MARINE BIOLOGICAL ASSOCIATION OF INDIA

MEMOIR III

GOAT FISHES (FAMILY MULLIDAE) OF THE INDIAN SEAS

BY

P. A. THOMAS

Central Marine Fisheries Research Institute, Mandapam Camp

1969

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FOREWORD

DETAILED accounts on the systematics, biology and fishery of economically important groups of fishes of the Indian region are very few. The first Memoir of the Association on the "Ribbon fishes of the family Trichiuridae of India" by Dr. P. S. B. R. James is the only one of its kind so far and the present one on the "Goatfishes of the family Mullidae of India" by Dr. P. A. Thomas could be considered as a companion volume to the above. Both the accounts are based on the investigations carried out by the respective authors while working as Research Scholars in the Central Marine Fisheries Research Institute, Mandapam Camp.

The present Memoir on goatfishes or red mullets as they are popularly called, is the most detailed account brought out so far on fishes of this family. They constitute a subsistence fishery of some importance and as such contribute to some extent to the economy of the fishing industry in the country. The Memoir therefore is of both basic and applied interest.

Dr. P. A. Thomas has done his best to make the account exhaustive and informative, basing it mainly on the detailed investigations carried out by him for over three years and, in addition, bringing together all the scattered information on goatfishes known from the Indian Seas. I wish to record my appreciation of his work in the completion of this Memoir. It is hoped that, as the earlier ones issued by the Association, this Memoir too will be of use to the biologists and fishery workers of this region.

CENTRAL MARINE FISHERIES
RESEARCH INSTITUTE,
MANDAPAM CAMP, INDIA

OCTOBER 1, 1969

S. JONES
President,
Marine Biological Association of India

PREFACE

THE goatfishes or red mullets of the family Mullidae, though constitute one of the groups of the food fishes of India of considerable regional importance, have drawn very little attention from fishery scientists. Apart from the systematic account of Day (1878) and few other works on the food of some of the species, the group remained practically a virgin field to study. Day himself expressed doubts about the validity of some of the species described by him and remarked on the need for a detailed study of the family. It is needless to emphasize, in a group like Mullidae, biological information including observations on the life history, habits and life colouration of the species are quite important to the taxonomic understanding of the family. In view of this, a comprehensive study of the group was taken up in 1963, at the suggestion of Dr. S. Jones, Director, Central Marine Fisheries Research Institute, Mandapam Camp. The present work, which is based on my thesis approved for the Degree of Doctor of Philosophy in Zoology of the University of Rajasthan, covers the taxonomy and osteology of species of Mullidae, biology of *U. tragula*, the common species in Palk Bay and Gulf of Mannar and aspects of fishery.

I wish to record my deep sense of gratitude and indebtedness to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, Mandapam Camp, under whose supervision the present investigation was carried out. I am grateful to him for suggesting this study and for the constant encouragement, very valuable suggestions, guidance and the great interest he has taken in my work. Above all he was a source of great inspiration. The statistical analyses of the data were done on the advice of Mr. S. K. Banerji, Senior Research Officer (Statistics) of this Institute and I take this opportunity to express my profound thanks to him. No words will be sufficient to express my thanks to Dr. E.G. Silas, Research Officer of this Institute. It was to him I turned for help whenever confronted with a problem and he has always been helpful in the preparation of this Memoir. The systematic portion is written under his special guidance. I sincerely acknowledge the help received in the statistical analysis of the data from Mr. Varughese Philipose and Mr. Varughese Jacob of the Fishery Survey Division of this Institute.

I record my sincere thanks to Dr. Ernest A. Lachner, Curator, Division of Fishes, Smitshonian Institution, U. S. National Museum, Washington for sending me the reprints of his goatfish papers and also for sending some specimens of goatfishes on loan from the collections of U. S. National Museum. I am also thankful to Dr. P. H. Greenwood, Head of Fish Section, British Museum (Natural History), London for sending a few specimens of *Mullus*, *Pseudupeneus* and *Upeneichthys* which enabled me to prepare a key for all the genera of Mullidae.

Dr. M. Blanc, Director, Museum National D'Histoire Naturelle, Zoologie (Reptiles et Poissons); Paris has kindly re-examined for me the type of *Upeneus taeniopterus* Cuvier and I express my thanks to him. Mr. F. H. Berry, Research Systematist (Fishes) of the U. S. Bureau of Commercial Fisheries, Miami, Florida, U. S. A., who was on a visit to this place, has kindly gone through the section on systematics and my thanks are due to him for the suggestions offered.

I extend my thanks to the Ministry of Education, Government of India New Delhi for awarding me a Senior Research Scholarship during the tenure of which the present investigation was conducted. It is my privilage to express my sincere thanks to all members of the staff of the Central Marine Fisheries Research Institute, Mandapam Camp who have been very kind and helpful in many ways throughout the period of this study.

I wish to express my sincere thanks to Dr. E. G. Silas for his efforts in getting this Memoir published. To him and to Messers M. Srinivasan and P. Parameswaran Pillai of the Central Marine Fisheries Research Institute my thanks are due for going through the proofs. I also thank the Mathrubhumi Printing and Publishing Company for the very prompt and efficient execution of this work.

CENTRAL MARINE FISHERIES
RESEARCH INSTITUTE,
MANDAPAM CAMP.
JUNE, 1968

P. A. THOMAS

CONTENTS

INTRODUCTION

Goatfishes or redmullets of the family Mullidae are widely distributed in the Indo-Pacific Region. Some of the species are of economic importance and form a minor fishery along the coast of India. However, our knowledge about the biology of these fishes as a whole is very meagre and only very little attention has been given to their study till recently. Kuthalingam (1955) gave a brief account of the food habits of *Upeneus indicus* (= *Parupeneus indicus*) from Madras coast and the same author (1956) discussed the food of a species said to be *Upeneus cinnabarinus* from the same area, the identity of which is doubtful. Rabindra Nath (1966) briefly mentioned the food items of *Upeneus vittatus* from Trivandrum coast.

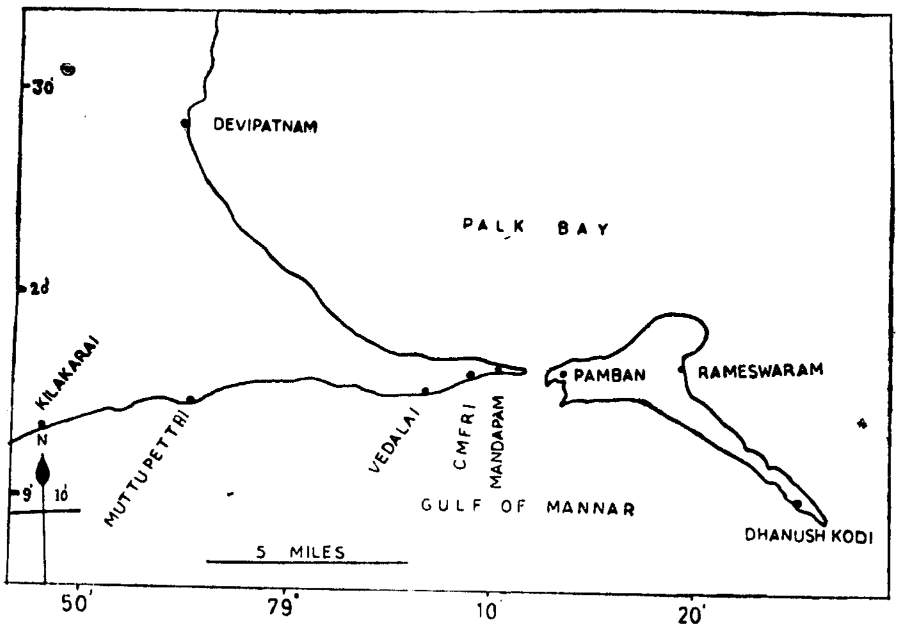
Sato (1937) studied the structure of barbels in *Upeneoides bensasi* (= *Upeneus bensasi*) from Japan. The anatomy and histology of the alimentary canal of *Mulloides auriflamma* (= *Mulloidichthys flavolineatus*) was studied by Al-Hussaini (1946) and the biology of the same species was studied by Laskaridis (1948) from the Mediterranean and Gottlieb (1953) from the coast of Israel. The biology of *Mullus barbatus* was studied by Ananiadis (1949) from the Aegean Sea and Wirszubski (1953) from the coast of Israel. Tham Ah Kow (1950) discussed the food of *U. sulphureus* and *U. sundaicus* from Singapore Straits and Gottlieb (1956) studied the age and growth of *Mullus barbatus* from the coast of Israel. The same author made observations on the age and growth of *U. moluccensis* (1957) from the same area. The development and distribution of larval and juvenile fishes of the family Mullidae of Western North Atlantic was studied by Caldwell (1962).

With a view to gaining more information about the biology of this group, the present work was initiated in September 1963. The major part of the work deals with the biology of *Upeneus tragula*, the common species along Palk Bay and Gulf of Mannar.

Apart from observations on the biology of this species, an account of the systematics of all the species occurring along the Indian coast and a comparative study of the osteology of 9 species, representing the three genera namely *Upeneus*, *Parupeneus* and *Mulloidichthys* are also given along with notes on their fishery. This account is thus divided into four parts namely, systematics, osteology, biology and fishery.

The first part deals with the taxonomy of 19 species, belonging to the three genera namely *Upeneus* Cuvier, *Parupeneus* Bleeker and *Mulloidichthys* Whitley, occurring in the Indian Seas. The other three genera of the family Mullidae viz., *Mullus* Linnaeus, *Upeneichthys* Bleeker and *Pseudupeneus* Bleeker, though not represented in the seas around India, also have been included in the key to the genera, based on the examination of 3 specimens of *Mullus barbatus*, 2 specimens of *Upeneichthys porosus* and 1 specimen of *Pseudupeneus prayensis*, obtained on loan from the British Museum (Natural History), London. The account of the species includes a complete list of synonyms, description and distribution. A key for the identification of the species, based on the material examined is also included. Apart from the 19 species collected from the coast of India, 5 more species, which, though not so far reported from the Indian coast, also have been included in the account as there are records of their presence in the Indian Ocean. The characters for these species have been taken from the works of Jenkins (1903), Barnard (1927), Lachner (1960) and Smith (1963). Notes on a few specimens each of *U. bensasi*, *U. vittatus*, *U. sulphureus*, *U. tragula* and *U. luzonius* collected from different areas of the Indo-Pacific region, obtained on loan from U. S. National Museum, Washington, have been included after the descriptive account of each species.

Part II deals with the comparative osteology of *U. tragula*, *P. indicus* and *M. flavolineatus* representing the three genera. The differences observed in the osteology of these three species have been further studied in three more species of *Upeneus* namely *U. vittatus*, *U. sulphureus* and *U. luzonius*, two more species of



Text-figure 1. Map showing important centres of collection along Palk Bay and Gulf of Mannar.

Parupeneus, namely *P. bifasciatus* and *P. macronemus* and one more species of *Mulloidichthys*, namely *M. samoensis*. Based on the degree of affinity or divergence observed between the osteology of these species the relationships between genera and within genus have been discussed. Osteology of all the species could not be studied due to lack of sufficient material.

Observations on the biology of *U. tragula* forms Part III of the present work. The important aspects discussed are food and feeding habits, length-weight relationship, relative condition factor, maturity, spawning, age and growth. For comparison the food and feeding habits of 3 other species namely *U. vittatus*, *U. luzonius* and *P. indicus* also have been studied. Populations of *U. tragula* from Palk Bay and Gulf of Mannar have been compared. Populations of 12 species of goatfishes collected from this area have been compared with the populations from different parts of the Indo-Pacific Region. For this purpose, the data published by Lachner (1954, 1960) have been utilised. In analysing the data on the various aspects of biology, standard statistical methods adopted by agricultural workers have been employed.

Part IV deals with the details of fishery of goatfishes along the Indian coast. The fishing methods, craft and tackle and fishing seasons with special reference to Palk Bay and Gulf of Mannar have been discussed. The details of the total marine fish production in India along with the total catch of goatfishes and their percentage in the total catch are also given.

Illustrations are given at relevant places. References pertaining to all sections have been given at the end.

The material for this study was collected mainly from fishing villages along Palk Bay and Gulf of Mannar in the vicinity of Mandapam (Fig. I). Samples were also collected from different centres along the east and west coasts of India, the Laccadive Sea and the Andaman Islands. A few specimens each of some of the species were obtained on loan from the U. S. National Museum, Washington and the British Museum (Natural History), London.

The relevant details of the material and methods used for each aspect of the study are described in the text under each section. The formulae used in the statistical analysis of the data are given in the appropriate places.

Part One

SYSTEMATICS

TAXONOMY OF THE INDIAN SPECIES OF MULLIDAE

DAY (1878) recorded fourteen species of goatfishes (Family Mullidae), six under the genus *Upeneoides* Bleeker, one species of *Mulloides* Bleeker and seven species of *Upeneus* Cuvier, from the seas around India.

Apart from the early account of Day (1878), no critical taxonomic study of this group is available from the Indian Region. Day himself expressed doubts about the validity of some of the species described by him and suggested that a detailed study of the group was necessary to assess the correct systematic position of the species.

Bleeker (1865) treated the genus *Upeneoides* that he had proposed in 1849 as a synonym of *Upeneus* Cuvier (1829) as restricted to a group of Mullidae characterised by the presence of teeth on vomer, palatines and in the form of villiform bands in both jaws. This essentially corresponds with the description of *Upeneus* by Cuvier (1829), "*Upeneus* des Indes a dents on velours aux deux machoires, au vomer et aux palatins". Those species with teeth in a single series on the jaws and with edentulous vomer and palatines, which were also placed under the genus *Upeneus* by Cuvier (in contrast to the description given above) and also referred to as *Upeneus* by Bleeker till 1865, have been given a new generic name, *Parupeneus* Bleeker (1868). Jordan and Evermann (1896) erroneously synonymised *Parupeneus* Bleeker with *Upeneus* Bleeker (as held by him till 1865), and they re-introduced the name *Upeneoides* Bleeker and substituted that name for the genus *Upeneus* Cuvier, as restricted above. The genus *Mulloides* Bleeker (1849) was replaced by *Mulloidichthys* Whitley (1929) as *Mulloides* Bleeker is preoccupied by *Mulloides* Richardson (1843). Thus the three genera of Mullidae reported by Day (1878) should be correctly referred to as follows:

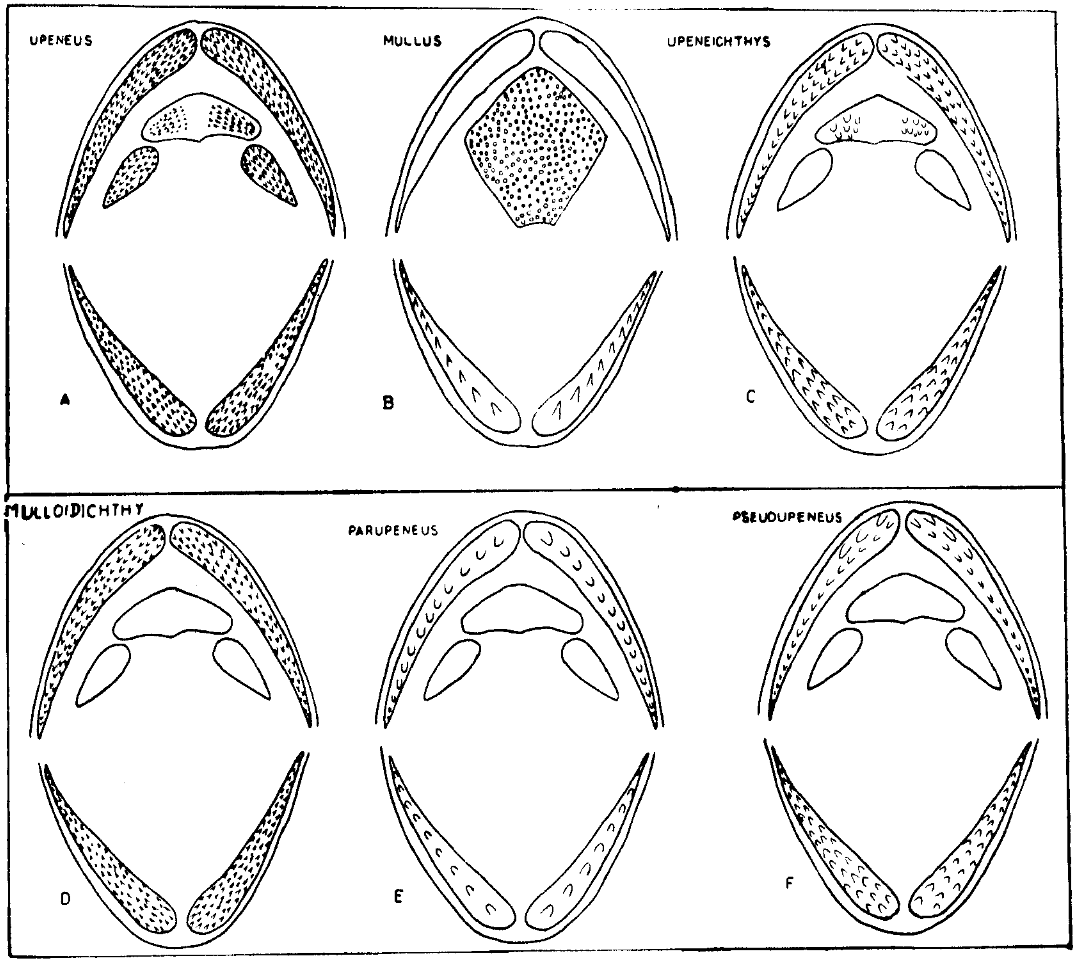
Day's genera	Current nomenclature
Upeneoides Bleeker (1849)	*Upeneus* Cuvier (1829)
Mulloides Bleeker (1849)	*Mulloidichthys* Whitley (1929)
Upeneus Cuvier (1829)	*Parupeneus* Bleeker (1868)

Regan (1913) in his classification of the percoid fishes placed the family Mullidae in the Order Percomorphi, Suborder Percoidea and Division Perciformes.

Jordan (1923) classified this family under the Order Percomorphi, Suborder Rhegnopteri and Series Kurtiformes. In classifying the Suborder Percoidei, Berg (1947) mainly followed Regan (1913) and included the family Mullidae in the Order Perciformes, Suborder Percoidei and Super-family Percoidae.

Family **Mullidae**

The goatfishes are characterised by the presence of a pair of barbels attached to the tip of the ceratohyal, behind the symphysis of the lower jaw. Teeth on jaws, uniserial or multiserial, present or absent on vomer and palatines; no incisors., canines or molars. Two short dorsal fins, remote from each other, the first with 7-8 spines, the first of which is very minute in many species; anal fin short with one or two spines; ventral fins with a single spine and five rays; pectorals usually short; caudal deeply forked. Body elongate and moderately compressed, covered with large scales; lateral line complete, sensory tubes branched. Branchiostegal rays 4; pseudobranchiae present. Opercle with a weak spine; pre-opercle entire or slightly serrated. Mouth subterminal, premaxillaries somewhat protractile. Maxillaries broad distally and mostly covered by the lacrymals; subocular shelf present. The lacrymal is excluded from the orbital margin. Occipital and parietal crests well developed. Scapula with two perforations. Vertebrae 24 (10+14). Most of the species are brilliantly coloured (hence also the popular name Redmullets).



Text-figure 2. Diagramatic representation of the dentition in (A) *Upeneus*, (B) *Mullus*, (C) *Upeneichthys*, (D) *Mulloidichthys*, (E) *Parupeneus*, and (F) *Pseudupeneus*.

The family Mullidae includes six genera of which only three, *Upeneus* Cuvier (1829), *Parupeneus* Bleeker (1868) and *Mulloidichthys* Whitley (1929) are represented in the seas around India. The other three genera, *Mullus* Linnaeus (1758), *Pseudupeneus* Bleeker (1862) and *Upeneichthys* Bleeker (1855), are found respectively, in the Atlantic, Eastern Pacific, and in the warmer waters of Australia, New Zealand and extending to Polynesia. The last three genera are also included in the key, but their identifying characters are based on the examination of material kindly lent by the British Museum (Natural History), London.

Key to the genera of Mullidae

1. Dentition complete, with villiform teeth on vomer, palatines and on both jaws in several rows (fig. 2A)............ *Upeneus* Cuvier
2. Dentition incomplete................ 3
3. Teeth absent on upper jaw; vomer and palatines form a broad palatal patch (fig. 2B)................ *Mullus* Linnaeus
4. Teeth present on upper Jaw; palatines edentulous, vomer with or without teeth.............. 5
5. A few blunt teeth on vomer (jaws with stout blunt teeth arranged in a single row laterally, and anteriorly in two or three rows, irregularly) (fig. 2C).............. *Upeneichthys* Bleeker
6. Vomer edentulous................ 7
7. Teeth on jaws villiform, in several rows (fig. 2D).................... *Mulloidichthys* Whitley
8. Teeth on jaws not villiform.............. 9
9. A single row of stout, blunt-tipped teeth on both jaws with wide interspaces (fig. 2E).............. *Parupeneus* Bleeker
10. Teeth on upper jaw in two rows anteriorly, the outer row with 1 to 3 teeth on each side, enlarged, curved and directed posteriorly; those on lower jaw in two or more rows, stout, blunt-tipped and widely spaced (fig. 2F)..........*Pseudupeneus* Bleeker

Genus **Upeneus** Cuvier (1829)

Upeneus Cuvier in Cuvier and Valenciennes, 1829, 448 (Genotype: *Mullus vittatus* Forskal, designated by Bleeker, 1876, 333).

Hypeneus Agassiz, 1846, 190 (Genotype: *Mullus vittatus* Forskal, corrected orthography).

Upeneoides Bleeker, 1849, 64 (Genotype: *Mullus vittatus* Forskal) (designated by Jordan, 1919, 240).

Diagnosis

Dentition complete with teeth in several rows on both jaws, in the form of a triangular patch on vomer and in the form of an elongated band on palatines. Scales ctenoid, present on head up to nostrils, present or absent on preorbitals, and present on soft dorsal, anal and caudal fins. Lateral line complete. Caudal with dark or brown oblique bars in many species. Genotype: *Mullus vittatus* Forskal designated by Bleeker, 1876.

Distribution

Tropical and subtropical Indo-Pacific and Western Atlantic. In his revision of the genus *Upeneus* Cuvier, Lachner (1954) recognised only 10 species including two new species:

1. *Upeneus bensasi* (Temminck and Schlegel)
2. *U. asymmetricus* Lachner
3. *U. parvus* Poey
4. *U. sulphureus* Cuvier
5. *U. moluccensis* (Bleeker)
6. *U. vittatus* (Forskal)
7. *U. arge* Jordan and Evermann
8. *U. luzonius* Jordan and Seale
9. *U. tragula* Richardson
10. *U. oligospilus* Lachner

Lachner (1954) considered two species, *Upeneoides sundaicus* Bleeker (1855) and *Upeneus taeniopterus* Cuvier (1829), as of doubtful status. The present study shows *Upeneus sundaicus* (Bleeker) to be a valid species (see discussion under *U. sundaicus*). *U. taeniopterus* is known only from the type specimen. Day (1878, p. 122) described the type kept in Jardin des plantes at Paris. Fowler (1928, p. 227 and 1933, p. 327) followed Day (1878). Munro (1955,p. 163) listed it from Ceylon but did not give an illustration.

The type of *Upeneus taeniopterus* has been kindly re-examined for me by Dr. M. Blanc of the Museum National D' Histoire Naturelle, Paris and informed that though the specimen is in a very bad condition, the following characters could be observed:

1. The number of spines on the first dorsal seems to be 7.
2. Number of gillrakers on the anterior gill arch 22 (7+15).
3. A band of small villiform teeth on jaws and some analogous teeth on vomer and palatines.
4. Both lobes of caudal fin with some clear bands though their design is partly obliterated.

The only other species of *Upeneus* with 7 spines in the first dorsal is *U. bensasi* (Temminck and Schlegel). But it differs from *U. taeniopterus* in having only the upper lobe of caudal fin with oblique bars. As such an intensive collection from this area and study is necessary before making any conclusion about this species. Therefore it has not been included in the present account.

Thus the number of species of *Upeneus* considered to be valid in the present study is only 11, including the 10 species recognised by Lachner (1954) and *U. sundaicus* (Bleeker). Out of these 11 species, *U. parvus* is an Atlantic form and *U. asymmetricus* has not so far been recorded from other areas except the type locality (Philippines). The remaining species have been recorded from the Indian Ocean. Out of the 9 species recorded from the Indian Ocean, *U. moluccensis* (Bleeker) could not be collected in the present study.

Upeneoides fasciolatus Day (1868, type locality: Madras) and *U. sulphureus* Day (1876, in part) were considered to be synonyms of *U. moluccensis* by Fowler (1933) and Lachner (1954). There is no subsequent record of this species from the coast of India. But Fourmanior and Crosnier (1963) have reported it from Mozambique Channel. Therefore this species is also included in the present account, the description of which is based on the characters given by Lachner (1954). The characters for the other species are based only on the specimens examined in the present study.

Key to the species of the genus *Upeneus* Cuvier

1. First dorsal with 7 spines, first spine longest (Plate I, fig. A).......... *Upeneus bensasi* (Temminck and Schlegel)
2. First dorsal with 8 spines, first spine minute (Plate I, fig. B)..........3
3. Preorbital scales absent 5
4. Preorbital scales present 11
5. Dusky oblique bars on caudal fin absent..........*U. sulphureus* Cuvier
6. Dusky oblique bars on caudal fin present 7
7. Caudal fin with 3 to 4 dusky oblique bars on upper lobe, lower lobe without bars..........*U. moluccensis* (Bleeker)
8. Caudal fin with dusky oblique bars on both lobes 9
9. Gillrakers 22-24 (peritoneum transparent)..*U. arge* Jordan and Evermann
10. Gillrakers 26-31 (peritoneum dark brown)........*U. vittatus* (Forskal)
11. Lateral line scales 30-32 13
12. Lateral line scales 33-34 15
13. Head length distinctly greater than caudal length (head and body with dense brown to black blotches, 2 to 3 dark brown oblique bars on both dorsal fins and 2 to 7 large irregular blotches of the same colour on caudal fin)......*U. tragula* Richardson
14. Head length almost equal to caudal length (diffused black spots on scales along body, both dorsal fins with a brown to blackish tip and with 2 narrow oblique bars of vermilion, caudal with 2 to 4 uniformly narrow oblique bars on each lobe) ....*U. oligospilus* Lachner
15. Caudal with 2-7 dusky oblique bars on each lobe, those on lower lobe more prominent ....*U. luzonius* Jordan and Seale
16. Caudal with 4-5 brownish oblique bars on upper lobe, lower lobe devoid of bars but with a violet or dark tinge along the inner margin ....*U. sundaicus* (Bleeker)

Upeneus bensasi (Temminck and Schlegel)
(Plate I, fig. B)

Mullus bensasi Temminck and Schlegel, 1843, 30, pl. 11, fig. 2 (Type locality: Bay of Nagasaki); Boeseman, 1947, 43 (Japan).

Upeneoides bensasi Bleeker, 1853, 10 (Japan); 1854, 71 (Nagasaki); 1858, 5 (Japan); 1859, 2 (Nagasaki); Gunther, 1859, 399 (compiled); Bleeker, 1860, 235 (Nagasaki); Gunther, 1880, 63 (Yokohama, Kobe); Karoli, 1881, 156 (Kobe, Nagasaki); Ishikawa and Matsuura, 1897, 54; Rutter, 1897, 71 (Swatow); Pellegrin, 1905, 84 (Baie 'd Along, Tonkin); Snyder, 1912, 416, 503 (Misaki, Schimizu, Kagoshima, Okinawa); Jordan, Tanaka and Snyder, 1913, 181, fig. 132 (Japan); Fowler and Bean 1922, art, 2: 43 (Takao); Jordan and Hubbs, 1925, 245 (Shizuoka, Kobe, Wakanoura, Toba, Tatoku, Kagoshima, Mikawa Bay, Toyama, Misaki, Fukui, Noo, Miyazu); Fowler, 1927, 285 (Orani, Orion); Schmidt and Lindberg, 1930, 1140 (Tsuruga); Sowerby, 1930, 195 (Fusan); Schmidt, 1931, 75 (Nagasaki).

Upeneoides guttatus Day, 1867, 938 (Type locality: Madras).

Upeneus bensasi Bleeker, 1873, 118 (China); Snyder, 1907, 97, fig. 3 (Wakanoura, Tokyo, Nagasaki); Steindachner, 1907, 137 (Gischin, South Arabia); Franz, 1910, 48 (Yokohama, Aburatzubu); Seale, 1914, 68 (Hong Kong); Jordan and Richardson, 1914, 259 (Misaki); Barnard, 1927, 584 (Delagoa Bay); Schmidt, 1931, 112 (Nagasaki), Fowler, 1933, 321, fig. 27 (Arabia, East Africa, India, Philippines, Indo-China, China, Formosa, Riu Kiu, Japan); Smith, 1949, 229, pl. 27; fig. 562 (Africa); Lachner, 1954, 509, pl. 13, fig. A (Japan, Formosa, Philippines).

Upeneoides japonicus (*nec* Houttuyn) Steindachner and Doderlein, 1884, 22 (Type locality: Tokyo, Kochi, Tango, Japan); Nystrom, 1887, 16 (Nagasaki); Jordan and Snyder, 1900, 358 (Japan); 1901, 83 (in part).

Upeneoides tokisensis Doderlein, in Steindachner and Doderlein, 1884, 22 (name in synonymy) (Japan).

Material examined

17 specimens, 90-152 mm. in total length from Mandapam (Gulf of Mannar).

Diagnosis

D. VII - 1, 8; P_1. 13 - 15 (Table I); L. l. 30 - 32 (Table II); L. tr. 3/7. Number of gillrakers on the upper and lower limbs 6 - 7/16 - 18 (Table III), total number 22 - 25 (Table IV). The frequency of occurrence and mean of the counts are given in the tables referred. Length of head 3.8 to 4.5, of caudal 4.5 to 5.0, greatest depth of body 5.0 to 5.6, all in total length. Diameter of eye 3.7 to 4.8 times and length of barbel 54 to 67 per cent of length of head.

Preorbital scales present. Interorbital space nearly flat, its width equal to or slightly higher than eye diameter. First dorsal spine the longest, reaching beyond the tips of all other spines when depressed. Peritoneum brown or blackish. Orange red or yellow on head and body and light brown below at belly. The dorsal fins with 3 or 4 reddish brown oblique bars each, one at base, one or two along middle and the last at tip. Four to five oblique bars of same colour on upper lobe of caudal fin. The lower lobe reddish but without any oblique bars. Other fins yellowish. In preserved material the bars on fins and colour of body disappear, leaving the fins clear and body dusky above and pale yellow at belly.

TABLE I

NUMBER OF PECTORAL FIN RAYS IN EIGHT SPECIES OF *UPENEUS*

Species	No. of specimens	Number of pectoral fin rays						Mean
		13	14	15	16	17	18	
U. bensasi	17	2	13	2	..	..	..	14.00
U. sulphureus	50	..	..	10	36	4	..	15.88
U. vittatus	100	..	..	3	37	59	1	16.58
U. arge	4	1	3	..	..	..	..	13.70
U. tragula	120	101	19	..	..	..	..	13.15
U. oligospilus	80	13	67	..	..	..	..	13.84
U. luzonius	42	..	36	6	..	..	..	14.14
U. sundaicus	40	..	26	14	..	..	..	14.30

TABLE II

RANGE OF VARIATIONS IN THE NUMBER OF LATERAL LINE SCALES IN EIGHT SPECIES OF *UPENEUS*

Species	No. of speci-mens	30	31	32	33	34	35	36	37	38	39	40	Mean
U. bensasi	17	2	10	5	..	..	..	..	..	..	..	..	31.18
U. sulphureus	75	..	..	..	..	..	9	47	19	..	..	..	36.13
U. vittatus	90	..	..	..	..	..	39	27	16	8	..	..	35.92
U. arge	4	..	..	..	..	..	..	..	..	1	2	1	39.00
U. tragula	100	21	45	34	..	..	..	..	..	..	..	..	31.13
U. oligospilus	70	..	42	28	..	..	..	..	..	..	..	..	31.40
U. luzonius	42	..	..	..	11	31	..	..	..	..	..	..	33.74
U. sundaicus	40	..	..	..	14	26	..	..	..	..	..	..	33.60

TABLE III

NUMBER OF GILLRAKERS IN THE UPPER AND LOWER LIMBS IN EIGHT SPECIES OF *UPENEUS*

Species	Upper limb					Lower limb									
	5	6	7	8	9	13	14	15	16	17	18	19	20	21	22
U. bensasi	..	10	7	..	..	..	..	..	6	9	2	..	..	..	..
U. sulphureus	..	..	6	27	17	..	..	..	..	..	10	12	11	14	3
U. vittatus	..	..	4	45	11	..	..	..	..	..	..	7	16	33	4
U. arge	2	2	..	..	..	..	..	..	..	3	1	..	..	..	..
U. tragula	20	54	26	..	..	..	..	18	61	18	3	..	..	..	..
U. oligospilus	10	61	9	..	..	2	20	38	16	4	..	..	..	..	..
U. luzonius	18	24	..	..	..	4	26	10	2	..	..	..	..	..	..
U. sundaicus	16	24	..	..	..	8	9	19	4	..	..	..	..	..	..

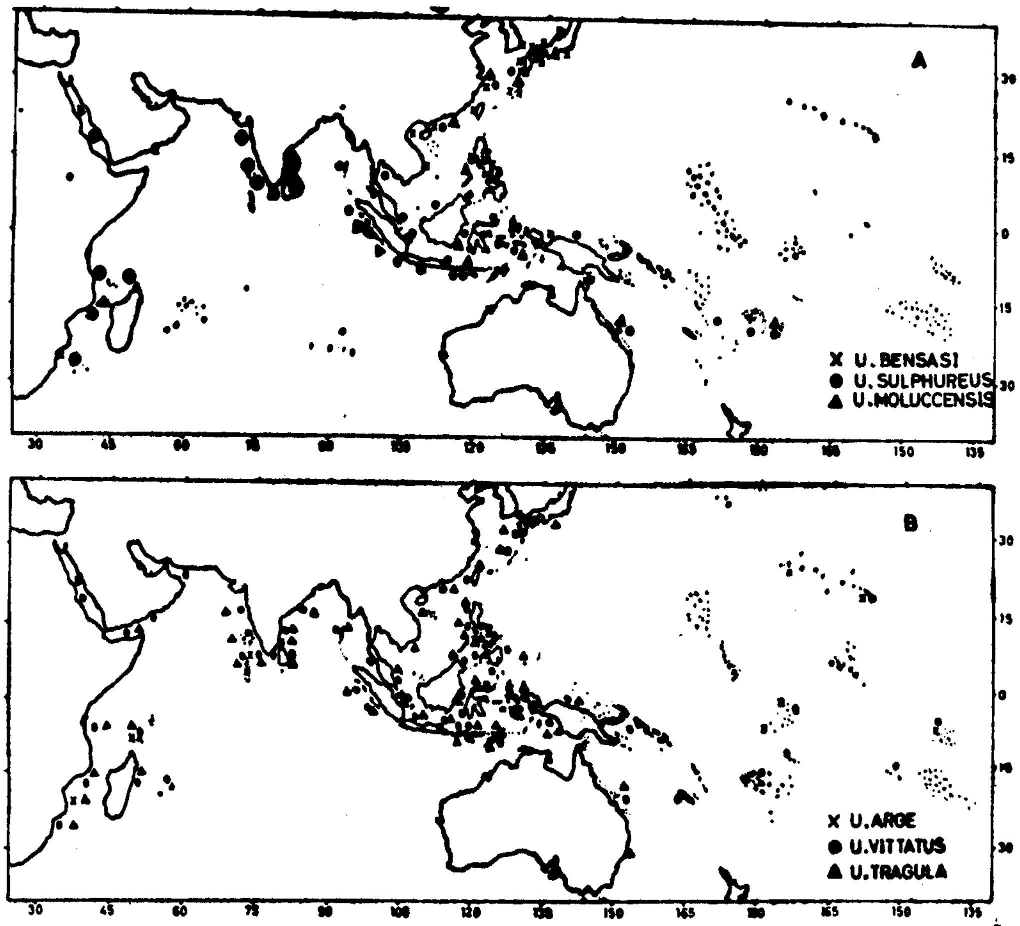
TABLE IV

TOTAL NUMBER OF GILLRAKERS IN EIGHT SPECIES OF *UPENEUS*

Species	No. of speci-mens	Number of Gillrakers														Mean
		18	19	20	21	22	23	24	25	26	27	28	29	30	31	
U. bensasi	17	..	..	..	..	6	4	5	2	..	..	..	..	..	..	23.18
U. sulphureus	50	..	..	..	..	..	..	..	2	4	16	11	8	6	3	27.98
U. vittatus	60	..	..	..	..	..	..	..	..	2	7	14	24	11	2	28.68
U. arge	4	..	..	..	..	2	1	1	..	..	..	..	..	..	..	22.75
U. tragula	100	..	..	10	18	35	27	7	3	..	..	..	..	..	..	22.12
U. oligospilus	80	..	7	20	28	21	4	..	..	..	..	..	..	..	..	20.94
U. luzonius	42	4	14	12	10	2	..	..	..	..	..	..	..	..	..	19.81
U. sundaicus	40	2	10	15	9	4	..	..	..	..	..	..	..	..	..	20.01

General Distribution (fig. 3, A)

East coast of Africa, Seas of India eastward through Indonesia, Philippines and northward to Formosa, East China, Riu Kiu Islands and southern Japan.



Text-figure 3. World distribution of *U. bensasi*, *U. sulphureus*, *U. moluccensis* (fig. 3 A); *U. arge*, *U. vittatus* and *U. tragula* (fig. 3 B).

Remarks

The material examined generally agrees with the descriptions and figures given by Snyder (1907, page 97, fig. 3) and Lachner (1954, page 509, Pl. 13, fig. A) for the specimens from Japan and Philippines respectively. Examination of two specimens from Bulan (U.S.N.M. collection) also did not reveal any difference from the specimens of this area (Table V). A comparison of the range given by various authors for the lateral line scales and gillrakers (Table VI and VII) also showed no significant differences. However, the range of gillrakers (22-25) is slightly lower than the range of 23-27 given by Lachner (1954).

The number of spines in the first dorsal fin varies from 6-8 according to Smith (1949) and 5-8 according to Fowler (1933). Moreover, Smith (1949) and Day (1878, pl. 30, fig. 5) have shown 5 and 4 oblique bars each on the upper and lower lobes of the caudal fin respectively. In *U. bensasi*, only the upper lobe of caudal is marked with oblique bars and these differences led Lachner (1954, page 510) to remark that "In the Western Indo-Pacific (East Africa, India) this species (*U. bensasi*) may be represented by another form entirely distinct from that of the Philippine-Japan area". But the 17 specimens collected from Gulf of Mannar did not show any significant difference from the descriptions given by Snyder (1907) and Lachner (1954) for the specimens from Japan and Philippines. However, the contention of Lachner (1954) that Day's account "may include or represent an undescribed species" is found to be correct, as *U. bensasi* of Day (1878) is considered to be a synonym of *U. sundaicus* (Bleeker) (see discussion under *U. sundaicus*) in the present study, which was considered to be of doubtful status by Lachner (1954, page 507).

TABLE V

MERISTIC COUNTS AND MORPHOMETRIC PROPORTIONS OF TWO SPECIMENS OF *UPENEUS BENSASI* FROM THE U. S. NATIONAL MUSEUM

No.	Date of collection	Locality	T.L.	T.L./H.L.	T.L./C.L.	T.L./Depth	H.L./E.D.	H.L./Sn.L.	Sn.L./E.D.	L.B.	No. P_1 rays	No. L.1.
U.S.N.M. 126412	1903	Bulan	108	4.0	5.3	5.0	3.8	2.7	1.4	63%	14	30
U.S.N.M. 56122	1903	Bulan	109	4.3	5.2	5.0	3.5	2.5	1.4	73%	14	31

TABLE VI

NUMBER OF LATERAL LINE SCALES IN EIGHT SPECIES OF *UPENEUS* ACCORDING TO DIFFERENT AUTHORS

Authors: Species	Present account	Gunther 1859	Day 1878	Herre and Montalban 1928	Weber and de Beaufort 1931	Fowler 1933	Smith 1949	Lachner 1954	Munro 1955
U. bensasi	30—32	30	..	..	..	28—29+2—3	28—33	29—31	..
U. sulphureus	35—37	38	35—38	35	34—36+2	32—35+2—5	33—37	34—37	33—37
U. vittatus	35—38	39	38—39	35	35—36	32—34+3—4	33—38	33—37	33—38
U. arge	38—40	..	..	..	..	38—39+ 3	..	37—38	..
U. tragula	30—32	30	30—32	31	30 + 2	30—32+ 2	30—32	28—32	30—32
U. oligospilus	31—32	..	..	..	..	..	..	29—31	..
U. luzonius	33—34	..	..	..	32—34	32—33+2—3	..	31—32	..
U. sundaicus	33—34	34—35	..	32—35	33—35	38	..	..	..

