0.68
Body depth $_2$	3.53	0.90
Eye Diameter (U)	30.08	7.68
Eye Diameter (L)	27.80	7.10
Interdorsal	44.55	11.37
Preorbital (U)	10.74	2.74
Preorbital (L)	8.88	2.27
Post orbital (U)	7.56	1.93
Post orbital (L)	9.17	2.34
Upper jaw length	9.82	2.51
Lower jaw length	14.94	3.81
Chin depth	17.90	4.57
Dorsal finlength	10.04	2.56
Anal finlength	13.50	3.45
Pelvic finlength (O)	17.77	4.53
Pelvic (B) FL	20.93	5.34
Caudal FL	8.76	2.24
Dorsal BL	0.87	0.22
Anal BL	1.21	0.31
Pelvic (O)	10.66	2.72
Pelvic (B)	9.40	2.40
Preanal	4.14	1.06
Pre pelvic (O)	6.67	1.70
Pre pelvic (B)	6.52	1.66

Colour: Body covered with ctenoid scales with wavy anastomosing white lines which surround irregular dark spots or rings. Eight large ocellii present on ocular side in two rows, one along the base of the dorsal fin and another along the base of the anal fin; each ocellii consists of two concentric dark rings. Dorsal and anal fins with blackish spots. Caudal fin with blackish spots and stripes.

Distribution:

World: British India, Malay Archipelago, Philippines (Evermann and Seale, 1907); Thailand, Ambon Island, Moluccas Islands, Indonesia (Bleeker, 1853). Map showing localities were *Heteromycteris hartzfeldii* has been recorded in the world is given in Fig. 111.

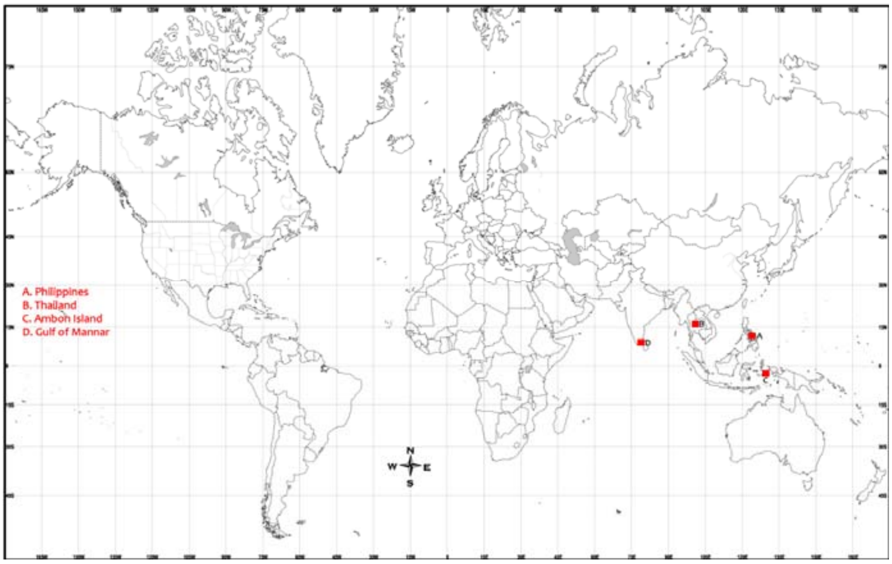


Fig. 111: Map showing localities were *Heteromycteris hartzfeldii* has been recorded in the world.

India: Gulf of Mannar; Tuticorin (present work). Map showing localities were *Heteromycteris hartzfeldii* has been recorded in India is given in Fig. 112.

Fig. 112: Map showing localities were *Heteromycteris hartzfeldii* has been recorded in India

Taxonomic remarks: The species was first described from Amboina based on two speciemens of TL 103 mm and 115 mm as *Achirus Hartzfeldii*. The present specimen matches well in description with the type description. Bleeker (1853) in a footnote also mentions that "*of the three genera Achirus, Achiroides and Plagusia, the most beautiful is Achirus*."

Observations: This species has been collected from the trawler landings at Tuticorin Fisheries Harbour (Gulf of Mannar). The species differs from *H. oculus* in the absence of scales on dorsal and anal fin rays.

Not much variation was seen with the Museum specimen, except that the size was smaller

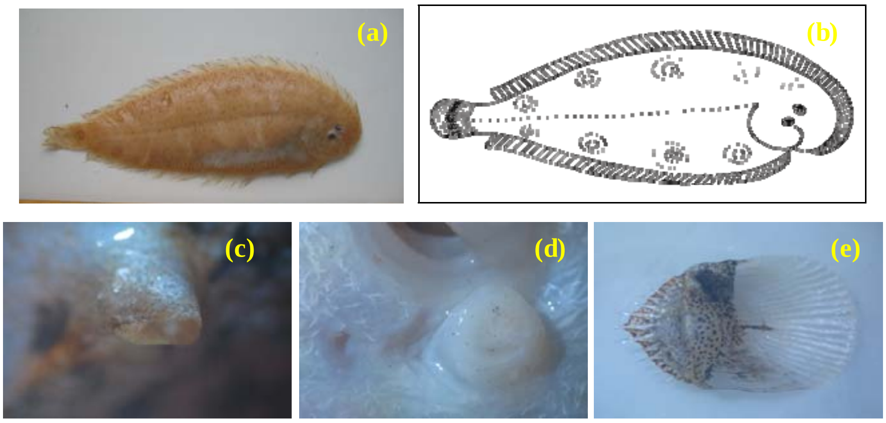
4.3.7.4.2 *Heteromycteris oculus* (Alcock, 1889)

Eyed sole

Solea oculus Alcock 1889, *J. Asiat. Soc. Bengal*, 58, pt 2 (3): 285, pl. 18, fig. 3 (type locality: 32 miles southwest Puri, Bay of Bengal); Menon and Rama Rao 1975, *Matsya*, I: 45; Johnstone, 1904, *Ceylon Pearl Oyster Fish. Supp. Rep.*, XV: 206.

Solea (Achirus) oculus Alcock, 1896, *J. Asiat. Soc. Bengal*, 65 (3):329.

Heteromycteris oculus Chabanaud, 1927, *Ann. Mag. Nat. Hist.*, (9) XX: 526; Norman, 1928, *Rec. Ind. Mus.*, 30:190, fig. 8 (Mekran, Ganjam, Orissa, Ceylon); Munroe, 1955, *Fish. Ceylon*: 262, pl. 50, fig. 759; Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull.*,:36, fig.11; Krishnan and Mishra, 1993, *Rec. Zool. Surv. India*, 93 (1and2): 235; Munroe in Randall and Lim 2000, *Raffles Bull. Zool. Suppl.*, 8: 646; Munroe, 2001, *FAO Sp. Iden. Guide*, VI: 3881; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (suppl. 1): S 122; Mishra and Krishnan, 2003, *Rec. Zool. Surv. Occ. Paper*, 216: 48.



(a), (b) Adult fish (c) Nostril (Ocular) (d) Nostril (Blind) (e) Body scale

Plate XXXVIII: *Heteromycteris oculus* (Alcock, 1889)

Material examined: N = 8 samples, TL 84.38 mm – 131.77 mm; one from Fort Kochi, 7 from Palk Bay.

Diagnosis: Body broadly elongate, tapering towards the tail, with ocular patterns in 4 pairs on the body.

Meristic characters: D 90 -100; A 61 - 67; C 3 +12+3; Ll 100 -102.

Body measurements as percent of SL (mean in parentheses): HL 21.9 – 25.5 (23.5); HW 16.2 - 34.4 (30.2); HD 12.02 - 32.2 (17.3); ED1 2.6 - 4.2 (3.4); ED2 2.6 -4.3 (3.2); RH 3.9 - 7.9 (6.1); LJL 3.5 - 7.3 (5.95); ID 1.7 - 3.2 (2.5); PrOU 6.7 – 11.5 (8.8); PrOL 8.3 – 11.4 (9.8); PBU 10.3 - 12.7 (11.9); PBL 8.5 – 11.1 (9.6); SNL_1 7.6 -9.7 (8.4); SNL_2 9.9 -11.3 (10.8); TKL 73.3 -77.9 (75.98); BD_1 23.1 - 34.2 (31.1); BD_2 34.2 - 37.5 (36.2); DFL 6.8 - 11.4 (8.6); AFL 7.4 - 9.7 (8.7); CFL 12.2 – 15.8 (14.7); P_2FLB 9.5 -10.7 (10.1); V_1FLO 5.7 - 9.1 (7.5); V_2FLB 5.3; DBL 88.9 - 101.5 (95.7); ABL 72.6 - 94.45 (81.1); CBL 6.6 – 9.4 (8.1); V_1LO 14.8 - 19.1 (17.1); V_2LO 15.3 - 17.96 (16.6); PDL 1.6 -6.6 (4.1); PAL 16.7 - 23.98 (20.6).

As percent of HL (mean in parentheses): HW 63.6 – 152.9 (129.5); HD 54.96 - 126.4 (72.8); ED_1 10.8 -18.9 (14.6); ED_2 10.5 - 18.9 (13.7); RH 15.4 - 33.4 (25.8); LJ 13.9 - 30.7 (24.8); ID 7.5 -13.99 (10.5); PrOU 29.8 - 45.1 (37.1); PrOL 32.8 - 47.96 (42.1); PBU 46.95 - 55.8 (50.95); PBL 36.2 - 48.9 (40.95); SNL_1 32.5 - 38.6; SNL_2 43.2 - 47.7 (45.98); BD_1 99.8 -151.8 (132.5); BD_2 147.02 - 161.4 (154.4); DFL 28.8 - 47.9 (36.8); V_1LO 63.9 - 77.7 (70.3); V_2LO 62.3 -70.6 (66.4); PDL 6.4 -27.86 (17.6); PAL 65.7 -109.6 (88.6).

Description: Body oval, elongate towards the tail, with a rounded caudal.Head blunt with mouth placed on the ventral profile of the body. Upper eye placed half way in front of the lower eye; two nostrils in the interorbital area, one tubular, the other an oval opening a little on top of the tubular one. The upper nostril base is bag like and is placed in front of the lower eye. The lower jaw has a white fleshy flap covering the upper nostril's tubular part. Dorsal fin origin a little in front of the lower eye; dorsal and anal fins not joined to caudal fin. Pectoral fins absent. Body covered with ctenoid scales on ocular side on the ocelli as well as on the blind side. Body scale is roundish in outline with 14 sharp pointed spines on the outer end; spines are brown in colour. On the blind side, lobulation of the nasal valve is seen. This is an important diagnostic character of the species. A comparative statement of the meristic characters of *Heteromycteris oculus* is given in Table 81.

Table 81: A comparative statement of the meristic characters of *Heteromycteris oculus*

Meristic characters	Earlier workers					Present work 2004 - 2010	
	Kaup 1889	Hilgendorf 1891	Norman 1928	Munroe 1955	Punpoka 1964	N = 7	Mean ± SD
Dorsal rays	98	98	90 -103	90 -103	90 -103	90 -100	99 ± 4.3
Anal rays	65	65	60 -67	60 -67	60 -67	61 - 67	65 ± 3.4
Lateral line scales	101	101	86 -91	86 -91	86 -102	100 - 102	101 + 1.1

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Heteromycteris oculus*** is given in Table 82.

Table 82: Results of the correlation coefficient analysis on non-meristic characters of *Heteromycteris oculus*

Characters	Ratio in SL	Mean	SD	R^2 on SL	Slope
Head Width	3.9 - 4.6	4.27	0.21	0.62	0.27
Head Depth	2.9 - 6.2	3.50	1.10	-0.09	-0.03
ED_1	3.1 - 8.3	6.28	1.58	0.65	0.03
ED_2	23.6 - 38.95	30.05	5.22	0.46	0.02
Pre orbital (L)	8.7 - 14.9	11.75	2.04	0.91	0.12
Post orbital (U)	8.8 - 11.98	10.29	1.16	0.86	0.08
Post orbital (L)	7.9 - 9.7	8.41	0.64	0.82	0.09
Body $depth_1$	1.3 - 1.4	1.32	0.03	0.78	0.26
Body $depth_2$	2.9 - 4.3	3.26	0.45	0.99	0.31
Dorsal	2.7 - 2.9	2.77	0.07	0.83	0.13
Anal	8.8 - 14.7	11.89	1.90	0.96	0.13
Caudal	10.4 -13.6	11.64	1.35	0.89	0.15
Pectoral (B)	6.3 - 8.2	6.87	0.64	1.00	0.02
Pelvic	9.4 - 10.5	9.92	0.81	0.11	0.03
Anal	0.99 - 1.1	1.05	0.04	0.84	0.73
Caudal	1.1 - 1.4	1.24	0.10	0.79	0.07
Pelvic (O)	10.7 -15.1	12.45	1.51	0.45	0.08
Prepelvic (B)	5.2 - 6.8	5.93	0.71	1.00	0.40
Predorsal	5.6 -6.5	6.05	0.68	0.51	0.06
Characters	**Ratio in SL**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head Width	0.7 - 1.6	0.83	0.30	0.43	0.96
Head Depth	0.8 - 1.8	1.46	0.33	0.13	0.22
ED_1	5.3 - 9.2	7.05	1.29	0.60	0.14
ED_2	5.3 - 9.2	7.55	1.36	0.45	0.09
Rostral hook	2.99 - 6.5	4.13	1.24	0.45	0.30
LJL	3.3 -7.2	4.38	1.63	-0.37	-0.31
Inter orbital	7.2 -13.3	9.90	2.10	0.43	0.07
Pre orbital (U)	2.2 -3.4	2.74	0.37	0.69	0.34
Pre orbital (L)	2.1 -3.1	2.42	0.37	0.83	0.59
Post orbital (U)	1.8 -2.1	1.97	0.14	0.85	0.42
Post orbital (L)	2.04 - 2.8	2.46	0.23	0.84	0.49
SNL_1	2.6 - 3.1	2.80	0.18	0.93	0.39
SNL_2	2.1 - 2.3	2.18	0.07	0.97	0.47
TKL	0.3 - 0.3	0.31	0.02	0.95	4.16
Body $depth_1$	0.7 - 1	0.77	0.11	0.73	1.25
Body $depth_2$	0.6 - 0.7	0.65	0.02	0.97	1.58
Dorsal	2.1 - 3.5	2.79	0.47	0.83	0.65
Pectoral (B)	2.2 - 2.3	2.21	0.13	1.00	0.10
Pelvic	2.8 - 4.2	3.37	0.73	0.60	0.61
Prepelvic (O)	1.3 - 1.6	1.43	0.14	0.64	0.82
Prepelvic (B)	1.4 - 1.6	1.51	0.13	1.00	1.23
Preanal	0.9 - 1.5	1.16	0.20	0.76	1.27

Distribution:

World: Ceylon (Norman, 1928), Gulf of Thailand (Punpoka, 1964).

Map showing localities were ***Heteromycteris oculus*** has been recorded in the world is given in Fig. 113.

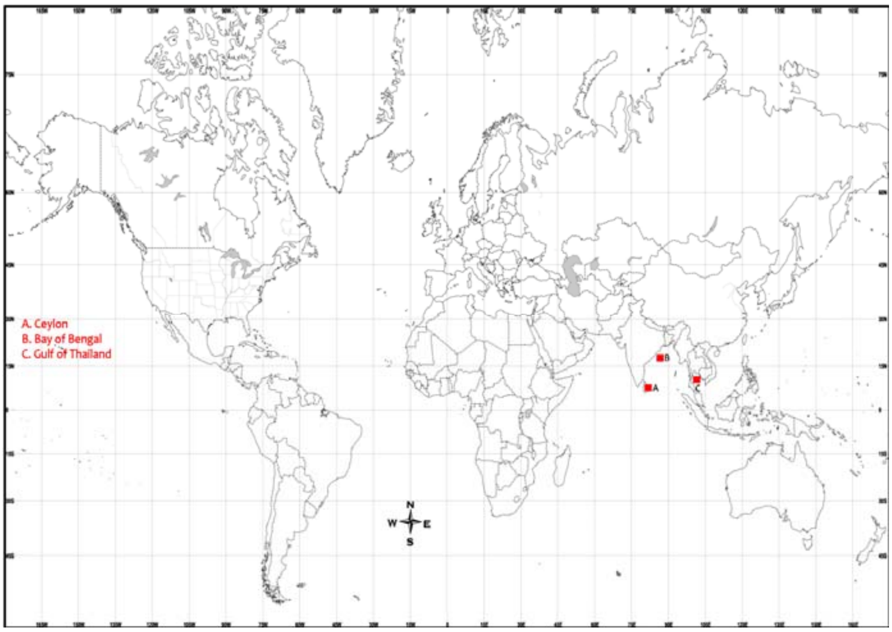


Fig. 113: Map showing localities were *Heteromycteris oculus* has been recorded in the world.

India: Puri, Bay of Bengal (Alcock 1889); Mekran, Ganjam, Orissa (Norman, 1928).

Map showing localities were ***Heteromycteris oculus*** has been recorded in India is given in Fig. 114.

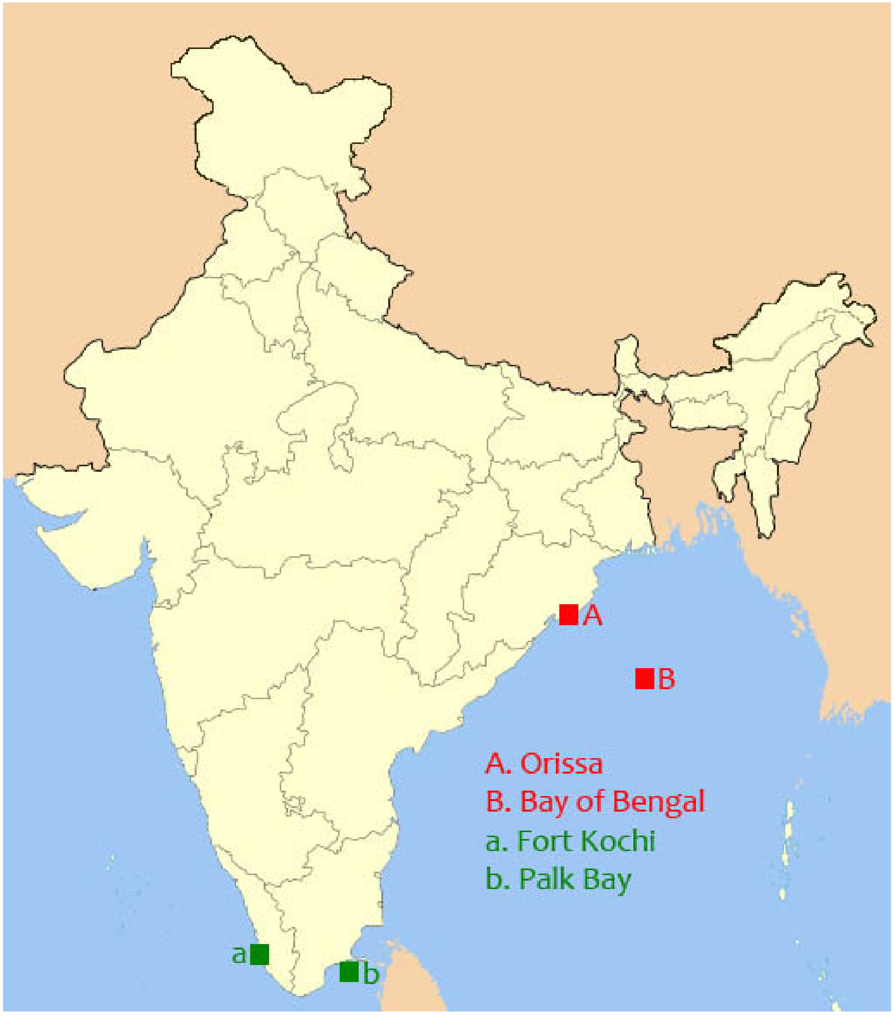


Fig. 114: Map showing localities were *Heteromycteris oculus* has been recorded in India

Heteromycteris oculus

Fig. 73: Map showing localities were ***Heteromycteris oculus*** has been recorded in India

Taxonomic remarks: *Heteromycteris oculus* was first described by Alcock (1889) as *Solea oculus* based on a sample from 32 miles southwest Puri, Bay of Bengal. It was Chabanaud (1927) who placed the species in genus *Heteromycteris* as *H. oculus.* Alcock (1889) presented a detailed description of the colour of live specimens of this species. "*Ground colour light brown, intersected by a most elegated network of irregular light olive – green lines forming a somewhat pentagonal pattern. Along the dorsal curve are five large, perfect and complicated ocellii with light green centre, brown irides and light green margins. Four similar ocellii along the ventral curve, and another mall one at the base of the caudal. A few small incomplete ocellii along the lateral line and numerous dark brown dots and rings scattered all over the body. Fins transparent grey green, every fourth or fifth ray uniform dark brown, and the intermediate rays streaked with brown*."

Remarks: *Heteromycteris oculus* is very close to *H. hartzfeldii* (Bleeker) in pattern, but differs from it in the absence of scales on the ocular side of the rays of the dorsal and anal fins and in the colouration pattern. Punpoka (1964) opines that "*from examination of H. japonica (Jordan and Snyder), it appears that H. oculus is also close to this species, but H. japonica has fewer scales in the lateral line than does H. oculus*."

4.3.7.5 *Genus Liachirus* Gunther, 1862

Liachirus Günther, 1862, *Cat. Brit. Mus.*, 4: 479 (Type: ***Liachirus nitidus*** Günther 1862); Weber and de Beaufort, 1929, *Fish. Indo – Aust. Arch.*, 5: 158; Ochiai in Masuda *et al.*, 1984, *Fish. Jap. Arch.*,: 354; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad.*,:186 ; Li and Wang, 1995, *Fauna Sinica*: 297.

Body ovoid, elongate, dextral eyes with a blunt snout. Mouth nearly terminal, narrow, more developed on blind side. Snout not so pronounced. Eyes placed close, separated by a narrow scaly interorbital;

upper eye nearly above lower eye. Dorsal origin above at an acute angle from the eye. Anal fin in front of a vertical from outer free end of operculum. Dorsal and anal fin rays scaleless, not joined with caudal. Pores absent at base of the dorsal and anal fin rays. Lateral line straight. Accessory lateral line absent. Gill openings narrow, membranes broadly united. Body covered with cycloid scales. Species of *Liachirus* resembles *Aseraggodes*, but differs in short snout and position of eye.

The genus is represented by one species *Liachirus melanospilos*, which is reported from Japan, China and the Indo – Australian Archipelago. In the present work, the species was collected from Kerala (Kalamukku). This is the first report of the same from the Indian mainland; the other being from Minicoy.

4.3.7.5.1 ***Liachirus melanospilus*** (Bleeker)

Carpet sole

Achirus melanospilos Bleeker, 1854, *Nat. Tijds. Ned. Indië*, 7:257 (Manado, Sulawesi (Celebes), Indonesia); Wu, 1932, *Thèse Facul. Sci. Univ. Paris*, A. 244 (268):133; Herre, 1953, *Checklist Philippine Fish*.,: 188; Chen, 1956, *Synop. Vert. Taiwan*: 104 (Giran, Kaohsiung).

Liachirus melanospilos Weber and de Beaufort, 1929, *Fish. Indo – Aust. Arch*., 5: 158, fig. 42, 43; Jones and Kumaran, 1966, *J. Mar. Biol. Ass. India*, 8: 174, fig. 14; Jones, 1969, *Bull. Cent. Mar. Res. Inst*., 8: 29; Jones and Kumaran, 1980, *Fish. Lacc. Arch*.,: 652, fig. 555 (Ameni, Minicoy); Ochiai in Masuda *et al*., 1984, *Fish. Japan. Arch*.,:354; Li and Wang, 1995, *Fauna Sinica*: 297; Mohsin and Ambak, 1996, *Marine fish. Malaysia*: 597; Chen and Weng, 1965, *Biol. Bull*., 27:45; Munroe in Randall and Lim, 2000, *Raffles Bull.*

Zool. Suppl., 8: 646; Nakabo, 2000, *Fish. Japan*, 2^0:1384; Hutchins, 2001, *Rec. W. Aust. Mus. Supp.,* 63: 47; Munroe 2001, *FAO Sp. Iden. Guide* IV (6):3881.

Aseraggodes melanospilos Matsubara, 1955, *Fish. Morph. Hierar.,* II: 1281(Japan, China, Formosa, Philippines); Chen, 1969, *Syn. Vertebrate Taiwan*: 220, fig. 199; Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sinica*, 20 (2): 32, fig. 2 (Kao–hsiung); Allen and Swainston, 1988, *Marine Fish. Aust.,*:146.

Liachirus nitidus Günther, 1862, *Cat. Brit. Mus.*, IV: 479 (China); Jordan and Evermann, 1902, *Proc. U.S Nat. Mus.*, XXV: 366 (Giran); Fowler and Bean, 1922, *Proc. U.S Nat. Mus.*, LXII: 67 (Takao); Oshima, 1927, *Jap. J. Zool.*, I (5): 196 (Giran); Chu, 1931, *Index Pisc. Sinen*: 93 (China, Hong Kong); Okada and Matsubara, 1938, *Keys. Fish. Japan*: 434 (Formosa, China).

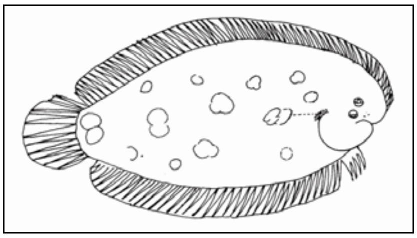


Plate XXXIX: *Liachirus melanospilus* (Bleeker)

Material examined: N = 31, TL 74.64 – 98.47 mm from Kalamukku Fishing Harbour, Kochi.

Diagnosis: Oval body with a tubular nostril.

Meristic characters: D 55 – 75 (65); A 40 – 51 (45); V_1 5; C 13 -20 (17); Ll 68 - 72 (70).

Body measurements as percent of SL (mean in parentheses): HL 25.7 – 35.1 (30.02); HW 35.7 – 42.03 (38.5); HD 18.7 – 23.99 (21.3); UJL 4.6 – 5.2 (4.9); LJL 8.7 – 13.7 (10.9); CD 4.6 – 5.2 (4.9); DFL 8.7 – 13.7 (10.9); AFL 8.9 -15.3 (11.4); V_1FLO 6 – 10.7 (7.8); CFL 16.1 – 22.4 (19.5); DBL 94.1 – 100.4 (96.7); ABL 61.4 – 76.04 (68.4); V_1BLO 1.6 – 8.7 (3.4); CBL 9.9 – 20.3 (11.6); ED_1 3.1 – 4.6(3.8); ED_2 2.7 – 4.3 (3.5); ID 1.4 – 3.6 (2.5); PrOL 5.4 – 71.1 (9.6); PBU 15.1 – 23.4 (19.3); PBLL 14.7 – 19.6 (17.5); PDL 2.1 – 11.3 (5); PAL 26.4 – 35.3 (30.3); V_1LO 20.6 – 24.6 (22.6); BD_1 37.9 – 44.7 (40.6); UHL 13.3 – 18.1 (15.5); LHL 18.9 – 29.2 (23.6); Eye – upper jaw 0.6 – 8.4 (2.1).

Body measurements as percent of HL (mean in parentheses): HW 116.3 – 150.2 (128.5); HD 62.4 – 84.97 (70.9); UJL 28.1 - 60 (35.1); LJL 24.9 – 36.97 (28.4); CD 15.3 -17.04 (16.2); ED_1 9.3 – 15.3 (12.7); ED_2 9.4 – 14.1 (11.7); ID 4.6 – 12.1 (8.1); PrOU 20.9 – 31.4 (28.1); PrOL 20.9 – 31.4 (28.1); PBU 40.03 – 55.6 (50.3); PBLL 49.5 - 67 (57.9); PDL 6.4 – 37.7 (16.7); PAL 78.7 – 121.3 (101.3); V_1LO 63.9 - 86.3 (75.3); BD_1 123.5 – 148.7 (131.8); UHL 43.3 – 62.2 (51.7); LHL 61.4 – 98.3 (78.4).

Description: Body oval, elongated, head broad, tapering to a thin tail. Upper profile of head projects in front of body profile. Eyes dextral, separated by a narrow slightly concave interorbital space. Mouth cleft semicircular in pattern, placed well down on front portion; cleft ending below front border of eye. Nostrils two, one placed above mouth, covered by a fleshy flap of skin, the flap not reaching front border of lower eye. Dorsal fin origin on snout in front of upper eye. Pectoral absent. Pelvic origin at middle of lower border of operculum. Pelvic on ocular side slightly in front of pelvic on blind side. Dorsal and anal fin end at caudal peduncle; caudal not contiguous with dorsal and anal. Interfin membrane of dorsal and anal fin black in colour. One lateral line passing from behind upper eye to caudal fin base. Scale is tubular with the opening of one tube into another. Body covered with small scales. Short barbels seen on lower profile of blind side.

A comparative statement of the meristic characters of ***Liachirus melanospilus*** is given in Table 83.

Table 83: A comparative statement of the meristic characters of *Liachirus melanospilus*

Meristic characters	Earlier workers		Present study 2004 – 2010	
	Talwar & Kacker 1980	Shen & Lee 1981	N = 31	Mean ± SD
Dorsal rays	62 - 65	63 - 66	55 – 75	65 ± 5.85
Anal rays	43 - 45	47 - 49	40 – 51	45 ± 3.7
Pelvic (O/B)	5	5-6/5 - 6	5	
Caudal	*	18	13 -20	16.7 ± 1.4
Lateral line scales	68 - 73	65 - 77	68 - 72	70 ± 3.1

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Liachirus melanospilus*** is given in Table 84

Colour: Body pale yellow with several small dark spots on ocular side. Blind side whitish. Pelvic fin on ocular side blackish.

Table 84: Results of the correlation coefficient analysis on non-meristic characters of *Liachirus melanospilus*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	2.9 - 3.9	3.34	0.19	0.62	0.28
Head Width	2.4 - 2.8	2.60	0.12	0.69	0.30
Head Depth	4.2 - 5.4	4.73	0.34	0.57	0.21
Upper jaw	5.8 - 11.95	9.75	1.31	0.08	0.07
Lower jaw	8.95 - 13.5	11.87	1.19	0.29	0.07
Dorsal fin length	7.3 - 11.6	9.28	1.03	0.29	0.09
Anal fin length	6.5 - 11.2	8.90	1.12	0.27	0.11
Pelvic fin length	9.3 - 16.6	13.19	1.94	0.11	0.06
Caudal fin length	4.5 - 6.2	5.16	0.46	0.19	0.09
Dorsal base length	1 - 1.1	1.03	0.02	0.96	0.91
Anal base length	1.3 - 1.6	1.47	0.08	0.66	0.64
Pelvic base length	11.5 - 61.9	33.75	11.84	0.00	-0.01
Caudal base length	4.9 - 10.1	8.74	0.99	0.16	0.09
Eye Diameter (U)	21.9 - 32.1	26.61	2.90	0.41	0.04
Eye Diameter (L)	23.1 - 36.5	28.92	3.16	0.23	0.03
Pre orbital (L)	10.03 -13.6	11.95	0.85	0.61	0.09
Post orbital (U)	4.3 - 6.6	5.21	0.42	0.62	0.22
Post orbital (L)	5.1 - 6.8	5.75	0.44	0.64	0.20
Pre anal	2.8 - 3.8	3.32	0.27	0.22	0.14
Pre pelvic (O)	4.1 - 4.9	4.44	0.19	0.76	0.20
Upper head length	5.5 - 7.5	6.50	0.57	0.22	0.07
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head Width	0.7 - 0.86	0.78	1.03	0.54	0.75
Head Depth	1.2 - 1.6	1.42	1.39	0.53	0.58
Upper jaw	1.7 - 3.6	2.92	1.52	0.07	0.18
Lower jaw	2.7 - 4.02	3.55	2.16	0.38	0.23
Chindepth	5.87 - 6.5	6.20	4.27	1.00	-0.62
Dorsal fin length	2.2 - 3.4	2.78	0.48	0.44	0.32
Anal fin length	2.1 - 3.9	2.67	1.16	0.33	0.35
Pelvic fin length	2.9 - 5.1	3.95	1.91	0.24	0.25
Caudal fin length	1.4 - 1.8	1.55	0.93	0.29	0.30
Dorsal base length	0.27 - 0.4	0.31	0.23	0.66	2.13
Anal base length	0.4 - 0.6	0.44	1.22	0.48	1.53
Eye Diameter (L)	7.1 - 10.6	8.66	2.12	0.32	0.09
Pre orbital (L)	3.2 - 4.8	3.59	12.19	0.43	0.22
Post orbital (u)	1.4 - 1.9	1.56	0.53	0.77	0.70
Post orbital (L)	1.5 - 2.02	1.74	1.23	0.62	0.56
Pre anal	0.8 - 1.3	1.00	0.95	0.12	0.30
Pre pelvic (O)	1.2 - 1.6	1.33	1.42	0.60	0.50
Upper head length	1.6 - 2.3	1.95	2.15	0.28	0.24
Lower head length	1.02 - 1.6	1.29	0.67	0.19	0.41

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph; the linear regression equations obtained were

Head length on SL	:	$y = 0.27\ x + 1.7;\ R^2 = 0.62$
Head width on SL	:	$y = 0.29\ x + 6.2;\ R^2 = 0.69$
Head depth on SL	:	$y = 0.11\ x + 0.21;\ R^2 = 0.57$
Body depth (BD_1) on SL	:	$y = 0.3\ x + 7.2;\ R^2 = 0.5$
Lower jaw length on HL	:	$y = 0.23x + 1.05;\ R^2 = 0.38$
Eye diameter (upper) on HL	:	$y = 0.1\ x + 0.36;\ R^2 = 0.35$
Preorbital distance on HL	:	$y = 0.17\ x + 3.3;\ R^2 = 0.81$

Regression of all the above characters on SL was found to be highly significant.

Distribution:

World:

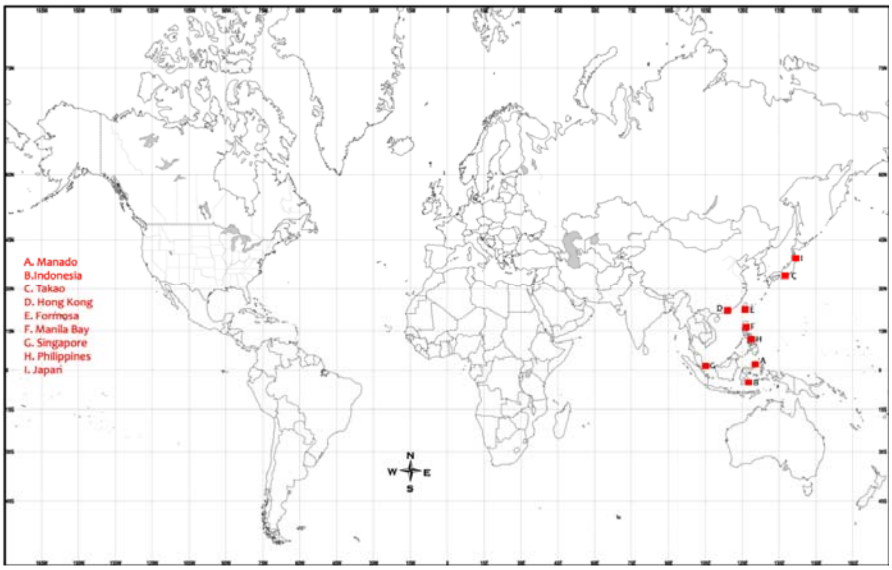


Fig. 115: Map showing localities were ***Liachirus melanospilus*** has been recorded in the world.

Manado, Sulawesi (Celebes), Indonesia (Bleeker, 1854); China (Günther, 1862); Takao (Fowler and Bean, 1922); Hong Kong (Chu, 1931); Formosa (Okada and Matsubara, 1938); Manila Bay (Herre 1953), Singapore, Philippines, China and Japan (Nakabo, 2000). Map showing localities were ***Liachirus melanospilus*** has been recorded in the world is given in Fig. 115.

India: Ameni (Minicoy) (Jones and Kumaran, 1980); Kochi (present work). Map showing localities were ***Liachirus melanospilus*** has been recorded in India is given in Fig. 116.

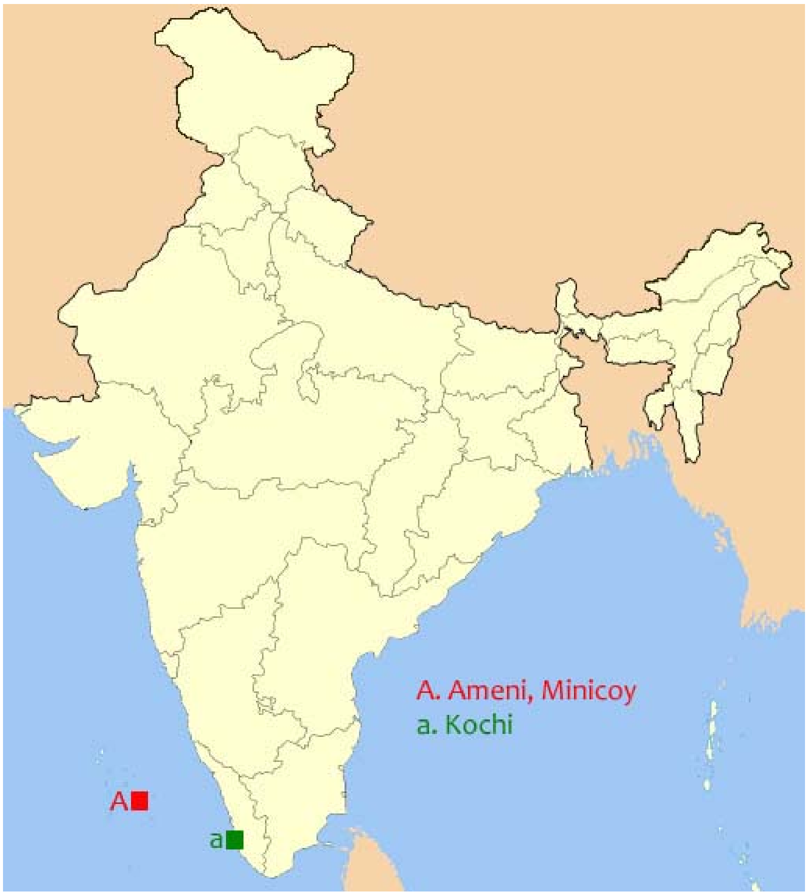


Fig. 116: Map showing localities were ***Liachirus melanospilus*** has been recorded in India

Taxonomic comments: The fish was originally described by Bleeker (1854) as *Achirus melanospilos* based on a sample from Manado, Sulawesi. Günther (1862) described a new fish *Liachirus nitidus* from China. Weber and Beaufort (1929) placed the fish in another genus Liachirus and also examined Bleeker's collection of *A. melanospilus* and the type of *Liachirus nitidus* in the British Museum and found that they were same and hence synonymised *L. nitidus* with *Liachirus melanospilus*. Allen and Swainston (1988) placed the fish in another genus and described it as *Aseraggodes melanospilus*. Mohsin and Ambak (1996) referred the species as *melanospilus.* However, in a note they added "*Liachirus nitidus* as described by Jordan and Starks (*Proc. U.S Nat. Mus*., XXXI. 1906, p.231) from Japan seems to be another species with smaller scales (Ll. 92).

Remarks: The dorsal fin counts of the present specimen are more close to the values by Weber and Beaufort (1929). The species can be easily mistaken for *Solea ovata;* the difference noted is in length of tubular nostril.

4.3.7.6 Genus *Pardachirus* Gunther, 1862

Pardachirus Gunther 1862, *Cat. Brit. Mus*., IV: 478 (Type species: ***Achirus marmoratus*** **Lacepede, 1802** (by subsequent designation of Jordan, 1919: 319); Clark and George, 1979, *Environ. Biol. Fishes* 4(2):104; Ochiai, 1963, *Mem. College Agric. Kyoto Univ*., 76: 29; Ochiai in Masuda *et al*. 1984, *Fish. Jap. Archip.,* : 354; Heemstra and Gon 1986, *Smith. Sea Fishes*: 872; Chapleau and Keast 1988, *Canadian J. Zoo*., 66: 2799; Randall and Lee, 1994, *Fauna Saudi Arabia*, 14: 341; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166 :186; Li and Wang 1995, *Fauna Sinica* : 291; Munroe, 2001, FAO *Sp. Ident. Guide*, IV (6): 3879; Hoese and Bray, 2006, *Zool. Cat. Australia*: 1847; Randall and Johnson, 2007, *Indo – Pacific Fish.*, 39: 3.

Normanetta Whiteley, 1931: 322 (type species: *Achirus protopterus* Bleeker).

Body oblong, scales feebly ctenoid; scales along dorsal and anal fins cycloid. Lateral line present on both sides commencing from the snout till caudal fin base. Eyes small, oval in outline, interorbital space present. Two nostrils present on ocular and blind side; on ocular side, first is tubular placed above mouth, the second a round opening placed before eye. Nostrils on blind side, both tubular placed above mouth region one in front of the other. Blind side of head covered with fringe like filaments on the lower profile. The skin on the blind side with circular papilla like structures. Mouth strongly curved downwards, well developed on ocular side than blind side. Teeth present on the lower jaw, small, feeble. Dorsal fin arises on snout, ends at caudal peduncle, not attached to caudal; finrays divided. Anal fin arising on a vertical below the outer end of operculum; finrays split; finrays of dorsal and anal connected by membrane, coloured with a pore at the base. Pectoral fin absent; pelvic fin very small, assymetrical. Anus placed on right side.

Taxonomic comments: The Indo–Pacific soleid genus *Pardachirus* Gunther has been subjected to much revisionary work. It was first reviewed by Clark and George (1979) who recognized four species in the genus – *Pardachirus marmoratus, P. pavoninus, P. protopterus* and *P. hedleyi*. They synonymised *Achirus barbatus* Lacepede with *P. marmoratus* and agreed with Weber and de Beaufort (1929) and Chabanaud in synonymising *Achirus thepassii* Bleeker with *P. protopterus*. They also synonymised *Achirus rautheri* Chabanaud with *P. hedleyi.* Later workers Larson and Williams (1997) and Desouter *et al*. (2001) synonymised *Achirus rautheri* with *P. protopterus*. These synonyms were however discarded by Randall and Johnson (2007), who commented that *Achirus rautheri* is a valid species with distribution in Queensland, Western Australia and New Guinea. At present seven species are recognized in the genus.

Species of genus *Pardachirus* are characterized by the presence of a distinct pore on the base of nearly all dorsal, anal and pelvic rays; a milky substance is extruded out of these pores when the animal is subjected to stress. Work of Ochiai (1957) and Clark and Chao (1973) show that a powerful crinotoxin is secreted out through these pores which is lethal to small teleosts and even repelling to sharks. Clark and George (1979) described the paired ampullae like poison glands present at the base of the finrays. The tubular anterior nostril seen on the ocular side of *Pardachirus marmoratus* and *Pardachirus pavoninus* have been attributed a respiratory function, analogous to the spiracle of rays. They opined that water can be drawn in as well as expelled out through these nostrils even when the animal lies buried with the mouth closed. However, Randall and Johnson (2007) opined that the anterior nostril does not lead to the buccal cavity, but to the labial groove.

The species has been reported from northern Europe and Iceland, throughout the eastern Atlantic and Indian Ocean to the West Central Pacific region.

Worldover, 7 species of *Pardachirus* has been reported, of which 2 species have been collected from India – *Pardachirus pavoninus* and

Pardachirus marmoratus. Both these specimens have been collected in the present work, the former from Pamban (Gulf of Mannar) and the other from Andamans.

4.3.7.6.1 *Pardachirus marmoratus* (Lacépède, 1802)
Red Sea Moses sole

Achirus barbatus Lacepede, 1802, *Hist. Nat. Poiss.*, IV: 660.

Achirus marmoratus Lacepede, 1802, *Hist. Nat. Poiss.*,4: 658, 660, Pl. 12 (fig.3) (Mauritius, Mascarenes, Southwestern Indian Ocean).

Pleuronectes ornatus Griffith and Smith, 1834, *Class Pisces*: 517, pl. 59.

Achirus punctatus Desjardins, *Rep. Ann. Soc. Hist. Nat. Maurice*, 8: 40.

Plagusia marmorata Day, 1877, *Fish. India*: 431, pl. xcv, fig. 1 (Madras); Bleeker, 1851, *Nat. Tjds. Ned. Ind.*, I: 311; Gunther, *Cat. Fish.*, IV: 491.

Pardachirus marmoratus Gunther, 1862, *Cat. Brit. Mus.*, 4: 478 (Red Sea); Gunter, 1866, *Fish. Zanzibar*: 112 (Aden); Klunzinger, 1871, *Verh. Zool. Bot. Ges. Wien*, 21: 572; (Koseir, Red Sea); Kossmann, 1877, *Verh. Nat. Med. Ver. Heidelberg n. f* 1: 411(Red Sea); Kossmann and Raeuber, 1877, *Zool. Ergebn Reis. R. Meer,* 1: 28 (idem); *Kossmann, 1879, Zool. Anzeiger,* 2: 21 (idem); Boulenger, 1887, *Proc. Zool. Soc. London* :665 (Muscat); Steindachner, 1907, *Denks. Ak. Wiss. Wien*, 71 (1):166 (East Arabia); Norman, 1928, *Rec. Ind. Mus.*, 30 (2): 186 (Persian Gulf, Muscat); Tortonese, 1935-36, *Boll. Mus. Zool. Anat. Comp.Un. Torino*, 45 (Ser. 3) 63: 20 (Red Sea); Sauvage, 1891, *H. Nat. Poiss Madagascar*: 472; Barnard, 1925, *Ann. S. Africa Mus.*, XXI: 405; Fowler, 1956, *Fish. Red Sea and*

S. Arabia, I: 179; Clark and George, 1979, *Env. Biol. Fish.*, 4(2):110; Dor, 1984, *Checklist Fish. Red Sea,* CLOFRES: 270; Kyushin *et al.*, 1982, *Fish. South China Sea*: 267; Ochiai in Masuda et al. 1984, *Fish. Jap. Arch.*,: 354; Heemstra and Gon, 1986, *Smith. Sea Fish.*,: 872; Allen and Swainston, 1988, *Mar. Fish. N. W Australia*: 146; Randall *et al.*, 1990, *Fish. Great Barrier Reef Coral Sea*: 450; Quero and Desoutter, 1990, *Cybium*, 14(2): 110; Kuiter, 1993, *Coastal Fish. N. E Australia*: 390; Goren and Dor, 1994, CLOFRES II: 72; Randall, 1995, *Coastal Fish Oman*: 361; Li and Wang, 1995, *Fauna Sinica*: 291; Mohsin and Ambak, 1996, *Mar. Fish. Malaysia*: 597; Allen, 1997, *Mar. Fish. Australia*: 234; Kuiter, 1997, *Guide Sea fish. Australia*: 384; Randall *et al.*, 1997, *Fish. Great Barrier Reef Coral Sea*: 450; Quero, 1997, *Cybium* 21(3): 323; Carpenter *et al.*, 1997, *FAO Sp. Iden. Guide*: 233 (Saudi Arabia); Anderson *et al.,* 1998, *Ichth. Bull.*, 67: 29; Myers, 1999, *Micronesian Reef Fish.,*: 450; Fricke, 1999, *Fish. Mascarene Islands*: 573; Laboute and Grandpurrin, 2000, *Nou. Cal.,*: 450; Munroe in Randall and Lim, 2000, *Raffles Bull. Zoo Suppl.*, 8: 646; Nakabo, 2000, *Fish. Japan*: 1384; Sakai *et al.*, 2001*, Bull. Nat. Sci. Mus. (Tokyo) Ser. A,* 27 (2): 123; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl.*, 63: 47; Desoutter *et al.*, 2001, *Cybium,* 25(4): 341; Munroe, 2001, *FAO Sp. Iden. Guide,* IV (6): 3886; Nakabo, 2002, *Fish Japan*, 2: 1384; Allen and Adrim, 2003, *Zool. Stud.,* 42 (1): 64; Matsuura *et al.*, in Kimura and Matsuura 2003, *Fish. Bitung*: 216; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43(1): S122 (Arabian Sea); Randall *et al.*, 2004, *Atoll. Res. Bull.*, 502: 31; Tan and Lim, 2004, *Raffles Bull. Zool. Suppl.,*11:

111; Heemstra *et al.*, 2004, *J. Nat. Hist.*,38 : 3331; Heemstra and Heemstra, 2004, *Coastal Fish. S. Africa*: 437; Randall 2005, *Reef Fish. S. Pacific*: 617; Hoese and Bray, 2006 *Zool. Cat. Aust.,*: 1847; Randall and Johnson 2007, *Indo –Pacific Fish.*, 39 : 11.

Material examined: 1 sample, TL 105.76 mm from Andaman islands.

Diagnosis: Scales on ocular side of head without marginal spinules. Presence of an open pore at the base of each dorsal and anal ray both on dextral and sinistral side

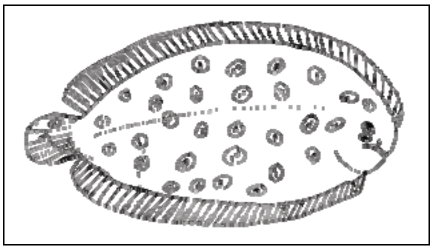



Plate XXXX: *Pardachirus marmoratus* (Lacépède, 1802)

Meristic characters: D 68, A 53; Lateral line pores 95; V 5

Body measurements as percent of SL: HL 19.54; HW 37.84; HD 18.6; BD_1 43.84; BD_2 35.61; ED_1 2.19; ED2 2.69;UJ 6.6; ID 3.32; PrOU 8.71; PrOL 12.31; PBU 12.31; PBL 9.6; DFL 10.84; AFL 7.4; V_1FL 87.7; V2FL 7.2; CFL 12.91; DFL 94.3;AFL 87.7; V_1FL 12.91; V_2FL 7.2; CFL 12.91; DBL 94.3; ABL 87.7; V_1BLO 5.7; V_2BLB 4.3; CBL 11.17; PDL 6.44; PAL 18.51; V_1LO 11.9; V_2LB 13.95.

As percent of HL: HW 193.7; HD 95.2; BD_1 43.84; BD_2 182.3; ED_1 11.2; ED_2 13.8; UJL 33.5; ID 17; PrOU 44.6; PrOL 34.3; PBU 63; PBL

49.1; DFL 55.5; AFL 37.8; V_1FLO 66.1; V_2FLB 36.7; CFL 66.1; PDL 33; PAL 94.8, V_1LO 60.7; V_2LB 71.4.

Description: Body flat, oval, elongate, dextral. Eyes placed close together separated by a flat interorbital space with colour patterns. Two nostrils placed in front of the eye on the upper head region in the preorbital area. Mouth placed in front of lower eye, straight lined. Lateral line origin at the upper outer free end of the operculum, proceeding in a straight line till the caudal. Anterior portion of lateral line in front of operculum divided into two branches, first one curving dorso-anteriorly, the second ventrally along the preopercular edge. Dorsal and anal fins separated from caudal. Dorsal fin origin in front of the upper eye, increasing in length till the middle of the body, then decreasing downward. Anal fin separated from pelvic fins. All rays of dorsal and anal fin branched. Pelvic fins separate, the ocular larger and placed a little in front of the blind one; finrays branched. Caudal peduncle absent. Blind side on the head with numerous fine small hair like structures. Scales present on body; each with a roughened patch posteriorly, marginal spinules absent; scales extending out on rays of the dorsal and anal fin from the scaly sheath. A comparative statement of the meristic characters of *Pardachirus marmoratus* is given in Table 85.

Table 85: A comparative statement of the meristic characters of *Pardachirus marmoratus*

Meristic characters	Earlier workers												Present Study 2004 - 2010
	Gunther, 1862	Cantor	Klunzinger 1870	Norman 1928	Weber & Beaufort 1929	Fowler 1956	Smith 1961	Punpoka 1964	Cheng & Weng 1965	Fowler 1967	Kuronuma & Abe 1986	Randall 1995	N = 1
Dorsal	67	67	66	64 - 71	63 - 68	70	67	63 - 70	70	63	65 – 67	63 – 72	68
Anal	50 -52	50	52 – 53	50 - 56	49 - 52	53	53	49 - 56	54	53	50 – 54	48 – 55	53
LL scales	90	*	100 - 110	78 -85	85 -90	93	100	85 - 100	86	83	90 - 107	83 – 102	95
Ventral	*	5	*	*	5	*	*	*	5	*	*	5	5
Caudal	*	3 + 12 +3	*	*	*	*	*	*	*	*	*	*	*

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Pardachirus marmoratus*** is given in Table 86

Table 86: Results of the correlation coefficient analysis on non-meristic characters of *Pardachirus marmoratus*

Characters	Ratio in SL	Ratio in HL
Head length	4.6 - 5.2	4.90
Head Width	2.64	0.52
Head Depth	5.38	1.05
Body depth $_1$	2.28	0.45
Body depth $_2$	2.81	0.55
Eye Diameter (U)	45.66	8.92
Eye Diameter (L)	37.15	7.26
Upper jaw	15.27	2.98
Inter orbital	30.09	5.88
Pre orbital (U)	11.49	2.24
Pre orbital (L)	14.92	2.92
Post orbital (U)	8.12	1.59
Post orbital (L)	10.42	2.04
Dorsal fin length	9.22	1.80
Anal fin length	13.56	2.65
Pelvic fin (O) length	7.74	1.51
Pelvic fin (B) length	13.95	2.72
Caudal fin length	7.74	1.51
Dorsal finbase	1.06	0.21
Anal finbase	1.14	0.22
Pelvic finbase (O)	17.72	3.46
Pelvic finbase (B)	23.47	4.59
Caudal finbase	1.1 - 1.2	1.16
Predorsal	5.5 - 8.5	6.59
Preanal	5.98 - 6.86	6.48
Prepelvic (O)	3.3 - 4.8	4.01
Prepelvic (B)	3.9 - 5.1	4.40

Colour: Body greyish black with numerous irregular patches bordered with black all over the body on the ocular side; 3 prominent spots with orange markings on the lateral line. Blind side bright white in colour. Patterns on the body extend onto fins on ocular side also. Fins on blind side also white.

Distribution: Reported from Mauritius, Mascarenes, Southwestern Indian Ocean (Lacepede, 1802); Red Sea (Ruppell, 1828; Tortonese, 1935 -36), eastern coast of Africa, Madagascar (1862); Aden, Zanzibar (Playfair and Gunther, 1867); Muscat (Boulenger, 1887; Norman, 1928); Persian Gulf (Norman, 1928; Blegvad, 1944; Randall 1995); Bazarutu Island, Mozambique (Smith, 1953); Reunion (Quero, 1997); Saudi Arabia (Carpenter *et al*., 1997); Arabian Sea (Manilo and Bogorodsky, 2003); Rodrigues (Heemstra *et al*., 2004).

Map showing localities were *Pardachirus marmoratus* has been recorded in the world is given in Fig. 117.

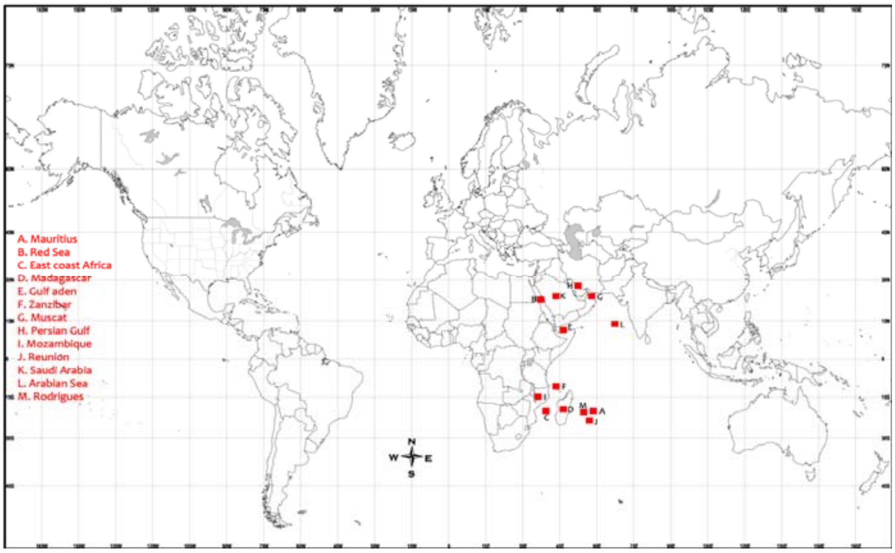


Fig. 117: Map showing localities were *Pardachirus marmoratus* has been recorded in the world.

Map showing localities were *Pardachirus marmoratus* has been recorded in India is given in Fig. 118.

Fig. 118: Map showing localities were *Pardachirus marmoratus* has been recorded in India

Taxonomic comments: Lacepede described *Achirus barbatus* (*L'Achire barbu*) with "*upper jaw superior, more advanced than the lower, with hair, body with numerous white circular patches*". However the pattern on the body showed slight variations in the present sample with greyish spots bordered with black. *Plagusia marmoratus* described by Day from Madras has higher dorsal fin counts (99-106) and anal fin counts

(75 -86) than reports by later workers (Fowler, 1956; Norman, 1927 and Randall, 2007). Hence, it can be concluded that *Plagusia marmoratus* of Day is not a synonym of *Pardachirus marmoratus*. Desjardins (1837: 40) described a sole *Achirus punctatus* based on a specimen 94.7 mm long from Mauritius; Fricke (1999: 573) later synonymised it with *Pardachirus marmoratus*. Since no holotype is known for *Pardachirus marmoratus*, Randall and Johnson (2007) designated a specimen of TL 207 mm collected off the east coast at Palomar as the neotype.

4.3.7.6.2 *Pardachirus pavoninus (Lacépède, 1802)*

Peacock sole

Achirus pavoninus Lacépède, 1802, *Hist. Nat. Poiss*, IV: 658, 661 (type locality: Dutch collection ceded to France); Cantor, 1850, *J. Asiat. Soc. Bengal*, XVIII, pt. 2: 1207 (Pinang); Bleeker, 1866-72, *Atl. Ichth.*, VI: 24, pleuron, pl. 241, fig. 1; Day, 1878 – 1888, *Fish. India*: 427, pl.XCIII, fig. 2 (Andamans Archipelago); Chu, 1931, *Index Pisc. Sinens*: 92 (China); Wu, 1932, *Thèse Facul. Sci. Univ. Paris*, A.244 (268): 135; Suvatti, 1936, *Index Fish. Siam.*, : 95; Bleeker, 1852, *Verh. Bat. Gen.*, 24: 18.

Pardachirus pavoninus Gunther, 1862, *Cat. Brit. Mus.*, IV: 479 (Singapore, Pinang, East Indies); Schmeltz, 1869, *Mus. Godeffroy Cat.*, 4: 24 (Pelew Islands); Gunther, 1873, Cruise of "Curacoa" (Brenchley): 410 (Solomon Islands); Gunther, 1909, *Fisch. Sudsee*, VIII: 347; Kendall and Goldsborough, 1911, *Mem. Mus. Comp. Zool. Harvard Coll.*, XXVI, 7: 332; Weber, 1913, "*Siboga" Exped. Monogr.*, 57 : 439; Ogilby, 1916, *Mem. Queensl. Mus.*, V: 142; Fowler and Bean, 1922, *Proc. U.S Nat. Mus.*, LXII (2): 67 (Zamboanga); Norman, 1926, *Biol. Res. "Endeavour"*, V (5): 288. (Malay Archipelago, S. Japan, Australia); Norman, 1928, *Rec. Ind. Mus.*, XXX: 187, fig. 6 (Andaman, Malay Peninsula); Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch.*, V: 165, fig. 46 (Singapore, Nias, Java, Philippines); Okada and Matsubara, 1938, *Keys Fish. Japan*: 435 (East India); Suvatti, 1950, *Fauna Thailand* :323; Herre, 1953, *Checklist Philippine Fish.*,: 187 (Phillipines, E. Indies); Matsubara, 1955, *Fish. Morph. Hier.*, II: 1280 (Japan); Cheng and Weng (1965), *Flatfish Taiwan*: 35 fig. 50; Kuronuma, 1961, *Checklist Fish. Vietnam*: 32; Punpoka, 1964, *Fish. Res. Bull. Kasetsart Univ.*,:39, fig. 13 (Rayong Province, Thailand); Fowler, 1967, *Mem. B.P. Bishop Mus.*, X: 94 (East Indies and Melanesia); Ramanathan, 1977, *Ph. D Thesis*: 202 (Parangipetta); Randall *et al.*, 1997, *Fish Great Barrier Reef and Coral Sea*: 450; Anderson *et al.*, 1998, *Ichth. Bull.*, 67: 29; Myers, 1999, *Micronesian Reef Fish.*, 3 ed.: 280; Fricke, 1999, *Fish. Mascarene Islands*: 574; Munroe in Randall and Lim, 2000, *Raffles Bull. Zoo Suppl.*, 8: 646; Nakabo, 2000, *Fish Japan*, 2^{ed}:1384; Laboute and Grandpurrin, 2000, *Poisson Nouv. Cal.,*: 450; Sakai *et al.*, 2001, *Bull. Nat. Sci. Mus., Ser.* A. 27(2):123; Hutchins, 2001, *Rec. W. Aust. Mus., Suppl.*, 63: 47; Desoutter et al., 2001, *Marine F.W Res.*, 53 (2): 341; Munroe, 2001, *FAO Sp. Iden. Guide*, IV (6): 3886; Nakabo, 2002, *Fish Japan*, 2^{o} ed.: 1384; Allen and Adrim, 2003, *Zool. Stud.*, 42(1): 64; Matsuura *et al.*, in Kimura and Matsuura, 2003, *Fish. Bitung.*, 216; Randall *et al.*, 2004, *Raffles Bull. Zool., Suppl.*, 11: 111; Randall, 2005, *Reef Shore fish. S. Pacific*: 617; Hoese and Bray, 2006, *Zool. Cat. Aust.*,:1847; Randall and Johnson, 2007, *Indo–Pac. Fish.*, 39:12; Fricke *et al.*, 2009, *Stutt. Beit. Nat., A, Neue Serie., 2*: 115; Matsuura in Matsuura and Kimura 2009, *Fish Andaman Sea*: 321; Motomura *et al.*, 2010, *Fish. Yaku-shima Island*: 231

Achirus maculates Bleeker, 1845. *Nat. Gen. Arch. Ned. Ind.*, II : 509; Kuhl and van Hasselt in Bleeker, 1852, *Verh. Bat. Gen. van. Kun. Wett.*, 24 :18.

Solea persimilis Gunther, 1909, *Fisch. Sud.,* VIII: 346. (type locality: New Britian Island, Bismarck Archipelago).

Achirus marmoratus Ruppell, 1852, *Samml. Des Senckenb. Mus*.,: 19 (nec. Lac.).

Solea (Pardachirus) pavonina Steindachner, 1870, *Sitzber. K. Akad. Wiss. Bd*. LX: 570.

Achirus barbatus (non Lacépède) Thiollière, 1857, *Fauna Woodlark*: 210 (Woodlark Island).

Achirus napai Montrouzier, 1857, *Annal. Soc. Agric. Hist. Nat. Arts Utiles de Lyon*, 8: 210; Thiollière, 1857, *Fauna Woodlark*: 210 (name in synonymy).

Aseraggodes ocellatus Weed, 1961, *Copeia* 3: 293, fig. 1 (type locality: North of Sweat Bay, Trincomalee, Sri Lanka, depth 0 – 6 feet).

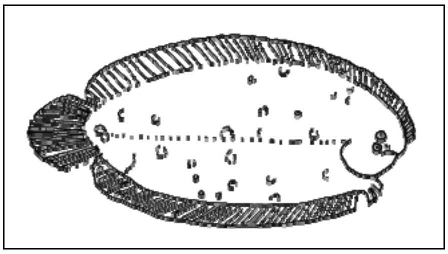


Plate XXXXI: *Pardachirus pavoninus* (Lacépède, 1802)

Material examined: N=5 specimens TL 114.87–212.22 mm from Mandapam; Additional specimen examined: 1 specimen, TL 92.46 mm, Mandapam Museum (F 150/424).

Diagnosis: Body oblong, thick with a bluish base colour on ocular side with numerous ocellii; blind side whitish.

Meristic characters: D 63 – 71; A 46 – 55; Pelvic (O/B) 5/5; C15 – 16; Lateral line 80 -96

Body measurements as percent of SL (mean in parentheses): HL 19.39 – 21.7 (20.5); HW 34.5 – 38.6 (36.1); HD 16.8 – 18.7 (17.6); ED_1 2.5 -3.5 (3.2); ED_2 3.03 -3.3 (3.1); UJL 4.3 – 6.6 (5.2); LJL 4 – 5.3 (4.7); ID 2.1 – 2.95 (2.7); P_rOU 4.98 -6.7 (5.7); P_rOL 4.98 - 6.7 (5.7); PBU 10.3 – 13.3 (11.7); PBL 10 – 11.8 (10.9); DFL 6.4 – 10.3 (8.7); AFL 81.1 – 85.4 (83.4); V_1FLO 5.8 -9.4 (7.5); V_2FLB 5.9 – 8.7 (7.04); CFL 14 – 17.8 (15.4); DBL 95 – 96.9 (96.1); ABL 81.1 – 85.4 (83.4); V_1BLO 2.59 – 7.4 (5.1); V_2BLB 4 – 5.2 (4.6); CBL 11.6 – 13.5 (12.3); CPD 11.2 – 12.2 (11.74); PDL 2.6 – 6.7 (5.1); PAL 17.5 – 21.7 (19.3); V_1LO 9 – 13.1 (11.2); V_2LB 8.97 – 11.3 (10.3); BD_1 40.4 – 45.75 (43.1).

As percent of HL (mean in parentheses): HW 168.3 – 186.2 (176.6); HD 81.7 – 93.7 (86.2); ED1 11.8 – 18.1 (15.5); ED2 14.6 – 16.7 (15.5); UJL 20.8 -30.2 (25.3); LJL 19.5- 25.5 (22.9); ID 10.7 – 14.8 (13.1); PrOU 18.6 – 30.6 (26.95); PrOL 25.6 – 30.8 (27.99); PBU 49.3 – 64.7; PBL 51.5 – 54.8 (53.5); DFL 29.4 – 49.6 (42.5); AFL 31.5 – 56.96 (46.8).

Description: Body oblong, with dextral eyes. Head small, with curved mouth, upper eye a little in front of lower eye. Interorbital width wide, scaly. Dorsal fin origin in front of upper eye. Mouth lunar, lower jaw tip ending just before lower eye. Pelvic fin origin well behind little eye. Pelvic fin on ocular side larger and a little in front of pelvic fin on blind side; left ventral smaller than right one, joined to genital pappilae, membrane extending upto second anal fin ray. Pectoral fin absent on ocular and blind side. Caudal rounded, free from dorsal and anal fin; caudal peduncle absent. A comparative statement of the meristic characters of ***Pardachirus pavoninus*** is given in Table 87

Table 87: A comparative statement of the meristic characters of *Pardachirus pavoninus*

Meristic characters	Earlier workers							Present work 2004 - 2010	
	Cantor 1850	Gunther 1862	Gunther 1909	Norman 1928	Weber & Beaufort 1929	Cheng & Weng 1965	Fowler 1967	N = 5	Mean ± SD
Dorsal	67	67	66 – 70	64 -71	63 -68	70	63	63 – 71	61 ± 1.7
Anal	50	50 - 52	50 – 52	50 - 56	49 - 52	54	53	46 – 55	43.9 ± 3.1
LL scales	*	90	90 – 95	78 -85	85 -90	86	83	80 - 96	92 ± 9.7
Ventral	5	*	*	*	5	5	*	5/5	5
Caudal	3 + 12 +3	*	*	*	*	*	*	15 - 16	16 ± 0.9

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Pardachirus pavoninus*** is given in Table 88

Table 88: Results of the correlation coefficient analysis on non-meristic characters of *Pardachirus pavoninus*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	4.6 - 5.2	4.90	0.21	0.94	0.21
Head Width	2.6 - 2.9	2.78	0.11	0.95	1.36
Head Depth	5.3 - 5.9	5.69	0.31	0.97	0.64
Eye Diameter (U)	28.6 - 40.8	32.15	5.18	0.51	0.09
Eye Diameter (L)	30.7 - 32.96	31.66	1.00	0.47	0.36
Upper jaw	15.3 - 23.1	19.64	2.81	0.14	0.30
Lower jaw	18.9 - 24.98	21.51	2.23	0.00	0.00
Inter orbital	33.9 - 48.2	38.11	6.12	0.76	0.59
Pre orbital (U)	15.9 - 27.7	18.86	4.97	0.92	2.11
Pre orbital (L)	15 - 20.1	17.65	2.22	0.86	0.56
Post orbital (U)	7.5 - 9.8	8.62	0.94	0.51	0.84
Post orbital (L)	8.5 - 10	9.17	0.57	0.59	0.56
Dorsal fin	9.7 - 15.7	11.87	2.35	0.49	0.65
Anal fin	9.1 -14.7	10.85	2.30	0.74	0.71
Depth of caudal peduncle	8.2 - 8.9	8.53	0.32	0.82	0.80
Predorsal	14.8 - 38.2	21.81	9.50	-0.01	-0.02
Preanal	4.6 - 5.7	5.23	0.47	0.09	0.13
Prepelvic(O)	7.6 - 11.1	9.13	1.37	0.39	0.18
Prepelvic (B)	8.9 - 11.1	9.77	0.91	0.74	0.63
Body depth	2.2 - 2.5	2.33	0.11	0.83	3.39
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head Width	0.5 - 0.6	0.57	0.02	0.95	1.36
Head Depth	1.1 - 1.2	1.16	0.06	0.97	0.64
Eye Diameter (U)	5.5 - 8.5	6.59	1.17	0.51	0.09
Eye Diameter (L)	5.98 - 6.86	6.48	0.41	0.47	0.36
Upper jaw	3.3 - 4.8	4.01	0.55	0.14	0.30
Lower jaw	3.9 - 5.1	4.40	0.47	0.00	0.00
Inter orbital	6.8 - 9.3	7.78	1.13	0.76	0.59
Pre orbital (U)	3.3 - 5.4	3.83	0.87	0.92	2.11
Pre orbital (L)	3.3 - 3.9	3.59	0.31	0.86	0.56
Post orbital (U)	1.6 - 2.03	1.76	0.18	0.51	0.84
Post orbital (L)	1.8 - 1.9	1.87	0.05	0.59	0.56
Dorsal fin	2.02 -3.4	2.44	0.57	0.49	0.65
Anal fin	1.8 - 3.2	2.23	0.57	0.74	0.71
Predorsal	3.02 - 7.6	4.45	1.9	-0.01	-0.02
Preanal	0.89 - 1.21	1.07	0.1	0.09	0.13
Prepelvic(O)	1.5 - 2.2	1.87	0.3	0.39	0.18
Prepelvic (B)	1.7 - 2.2	2.00	0.2	0.74	0.63
Body depth	0.4 - 0.5	0.48	0.0	0.83	3.39

Lateral line origin at the upper outer free end of the operculum; dorso-anterior branch of lateral line with 8-10 pored lateral lines and ventral preopercular branch with 4-6 pored lateral line scales. Body covered with cycloid scales; scales feebly ctenoid on both sides in smaller samples. A wide scaly basal sheath seen for both dorsal and anal fins; body scales do not extend onto fins. Sensory line on blind side in a pattern. Blind side of head papillate.

Colour: Base colour on ocular side light chocolate brown with large light blue spots and groups of bright yellow spots associated with slight blackish spots. The blue colour changed to brown in formalin on preservation. Randall and Johnson (2007) reports that the species exhibits considerable variation in colour.

Distribution:

World: Penang, Malaysia (Cantor, 1850); China (Chu, 1931); Singapore, Pinang, East Indies (Gunther, 1862; Bleeker, 1870); Pelew Islands (Schmeltz, 1869); Solomon Islands (Gunther, 1873); Queensland (Alleyne and Macleay, 1877; Macleay, 1881; Ogilby, 1916); Phillippines (Evermann and Seale 1907; Fowler and Bean 1922; Herre 1933); New Britian and Soloman Islands (Gunther 1909); Tonga (Gunther, 1909; Seale, 1906); Zamboanga (Fowler and Bean 1922); Malay Archipelago, S. Japan, Australia (Norman, 1926); Singapore, Nias, Java, Philippines (Weber and Beaufort,1929); East India (Okada and Matsubara,1938); Northern Territory (Whitley,1951; Taylor,1964); Phillipines, E. Indies (Herre, 1953); Sri Lanka (Weed, 1961); Japan (Ochiai,1963); Gulf of Thailand (Punpoka,1964); Taiwan (Chen and Weng,1965); New Guinea (Munro, 1967); New Caledonia (Fourmanoir and Laboute, 1976); Western Australia (Allen and

Swaintson, 1988); Palau (Myers, 1999); South China Sea (Munroe in Randall and Lim 2000); Libong Island, south western Thailand (Matsuura and Kimura, 2005). Map showing localities were ***Pardachirus pavoninus*** has been recorded in the world is given in Fig. 119.

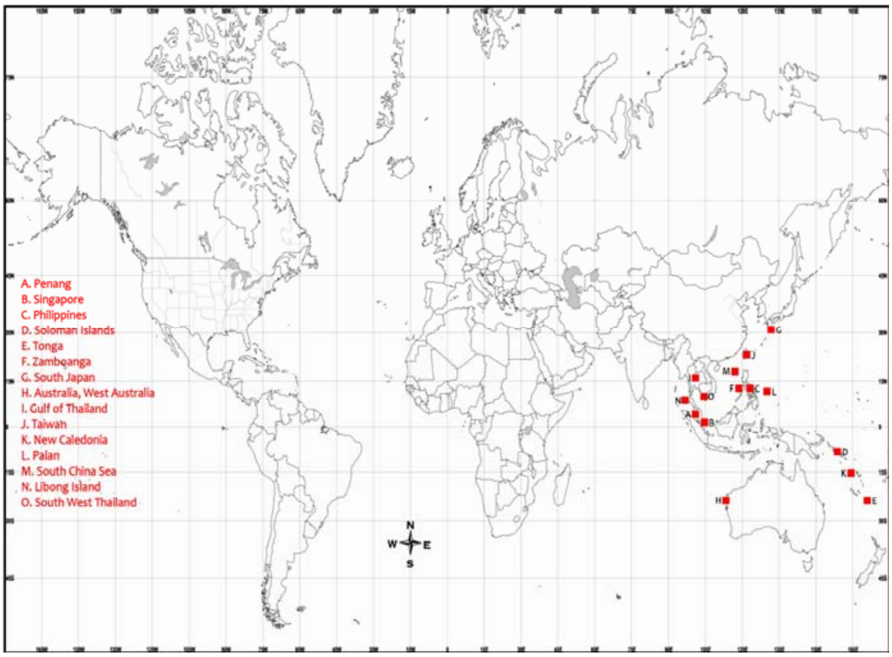


Fig. 119: Map showing localities were ***Pardachirus pavoninus*** has been recorded in the world.

India: Andamans Archipelago (Day, 1878; Norman, 1928); Mandapam (Gulf of Mannar (present work) Map showing localities were ***Pardachirus pavoninus*** has been recorded in India is given in Fig. 120.

Fig. 120: Map showing localities were *Pardachirus pavoninus* has been recorded in India

Taxonomic comments: *Pardachirus pavoninus* was first described by Lacepede based on a sample from the Dutch collection. Cantor (1849) described the species in genus *Achirus* as *Achirus pavoninus* based on samples from Sea of Pinang. The description given by Cantor in detail is very similar to the present work. However the absence of the left pelvic in the sample has been questioned by Cantor. Fowler (1967) opines that "*the account of Achirus barbatus by Thiollière mentions that his drawings may differ from the east African form as figured by Geoffery St. Hilaire and Ruppell. It is quite likely that this nominal form is P. pavoninus*". Thiollière says it differs in spots on brown side circular with brown dots in the centre and not scattered all over the body. Eschmeyer (1998:989) opines that *Achirus maculatus* Kuhl and van Hasselt in Bleeker (1852: 18) is not an available name due to being mentioned only in the synonymy of *A. pavoninus* by Bleeker. Clark and Brown (1979:113) included *Achirus napai* Montrouzier in the synonymy of *Pardachirus pavoninus*, following Fowler (1928: 94). Eschmeyer (1998:1150) noted that this name is not available due to being "*a manuscript name mentioned in passing in synonymy under Achirus barbatus*" (Randall and Johnson (2007: 13).

Remarks: The fish is found in the reef areas and is landed along with the discards. Not much economical value is attached to it; but the ornamental designs can make it a valuable fish in the ornamental trade.

4.3.7.7 Genus *Solea* Quensel 1806

Solea Quensel 1806, *Kun. Svens. Veten.,* 27: 53. (Type: ***Solea vulgaris*** **Quensel 1806** (= *Pleuronectes solea* Linnaeus 1758) Tautotypic; Torchio 1973, Checklist *fish. N.E Atlantic Mediterranean*. CLOFNAM: 628; Quéro *et al*., in Whitehead *et al*., 1986, *Fish. N.E Atlantic Medit.*, III: 1318; Heemstra and Gon, 1986, *Smith. Sea Fish.,*: 873; Desoutter, 1986, *Checklist F.W Fish. Africa*, CLOFFA: 431; Randall and McCarthy, 1989, *Japan. J. Ichth.*, 36 (2):196-199; Ben-Tuvia, 1990, *J. Fish Biol.*, 36: 947-960; Feng in Pan *et al.*, 1991, *F.W Fish. Guangdong Province*: 530; Desoutter in Lévêque *et al.,* 1992. *Collection Faune tropicale,* XXVIII, 2: 863; Li and Wang, 1995, *Fauna Sinica*: 272; Munroe, 2001, *FAO Sp. Iden. Guide,* IV (6):3880; Evseenko, 2003, *Vopr. Ikht*., 43 (Suppl. 1): S70; Vachon *et al*., 2008, *Cybium,* 31(4): 9.

Solea Cuvier 1816, *Le Regne Animal*: 223. (***Pleuronectes solea*** Linnaeus, 1758)

Microbuglossus Gunther, 1862, *Cat. Brit. Mus*. IV: 462, 471- 472 (type: ***Solea humilis*** Cantor 1849).

Pegusa Gunther, 1862. *Cat. Brit. Mus*., IV: 462, 467. (Type: ***Solea pegusa*** (not Lacepede); (Yarrell = *Solea aurantiaca* Gunther). Tautotypic.

Bathysolea Roule, 1916. *Bull. Inst. Ocean. Monaco*, 320: 28 (Type: ***Bathysolea albida* Roule**), Monotypic.

Dicologlossa Chabanaud, 1927, *Bull. Inst. Ocean. Monaco*, 488: 14 (Type: ***Solea cuneata***) (Moreau, Orthotype).