TABLE VII

TOTAL NUMBER OF GILLRAKERS IN EIGHT SPECIES OF *UPENEUS* ACCORDING TO DIFFERENT AUTHORS

Authors: Species	Present account	Herre and Montalban 1928	Weber and de Beaufort 1931*	Fowler 1933	Smith 1949*	Lachner 1954	Munro 1955*
U. bensasi	22—25	..	..	8/17	16—18	23—27	..
U. sulphureus	25—31	8—9/20—21	19—20	8—10/19—22	19—22	26—32	19—22
U. vittatus	26—31	7—8/17—20	12+ 5	6—8/16—20	16—20	26—31	16—20
U. arge	22—24	..	..	5/17	..	21—24	..
U. tragula	20—25	6/16—17	11—12+ some rudiments	4—7/16—18	16—18	21—25	16—18
U. oligospilus	19—23	..	..	..	..	20—23	..
U. luzonius	18—22	5—6/15	5—6/15	5/14	..	19—22	..
U. sundaicus	18—22	..	13+ 3	..	..	..	..

* Represent the number of gillrakers in the lower limb only.

Upeneus sulphureus Cuvier
(Pl. II, fig. A)

Upeneus sulphureus Cuvier in Cuvier and Valenciennes, 1829, 450 (Type locality: Anjer Straits of Sunda); Bleeker, 1875, 4 (Java, Madura, Bali, Sumatra, Singapore, Bintang, Bangka, Celebes, Sumbawa, Buru, Amboina, Waigiu); 1877, 393, fig. 4; Jordan and Seale, 1906 (1907), 26 (Cavite); Snyder, 1907, 99 (Samoa); Kendall and Goldsborough, 1911, 293 (Suva-Fiji Island) Weber, 1913, 293 (Lombok, Bima, Macassar); Jordan, Tanaka and Snyder, 1913, 183 (Japan); Hora, 1924, 487 (India); Weber and de Beaufort, 1931, 364 (Indo-Pacific); Fowler, 1933, 330, fig. 30 (Red Sea, India, Pinang, East Indies, Philippines, China, Japan, Melanesia, Polynesia); 1949, 95 (reference); Smith, 1949, 229, pl. 28, fig. 563 (Africa); Lachner, 1954, 513, pl. 13, fig. C) (Zanzibar, East Indies, Philippines, China, Okinawa, Fiji Islands, Suva); Munro, 1955, 163, pl. 32, fig. 479 (Ceylon); Lachner, 1960, 4, pl. 75, fig. A (East Africa through East Indies, Philippines, Fiji and New Hebrides); Smith and Smith 1963, 22, pl. 17, fig. D (Seychelles); Robert, William, Fehlmann and Vyvien, 1963, 190 (Thailand); Marshall, 1964, 253 (Queensland).

Upeneus bivittatus Valenciennes in Cuvier and Valenciennes, 1831, 520 (Type locality: Coromandel).

Mullus subvittatus Temminck and Schlegel, 1843, 30 (Type locality: Japan).

Upeneoides sulphureus Bleeker, 1849, 63 (Type locality: Java); Gunther, 1859, 398 (Red Sea, Amboina, China, New Hebrides); Day, 1878, 120, pl. 30, fig. 3 (Seas of India to the Malay Archipelago); Karoli, 1881, 156 (Yokohama); Steindachner and Doderlein, 1884, 23 (Nagasaki); Meyer, 1885, 16 (Manado, Celebes); Nystrom, 1887, 16 (Nagasaki); Day, 1889, 25 (Seas of India to the Malay Archipelago); Sauvage, 1891, 217, pl. 27, fig. 1 (Anjer); Elera, 1895, 479 (Manila Bay); Jordan and Snyder, 1901, 84 (Nagasaki); Jordan and Richardson, 1907 (1908), 260 (Manila); Seale, 1910, 279 (Sandakan, Borneo); Snyder, 1912, 416 (Kagoshima); Hase, 1914, 259, fig. 2 (Dentition) fig. 3 (Spinous dorsal) (Tami, Kaiser Wilhelms Land, New Guinea); Seale, 1914, 68 (Hong Kong); Pearson, 1918, P. F. 16 (1915-1918) (Ceylon); Vinciguerra, 1926, 571 (Sarawak); Herre and Montalban, 1928, 103, pl. 3, fig. 1 (Philippines); Fowler, 1928, 115 (Bombay); 1928, 227 (after Day); 1929 (1930), 648 (Padang; types of *Upeneoides belaque);* Herre and Myers, 1937, 30 (Muar, Johore, Singapore, Sumatra coasts).

Upeneoides bivittatus Bleeker, 1849, 64 (part); Day, 1867, 702 (Madras).

Upeneoides sulfureus Kner, 1865, 67 (Type locality: Java); Martens, 1876, 387 (Manila); Fowler, 1904, 530 (Padang); Duncker and Mohr, 1931, 66 (Rein Bay, north coast New Pomerania).

Mulloides pinnivittatus Steindachner, 1870, 624 (Type locality: Nagasaki).

Upeneus sulphurus Evermann and Seale, 1906 (1907), 88 (Error, San Fabian).

Upeneoides belaque Fowler, 1918a, 40, fig. 16 (Type locality: Philippines).

Upeneoides vittatus Fowler, 1925, 246 (Type locality: Delagoa Bay).

Material examined

Number of specimens	Size range in mm.	Locality
15	70—158	Rameswaram
12	83—146	Dhanushkodi
16	85—125	Tuticorin
10	110—175	Andaman Islands
12	90—149	Calicut
10	91—128	Bombay

Diagnosis

D. VIII-1, 8; P_1. 15-17 (Table I); L.1. 35-37 (Table II); L.tr. 3/7. Number of gillrakers on the upper and lower limbs of first arch 7-9/18-22 (Table III), total 25-31 (Table IV). Length of head 3.8 to 4.6; of caudal 4.2 to 4.7; greatest depth of body 4.0 to 4.6 in total length. Diameter of eye 3.2 to 4.2 in head length (Table VIII) and length of barbels 46-88 percent in head (Table IX).

Preorbital scales absent. Interorbital space flat. Maxilla extending to below anterior 1/3 of the orbit. Peritoneum dark to blackish brown. Head and body golden yellow and yellowish white at belly. Dorsal fins with 3 black oblique bars with clear white interspaces, the first bar at the base, second through middle and third at tip. Caudal with a black tinge along the margin in some specimens. Other fins without any colour bars. Three to five lemon yellow longitudinal stripes from eye to base of caudal fins three above lateral line and the rest below and parallel to it. These longitudinal stripes are not traceable in preserved material.

General distribution (fig. 3, A)

Red Sea, East Africa, Seas of India eastward through East Indies, Philippines, Fiji Islands, New Hebrides and northward to Japan.

TABLE VIII

RELATION BETWEEN HEAD LENGTH AND EYE DIAMETER IN *U. SULPHUREUS* ACCORDING TO SIZE GROUPS

Total length mm.	Head length/Eye diameter										
	3·2	3·3	3·4	3·5	3·6	3·7	3·8	3·9	4·0	4·1	4·2
70—80	..	..	..	1	2	1	..	..	..	..	..
81—90	..	1	..	..	..	..	2	..	..	..	..
91—100	..	1	..	2	2	..	1	..	..	..	..
101—110	1	..	5	3	..	1	2	..	..	..	..
111—120	1	..	..	1	..	4	1	..	1	..	..
121—130	..	..	..	1	1	1	..	..	1	..	..
131—140	..	1	1	1	1	..	..	..	..	..	..
141—150	1	1	1	..	2	..	..	..	..	..	..
above 150	..	..	..	..	..	2	1	..	..	..	1

TABLE IX

BARBEL LENGTH IN PER CENT OF HEAD LENGTH IN *U. SULPHUREUS* ACCORDING TO SIZE GROUPS

Total length mm.	Barbel length in per cent of head length										
	46-49	50-53	54-57	58-61	62-65	66-69	70-73	74-77	78-81	82-85	86-88
70—80	1	1	2	..	..	..	..	..	..	..	..
81—90	..	1	1	1	..	..	..	..	..	..	..
91—100	2	..	3	1	..	..	..	..	..	..	..
101—110	..	2	8	2	..	..	..	..	..	..	..
111—120	..	2	3	1	1	1	..	..	..	..	..
121—130	..	..	..	..	2	1	1	..	..	..	..
131—140	..	..	..	..	1	2	1	..	..	..	..
141—150	..	..	..	..	..	1	..	..	2	1	1
Above 150	..	..	..	..	1	1	2	..	..	..	..

TABLE X

MERISTIC COUNTS AND MORPHOMETRIC PROPORTIONS OF FOUR SPECIMENS OF *U. SULPHUREUS* FROM THE U. S. NATIONAL MUSEUM

No.	Date of collection	Locality	Total length mm.	No. of P_1 rays	No. of L. I.	T. L. / H.L.	T. L. / C.L.	T. L. / Depth	H. L. / E. D.	H. L. / Sn. L.	Bl. in % of H. L.
U.S.N.M. 145207	May, 23, 1908	Mindanao	112	16	37	4·3	5·0	4·8	3·7	2·6	73·0
-do-	-do-	-do-	115	16	37	4·4	4·7	4·3	3·7	2·6	76·0
-do-	-do-	-do-	117	16	37	4·3	4·7	4·6	3·3	2·7	77·7
-do-	-do-	-do-	141	16	37	4·2	4·6	4·4	3·3	2·4	81·00

TABLE XI

MERISTIC COUNTS AND MORPHOMETRIC CHARACTERS OF FIVE SPECIMENS OF *UPENEUS VITTATUS* FROM THE U. S. NATIONAL MUSEUM

No.	Date of collection	Locality	Total length mm.	No. of L. I.	No. of P_1 rays	T. L. / H. L.	T. L. / C. L.	T. L. / Depth	H. L. / E. D.	H. L. / Sn.L.	Sn. L. / E. D.	L. Bl. in % H. L.
U.S.N.M.19956		Mauritius	183	36	..	4·1	4·8	5·0	4.0	2·4	1·6	64·0
U.S.N.M. 145269	May 23, 1908	Mindanao	120	35	16	4·4	4·8	5·0	3·8	2·7	1·4	56·1
-do-	-do-	-do-	122	37	16	4·3	4·3	4·5	3·5	2·5	1·3	57·1
-do-	-do-	-do-	116	35	17	4·4	5·0	5·2	3·7	2·6	1·4	61·5
-do-	-do-	-do-	113	36	16	4·5	4·9	4·9	3·5	2·7	1·2	60·0

Remarks

A comparison of the counts of lateral line scales given by various authors are presented in Table VI. The differences noticed are evidently due to the different methods employed in counting, for example Weber and de Beaufort (1931) and Fowler (1933) have given separately those scales at the base of caudal fin, and when this is added to the range given, it agrees generally with the range given by other authors. The same was observed in the counts of gillrakers (Table VII). Herre and Montalban (1928) and Fowler (1933) have given the range for the upper and lower limbs separately while Weber and de Beaufort (1931), Smith (1949) and Munro (1955) have given the range only for the lower limb. Lachner (1954) has given both the total as well as the range for the upper and lower limbs. In the present study also the total range is given in Table IV and the range separately for the upper and lower limbs are given in Table III. A comparison of ranges given by various authors (Table VII) shows a general agreement in the number of gillrakers.

Barbel length varies considerably with growth. In smaller specimens (up to 100 mm.) the barbel length varies from 40 to 60 per cent of head length and in those above 100 mm. the range varies from 53 to 88 per cent (Table IX). However, no such difference was observed in the ratio of diameter of eye and head length associated with growth (Table VIII).

Four specimens from Mindanao, in the collection of the U. S. National Museum were examined and the meristic counts and morphometric proportions are given in Table X.

Upeneus moluccensis (*Bleeker*)

Upeneoides moluccensis Bleeker, 1855, 409 (Type locality: Amboina); Seale, 1914, 68, pl. 392, fig. 1 (Hong Kong); Herre and Montalban, 1928, 101, pl. 6, fig. 1.

Upeneoides dubius Kner, 1865, 67 (Australia).

Upeneoides fasciolatus Day, 1868a, 151 (Type locality: Madras).

Upeneoides sulphureus Day, 1878, 120 (part).

Upeneus moluccensis Bleeker, 1877, pl. (2) 392, fig. 1; Weber and de Beaufort, 1931, 367 (Nias, Sumatra, Sumbawa, Celebes, Ambon, Southern China, Philippines); Fowler, 1933, 328, fig. 29 (East Indies, Philippines, Indo-China, China, Queensland); Lachner, 1954, 514, pl. 13, fig. D (from India eastward through East Indies, Philippines and possibly Oceania (Samoan Islands); Japan (Kagoshima) Southward to Australia); Fowler and Steinitz, 1956, 277 (Turkey, Kosswig); Fourmanoir and Crosnier, 1963, 15 (Mozambique Channel); Ben-Tuvia, 1966, 265 (Mediterranean coast of Israel, Red Sea).

Diagnosis (after Lachner, 1954)

D. VIII-1, 8; P_1 15-18; L. l. 33-36; L.tr. 3/7. Number of gillrakers on the upper and lower arch 7-9/18-22, total 27-31.

Preorbital scales absent. Length of barbel 48 to 64 per cent in head length. Second and third dorsal spines about equal in length and slightly greater than fourth spine. Peritoneum uniform light brown to dark brown. Pale to brown on head and body above and light tan below. A lemon yellow longitudinal stripe from eye to above midbase of caudal fin. The first dorsal with 3 dark brown bars alternating with 3 transparent white bars, the tips of second to fourth spines whitish. Soft dorsal with brown bars separated by 2 transparent to white bars, with tips of longest rays sometimes white. Caudal with 3 or 4 brown to dusky oblique bars on upper lobe, lower lobe clear and devoid of bars. Pectoral, ventral and anal fins clear.

Distribution (fig. 3, A)

Eastern Mediterranean, Red Sea (Ben-Tuvia, 1966), Mozambique Channel (Fourmanior and Crosnier, 1963), India (Day, 1876, 1888), Indonesia, Philippines, Oceania (Samoan Islands), Japan (Kagoshima), Southern China and Australia.

Upeneus arge Jordan and Evermann
(Pl. II, fig. B)

Upeneus arge Jordan and Evermann, 1903, 187 (Type locality: Honolulu); Jenkins, 1902 (1903), 456 (Honolulu); Snyder, 1902 (1904), 527 (Honolulu); Jordan and Evermann, 1903 (1905), 264, pl. 39 (Honolulu, Pearl Harbour, Hilo); Fowler, 1933, 338 (Honolulu, Hawaiian Islands); Schultz, 1943, 128 (Canton Island); Fowler, 1949, 96 (reference); Lachner, 1954, 518, pl. 14, fig. A (Hawaiian Islands, Phoenix Islands); 1960, 4, pl. 75, fig. D (Hawaiian, Phoenix, Palmyra, Caroline and Gilbert Islands); Smith and Smith, 1963, 22, pl. 88, fig. G (Seychelles); Smith, 1963, 35 (East Africa to Seychelles); Jones and Kumaran, 1966, 113, fig. 8 (Minicoy).

Upeneoides arge Fowler, 1922, 83 (Hawaii); Jordan and Jordan, 1922, 52; Jordan, Evermann and Tanaka, 1927, 674 (Hawaiian Islands); Fowler, 1928, 227, pl. 19 C (Hilo, Hawaii, Honolulu, Palmyra, and Strong Islands, Apiang); 1931, 336 (Honolulu).

Material Examined

Four specimens, 177-220 mm. from Minicoy.

Diagnosis

D. VIII-1, 8; P_1. 13-14 (Table I); L. 1. 38-40 (Table II); L.tr. 3/6-7. Gillrakers on the upper and lower limbs 5-6/17-18 (Table III), total 22-24 (Table IV). Length of head 4.5 to 5.0, of caudal 4.1 to 4.5, greatest depth of body 5.0 to 5.6 in total length. Diameter of eye 4.6 to 5.4 and snout 2.2 to 2.5 in length of head. Barbel 63 to 71 per cent in head length.

Preorbital scales absent. Maxilla reaching to anterior 1/3 of orbit. Interorbital space nearly flat and broader than diameter of eye. Second dorsal spine the longest and the third subequal in some cases. A conspicuous swelling on snout just in front of orbit. Peritoneum transparent. Head and body yellowish white and lighter below at belly. Two very faint yellow longitudinal stripes from eye to base of caudal fin, one above lateral line and another below it. Dorsals with 2 to 3 dusky oblique bars. Caudal with 5 to 6 dusky narrow oblique bars on each lobe, those on lower lobe more intensely coloured and the last two wider than rest. Other fins clear.

Distribution (fig. 3, B)

Hawaii, Phoenix, Palmyra, Caroline and Gilbert Islands. Recently reported from Africa (Smith and Smith, 1963) and Minicoy Island (Jones and Kumaran, 1966).

Remarks

There is close resemblence between *U. vittatus* and *U. arge* in their external appearance and this made Fowler (1928, page 227) to remark that "*U. arge* may eventually be found inseparable with *U. vittatus.*" But the well marked differences in the number of pectoral fin rays and gillrakers (Tables I, III and IV) and the colour of the peritoneum readily separate the two species.

Upeneus vittatus (Forskal)

(Pl. II, fig. C)

Mullus vittatus Forskal, 1775, 31 (Type locality: Djedda, Red Sea); Bonnaterre, 1778, 144 (Red Sea); Gmelin, 1789, 1341 (Red Sea); Schneider, 1801, 79 (Red Sea); Lacepede, 1802, 382, 401, pl. 14, fig. 1 (Arabia); Shaw, 1803, 616, pl. 89 (Vizagapatnam); Playfair, 1866, 40 (Aden, Zanzibar, Mayotta).

Mullus bandi Shaw, 1803, 615 (Type locality: Vizagapatnam).

Upeneus vittatus Cuvier in Cuvier and Valenciennes, 1829, 448 (Pondicherry, Society and Sunda Island, Nukuhiva, Japan); Ruppell, 1835, 101 (Djedda); Thiolliere, 1857, 152 (Woodlark Island); Jouan, 1861, 295 (Canala and Port de France, New Caledonia); Guichenot, 1862, 24; Jouan, 1868, 253 (Hong Kong); 1870, 105 (Seychelles); Bleeker, 1875, 6 (East Indies, Philippines); 1877, 393, fig. 3; Klunzinger, 1884, 49; Steindachner, 1906, 1385 (Upolu); Seale, 1906, 51 (Tahiti, Nukuhiva); Jordan and Seale, 1905 (1906), 273 (Samoa); Smith and Seale, 1906, 78 (Cotabato, Mindanao); Seale and Bean, 1907, 245 (Zamboanga); Kendall and Goldsbourogh, 1911, 292 (Suva, Fiji); de Beaufort, 1913, 123 (Kairatu, West Ceram, Ambon, Buton); Weber 1913, 293; Barnard, 1927, 584, pl. 24, fig. 1 (Natal coast, Delagoa Bay); Weber and de Beaufort, 1931, 365 (Indo-Pacific); Fowler, 1932, 10. (Hivaoa, Marquesas Islands); 1933, 334, fig. 31 (Indo-Pacific); Schultz, 1943, 128 (Tutuita, Taiga, Apia, Samoa); Blegvad and Loppenthin, 1944, 134, pl. 7, fig. 2 (Iranian Gulf); Fowler, 1949, 95 (reference); Smith, 1949, 228, pl. 27, fig. 561 (Africa); Lachner, 1954, 516, pl. 13, fig. E (Indo-Pacific); Munro, 1955, 163, pl. 32, fig. 480 (Ceylon); Fowler and Steinitz, 1956, 277 (Tel Aviv, Israel); Lachner, 1960, 5, pl. 75, fig. C (Indo-Pacific); Smith and Smith, 1963, 22, pl. 17, fig. F (Seychelles); Fourmanior and Crosnier, 1963, 15, fig. 8 (Mozambique); Marshall, 1964, 235 (Queensland).

Upeneus bitaeniatus Bennett, 1831, 59 (Type locality: Mauritius).

Upeneoides vittatus Bleeker, 1849, 63 (Java); 1857, 42; Gunther, 1859, 397 (Philippines, Ceylon, Amboina, India); Day, 1865, 27 (Malabar coast); Schmeltz, 1865, 6 (Samoa); 1866, 7 (Samoa); Klunzinger, 1870, 741 (error); Martens, 1876, 387 (Amboina); Day, 1878, 120, pl. 30, fig. 2 (Red Sea, East coast of Africa, Seas of India to Malay Archipelago and beyond); Schmeltz, 1879, 40 (South Sea Islands); Macleay, 1881, 402 (Queensland); Karoli, 1881, 156 (Singapore); Pohl, 1884, 27, 45 (Samoa, New Guinea); Meyer, 1885, 15 (North Celebes, Kardo); Day, 1889, 25, fig. 10 (Red Sea, East coast of Africa, Seas of India to Malay Archipelago and beyond); Sauvage, 1891, 219 (not pl. 27, fig. 2) (Mauritius, Pondicherry, Batjan, Celebes, Amboina, Borabora, New Guinea, Tahiti); Elera, 1895, 479 (Luzon, Manila Bay, Batangas, Nasugbu); Jatzow and Lenz, 1899, 501 (Zanzibar); Jordan and Evermann, 1902, 335 (Keerun, Formosa); Jordan and Richardson, 1907 (1908), 260 (Lubang, Iloilo); Gilchrist and Thompson, 1908, 163 (1911) (Durban); Jordan and Richardson, 1909, 193 (Keerun record); Seale, 1910, 278 (Sandakan, Borneo); Pearson, 1913, P. E. 6 (1912-1913) (Ceylon); Zugmayer, 1913, 11 (Mekran); Gilchrist and Thompson, 1917, 365 (references); Jordan and Starks, 1917, 3,4, 454 (Ceylon); Bonde, 1923, 23; Jordan and Hubbs, 1925, 245 (Kagoshima Bay); Fowler and Bean, 1927, 7 (Benkoelen, Sumatra); Fowler, 1927, 259 (Bombay); 1928, 26 (Tahiti, Nukuhiva, Suva, Apia, Strong Island, Ebon Island, Society Islands); Herre and Montalban, 1928, 105, pl. 4, fig. 1 (Philippines); Fowler, 1929 (1930) 610, 617 (Hong Kong, Tahiti); 1931, 336 (Papua).

Hypeneus vittatus Cantor, 1850, 1017 (Type locality: Pinang).

Upeneoides caeruleus Day, 1868 b, 194 (Type locality: Madras).

Upeneoides philippinus Fowler, 1918, 37, fig. 15 (Type locality: Philippines).

Material examined

No. of specimens	Size range mm.	Locality
43	93-180	Rameswaram
17	90-185	Vedalai
15	85-130	Tuticorin
10	85-130	Vizhingam
20	105-163	Calicut
15	89-230	Andamans
120		

Diagnosis

D. VIII-1, 8; P. 15-18 (Table I); L. l. 35-38 (Table II); L. tr. 3/6-7. Number of gillrakers on the upper and lower limbs 7-9/19-22 (Table III), Total 26-31 (Table IV). Length of head 4.0 to 4.5, of caudal 4.0 to 4.6, greatest depth of body

4.2 to 5.0 in total length. Diameter of eye 3.3 to 4.5 in head (Table XII) and 1.2 to 1.6 in snout length (Table XIII). Snout 2.2 to 3.0 in head (Table XIII). Barbel 50 to 73 per cent in head length (Table XIV).

Preorbital scales absent. Interorbital space nearly flat. Third spine of spinous dorsal the longest, second sometimes subequal, peritoneum dark brown or brownish with a silvery cast. Head and body tan to yellow and silvery or pale white at belly. Tip of snout rosy and opercle pink in fresh specimen. Three to five yellow longitudinal stripes from eye to base of caudal fin, 2 or 3 of these above lateral line and the rest below and parallel to it. These yellow bands fading away in preserved material. Dorsal fins with 2 or 3 black oblique bars, tip of spinous dorsal dense black, the interspace of the black bands clear white, giving the appearance of white bands. Caudal with 3-5 black bars on upper and 2-4 on lower lobe, the last bar on lower lobe wider and more dense than all other bars. Other fins clear.

TABLE XII

RELATION BETWEEN HEAD LENGTH AND EYE DIAMETER IN *UPENEUS VITTATUS*

Total length mm.	Head length/Eye diameter												
	3·3	3·4	3·5	3·6	3·7	3·8	3·9	4·0	4·1	4·2	4·3	4·4	4·5
70—90	..	..	..	..	..	..	..	1	1	1	..	..	1
91—110	..	..	1	..	1	1	..	1	2	..	..	..	..
111—130	..	..	..	2	3	3	..	1	1	..	1	..	..
131—150	..	..	..	..	2	2	1	2	..	..	..	..	..
151—170	..	2	1	..	..	2	1	..	2	..	..	..	..
171—190	..	1	..	..	..	2	1	..	..	..	..	..	..
191—210	..	..	..	1	2	2	..	..	..	..	..	..	..
211—230	1	1	2	1	..	..	..	..	..	..	..	..	..

TABLE XIII

RELATION BETWEEN HEAD LENGTH AND SNOUT AND SNOUT AND EYE DIAMETER IN *UPENEUS VITTATUS*

Total length mm.	Head Length / Snout									Snout / Eye diameter				
	2·2	2·3	2·4	2·5	2·6	2·7	2·8	2·9	3·0	1·2	1·3	1·4	1·5	1·6
70—90	..	..	..	..	1	..	1	1	1	..	..	1	2	1
91—110	..	..	..	..	..	5	1	..	..	1	..	2	3	..
111—130	..	..	1	..	7	2	1	..	..	..	2	5	4	..
131—150	..	..	1	3	3	..	..	..	..	..	..	3	4	..
151—170	..	1	..	5	2	..	..	..	..	..	2	1	3	2
171—190	1	..	3	..	..	..	..	..	..	..	..	1	3	..
191—210	..	2	..	2	..	1	..	..	..	..	2	1	2	..
211—230	..	..	3	2	..	..	..	..	..	..	2	3	..	..

TABLE XIV

BARBEL LENGTH IN PER CENT OF HEAD IN *UPENEUS VITTATUS*

Total length mm.	Barbel length in per cent of head											
	50-51	52-53	54-55	56-57	58-59	60-61	62-63	64-65	66-67	68-69	70-71	72-73
70—90	..	..	..	2	1	1	..	..	..	..	..	..
91—110	..	..	..	1	..	..	2	3	..	..	..	..
111—130	..	..	..	..	..	..	2	3	4	..	1	1
131—150	1	..	..	..	..	..	1	2	1	1	1	..
151—170	..	..	..	..	1	2	..	..	2	1	1	1
171—190	..	..	..	..	1	2	1	..	..	..	..	..
191—210	..	1	..	..	..	..	2	2	..	..	..	..
211—230	..	1	..	2	1	1	..	..	..	..	..	..

Distribution (fig. 3, B)

Red Sea, East coast of Africa through Seas of India, Indonesia, Philippines, eastward in the Island group of Oceania to the Low Archipelago and from Japan southward to Australia.

Remarks

The oblique bars on the fins are dense black in the specimens collected from Andamans, whereas in other specimens they are light black with an yellow margin on either side.

The relation between diameter of eye and head length and head length and snout varies considerably with increase in body size. In smaller specimens, the ratio of head length to eye diameter and head length to snout is higher and it gradually decreases as the size increases (Table XII and XIII). No such variation was observed in the ratio of snout length to eye diameter (Table XIII). Length of barbel also did not show much variation in different size groups (Table XIV).

Five specimens in the collection of U.S. National Museum, collected from Mindanao and Mauritius were examined and no significant difference was found from specimens of this area. The important meristic counts and morphometric proportions of those specimens are given in Table XI.

Upeneus tragula Richardson

(Pl. III, fig. A)

Upeneus tragula Richardson, 1846, 220 (Type locality: Canton); Bleeker, 1875, 11 (East Indies, Philippines); 1877, 392, fig. 2; Macleay, 1883 (1884), 264 (Hood Bay, New Guinea); Jordan and Seale, 1905, 782 (Negros); Stead 1906, 131, fig. 48 (New South Wales); Jordan and Seale, 1906 (1907), 26 (Manila, Iloilo); Evermann and Seale, 1906 (1907), 88 (Bacon); Snyder, 1907, 100 (Formosa); Bean and Weed, 1912, 607; Pearson, 1912 (1913), E: 6 (Ceylon); Weber, 1913, 293 (Sumbawa, North Celebes, Obi Major, between Guebe and Fau); de Beaufort, 1913, 124 (Sorong, New Guinea); Jordan, Tanaka and Snyder, 1913, 184 (Japan); Barnard, 1927, 583 (Natal coast); Weber and de Beaufort, 1931, 368, fig. 75 (Indo-Pacific); Fowler, 1933, 339, fig. 32 (Indo-Pacific); 1949, 96 (reference); Smith, 1949, 228, pl. 27, fig. 560 (Africa); Lachner, 1954, 522, pl. 14, fig. C (Zanzibar, East Indies, Philippines China, Japan, Okinawa, Palau Islands, New South Wales); Munro, 1955, 162, pl. 32, fig. 477 (Ceylon); Fowler and Steinitz, 1956, 277 (Tel Aviv, Israel); Lachner, 1960, 4, pl. 75, fig, E (East Africa eastward through Philippines, to Pelew and Solomnn Island and from southern Japan to New South Wales, Australia); Smith and Smith, 1963, 22, pl. 17, fig. E (Seychelles); Robert, William, Fehlmann and Vyvien, 1963, 192 (Thailand): Marshall, 1964, 235, pl. 39, fig. 245 (Queensland); Ben-Tuvia, 1966, 265 (Eastern Mediterranean).

Upeneoides variegatus Bleeker, 1849, 64 (Type locality: Kagoshima, Batavia).

Upeneoides tragula Gunther, 1859, 398 (Amboina, Philippines, Canton); Kner, 1865, 66 (Singapore); Steindachner, 1870, 560 (Singapore); Day, 1870, 685

(Andamans); Gunther, 1873, 410 (Misol, Moluccas); Schmeltz, 1874, 23 (Bowen, Queensland); Day, 1878, 121, pl. 30, fig. 4 (Andamans); Martens, 1876, 387 (Amboina River); Macleay, 1878, 350 (New Guinea): Klunzinger, 1879, 354 (Port Darwin); Macleay, 1881, 402 (Port Darwin, Palm Islands, Port Jackson); Karoli, 1881, 156 (Singapore, Canton, Yokohama); Macleay, 1882, 245 (New Guinea); Steindachner and Doderlein, 1884, 22 (Kagoshima); Pohl, 1884, 45 (Zanzibar); Meyer, 1885, 16 (North Celebes, Ternate); Day, 1889, 26 (East coast of Africa, Coast of Sind, Andamans to Malay Archipelago); Thurston, 1890, 92 (Tuticorin, Pamban); Sauvage, 1891, 218 (Batavia, Amboina, Nias, Banka); Elera, 1895, 479 (Luzon, Manila Bay); Jatzow and Lenz, 1899, 502 (Zanzibar); Steindachner, 1900, 419 (Ternate); Jordan and Snyder, 1901, 84 (Kagoshima); Jordan and Evermann, 1902, 335 (Keerun, Giran, Formosa, Hokoto); Duncker, 1903 (1904), 150 (Singapore); Johnston, 1904, 220 (Arripu and south of Chevel Paar); Pellegrin, 1905, 84 (Baie 'dAlong, Tonkin); Regan, 1907, 228 (Mulaku, Maldives); Jordan and Richardson, 1907 (1908), 260 (Cuyo); Seale, 1910, 278 (Sandakan, Borneo); Snyder, 1912, 416 (Kagoshima, Tanegashima); Seale, 1914, 68 (Hong Kong); Regan, 1919, 200 (Durban, Natal); Fowler and Bean, 1922, 43 (Cebu and Zamboanga); Jordan and Hubbs, 1925, 245 (Toba, Kagoshima); Norman, 1927, 380 (Lake Timsah, Suez Canal); McCulloch, 1927, pl. 60, pl. 25, fig. 214a (New South Wales); Fowler and Bean, 1927, 7 (Venkoelen, Sumatra); Herre and Montalban, 1928, 99, pl. 2, fig. 1 (Philippines): Fowler, 1928, 227 (on Day); Tirant, 1929, 168 (Phu Yen); Fowler, 1920 (1930), 110 (Hong Kong): Schmidt, 1931, 75 (Kagoshima, Nagasaki); Herre and Myers, 1937, 30 (Singapore).

Mullus tragula Playfair in Playfair and Gunther, 1866, 40 (Aden, Zanzibar).

Upeneoides kuiskuiana (Doderlein) in Steindachner and Doderlein, 1884, 22 (Type locality: Kagoshima (name in synonymy).

Upeneus subvittatus Snyder, 1907, 101 (Type locality: Nagasaki).

Upeneoides tragulus Snyder, 1912, 503 (Okinawa: error).

Material examined

	No. of specimens	Size range mm.	Locality
	50	58-205	Rameswaram
	17	50-153	Manaikadu
	20	63-141	Dhanushkodi
	15	70-169	Vedalai
	20	110-173	Kilakarai
	3	128, 145, 172	Andamans
	5	120-129	Minicoy
Total	130		

Diagnosis

D. VIII-1, 8: P_1 13-14 (Table I); L. 1. 30-32 (Table II); L. tr. 3/6; Gillrakers on upper and lower limbs 5-7/15-18 (Table III), total 20-25 (Table IV). Length of head 3.8 to 4.2, of caudal 4.5 to 5.0, greatest depth of body 4.7 to 5.0 in total length. Diameter of eye 3.6 to 4.5 in head. Length of barbels 52 to 65 per cent of head length (Table XV).

Preorbital scales present. Interorbital space nearly flat and broader than eye. Third spine of first dorsal fin longest, 4th sometimes equal to it, peritoneum transparent. Brown to blackish above, lighter below. Head and body below lateral line covered with red or brownish irregular blotches, these colours disappearing immediately after death, appearing rather black in preserved material. A dark brown longitudinal stripe from eye to base of caudal fin. A dark brown saddle just behind soft dorsal, well developed in juveniles and obscure in adults. Two more saddles of the same colour, one each along the base of the dorsals, usually very faint and not visible in some preserved specimens. Spinous dorsal with 2-3 dark brown oblique bars alternating with white narrow interspaces. Two or three bands of same colour on soft dorsal, pectoral fin with a small brown spot at its base and two bars, apparent only in fresh specimens. Ventral and anal fins with brown dots arranged in two or three rows. Caudal with 2 to 6 oblique brown bars on upper lobe and 2 to 7 on lower lobe. These bars often in the form of irregular blotches, the blotches wider and intensely coloured on lower lobe. The interspaces between bars white or transparent. The lower lobe in most fish with one more bar than upper lobe. The number of bars increasing with size, smaller number of bars characteristic of young specimens.

Distribution (fig. 3, B)

Eastern Mediterranean (Ben-Tuvia, 1966), Suez canal (Norman, 1927), East Africa, Seas of India, Indonesia, Philippines to Palau Islands and from southern Japan to New South Wales, Australia.

Remarks

The number of bars on the caudal fin vary greatly. Day (1878) recorded 5 to 6 on each lobe, Snyder (1907) 4-5, Herre and Montalban (1928) 4-6, Weber and de Beaufort (1931) "usually 5", Fowler (1933) each lobe with 9 and Lachner (1954) 2-7. The number of bars varies with size and hence the differences may be due to variation in the size of the specimens examined by different authors.

Three specimens from East Indies in the collection of the U. S. National Museum were available for examination. The longitudinal stripe, the saddle on the caudal peduncle and the colour bars on fins are still retained in these specimens even after long preservation. The characteristic brown spots were, however, not traceable. The meristic counts and morphometric proportions are given in Table XVI.

This species superficially resembles *U. luzonius* Jordan and Seale. A comparative account of the characters by which they can be distinguished are given in the account of *U. luzonius.*

TABLE XV

LENGTH OF BARBEL IN PER CENT OF HEAD LENGTH IN TWO SPECIES OF *UPENEUS*

Species	Barbel length in per cent of head length													
	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
U. tragula	7	10	9	7	12	3	2	..	..	..	..	..	..	..
U. luzonius	..	..	..	..	..	1	5	8	10	9	5	2	1	1

TABLE XVI

MERISTIC COUNTS AND MORPHOMETRIC CHARACTERS OF THREE SPECIMENS OF *U. TRAGULA* FROM THE U. S. NATIONAL MUSEUM

No.	Date of collec-tion.	Locality	Total length mm.	No. of p. rays	No. of L. l.	T. L. / H.L.	T. L. / C. L.	T. L. / Depth	H. L. / E. D.	H. L. / Sn. L.	L. Bl. % in H.L.
U.S.N.M. 72695	1909	Batavia	242	13	31	4·2	4·8	5·3	4·0	2·3	66·6
U.S.N.M. 145234	July 30, 1909	Hinunangan Beach	124	13	31	4·7	4·4	5·1	3·7	2·4	58·0
-do-	-do-	-do-	80	13	31	4·4	4·4	5·3	3·6	2·5	61·0

TABLE XVII

MERISTIC COUNTS AND MORPHOMETRIC CHARACTERS OF TWO SPECIMENS OF *UPENEUS LUZONIUS* FROM U. S. NATIONAL MUSEUM

No.	Date of collection.	locality.	total length mm.	No. of L. 1.	No. of P_1. rays.	T.L. / H.L.	T.L. / Depth.	T.L. / C.L.	H.L. / E.D.	H.L. / Sn.L.	H.L. / D.C.	L.Bl in %of H. L.
U.S.N.M. 102649	April 6, 1929	Iloilo	110	33	14	4.4	4.5	5.5	4.1	2.2	2.0	64.0
U.S.N.M. 106829	April 2, 1929	Panay	98	33	14	4.4	4.6	5.4	4.4	2.2	2.2	68.1

Upeneus oligospilus Lachner

(Pl.III, fig. B)

Upeneus oligospilus Lachner, 1954, 525, pl. 14, fig. D (Type locality: Tarut Bay, Rastannura, Persian Gulf).

Upeneus tragula (*nec* Richardson) Blegvad and Loppenthin, 1944, 135, pl. 7, fig. 3 (Gulf of Oman).

Material examined

80 specimens, 50-139 mm. from Rameswaram, Palk Bay.

Diagnosis

D. VIII-1, 8; P_1. 13-14 (Table-I); L. 1. 31-32 (Table II); L. tr. 3/6. Gillrakers on upper and lower limbs 5-7/13-17 (Table III), total 19-23 (Table IV). Length of head equal to length of caudal and 4·0 to 4.5, greatest depth of body 4·6 to 5·5, both in total length. Eye 3·3 to 4·0 and snout 2·3 to 3·0 in head, barbels 57 to 70 per cent of head length.

Preorbital scales present. Interorbital space nearly flat. Maxilla reaching up to anterior border of orbit. Peritoneum transparent. Dusky on head and body, with diffused black pigments on scales along sides and pale white at belly. Large irregular brown blotches on opercle and sides of body, very clear in fresh material and completely faded in most preserved material; but retained in some specimens as obscure brownish black tinges. A brown longitudinal stripe from tip of snout to base of caudal fin. A dark saddle just behind soft dorsal extending over 4 scales wide and down to lateral line, this is clear in fresh but faded in preserved material. Traces of two more saddles, one each along the base of first and second dorsals present in some specimens. Dorsals with a brown to blackish tip and one or two narrow bands of vermilion with clear interspaces. Pectoral, ventral and anal with 2 or 3 rows of brownish black dots. Caudal with 2 to 4 brown, uniformly narrow oblique bars on each lobe with clear interspaces.

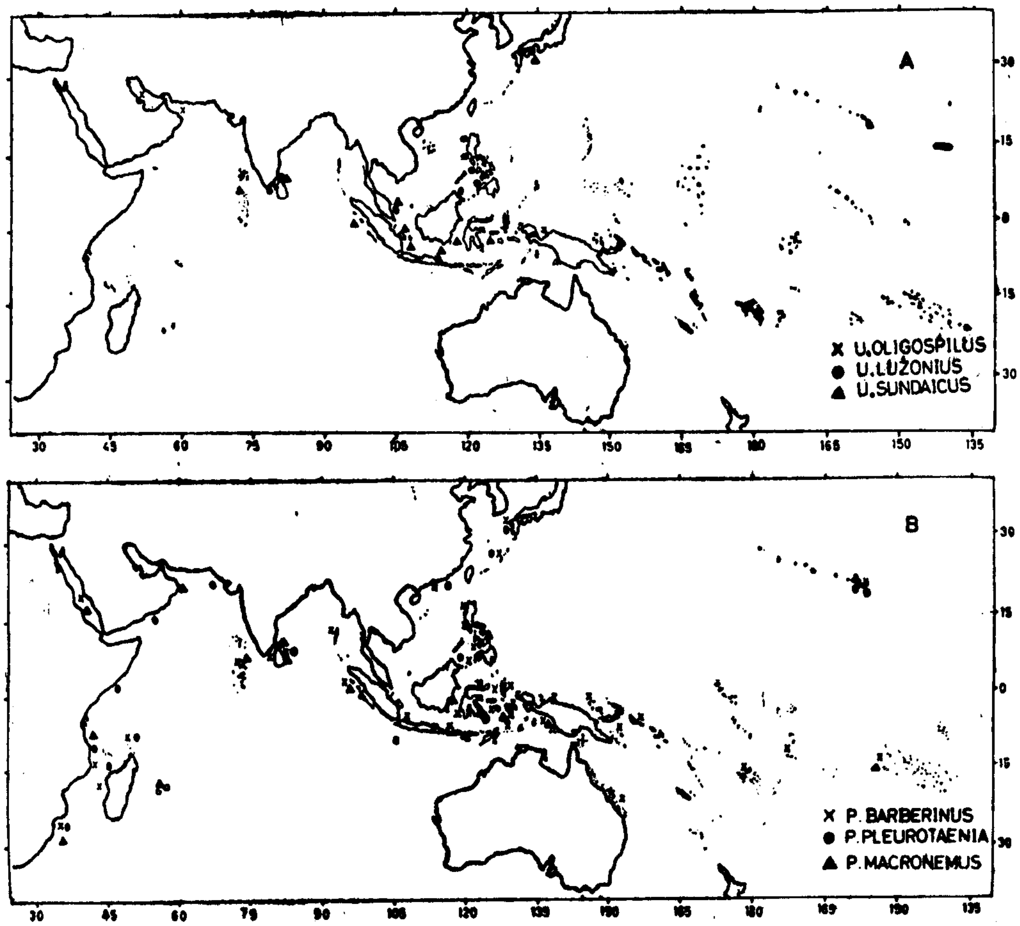
Distribution (fig. 4, A)

Persian Gulf, Gulf of Oman and from Palk Bay (Rameswaram) (new record).

Remarks

The significant difference observed in the description and figure of the colour in life given by Blegvad and Loppenthin (1944) for *U. tragula* from that of Herre and Montalban (1928) and the extreme resemblance of the former description and figure with that of *U. oligospilus* collected from the same faunal area enabled Lachner (1954) to treat *U. tragula* Blegvad and Loppenthin, as a synonym of *U. oligospilus*.

The specimens from Rameswaram agree with the description and figure given by Lachner (1954). The large irregular blotches on the sides of the body, are however, brown and not blackish, and the bars on the dorsals more vermilion than black. In this respect, the specimen from this area agree more with the colour description given by Blegvad and Loppenthin (1944). The length of the barbels



Text-figure 4. World distribution of *U. oligospilus*, *U. luzonius*, *U. sundaicus* (fig. 4 A); *P. barberinus*, *P. pleurotaenia* and *P. macronemus* (fig. 4 B)

varies from 57 to 70 per cent of head length, as against 50 to 64 per cent given by Lachner. Traces of two more saddles occur, in addition to the one just behind the soft dorsal mentioned by Lachner (1954). They are not traceable in preserved material, and as Lachner reported on the material which had been preserved for about six years or so, it is probable that these markings might have faded. These two saddles are clearly seen in the figure given by Blegvad and Loppenthin (1944). Moreover, the tip of spinous dorsal is not shown to be dense black, as Lachner (1954) has stated, but is brown to light black. In this respect also the specimens agree with the figure given by Blegvad and Loppenthin (1944).

Upeneus luzonius Jordan and Seale
(Pl. III, fig. C)

Upeneus luzonius Jordan and Seale, 1906 (1907), 25, fig. 9 (Type locality: Cavite); Weber and de Beaufort, 1931, 372 (after Herre and Montalban, 1928); Fowler, 1933, 325, fig. 28 (East Indies, Philippines); Lachner, 1954, 519, pl. 14, fig. D (Panay, Luzon, Linapacan); Thomas, 1967, 473 (Palk Bay and Gulf of Mannar).

Upeneoides luzonius Jordan and Richardson, 1907 (1908), 260 (Manila); Seale, 1910, 279 (Sandakan, Borneo); Herre and Montalban, 1928, 297, pl. 1, fig. 1 (Orani, Manila, Pasay, San Miguel, Capiz, San Pedro Bay, Tacloban, Cuyo, Sandakan, Borneo).

Upeneus sundaicus (*nec* Bleeker) Evermann and Seale, 1906 (1907), 88 (Bacon).

Material examined

42 specimens, 50-145 mm from Rameswaram and Vedalai.

Diagnosis

D. VIII-1, 8; P_1. 14-15 (85 % with 14, Table I); L. 1. 33-34 (Table II); Gillrakers on the upper and lower limbs 5-6/13-16 (Table III), total 18-22 (Table IV).

Length of head 4.0 to 4.4, of caudal 4·4 to 5·3, greatest depth of body 4·0 to 4·9 in total length. Eye diameter 4·0 to 4.6 and snout 2.0 to 2.5 in head length. Length of barbels 63 to 79 per cent (Table XV). Preorbital scales present. Interorbital space flat. Peritoneum transparent.

Dark brown on head and body and pale yellow at belly. A dark brown, longitudinal stripe from tip of snout through eye to base of caudal fin, passing below lateral line up to base of spinous dorsal and thereafter above it backwards. Three dark brown saddles, the first along base of spinous dorsal, second through base of soft dorsal and third along caudal peduncle just behind soft dorsal, extending on either side up to lateral line. A very faint fourth saddle present in some specimens on the upper base of caudal peduncle but not extending to sides. Spinous dorsal with 3 dusky to brown oblique bars and soft dorsal with 2 such bars in smaller and 3 in larger specimens. Caudal fin with 2 to 7 bands of same colour on each lobe, the bands on upper lobe narrow with clear interspaces, those on lower lobe wider and more intensely coloured.

Distribution (fig. 4, A)

Philippines, Borneo, Singapore and recently reported (Thomas, 1967) from Indian waters (Palk Bay and Gulf of Mannar).

Remarks

2 specimens of *Upeneus luzonius* (U. S. N. M. 102649 and 106829) have been examined and their meristic counts and morphometric characters are given in Table XVII.

The specimens from this area generally agree with the original description of *U. luzonius* Jordan and Seale (1907) and the comparative study of the two specimens from U. S. National Museum also did not reveal any significant differences, with one exception. Jordan and Seale stated that "the second dorsal spine is greater than depth of body, about equal in length to head". In the 42 specimens examined, the second dorsal spine is less than both the greatest depth of body and head length. The number of lateral line scales range from 33 to 34 for specimens from this area. This is higher than the range given by Lachner (1954) but agrees with Weber and de Beaufort (1931) and Fowler (1933) (Table VI). The number of oblique bars on the caudal fin varies with the size of the specimens and the differences observed in the number of bars given by various authors may be explained in that way. Jordan and Seale (1907, page 26, fig. 9) illustrated 4 bars on each lobe, Seale (1910) recorded 7 on lower lobe, Herre and Montalban (1928) have given the range 6-7 and illustrated 7 bars on each lobe. Lachner (1954) gave the range 2-7 and illustrated 5 bars. In the specimens examined by the author, the number of bars on the caudal fin vary from 2 to 7 on each lobe. Smaller numbers are characteristic of young speoimens and the number of bars increases with increase in size of the fish. Jordan and Seale (1907) gave the depth of caudal peduncle as 2.25 in head length and Herre and Montalban (1928) showed a range to be 2.2 to 2.4. In the present study it was observed to vary from 2.0 to 2.8 (42 specimens, 50-145 mm.). From Table XVIII it can be seen that the relation between the depth of caudal peduncle and the head length changes with growth. In young specimens the ratio is higher and gradually decreases as the specimen increases in length.

TABLE XVIII

VARIATION IN THE DEPTH OF CAUDAL PEDUNCLE IN RELATION TO HEAD LENGTH IN *UPENEUS LUZONIUS*

Total length mm.	Head length / Depth of caudal peduncle								
	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8
50—59	..	..	..	..	..	..	2	..	..
60—69	..	..	..	..	..	..	2	..	..
70—79	..	..	..	..	..	1	2	..	..
80—89	..	..	..	..	..	..	2	..	..
90—99	..	..	..	..	..	2	1	1	1
100—109	1	..	1	2	1	2	1	..	..
110—119	..	..	..	2	3	..	..	..	..
120—129	..	..	2	4	2	1	..	..	..
130—139	..	..	..	2	2	..	..	..	..
140—149	..	1	2	..	..	..	..	..	..

Upeneus sundaicus (Bleeker)

(Plate IV, fig. A)

Upeneoides sulphureus (*nec* Cuvier) Bleeker, 1849, 63 (Batavia).

Upeneoides sundaicus Bleeker, 1855, 411 (on Bleeker, 1849); 1856, 213 (name only); Gunther, 1859, 399 (compiled); Bleeker, 1865, 147; Steindachner, 1870, 560 (Singapore); Karoli, 1881, 156 (Sarangoon, Kobe); Herre and Montalban, 1928, 98 (Philippines); Herre, 1944, 56 (Philippines).

Upeneus sundaicus Bleeker, 1875, 10 (Java, Madura, Sumatra, Nias, Singapore, Banka, Celebes, Buru); 1878, 393, fig. 2; de Beaufort, 1913, 123 (Makassar, Celebes); Weber and de Beaufort, 1931, 370 (Singapore, Banka, Nias, Sumatra, Java, Madura, Muna Island, Celebes, Buru, Philippines, Japan); Fowler, 1933, 323 (East Indies); Jones and Kumaran, 1966, 114, fig. 7 (Minicoy).

?*Upeneoides bensasi* (*nec* Temminck and Schlegel) Day, 1878, 121, pl. 30 fig. 5 (Madras to the Malay Archipelago); 1883, 27 (Madras to the Malay Archipelago).

Material examined

40 specimens, 90-155 mm. collected from Rameswaram.

Diagnosis

D. VIII-1, 8; P. 14-15 (Table I); L. 1. 33-34 (Table II); L. tr. 3/6-7; Gillrakers on upper and lower limbs 5-6/13-16 (Table III), total 18-22 (Table IV). Length of head 4·0 to 4·6, of caudal 4·2 to 5·0, greatest depth of body 4·6 to 5·3 in total length. Diameter of eye 3·5 to 4·5 in length of head. Length of barbel 64 to 78 per cent in length of head.

Preorbital scales present. Interorbital space slightly convex, its width equal or a little more than diameter of eye. Maxilla scarcely reaching anterior border of orbit. First spine of spinous dorsal minute, second the longest and subequal to depth of body. Peritoneum transparent. Brownish yellow on head and upper portion of body, pale yellow or white at belly. Some reddish or pink blotches on sides of body below lateral line, these fading away immediately after death, leaving no traces in preserved material. A deep brown longitudinal stripe from eye to base of caudal fin. Dorsal fins rosy with 2 or 3 narrow dusky oblique bars. Caudal fin with 4 to 5 dusky, uniformly narrow oblique bars on upper lobe, lower lobe without oblique bars but with a black or violet tinge along tip of rays. These bars are present only in fresh specimens and not retained in preserved material.

Distribution (fig. 4, A)

Indonesia, doubtfully from Philippines, Palk Bay (range extension), Minicoy (Jones and Kumaran 1966).

Discussion

Lachner (1954, page 507) placed *Upeneoides sundaicus* Bleeker in a doubtful status and remarked that "*U. sundaicus* Bleeker may be represented by either *U. tragula* or *U. luzonius*". His statement was based on the fact that in the description of *U. sundaicus* by Bleeker (1855, p. 411) and (1877, pl. (4) 394, fig. 2), by Herre and Montalban (1928, p. 98) and by Weber and de Beaufort (1931, p. 371), the characters given such as dorsal spines 8, first spine minute, gillrakers 13+3, barbels reaching hind border of operculum are shared by *U. tragula* and *U. luzonius*, both of which are found in East Indies from where Bleeker's material was collected. Though Weber and de

Beaufort (1931) saw one of Bleeker's specimens, their account was partly extracted from Bleeker, and that of Herre and Montalban (1928) was compiled from Bleeker and Evermann and Seale (1907, page 88). The specimen reported by Evermann and Seale (1907) from Bacon (U. S. N. M. 56138) was found to be a "large poorly preserved specimen of *U. luzonius*" (Lachner, 1954).

The accounts given by Bleeker (1855) and Weber and de Beaufort (1931) and the present observation for *U. sundaicus* differ from both *U. tragula* and *U. luzonius* in having a higher number of lateral line scales, 33 to 35. There is marked difference in the colouration of the fins also. In *U. tragula* and *U. luzonius* both lobes of the caudal fin are with oblique bars or blotches as also the dorsals. The ventral and anal fins in *U. tragula* are also with brown dots arranged in the form of two or three bars.

The characteristic colour of the species fade away to a great extent in the preserved specimens. However, the bars on the lower lobe of the caudal fin in both *U. tragula* and *U. luzonius* are more pronounced and intensely coloured than those on the upper lobe, and in preserved specimens, while the bars on the upper lobe usually vanish completely at least traces of these bars will remain on the lower lobe. In *U. sundaicus*, only the upper lobe has oblique bars and the lower lobe is clear even in fresh material except for the dark or violet tinge along the inner margin. Examination of very fresh specimens of *U. sundaicus* (immediately after their removal from the net) did not reveal any trace of markings on pectoral, ventral and anal fins.

Specimens collected from this area clearly agree with the description of Bleeker (1855) and Weber and de Beaufort (1931). They differ from *U. tragula* in having a high range of lateral line scales, 33-34, and from both *U. tragula* and *U. luzonius* in having only the upper lobe of the caudal fin with oblique bars and lower lobe clear. It was also found to differ in the relative length of second dorsal spine. In *U. luzonius* the second dorsal spine was said to be "greater than depth of body, about equal in length of head" (Jordan and Seale, 1907), but always found far less than depth of body and head length in the present study, and the same is true for *U. tragula* also. But in *U. sundaicus* the second dorsal spine is found to be equal to depth of body in most cases or slightly less than it in the rest. However, it was always less than length of head in *U. sundaicus* also.

The specimens identified as *Upeneoides bensasi* by Day (1878) probably represent *U. sandaicus* (Bleeker). The number of lateral line scales (32-34) and pectoral fin rays (15) given by Day for *U. bensasi* are higher than what are actually found in *U. bensasi* and is more related to *U. sundaicus*. The number of spines in the first dorsal (7) given by him is less than that in *U. sundaicus*, but it is probable that he might have overlooked the first minute spine, as he had given the range of spines to be 7-8 in *U. tragula* and *U. caeruleus* (= *U. vittatus*) which always have 8 spines. His illustration of *U. bensasi* also differs from *U. sundaicus* in having 4 oblique bars on both lobes of the caudal fin. This also can be due to oversight as he mentioned the bars only on the upper lobe in his description "caudal reddish, the upper lobe having four oblique chestnut bars" (1878, p. 122).

Upeneus bensasi seems to be very rare in this area, and only 17 specimens were collected during the two years (1963-65) of intensive collection by the present author from Palk Bay and Gulf of Mannar. Munro (1955) did not record it from the coast of Ceylon, nor Weber and de Beaufort (1931) from the Indo-Australian Archipelago. But Day (1878) stated that "it (*U. bensasi*) appears to be abundant all the year round on the Coromondal coast". This fact further suggests that Day had only *U. sundaicus*, which is fairly abundant along this coast.

Genus **Parupeneus** Bleeker (1868)

Parupeneus Bleeker, 1863, 234; 1868, 344.

The generic name *Parupeneus* was used by Bleeker in different lists of fishes from 1863 onwards, though it was established in detail only in 1868.

Diagnosis

The Charaoteristic feature of this genus is its incomplete dentition consisting of a single row of stout and widely spaced teeth on both jaws and the vomer and palatines devoid of teeth. Lateral line scales usually 28-30. Scales present on caudal but absent on anal and dorsal fins. Preorbital scales absent. Spinous dorsal with 8 spines, the first one very small and soft dorsal with one spine and 8 rays. Pectoral fin rays 14-18. *Genotype*: *Mullus bifasciatus* Lacepede.

Distribution

Tropical Indo-Pacific.

Fourteen species of *Parupeneus* are described in the present account though only nine species were available for examination. The rest are included based on the reports of others from elsewhere, to make it a complete list of the species from the Indian Ocean. The source of the report and the description for each species is cited in the appropriate places.

Upeneus cinnabarinus (*Parupeneus cinnabarinus?*) was described by Cuvier (1829) from Ceylon. There is no subsequent record of this species from any other area and Day (1878) described it based on the type specimen kept in Paris, and gave the distribution as "Ceylon, where it is said to be abundant". Fowler (1933) followed Day (1878) and Munro (1955), in his well illustrated book on the fishes of Ceylon, listed it but has not given an illustration of this species. Kuthalingam (1956), studied the food and feeding habits of a fish reported under the name of *U. cinnabarinus* from the Madras coast. Two representative collections from the same area where Kuthalingam had oollected his material did not include a single speoimen that could be identified as *Parupeneus cinnabarinus.* All efforts made to get a few specimens of this species for examination from the National Museum, Colombo, Ceylon; Fisheries Research Station, Department of Fisheries, Ceylon and also from the Zoology Museum of the University of Madras, where Kuthalingam (1956) conducted the above study, were unsuccessful.

The type specimen available at the Museum National D' Histoire Naturelle, Paris, has been kindly re-examined for me by Dr. M. Blanc and he has given the following details regarding the specimen:

1. It has at least 27 or 28 scales along the lateral line but it is difficult to be precise as some are lost in between as the specimen is in a bad condition.

2. There are 27 branchiospines on the first branchial arch.

3. The peritoneum seems to be vaguely silvery coloured.

4. The colouration has disappeared in alcohol and the animal actually gives out a greenish colour which is almost uniform.

Since there is no other record of this species from any other area except Ceylon by Cuvier (1829) and the descriptions given by Day (1878), Fowler (1933) and Munro (1955) lack details, the validity of the species is uncertain. Therefore this species has not been included in the present account.

Key to species of the Genus *Parupeneus Bleeker*

1. Sides of body with brown or black longitudinal or vertical colour bars, blotches or small spots 3

2. Sides of body without brown or black bars, blotches or spots 19

3. Body with a dark brown longitudinal stripe from tip of snout through eye to base of caudal fin and a black or brown circular spot on caudal peduncle 5

4. Body with no longitudinal stripe or spot on caudal peduncle 9

5. Peritoneum brown or black (the black spot at the base of caudal fin extending from 26th to 28th scale of lateral line, gillrakers 25-30) *P. barberinus* (Lacepede)

6. Peritoneum silvery 7

7. A light or pale white saddle posterior to dorsal fin (followed by a dark brown saddle occasionally divided into two dorso-lateral spots on caudal peduncle; gillrakers 29-31) *P. pleurotaenia* (Playfair)

8. No saddle posterior to dorsal fin (black spot on caudal peduncle about midway between base of soft dorsal and base of caudal peduncle, extending over the 23rd to 25th scale of lateral line; gillrakers 32-37) ....*P. macronemus* (Lacepede)

9. Body with 3 or more vertical black bars 11

10. Body with no vertical bars but with a black or brown spot on each side 13

11. Body with 3 vertical black bars ....*P. bifasciatus* (Lacepede)

12. Body with 5 vertical black bars ....*P. trifasciatus* (Lacepede)

13. Peritoneum black or brown 15

14. Peritoneum transparent 17

15. A large black blotch on caudal peduncle (a large oval, yellow blotch on the lateral line below posterior part of spinous dorsal) ....*P. indicus* (Shaw)

16. No black blotch or spot on caudal peduncle (a small black spot about the length of one scale in diameter just below base of spinous dorsal on lateral line) ....*P. pleurospilus* (Bleeker)

17. A black spot almost in the form of a saddle on each side of caudal peduncle ....*P. fraterculus* (Valenciennes)

18. Saddle-shaped black spot on caudal peduncle absent; a dense black oval blotch on each side of body between dorsals, another pale yellow blotch just posterior to that, extending up to posterior extremity of base of soft dorsal ....*P. pleurostigma* (Bennett)

19. Gillrakers 24-28 21

20. Gillrakers 31-35 (a light spot or saddle just behind soft dorsal on caudal peduncle, another black saddle posterior to light spot) ....*P. porphyreus* (Jenkins)

21. A pale yellow saddle on caudal peduncle present..........*P. cyclostomus* (Lacepede)

22. Pale yellow saddle on caudal peduncle absent 23

23. Body yellow with no colour blotch or stripes; centre of each scale with a golden yellow spot ....*P. luteus* (Valenciennes)

24. Upper half of body with alternating narrow scarlet and yellow stripes, lower half silvery; scales without golden yellow spots............*P. seychellensis* (Smith and Smith)

Parupeneus barberinus (Lacepede)

(Pl. IV, fig. B)

Mullus barberinus Lacepede, 1802, 283, 284, pl. 13, fig. 3 (Type locality: near Moluccas).

Upeneus barberinus Cuvier in Cuvier and Valenciennes, 1829, 462 (compiled); Ruppell, 1835, 101 (Massaua); Bleeker, 1851, 172; Thiolliere, 1857, 153 (Woodlark Island); Gunther, 1859, 405 (Moluccas, India); Kner, 1865, 70 (Java, Australia); Schmeltz, 1869, 4: 14 (Kandavu); Klunzinger, 1870, 745 (Red Sea); Gunther, 1873, 409 (Solomons); 1874, 57, pl. 4 (Pelew Islands, Paumotus, Society, Harvey, Kingsmills, Solomon Islands, Upolu); Martens, 1876, 387 (Ternate); Day, 1878, 124 (Red Sea, India to Malay Archipelago and beyond); Schmeltz, 1879, 40 (Viti Islands); Gunther, 1880, 56 (Nares Harbour, Admiralty Islands); Macleay, 1881, 405; 1882, 245 (New Guinea); Pohl, 1884, 45 (Kandavu); Meyer, 1885, 16 (Cebu, Rubi, New Guinea); Nystrom, 1887, 17 (Nagasaki); Day, 1889, 30 (Red Sea, India to Malay Archipelago and beyond); Weber, 1895,264 (Coast of New Guinea);

Elera, 1895, 480 (Luzon, Manila Bay, Philippines); Jordan and Snyder 1901, 84 (Nagasaki); Jordan and Richardson, 1907 (1908), 260 (Cuyo); Snyder, 1912, 501 (Okinawa); Bamber, 1915, 481 (Sudanese Red Sea); Pearson, 1918, F. 17 (Ceylon); Fowler and Bean, 1922, 44 (Zamboanga); Fowler, 1923, 384 (Honolulu); 1923, 41 (Madagascar); 1925, 10 (Guam); Fowler and Ball, 1925, 16 (Johnston Island); Fowler, 1927, 17 (Christmas Island); Herre and Montalban, 109, pl. 3 (Philippines, Sulu Archipelago); Fowler, 1928, 230 (Johnston, Guam, Tahiti, Shortland Islands, Honolulu, Truk, Vavau, Ascension, Society, Kingsmill, Fiji Islands; Polynesia, Apia, Moen, Fakarava); 1929, (1930), 610 (Hong Kong); Duncker and Mohr, 1931, 66 (St. Matthias, Ekalin); Fowler, 1931, 337 (reference).

Parupeneus barberinus Bleeker, 1863, 234 (reference); 1875, 25 (Java, Cocos, Bawean, Bali, Sumatra, Nias, Celebes, Timor, Ternate, Buro, Ceram, Amboina, Banda); 1878, 393, fig. 1; 1878, 37 (New Guinea); Klunzinger, 1884, 52; Steindachner, 1900, 419 (Ternate); Weber, 1913, 296 (Paternoster Island, Makassar, Minado, Biaru, Karkaralong, Binongka, Ambon); Pellegrin, 1914, 231 (Diego, Suarez, Mahambo); Barnard, 1927, 588 (Delagoa Bay); Weber and de Beaufort, 1931, 392 (Indo-Pacific); Schultz, 1943, 130 (Apia, Samoa); Munro, 1955, 165, pl. 32, fig. 486 (Ceylon); Jones and Kumaran, 1959, 47 (Minicoy Island); Lachner, 1960, 16, pl. 78, fig. D (Indo-Pacific); Jones, 1964, 663, fig. 30 (Minicoy Island).

Mullus (Upeneus) barberinus, Martens, 1866, 378 (Koseir, Red Sea).

Pseudupeneus barberinus Jordan and Seale, 1905, 782 (Negros); Seale, 1906, 49 (Tahiti, Shortland Island); Jordan and Seale, 1905 (1906), 276 (Apia); Evermann and Seale, 1906 (1907), 88 (San Fabian and Bacon); Snyder, 1907, 92 (Samoa); Kendall and Goldsborough, 1911, 293 (Vavau, Fakarava, Moen, Truk); Fowler, 1933, 283, fig. 21 (Indo-Pacific); 1949, 94 (reference); Smith, 1949, 229, pl. 27, fig. 566 (Africa); Smith and Smith, 1963, 22, pl. 17, fig. J (Seychelles); Marshall, 1964, 237 (Queensland).

Pseudupeneus (Hogbinia) barberinus McCulloch, 1929, 223 (reference).

Material examined

40 specimens, 40 to 295 mm. total length, collected from Minicoy Island.

Diagnosis

D. VIII-1, 8; P. 16-17 (Table XIX); L. 1. 29-30 (Table XX); L. tr. 3/6. Gillrakers on the upper and lower limbs 4-7/20-23 (Table XX), total 25-30 (Table XXI). Length of head 3.6 to 4.2, of caudal 4. 2 to 5.0, greatest depth of body 4.5 to 5.3 in total length. Eye diameter 4.0 to 6.0 and snout 1.5 to 2.2 in head length. Barbels 63 to 76 per cent of head length (Table XXII).

Interorbital space convex. Eyes shorter than interorbital space. Scales present on opercle, cheek and also at the base of caudal fin but not on dorsals or anal fins. Peritoneum brown to blackish. Light tan or dusky on head and body and pale white below. A dark brown longitudinal stripe from tip of the snout through eye to the posterior end or a little beyond base of soft dorsal. A large black spot at mid-base of caudal fin starting from 26th to 28th scale of lateral line, which passes through its centre. No conspicuous colour bars on dorsals but with some black pigments especially at base giving the appearance of a faint black streak. Other fins clear.

Distribution (fig. 4, B)

Red Sea, East coast of Africa, Seas of India, Indonesia, Philippines, Southern Japan, southwards to Australia and Island groups of Oceania and up to Hawaii.

Remarks

There is considerable variation in the range given by various authors for body proportions especially in the ratios of head length and diameter of eye, head length and snout length, and snout length and diameter of eye. The range given for these proportions by Day (1878), Herre and Montalban (1928), Weber and de Beaufort (1931), Fowler (1933) and Lachner (1960) are given in Table XXIII, along with the range observed in the present study. The size range of the material examined by the above authors also are given in the Table. These differences can be due to the difference in size of the specimens examined by different authors, as the length of head, snout and diameter of eye undergo much change with growth. Herre and Montalban have given the size of the specimens examined by them as 215-280 mm., Fowler, 41-435 and Lachner, 30-249 mm. The present study is based on specimens ranging from 40 to 295 mm. in total length.

TABLE XIX

NUMBER OF PECTORAL FIN RAYS IN NINE SPECIES OF *PARUPENEUS*

Species	No. of Specimens	Number of pectoral fin rays			Mean
		15	16	17	
P. barberinus	40	..	3	37	16.93
P. macronemus	30	9	21	..	15·70
P. bifasciatus	14	1	11	2	16·07
P. trifasciatus	5	..	5	..	16·00
P. pleurospilus	12	..	12	..	16·00
P. indicus	58	..	47	11	16·19
P. pleurostigma	1	1	..	..	15·00
P. luteus	4	..	4	..	16·00
P. cyclostomus	2	..	..	..	16·00

TABLE XX

RANGE OF VARIATIONS IN THE NUMBER OF LATERAL LINE SCALES AND GILLRAKERS ON THE UPPER AND LOWER LIMBS IN NINE SPECIES OF *PARUPENEUS*

Species	No. of L. l. scales		Gillrakers: Upper limb							Gillrakers: Lower limb											
	29	30	4	5	6	7	8	9	10	18	19	20	21	22	23	24	25	26	27	28	29
P. barberinus	9	31	1	6	31	2	..	..	..	..	..	15	12	11	2	..	..	..	..	..	..
P. macronemus	7	23	..	..	2	13	15	..	..	..	..	..	..	..	..	..	2	13	12	1	2
P. bifasciatus	3	11	..	..	..	4	6	2	2	..	..	..	..	..	..	..	..	2	6	5	1
P. trifasciatus	1	4	..	..	..	..	4	1	..	..	..	..	..	..	..	..	..	..	..	2	3
P. pleurospilus	2	10	..	3	9	..	..	..	..	..	1	7	4	..	..	..	..	..	..	..	..
P. indicus	9	49	..	9	32	17	..	..	..	9	29	17	3	..	..	..	..	..	..	..	..
P. pleurostigma	1	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..
P. luteus	..	4	..	1	3	..	..	..	..	..	..	3	1	..	..	..	..	..	..	..	..
P. cyclostomus	..	2	..	..	2	..	..	..	..	..	..	..	1	1	1	..	..	..	..	..	..

TABLE XXI

TOTAL NUMBER OF GILLRAKERS IN NINE SPECIES *OF PARUPENEUS*

Species	No. of specimens examined	Number of gillrakers																Mean
		24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	
P. barberinus	40	..	2	12	13	11	1	1	..	..	..	..	..	..	..	..	..	27·00
P. macronemus	30	..	..	..	..	..	..	..	..	4	6	9	8	2	1	..	..	34·03
P. bifasciatus	14	..	..	..	..	..	..	..	..	..	..	2	5	3	2	1	1	35·86
P. trifasciatus	5	..	..	..	..	..	..	..	..	..	..	..	..	2	2	1	..	36·80
P. pleurospilus	12	1	2	5	4	..	..	..	..	..	..	..	..	..	..	..	..	26·00
P. indicus	58	9	29	17	3	..	..	..	..	..	..	..	..	..	..	..	..	25·24
P. pleurostigma	1	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	30·00
P. luteus	4	..	1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	26·00
P. cyclostomus	2	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	..	27·50

TABLE XXII

LENGTH OF BARBEL IN PER CENT OF HEAD IN *PARUPENEUS BARBERINUS* ACCORDING TO SIZE GROUPS

Total length mm.	Barbel length in per cent of head													
	63	64	65	66	67	68	69	70	71	72	73	74	75	76
40—60.	..	2	..	..	3	..	..	..	1	..	..	..	..	..
61—80	2	..	1	..	2	1	..	..	..	4	..	..	3	2
81—100	..	..	..	..	..	..	..	..	2	1	..	..	..	..
101—120	..	..	..	..	..	..	1	..	1	..	1	..	..	..
121—140	..	..	..	..	..	..	..	1	1	..	..	..	..	..
141—160	..	..	..	..	..	..	..	..	1	1	..	..	..	..
161—180	..	..	..	..	..	..	..	1	1	1	..	..	..	..
181—200	..	..	..	..	..	..	..	..	..	..	2	..	..	..
201—220	..	..	..	..	..	..	..	1	..	..	..	..	..	..
221—240	..	..	..	..	..	..	..	..	..	1	..	..	..	..
241—260	..	..	..	..	..	..	..	..	..	..	..	..	..	..
261—280	..	..	..	..	..	..	..	1	..	..	..	..	..	..
281—300	..	..	..	..	1	..	..	..	..	..	..	..	..	..

TABLE XXIII

RELATION BETWEEN HEAD LENGTH AND EYE DIAMETER, HEAD LENGTH AND SNOUT LENGTH & SNOUT LENGTH AND EYE DIAMETER IN *PARUPENEUS BARBERINUS* AS GIVEN BY VARIOUS AUTHORS

Author	Head length / Eye diameter	Head length / Snout length	Snout length / Eye diameter	Size range of material examined mm.
Day (1878)	5.5	..	3	..
Herre and Montalban (1928)	4.8—6.5	1.6—1.	92.5—4.0	215—230
Weber and de Beaufort (1931)	4.5—6.5	—	Snout length about thrice diameter of eye	—
Fowler (1933)	2.8	1.5—1.9	3—5.5	41—435
Lachner (1960)	4.6—5.5	1.8—2.2	2.4—3.3	30—249
Present observation	4.0—6.0	1.5—2.2	2.0—3.8	40—295

TABLE XXIV

RELATION BETWEEN SNOUT LENGTH AND EYE DIAMETER IN *PARUPENEUS BARBERINUS* ACCORDING TO SIZE GROUPS

Total length mm.	Snout length/Eye Diameter									
	2·0 to 2·1	2·2 to 2·3	2·4 to 2·5	2.6 to 2·7	2·8 to 2·9	3·0 to 3·1	3·2 to 3·3	3.4 to 3·5	3·6 to 3·7	3·8 to 3·9
40—60	4	2	..	..	..	..	..	..	..	..
61—80	12	3	..	..	..	..	..	..	..	..
81—100	3	..	..	..	..	..	..	..	..	..
101—120	..	1	1	..	..	..	..	..	..	..
121—140	..	..	1	1	..	..	..	..	..	..
141—160	..	..	..	2	..	..	..	..	..	..
161—180	..	..	..	..	..	1	..	..	..	..
181—200	..	..	..	1	1	..	..	..	..	..
201—220	..	..	..	..	..	1	..	..	..	..
221—240	..	..	..	..	..	..	2	..	..	..
241—260	..	..	..	..	..	..	..	1	1	..
261—280	..	..	..	..	..	..	..	..	1	..
281—300	..	..	..	..	..	..	..	..	..	1

TABLE XXV

RELATION BETWEEN HEAD LENGTH AND EYE DIAMETER IN *PARUPENEUS BARBERINUS* ACCORDING TO SIZE GROUPS

Total length mm.	Head length/Eye Diamater										
	4·0 to 4·1	4·2 to 4·3	4·4 to 4·5	4·6 to 4·7	4·8 to 4·9	5·0 to 5·1	5·2 to 5·3	5·4 to 5·5	5·6 to 5·7	5·8 to 5·9	6·0 to 6·1
40—60	5	..	..	1	..	..	..	..	..	..	..
61—80	6	5	3	1	..	..	..	..	..	..	..
81—100	1	2	..	..	..	..	..	..	..	..	..
101—120	..	..	2	..	..	1	..	..	..	..	..
121—140	..	..	2	..	..	..	..	..	..	..	..
141—160	..	..	1	1	..	..	..	..	..	..	..
161—180	..	..	1	1	..	..	1	..	..	..	..
181—200	..	..	..	..	..	2	..	..	..	..	..
201—220	..	..	..	..	..	..	..	1	..	..	..
221—240	..	..	..	..	..	..	..	..	1	..	..
241—260	..	..	..	..	..	..	..	..	..	..	1
261—280	..	..	..	..	..	..	..	..	..	..	..
281—300	..	..	..	..	..	..	..	..	..	..	1

TABLE XXVI

RELATION BETWEEN HEAD LENGTH AND SNOUT LENGTH IN *PARUPENEUS BARBERINUS* ACCORDING TO SIZE GROUPS

Total length mm.	Head length/Snout length							
	1·5	1·6	1·7	1·8	1·9	2·0	2·1	2·2
40—60	..	..	..	..	..	3	..	3
61—80	..	..	..	..	2	5	5	3
81—100	..	..	..	..	..	1	2	..
101—120	..	..	..	1	2	..	..	..
121—140	..	..	..	1	1	..	..	..
141—160	..	..	1	1	..	..	..	..
161—180	..	..	3	..	..	..	..	..
181—200	..	..	..	2	..	..	..	..
201—220	..	..	1	..	..	..	..	..
221—240	..	1	..	..	..	..	..	..
241—260	..	1	..	..	..	..	..	..
261—280	..	..	..	..	..	..	..	..
281—300	1	..	..	..	..	..	..	..

TABLE XXVII

NUMBER OF LATERAL LINE SCALES IN NINE SPECIES OF *PARUPENEUS* ACCORDING TO DIFFERENT AUTHORS

Authors Species	Present account	Gunther 1859	Day 1878	Herre and Montalban 1928	Weber and de Beaufort 1931	Fowler 1933	Smith 1949	Munro 1955	Lachner 1960
P. barberinus	29—30	29—31	29—31	28	30	28—29+2	28—31	28—31	29—31
P. macronemus	29—30	..	29—30	..	30—31	28+2	28—30	28—30	..
P. bifasciatus	29—30	..	30—32	28	28	28+2—3	..	28—31	28
P. trifasciatus	29—30	30	..	..	28—30	27—29+2—3	..	28—30	30
P. pleurospilus	29—30	30	..	28	29—30	25+4	25—29	..	30
P. indicus	29—30	30	30	28—29	30	27—28+2—3	27—30	27—30	30
P. pleurostigma	30	30	..	28	28—30	27—28+2—3	28—30	..	28
P. luteus	30	..	30	26	about 30	30	..	30	..
P. cyclostomus	30	27—30	..	28	30—31	26—28+2—3	27—30	..	27—30

The head is comparatively small in young specimens and the eyes are relatively larger, consequently the snout is reduced. In larger examples the growth of the snout is continued whereas that of eye remains almost stationary and hence the relation between length of snout and diameter of eye and head length and diameter of eye show a gradual increase associated with increase in size of the specimens and that of head length and snout decreases gradually as the size increases. These changes can be clearly observed from Tables XXIV, XXV, and XXVI. The differences observed in the range of lateral line scales and total number of gillrakers given by various authors are presented in Tables XXVII and XXVIII.

Parupeneus barberinus closely resembles *P. macronemus* (Lacepede), and Day (1878, page 124) wrote that "the similarity between this species and *Upeneus macronemus* (= *P. macronemus*) is so great that I have not considered it necessary to figure both" and gave the figure of *P. macronemus* only (pl. 31, fig. 1). Smith (1949 p. 229) cited the differences between these two species as "in *P. macronema* the last dorsal ray and last anal ray are quite elongate". The same difference was observed by Herre and Montalban (1928). Lachner (1960, p. 18) refuted the statement made by Smith (1949) and remarked that "the characters given by Smith to distinguish between these two species such as the elongation of the last rays of the soft dorsal and anal fins is completely erroneous for this represents an age character in both species".

It was observed in the present study that in *P. barberinus* the last ray of the soft dorsal does not reach even half-way to the black spot, which is located at the midbase of the caudal fin, irrespective of the size of the specimens. However, this is not a reliable character as pointed out by Lachner (1960) to differentiate the two species, beacause it undergoes great change with growth. It was observed during the present study that in *P. macronemus* below 70 mm. (total length) the last ray of the soft dorsal does not even touch the anterior border of the black spot which is about midway between the base of the soft dorsal and base of caudal. In specimens between 70 and 90 mm. it just reaches up to the anterior edge, in those above 100 mm. it reaches up to the middle of the black spot. In those above 150 mm. it goes beyond the posterior limit of the black spot and those above 170 mm. it touches even the base of caudal fin. The relative position of the black spot distinguishes the two species. In *P. barberinus* it is located at the midbase of the caudal fin, whereas in *P. macronemus* it is at the middle of the caudal peduncle and is slightly larger. The total number of gillrakers is quite different in these two species, in *P. barberinus* the range is between 25-30 and in *P. macronemus* 32-37 (Table XXI)

TABLE XXVIII

TOTAL NUMBER OF GILLRAKERS IN NINE SPECIES OF *PARUPENEUS* ACCORDING TO DIFFERENT AUTHORS

Authors / Species	Present account	Herre and Montalban 1928	Weber and de Beaufort 1931*	Fowler 1933*	Smith 1949*	Munro 1955*	Lachner 1960
P. barberinus	25—30	6-7/21—23	about 17	6/21	17—20	17—20	26—31
P. macronemus	32—37	—	24	7/24	24	24	31—33
P. bifasciatus	34—39	8/27—28	25	9/30	—	30	34—42
P. trifasciatus	36—38	7—9/27—29	27—28	7/28	—	28	37—42
P. pleurospilus	24—27	6/21—22	18+2	6/19	19	—	—
P. indicus	24—27	4—5/19—20	18	6/20	17—20	17—20	24—27
P. pleurostigma	30	6—7/22—23	17+7 small	7/24	18—22	—	29—32
P. luteus	25—27	6/19—21	20	—	—	—	27—29
P. cyclostomus	27	5/22	—	7/24	24	—	29—32

* Represent the gillrakers only on the lower limb.