Description: Eyes dextral, lower eye placed well behind the upper; cleft of mouth narrow, curved in a convex manner. Teeth well developed on blind side, villiform in nature, placed in bands. Vomerine and palatine teeth absent. Dorsal fin origin well in front of the upper eye on snout; dorsal and anal fin not confluent with caudal fin. Scales small, ctenoid. Lateral line straight, extending from the outer tip of the operculum to caudal fin. Nostrils present on both sides of the body.

Taxonomic note: Quensel (1806) describes *Solea* -"*jaws are covered with scales, the superior one not fully developed, and the scaly mandible not showing the usual folds at the chin. Gill openings wholly below the pectorals; inferior eye rather back than the superior one; nostrils on both sides near the jaws, all fin rays divided, no spine in the anal*". Cuvier (1816) defines *Solea* as follows-

"*Their peculiar character is that the mouth is twisted and as it were monstrous on the side opposite to the eyes, and furnished on that side only with slender teeth closely crowded together like the pile of velvet, while the side where the eyes are. Their form is oblong, their snout is round and always projecting beyond mouth; the dorsal fin commencing over the mouth, and extending like the anal upto the caudal. Their lateral line is straight; the side of the head opposite to the eyes is generally furnished with a sort of villosity. Their intestine is long, with several convulsions and without caeca.*"Cantor (1849) agreeing wit hthe characters listed by Cuvier, added "*dorsal commencing opposite or a little in front of the upper eye; caudal separated from dorsal and anal*".

Gunther (1862) in "*Catalogue of Fishes in British Museum"* divided *Solea* into 2 groups based on the height of the body on total length and size/presence of pectorals. 34 species were recognised in Genus *Solea*; genus *Solea* was described as "*Eyes on the right side, the upper being more or less in advance of the lower. Cleft of mouth narrow, twisted round to the left side. Teeth on the blind side only, where they are villiform, forming bands; no vomerine or palatine teeth. The dorsal fin sometimes commences on the snout and is not confluent with the caudal. Scales are very small, ctenoid; lateral line is straight*." Norman (1928:173) placed Soleidae and Cynoglossidae together in the division Solaeiformes. He states that "*subdivision into genera of the flatfishes of Solea and Cynoglossidae is a matter of some difficulty*". Weber and Beaufort (1929:146) mentions of 10 genera in the Family Soleidae; the genus *Cynoglossus* is included in the family as a genera. According to Weber and Beaufort (1929), flatfishes with "*eyes on right or left side*" are placed in the family. The characters of two families were combined into one here. Fowler (1936:509) has in *Marine Fishes of West Africa* arranged six genera in two subfamilies – Soleinae and Cynoglossinae in the family Soleidae – *Solea, Monochirus,* *Symphurus, Synaptura* and *Monodichthys* in the first subfamily and *Cynoglossus* in the second subfamily. The key was an adaptation from the revision work of Chabanaud. According to Catalogue of Life (2010, online), genus *Solea* is represented by 11 species. In the present work, the genus is represented by only one species *Solea ovata*.

Members of the *Solea* occur from northern Europe and Iceland, throughout the eastern Atlantic and Indian Ocean to the West Central Pacific region.

4.3.7.7.1 *Solea ovata* Richardson, 1846
Ovate sole

Solea ovata Richardson, 1846, *Rept. Brit. Assoc. Adv. Sci.,*: 279 (type locality: Canton, China); Gunther, 1862, *Cat. Brit. Mus.*, IV: 472 (Amoy, China); Day, 1877, *Fish. India*: 426, pl. xciii, fig.1; Alcock, *J. Asiat. Soc. Bengal,* 1889, LVIII, pt.2: 285; Gunther, 1880, *Rep. Voy. Challenger*, I, pt.6: 55 (off Hong Kong); Seale, 1914, *Philippine J. Sci.*, 9:78 (Hong Kong); Wu, 1929, *Contr. Biol. Lab. Sci. Soc. China*, 5 (4): 68, fig, 55 (Amoy); Chu, 1931, *Biol. Bull. St. John's University*, 1: 92; Shen, 1967, *Quart. J. Taiwan Mus.*, 20 (1 and2):198-200, figs. 93-96; Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sinica,* 20 (2): 33 (Kaohsiung, Taiwan); Feng in Pan *et al.*, 1991, *F.W Fish. Guangdong*: 530; Munroe in Randall and Lim, 2000, *Raffles Bull. Zoo. Suppl.*, 8: 646; Munroe, 2001, *FAO Sp. Iden. Guide,* IV (6): 3887; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (1): S122; Vachon *et al.*, 2008, *Cybium,* 31(4): 12; Krishnan and Mishra, 1993, *Rec. Zool. Surv. India*, 93 (1-2): 235.

Solea humilis Cantor, 1849, *Cat. Mal. Fish.*,:219 (Seas of Pinang); Cantor, 1849, *J. Asiat. Soc. Bengal*, XVIII (2):1202 (Sea of Pinang);

Gunther, 1862, *Cat. Brit. Mus*., IV: 471 (Pinang, Java, Bintang); Bleeker, *Atl. Ichth*., 1866, VI: 16, Pleuron, pl.vi, fig. 1.; Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch*.,:148; Herre, 1932, *Lignan Sci. Journ*., II (3):433 (Canton).

Solea (Microbuglossus) ovata Bleeker, 1873, *Ned. Tjds. Dierk*., 4: 130 (Amoy, China).

Solea maculata Bleeker, 1852, *Verh. Bat. Gen*., XXIV, Pleuron: 17.

Solea oculus Alcock, 1889, *J. Proc. Asiat. Soc. Bengal*, 58 (pt. 2, 3), (Puri, Bay of Bengal).

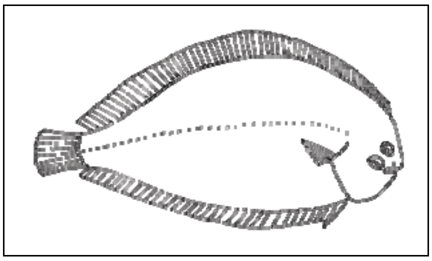



Plate XXXXII: *Solea ovata* Richardson, 1846

Material examined: N= 20, TL 79 -104 mm from Kalamukku Fisheries Harbour.

Diagnosis: Eyes close together, upper eye one half in advance of the lower.

Meristic characters: D 58-64 (61); A 39-47 (44); C 14 -16 (15); P_1 7, P_2 7; V_1/V_2 5, Ll. 79 -104 (92); SAL 19 - 29 (24).

Body measurements as percent of SL (mean in parentheses): HL 19.7 -26.3 (23.4); head height 16.8 -26.8 (22.9); BD_1 28.9 - 45.8 (40.7); ED_1 3.4 – 8.6 (5.9); ED_2 1.4 -3.5 (2.4); ID 2.1 -3.13 (2.4); SNL_1 3.03 – 5.9

(4.3); SNL_2 3.97 -6.7 (5.8); dorsal fin height 6.4 -12.5 (10.1); anal fin height 7.4 -12.4 (10.1); P_1FL (O) 7.3 -13.4 (10.6); P_2FL 6.95 -11.42 (8.3); V_1FLO 4.4 -10.5 (7.3); V_2FLB 4.4 -10.5 (7.3); CBL 12.5-20.8 (15.6); DBL 85.6 - 130.3 (93.5); ABL 68.9-106.8 (76.1); P_1BLO 2.9-5.2 (3.3); P_2BLB 1.2-3.1 (2.02); V_1BLO 1.5 -3.5 (2.2); V_2BLB 0.58 – 4.02 (1.7); predorsal 4.3-11.3 (6.5); prepelvic (O) 14.6 -23.09 (17.1); prepelvic (B) 14.6 -21.2 (7.01); caudal peduncle 6.5 -16.5 (10.1).

As percent of HL (mean in parentheses): Head height 85.2-106.3 (98.3); body depth 138.6-207.8 (175.9); ED_1/ED_2 5.7-13.7 (10.5); interorbital 7.9-13.3 (10.6); snout to upper eye 14 - 23.7 (18.1); snout to lower eye 16.7-31.2 (25.13).

Description: Head length contained 1.8 times in body depth and four times in SL. Eyes placed close together; nasal opening both round and tubular on ocular side, very minute on blind side. Eyes placed close together separated by a scaly interspace; the upper eye placed a little ahead of the lower eye; interorbital space contained 9.7 times in HL. Maxillary ends below middle point of lower eye. Pectoral fin on the coloured side longer than on blind; on the blind side only a small structure is noticed; contained 2.4 and 2.9 times in head length for pectoral (O) and pectoral (B) respectively. The pelvic fins on both sides equal in length, point of insertion of pelvic (O) slightly in front of pelvic (B). Scales on head region on blind side produced into fine barbel like/ thread like process.

A comparative statement of the meristic characters of *Solea ovata* is given in Table 89

Table 89: A comparative statement of the meristic characters of *Solea ovata*

Meristic characters	Earlier workers								Present work 2004 - 2010	
	Gunther 1862a	Gunther 1862b	Cantor 1849a *S. humilis*	Cantor 1849b *S. ovata*	Norman 1928	Ramanathan & Natarajan 1977	Talwar and Kacker 1984	Radhamanyamma 1988	N = 20	Mean ± SD
Dorsal rays	60	57	57	57	58 – 67	55- 64	58 – 67	58 - 68	58 - 64	61 ± 1.7
Anal rays	44	42	42	42	41 – 51	43 - 49	41 - 51	43 - 51	39 - 47	44 ± 3.1
Lateral line scales	120	95	*	*	100 - 108	92 – 109	*	*	79 - 104	92 ± 9.7
Caudal	*	*	12 5/4	12 5/4	*	18 - 20	*	16	14 -16	15 ± 0.9
Ventral	*	*	5	5	*	5	*	5	5	*
Pectoral	*	*	8	8	*	6-10/5- 7	*	7	7	*

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Solea ovata*** is given in Table 90.

Table 90: Results of the correlation coefficient analysis on non-meristic characters of *Solea ovata*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.8 - 5.1	4.35	0.47	0.70	0.15
Head height	3.7 - 5.96	4.44	0.65	0.72	0.22
Body depth	2.2 - 3.5	2.50	0.40	0.72	0.39
Eye diameter(U)	28.5 -70.2	43.4	10.59	0.08	0.00
Eye diameter(L)	28.5 - 70.2	42.6	10.77	0.01	0.00
Interorbital	31.96 - 48.2	41.8	5.43	0.85	0.03
Anal fin height	8.1-13.5	10.2	1.64	0.42	0.04
Pectoral (O)	7.5 -13.8	9.8	2.15	0.34	0.05
Pectoral (B)	8.76 -14.4	12.3	2.04	0.67	0.11
Pelvic (O)	9.6 - 22.7	14.6	4.54	0.34	0.05
Pre dorsal	8.8 - 23.34	16.55	4.66	0.01	0.00
Prepelvic (O)	4.3 - 6.9	5.97	0.74	0.61	0.06
Prepelvic (B)	5.82 - 6.9	6.4	0.47	0.07	0.09
Caudal peduncle	6.1 - 15.4	10.3	2.29	0.42	0.08
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head height	0.9 -1.2	1.02	0.09	0.94	1.34
Body depth	0.5 -0.7	0.58	0.07	0.76	1.88
Eye diameter(U)	7.3 -17.5	10.01	2.12	0.13	0.01
Eye diameter(L)	7.3 -17.5	9.82	2.08	0.16	0.02
Interorbital	7.5 -12.7	9.74	1.70	0.70	0.13
Snout to upper eye	4.2 - 7.1	5.64	0.87	0.52	0.13
Snout to lower eye	3.2 - 6	4.04	0.56	0.72	0.24
Pre dorsal	2.3 - 5.6	3.78	0.93	-0.17	-0.22
Prepelvic (O)	1.1 -1.6	1.36	0.14	-0.09	-0.12
Prepelvic (B)	1.4 -1.5	1.46	0.04	0.13	0.35
Caudal peduncle	1.2 - 3.2	2.33	0.54	-0.41	-0.67

Colour: Body colour brown, spotted with small black dots; occasionally white dots seen on dorsal and ventral profile, outer free end of pectoral fin (ocular) blackish.

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph; the linear regression equations obtained were

Head length on SL	:	$y = 0.15\ x + 5$; $R^2 = 0.49$ ($P \leq 0.001$)
Body depth (BD_1) on SL	:	$y = 0.39\ x + 1$; $R^2 = 0.52$ ($P \leq 0.001$)
Eye diameter (upper) on HL	:	$y = 0.01\ x + 1.3$; $R^2 = 0.02$ ($P \geq 0.5$)
Interorbital distance on HL	:	$y = 0.13\ x - 0.35$; $R^2 = 0.5$ ($P \leq 0.001$)

Regression of Head length and Body depth on SL and interorbital on HL was found to be highly significant.

Distribution:

World:

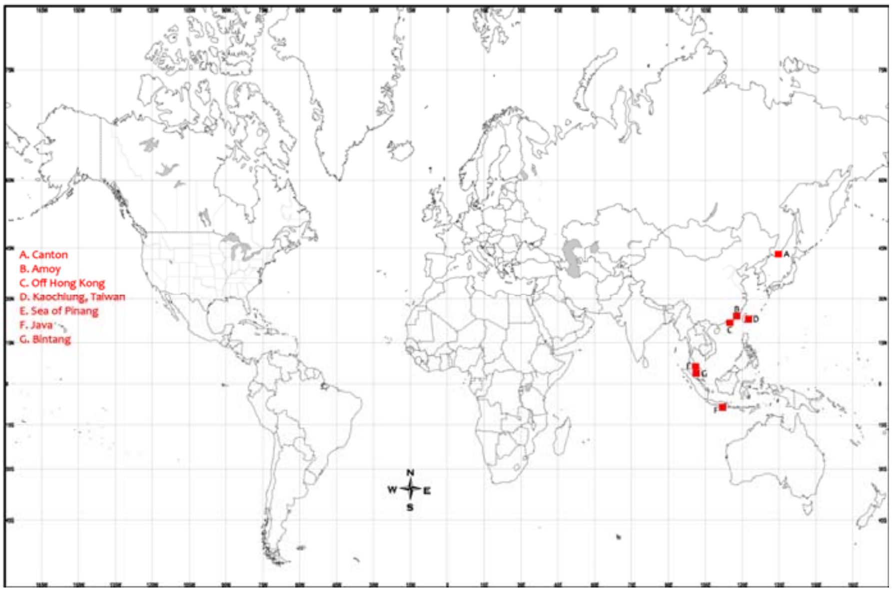


Fig. 121: Map showing localities were ***Solea ovata*** has been recorded in the world

Canton, China (Richardson, 1846); Amoy (Gunther, 1862; Bleeker, 1873); off Hong Kong (Gunther, 1880); Kaohsiung, Taiwan (Shen and Lee, 1981); Sea of Pinang (Cantor); Java, Bintang (Gunther, 1862), Penang, Java, through the Malaya Peninsula and Indo–Pacific Archipelago to China. Map showing localities were ***Solea ovata*** has been recorded in the world is given in Fig. 121.

In India: Reported from Puri, Bay of Bengal (Alcock, 1889); Vasco Bay, Marmugua in Goa, Kerala, Madras coast, Orissa. Map showing localities were ***Solea ovata*** has been recorded in India is given in Fig. 122.

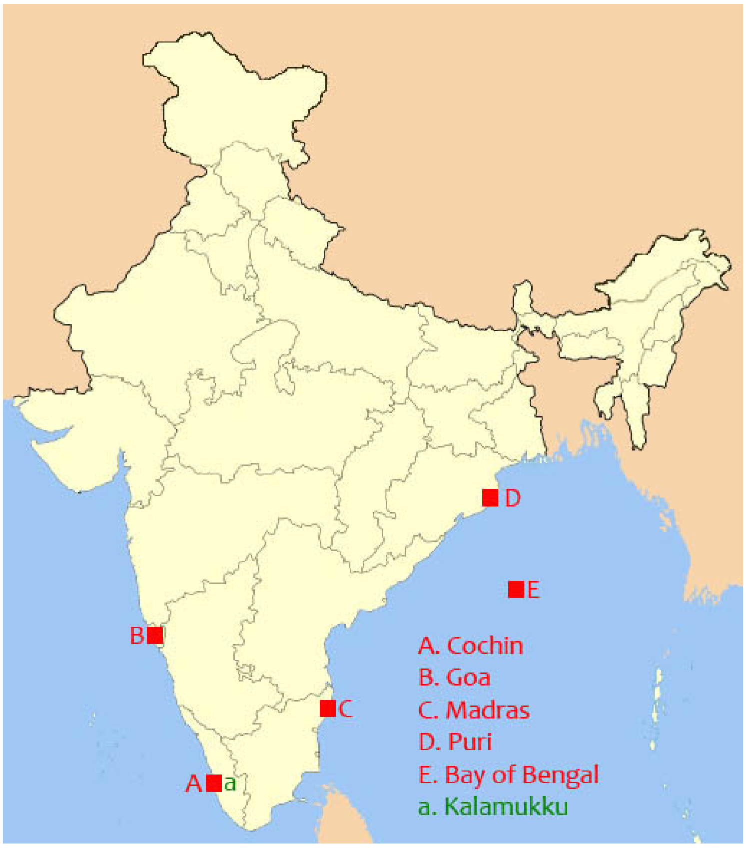


Fig. 122: Map showing localities were ***Solea ovata*** has been recorded in India

Taxonomic comments: The fish was first described as *Solea ovata* in 1846 based on samples from China Sea. Bleeker (1852) lists *Solea maculata* Cuvier from Batavia, Java, but such a description is not seen in Cuvier's list. Bleeker describes the fish with free dorsal, anal and caudal fin and dextral eyes. In a note, Bleeker has added that he agrees with Cuvier's naming of the species. *S. humilis* differs grossly from *S. ovata* described by Gunther (1862) in the lateral line counts; not much variation is noticed in the dorsal and anal counts. The fish was also variously described as *Solea variegata* by Shen and *Solea maculata* by Bleeker. The description of *Solea humilis* of Gunther and that of *Solea ovata* by the same author are one and the same and hence can be synonymised with the species described by Richardson. The valid name is *Solea ovata*.

Remarks: The species has been collected from nearshore waters as well as from estuarine waters during monsoon season.

4.3.7.8 Genus *Synaptura* Cantor 1849

Synaptura Cantor, 1849:1204 (Type: ***Pleuronectes*** Swainson, 1839 = *Pleuronectes orientalis* Bloch and Schneider, 1801) Type by being a replacement name for *Brachirus* Swainson, 1839). Torchio,1973, *Checklist Fish. N.E Atlantic and Medit.,* CLOFNAM: 634; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Arch*.,: 354 ; Heemstra and Gon, 1986, *Smith. Sea Fish.,*: 873; Quéro *et al*., in Whitehead *et al*., 1986, *Fish. N.E Atlantic Medit.*, III: 1323; Desoutter, 1986, *Checklist Fish. Africa*: 431; Kottelat, 1989, *Bull. Zoöl. Mus. Univ. Amsterdam,* 12 (1): 20; Rahman, 1989, *F.W Fish Bangladesh*: 27; Desoutter in Leveque *et al*., 1992, *Coll. Faun. Trop.,* XXVIII, 2:864; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad.,* 166: 187; Gomon *et al*., 1994, *Fish. Aust.,* 861; Munroe, 2001, *FAO Sp. Iden. Guide,* IV (6): 3880.

Solenoides Bleeker, Kaup, 1858, *Arch. Nat.*,: 96 (***Pleuronectes commersonianus*** **Lacepede**).

Taxonomic remarks: Cantor (1849) erected *Synaptura* and described *commersoniana* and *zebra* under it. Bleeker, following Cantor recognised *Synaptura* and described *commersoniana* in it. Menon and Joglekar (1978) synonimised *Austroglossus* Regan and *Trichobrachirus* Chabanaud with *Synaptura* Cantor. Genus *Trichobrachirus* Chabanaud is characterised by very minute sized pelvic fins, while *Austroglossus* Regan has well developed pelvic fins. Menon and Joglekar while synonymising the two genera with *Synaptura* suggested that the variation noticed in the pelvic fin size "*will fall in the normal size of variation met with in Synaptura*". According to Heemstra and Gon (1986), *Synaptura* differs from other genera in the presence of a thin tubular anterior nostril in comparision to an enlarged one in others.

4.3.7.8.1 *Synaptura albomaculata* Kaup, 1858

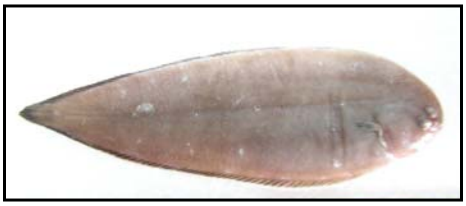
Kaup's sole

Synaptura albomaculata Kaup, 1858, *Arch. Nat.,*: 96 (Coramendal coast, India); Gunther, 1862, *Cat. Brit. Mus.*,: 483 (Coramendal); Day, 1878-1888, *Fish India*, 4^0: 429; Day, 1889, *Fauna Br. India*: 448, fig.161 (Indian Seas); Weber de Beaufort, 1929, *Fish. Indo - Aust. Arch*., V: 169 (British India); Talwar and Jhingran, 1991, *Inland Fish India,* 2:1048; Munroe, 2001, *FAO Sp. Iden. Guide* IV (6):

3881; Kapoor *et al*., 2002. *Fish Biod. India*: 680; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (*Suppl*., 1): S122.

Brachirus albomaculata Misra, 1959, *Rec. Ind. Mus.,* 57: 310, fig. 193 (Malabar, Travancore, Madras, Coramendal coast, Orissa, East Pakistan).***Dagetichthys albomaculatus*** Vachon *et al*., 2007, *Cybium,* 31 (4): 401 - 416.

Holotype (unique): MNHN 0000-3436



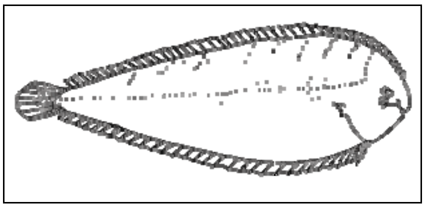


Plate XXXXIII: *Synaptura albomaculata* Kaup, 1858

Material examined: N = 10, TL 116.04 – 185.09 mm from Fort Kochi, Kalamukku, Ernakulam.

Diagnosis: Brown oval, elongated sole with thick body in central and small white tiny spots on the basal part of dorsal and anal fin on ocular side.

Meristic characters: D 67 - 76 (71), A 57 -59 (58), C12 -14 (12), Ltr 20 – 25 (23), Ll. 114 -120 (115)

Body measurements as percent of SL (mean in parentheses): HL 18.04 – 20.4 (18.2); HD 14.9 - 17 (15.5); BD_1 27.7– 32.99 (30.7); ED_1 2.2 - 3.9 (3.1); ED_2 2.5 - 3.9 (3); ID 0.9 – 2.12 (1.2); SNL_1 2.9 – 5.5 (4.01); SNL_2 4.9 – 6.97 (5.8); DFL 4.2 – 8.6 (6.7); AFL 4.8 – 7.6 (5.8); CFL 8.9– 13.6 (11.9); P_1FL 5.4 – 7.7 (6); P_2FL 4.2 – 6.1 (5.3); V_1FL 2.5 – 4.6 (3.4); DBL 95.6 101.5 (99.1); ABL 82.7 – 88.6 (85.5); CBL

4.4 –6.6 (5.3); PDL 2.4 – 4.4 (3.4); PAL 14.1–16.3 (14.9); eye–dorsal fin origin length 2.96 - 4.5 (3.9); mouth 5.9 – 7.6 (6.9).

As percent of HL (mean in parentheses): HD 74.1 – 92.2 (82.8); HW 150.1 – 175.3 (164.4); ED_1 11.8 – 20.6 (16.6); ED_2 13.1 -21.2 (16.1); ID 4.9 – 11.5 (6.5); SNL_1 15.6 – 27.1 (21.3); SNL_2 26.4 - 37.8 (31.04).

Description: Body oval, elongate with the head end broader, tapering to a point at caudal. Head small, with eyes placed close together, with a concave scaly interorbital space; upper eye placed well in front of the lower eye. Eyes covered partly by a thick membrane. Eye contained nearly 6 in HL. Two nostrils placed in the preorbital area, one tubular just above upper jaw, the second a small round aperture. Mouth groove like, concave in appearance, cleft ending a little beyond middle of eye, upper jaw bordered by a thick cartilage. 4-6 small papillae arise from the skin of the lower jaw giving it a fringed appearance. Nostrils placed nearly in between the eye, covered by fleshy papillae. On the blind side, mouth is covered with fleshy white folds of skin giving it a channel appearance. A patch of curved tissue seen near the snout region on the blind side, slightly protruding. Aperture of mouth bordered by papillae. Mouth on blind side has many rows of small sharp teeth arranged in rows. Body skin is thick. Pectoral (ocular) inserted at the outer free end of the operculum with 6 rays. Body scale (ocular) ctenoid, scales near outline nearly rectangular with 9 ctenii at its end, lines radiating from the ctenii to the outer part. Scales on the head and centre oval in outline, with fringed edges on side opposite to edge with ctenii. 6-7 ctenii present near the pigmented part of the scale. Scales on head with enlarged ctenii. Scales on blind side cycloid, the scales on head region on blind side produced into barbell like processes. Dorsal fin origin somewhat in a straight line with lower eye tip. Dorsal and anal fins runs parallel to body, fused completely with caudal; finlength of dorsal increases to middle of body, then decreases, same for anal also. Finrays joined by a membrane. Pectoral fin on both sides equal. Caudal fin tapering from sides to centre. Lateral line origin on ocular side a little in front of the upper opercular tip; on blind side lateral line is tubular, bulbous protruding out. Body scales ctenoid, with scales with stronger ctenii on the head region.

On the blind side, skin is whitish in colour, smooth; numerous papillae extend out towards the side of the body, more intense in the opercular area. Lateral line on the blind side has extensions into the head bordering the upper area as well intense branching in the lower area.

Digestive system with tubular thick walled stomach, long intestine curved in two loops in the body cavity.

Colour: Body brownish coloured with 5 pair of small white spots at the dorsal and anal fin ends, each pair widely spaced. Spots absent on head. Pectoral fin blackish with a pale outer end. Dorsal and anal finrays brown with light coloured interfin membrane; fin tip with a thin outer white border. Fins on blind side whitish.

A comparative statement of the meristic characters of *Synaptura albomaculata* is given in Table 91

Table 91: A comparative statement of the meristic characters of *Synaptura albomaculata*

Meristic characters	Earlier workers							Present study 2004 - 2010	
	Day, 1889	Misra, 1959	Weber & Beaufort, 1929	Gunther, 1862	Ramanathan, 1977	Talwar & Kacker 1984	Radhamanyamma 1988	N = 10	Mean ± SD
Dorsal rays	72 -74	*	71 -74	74	63 – 79	72 - 80	63 -79	67 -76	70.6 ± 3.4
Pectoral	7-8	*	9 / 7 (sin)	7 -8	6 - 9	*	6	6	*
Ventral	4	*	3- 4	*	3- 4	*	3	4	*
Anal rays	56-59	*	56 -59	59	52 – 62	57 - 63	53 -60	57 - 59	55.6 ± 3.9
Caudal	16	*	*	16	12 – 16	*	14 -16	12 -14	12.2 ± 3.11
Lateral line scutes	110-120	155	110 - 140	*	110 -142	*	113 -125	70 - 114	83.8 ± 17.3

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Synaptura albomaculata*** is given in Table 92

Table 92: Results of the correlation coefficient analysis on non-meristic characters of *Synaptura albomaculata*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	4.9 - 5.5	5.35	0.18	53.04	0.23
Head depth	5.9 - 6.7	6.47	0.28	55.04	0.15
Body depth	3.03 - 3.6	3.26	0.16	45.80	0.37
Eye Diameter (U)	25.9 - 44.97	32.88	5.09	62.70	0.01
Eye Diameter (L)	25.6 - 39.9	33.67	4.01	62.74	0.02
Inter orbital length	47.2 - 109.6	87.46	18.27	63.86	0.01
Snout-> U eye	18.1 - 34.7	25.62	4.40	62.15	0.08
Snout-> L eye	14.4 - 20.5	17.34	1.70	61.07	0.04
Dorsal	11.6 - 23.6	15.44	3.69	60.43	0.04
Anal	13.1 - 20.9	15.85	2.72	60.66	0.07
Caudal	7.4 - 11.2	8.53	1.21	57.38	0.04
Pectoral (O)	13.04 - 18.6	16.83	1.59	60.88	0.06
Pre dorsal	22.9 - 41.3	30.79	6.03	62.53	0.02
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	1.1 - 1.4	1.21	0.07	4.10	0.63
Body depth	0.6 - 0.7	0.61	0.03	9.47	1.58
Eye Diameter (U)	4.9 - 8.5	6.17	1.07	10.39	0.05
Eye Diameter (L)	4.7 - 7.6	6.32	0.89	10.44	0.08
Inter orbital length	8.7 – 20.2	16.37	3.39	11.53	0.03
Snout-> U eye	3.7 - 6.4	4.79	0.74	9.86	0.36
Snout-> L eye	2.7 -3.8	3.25	0.34	8.80	0.19
Dorsal	2.13 – 4.5	2.90	0.76	8.27	0.12
Anal	2.4 - 3.8	2.97	0.48	8.45	0.32
Caudal	1.4 - 2.3	1.61	0.28	5.48	0.14
Pectoral (O)	2.5 - 3.6	3.15	0.31	8.67	0.26

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph; the linear regression equations obtained were

Head length on SL : $y = 0.23 – 5.5 x; R^2 = 0.98 (P\leq 0.001)$
Head depth on SL : $y = 0.15 x + 0.53; R^2 = 0.9 (P\leq 0.001)$
Body depth (BD_1) on SL : $y = 0.37 x - 7.7; R^2 = 0.95 (P\leq 0.001)$
Eye diameter (upper) on HL : $y = 0.05 x + 2.7; R^2 = 0.2 (P\geq 0.001)$

Regression of all the above characters on SL was found to be highly significant, but regression of eye diameter on HL was not found to be significant.

Distribution:

India: Malabar, Coramendal coast, Orissa (Norman, 1928). Map showing localities were ***Synaptura albomaculata*** has been recorded in India is given in Fig.123.

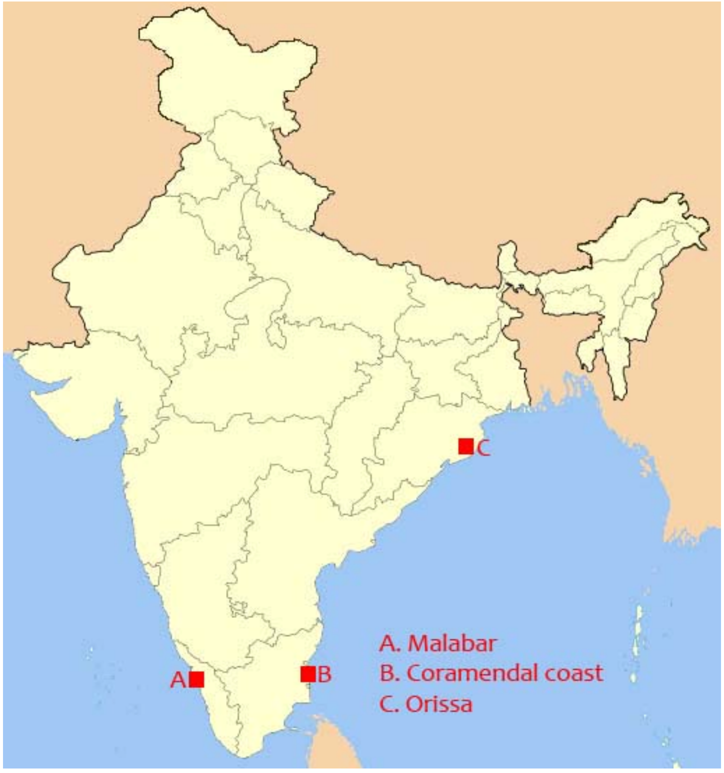


Fig. 123: Map showing localities were ***Synaptura albomaculata*** has been recorded in India

Taxonomic comments: The species was first described in the same name by Kaup from the Coramendal coast. Though there has been several revisions of the genus, Eschmeyer (2011, online) still paces the species in the genus *Synaptura*.

Remarks: Norman (1928) mentions of a tentacle in the interorbital area of *Synaptura albomaculata* and mentions it as a character used to differentiate the species with *S. commersoniana*. However, no such structure was seen in the interorbital area of the fish in the present work. The tentacle mentioned may be the long tubular nostril which to a plain eye can be misidentified as a fleshy tentacle.

4.3.7.8.2 *Synaptura commersoniana* (Lacépède, 1802)

Commerson's sole

Pleuronecten commersonien Lacepede, 1802, *Hist. Nat. Poiss.*, III: pl. 12, fig. 2.

Brachirus commersoni Swainson, 1839, *Nat. Hist. Fish.*, II: 308; Norman, 1928, *Rec. Indian Mus.*, 30 (2): 178 (Karachi).

Synaptura commersoniana Cantor, 1850, *J. Asiat. Soc. Bengal*, XVIII, pt. 2: 1204 (Penang, Malay Peninsula, Singapore); Bleeker, 1853, *Verh. Bat. Gen.*, XXV: 76 (Bengal); Gunther, 1862, *Cat. Fish.*, IV: 483; Bleeker, 1866, *Atl. Ichth.*, VI :18, Pleuron, pl. iv, fig. 3; Day, 1877, *Fish. India*: 428, pl. xciv, fig. I; Jenkins, 1910, *Mem. Ind. Mus.*, III: 29; Weber and Beaufort, 1929, *Fish. Indo–Aust. Arch.*, 5 :168; Suvatti, 1936, Index Fish. Siam: 95; Suvatti, 1950, *Fauna Thailand*: 324; Fowler, 1956, *Fish. Red Sea S. Arabia* I: 176. fig. 93 (from Bleeker); Punpoka, 1964, *Kasetsart Univ. Fish. Res. Inst.* 1:47 (Samut –Sarkorn Province); Krishnan and Misra, 1993, *Rec. Zool. Surv. India*, 93 (1-2):235 (Pentakota, Vishakapatnam).

Solea russellii Bleeker, 1851, *Nat. Tijds. Ned. Ind.*, I: 401; Bleeker, 1852, *Verh. Bat. Gen.*, XXIV, Pleuron: 15.

Synaptura commersoni Jerdon, 1851, *Madras J. Lit. Sci.*, XVII, 39: 148; Fowler, 1938, *Fish. Malaya*: 83; Munro, 1955, *Fish. Ceylon*: 262, pl. 50, fig. 761; Scott, 1959, *Sea Fish. Malaya*: 42.

Synaptura russellii Bleeker, 1853, *Verh. Bat. Gen.*, XXV, Bengal: 76.

"***Jerree Potoo***" Russell, 1803, *Descr. Fish. Vizag.*, I : 55, pl. lxx.

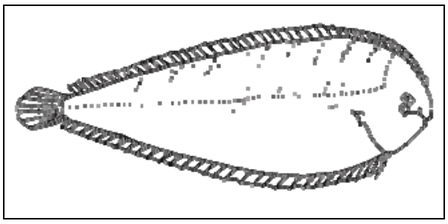


Plate XXXXIV: *Synaptura commersoniana* (Lacépède, 1802)

Material examined: N = 6, TL 132.92 – 188.31 mm from Fort Kochi, Ernakulam.

Diagnosis: Pectoral on both sides not equal, no white spots seen on body.

Description: D 66 – 74; A 45 – 63; C 9- 12; Ll 115 – 124.

Body measurements as percent of SL (mean in parentheses): HL 18. 4 – 20.6 (19.4), HD 13.6 – 17.4 (15.4), BD_1 27.7 – 33.9 (31.1), ED_1 2.2 - 3.4 (2.7), ED_2 2.2 -3.1 (2.6), ID 0.5 – 1.6 (1.1), SNL_1 1–1.4 (1.2), SNL_2 0.8 – 1.5 (1), DFL 5.4 – 8.1 (7.2), AFL 7 – 8.5 (7.6), CFL 12.1–14.4 (13), P_1FL 4.8 – 6.2 (5.5), P_2FL 4.8 – 6.2 (5.5), DBL 95.7 – 101.8 (98.5), ABL 81.3 – 90.1 (85.53), CBL 4.3–5.2 (4.8), PDL 2.7 – 5.4 (4), PAL 11.7 – 16 (14), UJL 5.9 – 7.2 (6.5).

As percent of HL (mean in parentheses): HD 65.9 – 89.5 (79.8), BD_1 134.6 -177.1 (160.7), ED_1 11.4 – 17.9 (14.1), ED_2 11.1 – 16.6 (13.2), ID

2.5 -8.6 (5.5), SNL_1 4.8 – 7.9 (6.2), SNL_2 4.2 -7.8 (5.1), DFL 28.8 -43.8 (37), AFL 34.6 -45.4 (39.5), CFL 59.7 -78.1 (67.4), P_1FL 25.8 – 32.6 (28.4), P_2FL 24.4 – 29.3 (27.1), DBL 480. 5 – 529.3 (508.3), ABL 414.8 -463.9 (440.1), CBL 23.1 – 27.8 (24.9), PDL 14.1 – 26.4 (20.4), PAL 63.6 – 84.8 (14), UJL 30.2 – 37.4 (33.6).

Description: Body oval, elongated with a broad head region and a tapering tail. Bony protrubrence on snout prominent, upper eye placed well in front of lower separated by a narrow scaly interorbital area. Mouth convex, subterminal, with cleft reaching to middle of lower eye, lower jaw with fine hair like pappillae projecting upward covering upper jaw giving a fringed look. Mouth on blind side with numerous villiform teeth on lower jaw in many rows. Two tubular nostrils in the preorbital space of lower eye; the anterior one with a valve at its tip, when folded the anterior one touches the posterior nostril. Nostrils on the blind side are encircled by dermal flaps. Pectoral (ocular) inserted at the outer free end of the operculum with 6 rays. Body scale (ocular) ctenoid, scales near outline nearly rectangular with 9 ctenii at its end, lines radiating from the ctenii to the outer part. Scales on the head and centre oval in outline, with fringed edges on side opposite to edge with ctenii. 6-7 ctenii present near the pigmented part of the scale. Scales on head with enlarged ctenii. Scales on blind side cycloid, the scales on head region on blind side produced into barbell like processes. Dorsal fin origin somewhat in a straight line with lower eye tip. A comparative statement of the meristic characters of *Synaptura commersoniana* is given in Table 93

Table 48: A comparative statement of the meristic characters of *Synaptura commersoniana*

Meristic characters	Earlier workers										Present study 2004 - 2010	
	Cantor 1849	Day, 1877	FAO	Norman 1928	Weber & Beaufort, 1929	Munroe 1955	Fowler 1956	Ramanathan 1977	Radhamanyamma 1988	Krishnan & Misra, 1993	N = 6	Mean ± SD
Dorsal rays	78 – 81	70 - 81	75 – 81	70 - 81	71 - 81	70 – 81	70 - 81	70 – 80	71 - 82	73	68 - 74	70.2 ± 2.23
Anal rays	65 - 66	60 - 63	61 – 64	58 - 66	57 - 63	58 – 66	58 – 66	56 – 67	60 - 68	57	56 - 63	60.3 ± 2.58
Pectoral	6	9	*	*	8 – 9/6 - 8	*	5 - 6	6 – 8 O/B	7 - 8	7/7	7- 8	
Total	155 - 159		83 - 89	*	*	*	*	*	*	*	*	
Pelvic	5/ 4	4	*	*	2 - 4	*	*	2 - 3	2-3	4	4	
Caudal	12	12	*	*		*	12		12 – 14	12	9 -12	7.3 ± 2.3
Lateral line	*	155 - 160	*	160	156 - 170	160	160	155 - 170	115 - 125	140	115 -124	118.7 ± 3.4

*Data not available

Dorsal and anal fins runs parallel to body, fused completely with caudal; finlength of dorsal increases to middle of body, then decreases, same for anal also. Finrays joined by a membrane. Pectoral fin on both sides not equal. Lateral line origin a little above the outer free tip of operculum; scale on ocular side tubular with ctenii, scale on blind side cycloid.

Results of the correlation coefficient analysis done on non-meristic characters of *Synaptura commersoniana* is given in Table 94

Table 94: Results of the correlation coefficient analysis on non-meristic characters of *Synaptura commersoniana*

Characters	Range in SL	Mean	SD	R^2 in SL	Slope
Head depth	4.9 - 5.4	5.16	0.23	0.94	0.20
Body depth	5.8 -7.4	6.51	0.54	0.99	0.47
Eye Diameter (U)	2.95 -3.6	3.24	0.29	0.29	0.01
Eye Diameter (L)	29.7 - 46.4	38.02	8.32	0.57	0.01
Inter orbital length	32.04 -46.3	39.68	4.96	0.85	0.03
SNL_1	62.8 -190.6	107.00	46.03	0.81	0.02
SNL_2	69.1 -101.8	84.38	12.01	0.60	0.01
Mouth	6.3 - 8.5	7.23	0.91	0.89	0.06
Dorsal FL	65.6 -124.9	106.57	21.63	0.90	0.10
Anal FL	12.4 - 18.5	14.21	2.22	0.87	0.08
Caudal FL	11.8 -14.4	13.18	1.08	0.87	0.13
Pectoral (O) FL	6.95 - 8.3	7.72	0.60	0.80	0.04
Pectoral (B) FL	16.2 - 21.04	18.31	1.64	0.92	0.05
Dorsal FB	18.03 -21.1	19.10	1.17	0.99	0.90
Anal FB	0.98 -1.04	1.02	0.02	0.98	0.90
Caudal FB	1.1 - 1.2	1.17	0.04	0.87	0.03
Pre dorsal	19.1 -23.5	20.80	1.63	0.73	0.06
Preanal	18.4 -37.5	26.82	7.69	0.57	0.05
Characters	**Range in HL**	**Mean**	**SD**	**R^2 in SL**	**Slope**
Head depth	1.1 -1.5	1.27	0.14	0.86	0.89
Body depth	0.6 - 0.7	0.63	0.07	0.94	2.23
Eye Diameter (U)	5.6 - 8.8	7.34	1.42	0.49	0.09
Eye Diameter (L)	6.1 -9	7.70	0.96	0.60	0.05
Inter orbital length	11.6 -39.3	20.96	9.81	0.69	0.11
SNL_1	12.7 - 20.97	16.44	2.94	0.65	0.06
SNL_2	12.8 - 23.6	20.64	4.04	0.61	0.07

Regression analysis was performed to study the variation of body parameters on standard and head length. Results obtained were plotted on a graph; the linear regression equations obtained were

Head length on SL : $y = 0.19 + 0.14\,x$; $R^2 = 0.91$; $P \leq 0.01$

Body depth (BD_1) on SL : $y = 0.5\,x - 23.8$; $R^2 = 0.97$; $P \leq 0.001$

Regression of only the above characters on SL was found to be highly significant.

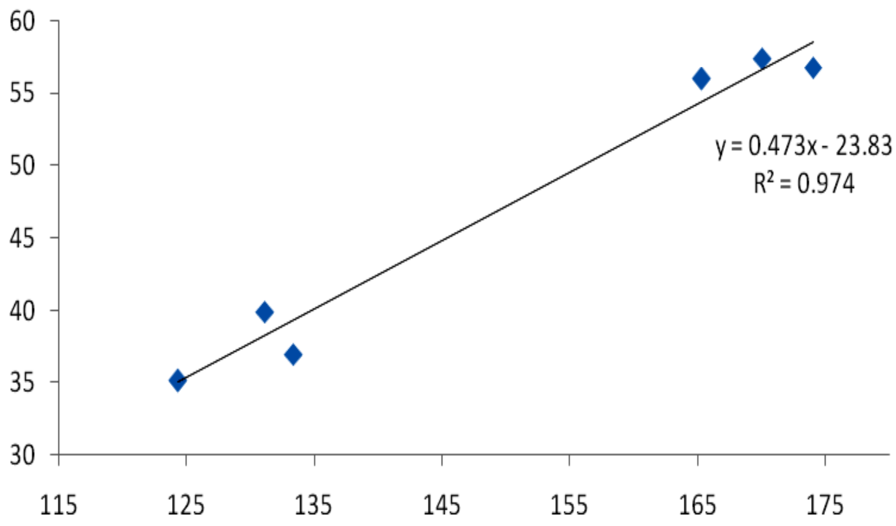


Fig. 124: Regression of Body depth on Standard length

Colour: Body deep brown with dusky pectoral with a pale outer end. Dorsal and anal fins darkish towards the outer ends with a conspicuous white margin.

Distribution

World: Penang, Malay Peninsula, Singapore (Cantor, 1850); Karachi (Norman, 1928). Map showing localities were *Synaptura commersoniana* has been recorded in the world is given in Fig. 125.

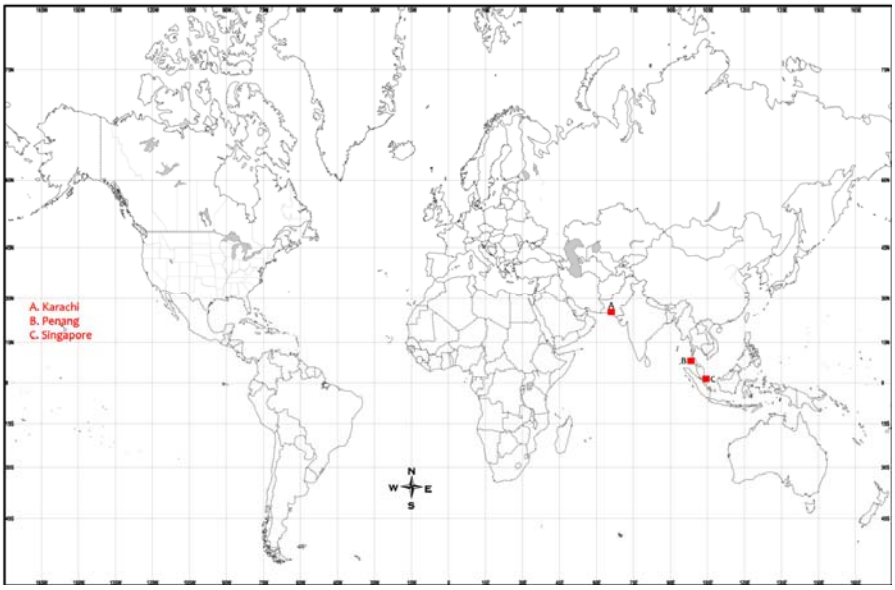


Fig. 125: Map showing localities were *Synaptura commersoniana* has been recorded in the world.

India: Bengal (Bleeker, 1853); Madras, South Canara (Norman, 1928); Pentakota, Vishakapatnam (Krishnan and Misra, 1993); Fort Kochi, Ernakulam (present work).

Map showing localities were *Synaptura commersoniana* has been recorded in India is given in Fig.126.

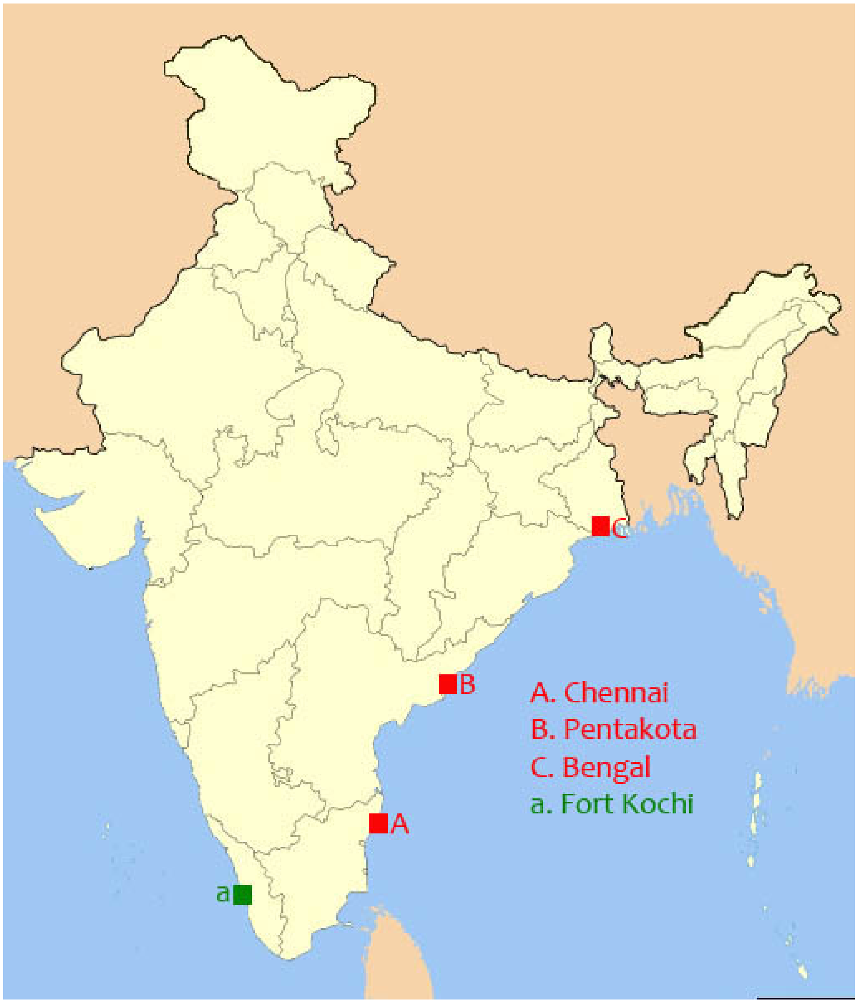


Fig. 126: Map showing localities were *Synaptura commersoniana* has been recorded in India

Taxonomic comments: *Le Pleuronecte commersonnien* was first described by Lacepède. Following this the fish was placed in various genera (*Brachirus* by Swainson (1839); *Synaptura* by Cantor (1850)). Norman (1928) followed Swainson and described the species as *Brachirus commersoniana* and included *B. russellii* of Bleeker's collection as a synonym. Fowler (1956) comments that "*as the reference Pleuronecte* *commersonien Lacepède, Hist. Nat. Poiss., vol. 3, 1802, pl. 12, fig. 2 is not admissible, for it is of improper form and since the reference Pleuronectes commersonii Lacepède, l.c., vol. 4, 1802, pp. 599, 654 pertains to an entirely different fish, I therefore feel obliged to accept Cantor as the earliest available author*". Later workers followed Fowler and designated the species as *Synaptura commersoniana*.

Remarks: Meristic counts given by Cantor (1850) for dorsal fin are in the slightly higher range compared to later workers. Dorsal fin counts of the present work have slightly lower range for dorsal fincount; the lateral line counts of the present specimen are in the lower range compared to earlier workers but match well with that of Radhamanyamma (1988). *Synaptura commersoniana* varies from *Synaptura albomaculata* in the unequal nature of the pectoral fins and in the absence of the white spots in the former.

4.3.7.9 Genus *Zebrias* Jordan and Snyder*, 1900*

Aesopia Kaup, 1858, *Weig Arch*.,: 95 (Type: ***Aesopia zebrias*** Kaup)

Zebrias Jordan and Snyder, 1900, *Proc. U.S Nat. Mus*., xxiii: 380. (Type: ***Solea zebrina*** Temminck and Schlegel 1846), Regan, 1920, *Ann. Durban Mus*., II: 218; Ochiai in Masuda *et al*., 1984, *Fish. Jap. Arch.,*: 355; Heemstra and Gon, 1986, *Smith. Sea Fish*.,:874 ; Chapleau and Keast, 1988, *Canadian J. Zoo*., 66: 2799 ; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166:197 ; Gomon *et al.,* 1994, *Fish. Australia*: 862; Li and Wang, 1995, *Fauna Sinica*: 311; Munroe, 2001, *FAO Sp. Iden. Guide* IV (6): 3880; Hoese and Bray, 2006, *Zool. Cat. Aust.,*: 1850; Gomon, 2008, *Fish. Aust. South. Coast*: 819.

Haplozebrias Chabanaud, 1943, *Bull. Mus. Nat. Hist. Nat.* (Ser. 2) 15 (5):292 (Type: ***Synaptura fasciata*** Macleay 1882)

Holonodus (subgenus of *Zebrias*) Chabanaud, 1936, *Bull. Soc. Zoo. France*, 61:383 (Type: ***Solea synapturoides*** Jenkins 1910).

Nematozebrias Chabanaud, 1943 *Bull. Mus. Nat. Hist. Nat.* (Ser. 2), 15(5): 292 (Type: ***Aesopia quagga*** Kaup 1858).

Diagnosis: Left pectoral fin rudimentary. Caudal fin confluent partly or fully with other vertical fins.

Description: Body ovate, flat, eyes dextral placed close together separated by a narrow scaly interorbital space. Two nostrils on eyed side, anterior tubular, posterior circular in outline, in front of lower eye. Mouth small, covered by skin, curved, not forming a prominent hook. Teeth minute in the jaws on blind side. Lips not fringed. Dorsal fin arising on snout, anal region in front of pectoral on ocular side. Dorsal and anal confluent with caudal. Gill membranes united but free from isthmus. Pectoral fins present, attached to opercular membrane. Pelvic fin short, broad based, free and not attached to anal fin. Body covered with ctenoid scales, with black cross bands, nearly arranged in pairs. Single straight lateral line.

Colour: Dorsal bands interlined with white present on ocular side only.

Distribution: *Zebrias* species are found throughout the Indo-west Pacific from east Africa, the Red Sea, Persian Gulf, India, Australia and Tasmania to coastal China, Taiwan and Japan. Jordan and Snyder (1901) listed species from India to Japan and Regan (1920) from Natal. Chabanaud (1934) listed eight species of *Zebrias* from the coasts of Australia, India, the Malay Archipelago, Indo – China and Japan.

Susequently, Herre and Myers (1937), Ochiai (1963; 1966), Punpoka (1964), Cheng and Chang (1965), Smith (1965), Rama Rao (1967); Talwar and Chakrapani (1967), Dor (1970), Kailola (1974), Scott (1975), Joglekar (1976), Hussain and Khan (1981), Shen and Lee (1981) have recognised 11 species from the Indo–Pacific, excluding the Philippine Islands. Seigel and Adamson (1985) collected *Zebrias lucapensis* from Philippines.

Taxonomic comments: Jordan and Snyder (1900) separated from the genus *Synaptura* Cantor a distinct genus *Zebrias* with *Pleuronectes zebra* as type, characterised by the rudimentary left pectoral. According to Jordan and Starks (1906), the genus is allied to *Synaptura* but differs in having two pectoral fins on the left side rudimentary or wanting. Jordan and Starks (1906) opined "*in our judgement, the name Aesopia should replace Zebrias for this genus*". Chabanaud (1936, 1943) created three new genera viz., *Haplozebrias* (type *Synaptura fasciata* Macleay), *Nematozebrias* (type:*Aesopia quagga* Kaup), *Stratozebrias* and a subgenus *Holonodus* with *Zebrias synapturoides* Jenkins as type species. Of these, the first *Haplozebrias* is separated from genus *Zebrias* Jordan and Snyder in having vertical fin rays simple only divided at the tips. (in *Zebrias*, they are split well), second with *Zebrias quagga* (Kaup) as its type species is said to differ from the first two *ie*., *Zebrias* and *Haplozebrias* in having contiguous eyes with tentacles at the corner. *Stratozebrias* is created to accommodate species having perfectly contiguous eyes and no tentacles at the corner of each eye. *Holonodus* is created with *Z. synapturoides* as type species and is said to differ from genus *Zebrias* in having premaxilla and dentary on blind side edentulous.

Joglekar (1976) opined that the genera *Zebrias* can be split into two subgenera –*Zebrias* and *Nematozebrias*, the former with *Zebrias zebra* as the type species and the latter with *Zebrias quagga* as type. Characters assigned for *Zebrias* were

a) Vertical fins completely confluent with caudal fins

b) Eyes separated by a scaly interspace

c) Lateral line scales more than 100

While, characters assigned to *Nematozebrias* were

a) Vertical fins partially confluent

b) Eyes more or less contiguous, rarely separated by a scaly interspace

c) Lateral line scales less than 100.

Remarks: The genus *Zebrias* Jordan and Snyder includes 19 species (Munroe, 2005) of small banded soles. The genus is represented by two species *Zebrias zebrinus* and *Zebrias japonicas* from Japanese waters (Jordan and Starks, 1906). According to Talwar and Kacker (1984), eight species has been reported from Indian region of which only two are seen in the fishery. In the present study only four species have been recorded of which one is a new record to Indian waters.

4.3.7.9.1 *Zebrias cochinensis* Rama Rao, 1967

Zebrias cochinensis, Rama Rao, 1967, *J. Zool. Soc. India*, 19 (1 and2): 99 (Cochin, Kerala).

Plate XXXXVI: *Zebrias cochinensis* Rama Rao, 1967

Material examined: N=1, TL 145. 98 mm from Cochin Fisheries Harbour, Kerala.

Diagnosis: Medium sized sole with differential banding pattern on ocular side, 12 bands in all on ocular side.

Meristic characters: D 65; A 57; P_1 6; P_2 4; Ll. 93

Body measurements as percent of SL: HL 19.9; HD 13.7; UJL 5.5; LJL 4.9; ED_1 3.9; ID 1.25; PrOU 3.3; PrOL 4.6; PBU 13.3; PBL 10.6; BD_1 37.3; BD_2 29.77.

As percent of HL: HD 68.9; UJL 27.9; LJL 24.6; PrOU 16.7; PrOL 23.2; PBU 66.9; PBL 53.2; ED_1 19.76; ID 6.3.

Description: Body oval, thick, with a blunt head, slightly pointing t o snout; eyes nearly contiguous. Mouth inferior, curved downwards only slightly. Snout not hooked at tip. Two nostrils present on ocular side, the anterior tubular, the posterior covered with a thick fleshy tissue. Dorsal fin origin on a horizontal in front of the eye; dorsal and anal fins only joined slightly to base of caudal. Pectoral fin on ocular attached to outer upper free end of operculum; fin rays not produced. Pectoral fin on blind side very small. Body covered with weak ctenoid scales, 12 thin ctenii seen on each ctenoid scale. Lateral line single on ocular and blind side.

Results of the correlation coefficient analysis done on non-meristic characters of ***Zebrias cochinensis*** is given in Table 95

Table 95: Results of the correlation coefficient analysis on non-meristic characters of *Zebrias cochinensis*

Characters	In SL	In HL
Head Length	5.02	
Head Width	3.06	0.608
Head depth	7.30	1.452
Upper jaw	18.02	3.587
Lower jaw length	20.43	4.066
Eye Diameter (U)	25.43	5.060
Inter orbital	80.30	15.981
Pre orbital (U)	30.07	5.983
Pre orbital (L)	21.65	4.309
Post orbital (U)	7.52	1.496
Post orbital (L)	9.45	1.882
Body depth1	2.68	0.533
Body depth 2	3.36	0.669
Pre dorsal	12.00	2.389
Pre anal	5.26	1.048
Pre pectoral	5.95	1.183
Pre pecteral	6.84	1.362
Pre pelvic	6.84	1.362
Dorsal FL	17.08	3.398
Anal FL	12.15	2.419
Caudal FL	6.59	1.311
Pelvic FL (O)	21.91	4.361
Pelvic FL (B)	19.20	3.820
Dorsal BL	1.02	0.202
Anal BL	1.12	0.223
Pectoral BL (O)	23.76	4.728
Pectoral BL (B)	31.25	6.219
Pelvic BL (O)	21.22	4.222
Pelvic BL (B)	31.25	6.219

Colour: Body covered with 12 brown vertical lines interspersed with white lines, the first three on head region, the fourth across the outer free tip of operculum; rest on body. Caudal fin with outer free end black with yellow spots, inner base is whiteish. Colour does not fade on preservation. Bands extend onto fins.

Distribution:

India: Cochin, Kerala, India. Not reported from elsewhere in the world. Map showing localities were ***Zebrias cochinensis*** has been recorded in India is given in Fig. 127.

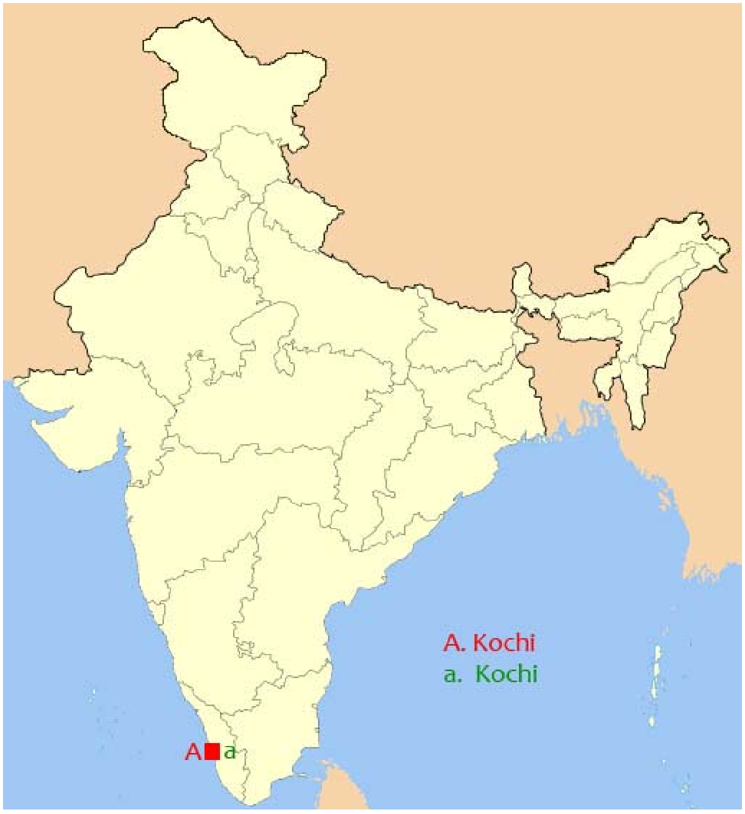


Fig. 127: Map showing localities were ***Zebrias cochinensis*** has been recorded in India

Taxonomic remarks: The fish was described from the present collection locality itself. Norman (1928) recorded three species from Indian waters, *Zebrias synapturoides*, *Z. altipinnis* and *Z. quagga*. Later two species *Zebrias cochinensis* by Rama Rao (1967) and Joglekar (1976) *Zebrias keralensis* were added. The species differs in the external appearance itself from the other three.

Remarks: The present species resembles the original description of *Z. cochinensis* in counts and meristics. This confirms the presence of this species in these waters.

New Record 12

4.3.7.9.2 *Zebrias crossolepis* Zheng and Chang, 1965

Zebrias crossolepis Cheng and Chang, 1965, *Acta. Zootax. Sinica*, 2(4):277-278, figs. 1D, 2D, 3 (Type locality: Jieshi, Kwang-tung, China); Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sinica*, 20 (2): 36 (Taiwan).

Zebrias zebra (non Bloch) Hubbs, 1915, *Proc. U.S Nat. Mus.*, 48:493.

Plate XXXXVII: *Zebrias crossolepis* Zheng and Chang, 1965

Material examined: N =1, TL 143.73 mm from Kochin Fisheries Harbour.

Diagnosis: An ovate, sole with a blunt head, contiguous eyes, and 13 paired bands on body, caudal with white dots. Dorsal and anal connected to basal half of caudal. Scales on ocular side with long marginal spinules; those on blind side barbell like, soft.

Meristic characters: D 62; A 60; P_1 10; P_2 7; V 5, Ll. 80

Body measurements as percent of SL: HL 21.35; HW 33.98; UJL 4.7; ED 3.97; ID 1.04; PrOU 4.74; PrOL 4.78; BD_1 38.9; BD_2 30.8; PDL 6.4; PAL 21.99; DFL 6.98; AFL 8.8; P_1FLO 5.6.

As percent of HL: HD 77.9; UJL 22.1; LJL 18.6; ID 4.89; PrOU 22.2; PrOL 22.4.

Description: Body thick, oval, with a blunt head region. Mouth inferior, highly semicircular in pattern. Eyes on right side, upper eye in advance of lower eye, contiguous, with a naked interorbital space. Two nostrils on ocular side, the first tubular, placed on a horizontal in front of the lower eye, the second covered by a flap of skin. On blind side, second nostril opening covered with a flap. Dorsal fin origin on blind side; anal fin and dorsal fin attached only to base of the caudal fin. Pectoral fin attached to operculum on ocular side as a flap with 5 rays; fin rays unbranched. Pelvic fin of both sides fused together at the base. Head and body covered with strongly ctenoid scales. Scales on head deeply oval with fringed margin, radiations seen from pigmented area into clear area; ctenii 6 in number, very long and slender. Body scales roundish oval in outline with a yellow basal pigmented area with thin ctenii, 8 in number. Scales on blind side with very weak ctenii. Lateral line scales without spines, but lateral line covered by spinules of surrounding scales.

A comparative statement of the meristic characters of ***Zebrias crossolepis*** is given in Table 96

Table 96: A comparative statement of the meristic characters of *Zebrias crossolepis*

Meristic characters	Earlier workers		Present study 2004 – 2010
	Shen and Lee 1965	**Shen & Wei 1965**	**N = 1**
Dorsal rays	65 - 76	65 - 76	62
Anal rays	54 - 63	54 - 63	60
Pectoral (O/B)	8 - 11/ 10 - 11	9 -11/ 10 - 11	10/7
Pelvic (O/ B)	4 – 5/ 4- 5	5 /4	5
Caudal	18	18	
Lateral line scales	61 - 80	60 - 80	80

Results of the correlation coefficient analysis done on non-meristic characters of ***Zebrias crossolepis*** is given in Table 97.

Table 97: Results of the correlation coefficient analysis on non-meristic characters of *Zebrias crossolepis*

Characters	In SL	In HL
Head Length	4.68	
Head Width	2.94	0.628
Head depth	6.01	1.283
Upper jaw	21.22	4.532
Eye Diameter (U)	25.17	5.374
Inter orbital	95.83	20.462
Pre orbital (U)	21.12	4.508
Pre orbital (L)	20.94	4.471
Post orbital (U)	0.57	0.121
Post orbital (L)	7.59	1.621
Body depth1	2.57	0.548
Body depth 2	3.25	0.694
Pre dorsal	15.55	3.321
Pre anal	4.55	0.971
Pre pectoral	4.60	0.982
Pre pecteral	5.26	1.122
Pre pelvic	5.54	1.184
Dorsal FL	14.34	3.061
Anal FL	11.34	2.420
Caudal FL	7.17	1.531
Pectoral FL (O)	17.98	3.838
Pelvic FL (O)	24.19	5.165
Pelvic FL (B)	21.44	4.578
Dorsal BL	1.03	0.221
Anal BL	1.18	0.252
Caudal BL	14.32	3.057
Pectoral BL (O)	15.67	3.346
Pectoral BL (B)	16.35	3.491
Pelvic BL (O)	76.43	16.319
Pelvic BL (B)	76.43	16.319

*Data not available

Colour: Body on ocular side with 12 brown coloured bands interspersed with white bands; each white band has a brown thin dotted line in the centre. The 12th band is on tail and black in colour. The 2nd and 3rd bands are split into two at the ventral part. All bands extend into dorsal and anal fins.

Distribution:

World: Jieshi, Kwang-tung, China (Cheng and Chang, 1965); Taiwan (Shen and Lee, 1981). Map showing localities were ***Zebrias crossolepis*** has been recorded in the world is given in Fig. 128.

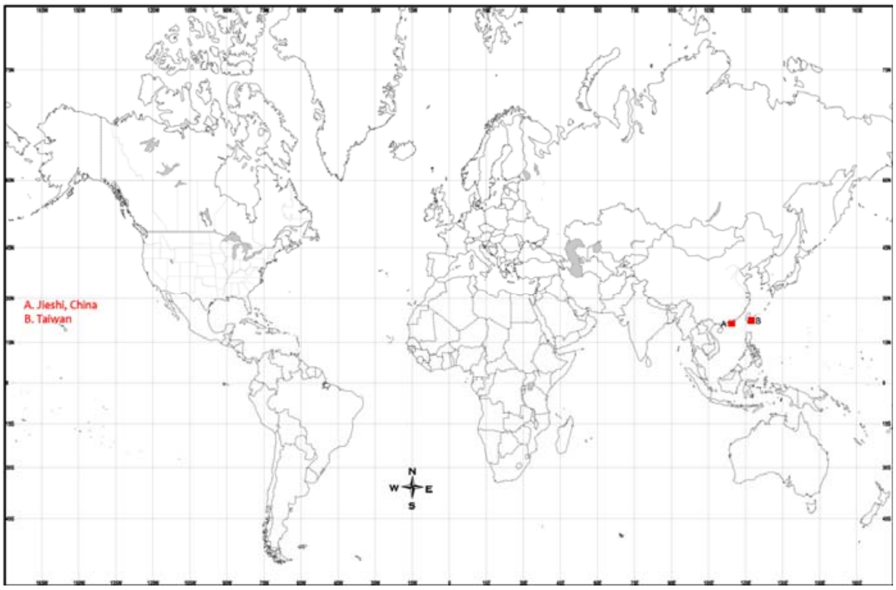


Fig. 128: Map showing localities were ***Zebrias crossolepis*** has been recorded in the world.

India: Cochin, Kerala. This is the **first report from Indian waters**.

Map showing localities were ***Zebrias crossolepis*** has been recorded in India is given in Fig.129.

Fig. 129: Map showing localities were ***Zebrias crossolepis*** has been recorded in India

Taxonomic comments: The fish was first described as *Zebrias zebra* (Hubbs, 1915). However, Cheng and Chang (1965) described the fish based on a sample from Jieshi, Kwang-tung, China. The fish has not been reported much outside its type locality.

Observation: The fish can be easily mistaken for any *Zebrias* species except for its band pattern. It differs from *Zebrias quagga* in the presence of the white spot on its tail and in the mode of attachment of the dorsal and anal fin with caudal fin. It differs from *Zebrias zebra* in the absence of scales in the interorbital region. The species differs from *Z. synapturoides* in the presence of teeth in the blind side of lower jaw. The counts and description of this fish matches well with the original counts and description. The presence of this fish in Indian waters extends the geographical location of the fish to the Western Indian Ocean also.

New Record 13

4.3.7.9.3 *Zebrias japonicus* (Bleeker, 1860)

Aesopia japonica Bleeker, 1860, *Acta. Soc. Sci. Indo- Neerl.*, 8: 71 (type locality: Nagaasaki, Japan).

Synaptura japonica Gunther, 1865, *Cat. Brit. Mus.*, 485 (Nagaasaki, Japan).

Synaptura smithi Regan, 1902, *Ann. Mag. Nat. Hist.*, 7(11): 57, pl. 6, fig. 1.

Zebrias japonicus Jordan and Stark, 1906, *Proc. U.S Nat. Mus.*, 31:234 (South Japan); Jordan, Tanaka and Snyder, 1913, *J. Coll. Sci. Tokyo*, XXXIII (1): 335; Okada and Matsubaara, 1938, *Keys. Fish. Japan* : 435 (South Japan); Matsubaara, 1955, *Fish. Morp. Hierar.*, II: 1282 (Japan, East China); Cheng and Weng, 1965, *Biol. Bull.*, :41, fig. 54 (Taiwan); Cheng and Chang, 1965, *Acta. Zootaxa Sinica*, 2 (4): 273, fig. 4; Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sinica*, 20(2): 29-39 (Kao–hsiung, Taiwan).

Pseudoaesopia japonica Ochiai, 1963, *Bull. Soc. Jap. Nat. Sci. Mus.*,:50. pl. 6; Masuda *et al.*, 1984, *Fish. Jap. Arch.*, 355; Pl 319 –J (Japan).

Plate XXXXVIII: *Zebrias japonicus* (Bleeker, 1860)

Material examined: N=1, TL 146.89 mm from Cochin Fisheries Harbour, Kerala. **Diagnosis:** Eyes on right side, contiguous; inter orbital without scales; band pattern very distinct with 12 brown bands with white bands, each white band with brown dotted line in centre.

Meristic characters: D 83; A 66; P_1 11; P_2 11; C 18, Ll. 108.

Body measurements as percent of SL: HL 20.1; HD 11.4; UJL 4.6; LJL 4.9; ID 1.9; PrOU 3.96; PrOL 4.5; PBU 13.3; PBL 11.2; BD_1 37.2; BD_2 27.1; PDL 5.6; PAL 18.6; DFL 8.2; AFL 9.2; P_1FLO 2.5; V_1FLO 4.7; V_2FLB 4.1; CFL 12.3; ED_1 3.6; DBL 96.7.

As percent of HL: HD 54.7; UJL 22.1; LJL 23.3; PrOU 18.96; PrOL 21.3; PBU 63.6; PBL 53.4; BD_1 177.7; BD_2 129.9; PDL 26.8; PAL 89; DFL 39.4; AFL 43.9; P_1FLO 11.8; V_1FLO 22.2; CFL 59.04; ED_1 17.4; ID 8.9.

Description: Body broad, ovate, compressed. Head small with moderate eyes, separated by a scaly interorbital space. Upper eye placed in advance of lower, lower touches upper jaw. Mouth curved, opening downward, jaws not projected. Dorsal profile of head from snout to above eye concave. Opercular margin fringed slightly. Teeth small present on lower jaw on blind side only. Two nostrils, anterior tubular well in front of lower eye,reaching anterior border of eye when pressed onto body; posterior one covered by a fleshy flap. Lateral line one on each side, straight, originating in front of upper free opercular tip, proceeding to tail. Pectoral fin present attached to outer free end of operculum on ocular side; on blind side rudimentary. Dorsal origin at an angle in front of upper eye, all rays of anal and dorsal fin simple. Dorsal and anal fin joined to caudal fin at base. Caudal fin rays split at its tip. Pelvic fins symmetrical.

A comparative statement of the meristic characters of *Zebrias japonicus* is given in Table 98.

Table 98: A comparative statement of the meristic characters of *Zebrias japonicus*

Meristic characters	**Earlier workers**			**Present study 2004 – 2010**
	Chen & Weng 1965	**Shen & Lee 1981**	**Masuda *et al.*, 1984**	**N = 1**
Dorsal rays	78	71 - 81	71 - 81	83
Anal rays	65	58 - 65	59 - 67	66
Lateral line scales	*	80 - 100	83 - 98	108
Pectoral (O/B)	4	6- 9/ 6 - 8	6 – 9/ 6- 8	11
Caudal	16	18	17 - 19	18

*Data not available

Scales ctenoid on ocular side with 16 -17 radii in each scale from pigmented portion.

Colour: Body slight yellowish with 12 brown vertical bands which extend into dorsal and anal fins interspersed with 12 yellowish bands with a central broen dotted line. Caudal fin slight brownish on the basal region with a broad black posterior two-third lined with a white margin on the outside. No white spots present on caudal fin.

Results of the correlation coefficient analysis done on non-meristic characters of ***Zebrias japonicus*** is given in Table 99

Table 99: Results of the correlation coefficient analysis on non-meristic characters of *Zebrias japonicus*

Characters	In SL	In HL
Head Length	4.78	
Head Width	3.23	0.676
Head depth	8.75	1.829
Upper jaw	21.64	4.522
Lower jaw	20.54	4.294
Eye Diameter (U)	27.52	5.753
Inter orbital	53.91	11.269
Pre orbital (U)	25.23	5.275
Pre orbital (L)	22.49	4.702
Post orbital (U)	7.53	1.574
Post orbital (L)	8.97	1.874
Body depth1	2.69	0.563
Body depth 2	3.68	0.770
Pre dorsal	17.87	3.736
Pre anal	5.38	1.124
Pre pectoral	5.78	1.208
Pre pecteral	6.20	1.297
Pre pelvic	7.02	1.468
Prepelvic	7.05	1.474
Dorsal FL	12.14	2.537
Anal FL	10.89	2.276
Caudal FL	8.10	1.694
Pectoral FL (O)	40.52	8.469
Pelvic FL (O)	21.53	4.500
Pelvic FL (B)	24.16	5.050
Dorsal BL	1.03	0.216
Anal BL	1.12	0.235
Caudal BL	8.10	1.694
Pectoral BL (O)	23.05	4.818
Pectoral BL (B)	22.93	4.793
Pelvic BL (O)	27.35	5.717
Pelvic BL (B)	34.06	7.120

Distribution:

World: Nagaasaki, Japan (Bleeker, 1860); South Japan (Jordan and Stark, 1906; Okada and Matsubaara, 1938); East China (Matsubaara, 1955); Tungkong, Taiwan (Cheng and Weng, 1965). Map showing localities were ***Zebrias japonicus*** has been recorded in the world is given in Fig. 130.

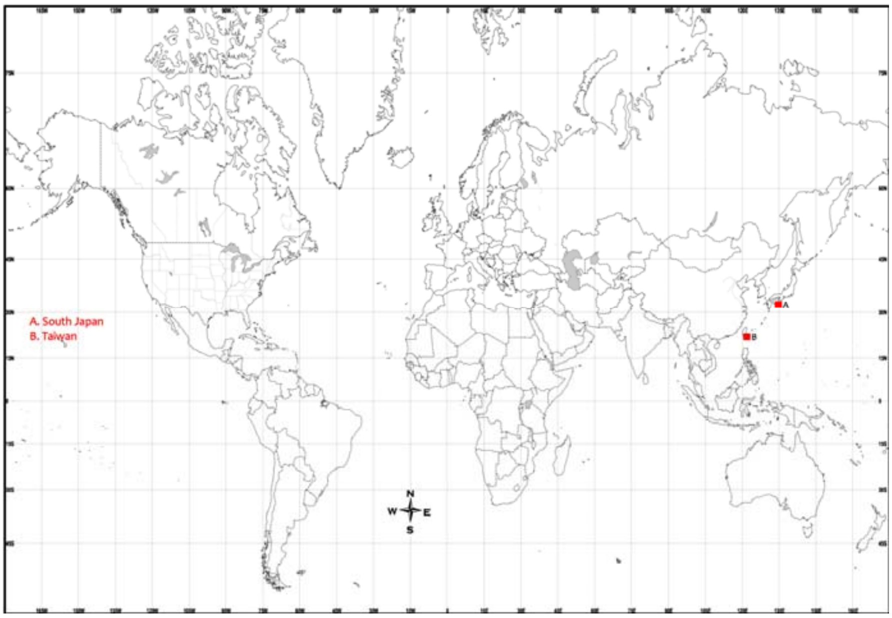


Fig. 130: Map showing localities were ***Zebrias japonicus*** has been recorded in the world.

India: Kochi, Kerala. This is the first record from Indian waters.

Taxonomic remarks: The first description of the fish was as *Aesopia japonica* by Bleeker (1869) based on collections from Japan. Gunther had earlier described a fish as *Synaptura japonica* from the same type locality. Later, Jordan and Starks (1906) synonymised the two and described the fish in a new genus as *Zebrias japonicus*. Ochiai (1963) described the same fish as *Pseudoaesopia japonica* from a sample from Japan; Masuda *et al*. (1984) followed the same name, though the name has been synonymised with *Zebrias japonicus*.

Remarks: The species closely resembles *Zebrias crossolepis* in appearance except for the absence of white spots on the caudal fin and the length of the pectoral finray. This fish is also a new record from the Western Indian Ocean.