Parupeneus pleurotaenia (Playfair)

Mullus pleurotaenia Playfair in Playfair and Gunther, 1866, 41, pl. 5, fig. 3 (not fig. 4) (Type locality : Zanzibar).

Mullus dispilurus Playfair in playfair and Gunther, 1866, 41, pl. 5, fig. 4 (not fig. 3) (Type locality: Zanzibar, Island of Pemba).

Upeneus displurus Day, 1878, 125, pl. 31, fig. 3 (Sind and probably East Africa).

Pseudupeneus fraterculus Fowler, 1933, 302, fig. 25 (Arabia, Zanzibar, Delagoa Bay, Natal, Madagascar, Seychelles, India, Philippines, China, Riu Kiu, Japan, Polynesia, Hawaii); Munro, 1955, 165, pl. 32, fig. 487 (Ceylon).

Pseudupencus pleurotaenia Smith, 1949, 230, pl. 20, fig. 571 (Africa); Smith and Smith, 1963, 22, pl. 17, fig. B (Seychelles).

Parupeneus pleurotaenia Lachner, 1960, 10 (Cataingan Bay, Jolo Market, Philippines).

Diagnosis (after Lachner, 1960)

Total number of gillrakers 29-31. Depth of body about 3·1 to 3·3 in standard length in adults, Peritoneum pale light to silvery. Second dorsal spine flexible in adults. Barbels extend up to the margin of preopercle. A light or pale saddle posterior to dorsal fin followed by a dark brown saddle which is occasionally divided into two dorso-lateral spots. A median and a dorso-lateral light stripe on body.

Distribution (fig. 4, B)

East coast of Afrioa, India (from Sind, Day), Philippines, China, Riu Kiu, Japan, Polynesia and Hawaii.

Remarks

Lachner (1960) remarked that the application of the name *Mullus pleurotaenia* Playfair is tentative beoause of the confusion in the nomenclatorial problems of this species. Playfair (1866) described two species, *M. pleurotaenia* (page 41, pl. 5, fig. 3, not fig. 4), and *M. dispilurus* (page 41, pl. 5, fig. 4, not fig. 3), but the figure numbers given and the descriptions do not agree with eaoh other. Day (1878) examined the types of the two species and treated them as synonyms and Lachner (1960), on the authority of Day (1878), treated *M. dispilurus* as a synonym of *M. pleurotaenia.* But the colour description given by Day (1878) for the specimens collected from Sind slightly differs from the description of *M. pleurotaenia* Playfair in having a golden yellow spot in the centre of each scale and in the absence of light horizontal stripes and based on these differences, Lachner (1960) stated that Day probably had another species. The presence of "two more narrow silvery lines, formed of short oblong spots, proceed from hind edge of orbit for a short distance" (Day, 1878, page 125) may represent the light stripes, characteristic of *M. pleurotaenia* Playfair.

M. pleurotaenia Playfair was considered to be a synonym of *Upeneus fraterculus* Valenciennes by Sauvage (1891). But the figure of *U. fraterculus* given by Sauvage (1891, Vol. 16, page 225, pl. 27, fig. 3) resembles more like *P. bifasciatus* (Lacepede), in having 2 dark dorsal saddles, which is certainly unlike *M. pleurotaenia.* Fowler (1933) followed Sauvage (1891) in synonymysing *M. pleurotaenia* Playfair with *U. fraterculus* Valenciennes. But Lachner (1960), who examined the same material on which Fowler reported, commented that "the inclusion of *Upeneus fraterculus* Sauvage in the synonymy of *P. fraterculus* by Fowler is certainly erroneous". He further stated that the name *Upeneus fraterculus* Valenciennes cannot be applied to the specimens he examined as there is no evidence for the presence of "light stripes" on body of the specimens described by Valenciennes.

Parupeneus macronemus (Lacepede)
(Pl. IV, fig. C)

Mullus macronemus Lacepede, 1802, 383 and 401, pl. 13 fig. 2 (Type locality not given).

Mullus auriflamma (*nec* Forskal) Lacepede, 1802, 400, pl. 13, fig. 1.

Upeneus lateristriga Cuvier in Cuvier and Valenciennes, 1829, 463 (on *Mullus macronemus* and *Mullus auriflamma* of Lacepede); Valenciennes in Cuvier and Valenciennes, 1836, pl. 19; Ruppell, 1839, 101.

Upeneus lateristriata Valenciennes in Cuvier and Valenciennes, 1836, page opp. pl. 19 (error).

Upeneus macronemus Gunther, 1859, 405 (compiled); Klunzinger, 1870, 744 (Koseir, Red Sea); Day, 1878, 123, pl. 31, fig. 1 (Red Sea, those of India to the Malay Archipelago and beyond); Boulenger, 1887, 658 (Muscat); Day, 1889, 29, fig. 12 (Red Sea, those of India to the Malay Archipelago and beyond); Sauvage, 1891, 224 (Red Sea, Reunion, Mauritius, Zanzibar, Hawaiian Islands); Jordan and Starks, 1917, 454 (Ceylon); Fowler, 1922, 83 (Hawaii); 1928, 230 (Hawaiian Islands); 1929 (1930), 648 (Honolulu); 1931, 337 (reference).

Mullus micronemus Playfair and Gunther, 1866, 40, (misprint) for *Mullus macronemus.*

Parupeneus macronema Bleeker, 1875, 24 (Sumatra, Celebes, Amboina); 1878, pl. 391, fig. 3; 1879, 2 (Mauritius); Klunzinger, 1884, 51; Steindachner, 1907, 138 (Ras Shoab, Sokotra); Zugmayer, 1913, 11 (Oman); Barnard, 1927, 587 (Delagoa Bay); Weber and de Beaufort, 1931, 388 (Indo-Pacific); Steinitz and Ben-Tuvia, 1955, 6 (Eylath, Gulf of Aqaba, Red Sea); Jones, 1964, 664, fig. 32 (Minicoy Island).

Apogon amherstinus Day, 1878, 124 (name in Synonymy).

Pseudupeneus macronemus Fowler, 1933, 279 (Red Sea, Arabia, Zanzibar, Mauritius, East Indies, Polynesia, Hawaii); 1949, 95 (Honolulu).

Pseudupeneus macronema Smith, 1949, 229, fig. 565 (Africa); Balan, 1958, 301 (Agathi, Ameni) (Laccadive Archipelago); Smith and Smith, 1963, 22, pl. 17, fig. A (Seychelles); Talbot, 1965, 465 (Tanganyika).

Parupeneus macronemus Munro, 1955, 164, pl. 32, fig. 485 (Ceylon); Jones and Kumaran, 1959, 47 (Minicoy Island); Lachner, 1960, 11 (Red Sea).

Material examined

30 specimens, 56-195 mm., from Minicoy Island.

Diagnosis

D. VIII-1, 8; P. 15-16 (Table XIX); L. l. 29-30 (Table XX); L. tr. 2-3/7. Gillrakers on the upper and lower limbs 6-8/25-29 (Table XX), total 32-37 (Table XXI). Length of head 3.5 to 4.0, of caudal 4.2 to 5.0, greatest depth of body 4.0 to 5.1 in total length. Diameter of eye 3.7 to 5.3 in head length and 1.5 to 3.0 in length of snout; length of snout 1.7 to 2.5 in length of head. Barbels 65 to 92 per cent of head length.

Interorbital space slightly convex. Preorbital scales absent. Peritoneum silvery. Brown or greyish above and pale below. A dark brown longitudinal stripe from tip of snout through eye to base of soft dorsal. The lateral line passes through above this band in the anterior region, subsequently through the line and then takes a course below it backwards. A black circular or oval spot dorso-laterally at the middle of the caudal peduncle. The black spot extending from 23rd to 25th scale of lateral line, which passes through a little below middle of the spot. The dorsal fins with a black or brown base and last rays of soft dorsal and anal rays prolonged and black in colour. Pectoral, ventral and anal fins with a black tinge.

Distribution (fig. 4, B)

Red Sea, East coast of Africa, Seas of India, Indonesia and doubtfully from Philippines and Hawaiian Islands (Fowler, 1933).

Remarks

The position of the black spot on the caudal peduncle is the most reliable external character by which this species can be differentiated from *P. barberinus* and the vague description and inaccurate illustration of this leads to confusion. The description given by Day (1878, page 124) "a black blotch at the base of the caudal fin" for *P. macronemus* rightly indicates the location of the black spot in *P. barberinus* but in the figure (1878, pl. 31, fig. 1) he has shown it more anteriorly on the caudal peduncle. Fowler (1933, page 280) stated that the black spot in *P. macronemus* is "close above lateral line" and Lachner (1960, page 11) wrote "the lateral line just touching its lower margin". However in all the 30 specimens examined during the present study the lateral line is found to be passing through just a little below middle of the black spot as figured by Bleeker, (1877, pl. 391, fig. 3), Day (1878) and Smith (1949, page 565).

Day (1878, page 124) stated that a specimen of *U. macronemus* in the Calcutta Museum "has on it an old label with *Apogon amherstinus*" which is probably a manuscript name of *Blyth's*. But because of some confusion in the descriptions of *U. macronemus* and *U. barberinus* of Day (1878), Lachner (1960) stated that it was difficult to determine with assurance what species Day had, and *Apogon amherstinus* on page 124 of Day (1878) may either represent *P. macronemus* or *P. barberinus.* Though the description given by Day (1878) is confusing, especially the position of black spot on caudal peduncle, in the figure (pl. 31, fig. 1) the position has been shown to be more or less correct for *U. macronemus* (=*P. macronemus*). Hence it may be that *Apogon amherstinus* is a synonym of *P. macronemus* as already treated by Day.

Parupeneus bifasciatus (Lacepede)

(Pl. V, fig. A)

Mullus bifasciatus Lacepede, 1802, 383, 404, pl. 14, fig. 2 (no locality); Quoy and Gaimard, 1824, 330, pl. LIX, fig. 1.

Upeneus bifasciatus Cuvier in Cuvier and Valenciennes, 1829, 468 (Bourbon); Guichenot, 1862, 24; Gunther, 1874, 59, pl. 44, fig. A (Rarotonga, Savaii, Solomons); Peters, 1876, 438 (Mauritius); Sauvage, 1891, 221, 223 (Marquesas, Carolines, Macao, Ternate, Amboina, Celebes); Fowler, 1922, 83 (Hawaii); 1925, 26 (Honolulu); Fowler and Bean, 1927, 14 (Tahiti); Herre and Montalban, 1928, 118, pl. 6, fig. 2 (Luna, Cabusao, Zamboanga, Cotabato); Fowler, 1828, 227 (Honolulu, Rarotonga, Guam, Marcus Island, Moilii, Hilo, Samoa, Apia, Papeete); 1928 (1930), 648 (Honolulu, Apia); 1931, 336 (reference).

Parupeneus bifasciatus Bleeker, 1868, 345 (Bourbon); Weber and de Beaufort, 1931, 386, fig. 79 (Indo-Pacific); Schultz, 1943, 130 (Enderbury Island, Hull Island, Canton Island, Rose Island, Samoan Islands, Apia); Munro, 1955, 164, pl. 32, fig. 482 (Ceylon); Lachner. 1960, 19, pl. 77, Fig. A (Guam, Rota Island, East Indies, Philippines, Phoenix and Samoan Islands, Society Islands); Jones, 1964, fig. 31 (Minicoy Island).

Upeneus semifasciatus Macleay, 1883, 263 (Type locality: Hood Bay, New Guinea).

Pseudupeneus bifasciatus Jenkins, 1902 (1903), 456 (Honolulu); Jordan and Evermann, 1903 (1905), 258, fig. 107 (Honolulu, Hilo, Kailua); Seale, 1906, 51 (Rarotonga); Jordan and Seale, 1905 (1906), 274 (Apia); Evermann and Seale, 1906 (1907), 88. (Bacon); Kendall and Goldsborough, 1911, 293, (Papeete, Tahiti); Fowler, 1933 291 (Philippines, Apia, Samoa, Tahili); 1949, 95 (Jarvis Island); Smith and Smith, 1963, 22, pl. 83, fig. F (Seychelles)·

Parupeneus andrewsii Regan, 1909, 403, pl. 65 (Type locality: Christmas Islands, Inidan Ocean).

Material examined

14 specimens, 90-205 mm. from Minicoy Island.

Diagnosis

D. VIII-1, 8; P. 15-18 (Table XIX); L. 1. 29-30 (Table XX); L. tr. 3/7. Number of gillrakers on the upper and lower limbs 7-10/26-29 (Table XX), total 34-39 (XXI). Length of head 3.7 to 4.3, of caudal 4.2 to 4.8, greatest depth of body

3.6 to 4.3 in total length. Diameter of eye 3.6 to 4.8 and snout 1.6 to 2.2 in length of head. Barbel rather short, 50-66 per cent in head length.

Preorbital scales absent. Scales present on caudal fin but absent on dorsals and anal fin. Peritoneum transparent. Pale brown on head and body, darker on back. Three broad black vertical bands along body. The first of these starts at the beginning of first dorsal and extends up to 5th spine and up to belly ventrally. The second band starts at the second ray of soft dorsal and extends backwards up to 6th ray and ventrally up to base of anal. The posterior band is on caudal peduncle and extends up to lateral line ventrally. This third band is not retained in preserved specimens. Fins all transparent with their edges a little dusky in preserved material.

Distribution (fig. 5, A)

Madagascar, Seas of India, Indonesia, Philippines, Island groups of Oceania eastward to Society Islands and North-east to Hawaiian Islands.

Parupeneus trifasciatus (Lacepede)

(Pl. V, fig. B)

Mullus trifasciatus Lacepede, 1802, 383, 404, pl. 15, fig. 1 (Type locality not given).

Upeneus trifasciatus Jenyns, 1842, 25 (Tahiti); Gunther, 1859, 407 (China, Amboina, Celebes, Ceylon, India); Kner, 1865, 71 (Tahiti); Schmeltz, 1866, 7 (Samoa); Gunther, 1874, 59, pl. 44, fig. B (not fig. C.) (China, Polynesia); Martens, 1876, 387 (Larentuka, Flores); Schmeltz, 1879, 40 (Samoa); 1882, 245 (New Guinea); Pohl, 1884, 27 (Samoa); Meyer, 1885, 16 (North Celebes); Steindachner, 1893, 238 (New Hebrides); Elera, 1895, 480 (Luzon, Batangas, Nasugbu, Cebu); Boulenger, 1897, 372 (Rotuma); Seale, 1901, 72 (Guam); Tirant, 1929, 168 (Phu Yen); Fowler, 1931, 336 (compiled).

Upeneus trifasciatus (Lac.) Var. Gunther, 1859, 408 (East Indies).

Parupeneus trifasciatus Bleeker, 1863, 242 (name only); Steindachner, 1900, 419 (Halmaheria, Ternate, Batjan); Weber, 1913, 295 (Sulu. Menado, Biaru, Karkaralong, Beo, Lirung, Sayleyer, Binongka, Banda); Weber and de Beaufort, 1931, 282, fig. 78 (Indo-Pacific); Schultz, 1943, 130 (Tutuila Island, Rose Island, Johnston Isalnd); Munro, 1955, 164, pl. 32, fig. 483 (Ceylon); Balan, 1958, 301 (Ameni, Laccadive Archipelago); Lachner, 1960, 22, pl. 77, fig. C (Bikini Atoll, Eniwetok Atoll, Kwajalein Atoll, Likiep Atoll, Rongerik Atoll, Rongelap Atoll, Guam, Rota Island, Saipan, East Indies, Philippines, Japan, Riu Kiu Islands, Formosa, China, Caroline Islands, Polynesia, Samoan Islands, Society Islands).

Upeneus atrocingulatus Kner in Steindachner and Kner, 1870, 443 (Type locality, Savay).

Upeneus multifasciatus Peters, 1876, 438 (Mauritius); Day, 1878, 124 (Seas of India to the Malay Archipelago and beyond); Macleay, 1883, 246 (Hood Bay, New Guinea); Day, 1889, 30 (Seas of India to the Malay Archipelago and beyond); Sauvage, 1891, 224 part); Weber, 1895, 264 (New Guinea); Waite, 1897, 185 (Faunafuti); Ishikawa and Matsuura, 1897, 54; Seale, 1900, (1901), 71 (Guam); Fowler, and Bean, 1922, 44 (Zamboanga); Fowler, 1925, 10 (Guam); 1928, 228(Tahiti, Bonin Islands, Kusaii, Papeete, Fate, Tubuai, Rarotonga, Guam Nukuhiva, Mangareva, Kingsmills, Society Islands); Schmidt, 1930, 57 (Oaikuma, Riu Kiu); 1930, 547 (Okinawa); Pietschmann, 1930, 14 (Guam).

Pseudupeneus moana Jordan and Seale, 1905, 274 (Type locality: Apia, Samoa); Jordan and Snyder, 1905, 354 (Tahiti).

Pseudupeneus atrocingulatus Jordan and Seale, 1905 (1906), 274 (Type locality: Samoa).

Parupeneus trifasciatus (Lac.) Var. *atrocingulatus* Kner Steindachner, 1906, 1388 (Samoa, Friendly Island); Weber and de Beaufort, 1931, 385 (Ambon, Samoa, Friendly Island).

Upeneus moana Snyder, 1912, 501 (Okinawa); Herre and Montalban, 1928, 124. pl. 4, fig. 24. (Philippines).

Pseudupeneus trifasciatus Fowler, 1933, 295, fig. 24 (Indo-Pacific); 1949, 95 (reference).

Material examined

5 specimens, 158-165 mm. from Minicoy Island.

Diagnosis

D. VIII-1, 8; P. 16; L.1. 29-30 (Table XX); L. tr. 3/6. Gillrakers on the upper and lower limbs 8-9/28-29 (Table XX), total 36-38 (Table XXI). Length of head 4.1 to 4.5, of caudal 4.0 to 4.3, greatest depth of body 4.0 to 4.6 in total length. Diameter of eye 4.3 and snout 1.6 to 2.0 in head. Barbel length 55 to 60 per cent of head length.

Interorbital space slightly convex and broader than eye. Peritoneum transparent. Pale brown to dusky on head and body. Four to five dark vertical bands along body. The first band is just in front of spinous dorsal, the second through base of spinous dorsal, the third in between spinous and soft dorsal, fourth through base of soft dorsal and the fifth along caudal peduncle. The first and third bands are not clear in preserved specimens. The soft dorsal with a black base. Other fins pale brown or transparent.

Distribution (fig. 5, A)

Madagascar, Mauritius, Seas of India, Indonesia, Philippines, Island groups of Oceania to Society and Tuamotu groups and from southern Japan to Southern China.

Parupeneus indicus (Shaw)

(Pl. V, fig. C)

Mullus indicus Shaw, 1803, 614 (Type locality: Indian Seas; on *Rhatee goolivinda* Russell, 1803, 42, pl. 157, Vizagapatnam).

Upeneus russelli Cuvier in Cuvier and Valenciennes, 1829, 465 (on *Rhatee goolivinda* Russell).

Upeneus waigiensis Cuvier in Cuvier and Valenciennes, 1829, 466.

Upeneus malabaricus Cuvier in Cuvier and Valenciennes, 1829, 467 (Type locality: Malabar); Bleeker, 1853, 34; Gunther, 1859, 407 (Philippines); Day, 1865, 29 (compiled); Schmelt, 1869, 14 (Kandavu); Gunther, 1874, 58, pl. 45, fig. B (Formosa, Philippines, Zanzibar, Savaii, Tonga); Schmelt, 1874, 23 (Viti, Savaii, Tongatabu); Alleyne and Macleay, (1873), 274 (Cape Grenville); Schmeltz, 1879, 40 (South Sea Islands); Macleay 1882, 245 (New Guinea); Fowler, 1904, 530 (Padang); Pearson, 1915-1918, F. 18; Duncker and Mohr, 1931, 66 (Dorper Point, South East Bay Guinea).

Upeneus indicus Gunther, 1859, 406 (China); Day, 1865, 28 (Seas of India and China); Gunther, 1874, 57 (Upolu); Day, 1878, 126, pl. 31, fig. 4 (Red Sea, East Coast of Africa, Seas of India to the Malay Archipelago and beyond); Gunther, 1880, 35 (Kandavu, Fiji); Pohl, 1884, 27 (Ponape); Meyer, 1885, 16 (Celebes); Day, 1889, 32 (Red Sea, East Coast of Africa Seas of India to the Malay Archipelago and beyond); Thurston, 1890, 92 (Pamban); Elera, 1895, 480 (Luzon, Camarines Sur, Pasacao); Ishikawa and Matsuura, 1897, 54; Fowler, 1900, 526 (Somoa); Jordan and Snyder, 1901, 84 (Nagasaki); Jordan and Evermann, 1902, 334 (Keerun, Giran, Formosa); Regan, 1905, 331. (Muscat); Jordan and Richardson 1909, 192 (Takao); Gilchrist and Thompson, 1911, 164 (Durban, Natal); Snyder, 1912, 502, (Okinawa); Pearson, 1918, P. F. 8, F. 9, F. 10, F. 11, F. 15, F. 17; Malpas. 1921, E. 5, E. 6, E. 8; Jordan and Hubbs, 1925, 247 (Kagoshima Bay); Fowler 1925, 23 (Samoa); Fowler and Ball, 1925, 16 (Wake Island); Herre and Montalban, 1928, 115, pl. 2, fig. 1 (La Uniou, Mindoro, Bacon, Tacloban, Bantayan, Cebu, Puerto Princesa, San Juan, Cagayan de Misamis, Zamboanga, Jolo); Fowler, 1928, 230 (Wake Island, New Guinea, Apia, Society Islands, Samoa); Tirant, 1929, 168 (Phu Yen); Fowler, 1929 (1930), 648 (Samoa, Padang); Schmidt, 1930, 60 (Itoman, Riu Kiu); Fowler, 1931, 337 (compiled).

Mullus malabaricus Playfair in Playfair and Gunther, 1866, 41 (Aden, Zanzibar).

Upeneus griseofrenatus Kner, 1868, 305, pl. 3, fig. 7 (Type locality: Fiji).

Pseudupenues indicus Steindachner, 1906, 1386 (Upolu); Jordan and Seale, 1905 (1906), 276 (Apia); 1906 (1907), 25 (Iloilo); Evermann and Seale, 1906 (1907), 88 (Bacon, Bulan); Snyder, 1907, 93 (Formosa, Apia); Franz, 1910, 48 (Yokohama, Kagoshima); Whitley, 1928, 12 (Santa Cruz Islands); Fowler, 1933, 287, fig. 22 (East Africa, Natal, Madagascar, India, East Indies, Philippines, China, Formosa, Riu Kiu, Japan, Micronesia, Polynesia); 1949, 95 (reference); Smith, 1949, 230, pl. 27, fig. 567 (Africa); Smith and Smith, 1963, 22, pl. 17, fig. 1 (Seychelles); Marshall, 1964, 237 (Queensland).

Parupeneus malabaricus Weber, 1913, 297 (name only); Weber and de Beaufort, 1931, 395 (Sumatra, Rotti, Bulan, New Guinea, Aden, Zanzibar, Madagascar, India, Australia, Fiji Island, Samoa, Tonga Island); Schultz, 1943, 130 (Apia, Somoa).

Parupeneus indicus Bleeker, 1875, 27 (Sumatra, Nias, Batu, Biliton, Java, Bali, Celebes, Timor, Ternate, Batjan, Buru, Ceram, Amboina, Waigiu, Philippines); 1878, 394, fig. 5; Weber, 1913, 296 (Paternoster Island); de Beaufort, 1913, 124 (Ambon); Pellegrin, 1914, 227 (Mahambo, Madagascar); Bernard, 1927, 589. (Delagoa Bay); Weber and de Beafufort, 1931, 394 (Indo Pacific); Munro, 1955, 164, pl. 32, fig. 481 (Ceylon); Lachner, 1960, 13, pl. 76, fig. A (East Indies, Philippines, China, Japan, Okinawa, New Guinea, Admiralty Islands, Fiji Islands, Samoa).

Material examined

	No. of specimens.	Size range. mm.	Locality
	33	60—300	Rameswaram (Palk Bay)
	25	71—240	Kilakarai and
Total	58		Muttupettai (Gulf of Mannar)

Diagnosis

D. VIII-1, 8; P. 16-17 (Table XIX); L. I. 29-30 (Table XX); L. tr. 3/6-7. Gillrakers on the upper and lower limbs 5-7/18-21 (Table XX), total 24-27 (Table XXI). Length of head 4·2 to 5·0, of caudal 4·0 to 4·8, greatest depth of body 4·2 to 5·0 in total length. Diameter of eye 3·4 to 5·6 in head length and barbels 60 to 79 per cent of head (Table XXIX).

Preorbital scales absent. Interorbital space convex and slightly broader than eye. Peritoneum dark or brownish. Purplish or rosy on head and cheeks. Above lateral line rather brownish and below it yellow becoming pale white at belly. Two or three yellow bands with blue margins from eye to tip of snout. Fins pinkish and in fresh specimens 2 yellow bands on dorsals and anal which disappear completely in preserved specimens. Traces of yellow lines at the caudal peduncle parallel to lateral line, visible only in fresh specimens. A golden yellow oval spot on side of body between the posterior half of spinous dorsal and anterior to base of soft dorsal, extending over 8th scale of lateral line to 13th scale (both inclusive) which passes through lower margin of the oval spot. A black circular spot on caudal peduncle, starting from 23rd scale of lateral line to 26th scale.

Distribution (fig. 5, A)

Red Sea, East coast of Africa, Seas of India, Indonesia, Philippines, Southern Japan, Southern China, Formosa, Samoa, Fiji, Tonga, Micronesia and Polynesian Islands.

Remarks

Weber and de Beaufort (1931, page 397) distinguished between *P. indicus* (Shaw) and *P. malabaribus* (Cuvier) based on the position of eye, length of barbel and the distance from eye to snout. The length of snout was stated to be twice the diameter of eye in *P. indicus* and thrice in *P. malabaricus*. These characters are not constant and change with increase in size of the specimens as seen in most species of *Parupeneus*. In small specimens the eyes are comparatively larger and the snout length is reduced. In larger specimens, the snout length increases considerably but the growth of eye is almost static or negligible. As a result, the relation of eye diameter and snout length is found to increase with size of the specimens as seen in Table XXX. The relation between head length and eye diameter also showed a similar change associated with growth (Table XXXI) whereas the relation of head length to snout length is found to decrease as the size increases (Table XXXII). However no such difference was observed in the relation between length of barbel and length of head in young and larger specimens (Table XXIX).

TABLE XXIX

BARBEL LENGTH IN PER CENT OF HEAD LENGTH IN *P. INDICUS* ACCORDING TO SIZE GROUPS

Total length mm.	Barbel length in per cent of head length									
	60-61	62-63	64-65	66-67	68-69	70-71	72-73	74-75	76-77	78-79
60—80	..	..	..	..	..	..	..	2	2	1
81—100	2	1	1	..	1	..	1	..	1	..
101—120	..	1	1	..	2	3	2	..	..	..
121—140	..	1	..	1	1	2	3	3	..	..
141—160	..	..	1	..	..	1	1	..	..	..
161—180	..	..	..	1	2	1	1	3	..	..
181—200	..	..	..	..	2	1	1	..	..	..
201—220	..	..	..	1	..	2	1	..	..	..
221—240	..	..	..	..	1	..	1	..	..	..
241—260	..	..	..	..	1	..	..	..	..	..
261—280	..	..	..	1	1	..	1	..	..	..
281—300	..	..	..	..	..	1	..	..	..	..

TABLE XXX

RELATION BETWEEN SNOUT LENGTH AND EYE DIAMETER IN *P. INDICUS* ACCORDING TO SIZE GROUPS

Total length mm.	Snout length/Eye diameter							
	1·6 to 1·7	1·8 to 1·9	2·0 to 2·1	2·2 to 2·3	2·4 to 2·5	2·6 to 2·7	2·8 to 2·9	3·0 to 3·1
60—80	4	1	..	..	..	..	..	..
81—100	1	4	1	..	..	..	..	..
101—120	1	4	3	..	..	..	..	..
121—140	..	1	4	4	..	..	..	..
141—160	..	..	2	2	..	..	..	..
161—180	..	..	1	1	6	..	..	..
181—200	..	..	..	..	2	2	..	..
201—220	..	..	..	..	..	1	1	1
221—240	..	..	..	..	..	..	2	1
241—260	..	..	..	..	..	..	1	2
261—280	..	..	..	..	..	..	..	3
281—300	..	..	..	..	..	..	..	2

TABLE XXXI

RELATION BETWEEN HEAD LENGTH AND EYE DIAMETER IN *P. INDICUS* ACCORDING TO SIZE GROUPS

Total length mm.	Head length / Eye diameter											
	3.4 to 3.5	3.6 to 3.7	3.8 to 3.9	4.0 to 4.1	4.2 to 4.3	4.4 to 4.5	4.6 to 4.7	4.8 to 4.9	5.0 to 5.1	5.2 to 5.3	5.4 to 5.5	5.6 to 5.7
60—80	1	3	1	..	..	..	..	..	..	..	..	..
81—100	..	..	1	4	1	..	..	..	..	..	..	..
101—120	1	2	2	2	1	..	..	..	..	..	..	..
121—140	..	1	..	4	1	2	1	..	..	..	..	..
141—160	..	..	..	..	2	2	..	..	..	..	..	..
161—180	..	..	..	..	1	3	2	2	..	..	..	..
181—200	..	..	..	..	..	..	2	1	1	..	..	..
201—220	..	..	..	..	..	..	1	..	1	1	..	..
221—240	..	..	..	..	..	..	..	..	2	1	..	..
241—260	..	..	..	..	..	..	..	..	..	..	2	1
261—280	..	..	..	..	..	..	..	..	..	..	1	2
281—300	..	..	..	..	..	..	..	..	..	..	1	1

TABLE XXXII

RELATION BETWEEN HEAD LENGTH AND SNOUT LENGTH IN *P. INDICUS* ACCORDING TO SIZE GROUPS

Total length mm.	Head length / Snout length								
	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4
60—80	..	..	..	..	1	1	2	1	..
81—100	..	..	..	..	1	1	3	..	1
101—120	..	..	..	..	4	3	1	..	..
121—140	..	..	1	..	4	2	2	..	..
141—160	..	..	2	2	..	..	..	..	..
161—180	..	..	2	3	3	..	..	..	..
181—200	1	..	2	1	..	..	..	..	..
201—220	..	2	1	..	..	..	..	..	..
221—240	..	1	2	..	..	..	..	..	..
241—260	..	2	1	..	..	..	..	..	..
261—280	..	2	1	..	..	..	..	..	..
281—300	1	1	..	..	..	..	..	..	..

Parupeneus pleurospilus (Bleeker)

(Pl. VI, fig. A)

Upeneus pleurospilos Bleeker, 1853, 110 (Type locality: Amboina); 1854, 69 (Japan); Gunther, 1859, 407 (compiled); Klunzinger, 1870, 746 (Koseir, Red Sea); Meyer, 1885, 16 (Menado, Celebes, Cebu); Elera, 1895, 480 (Luzon, Cavite, Santa Cruz, Cebu); Snyder, 1912, 502 (Okinawa); Jordan, Tanaka and Snyder, 1913, 183; Herre and Montalban, 1928, 128, pl. 1, fig. 2 (Polillo, Calapan, Cebu, Cagayan de Misamis, Davao); Schmidt, 1930, 59 (Daikuma, Riu Kiu).

Parupeneus pleurospilus Bleeker, 1875, 31 (Bali, Amboina, Saparua); 1878, pl. (1), 191, fig. 5; Weber and de Beaufort, 1931, 399 (Bali, Celebes, Ambon, Saparua, Red Sea (?), Japan, Okinawa, Philippines, Solomon Islands).

Upeneus pleurospilus Jordan and Snyder, 1901, 84 (Nagasaki).

Pseudupeneus pleurospilos Jordan and Seale, 1905 (1906), 276 (Samoa); Seale, 1906, 51 (Shortland Island, Solomons); Snyder, 1907, 96 (compiled); Fowler, 1933, 273, fig. 19 (Red Sea, East Indies, Philippines, Riu Kiu, Japan); Balan, 1958, 301 (Ameni, Laccadive Archipelago).

Material examined

12 specimens, 94-122 mm. from Muttupettai, Gulf of Mannar.

Diagnosis

D. VIII-1, 8; P. 16; L. 1. 29-30 (Table XX); L. tr. 2/6. Gillrakers on the upper and lower limbs 5-6/19-21 (Table XX), total 24-27 (Table XXI). Length of head 4.0 to 4.3, of caudal almost equal to the length of head and 3.9 to 4.2, greatest depth of body 3.7 to 4.1 in total length. Diameter of eye 3.7 to 4. 3 and snout 2.0 to 2.2 in head. Barbels 84-89 per cent of head length.

Interorbital space convex or nearly flat and broader than eye. Preorbital scales absent. Peritoneum dark to brownish. Body rosy or pinkish in life. A reddish brown longitudinal stripe from tip of snout to base of caudal fin, which disappears immediately after death leaving only a very faint yellow mark and may altogether absent in preserved material. The body colour also changes after death and appear to be pale yellow in preserved condition. A small black spot along lateral line extending on eighth and nineth scales. Fins with same colour as that of body and without any colour bars in preserved specimens, in fresh condition there are two very faint yellow lines on the dorsals.

Distribution (fig. 5, B)

Coasts of India, Indonesia, Philippines, Riu Kiu, Japan and Solomon Islands, and doubtfully from Red Sea.

Parupeneus fraterculus (Valenciennes)

Upeneus fraterculus Valenciennes, in Cuvier and Valenciennes 1831, 524 (Type locality: Mahe, Seychelles).

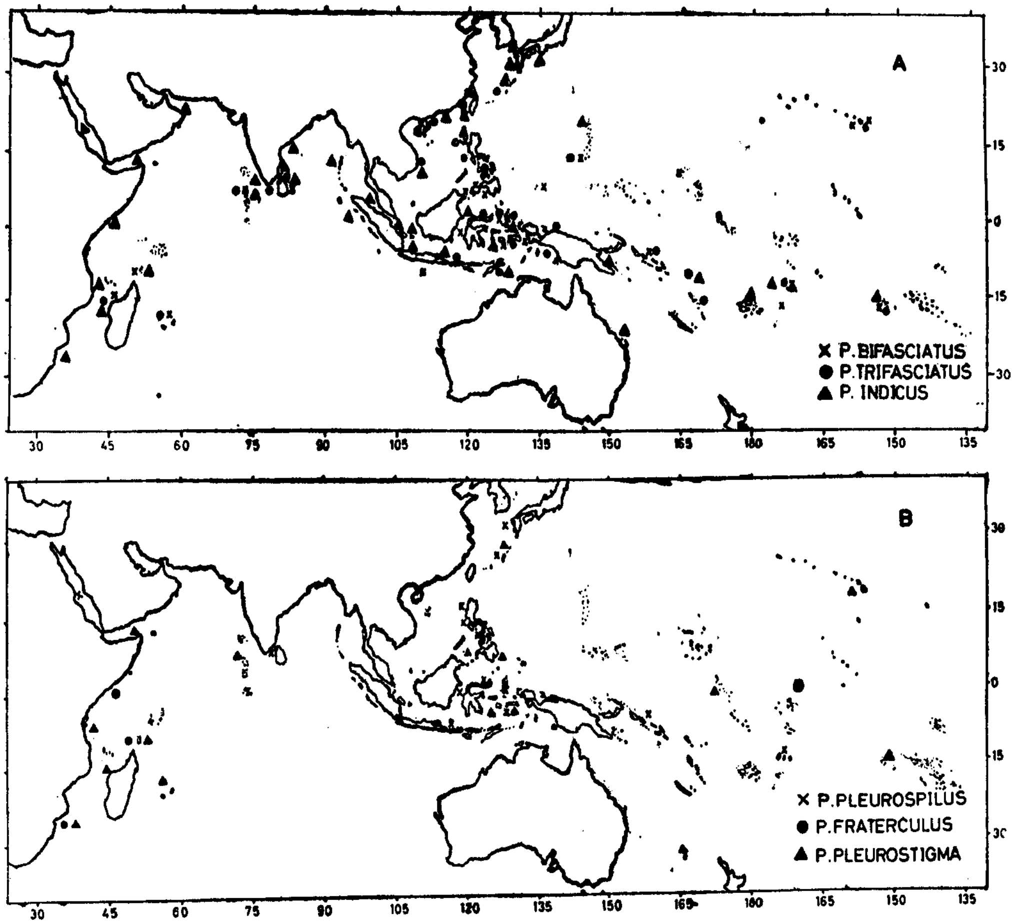
Parupeneus fraterculus Barnard, 1927, 588 (Natal coast, Delagoa Bay, Chinde).

Pseudupeneus fraterculus Smith, 1949, 229, pl. 27, fig. 564 (Africa); Smith and

Smith, 1963, 22, pl. 17, fig. C (Seychelles).

Diagnosis (after Barnard, 1927)

D. VIII-1, 8; L. 1. 29-31; L.tr. 2/6-7. Gillrakers on the lower limb 17-18. Length of head 3.0 to 3.25, greatest depth of body 3.0 to 3.5 in length of body. Diameter of eye 4.25 to 5.0 in head length and 1.75 to 2.5 in snout. Barbels reach a little beyond the angle of preopercle. First spine of the spinous dorsal short, 3rd and 4th longest, about 2/3 of depth of body. Reddish or carmine. A black saddle on upper part of caudal peduncle. A large golden blotch on back below end of soft dorsal. Scales on upper part usually with orange spots. A purplish band from



Text-figure 5. World distribution of *P. bifasciatus*, *P. trifasciatus*, *P. indicus* (fig. 5 A); *P. pleurospilus*, *P. fraterculus*, and *P. pleurostigma* (fig. 5 B)

snout to eye. Dorsals purplish or dusky, soft dorsal, anal and caudal more or less directly banded or mottled.

Distribution (fig. 5, B)

East coast of Africa, Mahe, Seychelles.

Remarks

Barnard (1927) included *Mullus dispilurus* Playfair and *M. pleurotaenia* Playfair in the snonymy of *P. fraterculus* (Valenciennes) and stated that "the specimens examined are clearly identical with Playfair's specimens from further up the East African coast". But in his description he has not mentioned the characteristic longitudinal stripes on body. Day (1878), who examined the two type specimens of Playfair, observed the longitudinal stripes on both the specimens. Based on the authority of Day (1878), Lachner (1960) synonymised *M. dispilurus* Playfair with *M. pleurotaenia* Playfair but as a questionable allocation. Further, he stated that the name *U. fraterculus* Valenciennes cannot be applied to the specimens of *P. pleurotaenia* (Playfair) as there is no evidence for the presence of the longitudinal stripes on the specimens of Valenciennes. Therefore, the inclusion of *M. dispilurus* Playfair and *M. pleurotaenia* Playfair in the synonymy of *P. fraterculus* (Valenciennes) by Barnard (1927) seems to be erroneous.

Parupeneus pleurostigma (Bennett)

(Pl. VI, fig. B)

Upeneus pleurostigma Bennett, 1831, 59 (Type locality: Mauritius); Gunther, 1874, 58 (Tahiti, Apamana, Gilbert Islands); Sauvage, 1891, 229 (on Lienard); Waite, 1901, 37, pl. 5 (Lord Howe Island); Snyder, 1912, 503 (Okinawa); Fowler, 1922, 83 (Hawaii); 1925, 245 (Delagoa Bay); 1925, 26 (Honolulu); Fowler and Ball, 1925, 16 (Laysan, Lisiansky); Fowler, 1928, 231, pl. 20 C (Maui, Honolulu, Laysan); Herre and Montalban, 1928, 122. pl. 5, fig. 2 (Zamboanga, Mindanao, Honolulu); Fowler, 1929 (1930), 648 (Honolulu); 1931, 337 (Honolulu).

Upeneus brandesii Bleeker, 1851, 236 (Type locality: Neira); Gunther, 1859, 407 (compiled).

Parupeneus brandesi Bleeker, 1865, 285 (Amboina).

Mullus pleurostigma Playfair in Playfair and Gunther, 1866, 40 (Zanzibar).

Parupeneus pleurostigma Bleeker, 1875, 29 (Amboina Banda); 1878, pl. 393, fig. 3; Steindachner, 1901, 485 (Laysan Island); Barnard, 1927, 590 (Delagoa Bay); Weber and de Beaufort, 1931, 398 (Banda, Ambon, Zanzibar, Aden, Delagoa Bay, Mauritius, Madagascar, Japan (Okinawa), Philippines, Lord Howe Island, Gilbert Island, Tahiti, Hawaiian Island (Laysan); Jones and Kumaran 1967, 387, fig. 9 (Minicoy Island); Lachner, 1960, 26, pl. 77, fig. E (Bikini Atoll, Rongelap Atoll, Philippines, Okinawa, Hawaiian Islands).

Pseudupeneus pleurostigma Jenkins, 1902 (1904), 456 (Honolulu); Snyder, 1902 (1904), 527 (Honolulu); Jordan and Evermann, 1903 (1905), 260, fig. 108 (Honolulu, Hilo); Fowler, 1933, 275 (Zanzibar) Mauritius, East Africa, East Indies, Philippines, RiuKui, Hawaii); 1949, 94 (reference); Smith 1949, 230 (Africa).

Pseudupeneus brandesi Smith and Smith, 1963, 22, pl. 88, fig. D (Seychelles); Smith, 1963, 35 (Seychelles).

Material examined

One specimen, 212 mm. from Minicoy Island.

Diagnosis

D. VIII-1, 8; P. 15; L. 1. 29; L. tr. 3/6. Gillrakers on the upper and lower limbs 7/23, total 30. Length of head 4.0, of caudal 5.0, greatest depth of body 4.6 in total length. Diameter of eye 4.7 in head and snout 1.7 in head. Barbels 71 per cent in head length.

Interorbital space convex and broader than eye. Last ray of the soft dorsal and anal slightly elongated. Peritoneum transparent. Pink or brownish, slightly darker above. A dense black oval blotch on sides of body between the dorsals, starting from 8th scale of lateral line and extending up to 12th scale (both inclusive) and lateral line passes through its centre. Immediately behind this another pale yellow blotch extending almost up to posterior extremity of base of soft dorsal and covering from 13th to 17th scales of lateral line which passes through its lower margin. Dorsally the yellow blotch extends a little below base of soft dorsal. Fins all with the same colour of body. The base of second dorsal with a dense black band, one or two more narrow bands visible at tip of soft dorsal. No bars of any colour found on other fins.

Distribution (fig. 5, B)

East coast of Africa, Seas of India, Indonesia, eastward up to Hawaiian Islands and northwards to Japan.

Remarks

The "dusky saddle located posterior to last two rays of soft dorsal fin" (Lachner, 1960, page 27), is not traceable in the specimen studied.

Discussion

Smith (1963, page 35) stated that *P. brandesi* appears to have been generally confused with *P. pleurostigma* (Bennett) and distinguished the two species based on the size of the black spot on the body. In *P. brandesi* the black spot is "at least twice eye" and in *P. pleurostigma* the black spot is "about eye size". But Whitehead, who examined the type specimen of *pleurostigma* for Smith, reported the black blotch on the side as larger than eye. Based on this, Smith (1963) concluded that *brandesi* and *pleurostigma* are probably conspecific.

Parupeneus porphyreus (Jenkins)

Pseudupeneus porohyreus Jenkins, 1902 (1904), 454, fig. 22 (Type locality: Honolulu); Snyder, 1902 (1904), 527 (Hanalei Bay, Kauai, Honolulu); Jordan and Evermann, 1903 (1905), 262, fig. 110 (Honolulu, Hilo); Seale, 1906, 51 (Raiatea); Fowler, 1933, 311, fig. 26 (Hawaiian Islands); Smith and Smith, 1963, 22, pl. 88, fig. C (Seychelles).

Upeneus porphyreus Fowler, 1922, 83 (Hawaii); Jordan and Jordan, 1922, 52 (Hawaii); Fowler, 1925, 26 (Honolulu); Fowler and Ball, 1925, 16 (Pearl and Hermes Reef, Laysan and Lisiansky); Fowler, 1928, 228, pl. 20 A (Honolulu, Raiatea, Fate, Pearl and Hermes Reef, Laysan, Lisiansky, Polynesia?, Kauai); 1929 (1930), 648 (Honolulu).

Parupeneus porphyreus Lachner, 1960, 15 (Hawaiian Islands).

Diagnosis (After Jenkins, 1902) (1904)).

D. VIII-1, 8; P_1 15. L.l. 30; L.tr. 2½/6. Gillrakers 5+25. Length of head 3.3, depth of body 3 in length. Diameter of eye 4 and length of snout 2 in head. The barbels though generally not reaching the posterior end of the preopercle, do so in some specimens. Interorbital space 3.5 in head and is convex. Preorbital scales absent. Head and body uniformly red and fins brighter in life. First dorsal with a, white tip, and soft dorsal and anal with golden tinge on membranes. In alcohol, with pale yellowish ground colour. A brownish yellow or white saddle on caudal peduncle, just behind soft dorsal and extending laterally about half way to lateral line. A faint dark stripe through eye, faded on body. A small dusky blotch just behind eye.

Distribution (fig. 6, A)

Hawaiian Islands, Seychelles (Smith and Smith, 1963).

Remarks

Lachner (1960) stated that this species may be endemic to Hawaiian Islands. But recently Smith and Smith (1963) reported it from Seychelles in the Western Indian Ocean. Based on the authority of Smith and Smith (1963) this species has been included in the present account.

Parupeneus cyclostomus (Lacepede)

(Pl. VI, fig. C)

Mullus cyclostomus Lacepede, 1802, 383, 404, pl. 14, fig. 3 (Type locality: not given).

Mullus chryserydros Lacepede, 1802, 384, 406, 408 (Type locality: Mauritius).

Upeneus chryserydros Cuvier in Cuvier and Valenciennes, 1829, 470 (Hawaii, Bourbon, Coromandel); Guichenot, 1862, 24; Macleay, 1882, 246 (New Guinea); Snyder, 1912, 502 (Okinawa); Fowler, 1922, 83 (Hawaii); 1925, 10, 26 (Guam, Honolulu); Fowler and Ball, 1925, 15 Johnston and Wake Islands); Herre and Montalban, 1928, 127, pl. 5, fig. 3 (Zamboanga); Fowler, 1928, 232 (Types of *Upeneus saffordi* and *Pseudupeneus aurantiacus*) (Honolulu, Fate, Johnston and Wake Islands, Guam, Apia, Bonin Islands, Tempe, Tahiti); 1929 (1930) 648 (Honolulu); Schmidt, 1930, 58 (Itoman and Daikuma, Riu Kiu); Fowler, 1931, 336 (compiled).

Upeneus cyclostomus Cuvier in Cuvier and Valenciennes, 1829, 472 (Seychelles); Schmeltz, 1869, 14 (Samoa); Boulenger, 1887, 658 (Muscat); Sauvage, 1891, 226, pl. 26, figs. 4, 4a (Mauritius); Snyder, 1912, 502 (Okinawa); Herre and Montalban, 1928, 123, pl. 6, fig. 3 (Tablas and Sibuyan Islands).

Upeneus cyclostoma Ruppell, 1835, 101 (Mohila); Gunther, 1859, 409 (Moluccas, Ceram, Amboina); Schmeltz, 1866, 7 (Samoa); Klunzinger, 1870, 745 (Koseir, Red Sea); Schmeltz, 1879, 40 (Samoa); Pohl, 1884, 27 (Samoa); Meyer, 1885, 16 (North Celebes); Norman, 1922, 321 (Natal).

Upeneus chryserijdros Bleeker, 1853, 34.

Upeneus oxycephalus Bleeker, 1856, 45 (Type locality: Menado, Celebes); Gunther, 1859, 409 (Mauritius); Schmeltz, 1864, 8 (South Seas); 1865, 6 (South Seas); 1869, 14 (Samoa); Gunther, 1873, 409 (Solomons); Pohl, 1884, 27 (South Seas).

Parupeneus cyclostomus Bleeker, 1865, 285 (Amboina); Steindachner, 1901, 486 (Honolulu); Pellegrin, 1914, 231 (Nossi Be, Madagascar); Barnard, 1927, 586 (Natal coast); Lachner, 1960, 29, pl. 76, fig. B (Bikini Atoll, Eniwetok Atoll, Rongelap Atoll, Rota Island, East Indies, Philippines, Admiralty Islands, Phoenix and Samoan Islands, Johnston Island, Marquesas Islands, Hawaiian Islands).

Mullus oxycephalus Playfair in Playfair and Gunther, 1866, 41 (Zanzibar).

Upeneus chryserythrus Gunther, 1874, 60, pl. 45, fig. A (Polynesia); Schmeltz, 1879, 40 (Tahiti); Klunzinger, 1884, 52; Pohl, 1884, 27 (Tahiti).

Parupeneus xanthospilurus Bleeker 1875, 37 (Type locality: Amboina).

Parupeneus cherserydros Bleeker, 1875, 35 (Celebes, Sangi, Amboina, Goram); 1878 pl. (3) 393, fig. 2.

Upeneus saffordi Seale, 1900 (1901), 71 (Type locality: Guam).

Pseudupeneus chryserydros Jenkins, 1902 (1904), 454 (Honolulu); Snyder, 1902 (1904), 527 (Honolulu); Jordan and Evermann, 1903 (1905), 255, fig. 106 (Honolulu, Hilo); Seale, 1906, 51 (Fate); Jordan and Seale, 1905 (1906), 275 (Apia); Smith and Smith, 1963, 22, pl. 83, fig. E (Seychelles).

Pseudupeneus cyclostomus Jordan and Seale, 1905 (1906), 275 (Pago Pago); Fowler, 1933, 304 (Red Sea, Arabia, Zanzibar, Natal, Mauritius, Reunion, Madagascar, India, East Indies, Philippines, Riu Kiu, Melanesia, Micronesia, Polynesia, Hawaii); 1949, 95 (Africa); Smith, 1949, 230 (Africa); Smith and Smith, 1963, 22, pl. 88, fig. A (Seychelles).

Pseudupeneus aurantiacus Seale, 1906, 48, fig. 14 (Type locality: Tubuai, Austral Islands).

Parupeneus chryserydros Weber, 1913, 296 (Karkaralong, Banda); Weber and de Beaufort 1931, 404, (Indo-Pacific); Schultz, 1943, 130 (Apia, Samoa).

Parupeneus cyclostoma Zugmayer, 1913, 11 (Oman).

Upeneus chrysercros Borodin, 1930, 53 (Singapore) (error).

Material examined

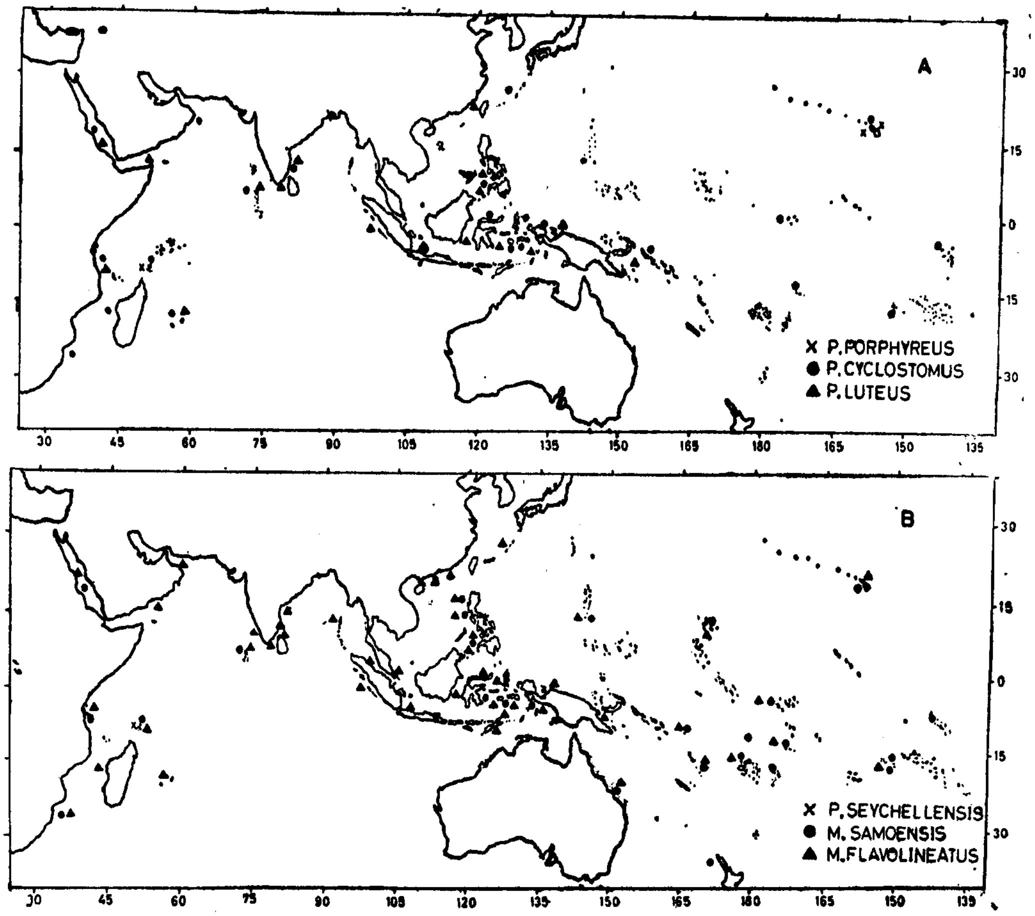
2 specimens, 156 and 332 mm. from minicoy Island.

Diagnosis

D. VIII-1, 8; P_1 16; L. 1. 30; L. tr. 3/7. Gillrakers on the upper and lower limbs 6/21-22 (Table XX), total 27-28 (Table XXI). Length of head 3·6 to 3·9, of caudal 4·8 to 4·9 and greatest depth of body 4·4 in total length. Diameter of eye

5 times in head length in smaller specimen (155 mm.) and 6·9 times in larger specimen (332 mm.). Length of snout 1·8 in head length in both specimens. Diameter of eye 2·7 in length of snout in smaller and 4·1 in larger specimen. Length of barbel 90 per cent of head in both specimens.

Interorbital space convex and broader than eye. The last rays of soft dorsal and anal slightly prolonged. Peritoneum transparent. Black tan along head and body, a little darker above and lighter below at belly. A pale yellow saddle middorsally along caudal peduncle, starting from just behind base of soft dorsal and extending up to but the last two scales from procurrent caudal rays and



Text-figure 6. World distribution of *P. porphyreus*, *P. cyclostomus*, *P. luteus* (fig. 6 A); *P. seychellensis*, *M. samoensis* and *M. flavolineatus* (fig. 6 B).

extends to the sides up to lateral line. Fins dusky. The base of dorsals with black band and one or two more narrow dark bands on both dorsals and anal. Caudal fin with blackish tinge.

Distribution (fig. 6, A)

Red Sea, East Coast of Africa, Seas of India, Indonesia and eastward up to Hawaiian Islands.

Discussion

Parupeneus cyclostomus (Lacepede) has been distinguished from *P. chryserydros* (Lacepede) based on the relative size of the eye and snout and the differences in the colour forms, by Gunther (1873), Sauvage (1891), Jordan and Seale (1906), Herre and Montalban (1928), Weber and de Beaufort (1931) and Fowler (1933). These characters are not constant as they change with growth. The differences observed in the relation of diameter of eye and snout length were significant even in the two specimens examined in the present study, a character observed in many species of *Parupeneus* and as specifically shown in case of *P. barberinus*, *P. macronemus* and *P. indicus*.

Lachner (1960, pp. 31, 32) has given a detailed account of the confusion existing regarding these two species and has recognised only one species, *P. cyclostomus* and treated *P. chryserydros* (Lacepede), *P. xanthospilurus* Bleeker, *Upeneus oxyecephalus* Bleeker, *U. safforodi* Seale and *Pseudupeneus aurantiacus* Seale as synonyms.

Lacepede's figure of *M. cyclostomus* (1802, pl. 14, fig.3) does not show the pale saddle on the caudal peduncle. Sauvage (1891) examined the specimens in the Paris Museum and distinguished the two species *cyclostomus* and *chryserydros* but showed no light saddle on caudal peduncle in the illustrations. Weber and de Beaufort (1931, p. 406) commented that the figure given by Sauvage for *cyclostomus* (pl. 26, fig. 4) "represents not *cyclostomus* Lacepede, but what is generally named *chryserydors* Lacepede, while his species with a much shorter snout, represented in fig. 3 on pl. 26 corresponds with *cyclostomus*".

Bleeker (1878, fig. 2) distinguished *chryserydros* as a valid species with a light saddle on the caudal peduncle starting from the posterior base of soft dorsal to the procurrent rays of caudal fin, whereas his nominal species *Pseudupeneus xanthospilurus* was illustrated (1878, fig. 5) as having the light spot extending half the length of the caudal peduncle. Weber and de Beaufort (1931, pp. 404, 407) recognised both *chryserydros* and *cyclostomus* from the same area from where Bleeker's specimens were collected, but they did not have specimens of *cyclostomus* and questioned the occurrence of this species in the Archipelago. Herre and Montalban (1928) recognised both the species from Philippines and stated that *cyclostomus* is "characterised by its notably compressed deep body, small eye, long snout, long barbels and the absence of a yellow saddle on caudal peduncle" and *chryserydros* "the colour of the body and fin is uniformly yellowish brown, with a conspicuous paler saddle on the caudal peduncle". Fowler (1933) described *cyclostomus* from Philippines and *xanthospilurus* based on one specimen and listed *chryserydros* from Mauritius but had no specimen of it.

Jordan and Seale (1906) described *chryserydros* as having a "pale saddle on the tail, while the general colour is clear red without markings" from Samoa. Jordan and Evermann (1905) recorded only *chryserydros* from Samoa and Schultz (1943) also recorded only *chryserydros* from the same area. Smith (1949) recorded *cyclostomus* from Southern Africa and Smith and Smith (1963) recorded both *chryserydros* and *cyclostomus* from Seychelles.

The resume given above reveals the confusion and vague picture regarding the specific status of the two species. The morphometric proportions are so inconsistent with growth stages, and the colour also may vary. Most of the above accounts are based on one or two specimens and in some cases they did not have the species in question at all. In the present study also only two specimens were available for examination. As such the possibility of more than one species involved in the above accounts cannot be completely ruled out. Still at present, it seems reasonable to agree with Lachner 1960 in considering *chryserydros* as a synonym of *cyclostomus* Lacepede.

Fowler (1928) who examined the types of *Upeneus saffordi* Seale and *Pseudupeneus aurantiacus* Seale, kept in the Bishops Museum, found them to be synonymous with *P. chryserydros* (Lacepede).

Parupeneus luteus (Valenciennes)

(Pl. VII, fig. A)

Upeneus luteus Valenciennes in Cuvier and Valenciennes, 1831, 521 (Type locality: Mauritius); Bleeker, 1849, 63 (Batavia); Montrouzier, 1856, 430; Thiolliere, 1857, 152 (Woodlark Island); Day, 1878, 125, pl. 31, fig. 2 (East coast of Africa, Seas of India); Macleay, 1882, 246 (New Guinea); Meyer, 1885, 16 (Kordo, Mysore); Day, 1889, 31 (East coast of Africa, Seas of India); Pearson, 1918, F. 18; Malpas, 1921, E. 7; Herre and Montalban 1928, 114, pl. 5, fig. 1 (Dumaguete, Zamboanga); Fowler, 1928, 231 (Red Sea, Zanzibar Mauritius, East Indies, Melenesia, Polynesia).

Mullus luteus Playfair in Playfair and Gunther, 1866, 41 (Zanzibar, Aden).

Parupeneus luteus Bleeker, 1875, 32 (Sumatra, Java, Ceram, Amboina, New Guinea); 1878, 9, pl. (4) 394, fig. 1; Klunzinger, 1884, 52; Weber, 1913, 296 (Makassar, Sulu); Weber and de Beaufort, 1931, 401 (Red Sea, Aden, Zanzibar, Bourbon, Mauritius, Seychelles, Sumatra, Java, Celebes Ambon, Ceram, Mysore, New Guinea, Formosa, Philippines, Louisidae Archipelago, Woodlark Isiand); Lachner, 1960, 15, pl. 76, fig. C (East African coast to Philippines and New Guinea.

Pseudupeneus luteus Evermann and Seale, 1906 (1907), 89 (Philippines); Fowler, 1933, 313 (Red Sea, Zanzibar, Mauritius, India, East Indies, Philippines, Melanesia); 1949, 96 (reference).

Material examined

3 specimens, 161, 220, and 245 mm. from Minicoy Island and 1 specimen, 125 mm. from Mandapam, Gulf of Mannar.

Diagnosis

D. VIII-1, 8; P_1. 16; L. 1. 30; L.tr, 2/7. Gillrakers on the upper and lower limbs 5-6/20-21 (Table XX), total 25-27 (Table XXI). Length of head 3.6 to 4.0, of caudal 4.5 to 5.2, greatest depth of body 4.0 to 4.8 in total length. Diameter of eye 5.0 to 6.1 and snout 1. 7 to 2.0 in head length. Barbels 73 to 85 per cent of head.

Preorbital scales absent. Interorbital space convex and broader than eye. Peritoneum transparent. Yellowish on head and body, belly pale white or yellow. Fins also of same colour with one or two deep yellow bands on second dorsal and anal fins. Three to four bluish bands along head, from eye to tip of snout. Scales with a golden yellow spot at the centre which give the appearance of some longitudinal golden yellow bands. In preserved specimens all these colours fade away leaving the specimens somewhat pale yellow with fins clear and the spots on scales also disappear completely.

Distribution (fig. 6, A)

Red Sea, East Coast of Africa, Seas of India, Indonesia, Philippines, Formosa and Melanesia.

Remarks

Herre and Montalban (1928, p. 114) stated that the length of pectorals to be 4 times in head length. Weber and de Beaufort (1931, p. 402) observed it only as 1.2 in head and remarked that the statement of Herre and Montalban (1928) may be a misprint. In the present study also it showed a range from 1.4 to 1.7 times in head length.

Parupeneus seychellensis (Smith and Smith)

Pseudupeneus seychellensis Smith and Smith, 1963, 22, pl. 88, fig. B (Type locality: Seychelles); Smith, 1963, 34 (Mahe, Seychelles).

Diagnosis (after Smith, 1963)

D. VIII-1, 8; P_1. 2, 14; L. 1. 28; L.tr. 2/6. Gillrakers 6+1+17. Depth of body equals head, 3.4 in body. Diameter of eye 5.5 in head, 1.9 in interorbital and 2.5 to 3.0 in snout. Barbels reach below hind end of opercle. Third dorsal spine the longest. Upper half of body with alternating narrow scarlet and yellow stripes, lower half silvery. Head reddish and with 4 or 5 bright yellow lines from preorbital through eye. The spines of first dorsal red, membranes yellow. Soft dorsal with pink apex and 2 narrow red bars. Caudal pink, anal pink with 3 yellow lines, pectoral and ventral fins pink.

Distribution (fig. 6, B)

So far known only from Mahe, Seychelles.

Genus **Mulloidichthys** Whitley (1929)

Mulloides (*nec* Richardson), Bleeker 1849, 6 (Genotype: *Mullus flavolineatus* Lacepede).

Mulloidichthys Whitley, 1929, 122 (Genotype: *Mullus flavolineatus* Lacepede). (*Mulloidichthys* Whitley proposed to replace *Mulloides* Bleeker).

Diagnosis

Dentition incomplete, teeth on jaws in the form of villiform bands and in several rows anteriorly and in one or two irregular rows posteriorly. No vomerine or palatine teeth. Scales present on caudal fin but absent on dorsal and anal fins. First dorsal with 8 spines, the first spine minute.

General distribution

Tropical and subtropical Indo-Pacific and Western Atlantic regions.

Four species of *Mulloidichthys* have been recorded from the Indian Ocean, including *M. vanicolensis* Valenciennes (a nominal form according to Lachner, 1960) and the recent *Mulloides auratus* Fourmanoir and Crosnier (1963). On account of the doubtful nature and the absence of any reliable record of *M. vanicolensis* from the Indian Ocean, except Fourmanoir and Crosnier 1963 (though Bleeker, 1853 and Weber and de Beaufort, 1931 recorded it from East Indies, the latter authors have commented that "in the Indo-Australian Archipelago it is principally known from the North Eastern part and seems to be rare"), this species is not included in the present account.

The description of *Mulloides auratus* given by Fourmanoir and Crosnier 1963 is inadequate to determine with assurance what species they had. The colour description given by them agrees with that of *M. flavolineatus* and they have stated that this species could be confused with *M. flavolineatus* (Lacepede). Hence it is likely that it may be a synonym of *M. flavolineatus* (Lacepede). Because of its doubtful status, this species also is not included in the present account.

Key to the Indian species of the genus *Mulloidichthys* Whitley

1. Black spot on sides of the body just below lateral line, at the tip of spinous dorsal, another black spot on the inner side of the operculum. Total number of gillrakers 24 to 28. Peritoneum black............ ....*Mulloidichthys samoensis* (Gunther)

2. No black spot on sides of body or inside the operculum. Number of gillrakers 27 to 33. Peritoneum deep black........ ....*M. flavolineatus* (Lacepede)

Mulloidichthys samoensis (Gunther)
(Pl. VII, fig. B)

Mulloides samoensis Gunther, 1873, 57, pl. 43, fig. B (Type locality: Apia, Samoa); Schmeltz, 1877, 12 (Ponape); 1879, 40 (Ponape); 1884, 27 (New Zealand); Jenkins, 1902 (1904), 453 (Honolulu); Snyder, 1902 (1904) 527 (Honolulu); Jordan and Evermann, 1905, 253, fig. 105 (Oahu, Hilo); Jordan and Seale, 1905 (1906), 276 (Apia); Evermann and Seale, 1906 (1907), 87 (San Fabian, Bacon); Kendall and Goldsborough, 1911, 204 (Faunafuti, Vavau, Makemo, Fakarava, Rangiroa, Guam); Kendall and Radcliffe, 1918, 123 (Rikitea); Weber, 1923, 294 (Lirung, Salibabu Island); de Beaufort, 1913, 124 (Ambon); Fowler, 1925, 10, 26, 33 (Guam, Samoa); Fowler and Ball, 1925, 15 (Laysan, Lisiansky); Herre and Montalban, 1928, 132, pl. 3, fig. 4 (Manila, Bacon, Romlon, Borongan, Cebu, Camiguin Island, Samal Island, Davao, Caldera Bay, Zamboanga, Guam); Whitley, 1928, 12 (Santa Cruz Islands); Fowler, 1928, 234 (Honolulu, Tahiti, Guam, Fate, Raiatea, Nuuyhiva, Shortland, Palmyra, Lisiansky, Laysan, Society Islands, Gillbert Islands, Oceania?, Maui, Bonin Islands, Apia, Hilo, Makemo, Faunafuti, Rangiroa, type of *Upeneus preorbitalis*).

Mulloidichthys samoensis Fowler, 1929 (1930), 649 (Honolulu, Apia); 1931, 337 (Honolulu); Weber and de Beaufort, 1931, 374, fig. 76 (Simalur, Ambon, Salibabu, Philippines, Marianas, Samoa, Hawaii, Marquesas, Tahiti, New Hebrides, Pleasent Island); Fowler, 1933, 226 (East Indies, Philippines, Queensland, Lord Howe Islands, Micronesia, Polynesia, Hawaii); Schultz, 1943, 129 (Hull Island, Canton Island, Swains Island, Tutuila Island, Apia, Samoa); Smith, 1949, 231, pl. 28, fig. 573 (Africa); Balan, 1958, 301 (Agathi, Kadamat, Laccadive Archipelago); Lachner, 1960, 40, pl. 78, fig. A (Red Sea eastward through East Indies, Philippines and Islands of Oceania through Hawaiian Islands); Smith and Smith, 1963, 22, pl. 17, fig. H (Seychelles); Talbot, 1965, 466 (Tutia Reef, Tanganyika).

Upeneus preorbitalis Smith and Swain, 1882, 132 (Type locality: Johnston Island).

Pseudupeneus preorbitalis Jordan and Evermann, 1905, 263, fig. 111 (on the type of *U. preorbitalis* (Smith and Swain).

Material examined

28 specimens, 79 to 282 mm. from Minicoy Island.

Diagnosis

D. VIII-1, 8; P_1 16-17 (Table XXXIII); L. 1. 35-38 (Table XXXIV); L. tr. 3/6. Gillrakers on the upper and lower limbs 6-10/17-20 (Table XXX1V), total 24-28 (Table XXXIII). Length of head 4.0 to 4.5, of caudal equal to or slightly shorter than head and 4.0 to 5.2, greatest depth of body 5.0 to 5.8 in total length. Diameter of eye 3.4 to 4.4 and snout 2.0 to 2. 8 in head length. Barbels 50 to 75 per cent of head length.

Interorbital space equals to diameter of eye in width in most cases and in some a little broader than eye. Peritoneum black. Head and body light grey above and silvery white below. An yellow longitudinal stripe from eye to base of caudal fin on sides of body. A black small spot just below lateral line at the posterior tip of spinous dorsal. A similar black blotch on inner side of operculum is retained in some specimens. Fins nearly transparent. In preserved specimens the grey colour of body becomes pale white or darker above and yellowish white below. The longitudinal stripes on side also fade away in most specimens.

Distribution (fig. 6, B)

Red Sea, East Coast of Africa, Seas of India, Indonesia, Philippines, Islands of Oceania and up to Hawaiian Islands.

TABLE XXXIII

TOTAL NUMBER OF PECTORAL FIN RAYS AND GILLRAKERS IN TWO SPECIES OF *MULLOIDICHTHYS*

Species	Pectoral fin rays		Gillrakers										Mean
	16	17	24	25	26	27	28	29	30	31	32	33	
M. samoensis	9	16	2	1	7	7	8	..	..	..	..	..	26.72
M. flavolineatus	8	10	..	..	..	3	5	3	2	2	1	2	29.33

Mulloidichthys flavolineatus (Lacepede)
(Pl. VII, fig. C)

Mullus auriflamma Forskal, 1775, 30 (Type locality: Djedda, Red Sea); Bonnaterre, 1788, 144 (Red Sea); Gmelin, 1789, 1341 (Red Sea); Walburn, 1792, 620 (on Forskal); Schneider, 1801, 79 (Red Sea); Lacepede, 1802, 382, 400 (not pl. 13, fig. 1) (Arabia).

Mullus flavolineatus Lacepede, 1802, 384, 406 (Locality not given).

Mullus aureovittatus Shaw, 1803, 618 (Type locality: Indian Seas).

Upeneus zeylonicus Cuvier in Cuvier and Valenciennes, 1829, 459 (Type locality: Trinquemale, Ceylon); 1831, 520 (New Guinea).

Upeneus flavolineatus Cuvier in Cuvier and Valenciennes, 1829, 456 (Mauritius, Massauah); Ruppell, 1835, 101, pl. 26, fig. 1 (Mohila); Jenyns, 1842, 24 (Keeling Islands); Guichenot, 1862, 24.

Upeneus mauritianus Bennett, 1831, 59 (Type locality: Mauritius).

Mulloides flavolineatus Bleeker, 1849, 12 (name only); Gunther, 1859, 403 (China, Madagascar); Kner, 1885, 69 (New Holland); Schmeltz, 1869, 14 (Savay); Gunther, 1874, 56 (South Pacific); Bleeker, 1875, 15 (Cocos, Celebes, Timor, Ternate, Buru, Batjan, Amboina, Ceram, Banda); Peters, 1876, 438 (Mauritius); Martens, 1876, 387 (Singapore); Streets, 1877, 89 (Fanning Islands); Bleeker, 1878, pl. (4), 394, fig. 3; Day, 1878, 122, pl. 30, fig. 6 (Type of *Upeneus zeylonicus*, Andamans); Schmeltz, 1879, 40 (Savay); Gunther, 1879, 471 (Rodriguez); Sauvage, 1881, 105 (Swatow, China); Pohl, 1884, 27 (Savay); Meyer, 1885, 16 (Menado, Celebes, Tabukan, Sangi); Boulenger, 1887, 658 (Muscat, East Africa); Day, 1889, 28 (Red Sea through Seas of India to the Malay Archipelago and beyond); Sauvage, 1891, 231 (Red Sea, Mauritius, Reunion, Ternate, Hawaii, Guam, Buru, Borabora, Fiji); Elera, 1895, 480 (Luzon, Manila); Weber, 1895, 264 (New Guinea); Kendall and Goldsborough, 1911, 294 (Makemo, Vavau, Faunafuti, Borabora); Snyder, 1912, 503 (Okinawa); Gilchrist and Thompson, 1917, 364 (compiled); Duncker and Mohr, 1931, 66 (Jacquinot Bay, South coast New Pomerania, Dorpor Point, South East Bay, New Guinea).

Mulloides zeylonicus Bleeker, 1849, 12 (name only); Gunther, 1859, 404 (compiled); Bleeker, 1875, 16 (compiled); 1878, 46 (New Guinea); Karoli, 1881, 156 (Ceylon); Boulenger, 1887, 658 (Muscat); Zugmayer, 1913, 11 (Oman).

Hypeneus flavolineatus Cantor, 1849 (1850), 1018 (Type locality: Pinang).

Mullus (*Mulloides*) *flavolineatus* Martens, 1865, 378 (Red Sea).

Mulloides auriflamma Klunzinger, 1870, 742 (Koseir, Red Sea); 1884, 50; Steindachner, 1901, 485 (Laysan, Honolulu); Jenkins, 1902 (1904), 454 (Honolulu); Snyder, 1902 (1904), 527 (Honolulu); Jordan and Evermann, 1903 (1905), 250, fig. 103 (Honolulu, Hilo); Jordan and Seale, 1905, 32, 782 (Negros); Steindachner, 1906, 1386 (Samoa); Jordan and Seale, 1905 (1906), 276 (Pago Pago, Apia); Steindachner, 1907, 138 (Scheich Othman); Kendall and Radcliffe, 1912, 123 (Rikitea, Mangareva); Fowler, 1922, 83 (Hawaii); Fowler and Bean, 1922, 44 (Zamboanga); Fowler, 1925, 26 (Honolulu); Barnard, 1927, 585 (Natal coast Delagoa Bay); Fowler and Bean, 1927, 7 (Poeloe Toekus Island, Sumatra); Herre and Montalban, 1928, 130, pl. 2, fig. 3 (Philippines); Fowler, 1928, 233, pl. 21, fig. A (Honolulu, Tubuai, Tahiti, Nukuhiva, Fate, Marcus Island, Johnston Island, Apia, Fanning Island, Faunafuti, Borabora, Rikitea, Makemo, Vavau, Guam, New Guinea, Bonin and Society Islands); McCulloch, 1929, 222 (compiled); Schmidt, 1930, 54 (Yaeyama, Riu Kiu).

Upeneoides flavolineatus Pohl, 1884, 45 (Madagascar).

Mulloidichthys auriflamma Fowler, 1929 (1930), 610, 649 (Hong Kong, Honolulu); 1731, 337 (Honolulu) Weber and de Beaufort, 1931, 376 (Indo-Pacific); Fowler, 1933, 263 (Indo-Pacific); Blegvad and Loppenthin, 1944, 133, pl. 7, fig. 1 (Iranian Gulf); Smith, 1949, 231, pl. 28, fig. 572 (Africa); Munro, 1955, 163, pl. 32, fig. 481 (Ceylon); Lachner, 1960, 42, pl. 78, fig. B (Indo-Pacific); Smith and Smith, 1963, 22, pl. 17, fig. G (Seychelles); Jones, 1964, 663, fig. 29 (Minicoy); Talbot, 1965, 466 (Tutia Reef, Tanganyika).

Material examined

18 specimens, 145 to 223 mm. from Rameswaram and Dhanushkodi.

Diagnosis

D. VIII-1, 8; P_1. 16-17 (Table XXXIII), L. 1. 35-38 (Table XXXIV), L. tr. 3/7. Number of gillrakers on the upper and lower limbs 6-8/21-25 (Table XXXIV), total 27-33 (Table XXXIII). Length of head and caudal 4.0 to 4.5, greatest depth of body 4.7 to 5.3 in total length. Diameter of eye 3.2 to 3.8 and snout 2.2 to 2.6 in head length. Barbels 62 to 76 per cent in head.

Interoribtal space slightly shorter than diameter of eye in most and equal in some cases. Peritoneum black. Head and body pink, pale on sides and yellowish below. A golden yellow longitudinal stripe from eye to base of caudal fin. Fins flesh coloured without any markings. In preserved material the colour become pale yellow on body and lighter below. Fins also of the same colour. The golden yellow stripe not traceable in preserved specimens.

Distribution (fig. 6, B)

Red Sea, East Coast of Africa, Seas of India, Indonesia, Philippines, Islands of Oceania and Hawaiian Islands.

Remarks

A comparison of the range given by various authors for lateral line scales and gillrakers are given in the tables XXXV and XXXVI. The slight difference observed in the colour descriptions given by various authors may be due to the state of preservation of the material examined. Fresh specimens will have bright colouration which may partially be retained in preserved material for some time. But in long preserved material none of the original colours can be noticed.

TABLE XXXIV

RANGE OF VARIATION IN THE NUMBER OF LATERAL LINE SCALES AND GILLRAKERS IN THE UPPER AND LOWER LIMB IN TWO SPECIES OF *MULLOIDICHTHYS*

Species	No. of L. l. scales				Gillrakers upper limb					Gillrakers lower limb								
	35	36	37	38	6	7	8	9	10	17	18	19	20	21	22	23	24	25
M. samoensis	3	5	4	16	1	3	16	4	1	1	11	8	5	..	..	..	..	..
M. flavolineatus	4	5	7	2	5	6	7	..	..	..	..	..	..	6	7	2	1	2

TABLE XXXV

NUMBER OF LATERAL LINE SCALES IN TWO SPECIES OF *MULLOIDICHTHYS* ACCORDING TO DIFFERENT AUTHORS

Authors: / Species	Present account	Gunther 1859	Day 1878	Herre and Montalban 1928	Weber and de Beaufort 1931	Fowler 1933	Smith 1949	Munro 1955	Lachner 1960
M. samoensis	35-38	..	..	35	35+2-3	36-37+4-5	36-38	..	33-38
M. flavolineatus	35-38	35-36	35-36	36	36-38+4-5	35-36+4-5	35-38	35-38	35-38

TABLE XXXVI

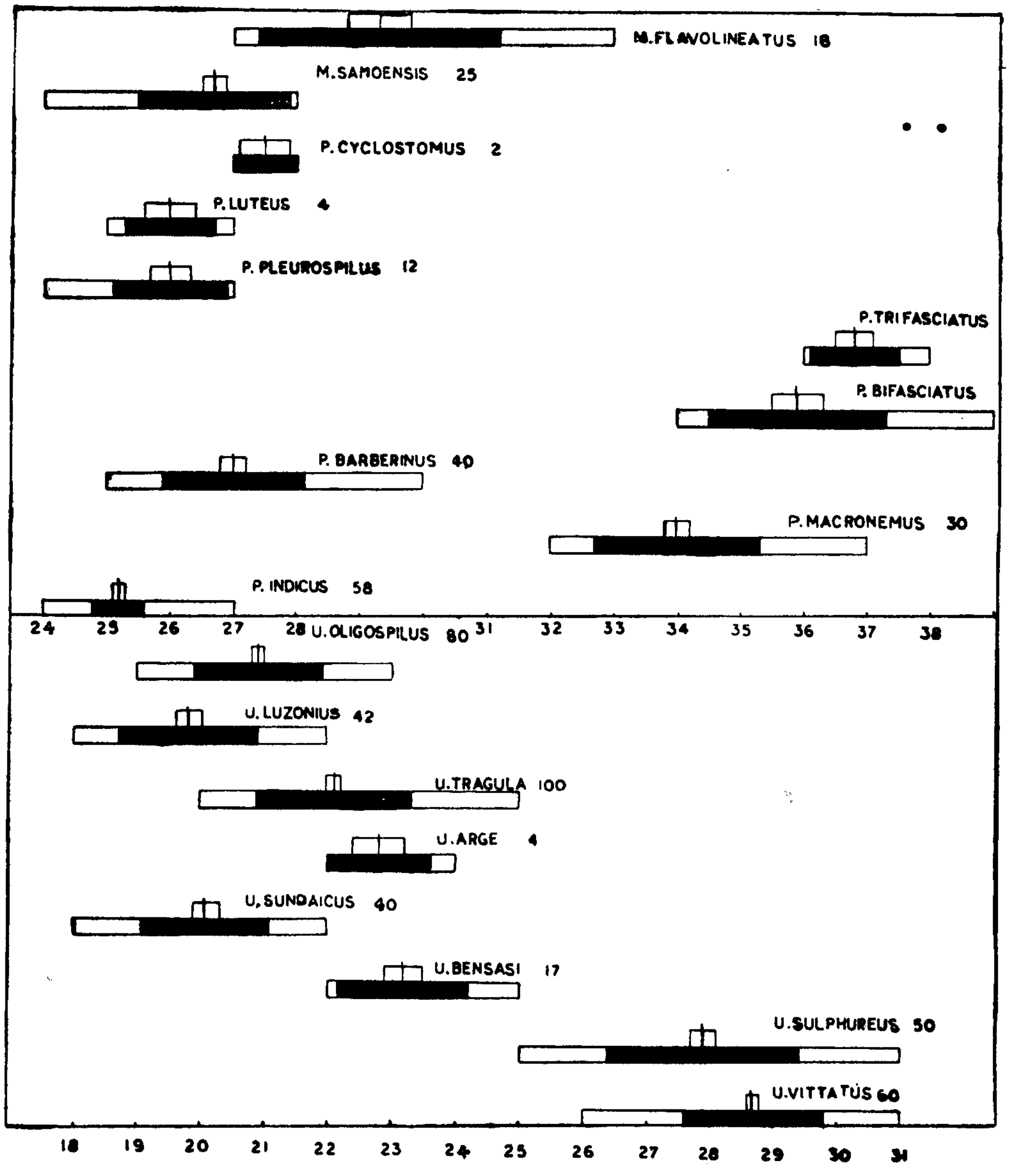
TOTAL NUMBER OF GILLRAKERS IN TWO SPECIES OF *MULLOIDICHTHYS* ACCORDING TO DIFFERENT AUTHORS

Authors: / species	Present account	Herre and Montalban 1928	Weber and de Beaufort 1931*	Fowler 1933	Smith 1949*	Munro 1955*	Lachner 1960
M. samoensis	24-28	7-8/18-20	18-20	7-8/17-20	16-19	..	24-31
M. flavolineatus	27-33	8/23-24	About 15+some rudiments.	8/20-23	20	20	29-35

* Represent the gillrakers on the lower limb only.