4.3.7.9.4 *Zebrias synapturoides* (Jenkins)

Indian zebra sole

Synaptura synapturoides Jenkins, 1910: *Mem. Ind. Mus*., 3: 28, pl. 3, fig. 3 (type locality: Off Ganjam coast, Orissa).

Zebrias synapturoides Norman, 1928, *Rec. Ind. Mus*., 30 : 83, pl. 5; Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 870; Kuronuma and Abe, 1986, *Fish. Arabian Sea*: 252 (Arabian Gulf).

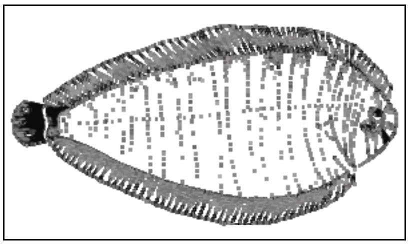


Plate XXXXIX: *Zebrias synapturoides* (Jenkins)

Material examined: N =2; TL 127.06 -158.37 mm from Cochin Fisheries Harbour.

Diagnosis: Body with ctenoid scales, 13 dark vertical bands and absence of a fleshy horn in front of the dorsal fin.

Meristic counts: D 70; A 51; P_1 11; V_1 5; Ll 65, C 18

Body proportions as percent of SL: HL 18.9; HW 29.9; HD 12.5; ED_1 3.2; ED_2 2.9; PrOU 3.4; PBU 12.2; PBL 12.6; DFL 8.5; AFL 8.5; CFL 8.9; P_1FLO 3.7; P_2FLB 2.1; V_1FLO 5.99; V_2FLB 4.5

As percent of HL: HD 65.9; ED_1 17.1; ED_2 15.4; PrOU 17.7; PBU 66.7; PBL 66.7; DFL 45.2; AFL 45.1; CFL 47.2; P_1FLO 20.1; P_2FLB 11.1; V_1FLO 31.7; V_2FLB 23.9.

Description: Body elongate, flat, dextral eyes, nearly contiguous, tentacles absent on eyes. Upper eye a little in front of lower. Mouth curved, cleft reaching to nearly middle of eye. Mouth inferior, maxilla reaching to a vertical from middle of eye. Nostrils in pairs, one thick horn like tissue in front of lower eye on upper jaw region covering posterior nostril, the first a small aperture. In front of fleshy tissue a smaller horn like tissue is present. On blind side of head on the outer free end of operculum white thread like tentacular structures seen which are probably of sensory function. Body covered with ctenoid scales, scales extend onto fin rays. Dorsal and anal fins only partly confluent with caudal, only basal part attached. Right pectoral fin short, upper rays not produced. Fused with upper outer end of operculum to form a skin like structure with rays. Pelvic origin of both sides together. Fine teeth present on blind side of jaw. Caudal fin central 14 rays branched; outer tip oval in outline. Scales strongly ctenoid, each oblong with 12–13 spines, middle longest. Lateral line arising from behind eye proceeding nearly straight on body, each scale with a groove in the centre.

A comparative statement of the meristic characters of *Zebrias synapturoides* is given in Table 100

Table 100: A comparative statement of the meristic characters of *Zebrias synapturoides*

Meristic characters	Earlier workers						Present study 2004 – 2010
	Norman 1928	Ramanathan 1977	Talwar & Kacker 1984	Kuronuma & Abe 1986	Radhamanyamma 1988	Randall 1995	N = 1
Dorsal rays	69 – 76	65 – 86	*	60 – 66	65 – 70	69 – 76	70
Anal rays	59 – 63	53 – 62	*	53 – 55	52 – 58	59 – 63	51
Pelvic rays	*	4 – 5	*	*	5	4 – 5	5
Caudal	18	16 – 18	*	*	15	18	15
Lateral line	*	66 – 73	61 - 71	68 - 73	78 – 87	66 – 71	65
Pectoral (O/B)	*	8 – 9 (O)			9 - 10		11

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Zebrias*** *synapturoides* is given in Table 101

Table 101: Results of the correlation coefficient analysis on non-meristic characters of *Zebrias synapturoides*

Characters	In SL	In HL
Head length	5.30	
Head Width	3.35	0.63
Head Depth	8.03	1.52
Upper jaw	14.86	2.81
Lower jaw	19.13	3.61
Chindepth	20.64	3.90
Dorsal FL (20 ray)	11.73	2.21
Anal FL	11.77	2.22
Pectoral (O) FL	26.37	4.98
Pectoral(B) FL	47.92	9.05
Pelvic (O) FL	16.70	3.15
Pelvic (B) FL	22.16	4.18
Caudal FL	11.23	2.12
Dorsal BL	1.07	0.20
Anal BL	1.25	0.24
Pectoral BL	14.75	2.79
Pelvic BL	23.84	4.50
Caudal BL	17.07	3.22
Eye Diameter (U)	31.02	5.86
Eye Diameter (L)	34.35	6.49
Inter orbital	169.71	32.05
Pre orbital (U)	29.87	5.64
Pre orbital (L)	18.49	3.49
Post orbital (U)	8.19	1.55
Post orbital (L)	7.93	1.50
Pre dorsal	14.27	2.69
Pre anal	4.15	0.78
Pre pectoral (O)	4.92	0.93
Pre pectoral (B)	5.13	0.97
Prepelvic	4.86	0.92

Colour: 13 dark bands on body which extend into fins interlined with white bands. Caudal fin brownish with a yellow ocellii in the centre. Pectoral blackish. Blind side whitish. In preserved specimen colour is retained.

Distribution:

World: Arabian Gulf (Kuronuma and Abe, 1986).)**.** Map showing localities were ***Zebrias synapturoides*** has been recorded in the world is given in Fig. 131.

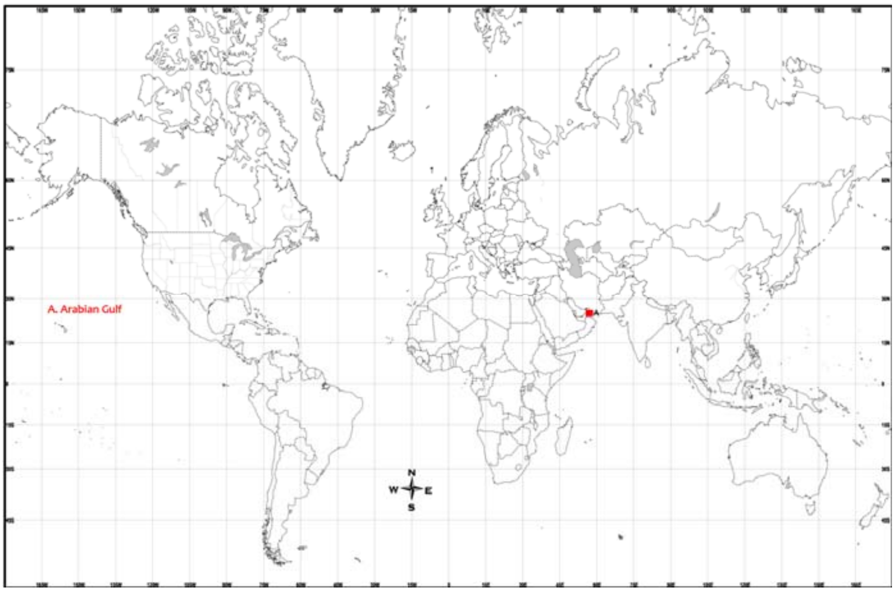


Fig. 131: Map showing localities were ***Zebrias synapturoides*** has been recorded in the world.

India: Reported from Ganjam coast, Orissa (Jenkins, 1910); Southwest, east coast of India (Talwar and Kacker, 1984); Veli, Trivandrum (Radhamanyamma, 1988); Porto Novo (Ramanathan, 1977); Cochin Fisheries Harbour (present study).

Map showing localities were ***Zebrias synapturoides*** has been recorded in India is given in Fig. 132.

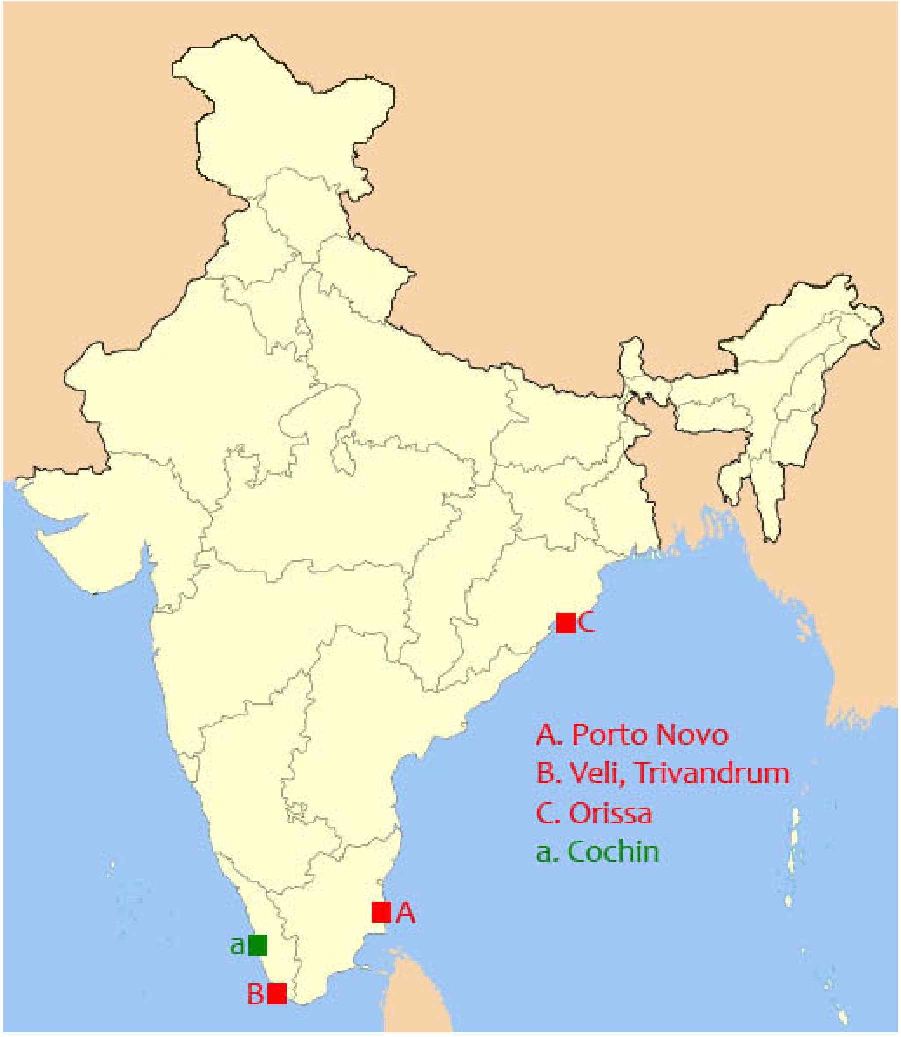


Fig. 132: Map showing localities were ***Zebrias synapturoides*** has been recorded in India

Taxonomic comments: Joglekar (1976) opined that "*I have examined specimens of Zebrias synapturoides including Jenkin's type and found that teeth are present on half of these bones near the angle of the mouth*". Scales on ocular side are strongly ctenoid, blind side less, vertical fins confluent with caudal. Randall (1995) stated that "*the specimen from the Arabian Gulf 62 mm in standard length tentatively identified by Kuronuma and Abe (1986) as Z. quagga is Z. synapturoides with an aberrant caudal region*" (appears to have regenerated after having the end of the tail removed).

Observation: This fish differs from *Aesopia cornuta* in the presence of ctenoid scales on body and absence of fleshy horn. The dorsal, anal counts of the specimen are well in agreement with Ramanathan (1977) and Radhamanyamma (1988) from Indian coast. However, lateral line counts given by Radhamanyamma (1988) are very high. The present lateral line counts (65) agree with Talwar and Kacker (1984) as well as with Ramanathan (66 -73).

4.3.7.9.5 *Zebrias quagga (*Kaup, 1858)
Fringe fin zebra sole

Aesopia quagga Kaup, 1858, *Archiv. Nat*., 1: 98 (Bombay).

Synaptura quagga Gunther, 1862, *Cat. Brit. Mus*.,: 485; Weber and Beaufort, 1929, *Fish. Indo-Aust. Arch*., :173.

Synaptura zebra Day (nec. Bloch), 1877, *Fish. India*: 430, pl. 94, fig. 3; Day, 1889, *Fauna Br. India, Fish*. 2: 450.

Zebrias quagga Hubbs, 1915, *Proc. U.S Nat. Mus*., XLVIII: 493 (Hong Kong, China); Norman, 1928, *Rec. Ind. Mus*., 30 (2): 184, pl. 6 (Persian Gulf); Chu, 1931, *Index Pisc. Sinen*.,: 93 (China, Chefoo); Wu, 1932, *Thèse Fac. Sci. Univ. Paris A* 224 (268): 129; Fowler, 1956, *Fish. Red. Sea*, I: 178 (China); Shen and Lee, 1981, *Bull. Inst. Zool. Acad. Sinica,* 20 (2): 36, fig. 13; Munroe, 1955, *Fish. Ceylon*: 263, fig. 763; Chen and Weng, 1965, *Tunghai Univ. Biol.*, 27 (5): 42 – 44; fig. 55; Shen, 1969, *Rep. Inst. Fish. Bio.*, 2 (4): 19, figs 1- 4.

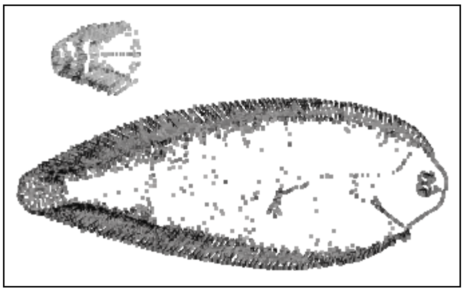


Plate L: *Zebrias quagga (*Kaup, 1858)

Material examined: N=1, 110.88 TL from Pamban landing centre.

Meristic counts: D 61, A 52, V_1 4; V_2 4; Ll. 85

Body proportions as percent of SL: HL 18.9; HW 30.9; HD 14.5; BD1 27.8; BD2 34.95; ED1 4.8; ED2 4.7; PrOU 4.7; PBU 10.1; PBL 9.4; DFL 7.1; AFL 6.2; CFL 13.8; P_1FLO 4.98; P_2FLB 4.1; V_1FLO 3.8; V_2FLB 5.3; DBL 100.6; ABL 85.2; P_1BLO 4.9; P_2BLB 4.9; V_1BLO 2.1; V_2BLB 4.1; CPD 8.6.

As percent of HL: HW 162.9; HD 76.7; BD_1 146.9; BD_2 184.5; ED_1 25.2; ED_2 25.0; PrOU 24.8; PBU 53.1; PBL 49.7; DFL 37.3; AFL 32.7; CFL 72.6; P_1FLO 26.3; P_2FLB 21.6; V_1FLO 20; V_2FLB 27.9; P_1BLO 25.8; V_1BLO 11.1; V_2BLB 21.8.

Description: Body flattened, oval, broad, eyes dextral, placed close together, upper placed close to dorsal profile, slightly in front of lower; both eyes with a short tentacle. Nostrils on blind side not conspicuous. Mouth cleft small, reaches upto 1/3 of lower eye.

Lips not fringed. Teeth very small. Two nostrils, anterior with a short tube. Dorsal origin on head in front of eyes. Anal fin origin. Dorsal and anal fins confluent with caudal. Pectoral fin prominent on right side, left side smaller. Pelvic fin small. Single lateral line origin from upper outer free end of operculum, procceding to tail on ocular side. Body covered with weakly ctenoid scales. On blind side of snout, scales modified into thin sensory papillae. A comparative statement of the meristic characters of *Zebrias quagga* is given in the Table 102

Table 102 : A comparative statement of the meristic characters of *Zebrias quagga*

Meristic characters	Earlier workers				Present study
	Norman 1928	Fowler 1956	Shen & Lee 1981	Kuronuma & Abe 1986	N = 1
Dorsal rays	66 -73	64 – 73	63 -75	59	61
Anal rays	56 – 61	53 – 61	53– 61	53	50
Pelvic rays	*	*	4	*	4
Caudal	*	16 – 18	18	*	16
Stripes	*	10 - 11	*	11	12
Lateral line	92 - 99	85 - 99	85 – 89	*	*
Pectoral (O/B)	*	*	5-7/6-8	9/11	85

*Data not available

Results of the correlation coefficient analysis done on non-meristic characters of ***Zebrias quagga*** is given in Table 103.

Table 103: Results of the correlation coefficient analysis on non-meristic characters of *Zebrias quagga*

Characters	In SL	In HL
Head length	5.28	
Head width	3.24	0.61
Head depth	6.89	1.30
Body depth 1	3.59	0.68
Body depth 2	2.86	0.54
Eye Diameter (U)	20.96	3.97
Eye Diameter (L)	21.14	4.00
Pre orbital (U)	21.10	4.00
Pre orbital (L)	21.33	4.04
Post orbital (U)	9.94	1.88
Post orbital (L)	10.62	2.01
Mouth	15.20	2.88
Dorsal finlength	14.17	2.68
Anal finlength	16.17	3.06
Caudal finlength	7.28	1.38
Pectoral (O) finlength	20.07	3.80
Pectoral (B) finlength	24.46	4.63
Pelvic (O) finlength	26.36	4.99
Pelvic (B) finlength	18.91	3.58
Dorsal baselength	0.99	0.19
Anal baselength	1.17	0.22
Pectoral (O) baselength	20.44	3.87
Pectoral (B) baselength	20.44	3.87
Pelvic (O) baselength	47.50	9.00
Pelvic (B) baselength	24.22	4.59
Caudal peduncle depth	11.58	2.19

Colour: Ocular side with 10 bands separated by narrow white bars in addition to 2 bands one at caudal region region and one at head tip. Bands extend onto fins. Pectoral fin prominent on right side, outer free tip black. Caudal fin black with white patterns.

Distribution:

World: Reported from Persian Gulf, India through East Indies to China; Hong Kong, China (Hubbs, 1915; Chu, 1931; Fowler, 1956). Map showing localities were ***Zebrias quagga*** has been recorded in the world is given in Fig. 133.

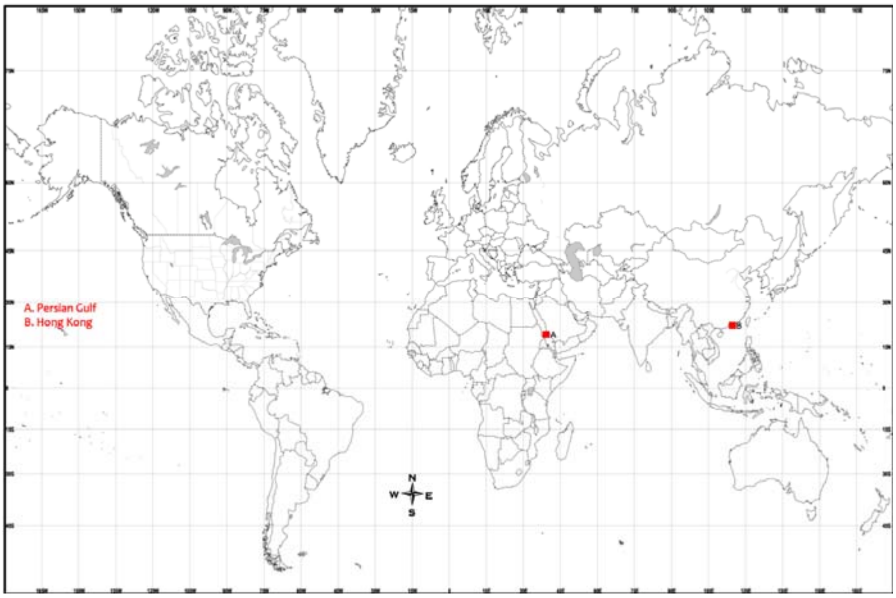


Fig. 133: Map showing localities were ***Zebrias quagga*** has been recorded in the world.

India: Bombay (Kaup, 1858); Gulf of Mannar (present study).

Map showing localities were ***Zebrias synapturoides*** has been recorded in India is given in Fig. 134.

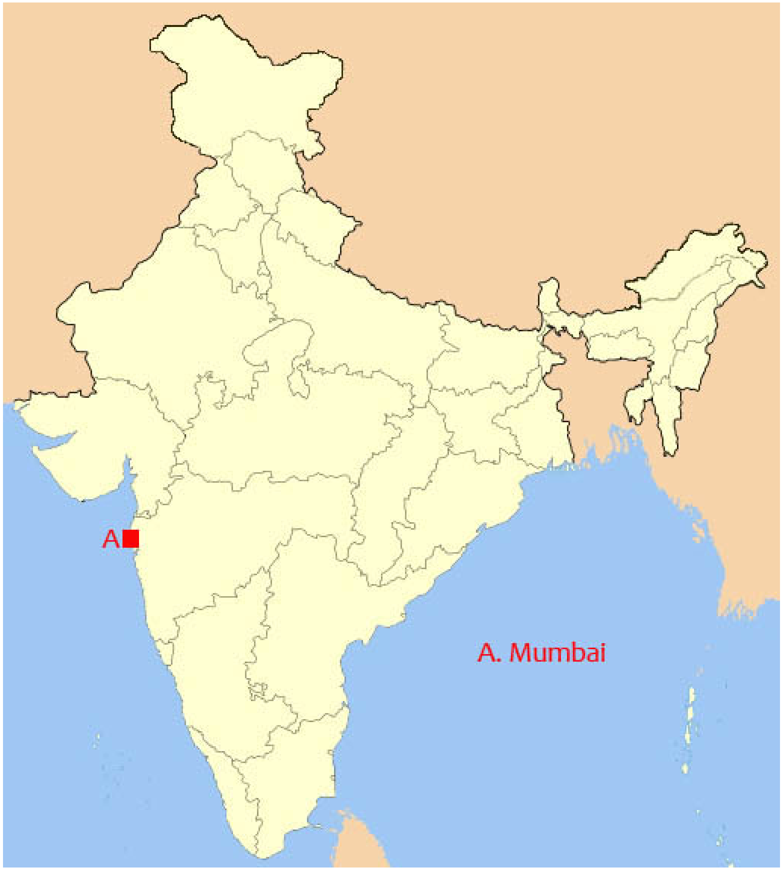


Fig. 134: Map showing localities were ***Zebrias quagga*** has been recorded in India

Taxonomic comments: The fish was first described as *Aesopia quagga* by Kaup (1858), but the absence of the first thickened dorsal fin ray makes it differ from the other member of the *Aesopia* genus. Gunther (1862) placed it in *Synaptura* genus; however, Hubbs (1915) placed the species in genus *Zebrias* based on examination of a sample from Hong Kong.

Remarks: The fish is said to resemble *Z. zebra*, but mouth is sharper and eyes contiguous.

4.3.8 Family Cynoglossidae

The **tongue soles** are a very diverse family of specialized marine, estuarine and freshwater flatfishes comprising of about 127 primarily small, sinistral species (Munroe, 1998) distributed in three genera *Symphurus* Rafinesque 1810, *Cynoglossus* Hamilton–Buchanan 1822 and *Paraplagusia* Bleeker 1886. The genera *Symphurus* and *Cynoglossus* contain most of the species, while *Paraplagusia* contains only 4 species. Eleven species of Cynoglossids were recorded by Alcock (1889) during the *Investigator* collections. Family Cynoglossidae was placed in Division Solaeiformes by Regan (1910) with "*sinistral vertical fins confluent, no pectorals, pelvic fin of blind side present, four rayed, median in position. Three genera Symphurus, Paraplagusia and Cynoglossus were recognised. Regan also adds that the two families Soleidae and Cynoglossidae are "closely related*". Fowler (1934) mentions that these fishes are "*distinguished from soles chiefly by having their eyes and colour on the left side of the body*". Norman (1927) recorded three genera with 27 species in all from Indian waters. Menon (1977) recognised 49 species of cynoglossids from the Atlantic coast of Africa to Indo-West Pacific waters. Heemstra (1986) also recognized the three genera in Family Cynoglossidae. The genera *Cynoglossus* and *Paraplagusia* have been revised by Menon (1977) and Chapleau and Renaud (1993) respectively. Various geographic assemblages of species within the species–rich genus *Symphurus* has also been revised (Munroe, 1990, 1998) or updated (Munroe, 1992; Munroe *et al*., 1995; Munroe and Marsh, 1997; Munroe and Amaoka, 1998). Species–level taxonomy of *Cynoglossus* remains problematic, and new species of *Symphurus* continue to be discovered especially from Indo – Pacific deep water habitats. According to Nelson (2006), the family is divided into two subfamilies –

Symphurinae with one genus and about 77 species and Cynoglossinae with two genera *Cynoglossus* with 50 species and *Paraplagusia* with three species. Chapleau (1988) provided convincing evidence based on 27 derived characters that corroborate the monophyly of this family. Diagnosis of monophyletic genera and their intra-relationships within the family still require further study (Munroe, 2005).

The members of the family Cynoglossidae are typically sinistral, the jaws are strongly asymmetrical; usually there are two nares on each side of the head, the anterior one tubular, the narial tube of the eyed side always arising in front of the fixed eye. Eyes small, placed close together not separated by a ridge. Margin of the pre-operculum is concealed by skin and scales. Mouth inferior, curved, snout overhanging mouth, hook like, 2 - 3 lateral line on ocular side. Lips on coloured side sometimes fringed with a row of tentacles. The dorsal and anal fins are confluent with the caudal; the dorsal fin extends onto the head parallel to the body; ends above the upper eye; the pectoral fin and pelvic fin on ocular side absent in adult. Pelvic fin on blind side with four rays along mid ventral line; in some attached to anus. Anus is on the blind side. Body generally covered with ctenoid scales. The sensory fringes on the ventral side of the head are absent in most species. Epidermal hairs are absent. Lateral line present – one to three on ocular side none to two on blind side.

Review of observations done by various workers on Family Cynoglossidae is given in Table 104

Table 104: Review of observations by various workers on Family Cynoglossidae

Genus	Synonym	Type	Observations			
			Norman	Others	Menon	Eschmeyer
Cynoglossus Hamilton 1822	***Arelia*** Kaup 1858	Fem. *Pleuronectes arel* Bloch & Schneider 1801	Synonym		Synonym	**VALID**
	Areliscus Jordan & Snyder, 1900	Masc. *Cynoglossus joyneri* Günther 1878 Type by monotypy.	Synonym		Synonym	**Synonym**
	Cantoria Kaup 1858	Fem. *Cantoria pinanganensis* Kaup 1858	Synonym		Synonym	**Synonym**
	Cantorusia Whitley 1940	Fem. *Cantoria pinanganensis* Kaup 1858	Synonym		Synonym	**Synonym**
	Cynoglossoides von Bonde 1922	Masc. *Cynoglossus attenuatus* Gilchrist 1904	Synonym		Synonym	**Synonym**
	Cynoglossoides Smith 1949	Masc. *Cynoglossus acaudatus* Gilchrist 1906	Synonym	Li & Wang 1995:334 treated it as valid	Synonym	**Synonym**
	Dexiourius Chabanaud 1947	Masc. *Cynoglossus semilaevis* Günther 1873	Synonym		Synonym	**Synonym**
	Dollfusichthys Chabanaud 1931	Masc. *Dollfusichthys sinusarabici* Chabanaud 1931	Synonym		Synonym	**Synonym**
	Icania Kaup 1858	Fem. *Achirus cynoglossus* Hamilton 1822	Synonym		Synonym	**Synonym**
	Notrullus Whitley 1951	Masc. *Cynoglossus acaudatus* Gilchrist 1906	Synonym		Synonym	**Synonym**
	Trulla Kaup 1858	Fem. *Plagusia trulla* Cantor 1849	Synonym	Synonym but a valid sub-genus	Synonym	**Synonym**
Paraplagusia Bleeker 1865:274		Fem. *Pleuronectes bilineatus* Bloch 1787	Synonym		Synonym	**VALID**
	Rhinoplagusia (subgenus of *Paraplagusia*) Bleeker 1870	Fem. *Plagusia japonica* Temminck & Schlegel 1846	Synonym		Synonym	**Synonym**
	Usinostia Jordan & Snyder 1900	Fem. *Plagusia japonica* Temminck & Schlegel 1846				

According to Norman (1928), three genera were reported in Indian waters – *Paraplagusia*, *Cynoglossus* and *Symphurus* with 2, 21 and 4 species respectively Norman (1928). The main character differentiating the genera *Paraplagusia* and *Cynoglossus* with *Symphurus* is the presence/absence of the lateral line on the ocular side; the two genera *Cynoglossus* and *Paraplagusia* are differentiated by the absence/presence of fringes on lips.. Fowler (1934) reported 4 genera in Family Cynoglossidae from China –*Paraplagusia*, *Trulla*, *Cynoglossus* and *Symphurus*. Munroe (1955) reports of 12 species of cynoglossids in 3 genera *Paraplagusia*, *Cynoglossus* and *Symphurus* from Ceylonese waters. Smith (1961) mentions of seven genera in South African waters – *Symphurus*, *Paraplagusia*, *Cynoglossoides*, *Cynoglossus, Arelia*, *Trulla* and *Areliscus* with 12 species. Chen and Weng (1965) recognized four genera in Family Cynoglossidae – *Paraplagusia*, *Cynoglossus*, *Areliscus* and *Symphurus*; the distinguishing characters wee fringes on lips and number of lateral lines on body. Talwar and Kacker (1984) reported three genera with seventeen species from Indian waters. Of the three genera, *Symphurus*, *Cynoglossus* and *Paraplagusia*, they opined that "*the fishes of the genus Symphurus Rafinesque occur in depths of 400 - 1500 m and are rare in our area*". Genus *Symphurus* is said to occur on both sides of the America, in the eastern Atlantic and Indo–west Pacific (including Hawaii) (Munroe, 1998; 2003; Munroe *et al.*, 2000; Munroe in Carpenter and Niem, 2001; Krabbenhoft and Munroe, 2003). Species in the subfamily Cynoglossinae are said to occur from the eastern Atlantic to the western Pacific. Tongue soles differ from true soles (Soleidae) in their sinistral eyes and absence of pectoral fin.

In the present study, 2 genera *Cynoglossus* with 12 species and genus *Paraplagusia* with 1 species were collected in subfamily Cynoglossinae.

Cynoglossus acutirostris

Cynoglossus arel

Cynoglossus bilineatus

Cynoglossus carpenteri

Cynoglossus cynoglossus

Cynoglossus dubius

Cynoglossus itinus

Cynoglossus lida

Cynoglossus macrolepidotus

Cynoglossus macrostomus

Cynoglossus punticeps

Paraplagusia bilineata

4.3.8.1 Genus *Cynoglossus* Hamilton – Buchanan

Cynoglossus Hamilton–Buchanan, 1822, *Fish. Ganges*: 32, 365 (type: ***Cynoglossus lingua*** Hamilton–Buchanan, monotypy); Norman, 1928, *Rec. Ind. Mus*., XXX: 193; Menon, 1977, *Smithsonian Cont. Zoo*., 238:1; Talwar and Kacker, 1984, *Comm. Sea Fish.,*: 871; Regan, 1920, *Ann. Durban Mus*., II: 220.

Cantoria Kaup, 1858, *Arch. Natur.* 24 (1):106 (type: ***Plagusia potous*** Cantoria = *Cantoria penanganensis* Kaup).

Arelia Kaup 1858, *Arch. Natur.* 24(1): 107 (type: ***Pleuronectes arel*** Schneider = *Arelia schneider* Kaup, tautonymy).

Icania Kaup, 1858, *Arch. Natur.* 24(1): 109 (type: ***Trulla cantori*** Kaup= *Plagusia trulla* Cantor, tautonymy.

Trulla Kaup, 1858, *Arch. Natur.* 24 (1):109 (type: ***Trulla cantori*** Kaup = *Plagusia trulla* Cantor, tautonymy).

Areliscus Jordan and Snyder, 1900, *Proc. U. S Nat. Mus.* 23 (1213): 380 (type: ***Cynoglossus joyneri*** Gunther, monotypy.

Cynoglossoides Bonde, 1922, *Rep. Fish. Mar. Biol. Surv. Union S. Africa, 2 (Sp. Rep.* 1*)*: 23 (type: ***Cynoglossus attenuatus*** Gilchrist, 1905, monotypy).

Dollfusichthys Chabanaud, 1931, *Zool. Anz., 93* (3/4): 304 (type: ***Dollfusichthys sinusarabici*** Chabanaud, monotypy).

Dexiourius Chabanaud 1947, *Bull. Mus. Nat. Hist. Nat*., (2)19: 443 (type: ***Cynoglossus semilaevis*** Gunther 1873, monotypy).

Description: Lanceolate body, sinistral, upper migratory eye placed well in advance of the fixed lower eye; jaws strongly assymetrical, two nostrils on each side of the head, anterior tubular, rising in front of the lower fixed eye; on blind side, anterior nostril is tubular, posterior is slit like. Mouth asymmetrical; teeth present on the lower jaw of the blind side, villiform in bands. Gape of mouth narrow, snout is hooked, overhanging the mouth. Lips plain, not fringed. Gill opening is narrow, operculum not very bony, gill membranes are united. Dorsal and anal fins confluent with the caudal, dorsal fin extends onto front portion of head in front of eyes upto snout; pectorals absent. Ventral on blind side present with 4 rays, fin attached to anal fin by a membranous extension of the last fin ray. Body covered with ctenoid and/or cycloid scales, sometimes both seen on same species. Two to three lateral lines on body, connected by tubules; one lateral line seen at the centre, the other two if present parallel to the dorsal and anal fins. Lateral line on the dorso – anterior border either zigzag in pattern or broken and enters the dorsal fin near the hind end, the point of entry varying species wise and even individual wise among species. The lateral line near the anal finbase ie venterolateral line arises from the base of the pelvic fin and runs parallel to the anal finbase, entering it near the anal base end, a few rays before the caudal fin. A complex system of lines present on the cephalic region. Blind side with either no lateral line or one to two lines. Lateral line tubules on ocular side seen passing through scales, on blind side, seen above the scales. Body covered with ctenoid scales on ocular side, cycloid or ctenoid scales on blind side.

Distribution: The geographical area of *Cynoglossus* comprises the eastern tropical Atlantic, the eastern Mediterranean, the whole of the Indian Ocean, including the Malay area in the east, the Persian Gulf, the Gulf of Oman and the Red Sea, the whole of the East Coast of Africa as far south as the Cape of Good Hope in the west, the West Pacific from south China to south Japan, and the whole of the periphery of the Australian continent. The eastern and northern limit of *Cynoglossus* is Tokyo at 35°40'N (*C. interruptus);* the southern limit is the mouth of the Murray River, South Australia, at 34°10'S (*C. broadhursti).* The western limit is marked by the Canary Islands, about 30°N (*C. canariensis)* in the Northern Hemisphere, and Angola, about 10°S (*C. canariensis)* in the Southern Hemisphere (Menon, 1977).

Taxonomic comments: The first description of a cynoglossid was by Schneider on *Pleuronectes arel* from Tranquebar. Lacepede (1802) later described *Achirus bilineatus* from China and the East Indies. Genus *Cynoglossus* described by Hamilton – Buchanan was the seventh in the order Apodes with the character "*fishes having the dorsal spine of bone and wanting ventral fins*." The genus was characterised with "*both eyes on one side of the head with a flat body formed for swimming on the side opposite to the eye*". Under the genus *Cynoglossus,* Hamilton-Buchanan included only one species, *C. lingua.* In the same work Hamilton-Buchanan described another species, *Achirus cynoglossus* under a fourth order Thoracini, comprising of fishes having the dorsal spine of bone and ventral fin placed immediately under the pectorals. He recognized, however, the close relationship of this species to *C. lingua.* Jordan and Starks (1906a) restricted the genus name *Cynoglossus* to species with two lateral lines on the ocular side; species with three lateral lines were placed in *Areliscus.* According to Hensley and Ahlstrom (1984) the tongue soles are monophyletic. They are unique in having the ventral fin of the blind side oriented along the midventral line and the ocular fin placed either more dorsally or missing. The relationship of this family to other groups however is obscure. Gunther (1862) did not consider any of Kaup's genera distinct and grouped them all under *Cynoglossus.* Bonde (1922) considered forms with two lateral lines on each side as *Cynoglossoides* and commented (1925) on the utility of splitting the original genus *Cynoglossus* into separate genera and subgenera; however he observed that "*if carried too far it may lead to complications and an undue number of monotypic genera.*" Further he added that "*the lateral line which is the main* *character used in splitting the genera is not always a constant one*." Unaware of the generic name *Cynoglossoides* proposed by Bonde, Smith (1949), included forms with two lateral lines on ocular side and none on the blind side under his genus *Cynoglossoides,* with C. *ecaudatus* as the type species. Agreeing with Norman (1926), Menon (1977) opined that "*I find that the number and nature of nostrils and the number of lateral lines on the ocular side are of little value in generic differentiation. Cantoria is characterized by two nostrils on the ocular side, both located above the upper lip; Arelia by the presence of two nostrils, one tubular on the upper lip before the eyes and the other between the eyes; Trulla by the presence of only one nostril in front of the lower eye; and Icania with no conspicuous nostril at all*". Weber and Beaufort (1929) proposed an identification key for the Indo –Australian Cynoglossus species; 24 species were recorded and classified based on the presence of 2.3 lateral lines on coloured side. Chabanaud (1981) proposed *Dollfusichthys* for a form characterized by a single lateral line on the ocular side. Chabanaud (1947c) proposed the genus *Dexiourius* for certain individuals of *C. semilaevis* from China with a vestigial pelvic fin persisting on the eyed side.

Remarks: 20 species of *Cynoglossus* were reported by Norman (1928). Munroe (1955) recorded nine species of cynoglossids from Ceylonese waters. Two species of cynoglossids were recorded by Smith (1971) from South Africa – *Cynoglossus lingua* and *C. lida*. Menon (1977) recognized 49 species in the genus. Of these, except four species from west coast of India, all the others were collected from Orissa, Sunderbans or West Bengal. Many of these species have been subsequently synonymised. Eight species of cynoglossids were recorded by Chen and Weng (1965) from Taiwan. Heemstra (1986) mentions of

9 species of *Cynoglossus* from South African waters of which only species *C. lida* is common to Indian waters. Talwar and Kacker (1984) reported 15 species from Indian waters out of 49 reports from Indian Ocean. Seven species were reported from Gulf by Kuronuma and Abe (1977) – *C. kopsi*, *C. arel*, *C. carpenteri*, *C. bilineatus*, *C. sealarki*, *C. lingua* and *C. punticeps*. Twelve species of *Cynoglossus* has been collected in this present work.

4.3.8.1.1 *Cynoglossus acutirostris* Norman, 1939.

Sharp nose tongue sole

Cynoglossus (Areliscus) acutirostris Norman, 1939, *John Murray Exped.*, 7 (1):104, fig. 35 (Gulf of Aden, northwestern Indian Ocean, station 194, depth 220 meters); Menon, 1977, *Smith. Contr. Zoo.,* 238: 84; Klausewitz, 1994, *Proc. Fourth Indo-Pac. Fish Conf.*,:466; Goren and Dor, 1994, CLOFRES II:72; Desoutter *et al.*, 2001, *Cybium*, 25 (4):330 ; Manilo and Bogorodsky 2003, *J. Ichth.*, 43 (Suppl. 1):S123.

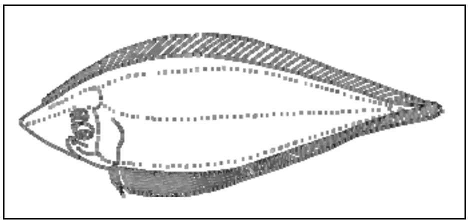


Plate LI: *Cynoglossus acutirostris* Norman, 1939.

Material examined: N= 1, TL 178.32 mm from Cochin Fisheries Harbour.

Diagnosis: The species has an acutely pointed long snout which makes it easily distinguished from other Cynoglossid species.

Meristic counts: D 108; A 89; C 12; P_1 10; P_2 7; V_1/V_2 5/5.

Body measurements as percent of SL: TKL 81.7; HL 21.4; HW 33.97; HD 16.6; UJL 4.7; CD 6.8; ED_1 3.97; ED_2 3.9; ID 1.1; PrOU 4.74; PrOL 4.8; PBU 16.3; PBL 13.2; UHL 13.2; LHL 17.7; PDL 6.4; PAL 21.99; P_1LO 21.8; P_2LB 19.03; V_1LO 18.03; BD_1 30.8; BD_2 38.9; DFL 6.97; AFL 8.8; CFL 13.9; P_1FLO 5.6; P_2FLB 4.1; V_1FLO 4.7; DBL 96.7; ABL 84.6; CBL 6.98; P_1BLO 6.4; P_2BLB 6.1; V_1BLO 1.3; V_2BLB 1.3.

As percent of HL: HW 159.1; HD 77.9; UJL 22.2; CD 31.7; ED_1 18.6; ED_2 18.1; ID 4.9; PrOU 22.2; PrOL 22.4; PBU 76.1; PBL 61.7; UHL 61.7; LHL 83.1; PDL 30.1; PAL 103.01; P_1LO 101.9; P_2LB 89.1; V_1LO 84.5; BD_1 144.2; BD_2 182.3; DFL 32.7; AFL 41.3; CFL 65.3; P_1FLO 26.1; P_2FLB 19.4; V_1FLO 21.8; CBL 32.7; P_1BLO 29.9; P_2BLB 28.7; V_1BLO 6.1; V_2BLB 6.1.

Description: Body lanceolate with a acutely pointed snout and tail. Body broadest just behind head. Eyes sinistral separated by a concave interorbital space; eyes placed one above the other, the upper a little ahead of lower on ocular side. Nostrils in pairs, anterior one fleshy and tubular above the upper lip, the second round in shape in the interorbital space. On blind side, two nostrils present, stump like above upper lip. Rostral hook long, reaches well beyond posterior border of lower eye; angle of mouth nearer to opercular tip than tip of snout. Mouth slit like on ocular side; on blind side, upper and lower jaws are thick, fleshy and semi circular in pattern. Teeth close set, sharp, villiform on lower jaw. Upper jaw with small sharp teeth in many rows. Dorsal fin origin well in front of the eyes. Body raised a little behind the head region, sloping gently towards tail; blind side flat. Three lateral lines present on ocular side; with 74 lateral line scales in the central row from behind the junction on head, dorso lateral branch proceeding straight and touching the lateral line below dorsal fin base; 18 scale rows separating the two. The lateral line at the anal fin base or the ventro –lateral branch at its anterior end ends into the anal fin at the 10^{th} ray. One branchlet of lateral line enters the snout passing above the eye; 18 scale rows present here. Two other small branchlets seen on head –one from the interorbital space into the rostral hook, the second into the opercular margin at the ventral part.

A comparative statement of the meristic characters of *Cynoglossus acutirostris* is given in Table 105.

Table 105: A comparative statement of the meristic characters of *Cynoglossus acutirostris*

Meristic characters	Earlier workers		Present study 2004 – 2010
	Menon 1977	Klausewitz 1994	N = 1
Dorsal rays	110	125	108
Anal rays	94	100	89
Pectoral (O/B)	*	*	10/7
Caudal	*	*	12
Lateral line scales	84 - 92	*	84

Results of the correlation coefficient analysis on non-meristic characters of ***Cynoglossus acutirostris*** is given in Table 106.

Table 106: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus acutirostris*

Characters	in SL	In HL
Trunk Length	1.22	
Head Length	4.68	
Head Width	2.94	0.63
Head depth	6.01	1.28
Upper jaw	21.22	4.53
Chin depth	14.76	3.15
Eye Diameter (U)	25.17	5.37
Eye Diameter (L)	25.95	5.54
Inter orbital	95.10	20.31
Pre orbital (U)	21.12	4.51
Pre orbital (L)	20.94	4.47
Post orbital (U)	6.16	1.31
Post orbital (L)	7.59	1.62
UHL	7.59	1.62
LHL	5.64	1.20
Pre dorsal	15.55	3.32
Pre anal	4.55	0.97
Pre pecteral	4.60	0.98
Pre pecteral	5.25	1.12
Pre pelvic	5.54	1.18
Body depth	3.25	0.69
Max. depth	2.57	0.55
Dorsal FL	14.34	3.06
Anal FL	11.34	2.42
Caudal FL	7.17	1.53
Pectoral FL(O)	17.98	3.84
Pectoral FL (B)	24.19	5.17
Pelvic FL	21.44	4.58
Dorsal BL	1.03	0.22
Anal BL	1.18	0.25
Caudal BL	14.32	3.06
Pectoral BL (O)	15.67	3.35
Pectoral BL (B)	16.35	3.49
Pelvic BL (O)	76.43	16.32
Pelvic BL (B)	76.43	16.32

Scales: Body with cycloid scales on ocular side with ctenoid scales posteriorly in the latter part of body; scales cycloid on blind side. Cycloid scales roughly rhomboidal in shape; ctenoid squarish with fine sharp ctenii 5- 6 projecting out.

Colour: Ocular side uniform brownish, blind side white.

Distribution:

World: Red Sea, Gulf of Aden (Norman, 1939). Map showing localities were *Cynoglossus acutirostris* has been recorded in the world is given in Fig. 135.

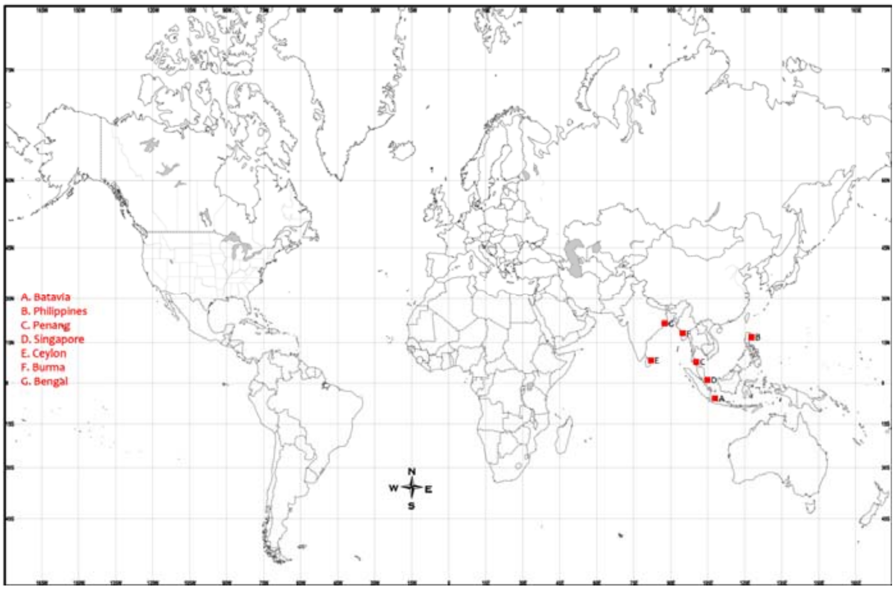


Fig. 135: Map showing localities were *Cynoglossus acutirostris* has been recorded in the world

India: Cochin, Kerala (present study). This is the first record from the Indian coast. Map showing localities were *Cynoglossus acutirostris* has been recorded in India is given in Fig. 136.

Fig.136: Map showing localities were *Cynoglossus acutirostris* has been recorded in India

Taxonomic remarks: The fish was originally described in the same name based on 11 specimens, 182.0-238.0 mm SLfrom Gulf of Aden by Norman (1939) from a depth of 220 m.

Remarks: The morphometric and meristic values of the present specimen agree fully with that of the original description, confirming the presence of the fish in Indian waters.

4.3.8.1.2 *Cynoglossus arel* (Schneider, 1801)

Brown tongue sole

Pleuronectes arel Bloch and Schneider, 1801, *Syst. Ichth*.,: 159 (type locality: Tranquebar, east coast of Madras, India).

Cynoglossus arel Norman, 1928, *Rec. Ind. Mus*., 30 (2): 201; Fowler, 1934, *Fish. China*, V:209; De Silva, 1956, *Ceylon J. Sci., C*, 7(2): 199 (Palk Bay, Ceylon); Munroe, 1955, *Fish. Ceylon*: 265, pl. 51, fig. 769 (coastal waters of Ceylon); Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean*., 1:76 (Kerala coast); Menon, 1977, *Smith. Contr. Zool*., 238: 60, fig. 29; Dor 1984, *Fish. Red Sea*, CLOFRES: 271; Ochiai in Masuda *et al*. 1984, *Fish. Jap. Archip.,*: 356, pl. 369-N; Rahman, 1989, *Freshwater Fish. Bangladesh*: 34; Coad, 1991, *Syllogeus*, 68: 27; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166: 209; Krishnan and Mishra, 1993, *Rec. Zool. Surv. India*, 93 (1-2): 235 as *areal*; Krishnan and Mishra, 1994, *Rec. Zool. Surv. India*, 94:300; Goren and Dor 1994, *Fish. Red Sea*, CLOFRES: 72; Li and Wang, 1995, *Fauna Sinica*: 341; Randall, 1995, *Coastal fish. Oman*: 363; Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 599; Carpenter *et al*., 1997, *FAO Sp. Iden. Kuwait*: 231; Chen *et al*., 1997, *Fish. Nansha Islands*: 177; Munroe in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 646; Nakabo, 2000, *Fish. Japan*, 2: 1389; Bijukumar and Sushama, 2000, *J. Mar. Biol. Ass. India,* 42 (1-2):187; Munroe in Carpenter and Niem, 2001, FAO *Sp. Iden.*,: 3894; Nakabo 2002, *Fish. Japan*: 1389; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1): S.123; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India*, 216: 47.

Cynoglossus elongatus Gunther, 1862, *Cat. Fish.*, IV: 501; Bleeker, 1866, *Atl. Ichth.*,VI:34.

Plagusia cantoris Bleeker, 1854, *Verh. Bat. Gen.,* 25: 78, 153 (type locality: Malay Peninsula) (Based on *Plagusia potous* of Cantor 1849 (not of Cuvier)).

Cynoglossus melampetala Richardson, 1846, *Rep. Brit. Ass. Adv. Sci.*, :281 (China); Whitehead, 1969, *J. Soc. Bib. Nat. Hist.,* 5 (3): 218, pl. 29a.

Cynoglossus melampetalus Gunther, 1862, *Cat. Brit. Mus.,* 4: i-xxi + 1-534:496.

Plagusia grandisquamis Cantor, 1850, *J. Royal Asiat. Soc. Bengal*, 18:1214 (type –locality: seas of Penang).

Trulla grandisquamis Kaup, 1858, *Arch. Nat.*, 24 (1):109.

Cynoglossus grandisquamis Gunther, 1862, *Cat. Brit. Mus.*, 3: 503; Duncker, 1904, *Mitt. Nat. Mus. Hamburg* 21:169; Weber and Beaufort, 1929, *Fish. Indo – Aust. Archip.*, 5: 208; Duncker, 1904, *Die Fische Nat. Mus.*, 21 : 169.

Arelia kaupii Bleeker, 1860, *Acta Soc. Sci. Indo-Neêrl.,* 8(art.2): 73. (type locality: Benkulen, Sumatra, Indonesia).

Cynoglossus kaupii Gunther, 1862, *Cat. Brit. Mus.*, 3: 497; Bleeker, 1875, *Atl. Ichth.*, 6 : 34, pl. 242, fig. 3.

Arelia schneideri Kaup, 1858. *Arch. Nat.,* 24 (1): 107.

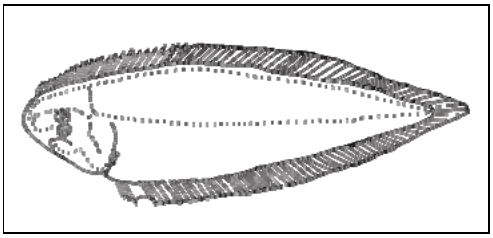


Plate LII: *Cynoglossus arel* (Schneider, 1801)

Material examined: N = 35, 20 from Kochi Fisheries Harbour, 10 from Calicut, 5 from Mangalore Fishing Harbour.

Diagnosis: Snout obtusely pointed; rostral hook short. Eyes with a small scaly interorbital space. Corner of mouth reaching posteriorly to or beyond lower of eye, about midway between gill opening and tip of snout; 7 – 9 scales between two lateral lines.

Meristic characters: D 108 – 114; A 63 – 83; C 11-12; Ll 56 - 69.

Body proportions as percent of SL (mean in parentheses): HL 20.7 – 39.9 (24.9); HD 13.7 - 23.1 (15.9); HW 17.7 - 33.99 (21.4); ED_1 1.9 - 3.6 (2.23); ED_2 1.5 – 3.5 (2.1); ID 0.9 - 3.1 (1.8); SNL_1 1.8 - 3.5 (2.4); SNL_2 1.6 -3.5 (2.3); BD_1 20.7 - 37.95 (24.9); V_2FL 3.4 – 7.1 (4.3); CFL 7.6 - 14.1 (9.6); CPD 3.7 – 7.3 (5.3); Ll curve 8.6 -17.95 (11.1); LHL 12.8 - 21.5 (17.2); Ll in between 4.7 - 6.3 (5.5); TKL 100.6 - 132.7 (116.7); PAL 28.3 – 42.2 (35.2); DFL 11 – 12.9 (11.97); PBL 5.03 - 5.04 (5.03); AFL 9.2 – 106.8 (58); CFL 10.4 – 10.9 (10.7); PDL 13.7 – 21.7 (17.7); CD 7.2 – 9.03 (8.1); UJL 6.9 – 9.79 (8.4).

As percent of HL (mean in parentheses): HD 55.5 - 74.9 (64); HW 72.7 -101.1 (86.1); ED_1 7.5 -10.8 (8.97); ED_2 6.6 -11.5; ID 3.5 - 8.8; SNL_1 8.04 -13.4; SNL_2 7.1 -13.3 (9.4); BD_1 89.3 - 114.4 (100.2); V_2FL 13.2 - 21.4 (17.2); CFL 30.1 – 49.1 (38.4); CPD 14.4 -28.9 (21.3); Ll curve 34.4 -58.96 (44.6); LHL 49.9 - 53.96 (51.9); TKL 333.03 -390.9 (361.95); PAL 105.8 - 109.8 (107.8); DFL 27.6-50.3 (38.96); PBL 12.6 - 19.5 (16.1); CFL 27.4 - 40.4 (33.9) PDL 53.4 - 54.4 (53.9); CD 22.7 - 27.8 (25.2); UJL 24.6 - 26.9 (25.7); RH 16.7 – 46.9 (31.8).

Description: Body flat, elongate, with a semi-pointed head region and tapering tail. Eyes dextral separated by a narrow interspace. The upper a little in advance of the lower. Two nostrils, the first one tubular in front of the lower eye, the second one in front of the interorbital space, simple oval in outline. Snout semi pointed with short rostral hook. Mouth a convex slit, maxillary reaching beyond lower eye more nearer to gill opening than snout end. Body covered with large ctenoid scales with two lateral lines separated by 7 – 9 rows of scales in between. Blind side with cycloid scales.

Habitat: Sandy bottom of continental shelf.

Distribution:

World: Hong Kong (Gunther, 1880); Swatow (Sauvage, 1881); Malay Peninsula (Bleeker, 1854); seas of Penang, Malay Peninsula and islands (Cantor, 1850; Günther, 1862); Batavia (Bleeker, 1851); Benkulen, Sumatra, Indonesia (Bleeker, 1860); Palk Bay, Ceylon (De Silva, 1956); Hong Kong (Gunther, 1880); Persian Gulf (Norman, 1928); Formosa, Java, Banka (Okada and Matsubara, 1938); Iranian Gulf (Blegvad, 1944); Japan (Nakabo, 2000).

A comparative statement of the meristic characters of *Cynoglossus arel* is given in Table 107.

Table 107: A comparative statement of the meristic characters of *Cynoglossus arel*

Meristic characters	Earlier workers							Present study 2004 – 2010	
	Norman 1928	Fowler 1934	Menon 1977	Talwar & Kacker 1984	Kuronuma & Abe 1988	Radhamanyamma 1988	Krishnan & Mishra 1993	N = 35	Mean ± SD
Dorsal rays	122 - 138	104 - 114	116 -130	116 - 130	100 - 112	105 -113	116	108 – 114	111 ± 4.24
Anal rays	90 – 109	85	85 - 98	85 - 98	80 - 91	80 - 85	86	63 – 83	73 ±8.24
Caudal	*	*	*	*	*	10 - 12	11	11-12	-
Lateral line scales	60 - 65	95	56 -70	56 - 70	55 - 56	*	65	56 - 69.	58 ± 5.3

Results of the correlation coefficient analysis on non-meristic characters of ***Cynoglossus arel*** is given in Table 108.

Table 108: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus arel*

Characters	Ratio in SL	Mean	SD	R^2 on SL	Slope
Head length	2.5 - 4.8	4.07	0.451	0.12	0.13
Head height	4.3 - 7.3	6.37	0.640	0.20	0.08
Head width	2.9 - 5.6	4.75	0.512	0.17	0.14
ED_1	27.6 - 51.7	45.75	5.458	0.03	0.01
Inter orbital	36.04 - 109.8	65.77	21.349	0.01	0.01
SNL_1	28.5 - 55.1	43.04	6.336	0.00	0.00
SNL_2	28.9 - 62	44.64	8.333	0.00	0.00
BD_1	2.6 - 4.8	4.06	0.421	0.01	0.05
Pelvic (B) FL	14.2 - 29.3	23.94	3.563	0.01	0.02
Caudal FL	7.1 - 13.1	10.68	1.440	0.00004	0.01
Caudal peduncle depth	13.7 - 26.95	19.79	4.133	0.00	0.02
Lateral line curve	5.6 - 11.7	9.29	1.516	0.00	0.03
LHL	4.7 - 7.8	6.22	2.217	1.00	-0.14
TKL	0.8 - 0.99	0.87	0.170	1.00	0.03
PAL	2.4 - 3.5	2.96	0.826	1.00	-0.14
DFL	7.7 - 9.1	8.41	0.969	1.00	0.19
Interorbital	31.9 - 37.1	34.49	3.630	1.00	0.01
Ll to upper	6.4 - 6.9	6.63	0.329	1.00	0.11
Rostral hook	8.3 - 14.99	11.64	4.736	1.00	0.28
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head height	1.3 - 1.8	1.57	0.13	0.38	0.43
Head width	0.99 - 1.4	1.17	0.10	0.35	0.75
ED1	9.3 - 13.3	11.28	1.22	0.10	0.04
ED2	8.7 - 15.1	11.99	1.83	0.00	0.03
Inter orbital	11.3 - 28.4	16.36	5.65	0.00	0.04
SNL1	7.4 - 12.4	10.65	1.44	0.00	0.00
SNL2	7.5 - 14	11.04	1.92	0.00	0.00
BD1	0.9 -1.1	1.00	0.08	0.21	0.42
Pelvic (B)	4.7 - 7.6	5.92	0.82	0.06	0.13
Caudal	2.04 - 3.3	2.64	0.32	0.00	0.08
Caudal peduncle depth	3.5 - 6.97	4.93	1.13	0.00	-0.01
Lateral line curve	1.7 -2.9	2.30	0.38	0.00	0.16

Colour: Ocular side brown with dark blackish brown patch on the opercular cover. Blind side whitish.

India: Tranquebar, east coast of Madras, (Bloch, 1787; Bloch and Schneider, 1801); Kerala coast (Saramma, 1963); Andaman Islands (Herre, 1941); Palk Bay (De Silva, 1956).

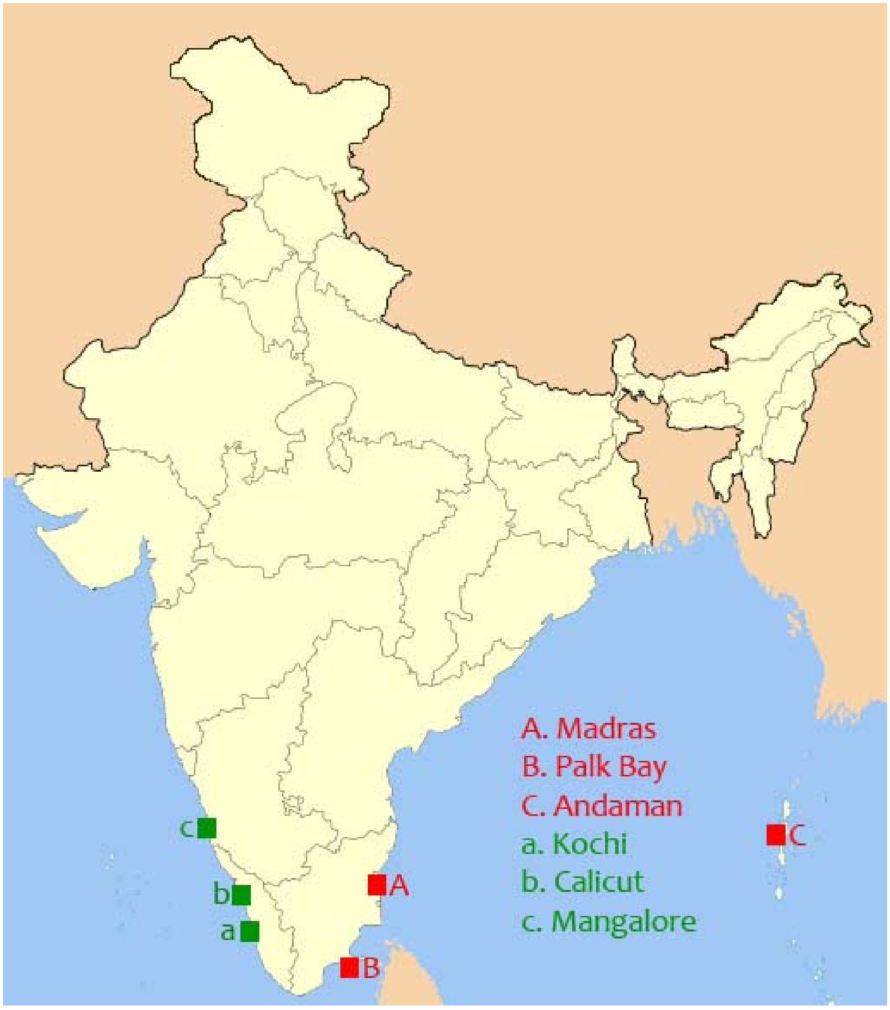


Fig.137: Map showing localities were *Cynoglossus arel* has been recorded in India

Taxonomic comments: Schneider (1801:159) described *Pleuronectes arel* based on four dried specimens from Tharangambadi, Tamil Nadu State neither giving any illustration of the species nor mentioning the size of his specimens. In the original description, the number of scale rows between the upper and middle lateral lines was not indicated, which has created the confusion in the identity of the species**.** Richardson (1846:281) described C. *melampetala* from China, based on John Reeve's collections of Chinese drawings; Cantor (1850:1214) described *Plagusia grandisquamis* on the basis of a specimen from Penang; Bleeker (1860:73) described *Arelia kaupii* from Sumatra. Bleeker (1853a: 153) described another species *P. cantoris* based on two stuffed specimens of Cantor's *Plagusia potous,* 217 and 322 mm SL, from Singapore, which he differentiated from all the known species on the basis of both nostrils being placed above the upper lip in front of the lower eye. Menon (1977) however opined that "*I have examined the types of P. cantoris; even though varnished over; the position of the nostrils cannot be detected. Likewise, Cantor's P. grandisquamis, which is differentiated by only one nostril in front of the lower eye, the absence of the narial openings between the eyes, and two lateral lines on ocular side separated by six scale rows, is also represented in the British Museum by a stuffed specimen*". Bleeker considered *P. oligolepis* different from C. *macrolepidotus* on the basis of a narrower interorbital space, the situation of the angle of the mouth being somewhat nearer to the gill opening than to the tip of mouth, and a slightly greater depth of the body. Norman (1928: 201) examined the type of *C. arel* and synonymised *C. oligolepis* with it; however, he separated *C. macrolepidotus* as a separate species, differentiating it from *C. arel* by its somewhat deeper body. Munroe (1955) described the two species of *C. arel* and *C. macrolepidotus* as separate species; the difference noted was in the ratio of eye diameter in head length and body depth in standard length. Menon (1977:60) considered *C. macrolepidotus* and *C. arel* synonyms after examining a large number of specimens of various sizes including specimens from Madras, the type-locality of *C. arel,* and comparing them with the specimens labelled as *C. macrolepidotus* in the British Museum with the comments "*that the differences noted by Norman in the proportional measurements are attributable to intraspecific variation and that they are conspecific. Cynoglossus kaupii, from the original description as well as from Bleeker's excellent illustration, appears to exhibit no significant difference from C. arel; eight or nine scales between the lateral lines on the left side fairly well confirm the identity of the species. Plagusia melampetalus Richardson (1846) is synonymized with C. arel, because from the characterization of the species in the original description, especially the indication that the two lateral lines on the left side are separated by seven series of scales, the identity of the species is unmistakable*". Randall (1995) agrees with Menon's conclusion that *C. macrolepidotus* is a synonym of *C. arel*. Li and Wang (1995: 342) while describing the soles of Japan and Mishra *et al*. (1999:89) however have resurrected *Cynoglossus macrolepidotus* as a separate species designating *Plagusia macrolepidota* Bleeker, 1851 as type. Eschmeyer (2011, online) has also agreed to this classification, thereby placing the two species as separate.

Observation:

The samples from different localities in the present work match well with the morpho-meristics given by earlier workers.

4.3.8.1.3 *Cynoglossus bilineatus* (Lacépède, 1802)

Four lined tongue sole

Pleuronectus bilineatus Artedi, 1792, *Gen. Pisci.*, III: 119 (China) Bloch, 1801, *Syst. Ichth.,*: 188; *Gmel. Linn.*,: 1235; Russell, *Fish. Vizag.*, :58 (Coromendal coast); Bennett, *Life of Sir Raffles* : 692.

Achirus bilineatus Lacépède, 1802, *Hist. Nat. Poiss.,* V: 6 (type locality: China and the East Indies).

Plagusia bilineata Ruppell, 1828, *Atlas Reise N. Africa*: 120; Klunzinger, 1871, *Verh. zool. Bot. Ges. Wien*, 21:573 (Koseir, Red Sea); Day, 1887, *Fish. Malabar*: 174 (Indian seas); Day, 1889, *Fishes of India*, 4^0: 435 (Red Sea, India, Malaya Archipelago).

Plagusia quadrilineata Bleeker, 1851, *Nat. Tijds. Ned. Indie* I: 412 (Padang) Bleeker, 1852, *Verh. Bat. Gen.* XXIV, Pleuron : 21 (Makassar, in sea, Celebes).

Plagusia blochii Bleeker, 1852, *Verh. Bat. Gen.*, XXIV: 21 (Benkulen); Bleeker, 1851, *Nat. Tijds. Ned. Indie,* I: 411 (Trussan)

Arelia quadrilineata Kaup, 1858, *Arch. Natur.,*: 107 (Java, Sumatra); Oshima, 1927, *Jap. J. Zool.*, I: 1981 (Taiwan, Taihoku).

Arelia bilineata Smith, 1961, *Sea Fish. S. Africa*: 166, pl. 11 (Durban); Matsubara, 1955, *Fish. Morph. Hierar.*, II: 1218 (Japan, Formosa, Philippines, Red Sea).

Cynoglossus quadrilineatus Gunther, 1862, *Cat. Brit. Mus.*, IV: 497 (Amboyan, East Indian Archipelago); Gunther, 1866, *Fish. Zanzibar*: 113 (Aden); Kner, 1867, *Novara Exp. Fische*, 3. *Abth.*, I: 295; Bleeker, 1866-1872, *Atl. Ichth.*, VI: 32; Klunzinger, 1871, *Verhandl. Zool. Bot. Ges. Wien,* XXI: 573 (Koseir, Red Sea); Macleay, 1884, *Proc. Linn. Soc. N. S. Wales,* IX: 53; Day, 1889, *Fishes of India*, 4^0: 435 (Indian Seas); Alcock, 1889, *J. Asiat. Soc. Bengal,* LVIII: 288 (Puri); Steindachner, 1902, *Denkschr. Akad. Wien,* LXXI: 154 (Gischin); Smith and Pope, 1906, *Proc. U.S. Nat. Mus.*, XXXI: 498, (Kochi); Jenkins, 1910, *Mem. Indian Mus.*, 3: 30; Wu, 1932, *Contr. Poiss. China*: 144.

Cynoglossus bilineatus, Ogilby, 1910, *Proc. R. Soc. Queensland*, 23: 39 *Exp. Fische*: 443; Weber, 1913, *Siboga Exped.*,: 443 (Makassar); Norman, 1926, *Biol. Results "Endeavour", Fish. Austral.,* V (5): 301 (India, Australia, Queensland); Weber and Beaufort, 1929, *Fish. Indo-Austr. Archip.*, V: 194 (Malay, Batavia); Chabanaud, 1932, *Bull. Soc. Zool. France*, 57:197 (Italian Somaliland); Wu, 1932, *These. Fac. Sci. Univ, Paris*, A. 244 (268): 144 (Haiman); Herre, 1933, *J. Pan-Pac. Res. Inst.*, 8: 5 (Sandakan; N. Borneo); Fowler, 1934, *Hong Kong Nat.*, V(3): 217, fig. 31 (China); Herre, 1934, *Fish. Herre Phil. Exp.*,: 105 (Manila); Hardenberg, 1941, *Treubia*, 18: 226 (Meranke, New Guinea); Blegvad, 1944, *Fishes Iranian Gulf*: 206 (Red Sea); Suvatti, 1950, *Fauna Thailand*: 326; Herre, 1953, *U.S. Fish Wildlife Res. Rept.*, 20: 189 (Philippines); Munroe, 1955, *Fish. Ceylon*: 264, pl. 50. fig. 767 (Pearl banks); Fowler, 1956, *Fish. Red Sea*, I: 184 (Siam, Philippines); Munroe, 1958, *Fish. New Guinea*, 1: 285 (Merauke); Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean*, 1: 75 (Kerala coast); Marshall, 1964, *Fish. Great Barrier Reef*: 468, pl. 64, fig. 454 (east coast of North Queensland); Pradhan, 1964, *J. Bombay Nat. Hist. Soc.*, 61(2): 458 (Bombay coast); Menon, 1977, *Smith. Contribn.*, 238: 36, fig 17; Fowler, 1972, *Fish. China*, 1: 208, fig. 31 (India, Japan); Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull*., 1: 58 (Thailand); Kyushin *et al*., 1982, *Fish. China Sea*: 268; Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 874, fig. 360; Lindberg and Fedorov, 1993, *Zool. Inst. Russian Acad*., 166:208, 223; Randall, 1995, *Coastal Fish. Oman*: 363 (Arabian Gulf); Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 600; Larson and Williams, 1997, *Proc. Sixth Intl. Marine Biol. Workshop*: 374; Evseenko, 1998, *Russian Acad. Sci*.,: 61; Johnson, 1999, *Mem. Queensland Mus*., 43 (2):753; Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 646; Li and Wang, 2000, *Fauna Sinica*: 355; Hutchins, 2001, *Rec. W. Aust. Mus. Suppl*., 63: 47; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1) : S123; Hoese and Bray, 2006, *Zool. Cat. Australia*: 1854.

Cynoglossus lineolatus Steindachner, 1867, *Sitzung, Akad. Wissenchafter Wien*, 55: 588 (Hong Kong) ; Bleeker, *Ned. Tijds. De Dierk*., 4: 133; Rutter, 1897, *Proc. Acad. Nat. Sci. Philadelphia*: 88 (Swatow); Reeves, 1927, *J. Pan-Pacific Res. Inst*, 2: 14; Chu, 1931, *Biol. Bull. St. John. Univ*., 1: 95, Wu, 1932, *Contr. Poiss. China*: 150; Fowler, 1934, *Proc. Acad. Nat. Sci. Philadelphia*, 85: 218, (Hong Kong, Swatow).

Cynoglossus quinquelineatus Day, 1877, *Fish. India*: 432, pl. 98, fig. 1 (type locality: Madras); Day, 1889, *Fauna Br. India*, 2: 453; De Silva, 1956, *Ceylon J. Sci*, C, 7 (2):198; Norman, 1928, *Rec. Ind. Mus*., 30(2): 197 (Madras); Munroe, 1955, Fish. Ceylon :264, fig. 766 (Pearl banks).

Cynoglossus sindensis Day, 1877, *Fish. India*, 3: 434, pl. 90, fig. 6 (type locality: from Sind through Seas of India); Jordan and Richardson, 1908, *Bull. U. S. Bureau Fish*., 27: 281; Ogilby, 1910, *Proc. Royal Soc. Queensland,* 23:37; Norman, 1926, *Biol. Res. "Endeavour"*, 5(5): 302; De Silva, 1956, *Ceylon J. Sci*., C, 7(2): 198.

Arelia diplasios Jordan and Evermann, 1903, *Proc. U.S. Nat. Museum*, 25: 367, fig. 29 (type locality; Formosa Taiwan); Jordan and Richardson, 1909, *Mem. Carnegie Mus*., 4: 202, fig. 25 (Formosa).

Cynoglossus diplasios Oshima, 1927, *Jap. J. Zool*.,I (5): 204

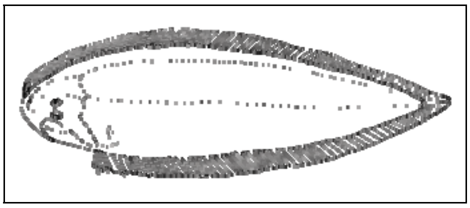


Plate LIII: *Cynoglossus bilineatus* (Lacépède, 1802)

Material examined: N = 2, TL 296 - 301 mm from Fort Kochi.

Diagnosis: Body covered by ctenoid scales on ocular side except for a line of the lateral line scales; two lateral lines on the blind side; 12 rays in caudal fin.

Meristic characters: D 108 - 114 (111); A 78 - 83 (81); C 11- 12 (11.5); Ll 89 -97; lateral lines 2; scales in between 13.

Body proportions as percent of SL (mean in parentheses): HL 22.4–25.6 (24); HD 14.2 -14.4 (14.3); ED_1 1.96 - 2.03 (2); ED_2 2.01–2.2 (2.1); HW 22.6–23.2 (22.9); LHL 9.9–12.1(10.96); TKL 74.5–77.1 (75.8); PAL 21.7–23.7 (22.7); DFL 6.2–9.9 (8.1); PBL 2.8–3.9 (3.3); CFL 6.1–7.97 (7.1); SNL_1 9.6–10.9 (10.2); PDL 10.5–12.2 (11.3); CD 5.1–5.5 (5.3); UJL 5.3–5.5 (5.4); ID 1.8–2.1 (1.9); RH 3.7–9.3 (6.5).

As percent of HL (mean in parentheses): HD 56.1 – 63.4 (59.7); ED1 7.7 - 9.1 (8.4); ED2 7.8–9.7 (8.8); HW 90.4–101.1; LHL 43.99–47.1 (45.5); TKL 290.4 – 344.4 (317.4); PAL 92.3–96.8 (94.5); DFL 24.1–44.3 (34.2);

PBL 11.03 -17.2; CFL 23.9-35.6 (29.8); SNL_1 42.7 - 43.1 (42.9); PDL 47 - 47.4 (47.2); CD 19.8 - 24.5 (22.1); UJL 21.4 -23.7 (22.6); ID 6.9 - 9.2 (8.1).

Description: Body elongate, head contained 4 times in standard length; eye contained 12 times in HL and 50 times in SL. Mouth semi circular slit on ocular side, on the blind side; jaws with thickened walls. Two nostrils on eyed side, anterior one tubular, placed in front of lower eye, posterior one in the middle area of interorbital space. Two nostrils on blind side covered by a flap of skin, the first tubular above mouth, the second semi-lunar on the area between mouth and snout. Eyes placed slightly above the body surface, upper eye placed slightly in advance of the lower. Snout rounded, with a short rostral hook ending before the origin of the anterior nostril. Maxillary ends a little after the lower eye; mouth angle ends on a line below the lower eye. On the blind side, at the inner end of the mouth is a concave structure with thick fleshy wall. Body covered with ctenoid scales on ocular side and cycloid scales on the blind side and on the lateral line. Two lateral lines on ocular side, the main in the centre extending from area behind the upper eye to the caudal fin tip; three branches arise from the front tip to the snout, another rises up to join the second lateral line on the upper profile just below the dorsal finbase. A branch from the upper lateral line also extends to the snout and joins with the branch from the main lateral line to form a network. A small branch of lateral line seen on the lower part of the operculum in the area in front of pelvic fin insertion.

A comparative statement of the meristic characters of *Cynoglossus bilineatus* is given in Table 109.

Table 109: A comparative statement of the meristic characters of *Cynoglossus bilineatus*

Meristic characters	Earlier workers							Present work 2004 - 2010	
	Fowler 1934	Punpoka 1964	Saramma 1963	Marshall 1964	Chen and Weng 1965	Talwar & Kacker 1984	Randall 1995	N = 3	Mean ± SD
Dorsal rays	102 – 112	102 – 112	102 – 114	102 – 112	102 – 112	107 – 113	107 – 113	108 -114	111 ± 4.24
Anal rays	82 – 97	82 – 97	90	82 – 97	82 – 97	80 – 88	80 – 88	78 – 83	80.5 ± 3.5
Lateral line scales	95	84 – 96	*	86 – 98	86 – 98	88 – 96	88 – 96	89 - 97	93 ± 5.7
Ventral	*	*	*	*	4	*	*	*	4
Caudal	*	*	*	*	*	12	12	11 - 12	11.5 ± 0.71

*Data not available

Table 110: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus bilineatus*

Characters	Ratio/Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.9 - 4.5	4.18	0.4	1	1.38
Head depth	6.96 -7.04	7	0.06	1	0.21
Eye Diameter (U)	49.4 - 50.9	50.13	1.08	1	0
Eye Diameter (L)	46.1 - 49.7	47.91	2.59	1	-0.03
Head width	4.3 - 4.4	4.37	0.07	1	0.42
LHL	8.3 - 10.2	9.22	1.32	1	0.88
TKL	1.3 - 1.34	1.32	0.03	1	-0.17
PAL	4.2 - 4.6	4.42	0.28	1	0.93
DFL	10.1 - 16.2	13.14	4.34	1	-1.24
PBL	25.9 -35.4	30.65	6.67	1	-0.33
CFL	12.5 -16.3	14.43	2.67	1	-0.57
SNL (U)	9.1 - 10.4	9.76	0.87	1	0.56
PDL	8.2 -9.5	8.86	0.9	1	0.69
UJL	18.2 - 18.8	18.52	0.44	1	0.12
Rostral hook	10.8 -26.7	18.76	11.25	1	-1.86
Characters	**Ratio/Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	1.6 -1.8	1.68	0.15	1	0.15
Eye Diameter (U)	11.1 -13.1	12.05	1.41	1	0
Eye Diameter (L)	10.3 -12.8	11.53	1.72	1	-0.03
Head width	0.99 - 1.1	1.05	0.08	1	0.31
LHL	2.1 - 2.2	2.2	0.1	1	0.64
TKL	0.29 - 0.3	0.32	0.04	1	-0.13
PAL	1.03 -1.08	1.06	0.04	1	0.67
DFL	2.3 - 4.2	3.21	1.34	1	-0.9
PBL	5.8 - 9.1	7.44	2.31	1	-0.24
SNL (U)	2.32 - 2.34	2.33	0.02	1	0.4
PDL	2.1 - 2.13	2.12	0.01	1	0.5
CD	4.1 - 5.1	4.57	0.69	1	-0.07
UJL	4.2 - 4.7	4.44	0.32	1	0.09
Interorbital	10.8 - 14.6	12.71	2.67	1	-0.07
Ll to upper	2 - 2.9	2.46	0.65	1	-0.54
Rostral hook	2.4 - 6.9	4.63	3.13	1	-1.35

Colour: Ocular side brownish with an irregular patch on the operculum, blind side whitish.