RELATIONSHIP BETWEEN SPECIES

Lachner (1954) divided the ten species of *Upeneus* into two groups in three different ways based on a single character or by using a combination of characters. The first character is the presence or absence of the first minute spine of the spinous dorsal. Based on this *U. bensasi* can be separated from all the rest



Text-figure 7. Graphical representation of the gillraker counts in 8 species of *Upeneus*, 8 species of *Parupeneus* and 2 species of *Mulloidichthys*.

of the species studied in the present account in which the minute spine is always present, while it is absent in *U. bensasi*.

The colour of the peritoneum and number of gillrakers together form another basis of division. *U. bensasi*, *U. arge*, *U. tragula*, and *U. oligospilus* are related in having a light to silvery coloured peritoneum. The gillraker counts also are fewer in these species and can be separated from the other species namely *U. vittatus* and *U. sulphureus* where the number of gillarkers are relatively higher. The gillraker counts are graphically represented in figure 7, for all the species studied, where the range, mean, standard deviation and standard error of mean are shown along with the number of specimens examined in each case. As seen in figure 7, the 8 species of *Upeneus* fall into two groups, *U. vittatus* and *U. sulphureus* forming the first and the other species forming the second group where the gillrakers range from 25-31 in the first and 18-25 in the second group.

The third method is based on the number of pectoral fin rays. The range of the total number of pectoral fin rays in the 8 species of *Upeneus* are given in the Table 1 along with the frequency distribution and mean. This character also divides the species into the two groups as above, *U. vittatus* and *U. sulphureus* forming one group and all the rest of the species another group.

The osteology of the 4 species of *Upeneus* namely, *U. tragula*, *U. luzonius*, *U. vittatus*, and *U. sulphureus* also suggest a similar group relationship. *U. tragula* and *U. luzonius* are related in many osteological characters and fall into a group which can be readily separated from the other group consisting of *U. vittatus* and *U. sulphureus* (see Table XXXIX in the section on osteology).

The nine species of *Parupeneus* examined can be divided into two groups based on the number of gillrakers and colour of peritoneum. The gillaraker counts, graphically represented divide *P. macronemus*, *P. bifasciatus* and *P. trifasciatus* into one group where the range is from 32-39 and all the rest of the species into another group with a range of 24-30 (See Table XXI). The peritoneum is transparent to silvery in the first group and dark or brownish in most of the other species.

The osteological characters of *P. indicus*, *P. macronemus* and *P. bifasciatus* have been studied and the differences and similarities in case of individual bones in these species show a closer relationship between *P. macronemus* and *P. bifasciatus* and *P. indicus* can be separated from the above two species easily (see relationship within genus in the section on osteology).

The two species of *Mulloidichthys* studied cannot be separated based on any of the characters mentioned as the range of the number of pectroal fin rays and gillrakers overlaps. The colour of the peritoneum also is black in both species. No characteristic difference could be observed in their osteology also.

Part Two

COMPARATIVE OSTEOLOGY

COMPARATIVE OSTEOLOGY OF GOATFISHES

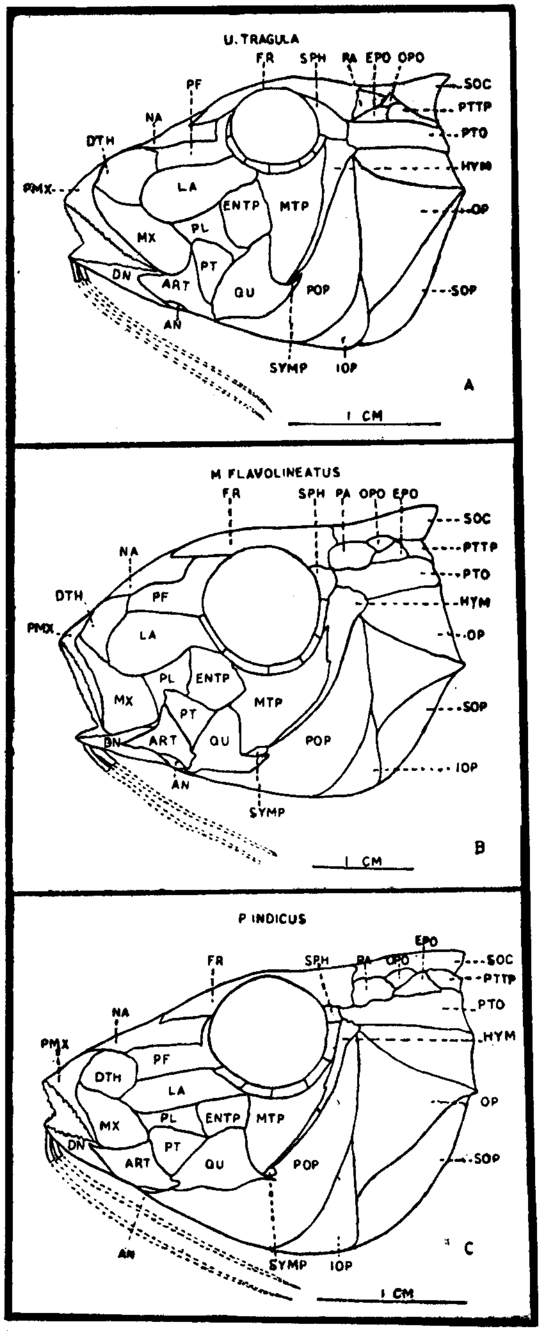
BOULENGER (1904) traced the relationship of the family Mullidae with Sparidae based on general agreement in the "Structure of vertebral column and the presence of a subocular shelf" and also pointed out the differences between Mullidae and Sparidae in the presence of hyoid barbels, very weak dentition, reduced (4) number of branchiostegals and the double perforation of the scapula in case of the former. According to Regan (1913) the Mullidae are specialised in several characters than Lutianidae with which they are related in the presence of strong subocular shelf, protractile mouth, villiform teeth in jaws and often on palatines and vomer, well developed occipital and parietal crests, palatine without ridge, the number of vertebrae (24 = 10 + 14) and having a scaly axillary process for the ventral fins. They differ from Lutianidae in having a lesser number (4) of branchiostegals, all the precaudal vertebrae with parapophyses and all the ribs on parapophyses (Regan, 1913) and in the presence of a pair of barbels.

A review of the literature shows that our knowledge about the osteology of goatfishes is very scanty except for some general accounts by Gunther (1859), Starks (1899), Boulenger (1904), Regan (1913), Gregory (1933) and Ford (1937). Hence it is thought that a detailed study of the osteology of the three genera of goatfishes namely *Upeneus* Cuvier, *Mulloidichthys* Whitley and *Parupeneus* Bleeker which occur in the Seas of India will greatly enrich our knowledge on the subject.

In the present account, the osteological characters of the three genera mentioned above have been studied by selecting a species representing each genus viz., *Upeneus tragula* Richardson, *Mulloidichthys flavolineatus* (Lacepede) and *Parupeneus indicus* (Shaw). To know whether the differences observed between these species are typical of the genus which they represent and also to know the differences between the species of a genus, 3 more species of *Upeneus* namely *U. vittatus* (Forskal), *U. sulphureus* Cuvier and *U. luzonius* Jordan and Seale and 2 more species of *Parupeneus* namely *P. bifasciatus* (Lacepede) and *P. macronemus* (Lacepede) and one more species of *Mulloidichthys* viz. *M. samoensis* (Gunther) were examined with special reference to those characters in which the three genera are found to differ. The study is limited to these species due to the lack of adequate material of other species.

All the material for the present study has been collected from Rameswaram Island except the specimens of *P. bifasciatus*, *P. macronemus* and *M. samoensis* which were obtained from the Minicoy Island.

Fresh fish were boiled in water to make the tissues soft for easy removal. After preparing the skeleton, all the individual bones were disarticulated and studied. Alizarin stained material was used to study the skeleton *in situ*. As fresh material of *P. bifasciatus*, *P. macronemus* and *M. samoensis* were not available, individual bones were studied after disarticulating the alizarin stained skeletons. Alizarin staining technique employed by Hollister (1934) as modified by Clothier (1950) was used in the present study.



Text-figure: 8. Lateral view of the skull of

(A) *U. tragula,*

(B) *M. flavolineatus* and

(C) *P. indicus*

The works of Gunther (1859), Starks (1901), Gregory (1933), Ford (1937), Clothier (1950), Ramaswami (1952) and Harrington (1955) were chiefly followed in naming the individual bones.

The Neurocranium

The neurocranium in all the three genera is triangular, narrow at the anterior region and broad posteriorly (fig. 8). Supraoccipital crest is well developed and is carried forward by the close apposition of the dorsal elevated rim of the frontals. Three grooves, the supratemporal, temporal and dialator grooves are present on either side of the supratemporal ridge, separated by the temporal and pterotic ridges. In *Parupeneus* species, besides the supratemporal and temporal ridges the external pterotic ridge also is continued on to the frontals and consequently all the three ridges and grooves are present on the frontals. But in *Upeneus* species and *Mulloidichthys* species the external or pterotic ridge is not continued on to the frontals and as a result only the supratemporal and temporal ridges and the corresponding grooves are seen on the frontals.

The orbit is slightly larger in *Mulloidichthys* species than in species of *Upeneus* and *Parupeneus* and the length of the snout is a little longer in *Parupeneus* than in the other two genera. No other external differentiation could be made out in the skull. Individual bones in the skull of the three species, namely *U. tragula*, *M. flavolineatus* and *P. indicus* are described below in detail, the number given in brackets indicates the figure number of that particular bone in figures 9, 10 and 11 respectively of the above 3 species. Only those bones which were found to differ in the 3 genera studied were examined in the other species namely *U. vittatus*, *U. sulphureus*, *U. luzonius*, *P. bifasciatus*, *P. macronemus* and *M. samoensis* and they are figured in text figures 12 and 13.

The olfactory region

The **dermethmoid** (1) is the most anterior bone of the neurocranium. It is a median unpaired bone with an anterior pointed and broad posterior region. The anterior end is pointed and rests over the vomer dorsally. Posteriorly it is connected with the prefrontals and dorso-laterally with the nasals.

The **prefrontals** (2) are two massive irregular bones articulating with the dermethmoid in front and posteriorly they form the anterior wall of the orbit. The two bones meet along the median line and are firmly united. Dorsally they are overlapped by the anterior end of the frontals and dorsolaterally by the nasals. Ventrally they are supported by the posterior extension of the vomer and anterior end of the parasphenoid. The posterior end is concave and forms the anterior limit of the orbit. The shape and structure of the prefrontals are similar in all the 3 species.

The **nasals** (3) are flat and elongate bones with an anterior pointed end and broad posterior end with slight concavity. They are forked posteriorly and in between these forked ends of each nasal fits the anterior pointed end of tontfrhe al.

The nasals lie over the dermethmoid dorso-laterally and anterior ends rest over the anterodorsal margin of the vomer.

The shape of the nasals differ in the 3 species and there is some similarity between *U. tragula* and *M. flavolineatus* in this respect. In *U. tragula* the anterior pointed end is relatively short while in *M. flavolineatus* it is comparatively longer.

In *P. indicus* this region is just a small projection immediately followed by a flat semicircular lateral extension. It is not forked posteriorly along the median line as in the other 2 species but a definite articulating facet is present for attachment of the anterior end of the frontal.

Vomer (4) is a median, unpaired, roughly triangular bone with a broad anterior region and narrow posterior region and ending in a sharp point. The vomer articulates with the maxilla in front. Dorsally it is grooved and supports the dermethmoid. The posterior pointed end is inserted into a shallow groove on the ventral side of the parasphenoid in the anterior region. The vomer bears fine villiform teeth on the ventral side at the anterior broad end in *U. tragula.* These vomerine teeth are absent in *P. indicus* and *M. flavolineatus* and except for this the vomer is alike in all the 3 species.

The Orbital region

The **frontals** (5) are paired large bones forming more than three fourth of the roof of the skull. They are broad at the posterior end and become slightly narrow and pointed anteriorly. The frontals are closely apposed together medially along their entire length except the anterior tip and the dorsal elevated margins form a median ridge. The pointed anterior ends fit in between the posterior froked ends of the nasal and overlap the prefrontals. Laterally, they form the dorsal margin of the orbit and posteriorly join with the supraoccipital, posterolaterally with the parietals, pterotics and sphenotics and ventrally with the alisphenoids.

The frontals are alike in *U. tragula* and *M. flavolineatus* but in *P. indicus* it differs from the other 2 species. In *U. tragula* and *M. flavolineatus* the frontals have got a single ridge, (temporal ridge) other than the median supratemporal ridge, formed as a result of the union with the parietal crest posteriorly and runs forward laterally and terminates near the anterior limit of the orbit. As a result, there are three grooves formed in *P. indicus* viz., dialator, temporal and supratemporal and three ridges in the frontal whereas in *U. tragula* and *M. flavolineatus* the dialator ridge is not continued forward towards the frontal and so only the temporal and supratemporal grooves are seen at the posterior region of the frontals.

The **alisphenoids** (6) are small flat bones and nearly triangular in shape. They are connected to the frontals dorsally, with the sphenotics dorsolaterally, with the prootic posterolaterally and with the basisphenoid ventrally. They form the posterodorsal angle of the orbit wall.

The **parasphenoid** (7) is a median long bone with an anterior pointed end and a posterior bifurcated end with a dorsal wing-like expansion on either side in the posterior half. The ventral surface of the anterior pointed end is grooved and it encloses the posterior end of the vomer. Anterodorsally it articulates with the base of the prefrontals. The dorsal wing-like expansion supports the prootic on either side. The posterior end articulates with the basisphenoid.

The circumorbital bones

A chain of bones encircling the orbit wall are termed the circumorbital bones. The bones that form the upper boundary are termed supraorbital bones which are absent in the family Mullidae as in many other advanced groups of recent teleosts (Gosline 1961, 1965). The other bones of the series are called suborbital bones.

The **lacrymal** (8) or first suborbital is a flat and relatively large bone and is the largest of the suborbital series. The shape is nearly oval with small projection at the posterior end in *U. tragula* and *M. flavolineatus* but in *P. indicus* it is triangular with a concavity at the posterior end. Anteriorly it rests lateral to the nasal and overlaps vomer. The lacrymal is excluded from the margin of the orbit (Smith and Bailey, 1962) and is connected to the angle at the union of the second and third suborbitals by the small posterior pointed end in *U. tragula* and *M. flavolineatus* and in *P. indicus* the posterior concave end is connected with the convex anterior margin of the second suborbital.

The **second** (9) and **third** (10) suborbital bones form a well developed subocular shelf. The second suborbital forms the anteroventral and the third forms the ventral limit of the orbit. They are rectangular bones with a bony lamella extending inwards forming the subocular shelf.

The fourth, fifth and sixth suborbitals are minute rod-like bones connected by ligaments. The sixth suborbital (dermosphenotic) forms the posterodorsal limit and is joined with the sphenotic by ligamentous connection. Apart from the differences in the shape of lacrymal the rest of the bones of the circumorbital series are similar in all the 3 species.

Otic region

The **parietals** (11) are paired small bones with a well developed median parietal crest. They are connected to the frontals in front and supraoccipital behind. Posterolaterally they are attached with the epiotic.

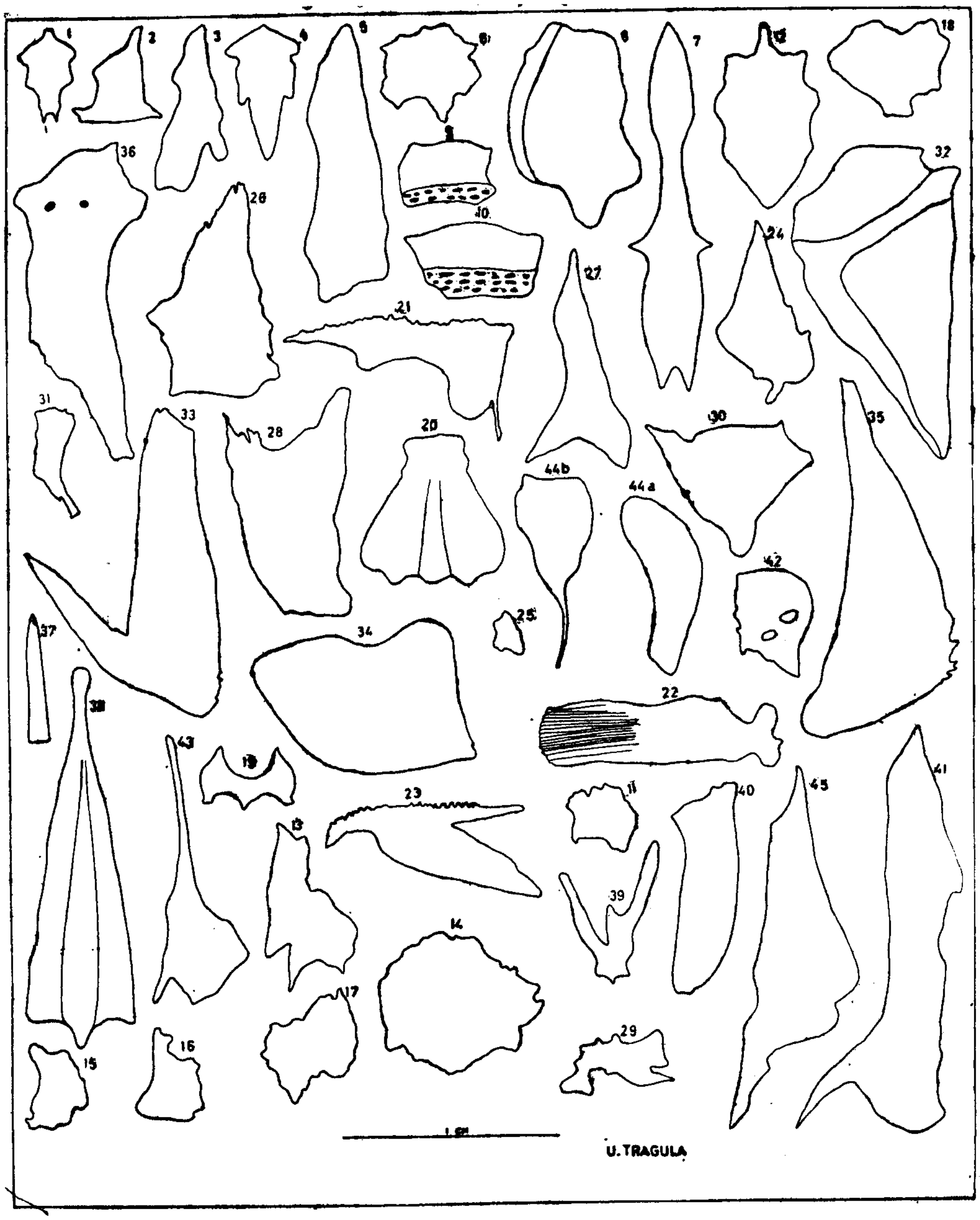
The **supraoccipital** (12) forms the median postero, dorsal region of the neurocranium. It is narrow at the anterior end and broad at the posterior region. The broad posterior region is bent downwards and ends in a sharp point. Middorsally it bears a well developed ridge, the supraoccipital crest, and separates the supratemporal grooves of either side. The supraoccipital is connected to the frontals in front, anterolaterally with the parietals and with the opisthotics posterolaterally, and with the exoccipitals ventrally.

The anterior tip of supraoccipital ends in a median small knob-like point with a concave articulating suface on either side in *U. tragula.* But in *P. indicus* and *M. flavolineatus* the anterior region is more narrow and terminates in a sharp point without the concave articulating surface on either side.

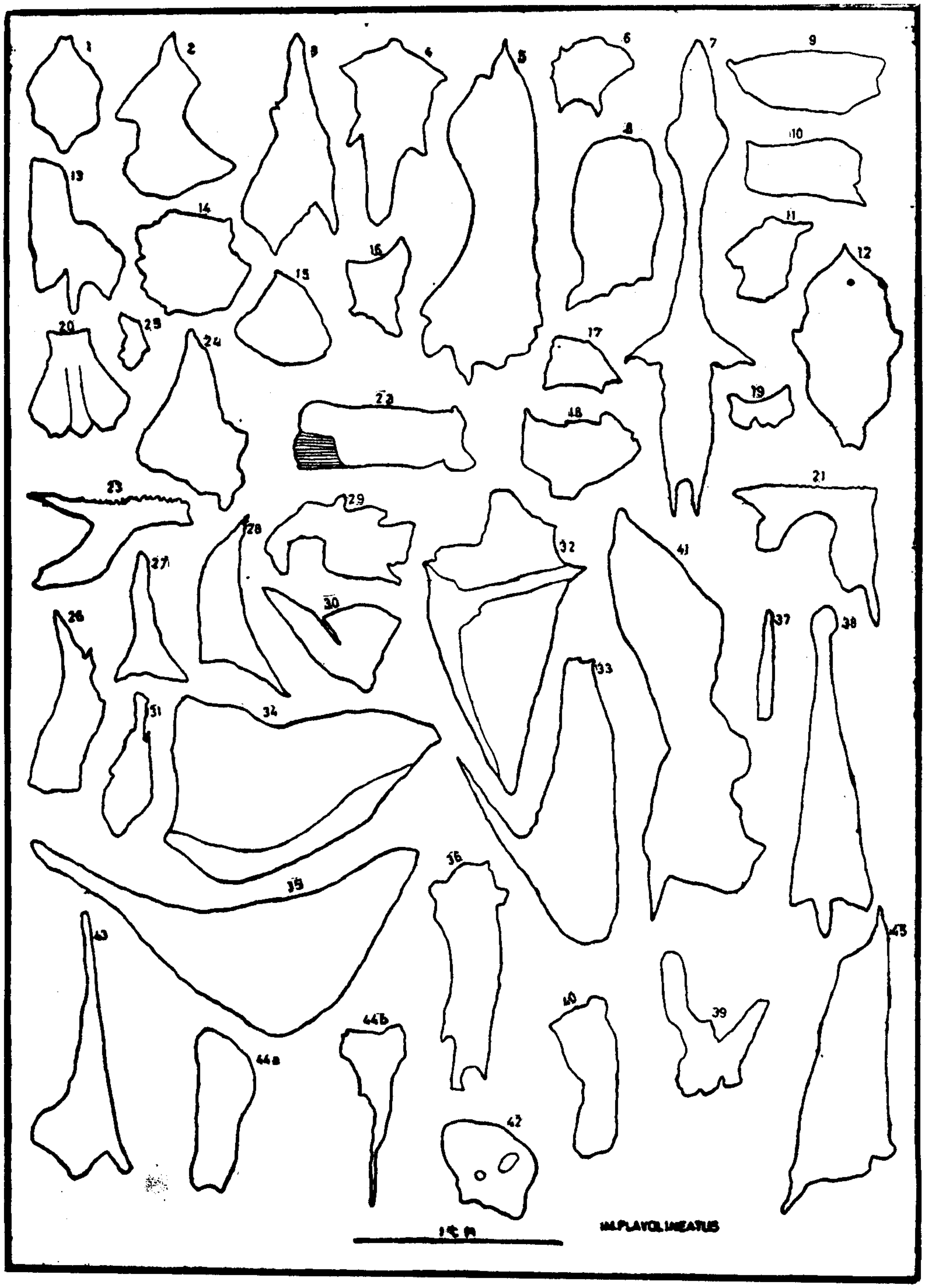
The **pterotics** (13) form the posterolateral corners of the skull and are produced into a spine on either side. Dorsally the pterotic ridge is well developed. Ventrally there is a small cavity to accommodate one of the articulating condyles of the

Text-figure 9. Individual bones in the skeleton of *U. tragula*

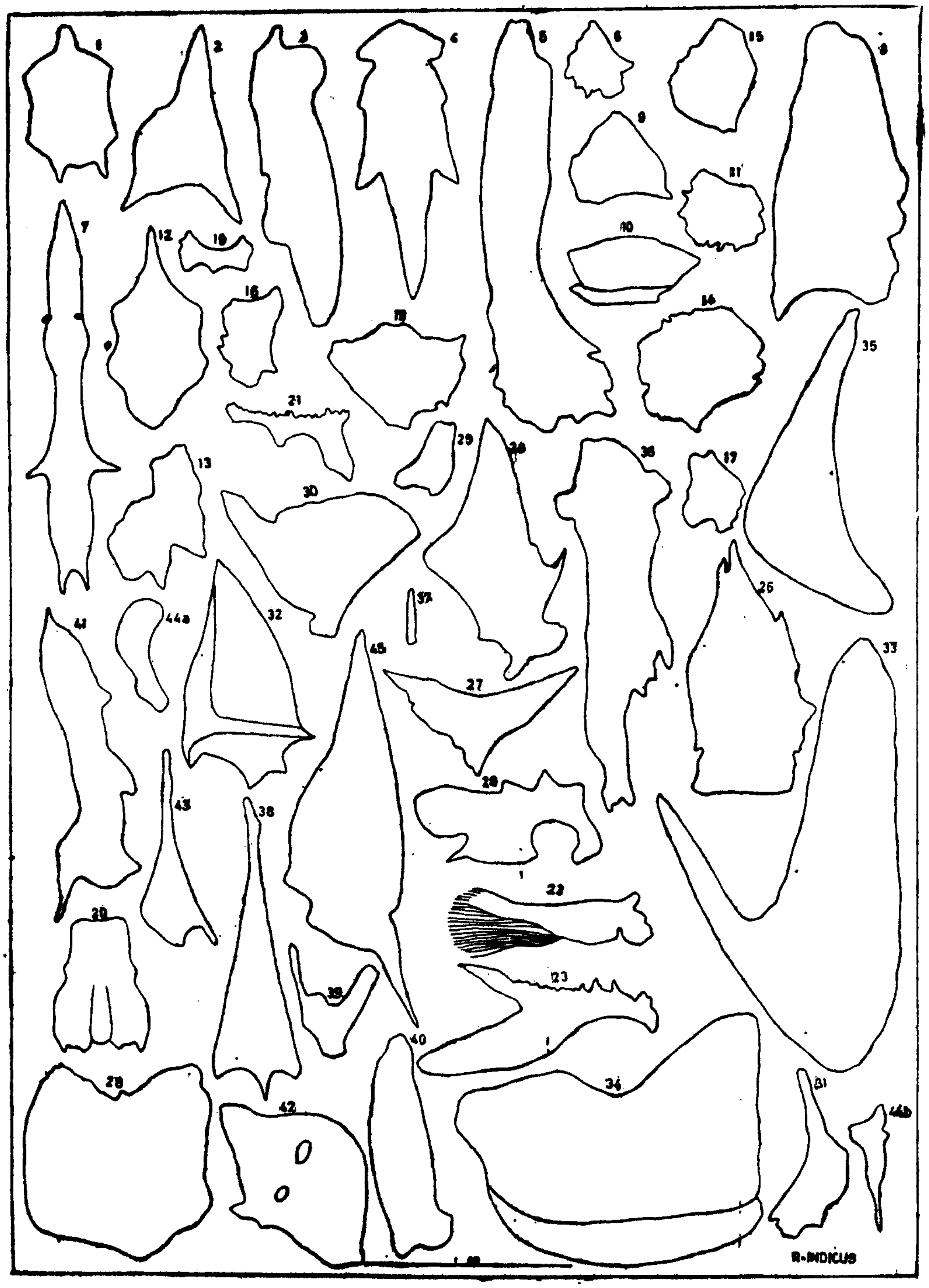
1.	Dermethmoid	24.	Articular
2.	Prefrontal	25.	Angular
3.	Nasal	26.	Metapterygoid
4.	Vomer	27.	Ectopterygoid
5.	Frontal	28.	Entopterygoid
6.	Alisphenoid	29.	Palatine
7.	Parasphenoid	30.	Quadrate
8.	Lacrymal	31.	Sympletic
9.	Second suborbital	32.	Opercle
10.	Third suborbital	33.	Subopercle
11.	Parietal	34.	Interopercle
12.	Supraoccipital	35.	Preopercle
13.	Pterotic	36.	Hyomandibular
14.	Prootic	37.	Glosohyal
15.	Epiotic	38.	Urohyal
16,	Sphenotic	39.	Post-temporal
17.	Opisthotic	40.	Supracleithrum
18.	Exoccipital	41.	Cleithrum
19.	Basisphenoid	42.	Scapula
20.	Basioccipital	43.	Coracoid
21.	Premaxilla	44a.	Postcleithrum
22.	Maxilla	44b.	Postcleithrum
23.	Dentary	45.	Pelvic bone



Text figure 9. Individual bones in the cranium of *Upeneus tragula* (See for explanation page 84)



Text-figure 10. Individual bones in the cranium of *Mulloidichthys flavolineatus*.
(For explanation see page 84)



Text-figure 11. Individual bones in the cranium of *Parupeneus indicus*.
(For explanation see page 84)

hyomandibular. It is connected with the sphenotic anteriorly, dorsolaterally with the opisthotic and epiotic and ventrally with the prootic. The pterotics are similar in all the species.

The **prootics** (14) are prominent bones on the ventral region of the neurocranium. They are paired irregular bones attached to the sphenotic and alisphenoids dorsolaterally. Ventrally they are supported by the wing-like expansions of the parasphenoid and the basioccipital and posterodorsally with the pterotics. They enclose a cavity dorsolaterally to lodge the otolith. There is a median perforation in the prootic. The prootics are alike in all the species.

The **epiotics** (15) are two pyramid-shaped bones at the posterodorsal corner of the skull and their internal cavities form the posterodorsal limit of the brain chamber.

To the conical elevation or ridge is connected the upper branch of the post-temporal. The dorsal ridge is continuous with the parietal crest and forms the temporal ridge. The epiotics are connected with the pterotic laterally, the exoccipital posteriorly and with the opisthotic dorsolaterally.

The **sphenotics** (16) are small bones and form the roof of the orbit posteriorly. Dorsally they are connected with the frontals, laterally with the pterotics and ventrally with the prootics.

The **opisthotics** (17) are thin scale-like bones, triangular in shape. They are placed at the junction of the pterotic, epiotic and supraoccipital.

The **exoccipitals** (18) are two flat bones with two small perforations. The exoccipitals articulate with the prootics anteriorly and with the pterotics laterally. The posterior articulating condyles for the atlas are concave and extend beyond the basioccipital posteriorly. The bases of the exoccipitals encircle the foramen magnum.

Basicranial region

The **parasphenoid** (7) is the most prominent bone of the basicranial rgion. It extends from the olfactory region in front to the otic region behind in connection with the orbital region.

The **basisphenoid** (19) is a median, bone articulating with the parasphenoid, prootics laterally and with the alisphenoids dorsolaterally. It is alike in all the species.

The **basioccipital** (20) is a median, nearly traiangular and hollow bone with two anterior wing-like expansions. The forked posterior end of the parasphenoid fits into the ventral median pointed edge of the basioccipital. The posterior end is solid and support dorsally the paraoccipital condyles of the exoccipitals and anteriorly attached to the prootics of the corresponding side. The form and disposition of the basioccipital is essentially the same in all the species.

The Branchiocranium

The Oromandibular region

The **premaxilla** (21) is a long narrow bone with a stem-like descending process backwards at the point where it meets its fellow of the opposite side. It is thicker along the anterior ridge where the teeth are present and thin and nearly flat posteriorly. The posterior portion is curved in a semicircular fashion into which fits the anterior convex edge of the maxilla. The narrow lateral end is partly covered over by the maxilla. A series of small villiform teeth are present ventrally along the anterior portion. The bending of the premaxilla at the posterior side is more deep in *P. indicus* and the maximum bend is found in *M. flavolineatus* and also the length of the portion to the sides after the bend is shorter in *M. flavolineatus* than in the other 2 species. There is only a single row of teeth with wide interspaces in *P. indicus* whereas in the other two species there are several rows of small villiform teeth.

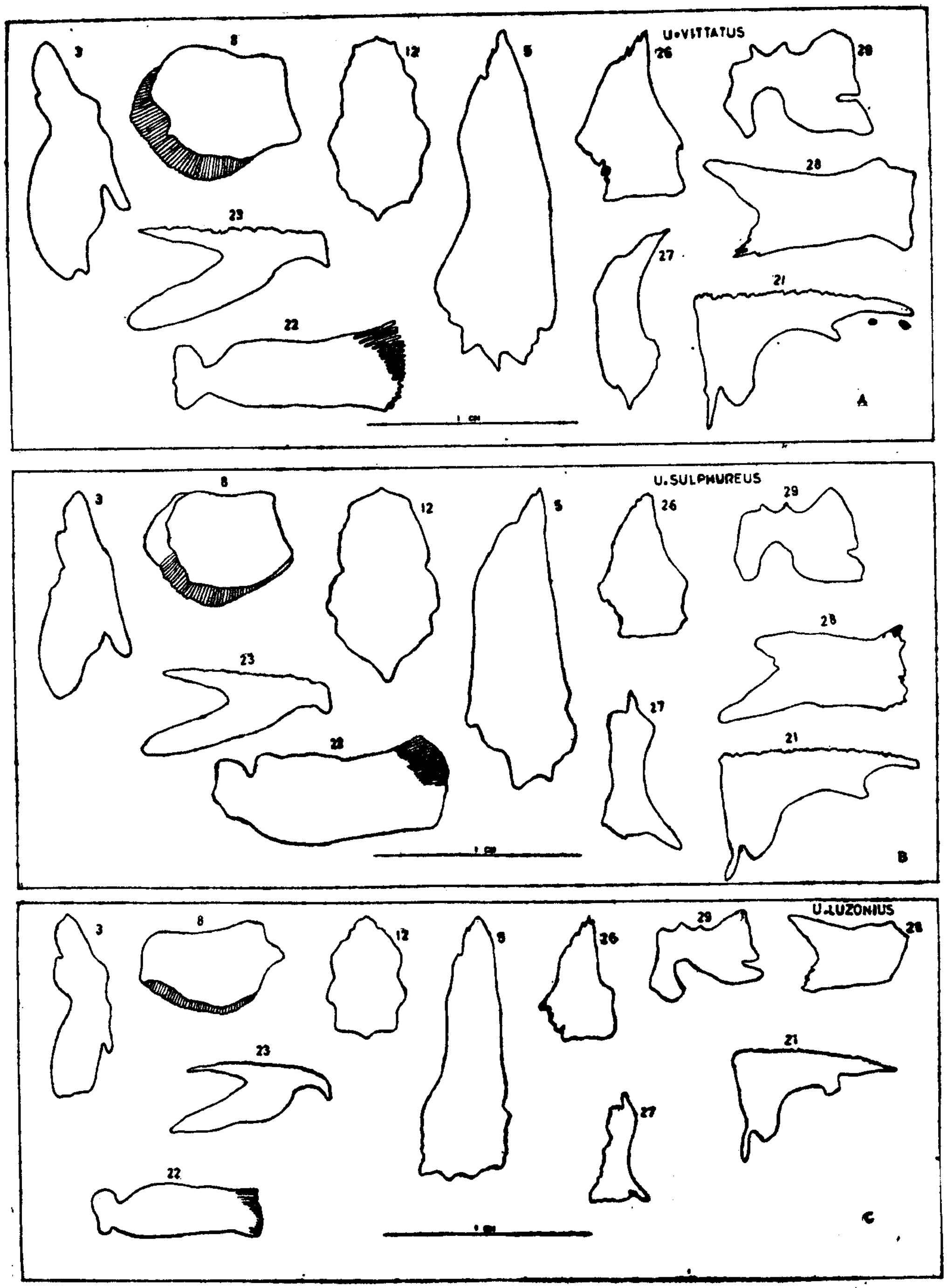
The **maxilla** (22) is flat and thin bone, slightly narrow in the middle and broadest distally. The head of the maxilla is with a depression in the middle where it joins with its counterpart on the opposite side. It is covered over for the greater part by the lacrymal. The middle portion of the maxilla is narrower in *P. indicus* than in *U. tragula* and nearly straight in *M. flavolineatus.*

The **dentary** (23) is forked posteriorly. The ventral arm is longer than the dorsal one, which bears the teeth. At the point of union of the two arms is formed a small groove into which is inserted the anterior pointed end of the articular. The dentary is much alike in all the species except that there is only a single row of teeth in *P. indicus* while in the other 2 species there are several rows. They also differ a little in the relative length of the ventral arm, in *U. tragula* and *P. indicus* the ventral arm is longer than the dorsal arm while in *M. flavolineatus* both the arms are nearly equal.

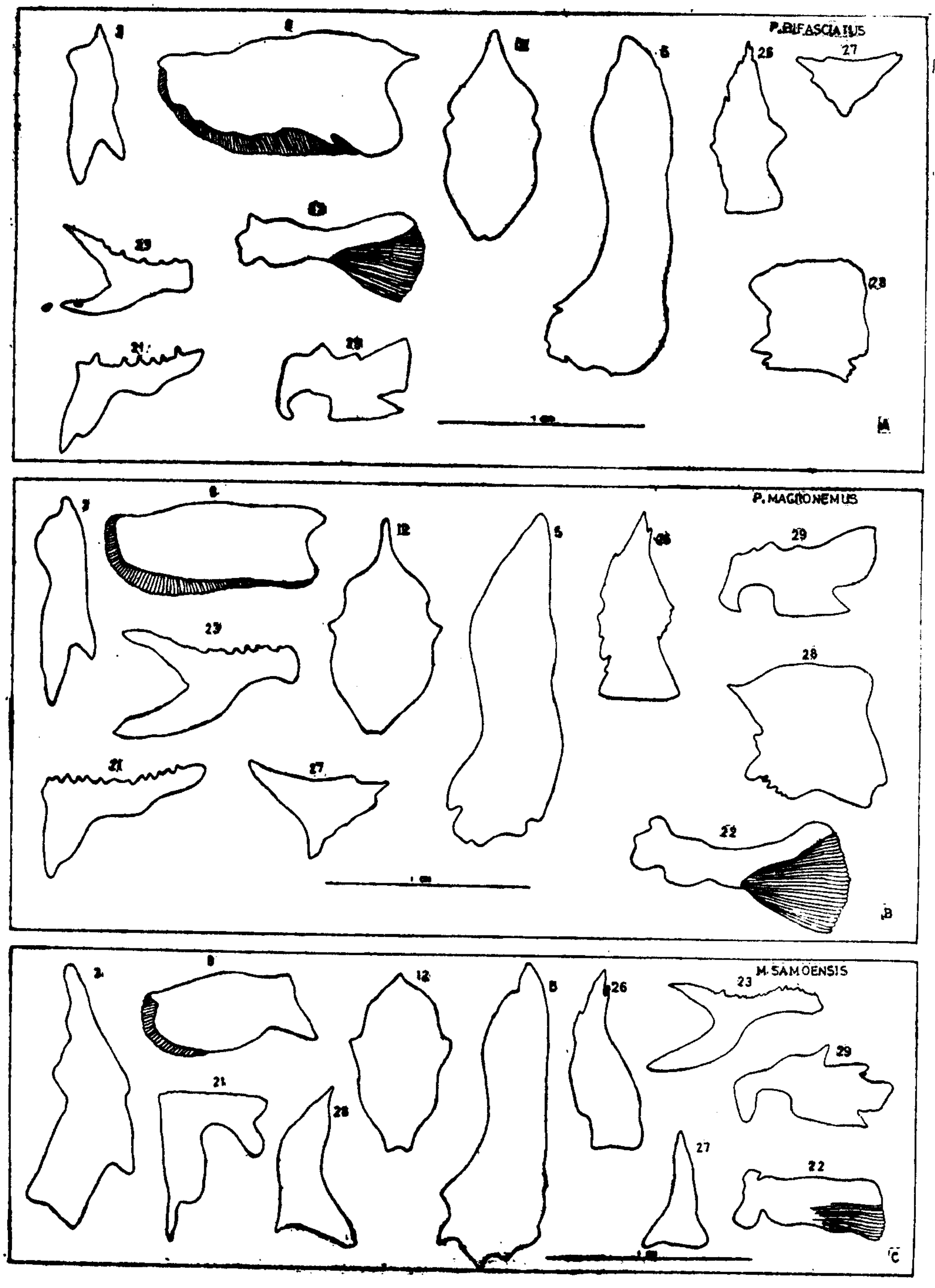
The **articular** (24) a spear-shaped bone with the anterior narrow region held in between the posterior bifurcation of the dentary and the extreme pointed tip is inserted into a groove of the dentary at the angle of bifurcation. Two small anterior processes, one anterodorsal and another anteroventral join with the two arms of the dentary. The coronoid process is well developed at the posterior end to which is attached the head of the quadrate.