Distribution:

World: China (Artedi, 1792); China and the East Indies (Lacépède, 1803); Massaua (Ruppell, 1828); Koseir, Red Sea, (Klunzinger, 1871; Blegvad, 1944); Trussan, Padang (Bleeker, 1851); Makassar, in sea, Celebes (Bleeker, 1852); Benkulen (Bleeker, 1852); Java, Sumatra (Kaup, 1858); Aden (Gunther, 1866); Hong Kong (Steindachner, 1867; Fowler, 1934); Malaya Archipelago (Day, 1889); Swatow (Rutter, 1897; Fowler, 1934); Amboyan, East Indian Archipelago (Gunther, 1862); Formosa Taiwan (Jordan and Evermann, 1903; Jordan and Richardson, 1909); Gischin, Saudi Arabia (Steindachner, 1907); Taiwan, Taihoku (Oshima, 1927); Malay, Batavia (Weber and Beaufort, 1929); Italian Somaliland (Chabanaud, 1932); Sandakan; N. Borneo (Herre, 1933); Persia (Tortonese, 1934); Philadelphia (Roxas and Martin, 1937); Meranke, New Guinea (Hardenberg, 1941); Philippines (Herre, 1953); Pearl banks (Munroe, 1955); Cote Ouest de Madagascar (Fourmanoir, 1957); east coast of North Queensland (Marshall, 1964); Merauke (Munroe, 1958); Japan (Fowler, 1972); Pakistan (Bianchi, 1985); continental shores to the Indo–Malayan region, northern Australia and Queensland, north to Japan (Randall, 1995). Map showing localities were *Cynoglossus bilineatus* has been recorded in the world is given in Fig. 138.

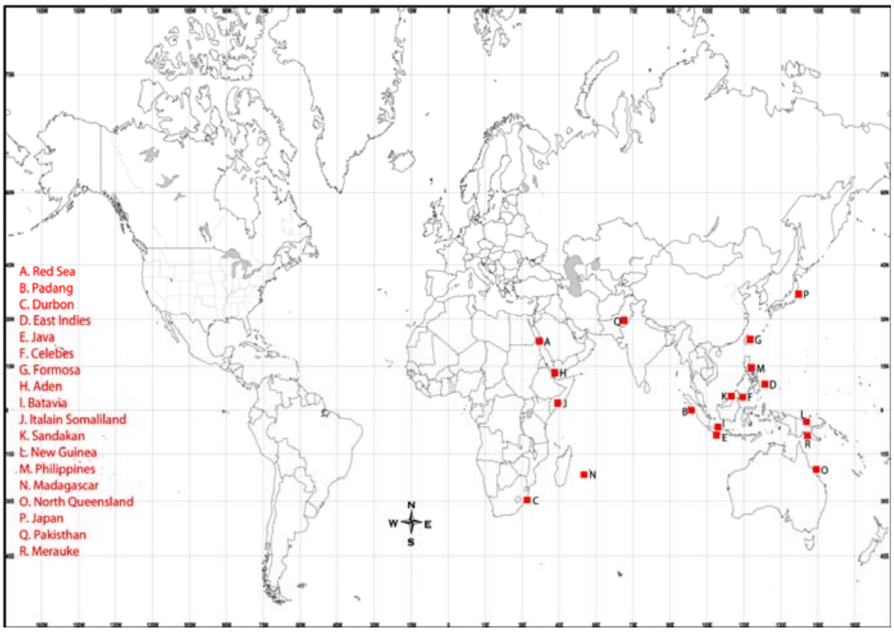


Fig 138: Map showing localities were *Cynoglossus bilineatus* has been recorded in the world

India:

Kerala coast (Saramma, 1963); Bay of Bengal (Cantor, 1850); Sind through Seas of India (Day, 1877); Bombay coast (Pradhan, 1964); Puri (Alcock, 1889); Madras (Day, 1877; Norman, 1928).). Map showing localities were *Cynoglossus bilineatus* has been recorded in India is given in Fig.139.

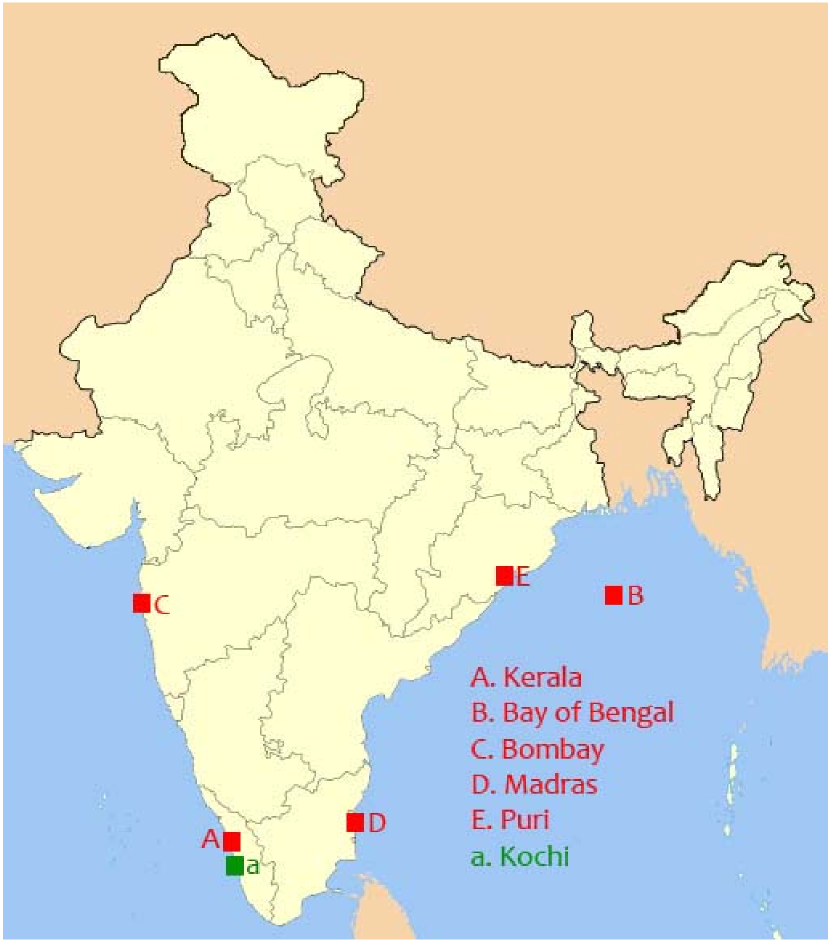


Fig 139: Map showing localities were *Cynoglossus bilineatus* has been recorded in India

Taxonomic comments: *C. sindensis* Day 1889 has been synonymised with *C. bilineatus* Blegvad, but counts are very different. The lateral line counts of *C. sindensis* (Ll 108) vary greatly with that of *C. quadrilineatus* Day (1889) (Ll 86); the other counts being dorsal 106 -116, anal 83, ventral 4 and caudal 12. Norman (1928) comments on the status of *Cynoglossus quinquelineatus* "*this species is known only from this specimen, which may prove to be an abnormal example of C. bilineatus, in which an* *incomplete lateral line has developed on the lower part of the bodyon the ocular side. It seems to differ from that species however in having a somewhat smaller eye, a shorter rostral hook and in the position of the angle of the mouth*". Menon (1977) agrees with both Norman (1928:198) in the synonymy of *C. quadrilineatus* Bleeker and *C. sindensis* and Ochiai's (1963) synonymy of *A. diplasios* Jordan and Evermann. Day (1878: 432) described *C. quinquelineatus* based on a single specimen in which a single lateral line on the lower side is present. Day also specified that besides the lower line, his specimen differs from *C. bilineatus* in a somewhat smaller eye, a shorter rostral hook, in the angle of the mouth. Munroe (1955) reported the species from Pearl Banks with 3 lateral lines on ocular side, the lower incomplete and extending from the middle of body to caudal base. However, Menon (1977:38) mentions that he has examined the holotype of *C. quinquelineatus* from Calcutta and opines that except the lateral line on the lower side, no difference was noted with *C. bilineatus.* Menon (1977: 38) also opines that the nature and extent of lines in *Cynoglossus* are of no significance and hence the development of incomplete lateral line in *Cynoglossus* is of no significance. Randall (1995) states that "*Cynoglossus quadrilineatus and C. quinquelineatus Day are synonyms*".

Observation: The species is said to attain 35 cm TL. The meristic counts given in the present work match well with that reported by Talwar and Kacker (1984) from Indian waters as well as with that of Randall (1995). However, the dorsal fin count range given by earlier workers vary from 102 – 114 in different areas. Cheng and Weng (1965) reported higher counts for anal fin from Taiwanese waters, which were similar to Marshall (1964) and Punpoka (1964) from the same region. No variation was noticed in pelvic fin ray count.

4.3.8.1.4 *Cynoglossus carpenteri* Alcock,1889

Alcock's tongue sole/Carpenter's sole

Cynoglossus carpenteri Alcock, 1889, *J. Asiat. Soc. Bengal*, LVIII, pt.2:287, pl. xviii, fig. 1 (68 miles east of mouth of Devi River, Máhánadi delta, Bay of Bengal, Investigator, depth 68 fathoms); Alcock, 1890, *Ann. Mag. Nat. Hist.*, (6) VI: 217; Alcock, 1896, *J. Asiat. Soc. Bengal*, LXV, pt.2:330; Alcock, 1898, *Illust. Zool. "Investigator", Fish.*,: pl. xxii, fig. 5; Alcock, 1899, *Cat. Indian Deep Sea Fish*: 133; Boulenger, 1901, *Ann. Mag. Nat. Hist.*, (7) VII: 263; Regan, 1905, *J. Bombay Nat. Hist. Soc.*, XVI: 329; Saramma, 1963, *Bull. Dept. Mar. Biol.*,: 75 (Cochin, Kerala coast);Menon and Rama-Rao, 1975, *Matsya*, 1: 46; Menon, 1977, *Smith. Contr. Zoo.*,: 238; Randall, 1995, *Coastal Fish. Oman*: 363; Carpenter *et al.*, 1997, *FAO Sp. Iden. Guide*: 232; Manilo and Bogorodsky, 2003, *J. Ichth.*, 43 (suppl. 1): S123.

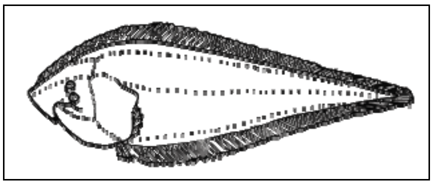



Plate LIV: *Cynoglossus carpenteri* Alcock,1889

Material examined: N = 4; TL 186.75 – 208.68 mm from Cochin Fisheries Harbour.

Diagnosis: Three lateral lines on ocular side, blind side with cycloid scales. Ocular side anterior half with cycloid scales, posterior with ctenoid scales.

Meristic counts: D 100 – 115 (106); A 86 – 89 (88); Ll. 75 - 96 (78); V 4-5 (4)

Body proportions as percent of SL (mean in parentheses): HL 26.1 – 27.5 (26.8); HW 25.1 – 26.8 (25.7); HD 10.8 –13.8 (12.2); BD1 24.6 –

29.2 (26.8); BD1 24.6 – 29.2 (26.8); ED_1 1.7 -3 (2.1); ED_2 1.95 – 2.4 (2.2); ID 0.9 -1.5 (1.1); UJL 9.2 -11.8 (10.5); LJL 6.7 -7.1 (6.9); CD 4.97-6.4 (5.75); DFL 8.3 – 9.6 (8.8); AFL 8.1 -10.1 (9.02); V_1FLO 4.4 – 5.8 (5.1); CFL 8.3; DBL 97.1 -100.9 (9.4); ABL 75.3 – 81.5 (78.6); V_1BLO 0.9 -1.1 (0.98); V_2BLB 0.8 – 1.1 (0.98); PrOL 9.56; PBL 3.9-4.7 (4.3); PAL 26.9-28.8 (27.6); V_1LO 25.8-26.03 (25.9).

As percent of HL (mean in parentheses): HW 93.02 - 97.3 (96.1); HD 40.1- 49.98 (45.6); BD1 91.2 -111.7 (100.2); ED_1 6.3 – 10.9 (7.7); ED_2 7.4 – 9.1 (8.2); ID 3.3 – 5.6 (4.2); UJL 34.8 – 42.7 (39.1); LJL 24.2 – 27.3 (25.8); CD 18.8 – 23.1 (21.5); DFL 31.4 – 35.01 (32.9); AFL 30.99 - 37.5 (33.7); V_1FLO 16.6 – 22.4 (19.3).

Description: Body flat, lanceolate, elongate, broader at opercular end and tapering towards tail. Eyes sinistral, very small with a moderate interspace. Upper eye a little in advance of the lower. Two nostrils on ocular side, the anterior one round, in front of interorbital space, the posterior one tubular above the mouth. Snout obtusely pointed, ends on a vertical through the anterior border of eye. Rostral hook short. Mouth curved, large angle of mouth extending on a vertical below posterior margin of fixed eye, nearer to gill opening. Three lateral lines on ocular side, mid lateral line with 79 – 86 scales, 15- 19 scales in between the lateral lines. No lateral lines on blind side. Teeth present in the posterior two–third of the jaws on the blind side. Lips plain, not fringed. Opercle big flat, expanded towards ventral profile, branchiostegal rays extend outward. Ventral fin confluent with anal. Scales cycloid on ocular side except the posterior part of the body where they are armed with strong spines. Scales on blind side cycloid.

A comparative statement of the meristic characters of *Cynoglossus carpenteri* is given in Table 111.

Table 111: A comparative statement of the meristic characters of *Cynoglossus carpenteri*

Meristic characters	Earlier workers				Present study 2004 – 2010	
	Alcock 1889	**Saramma 1963**	**Talwar & Kacker 1984**	**Randall 1995**	**N = 4**	**Mean ± SD**
Dorsal rays	105	99 - 104	101 -110	101 – 110	100 – 115	105.5 ± 6.86
Anal rays	85	83 - 88	80 - 89	80 - 89	86 – 89	88 ± 1.41
Pelvic (O/B)	4	*	*	*	4 - 5	4.3 ± 0.5
Caudal	12	*	10	10	12	-
Lateral line scales	95	*	75 – 96	75 - 96	75 - 96	78
Scales in between Ll	*	*	15 - 19	*	15 - 19	-

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of ***Cynoglossus arel*** is given in Table 112

Table 112: Results of the correlation coefficient analysis on non-meristic characters of ***Cynoglossus carpenteri***

Characters	Ratio/ Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.6 - 3.8	3.74	0.09	0.94	0.36
Head width	3.7 - 3.9	3.89	0.11	0.99	0.40
Head depth	7.3 - 9.2	8.26	0.92	0.97	0.38
Body depth	3.4 - 4.1	3.75	0.28	0.41	0.31
Body depth max.	3.4 - 4.1	3.85	0.29	0.11	0.13
Eye Diameter (U)	33.3 - 59.9	50.93	12.02	0.77	0.13
Eye Diameter (L)	41.8 - 51.4	45.83	4.17	0.24	0.02
Inter orbital	68.1 - 109.2	93.00	19.83	0.01	0.00
UJL	8.5 - 10.9	9.61	0.99	0.54	0.21
LJL	14.01 -14.98	14.47	0.40	0.76	0.04
Chin depth	15.7 - 20.1	17.53	1.89	0.44	0.10
Dorsal	10.4 -12.1	11.37	0.77	0.79	0.17
Anal	9.89 - 12.34	11.17	1.13	0.31	0.12
Pelvic1	17.1 - 22.8	19.80	2.86	0.71	-0.18
Pelvic2	12.2 - 22.8	17.89	4.49	0.71	-0.18
Dorsal	0.99 - 1.24	1.07	0.11	0.93	1.14
Anal	1.2 - 1.33	1.29	0.05	0.75	1.00
Pelvic1	88.2 - 118.2	103.42	15.00	0.00	0.00
Pelvic2	88.2 - 118.2	103.42	15.00	0.00	0.00
Pre dorsal	21.2 - 24.1	22.40	1.51	0.01	0.01
Pre anal	3.6 - 3.7	3.67	0.04	0.99	0.44
Pre pelvic	3.84 - 3.88	3.86	0.02	1.00	0.21
Characters	**Ratio/ Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	1.03 -1.08	1.04	0.02	0.94	1.07
Head depth	2.0 - 2.5	2.21	0.23	0.83	0.97
Body depth1	0.9 - 1.1	1.00	0.08	0.29	0.71
Eye Diameter (U)	9.2 - 15.8	13.60	3.04	0.85	0.37
Eye Diameter (L)	10.9 - 13.6	12.27	1.10	0.27	0.06
Inter orbital	18 - 30	24.98	5.78	0.02	-0.02
Upper jaw length	2.34 - 2.9	2.57	0.22	0.72	0.65
Lower jaw length	3.7 - 4.1	3.88	0.20	0.54	0.09
Chin depth	4.3 - 5.3	4.69	0.46	0.53	0.30

Colour: Ocular side uniformly brownish, opercular region blackish, blind side whitish.

Distribution:

World: Persian Gulf, Gulf of Oman (Alcock, 1898). Map showing localities were *Cynoglossus arel* has been recorded in the world is given in Fig. 140.

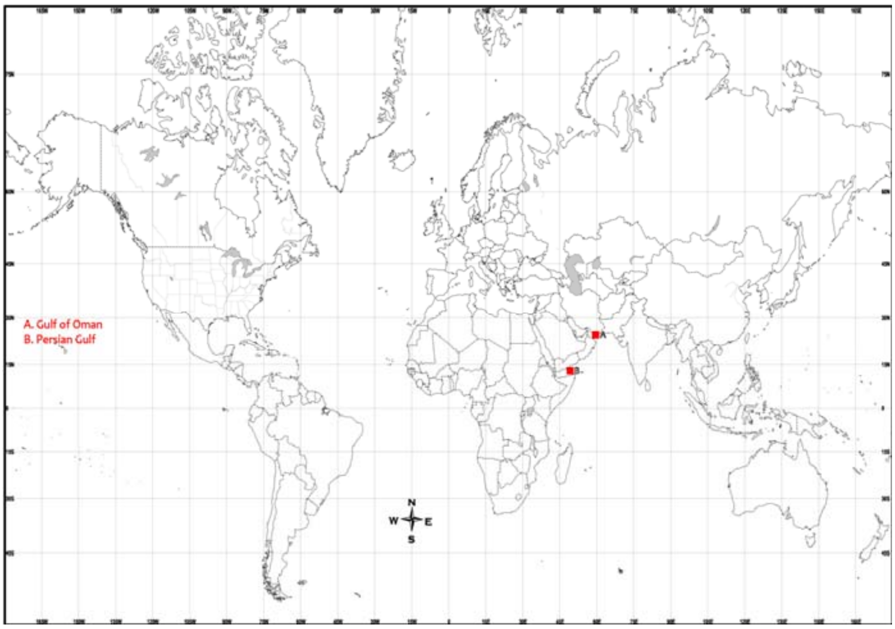


Fig. 140: Map showing localities were ***Cynoglossus carpenteri*** has been recorded in the world

India: Seas of India (Talwar and Kacker, 1984), Bay of Bengal (68 – 107 fathoms), Arabian Sea, off Malabar coast (100 fathoms). Map showing localities were ***Cynoglossus carpenteri*** has been recorded in the world is given in Fig. 141.

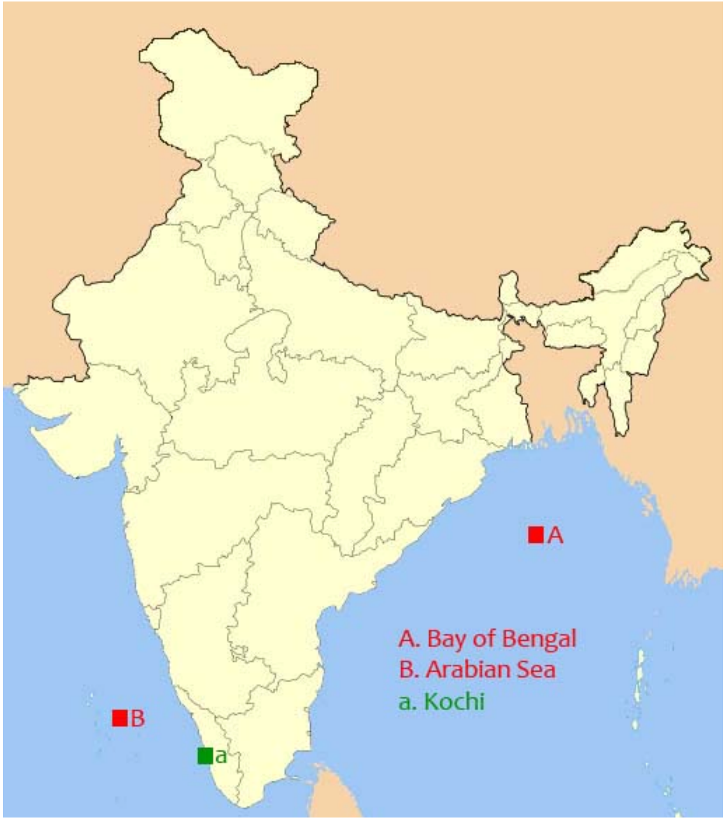


Fig. 141: Map showing localities were ***Cynoglossus carpenteri*** has been recorded in India

Fishery: Not much in commercial fisheries, seen in deep sea landings.

Taxonomic remarks: The fish was described by Alcock (1889) based on the '*Investigator*' collections from a depth of 68 fathoms, 68 miles east of mouth of Devi River, Máhánadi delta, Bay of Bengal. The fishes collected had SL of 60.0-181.0 mm SL. According to Menon (1977), the species belongs to a complex under the *carpenteri* group comprising of *Cynoglossus carpenteri, C. acutirostris, C. marleyi* and *C. suyeni.*

Remarks: Reported from the depth range of 27 - 400 m. The fish has been collected from the sample locality (Saramma, 1963) from a depth of 125 m. The fish resembles *C. acutirostris* in appearance and in the small, closely placed eyes, wide mouth cleft extending below or beyond the posterior border of fixed eye, and long pointed snout, but can be separated from it by its shorter snout and somewhat larger scales. The short snout helps it in "*living on a sandy or muddy bottom and plowing or burrowing into the substratum for feeding*" (Menon, 1977).

4.3.8.1.5 *Cynoglossus cynoglossus* (Hamilton –Buchanan, 1822)

Bengal tongue sole

Achirus cynoglossus Hamilton–Buchanan, 1822, *Fish. Ganges*: 132, 373 (type locality: Ganges mouth)

Plagusia cynoglossus Cantor, 1850, *J. Royal Asiat. Soc. Bengal*, 18: 1211

Icania cynoglossa Kaup, 1858, *Arch. Naturg*., 24(1): 109

Cynoglossus cynoglossus Norman, 1928, *Rec. Ind. Mus*., 30 (2): 208 (Bengal); Weber anf Beaufort, 1929, *Fish. Indo –Austral. Arch*., V: 199; Munroe, 1955, *Fish. Ceylon*: 266, pl. 50, fig. 773; Punpoka, 1964, *Bull. Fish. Res. Kasetsart Univ*., 1: 60 (Taiwan); Menon, 1971, *Smith. Contr. Zoo*., 238: 68, fig. 32, pl. 13; Rahman, 1989, *Zool. Soc. Bangladesh* :32, Talwar and Jhingran 1991, *Inland Fish. India*: 1041; Kottelat *et al*., 1993, *Freshwater fish. Western Indonesia*: 169 (Western Indonesia); Mohsin and Ambak, 1996, *Marine Fish. Malaysia*: 600; Rainboth 1996, *FAO Sp. Iden. Guide*: 223; Evseenko 1998, *Russ. Acad. Sci.,*:61; Munroe in Randall and Lim, 2000, *Raffles Bull. Zool. Suppl*., 8: 646; Bijukumar and Sushama, 2000, *J. Mar. Biol. Ass. India*, 42 (1-2):187; Munroe, 2001, *FAO Sp. Iden. Guide*, IV (6):3898; Manilo and Bogorodsky 2003, *J. Ichth*., 43 (suppl. 1):S123; Matsuura *et al*., in Kimura and Matsuura, 2003, *Fish. Bitung*: 217; Khan 2003, *Rec. Zool.*

Surv. India Occ. Paper, 209:11; Matsuura in Matsuura and Kimura 2009, *Fish. Andaman Sea*:323.

Plagusia oxyrhynchos Bleeker, 1851a, *Nat. Tijds. Voor Ned. Indië*, 1:416 (Batavia); Bleeker, 1852, *Verh. Batav. Gen. Kunsten en Weten*., 24:26.

Arelia oxyrhynchos Bleeker, 1859, *Acta Soc. Sci. Indo –Neerl*., 6: 185.

Cynoglossus oxyrhynchos Gunther, 1862, *Cat. Brit. Mus*., III: 499; Bleeker, 1875, *Atlas. Ichth. Ind. Orient. Neerl*., 6:36, pl. 245, fig. 1; Weber and Beaufort, 1929, *Fish. Indo – Austr. Arch.*, V: 201.

Plagusia sumatrana Bleeker, 1853, *Nat. Tijd. Neder. Indië*, 5:529 (type locality: Benculen, Sumatra).

Arelia sumatrensis Bleeker, 1859, *Acta. Soc. Sci. Indo –Neerl*., 6:185.

Cynoglossus sumatrensis Gunther, 1862, *Cat. Brit. Mus*., IV: 497; Bleeker, 1875, *Atlas Ichth. Ind. Orient. Neerl*., VI: 35, pl. 243, fig. 1; Jordan and Richardson, 1908, *Bull. U.S Bur. Fish*., 27:281 (Ticao Island); Fowler, 1918, *Copeia*, 58: 65 (Philippines).

Cynoglossus sumatranus Norman, 1928, *Rec. Ind. Mus*., 30 (2):209; Weber and Beaufort, 1929, *Fish. Indo – Aust. Arch*., V: 202; Fowler, 1938, *Fish. Malaya*: 88; Herre, 1953, *U.S Fish. Wildlife Ser. Res. Rept*., 20: 191; Punpoka, 1964, *Bull. Fish. Res*., 1:72.

Plagusia bengalensis Bleeker, 1853 a, *Verh. Bat. Gen. Kun*.,: 25:152 (type locality: Hooghly, Calcutta).

Cynoglossus bengalensis Gunther, 1862, *Cat. Brit. Mus*., IV: 499 (Ganges; Pinang); Day, 1889, *Fish. India*:432, pl. xcvii, fig. 4; Duncker, 1904, *Mitt. Nat. Mus*., 21:169.

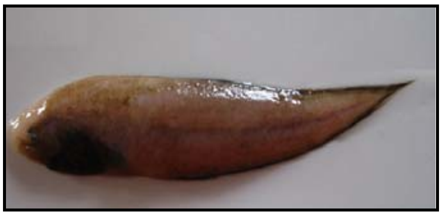
Cynoglossus buchanani Day, 1869, *Proc. Zoo. Soc. London*: 522 (India); Whitehead and Talwar, 1976, *Bull. Brit. Mus. (Nat. Hist.). Hist. Series*, 5 (1):162; Ferraris *et al*., 2000:295

Cynoglossus deltae Jenkins, 1910, *Rec. Ind. Mus*., 14: 130 (type locality: Khulna, East Bengal); Norman, 1928, *Rec. Ind. Mus*., 30 (2): 212.

Cynoglossus semifasciatus (not Day) Suvatti, 1936, *Fish. Siam*.,:98; Suvatti, 1950, *Fauna Thailand*: 328; Punpoka, 1964, *Bull. Fish. Res*., 1:70.

Cynoglossus cynoglossus Menon, 1977, *Smith. Contr. Zool*., 238: 68, fig. 32, pl .13; Weber and Beaufort, 1929, *Fish. Indo –Aust. Arch*., V: 199 (Singapore, Penang, Seas and estuaries of India, Ceylon, Pearl banks of Aripu).

Cynoglossus hamiltonii Gunther, 1862, *Cat. Brit. Mus*., IV: 504; Day, 1879, *Fish. India*, 4°: 436; Day, 1889, *Fauna Brit. India*, II: 458 (Burma, Malay Archipelago); Duncker, 1904, *Mitth. Nat. Mus*., XXI: 169



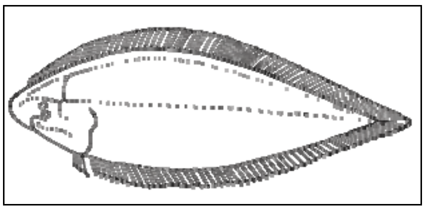


Plate LV: *Cynoglossus cynoglossus* (Hamilton –Buchanan, 1822)

Material examined: N=4, TL 141.6 -158.4 mm from Cochin Fisheries Harbour.

Diagnosis: 10-15 scales in the inter lateral line; 2 lateral lines on ocular side, none on blind side; snout pointed. Body scales ctenoid on both sides.

Meristic characters: D 94 – 204 (98); A 77 – 80 (78); C 8- 10 (8.5); V 4; Ll. 78 -120 (91); Head scale count 18 – 20 (18.7).

Body proportions as percent of SL (mean in parentheses): TKL 79.7 – 82.1 (81.1); BD1 21.7 – 26.5 (24.7); PAL 21.4 – 25.1 (24.7); DFL 4.1 – 5.7 (4.8); AFL 5.7 – 6.03 (5.9); CFL 6.95 – 7.9 (7.4); V_1FLO 4.4 – 6.5 (5.1); HL 18.1 – 19.8 (18.9); HD 12.7 – 14.97 (13.9); HW 21.02 – 24.7 (22.3); POL 11.8 – 13 (12.4); SNL_1 5.1 – 5.7 (5.5); SNL_2 5.4 – 7.2 (6.5); CD 4.1 – 4.7 (4.3).

As percent of HL (mean in parentheses): POL 59.4 – 65.8 (63.5); UHL 50.9 – 55.2 (52.9); LHL 64.2 – 74.95 (72); SNL_1 27.5 – 29.1 (28.3); SNL_2 29.5 – 35.5 (33.4); CD 20.4 – 24 (22); ED_1 8.3 – 10.96 (9.7); ED_2 8.52 – 10.1 (9.4); ID 5.6 – 8.3 (7.2).

Description: Body oval, elongate, thick, fleshy, with a broad central region, blunt head area and tapering tail. Eyes placed close, the upper a little in front of the lower separated by a narrow interorbital space less than the eye diameter. Snout pointed, rostral hook short hardly reaching the mandibular symphysis. Two nostrils on ocular side, a simple oval one in between the eyes, a tubular one in front of the lower eye. Maxillary ending a little beyond a vertical from posterior portion of lower eye. Scales ctenoid on ocular side and blind side. Dorsal fin origin just in front of the upper eye. Pelvic fin inserted at junction of operculum with ventral side of body. Caudal fin confluent with dorsal and anal fin.

Two lateral lines on ocular side separated by 10-15 scales in between. Lateral line absent on blind side. Scales on blind side oval with vertical striations from pigmented area to the outer. Lateral line branches on the head shows variations in different samples.

A comparative statement of the meristic characters of *Cynoglossus cynoglossus* is given in Table 113.

Table 113: A comparative statement of the meristic characters of *Cynoglossus cynoglossus*

Meristic characters	Earlier workers				Present study 2004 – 2010	
	Hamilton 1822	Norman 1928	Munroe 1955	Talwar & Kacker 1984	N = 4	Mean ± SD
Dorsal rays	102	97 - 105	98 - 106	95 - 102	94 -104	98.5 ± 4.4
Anal rays	78	74 - 81	78 - 83	72 - 78	77 – 80	78 ± 1.41
Pelvic (O/B)	*	4	*	*	4 - 5	4.3 ± 0.5
Caudal	12	*	*	10	8 - 10	8.5 ± 1
Lateral line scales	*	75 - 84	80 - 89	70 - 90	78 - 106	91 ± 8.2
Scales in between Ll	*	12 - 14	13 - 15	12 - 14	15 - 19	-

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of C*ynoglossus cynoglossus* is given in Table 114.

Table 114: Results of the correlation coefficient analysis on non-meristic characters of C*ynoglossus cynoglossus*

Characters	Range	Mean	SD	R^2on SL	Slope
Trunk length TKL	1.2 -1.3	1.23	0.02	0.912	0.830
Body depth (BD)	3.8 - 4.6	4.08	0.37	0.738	0.575
Preanal length (PAL)	3.99 - 4.7	4.40	0.32	0.951	0.604
Dorsal fin ray (20)	17.7 -24.7	21.09	3.13	0.797	0.187
Anal fin length	16.6 -17.5	17.10	0.46	0.625	0.031
Cudal fin length	12.7 - 14.4	13.59	0.71	0.211	0.044
Pelvic length	15.3 - 22.5	19.91	3.21	0.041	-0.042
Head length HL	5.1 - 5.5	5.29	0.23	0.400	0.156
Head depth (HD)	6.7 -7.9	7.22	0.56	0.400	0.191
Head width (HW)	4.04 - 4.8	4.50	0.31	0.259	0.222
Post orbital length(PDL)	7.7 - 8.5	8.09	0.34	0.308	0.074
Upper head lobe width (UHL)	9.2 - 10.2	9.71	0.44	0.086	0.023
Lower head lobe width (LHL)	6.8 - 7.6	7.15	0.34	0.646	0.188
Snout-> U eye	17.5 - 19.6	18.15	0.98	0.013	-0.004
Snout-> L eye	13.8 - 18.3	15.50	2.01	0.784	-0.111
Mouth	18.7 - 23.6	21.59	2.11	0.003	-0.005
Chin depth (CD)	21.1 - 24.6	23.34	1.54	0.066	0.017
Distance b/w	16.9 - 19.3	18.08	1.35	0.260	-0.028
Eye diameter (U)	46.2 - 58.9	53.56	5.37	0.224	0.024
Eye diameter (U)	52.6 - 59.4	54.83	3.10	0.445	0.020
Dorsal fin base	1 - 1.02	1.01	0.01	0.949	1.005
Anal fin base	1.23 - 1.3	1.25	0.02	0.946	0.489
Caudal fin base	28.8 - 37.9	34.27	3.93	0.627	0.087
Characters	**Range in HL**	**Mean**	**SD**	**R^2on HL**	**Slope**
Head depth (HD)	61.7 - 75.9	71.43	6.70	0.97	1.20
Post orbital length	59.4 - 65.8	63.56	2.98	0.96	0.53
Upper head lobe width	50.9 - 55.2	52.93	1.78	0.50	0.23
SNL_1	27.5 - 29.1	28.31	0.72	0.44	0.09
SNL_2	29.5 -35.5	33.40	2.78	0.04	-0.10
Mouth	22.1- 27.02	23.93	2.19	0.06	0.10
Chin depth (CD)	20.4 -24	22.06	1.48	0.53	0.20
Eye diameter (U)	8.3 - 20.96	9.67	1.13	0.50	0.15
Eye diameter (U)	8.52 - 10.05	9.39	0.66	0.00	0.00
Inter orbital	5.6 - 8.3	7.18	1.20	0.01	0.02

Colour: Brownish on ocular side with slightly darker shades in some areas; blind side whitish. Black markings o ventral side of vertical fins.

Distribution:

World: Taiwan (Punpoka, 1964); Western Indonesia (Kottelat et al., 1993); Batavia (Bleeker, 1851); Benculen, Sumatra (Bleeker, 1853); Ticao Island (Jordan and Richardson, 1908); Philippines (Fowler, 1918); Pinang (Gunther, 1862); Singapore, Penang, Ceylon, (Weber and Beaufort, 1929); Burma, Malay Archipelago (Day, 1889).

Map showing localities were *Cynoglossus cynoglossus* has been recorded in the world is given in Fig. 142.

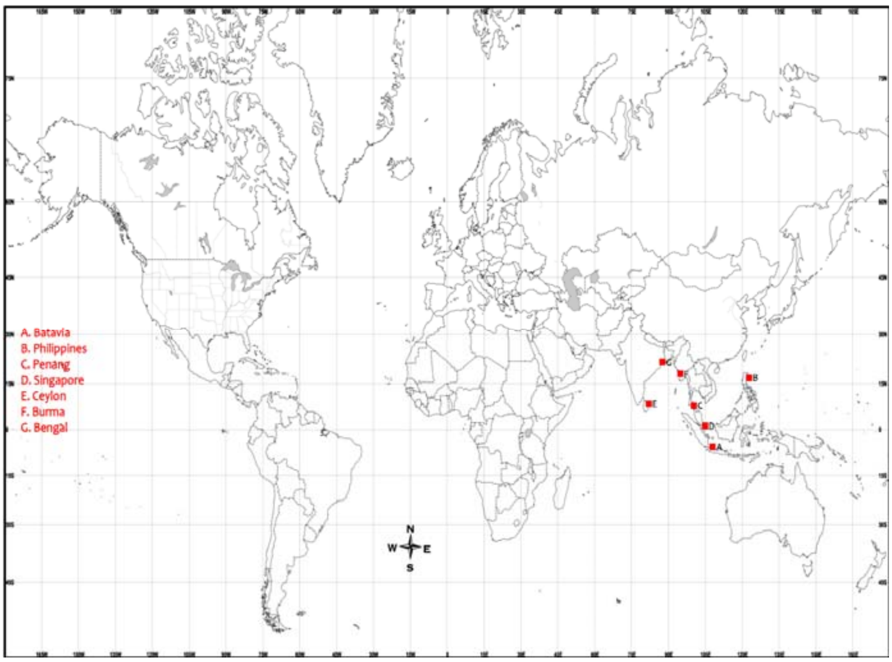


Fig. 142: Map showing localities were C*ynoglossus cynoglossus* has been recorded in the world

India: Bengal (Norman, 1928); Khulna (Jenkins, 1910); Pearl banks of Aripu, estuaries of India (Weber and Beaufort, 1929); Cochin Fisheries Harbour (present study).

Map showing localities were *Cynoglossus cynoglossus* has been recorded in India is given in Fig. 143.

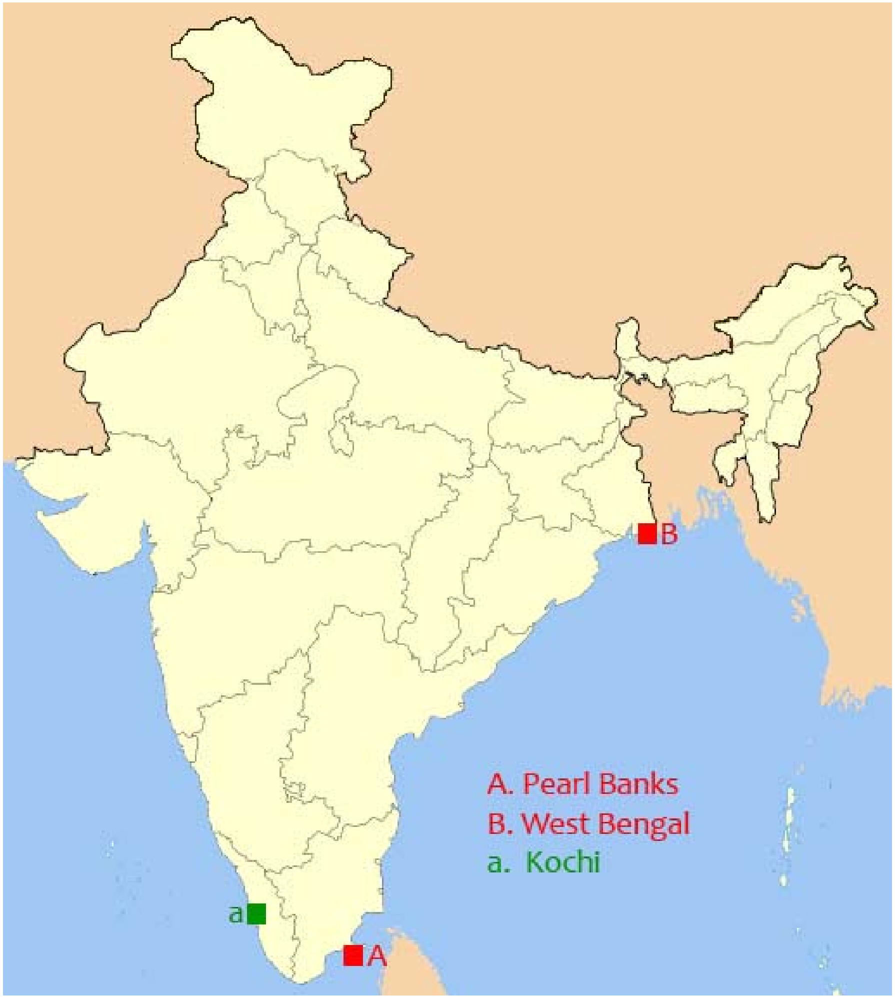


Fig. 143: Map showing localities were C*ynoglossus cynoglossus* has been recorded in the world

Taxonomic comments: The original description of "*oculis sinistris, pinnarum dorsi caudæ anique unitatrum*" was by Hamilton (1822) based on the collection from Ganges River. He mentions that "*it has utmost affinity to the Achirus bilineatus of Lacepede*" and "*strong resemblance to Jeree potoo of Dr. Russell*" as well to *Cynoglossus lingua* described by him in the same volume. However, Norman (1928) in a comment mentions that "*examinations of Hamilton's figure, which is preserved among a collection of drawings in the British Museum leave little doubt that he depicted the same species as that described by Bleeker as C. bengalensis. This figure is mentioned Acherius kukur jibba*". He also adds that the specimen of *C. bengalensis* in the British Museum collection and entered as *Achirus gibba* "*is in all probability the type of his Achirus cynoglossus*".

Cynoglossus cynoglossus of Munroe (1955) has two lateral lines on ocular side separated by 13 – 15 scales and no lateral line on blind side, rostral hook short, body brownish or grayish vaguely marbled with darker pattern. Hamilton–Buchanan (1822: 132) described *C. cynoglossus* as *Achirus cynoglossus* from a specimen from Ganges and based on his original drawing of the fish. Hora (1929: pl.19, figs. 2, 3) has reproduced this drawing. Norman (1928:208) synonymised *Plagusia bengalensis* Bleeker with *C. cynoglossus* and Blekker's *C. oxyrhynchos* and *P. sumatrana* as synonyms by Menon (1977: 68). Bleeker (1851a:416) described *P. oxyrhynchos* with the two lateral lines on the ocular side separated by 13 scale rows, a single lateral line on the blind side, two nostrils, subcontiguous eyes; *P. sumatrana* (Bleeker, 1853c:529) was characterized by two lateral lines on ocular and one on blind side, two nostrils and a wide interorbital space. Menon (1977:69) had personally examined the types of *P. oxyrhynchos* (BMNH 1862.6.3.17) and

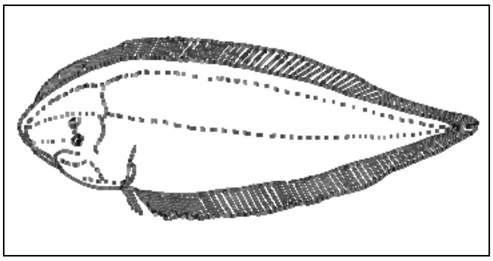
P. sumatrana (BMNH 1862.6.3.9) and compared them to samples of *C. cynoglossus* from the Ganges and confirmed their synonymy. However, he mentions that the lateral line on the blind side mentioned by Bleeker for his samples is absent in *C. cynoglossus*. *C. deltae* Jenkins (1910b:130) was described based on two specimens from Morrelganj, Kulna, Bangladesh. The fish had two lateral lines on ocular side.

Observatios: *Cynoglossus cynoglossus, C. semifasciatus,* and *C.macrostomus* form the *cynoglossus* complex. This complex ranges through the Malay Archipelago and the seas of India and Pakistan.(Menon, 1977). The fish resembles *C. semifasciatus;* however, it differs from it in the obtusely pointed and longer snout, wider interorbital space and the greater number of interlinear scale rows. The morpho-meristics of the present collection are in agreement with that of the earlier workers.

4.3.8.1.6 *Cynoglossus dubius* Day, 1873

Carrot tongue sole

Cynoglossus dubius Day, 1873, *J. Linn. Soc.Zool*., XI: 525 (type locality: Gwadur); Day, 1877, *Fish. India*: 435, pl. xcv, fig. 2; Norman, 1928, *Rec. Ind. Mus*., XXX: 200, fig. 15 (Travancore, Karachi, Bombay); Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean*, 1:75 (Kerala coast); Pradhan, 1964, *J. Bom. Nat. Hist. Soc*.,:458 (Bombay coast); Menon, 1977, *Smith. Contr. Zool*., 238:32 (Kumta, Udipi, Neendakara, Kerala, Travancore, Calicut); Mishra and Srinivasan, 1999, *Rec. Zool. Surv. India*, 97 (2):253; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (1):S123



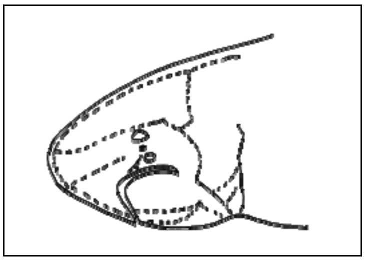


Plate LVI: *Cynoglossus dubius* Day, 1873

Material examined: N = 24; TL 205.04 – 343 mm from Kalamukku, Cochin and Neendakara Fisheries Harbour.

Diagnosis: Two lateral lines on ocular side, one lateral line on blind side, scales cycloid on ocular side.

Body proportions as percent of SL (mean in parentheses): HL 21.9 - 27.7 (26.0); TKL 73.9 - 77.3 (75.6); HD 16.1 - 25.2 (16.1); HW 12.6 - 25.2 (22.1); BD_1 22.5 - 27.9 (24.7); BD_2 1.6- 2.5 (10.6); ED_1 1.4 - 2.3 (1.9); ED_2 1.7 - 2.2 (2.0); ID 11.1 – 12 (5.2) PBU 9.7 - 11.6 (12.1) PDL 12.6 - 15.1 (14.0) UHL 8.8 - 11.7 (10.2); LHL 9.1 - 12.6 (12.7); SNL1 6.8 - 12.4 (11); SNL2 2.5 - 3.5 (8.9); Rostral hook 2.6 - 4 (3.1); Mouth 8.2 - 11.3 (7.4); Eye - Dorsal fin origin 4.5 - 6.7 (7.3); DFL ($20^{th)}$ 3.9 - 6.5 (5.2); CFL 5.8 - 9.6 (6.8); V1FLO 2.9 – 4 (3.6); DBL 84.8 - 101.8 (98.3); ABL 4.2 - 77.4 (74.9); CBL 1.5 - 2.9 (2.2); V1BLO 2 - 3.7 (2.4); PDL 2.3 - 4.2 (3.1); PAL 24.2 - 28.7 (26.8); Mouth 5.2 - 6.9 (5.7); CD 4.5 - 5.1 (4.9).

Description: Body lanceolate, broad at head and opercular region; snout rounded or obtusely pointed with short rostral hook ending well in front of lower eye. Eyes small, separated by a concave interorbital space; two nostrils on ocular side, Anterior nostril of eyed side round in the interorbital space, the second tubular in front of the lower eye above the mouth. Snout obtusely pointed. Maxillary extending to beyond posterior border of fixed eye; angle of mouth extending below vertical from posterior border of fixed eye, or a little beyond, nearer to branchial opening than to tip of snout. Body covered with cycloid scales on both sides, except along both dorsal and anal fins toward the posterior side of the ocular side, where the scales are weakly ctenoid. A sheath of skin extends onto fins. 5-6 rows of ctenoid scales seen on dorsal and ventral fin. Body scale oval with a wavy margin.

Two lateral lines on ocular side, a single one on blind side in the midlateral portion of body. The two lateral lines on ocular side joined by a median line and ending on the snout separately; midlateral line with 98-104 scales, 17-21 scales between two lateral lines. One branch arise from both lateral line and meets above snout which then proceeds downwards into rostral hook. Branchlets arise from these into the preorbital area. One branch arises from behind eye and proceeds into ventro-lateral margin of operculum. The midlateral line on ocular side instead of opening through simple pores on every scale opens by means of ducts into the adjoining scale, generally one duct on one side followed by three ducts on the other side. Lateral line on blind side seen in the middle with small branchlets towards the ventral side near operculum as well as cephalic towards lips.

A comparative statement of the meristic characters of *Cynoglossus dubius* is given in Table 115.

Table 115: A comparative statement of the meristic characters of *Cynoglossus cynoglossus*

Meristic characters	Earlier workers				Present study 2004 – 2010	
	Hamilton 1822	Norman 1928	Munroe 1955	Talwar & Kacker 1984	N = 4	Mean ± SD
Dorsal rays	102	97 - 105	98 - 106	95 - 102	94 -104	98.5 ± 4.4
Anal rays	78	74 - 81	78 - 83	72 - 78	77 – 80	78 ± 1.41
Pelvic (O/B)	*	4	*	*	4 - 5	4.3 ± 0.5
Caudal	12	*	*	10	8 - 10	8.5 ± 1
Lateral line scales	*	75 - 84	80 - 89	70 - 90	78 - 106	91 ± 8.2
Scales in between Ll	*	12 - 14	13 - 15	12 - 14	15 - 19	-

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus dubius* is given in Table 116.

Table 116: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus dubius*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Head length	3.5 - 4.6	3.9	0.2	0.83	0.28
Trunk length (TKL)	1.2 - 1.5	1.3	0.0	0.86	0.74
Head depth	4 - 10.3	6.8	2.0	0.02	0.14
Head width	4 - 8	4.6	1.0	0.33	0.20
BD_1	3.6 - 4.4	4.1	0.2	0.86	0.29
BD_2	4.1 - 4.7	4.4	0.2	0.93	0.29
ED_1	39.5 - 81.4	53.8	10.6	0.09	0.02
ED_2	37.2 - 75.5	52.9	10.6	0.06	0.02
UHL	8.6 - 15.1	9.8	1.3	0.29	0.08
LHL	6.6 - 8.0	7.3	0.4	0.73	0.12
SNL_1	8.1 - 14.8	9.4	1.4	0.60	0.14
SNL_2	7.6 - 13.2	8.7	1.2	0.67	0.15
Rostral hook	25 - 40.8	32.7	4.0	0.15	0.02
Dorsal 20^{th} FL	15 - 24.5	19.6	2.4	0.48	0.06
Pre dorsal	23.9 - 49.5	34.5	5.9	0.03	0.01
Preanal	3.3 - 4.1	3.7	0.2	0.82	0.26
Mouth	14.6 - 19.1	17.6	1.5	0.64	0.08
Chin depth	18.6 - 22.5	20.4	1.3	0.69	0.05
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head depth	0.98 - 2.76	1.78	0.56	0.00	0.31
Head width	0.97 - 2.1	1.23	0.26	0.29	0.69
Body depth	0.9 - 1.2	1.05	0.07	0.81	0.97
Eye Diameter (U)	9.5 - 21.4	14.23	3.03	0.08	0.05
Eye Diameter (L)	9.95 - 19.9	13.58	2.34	0.08	0.06
Post orbital	1.8 - 2.5	2.15	0.18	0.87	0.39
PDL	1.5 - 1.9	1.78	0.17	0.61	0.46
UHL	2.3 - 3.98	2.57	0.33	0.20	0.26
LHL	1.6 - 2.4	2.07	0.18	0.51	0.37
SNL_1	2.2 - 3.6	2.44	0.35	0.81	0.49
SNL_2	2 - 10	4.17	2.82	0.88	0.55
Rostral hook	6.8 - 10.4	8.67	1.13	0.18	0.06
Mouth	2.3 - 5.04	3.75	0.99	0.79	0.17
Eye - Dorsal fin origin	2. 5 - 9.1	4.15	1.77	0.30	0.45

Digestive system: Mouth thick in nature, leads to a tubular oesophagus and stomach into which opens the thick fleshy liver. Roof of the mouth–oesophagus junction has white rasping circular structure which probably helps to tear food. On the blind side, mouth is surrounded by thick fleshy lips. Two nostrils are seen on blind side above lips.

Colour: Ocular side of body light brownish, white on blind side; colour is retained in formalin preserved specimens also.

Distribution:

World: Reported from Sind, Baluchistan, Karachi (Norman, 1928). Map showing localities were *Cynoglossus dubius* has been recorded in India is given in Fig. 144.

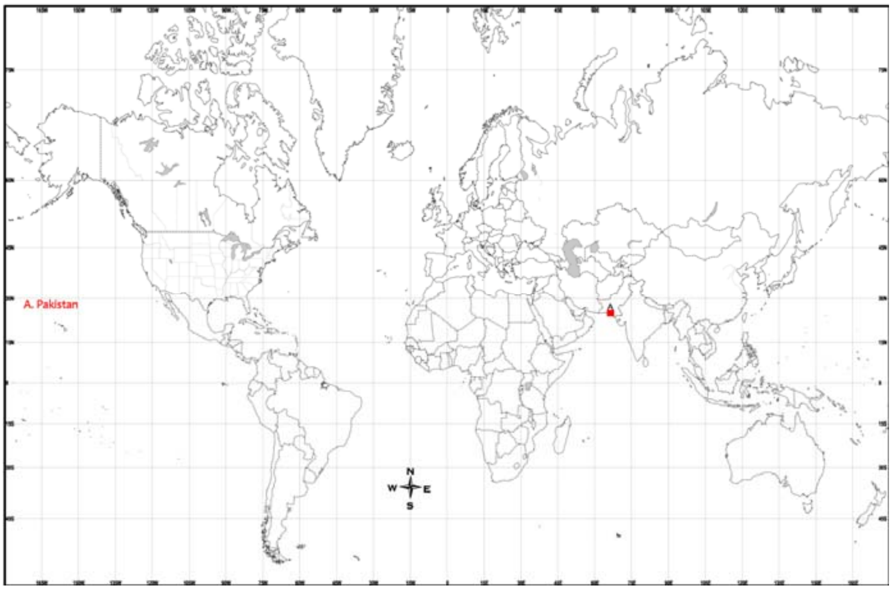


Fig. 144: Map showing localities were ***Cynoglossus dubius*** has been recorded in the world

India: Bombay, Travancore (Norman, 1928); West coast of India (Menon, 1977); Kalamukku, Cochin and Neendakara Fisheries Harbour (present study).

Map showing localities were *Cynoglossus dubius* has been recorded in India is given in Fig. 145.

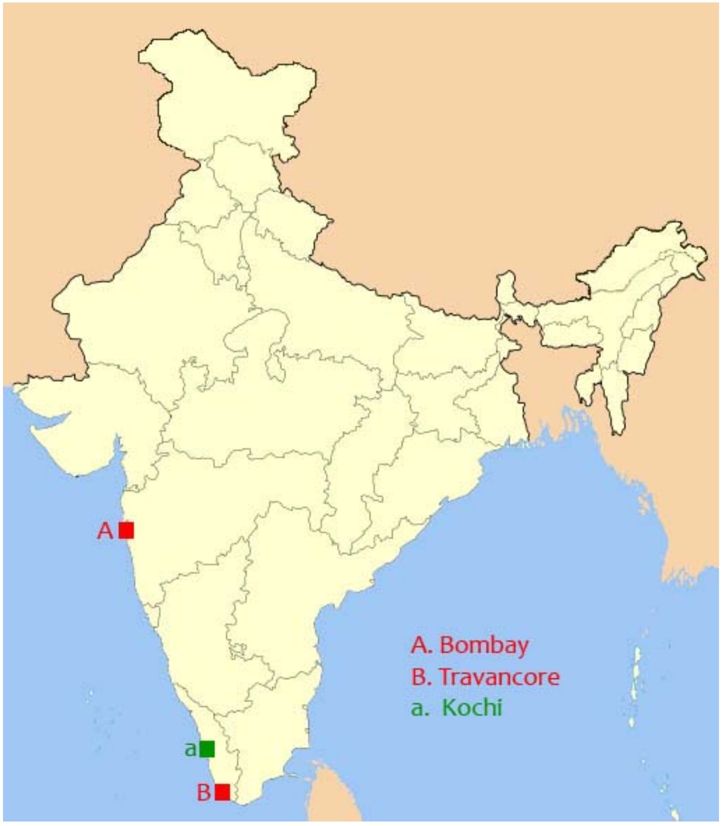


Fig. 145: Map showing localities were ***Cynoglossus dubius*** has been recorded in India

Taxonomic comments: Menon (1977) opines that "*originally described on the basis of a single specimen by Day, C. dubius was well diagnosed and there has been no confusion with regard to its identity*".

Remarks: Day (1873:525) described C. *dubius* from a single specimen, 500 mm in TL, from Gwadur and illustrated the specimen in his *Fishes of India* (59, fig. 2). Norman (1928:200) described the species from four specimens, 220- 460 mm in TL, and stated that it included an example "*believed to be the type of the species*." Day's type specimen was lost during the Varuna floods in Banaras in 1943, where the collections of the Zoological Survey of India were removed for safety during World War II (Menon, 1977: 33).

4.3.8.1.7 *Cynoglossus itinus* (Snyder, 1909)

Trulla itina Snyder, 1909, *Proc. U. S. Nat. Mus.*,36:609 (Naha market, Okinawa Island, Ryukyu Islands, Japan).

Cynoglossus punctatus Shen, 1969, Rep. Inst. Fish. Biol., Taipei, 2 (3):21, figs. 9-12.

Cynoglossus itinus Ochiai, 1959,:200; 1963, *Fauna Japonica* :79, pl. 17; Menon 1977, *Smith. Contr. Zool.*, :48; Ochiai in Masuda et al. 1984, *Fish. Japan. Arch.*,:356; Lindberg & Fedorov, 1993, *Fish. Sea Japan*, :216; Li and Wang, 1995, *Fauna Sinica*:378; Uyeda and Sasaki, 2000, Ichth. Res., 47(4):401; Munroe in Randall & Lim, 2000, *Raffles Bull. Zool. Suppl.*, 8:646; Nakabo, 2000, *Fish. Japan*:1390; Munroe, 2001, FAO SP. Iden Guide IV (6):3894; Nakabo, 2002, *Fish. Japan*:1390; Mishra & Krishnan, 2003, *Rec. India, Occ. Paper,* 236:47; Evseenko, 2003, *Vopr. Ikht.*, 43 (1):S71.

Plate LVII: *Cynoglossus itinus* (Snyder, 1909)

Material examined: N =4. TL 118.5 – 155.8 mm from Cochin Fisheries Harbour.

Diagnosis: Three lateral lines on eyed side of body.

Meristic characters: D 95 – 100; A 79 -80; C 8 -10.

Body measurements as percent of SL (mean in parentheses): TKL 81.8 -85.3 (83.3); HL 17.9 -20.2 (19.2); HW 22.2 – 25.9 (24.2); HD 10.3 -14.3 (12.2); UJL 4.6 -5.6 (5.1); LJL 4.5 -5.04 (4.7); ED_1 1.6 -2.2 (1.9); ED_2 1.9 -2.5 (2.1); ID 1.2 – 1.9 (1.4); PrOU 4.95 -6.2 (5.7); PrOL 4.97 -6.4 (5.9); UHL 8.9 -10.6 (9.9); DFL 3.9 -7.5 (5.8); AFL 4.1 – 7.7 (6.1); CFL 7.7 – 8.3 (9.3).

As percent of HL: HD 51.3 – 77.4 (63.6); UJL 22.99 -30.4 (26.7); LJL 22.4 -25.6 (24.5); ED_1 8.4 -11.1 (10.1); ED_2 9.5 -13.5 (11.2); ID 5.9 -10.4 (7.5); PrOU 27. 8 -33.3 (29.8); PrOL 27.95 -32.1 (30.7).

Description: Anterior nostril on ocular side tubular, on upper lip, in front of lower eye, posterior nostril absent. Snout rounded, with rostral hook short, not extending to vertical through the front of anterior nostril. Maxillary extending to below posterior half of fixed eye; angle of mouth extending to below vertical from middle of fixed eye, much nearer to snout tip than to branchial opening. Teeth on lower side (B) in two rows, closely set on both lower and upper jaws. Three lateral lines on ocular side, dorsolateral line slightly undulated, runs backward along the dorsal contour of body, entering dorsal fin at 20^{th} dorsal ray. A comparative statement of the meristic characters of *Cynoglossus itinus* is given in Table 117.

Table 117: A comparative statement of the meristic characters of *Cynoglossus itinus*

Meristic characters	Earlier workers			Present study 2004 – 2010	
	Norman 1928	Munroe 1955	Talwar & Kacker 1984	N = 4	Mean ± SD
Dorsal rays	97 - 105	98 - 106	95 - 102	94 -104	98.5 ± 4.4
Anal rays	74 - 81	78 - 83	72 - 78	77 – 80	78 ± 1.41
Pelvic (O/B)	4	*	*	4 - 5	4.3 ± 0.5
Caudal	*	*	10	8 - 10	8.5 ± 1
Lateral line scales	75 - 84	80 - 89	70 - 90	78 - 106	91 ± 8.2
Scales in between Ll	12 - 14	13 - 15	12 - 14	15 - 19	-

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus itinus* is given in Table 118.

Table 118: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus itinus*

Characters	Range	Mean	SD	R^2 on SL	Slope
Trunk length	1.2 - 1.22	1.20	0.025	0.981	0.942
Head length	4.96 - 5.6	5.22	0.280	0.796	0.196
Head width	3.87 - 4.5	4.14	0.246	0.690	0.199
Head depth	6.99 - 9.7	8.34	1.152	0.001	-0.003
Upper jaw	17.85 - 21.6	19.63	1.536	0.758	0.065
Lower jaw	19.86 - 22.1	21.29	0.974	0.885	0.055
Eye Diameter (U)	44. 99 - 61	51.99	6.146	0.297	0.014
Eye Diameter (L)	40.2 - 52.5	47.32	5.521	0.089	0.006
Inter orbital	53.8 - 85.3	71.61	12.375	0.347	0.020
Pre orbital (U)	16.12 - 20.2	17.59	1.645	0.295	0.023
Pre orbital (L)	15.6 - 20.05	17.07	1.810	0.429	0.050
Post orbital (U)	8.09 - 9.43	8.52	0.544	0.687	0.107
Dorsal	13.4 - 25.4	18.05	4.505	0.038	0.024
Anal	13 - 24.4	17.07	4.374	0.032	0.023
Caudal	10.8 - 12.9	11.91	1.057	0.995	0.031
Pelvic	19.96 - 28.9	24.64	3.682	0.438	0.051
Dorsal	1.0 - 1.02	1.01	0.007	0.995	0.981
Anal	1.2 - 1.23	1.21	0.020	0.976	0.836
Body depth 1	3.6 - 4.14	3.86	0.204	0.927	0.341
Body depth 2	3.6 - 3.7	12.84	15.887	0.903	1.064
Pre dorsal	22.5 - 72.4	36.25	20.672	0.823	0.123
Pre anal	4.16 - 4.83	4.39	0.271	0.936	0.310
Pre pelvic	4.91 - 5.3	5.11	0.149	0.916	0.192
Characters	**Range**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head width	0.77 - 0.8	0.79	0.03	0.916	1.047
Head depth	1.3 - 1.95	1.60	0.26	0.016	-0.054
Upper jaw	3.3 - 4.4	3.78	0.42	0.849	0.247
Lower jaw	3.91 - 4.5	4.09	0.21	0.392	0.073
Eye Diameter (U)	9.01 - 11.9	9.98	1.19	0.036	0.016
Eye Diameter (L)	7.4 - 10.5	9.10	1.27	0.028	0.026
Inter orbital	9.61 - 17.1	13.85	3.03	0.731	0.164
Pre orbital (U)	3.01 - 3.6	3.37	0.24	0.848	0.321
Pre orbital (L)	3.12 - 3.6	3.27	0.18	0.925	0.565
Post orbital (U)	1.58 - 1.7	1.63	0.05	0.881	0.637
Post orbital (L)	1.6 - 1.8	1.72	0.09	0.873	0.406
UHL	1.8 - 2.1	1.95	0.09	0.915	0.454
LHL	1.23 -1.43	1.35	0.07	0.316	0.180
Chin depth	3.24 - 4.4	3.75	0.45	0.030	0.020

Scale: Body with ctenoid scales on ocular side including lateral lines; on blind side, cycloid on head and weakly ctenoid on body; central part with cycloid scales. Scales with sharp ctenii on the posterior part of body.

Lateral line system: On the head, a supra orbital canal extends from snout through the area above eye and is connected to the mid lateral line in the posterior part of the head. Above the supra orbital, the cephalo dorsal canal commences at the snout, runs posterior ward along the dorsal edge of the head and is connected to the supra orbital commissure (ie a dorsal branch of the supra orbital lineat the posterior end of head). From the posterior part of the supra orbital canal, the pre opercular canal commences, running ventrally towards the pre opercular region. From this point it turns backward and runs towards edge of the opercular region. From the anterior end of the lower jaw to the operculum stretches the mandibulo opercular canal. At its posterior end, it turns upward and is connected to the preopercular canal.

Colour: Body greyish brown with brown fine dots all over

Distribution:

World: Hong Kong (Shen, 1969); Naha, Okinawa, Japan (Snyder, 1909).

India: Pondicherry (Mishra and Krishnan, 2003);Cochin Fisheries Harbour (present record).

Taxonomic comments: *C. itinus* was described by Snyder (1909) based on a single specimen 115 m in TL, from Naha, Okinawa, Japan. He described the fish as having a single nostril and three lateral lines on ocular side, the upper and the middle being separated by 12 or 13 scale rows. Shen (1969) described *Cynoglossus punctatus* from Hong Kong based on a single specimen and with the same characters. Menon (1977) synonymised the two and made *C. punctatus* a junior synonym of *C. itinus*.

Remarks: This species has been recorded in India earlier from Vishakapatnam. The collection from Cochin makes a new distributional record from the west coast of India.

4.3.8.1.8 *Cynoglossus lida* (Bleeker, 1851)

Shoulder spot tongue-sole

Plagusia lida Bleeker, 1851, *Nat. Tijds. Ned. Ind*., i: 413.

Arelia lida Bleeker, 1859, *Act. Soc. Sci. Indo –Neerl*., VI, *Ennum Spec*.,:184.

Cynoglossus lida Gunther, 1862, *Cat. Brit. Mus*., IV: 198; Bleeker, 1866, *Atl. Ichth*., VI: 36, pleuron, pl. xii, fig. 2; Day, 1878, *Fish. India*, pl. XCVII, fig. 3 (pl. 51); Munroe, 1955, *Fish. Ceylon*: 266, pl. 51, fig. 774 (Pearl banks); Smith, 1961, *Sea Fish. S. Africa*: 166 (Durban to Delagoa Bay); Heemstra, 1986, *Smith Sea Fish*.,:867, fig. 261.7 (Philippines to Mozambique, south to Durban); Menon, 1961, *Rec. Ind. Mus*., 59 (3): 399 (Tranquebar, Karaikkal, Cuddalore); Heemstra, 1986, *Smith Sea Fish*., :867; Quéro and Maugé, 1989, *Cybium*, 13 (4):392; Krishnan and Mishra, 1994, *Rec. Zool. Surv. India,* 94 (2-4):300; Li and Wang, 2000, *Fauna Sinica*: 350; Munroe, 2001, *FAO Sp. Iden. Guide*, VI: 3894; Manilo and Bogorodsky, 2003, *J. Ichth*., 43(1):S123; Heemstra and Heemstra 2004, *Coastal Fish. S. Africa*:436.

Cynoglossus intermedius**,** Alcock, 1889, *J. Asiat. Soc. Bengal*, 58 II (3):288 (32 miles southwest of Puri, Bay of Bengal, Investigator, depth 7 fathoms).

Cynoglossus os Fowler, 1904, *J. Acad. Nat. Sci.*, 12 (4):556, pl. 28 (Padang, Sumatra, Indonesia).

Plagusia polytaenia Bleeker, *Nat. Tijds. Ned. Ind.*, 5: 1853:529 (Priaman, Sumatra, Indonesia).

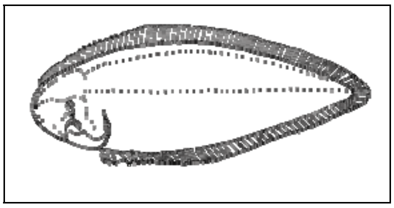


Plate LVIII: *Cynoglossus lida* (Bleeker, 1851)

Material examined: N =5; TL 152.42-165.83 from Calicut,

Diagnosis: Broad round prominent snout, the angle of the mouth nearer to the branchial opening than to the snout tip; rostral hook extending to below the middle of the fixed eye.

Meristic characters: D 100 – 101 (100); A 72 -78 (75); V_1 4; C 10 -12; Ll.78

Body proportions as percent of SL (means in parentheses):TKL 79.1 – 80.6 (79.7); HL 21.2 – 24.6 (23.2); HW 21.3 – 22.7 (21.8); HD 10.9 – 13.8 (12.3); ED_1 1.7 – 3.2 (2.8); ED_2 1.96 -2.9 (2.4); ID 1 – 1.3 (1.13); E-UJ 0.3 – 0.95 (0.6); CD 4.6 -5.3 (4.96); DFL 4.4 – 6.2 (5.1); AFL 4.4 – 5.7 (4.95); V_1FLO 3.7 – 4.99 (4.1); CFL 6.2 – 8.04 (6.8); DBL 95.9 - 100.2 (98.5); ABL 68.8 – 80.1 (74.6).

As percent of HL (means in parentheses): HW 86.6 -104.5 (94.4); HD 47.3 -59.97 (53.2); ED_1 7.4 – 14.5 (12.2); ED_2 8.4 -12.1 (10.5); ID 4.1 – 5.5 (4.9); E-UJ 1 – 4.5 (2.5); CD 19.97 -24.2 (21.5); DFL 18.5 -25.3 (21.5); AFL 18.7 – 33 (21.4); V_1FLO 16.2 -20.99 (17.7); CFL 25.96 - 31.76 (29.5).

Description: Body, moderately big, elongate with a broad head region and tapering tail. Eyes placed close, separated by a narrow interorbital space, lesser than eye diameter; upper eye a little in advance of the lower. Snout rounded, rostral hook prominent, moderate in size. Mouth convex in outline; maxillary ending a little beyond the posterior part of the lower eye. Angle of mouth nearer to snout than the operculum. Two nostrils on ocular side of eye, a posterior oval one in the interorbital space and anterior tubular one in front of the lower eye. Body covered with ctenoid scales on both sides. Two lateral lines on ocular side, separated by 13-15 scale rows; no lateral line on blind side.

A comparative statement of the meristic characters of *Cynoglossus lida* is given in Table 119.

Table 119: A comparative statement of the meristic characters of *Cynoglossus lida*

Meristic characters	Gunther 1862	Norman 1928	Weber & Beaufort 1929	Munroe 1955	Seshappa 1968	Menon 1977	Cheng and Weng 1965	Punpoka 1964	Radhamanyamma 1988	Present work 2004 - 2010 N= 1
Dorsal rays	103 -104	99 -112	100 – 110	99 – 112	103 – 109	99 – 108	100 -104	99 – 112	100 -103	100 – 101
Anal rays	82 -83	75 - 87	77 – 86	75 – 87	80 – 84	77 - 85	78 – 82	75 - 87	76 -78	72 – 78
Caudal	10 -12	*	*	*	10 – 11	*	8	*	10	10 -12
Ventral	4	*	*	*	*	*	4	*	*	4
Lateral line scales	90	82 - 95	90	82 – 95	94 – 104	72 – 90	90	82 – 95	*	72 -75
Ltr	*	13 -15	13 – 14	13 - 15	15 - 16	12 - 15		13 – 15	*	14 – 15

Results of the correlation coefficient analysis on non-meristic characters of ***Cynoglossus lida*** is given in Table 120.

Table 120: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus lida*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Trunk length	1.2 -1.3	1.25	0.008	0.964	0.71
Head length	4.1 - 4.7	4.34	0.279	0.071	0.08
Head width	4.4 - 4.7	4.56	0.131	0.682	0.24
Head depth	7.3 - 9.2	8.26	0.869	0.010	0.03
Eye Diameter (U)	31.5 - 33.3	32.49	0.733	0.364	-0.09
Eye Diameter (L)	34.8 - 44.9	39.44	4.535	0.305	-0.05
Inter orbital	79.2 -100.2	88.51	9.139	0.408	0.02
Chin depth	18.7 - 21.8	20.22	1.357	0.031	-0.02
Dorsal FL	15.1 - 22.8	19.20	2.743	0.621	-0.13
Anal FL	17.7 - 22.6	20.02	2.096	0.348	-0.06
Pelvic FL	20.1 - 27.1	24.23	2.976	0.021	0.02
Caudal FL	12.4 - 16.2	14.46	1.563	0.608	-0.11
Dorsal BL	1 - 1.02	1.01	0.008	0.788	0.77
Anal BL	1.3 - 1.5	1.34	0.099	0.564	1.30
Characters	**Range in HL**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head width	0.96 -1.2	1.06	0.081	0.01	0.08
Head depth	1.7 - 2.1	1.91	0.219	0.00	0.05
Eye Diameter (U)	6.9 - 8.01	7.51	0.462	0.38	-0.30
Eye Diameter (L)	8.3 - 9.5	9.07	0.585	0.01	0.03
Inter orbital	18.2 - 24.6	20.49	2.825	0.02	0.01
Chin depth	4.1 - 5.01	4.67	0.402	0.28	-0.14
Dorsal	3.95 - 5.4	4.43	0.660	0.24	-0.25
Anal	4.4 - 5.4	4.62	0.495	0.07	-0.08
Pelvic	4.8 - 6.2	5.58	0.587	0.20	0.20
Caudal	3.1 - 3.9	3.34	0.359	0.11	-0.15
Dorsal	0.2 - 0.3	0.23	0.015	0.00	0.17

Colour: Body muddy brown with a dark patch on the opercular cover near the pelvic fin; blind side whitish.

Distribution:

World: Pearl banks (Munroe, 1955); Durban to Delagoa Bay (Smith, 1961).

Map showing localities were ***Cynoglossus lida*** has been recorded in the world is given in Fig. 146

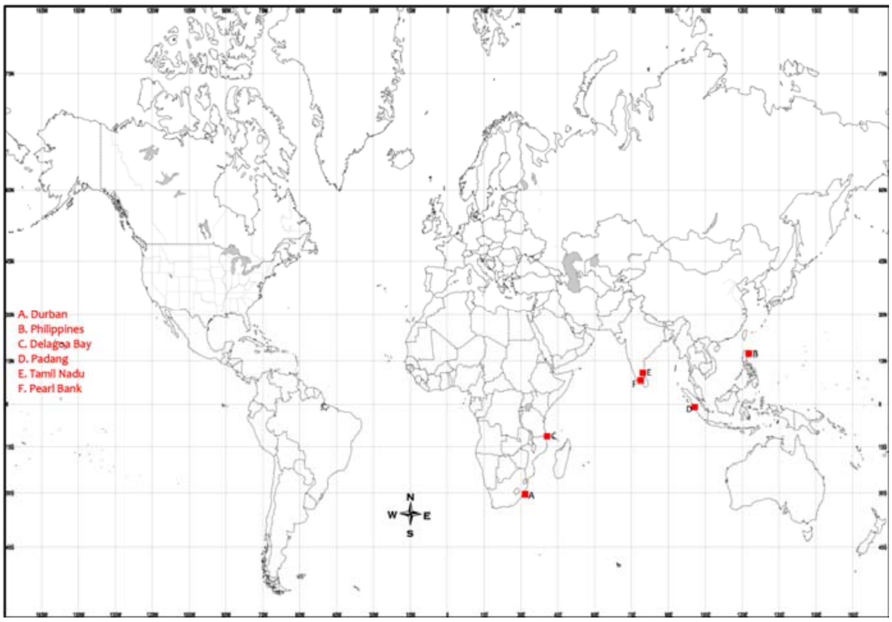


Fig. 146: Map showing localities were ***Cynoglossus lida*** has been recorded in the world

India: Tranquebar, Karaikkal, Cuddalore (Menon, 1961), southewest of Puri (Alcock, 1889). Map showing localities were ***Cynoglossus lida*** has been recorded in India is given in Fig. 147

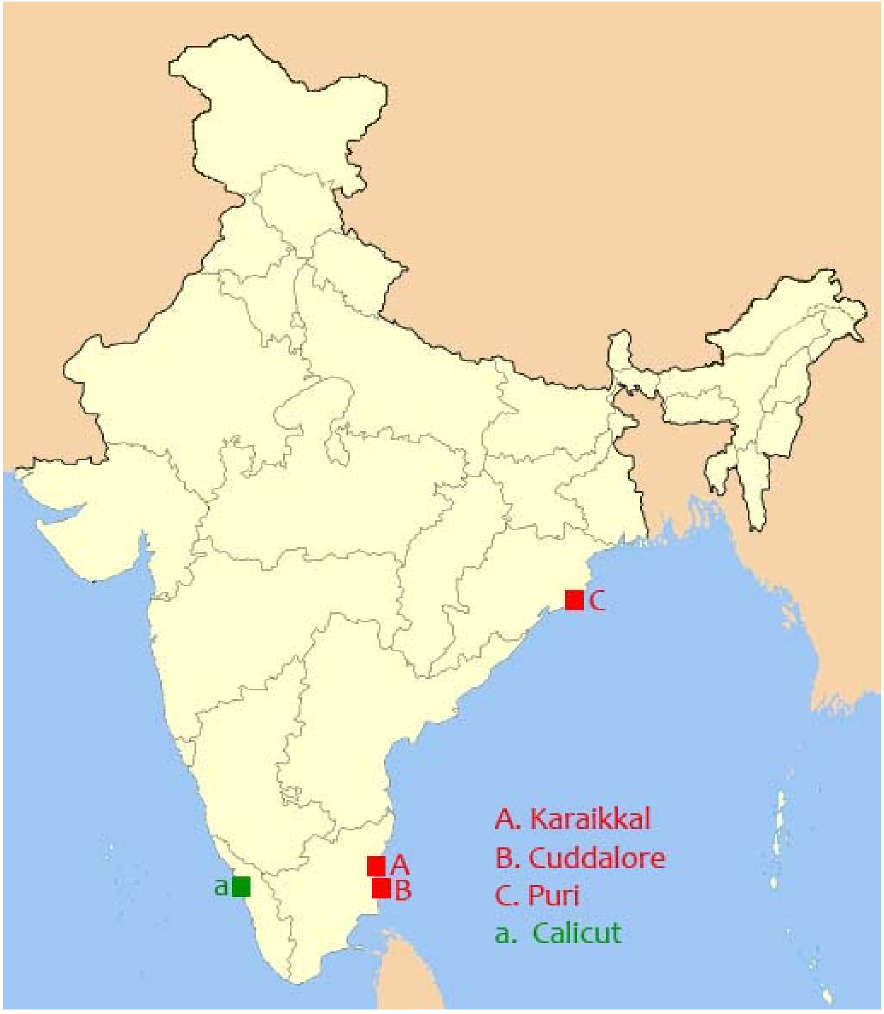


Fig.147: Map showing localities were ***Cynoglossus lida*** has been recorded in India

Taxonomic comments: Bleeker (1851) described the fish as *Plagusia lida* based on five samples from Batavia with TL 100 – 145 mm. The sample had 2 lateral lines on the ocular side with 13 inter-row scales, and the angle of mouth nearer to snout than gill opening. Bleeker later described another species as *Arelia lida* from the same locality and later synonymised the two. Gunther (1862) placed the fish in genus

Cynoglossus in which it continues to date. *Cynoglossus intermedius* described by Alcock (1889) from the *Investigator* collections from a depth 7 fathoms, southwest of Puri was later synonymised by Norman (1928) with *C. lida*. Menon (1977) confirms this with the comment "*I have examined the holotype of C. intermedius in the Zoological Survey of India and find that the differences noted by Alcock in the type of C. intermedius, such as the more numerous, weakly ctenoid scales and the longer head, are attributable to intraspecific variation and that they are conspecific*". Menon (1977) further synonymised *P. polytaenia* of Bleeker and *C. os* from Pedang with *C. lida* of Gunther.

Observations: Munroe (1955) described the fish with ctenoid scales on both sides, no lateral line on blind side and two lateral lines on ocular side separated by 13-15 scales. The meristic characters of the present specimen are very well within the range given by earlier workers.

4.3.8.1.9 *Cynoglossus macrolepidotus* (Bleeker, 1850)

Large scale tongue sole

Plagusia macrolepidota Bleeker, 1850, *Nat. Tijds. Neder. Indië*, 1: 415. (type locality: Batavia); Bleeker, 1852, *Verh. Batav. Kun. Weten.*, 24: 25.

Arelia macrolepidota Bleeker, 1859, *Acta Soc. Sci.. Indo – Neerl.*, 6:184.

Cynoglossus macrolepidotus Bleeker, 1875, *Atlas. Ichth.*, 34, pl. 242, fig. 2; Day, 1877, *Fish India*, 4º: 434, pl. 96, fig.3; Alcock, 1889, *J. Asiatic Soc. Bengal*, 58 (2): 288; Rutter, 1897, *Proc. Acad. Nat. Sci. Philad.*,: 89; Seale, 1910, *Phil. J. Sci.*, (4): 288; Jenkins, 1910, *Mem. Ind. Mus.*, III: 30; Norman, 1928, *Rec. Ind. Mus.*, 30 (2):202, fig.18 (Persian Gulf, 13 fathoms; North end of Persian Gulf, 15 fathoms); Herre, 1933, *J. Pan Pac. Res. Inst.*,: 5; Fowler, 1934, *Hong Kong Nat.*, 5(3):219; Fowler, 1937, *Fish. Malaya*: 87; Okada and Matsubaara, 1938, *Key Fish. Japan*: 437 (Formosa, Java, Banka); Herre, 1941, *Mem. Ind. Mus.*, 13: 392 (Andaman Islands); Blegvad, 1944, *Danish. Sci. Invest. Iran*, 3: 207, fig. 127 (Iranian Gulf); Suvatti, 1950, *Fauna Thailand*: 327; Herre, 1953, *U.S Fish. Wildlife Ser. Res. Rept.*, 20: 190 (Philippines); Munroe, 1955, *Fish. Ceylon*: 265, pl. 51, fig. 770; De Silva, 1956, *Ceylon J. Sci.*, C, 7 (2): 197; Fowler, 1956, *Fish. Red Sea*: 186, fig. 101; Scott, 1959, *Sea Fish Malaya*, XII: 43; Kuronuma, 1961, *Checklist Fish. Vietnam*: 32; Menon, 1961, *Rec. Ind. Mus.*, 59 (3):399 (Tranquebar, Pondicherry, Cuddalore); Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean*, 1:76; Punpoka, 1964, *Kasetsart Univ. Fish. Res. Bull.*, 1: 64; Pradhan, 1964, *J. Bombay Nat. Hist. Soc.*, 61(2): 458; Chen and Weng, 1965. *Biol. Bull.*,: 95, fig. 66; Shen, 1967, *Quart. J. Taiwan Mus.*, 20 (1, 2): 215; Li and Wang, 1995, *Fauna Sinica*: 342; Mishra *et al.*, 1999, *Rec. Zool. Surv. India*, 93(3):89.

Plate LVIX: *Cynoglossus macrolepidotus* (Bleeker, 1850)

Material examined: N=12; TL 200 - 389 mm from Cochin Fisheries Harbour.

Diagnosis: One lateral line and cycloid scales on blind side; 2 lateral lines on ocular side separated by 10-13 scales in between.

Meristic characters: D 101 – 112; A 86 – 96; C 8 -10; V1 3 -5; SLL 111 – 135.

Body measurements as percent of SL: HL 18.4 – 24.1 (20.3); Hht. 12.7 – 17.99 (14.2); BD 25.3 – 46.03 (29.4); ED_1 1.5 – 2.4 (1.8); ID 1.7 – 2.3

(1.9); SNL_1 7.2 – 10.6 (8.8); SNL_2 8.4 – 11.8 (9.9); DFLO 3.5 – 9.7 (5); AFLO 3.9 -7.99 (4.9); V_1FLO 3.5 -5.9 (4.1); DBL 84.1 – 116.9 (99.8); ABL 71.7 -89.9 (78.9); V_1BLO 2.1 – 4.7 (3.1); PDL 1.3 -4.6 (2.3); P_1VLO 3.8 -24.2 (16.99).

Body measurements as percent of HL: ED_1 8.1 – 12.2 (9.1); ID 8.3 – 11.4 (9.4); SNL_1 37.5 – 54.3 (43.4); SNL_2 43.3 – 60.3 (48.8) PDL 6.5 – 19.6 (11.2)

Description: Body big, broad, elongated, flattened with broad head end and tapering tail. Eyes placed close separated by a concave scaly interorbital space; upper eye a little in front of the lower eye, lower eye placed midway between snout and gill opening. Eye diameter of the lower eye exceeds or is nearly equal to interorbital; rostral hook short; extends back to a little beyond lower jaw. Two lateral lines on ocular side separated by 6 – 9 scales. Lateral line absent on blind side. Ctenoid scales on ocular side, cycloid on blind side.

A comparative statement of the meristic characters of ***Cynoglossus macrolepidotus*** is given in Table 121

Table 121: A comparative statement of the meristic characters of *Cynoglossus macrolepidotus*

Meristic characters	Earlier workers			Present study 2004 – 2010
	Day 1877	Munroe 1955	Fowler 1956	N = 2
Dorsal rays	116 - 118	105 - 130	105 - 130	101 – 112
Anal rays	86 -90	56 - 66	80 - 96	86 - 96
Pelvic (O/B)	*	*	*	3 - 5
Caudal	*	*	*	8 - 10
Lateral line scales	50 - 55	*	48 - 66	111 - 135
Scales in between Ll	6 - 7	7 - 8	6 - 9	15 - 19

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus macrolepidotus* is given in Table 122.

Table 122: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus macrolepidotus*

Characters	Ratio/Range in SL	Mean	R^2 on SL	Slope
Head length	4.2 - 5.4	4.95	0.92	0.23
Head ht.	5.6 - 7.9	7.13	0.90	0.17
Body depth	2.2 - 3.95	3.49	0.62	0.24
Eye diameter	42 - 65.1	54.93	0.77	0.01
Inter orbital	44.5 - 60.5	52.72	0.88	0.02
to upper eye	9.4 -13.96	11.51	0.77	0.08
to lower eye	8.5 -11.9	10.21	0.84	0.08
Dorsal fin ht	10.3 - 28.5	21.80	0.07	0.02
Anal fin ht	12.5 - 25.4	21.08	0.42	0.03
Pelvic (O)	17.03 - 28.8	25.07	0.67	0.04
Caudal	9.1 - 18.4	15.78	0.34	0.04
Dorsal	0.9 - 1.2	1.01	0.92	0.99
Anal	1.1 - 1.4	1.27	0.91	0.68
Pelvic (O)	21.2 - 48.3	33.85	0.69	0.04
Pre dorsal	21.9 - 76.6	53.48	0.27	0.03
Prepelvic (O)	4.1 - 26.5	9.78	0.17	-0.14
Caudal peduncle	17.9 - 47.95	34.21	0.75	0.09
Characters	**Ratio/Range in HL**	**Mean**	**R^2 on HL**	**Slope**
Head ht.	1.3 -1.5	1.44	0.98	0.74
Body depth	0.4 - 0.79	0.71	0.70	1.07
Eye diameter	8.2 - 12.4	11.13	0.91	0.06
Snout to upper eye	8.8 - 12.01	10.65	0.95	0.09
Snout to lower eye	1.8 - 2.7	2.33	0.83	0.33
Dorsal fin ht	1.7 - 2.3	2.07	0.91	0.34
Anal fin ht	2.02 - 5.9	4.41	0.12	0.11
Pelvic (O)	2.5 - 5.2	4.27	0.54	0.13
Caudal	3.3 - 5.8	5.07	0.74	0.20

Colour: Dark brown on ocular side, whitish on blind side. Fins greyish, dorsal and anal fin marked with a streak of brown.

Distribution: Map showing localities were *Cynoglossus macrolepidotus* has been recorded in the world is given in Fig.148

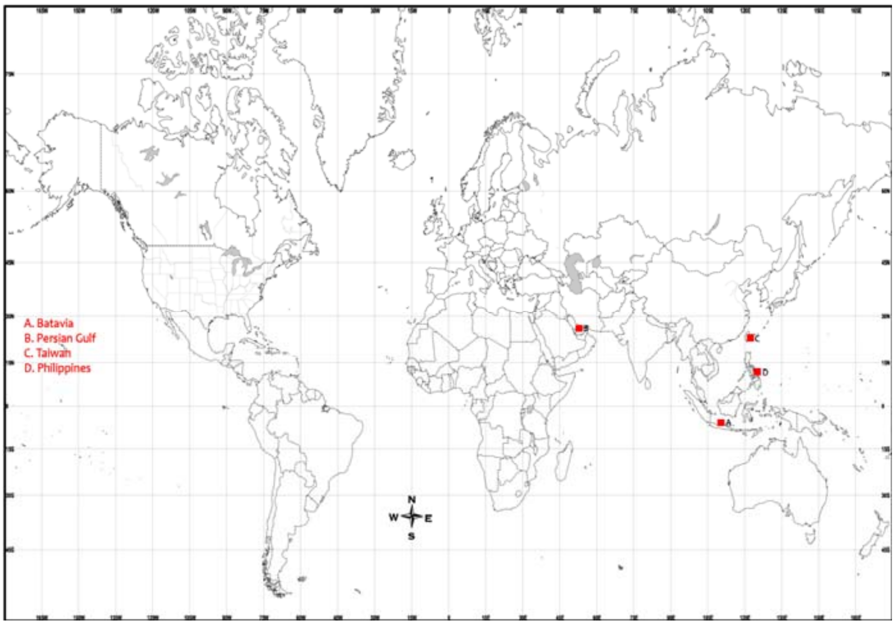


Fig.148: Map showing localities were *Cynoglossus macrolepidotus* has been recorded in the world

Map showing localities were ***Cynoglossus macrolepidotus*** has been recorded in India is given in Fig. 149

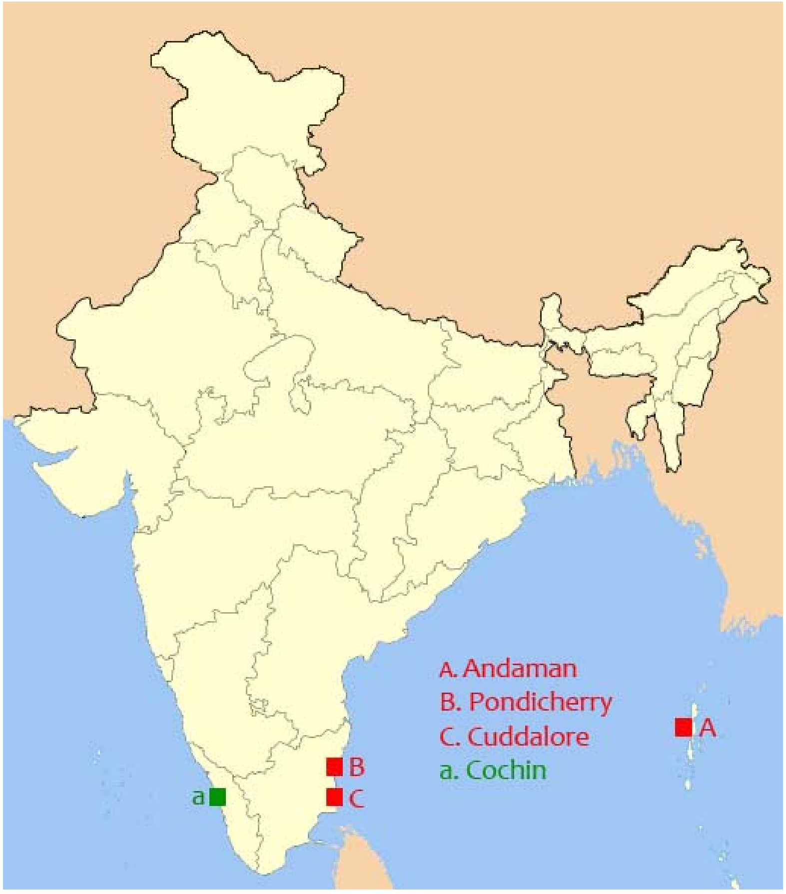


Fig. 149: Map showing localities were *Cynoglossus macrolepidotus* has been recorded in India

Taxonomic comments: Bleeker (1851:415) described *Plagusia macrolepidota* from Batavia; later Bleeker (1875) in his *Atlas* redescribed *Cynoglossus macrolepidotus* and illustrated it. His description and illustration were so good that subsequent workers identified this common and widely distributed Indo-West Pacific species with *C. macrolepidotus.* Menon (1977) synonymised this species with *C. arel*. After a long list of synonymy, Eschmeyer has placed the species as distinct from *C. arel* as a valid species.

Observations: Scales large in size, hence the name "*macrolepidotus*".

4.3.8.1.10 *Cynoglossus macrostomus* Norman, 1928.

Malabar sole

Achirus cynoglossus Hamilton Buchanan, 1822, *Fish. Ganges*: 132, 373 (Hooghly at Calcutta).

Plagusia cynoglossa Cantor, 1850, *J. Asiat. Soc. Bengal*, xviii: 1211.

Icania cynoglossa Kaup, 1858, *Arch. Natur*. xxiv, I : 109.

Cynoglossus hamiltonii (not Gunther) Day, 1877, *Fish. India*: 436, pl. 95, fig. 3 (Hooghly at Calcutta); Day, 1889, *Fauna Br. India*, 2: 458; Duncker, 1904, *Mitth. Naturh. Mus. Hamburg* xxi :169.

Cynoglossus macrostomus Norman, 1928, *Rec. Ind. Mus*.,: 204, fig. 20 (Calcutta, Portuguese India, Orissa); Menon, 1977, *Smith. Contri. Zool*., 238: 72, fig. 34 (Tanur, Malabar coast); Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean* 1: 77 (Kerala coast); Menon, 1977, *Smith. Contr. Zool*., 238: 72, pl. 14, fig. 34 (Tanur); Talwar and Jhingran, 1991, *Inland Fish. India*, 2: 1042; Evseenko, 1998, *Russian Acad. Sci*.,: 61; Mishra and Sreenivasan, 1999, *Rec. Zool. Surv. India*, 97 (2): 253; Misra *et al*. 1999, *Rec. Zool. Surv. India,* 93 (3): 89; Manila and Bogorodsky, 2003, *J. Ichth*.,: S.123.

Cynoglossus luctusos Chabanaud, 1948, *Ann. Mag. Nat. Hist*., (Series 11), 14 (119): p. 813, (type locality: Tanur, Madras, India).

Cynoglossus semifasciatus (not Day) Seshappa and Bhimachar, 1955, *Indian J. Fish*., 2(1): 183, pl., 1, fig. 21

Cynoglossus cynoglossus (not Hamilton – Buchanan) Saramma, 1963, *Bull. Dept. Mar. Biol. Ocean,* 1: 77 (Kerala coast).

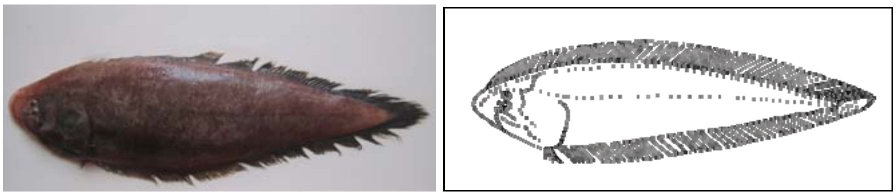


Plate LX: *Cynoglossus macrostomus* Norman, 1928.

Material examined: N = 205; TL 76 -150 mm; males: N = 97; TL 76 - 148 mm; females N =108; TL 76 -150 mm.

Diagnosis: 14 -15 interlinear scale rows on ocular side.

Meristic characters: D 98 - 108; A 72 - 96; C 9 – 10; Ll. 80-94

Male: **Body proportions as percent of SL (mean in parentheses):** HL 20.2 -24.6 (22.2); HD 21.4 -26 (24.1); HW 3.3 - 6.4 (4.3); ED_1 2 - 3.5 (2.8); ED_2 2.8 -4.6 (3.7); SNL_1 5.3 -6.7 (6.1); SNL_2 6.1 -7.8 (6.95); BD_1 23.9 -28.4 (25.3); V_1FLO 3.3 -5.3 (4.4); CFL 9.1 -10.8 (9.8); DBL 77.3 - 102.7 (84.9); ABL 70.9 -79.7 (75.9); V_1BLO 2.5 - 4.9 (3.3).

As percent of HL (mean in parentheses): 96.2 -119 (108.6); HW 14.3 - 27.6 (19.2); ED_1 8.3 -16.7 (12.5); ED_2 12.5 -20 (16.8); SNL_1 22– 31.3 (27.3); SNL_2 25.9 -36 (31.3); BD_1 100 – 126.1 (114.1); V_1FLO 16 -23.8 (19.6); CPL 37-50 (44.2); DBL 314.8 -495.7 (382.9).

Female: **Body proportions as percent of SL (mean in parentheses):** HL 18.3 -25 (22.2); HD 20.4 -26.8 (24.1); HW 3.3 -5.1(4.2); ED_1 1.5 – 3.6 (2.8); ED_2 2.8 - 4.4 (3.7); SNL_1 5.2 -7.1(6.1); SNL_2 3.96 -8.04 (6.87); BD_1 21.3 -26.4 (25.2); V_1FLO 3.4 -4.9 (4.3); CFL 2.2 – 10.4 (9.7); DBL 78.3 – 87.2 (84.5); ABL 6.9 – 81.7 (75.2); V_1BLO 2.6 -4.6 (3.4).

As percent of HL (mean in parentheses): HD 92.8-127.3 (109.2); HW 14.3 – 21.7 (18.8); ED_1 6.7 -17.4 (12.8); ED_2 13.3 – 20 (16.7); SNL_1 21.4 -36.4 (27.4); SNL_2 17.4 - 40.9 (31.1); BD_1 100 -131.8 (113.9); V_1FL 14.3

-23.8(19.4); CFL 9.6 -50 (43.9); DBL 342.3 -463.6 (382.7); AFL 30 - 445.5 (340.8); V_1BLO 10.7 - 22.7 (15.3).

Description: Body short, broad and not so elongated. Head broad, with two eyes placed close together, interorbital space absent sometimes. Two nostrils present in the head, the first oval in the interorbital space, the second tubular on the upper lip area. Snout obtusely pointed, rostral hook short reaching up to just behind anterior nostril. Maxillary ends a little beyond posterior margin of lower eye. Two lateral lines seen on ocular side; a median lateral line extending from a little in front of the operculum to the caudal fin origin; the second one on the dorso- lateral margin just beneath the dorsal fin, entering it a little in front of the caudal fin origin. Both the lateral lines have preorbital branches, extending into the snout. Midlateral line with 80 - 90 scales and with 13 - 16 midlateral scales in between the two lateral lines. Lateral line absent on the blind side.

A comparative statement of the meristic characters of *Cynoglossus macrostomus* is given in Table 123.

Table 123: A comparative statement of the meristic characters of *Cynoglossus macrostomus*

Meristic characters	Earlier workers			Present work 2004 - 2010	
	Norman 1928	Menon 1977	Saramma 1963	N = 205	Mean ± SD
Dorsal rays	100-104	100-106	109-110	98 - 108	102 ± 3.1
Anal rays	76-80	78-84	84-85	72 - 96	78 ± 3.6
Lateral line scutes	95	80-92	*	80-94	15 ± 0.6
Caudal	*	*	*	9 -10	9 ±1.1

*Data not available

Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus macrostomus* is given in Table 124.

Table 124: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus macrostomus*

Male characters	Range in SL	Mean	SD	R^2 on SL	Slope
Head length	4.1 -5	4.5	0.19	0.93	0.23
Head height	3.3 -6.5	4.5	0.81	0.97	0.24
Head width	16.3 - 37.8	28.1	4.97	0.64	0.05
ED_1	10.9 - 40	17.8	4.71	0.69	0.03
ED_2	9.7 - 30	15.4	3.35	0.71	0.03
SNL_1	2.7 -17.7	4.5	2.33	0.87	0.06
SNL_2	13.3 - 33	23.6	4.06	0.91	0.07
Body depth	3.8 - 13.6	10.4	2.03	0.97	0.26
ABL	1 - 2	1.4	0.25	0.99	0.76
V_1BL	21.2 - 53	32.4	8.65	0.60	0.04
Male characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head height	0.8 -1.1	0.919	0.050	0.90	0.99
Head width	4.6 - 7	5.361	0.471	0.64	0.22
ED_1	5.8 - 15	7.944	1.125	0.60	0.10
SNL_1	2.7 - 4.7	3.675	0.302	0.80	0.25
SNL_2	2.4 - 5.8	3.241	0.318	0.83	0.29
Body depth	0.8 -1	0.880	0.047	0.91	1.06
V_1FLO	4.2 - 7	5.204	0.527	0.76	0.19
DBL	0.2 - 0.3	0.262	0.014	0.88	3.45
ABL	0.2 - 3.3	0.321	0.300	0.92	3.12
V_1BLO	4.4 - 9.3	6.670	0.877	0.60	0.17
Female characters	**Range**	**Mean**	**SD**	**R^2 on SL**	**Slope**
Head length	4 - 5.5	4.52	0.243	0.91	0.23
Head height	3.7 - 4.9	4.15	0.141	0.97	0.24
Head width	19.5 - 30.8	24.11	1.982	0.77	0.04
ED_2	22.8 - 35.5	27.30	2.660	0.73	0.03
SNL_1	14 - 19.3	16.60	0.965	0.90	0.06
SNL_2	12.4 - 25.3	14.73	1.609	0.88	0.07
Body depth	3.8 - 4.7	3.98	0.116	0.98	0.25
V_1FL	20.6 - 29.3	23.51	1.921	0.81	0.04
DBL	1.2 - 1.3	1.18	0.016	0.99	0.85
V_1BLO	21.6 -38.7	30.21	3.897	0.76	0.04
Female characters	**Range in HL**	**Mean**	**SD**	**R^2 on HL**	**Slope**
Head height	0.8 -1.1	0.920	0.052	0.09	0.00
Head width	4.6 -7	5.346	0.472	0.01	0.01
ED_1	5.8 -15	7.983	1.331	0.00	0.02
SNL_1	2.7 - 4.7	3.683	0.315	0.08	0.02
SNL_2	2.4 -5.8	3.264	0.401	0.01	0.01
Body depth	0.8 - 1	0.881	0.049	0.11	0.00
V_1FLO	4.2 - 7	5.219	0.556	0.02	0.02
DBL	0.2 - 0.3	0.262	0.014	0.08	0.00
ABL	0.2 - 3.3	0.351	0.422	0.02	0.01
V_1BLO	4.4 - 9.3	6.694	0.899	0.00	-0.01

Colour: Ocular side light brownish with dark brown marks, in some faint irregular patches seen; blind side whitish. Colour remains the same in preserved specimen.

Distribution:

India: Hooghly at Calcutta (Hamilton Buchanan, 1822; Day, 1877); Calcutta, Portuguese India, Orissa (Norman, 1928); Tanur, Malabar coast (Menon, 1977); Kerala coast (Saramma, 1963).

Map showing localities were *Cynoglossus macrostomus* has been recorded in India is given in Fig. 150.

Fig. 150: Map showing localities were ***Cynoglossus macrostomus*** has been recorded in India

Fishery: Common in the flatfish fishery in the southwest coast of India from Karnataka to Kochi. This species forms more than 96 % of the total flatfish landings of the region.

Taxonomic remarks: This species was described as a new fish based on two specimens 135 and 140 mm in total length from "Calcutta and Orissa". *C. hamiltonii* described by Day (1877: 204) was considered as distinct from *C. hamiltonii* Gunther (1877: 504) in the larger head and greater number of scales in the lateral lines. Norman (1928: 204) described *Cynoglossus macrostomus* as "*having two lateral lines on ocular side, divided by 15 or 16 rows of scales*". Menon (1971) mentions that "*this species, which forms an important commercial fishery on the west coast of India and popularly known as the "Malabar sole", has all along been confused with C. semifasciatus*". Menon (1977) further adds that *C. macrostomus* can easily be distinguished from *C. semifasciatus* by its larger number of interlinear scales (14 -16) compared to 11- 14 in the latter. *C. luctosus* described by Chabanaud had 14 -15 rows of scales in the interlateral line; Menon (1979) however after examining the type of the species concluded that *C. luctuosus* is a synonym of *C. macrostomus*.

Observations: *Cynoglossus macrostomus* resembles *C. cynoglossus* especially the extension of the maxillary beyond the posterior border of the fixed eye; the difference seen in the interlateral scale counts.

4.3.8.1.11 *Cynoglossus punticeps* (Richardson, 1846)

Speckled tongue sole

Plagusia punticeps Richardson, 1846, *Rept. Brit. Ass. Adv. Sci*.,: 280 (type locality: China); Whitehead, 1969, *Bull. Brit. Mus*., 3 (7): 218, pl. 29.

Cynoglossus punticeps Gunther, 1862, *Cat. Brit. Mus.*, IV: 500 (East Indian Archipelago); Bleeker, 1875, *Atl. Ichth. Ind. Orien. Neerl.,* 6: 37, pl. 245, p. 15, fig. 7; Day, 1877, *Fish. India*: 437, pl.97, fig. 1 (China); Day 1889, *Fauna Br. India*, 2: 459 ; Alcock, 1889, *J. Asiat. Soc. Bengal,* 58(2): 289; Bowers, 1906, *Bull. Bur. Fish.*, XXVI: 46 (Manila); Jordan and Seale, 1907, *Bull. Bur. Fish.*, 26: 46: Jenkins, 1910, *Mem. Indian Mus.*, 3: 30; Norman, 1928, *Rec. Ind. Mus.*,: 205 (West Coast of India, Ganjam, Orissa); Weber and de Beaufort, 1929, *Fish. Indo-Austr. Arch.*,: 198 (Singapore, Java, Ceylon); Chu, 1931, *Biol. Bull. St. John's Univ.*, 1: 94; Herre, 1932, *Lingnan Sci. Journ.*, 11: 433 (Canton); Wu, 1932, *Contrib. Poiss. China*: 151 (Amoy, Pehai, Canton, Hongkong and Hainan); Smith, 1933. *J. Nat. Hist. Soc.*, Siam, 9(1): 84; Fowler, 1934, *Hong Kong Natural.*, 5(3): 220, fig.34 (China, India, Ceylon, Burma); Blegvad, 1944, *Danish Sci. Invest. Iran*, 3:208 (Hormuz); Suvatti, 1950, *Fauna Thailand*: 328; Herre, 1953, *U. S. Fish Wildlife Ser.*, 20: 190; Munroe, 1955, *Fish. Ceylon*: 265, pl. 51, fig. 771 (Pearl Banks); Fowler, 1956, *Fish. Red Sea S. Arabia*: 137, (Siam, Philippines); De Silva, 1956, *Ceylon J. Sci.*, C, 7: 198 (Panadura); Munroe, 1958, *Fish. Bull. Dept. Agric. Stock Fish.*, 1: 285 (Kau Kau); Kuronuma, 1961, *Checklist Fish. Vietnam*: 32; Punpoka, 1964, *Bull. Fish. Res.*, 1: 69 fig. 21 (Thailand); Pradhan, 1964, *J. Bombay Nat. Hist.*, 61(2): 458; Chen and Weng, 1965, *Biol. Bull.*, : 91, fig. 62 (Tainan and Tungkong); Shen, 1967, *Quart. J. Taiwan Mus.*, 20(1,2): 214, figs. 138-141 (Lamma Island); Menon, 1977, *Smith Contrib. Zool.*, 238: 75, pl 15, fig. 36 (West Coast of India through Malay Archipelago); Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 883, fig. 367 (Kerala); Desoutter, 1986, *Checklist Fish. Africa*: 432; Kuang *et al.*, 1986, *Freshwater Est. Fish.*

Hainan Island, 336; Randall, 1995, *Coastal Fish. Oman*: 364; Talwar and Jhingran, 1991, *Inland Fish. India*, 2 : 1043; Poll and Gosse, 1995, *Gen. Poiss. Afrique*: 9; Mohsin and Ambak, 1996, *Marine Fishes Malaysia*: 601; Rainboth, 1996, *FAO Species Sheet*: 224, Larson and Williams, 1997, *Proc. Sixth Intl. Marine Biol. Workshop*: 374, Evseenko, 1998, *Russian Acad. Sci*.,: 61; Liz and Wang, 2000, *Fauna Sinica*: 351; Bijukumar and Sushama, 2000, *J. Mar. Biol. Ass. India*, 42(1and2):188; Manilo and Bogorodsky, 2003, *J. Ichth*., 43 (Suppl. 1): S123; Khan, 2003, *Rec. Zool. Surv. India Occ. Pap*er 209: 11; Mishra and Krishnan, 2003, *Rec. Zool. Surv. India, Occ. Paper* 216: 47.

Plagusia javanica Bleeker, 1851, *Nat. Tijds. Ned. Ind*., I: 414 (type locality: Batavia); Bleeker, 1852, *Verh. Bat. Gen*., 24, Pleuron: 24.

Plagusia brachyrhynchos Bleeker, 1852, *Nat. Tijds. Ned., Ind*.,I: 414 (type locality: Batavia); Bleeker, 1852, *Verh. Bat. Gen*., 24, Pleuron: 24.

Arelia javanica Bleeker, 1859, *Act. Soc. Sci. Indo-Neerl*., vi, *Enum. Spec*., :184

Arelia brachyrhynchos Bleeker, 1859. *Act. Soc. Sci. Indo-Neerl*., VI, *Enum. Spec*.,: 184

Cynoglossus bengalensis (part) Gunther, 1862, *Cat. Fish. Brit. Mus*., VI : 499 (Ganges).

Cynoglossus brachyrhynchus Gunther, 1862, *Cat. Fish. Brit. Mus.,* IV: 499 (Java, Singapore, Celebes); Bleeker, 1866. *Atl. Ichth*., vi: 37, *Pleuron*, pl xv, fig. 7; Day, 1877. *Fish. India*, pl. xcvii, fig. 1; Alcock, 1889 *J. Asiat. Soc. Bengal*, LVIII, pt. 2: 289; Jenkins, 1910, *Mem. Ind. Mus*., III: 30; Pellegrin, 1912, *Ann. Mus. Un. Napoli*, 3: 9 (Eritraea); Weber, 1913, *Siboga Exped. Rep*., 57: 443.

Plagusia nigrolabeculata Richardson, 1846, *Rept. British Assoc. Adv. Sci.*, : 280 (Coasts of China, Canton); Kaup, 1858, *Arch. Nat.*, 24(1): 110; Whitehead, 1969, *Bull. Br. Mus. Zool.*, 3(7): 218, pl. 29b.

Cynoglossus nigrolabeculatus Bleeker, 1873, *Ned. Tijds. De Dierk.*, 4: 131.

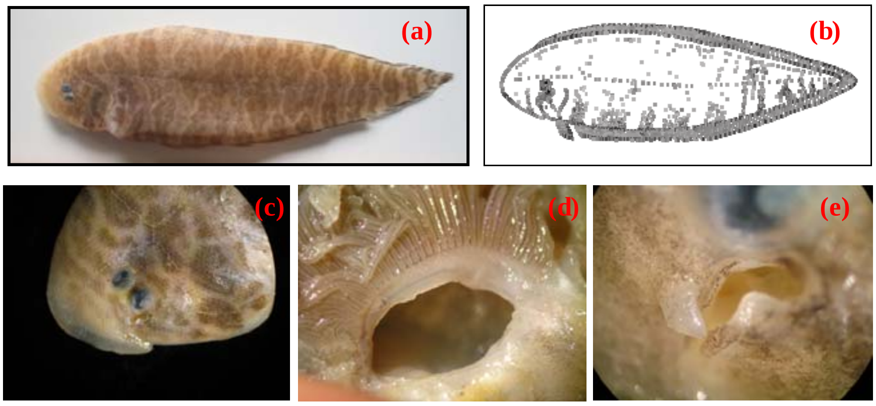
Plagusia aurolimbata Richardson, 1846, *Rept. Br. Ass. Adv. Sci.*, : 280 (Coasts of China); Kaup, 1858, *Arch. Nat.*, 24(1): 110; Whitehead, 1969, *Bull. Br. Mus. Zool*, 3(7): 218, pl. 28b.

Cynoglossus aurolineatus Bleeker, 1873, *Neder. Tijds. Dierk.*, 4: 130

Cynoglossus brevis Gunther, 1862. *Cat. Brit. Mus.*, 4: 500 (type locality: Ganges); Day, 1877, *Fish. India*: 437, pl. 97, fig. 2; Alcock, 1889, *J. Asiatic Soc. Bengal*. 58(2): 289: Hora, 1923, *Mem. Ind. Mus.*, 5: 760; Norman, 1928, *Rec. Ind. Mus.*, 30(2): 206

Cynoglossus lida* var. *punctatus Jenkins, 1910, *Mem. Ind. Mus.*, 3: 30.

Cynoglossus punticeps immaculate Pellegrin and Chevery, 1940, *Bull. Soc. Zoo. France*, 65: 154 (Vietnam).



(a), (b) Fish, (c) Head with rostral hook (c) Gill filaments (d) Mouth, Nostril

Plate LXI: *Cynoglossus punticeps* (Richardson, 1846)

Material examined: N = 31, TL 83.1-162.2 mm.

Diagnosis: The fish is distinguished by the presence of vertical striations in fresh specimens; 91 – 110 scales in the lateral line.

Meristic counts: D 90 -110; A 69 -84; C 10; P 4-5; Ll 85 -127 (102); head scale count 20 -24; interlinear scales 13 - 20.

Body proportions as percent of SL (mean in parentheses): TKL 77.5 - 121.5 (82.7); HL 17.9 - 26.2 (20.6); BD_2 22.7 -26.4 (24.5); BD_1 24.04 - 27.6 (26.2); PAL 19.7 -29.3 (23.8); DFL 3.4 -8.3 (5.4); PDL 1.4 -6.6 (2.9); V_1LO 17.8 -26.9 (21.1); AFL 4 -9.3 (6.2); CFL 5.9 -11.5 (8.1); V_1FL 3.2 -6.6 (4.4); HD 9.98 -14.7 (12.9); HW 21.1 -29.7 (23.4); UHLW 8.6 -11.9 (9.9); LHL 12.5 -17.7 (14.4); SNL_1 6.1 -7.6 (6.8); SNL_2 6.99 -8.5 (7.6); MOUTH 3.6 -5.1 (4.1); CD 0.3 -6.3 (4.8); ED_1 1.7 - 3.7 (2.5); ED_2 1.9 -3.2 (2.5); ID 0.5 -1.5 (1.1); DBL 97.3 -120.7 (100); V_1BL 0.6 - 2.9 (1.5); ABL 76.3 -100.4 (80.8); CBL 1.5 -4 (2.5); E –UJ 0.5 -1.3 (0.8); PrOU 6.2-8.3 (7.1); PrOL 6.4 -9.9 (7.6); PBU 9.8 -14.6 (11.9); PBL 9.3 -13.2 (11.1).

As percent of HL (mean in parentheses): BD_2 108.3 - 144.6 (126.7); BD_1 108.3 -134.8 (119.9); HD 49.7 -73.7 (62.9); HW 104.1 - 125 (113.9); UHL 38.7-56.2 (48.1); LHL 60.8 -81.6 (70); SNL_1 29.5 -37.8; SNL_2 35 -40.6 (37.6); ED_1 8 -15.2 (11.9); ED_2 8.6 -15.2 (12.2); PrOU 30.3 -36.6 (33.6); PrOL 32.4 – 41.2 (36); PBU 51.9 -61.1 (56.2); PBL 47 -57.9 (52.5).

Description: Body lanceolate. Small head with small eyes separated by a narrow ridge; upper eye a little in advance of the lower. Two nostrils on ocular side, one circular in the interorbital area, the other tubular with a thin stalk and a bulbous tip, on the upper lip wall. On blind side two nostrils present, one blunt tubular, the other circular. Mouth short, curved, in a half C form, the inner end just below midway of lower eye. Lower jaw thick with very fine tteth in 2-3 rows. Rostral hook short, reaching to a vertical through front border of upper eye. Operculum fused with body with a small opening. Gill rakers small, bulb like, with very small gill filaments, soft with smooth edges. Two lateral lines on ocular side, none on the blind side. A median one extending from the post orbital area to the caudal fin, the second near the dorsal profile below the dorsal finbase, entering the dorsal fin near the caudal finbase. Both the median lateral line and dorso –anterior lateral line extends into the snout and joins in the snout region; a branch then extends into the rostral hook. A postorbital branch of the lateral line extends downwards into the post orbital area. Dorsal fin origin well in front of the upper eye, on the snout a little behind the median point. Pelvic attached to anal by a membrane; anal and dorsal joined with caudal; caudal pointed. Scales ctenoid on both sides, scales on lateral lines ctenoid. Body scale on ocular side oval with the outer region with short 8 spines. Striations arise from pigmented part to the outer part. Scales on blind side similar, but pigmented part absent, spines present. Lateral line scale also rectangular with a basal pigmented portion and an outer transparent portion; a central tubular portion present through which lateral line passes. Body scale rectangular with a basal double layered pigmented form with 16 sharp long ctenii. Vertical radiations arise from the basal pigmented portion to the outer free end.

A comparative statement of the meristic characters of *Cynoglossus punticeps* is given in Table 125.

Table 125: A comparative statement of the meristic characters of *Cynoglossus lida*

Meristic characters	Gunther 1862	Norman 1928	Weber & Beaufort 1929	Munroe 1955	Seshappa 1968	Menon 1977	Cheng and Weng 1965	Punpoka 1964	Radhamanyamma 1988	Present work 2004 - 2010 N= 1
Dorsal rays	103 -104	99 -112	100 – 110	99 – 112	103 – 109	99 – 108	100 -104	99 – 112	100 -103	100 – 101
Anal rays	82 -83	75 - 87	77 – 86	75 – 87	80 – 84	77 - 85	78 – 82	75 - 87	76 -78	72 – 78
Caudal	10 -12	*	*	*	10 – 11	*	8	*	10	10 -12
Ventral	4	*	*	*	*	*	4	*	*	4
Lateral line scales	90	82 - 95	90	82 – 95	94 – 104	72 – 90	90	82 – 95	*	72 -75
Ltr	*	13 -15	13 – 14	13 - 15	15 - 16	12 - 15		13 – 15	*	14 – 15

Results of the correlation coefficient analysis on non-meristic characters of *Cynoglosssus punticeps* is given in Table 126.

Table 126: Results of the correlation coefficient analysis on non-meristic characters of *Cynoglossus punticeps*

Characters	Range in SL	Mean	SD	R^2 on SL	Slope
Trunk length	0.8 -1.3	1.22	0.08	0.89	0.74
Head length	3.82 -5.6	4.88	0.35	0.90	0.14
Body depth	3.8 - 4.4	4.10	0.17	0.96	0.22
BD1	3.6 - 4.2	3.82	0.16	0.98	0.30
Preanal length	3.4 - 5.1	4.24	0.38	0.84	0.19
Dorsal fin length	12.1 - 29.1	19.53	4.79	0.36	0.03
Pre pelvic	3.7 - 5.6	4.79	0.47	0.78	0.16
Anal fin length	10.8 - 25.03	16.57	2.87	0.35	0.02
Caudal fin length	8.7 - 16.9	12.71	2.26	0.10	0.01
Pelvic length	15.3 - 31.5	23.18	3.83	0.63	0.04
Head depth	6.8 - 10.02	7.81	0.77	0.89	0.14
Head width	3.4 - 4.7	4.28	0.24	0.93	0.19
Post orbital length	7.6 -10.2	9.06	0.63	0.91	0.08
Upper head lobe width	8.4 -11.7	10.18	0.66	0.92	0.10
Lower head lobe width	5.6 - 7.98	6.99	0.47	0.91	0.12
SNL1	13.2 - 16.3	14.78	0.99	0.90	0.06
SNL2	11.8 - 14.3	13.22	0.75	0.93	0.06
Mouth	19.5 - 27.9	24.41	2.09	0.87	0.03
Chin depth	15.8 - 25.5	20.45	2.46	0.49	0.04
ED_1	26.7 -57.8	41.82	6.50	0.61	0.02
ED_2	31.5 - 52.8	40.68	5.81	0.66	0.02
Dorsal fin base	0.8 - 1.03	1.00	0.03	0.98	0.91
Anal fin base	1 - 1.3	1.24	0.05	0.96	0.80
Pre orbital U	12.1 -16.2	14.20	1.27	0.84	0.05
Pre orbital L	10.1 -15.5	13.29	1.60	0.65	0.04
Post orbital U	6.9 - 9.8	8.49	0.74	0.83	0.07
Post orbital L	7.6 - 10.8	9.08	0.81	0.82	0.07

Characters	Range in HL	Mean	SD	R^2 on HL	Slope
BD_2	0.7 - 0.9	0.84	0.047	0.92	1.30
BD_1	0.7 - 0.9	0.79	0.070	0.92	1.85
Preanal length	0.8 -1.03	0.87	0.071	0.85	1.21
Dorsal fin length	2.6 - 6.3	4.03	0.957	0.42	0.22
Pre pelvic	0.8 -1.1	1.01	0.085	0.79	1.17
Anal fin length	2.4 - 4.6	3.41	0.480	0.48	0.19
Caudal fin lenth	1.98 - 3.3	2.61	0.357	0.26	0.08
Pelvic length	3.3 - 6.7	4.74	0.837	0.62	0.26
Head depth	1.3 - 2.01	1.60	0.172	0.85	0.85
Head width	0.8 - 0.96	0.88	0.039	0.95	1.23
Post orbital length	1.5 - 2.04	1.83	0.135	0.84	0.44
Upper head lobe width	1.8 - 2.6	2.09	0.193	0.85	0.56
Lower head lobe width	1.2 - 1.7	1.43	0.100	0.87	0.70
SNL_1	2.6 - 3.4	2.98	0.207	0.90	0.32
SNL_2	2.5 - 2.9	2.66	0.117	0.95	0.37
Mouth	4.2 - 5.8	4.92	0.395	0.85	0.17
Distance from eye to DFB	2.8 - 3.4	3.05	0.158	0.95	0.35
ED_1	6.6 - 12.6	8.63	1.220	0.73	0.13
ED_2	6.6 - 11.7	8.34	1.18	0.64	0.11
Inter orbital	13 - 35.95	20.55	5.32	0.60	0.07
Dorsal fin base	0.2 - 0.2	0.21	0.012	0.92	5.42
Anal fin base	0.2 - 0.3	0.25	0.019	0.89	4.66
Caudal base	5.4 -12.4	8.49	1.819	0.45	0.10

Colour: Ocular side brownish with dark vertical blotches on the body; in some bigger specimens the markings are very faint to see. Blind side whitish. In formalin preserved specimens, the vertical markings have become very pale.

Distribution:

World: China (Richardson, 1846); Batavia (Bleeker, 1851); China (Day, 1877); Singapore, Java, Ceylon (Weber and Beaufort, 1929); Canton (Herre, 1932); Amoy, Pehai, Canton, Hongkong and Hainan (Wu, 1932); China, Ceylon, Burma (Fowler, 1934); Pearl Banks (Munroe, 1955); Siam, Philippines (Fowler, 1956); Panadura (De Silva, 1956); Kau Kau (Munroe, 1958); Thailand (Punpoka, 1964); Tainan and Tungkong (Chen and Weng, 1965); Lamma Island (Shen, 1967).
Map showing localities were *Cynoglossus punticeps* has been recorded in India is given in Fig. 151.

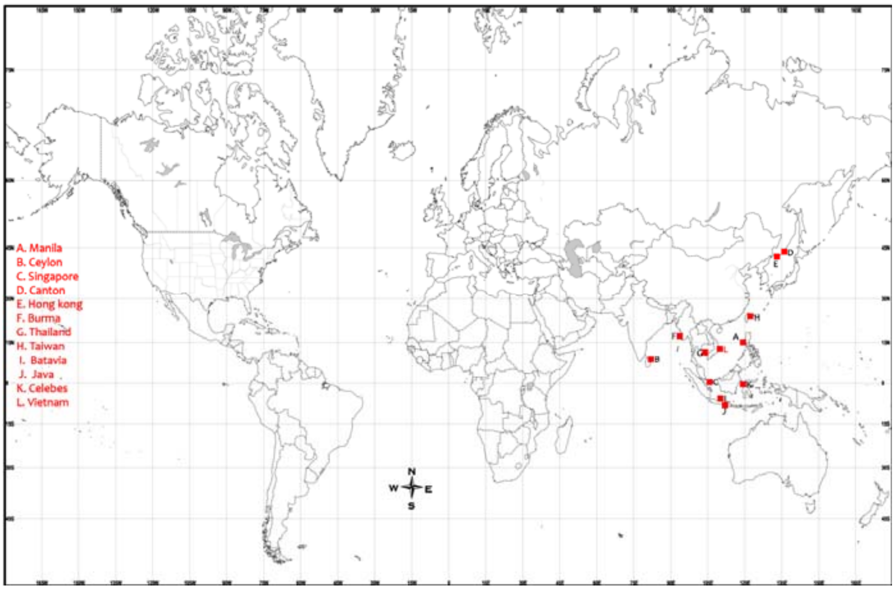


Fig. 151: Map showing localities were *Cynoglossus punticeps* has been recorded in the world

India: West Coast of India through Malay Archipelago (Gunther, 1862; Fowler, 1934; Menon, 1977); Ganges (Gunther, 1862); Ganjam, Orissa (Norman, 1928); Porto Novo (Ramanathan, 1977); Neendakara (Radhamanyamma, 1988).

Map showing localities were *Cynoglossus punticeps* has been recorded in India is given in Fig. 152.

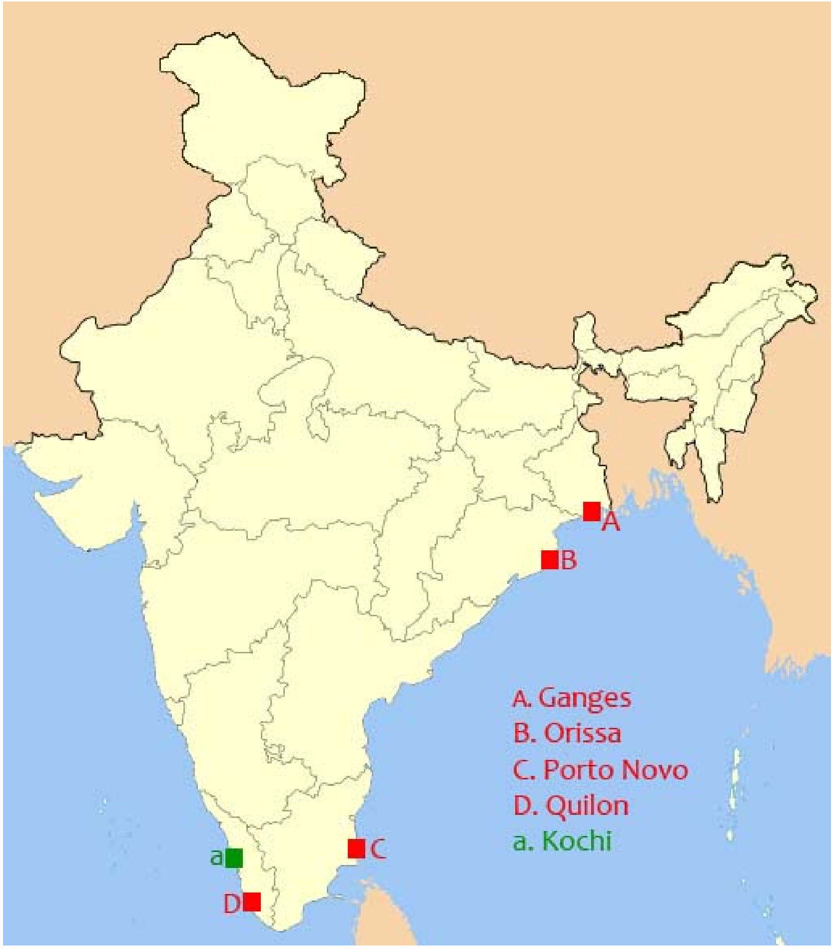


Fig. 152: Map showing localities were *Cynoglossus punticeps* has been recorded in India

Remarks: The results of the present work are similar to that recorded by earlier workers; the difference was noticed only in the inter lateral line counts 13-20 scales were noticed in the present work; however, Radhamanyamma (1988) recorded 15 -18 scales; 14 - 19 scales were recorded by Menon (1977) and 16 - 21 by Ramanathan (1977).

Taxonomic remarks: The fish was first described by Richardson (1846) based on Reeves Chinese fish drawings (Whitehead, 1969); two other species *Plagusia aurolimbata* and *P. nigrolabiculata* were also described along with it. Fowler (1934) and Menon (1977) examined the two species and found them to be similar to *C. punticeps* and hence synonymised them with it. Menon also synonymised *C. brevis* with *C. punticeps* after re-examination of the holotype of *C. brevis* with the comments "*differences in the proportional measurements such as the longer head length and longer snout in the type are attributable to intraspecific variations*" and that "*considerable variation in pigmentation with age and change in substratum is exhibited by the fish*". Menon (1977) also examined the holotype of *C. p. immaculata* and found it to exhibit no significant difference with *C. punticeps*; hence it was synonymised with *C. punticeps*.

4.3.8.2 Genus *Paraplagusia* Bleeker

Fringe lip tongue sole

Paraplagusia Bleeker, 1865, *Ned. Tijds. Dierk.*,2: 274 (type species: *Pleuronectes bilineata* Bloch); Regan, 1920, *Ann. Durban Mus*., II :219; Fowler, 1934, *Fish. China*, V: 201; Menon, 1980, *Matsya* 5:13; Talwar and Kacker, 1984, *Comm. Sea Fish. India*: 884.

Description: Body flat, elongate with dorsal and anal fins confluent with caudal fin. Eyes sinistral with scaly space in between them. Mouth asymmetrical, lips fringed. Snout blunt, rostral hook prominent overhanging mouth. Nostril tubular on ocular side, with a fleshy valve at its tip; two nostrils on blind side –one small tubular and the other oval. Pectoral fins absent, pelvic on ocular side only. Body covered on both sides with ctenoid scales. 2 – 3 lateral lines on ocular sides. Left side with 2 lateral lines, right side with one. Lateral lines on ocular side connected at head.

Taxonomic comments: Regan (1920) mentions of 2 - 3 lateral lines on eyed side.

Remarks: *Paraplagusia* has been reported from Indo – Australian Archipelago. Of the species reported, *Paraplagusia unicolor* and *P. guttata* have been reported from Queensland, *P. dipterygia* from Japan (Jordan and Starks, 1906), *P. bilineata* and *P. blochii* (Norman, 1928); *P. bilineata* and *P. japonica* from China (Fowler, 1934); *P. bilineata* from Natal (Smith, 1961), *Paraplagusia japonica* from Japan (Masuda *et al*., 1975). Five species of *Paraplagusia* have been reported from Taiwan –*P. bilineata, P. blochi, P. formosa, P. japonica* and *P. guttata*.

4.3.8.2.1 *Paraplagusia bilineata* (Bloch, 1784)

Double lined tongue sole

Pleuronectes bilineatus Bloch, 1784, *Nat. Ausl. Fische*, 3: 29, pl. 188 (type locality: Chinese waters); Cuvier, 1817, *Regne Animal*, ed. 1, II: 224.

Plagusia marmorata Bleeker, 1828, *Nat. Tijds. Ned. Ind*., I: 411; Gunther, 1862, *Cat. Brit. Mus*., IV: 491 (Red Sea, E. Indies); Bleeker Day, 1877, *Fish. India*: 431, pl. 95, fig. 1; Day, 1889, *Fauna Br. India, Fish.,*: 451, fig. 162 (East Africa, India, China); Jenkins, 1910, *Mem. Ind. Mus*., III: 29.

Paraplagusia marmorata Bleeker, 1866, *Atl. Ichth*., VI:28, Pleuron, pl.xv, fig. 5; Bleeker, 1879, *Verh. Akad. Amsterdam*, XVIII: 22; Regan, 1920, *Ann. Durban Mus*., II:219; Barnard, 1925, *Ann. S. African Mus*., XXI:410.

Plagusia bilineata Klunzinger, 1871, *Verh. Zool. Bot. Ges. Wien*, XXI: 573.

Paraplagusia bilineata Jordan and Evermann, 1902, *Proc. U.S Nat. Mus*., XXV: 366 (Keerun); Oshima, 1927, *Jap. J. Zool*., I (5):200; Norman, 1928, *Rec. Ind. Mus*., 30: 191, fig. 9; Weber and Beaufort, 1929, *Fish. Indo - Austr. Arch*., 5: 183, figs. 50, 51 (Singapore, Sumatra, Java, Celebes, Red Sea, China, Japan); Wu, 1932, *Thèse Fac. Sci. Univ. Paris* A, 244 (268):139; Fowler, 1934, *Hong Kong Nat*., V (3):211, fig. 28 (China); Okada and Matsubara, 1938, *Keys Fish. Japan*: 436 (Formosa, Malay); Smith, 1949, *Fish. South Africa*: 165, fig. 335; Herre, 1953, *Checklist Philippine Fish*.,:191 (Red Sea, Africa, India, Philippines, Japan); Matsubara, 1955, *Fish. Morph. Hierar*., II: 1284 (Japan, China, Formosa, Malay, Red Sea); Munroe, 1955, *Fish. Ceylon*: 264, pl. 51, fig. 765; Fowler, 1956, *Fish Red Sea S. Arabia*, I: 180 (Siam, Borneo); Smith, 1961, *Sea Fish S. Africa*: 165, fig. 335 (Natal); Chen and Weng, 1965, *Biol. Bull*., 27: 47 (Taichung market); Jones, 1969, *Bull. Cent. Mar. Fish. Res. Inst*., 8: 29; Jones and Kumaran, 1980, *Fish. Lacc. Arch*., 653, fig. 556 (Ameni).

Paraplagusia dipterygia Jordan and Starks, 1907, *Proc. U.S Nat Mus*., XXXI: 236; Okada and Matsubara, 1938, *Keys Fish Japan*: 436 (Japan, China, Red Sea, Natal).

Plagusia marmorata var. Africana Gilchrist, 1908, *Mar. Invest. S. Africa*, IV: 163, pl. xlvii.

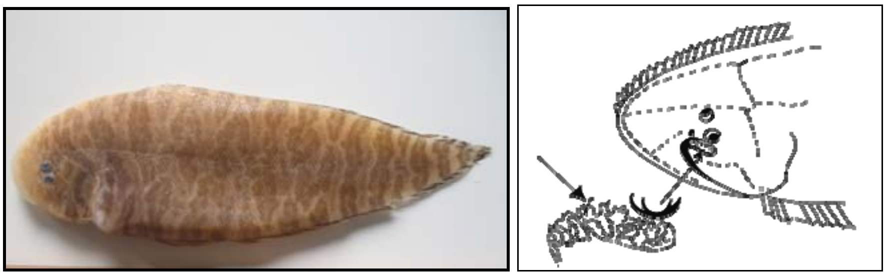


Plate LXII: *Paraplagusia bilineata* (Bloch, 1784)

Material examined: N= 2, from Pamban landing centre, Tamilnadu

Diagnosis: Scales 16 – 19 between upper and middle lateral lines, rostral hook, long, reaching beyond upper eye.

Meristic characters: D 106 -118; A 86 -93; Ll 98 -114.

Description: Body flat, lanceolate with large head, rounded snout. Eyes small, separated by a concave, scaly interspace; upper a little ahead of lower. Rostral hook prominent, extending to beyond vertical from behind lower eye. Mouth nearing gill opening, lips deeply fringed, plain on blind side; teeth small, present on blind side. Two lateral lines on ocular side, none on blind side. Dorsal and anal confluent with caudal. Scales ctenoid, denticulations on scale stronger on ocular side than on blind side.

A comparative statement of the meristic characters of *Paraplagusia bilineata* is given in Table 127.

Table 127. A comparative statement of the meristic characters of *Paraplagusia bilineata*

Meristic characters		Earlier workers		Present study 2004 – 2010
	Fowler 1934	**Masuda *et al.*, 1984**	**Munroe 2004**	**N = 1**
Dorsal rays	96 - 119	99 - 115	105 +	106
Anal rays	75 - 90	72 - 89	81 - 88	86
Lateral line scales	90 - 106	75 - 109	*	104

Colour: Ocular side brownish, marbled with darker patches; blind side yellow.

Habitat: Muddy and sandy bottoms of the continental shelf, in shallow and estuarine waters.

Distribution:

World: East Africa, Indian Ocean, Indo-west Archipelago to China and Japan (Norman, 1928); Burma. Map showing localities were *Paraplagusia bilineata* has been recorded in the world is given in Fig. 153

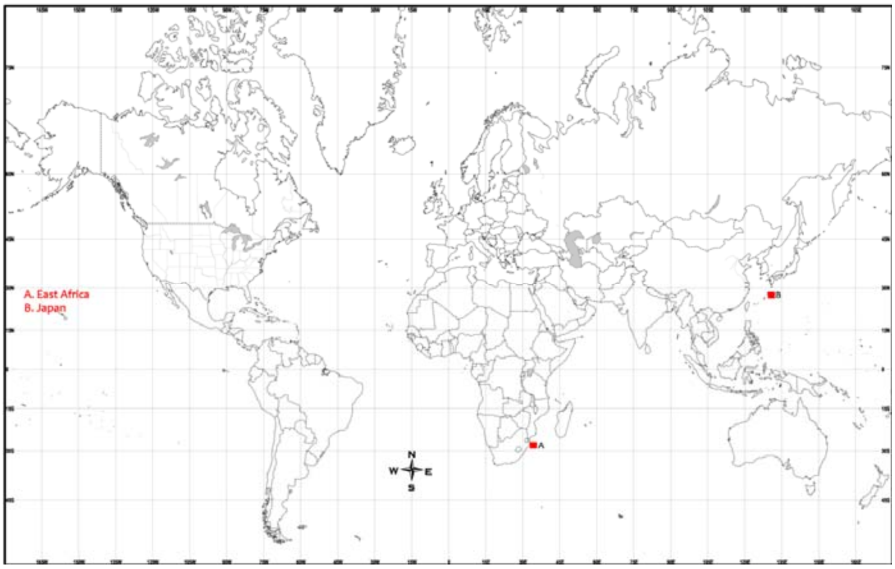


Fig.153: Map showing localities were *Paraplagusia bilineata* has been recorded in the world

India: Puri, Orissa, Gopalpur, Sundarbans (Norman, 1928); Porto Novo (Ramanathan, 1977); Neendakara (Radhamanyamma, 1988), Pamban (present study). . Map showing localities were *Paraplagusia bilineata* has been recorded in India is given in Fig. 154

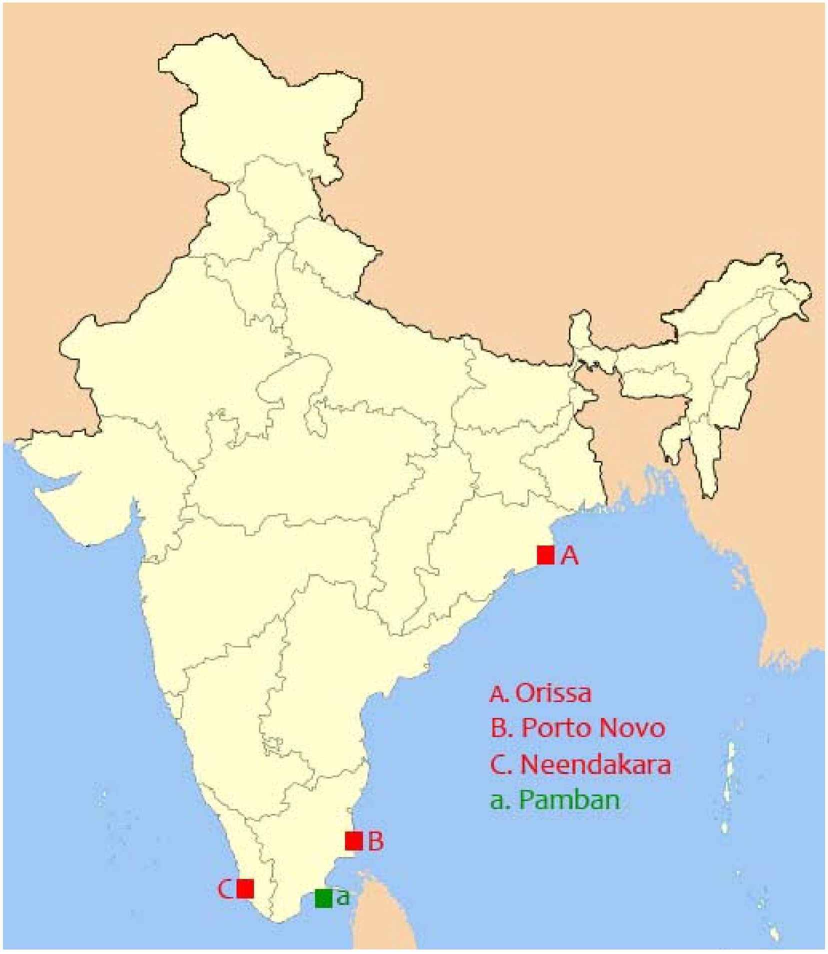


Fig. 154: Map showing localities were *Paraplagusia bilineata* has been recorded in India

Taxonomic comments: Norman (1928) mentions that Klunzinger examined the type of *P. bilineata* and concluded that it is identical to the species described by Bleeker and Gunther as *Paraplagusia marmoratus*.

Remarks: This species is said to be close to *P. unicolor* Macleay from Australia but differs in having a larger head, rather strong rostral hook, greater number of anal rays and smaller scales.

4.4 New records

During the study period 2004–2010, 15 new records were collected. The family wise list of species and the location of collection is given in the Table 128. Localities of collection of the new records is given in Fig 155.

Table 128: List of new records of flatfishes and the location of collection

Species	Location
Chascanopsetta lugubris	West coast
Cynoglossus acutirostris	Kochi, Kerala
Zebrias crossolepis	Cochin, Kerala
Zebrias japonicus	Cochin, Kerala
Pseudorhombus dupliciocellatus	Neendakara, Kerala
Pseudorhombus argus	Tuticorin
Brachirus annularis	Munambam, Kerala
Laeops natalensis	Munambam, Kerala
Poecilopsetta natalensis	Munambam, Kerala
Aseraggodes kobensis	West coast of India.
Pseudorhombus diplospilus	Neendakara, Kerala
Engyprosopon maldivensis	Neendakara, Kerala
Engyprosopon mogkii	Neendakara, Kerala
Laeops parviceps	Neendakara, Kerala
Arnoglossus aspilos	Neendakara, Kerala

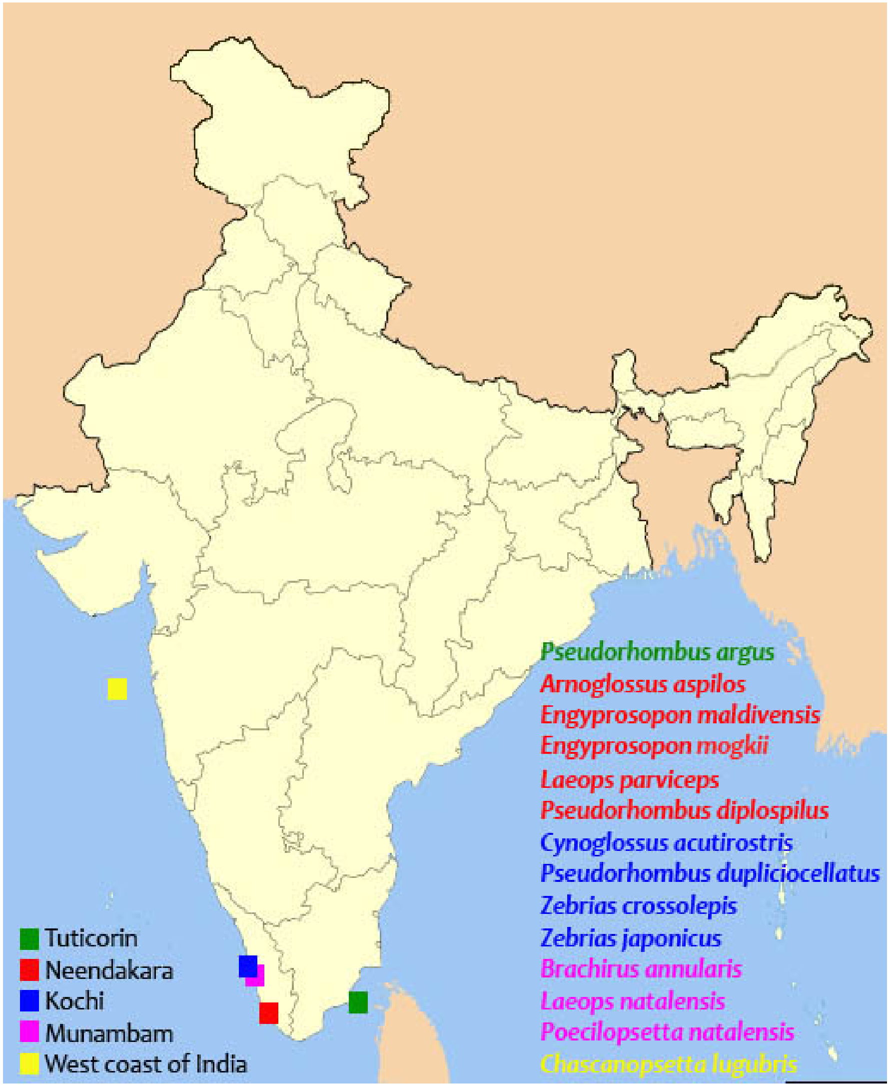


Fig. 155 Map showing locations in India were some flatfishes were recorded for the first time

4.5 Scale relationships

Scales of teleosts are flexible, calcified plates lying within shallow envelopes, or scale pockets, in the upper layers of the dermis (Bullock & Roberts, 1974). Scales provide multiple functions, including protection of the lateral line, storage area for minerals and nutrients (van Oosten, 1957), drag reduction (Videler, 1994) and a useful means of ageing (Jerald, 1983; Busacker et al., 1990), and identifying fishes (Batts, 1964; De Lamater & Courtenay, 1974; Daniels, 1996).

The value of scale morphology in fish classification was recognized almost 160 years ago by Louis Agassiz who classified fishes on the basis of four scale types "*Les Placoides*" (with spine like denticles of enamel and dentine), "*Les Ganoides*" (with thick plates of ganoine and bone), "*Les Ctenoides*" under which Pleuronectoides come (having thin plates with comb like posterior borders) and "*Les Cycloides*" (with thin plates with smooth borders). Cockerell (1909, 1911, 1913) pioneered the study of fish scales, which he called "*lepidology*". By using the morphological and meristic characteristics of scales, he was able to separate groups of fishes. It was generally believed that scales had "*limited use in fish systematics*" (Van Ossten, 1957:204). Batts (1964) studied the lepidology of the adult pleuronectiform fishes of the Puget Sound, Washington. Roberts (1993) studied the comparative scale morphology in Teleostei and has reported three scale types in Pleuronectiformes – cycloid, spinoid and crenoid. *Psettodes, Arnoglossus*, *Bothus pantherinus* (Bothidae) is said to possess a transforming ctenoid (Tr) scale.

Family Psettodidae

Genus *Psettodes*

Scales ctenoid on ocular side. Ocular side scale adherent, with fine diverging striations and finely crenulated margins. Roberts (1993) has named it a transforming ctenoid (Tr) scale.

Family Bothidae:

I. Subfamily Paralichthinae

Genus *Pseudorhombus* –Scales are small to moderate in size, 58 -100 in lateral line, lateral line with a distinct supra-temporal branch.

Pseudorhombus arsius – Scales on ocular side with fine ctenii with prominent striations from the ctenii outward. Scales on blind side cycloid with ctenii radiating from central part outward. Scales near dorsal and anal base ctenoid; lateral line tubular.

Pseudorhombus triocellatus –Scales on ocular side ctenoid with fine ctenii. Body scales were more or less squarish with fine ctenii at the outer end.

P. dupliocellatus –Scales ctenoid on ocular side, cycloid on blind side. Lateral line scale oval in outline with a central transparent tube with divergent ends.

P. elevatus – Scales on ocular side fully ctenoid, blind side cycloid. Ocular side scale is oval or round in shape with five long ctenii, central part with concentric circles, broad striations arise from these concentric circles, outer free end of scale with a slight wavy edge. Blind side scale cycloid. Scale roundish in shape with concentric ring patterns; outer end with wavy margins.

Lateral line: Scale cycloid, oval to round with a stalk like area at one end. The central part has a tube with one end globular and the other end straight. Rows of these lie close to one another in a line to form a tubular lateral line.

Except *Pseudorhombus triocellatus*, all the other *Pseudorhombus* species had similar shape for their body scales. However, the shape of the lateral line scale was similar in all the species of the genus *Pseudorhombus*.

Genus *Cephalopsetta*

Cephalopsetta ventrocellata: Ocular side scale ctenoid, scale nearly round in shape with fine ctenii, concentric ring patterns on scale. Blind side scale cycloid.

II. Subfamily Bothinae

Genus *Arnoglossus*: Body scale small to moderate in size, feebly ctenoid or cycloid on ocular side, cycloid on blind side, no supratemporal branch for lateral line. Roberts (1993) has named it a transforming ctenoid (Tr) scale. On ocular side, scale has fine/feeble ctenii, while on blind side scales are cycloid.

Genus *Engyprosopon*: Scales of moderate size or rather large, somewhat feebly ctenoid on ocular side, cycloid on blind side; no supplementary scales. Lateral line developed only on ocular side with a distinct curve around pectoral fin; no supratemporal branch.

Engyprosopon mogkii: Scales on ocular side ctenoid, scale is moderately oval in outline with vertical striations arising outward from the pigmented base. Ctenii long, pointed. Scale on blind side cycloid.

E. grandisquama: Body scale on ocular side semi oval or round in shape with fine well developed ctenii on pigmented part; striations present in different patterns on the scale. Lateral line scale elongated with a central tubular portion and fine ctenii arising from base. Striations present in both horizontal and vertical patterns; free end of scale smooth in outline.

Genus *Crossorhombus*: Scales of moderate size, strongly ctenoid on ocular side, ctenoid/cycloid on blind size.

Crossorhombus azureus: Body scale on ocular side oval in outline with fine concentric ring patterns on it, fine ctenii are seen on inner pigmented end. Scales on blind side cycloid in outline with concentric rings in it. Lateral line tubular scale cycloid –a tube like /buldged area with a vase like end and the other end flat.

Genus *Bothus*: Scales small, ctenoid /cycloid on ocular side, cycloid on blind side, no supplementary scales. Lateral line developed only on ocular side of body with a distinct curve above lateral line, a bifurcated supra-temporal branch behind an upper eye.

Bothus myriaster: Ocular side cycloid, except for outer ends of body; scale small in size, with concentric rings arising from basal pigmented part and vertical striations cutting across rings. Free end of scale in a wavy pattern. Blind side cycloid.

Genus *Parabothus*

Parabothus polylepis: Body scale, small, ctenoid/ cycloid on ocular side, cycloid on blind side. Lateral line developed on ocular side only with a prominent curve around pectoral fin.

Genus *Grammatobothus*: Body scale (ocular) ctenoid, with semi-oval shape, with concentric rings and long ctenii, scales on blind side cycloid. Lateral line equally developed on both sides of body.

Grammatobothus polyopthalmus: Scale ctenoid on ocular side, semi oval in outline with concentric rings in centre and striations to outer free end. Outer end wavy in pattern. Fine long ctenii near pigmented end. Blind side of body scale cycloid similar in pattern to ocular side, but ctenii absent.

Genus *Chascanopsetta*: Scales very small, cycloid on both sides of body, no supplementary scales. Lateral line equally developed on both sides of body, with a low flat topped curve above the pectoral fin; no supra temporal branch.

Chascanopsetta lugubris: Body scale cycloid, lateral line tubular with one end diverging into two.

Genus *Laeops*: Scales very small, all cycloid, no supplementary scales. Lateral line well developed on ocular side with a distinct curve around the pectoral fin with /without supra temporal branch.

Laeops macropthalmus: Body scale cycloid with concentric ring pattern arising from pigmented area. Lateral line tubular with outer end divergent.

Family Poecilopsettidae

Lateral line well developed on both sides of the body.

Subfamily Poecilopsettidae

Lateral line rudimentary or absent on blind side of body.

Genus *Poecilopsetta*: Scales moderate or small in size, rather feebly ctenoid or cycloid on ocular side, cycloid on blind side. Lateral line on ocular side well developed extending upto caudal fin, with a flat topped curve above pectoral fin; no supra temporal or suborbital branches; lateral line of blind side rudimentary or absent.

Poecilopsetta inermis: Body scale cycloid on ocular and blind side, lateral line scale tubular–a tube like structure with a bifurcated end into which the straight part of previous scale tube fits.

Poecilopsetta colorata: Body scale round to oval in shape with concentric rings and feeble ctenii spaced at pigmented end.

Poecilopsetta maculosa: Body scale small, round with concentric ring pattern on it and small ctenii at pigmented end. Lateral line scale with a central tube with a bulbous portion and a straight tubular portion.

Subfamily Samarinae

Lateral line rudimentary and scarcely seen on blind side of body. On ocular side, lateral line straight, scales small.

Genus *Samaris*: Scales rather small, adherent, imbricated, strongly ctenoid on ocular side, cycloid or moderately ctenoid on blind side, more than 50 scales in lateral line.

Samaris cristatus: Scales ctenoid on ocular side with concentric rings, free end wavy, blind side with small ctenii.

Family Soleidae

Genus *Brachirus*

Brachirus pan : Scales ctenoid on both sides of body those on upper part of head and nape distinctly enlarged, those on blind side produced into barbed like processes.

Genus *Synaptura*

Synaptura commersoniana: Ocular side ctenoid, blind side cycloid. 160 in longitudinal series, those on upper part of head and nape enlarged, many on blind side produced into barbel like processes . Lateral line scale with a tubular structure.

Synaptura albomaculata: Scales on ocular side ctenoid, those on blind side cycloid, 155 in longitudinal series, those on upper side of head enlarged, many on blind side of head somewhat enlarged and produced into a barbell like processes.

Genus *Aesopia*

Aesopia cornuta: Scales cycloid on both sides of body, some of those on blind side of head produced into barbel like processes; 87 -98 scales in longitudinal series. Scale oval in outline with fine radiating ridges arising outward from pigmented part.

Genus *Aseraggodes:* Scales ctenoid on both sides of body.

Genus *Heteromycteris*

Heteromycteris oculus: Body covered by ctenoid scales, ctenii are very long and thin.

Genus *Liachirus*

Liachirus melanospilos: Lateral line has a tubular structure in the centre which inter connects to form a tube.

Genus *Pardachirus*

Each scale on posterior side of head with a roughened patch posteriorly, with /without marginal spicules.

Pardachirus pavoninus: Body ocular, blind side with ctenoid scales. Scales oval in outline with fine ctenii on pigmented end.

Genus *Zebrias*: Body scales ctenoid.

Zebrias synapturoides: Scales strongly ctenoid on both sides of body, each scale with a single series of 10 -12 strong spicules on the posterior margin, some of these on blind side produced into barbel like processes. Lateral line with 66 -71 scales. Lateral line scale with a tubular structure in it with a groove like area.

Zebrias quagga: Scales moderately/weakly ctenoid on both sided of body, each scale with several series of small spines posteriorly, some on blind side of head produced into barbell like processes.

Zebrias crossolepis: Ocular side strongly ctenoid, scale highly oval with outer free end deeply fringed and wavy; inner pigmented end with fine elongated ctenii. Concentric oval circles on scale arising from pigmented region, cut vertically by radiating ridges to outer wavy margin.

Family Cynoglossidae

Scales are generally ctenoid, the tactile fringes on the side of the head are either short or absent, replaced by epidermal thickness and there are epidermal hairs.

Genus *Cynoglossus*:

Cynoglossus dubius: Body scale on ocular side is cycloid except along dorsal and anal fins towards the posterior ocular side which is ctenoid. Scale is nearly oval with one end pointed, radiatins to the outer end arising from centre, vertical radiations parallel to scale also present. On either side on ocular side ctenoid scale present. Scale is oval with ends fringed, radiations arise from pigmented partly outward. Ctenii well placed, thin long. Lateral line nearly circular with a clear central groove. The groove/canal opens by means of ducts into the adjoining scale above or below.

Cynoglossus arel: Modification of scale with age: In big specimens of *C. arel*, which has ctenoid scales including those on lateral line, a number of cycloid scales are found in the lateral line towards the posterior end especially near the base of caudal fin. The scales which remain ctenoid are those of the rows close to the dorsal and anal fins. Scales ctenoid on the ocular side, including scales on lateral line, those on head rather weakly serrated, scales on blind side cycloid.

Cynoglossus bilineatus: Ctenoid on ocular side except those on lateral line. Scales on blind side and lateral line cycloid.