The **angular** (25) a small bone attached to a small concavity at the posteroventral region of the articular.

The **metapterygoid** (26) is a flat, thin nearly triangular bone. The anterior margin is straight where it is attached with the straight posterior end of the quadrate. Dorsally the margin is slightly concave for attachment with the convex edge of the ëntopterygoid. It joins with the palatine and ectopterygoid anteriorly and anterodorsally. Anteroventrally it connects wilh the sympletic. The posterodorsal margin is forked and encloses the anterior margin of the hyomandibular. The metapterygoid is alike in *U. tragula* and *P. indicus* but in *M. flavolineatus* the posterior end is narrower and a little curved upwards.



Text-figure 12. Individual bones in the skull of: (A) *Upeneus vittatus*, (B) *U. sulphureus* and (C) *U. luzonius*. (see for explanation page 84)



Text-figure 13. Individual bones in the skull of: (A) *Parupeneus bifasciatus*, (B) *P. macronemus* and (C) *Mulloidichthys samoensis*. (For explanation see page 84)

The **ectopterygoid** (27) is 'T' shaped, the vertical part of 'T' forming the anterior end. Dorsally it is connected with the entopterygoid, posteriorly with the quadrate and metapterygoid and anterolaterally with the palatine. The ectopterygoid is very similar in *U. tragula* and *M. flavolineatus* but differs in *P. indicus* in that the two halves of horizontal part of 'T' meet at a wider angle and the anterior portion is shorter in length.

The **entopterygoid** (28) is a flat thin bone. Dorsally it is a little concave. The ventral margin is straight and is connected to the quadrate. It articulates posteriorly with the metapterygoid and anteriorly with the ectopterygoid and palatine laterally. The shape of the entopterygoid differs in the three species to a certain extent. In *U. tragula* it is nearly rectangular with an anterior fringed margin in the middle and slightly narrow posteriorly. In *P. indicus* the shape is nearly that of a square with the concavity on the dorsal side more deep and in *M. flavolineatus* it is nearly crescent-shaped.

The **palatine** (29) is thin and flat. It is produced into a beak-like process ventrally on which is found a patch of villiform teeth in *U. tragula*. The distal end of the dorsal arm is nearly straight. Ventrally, at the base of the beak-like process, is a deep concavity to receive the articulating process of the maxilla. Just dorsal to the concavity there are three small protuberances. The palatine differs in structure in the 3 species. In *U. tragula* teeth are present on the palatine on its ventral beak-like process but are absent in the other 2 species. It also differs in that the tip of the beak-like extension (bearing teeth) extends beyond the distal straight margin of the dorsal arm in *U. tragula*, in *M. flavolineatus* it is parallel to the distal edge of the dorsal arm while in *P. indicus* the lower arm does not even reach up to the tip of the dorsal arm.

The **quadrate** (30) is a flat triangular bone with an inferior knob-like process by which it is attached to the coronoid process of the articular. Dorsally it is connected with the metapterygoid and hyomandibular. Along the posterior margin there is a thickened spine-like process with a longitudinal groove on the inner side of which is inserted the sympletic bone. The process extends forwards and serves for articulation with the preopercle. The quadrate is alike in *U. tragula* and *P. indicus* while in *M. flavolineatus* the length of the ventral process is comparatively longer.

The **sympletic** (31) is a small narrow bone the posterior end of which is broad. The anterior end is inserted into a lateral groove on the inner side of the quadrate. Posteriorly it connects with the lower end of the hyomandibular.

The hyoid-opercular region

The **opercle** (32) is a long nearly triangular bone, the narrow pointed end directed downwards and rests over the angle of the suboperole. It is more hard along the anterior edge and posteriorly bears an opercular spine directed backwards. There is an articular surface dorsally for the articulation of the hyomandibular. The anterior margin is plain and is partially covered over by the hind edge of the preopercle. The opercle is similar in shape and structure in all the species.

The **subopercle** (33) is long, flat and thin with the anterior end broader than the posterior end. A well developed spine-like process arises from below the anterior end and projects upwards and to its angle fits the lower narrow end of the opercle. The inferior margin is slightly fringed. It is alike in all the species in shape and structure.

The **interopercle** (34) a flat bone with a straight posterior edge where it joins with the subopercle. The dorsal margin is concave with a small longitudinal ridge externally and is overlapped by the ventral margin of the preopercle. The ventral margin is free and serrated. Along its inner surface it articulates with ceratohyal. It forms the anterior and inferior free margin of the gill cover. The three species differ little from each other in the shape of this bone. In *U. tragula* it is nearly rectangular and the anterior end is almost blunt. In *P. indicus* the concavity at the dorsal margin is more deep and the posterior margin extends upwards more than in the other two species and is pointed. In *M. flavolineatus* it is triangular and the anterior end is more conical.

The **preopercle** (35) is crescentic with broad ventral and narrow dorsal end. Ventrally along the inner side it is connected with the quadrate and sympletic. Dorsally it bears a groove on the inner side into which fits the narrow anterior end of the hyomandibular and externally overlaps the anterior tip of the interopercle. It is essentially the same in form and structure in all the three species.

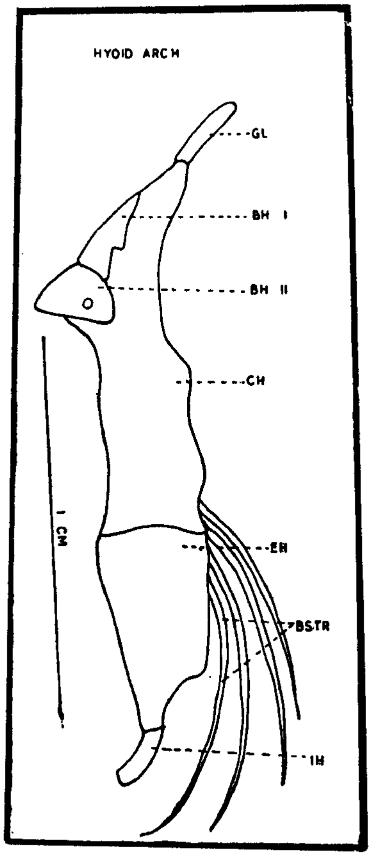
The **hyomandibular** (36) is a long bone with three condyles at the top, two of which are for articulation with the neurocranium and the third for articulation with the opercle posteriorly. Ventrally the narrow portion of the hyomandibular joins with the metapterygoid, sympletic and interhyal. Along the posterior margin is a longitudinal groove to receive the vertical edge of the preopercle. The hyomandibular is similar in the 3 species.

The **hyoid arch or cornu** (fig. 14) is composed of the basihyal, ceratohyal, epihyal, interhyal and glossohyal, the last one embedded in the tissues of the tongue. The individual bones are connected together by plain joints and fibrous connections. The hyoid arch is connected posteriorly to the hyomandibular by means of the interhyal. In addition to these elements, the two slender and straight bones attached to the tip of the ceratohyal and which form the base of the barbels also form part of the hyoid arch.

The **glossohyal** (37) (fig. 14, GL) is a small rod-like bone embedded in the tissues of the tongue and supports it. Basally it is attached to the basihyal and urohyal.

The **basihyal** (fig. 14, BH) is formed of two small bones attached to the anterodorsal side of the ceratohyal. The anterior one is longer and triangular and has two articulating surfaces on the ventral side for articulation with the ceratohyal and another one posteriorly to accommodate the pointed anterior end of the posterior component which is a small piece of bone with a dorsal backwardly directed process. It is perforated by a foramen at its base. The basihyal is connected with its counterpart of the opposite side and also with the first basibranchial.

The **ceratohyal** (fig. 14, CH) is the largest of the hyoid complex with a broad posterior end and a narrow anterior end. The dorsal margin is slightly concave. Dorsally at the base of the anterior narrow region there are two processes for articulation with the two components of the basihyal. The base of the posterior process is perforated by a small foramen. The posterior surface is nearly straight and is attached to the epihyal. The tip of the anterior narrow region projects beyond the basihyal and articulates with a small rod-like bone supporting the



Text-figure 14. The hyoid arch of ***Upeneus tragula.*** (GL. Glossohyal; BH-1 and BH-11. Basihyals; CH. Ceratohyal; EH. Epihyal; IH. Interhyal; and BSTR. Branchiostegal rays).

barbel. This is against the finding of Gunther (1859) according to whom "the barbels are fixed to the basihyal" and agrees with that of Starks (1899) who states that the "barbels are suspended from the tip of a slender, nearly straight ray of bone attached to the end of the ceratohyal". The anterior two branchiostegals are attached to the ceratohyal ventrally at the posterior end.

The **epihyal** (fig. 14, EH) is flat, thin and roughly triangular with the narrow end forming the posterior region. The anterior end is straight and is attached to the straight posterior end of the ceratohyal. The dorsal rim is slightly concave. The ventral edge is straight up to the middle of its length and then tapers and ends in a condyle for articulation with the interhyal. The two posterior branchiostegals are attached to the straight anterior region on the ventral side.

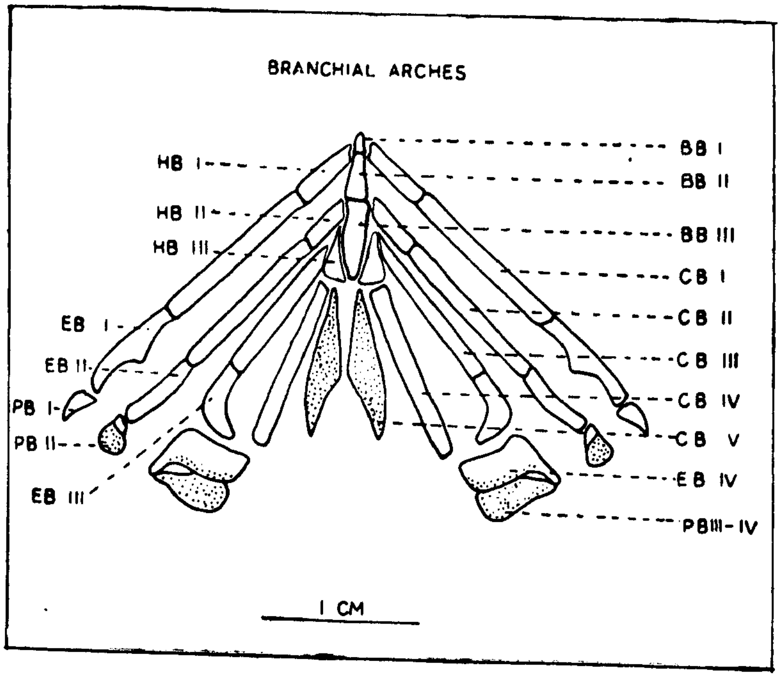
There are 4 branchiostegal rays on each side, 2 each attached to the ceratohyal and epihyal. The anterior-most branchiostegal on the ceratohyal is the shortest and there is a gradual increase in length from the first to fourth.

The **interhyal**, (fig. 14, IH) is a small rod-like bone attached to the posterior end of the epihyal. It is directed slightly upwards and articulates with the hyomandibular and sympletic.

The **urohyal** (38) a long bone with the anterior narrow and broad posterior region and is placed medially between the basihyals. The posterior end is laterally compressed, blade-like and is embedded free in the muscular mass of the throat. The lateral and ventral sides are grooved. The median dorsal ridge projects back a little in the form of a spine. The bones of the hyoid complex are similar in all the species.

The Branchial region

The **branchial arches** (fig. 15) are covered externally by the hyoid arch and connected to it at the base. The gills are supported by the branchial arches composed of a series of bones which are identical in the 3 species that a singlet description holds good for all of them.



Text-figure 15. The branchial arches of *Upeneus tragula:* BB-I to BB-III. Basibranchials; HB-I to HBIII. Hypobranchials; CB-I to CB-IV. Ceratobranchials; EB-I to EB-IV. Epibranchials; and PB-I to PB-IV. Pharyngobranchials.

The **basibranchials** (fig. 15, BB) are three in number, lie in a linear series along the median line and support the branchial arches. The first basibranchial is the smallest rod-like with the posterior end slightly broader. The anterior end is attached to the posterior end of the glossohyal and the posterior end with the second basibranchial. The second basibranchial is broader and larger than the first. Its anterior half is narrower than the posterior half. There are two deep grooves, one each on either side, to receive the first hypobranchial. The third basibranchial is the largest with a small constriction near the anterior end to receive the second hypobranchial. It broadens behind the constriction and then gradually becomes narrow and ends in a blunt point.

The **hypobranchials:** the first hypobranchial is a small bone with an articulating surface at the base where it joins with the anterior end of the second basibranchial. The second hypobranchial is slightly shorter than the first and the articulating surface at the base is not so prominent as in the case of the first. It arises from the anterior tip of the third basibranchial. The third hypobranchial differs much in shape from the first two. It is nearly triangular and flat with the anterior end narrow. It is placed on either side of the posterior pointed end of the third basibranchial.

The **ceratobranchials** (fig. 15, CB) are long and narrow bones with a slight curve and form the main support of the ventral half of the branchial arches. All the ceratobranchials are of the same length. The first three ceratobranchials are similar in shape but the fourth differs a little in that it is twisted at its anterior end. The ventral side of the ceratobranchials are grooved.

The fifth ceratobranchial is modified as the lower pharyngeal. It is triangular in shape and bears villiform teeth on its entire surface.

The **epibranchials** (fig. 15, EB) form a series of short and forked bones except the second one which is slightly twisted at the middle but not forked. They support the dorsal half of the branchial arches. The first is the longest and forked at the middle, second a little smaller and the second half of the third is bent at right angles to the first half. The fourth epibranchial is curved and bears a series of small villiform teeth along its outer margin.

The upper **pharyngeals** (fig. 15, PB) or pharyngobranchials differ in shape and size from each other but all of them are provided with a patch of villiform teeth. The first one or suspensary pharyngeal is a tiny rod-like bone connecting the branchial arches to the neurocranium on its ventral side posteriorly. The second one is nearly oval in shape and is attached to the second epibranchial. The third and fourth are joined together to form a large structure and jointly articulate with the third and fourth epibranchials.

The pectoral girdle and fin

The pectoral girdle is conneted to the posterior part of the neurocranium by the post-temporal.

The **post-temporal** (39) articulates with the neurocranium by its anterior end which is forked into a long and stout dorsal and a short ventral process. The dorsal process articulates with the epiotic and the ventral process with the pterotic.

Its posterior portion is slightly broader than the anterior portion and ends in a small cavity for the articulation of the anterior convex end of supracleithrum.

The **supracleithrum** (40) is a long bone with its dorsal margin slightly concave. It articulates dorsally with the post-temporal by its anterior, nearly round edge and posteriorly with the cleithrum. The supracleithrum is alike in all species.

The **cleithrum** (41) is the most prominent bone of the pectoral girdle. It is long and flat with a longitudinal median ridge dorsally, forming two longitudinal grooves on either side. The cleithrum is bent inwards at the posterior region and ends in a sharp point. Its outer margin bears two articulating facets, the anterior one for the coracoid and the posterior one for the scapula.

The **scapula** (42) a flat irregular bone with two perforations. It articulates at the ventral side of the cleithrum where it is bent inwards and anteriorly with the posterior end of the coracoid. At the outer margin it articulates with the pterygials.

The **coracoid** (43) is a long bone with dorsal expanded and ventral rod-like portion. The coracoid articulates with the scapula above and the ventral rod-like extension lies in a groove along the outer side of the cleithrum.

The **postcleithrum** (44a, 44b) is formed of two small bones. The anterior bone is long and flat while the posterior component is spine-like with a broad base.

The **pterygials** are four short bony structures attached to the scapula and support the pectoral fin rays.

There is no noticeable difference in the relative size of the pectoral fin between the species. But the number of fin rays varies in the 3 species. In *U. tragula* they range from 13-14, in *P. indicus* and *in M. flavolineatus* 16-17.

The pelvic girdle and fin

The pelvic girdle consists of a pair of pelvic bones. Each pelvic bone (45) is triangular with a spine-like process at the posterior end. Both the anterior and posterior ends are pointed. The dermal fin rays are directly connected to its base without any intervening radials. The girdle is inserted into the flesh ventral to the pectoral girdle and is similar in structure and shape in all the species. The fin is formed of a single spine and five branched rays.

The unpaired fins

There are two **dorsal fins** separated from each other. The first dorsal fin originates from a little behind the occipital crest and extends posteriorly up to the level of 8th vertebra. The second one originates opposite the 10th vertebra.

The first dorsal fin consists of 8 spines, the first of which is very small and the second of 1 spine and 8 rays.

The third spine of the first dorsal is the longest and the rest of the spines gradually decrease in length. The spines are thicker at their base and end in sharp points. Their bases are bifurcated into a right and left condyle. In between these condyles is concealed the third pterygiophore with a slight concavity in the middle into which articulates the second pterygiophore. The dorsal surface of the second pterygiophore has three protuberances, one median and two lateral. The median one fits into the concavity of the third pterygiophore and the two laterals support the base of the spine. The first pterygiophore (interneural spine) is stiff and forms the major support for the fin. Each interneural spine is compressed in the antero-posterior direction and with a median ridge on either side. Its dorsal edge has got a constriction and two lateral articulating processes with a cavity in the middle for articulation with the ventral convex end of the second pterygiophore and the lateral processes support the two lateral protuberances of the second pterygiophore. This ball and socket like joint allow free movement for the spines. Ventrally the interneural spine ends in a sharp point and articulates with the neural spines.

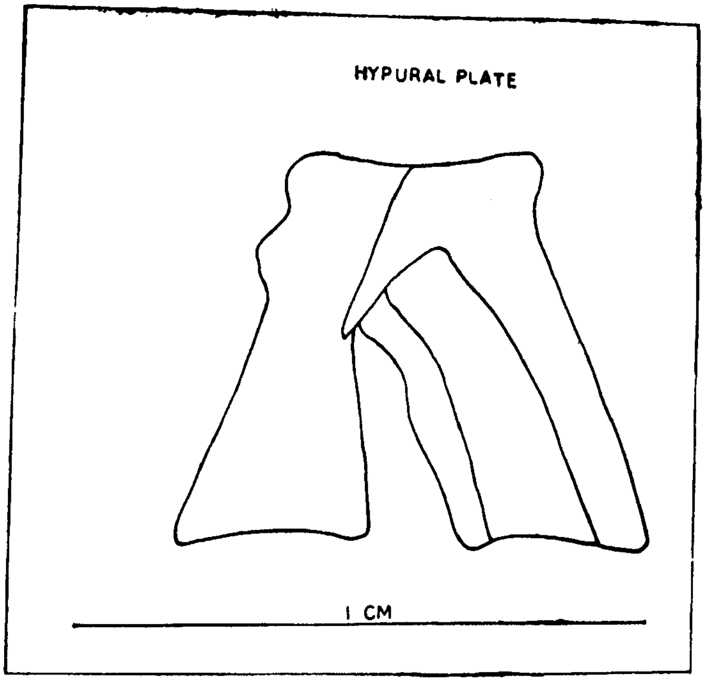
The number of fin spines are less than the number of interneural spines with regard to the first dorsal in all the 3 species. But the species differ from each other in the number of interneural spines. In *U. tragula* and *M. flavolineatus* there are 10 interneural spines whereas in *P. indicus* only 9 are present and the number of fin spines are 8 in all the species. The first minute fin spine arises as an off-shoot of the second larger spine from its base and does not have a separate set of pterygiophores for support as in the case of other spines. Its base is bifurcated and the resulting narrow cavity rests on the upper tip of the median ridge of the interneural spine which supports the second spine.

The second dorsal consists of one spine and 8 rays in all the species. The spine is slender and shorter than the first ray which is the longest and the subsequent rays gradually decrease in height. Each ray is composed of a base and a long slender filament formed by the union of two lateral halves. The base is laterally compressed and bifurcated and holds the third pterygiophore in between the fork. The fin rays are branched at their ends. The number of fin spines and rays correspond with the interneural spines, unlike in the first dorsal.

The **anal fin** arises just behind the anus, opposite the 11th (first caudal) vertebra and extends backwards up to the level of the 16th vertebra. Its posterior extremity corresponds to that of the second dorsal. The structure of the anal fin is similar to that of second dorsal and the only difference is in the number of rays. The anal fin consists of 1 spine an 6 rays in all the 3 species and there is no difference in its form and structure.

The **hypural plate** (fig. 16) is formed of an upper and lower part firmly united at their anterior end and bifurcated posteriorly. The upper part is a single piece while the lower part is formed by the union of three smaller parts. The posterior extremity of the lower half is slightly broader than that of the upper half. A median lateral spine-like process is present on either side originating from the base of the lowermost component of the lower half. The posterior rim of hypural plate is straight and support the principal caudal rays and the dorsal and ventral surfaces support the dorsal and ventral caudal rays respectively.

The **caudal fin** is deeply forked with 15 principal rays of which 13 are branched. The upper caudal lobe has 7 branched rays attached to the vertical edge of the upper half of the hypural plate (fig. 16) and the lower lobe with 6 branched rays attached to the lower half of the hypural plate. Besides 2 or 3 more minor unbranched rays also are present on each lobe attached to the dorsal and ventral edge of the hypural plate. The number and arrangement of the caudal rays is similar in all the species.



Text-figure 16. The hypural plate of *Upeneus tragula.*

The vertebral column

The vertebral column is composed of 24 vertebrae. There is no interspecific or intraspecific variation in the number of vertebrae in all the three species studied. The vertebrae are strongly attached to one another except the few posterior caudal vertebrae so that little lateral movement is possible.

The vertebrae can be divided into precaudal and caudal vertebrae and the criterion for the division being the modification of the haemal arches to haemal spine in the caudal vertebrae. This change occurs at the 11th vertebra in all the species and hence the vertebral count can be represented as $10 + 14 = 24$.

The first vertebra or atlas is united to the basioccipital and with articulating condyles of the exoccipitals dorsally. The neural arch and spine are well developed. The parapophyses are represented by a small lateral process on either side and are not so prominent as in the succeeding vertebrae.

The neural pre and postzygapophyses are well developed on all the vertebrae except the atlas. The neural spines are long and stiff and are compressed in the anteroposterior direction and grooved anteriorly and posteriorly. They gradually increase in height from the first vertebra and the maximum is reached at the 10th or the last precaudal vertebra. Thereafter the length of the neural spines decrease gradually towards the caudal end.

The haemal spine is present from the 11th (1st caudal) vertebra. They are laterally compressed and grooved on their anterior and posterior faces as the neura. spines. The height of the haemal spines decrease gradually from the first to lastl The haemal arch and canal are larger in the anterior vertebrae and gradually reduces in size towards the posterior end.

There is considerable difference between the 3 species regarding the arrangement of the haemal pre and postzygapophyses. In *U. tragula* the first haemal prezygapophysis originates from the 1st caudal or 11th vertebra and is well developed on all the vertebrae backwards. The first haemal postzygapopysis arises from the 5th vertebra and is well developed on 6th to 9th and are considerably reduced from 10th to the last. In *P. indicus* the haemal prezygapophyses occurs from the 11th vertebra as in *U. tragula* but the haemal postzygapophyses are very small processes and arise only from the 7th vertebra. In *M. flavolineatus* the haemal prezygapophyses are found well developed from the 9th vertebra and the postzygapophyses are rudimentary processes arising from the 7th vertebra as in *P. indicus.*

The parapophyses for the articulation of the ribs are small lateral process in the first vertebra. In the succeeding precaudal vertebrae they are well developed and are dilated at their end from the third to the seventh vertebra. There is a gradual change in the disposition of the parapophyses from the lateral to the ventral side from the first vertebra backwards and at the 8th vertebra they unite with the haemapophyses to from the haemal arch. As a result, the parapophyses do not exists as separate process on 8th, 9th and 10th vertebrae but are represented by the broad base of the haemal arch. Parapophyses are not formed on any of the caudal vertebrae.

All the precaudal vertebrae bear a pair of pleural and epipleural ribs attached to the parpophyses. The epipleural ribs are small and fragile compared to the pleural ribs and are attached to the dorsal process of the dilated end of the parapophyses. To the ventral processes are attached the pleural ribs which are larger and stronger than the epipleural ribs. They are placed between the muscles and peritoneum encircling the abdominal cavity but not forming a complete basket.

Differences between genera

The osteology of representative species of the three genera conform to a similar pattern in the shape of individual bones, the position of articulating surfaces and grooves and also in the number of vertebrae. At the same time they exhibit some reliable differences by which they may be distinguished. The dependability of these differences as generic characters has been elucidated by an analysis of these characters between species of each genus, viz., 3 under the geneus *Upeneus* namely *U. vittatus*, *U. sulphureus* and *U. luzonius*, 2 species of *Parupeneus* namely *P. bifasciatus* and *P. macronemus* and 1 species of *Mulloidichthys* namely *M. samoensis.*

TABLE XXXVII

CHARACTERS DISTINGUISHING *PARUPENEUS* FROM *UPENEUS* AND *MULLOIDICHTHYS*

Characters	*Upeneus* and *Mulloidichthys*	*Parupeneus*
1.• Shape of nasal	Narrow at the anterior end	Anterior end round with a small pointed process
2. Lacrymal	Oval in shape	Nearly rectangular
3. Frontal	Does not take part in the formation of pterotic ridge	Takes part in the formation of pterotic ridge
4. Ectopterygoid	'T' shaped with a long anterior tail-like portion	'T' shaped but the tail-like anterior region is very short
5. Number of interneural spines at the base of first dorsal	10	9

TABLE XXXVIII

CHARACTERS SEPARATING *UPENEUS FROM MULLOIDICHTHYS*

Characters	*Upeneus*	*Mulloidichthys*
1. Teeth on vomer and palatines	Present	Absent
2. Supra occipital	Anterior end knoblike with a concave articulating facet at its base on either side	Anterior end narrow with no concave facet at its base
3. Entopterygoid	Nearly rectangular with a median fringe at the dorsal edge	Crescent shaped
4. First haemal prezygapophysis	Originate from the 11th (first caudal vertebra)	Originates from the 9th precaudal vertebra

Though there were many characters common to all the three genera, more affinity has been observed between *Upeneus* and *Mulloidichthys*. As such *Parupeneus* can be distinguished from the other two genera based on the characters given in Table XXXVII.

At the same time the differences observed between *Upeneus* and *Mulloidichthys* are given in Table XXXVIII by which they can be separated from each other.

Though the genus *Upeneus* Cuvier is characterised as "*Upeneus* des Indes a dents en velours aux deux machoires, au vomer et aux palatins". (*Hist. Nat. Poiss.*, 3: 448, 1829), it also included species with an edentulous vomer and palatines. Bleeker (1868) restricted the term *Upeneus* to those species strictly conforming to the description given above and separated those species with an incomplete dentition and placed in a new genus *Parupeneus*. The osteological differences between *Upeneus* and *Parupeneus* revealed by the present study further justify the restriction imposed on the original *Upeneus* of Cuvier and the creation of a new genus *Parupenens* by Bleeker (1868).

Species groups

The osteology of different species under each genus exhibits very little interspecific differentiation. In this context it may be mentioned that the extreme similarity in the osteology of *Mullus barbatus* and *M. surmuletus* made Gunther (1859, P. 402) to remark that the skeletons of the two species "are so much like each other, that they need only one description. There is no difference at all between them except in the more abrupt upper profile of the snout in *M. barbatus*".

However, the 4 species of *Upeneus* studied can be divided into two groups based on the differences in their osteology. *U. tragula* and *U. luzonius* forming one group and *U. vittatus* and *U. sulphureus* forming the other group as shown in Table XXXIX.

Upeneus tragula can be distinguished from *U. luzonius* in that *U. tragula* has the nasal at its posterior tip a single wide concave facet while in *U. luzonius* the posterior tip of the nasal has two concave facets. *U. vittatus* can be separated from *U. sulphureus* by the same character, in *U. vittatus* the nasal has at its posterior tip a single narrow concave facet while in *U. sulphureus* the posterior tip is blunt with no concave facet. This division of *U. tragula* and *U. luzonius* into one group and *U. vittatus* and *U. sulphureus* into another based on the osteological characters further supports the group relationships discussed at the end of systematic account.

The osteology of 3 species of *Parupeneus* studied is strikingly similar in all respects except that in *P. indicus* the nasal is not forked posteriorly while in the other two species it is forked as in species of *Upeneus*. Similarly no difference was observed in the osteology of the 2 species of *Mulloidichthys* namely *M. flavolineatus* and *M. samoensis*.

TABLE XXXIX

CHARACTERS DISTINGUISHING *U. TRAGULA* AND *U. LUZONIUS* FROM *U. VITTATUS* AND *U. SULPHUREUS*

Characters	Group I (*U. tragula* and *U. luzonius*)	Group II (*U. vittatus* and *U. sulphureus*)
1. Shape of lacrymal	Oval with a median pointed process at the posterior end.	Oval but the posterior margin is nearly concave with no pointed process.
2. Palatines	The teeth bearing ventral arm is pointed at the end.	The teeth bearing ventral arm is nearly blunt at the end.

Part Three

BIOLOGY

I. FOOD AND FEEDING HABITS

IN recent years much attention has been given to the study of food and feeding habits of fishes. However, very little work has been done on the food and feeding habits of goatfishes. Accounts available on this aspect from India are those of Kuthalingam (1955, 1956) and casual references by Chacko (1949) and Rabindra Nath (1966). A similar reference is available from the Singapore Straits by Kow (1950) and a detailed account by Wirszubsky (1953) from the Israel coast. Therefore, a comprehensive study of the food and feeding habits of four species of goatfishes namely *Upeneus tragula*, *U. vittatus*, *U. luzonius* and *Parupeneus indicus* has been attempted with special reference to the first species as it is available throughout the year from the Palk Bay and the Gulf of Mannar.

In the present study, the method of the "Index of Preponderance", which takes into account the occurrence as well as the quantity of the food item, described by Natarajan and Jhingran (1961) was used in the analysis of the food of *U. tragula.* The percentage of occurrence of individual items of food in the stomach contents in different months from different localities was determined by summing the total number of occurrences of all the items from which the percentage occurrence of each item was calculated. The volume of each item was measured by the volumetric (displacement) method and the percentage of volume was calculated from the total volume of all the items of food. The Index of Preponderance was then found by using the formula $\frac{V\,O \times 100}{\Sigma V\,O}$, where 'V' and 'O' represent the percentage of volume and occurrence respectively of each item.

The various items of food were identified up to the generic or specific level depending on the stage of digestion. However, where identification was not possible owing to the advanced stage of digestion they were grouped as semidigested matter. Since the goatfishes are bottom feeders the occasional presence of sand particles, mud and fragments of algae was not considered in the analysis.

Qualitative and quantitative analysis of the stomach contents of Upeneus tragula

The present study is based on an examination of a total of 3,138 stomachs of *U. tragula* collected from Palk Bay and Gulf of Mannar from October 1963 to September 1965. The data were analysed using the volumetric and occurrence methods as indicated above and graded according to the Index of Preponderance. The ranks obtained by different items of food in each month from different places during the two years 1963-1964 and 1964-1965 are presented in Tables XL and XLI respectively.

Among the different groups which formed the food of *U. tragula*, the following items were identified up to species or generic level as was possible.

Prawns: *Penaeus indicus*, *P. monodon*, *Metapenaeus monoceros*

Crabs: *Thalamita* sp.,*Portunus* sp.,*Charybdis* sp., *Porcellana* sp.

Fishes: *Therapon* sp., *Leiognathus* sp. *Anchoviclla* sp.

Isopods: *Sphaeroma triste*, *S. terebrans*

Copepods: *Acartia* sp., *Calanopia* sp.

Bivalves: *Lithodomus* sp., *Nuculana* sp.

Decapod larvae: *Zoea* and *megalopa* stages.

Variations in food during different years

The data presented in Tables XL and XLI reveal that the food of *U. tragula* during the years 1963-1964 and 1964-1965 was essentially the same, though there were slight changes in the abundance of different items during different months.

Variation in food between places

The data for comparing the variations in food between different places have been collected from fishing centres along Palk Bay and Gulf of Mannar.

Data from any particular place could not be collected throughout the year nor from two places along Palk Bay and Gulf of Mannar for the same period because of different weather conditions during different seasons. As such a comparison could be made of between places only along the Palk Bay or the Gulf of Mannar for the same period. A scrutiny of the Tables (XL and XLI) reveal that almost all items of food of *U. tragula* were represented in the stomach contents of samples collected from different places. Even the relative importance of major food items such as prawns, crabs and isopods were more or less constant in different places. Minor changes in the gradations of food items between places and the presence or absence of some of the items from place to place were however noticed.

Occurrence of food organisms in relation to size of fish

Details of the percentage occurrence of various food items of *U. tragula* in the different size groups of fish from October 1963 to September 1965 are given in tables XLII and XLIII.

As Tables XLII and XLIII show, all the major food items namely prawns, crabs, isopods and amphipods were present in the food of almost all the size groups in both years though there were slight changes in the percentage of occurrences in different size groups during the two years. Fishes were also present in the food of a wide range of size groups but were found to be absent in the stomachs of fish up to 8 cm. in second year.

Though mysids were present in the food of fish up to 16 cm. group, their percentage of occurrence was significantly higher in the 4 cm. groups during

TABLE XL

THE RANKS OBTAINED BY VARIOUS ITEMS OF FOOD OF *U. TRAGULA* AS ANALYSED BY THE METHOD OF INDEX OF PREPONDERANCE (OCTOBER 1963 TO SEPTEMBER 1964)

Month	Locality	Prawns	Crabs	Isopods	Amphipods	Semi-digested matter	Mysids	*Acetes*	Fishes	Copepods	Bivalves	Decapod larvae	Gastropods	Stomat-opods	Caprellids	Polychaetes
Oct.	Rameswaram	3	5	4	2	6	1	..	9	..	..	7	..	..	8	..
	Manaikadu	5	3	2	1	4	7	..	8	6	..	..	..	..	..	..
Nov.	Rameswaram	1	3	2	4	5	6	..	7	..	..	..	..	..	..	..
Dec.	Rameswaram	2	1	6	4	3	5	..	..	..	..	..	..	..	..	..
Jan.	Vedalai	1	2	..	3	4	..	..	..	..	..	..	..	..	..	..
	Muttupettai	1	2	6	3	4	5	..	..	..	..	..	..	..	..	..
Feb.	Vedalai	1	2	3	4	6	..	..	..	..	5	..	..	..	..	..
	Muttupettai	1	2	3	5	4	..	..	..	..	..	..	..	..	..	..
Mar.	Muttupettai	1	5	4	6	2	3	..	7	..	9	..	..	..	8	..
Apr.	Muttupettai	4	1	2	5	6	7	3	..	..	..	8	..	..	..	..
	Vedalai	4	2	1	5	3	..	..	..	..	..	..	..	..	..	..
Apr.	Rameswaram	1	2	7	5	3	4	6	..	8	..	9	..	..	..	..
May.	Rameswaram	2	1	5	4	3	7	6	..	8	..	..	..	10	11	9
	Manaikadu	1	5	3	2	4	9	6	7	..	..	..	8	..	..	..
Jun.	Rameswaram	5	3	1	2	4	8	9	7	6	..	..	..	..	10	..
	Manaikadu	1	2	3	4	6	..	7	8	5	..	..	9	..	..	..
Jul.	Rameswaram	2	1	3	5	4	11	..	8	7	10	..	12	9	..	6
Aug.	Rameswaram	4	1	2	5	3	..	..	6	7	10	..	..	..	8	9
Sep.	Rameswaram	2	1	3	6	4	..	..	5	7	..	..	..	..	..	..

TABLE XLI

THE RANKS OBTAINED BY VARIOUS ITEMS OF FOOD OF *U. TRAGULA* AS ANALYSED BY THE METHOD OF INDEX OF PREPONDERANCE (OCTOBER 1964 TO SEPTEMBER 1965)

Month	Locality	Prawns	Crabs	Isopods	Amphipods	Semi-digested matter	*Acetes*	Fishes	Copepods	Bivalves	Decapod-larvae	Gastropods	Polychaetes	Stomatopods	Caprellids	Mysids
Oct.	Rameswaram	2	1	3	7	4	..	5	..	9	8	..	..	..	6	..
Nov.	Rameswaram	1	2	5	6	3	7	4	10	9	..	8	..	..	..	..
Dec.	Vedalai	3	1	5	2	4	..	..	7	..	6	..	..	..	..	..
Jan.	Vedalai	2	5	4	1	3	..	..	6	..	..	..	..	..	..	..
Feb.	Vedalai	1	3	4	2	5	7	..	8	..	..	..	6	..	..	..
Mar.	Muttupettai	3	4	1	2	5	..	..	..	..	..	..	6	..	7	..
Apr.	Rameswaram	2	1	3	5	4	7	..	..	..	..	6	..	..	..	..
May.	Rameswaram	2	1	3	4	6	7	..	..	..	..	8	5	..	..	..
Jun.	Rameswaram	2	1	3	4	6	7	5	9	..	..	10	..	8	..	..
Jul.	Rameswaram	2	1	3	5	4	..	6	9	8	..	..	7	..	..	..
Aug.	Rameswaram	2	1	3	4	6	..	5	7	..	..	..	..	..	..	8
Sep.	Rameswaram	2	1	3	5	4	..	6	7	..	..	8	..	..	..	..

TABLE XLII

PERCENTAGE OCCURRENCE OF FOOD ITEMS IN THE STOMACHS OF *U. TRAGULA* IN RELATION TO SIZE OF FISH
(OCTOBER 1963 TO SEPTEMBER 1964)

Size groups cm.	Total	Prawns	Crabs	Isopods	Amphipods	Fishes	Mysids	Bivalves	Decapod-larvae	Caprellids	Copepods	Acetes	Polychaetes	Gastropods	Stomato-pods
4—4.9	5	20	..	..	..	..	40	..	..	..	40	40	..	..	..
5—5.9	41	46	7	15	29	2	10	..	..	2	44	29	..	..	..
6—6.9	127	42	14	18	37	..	4	..	2	..	42	16	..	..	..
7—7.9	225	41	19	44	40	2	12	..	3	1	9	9	..	..	..
8—8.9	207	40	27	47	43	1	14	..	3	1	3	14	..	1	..
9 –9.9	195	32	45	45	38	..	13	2	3	..	3	8	1	..	..
10—10.9	204	42	47	41	35	3	5	1	1	2	4	4	1	1	..
11—11.9	175	44	57	45	28	1	7	..	3	..	3	3	..	..	1
12—12.9	237	41	53	46	17	3	2	2	..	2	..	7	2	..	..
13—13.9	150	39	68	24	11	3	3	..	..	..	..	3	2	..	..
14—14.9	105	44	65	36	9	6	3	3	..	..	..	2	3	..	2
15—15.9	70	40	70	14	10	6	3	..	..	..	..	3	..	..	..
16—16.9	45	53	69	16	7	7	3	3	..	..	..	..	..	..	..
17—17.9	21	81	67	..	..	5	..	5	..	..	..	..	..	..	..
18—18.9	4	75	100	..	..	..	..	..	..	..	..	..	..	..	..
19—19.9	2	50	100	..	..	..	..	..	..	..	..	..	..	..	..