Cynoglossus punticeps: Ctenoid scale on both sides including lateral line. Scales nearly oval with fine clear ridges radiating towards outside, fine sharp ctenii placed on pigmented part slightly spaced, numerous radiations present. Lateral line scale also ctenoid with a central narrow groove running to centre of scale with a bulbous base.

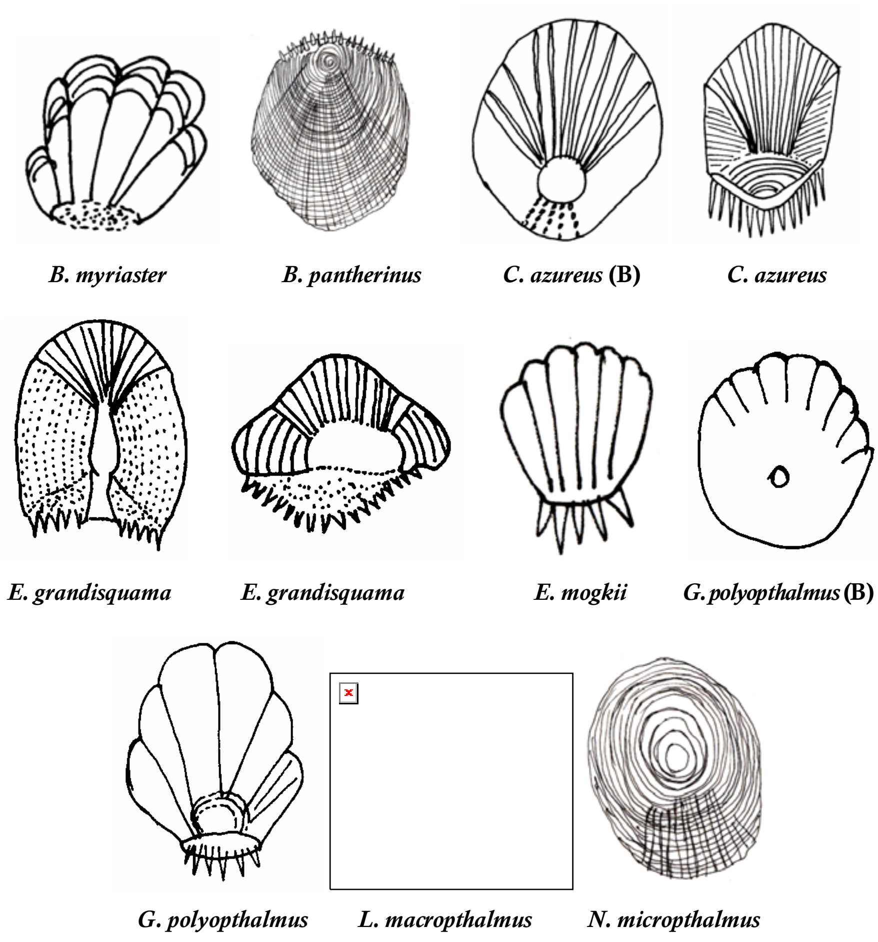
Cynoglossus acutirostris: Cycloid scales on upper half of body, ctenoid posteriorly (lower part of body). Cycloid scale semi rectangular in outline with a triangular end which has concentric rings from which arise radiations to outer end, which is fringed. The ctenoid scale on ocular side lower half slender, rectangular with sharp ctenii on pigmented part with concentric circles inter crossed with radiations to outer tip, scale margin wavy.

Cynoglossus lida: Ocular side ctenoid scale. Scale is nearly oval in outline with few strong, long ctenii. Fine clear radiations arise from pigmented area outward, end of scale slightly wavy. Blind side with ctenoid scales.

Cynoglossus semifasciatus: Ocular side with ctenoid scales. Scale nearly oval in outline with five strong ctenii at pigmented end.Fine radiations extending outward from pigmented end to outer end. Blind side and lateral line with ctenoid scales.

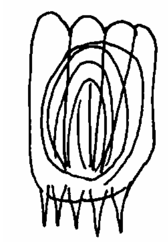
Cynoglossus itinus: Ctenoid scales on ocular side including lateral line. Blind side with cycloid scale on head, weakly ctenoid on body. (Figs. 150a,b,c,d,e)

Bothidae

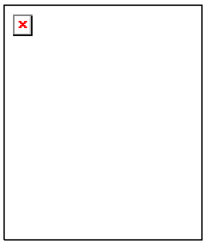


(a)

Cynoglossidae

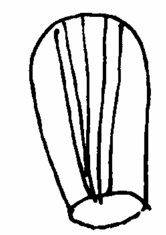


C. acute

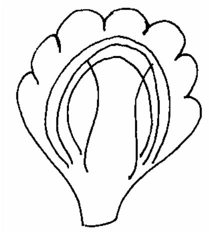


C. acute (1)

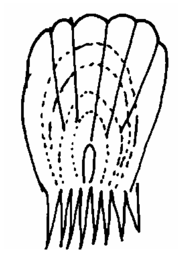
C. dubius



C. dubrius head

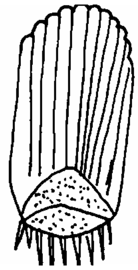


C. dubuis

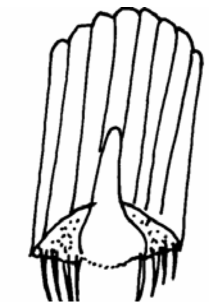


C. lida scales

C. punticeps

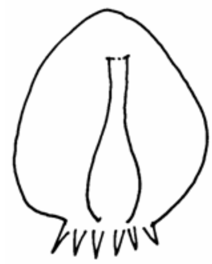


C. punticeps



C. punticeps

C. punticeps



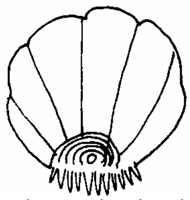
C. punticeps Lateral line

(b)

Paralichthyidae

C. ventrocellata

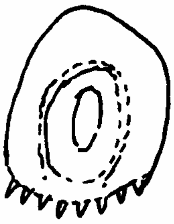
P. dupliciocellatus



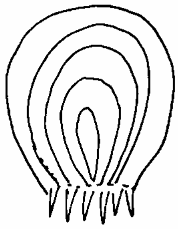
P. elevatus head scale

P. elevatus mid body

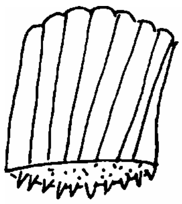
P. elevatus scale



P. natalensis

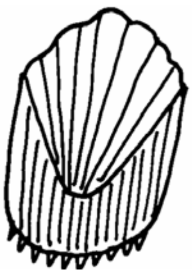


P. natalensis



P. triocellatus

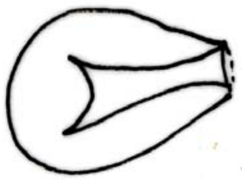
P. triocellatus



P. triocellatus

Poecilopsettidae

P. colorata

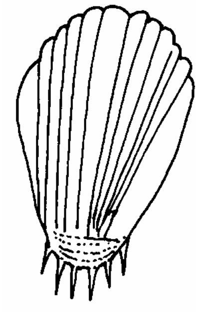


P. inermis

(c)

Samaridae

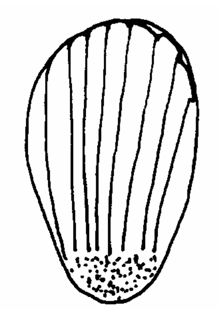
Samaris cristatus



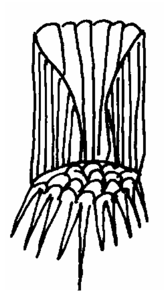
Samaris cristatus

Samaris cristatus

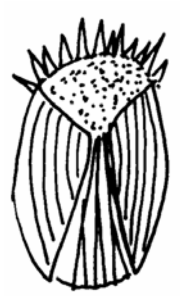
Soleidae



A. cornuta

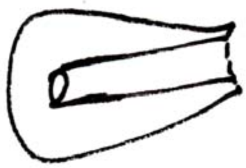


B. pan

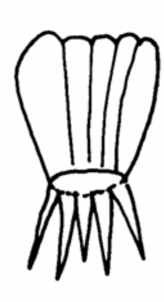


B. pan

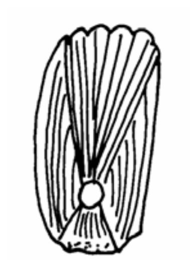
H. oculus



L. melanospilus

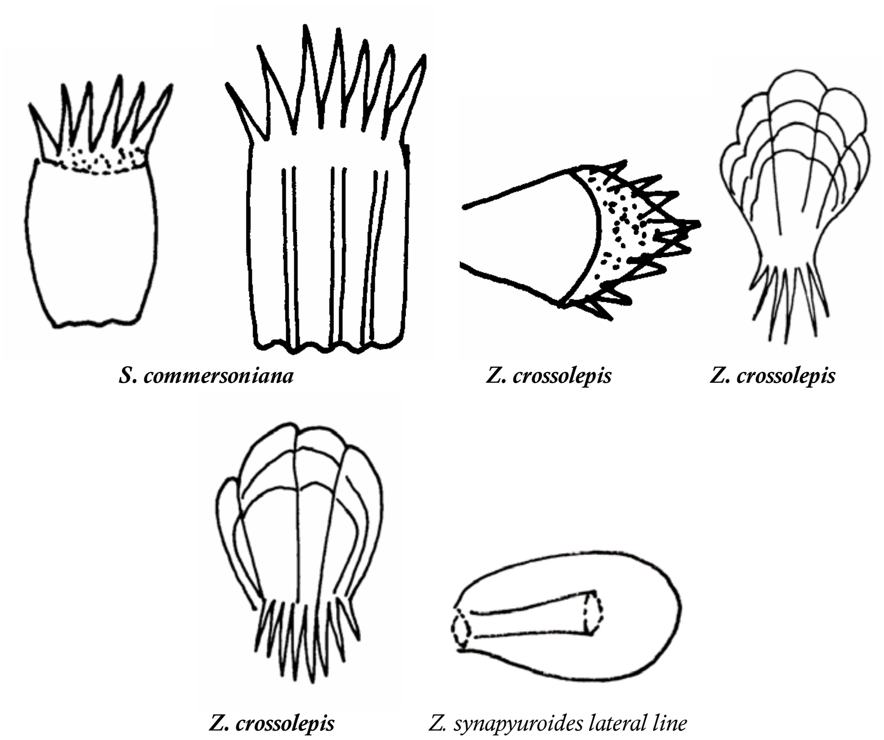


S. albomaculata



S. albomaculata

(d)



(e)

Fig. 156 (a,b,c,d,e): Scale patterns in different species

4.6 Phylogeny:

Hierarchial cluster methods were used to find the phylogenetic relationships in major families. Meristic characters were involved in cluster analysis as most of the classification is based on the meristic counts in flatfishes. A cluster analysis was run on four cases, family wise, each case responding to one meristic character (dorsal, anal, pectoral (O), caudal fin count and lateral line count). A hierarchical cluster analysis using Ward's method produced clusters, between which the variables were significantly different in the main (Figs. 157,158,159.

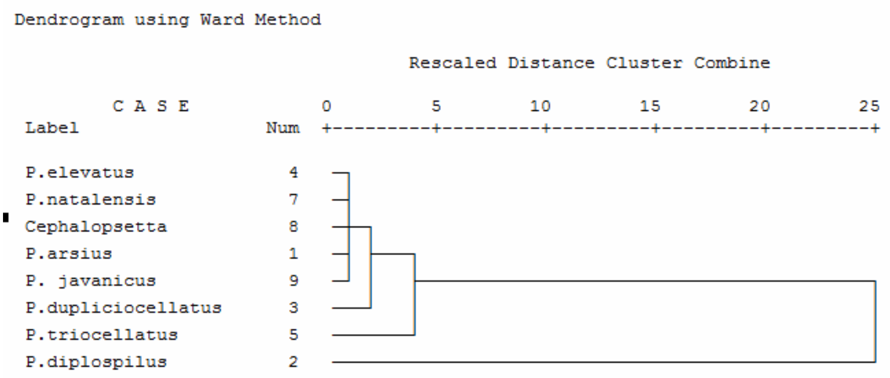


Fig. 157: Dendrogram for Paralichthyidae family

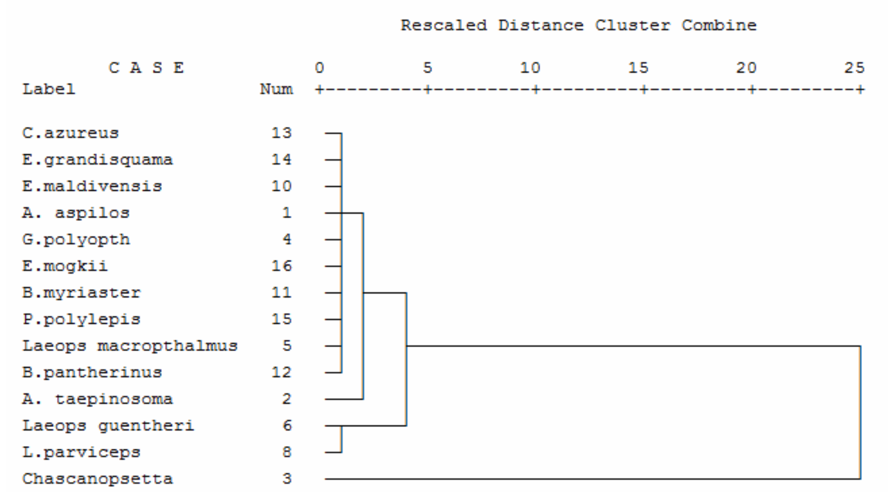


Fig. 158: Dendrogram for Bothidae family

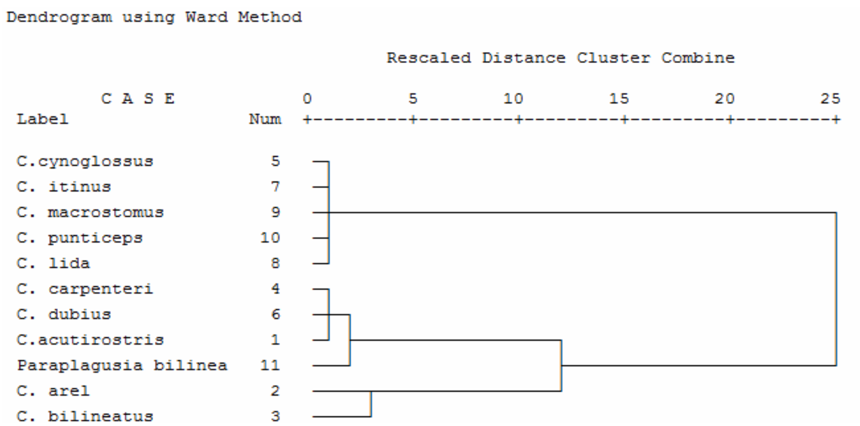


Fig. 159. Dendrogram for Cynoglossidae family

In the family Paralichthyidae, four clusters were recognised; the first cluster was formed by the congeneric species *Pseudorhombus elevatus, P. natalensis*, and *P. arsius* along with *Cephalopsetta ventrocellata*. Genus *Cephalopsetta* was seen to be closely related to *Pseudorhombus arsius*. This matches well with that of the external appearance. This cluster had close affiliation to *P. dupliocellatus*. *P. diplospilus* was seen to be the most dissimilar species in the group. In family Bothidae, clustering was seen across genera; three main clusters were noticed. The first cluster was formed by species from many genera–*Crossorhombus azureus, Engyprosopon grandisquama, E. maldivensis, Arnoglossus aspilos, G. polyopthalmus, E. mogkii, Bothus myriaster, Parabothus polylepis, Laeops macropthalmus* and *B. pantherinus.* The second cluster had two congeneric species *Laeops guenther*i and *Laeops parviceps*. *Chascanopsetta lugubris* was the outgroup. The results are similar to the external appearance of the different species. In the family Cynoglossidae, three main clusters were identified. The first cluster was formed by *Cynoglossus cynoglossus, C. itinus, C. macrostomus, C. punticeps* and *C. lida;* the second cluster by the congeneric species *C. carpenteri, C. dubius* and with *Paraplagusia bilineata* and the third cluster by *C. arel* and *C. bilineatus.*

4.7 Key to the Species listed in this study

Order Pleuronectiformes

1. Dorsal fin origin not on snout ....Family Psettodidae
   Dorsal fin origin in head 2
2. Pelvic fin with 1 spine, rest rays ....Family Citharidae
   Pelvic fin with no spines 3
3. Eyes sinistral..4
   Eyes dextral 7
4. Pectoral fin present 5
   Pectoral fin absent 6
5. Pelvic fin base on the ocular side
   longer than that of the blind side................Family Bothidae
   Pelvic bases equal ....Family Paralichthyidae
6. Pectoral fin absent ....Family Cynoglossidae
7. Dorsal fin origin above eye ....Family Poecilopsettidae
   Dorsal fin origin in front of eye..................8
8. Pre opercle margin hidden ....Family Soleidae
   Pre opercle margin free ....Family Samaridae

1. FAMILY PSETTODIDAE

Well developed lateral line on both sides, upper eye placed on dorsal profile, teeth biserial in both jaws....................................*Psettodes erumei*

2. FAMILY CITHARIDAE

Scales deciduous, less than 35 in lateral line; snout, jaws, interorbital space and upper parts of orbit not scaled......................................Genus *Brachypleura*

Eyes dextral, closely placed, with ctenoid scales on ocular side and cycloid scales with feeble denticulations on blind side.............. *Brachypleura novaezeelandie*

3. FAMILY PARALICHTHYIDAE

A. Eyes sinistral, separated by narrow ridge, spines absent on head in both sexes. ....**Genus *Pseudorhombus***

i. Gill rakers palmate, 3 or more distinct ocellii/double ocellii on ocular side; origin of dorsal fin just behind nostril on blind side, notch present on upper profile of head.

a. Two pairs of double ocellii on ocular side, maxilla reaches beyond middle of lower eye, strong teeth on lower jaw, 5 in number..............................*P. diplospilus*

b. Four –five large double ocellii, maxilla reaches just below middle of lower eye...*P. dupliocellatus*

ii Gill rakers longer, pointed, scales on ocular side more or less ctenoid at least anteriorly

a. Origin of dorsal fin behind posterior nostril on blind side five large single or double ocellii on ocular side ....*P. argus*

iii Origin of dorsal fin above or a little in front of the nostrils on blind side, well in advance of eye,

a. Blind side with cycloid scales

i. D 72 – 80, A 54 – 62, tip of first interhaemal spine feeble, teeth strong. Widely set, large canines, 6 – 16 teeth on blind side of lower jaw..........*P. arsius*

b. Teeth closely set, more than 20 on blind side of lower jaw, 58 scales in lateral line, body with dark markings...........*P. natalensis*

Dorsal 67 – 76, A 51 – 58

c. Upper profile of head weakly notched, body scales ctenoid anteriorly, cycloid posteriorly ....*P. javanicus*

d. Upper profile deeply notched, scales ctenoid on ocular side ....*P. elevatus*

e. Body scales on ocular side ctenoid, cycloid on blind side, except anteriorly and at sides of the body; three conspicuous ocellii on ocular side, anterior rays of dorsal elongated ....*P. triocellatus*

B. Large eyes present. Scales weakly ctenoid on the ocular side, cycloid on head and blind side. Gill rakers elongated and pointed...............................**Genus *Cephalopsetta***

i. Clear ocelli present on pelvic fin on ocular side ....*C. ventrocellata*

4. FAMILY BOTHIDAE

Body broad, thin, oval or round in outline

i. Body elongate, eyes close together, scales on eyed side feebly ctenoid ....**Genus *Arnoglossus***

a. Slender bothid with very less interorbital space, with 80 dorsal fin rays and 63 anal finrays.............................*A. aspilos*

b. Slender bothid with 4 anteriormost dorsal rays slightly elongated, with 92 dorsal fin rays and 67 anal finrays . ...*A. taepinosoma*

i. Body deep, oval with a forked anterior tip of lateral line below upper eye ....**Genus *Bothus***

a. Body scales cycloid on ocular side, ctenoid at base of dorsal and anal profile...*B. myriaster*

b. Body scales fully ctenoid on ocular side..*B. pantherinus*

iii. Body elongate, mouth gape wide, oblique in outline; maxillary extending to a vertical from the lower eye or to a little beyond it ....**Genus *Chascanopsetta***

Body elongate, very flaccid, mouth very large with a gular pouch.....................*C. lugubris*

iv. Eyes sinistral, mouth small. Teeth biserial in jaws; gill rakers short, two nostrils present on either side ....**Genus *Crossorhombus***

Broad, oval body with 5 pairs of blue dots on the snout, a broad blackish band across caudal fin on hinder part a narrower one at caudal fin base..*C. azureus*

v Body not very deep, thin, no forked branch for lateral line ....**Genus *Engyprosopon*** *a.* Caudal fin double truncate with 2 conspicuous dots at upper and lower margin; pectoral fin on ocular side with brown bands ....*E. grandisquama*

b. Caudal fin with numerous markings. Pectoral fin on both sides longer than head length ....*E. maldivensis*

c. Body width 3.1 in total length; maxillary ends at anterior one-third of eye ....*E. mogkii*

vi Lateral line well developed on both sides, 3 conspicuous ocellii on ocular side of body ....**Genus *Grammatobothus***

a. Dorsal with 80 – 86 rays, second to sixth rays prolonged, anal with 64 – 67 rays. ....*G. polyopthalmus*

vii. Body elongate, strongly compressed, broad just behind eyes, with a very narrow caudal peduncle; eyes large, sinistral, separated by a narrow bony interorbital ridge, the lower eye little in advance of the upper................**Genus *Laeops***

a. Body elongate with a broad head and tapering tail.......................................c

b. Dorsal fin origin above posterior nostril on blind side, first 2 rays detached from rest ....d

c. Dorsal 85 – 90, anal 67 – 70, head 3 – 3.6 in SL, pectoral on ocular long ....*L. macropthalmus*

d Dorsal 95 – 115, anal 75 – 95, head 4 – 6.5 in HL, pectoral shorter than head

i. Upper profile nearly straight above head, D 104, A 86......................................*L. parviceps*

ii. Upper profile slightly convex, D 97 – 102, A 77 – 81 ....*L. guentheri*

iii. Upper profile deeply convex above and behind eyes D 99, A 77.......................*L. natalensis*.

viii Body oval, elliptical, strongly compressed; snout hooked, dorsal profile deeply convex....................... **Genus *Neolaeops***

i. Elongate body, eyes sinistral, with a deep concavity in front of the upper eye, very small eye, deciduous scales ....*N. micropthalmus*

ix. Body elliptical, not strongly compressed; eyes sinistral, separated by a concave interorbital space ....**Genus *Parabothu***

I Elongate body with tapering tail, with wide and concave interorbital space ....*P. polylepis*

5. FAMILY POECILOPSETTIDAE

Short tentacles absent on eye ....Genus ***Poecilopsetta***

i. Teeth in narrow bands, 90-109 scales in lateral line; eyes separated by a narrow ridge; two rays of the right pectoral branched..............................*P.* ***colorata***

ii. Body covered with cycloid scales on its ocular side ....***P. inermis***

iii. Teeth in narrow bands; less than 90 scales in lateral line....................................***P. natalensis***

iv. 95 – 99 scales in the lateral line on ocular side. ....***P. praelonga***

6. FAMILY SAMARIDAE

Pectoral fin absent on blind side, a straight lateral line, small mouth short gill rakers ....**Genus *Samaris***

First 10 (usually 12 to 15) dorsal-fin rays greatly elongate, about 4 or 5 times head length ....***S. cristatus***

7. FAMILY SOLEIDAE

i. Body covered with cycloid scales, first dorsal fin ray enlarged and placed upright ....**Genus *Aesopia***

First dorsal fin ray free enlarged, longer, coloured on dextral side with vertical band pattern ....***A. cornuta***

ii. Pectoral fin absent, ctenoid scales on body....**Genus *Aseraggodes***

Ocular side with brown spots in pairs, one each on the dorsal and ventral profile.....................................***A. kobensis***

Ocular side with three rows of dark brown blotches nearly twice the eye diameter seen ....***A. umbratilis***

iii. Dorsal fin origin on snout, first few rays very short. Dorsal and anal confluent with caudal, rays simple/bifid branched at tip. ....**Genus *Brachirus***

Large clear annular patches on the body and an unbranched pectoral fin. ....***B. annularis***

Body deeply oval; body greenish – black with filaments on the bands blackish.................. ***B. orientalis***

Body deeply oval, with caudal partially joined to dorsal and anal,Scales of the nape and upper part of head enlarged.................................***B. pan***

ii. Snout hooked, lips not fringed, rostral hook prominent ....**Genus *Heteromycteris***

A sole with hazy patterns on its ocular side, 8 large ocellii present on ocular side in two rows ....***H. hartzfeldii***

Ocular patterns in 4 pairs on the body, on the blind side, lobulation of the nasal valve is seen...***H. oculus***

iii. Eyes separated by a narrow slightly concave interorbital space ....**Genus *Liachirus***

Mouth cleft semicircular in pattern, placed well down on front portion ....***L. melanospilos***

iv Body broad, oblong, scales feebly ctenoid along dorsal and anal fin...............**Genus *Pardachirus***

Scales on ocular side of head without marginal spinules. Presence of an open pore at the base of each dorsal and anal ray both on dextral and sinistral side.................. ***P. marmoratus***

Scales on ocular side of head with marginal spinules. Pores at the base of each dorsal and anal ray only on one side Body oblong, thick with a bluish base colour on ocular side with numerous ocellii ....***P. pavoninus*** vii Dorsal fin origin well in front on snout; dorsal and anal fin not confluent with caudal fin. Scales small, ctenoid..**Genus *Solea***

Eyes close together, upper eye one half in advance of the lower..***S. ovata***

viii Scales on head and nape of eyed side larger than those on body; scales on blind side of head modified into cutaneous sensory processes ....**Genus *Synaptura***

Thick body in central and small white tiny spots on the basal part of dorsal and anal fin on ocular side ....***S. albomaculata***

Pectoral on both sides not equal, no white spots seen on body ....***S. commersoniana***

ix. Body covered with ctenoid scales, with black cross bands, nearly arranged in pairs. Single straight lateral line ....**Genus *Zebrias***

Medium sized sole with differential banding pattern on ocular side, 12 bands in all on ocular side. **..*Z. cochinensis***

Contiguous eyes, and 13 paired bands on body, caudal with white dots. ....***Z. crossolepis***

Eyes contiguous; inter orbital without scales; band pattern very distinct with 12 brown bands with white bands, each white band with brown dotted line in centre **.................*Z. japonicas***

13 Dark vertical bands, fleshy horn absent in front of the dorsal fin ....*Z. synapturoides*

Mouth sharp, 10 vertical bands...........................*Z. quagga*

8. FAMILY CYNOGLOSSIDAE

Eyes sinistral, upper migratory eye placed well in advance of the fixed lower eye

Mouth asymmetrical; teeth present on the lower jaw of the blind side

Dorsal and anal fins confluent with the caudal

i. Lips not fringed on ocular side ....Genus ***Cynoglossus***

Snout long acutely pointed ....***C. acutirostris***

Snout obtusely pointed; rostral hook short, 7 – 9 scales between two lateral lines ....***C. arel***

Body covered by ctenoid scales on ocular side except for a line of the lateral line scales; two lateral lines on the blind side. **..........*C. bilineatus***

Three lateral lines on ocular side, blind side with cycloid scales. Ocular side anterior half with cycloid scales, posterior with ctenoid scales **..*C. carpenteri***

10-15 scales in the inter lateral line; 2 lateral lines on ocular side, none on blind side; snout pointed. Body scales ctenoid on both sides...***C. cynoglossus***

Two lateral lines on ocular side, one lateral line on blind side, scales cycloid on ocular side ....***C. dubius***

Three lateral lines on eyed side of body...............***C. itinus***

Broad round prominent snout, angle of the mouth nearer to the branchial opening than to the snout tip; two lateral lines on ocular side, separated by 13-15 scale rows; no lateral line on blind side.................................***C. lida***

One lateral line and cycloid scales on blind side; 2 lateral lines on ocular side separated by 10-13 scales in between ....***C. macrolepidotus***

14 -15 interlinear scale rows on ocular side ....***C. macrostomus***

Vertical striations in fresh specimens; 91 – 110 scales in the lateral line ....***C. punticeps***

ii. Lips not fringed on ocular side ....**Genus *Paraplagusia***

Scales 16 – 19 between upper and middle lateral lines, rostral hook, long, reaching beyond upper eye ....***P. bilineata***

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Chapter 5

DISCUSSION

Contents

Flatfishes are deep bodied, laterally compressed fishes, easily recognizable by the presence of both eyes on one side in juvenile and post-metamorphic individuals. They are well known organisms as they occur in all of the world's oceans, are represented by large numbers of species and genera. Flatfishes have been extremely successful in conducting life on or near the bottom where they function pivotal roles of both prey and predator. For flatfishes inhabiting tropical seas, despite recent progress, considerable diversity is still being discovered and the taxonomy of many tropical flatfishes remains especially problematic. Failure to identify species, and erroneous species identifications, still represent serious impediments to collection of meaningful data for many of these smaller sized species (Gibson, 2005). A study of the flatfishes available in the Indian waters is a requisite for successful management of the fishery as well as maintenance of biodiversity.

The present study highlights an amazing diversity of flatfishes over a wide habitat. Morpho-meristic characters of all species were dealt in detail to prepare a consolidated data on each species. Centres selected along both coasts provided ample areas for collection of a wide variety of species across different geographical locations. Consultation of the original description as well as descriptions by subsequent authors provided a clear picture on the evolution of synonymy for each species. Patterson (1996) who opines that "*synonyms are not purely errors in applying systematic classifications, but are also by-products of systematic concepts used by investigators*". The present study is a first step towards preparation of a concise document on the diversity of flatfishes in India.

5.1 Present status of flatfish records

During the study period 2004 - 2010, based on the collections from different parts of South India and Andaman Islands, 63 species of flatfishes belonging to 8 families and 26 genera have been collected. World over, only 716 species were recognised as valid, while another 670 names were recognised as synonyms for pleuronectiform fishes (Munroe, 2005). Although Norman (1928) had reported 69 flatfishes from Indian waters, many species of Family Cynoglossidae have later been synonymised with similar species bringing down the total number recorded. Radhamanyamma (1988) who gave an account of the flatfishes from South west coast of India reported only 23 species. The present work has increased the total count of flatfishes to 63 species.

5.2 New records

Fifteen flatfishes were recorded from Indian waters for the first time; they were range extensions from African and South East Asian waters. The new records from Indian waters are *Pseudorhombus argus*

Weber, 1913; *Pseudorhombus natalensis* Gilchrist, 1905; *Pseudorhombus dupliciocellatus* Regan, 1905; *Parabothus polylepis* (Alcock, 1889); *Laeops parviceps* Gunther, 1880; *Laeops natalensis* Norman, 1931; *Engyprosopon mogkii* (Bleeker, 1834); *Engyprosopon maldivensis* (Regan, 1908); *Poecilopsetta natalensis* Norman, 1931; *Poecilopsetta inermis* (Breder, 1927); *Aseraggodes kobensis* (Steindachner, 1896); *Brachirus annularis* Fowler, 1934; *Heteromycteris hartzfeldii* (Bleeker, 1853) and *Zebrias crossolepis* Zheng & Chang, 1965. These fishes were recorded only in few numbers and from selected localities. The additional species which have been recorded in the present study are also from existing families, no new families have been erected. This point out that the species may have been present in the waters earlier itself, but lack of detailed and specific study on the Order Pleuronectiformes has resulted it being mistaken as an already reported species. Moreover, descriptions of flatfishes began on a slow rate; from 1833 to the present day, discoveries of new species, distribution extensions of already reported species has been on the increase. In addition, revision of families has resulted in recognition as valid species other nominal species that were once formerly placed in synonymy. Therefore the listed synonyms for each species and genus probably points to a potential source of species/genus currently unrecognised, which under further analysis could be new species/genus. The listing out of species in the present study could be a possible pointer to existence of even newer species. Heemstra (*pers comm.*) opines that "*the fish fauna of the Indian Ocean is vast, poorly known, and not thoroughly sampled. We can therefore expect to find many new records for fishes not previously known from this area. New records are also being generated with improvements to our fish taxonomy as when what we thought was a well known and widely distributed species is found to represent a species* *complex of 2 or more very similar species that we have only recently learned to distinguish with previously overlooked characters*". Eschmeyer *et al*. (2010) also add that "*two habitats where most new marine taxa will likely be found are deep-reefs and deep-slopes, areas poorly sampled and studied. Some deep-sea areas, particularly in the Southern Hemisphere and throughout the Indian Ocean and in Indonesia, should reveal many new taxa from increased collecting efforts*".

Many of the species of flatfishes collected in the present study were from the discards from the trawlers and deep sea vessels. Though discards from Indian fisheries have generally been reported as very low in global analyses (Kelleher, 2005), Pramod (2010) estimates that the total discards may be in excess of 1,000,000 tonnes per annum. The non–commerical biota are just discarded either in the sea or landed as 'trash' in harbours leading to loss of 'additional species reports'. The new records collected in the present work has been well preserved and kept for further reference.

5.3 Taxonomy

Morphometric and meristic are the two types of characters that have been most frequently employed to delineate stocks of fish. Morphometric characters are continuous characters describing aspects of body shape. Meristic characters are the number of discrete, serially repeated, countable structures that are fixed in embryos or larvae. Comparitive studies on the meristic characters of all species recorded revealed an intersting pattern of results.

The results of the present work on *Psettodes erumei* match well with the studies of Amaoka (1969) from Japanese waters as well as

Munroe (1955) from Ceylonese waters. According to Norman (1934), *P. erumei* differs from *P. belcheri* in the absence of markings on fins and shape of the caudal fin. Kuronuma and Abe (1986) compared three fishes from the Arabian Gulf with five from Java Sea and found that *P. erumei* from Arabian Gulf had lower dorsal fin counts (47 - 50) compared to those from Java Sea (51 - 56). Kuronuma and Abe (1986) opined that "*the difference as such, however is reflected by variation within the species but by no means indicating natural trend by regions, which is confirmed by checking the data presented by authors…*".

The sample of *Brachypleura novaezeelandie* collected has a clear curve on the lateral line near the pectoral fin which is absent in the original description of Gunther. In a note, Alcock (1889) adds "*the fish goes beyond the confines of the genus Brachypleura in the double row of teeth in the lower jaw and in the curved lateral line*". However, Norman's (1927) description of *B. xanthosticta* clearly mentions of the presence of an anterior curve in the lateral line. The presence of the curve in the lateral line has also been reported by Punpoka (1964). Gunther could have missed the curve since the scales were missing in the type which was later re-examined by Norman. Fowler (1928: 320) mentions that "the specific name was wrongly spelled as "*novae-zealandiae*" in his *Fishes of Oceania*. The specimen has been reported already from the East coast of India, but not from the west coast although there are reports of this species from the Arabian Gulf off Oman. Kuronuma and Abe (1986) reports of its first occurrence from the Arabian Gulf at a depth of 47 m, suggesting that it is a deep water species in accordance to that of Norman (1934: 401). As to the type locality of the species New Zealand, Norman (1934:401, footnote) mentions "*It is possible that the type locality of the species is incorrect*".

The presence of double ocellii in *Pseudorhombus argus* is a difference noted with the description given by Weber (1913), Weber and Beaufort (1929) and Norman (1934). However, the description agrees with that of Amaoka and Hensley (2001) "*2 double or triple ocellii above and below the lateral line*….".

Indistinct marks on the body were absent in samples of *Pseudorhombus arsius* collected; the same feature was reported by Radhamanyamma (1988); variations could be due to the substratum differences since these fishes have the capacity to change colour based on the substratum. This feature was earlier pointed by Jenkins (1909) "*as in the case of the British Pleuronectidae, there is considerable variation in colour and marking within the limits of a single species. This is especially noticeable in the case of the specimens of Pseudorhombus arsius. The presence of intermediate specimens between the extreme colour varieties however renders it certain that only one species is represented*."

The ocelli pattern of the samples of *Pseudorhombus dupliocellatus* varies with that of Norman (1934) in the presence of 4 and 5 double ocelli respectively. However, Punpoka (1964) mentions of the presence and position of the 4 - 5 double ocelli on the ocular side. Similar double ocelli pattern was also noticed in the description given by Evermann and Seale and Jordan and Starks (1907). Eventhough, Weber & Beaufort (1929) mentions that the supra temporal branch of the lateral line touches the dorsal profile at 7th dorsal ray, in the present work, it reaches the 9th dorsal ray in agreeance with that of Punpoka (1964). In *Pseudorhombus javanicus*, ctenoid scales were seen on ocular anterior side of the body, and cycloid scales posteriorly. The results are in agreement with that of Munroe (1955) and Radhamanyamma (1988) who mentions of the presence of cycloid scales on the ocular side.

Though, Gilchrist (1905) described the largest specimen reported of *P. natalensis* as 132 mm TL, the present specimens collected from Neendakara are much bigger (TL 186.11 – 289 mm). This shows that much larger specimens are senn in the Indian waters. Regression studies on interorbital width, body depth and caudal length shows a negative correlation with SL. This shows that as the fish increases in size, corresponding increase in these morphometric measurements is not noticed.

Weber & Beaufort (1929) described *P. triocellatus* as having ctenoid scales on the ocular side and anterior half of blind side and cycloid on posterior half of blind side. Ramanathan and Natarajan (1980) described *Pseudorhombus triocellatus* as having ctenoid scales all over the body and cycloid scales on blind side except at the anterior base of dorsal and anal fins. Norman (1934) also described the presence of cycloid scales on the ocular side. In the present study, samples of *P. triocellatus* were seen to have the same pattern of scales as described by Norman (1934) and Ramanathan and Natarajan (1930).

The record of *Cephalopsetta ventrocellata* from the Indian Ocean by Dutt and Rao (1965) is the first record of this group from the Indian Ocean, the other two genera having been recorded from the warm waters of the West Atlantic (Norman, 1934; Caldwell, 1954; Tyler, 1959) and one species *Ancylopsetta dendritica* Gilbert from the East Pacific. Most of Hensley and Amaoka's (1989) specimens showed distinct dark spots arranged in about five longitudinal rows. The present specimen shows closer similarity to that described by Dutt and Rao

(1965) in the presence of few irregular spots which have a faint outline when collected fresh. The presence of faint dark bars given mentioned by Hensley and Amaoka (1989) are also absent here. In the present sample, pelvic fin was not seen to show the corresponding increase in length compared to the increase in SL. These results agree with that of Hensley and Amaoka (1989) who mentions that the left pelvic fin shows negative allometric growth.

Alcock (1889) in the description of the type of *A. macrolophus* mentions of strongly and sharply ctenoid scales on ocular side and cycloid and deciduous scales on blind side. None of the subsequent authors have mentioned of the strongly ctenoid scales; scales have been seen to be weakly ctenoid. However, in the present sample, scales have been noticed to be deciduous on ocular side also. *A. tapeinosomus* has been described as a bothid flounder with anterior dorsal rays greatly elongated in males and with a large dark spot on the posterior dorsal and anal fin bases (Weber and Beaufort, 1929; Fowler, 1934, 1956; Norman, 1934; Baoshan, 1962; Abraham, 1963; Shen, 1966, 1983; Munroe, 1967; Dor, 1970; Amaoka, 1971; Kotthaus, 1977; Amaoka *et al.*, 1992).The present specimen is a female and hence the dorsal fin rays are not highly elongated. This can be a case of sexual dimorphism which needs to be confirmed with larger number of specimens from different ecosystems.

Much variation is seen in the head length and body depth of *Bothus myriaster* as growth occurs. The meristic counts of the present specimen match well with that of the type specimen described by Temminck and Schlegel (1846). In the present samples, the dorsal fin count range is very high, probably due to the difference in the total length of the samples encountered. However, the range falls in line with the results given by the earlier workers (84 – 97).

Although, *Bothus pantherinus* was recorded among 89 species of flatfishes reported by Norman (1927, 1928), studies by Radhamanyamma (1988) along the West coast and Ramanathan and Natarajan (1980) and Rajaguru (1987) along east coast did not report of the presence of this species. Gunther (1866) reports that some of his specimens were only 1.25 inches in length; this was quite similar to the sample in the present study. Gunther reports that "*they were quite colourless, without any traces of scales*". Results of the present specimen match well with that reported in Day (1889) and Gunther's study as well as with the morphometric measurements given by Kuronuma and Abe (1986). Fowler (1928) described the fish with about 12 irregular slate black blotches and anal with eight blotches and numerous smaller scattered grey spots or dots on each fin ray. Marshall (1964) reports that the fish grows to 9 inches in Queensland waters, but is said to reach 18 inches in South Africa. Kuronuma and Abe (1986) comments that "*within the species, the specimens from the Arabian Gulf show smaller finray counts than those of other seas, the fact might suggest differentiation in the Gulf*". The results of the present study is in concordance with this observation.

Chascanopsetta lugubris shows a wide variation in the morphomeristic characters. The variation could be attributed to the comments of Amaoka and Yamamoto (1984) who opined that "*the characters described are so variable that they are actually of no value*" ; "*this species has so many synonyms because of the wide range of morphometric characters, which are due to the flexible body, change of body form during* *metamorphosis, decreasing of body size during metamorphosis, and a difficulty of accurate measurements, and also because of rather wide range of meristic characters, which may result from the wide distribution of the species*".

In the present study, *Crossorhombus azureus* is seen to have biserial teeth. Though this is in contrast to Norman (1934), who described *Crossorhombus* species with uniserial teeth, the results agree with the findings of Amaoka (1969) who mentioned that Japanese species of *Crossorhombus* have biserial teeth.

A wide variation was noticed in the meristic counts of *Engyprosopon grandisquama*. This could probably be the same as the observations of Norman (1927) who examined specimens from different localities and found that the relative position of the eyes and the interorbital space appears to differ in specimens from different localities, which made him comment that "*they all represent a single variable species*". He also added that "*probably if sufficient material were studied, two or three races would be recognized*" and later the same author (1934: 210) added "*…it is possible that the examination of a large specimens from various localities would reveal the existence of more than one species with a pair of dark spots on the caudal fin*".

Weber and Beaufort (1929) placed the species *Grammatobothus polyopthalmus* in Genus *Bothus* and described *Bothus polyopthalmus* as having dorsal origin on blind side with the first 8 - 10 rays produced into filaments, probably in males. No branched nature of anal fin was mentioned by them. Norman (1934) further divided the genus *Bothus* and *Grammatobothus* with the key identifying character being interorbital space, eyes placed apart in Genus *Bothus* and close together in *Grammatobothus*. He mentions that second–fifth/sixth rays of dorsal fin are moderately prolonged. In the present work, first five rays are seen to be prolonged. The results of the present study therefore agree with that of Weber & Beaufort (1929) and Amaoka (1934) in description except in the forked rays of anal fin. Mc Culloch in his description might be referring to male specimens of *G. polyopthalmus* since in the present study the male specimens of *G. polyopthalmus* have an elongated pectoral fin.

In the present samples of *Poecilopsetta praelonga* examined, teeth are in narrow villiform bands. The description of *Boopsetta umbrarum* says "*teeth are seen in broad bands on the blind side*"; however, *Boopsetta umbrarum* has been synonymised with *Poecilopsetta praelonga* by Alcock (1899) and the dentition pattern is described as "*teeth are in narrow, but distinct band in either jaw*". Though Alcock (1899) has mentioned that the description is based on the types of both the species, he could be probably referring to *P. praelonga* alone.

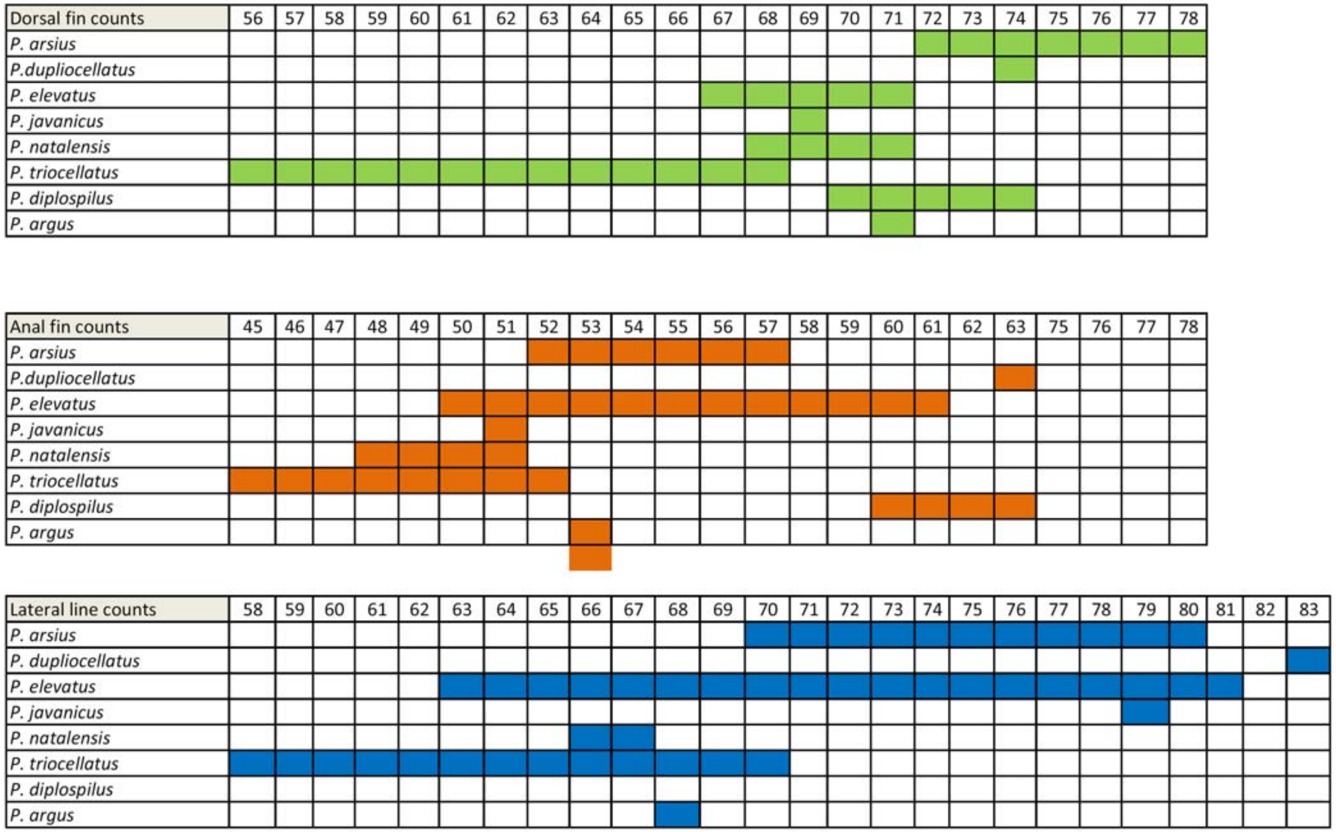
In the samples of *Aesopia cornuta* examined, body scales were cycloid. These results match with that of Day (1787 - 1888), Norman (1928) and Saramma (1963) who mentions that the body scales are cycloid; however according to Punpoka (1964) and Radhamanyamma (1988) the scales are ctenoid on both sides. Though the species of *Heteromycteris oculus* was reported earlier from the east coast of Ceylon (Munroe, 1955), *H. hartzfeldii* has not been reported earlier from Indian waters and hence is a new record from these waters. The two species has ornamental value due to its design on its body and can probably be used in the marine ornamental fish trade. One sample of *Heteromycteris oculus* has been collected live from Chinese dip nets operating along

Fort Kochi bar mouth during monsoon period. This probably points to the presence of this species in estuarine waters.

Comparative studies done on an intragenus level showed a very high range for the meristic counts of the different species of the same genus unlike other teleosts. The high range has been reported in all the species studied from the original literature also. To quote Bill Eschmeyer (pers. comm..) "*flatfishes have evolved with higher variation in their meristic features. If all flatfishes derive from a common ancestor, which had high variation in their meristic features, then the modern flatfishes just reflect the condition that was present in their ancestor. Moreover, their mode of locomotion favors serial replication of lots of smaller units to pass waves of muscle contraction along their bodies. Same kind of thing happens in elongate fishes such as eels, needlefishes. There are higher numbers of replication of body segments in all these groups compared with groups that rely on caudal locomotion.*"

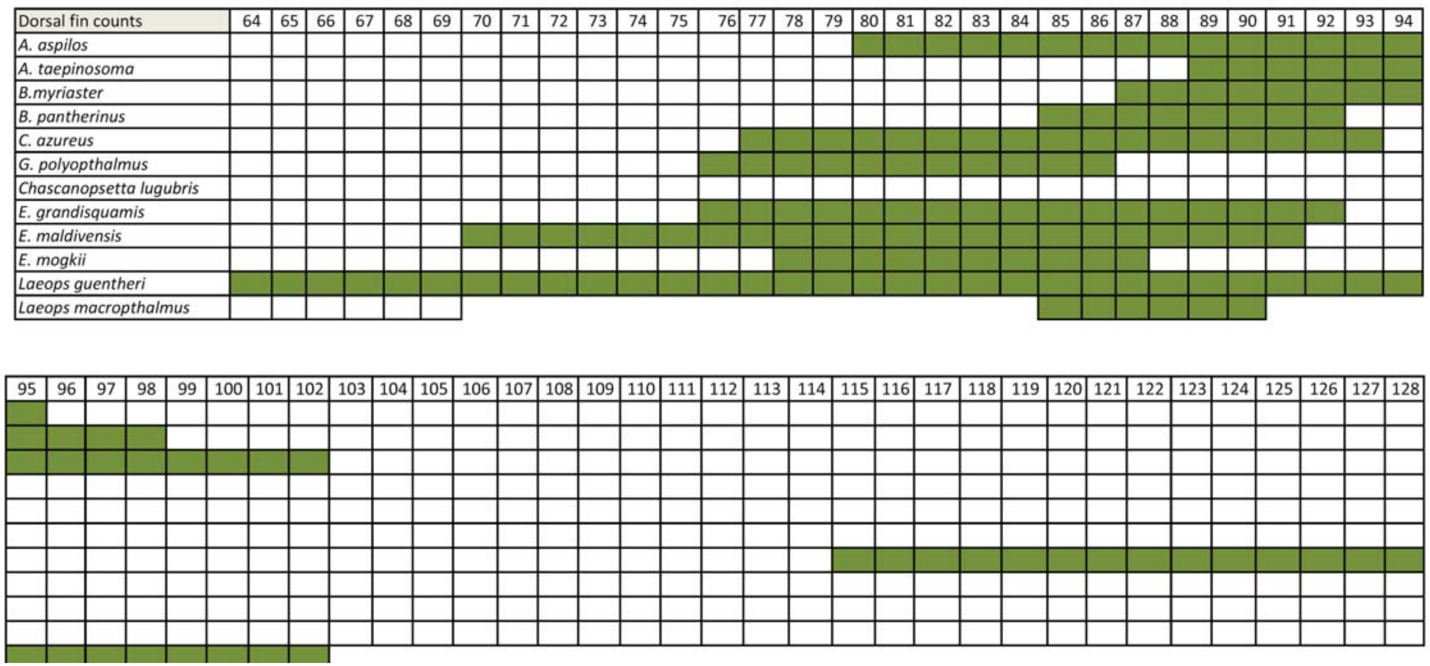
A humble method of representation of the range of meristic characters has been attempted (Figs. 160 a,b,c). Very few taxonomic works have approached this method; however, the compilation of meristic data of previous studies along with the present study gives a bird's eye view of all information as well as the range in different localities studied. This will help easier identification of species. These results agree with the comments of the Swain and Foote (1999) "*Studies of morphological variation among populations continue to have an important role to play in stock identification, despite the advent of biochemical and molecular genetic techniques which accumulate neutral genetic differences between groups*". Hence methods in classical taxonomy are to be given more importance and stress in such taxonomic studies.

Variation in meristic counts in Genus ***Pseudorhombus***

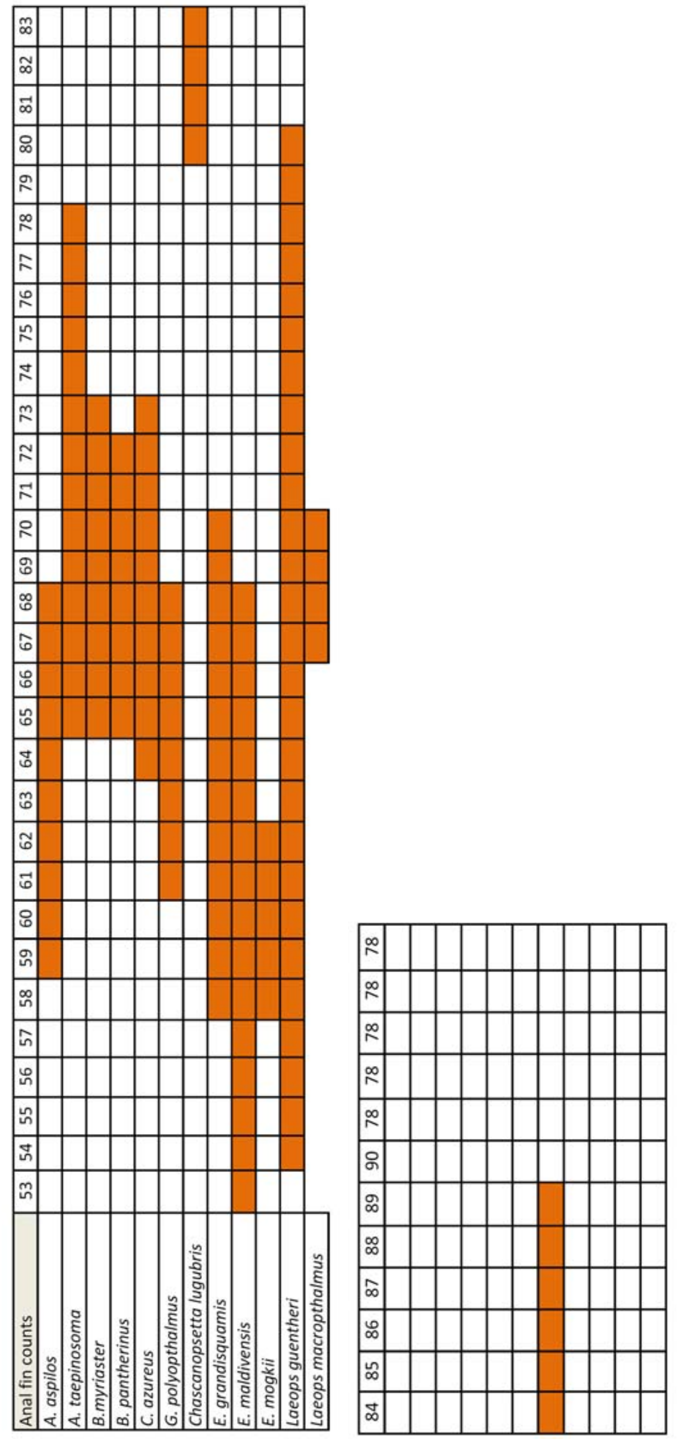


(a)

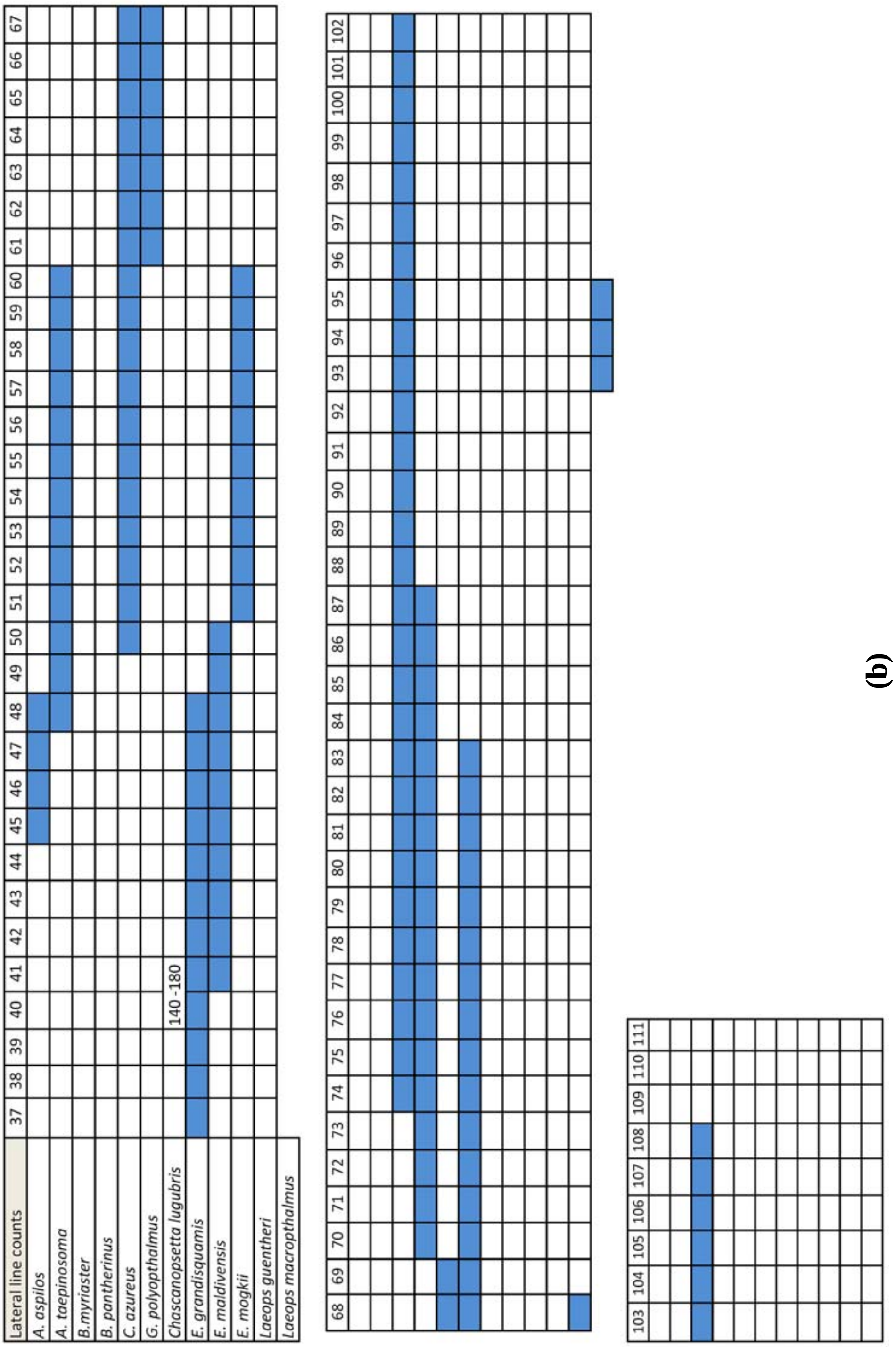
Variation in meristic counts in Family Bothidae



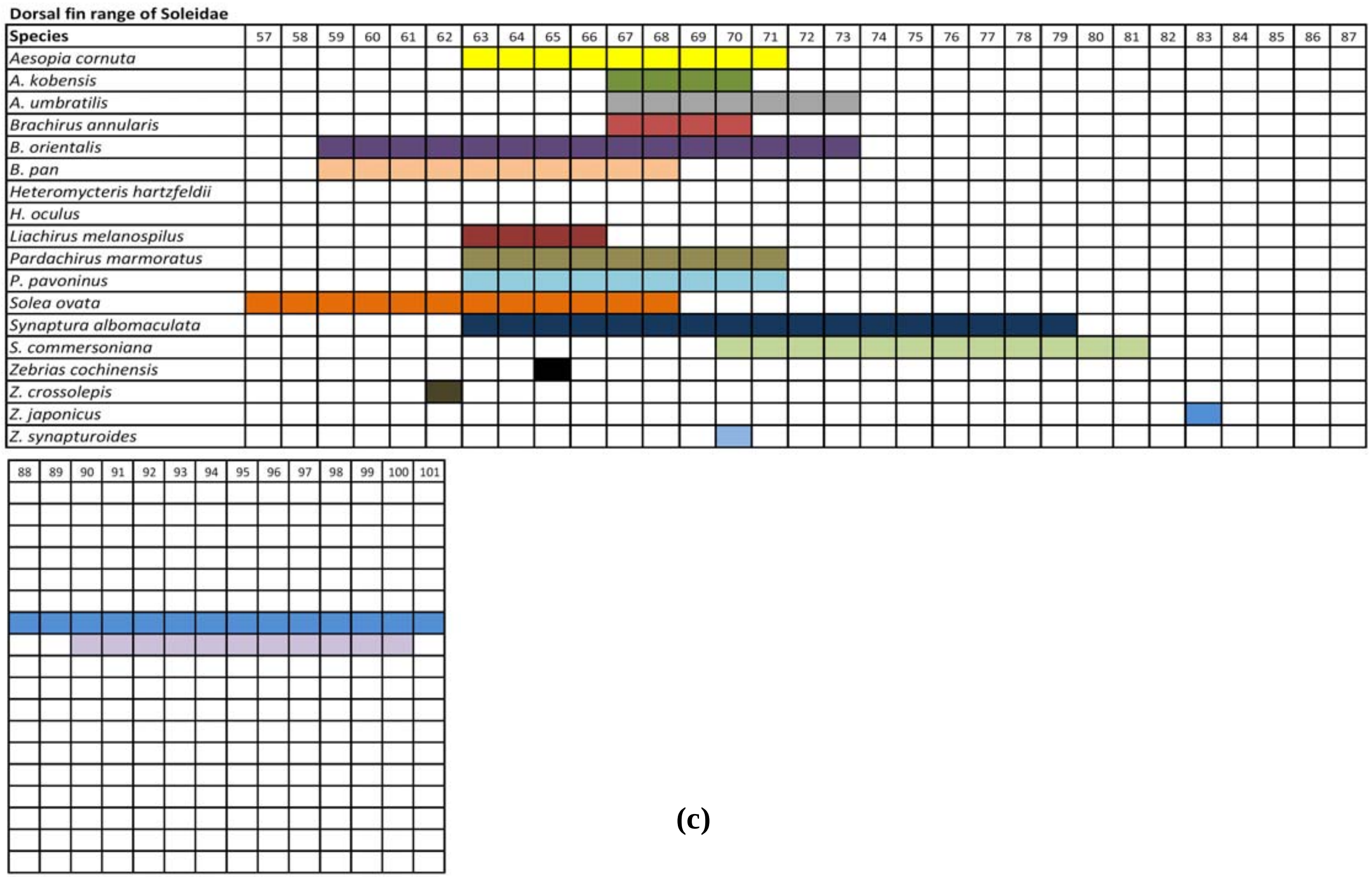
(b)


Anal fin counts
A. aspilos
A. taepinosoma
B.myriaster
B. pantherinus
C. azureus
G. polyopthalmus
Chascanopsetta lugubris
E. grandisquamis
E. maldivensis
E. mogkii
Laeops guentheri
Laeops macropthalmus
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83
84 85 86 87 88 89 90 78 78 78 78 78

(b)


Lateral line counts
A. aspilos
A. taepinosoma
B.myriaster
B. pantherinus
C. azureus
G. polyopthalmus
Chascanopsetta lugubris
E. grandisquamis
E. maldivensis
E. mogkii
Laeops guentheri
Laeops macropthalmus
140 -180
37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67
68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102
103 104 105 106 107 108 109 110 111

(b)



(c)

Fig 160 (a,b,c): Comparison of meristic characters

An effort has been made to depict the scale patterns of the flatfishes across genus. Though an initial study on the same was done by Batts (1964), no significant work in this line was done in Indian flatfishes. The work of Murty and Manikyam (2007) throws some light on the classification of genera of Platycephalidae based on the nature of pored lateral line scales across species. From the study, it was seen that the body scale of *Psettodes erumei* which was adherent and called an transforming ctenoid by Roberts (1994) had a clear cut difference from the scales of the rest of the species, showing its closeness to the perches. Detailed study of the scale patterns can provide clues to various taxonomic issues and these results may be used for further studies on these lines.

An effort was also made to depict the range of meristic characters of the different species at an intra-generic and inter generic level. This will help in the easy identification of the species as well as highlight the maximum range available for the meristic characters across species.

A dichotomous key has also been attempted using the present collection. Emphasis has been given more on easy field identification of flatfish rather than a detailed text based identification.

5.4 Distribution pattern

The pattern of distribution of flatfishes has been well studied in this work and has yielded interesting results. Exploitation of the marine resources depends on the knowledge of their distribution and abundance which vary with environmental characteristics of the ecosystem. Any additional or new information emerging out of subsequent search are of crucial importance to formulate more viable economic policies for better management of the ecosystem. The parameters which have direct relationship with growth, reproduction, abundance and distribution of organisms are mainly temperature, salinity, dissolved oxygen, nutrients, trace elements, water currents, transparency etc. All these parameters vary depending on the topography, latitude, seasons and prevailing atmospheric conditions.

Devi (1988) summarised that the Bay of Bengal appears to be favourable for the growth and distribution of bothid larvae because 20 out of 22 species found in the Indian Ocean are represented in the Bay. The distribution of larvae in the equatorial area is governed by the eastward drift and the westward flow. A notable numerical and specific decrease was found near the equator as well as towards the southern latitudes. The maximum number of species (9) was encountered from 12°N to 14°N. From 2°S and beyond, the distribution was restricted to one or two species. Even though the dominant species varies in different latitudes. *Engyprosopon grandisquamis* and *A. tapeinosoma* out number others in the Indian Ocean. In the present work also the maximum distribution of species was between 15^0E -125^0E longitude and between 30 ^{0}N and 30^0S latitude. The occurrence of good concentration of larvae as reported by Devi (1988) could have possibly resulted in the occurrence of good numbers of the species in this belt.

The hydrography of the Indian Ocean is also influenced to some extent by the marginal seas and identifiable water bodies such as those in the Mozambique Channel, the Red Sea, the Gulf of Aden, the Persian Gulf, the Gulf of Oman, the Arabian Sea, the Laccadive Sea, the Bay of Bengal, the Andaman Sea, the Java Sea, the Davis Sea off Antarctica. The Red Sea forms an extension of the Arabian Sea connected through the Gulf of Aden, a long, narrow but deep basin with a very shallow sill of 125 m at the narrow southernmost entrance the Strait of Bab-el-Mandeb. The Persian Gulf is a shallow basin having a maximum depth of 150 m and an average depth of 35 m. It is connected with the Arabian Sea through a 50 m sill at Hormuz Strait. The northern part of the Indian Ocean is formed by the Arabian Sea in the north-west, Laccadive Sea in the south-west and Bay of Bengal and Andaman Sea in the east. It is reported that the Indian Ocean Basin was formed by the on-going processes of continental drift suggesting that the Indian Ocean is comparatively young with a complex basin. The highest occurrence of species reported in the present study was in the areas 15^0E-125^0E longitude and between 30^0N and 30^0S latitude. This could probably be due to the continuous stretch of water with very similar temperature and the currents prevalent in the region.

In this study, species *Engyprosopon maldivensis*, *E. mogkii, Laeops natalensis. Poecilopsetta natalensis* and *Poecilopsetta inermis* recorded were range extensions of fishes which were previously recorded from South Africa. Similarly, *Aseraggodes kobensis, Brachirus annularis, Heteromycteris hartzfeldii* and *Zebrias crossolepis* were recorded as range extensions of fishes from S.E Asia and Japan. These results probably are in tally with the views of Ruiz *et al*. (1997) who opines that most introductions of exotic and invasive species result from anthropogenic dispersal. The relative importance of different mechanisms of dispersal varies spatially and temporally, but the worldwide movement of ships seems to be the largest single introduction vector (ballast water and ship fouling) (Ruiz *et al*., 1997, Gollasch, 2006). Indeed, the patterns of dispersal are strongly concurrent with major shipping routes, while the establishment globally appears to be strongly concurrent with intensity of fisheries, bottom trawling, pollution and other stressors (Nellemann *et al*., 2008).

Changes in the distributional range or extensions of distribution ranges of fishes could possibly be due to climate change also. The climate changes cause the oceans to warm, but this warming is not geographically homogeneous (FAO, 2010). The combined effect of temperature and salinity changes caused by climate warming is expected to reduce the density of surface waters and thus increase vertical stratification. These changes are likely to reduce nutrient availability in the surface layer and, therefore, primary and secondary production in a warmed world (FAO, 2010). There is also increasing evidence from a number of regions in the world of a poleward movement of warmer water species of plankton, fish, benthic and intertidal organisms in the last 50 years These biogeographic changes have been observed in both the northern and southern hemispheres (e.g. NE Atlantic, Tasman Sea, China Sea, Bering Sea) (Roessig *et al*., 2005). Perry *et al.* (2005) showed a northward shift of fish species in the North Sea over the last 25 years, related to changes in seawater temperature. Other studies have related successive northward and southward migrations of fish species to alternating warming and cooling events of the North Atlantic seawater (Drinkwater, 2005). Désaunay *et al.* (2006) studied changes in abundance of 4 selected commercial flatfishes with regard to their biogeographic distribution and noted a regression of northern winter spawners such as plaice and dab, and an expansion of a southern summer spawner, the wedge sole. Perry *et al.* (2005) showed a significant change in mean latitudes in relation to warming for 15 fish species in the North Sea. Their centre of distribution moved from 48 to 403 km over the last 25 years and most of these shifts were northward.

They notably indicated polar shifts for the scaldfish, the dab and the common sole. In the same way, several studies have reported successive northward and southwards migrations in cod (*Gadus mordhua*) caused by alternating events of warming and cooling of North Atlantic seawater since the beginning of the 20th century (Drinkwater, 2005). Thus, northward redistribution, or polar drift, appeared as a response to climate change of flatfish species according to their temperature requirements (Stebbing *et al.*, 2002; Perry *et al.*, 2005; Drinkwater, 2005). Because most of fish species tend to prefer a specific range of temperature, changes of geographical distribution of species often matches with long term changes in temperature. In the northern hemisphere, seawater warming induced a northward shift of fish distributions (Rose, 2005). Studies have shown an increase in the northerly range of a number of warm temperate and subtropical fish species with evidence for dispersion along the continental slope to the west of Europe and in some cases establishment of breeding populations of species such as red mullet, anchovies and sardines in the North Sea, much further north than ever recorded before (Nellemann *et al.*, 2008). Ocean warming will also alter the predator–prey matches because of the differential responses between plankton components (some responding to temperature change and others to light intensity). (FAO, 2010).

Studies on the distributional pattern shift of fishes along Indian coast due to climate change has shown that extension of oil sardine distribution to the east coast of India was noticed during the period 1997 – 2006. The Indian mackerel *Rastrelliger kanagurta* was also found to extend their distribution to the northern latitudes of the Indian seas during the same period. (Vivekanadan, 2011).

5.5 Fishery of Indian Halibut

Landings of Indian halibut decreased from 6.7 % in 1985 to about 2.0 % of the total flatfish landed during 2010 (CMFRI, 2010); landings of *Psettodes erumei* in the regular trawl fishery has also declined drastically in Kerala during the period under study. This decrease has been reflected in the samples studied also. Except for occasional large sized samples of *Psettodes erumei*, which were landed in fishing harbours, *Psettodes erumei* was not available in the samples. The present study points to the alarming decrease in the population of the fish. Several reasons can be attributed to this decrease. Climate change could affect the distribution of a particular species and hence their susceptibility to particular fishing fleets, becoming more or less "catchable" as a result (Van Keeken *et al*., 2007). Moreover, extensive fishing may cause fish populations to become more vulnerable to short term natural climate variability (O' Brien *et al*., 2000; Walther *et al*., 2002; Beaugrand *et al*., 2003; Anderson *et al*., 2008), by making such populations less able to "buffer" against the effects of the occasional poor year classes. The results also agree with the findings of Gibson (2005) who suggests that the impact of fishing on flatfish populations tends therefore to combine with climate change, with a reduction of abundance for 45% of the large northern exploited species and an increase for 50% of the small southern non-commercial species. The results are also in agreement with Pauly *et al*. (1998) "*fishing pressure can increase this pattern through overexploitation of commercial species and also through reduction of higher levels of the food webs and lower predation on small southern species*". The results call for more details studies to assess the stock size of *Psettodes erumei*. Pauly *et al*. (1998) examined the FAO capture fisheries production database for 1950–1994 in terms of trophic levels of the catch and showed that landings from global fisheries have shifted from large piscivorous fishes toward small invertebrates and planktivorous fishes, a process now called "*fishing down marine food webs*". *Psettodes erumei* being a mid–level carnivore will occupy a higher trophic niche and hence changes in its stock size will cause further changes to the trophic balance. Overfishing is primarily responsible for reductions in many flatfish populations, especially for large, commercially important species. Throughout the world, stocks of commercially important flatfishes are considered to be fully exploited-for many, even overexploited. Other factors contributing to reductions in populations of flatfishes include habitat destruction and pollution, especially serious situations for flatfishes that utilize estuaries and other coastal habitats, such as sea grass meadows and mangrove forests, as nursery habitats (Gibson, 2005). The swimming pattern of the halibut as well as its habitat is very different compared to the other large fast moving predators; extensive trawling of the sea bottom greatly increases the vulnerability of the species to fishing (Vivekanandan, 2011). All this points to possible reasons for its decline in the fishery.

5.6 Conservation

Two pleuronectids are cited by the IUCN (online) - the Atlantic halibut, which is listed as Endangered, and the yellowtail flounder, which is listed as Vulnerable. Fishery has drastically declined there; however, efforts were already initiated to breed the flounders and halibuts of temperate waters. Looking at the decline in population of the Indian halibut, *Psettodes erumei* calls for stringent conservation measures as well as conservation mariculture. In contrast to the temperate species, no major effort has been initiated in India on the development of breeding technologies, nor on cryopreservation or gene pool banking of these species. Very little information has been also been generated on the breeding biology of *Psettodes erumei*, *Pseudorhombus javanicus* and *Pseudorhombus arsius*, the three large sized flatfish which can serve as food fish. It is suggested that conservation mariculture and capture based aquaculture in cages can be initiated for development of broodstocks and culture of the species developed to augment the fishery of Indian halibuts keeping an eye on its resource potential.

Malabar sole or *Cynoglossus macrostomus* is endemic to Malabar region of West coast of India and is distributed from Mulki in Karnataka to Quilon in Kerala. This species is endemic to the region and its resource management should be taken up seriously to prevent decrease of its stock in the Indian waters.

5.7 Aquarium purposes

The ornamental fish sector is a widespread and global component of international trade, fisheries, aquaculture and development. Most flatfish are cryptically coloured, that is, camouflaged, and have a pale or mottled coloration that allows them to blend in with their surroundings. Many flatfish occurring in the tropics have beautiful designs on the ocular side giving it a highly ornamental value. Species which can be easily used for aquarium purposes are *Pardachirus pavoninus, Pardachirus marmoratus, Heteromycteris hartzfeldii, Heteromycteris oculus, Aseraggodes kobensis, Pseudorhombus dupliciocellatus, Brachirus annularis*. Moreover, flatfishes are actually rather hardy, interesting animals that can work well in a community tank, and once settled in they become much less shy. Though they are unlikely to become as bold or inquisitive and an acclimated and comfortable flatfish will swim about by day and provide its keeper with a great deal of satisfaction. (http://www.wetwebmedia.com/fwsubwebindex/fwflatties.htm). The ornamental species should be cultured for marine ornamental purposes and the industry for it may be developed.

5.7 Phylogeny

Cluster analysis includes a broad suite of techniques designed to find groups of similar sets within a data set. Hierarchial cluster methods which were used here provides a hierarchy of clusters of similar sets and separates it from dissimilar sets. Here the method is useful to relate similar species within a family and across families. Meristic characters were involved in cluster analysis as most of the classification is based on the meristic counts in flatfishes. A cluster analysis was run on 4 cases, family wise, each case responding to one meristic character (dorsal, anal, pectoral (O), caudal fin count and lateral line count). A hierarchical cluster analysis using Ward's method produced clusters, between which the variables were significantly different in the main.

In the family Paralichthyidae, 4 clusters were recognised; the first cluster was formed by the congeneric species *Pseudorhombus elevatus, P. natalensis*, and *P. arsius* along with *Cephalopsetta ventrocellata*. Genus *Cephalopsetta* was seen to be closely related to *Pseudorhombus arsius*. This matches well with that of the external appearance. This cluster had close affiliation to *P. dupliocellatus*. *P. diplospilus* was seen to be the most dissimilar species in the group. In family Bothidae, clustering was seen across genera; however *Chascanopsetta* was the outgroup. The results are similar to the external appearance also. In the family Cynoglossidae, three main clusters were identified. The first cluster was formed by *Cynoglossus cynoglossus, C. itinus, C. macrostomus, C. punticeps* and *C. lida;*

the second cluster by the congeneric species *C. carpenteri, C. dubius* and with *Paraplagusia bilineata* and the third cluster by *C. arel* and *C. bilineatus*. Though *Paraplagusia* comes in the second clade along with *C. capenteri, C. dubius and C. acutirostris*, it forms a distincr branch. The major difference between the two genera *Paraplagusia* and *Cynoglossus* is the presence of fringed lips on ocular side in the former. However, phylogenetic relationship between the two genera *Paraplagusia* and *Cynoglossus* need to be further studied using molecular markers. Phylogenetic relationships based mostly on morphological characters and molecules are concordant (Ward *et al*., 2005; Bernardi *et al*., 2000).

The relation between certain body lengths and standard length and between certain dimensions in the head and head length were calculated after ascertaining the type of relationship. This helped to understand variations in allometric growth as well as intraspecific variations better.

The results of the present study therefore highlight the importance of such studies in India. With India being a party to Convention of Biological Diversity, it is imperitive that the present status of the different fish species in India is ascertained. The recent decrease in the population of Indian Halibut brings out the importance of conservation of these overfished stocks. Recently the Ministry of Environment and Forests, Government of India has decided to recover the highly threatened marine species using the 'Species Recovery Plans'. More species need to be included in this programme and all the 'Species Recovery Plans' must be prepared with scientifically validated data. Therefore, required scientific information need to be collected for preparation of species recovery plans of threatened marine species. For these aspects, further studies on these lines should be undertaken for other marine groups.

As a part of long term monitoring of population and distribution range of all threatened and endemic coastal and marine species, periodic assessment at the interval of five years need to carried out to periodically review the scheduled species of Wildlife (Protection) Act, 1972 and also support the periodic revision of red list of IUCN, appendices of CITES etc. The Indian halibut *Psettodes erumei* needs to be conserved since the stock has declined drastically. Steps to develop the breeding protocol of *Psettodes erumei* should also be developed to augment production from the seas. Cryopreservation of gametes of this species should be attempted in future to conserve this species.

Flatfishes are mostly landed by trawlers and handling causes them to loose scales on their body which leads to taxonomic ambiguity. In addition, for genera like *Cynoglossus* and *Paraplagusia* which are closely related externally also, molecular genetic markers such as partial sequence information of mitochondrial 16S rRNA and COI and nuclear markers such as ITS or RAG can be used to resolve taxonomic ambiguity. This should however be done after the voucher specimen has been correctly identified.

Flatfishes being a mixture of highly valuable table fish as well as an export item requires more attention, both to protect the dwindling species as well as breed the bigger sized fishes to augment production

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Chapter 6

CONCLUSION

[1]. Flatfishes are deep bodied, laterally compressed fishes, easily recognizable by the presence of both eyes on one side in juvenile and post-metamorphic individuals. They are well known organisms as they occur in all of the world's oceans, are represented by large numbers of species and genera. An amazing diversity was seen in the morphology of flatfishes over the areas sampled.

[2]. In this present work, based on the collections from different parts of South India and Andaman Islands during the period 2004 - 2010, 63 species of flatfishes belonging to 8 families and 26 genera have been collected.

[3]. 15 fishes were recorded from Indian waters for the first time; they were range extensions from African and South East Asian waters. The new records from Indian waters are *Pseudorhombus argus* Weber, 1913; *Pseudorhombus natalensis* Gilchrist, 1905; *Pseudorhombus dupliciocellatus* Regan, 1905; *Parabothus polylepis* (Alcock, 1889); *Laeops parviceps* Gunther, 1880; *Laeops natalensis* Norman, 1931; *Engyprosopon mogkii* (Bleeker, 1834); *Engyprosopon maldivensis* (Regan, 1908); *Poecilopsetta natalensis* Norman, 1931; *Poecilopsetta inermis* (Breder, 1927); *Aseraggodes kobensis* (Steindachner, 1896); *Brachirus annularis* Fowler, 1934; *Heteromycteris hartzfeldii* (Bleeker, 1853) and *Zebrias crossolepis* Zheng & Chang, 1965.The listing out of

species in the present study could be a possible pointer to existence of even newer species. Most of these new records were collections from the discards from the trawlers and deep sea vessels.

[4]. Comparitive studies on the meristic characters of all species recorded revealed an intersting pattern of results. This can help in easy identification of the species.

[5]. An effort has also been made to depict the scale patterns of the flatfishes across genus which if done in detail will provide a good taxonomic tool by itself.

[6]. The distribution pattern of flatfishes has been well studied in this work and has yielded interesting results. The hydrography of the Indian Ocean and the interconnecting patterns of water bodies in it could be the reason for maximum common diversity of flatfishes within the region.

[7]. Landings of *Psettodes erumei* in the regular trawl fishery has declined from 6.7 % in 1985 to about 2.0 % of the total flatfish landed during 2010. This decrease has been reflected in the samples studied also. The resource *Psettodes erumei* therefore calls for stringent conservation measures as well as conservation steps like cryopreservation.

[8]. Many flatfish occurring in the tropics have beautiful designs on the ocular side giving it a highly ornamental value. These species may be used for aquarium purposes-*Pardachirus pavoninus, Pardachirus marmoratus, Heteromycteris hartzfeldii, Heteromycteris oculus, Aseraggodes kobensis, Pseudorhombus dupliciocellatus, Brachirus annularis*.

[9]. In cases were taxonomic ambiguity exists, molecular genetic markers such as partial sequence information of mitochondrial 16S rRNA and COI and nuclear markers such as ITS or RAG can be used to resolve taxonomic ambiguity. This should however be done after the voucher specimen has been correctly identified.

[10]. The flatfish resources require more attention as these are a mixture of highly valuable table fish as well as an export item and many species are dwindling in the landings. A study on the diversity of the flatfishes available in the Indian waters is a requisite for successful management of the fishery as well as accurate documentation and maintenance of biodiversity.

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References

Abraham, M and N.B. Nair. (1976). Food and feeding habits and breeding biology of the Indian Halibut *Psettodes erumei* (Bloch and Schneider). *Aquatic Biology,* 1: 43 – 63.

Adam, M. S., N. R. Merrett, and R. C. Anderson. (1998).Additions to the fish fauna of the Maldive Islands. Part 1: An annotated checklist of the deep demersal fishes of the Maldive Islands. *Ichthyology Bulletin, J. L. B. Smith Institute of Ichthyology,* 67: 1-19.

Agassiz, L. (1834–1842) *Recherches sur les Poissons Fossiles.* Neuchâtel, Switzerland.

Agassiz, J. L. R. (1842). *Nomenclator Zoologicus, continens nomina systematica generum animalium tam viventium quam fossilium secundum ordinem alphabeticum disposita, adjectis auctoribus, libris, inquibus reperiuntur, anno editionis, etymologia et familiis, ... Soloduri. Nomenclator Zoologiscus. A list of the names of genera and subgenera in zoology ...* PISCES: vi, 1-69.

Ahlstrom, E. H., K. Amaoka, D. A. Hensley, H. G. Moser and B. Y. Sumida (1984). Pleuronectiformes: development. In. Ontogeny and Systematics of Fishes. Moser, H.G, Cohen, D.M, Fahay M.P, Kendall, A.W. Jr, Richardson, S.L, Lawrence, K.S, (eds.). American Society of Ichthyology and Herpetology, Special Publication, 1: 640-670.

Al-Baz, A.F. and A.S. Bawazeer (1989). Population dynamics of the large-scaled tongue sole, *Cynoglossus macrolepidotus* (Bleeker) in Kuwait's waters. *Indian Journal of Fisheries*, 36(4):269-274.

Alcock, A. W. (1890). Natural history notes from H. M. Indian marine survey steamer `Investigator,' Commander R. F. Hoskyn, R. N., commanding.– No. 20. On some undescribed shore-fishes from the Bay of Bengal. *Annals of Magazine of Natural History, (Ser*ies 6) 6 (36): 425-443.

Alcock, A. W. (1894). Natural history notes from H. M. Indian marine survey steamer `Investigator,'... Series II., No. 11. An account of a recent collection of bathybial fishes from the Bay of Bengal and from the Laccadive Sea. *Journal of the Asiatic Society of Bengal*, 63(2): 115-137, Pls. 6-7.

Alcock, A. W. (1889a). A descriptive catalogue of the Indian deep sea fishes in the Indian Museum collected by the Royal Indian Marine Survey Ship Investigator, Calcutta, 8^0: 220 pp.

Alcock, A. W. (1889b). List of Pleuronectidae obtained in the Bay of Bengal in 1888 and 1889 with descriptions of new and rare species. *Journal of the Asiatic Society of Bengal*, 58: 279 – 295.

Alcock, A. W. (1889c). Natural history notes from H. M. Indian marine survey steamer `Investigator,' ... .--No. 10. List of the Pleuronectidae obtained in the Bay of Bengal in 1888 and 1889, with descriptions of new and rare species. *Journal of the Asiatic Society of Bengal*, 58 (Pt. 2, no. 3): 279-295, Pls. 16-18.

Alcock, A. W. (1889d). Natural history notes from H. M. Indian marine survey steamer `Investigator,' Commander Alfred Carpenter, R. N., D. S. O., commanding.–No. 13. On the bathybial fishes of the Bay of Bengal and neighbouring waters, obtained during the seasons 1885-1889. *Annals of Magazine of Natural History,* (Series 6) 4 (24): 450 - 461.

Alcock, A. W. (1899e). A descriptive catalogue of the Indian deep sea fishes in the Indian Museum being a revised account of the deep sea fishes collected in the R.I.M.S. Investigator.

Alcock, A. W. (1899f). Illustrations of the zoology of the Royal Indian marine surveying steamer Investigator,...Fishes. Calcutta. Illustrations of the zoology of the Royal Indian marine surveying steamer Investigator,...Fishes. Part 6: no p., Pls. 25-26.

Amaoka, Kunio. (1962). Development and growth of the sinistral flounder, *Bothus myriaster* (Temminck and Schlegel) found in the Indian and Pacific Oceans. *Bulletin of Misaki. Marine Biology Institute, Kyoto University,* 5: 11 – 29.

Amaoka, Kunio. (1963). A revision of the flatfish referable to the genus *Engyprosopon* found in the waters around Japan. *Bulletin of Misaki Marine Biology Institute, Kyoto University,* 4: 107-121.

Amaoka, Kunio. (1964). Development and growth of the sinistral flounder *Bothus myriaster* (Temminck and Schlegel) found in the Indian and Pacific Oceans. . *Bulletin of Misaki. Marine Biology Institute, Kyoto University,* (5): 11 – 29, figs. 1 – 8.

Amaoka, Kunio. (1969). Studies on the sinistral flounders found in the waters around Japan -- taxonomy, anatomy and phylogeny. *Journal of the Shimonoseki University of Fish*eries, 18 (2): 65-340.

Amaoka, Kunio. (1970). Studies on the larvae and juveniles of the sinistral flounders I. *Taeniopsetta ocellata* (Gunther). *Japanese Journal of Ichthyology*, 17: 95 – 104.

Amaoka, Kunio. (1971). Eleven species of flounders collected from South China Sea. *Journal of the Shimonoseki University of Fish*eries,20 (1): 19 – 33, pl. I – IV.

Amaoka, Kunio. (1972). Osteology and relationships of the citharid flatfish *Brachypleura novaezeelandie*. *Japanese Journal of Ichthyology,* 19: 263 – 273.

Amaoka, Kunio. (1973). Studies on the larvae and juveniles of the sinistral flounders – IV. *Arnoglossus japonicus*. *Japanese Journal of Ichthyology,* 20 (3): 145 – 156.

Amaoka, Kunio. (1974). Studies on the larvae and juveniles of the Sinistral flounders. V. *Arnoglossus tenuis. Japanese Journal of Ichthyology,* 21 (3): 153 – 157.

Amaoka, Kunio. (1976). Studies on the Larvae and Juveniles of the Sinistral Flounders-VI. *Psettina iijimae*, *P. tosana*, and *P. gigantean. Japanese Journal of Ichthyology*, 22 (4): 201 – 206.

Amaoka, Kunio. (1984). Family Bothidae, pages 347 – 350, pls. 312 – 313, 368 – 369. In: Masuda, H., K. Amaoka, C. Araga, T. Uyeno and T. Yoshino (eds). The Fishes of the Japanese Archipelago. English text and plates, Tokai University Press, Tokyo.

Amaoka, K., and Bernard Seret. (2005a). *Engyprosopon vanuatuensis*, a new species of bothid flounder (Pleuronectiformes: Bothidae) from off Vanuatu, South West Pacific. *Ichthyological Research,* 52 (4): 15 – 19.

Amaoka, K. and Bernard Séret (2005 b). *Engyprosopon marquisensis*, a new species of bothid flounder (Pleuronectiformes: Bothidae) from the Marquesas Islands (French Polynesia). *Ichthyological Research*, 52 (4): 373-378.

Amaoka, K., and E. Mihara. (1995). A new species of the genus *Engyprosopon* (Pleuronectiformes: Bothidae) from the south-west Pacific Ocean. *New Zealand Journal of Marine Freshwater Res*earch, 29: 51-57.

Amaoka, K., and E. Mihara. (2000). Pisces Pleuronectiformes: Flatfishes from New Caledonia and adjacent waters. Genus *Arnoglossus*. In: A. Crosnier (ed.). Résultats des Campagnes MUSORSTOM, 21. *Memoirs of the Museum National History,*184: 783-813.

Amaoka, K. and E. Mihara. (2001). *Asterorhombus annulatus* (Weber, 1913), a valid species distinct from *Asterorhombus intermedius* (Bleeker, 1865) (Pleuronectiformes: Bothidae). *Ichthyological Research*, 48 (2): 192-196.

Amaoka, K., and E. Yamamoto.(1984). Review of the genus *Chascanopsetta*, with the description of a new species. *Bulletin of the Faculty of Fisheries Hokkaido University,* 35 (4): 201-224.

Amaoka, K., and H. Imamura. (1990). Two new and one rare species of bothid flounders from Saya de Malha Bank, Indian Ocean (Teleostei: Pleuronectiformes). *Copeia,* 1990(4): 1011-1019.

Amaoka, K., and H. Imamura. (2000). A new flounder, *Monolene helenensis* (Pleuronectiformes: Bothidae) from the eastern tropical Atlantic. *Ichthyological Research,* 47 (3): 243 - 247.

Amaoka, K., and J. Rivaton. (1991). Pisces: Pleuronectiformes: a review of the genus *Tosarhombus* (Bothidae) with descriptions of two new species from Saya de Malha Bank (Indian Ocean) and the Chesterfield Islands (Coral Sea). In: A. Crosnier (ed.), Résultats Campagnes MUSORSTOM, vol. 8. *Memoirs of the Museum of the National History,* (*Sér. A) Zoology*, 151: 449-466.

Amaoka, K. and M. Arai (1998). Redescription of a rare bothid, *Asterorhombus bleekeri* (Macleay), and description of a new species of *Asterorhombus* from northwestern Australia (Teleostei: Pleuronectiformes). *Ichthyological Research*, 45 (3): 249-257.

Amaoka, K., and N. V. Parin. (1990). A new flounder, *Chascanopsetta megagnatha*, from the Sala-y-Gomez Submarine Ridge, eastern Pacific Ocean (Teleostei: Pleuronectiformes: Bothidae). *Copeia,* 1990 (3): 717-722.

Amaoka, K., and S.C. Shen. (1993). A new bothid flatfish *Parabothus taiwanensis* collected from Taiwan (Pleuronectiformes: Bothidae). *Bulletin of Marine Science,* 53 (3): 1042-1047.

Amaoka, K., E. Mihara, and J. Rivaton. (1993). Pisces, Pleuronectiformes: flatfishes from the waters around New Caledonia. - A revision of the genus *Engyprosopon*. *Memoirs of the Museum National History,*158: 377- 426.

Amaoka, K., E. Mihara, and J. Rivaton. (1997). Pisces, Pleuronectiformes: flatfishes from the waters around New Caledonia. Six species of the bothid genera *Tosarhombus* and *Parabothus*. *Memoirs of the Museum National History,* 174: 143-171.

Amaoka, K. , H. Senou, and A. Ono (1994). Record of the bothid flounder *Asterorhombus fijiensis* from the western Pacific, with observations on the use of the first dorsal-fin ray as a lure. *Japanese Journal of Ichthyology*, 41 (no. 1): 23-28.

Amaoka, K., M. Arai & Gomon, M.F. (1997). A new species of *Arnoglossus* (Pleuronectiformes: Bothidae) from the southwestern coast of Australia. *Ichthyological Research,* 44, 131–136.

Amaoka, K., O. Okamura and T. Yoshino. (1992). First records of two bothid flounders *Grammatobothus polyopthalmus* and *Arnoglossus tapeinosoma* from Japan. *Japanese Journal of Ichthyology*, 39 (3): 259 – 264.

Amaoka, K. , T. Kawai, and B. Séret (2006). *Nematops nanosquama*, a new species of righteye flounder (Pleuronectiformes: Poecilopsettidae) from off the Marquesas Islands. *Ichthyological Research*, 53 (3): 223-227.

Anderson, W. W., and E. J. Gutherz. (1967). Revision of the flatfish genus *Trichopsetta* (Bothidae) with descriptions of three new species. *Bulletin of Marine Science*, 17 (4): 892-913.

Anderson, C.N. K., Hsieh, C.H., Sandin, S.A., Hewitt, R., Hollowed, A., Beddington, J., May, R.M. (2008). Why fishing magnifies fluctuations in fish abundance, *Nature,* 452: 835 -839.

Andriashev A.P. (1954a). Fish fauna of the northern seas of USSR and its origin. *Publications of the Zoology Institute of Academy of Science*, 566 pp.300 fgs.

Andrnasheva, P., (1954b). *"Fishes of the northern seas of USSR." Israel Progressive Scientist*, Jerusalem (1964): 617 pp. OTS 63-1 1160.

Andriashev, A. P. (1960). Families of fishes new to the Antarctic. Communique 3. Pelagic young of flatfish (Pisces, Bothidae) off the Antarctic coast. *Zoological Journal* 39 (7): 1056-1061.

Anna Mercy T.V., A. Gopalakrishnan, D. Kapoor and W.S Lakra. (2007). Ornamental fishes of the Western Ghats, Publication NBFGR, Lucknow, 235 pp.

Apte, D and Rao, M. (1992). Morphometric and meristic studies in *Zebrias quagga* (Kaup, 1858) and *Pseudorhombus elevatus* Ogilby (1912). *Environmental Ecology,* 10 (2) : 330 – 332.

Arora, H.L. (1951). An investigation of the California sand dab, *Citharichthys sordidus* (Girard). *California Fish and Game*, 37 (1): 3 – 42.

Artedi, P. (1738) Genera piscium. In quibus systema totum ichthyologiæ proponitus cum classibus, ordinibus, generum characteribus, specierum differentiis, observationibus plurimis. Redactis speciebus 242 ad genera 52. Ichthyologiæ pars 3. Conradus Wishoff, Lugduni Batavorum (Leiden). Genera piscium: 1-84 + i-i.

Azevedo, Maria, F.C., Claudio Oliveira, Belen G. Pardo, Paulino Martinez and Fausto Foresti. (2008). Phylogenetic analysis of the order Pleuronectiformes (Teleostei) based on sequences of 12 S and 16 S mitochondrial genes. *Genetics and Molecular Biology*, 31 (1) (Suppl.): 284 – 292.

Bagenal, T.B. (1955b). The growth rate of the Long Rough Dab *Hippoglossoides platessoides* (Fabr.). *Journal of the Marine Biological Association of United Kingdom,* 34: 297-311.

Bagenal, T.B. (1956). The breeding and fecundity of the long rough dab *Hippoglossoides platessoides* (Fabr.) and the associated cycle in condition. *Journal of the Marine Biological Association of United Kingdom,* 36: 339-375.

Bagenal, T.B. (1957). Annual variations in fish fecundity. *Journal of the Marine Biological Association of United Kingdom,* 36: 377-382.

Bagenal, T.B. (1957). The breeding and fecundity of long rough dab *Hippoglossoides platessoides* (Fabr.) and the associated cycle in condition. *Journal of the Marine Biological Association of United Kingdom,* 36: 377 - 382.

Bagenal, T.B. (1958). The fecundity of Clyde plaice. *Journal of the Marine Biological Association of United Kingdom,* 37:309 - 313.

Bagenal, T.B. (1960). The fecundity of English Channel plaice. *Journal of the Marine Biological Association of United Kingdom,* 39:249 - 254.

Bagenal, T.B. (1960). The fecundity of plaice from the south and west coasts of Ireland. *Journal of the Marine Biological Association of United Kingdom,* 39:255 – 262.

Bagenal, T.B. (1963). Variations in plaice fecundity in the Clyde area. *Journal of the Marine Biological Association of United Kingdom,* 43:391 – 392.

Bagenal, T.B. (1966). The ecological and geographical aspects of the fecundity of plaice. *Journal of the Marine Biological Association of United Kingdom,*46: 161-186.

Bagenal, T.B. (1967). A short review of fish fecundity. Pp 89 – 111 In: Shelby. D. Gerking (ed). *The biological basis of freshwater fish production*, Blackwell, Oxford.

Balakrishnan K.P. (1963). Fish eggs and larvae collected by the Research Vessel 'Conch'. II. Larvae of *Arnoglossus taepinosoma* Bleeker; *Bothus Ocellatus* Agassiz, *Laeops guentheri* Alcock, *Solea ovata* Richans *Cynoglossus monopus* Bleeker. *Bulletin Department of Marine Biology and Oceanography, University of Kerala,* 1: 81 – 96.

Balakrishnan K.P and C.B.L Devi. (1974).The larvae of some fishes from a tropical estuary. In: J.H.S. Blaxter (ed). *The early life history of fish*. Springer Verlag, Berlin, Heidelberg.

Bamber, R. C. (1915). Reports on the marine biology of the Sudanese Red Sea, from collections made by Cyril Crossland, M.A., D.Sc., F.L.S. XXII. The Fishes. *The Journal of the Linnean Society of London. Zoology*, 31 (210): 477- 485, Pl. 46.

Baoshan, Z. (1962). Pleuronectiformes. pp: 950-1014, In:*The fishes of South China Sea*. Y.T Chu and eleven coauthors, (Eds).Science Press, Peking. (In Chinese).

Barr, (1963). The endocrine control of the sexual cycle in the plaice, *Pleuronectes platessa* (L). I-III. *General Comparitive Endocrinology*.,3: 197-225.

Barrett, J.H., Nicholson, R.A and Ceron-Carrasco, R. (1999). Archaeo-ichthyological evidence for long term socioeconomic trends in northern Scotland: 3500 BC to AD 1500. *Journal of Archeaological Science,* 26: 353 -388.

Batts, B. S. (1964). Lepidology of the adult pleuronectiform fishes of Puget Sound, Washington. *Copeia* 1964: 666–673.

Bawazeer, S. (1987). Stock assessment of the large toothed flounder (*Pseudorhombus arsius*) in Kuwait waters. *Kuwait Bulletin of Marine Science*, 9: 201 – 214.

Bawazeer, A.S and AL-BAZ, A. F. (1990). Growth, mortality and yield per recruit of large toothed flounder, *Pseudorhombus arsius* (Hamilton and Buchanan) in Kuwait waters. *Pakistan Journal of Zoology,* 22 (2): 193 – 202.

Baxter, I.G. (1959). Fecundities of winter- spring and summer – autumn herring spawners. *ICES Journal of Marine Science,* 25: 73 – 80.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S. and Reid, P.C. (2003). Plankton effect on cod recruitment in the North Sea, *Nature*, 426: 661 -664.

Ben Tuvia, A. (1990). A taxonomic reappraisal of the Atlanto – Mediterranean soles *Solea solea, S.senegalensis* and *S. lascaris*. *Journal of Fish Biology 36: 947 – 960*.

Bennett, E. T. (1831). Characters of new genera and species of fishes from the Atlantic coast of northern Africa presented by Captain Belcher, R.N. *Proceedings of the General Meetings for Scientific Business of the Zoological Society of London* 1830-31 (pt 1): 145-148.

Berendzen Peter. B and Walter Wheaton Dimmick, (2002). Phylogenetic relationships based on molecular evidence. *Copeia* 2002(3): 642 – 652.

Berg, Lee.S. (1940). *Classification of Fishes both recent and fossil*. Trudy Zoologische Skogo Institute, V. 2, 517 pp.

Bianchi, Gabriella. (1985). Field Guide to the Commercial Marine and Brackish water species of Pakistan. FAO Species Identification Sheets for Fishery Purposes.

Bigelow, H.B and Schroeder, W.C.,(1953). Fishes of the Gulf of Maine. *United States Wildlife Series Fisheries Bulletin*, 53, 1 – 577.

Bijukumar,A and G.R Deepthi. (2009). Diversity of flatfishes (Order Pleuronectiformes) along the Kerala Coast of India, with notes on two rare species. *Indian Journal of Fisheries*, 56 (3): 211 – 214.

Bishai, H.M., (1960). The effect of water currents on the survival and distribution of fish larvae. *Journal Consiel International Exploration de Mer.,* 25 : 134-146.

Bishai, H.M., (1961). The effect of salinity on the survival and distribution of larval and young fish. *Journal Consiel International Exploration de Mer.,* 26 : 166-179.

Blackwelder, (1967). *Taxonomy*. A Text and Reference Book. Wiley, New York, 1967. 714 pp.,

Blainville, H. de (1816). Prodrome d'une nouvelle distribution systématique du règne animal. *Bulletin de la Société Philomathique de Paris*, 8: 105-112 [sic for 113-120] +121-124.

Bleeker, P. (1851). Bijdrage tot de kennis der ichthyologische fauna van Riouw. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, 2: 469-497.

Bleeker, P. (1852). Bijdrage tot de kennis der ichthyologische fauna van Singapore. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, 3: 51-86.

Bleeker, P. (1853). Nalezingen op de ichthyologische fauna van Bengalen en Hindostan. *Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen*., 25 (8): 1-164, Pls. 1-6

Bleeker, P. (1853). Pisces japonici hucusque cogniti eorumque distributio geographica. *Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen*, XXV (7): 1 – 56.

Bleeker, P. (1854). Vijfde bijdrage tot de kennis der ichthyologische fauna van Celebes. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, 7: 225-260.

Bleeker, P. (1855). Derde bijdrage tot de kennis der ichthyologische fauna van de Kokos-eilanden. *Natuurkundig Tijdschrift voor Nederlandsch Indië*, 8: 169-180.

Bleeker, P. (1856). Beschrijvingen van nieuwe en weinig bekende vischsoorten van Manado en Makassar grootendeels verzameld op eene reis naar den molukschen archipel in het gevolg van den gouverneur generaal duymaer van twist... *Acta Societatis Regiae Scientiarum Indo-Neêrlandicae,* I: 1 –80.

Bleeker, P. (1856). Beschrijvingen van nieuwe en weinig bekende vischsoorten van Amboina, verzameld op eene reis door den Molukschen Archipel gedaan in het gevolg van den Gouverneur Generaal Duymaer van Twist, in September en Oktober 1855. *Acta Societatis Regiae Scientiarum Indo-Neêrlandicae* , 1: 1-76.

Bleeker, P. (1860a). Achtste bijdrage tot de kennis der vischfauna van Sumatra. *Acta Societatis Regiae Scientiarum Indo-Neêrlandicae*, VIII: 1- 88.

Bleeker, P. (1860b). Zesde bijdrage tot de kennis der vischfauna van Japan. *Acta Societatis Regiae Scientiarum Indo-Neêrlandicae,* VIII: 1-104, 2 pls.

Bleeker, P. (1862). Sur quelques genres de la famille des Pleuronectoïdes. *Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeling Natuurkunde*, 13: 422-429.

Bleeker, P. (1863). Mémoire sur les poissons de la côte de Guinée. *Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem* (Ser. 2),18: 1-136, col. Pls. 1-28.

Bleeker, P. (1866). Description de quelques espèces inédites ou peu connues de Clupéoïdes de l'Inde archipélagique. *Nederlandsch Tijdschrift voor de Dierkunde*, 3: 293-308.

Bleeker, P. (1875). Atlas ichthyologique des Indes Orientales Néêrlandaises, publiés sous les auspices du Gouvernement colonial néêrlandais. Tome VI. Pleuronectes, Scombrésoces, Clupées, Clupésoces, Chauliodontes, Saurides. 1-170, Pls. 232-278. [Text published 1870-1875, plates published 1865-1871.

Blegvad, H. (1944). Fishes of the Iranian Gulf. *Danish Scientific Investigations of Iran*, III Knud Jessen and Ragnar Sparck (Eds.), 234 pp.

Bloch, M. E. (1794). Naturgeschichte der ausländischen Fische. Berlin. *Naturgeschichte der Ausländischen Fische*, 8: i-iv + 1-174, Pls. 361-396.

Bloch, M. E., and J. G. Schneider, (1801), M. E. Blochii, Systema Ichthyologiae iconibus cx illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Austoris Impressum et Bibliopolio Sanderiano Commissum. i-lx + 1-584, Pls. 1-110.

Boeseman, M. (1947). Revision of the fishes collected by Burger and Von Siebold in Japan. *Zoologische Mededelingen* (Leiden) v. 28: i-vii + 1-242, Pls. 1-5.

Borets, L. A. (1983). A new species of flatfish, *Microstomus shuntovi* sp. n. (Pleuronectidae), and two rare flounder species (Bothidae) from seamounts of the northwestern and Hawaiian ridges. *Voprosky Ikhthiology,* 23 (no. 5): 718-723.

Boulenger, G. A. (1881). Pisces. *Zoological Record*, 9 (for 1880): Pisces pp. 1-23.

Boulenger, G. A. (1887). An account of the fishes collected by Mr. C. Buckley in eastern Ecuador. Proceedings of the General Meetings for Scientific Business of the Zoological Society of London,1887 (2): 274-283, Pls. 20-24.

Boulenger, G. A. (1902). Notes on the classification of teleostean fishes. II. On the Berycidae. *Annals and Magazine of Natural History* (Series 7), 9 (51): 197-204.

Boulenger, G. A. (1904). A synopsis of the suborders and families of teleostean fishes. *Annals and Magazine of Natural History* (Series 7), 13 (no. 75): 161-190.

Bowman, A.(1935). Lemon soles *(Pleuronectes microcephalus*) marking experiments in Scottish waters during the period 1919-1913. *Fisheries Board of Scotland Scientific Investigations.*

Brewster, B., (1987). Eye migration and cranial development during flatfish metamorphosis: a reappraisal (Teleostei: Pleuronectiformes*) Journal of Fish Biology,* 31: 805 – 833.

Brien, C.M., Fox, C.J., Planque, B., and Casey, J. (2000). Climate variability and North Sea cod. *Nature*, 404: 142.

Briggs, J.C. (1974).*Marine Zoogeography*, Mc Graw-Hill, New York.

Briggs, J.C. (1999). Modes of speciation: marine Indo–west Pacific. *Bulletin Marine Science,* 65:645 – 656.

Broussonet, P. M. A. (1782). Ichthyologia sistens piscium descriptiones et icones. 452 pp

Buchanan-Wollaston, H. J., (1924). The spawning of plaice in the Southern part of North Sea in 1913-14. *Ministry of Agriculture and Fisheries, London, Fishery Investigation Series,* II, 5, (2) : 35 pp.

Bullock, A. M. & Roberts, R. J. (1974). The dermatology of marine teleost fish. I. The normal integument. *Oceanography and Marine Biology Annual Review*, 13, 383–411.

Busacker, G. P., Adelman, I. R. & Goolish, E. M. (1990). Growth. pp. 363–387, In: Schreck, C. B. & Moyle, P. B., (eds) Methods for Fish Biology, Bethesda, MD, American Fisheries Society.

Cabanban, A., Capuli, E., Froese, R., Pauly, D. (2010). An annotated checklist of Philippine flatfishes: ecological implications. p.15-31, In: Palomares, M.L.D., Pauly, D. (eds.), Marine Biodiversity of Southeast Asian and Adjacent Seas. Fisheries Centre Research Reports 18(3), Fisheries Centre, University of British Columbia.

Cabral H.N., Marques J.F., Rego A.L., Catarino A.I., Figueiredo J., Garcia J. (2003). Genetic and morphological variation of *Synaptura lusitanica* Capello, 1868, along the Portuguese coast. *Journal of Sea Research* 50:167-175.

Cadenat, Par. J. (1950).Poissons de Mer du Senegal. In: *Institute Francais D'Afrique Noire, Initiations Africaines.*

Cantor, T. E. (1849). Catalogue of Malayan fishes. *Journal and Proceedings of the Asiatic Society of Bengal*, 18 (2): i-xii + 983-1443, Pls. 1-14.

Cavalcanti, M.J., Monteiro, L.R., Lopez, P.R.D. (1999). Landmark based morphometric analysis in selected species of Serranid fishes (Perciformes: Teleostei). *Zoological Studies*, 38 (3), 287–294.

Chabanaud, P. (1928). Revision des poissons Hétérosomes de la sous-famille des Achirinae, d'après les types de Kaup, de Günther et de Steindachner. *Bulletin de l'Institut Oceanographique* (Monaco) 523: 1-53

Chabanaud, P. (1929). Poissons Hétérosomates recueillis en Indo-Chine par M. le Dr. A. Krempf. *Bulletin du Muséum National d'Histoire Naturelle* (Série 2), 1 (6): 370-382.

Chabanaud, P. (1934a). Les soléidés du groupe *Zebrias*. Définition d'un sous-genre nouveau et description d'une sous-espèce nouvelle. *Bulletin de la Société Zoologique de France*,59: 420-436.

Chabanaud, P., (1934b). Contribution a la morpholgie des poissons heterosomes. *Bulletin Society of Zoological Society of France,* 59 *:* 123-129.

Chabanaud, P. (1936). Sur divers soléidés apparentés au genre *Zebrias*. *Bulletin de la Société Zoologique de France*, 61: 382-404, Pl. 6.

Chabanaud, P. (1937) Teleosteens dissymetriques du Mokkattam inferieur de Tourah. *Memoirs L'Institute de Egypt*, 32, 1 -121.

Chabanaud, P. (1940). Les espèces et les sous-espèces atlantiques du genre *Achirus* [Pisces Pleurinectoidea [sic] Achiridae]. *Bulletin du Muséum National d'Histoire Naturelle* (Série 2), 12 (no. 2): 86-90.

Chabanaud, P. (1948). Notules ichthyologiques (Suite). XXXIV.-- Description d'un nouveau Bothidé du Pacifique asiatique. *Bulletin du Muséum National d'Histoire Naturelle* (Série 2), 20 (1): 64-67.

Chakrapani . K and Seshappa, G. (1982). A morphometric comparison *of the* Malabar sole *Cynoglossus semifasciatus* Day from different centres of the west coast of India. *Journal of the Marine Biological Association of India*, 24 (1 & 2): 72 – 79.

Chakrapani. K and Seshappa, G. (1984).Comparison of the meristic characters of *the* Malabar sole *Cynoglossus semifasciatus* Day from the west coast of India. *Journal of the Marine Biological Association of India*, 26: (1 & 2), pp 125-131.

Chanet, B. (1994) *Eobuglossus eocenicus* (Woodward, 1910) from the Upper Lutetian of Egypt, one of the oldest soleids [Teleostei, Pleuronectiformi]. *Neues Jahrbuch für Paläontologie Monatehefte,* 7, 391–398.

Chanet, B. (1997) A cladistic reappraisal of the fossil flatfishes record consequences on the phylogeny of the Pleuronectiformes (Osteichthyes: Teleostei). *Annales des Sciences Naturelles, Zoologie, Paris* (13th Series), 18, 105–117.

Chanet,B.(1999) Supposed and true flatfishes [Teleostei: Pleuronectiformes] from the Eocene of Monte Bolca, Italy. *Museo Civico di Storia Naturale di Verona, Studi e Ricerche sui Giacimenti Terziari di Bolca,* Vol. VIII, *Miscellanea Paleontologica* (ed. J.C. Tyler), pp. 220–243.

Chanet, B. (2003). Interrelationships of scophthalmid fishes (Pleuronectiformes: Scophthalmidae). *Cybium,* 27 (no. 4): 275-286.

Chapleau, F. (1988). Comparative osteology and intergeneric relationships of the tongue soles (Pisces; Pleuronectiformes; Cynoglossidae). *Canadian Journal of Zoology,* 66: 1214-1232.

Chapleau, F. (1993). Pleuronectiform relationships: A cladistic reassessment. *Bulletin Marine Science 52 (1): 516 – 540.*

Chapleau, F., and A. Keast. (1988). A phylogenetic reassessment of the monophyletic status of the family Soleidae, with comments on the suborder Soleoidei (Pisces: Pleuronectiformes). *Canadian Journal of Zoology*, 66: 2797-2810.

Chapleau, F., and C. B. Renaud. (1993). *Paraplagusia sinerama* (Pleuronectiformes: Cynoglossidae), a new Indo-Pacific tongue sole with a revised key to species of the genus. *Copeia,* 1993 (no. 3): 798-807.

Chaudhary, H.S. and O.P. Khandelwal, (1960). Fish survey of Nainital district. *Vigyan parishad Anusandhan Patrika,* 3:139-145.

Chaudhuri, B.L., (1912). Descriptions of some new species of freshwater fishes from north India. *Records of the Indian Museum* (Calcutta), 7: 437-444, pls.5.

Chen, J. T. F., and H. T. C. Weng (1965). A review of the flatfishes of Taiwan. *Biological Bulletin Tunghai University of Ichthyology Series,* 25, 27: 1-103.

Chen, J.-P. , R.-Q. Jan, and K.-T. Shao (1997). Checklist of reef fishes from Taiping Island (Itu Aba Island), Spratly Islands, South China Sea. *Pacific Science,* 51 (2): 143-166.

Chidambaram, K. (1945). The spawning season of the Malabar sole. *Proc. 32nd Indian Science Congress (Nagpur, 1945), Pt 3, Abstracts, Calcutta. P 113.*

Chidambaram, K., and R.S. Venkataraman (1946). Tabular Statements on the Natural History of Certain Marine Food-fishes of the Madras Presidency—West Coast. Government Press, Madras, 1-26

Chong, V.C., Sasekumar, A., Leh, M.U.C. & D'Cruz, R. (1990). The fish and prawn communities of a Malaysian coastal mangrove system, with comparisons to adjacent mud flats and inshore waters. *Estuarine and Coastal Shelf Science*, 31, 703–722.

Clark, E. and A. George (1979). Toxic soles, *Pardachirus marmoratus* from the Red Sea and *P. pavoninus* from Japan, with notes on other species. *Environmental Biology of Fishes*, 4 (no. 2): 103-123.

CMFRI, Kochi (2010). CMFRI Annual Report 2009-2010. Technical Report. CMFRI, Kochi

CMFRI 2008, Kochi (2008). CMFRI Annual Report 2007-2008. Technical Report. CMFRI, Kochi

CMFRI, Kochi (2006). CMFRI Annual Report 2006-2007. Technical Report. CMFRI, Kochi

Cocco, A. (1844). Intorno ad alcuni nuovi pesci del mare di Messina. Lettera del Prof. Anastasio Cocco al Signor Augusto Krohn. Giorn. Gabin. Litt. Messina Anno. 3, Tome 5: 21-30, Pl. 2.

Cockerell, T.D.A. (1909). Notes on the scales of fishes. *Proceedings of the Biology Society of Washington,* 23 : 121 -123)

Cockerell, T.D.A. (1913). Observations on fish scales. *Bulletin of the United States Bureau Fisheries*, 32 : 117 -174.

Cockerell, T.D.A. (1911). Some notes on fish scales. *Proceeedings of the Biological Society of Washington,* 24 : 209 -214.

Cooper, J. A., and F. Chapleau (1998). Phylogenetic status of Paralichthodes algoenis (Pleuronectiformes: Paralichthodidae). *Copeia,* 1998 (no. 2): 477-481.

Cooper, J. A., K. Graham and F. Chapleau. (1994). New record of the tongue flatfish, *Plagiopsetta glossa* (Samaridae, Pleuronectiformes) from Australia. *Japanese Journal of Ichthyology,* 41 (2): 215-218.

Cope,E.D., (1871). Contribution to the Ichthyology of the Lesser Antilles. *Transactions of the American Philosophical Society*, XIV (2): 445-483.

Cotterill, F.P.D and Dangerfield, J.M. (1997). The state of biological knowledge. *Trends in Ecology and Evolution*, 12: 206.

Crawford, C. M. (1986). Development of eggs and larvae of the flounders *Rhombosolea tapirina* and *Ammotretis rostratus* (Pisces: Pleuronectidae). *Journal of Fish Biology*, 29: 325-334.

Cunningham, J.T., (1891-1892). On some larval stages of fishes. *Journal of the Marine Biological Association of United Kingdom*: 68-72.

Cunningham,T., (1887). The eggs and larvae of teleosteans. *Transactions of the Royal Society of Edinburgh*, 33 (1) : 97-136.

Cunningham. T. (1896). The natural history of the marketable marine fishes of the British Islands. Macmillan and Co., London

Cuvier, G and A. Valenciennes. (1829). *Histoire naturelle de poisons*, Vol 2-21, Paris.

Cuvier, G. (1816). Le Règne Animal distribué d'après son organisation pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée. Les reptiles, les poissons, les mollusques et les annélides. Edition 1. v. 2: i-xviii + 1-532.

Daniels, R. A. (1996). Guide to the Identification of Scales of Inland Fishes of Northeastern North America. Albany, NY: The State Education Department.

Dawson, C. E., (1976). Review of the Indo-Pacific pipefish genus *Choeroichthys* (Pisces: Syngnathidae), with descriptions of two new species. *Proceedings of the Biological Society of Washington*, 89 (3): 39-65.

Day, F. (1875-1878) [1888]. The Fishes of India, being a Natural History of the Fishes known to inhabit the Seas and Fresh Water of India, Burma and Ceylon. London. Part 1, 1875: pp. 1-168, pl. I-XL. Part 2, 1876: pp. 169-368, pl. XLI-LXXVIII (+LI A-C). Part 3, 1877: pp. 369-552, pl. LXXIX-CXXXVIII. Part 4, 1878: pp. i-xx+553-778, pl. CXXXIX-CXCV. Suppl., 1888: pp. 779-816, 7 fig.

Day, F. (1877). Geographical Distribution of Indian Freshwater Fishes.— Part I. The Acanthopterygii, Spiny-rayed Teleostean Fishes. *Journal Linnean Society London*, Zoology. 13(no. 67): 138-154.

Day, F. (1889) Fishes. In: The fauna of British India, including Ceylon and Burma W. T. Blanford (ed.). *The fauna of British India, including Ceylon and Burma*. v. 1: i-xviii + 1-548.

Day, F. 1875-1878 [1888]. The Fishes of India, being a Natural History of the Fishes known to inhabit the Seas and Fresh Water of India, Burma and Ceylon. London. Part 1, 1875: pp. 1-168, pl. I-XL. Part 2, 1876: pp. 169-368, pl. XLI-LXXVIII (+LI A-C). Part 3, 1877: pp. 369-552, pl. LXXIX-CXXXVIII. Part 4, 1878: pp. i-xx+553-778, pl. CXXXIX-CXCV. Suppl., 1888: pp. 779-816, 7 fig.

De Sylva D. P. (1975). Barracudas (Pisces: Sphyraenidae) of the Indian Ocean and adjacent seas -- a preliminary review of their systematics and ecology. *Journal of the Marine Biological Association of India,* 15 (1): 74-94

De VIS, C. W. (1882). Description of three new fishes of Queensland. *Proceedings of the Linnean Society of New South Wales,* 7 (pt 3): 318-320.

De Lamater, E. D. & Courtenay, W. R., Jr. (1974). Fish scales as seen by scanning electron microscopy. *Florida Scientist* 37, 141–149.

Deubler, E.E Jr. and W.F. Rathjen. (1958). Records of the flounder *Chascanopsetta lugubris* Alcock, from the western Atlantic. *Copeia,*1958 (2): 132 – 133.

Devadoss, P., P.K.M Pillai, P Natarajan and K. Muniyandi. (1977). Observations on some aspects of the biology and fishery of *Psettodes erumei* (Bloch) at Porto Novo. *Indian Journal of Fisheries* 24(1& 2): 62 – 68.

Devi, C.B.L (1969). Occurrence of larvae of *Pseudorhombus elevatus* Ogilby (Heterosomata—Pisces) along the South-West Coast of India. *Proceedings: Plant Sciences*, 1969, 70 (4): 178-186.

Devi, C.B.L (1989). Developmental characters of *Psettina iijimae* (Jordan and Starks), Bothid flat fishes – Pisces) J*ournal of the Indian Fisheries Association,* 19, 7-17.

Devi, C.B.L (1989). Larvae of *Crossorhombus valde-rostratus* (ALcock) and *C. azureus* (Alcock) (Heterosomata: Pisces) collected during the International Indian Ocean Expedition and Naga Expedition. *Journal of the Marine Biological Association of India,* 31 (1 & 2): 287 – 296.

Devi, C.B.L (1993). Seasonal fluctuations in the distribution of eggs and larvae of flat fishes (Pleuronectiformes-Pisces) in the Cochin backwater. *Journal of the Indian Fisheries Association,* 23 :21-34.

Devi, C.B.L (2004). Monograph on Bothid Larvae, National Institute of Oceanography, Kochi, 137 pp.

Devi, C.B.L.(1977). Distribution of larvae of flat fishes (Heterosomata) in the Indian Ocean. *Proceedings of the Symposium of Warm. Water Zooplankton, Special Publication, UNESCO/NIO* : 18- 20.

Devi, C.B.L.(1986). Studies on the flat fish (Heterosomata) larvae of the Indian Ocean. Ph.D. Thesis, University of Kerala, India, 480 pp.

Devi, C.B.L.(1991). First records and a comparative study of larvae of *Arnoglossus tapeinosoma* (Bleeker) and *Arnoglossus aspilos* Bleeker) (Bothidae-Pisces) from the Indian Ocean and adjacent waters. *Proceedings of the Kerala Science Congress, Kozhikode*, 158-160.

Diaz DE Astarloa, J.M and T.A MUNROE. (1988). Systematics, distribution and ecology of commercially important species of paralichthyid flounders occurring in Argentinean–Uruguayan waters (*Paralichthys*: Paralichthyidae): an overview. *Journal of Sea Research,* 39: 1- 9.

Dor, M. (1970). Contributions to the knowledge of the Red Sea, No. 44. Nouveaux poisons pour la faune de la Mer Rouge. *Bulletin Sea Fisheries Research Station, Israel*, 54: 7 – 28.

Dor, M. (1984). CLOFRES. Checklist of the fishes of the Red Sea. Israel Academy of Sciences and Humanities. i-xxii, map + 1-437.

Drinkwater K.F., (2005). The response of Atlantic cod (*Gadus morhua*) to future climate change. *ICES Journal of Marine Science*, 62, 1327-1337.

Duméril, A. M. C. (1804). Zoologie analytique, ou méthode naturelle de classification des animaux, rendue plus facile à l'aide de tableaux synoptiques. - pp. i-xxxiii [= 1-33], 1-344. Paris. (Allais).

Dutt, S and K. Hanumantha Rao (1965). A new bothid flatfish *Cephalopsetta ventrocellatus* Gen. et Sp. Nov. from Bay of Bengal. *Proceedings Indian Academy of Science,* 62 (4): 180 – 187.

E. P. Voronina, (2007). “Diversity of the Structure of Lateral Line Scales in Pleuronectiformes,” *Voprosky Ikhtiology*, 47 (2), 157–167.

Edwards, R. And J.H.Steele, (1968). The ecology of O-group plaice and common dabs at Loch Eve Scotland. 1. Population and food. *Journal of Experimental Marine Biology and Ecology,* 2 (3) : 215-238.

Ehrenbaume, (1911). “Die Plattfischlarven der Nordsee und benachbarter Gewasser nach Zeit und Ort ihres Vorkommens.” *Rapp. P.-v. Rkun. Cons. perm. int. Explor. Mer*, 13C (3): 22 pp. and Append: 19 pp.

Ehrenbaume. (1905). “Eier und Larven von Fischen.” Nord. Plankton., (1): 413 pp.

Eschmeyer, W. N. (1969). A systematic review of the Scorpionfishes of the Atlantic Ocean (Pisces, Scorpaenidae). *Occassional Papers of the Californian Academy of Science*, 79, p. i-iv+1-143.

Eschmeyer, W.N. (2011). Catalog of Fishes online, Californian Academy of Sciences, San Francisco, CA ((updated 2 July 2011). http://research.calacademy.org/ichthyology/catalog/fishcatsearch.html

Eschmeyer, William N., Ronald Fricke, Jon D. Fong & Dennis A. Polack. (2010). Marine fish diversity: history of knowledge and discovery (Pisces). *Zootaxa*, 2525: 19–50.

Evermann, B. W. and A. Seale (1907). Fishes of the Philippine Islands. *Bulletin of the Bureau of Fisheries*, 26 (for 1906): 49-110.

Evseenko, S. A. (1984). New genus and species of ‘Armless’ flounders *Pseudomancopsetta andriashevi* gen. et sp. Nova (Pisces, Pleuronectoidei) and its position in the suborder Pleuronectoidei. *Voprosy Ikhtiologii,* 24: 709 – 717.

Evseenko, S. A. (1987). A review of "armless" flounders of the genus *Achiropsetta* (Pleuronectoidei) with description of a new species, *Achiropsetta heterolepis* sp nov. *Voprosy Ikhtiologii,* 27 (no. 5): 771-783.

Evseenko, S. A. (1996). Ontogeny and relationships of the flatfishes of the Southern Ocean (Achiropsettidae, Pleuronectoidei). Voprosy Ikhtiologii, 36 (no. 6): 725-752.

Evseenko, S. A. (1999). Early developmental stages of two flounder species of the genus *Monolene* -- *M. dubiosa* and *M. maculipinna* (Bothidae) -- from central waters of the eastern Pacific with notes on taxonomic status of *M. asaedai* and *M. danae*. *Voprosy Ikhtiologii* , 39 (5): 625-630.

Evseenko, S. A. (2000). Family Achiropsettidae and its position in the taxonomic and ecological classifications of Pleuronectiforme*s. Journal of Ichtyhology*, 40 (Suppl.1), S 110 -138.

Evseenko S.A. (2004). Family Pleuronectidae Cuvier, 1816. Righteye flounders. Annotated checklists of fishes, vol 37. California Academy of Sciences, San Francisco, pp 1–37

Fahay, M. (1983). Guide to the early stages of marine fishes occuring in the Western North Atlantic Ocean, Cape Hatteras to the Southern Scotian Shelf. *Journal of Northwest Atlantic Fishery science,* 4:1-423.

Fischer, W., and G. Bianchi. (1984). FAO species identification sheets for fishery purposes. II. Western Indian Ocean –Fishing Area 51. FAO, Rome.

Fischer, W., and Whitehead, (1974). FAO species identification sheets for fishery purposes. II. Eastern Indian Ocean –Fishing Area 57. FAO, Rome.

Foroshchuk, V. P. (1991). A new species of the genus *Chascanopsetta* from the Saya-de-Malha Bank (Indian Ocean). *Voprosy Ikhtiologii*, 31 (1): 3-8.

Fourmanoir,P. (1957). Poissons Teleosteens des eaux malgaches du canal de Mozambique. *Mem. De L'Institut Scientifique de Madagascar Serie F-Tome I.*

Fowler, H.W. (1925). Fishes from Natal, Zululand and Portuguese East Africa. *Proceedings of the Academy of Natural Science, Philadelphia,* 77:187–268

Fowler, H.W. (1928). *The fishes of Oceania*. Memoirs of the Bernice P. Bishop Museum. No. 10: i-iii + 1-540, Pls. 1-49.

Fowler, H.W. (1929). New and little-known fishes from the Natal coast. *Annals of the Natal Museum*, 6 (pt 2): 245-264.

Fowler, H.W. (1931). *The fishes of Oceania--Supplement* I. Memoirs of the Bernice P. Bishop Museum. v. 11 (no. 5): 313-381.

Fowler, H.W. (1934) Descriptions of new fishes obtained 1907 to 1910, chiefly in the Philippine Islands and adjacent seas. *Proceedings of the Academy of Natural Science, Philadelphia,* 85 (for 1933): 233-367.

Fowler, H.W. (1936) The marine fishes of West Africa. *Bulletin American Museum Natural History,* Vol. LXX, Part 1: 494 – 529.

Fowler, H.W. (1938). Studies of Hong Kong fishes -- No. 3. *Hong Kong Naturalist* No. 6, Suppl.: 1-52.

Fowler, H.W. (1939). Zoological results of the Denison-Crockett South Pacific Expedition for the Academy of Natural Sciences of Philadelphia, 1937-1938. Part III.--The fishes. *Proceedings of the Academy of Natural Sciences of Philadelphia* v. 91: 77-96.

Fowler, H.W. (1956). *Fishes of the Red Sea and Southern Arabia*. Vol. I: Branchiostomidae to Polynemidae. The Weizmann Science Press of Israel, Jerusalem.

Fowler, H.W. (1972). *A Synopsis of the Fishes of China*. Part I, II (3 parts complete); III (2 parts); IV (1 part); V (8 parts); VI (3 parts); VII (10 parts); VIII (1 part); IX (3 parts); X (1 part), altogether 33 parts.

Franz, V. (1910) Die japanischen Knochenfische der Sammlungen Haberer und Doflein. (Beiträge zur Naturgeschichte Ostasiens.). Abhandlungen der math.-phys. *Klasse der K. Bayer Akademie der Wissenschaften*, 4 (Suppl.) (1): 1-135, Pls. 1-11.

Fukuhara, O. (1986). Morphological and functional development of Japanese flounder in early life stage. *Bulletin of the Japanese Society of Science, Fisheries,* 52: 81 – 91.

Fukui A (1999) Larvae of *Arnoglossus debilis* (Bothidae) from Hawaii. *Ichthyological Research,* 46:199–202

Fukui, A. (1997). Early ontogeny and systematics of Bothidae, Pleuronectoidei. *Bulletin Marine Sci*ence, 60 (1) 192-212.

Fukui, A., and H.-C. Liew (1999). Larva of *Taeniopsetta radula* (Bothidae) from Hawaii. *Ichthyological Research*, 46 (3): 318-322.

Futch, C.R. (1977) Larvae of *Trichopsetta ventralis* (Pisces: Bothidae) with comments on the intergeneric relationships within the Bothidae. *Bulletin Marine Science*, 27 (4): 740 – 757.

Gibson R.N., (2005). *Flatfishes.* Biology and exploitation. Fish and aquatic resources series 9. Blackwell Pub. Oxford UK. 391 pp.

Gilbert, C. H., and F. Cramer (1897). Report on the fishes dredged in deep water near the Hawaiian Islands, with descriptions and figures of twenty-three new species. *Proceedings of the United States National Museum*, 19 (1114): 403-435, Pls. 36-48.

Gilchrist, J. D. F. (1904). Descriptions of new South African fishes. *Marine Investigations of South Africa*, 3: 1-16, Pls. 19-25.

Gill, T.N., (1887). The classification and relations of the Ribbon fishes. *American Naturalist,* XXI, 86.

Gill, T.N., (1893). Families and subfamilies of Fishes *Memoirs National Academy of Washington*, VI : 127-138.

Gloerfelt-Tarp, T. and P.J. Kailola (1984). Trawled fishes of southern Indonesia and northwestern Australia. Australian Development Assistance Bureau, Australia, Directorate General of Fishes, Indonesia, and German Agency for Technical Cooperation, Federal Republic of Germany. 407 p.

Gmelin, J. F., (1789). *Systema Naturae*, Ed. 13. Pp. 1126-1516. Delamoilliere, Leiden.

Goldfuss, G. A. (1820). Handbuch der Zoologie. Nürnberg. Handbuch der Zoologie. 2 parts: i-xxiv + 1-510 (1), i-xlvi + 1-696 (2), Pls. 1-2 (pt. 1), 3-4 (pt. 2).

Gollasch, S. (2006) Overview on introduced aquatic species in European navigational and adjacent waters. *Helgoland Marine Research*, 60: 84-89.

Gonzales, B. J., O. Okamura, K. Nakamura and H. Miyahara. (1994). New record of the annular sole, *Synaptura annularis* (Soleidae, Pleuronectiformes) from Japan. *Japanese Journal of Ichthyology*, 40 (4): 491- 494.

Goode, George Brown, and Tarleton H. Bean. 1896. Oceanic ichthyology, a treatise on the deep-sea and pelagic fishes of the world, based chiefly upon the collections made by the steamers *Blake, Albatross,* and *Fish Hawk* in the northwestern Atlantic, with an atlas containing 17 figures. *United National Museum Special Bulletin*, 2, xxxv + 553 pp. + atlas.

Goodrich, E.S., (1906). The development and origin of median and paired fins of fish. *Quarterly Journal Microbiological Society,*50 : 333-376.

Goodrich, E.S., (1930). *Studies on the structure and development of vertebrates*. London, 1930. Dover Publ. Inc. New York, 1xix : 837 pp.

Gopinath, K. (1946). Notes on the larval and postlarval stages of fishes found along the Trivandrum coast. *Proceedings of the Indian National Science Academy,* 12 (1): 7 – 21.

Gosline W. A. and V. E. Brock. (1960). *Handbook of Hawaiian Fishes*. University of Hawaii Press. Handbook of Hawaiian Fishes.: i-ix + 1-372.

Grace Mathew, M. Feroz Khan and K. Nandakumaran. (1992). Present status of exploitation of fish and shell fish resources: Flatfishes and flatheads. *Bulletin Central Marine Fisheries Research Institute,* 45: 197-204.

Gray, J. E. (1831). Description of a new genus of percoid fish, discovered by Samuel Stutchbury, in the Pacific sea, and now in the British Museum. *Zoological Miscellany* 1831: 20.

Groot De, S.J. & F.A. Schuy, (1967). A new method for recording the swimming activity of flat fishes. *Experientia,* 23: 574-576.

Groot, De, S.J (1973) Gaps in the studies on behaviour of Indian ocean flatfishes belonging to the Psettodidae and Cynoglossidae. *Journal of the Marine Biological Association of India,* 15(1): 251-261.

Günther, A. (1862) *Catalogue of the fishes in the British Museum*. Catalogue of the Acanthopterygii Pharyngognathi and Anacanthini in the collection of the British Museum, 4: i-xxi + 1-534.

Günther, A. (1866). Catalogue of fishes in the British Museum. Catalogue of the Physostomi, containing the families Salmonidae, Percopsidae, Galaxidae, Mormyridae, Gymnarchidae, Esocidae, Umbridae, Scombresocidae, Cyprinodontidae, in the collection of the British Museum. Catalogue of the fishes in the British Museum. v. 6: i-xv + 1-368.

Günther, A. (1880). Report on the shore fishes procured during the voyage of H. M. S. Challenger in the years 1873-1876. In: Report on the scientific results of the voyage of H. M. S. Challenger during the years 1873-76. *Zoology*, 1 (pt 6): 1-82, Pls. 1-32.

Günther, A. (1887). Report on the deep-sea fishes collected by H. M. S. Challenger during the years 1873-76. *Report Scientific Research Voyage H.M.S. Challenger*, 22 (pt 57): i-lxv + 1-268, Pls. 1-73.

Gupta ,A., K. Datta, PKB Menon, CKG Nair & CR Das (1961). An Annotated List Of Fishes Of Rajasthan. *Proceedings of the Rajasthan Academy of Sciences*, 3: 129 – 140.

Gupta, S. K. , K. C. Jayaram, and K. P. Hajela (1981). On a new silurid cat-fish from Uttar Pradesh, India. *Journal of the Bombay Natural History Society*, 77 (pt 2): 290-291.

Gutherz, E. J. (1967). Field Guide to the flatfishes of the family Bothidae in the western North Atlantic. *United States Interior Circular* 263 i-iv + 1-47.

Haddon, M., and Willis, T. J. (1995). Morphometric and meristiccomparison of orange roughy (Hoplostethus atlanticus, Trachichthyidae) from the Puysegur Bank and Lord Howe Rise, New-Zealand, and its implications for stock structure. *Marine Biology*, 123: 19 - 27.

Haertel, L., & C. Osterberg, (1967). Ecology of zooplankton, benthos and fishes in the Columbia River estuary. *Ecology,* 48 (3) : 459-472.

Haig, J. (1952). Studies on the classification of the catfishes of the Oriental and Palaearctic family Siluridae. *Records of the Indian Museum* (Calcutta), 48 (pts 3-4): 59-116.

Hamilton, F. (1822). An account of the fishes found in the river Ganges and its branches. Edinburgh & London. An account of the fishes found in the river Ganges and its branches.: i-vii + 1-405, Pls. 1-39.

Hector, J. (1872). Notes on the edible fishes of New Zealand. Colonial Museum and Geological Survey Department, Wellington. Notes on the edible fishes of New Zealand: 97-133, Pls. 1-12.

Heemstra, P. C. and E. Heemstra. (2004). Coastal Fishes of Southern Africa. NISC and SAIAB. Coastal Fishes of Southern Africa.: i-xxiv + 1-488.

Heemstra, P. C. (1999). Order Zeiformes, and family Scombropidae. In: Carpenter, K. E. and V. H. Niem. 2001. Species identification guide for fishery purposes. The living marine resources of the western central Pacific. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles, sea turtles, sea snakes and marine mammals. FAO, Rome. Species identification guide for fishery purposes. Bony fishes part 4. v. 6: iii-v; 3381-4218, Pls. I-XIX.

Heincke, D. F. (1898). Naturgeschichte des herring. *Abhandlungen Doutsch Seefisch Verein*, 2: 128e233.

Hensley D.A. (1977). Larval development of *Engyophrys senta* (Bothidae) with comments on intermuscular bones in flatfishes. *Bulletin Marine Science, 27: 681 – 703.*

Hensley D.A. (1984). *Bothidae* pp: 854 – 863 In: M.M Smith and P.C Heemstra, (eds) Smiths Sea Fishes. Macmillan South Africa Ltd., Johannesburg.

Hensley D.A. (1986). Family No. 259: Bothidae. Pp:854-863, In: M.M Smith and P.C Heemstra, (eds) *Smiths' Sea Fishes*, Macmillan South Africa Ltd., Johannesburg.

Hensley D.A. (1997). A new species of *Bothus* (Pleuronectiformes: Bothidae) from Mozambique. *J. L. B. Smith Institute of Ichthyology Special Publication* No. 58: 1-8.

Hensley D.A. (2005). Revision of the genus *Asterorhombus* (Pleuronectiformes: Bothidae). *Copeia* 2005 (3): 445-460.

Hensley D.A. and Ahlstrom, E.H. (1984). Pleuronectiformes: relationships. In: Ontogeny and systematic of fishes. American Society of Ichthyology and Herpetology. (eds. H.G Moser, W.J Richards, D.M Cohen, M.P Fahay, A.W Kendall Jr. and S.L Richardson): 670 – 687.

Hensley D.A. and Amaoka, K. (1989). A redescription of *Pseudorhombus megalops,* with comments on *Cephalopsetta ventrocellata* (Osteicthyes: Pleuronectiformes: Paralichthydae). *Proceedings of the Biological Society of Washington,* 102(3): 577 – 585.

Hensley D.A. and John E. Randall. (1990). A redescription of *Engyprosopon macrolepis* (Teleostei: Bothidae) *Copeia,* 1990 (3): 674 – 680.

Hensley D.A. and John E. Randall. (1993). Description of a new flatfish of the Indo – Pacific genus *Crossorhombus* (Teleostei: Bothidae), with comments on congeners. *Copeia*, 1993 (4):111 9 – 1126.

Hensley D.A., and A. Y. Suzumoto. (1990). Bothids of Easter Island, with the description of a new species of *Engyprosopon* (Teleostei: Pleuronectiformes). *Copeia,* 1990 (1): 130-137.

Hensley, D. A., and J. E. Randall (1993). Description of a new flatfish of the Indo-Pacific genus *Crossorhombus* (Teleostei: Bothidae), with comments on congeners. *Copeia* 1993 (4): 1119-1126.

Hensley D.A., and J.E Randall, (2003). A new flatfish of the Indo-Pacific genus *Asterorhombus* (Pleuronectiformes: Bothidae). *Smithiana Special Publication*, 2:1-8.

Hensley, D. A., and M. J. Smale (1997). A new species of the flatfish genus *Chascanopsetta* (Pleuronectiformes: Bothidae), from the coasts of Kenya and Somalia with comments on *C. lugubris*. *J. L. B. Smith Institute of Ichthyology Special Publication No*. 59: 1-16.

Hognestad, Per T., (1969). Notes on Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum) in the eastern Norwegian Sea. *Fiskeridir skr ser Havunders,* 15 (3): 139- 144.

Holliday, F.G.T. & M.P. Jones, (1967). Some effects of salinity on the developing eggs and larvae of the plaice (Pleuronectes platessa) *Journal Marine Biological Association, U.K.,* 47: 39- 48.

Holt, E.W.L. (1983). Survey of fishing grounds, West coast of Ireland, (1980). On the eggs and larvae of teleosteans. *Scientific Transactions Royal Dublin Museum*, 2,4: 435-474

Holt, E.W.L., (1893). Studies in Telecostean morphology from the Marine Laboratory at Cleethropes. *Proceedings Zoological Society of London*. : 413-446, pls. xxviii-xxx.

Hora, (1920). Revision of the Indian Homalopteridae and of the genus *Psilorhynchus Records of the Indian Museum* (Calcutta), 19 (5): 195-215, Pls. 10-11.

Hora, S. L. (1920-1950). Fishes, *Records Indian Museum* (Calcutta) Vols. 19-48.

Horwood, J. (2001). Population biology and ecology of the sole. *Natural Resource Modeling, 14, (2): 233 – 256.*

Hoshino, K. (2000). Redescription of a rare flounder, *Poecilopsetta inermis* (Breder) (Pleuronectiformes: Pleuronectidae: Poecilopsettinae), a senior synonym of *P. albomarginata* Reid, from the Caribbean Sea and tropical western Atlantic. *Ichthyological Research*, 47 (1): 95-100.

Hoshino, K. (2001) Morphology of the Citharidae (Pleuronectoidae: Pleuronectiformes: Teleostei) with considerations of Pleuronectoid phylogeny. *Ichthyological Research,* 48 (4):391-404.

Hoshino, K., and K. Amaoka. (1998). Osteology of the flounder, *Tephrinectes sinensis* (Lacepède) (Teleostei: Pleuronectiformes), with comments on its relationships. *Ichthyological Research*, 45 (no. 1): 69-77.

Hoshino and K. Amaoka (1999). A new type of flatfish sexual dimorphism in the sinsitral flounder *Monolene maculipinna* (Pleuronectiformes: Bothidae). *Ichthyological Research,* 47 (3):293-298

Hoshino, K., H. Imamura, and K. Amaoka. (2000). A new type of flatfish sexual dimorphism in the sinistral flounder *Monolene maculipinna* (Pleuronectiformes: Bothidae). *Ichthyological Research*, 47 (3): 293-298.

Hoshino. K., Amaoka. K, Last. P. (2001). A new dextral flounder, *Poecilopsetta macrocephala* (Pisces: Pleuronectiformes: Poecilopsettidae), from northwestern Australia. *Species Diversity*, 6:73–81

Hoss, D.E., W.F. Hettler Jr. & L.C. Coston, (1974). Effects of thermal shock on larval estuarine fish – Ecological implications with respect to entrainment in power plant cooling system. *In*: *The Early Life History of Fish*. J.H.S. Blaxter (Ed.), Springer Verlag, Berlin, 357-372.

Hubbs and Lagler (1958) Flounders and soles from Japan collected by the United States Bureau of Fisheries steamer "Albatross" in 1906. *Proceedings of the United States National Museum*, 48 (.2082):449-496, pls.25-27.

Hubbs, C. L. (1915). Flounders and soles from Japan collected by the United States Bureau of Fisheries steamer "Albatross" in 1906. *Proceedings of the United States National Museum*, 48 (no. 2082): 449-496, Pls. 25-27.

Hubbs, C.L. (1945).Phylogenetic position of the Citharidae, a family of flatfishes. *Miscellaneous Publications of the Museum of Zoology of University of Michigan*, 63: 1- 38.

Hussain, S.M.(1990). Biology of *Psettodes erumei* (Schneider, 1801) and *Pseudorhombus arsius* (Hamilton, 1822) from the northern Arabian Sea. *Indian J. Fish.,* 37 (1): 63 – 66.

Hussain, S.M and Ali-Khan, (1981). Species of the family Soleidae (Pleuronectiformes) from Pakistan. *Biologia,* 27 (1): 19 – 32.

Hutchins, J.B. (2001). Checklist of the fishes of Western Australia. Rec. *Western Australian Museum Supplement*, 63: 9 – 50.

Imam A.A. Mekkawy, Egbal T. Wassif and Abdulla A.M. Basmidi, (2011). Scale Characteristics of Three *Lutjanus* species (Family: Lutjanidae) from the Red Sea, Egypt. *Journal of Fisheries and Aquatic Science, 6: 506-522.*

Irvin, D.N., 1974. Temperature tolerance of early developmental stages of *Dover sole, Solea solea* (L). In : J.H.S. Blaxter (Ed.), The early life History of Fish, Springer Verlag, Berlin : 449-464.

James, P. S. B. R. (1978). A systematic review of the fishes of the family Leiognathidae. *Journal of Marine Biological Association of India,* 17(1): 138-172.

James, P.S.B.R. (1967) Ribbon fishes of the family Trichiuridae of India. *Memoirs of the Marine Biological Association of India*, 1:1-227.

Jayaprakash, A. A and Inasu, N. D.(1998). Age and growth of Malabar sole Cynoglossus macrostomus Norman off Kerala Coast. *Journal of the Marine Biological Association of India,* 40 (1 & 2). pp. 125-132.

Jayaprakash, A. A. (1999). On the breeding biology of the Malabar sole *Cynoglossus macrostomus* Norman off Kerala. *Journal of the Marine Biological Association of India,* 41 (1 & 2): 85-95.

Jayaprakash, A. A. (2000). Food and feeding habits of Malabar sole *Cynoglossus macrostomus* Norman. *Journal of the Marine Biological Association of India,*42 (1 & 2): 124-134.

Jayaprakash, A. A. (2001). Length weight relationship and relative condition in *Cynoglossus macrostomus* Norman and *C.arel* (Schneider). *Journal of the Marine Biological Association of India,* 43 (1 & 2):148-154.

Jayaram K.C and Dhas J.J., (2000). Revision of the genus Labeo cuveir from the Indain region with a discussion on its phylogeny and zoogeography.(Pisces:Cypriniformes, Cyprinidae, cyprininae) *Records of the Zoological Survey of India Occassional Paper*, 183.147pp

Jayaraman, R (1954). Seasonal variations in salinity, dissolved oxygen and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam (S. India). *Indian Journal of Fisheries*, 1 (1&2). pp. 345-364.

Jenkins, (1910). on a collection of Indian Pleuronectidae. *Memoirs of the Indian Museum*, 3:23-31

Jenkins, J.T. (1909). On a collection of Indian Pleuronectidae. *Memoirs of the Indian Museum* 3: 23 – 31.

Jerald, D., Jr. (1983). Age determination, pp. 301–324. In:Nielsen, L. A. & Johnson, D. L., (eds), Fisheries Techniques, Bethesda, MD: American Fisheries Society.

Joglekar, A. (1973). Systematic status of species of the subfamily Heteromycterinae, with the description of *Heteromycteris normani* Chabanaud, a new record for Indian Seas. *Journal of the Marine Biological Association of India,*15(2): 882 – 885.

Joglekar, A.(1976). On a new species of the genus *Zebrias* Jordan and Snyder (1900) (Pisces: Solidae) from Kerala coast (India). *Zoological Anszena* 197,(1/2):67-70.

John, M.A. (1951). Pelagic fish and larvae of the Madras coast. *Journal of the Zoological Society of India,* 3 (1): 38 – 66.

Jones, S and E.G Silas. (1962a).A systematic review of the scombroid fishes of India. Proceedings of the Symposium on Scombroid Fishes, Marine Biological Association of India, 1:1-105.

Jones, S and E.G Silas. (1962 b). Tuna and tuna-like fishes from Indian seas *FAO Fisheries Reports,* 6(3): 1775-1796.

Jones, S and E.G Silas. (1962c). The fishes of the sub-family Scomberomorinae (Family Scombridae) from Indian waters. *Indian Journal of Fisheries,* 8 (1): 189-206.

Jones, S and M. Kumaran. (1966). New records of fishes from the seas around India. *Journal of the Marine Biological Association of India, 8 (1): 163 – 180.*

Jones, S and M. Kumaran. (1980). *Fishes of the Laccadive Archipelago,* Today and Tomorrow Publishers, 653 pp.

Jones, S and P.M.G Menon. (1951). Notes on the bionomics and developmental stages of some Indian flatfishes. *Journal of the Zoological Society of India, 3 (1): 71 – 83.*

Jones, S and V.R. Pantulu. (1958). On some larval and juvenile fishes from the Bengal and Orissa coasts. *Indian Journal of Fisheries,* 5 (1) : 118 – 143.

Jones, S. (1951). Bibliography of breeding habits and development of estuarine and marine fishes of India. *Journal of the Zoological Society of India,* 3 (1): 121 - 139.

Jones, S. and E.G. Silas. (1962) A systematic review of the scombroid fishes of India. *Proceedings of the Symposium of Scombroid Fishes, Marine Biological Association of India,* 1:1-105,

Jones, S. and E.G.Silas. (1962) The fishes of the sub-family Scomberomorinae (Family Scombridae) from Indian waters. *Indian Journal of Fisheries,* 8 (1): 189-206.

Jones, S. and E.G.Silas. (1962). Tuna and tuna-like fishes from Indian seas *FAO Fishery Reports,* 6(3): 1775-1796.

Jordan, D.S. (1923). A classification of fishes including families and genera as far as known. *Stanford University Publication Biological Science*, 3(2): 79 – 243.

Jordan, D. S., and B. W. Evermann (1898). The Fishes of North and Middle America. *United States National Museum Bulletin,* XLVII (3): 2602-2712.

Jordan, D.S. and B.W. Evermann, (1902). Preliminary report on an investigation of the fishes and fisheries of the Hawaiian Islands., p. 353-380. In G.M. Bowers (Commissioner) Report of the Commissioner for the year ending June 30, 1901: Part 27. The Commission, USA.

Jordan, D. S., and B. W. Evermann. (1903). Descriptions of new genera and species of fishes from the Hawaiian Islands. *Bulletin of the United States Fisheries Commission*, 22: 161-208.

Jordan, D. S., and D. K. Goss, (1889). A review of the flounders and soles (Pleuronectidae) of America and Europe. *Report of the United States Fisheries Commission,* 14: 225-342, Pls. 1-9.

Jordan, D. S., and E. C. Starks, (1902). List of fishes dredged by the steamer Albatross off the coast of of Japan in the summer of 1990, with descriptions of new species and a review of the Japanese Macrouridae., *Bulletin of the United States. Fisheries Commission*, 22[1902]: 577-630. Pls. 1-8.

Jordan, D. S., and E. C. Starks (1906). A review of the flounders and soles of Japan. *Proceedings of the United States National Museum,* 31 (1484): 161-246.

Jordan, D.S., and Robert E. Richardson, (1909a). A catalogue of the fishes of the Island of Formosa, or Taiwan on the collections of Dr. Frans Sauter. *Memoirs of the Carnegie Museum*, 4(4):159-204, figs 1-29, pls.63-74.

Jordan, D.S., and Robert E.Richardson, (1909b). Fishes from the islands of the Philippine Archipelago. *Bulletin of the United States Fisheries Commission*, 27:233-287

Jordan, D.S., Robert E. Richardson and George M.Bowlers. (1907). Fishes from Islands of the Phillipine Archipelago. *Bulletin of the Bueeau of Fisheries*., 27: 233 – 287.

Jordan D.S., S. Tanaka and J.O Snyder. (1913). A catalogue of the fishes of Japan. *Journal of the college of Science, Imperical University of Tokyo, Vol. XXXIII, Art. I.*

Kamohara, T. (1952). Revised descriptions of the offshore bottom-fishes of Prov. Tosa, Shikoku, Japan. *Research Reports of the Kôchi University*, (Ser.) *Natural Science*. No. 3: 1-122.

Kapoor, A.S. and P.P. Ojha (1973). The olfactory apparatus in the flatfish *Cynoglossus oligolepis. Transactions of the American Microscopic Society, 92*(*2*): 298-304.

Kaup, J. J. (1858). Uebersicht der Familie Gadidae. *Archiv für aturgeschichte*, 24 (no. 1): 85-93.

Kawai. T and K. Amaoka. (2006). A new right eye flounder, *Poecilopsetta pectoralis* (Pleuronectiformes: Poecilopsettidae) from New Caledonia. *Ichthyological Research* 53: 264 – 268.

Kawai, T. , K. Amaoka, and B. Séret (2010). A new righteye flounder, *Poecilopsetta multiradiata* (Teleostei: Pleuronectiformes: Poecilopsettidae), from New Zealand and New Caledonia (South-West Pacific). *Ichthyological Research*, 57 (no. 2): 193-198.

Khan Mohammed Atiqullah and S.M Shamsul Hoda. (1988). Length weight relationship of sole *Euryglossa orientalis* (Bl. & Schn.) (Family: Soleidae) from Karachi coast, Pakistan. *Journal of the Marine Biological Association of India,* 40 (1 & 2): 125 -132.

Khan M.F and K. Nandakumaran. 1993. Population dynamics of Malabar sole *Cynoglossus macrostomus* Norman along Calicut coast. *Indian Journal of Fisheries,* 40(4): 225-230.

Khan M.F and S. M. S. Hoda (1993). Observation on the food and feeding habits of Euryglossa orientalis (Bl. and Schn.) (Family : Soleidae) from Karachi Coast. *Journal of Islamic Academy of Sciences*, 6:3, 185-188.

Kim, I.-S., and C.H. Youn. (1994). Taxonomic revision of the flounders (Pisces: Pleuronectidae) from Korea. *Korean Journal of Ichthyol*ogy, 6 (2): 99-132.

Kim, I.-S., and Y. Choi. (1994). A taxonomic revision of the family Cynoglossidae (Pisces, Pleuronectiformes) from Korea. *Bulletin of the Korean Fisheries Society,* 27 (no. 6): 2 -12.

Klunzinger, C. B. (1870). *Synopsis der Fische des Rothen Meeres*-Von. :570 – 574.

Kner, R. (1865). Fische. Reise der österreichischen Fregatte "Novara" um die Erde in den Jahren 1857-1859, unter den Befehlen des Commodore B. von Wüllerstorf-Urbain. Wien. Zool. Theil. Fische. Reise der öesterreichischen Fregatte "Novara" um die Erde in den Jahren 1857-59, ... v. 1 (pt 2): 111-272, Pls. 6-11.

Kotlyar, A. N. (1978). A contribution to the systematics of the "armless" flounders (Pisces, Bothidae) from southwestern Atlantic. *Voprosky Ikhtiologii*, 18 (no. 5): 799-813. [In Russian. English translation in *Journal of Ichthyology* v. 18 (no. 5):708-721.]

Kotthaus, A. (1977). Fische des Indischen Ozeans. Ergebnisse der ichthyologischen Untersuchungen während der Expedition des Forschungsschiffes "Meteor" in den indischen Ozean, Oktober 1964 bis Mai 1965. A. Systematischer Teil, XX. Pleuronectiformes (Heterosomata). Meteor Forschungsergeb. Reihe D Biol. No. 26: 1-20. [English summ.]

Krishnan, S and S.S. Mishra, (1992). New records of fishes from Andaman Islands. *Journal of the Andaman Science Association,* 8, (1), pp 82 – 84.

Krishnan, S and S.S. Mishra (1993). On a collection of fish from Kakinada--Gopalpur sector of the east coast of India. *Rec. Zool. Surv. India*, 93 (1-2): 201-240, 1 pl.

Krishnan, S., and S. S. Mishra. (2003). Marine fishes of Pondichery and Karaikal. *Records of the Zoological Survey of India*. Miscellaneous Publication, Occasional Paper No. 216: 1-53.

Krishnankutty, M and S.Z Qasim. (1969). Theoretical yield studies on the large scaled tongue sole *Cynoglossus macrolepidotus* (Bleeker) from the Arabian Sea. *Bull. Nat. Inst. Sci. India*, 38 (II): 864 – 875.

Kuronuma, K. (1940). The heterosomate fishes collected in deep waters of Japan. I. *Bull. Biogeographical Society of Japan,* 10 (3): 29-61.

Kuronuma, K and Yoshitaka Abe. (1986). *Fishes of the Arabian Gulf*, 344 pp; 30 plates.

Kuthalingam, M.D.K. (1957). Life history and feeding habits of *Cynoglossus lingua* (Ham. Buch.) *Journal of the Zoological Society of India,* 9: 208 –215.

Kuthalingam, M.D.K. (1960). An account of the life history and feeding habits of a sole (Solea elongata). *Journal of Madras University,* 30: 87 – 96.

Kutty, M. Krishnan, (1967). Observations on the growth and mortality of the large scaled tongue sole, *Cynoglossus macrolepidotus* (Bleeker). *Proceedings National Institute of Science,India,* Part B, 33 (1/2) : 94-109.

Kyle, H.M., (1900). The classifications of the flat fishes (Heterosomata). *Scotland Fisheries Board Report,* XVIII,: 335-368.

Kyle, H.M (1913). Flat-fishes (Heterosomata). Report on the Danish Oceanographical expeditions 1908-10 to the Mediterranean and adjacent seas. v. 2: 1-150, Pls. 1-4.

Kyle, H.M (1921). The asymmetry, metamorphosis and origin of the flatfishes. *Philosophical Transactions of the Royal Society of London B211, 75 – 129.*

Kyushin, K., K. Amaoka, K. Nakaya, H. IDA, Y. Tanino and T. Senta (eds). (1982). *Fishes of the South China Sea*. Japan Marine Fishery Resource Research Center. 1-333, Pls. 1-291.

Lacépède, B. G. E. (1801). Histoire naturelle des poissons. v. 3: i-lxvi + 1-558, Pls. 1-34.

Lal Mohan, R. S. (1972). A synopsis to the Indian genera of fishes of the family Sciaenidae. *Indian Journal of Fisheries,* 16 (1&2): 82-98.

Larson, H. K., and R. S. Williams (1997). Darwin Harbour fishes: a survey and annotated checklist. In: Hanley, J.R., Caswell, G., Megirian, D. and Larson, H.K. (eds) Proceedings of the Sixth International Marine Biological Workshop. The Marine Flora and Fauna of Darwin Harbour, Northern Territory, Australia. Museum and Art Galleries Northern Territory and Australian Marine Science Association 1997: 339-380.

Lauder, G.V. Jr. and K.F. Leim, (1983). The evolution and interrelationships of the Actinopterygian fishes. *Bulletin of Museum Comparitive Zoology Harvard University,* 150 (3) : 95-197.

Lima Filho, J. M.; Lessa R.; Stosic B.; Duarte Neto P. J. and Vieira J. W. (2006), Morphological Discrimination in Juveniles of Two *Selene* Species (Teleostei: Carangidae) Using Truss Net Distances. *Brazilian Archives of Biology and Technology*, 49: (2), 231-238.

Lindberg, G. U., and V. V. Fedorov. (1993). Fishes of the Sea of Japan and the adjacent parts of the Sea of Okhotsk and the Yellow Sea. Part 6. Teleostomi. Osteichthyes. Actinopterygii. XXI. Pleuronectiformes (Fam. CXCV. Psettodidae -- Fam. CCI. Cynoglossidae). Handbook Identification of Animals, Zool. Inst. Russian Acad. Sci. No. 166: 1-271. [In Russian.]

Linnaeus, C. (1758) *Systema Naturae*, 10th edn, Vol. 1. Laurentii Salviii Holmiae, Stockholm.

Lloyd, R.E. (1909). A description of the deepsea fish caught by R.I.M.S. ship INVESTIGATOR since the year 1900, with supposed evidence of mutation in *Malthopsis. Memoirs of the Indian Museum, Calcutta,* 2 (3), 139-80.

Longhurst, A.R. & Pauly, D. (1987). *Ecology of Tropical Oceans*. Academic Press, San Diego, CA.

Luther, G. (1968). On the little known fish, *Chirocentrus nudus* Swainson from the Indian seas, and its comparison with *Chirocentrus dorab* (Forskal). *Journal of the Marine Biological Association of India,* 8(1): 193-201.

Macleay, W. (1881). Descriptive catalogue of the fishes of Australia. Part III. Proc. Linn. Soc. N. S. W. v. 6 (pt 1): 1-138. [Continues on pp. 202-387 [ref. 6222]. Sometimes dated to 1882; our dates from Index to volumes I-L in *Proceedings of the Linnaean Society New South. Wales* (1929).]

MAFF (2000). *Statistical Yearbook of Fisheries and Aquaculture Production.* Statistics and Information Division, Ministry of Agriculture, Forestry and Fisheries, Tokyo.

Manuel Castillo-Rivera, Rocío Zárate-Hernández, Selene Ortiz-Burgos, José Zavala-Hurtado. (2000). Diel and seasonal variability in the fish community structure of a mud-bottom estuarine habitat in the Gulf of Mexico, *Marine Ecology*, 4: 633 – 642.

Markle, D.F., Harris, P.M. & Toole, C.L. (1992). Metamorphosis and an overview of early-life-history stages in Dover sole *Microstomus pacificus*. *Fishery Bulletin*, 90, 285–301.

Marr. J.C., (1956). The critical period in the early life history of marine fishes. *Journal Conseil International Exploration Mer.*, 21 (2) : 160-170.

Marshall, T.C. (1964). Fishes of the Great Barrier Reef and Coastal waters of Queensland. Anges and Robertson, p. 470.

Martin, F.D. and G.E. Drewry. (1978). Development of fishes of the Mid-Atlantic Bight. An atlas of egg, larval and juvenile stages, Volume VI, Stromateidae through Ogcocephalidae. *United States Deptartment of the Interior, Fish and Wildlife Service*. 416 pp.

Masuda, H., K. Amaoka, C. Araga, T. Uyeno and T. Yoshino (1984). *The fishes of the Japanese Archipelago*. Tokai University Press. Text: i-xxii + 1-437, Atlas: Pls. 1-370.

Mathew, Grace., M. Feroz Khan and K. Nandakumaran (1992). Present status of exploitation of fish and shell fish resources: Flatfishes and flatheads. *Bulletin of the Central Marine Fisheries Research Institute,* 45: 197 - 204.

Matsubara, K. (1955). Fish morphology and Hierararchy. Ishizaki Stolen,Tokyo.part II, i-v +790-1605 (In Japanese) Shen, S.C.(1967). Studies on flat-fishes (Pleuronectiformes or Heterosomata) in the adjacent waters of Hong Kong. *Quarterly Journal of Taiwan Museum*, 20(1, 2):150-281.

Matsubara, K. and H. Takamuki. (1951). The Japanese Flatfishes of the Genus *Samariscus. Japanese Journal of Ichthyology,* 1 (6): 361 – 367.

Matsubara, K., (1955). *Fish morphology and hierarchy*. Part II. Ishizaki – Shoten, Tokyo, V 816 pp.

Mayr, E. (1969). Principles of Systematic Zoology. TMH Edition, Bombay, 428 pp.

Mc Hugh, J.S. and B.W. Walker (1948). Rearing of marine fishes in the laboratory. *California Fish and Game*, 34 : 37-38.

Mcculloch. (1922). Checklist of the fishes and fish-like animals of New South Wales. *Royal Society of New South Wales*, LXVIII : 35 – 39.

Mcintosh W, C. and Prince, . E., (1890). On the development and life-histories of the teleostean food- and other fishes. *Transactions Royal Soceity of Edinburgh*, 35 (3) (19) : 665-944.

McIntyre, A.D. and A. Eleftheriou. (1968). The bottom fauna of a flat fish nursery ground. *Journal of the Marine biological Association of U.K,* 48 (1) : 113-142.

Menezes, M.R. (1980). Some observations on the morphometry and biology of *Psettodes erumei (Bloch.)* and *Pseudorhombus arsius* from the Goa region. *Mahasagar Bulletin National Institute of Oceanography,* 13(4): 377 – 381.

Menon, A. G. K. (1949). On a remarkable blind siluroid fish of the family Clariidae from Kerala (India). *Records of the Indian Museum* (Calcutta), 48 (pt 1): 59-66, Pl. 1.

Menon, A. G. K. (1952). Notes on fishes in the Indian Museum. XLVI. On a new fish of the genus *Laubuca* from Cochin. *Records of the Indian Museum* (Calcutta), 49 (pt 1): 1-4.

Menon, A.G.K. (1961). On a collection of fish from the Coramendal Coast of India including Pondicherry and Karaikkal areas. *Records of the Indian Museum*, 59 (3): 223 – 303.

Menon A.G.K. (1962). Determination of authorship of names proposed in Cuvier and Valenciennes "Histoire Naturelle des Poissons." *Journal of the Zoological Society of India*, 13(2): 152 – 153 (1961).

MENON, A. G. K. (1977). A systematic monograph of the tongue soles of the genus *Cynoglossus* Hamilton-Buchanan (Pisces: Cynoglossidae). *Smithsonian Contributions to Zoology*, 238: i-iv + 1-129, Pls. 1-21.

Menon A.G.K. & A. Joglekar (1978). Taxonomic status of the genera *Synaptura* Cantor, 1550 (sic) and *Euryglossa* Kaup, 1858 with descriptions of species referable to these occurring in seas of India. *Journal of the Marine Biological Association of India*, 20(1-2): 10-21.

Menon, A. G. K., and K. V. Rama-Rao. (1975). A catalogue of type-specimens of fishes described in the biological collections of R.I.M.S. "Investigator" during 1884-1926. *Matsya* No. 1: 31-48.

Millner R.S and Whiting, C.L. (1996). Long term changes in growth and population abundance of sole in the North Sea from 1940 to the present. *ICES Journal of Marine Science*, 53, 1185 – 1195.

Minami, T. and Tanaka, M. (1992). Life history cycles in flatfish from the northwestern Pacific, with particular reference to their early life histories. *Netherlands Journal of Sea Research*, 29, 35–48.

Misra, K. S. (1950). On a new species of scyliorhinid fish from Andaman Sea, Bay of Bengal. *Journal of the Zoological Society of India*, 2 (no. 2): 87-90, Pl. 1.

Muller, J., (1846). Uber den Bau und die Grenzen der Ganoiden und uber das naturliche System der Fische. *Abhern K Akademie Wissien Berlin*, (1844), 117-216.

Müller, J. and F. H. Troschel (1845) Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische. Die Familie der Characinen. Erstes und Zweites Heft. Berlin. Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische. Die Familie der Characinen. Nos. 1 & 2: 1-40, Pls. 1-11.

Müller, J. and F. H. Troschel (1849). Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische. Berlin. Horae Ichthyologicae. Beschreibung und Abbildung neuer Fische. Die Familie der Characinen. No. 3: 1-27 + additional p. 24, Pls. 1-5.

Munroe I.S.R. (1955). *The marine and freshwater fishes of Ceylon*. Dept. External Affairs Canberra, xvi, 349 p., plates 28.

Munroe I.S.R. (1967). *The fishes of New Guinea*. Dept. Agric., Stock and Fisheries, Port Moresby, New Guinea. xxxvii + 650 pp., plates 78.

Munroe, Thomas, A. (2005). Distributions and biogeography. In: Robin. N. Gibson (Ed.) Flatfishes – Biology and Exploitation, Blackwell Publishing. 42 - 63 pp.

Munroe, T. A., and B. N. Marsh (1997). Taxonomic status of three nominal species of Indo-Pacific symphurine tonguefishes (*Symphurus*: Cynoglossidae: Pleuronectiformes). *Ichtyological Research,* 44 (2): 189-200.

Munroe, T. A., and M.N. Mahadeva. (1989). *Symphurus callopterus* (Cynoglossidae, Pleuronectiformes), a new deepwater tonguefish from the eastern Pacific. *Proceedings of the Biological Society of Washington,* 102 (2): 458-467.

Munroe, T. A. and M. S. Nizinski. (1990). *Symphurus melasmatotheca* and *S. undecimplerus* (Cynoglossidae, Pleuronectiformes), two new eastern Pacific tonguefishes with eleven caudal-fin rays. *Copeia* 1990:985-996.

Murty, V.S.R., (1982). On the fishes of the family Platycephalidae of the seas around India. *Journal of the Marine Biological Association of India,* 17(3): 679-694.

Murty, V.S.R. and Y. Manikyam (2007). Taxonomic revision of the flatheads (Platycephalidae : Pisces) of India. *Records of the Zoological Survey of India Occassional Paper No*. 259: 1 – 100, Plates I - VIII, pp. 91.

Musienko, L.N., (1961). Distribution of the fry of flat fishes in the Karaginsky and Kamchatka Bays in August and September, 1956. *Trud. Institute of Okeanology and Moskva*, 43 : 282-284.

Muus , B.J and J.G Nielsen. (1999). Sea fish. Scandinavian Fishing Year Biik, Hedehusene, Denmark.

Nair, R.V. (1953). Studies on the revival of the Indian oil sardine fishery. *Proceedings of the Indo–Pacific Fisheries Council*, 1953, 115 – 129.

Nash, C.E., (1968). Power stations as sea farms. *New Scientsit*, 40 : 367-369.

Nellemann, C., Hain, S., and Alder, J. (Eds). February (2008). In Dead Water – Merging of climate change with pollution, over-harvest, and infestations in the world's fishing grounds. United Nations Environment Programme, GRID-Arendal, Norway

Nelson, Joseph S. (2006). Fishes of the World. John Wiley and Sons, Inc. New York. 4th edition. 601 pp.

Nicholson, R.A. (1998). Fishing in the Northern Isles: a case study based on fish bone assemblages from two multiperiod sites on Sunday, Orkney. *Environmental Archaelogy*, 2, 15 – 28.

Norman, J. R. (1931). Notes on flatfishes (Heterosomata).-- I. Notes on flatfishes of the family Bothidae in the British Museum, with descriptions of three new species. *Annals of Magazine of Natural History,* (Series 10) 8 (48): 507-510.

Norman, J. R. (1931). Notes on flatfishes (Heterosomata).-- III. Collections from China, Japan and Hawaiian Islands. *Annals of Magazine of Natural History,* (Series 10), 8 (48): 594 - 604.

Norman, J.R. (1926). Flatfishes. Pp. 219–308 in: *Biological Results of the Fishing Experiments carried on by the F.I.S. "Endeavour" 1909–14.* Ministry of Trade and Customs: Sydney.

Norman, J. R. (1927). The flatfishes (Heterosomata) of India, with a list of specimens in the Indian Museum. Part I. *Records of the Indian Museum* (Calcutta) 29: 7-48, pls. 1.

Norman, J.R. (1927). The flatfishes (Heterosomata) of India, with a list of the specimens in the Indian Museum. Part I: *Records of the Indian Museum (Calcutta),* 29(1): 7 – 48.

Norman, J. R. (1928). The flatfishes (Heterosomata) of India with a list of specimens in the Indian Museum. Part II. *Records of the Indian Museum* (Calcutta) 30: 173-215, pls. 2.

Norman, J. R. (1934). A systematic monograph of the flatfishes (Heterosomata). Vol. 1. Psettodidae, Bothidae, Pleuronectidae. British Museum (Natural History). p,i-viii+1-459.

Norman, J.R. (1937). Discovery Reports. Vol. XVI, Coast fishes. Part II (The Patagonian Region).

Norman, J. R. (1939). Fishes. The John Murray Expedition 1933-34. Sci. Reports, John Murray Expedition 7 (1): 1-116.

Norman, J.R., (1966). A draft synopsis of the orders, families and gene of recent fishesand fish-like vertebrates. *British Museum Natural History*, London.

Ochiai A, (1966). Studies on the comparative morphology and ecology of the Japanese soles *Special Report of the Marine Biology Institute of the Kyoto University*, 3:1-97.

Oda D. (1991). Development of eggs and larvae of California halibut *Paralichthys californicus* and fantail sole *Xystreurys liolepis* (Pisces: Paralichthydae*). Fishery Bulletin,* 89 : 387 – 402.

Ogilby, J.D. (1916). Edible fishes of Queensland. Parts IV–IX. *Memoirs of the Queensland Museum* 5: 127–177.

Orcutt, H.G. (1950). The life history of the starry flounder, *Platichthys stellatus* (Pallas). *California Department of Natural Resources Division of Fish and Game Fish Bulletin,* No. 78, 1–64.

Orr James. W, and Ann C. Matarese. (2000). Revision of the genus *Lepidopsetta* Gill, 1862 (Teleostei: Pleuronectidae) based on larval and adult morphology, with a description of a new species from the North Pacific Ocean and Bering Sea. *Fishery Bulletin, 98 (3): 539 – 582.*

Orsi, J.J. (1968). The embryology of the English sole, *Parophrys vetulus. California Fish and Game, 54: 133 – 155.*

Oshima, M. (1927). List of Flounders and Soles Found in the Waters of Formosa, with Descriptions of Hitherto Unrecorded Species. *Japanese Journal of Zoology,* 1:177-204.

Padoa, D.E., (1956). Fauna e Flora Del Golfo Di Napoli 38. Monographia Uova larve e stadi gio vanili di Teleostei. *Fauna and Flora Del Golgo Di Neaple*, 38, 457- 1064.

Pauly D., Christensen V., Dalsgaard J., Froese R., Torres F., (1998). Fishing down marine fod webs. *Science*, 279, 860-863.

Pearcy, W.G., (1962). Ecology of an estuarine population of winter flounder, *Pseudopleuronectes americanus* (Wacbaum), IV. Food habits of larvae and juveniles (Russian summary). *Bulletin of Bingham Oceanography Coll*ege, 18 (1): 65-78.

Penrith, M. J. (1965). A new species of flat fish, *Mancopsetta milfordi*, from South Africa, with notes on the genus *Mancopsetta Volume 48, Part 7 of Annals of the South African Museum*, South African Museum Cape Town.

Perry A.L., Paula J.L., Ellis J.R., Reynolds J.D., (2005). Climate change and distribution shifts in marine fishes. *Science,* 308, 1912-1915.

Pertseva - Ostroumova. (1961). The reproduction and development of far-eastern flounders. *Tr. Institute of Okeanology Akademie. Nauk* SSSR.

Petersen., G. J., (1904). ‘‘on the larval and post-larval stages of the long rough dab and the genus *Pleuronectes."* Meddr Kommn Havunders., Ser. Fisk., 1 (1) : 13 pp.

Petersen.,. G. J., (1906). “On the larval and post-larval stages of some Pleuronectidae *(Pleuronectes, leugopterus)"* Meddr Kommn Havunders., Ser. Fisk., 2 (1) : 10 pp.

Pillay, T.V.R., (1967). Estuarine fisheries of the Indian Ocean coastal zone. *In* : Lauff,

PITT, (1965). Fecundity of the American plaice *Hippoglossodes platessoides* (Fabr.). *Journal of the Fisheries Research Board Canada*, 21 (3): 597-612.

Powles, P.M. & A.C. Kohler, (1970). Depth distribution of various stages of witch flounder (Glyptocephalus cynoglossus) off Nova Scotia and in the Gulf of St.Lawrence. *Journal Fisheries Research Board Canada,* 27 (11) : 2053-2062.

Pradhan, M J (1962). *Observations on the maturity and spawning of Psettodes erumei* (Schneider). *Indian Journal of Fisheries,* 9 (2). pp. 580-589.

Pradhan, M. J and Dhulkhed, M H. (1962). On the natural distribution of the flatfish *Laeops guentheri* Alcock. *Journal of the Marine Biological Association of India*,4 (2): 240-241.

Pradhan, M.J. (1964). A preliminary account of the flatfishes (Heterostomata) found along the Bombay Coast. *Journal of the Bombay Natural History Society,* 61(2): 456 – 459.

Pradhan, M.J.(1969). Fishery biology of the *Psettodes erumei* (Schn.) – an Indian Ocean flatfish. *Bulletin of the National Institute of Science, India*, 38: 895 – 905.

Prasad B (1962). The Wealth of India, Vol. IV, Fish and Fisheries. New Delhi: CSIR

Punpoka, S. (1954). A review of the flatfishes (Pleuronectiformes — Heterosomata) of the Gulf of Thailand and its tributaries in Thailand. *Kasetsart University of Fisheries Research Bulletin,* No. 1: 86 pp.

Quensel, C. (1806) Försök att närmare bestämma och naturligare uppställa svenska arterna af flunderslägte. *Kungliga Svenska Vetenskapsakademiens handlingar,* 27: 44-56 (continues on pp. 203-233).

Quéro, J.-C. (1997). Soleidae et Cynoglossidae (Pleuronectiformes) de l'Ile de la Réunion (Océan Indien): description d'une nouvelle espèce. *Cybium ,* 21 (no. 3): 319-329.

Radhamanyamma, P.(1988). Studies on Pleuronectiformes occurring along the southwest coast of India. Ph.D Thesis, pp. 288.

Rafinesque, C. S. (1810) . Caratteri di alcuni nuovi generi e nuove specie di animali e piante della sicilia, con varie osservazioni sopra i medisimi. (Part 1 involves fishes, pp. [i-iv] 3-69 [70 blank], Part 2 with slightly different title, pp. ia-iva + 71-105 [106 blank])., Pls. 1-20.

Rafinesque, C. S. (1810). Indice d'ittiologia siciliana; ossia, catalogo metodico dei nomi latini, italiani, e siciliani dei pesci, che si rinvengono in Sicilia disposti secondo un metodo naturale e seguito da un appendice che contiene la descrizione de alcuni nuovi pesci sicilian.

Rafinesque, C. S. (1814). Précis des découvertes et travaux somiologiques de Mr. C. S. Rafinesque-Schmaltz entre 1800 et 1814; ou choix raisonné de ses principales découvertes en zoologie et en botanique, pour servir d'introduction à ses ouvrages futurs. Palerme. 1-55.

Railey, J.D. and G.T. Thacker. (1963). Marine fish culture in Britain. III. Plaice (*Pleuronectes platessa*) rearing in closed circulation at Lowestoft, 1961. *Journal Conseil. International Exploration de Mer*, 28 : 80-90.

Rajaguru, Arjun. (1992). Biology of two co-occurring tongue fishes *Cynoglossus arel* and *C. lida* (Pleuronectiformes:Cynoglossidae) from Indian waters. *Fishery Bulletin,* 90: 328 – 367.

Rama Rao, K.V. (1967). A new sole *Zebrias cochinensis* from India. *Journal of the Zoological Society of India*, 19(1 & 2): 99 – 100.

Ramanathan, N., (1977). Studies in flat fishes of Porto Novo waters (Telecostei : Pleuronectiformes). *Ph.D. Thesis*, 250 pp. Annamalai University.

Ramanathan, N., Natarajan, R. (1979). Flatfish eggs, larvae and their development. *Aquaculture,* 18 (4) : 349 – 366.

Ramanathan, N., P. Vijaya, V. Ramaiyan and Natarajan, R. (1977). On the biology of the large scaled tongue sole *Cynoglossus macrolepidotus* (Bleeker). *Indian Journal of Fisheries*, 24 (1 *& 2):*83 – 89.

Ramanathan, N., V. Ramaiyan and Natarajan, R. (1975). On the interrelationships between the morphology of the alimentary tract and food and feeding habits of flatfishes of Porto Novo (Order: Pleuronectiformes). *Bulletin of the Department of Marine Science, University of Cochin,* 7(13): 529 – 536.

Ramanathan, N., Venkataramani, V.K and Venkataramanujan, K. (1990). Breeding biology of flatfish *Pseudorhombus triocellatus* (Bloch & Schn.) from Tuticorin waters, east coast of India. *Indian Journal of Marine Sciences,* 19 (2): 151 – 152.

Ramos, RTC (1998) Estudo filogenético da família Achiridae (Teleostei, Pleuronectiformes, Pleuronectoidei), com a revisão das formas de água doce da América do Sul Cis-Andina e a reavaliação do monofiletismo de Soleomorpha (“Soleidae”). PhD. Thesis, Museu de Zoologia da Universidade de São Paulo, São Paulo

Randall, J. E. (1995). Coastal fishes of Oman. Crawford House Publishing Pty Ltd, Bathurst, Australia. 1-439.

Randall, J. E. (2005). Reef and shore fishes of the South Pacific. New Caledonia to Tahiti and the Pitcairn Islands. *Beaufortia* : i-xii + 1-707

Randall, J. E. (1995). *Zebrias captivus*, a new species of sole (Pleuronectiformes: Soleidae) from the Persian Gulf. *Journal of the South Asian Natural History*, 2 (no. 2): 241-246.

Randall, J. E., and Hiroshi, Senou. (2007) Two New Soles of the Genus *Aseraggodes* (Pleuronectiformes: Soleidae) from Taiwan and Japan. *Zoological Studies* 46(3): 303-310 (2007).

Randall, J. E., and J. K. L. Mee (1994). *Pardachirus balius*, a new sole (Pleuronectiformes: Soleidae) from Oman. *Fauna Saudi Arabia*, 14: 341-347.

Randall, J.E. and Johnson, J.W., (2007). Revision of the soleid fish genus *Pardachirus*. *Indo-Pacific Fishes* 39. 22 pp.

Randall, J. E., and MC Carthy. (1989). *Solea stanalandi*, a new sole from the Persian Gulf. *Japanese Journal of Ichthyology* 36(2): 196-199.

Randall, J. E., and O. Gon. (2005). Review of the soles of the genus *Aseraggodes* of the western Indian Ocean, with descriptions of three new species. *Israel Journal of Zoology*, 51: 165-190.

Rao, D. V., K Devi, P T Rajan (1993). Additions to the fish fauna of Andaman and Nicobar Islands, *Environmental Ecology*, 11(4),: 882-887

Rao, S.R. (1935). A study of the otoliths of *P. erumei* (Bl. Schn.). *Proc. 22 nd Indian Science Congrress Calcutta,* Abstracts III: 319.

Rapson, A.M., (1940). The reproduction, growth and distribution of the Lemon Sole (*Pelotretis flavilatus* Waite) of Tasman Bay and Marlborough Sounds. *New Zealand Marine Department Research Bulletin,* 7 : 1-56.

Rass, T.S. (1996). On the taxonomy of Pleuronectini (Pleuronectidae). *Journal of Ichthyology,* 36 : 546 – 548.

Rass, T.S., 1965. Commercial ichthyofauna and fisheries resources of the Indian Ocean. *Trudy Inst. Okeanol*ogy, 80 : 3-31. (English summary).

Regan, C. T. (1908). Report on the marine fishes collected by Mr. J. Stanley Gardiner in the Indian Ocean. *Transactions of the Linnean Society of London* (Ser. 2, Zoology) 12 (pt 3): 217-255, Pls. 23-32.

Regan, C. T. (1905 a). On a collection of fishes from the Inland Sea of Japan made by Mr. R. Gordon Smith. *Annals of the Magazine of Natural History* (Ser. 7) XV: 17 – 25.

Regan, C.T (1910). The origin and evolution of the Teleostean fishes of the order Heterosomata. *Annals of the Magazine of Natural History.* VI (8): 484-496.

Regan, C.T. (1920). A revision of the flat-fishes (Heterosomata) of Natal. *Annals of the Durban Museum*, 2 (pt 5): 205-222.

Regan, C.T., (1905b). Description de six poissons nouveau faisant partie de la collection du Musée d'Histoire naturelle de Genêve. *Revue Suisse de Zoologie* 13: 389–393.

Regan, C.T., (1929). *Fishes. Article in Encyclopedia Britannica*, 14th Ed., IX. (Heterosomata : 324-325).

Rekha, J Nair (2006). *First record of Spearnose skate, Rostroraja alba (Lacep&de1, 803) (Rajiformes: Rajidae) from Indian waters. Journal of the Marine Biological Association of India*, 48 (1). pp. 115-117.

Rekha, J Nair (2006). *First record of the Annular sole, Synaptura annularis (Fowler, 1933) (Pleuronectiformes: Soleidae) from India. Journal of the Marine Biological Association of India*, 48 (1). pp. 118-120.

Rekha, J Nair (2007). Flatfish fishery off Cochin and some aspects of the biology and stock of Malabar sole *Cynoglossus macrostomus* (Norman). *Indian Journal of Fisheries*, 54 (1). pp. 45-49.

Relyea, K., (1981). Inshore fishes of the Arabian Gulf. George Allen & Unwin, London, 149 p., 8 pls.

Richardson, J. (1843). Contributions to the Ichthyology of Australia. *Annals and Magazine of Natural History* (New Series), 11 (no. 72): 422-428.

Richardson, J. (1846). Descriptions of six fish. Pp. 484-497, Pls. 1-4. In: J. L. Stokes, vol. 1, Appendix. Discoveries in Australia with an account of the coasts annd reivers explored and surveyed during the voyage of H. M. S. Beagle, in the years 1837-38-39-40-41-41-42-43. By command of the Lords Commissioners of the Admirality. Also a narrative ... islands in the Arafura Sea. London. T. and W. Boone, Lodon. Discoveries in Australia ... surveyed during the voyage of H. M. S. Beagle, between the years 1837 and 1843.: xii + 521 pp., Pls.

Richardson, S. L., Laroche, J. L., Richardson, M. D. (1980). Larval fish assemblages and associations in the north-east Pacific Ocean along the Oregon coast, winter-spring 1972-1975, *Estuarine and Coastal Marine Science*,11:671-699.

Riley. (1964). Survey techniques for young plaice populations. *Report Challenger Society,* 16 : 32-33 (Abstract).

Risso, A. (1810). Ichthyologie de Nice, ou histoire naturelle des poissons du département des Alpes Maritimes. F. Schoell, Paris. i-xxxvi + 1-388, Pls. 1-11.

Risso, A. (1827). Histoire naturelle des principales productions de l'Europe méridionale, et particulièrement de celles des environs de Nice et des Alpes maritimes. F. G. Levrault, Paris & Strasbourg. v. 3: i-xvi + 1-480, Pls. 1-16.

Rose G.A., (2005). On distributional responses of North Atlantic fish to climate change. *ICES Journal of Marine Science,*62, 1360-1374.

Ruiz, G. M., Carlton, J. T., Grosholz, E. D. and Hines, A. H. (1997) Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent and consequences. *American Zoologist*, 37: 621-632.

Russel, F.S, (1976). The eggs and planktonic stages of British marine fishes. Academic Press, London.

Rustad, D., (1961). Improved rearing of young plaice (*Pleuronectes platessa* L.) byapplication of penicillin. *K. norske Vidensk Selsk. Forh*., 33 : 1-4..

Ryland, J.S. & J.H. Nichols, (1967). Effect of temperature on the efficiency of growth of plaice prolarvae. *Nature,* London, 214 : 529-530, 1 fig., 1 tab.

S.J. De Groot, (1964). Diurnal activity and feeding habits of plaice. *Rapport P.-v. Réun. Conseil. Permanent. International Exploration de Mer,* 155 (1964) : 48–51.

Sahayak, Satish. (2004). *Studies on the taxonomy and some aspects of biology of the fishes of the Family Balistidae from the Indian seas (TH 122).* Ph.D thesis, University of Kerala, Thiruvananthapuram.

Sainsbury, K.J., P.J. Kailola & G.G. Leyland, (1985). Continental shelf fishes of Northern and North-Western Australia. CSIRO, Canberra, Commonwealth of Australia, 375 p.

Sakamoto, K. (1984). Interrelationships of the family Pleuronectidae (Pisces:Pleuronectiformes). *Memoirs Faculty Fisheries Hokkaido University,* 31 (1/2): 95 – 215.

Sakamoto, K. (1984). Pleuronectidae. In: The fishes of the Japanese Archipelago (H.D Masuda, K.Amaoka, C.Araga, T.Uyeno and T.Yoshino, eds.), p 351 – 354 . Tokai Univ.Press, Tokyo , Japan.

Saramma, Abraham, D. (1963). Bottom fishes collected by the research vessel "Conch", off the Kerala coast during 1958 – 63. Heterosomata. *Bulletin of Department of Marine Biology and Oceanography, University of Kerala*, 1:57 – 80.

Sarojini, R. Pillay, (1962). A revision of Indian Mugilidae. Part I. *Journal of the Bombay Natural History Society,* 59(1): 254-270.

Sarojini, R. Pillay, (1962). A revision of Indian Mugilidae. Part II. *Journal of the Bombay Natural History Society*, 59(2): 547-576.

Schmidt, P.J. (1904). The pelagic post-larval stages of the Atlantic species of *Gadus*. Part I., *Medd. Komm. Havunders Ser. Fiskeri* 1(4):1-77.

Schmidt, P.J., (1930). Fishes of the Riu-Kiu Islands., *Transactions of the Pacific Commission of Academy of Science*, USSR 1:19-156.

Schultz, L.P., (1943). Fishes of the Phoenix and Samoan Islands collected in 1909 during the expedition of the U.S.S. 'Bushnell'., *Bulletin of the United States National Museum*, 180:1-316.

Schwarzhans, W. (1999). *Piscium Catalogus: Part Otolithi piscium*, Vol. 2. *A Comparative Morphological Treatise of Recent and Fossil Otoliths of the Order Pleuronectiformes*. Verlag Dr Friedrich Pfeil, München.

Seshappa, G and Bhimachar,B.S (1955). Studies on the fishery and biology of the Malabar sole *Cynoglossus semifasciatus* Day. *Indian Journal of Fisheries*, 2: 180 – 230.

Seshappa, G. (1964a). Length frequency studies on the Malabar sole *Cynoglossus semifasciatus* Day at West Hill, Calicut during the years 1959 -60 to 1962 - 63. *Indian Journal Fisheries,* 11 : (2). pp. 533-546.

Seshappa, G. (1964b). Length frequency studies on the Malabar sole *Cynoglossus semifasciatus* Day at West Hill, Calicut during the years 1959 -60 to 1962 - 63. *Indian Journal of Fisheries,* 11 (2): 533-546.

Seshappa, G. (1964c). On a case of reversal in *Cynoglossus semifasciatus* Day. *Journal of Marine Biology Association of India, 6 (2): 319 – 320.*

Seshappa, G. (1970). Some morphometric studies on five species of Cynoglossus (Family Cynoglossidae, Order Heterosomata) from the West Coast. *Indian Journal of Fisheries*, 17: 149 – 158.

Seshappa. G. (1970). On some eye abnormalities in the Malabar sole *Cynoglossus macrostomus* Norman. *Journal of the Marine Biological Association of India*, 12 (1 & 2): 171 – 174.

Seshappa, G. (1972a). On a partially ambicoloured specimen of *Cynoglossus dubius* day. *Journal of the Marine Biological Association of India*: 14(2); 1972; 875-877.

Seshappa, G. (1972b). *On a partially ambicoloured specimen of Cynoglossus dubius* Day. *Journal of the Marine Biological Association of India*, 14 (2). pp. 875-876.

Seshappa, G. (1973). The flatfish resources of the west coast of India. CMFRI *Special. Publication*.: 470 – 482.

Seshappa, G. 1974. On the fishery and biology of the large tongue-sole, *Cynoglossus dubius* Day, at Calicut, Kerala. *Indian Journal of Fisheries*, 21 (2). pp. 345-356.

Seshappa, G. (1981). Length-weight relationships in three species of flatfishes at Calicut. *Journal of the Marine Biological Association of India*, 23 (1&2). pp. 141-150.

Seshappa, G and Bhimachar, (1951). Age determination studies in fish by means of scales with special reference to the Malabar sole *Cynoglossus semifasciatus* Day. *Current Science*, 20 : pp. 260-262.

Seshappa, G. and B.S Bhimachar. (1951). A scalimetric comparison of the Malabar sole *Cynoglossus semifasciatus* Day from different parts of the west coast. *Indian Journal of Fisheries*, 31 (1): 82 – 89.

Seshappa, G. and B.S Bhimachar. (1953). Studies on the age and *growth* of the Malabar sole *Cynoglossus semifasciatus* Day. *Indian Journal of Fisheries*, 1 (1): 145-162.

Seshappa, G and Bhimachar, B S (1954). Studies on the age and growth of the malabar sole, *Cynoglossus semifasciatus, Day*. *Indian Journal of Fisheries*, 1 (1&2). pp. 145-162.

Shafi, M., Quddus, M.M.A., Rahman, S. (1978). Fecundity of the Indian Halibut *Psettodes erumei* (Bloch & Schneider) (Psettodidae: Pleuronectiformes) from the Bay of Bengal. *Bangladesh Journal of Zoology,* 6(2): 113 – 120.

Shaw, G. E. and E. O. Shebbeare (1937). Description of a new species of fish from northern Bengal. *Journal of the Bombay Natural History Society,*39 (pt 1): 188-189, Pl.

Shellbourne, J.E., (1953). The feeding habits of plaice post larvae in the southern Bight. *Journal of the Marine Biological Association of the United Kingdom*, 32 : 149-159.

Shellbourne, J.E., (1956). The abnormal development of plaice embryos and larvae in marine aquaria. *Journal of the Marine Biological Association of the United Kingdom*, 35 : 177-192.

Shellbourne, J.E., (1957). The feeding and condition of plaice larvae in good and bad plankton catches. *Journal of the Marine Biological Association of the United Kingdom*,36 : 539-552.

Shellbourne, J.E., (1962). A predator-prey size relationship for plaice larvae feeding on Oikopleura. *Journal of the Marine Biological Association of the United Kingdom*,42 : 243-258.

Shellbourne, J.E., (1963 a). Marine fish culture in Britain. II. A plaice rearing experiment at Port Erin, Isle of Man, during 1960, in open sea water circulation. *J. Cons. Int. Explor. Mer .,* 28 : 70-79.

Shellbourne, J.E., (1963 b). Marine fish culture in Britain. IV. High survivals of metamorphosed plaice during salinity experiments in open circulation at Port Erin, Isle of Man, 1961. *ICES Journal of Marine Science,* 28 : 246-261.

Shellbourne, J.E., (1964). The artificial propagation of marine fish *Advances in Marine Biology*, 2 : 1- 83.

Shelbourne, J.E. (1957a). The feeding and condition of plaice larvae in good and bad plankton patches. *Journal of the Marine Biological Association of the United Kingdom*, 36, 539–552.

Shelbourne, J.E. (1957b). The feeding and condition of plaice larvae in good and bad plankton patches. *Journal of the Marine Biological Association of the United Kingdom*, 36, 539–552.

Shellbourne, J.E., (1975). Marine fish cultivation : pioneering studies on the centre of the Shelbourne, J.E. (1964) The artificial propagation of marine fish. *Advances in Marine Biology,* 2, 1–83.

Shelbourne, J.E., Riley, J.D. & Thacker, G.T. (1963). Marine fish culture in Britain. I. Plaice rearing in closed circulation at Lowestoft, 1957–1960. *Journal du Conseil International pour l'Exploration de la Mer*, 28, 50–69.

Shen, S.C. (1966). Studies on the flatfishes (Pleuronectiformes or Heterosomata) in the adjacent waters of Hong Kong. *Q.J. Taiwan Mus*., 20: 149 – 281.

Shen, S.-C. (1967). Studies on flat-fishes (Pleuronectiformes or Heterosomata) in the adjacent waters of Hong Kong. Q*uaternary Journal of the Taiwan Museum*, 20(1, 2): 150–281.

Shen, S.C. (1983). Study on the bothid fishes (Family Bothidae) from Taiwan. *Journal of the Taiwan Mus*eum, 36: 1- 42.

Shen, S.-C. and Chian –Hsing Lee. (1981). Study on the Sole Fishes (Family Soleidae) from Taiwan. *Bulletin of the Institute of Zoology, Academia Sinica* 20 (2): 29 – 39.

Shuntov, V.P., (1965). Distribution of Green land and arrow-toothed halibut in the North Pacific. *Tr. Vses. Nauch. Issled Inst. Morsk Rybn. Khoz. Okeanogr*aphy, 58 : 155-163.

Sidlauskas, Brian L., Jan H. Mol and Richard P. Vari. (2011). Dealing with allometry in linear and geometric morphometrics: a taxonomic case study in the *Leporinus cylindriformis* group (Characiformes: Anostomidae) with description of a new species from Suriname. *Zoological Journal of the Linnean Society*, 162, 103–130, 12 figures

Silas, E G (1951). Fishes from the high range of Travancore. *Journal of Bombay Natural History Society*, 50 (2). pp. 323-330.

Silas, E G (1958). Studies on Cyprinid fishes of the oriental genus *Chela* Hamilton. *Journal of the Bombay Natural History Society*, 55 (3). pp. 54-99.

Silva, A. (2003). Morphometric variation among sardine (Sardina pilchardus) populations from the northeastern Atlantic and the western Mediterranean. ICES *Journal of Marine Science*, 60: 1352-1360.

Simon K. D., Y. Bakar, S. E. Temple, A. G. Mazlan. (2010) Morphometric and meristic variation in two congeneric archer fishes *Toxotes chatareus* (Hamilton 1822) and *Toxotes jaculatrix* (Pallas 1767) inhabiting Malaysian coastal waters. *Journal of the Zhejiang Univ-Sci B (Biomed & Biotechnol) 2010- 11(11):871-879*

Simpson A.C. (1951). The fecundity of plaice. *Fishery Investigation London*. Series 2, 17 : 27 pp.

Simpson A.C. (1959a). The spawning of plaice in the North Sea. *Fishery Investigation Series,* 2 22: 1-111.

Simpson, A. C. (1959b). The spawning of plaice *(Pleuronectes platessa)* in the Irish Sea. *Fishery Investigation Series,* 2 22, 111-300

Sivasubramaniam K. and Ibrahim M. A. (1982). Common fishes of Qatar. Scientific atlas of Qatar, No. 1. Doha modern printing press. Doha, Qatar.

Smith, J. L. B. (1961). The sea fishes of southern Africa. Fourth Edition. Central News Agency, Ltd. The sea fishes of southern Africa. Fourth Edition.: 1-580, Pls. 1-111.

Smith, H. M., and T. E. B. Pope. (1906). List of fishes collected in Japan in 1903, with descriptions of new genera and species. *Proceedings of the United States National Museum*, 31 (no. 1489): 459-499.

Smith, J. L. B. & M. M. Smith, (1963). The fishes of the Seychelles. Rhodes University, Grahamstown, 215 p., 98 pls

Smith, J. L. B. & M. M. Smith, (1986). Sea Fishes of Southern Africa, 1 – 585 pp.

Smith, M. M. and P. C. Heemstra (1986). (eds.) Smiths' Sea Fishes. Macmillan South Africa, Johannesburg. i-xx + 1-1047, Pls. 1-144. [Revision of J. L. B. Smith's, The Sea Fishes of Southern Africa, first published in 1949.

SOFIA, (2008). *The State of World Fisheries and Aquaculture*. 2008. FAO Fisheries and Aquaculture Department Food and Agriculture Organization of the United Nations.

Staunch, A. and J. Cadenat. (1965). Revision du genere *Psettodes* Bennet, 1831, (Pisces, Teleostei, Hetrostomata). *Orstom – Oceanographie, 3(4): 19 – 30.*

Stebbing A.R.D., Turk S.M.T., Wheeler A, Clarke K.R., (2002). Immigration of southern fish species to south-west England linked to warming of the North Atlantic (1960-2001). *Journal of the Marine Biological Association of U.K.* 82, 177-180.

Steindachner, F. (1907). Über zwei neue Arten von Süsswasserfischen aus dem Stromgebiete des Parnahyba. *Anzeiger der Akademie der Wissenschaften in Wien* v. 44 (no. 10): 152-155.

Suzuki S, Kawashima T, Nakabo T (2009) Taxonomic review of East Asian Pleuronichthys (Pleuronectiformes: Pleuronectidae), with description of a new species. *Ichthyological Research*, 56:276–291.

Swain, D. P., and Foote, C. J. (1999). Stocks and chameleons: the use of phenotypic variation in stock identification. *Fisheries Research*, 43: 1123-1128.

Talwar P.K. (1973). A new bathypelagic fish *Sphenanthias whiteheadi* (Pisces: Owstoniidae). from India. *Proceedings of the Zoological Society of Calcutta,*25 (2): 87-91.

Talwar P.K and T.K Sen. (1967). A note on the natural distribution of the flatfish, *Zebrias altipinnis* (Alcock). *Advance Abstracts,* 1(3): 6.

Talwar, P.K and Kacker. (1984). Commercial Sea Fishes of India.

Talwar, PK and Jhingran. (1991). Inland fishes of India and adjacent countries. In 2 vols. Oxford & IBH Publishing Co., New Delhi, Bombay, Calcutta. Inland fishes of India and adjacent countries. v. 1-2: i-xvii + 36 unnumbered + 1-1158, 1 map.

Talwar, PK and S. Chakrapani. (1968). A new flat fish of the genus *Zebrias* Jordan and Snyder (Soleidae) from Orissa coast, India. *Proceedings of the Zoological Society, (Calcutta)* 20: 119-121.

Tarp, T.G and P.J Kailola. (1985). Trawled fishes of southern Indonesia and north western Australia. Australain development Assistance Bureau, Directorate General of fisheries, Indonasia and German Agency for Technical Cooperation, Xvi+405pp. pls.1-3.

Temminck, J. C., and H. Schlegel, (1842-1850). *Pisces*. *In* P. Siebold, Fauna Japonica. Leyde. pp. 324.

Terwilliger, M.R. and Munroe, T.A. (1999). Age, growth, longevity, and mortality of blackcheek tonguefish, *Symphurus plagiusa* (Cynoglossidae: Pleuronectiformes), in Chesapeake Bay, Virginia. *Fishery Bulletin*, 97, 340–361.

Thomas Wilderbuer, Bruce Leaman, Chang Ik Zhang, Jeff Fargo and Larry Paul (2005). *Pacific flatfish fisheries.* In: Flatfishes –Biology and Exploitation. Gibson, R. (Ed). 2005, Blackwell Science Ltd, a Blackwell Publishing company, 391 pp.

Thomas, P.A. (1969). The Goatfishes (Family Mullidae) of the Indian Seas. Marine Biological Association of India, Memoir *3:* 1- 174.

Thompson, W.F., (1936). Conservation of the Pacific Halibut, an international experiment. *Reports of the Smithsonian Institution:* 361-382.

Thomson, W.F. & R. Van Cleve, (1936). Life history of the Pacific Halibut. 2. Distribution and early life history. *Report Seattle,* 9, 184 of the International Fish Commission, pp,

Tinker. S.W. (1978). *Fishes of Hawaii* – a handbook of marine fishes of Hawaii and the Central Pacific Ocean. (Published by Hawaiin Service INC., Hawaii, 1 – 532.

Torchio, M. (1961). *Arnoglossus moltonii*, nuova specie di Bothidae del Mediterraneo (pisces Pleuronectiformes). Atti Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Milano v. 100: 213-224, 1 pl.

Tortonese, E. (1936). Un nuovo Percoide dell'Oceano Indiano *(Hapalogenys pictus*, n. sp.). *Bollettino dei Musei di Zoologia ed Anatomia Comparata della R. Università di Torino.* (Ser. 3), 45 (1935-36) (67): 1-4, Pl. 1.

Trewavas, E. (1977). The Sciaenid fishes (croakers or drums) of the Indo-West-Pacific. *Transactions Zoological Society of London*, 33: 253-541.

Turan, C., (2004). Stock identification of Mediterranean horse mackerel (*Trachurus mediterraneus*) using morphometric and meristic characters. *ICES Journal of Marine Science*, 61, 774–781.

Vachon, Josiane, Francois Chapleau, and Martine Desoutter-Meniger, (2007). Revision taxonomique et phylogenie de *Dagetichthys* et *Synaptura* (Soleidae). *Cybium* 31 (4): 401-416.

Van Keeken, O.A., Van Hoppe, M., Grift, R.E., and Rijnsdrop, A.D. (2007). The implications of changes in the spatial distribution of juveniles for the management of North Sea plaice (Pleuronectes platessa). *Journal of Sea Research*, 57: 187 – 197.

Van Oosten, J. V. (1957). Skin and scales. In The Physiology of Fishes (Brown, M. E.,ed.), pp. 207–255. New York: Academic Press.

Venkataramanujan K. and K.Ramamoorthi (1973). A rediscription of *Samaris cristatus* Gray (Pisces: pleuronectidae) from Porto Novo, South India. *Journal of the Marine Biological Association of India*, (2): 875-877.

Videler, J. J. (1994). Fish Swimming. London: Chapman & Hall.

Villaluz, A. C., and Maccrimmon, H. R. (1988). Meristic variations in milkfish *Chanos chanos* from Philippine waters. *Marine Biology*, 97: 145-150.

Vivekanandan, E , Zacharia, P U, Feroz Khan, M and Nair, Rekha J (2003). Flatfishes. In: *Status of Exploited Marine Fishery Resources of India*. Mohan Joseph, M and Jayaprakash, A A, (Eds.) CMFRI, Cochin, pp. 164-170. ISBN 81-901219-3-6

Von Bonde, C. (1922). The Heterosomata (flat fishes) collected by the S. S. "Pickle.". *Report of the Fisheries Marine Biological Survey Union of South Africa Report*, 2 (art. 1): 1-29, Pls. 1-6.

Von Bonde, C. (1925). A collection of Heterosomata from Portuguese East Africa. *Transactions of the Royal Society of South Africa,* 12 (pt 4): 285-294.

Voronina, E. P. and S. A. Evseenko (2008). Second finding of *Nematops microstoma* Günther, 1880 (Pleuronectiformes, Poecilopsettidae) in the Equatorial Pacific. *Journal of Ichthyology*. 48 (7): 493-498. [In Russian in *Voprosy Ikhtiologii*, 48 (no. 4):479-484.]

Voronina, E.P. and H.M. Dias de Astarloa 2007 Structure of seismosensory system in *Oncopterus darwinii* (Rhombosoleinae, Pleuronectidae). *Journal of Ichthyology* 47(1):32-36.

Walther, G.R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T.J.C., Fromentin, J.M., etal., (2002). Ecological responses to recent climate change. *Nature*, 416: 389 -395.

Weber, M. 1913. *Die Fische der Siboga-Expedition*. E. J. Brill, Leiden. i-xii + 1-710, Pls. 1-12.

Weber, M. and L.F. De Beaufort, (1929). The fishes of the Indo-Australian Archipelago. V. Anacanthini, Allotriognathi, Heterostomata, Berycomorohi, Percomorphi: Kuhliidae, Apogonidae, Plesiopidae, Pseudoplesiopidae, Priacanthidae, Centropomidae., E.J. Brill Ltd., Leiden

Weed, W. H., III (1961). A new species of *Aseraggodes* (Soleidae) from Ceylon. *Copeia*, 1961 (no. 3): 292-295.

Whitehead, P.J.P.(1965). A new genus and subgenus of clupeiod fishes and notes on the genera *Clupea, Sprattus* and *Clupeonella*. *Annals and Magazine of Natural History Series*, 13, 7 (78): 321 – 330.

Whitehead, P.J.P. (1973). The clupeoid fishes of the Guianas. *Bulletin British Museum Natural History, Zoological Supplement* 5: 1 – 227.

Whitehead, P.J.P. (1985). FAO Species Catalogue, Volume 7. *Clupeoid fishes of the world*. (Suborder Clupeoidei), Part I. Chirocentridae, Clupeidae and Pristigasteridae. *FAO Fisheries Synopsis*. 125,

Whiteley, G.P and A.N. Colefax, (1938).Fishes from Nauru, Gilbert Islands, Oceania. *Proceedings of the Linnean Society New South Wales*, 43 (3 -4): 282 – 304.

Woods, L.P.(1966). Family Bothidae, pp. 62 – 66. In: *Fishes of the Marshall and Marianas Islands*. Vol. 3. Families Kraemeriidae through Antennaridae. L.P Schultz and collaborators: L.P Woods and E.A Lachner. Bulletin Unites States National Museum, 202: vii + 165.

Wu. H.W (1932). Contribution a l'etude morphologique, biologique et systematique des poisons heterosomes (Pisces Heterosomata) de la Chine. Thesis, University of Paris.

Yamamoto, K. (1939). Effects of temperature and salinity on the embryonal development of the eggs of *Pseudopleuronectes yokohamae* (Gunther). *Bullettin Japanese Society of Scientific Fisheries, Tokyo,* 8: 102-106.. (Japanese, English summary).

Yesaki, M. and R.J. Wolotira Jr., (1968). Extension of recorded range of better soles *Isopsetta isolepis* into the Bering Sea. *Journal Fisheries Research Board, Canada,* 25 (5): 1077-1078.

Yokogawa Koji, Hiromitsu Endo and Hideo Sakaji. 2008. *Cynoglossus ochiaii*, a new Tongue Sole from Japan (Pleuronectiformes: Cynoglossidae). *Bulletin National Museum Natural Science Series* A, Supplement 2, pp. 115–127

Yu. S. Mel'nikov (1981). Distribution and some biological features of three flatfish species (Family Psettodidae and Bothidae) off the Western coast of Hindustan. *Voprosky Ikthiology*, 21 (6): 1122 – 1125.

Zheng, P.-S. and Y.-W. Chang 1965. Studies on the Chinese soleoid fishes of the genus *Zebrias*, with description of a new species from the South China Sea. *Acta Zoologica Sinica*, 2 (4): 267-278.

Zimmermann, Mark. (1997). Maturity and fecundity of arrow tooth flounder *Atheresthenes stomias* from the Gulf of Alaska. *Fisheries Bulletin*, 95: 598 – 611.

Zoutendyk, P. (1974a). The biology of the Agulhas sole, *Austroglossus pectoralis*. Part 2. Age and growth. *Transactions Royal Society of South Africa,* 41(1):33-41.

Zoutendyk, P. (1974b). The biology of the Agulhas sole, *Austroglossus pectoralis*. Part 3. Length –weight relationships. *Transactions Royal Society of South Africa*, 41 (2): 99 – 108.

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S11 – 20

STUDIES ON THE FLATFISH DIVERSITY IN INDIAN WATERS

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Fishes constitute slightly more than half of the total number of approximately 54,711 recognized living vertebrate species of the world. Fishes have been exploited using a wide variety of gears from various depths and in all sizes leading to heavy recruitment overfishing as well as growth overfishing. As a consequence, humans have now realized that conservation of this resource is needed in this century to preserve the varied species for posterity. As per FAO (2008), in 2007, about 28 percent of stocks were either over exploited, depleted or recovering from depletion and thus yielding less than their maximum potential owing to, *inter alia*, excess fishing pressure. The Western Indian Ocean is one of the areas showing highest proportions of fully-exploited stocks.

Flatfishes are deep bodied, laterally compressed fishes, easily recognizable by the presence of both eyes on one side in juvenile and post-metamorphic individuals. They are well known organisms as they occur in all of the world's oceans and are represented by large numbers of species and genera. They are common species in most marine fish assemblages from the poles to the tropics. Tropical seas are the largest marine biomes of the world and in these waters from a depth of 30 – 100 m a major portion of coastal aquatic life exist. In this area are found diverse assemblages of marine fish, among them are the flatfishes in a variety of forms and extreme length ranges. In tropical areas, flatfishes occur in a variety of habitats including mangrove estuaries and adjacent mudflats, in seagrass beds and on mud bottoms. Although tropical flatfishes are frequently caught, are species-rich and even sometimes numerically abundant, most are thin bodied, small sized species reaching only to 30 – 40 cm total length (Munroe, 2004). Seldom do flatfishes exceed 5% of the fish biomass of tropical fish demersal communities. Most landings data reported to FAO from tropical regions do not list statistics for individual flatfishes (except Indian halibut). Flatfishes captured in tropical fisheries are often not identified even to genus or family level, rather much of the catch is merely identified as "Pleuronectiformes"; 54% – 80% of the total landings of tropical flatfishes consist of unidentified species. About 70% – 75% of flatfishes reported from the eastern Indian Ocean and Western Central Pacific are now identified to family. In contrast even 80% of the annual catches from the Western Indian Ocean are not identified even to family level. Only when species harvested by fisheries are correctly identified will it be possible to critically evaluate impacts of fishing and other perturbations on individual species or changes in biodiversity within demersal communities (Munroe, 2005). In India, an estimated 2.7 million tonnes of marine fish were landed in 2006 (CMFRI, 2006). Of the 2.7 million tonnes landed in 2006, flatfishes accounted for 1.44%, which remained the same the next year also. Landings in 2008 showed a marginal decrease of 2 tonnes over the previous year, the catch percentage declined by 1.2%. Landings of Indian halibut decreased from 3.4% in 2006 to about 2.5% of the total fisheries during the period 2006 – 2008 (CMFRI, 2008).

Due to these changes in fishery, systematic work on Indian flatfishes of Indian coast especially South India and Andamans was undertaken during 2004 – 2010. Results showed that 62 species of flatfishes belonging to 7 families and 26 genera have been collected. This is much higher than most previous studies. The results point to a rich diversity of flatfishes along the Indian coast. Moreover many of the flatfishes collected were of ornamental nature especially *Pardachirus* spp. and *Heteromycteris* spp. paving way for their use in the marine aquarium. Some species like *Psettodes erumei* which were of high commercial value have nearly disappeared from the regular fishery also. The present study thus offers a peek into the fish biodiversity of these waters.

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Flatfish fishery off Cochin and some aspects of the biology and stock of Malabar sole *Cynoglossus macrostomus* (Norman)

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ABSTRACT

Flatfish landings increased from an estimated 58 t in 2000 to 299 t in 2002, but declined to 65 t in 2003 and 61 t in 2004 at Cochin. August and September were the months of peak landings, which were also the peak spawning months. The optimum length of exploitation was 124 mm. Annual growth coefficient (K) and Lα were 0.79 and 212.5 mm respectively. The resource is being exploited at a level (E = 0.78) higher than the optimum (Emax = 0.458). Appropriate management measures are discussed.

Introduction

Among flatfishes occurring along the west coast, the Malabar sole *Cynoglossus macrostomus* form a major trawl fishery along the coastal region from Mulki in Karnataka to Kollam in Kerala. Though there is no targeted fishery for the species, it is obtained as a by-catch in shrimp trawls. With the increase in targeted fishery for shrimps, this species is also being heavily fished. Market demand for fresh flatfishes is only in the Malabar area; towards South Kerala, the fish is being dried and sold through consumer markets. The fish costs Rs.40 /kg in fresh and 50/kg in dried condition. Decayed fish from multi-day shrimp fishing vessels are being dried and sold as ingredient for poultry feed at Rs. 20/kg. Studies on the fishery, biology and stock characteristics of flatfishes along the Indian coasts have been carried out by Vivekanandan *et al.* (2003), Jayaprakash (1998), Khan and Nandakumaran (1993), Grace Mathew *et al.* (1992), Seshappa and Chakrapani (1983), Victor (1978), Seshappa (1964,1974, 1978) and Seshappa and Bimachar (1955, 1954, 1951).The present paper gives an insight into the flatfish fishery and stock of *C. macrostomus* based on investigations at Cochin from 2000-2004.

Materials and methods

Data on landings of flatfishes and effort expended by trawlers were collected from weekly observations in the fishing harbours at Cochin and Munambam. To estimate catch (weight and numbers) of each species, the data collected at the observation centres were weighted to get estimates for each centre. Samples of the dominant species, *C. macrostomus*, were collected, length–weight measurements taken and length–weight relationship calculated by the method of least squares using the formula

Log W = log a + b Log L

where, W = weight in grams, L= length in mm, a = constant and b = exponent. W^{α} was calculated using the L^{α} value and the length–weight relationship. For studies on reproductive biology, gonads of female were examined microscopically and classified into four stages - immature (Stages I and II), developing (Stages III and IV), mature/ gravid (Stage V) and spent (Stage VI). Fishes in Stage III and above were considered for the purpose of estimating length at first maturity. For determination of spawning period, only fishes in Stages V and VI were considered. Length frequency data were grouped at 5 mm interval to estimate the growth parameters. The parameters of growth in length were estimated following the ELEFAN method (Gayanilo *et al.*, 1988) using the monthly length frequency data for the years 2000-2004. The estimates of instantaneous mortality (Z) were made using length converted catch curve method (Pauly, 1982) with the combined data for five years.

The natural mortality rate (M) was estimated using the empirical formula of Pauly (1980) by taking into account the mean annual temperature off Cochin as 28.5oC. The fishing mortality F was estimated as Z – M. The optimum length of exploitation (Lopt) was estimated from the empirical equation of Froese and Binohlan (2000) using the relationship

Lopt = 3 x Lα / (3 + M/K)

The life span was estimated using the equation Tmax = 3/K (Pauly, 1983)

To assess the long-term impact of fishing, yield per recruit analysis (Y/R) was carried out following Beverton and Holt (1957). From the exploitation ratio, E, the yield (MSY) was estimated. Average standing stock (Y/F) and the annual stock or biomass (Y/U) were estimated for the five year period. The exploitation rate, U was estimated as F/Z (1 – e-Z). Recruitment pattern was obtained by backward projection on the length axis of the set of length–frequency data (seasonal growth curve) by using the routine ELEFAN II.

Results

The total annual effort decreased from 14,803 units in 2000 to 2,980 units in 2003, but increased to 6,709 units in 2004. The catch per unit effort, however, increased from 3 kg in 2000 to 38 kg in 2002, but decreased to 9 kg in 2004. Flatfish landings increased from an estimated 58 t in 2000 to 299 t in 2002, an increase of 241 t in two years, followed by a drastic decline to 65 t in 2003 and 61 t in 2004. Generally, maximum trawl effort was expended in the pre and post-monsoon months (May and August). During 2000-04, August and September were the months of peak production (Fig 1). Landings were poor during the pre

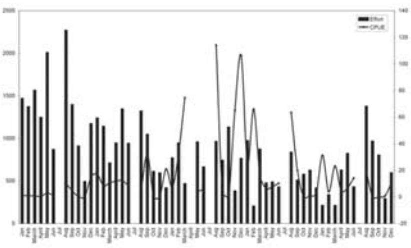

Fig. 1. Seasonal production of flatfishes by trawlers at Cochin during 2000-2004

monsoon months of April - June. During 2002 and 2003, however, good landings were observed during February and March also.

Fourteen species of flatfishes were recorded in the fishery. Of these, *C. macrostomus* dominated the landings contributing over 65 %, followed by *C. macrolepidotus* with 18 %. The other species, which contributed to the fishery, were *C. puncticeps, C. bilineatus, C. dubius, Psettodes erumei, Synaptura commersoniana, Bothus myriaster, B. ovalis, Pseudorhombus elevatus, P. javanicus, Aesopia cornuta and Zebrias quagga.*

A total of 500 specimens ranging from 50 -160 mm in total length were used for the estimation of length –weight relationship. The data for both sexes were pooled to get the estimates of a and b. The length –weight relationship for *C. macrostomus* is

Log W = -5.16 + 3 Log L

Using the availability of mature and spent gonads in the samples, the spawning season off Cochin was found to be January –April and August – October, with the peak during August- September. The predominant maturity class is Stage IV when the commercial fishery commences after the trawl ban at Cochin

Growth parameters were estimated assuming that the growth in length of the species follows von Bertalanffy equation. The length at first capture is 45 mm. A total of 5,289 fishes in the range 45 -190 mm total length were used for the estimation. (Fig. 2).

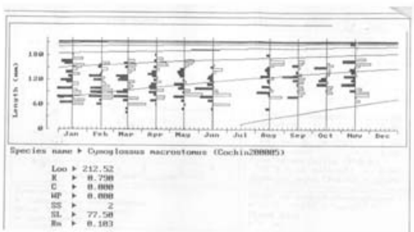

Fig. 2. Growth of *C. macrostomus* at Cochin.

The growth parameters estimated was L_∞212.5 mm using Powell – Weatherall plot, K at 0.79 year -1 and to at -0.014. Using these results the VBGF equation for *C. macrostomus* can be written as

Lt = 212.5 (1 – e - 0.79 (1- (-0.014)).

Optimum length of exploitation (Lopt) was estimated as 124 mm and the maximum life span Tmax as 3.8 years. Natural mortality M was estimated as 1.7. Instantaneous mortality Z was estimated using length–converted catch curve method at 7.78. (Fig. 3). Using Z and M, fishing mortality F was estimated at 6.08 and exploitation rate E at 0.78. The cutoff length L' was estimated at 117.5 mm and the mean length in the fishery at 131.5 mm. Using E values, and

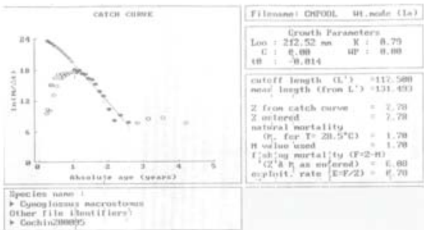

Fig. 3. Length converted catch curve of *C. macrostomus* at Cochin

taking the present average yield at 60 t, the MSY was estimated at 99 t. The standing and total stocks were estimated at 16 t at 126 t respectively.

Discussion

The fluctuations in the landings of flatfish noticed during 2000 - 2004 were similar to the results of Jayaprakash (1998). The fluctuations in the flatfish fishery may be attributed to the large scale shoaling of the species in the surface and subsurface waters of the inshore areas in enormous numbers (Jayaprakash, 1998). In the present study, the peak production period was during August and September immediately after the monsoon trawl ban, followed January -March. The results are different

TABLE 1. *Length weight relationship for* C. macrostomus *worked out by various authors*

Area	Sex	No.	a	b	Author
Mangalore	M	761	0.000004327	3.04	Victor (1978)
	F	657	0.00001415	2.7886	-do-
	P	1418	0.000007872	2.9145	-do-
Calicut	P	150	0.00003759	2.618	Khan and Nandakumaran (1993)
Cochin	M	340	0.000002194	3.163	Jayaprakash (1998)
	F	329	0.0000002953	3.10	-do-
	P	669	0.000002576	3.13	-do-
Cochin	P	500	0.005737108	3	Present study

from those reported by Grace Mathew *et al.* (1990) that the peak flatfish landings was during May and June during 1984 –1988 at Cochin. Khan and Nandakumaran (1993) also reported similar landing pattern at Calicut. It appears that the difference in the months of peak landings may be due to change in the fishery pattern after the implementation of trawl ban.

Seshappa and Bimachar (1955) observed the spawning season of the Malabar sole as September – October off Calicut. . However, in the present study, two spawning seasons (January-April, August-October) were noticed; these results agree with that of Jayaprakash (1998) from the same area. The commercial catches consist of fishes in different maturity stages and belong to two recruitment batches.

The length weight relationship for *C. macrostomus* worked out by various authors is given in Table 1. The growth in weight is isometric for this species. Jayaprakash (1998) reported size at first maturity to be 97 mm. Results of the present study, however, point to a higher size at first maturity (118.5 mm). Similarly, results on the length of the fish attained at the end of the first and second year were higher than that recorded by Khan and Nandakumaran (1993). The largest specimen they obtained was 159 mm which was much lesser than that of the present study.

The optimum length of exploitation in the present study point to the fact that fishes over one year class alone should be exploited. The length at first capture in the trawl (45 mm) is much below the optimum length as well as the cut off length. The present exploitation rate E is much higher than E max; this value along with the high F value shows that this species is being heavily exploited and there is need for reducing the trawl effort.

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References

Beverton R.J.H and S.J. Holt 1957. *On the dynamics of the exploited fish populations.* Fishery Investigation Series, London 19: 533 pp.

Froese, R and C. Binohlan 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes with a simple method to evaluate length frequency data. *J. Fish Biol.*, 56: 758 -772.

Gayanilo, F.C Jr., M. Soriano, and D. Pauly

1988. A draft guide to COMPLETE ELEFAN. *ICLARM Software Project* 2: 65 pp.

Grace Mathew, M. Feroz Khan and K. Nandakumaran 1992. Present status of exploitation of fish and shell fish resources: Flatfishes and flatheads. *Bull. Cent. Mar. Fish. Res. Inst.*, 45: 197 -204.

Jayaprakash, A.A 1998. *Studies on the fishery, biology and population dynamics of flatfishes (Cynoglossus spp; Family Cynoglossidae) along Kerala coast.* Ph.D Thesis, University of Calicut. 307 pp.

Khan M.F and K. Nandakumaran 1993. Population dynamics of Malabar sole Cynoglossus macrostomus Norman along Calicut coast. *Indian J. Fish.*, 40 (4): 225-230.

Pauly, D. 1982. *Studying single –species dynamics in a tropical multispecies context. Theory and Management of Tropical Fisheries pp* 33 – 70. (Eds) Pauly, D and Murphy C.I, ICLARM, ISIRO.

Pauly, D. 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Paper,* 234:52 pp.

Seshappa, G. 1978. Some observations on the size distribution and the occurrence of growth rings in the scales of three species of *Cynoglossus* at Calicut. *Indian. J. Fish.*, 25 (1 & 2): 188-196.

Seshappa, G. 1974. Flatfish resources of west coast of India. *Proc. Sym. Liv. Res. Seas around India.* CMFRI Spec. Publ.: 470 - 482.

Seshappa, G. 1964. Length frequency studies on the Malabar sole *Cynoglossus semifasciatus* Day at West Hill, Calicut during the years 1959 -60 to 1962 -63. *Indian J. Fish.*, **11** (2): 533-546.

Seshappa, G and B.S. Bimachar 1955. Studies on the fishery and biology of Malabar sole *Cynoglossus semifasciatus* Day. *Indian J. Fish.*, 2 (1): 180 -230.

Seshappa, G and B.S. Bimachar 1954. Studies on the age and growth of the Malabar sole *Cynoglossus semifasciatus* Day. *Indian J. Fish.*, **1 (1 & 2)**: 145 -162.

Seshappa, G and B.S. Bimachar 1951. Age determination studies in fishes by means of scales with special reference to Malabar sole *Cynoglossus semifasciatus* Day. *Curr. Sci.*, 20: 260 -262.

Seshappa G and B.K. Chakrapani 1983. Length frequency distribution in *Cynoglossus semifasciatus* Day on the West Coast during 1980-81. *Indian. J. Fish.*, 30 (1): 74-86.

Victor A.C.C 1978. Length weight relationship in the Malabar sole, *Cynoglossus macrostomus* Norman. *Indian J. Fish.*, 25(1 & 2): 259 -262.

Vivekanandan, E., P.U. Zacharia, M. Feroz Khan and Rekha J. Nair. 2003. Flatfishes In: Mohan Joseph, M and Jayaprakash A.A (Eds.) *Status of Exploited Marine Fishery Resources of India,* CMFRI: 164 – 170.

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Note

First record of the Annular sole, *Synaptura annularis* (Fowler, 1933) (Pleuronectiformes: Soleidae) from India

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Abstract

The Annular sole, *Synaptura annularis* (Fowler, 1933) has been recorded for the first time from Indian waters. This fish is distinguished from other congeneric species occurring in this area (*S. commersoniana* and *S. albomaculata*) by the presence of large annular patches on the body and an unbranched pectoral fin. Comparitive statement with the holotype and paratype of the species are given.

During a routine deep-sea trawl operation for shrimps by private trawlers off Cochin, a soleid flatfish measuring 145.7 mm in total length, with annular patches on the body was caught by a fishing vessel in May 2001. The specimen was later identified as the Annular sole, *Synaptura annularis* (Fowler, 1933). This is the first record of the species from Indian waters.

Distribution: The species has been earlier recorded from China Sea (Fowler, 1933), Taiwan (Chen and Weng, 1935; Shen and Lee, 1981), Australia (Keith *et al*., 1985) and Japan (Gonzales *et al*., 1994).

Since the present specimen is from a new locality, descriptions, comments and figure are given herein. Measurements were taken after Norman (1934). Institutional abbreviations follow Leviton *et al*. (1981).

Synaptura annularis (Fowler, 1933). Annular sole

Brachirus annularis Fowler, 1933: 346, fig 99, China Sea, Vicinity of Formosa

Synaptura nebulosa Chen and Weng 1965: 76 –77, fig 52, Tungkong.

Synaptura annularis Shen and Lee, 1981: 35, fig 11, Taiwan.

Synaptura annularis Keith *et al*., 1985: 292 –293, N.W Australia.

Diagnosis: Description is based on a single specimen. An elongated sole with distinct brown annular patches with a dark black margin on fawn colour body, including six large and six small patches. (Fig.1). Fins dark brown on ocular and blind side with black on tips. Blind-side white in colour. In preserved specimen, body colour is light brown. Colour of annular patches remains the same. Pectoral fins small, with unbranched elements.

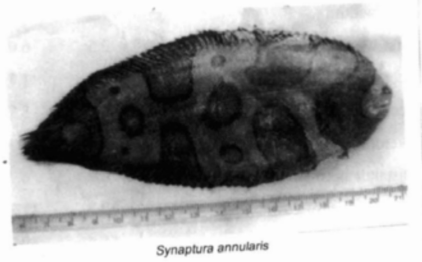

Fig. 1. *Synaptura annularis*

Description: D 76; A 56; P 9 on ocular side, 8 on blind side; V 5 on both sides; C13; LL 106; scales above lateral line (SAL) 33; scales below lateral line (SBL) 28; body depth 2.7 times in SL; head length 4.4 times in SL. Measurements are given to the nearest mm. Snout to lower orbit 8.65; snout to upper orbit 7.42; upper eye diameter 3.14, lower eye diameter 2.43; interorbital width 4.97; upper jaw 5.84 on ocular side, 7.53 on blind side; lower jaw 6.65 on ocular and 5.83 on blind side; pectoral fin (P) 11.2 on ocular, 11.35 on blind side; pelvic fin (V) 5.08 on ocular, 4.85 on blind side; longest dorsal fin ray 15.24; longest anal fin ray 9.9, longest caudal fin ray 12.6, longest pectoral fin ray on ocular side 4.61 and on blind side 4.20.

Eyes on the right side, separated by a wide scaly interorbital area with ctenoid scales in 9 rows. Upper eye slightly in advance of the lower. Anterior nostril is elongated, tubular, immediately above upper jaw, posterior nostril slit like, covered by a small tubular fleshy papilla

Table 1. *Comparision of samples of* S. annularis *recorded from different localities*

Author	Fowler (1933)		Chen and Weng (1965)	Shen and Lee (1981)		Keith *et al.* (1985)	Gonzales *et al.* (1994)	Present study (2003)
Locality	China Sea		Tungkong	Tungkong		Australia	Japan	India
Cat. No.	USNM 93095 holotype	USNM 93206 paratype	THUP 02768	NTUM 05173	THUP 02768	AMS 462014	BSKU 81384	CMFRI Reg. No. 1027
Body length (mm)	151	*	137 SL	139 SL	137 SL	130 TL	122 SL	145.7 TL 132.6 SL
Dorsal fin rays	70	*	71	70	71	*	70	76
Anal fin rays	57	*	59	57	59	*	57	56
Pectoral fin rays (O/B)	9/8	9/9	6/6	6/7	6/7	Short	9/10	9/8
Pelvic fin rays (O/B)	5/5	5/5	5/5	5/5	5/5	*	5/5	5/5
Caudal fin rays	*	*	18	18	18	*	18	13
Lateral line scales	104	105	85	85	89	*	100	106
Scales above LL (SAL)	29	*	*	*	*	*	32	33
Scales below LL (SBL)	37	*	*	*	*	*	35	28
Large annular patches	7	*	5	5	*	6-7	6	6

* data not available

in front of the lower eye. Four rows of fleshy papillae on the blind side, below the lower jaw, extending upto base of head and onto ocular side margin; they are white on the blind side and dark brown on ocular side. Lateral line straight on both sides.

Dorsal, anal and caudal fin rays branched. Opercular membrane joined to upper rays of pectoral fins to form a pocket. First and last elements of the pectoral fin on the ocular side are elongated to form small fleshy pointed lobes like horns. Pectoral fin on the blind side has 7 rays covered by a flap of white skin. Caudal fin rounded, confluent with dorsal and anal fins. Origin of pelvic fin on the ocular side is at junction of head and operculum. Five rays on pelvic fin joined by a flap of skin; pelvic fin on blind side slightly smaller than ocular. Fin bases scaled, all fin rays joined by flap of skin.

Scale: Scales on lateral line are tubular and in the interorbital region ctenoid, with 6 ctenii, central one being the longest.

Discussion

This species was first described by Fowler (1933) based on the specimens from Station D.5315, China Sea, vicinity of Formosa in 148 fathoms. In the original description, Fowler noted that this species has no pectoral fin on the left side; however in the present specimen, 9 pectoral fin rays are present on the ocular side and 8 on the blind side, covered by a flap of skin. Dr. Kunio Sasaki, who re-examined the holotype (USNM 93095) and one paratype (USSNM 93206) of *S. annularis*, noted 9 pectoral fin rays on the ocular side of both and 8 and 9 on the blind side of the holotype and paratype respectively (Gonzales *et al.*, 1994). The pectoral fin counts and pelvic fin counts of the present specimen of *S. annularis* agree well with that of the holotype and those by given by earlier authors (Table 1).

S. annularis is distinguished from other congeneric species occurring in this area (*S. commersoniana* and *S. albomaculata*) by the presence of large annular patches on the body and an unbranched pectoral fin. This specimen represents the first record of the annular sole from India. The specimen has been deposited in the Reference Museum of CMFRI. (CMFRI Reg. No. 1027)

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References

Chen, J.T.F and H.T.C Weng. 1965. *Tunghai Univ. Biol. Bull.*, 27: 76 – 77.

Fowler, H.W. 1933. *Proc. Acad. Nat. Sci. Philad.*, 85:233-367.

Gonzales, B.J., O. Okamura, K. Nakamura and H. Miyahara. 1994. *Japan. J.Ichthyol.*, 40 : 491 – 494.

Keith, S.J., P.J. Kailola and G.G Leyland. 1985. Continental shelf fishes of northern and northwestern Australia. *CSIRO Div. Res., Canberra, viii.* 375 pp.

Leviton, A.E., R.H Gibbs, Jr, E.Heal and C.E Dawson. 1985. *Copeia,* 1985: 802 – 832.

Norman, J.R. 1934. A systematic monograph of the flatfishes (Heterosomata). *Brit. Mus. Nat. Hist. London. viii,* 459 pp.

Shen, S.C and C.H Lee. 1981. *Bull. Inst. Zool. Academia Sinica,* 20: 29 – 39.

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Terms Used

Blind side	:	Ventral surface of fish with no eyes, facing down.
Interorbital	:	Situated or extended between the orbits of the eyes.
Meristic Characters	:	Meristic Pertains to those countable characters that occur in series (e.g. teeth, vertebrae, scales, fin rays, gill rakers, etc.).
Monophyletic	:	A group of related taxa is monophyletic if it consists of a common ancestor and all its descendants.
Ocular Side	:	Upper side on which eyes are present.
Opercle	:	Upper, posterior, and usually the largest bone of the operculum of a fish's "cheek" region.
Operculum	:	Pertaining to the gill cover; a complex of flat bones in cheek region comprised of opercle, interopercle, subopercle and preopercle bones.
Orbital	:	Referring to the orbit or eye
Palatine teeth	:	Teeth that originate on the palatine bones in the roof of the mouth
Papilla	:	Fleshy projection or protuberance
Postorbital	:	Situated behind (posterior to) the orbit
Premaxillae	:	Paired bones of upper jaw, usually bearing teeth and associated with paired maxillae.
Snout	:	Forward part of head, anterior to eye.
Terminal mouth	:	Located at termination of head or anterior tip of larva.

Abbreviations Used

16S rRNA	:	*16S ribosomal RNA*
A	:	Anal fin
BMNH	:	British Museum Natural History
C	:	Caudal fin
CA	:	Cluster analysis
CITES	:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMFRI	:	Central Marine Fisheries Research Institue
COI	:	Cytochrome Oxidase I
D	:	Dorsal fin
HL	:	Head length
ITS	:	Internal Transcribed Spacer
IUCN	:	International Union for Conservation of Nature
P_1	:	Pectoral fin (Ocular)
P_2	:	Pectoral fin (Blind)
RAG	:	Recombinase-Activating Gene
SL	:	Standard length
TL	:	Total length
V_1	:	Pelvic fin (Ocular)
V_2	:	Pelvic fin (Blind)
ZMB	:	Zoologisches Museum Berlin