TABLE XLIII

PERCENTAGE OCCURRENCE OF FOOD ITEMS IN THE STOMACHS OF *U. TRAGULA* IN RELATION TO SIZE OF FISH
(OCTOBER 1964 TO SEPTEMBER 1965)

Size groups cm.	Total no. of fish examined	Prawns	Crabs	Isopods	Amphipods	Fishes	Mysids	Bivalves	Decapod-larvae	Caprellids	Copepods	Acetes	Polychaetes	Gastropods	Stomato-pods
4—4.9	6	..	..	..	..	..	60	..	..	..	60	20	..	..	..
5—5.9	10	20	..	30	60	..	20	..	20	..	40	..	..	..	..
6—6.9	43	37	16	44	67	..	16	..	5	9	35	5	..	..	..
7—7.9	89	28	20	22	81	..	11	..	6	6	11	8	..	..	..
8—8.9	170	40	29	26	50	..	9	..	5	4	7	13	1	..	..
9—9.9	200	34	46	33	38	1	3	1	1	1	7	9	2	1	..
10—10.9	185	35	60	30	24	1	2	1	1	1	2	5	1	2	..
11—11.9	165	39	65	38	25	2	2	..	..	..	..	2	2	1	..
12—12.9	136	32	74	35	8	6	..	1	..	1	..	2	2	1	2
13—13.9	100	35	83	22	9	6	1	2	..	..	..	2	2	3	2
14—14.9	89	27	74	26	11	8	..	..	..	..	..	4	3	2	..
15—15.9	66	36	79	21	7	10	..	..	..	..	..	2	2	2	2
16—16.9	32	50	81	22	3	9	..	3	..	..	..	..	..	..	..
17—17.9	24	50	50	25	..	13	..	8	..	..	..	..	..	..	..
18—18.9	5	100	60	..	..	20	..	20	..	..	..	..	..	..	..
19—19.9	3	100	67	..	..	..	..	..	..	..	..	..	..	..	..
20—20.9	2	100	100	..	..	100	..	..	..	..	..	..	..	..	..

the first year and were completely absent in the food of fish above 11 cm. in the 13 cm. group. Again caprellids and copepods also were found only in the stomach contents of fish below 12 cm. in both years.

Condition of feed

To determine the condition or degree of feeding, all the stomachs examined were classified into full, $\frac{3}{4}$ full, $\frac{1}{2}$ full, $\frac{1}{4}$ full 'little' and 'empty' depending on the relative fullness of the stomach. The percentage occurrence of stomachs under each category was calculated for each month. The stomachs classified as 'full', '$\frac{3}{4}$ full' and '$\frac{1}{2}$ full' were considered to be actively fed and those under the categories of '$\frac{1}{4}$ full', 'little', and 'empty' were considered to be poorly fed.

In October 1963, majority of the fish examined were found to be actively fed while there was a slight slackening of feeding activity in November as the percentage of actively fed group was a little below 50. In December again the feeding activity was high but was found to be poor in the months of January and February. From March to June there was intense feeding except in May, when the percentage of actively fed fish was a little below 50. From July to August the feeding activity was poor and the lowest was found in September.

In the months of October and November 1964, the feeding activity was poor. From December to March there was intense feeding activity as the percentages of actively fed fish were always above 50 during these months. From April to June the feeding activity was moderate and found to be poor from July to September.

The condition of feed was further studied in relation to maturity. Since majority of the fish above 12 cm. in total length were found to be mature, all the fish measuring 12 cm. and above were treated as mature and all below 12 cm. were considered as immature for this study. The total volume of food of mature and immature fish were taken separately and the average volume was calculated.

In October 1963, the average volume of food of immature fish was the same as that for the whole year and was higher in November. From December 1963 to February 1964 the average volume was lower than the grand average. From March to May the volume was very high than the annual average and the feeding activity was at its peak during these months. In June the monthly average volume and grand average were found to be equal. The average volume of food was slightly lesser than the annual average in July and showed an increase in August. In September again the feeding activity was low as the monthly average was below the grand average.

In October 1964, the average volume of food of immature fish was higher than the total average for the entire year. From November to January the average monthly volume was much lower than grand average. In February it was a little above the average for the whole year and came down in March. From April to September the immature fish were observed to be feeding actively with higher monthly average volumes during these months.

Mature fish fed actively from October 1963 to June 1964 as the average volume of food taken during these months were higher than the grand average volume. The intensity of feeding was generally very poor in the months from July to September and the average volume during these months was far below the annual average volume. The same trend was observed in the second year (1964- 1965) also. From October to March there was intense feeding with a slight decline in April and again it went up in May. From June to September the feeding was poor as in the previous year.

Feeding in relation to sexual cycle

The intensity of feeding in case of mature fish was found to be very poor during the months of July to September in the first year and June to September in the second year with the exception of August. This low feeding activity in case of mature fish may not be due to the shortage of food items available as the immature fish were found to feed actively during these months on those food items also which occur in the stomach contents of all size groups. This period of poor feeding activity in case of mature fish coincides with the peak spawning season of the species and suggest a slackening in feeding during spawning seasons.

With a view to understand more clearly the relation between feeding activity and spawning, the percentage occurrence of empty stomachs were calculated separately for mature and immature fish in each month for two years.

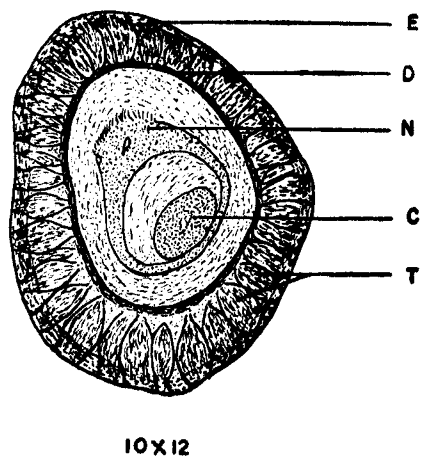
Empty stomachs were observed in immature fish in all the months except October, December, May and September in first year and except April, May and August during the second year. In case of mature fish, empty stomachs appeared in the months of October to November and April to September during the first year and from October to December and April to September during the second year.

The appearance of empty stomachs in immature fish was in low percentages though they were observed in all the months except a few during both years. In case of mature fish they were observed only in certain particular months in high percentage and there was a striking uniformity in the months in which they appeared in both years. These months correspond with the spawning period of the species and the very high percentages of empty stomachs together with the lowest average volume of food taken in the months of July to September in both years indicate that there is a slackening in the feeding activity during the spawning season. Moreover, it was often noticed that fish in the advanced stage of maturity had their abdominal cavity fully occupied by the voluminous ripe gonads and the stomachs were always empty.

Feeding habits

The presence of a pair of barbels just below the symphysis of the lower jaw, attached to the tip of the ceratohyal, suggests the bottom feeding habits of goatfishes. That these barbels contain 'terminal buds' (taste buds) have been shown by many earlier workers, among which the works of Schulze (1863, 1870), Merken (1880), Bateson (1890) and Herrick (1904) may be specially mentioned. Sato (1937) and Suyehiro (1942) observed numerous flask-shaped cutaneous taste buds and bundles of myelinated nerve fibres in the barbels of *U. bensasi.* Herrick (1904) after experimenting with *Ameiurus nebulosus* and three other species namely *Pollachius virens*, *Urophycis tenuis* and *Microgadus tomcod*, concluded that "Fishes which possess terminal buds in the outer skin taste by means of these organs and habitually find their food by their means".

Cutaneous taste buds as observed by Sato (1937) in *U. bensasi* are found in the barbels of *U. tragula* also (fig. 17). The barbels are formed of an outer layer of epidermis and an inner layer of dermis. The flask-shaped cutaneous taste buds are imbedded in the dermis almost at regular intervals and the nerve fibres occupy most part of the dermis. Such an abundant supply of taste buds and nerve fibres makes it clear that the barbels serve as organs of taste. Moreover it has been noticed during the present study that the barbels are kept incessantly in motion, ploughing through sand and mud evidently in search of food organisms.



Text-figure 17. Transverse section of the barbel of *Upeneus tragula.*

(E. Epidermis, D. Dermis, N. Nerve cord, C. Cartilage, T. Taste buds)

Teeth are present on both jaws in several rows and also on vomer and palatines but they are so minute that they cannot serve the purpose of biting and crushing large food organisms. But the pharyngeal teeth are well developed and Ridewood (1896) stated that the development of jaw teeth and pharyngeal teeth are inversely proportional to one another. The pharyngeal teeth serve as efficient masticatory organs.

Very often *U. tragula* was observed to feed exclusively on particular items such as prawns, crabs, isopods, amphipods, mysids, Acetes, copepods, fishes and polychaetes. Even when only one item was present, the stomachs were full in many cases indicating the abundant availability and the preference shown to that particular item by the fish. Among these prawns, crabs and isopods ranked high.

Though *U. tragula* is a bottom feeder, certain planktonic forms like copepods, decapod larvae, caprellids and mysids were also met with in food items and their presence was generally confined to fish below 12 cm. Some fish, 4-5 cm. were found to feed exclusively on copepods. The percentage occurrence of these items gradually came down with increase in size of the fish and were almost completely absent in fish above 12 cm. Their total absence in the stomach contents of mature fish (above 12 cm.) cannot be due to the non-availability of these organisms as food at least in case of copepods which are observed to be abundant in the plankton from Palk Bay and Gulf of Mannar during all seasons (Prasad, 1954, 1958). This may suggest that young fish (below 6 cm.) remain at the surface feeding mainly on plankton while juveniles (below 12 cm.) though found at the bottom come to surface occasionally in search of food. But mature fish are strictly confined to bottom feeding.

Food of other species of goatfishes

To have a comparative knowledge of the food of goatfishes, three more species viz., *Upeneus vittatus*, *U. luzonius* and *Parupeneus indicus* were collected and examined for their food and feeding habits. However, the number of specimens examined in each of these species were less and moreover samples could not be obtained every month for a detailed study. Still a preliminary study of the food and feeding habits of these species was attempted and the details are briefly described below.

Upeneus vittatus

A total of 266 specimens (75-181 mm.) were colleoted from Vedalai, Muttupettai, Kilakarai and Tuticorin (Gulf of Mannar), Rameswaram and Manaikadu along Palk Bay and from Calicut and Vizhingam along the west coast and also from Andaman Islands. These samples were small lots collected during different months.

A qualitative analysis of the stomach contents of *U. vittatus* revealed no significant difference in their diet from that of *U. tragula.* Crustaceans were found to be the major food of this species also and among crustaceans prawns, crabs and isopods dominated the stomaoh contents. The two species of prawns frequently met with were *Penaeus indicus* and *Metapenaeus monoceros.* The most common crabs in the food items were *Portunus* sp. and *Thalamita* sp. Isopods were mainly represented by *Sphaeroma* sp.

The percentage occurrences of bivalves and fishes were comparatively higher in stomach contents of *U. vittatus* than in *U. tragula.* Out of the 266 stomachs examined, 19·17 per cent had bivalves and 15·78 per cent had fishes as the major items of food. The fishes found in the stomach contents were *Leiognathus* sp. and *Anchoviella* sp. Majority of the bivalves were *Nuculana* sp. and *Modiolus* sp. Other molluscs found in a few stomachs were *Cerathium* sp., *Epitomium* sp. and *Dentalium* sp. Amphipods, mysids, polychaetes and stomatopods also were found in small quantities in a number of stomaohs.

Echinoderms were represented by *Amphipholis squmata* and *Ophiactis* sp. (opiuroid) in two or three instances and probably they are accidental inclusions. Echinoderms were never found in the stomach contents of *U. tragula.*

Upeneus luzonius

The study of *U. luzonius* is based on the examination of 165 specimens (70-176 mm.) collected from Rameswaram during June to October 1965. The relative importance of the food of this species was observed to be significantly different from that of *U. tragula* and *U. vittatus*. In *U. tragula* and *U. vittatus*, crustaceans and specially prawns, crabs and isopods were the major constituents of food whereas in *U. luzonius*, bivalves were found to be the dominant item in the food. Out of the 165 specimens examined, 44·84 per cent had bivalves in various degree of fullness. In many instances the stomach contents were exclusively bivalves, mostly *Nuculana* sp. and *Modiolus* sp.

Prawns and crabs were found only in 9·09 and 5·45 percentage of fish examined. Isopods, copepods, amphipods, decapod larvae and polychaetes were also found in a few cases. Fishes were totally absent in the stomach contents.

Thus it seems that there is no keen competition between *U. tragula* and *U. luzonius* for a particular food item. This lack of competition and individual preference for different items as food enable both the species to occur together in large numbers in the same feeding ground. These two species were generally caught together by shore seines and "Olavalai" at Rameswaram. It is significant to note in this connection that *U. vittatus* was rarely caught along with *U. tragula* and the parallelism in their food habits might have forced them to occupy different feeding grounds.

Parupeneus indicus

The material for the study was 130 specimens (70-217 mm.) collected from Rameswaram, Manaikadu, Muttupettai and Vedalai in different months. A qualitative analysis of the stomach contents revealed crustaceans to be the dominant food as in *U. tragula* and *U. vittatus*. The major items in the stomachs were prawns, isopods and crabs in the order of importance. Other groups like amphipods, copepods, polychaetes and bivalves were also observed less frequently. Fishes were not observed in the food as in the case of *U. luzonius*.

Remarks on Previous works

In a general account of the food and feeding habits of the fishes of Gulf of Mannar, Chacko (1949) described the feeding habits of *U. tragula* to be "Carnivorous, predaceous at midwater and bottom". Kow (1950) reported on the food of *U. sulphureus* and *U. sundaicus* based on an examination of the stomach contents of 85 specimens (35-120 mm) from the Singapore Straits. He observed no difference in the diet of the two species.

Wirszubski (1953) made a detailed study on the 'Biology and Biotope of the Red Mullet, *Mullus barbatus*, from Israel and came to the conclusion that crustacea forms the staple food in the diet of the fish in that area. The percentage occurrence of different food items in the stomachs of adults were recorded to be crustacea, 81%; mollusca, 58%; vermes, 53%; echinodermata, 24%, pisces, 1·30% and undetermined 7·7%. The principal group among crustacea was penaeids and lamellibranchs among mollusca (genera *Abra*, *Leda*).

Kuthalingam (1955) recorded the food of adult *Upeneus indicus* (*Parupeneus iudicus*) to be mainly crustaceans. Juveniles also were observed to feed mainly on crustacea but showed a preference to smaller crustacea like mysis, cumacea, zoea larva, young ones of *Acetes* and other items included were veliger larva, larval bivalves, larval gastropods, peteropods, fish eggs and post larval forms of teleosteans. From this study he concluded that juveniles may be surface feeders whereas the adults are vertically migratory in their feeding habits.

The food of *Upeneus cinnabarinus* was studied by Kuthalingam (1956) and he observed that the food of this species was mainly fast swimming crustaceans like *Squilla mantis*, *Acetes erythraeus*, *Matuta victor*, prawns and cumacea. He observed no difference in the food of mature and immature fish but found to exhibit selectivity in feeding.

Rabindra Nath (1966) stated that *U. vittatus* feeds voraciously on crustaceans, teleosts, molluscs and polychaetes after examining the stomach contents of 73 specimens. The crustacean items were mainly *Acetes erythraeus*, prawns, mysids, lucifers and copepods. He observed that during the season of zooplankton abundance the fish feed largely on crustaceans while during the period of phytoplankton abundance, it depends almost entirely on teleosts and polychaetes.

The present observation on the food and feeding habits of four species of goatfishes generally agrees with the findings of all the previous authors. But certain differences were observed in the relative importance of food items from place to place which may be due to the environmental conditions and availability of particular food organisms.

Wirszubski (1953) observed a mixture of organisms from benthos and plankton in the food of young ones of *Mullus barbatus* from Israel. Kuthalingam (1955) stated that though the juveniles of *Upeneus indicus* also fed mainly on crustaceans like the adults, showed a preference to smaller crustacea and concluded that the juveniles may be surface feeders while the adults are vertically migratory in their feeding habits. The present study also leads to such a conclusion especially in case of *U. tragula* where large number of juveniles were available for examination. Though the juveniles also were found to feed on all the organisms which the adults take as food, their major items of food were planktonic organisms like copepods, mysids, decapod larvae and caprellids. These items were completely absent in the food of adults and their absence cannot be due to the scarcity of these organisms at least in case of copepods which are abundant in the plankton from Palk Bay and Gulf of Mannar at all seasons but may be due to the difference in their feeding habits. Further, the percentage occurrence and relative importance of planktonic items in the food gradually decrease with increse in the size of the fish and are completely absent in the food of adults or the percentages were negligible.

In his study on *Mullus barbatus* Wirszubski (1953) stated that it was difficult to ascertain whether this fish prefered a particular item to another in its quest of food since some stomachs contained only a particular organism while a mixture of items were present in most cases. Kuthalingam (1956) found *U. cinnabarinus* to be highly selective in feeding. In the present study also it was found that all the four species of goatfishes examined fed on a variety of organisms in most cases. But the percentages of certain items of food like prawns and crabs exclusively present in the stomachs of *U. tragula* were significant enough to suggest some degree of preference or selectivity in its feeding habits.

II. LENGTH-WEIGHT RELATIONSHIP

In fishery biology the study of length-weight relationship serves a twofold purpose (LeCren, 1951) first, to establish a mathematical relationship between the two variables, length and weight and second, to measure the variations from the expected weight for length of individual or groups of fish.

Weight of fish is a function of length and since length is a linear measure and weight a measure of volume, it has been observed that the length-weight relationship of fish could be expressed by the hypothetical cube law, $W=C L^3$, where 'W' represents the weight, 'L' the length and 'C' a constant. This formula holds good only if the the density and form is constant. Martin (1949) stated that most species change their form or shape as they grow and in such cases the value of the exponent in the formula may considerably alter from 3. The length-weight relationship may then be better expressed by a parabolic equation $W=aL^n$ where 'W' and 'L' are weight and length respectively, 'a' a constant equivalent to 'C' and 'n' another constant to be calculated empirically. However, significant variations from the isometric growth ('n'=3.0) are found to be rare (Beverton and Holt, 1957) and for an ideal fish which maintains the shape throughout without any change, the value of n=3.0 (Allen, 1938).

The general equation $W=a L^n$ can be expressed in the logarithmic form as $\log W=\log a+n \log L$. i.e. $Y=A+B X$, where $A=\text{Log } a$, $B=n$, $Y=\log W$ and $X=\log L$ which is a linear relation between Y and X. This linear equation was fitted separately for immature, mature females and males and the estimates of parameters 'A' and 'B' for each category was obtained by the method of least squares. The details are presented below.

Since the value of the exponent 'n' has been observed to vary for fish from different localities, of different sexes and for larval, immature and mature fish (LeCren, 1951) the data of length-weight relationship of *U. tragula* was analysed separately for immature (both sexes together, below 12 cm. in total length), mature females and mature males (12 cm. and above in total length). Tables XLIV to XLVI show the sum of squares and products of X and Y and Tables XLVII to XLIX give the corrected sum of squares and products, the estimates of the regression (coefficient 'B' for each case and the deviation from the regression). Tables L, LI and LII present the analysis of covariance to test whether the regression of Y on X are significantly different for mature females and immature, mature males and immature and mature females and mature males respectively. It is evident from Tables L and LI that the regression coefficient of mature females and immature and mature males and immature show signifiicant differences while no significant difference was observed in the regression coefficient of mature females and mature males (Table LII). As the regression coefficient of immature fish was significantly different from that of mature females and mature males a separate length-weight relationship was fitted for immature fish. The data for mature females and males were pooled together and a common length-weight relationship fitted as there was no significant variation in their regression coefficients.

TABLE XLIV

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF IMMATURE AND MATURE FEMALES OF *U. TRAGULA*

	No. of fish	SX	SY	SX^2	SY^2	SXY
Mature females	195	422.9765	305.8920	917.90943809	484.38371340	664.87847264
Immature	186	365.9614	177.4003	721.46528536	181.90860287	353.26059822

TABLE XLV

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF IMMATURE AND MATURE MALES OF *U. TRAGULA*

	No. of fish	SX	SY	SX^2	SY^2	SXY
Mature males	115	244.1614	163.5254	518.53209114	234.09596556	347.64715084
Immature	186	365.9614	177.4003	721.46538536	181.90860287	353.26059822

TABLE XLVI

SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA OF MATURE FEMALES AND MATURE MALES OF *U. TRAGULA*

	No. of fish	SX	SY	SX^2	SY^2	SXY
Mature females	195	422.9765	305.8920	917.90943809	484.38371340	664.87857264
Mature males	115	244.1614	163.5254	518.53210911	234.09605965	347.64715084

SY. SY = sum of X and Y; SX^2, SY^2, SYX = sum of squares and products

TABLE XLVII

CORRECTED SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA, REGRESSION COEFFICIENT AND DEVIATION FROM THE REGRESSION FOR *U. TRAGULA*

	D.F.	Sum of squares and products			b	Errors of estimates	
		X^2	XY	Y^2		D.F.	S.S.
Mature females	194	0.42677372	1.36499809	4.53799205	3.19841177	193	0.17216608
Immature	185	1.42363864	4.21940387	12.71039620	2.96381663	184	0.20485686
TOTAL	379	1.85041236	5.58440196	17.24838825	3.01792297	377	0.37702294

TABLE XLVIII

CORRECTED SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA, REGRESSION COEFFICIENT AND DEVIATION FROM THE REGRESSION FOR *U. TRAGULA*

	D.F.	Sum of squares and products			b	Errors of estimates	
		X^2	XY	Y^2		D.F.	S.S.
Mature Males	114	0.14261940	0.45940650	1.56938778	3.22120623	113	0.08954472
Immature	185	1.42363864	4.21940387	12.71039620	2.96381663	184	0.20485686
TOTAL	299	1.56625804	4.67881037	14.27978398	2.98725386	297	0.29440158

TABLE XLIX

CORRECTED SUM OF SQUARES AND PRODUCTS OF LENGTH-WEIGHT DATA, REGRESSION COEFFICIENT AND DEVIATION FROM THE REGRESSION FOR *U. TRAGULA*

	D.F.	Sum of squares and products			b	Errors of estimates	
		X^2	XY	Y^2		D.F.	S.S.
Mature females	194	0.42677372	1.36499809	4.53799205	3.19841177	193	0.17216608
Mature males	114	0.14261940	0.45940650	1.56938778	3.22120623	113	0.08954472
TOTAL	308	0.56939312	1.82440459	6.10737983	3.20412124	306	0.26171080

D.F.=Degrees of freedom; X, XY and Y=corrected sum of products and squares; b=regression coefficient, S.S.=sum of squares.

TABLE L

ANALYSIS OF COVARIANCE FOR TESTING DIFFERENCES IN REGRESSIONS OF LOG W ON LOG L BETWEEN MATURE FEMALES AND IMMATURE SPECIMENS OF *U. TRAGULA*

Source of variations	Degrees of freedom	Sum of squares	Mean square	Observed F.
Deviation from individual regressions	377	0.37702294	0.00100006	
Differences among regressions	1	0.01807038	0.01807038	18.06929584
Deviation from average individual regressions	378	0.39509332	•	

TABLE LI

ANALYSIS OF COVARIANCE FOR TESTING DIFFERENCES IN REGRESSION OF LOG W ON LOG L BETWEEN MATURE MALES AND IMMATURE SPECIMENS OF *U. TRAGULA*

Source of variations	Degrees of freedom	Sum of squares	Mean square	Observed F.
Deviation from individual regressions	297	0.29440158	0.00099125	
Differences among regressions	1	0.00858808	0.00858808	8.66388929 (significant)
Deviation from average individual regressions	298	0.30298966		

TABLE LII

ANALYSIS OF COVARIANCE FOR TESTING DIFFERENCES IN REGRESSIONS OF LOG W ON LOG L BETWEEN MATURE FEMALES AND MATURE MALES OF *U. TRAGULA*

Source of variations	Degrees of freedom	Sum of squares	Mean square	Observed F.
Deviation from individual regressions	306	0.26171080	0.00085526	
Differences among regressions	1	0.00005553	0.00005553	*(non-significant)
Deviation from average individual regressions	307	0.26176633		

* Since the deviation from individual regression is greater than the differences among regressions it is evident that the difference between the two samples is non significant and hence it was not necessary to find out the F. values.

The equations for the two groups, immature and mature fish were found to be respectively:

$$W=0.00001325\ L^{2.9638}$$ and

$$W=0.000004211\ L^{3.2015}$$

The corresponding logarithmic equation for immature fish may be written as:

$\text{Log } W= -4.8776+2.9638 \log L$
and for mature fish

$\text{Log } W= -5.3756+3.2015 \log L.$

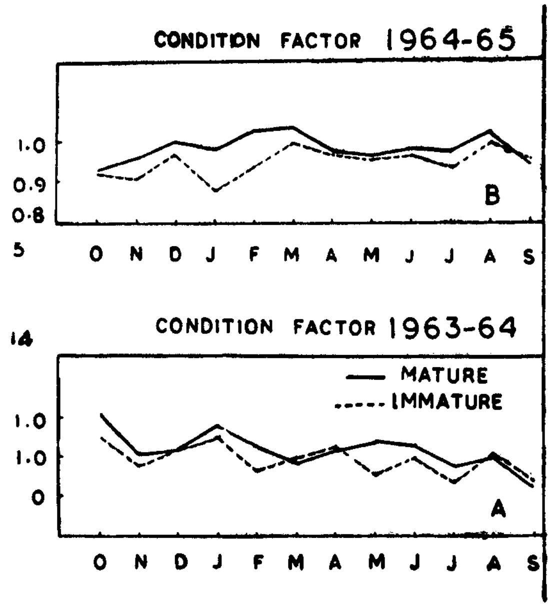
III. RELATIVE CONDITION FACTOR

LeCren (1951) applied the term "condition" as a general term for the analysis of length-weight relationship with a view to finding out the variations from expected weight for length of individual fish or groups of individuals as indicating fatness, 'general well being' or the state of development of gonad. Variations in the specific gravity of flesh of fish occur as shown in the herring *Clupea pallassii* (Tester, 1940) and Kesteven (1947) has discussed their importance in studies on condition. Changes in weight for length are generally not due to changes in specific gravity but due to changes in the form or volume since, usually, the equilibrium is maintained between the density of fish and that of the surrounding water. Such changes are analysed by the condition factor or coefficient of condition or ponderal index (Thompson, 1943, Hile, 1936) which is given by the formula $K = \frac{100\ W}{L^3}$, where

'K' represents the condition factor, 'W' the weight and 'L' the length of fish respectively.

The above formula is applicable only when the cubic relationship between length and weight holds good and the value of 'K' will be affected if it does not obey the cube-law. Other factors like age, sex, maturity, racial differences, food, degree of parasitation, environment and selection in sampling may also affect the value of 'K'. The factors affecting the value of 'K' can be eliminated by using an empirical, calculated length-weight relationship, $W = aL^n$ (LeCren, 1951). The condition factor calculated this way is called the relative condition factor and denoted as Kn to distinguish it from the condition factor 'K' based on the cube-law, and is given by the formula $Kn=W/aL^n$. The length-weight relationship is calculated by the logarithmic formula and Kn by the equation $Kn = W/\bar{w}$, where 'W' represents the observed weight and '$\bar{w}$' calculated weight.

The relative condition factor Kn for *U. tragula* was calculated by the formula $Kn=W/\bar{w}$ as given above. Since the purpose of the study is to trace the condition cycle of the fish through the year and in two successive years and its relation to maturity and feeding habits, they were classified into two groups, immature (below 12 cm. total length) and mature (12 cm. and above). The geometric means of the condition factor for monthly samples of *U. tragula* for immature and mature fish separately for two years from October 1963 to September 1964 and October 1964 to September 1965 respectively are plotted (fig. 18, A & B).



Text-figure 18. The relative condition factor for *U. tragula* for immature and mature fish for the year 1963-64 (A) and 1964-65 (B).

Variations in the condition factor have been attributed to different factors in case of different fishes by Hecht (1916), Thompson (1943), Hickling (1945), Qasim, (1957) and Blackburn (1960).

The present study showed that in the case of *U. tragula*, though the condition of immature and mature fish were always different from each other, the values showed almost the same pattern of rise and fall even during the spawning season. Again it was not possible to explain these changes as due to the variations in the intensity of feeding since the values were found to be higher in some months when the feeding intensity was observed to be low and in certain other months the values of Kn were lower even when there was intense feeding. Hence it may be concluded that in the case of *U. tragula*, changes in the condition do not appear at least to be related to sexual cycle or feeding intensity but may be due to some other factors.

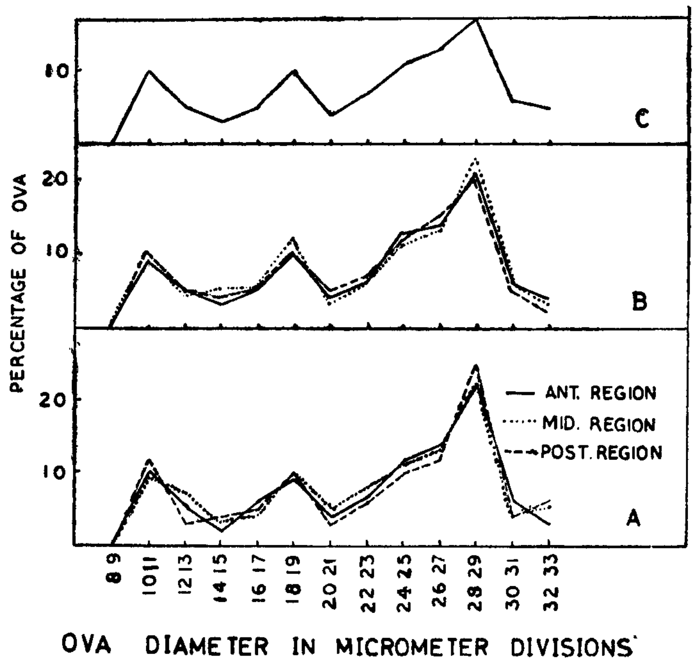
IV. REPRODUCTION

The present study on the reproduction of *U. tragula* is based on the material collected from Rameswaram, Vedalai and Muttupettai during October 1963 to September 1965. As soon as the samples were brought to the laboratory, the length, weight, sex and stage of the maturity of each specimen were noted. The ovaries were then removed and hardened in 5% formalin. No shrinkage or swelling of ova was noticed due to preservation.

Maturity

Distribution of ova in the ovary

To know whether there is any difference in the pattern of the distribution of ova in different regions of the ovary, an ovary in the Vth stage of maturity was examined. Small bits were removed from the anterior, middle and posterior regions of the right ovary. The ova were then teased out into a microslide and their diameter measured and plotted for each region separately (fig. 19,A). The three regions showed exactly the same pattern of distribution of ova of different sizes. Similarly the study of the ova from the corresponding three regions of the left ovary also led to the same conclusion (fig. 19, B). The ova from the three regions



Text-figure 19. Ova diameter frequency polygons of the anterior, middle and posterior regions of a mature ovary (right lobe, fig. A), left lobe (fig. B) and right and left lobes combined (fig. C).

of the right ovary were then pooled together and plotted. The frequency polygon showed the same picture (fig. 19, C). However, to eliminate the possibility of any difference between different regions, ova from the middle region of the right ovary only were taken into consideration in the subsequent studies.

Classification of maturity stages

Based on the macroscopic examination of ovaries and microscopio structure of the ova, the following seven maturity stages have been fixed for the females of *U. tragula.* The stages fixed for males are based only on the microscopio examination of the testes. The description of the seven stages given below applies only to females (unless otherwise mentioned) since males in the advanced stages of maturity were not available for study.

Stage I - Immature

• In this stage, ovaries are small, thread-like and nearly whitish in colour. Ova not visible to the naked eye. Under microscope they are irregular in shape and completely transparent with a nucleus in the centre. Yolk formation has not started. The ova range between 0·04 to 0.10 mm. with a mode at 0·07 mm.

Testes small and slender and the colour is nearly white.

Stage II - Maturing

Maturing group of ova with a mode at 0·13 mm, the range from 0·04 to 0·20 mm. The maturing group of ova get separated from the general stock, they are spherical and partly opaque due to the commencement of yolk formation while the immature group of ova are transparent and irregular in shape. Colour of ovaries remains white.

Testes show a corresponding increase in size but not equal to that of ovaries of same stage.

Stage III - Maturing

Largest group of ova with a mode at 0·22 mm., the range from 0·12 to 0·32 mm. Ova spherical, opaque and fully yolked. Ovaries occupy about half the space of the body cavity and yellow white in colour.

Testes also show a little increase in size, the colour remains white.

Stage IV - Mature

The mode of the largest group of ova falls at 0·35 mm., the range from 0·12 to 0·41 mm. Ova spherical in majority of cases and in the rest slightly oval and transparent at the periphery. Ovaries nearly flesh coloured and occupy $\frac{3}{4}$ of the space of the body cavity.

Testes show a little yellowish colouration and occupy half the space of the body cavity.

Stage V - Ripe

Largest group of ova with a mode at 0·44 mm., the range from 0·12 to 0·51 mm. Majority of ova are spherical, a few oval in shape and the outer half of the ova are transparent. Ovaries flesh coloured and occupy the entire body cavity.

Stage VI - Spawning

Ripe ova with a mode at 0·66 mm., the range from 0·12 to 0·80 mm. Ova completely transparent with a single, large oil glouble (the oil globule measuring a maximum of 0·18 mm.) Ova slightly yellowish.

Stage VII - Spent

This stage includes ovaries in the partially spent and fully spent condition. In the former case (Stage VIIa) the ovaries occupy about half the space of the abdominal cavity as in the third stage, but can be distinguished from it in its rather flaccid nature and nearly flesh colour. The mode of the largest group of ova falls at 0·29 mm. and the size range of the ova at this stage is from 0·12 to 0·36 mm. The fully spent ovary (Stage VIIb) is blood shot in fresh condition and appears like empty bag. The modal size of ova at this stage corresponds with that of stage II.

The classification of the maturity stages fixed for *U. tragula* are summarised (Table LIII) and compared with the seven stages of maturity, defined by the International Council for the Exploration of the Sea (Wood, 1930), as reproduced by Lovern and Wood (1937) with which it almost corresponds.

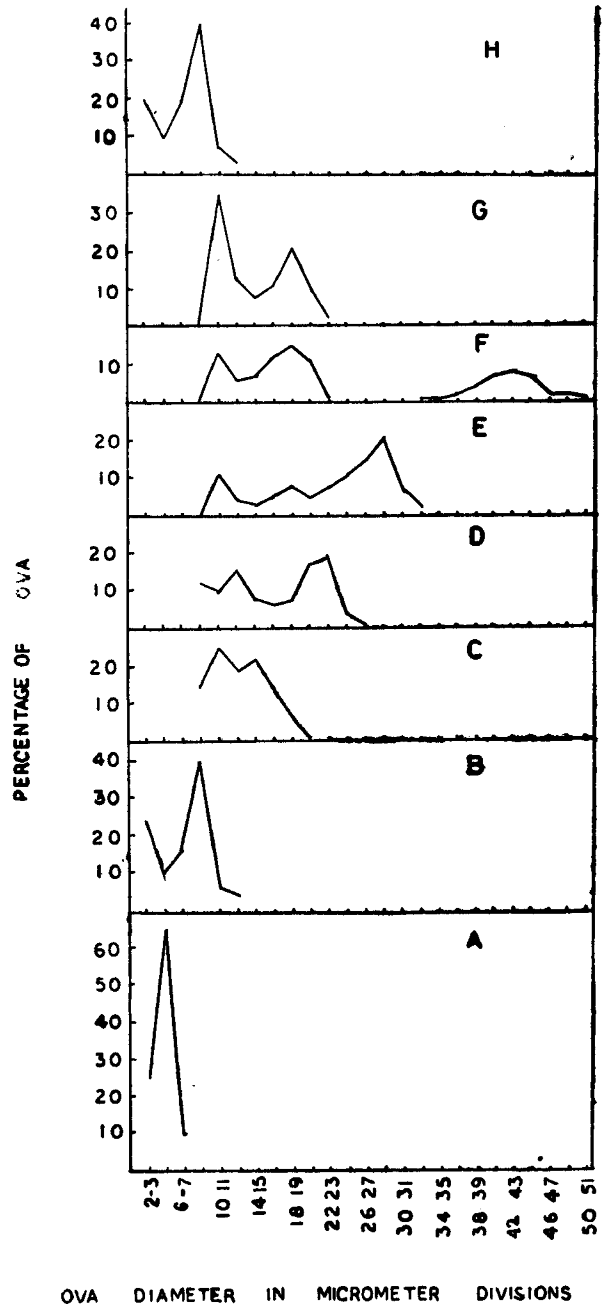
TABLE LIII

CLASSIFICATION OF MATURITY STAGES IN *U. TRAGULA*

Stages of maturity in *U. tragula*	Description of the intra-ovarian ova.	Mode of largest group of ova. mm.	Size range of intra-ovarian ova mm.	Stages defined by ICES
I	Immature	0.07	0·04 to 0·10	I
II	Maturing	0·13	0·04 to 0·20	II
III		0·22	0·12 to 0·32	III
IV	Mature	0·35	0·12 to 0·41	IV
V	Ripe	0·44	0·12 to 0·51	V
VI	Spawning	0·66	9·12 to 0·80	VI
VII a	Partially spent	0·29	0·12 to 0·36	VII
Spent				
VII b	Fully spent	0·13	0·04 to 0·20	VII

Development of ova to maturity

Ova diameter measurements have been taken of ovaries representing all the typical stages described above. The measurements were grouped into two ocular micrometer divisions, each division with a magnification of 0·015 mm. and frequency polygons were drawn. In stage I, the measurements of ova showed a mode at 0·07 mm. (fig. 20, A) and the maximum size of the ova was 0·10 mm. Ova measuring between 0·04 — 0·10 mm. are the general immature stock and since ova of this range are invariably present in all stages of maturity, only those measuring above 0·10 mm. were taken into consideration in the subsequent stages. In stage II



Text-figure 20. Ova diameter frequency polygons of the ovaries of *U. tragula* in various stages of maturity.

(fig. 20, B) a baoh of ova get separated from the general immature stock, the maturing group, with a mode of 0·13 mm. and the maximum size reached at this stage being 0·20 mm. In stage III, the maturing group of ova observed in stage II showed further increase in size with a mode at 0·22 mm. A second batch of maturing group appeared at this stage with a mode at 0·16 mm. The largest size of the ova in this stage was 0·32 mm. (fig. 20, C). In stage IV, the first batch of maturing ova advanced further towards maturity with a mode at 0·35 mm. and the second batch of maturing ova also showed a corresponding advance towards maturity and their mode was observed at 0·19 mm. (fig. 20, D). In stage V, the mode of the first group of mature ova shifted from 0·35 mm. in the previous stage to 0·44 mm. and the second batch of ova from 0·19 mm. to 0.29 mm. A third batch of maturing ova showed their appearance with the mode at 0·16 mm. The largest ova in this stage measured 0·51 mm. (fig. 20, E). In stage VI, the first batch of ripe eggs were seen with the mode at 0·66 mm. and the largest ova measured 0·80 mm. The second batch of maturing ova did not show any further increase in size in this stage and remained stationary with the mode at 0·16 mm. as in the previous stage (fig. 20,F).

Frequency of spawning

Based on the observations of Hickling and Rutenberg (1936) and de Jong (1940) teleosts can be broadly divided into four different groups based on their spawning habits namely spawning once a season, during a short and definite period, spawning only once but extends over a long duration, spawning twice a season and spawning intermittently over a long period.

U. tragula may be considered as belonging to the group which spawns twice a season, as evidenced from the ova diameter studies. The ovary showed two distinct modes of ova right from the second stage but not widely separated (fig. 20, B). In the IVth stage the two modes have become well separated from each other (fig. 20, D) and in the Vth stage the two modes of ova progressed further towards maturity while keeping themselves apart and a third group of maturing ova showed their appearance (fig. 20, E). In the VIth stage the first batch of eggs become ripe and their mode is distinct from the second batch of maturing eggs which has undergone about half the maturation process. The clear separation of the ripe eggs from the rest suggests that spawning at a time may be of short duration. In the partially spent ovary (fig.20,G) though the mode of the maturing eggs remained where it was in the previous stage, there has been significant addition in their numbers. This substantial increase in the number of maturing eggs in partially spent ovaries coupled with the absence of degenerating eggs may rule out the possibility of them being resorbed and since they have already undergone about half of the maturation process they are to be spawned in about half the time necessary for the immature eggs to grow to maturity (de Jong, 1940).

The study of the gonado-somatic index of mature females of *U. tragula* for two years showed two distinct modes in the values during the months of July and September. These high values of gonado-somatic index may indicate the two peak periods of spawning. The occurrence of spent individuals over a long period with the peak period in different months also suggest the possibility of the inividual fish spawning more than once during a season.

Spawning season

A total of 1,565 fish during the first year (October 1963 to September 1964) and 1,230 fish during the second year (October 1964 to September 1965) were examined to find out the percentage occurrence of fish in different stages of maturity during different months. The details are presented in Tables LIII A and LIV.

It is clear from the tables LIII A and LIV that the mature fish occur in the catch from May to November except October during the year 1963-64 and from May to October during 1964-65. Spent fish were recorded from May to November except October and May to October during the first and second years of observation respectively. This indicates that the spawning season of *U. tragula* extends from May to November. The occurrence of young individuals in different months observed in the length frequency studies further support the view that the spawning season of the species extends over a long period.

TABLE LIII A

PERCENTAGE OCCURRENCE OF *U. TRAGULA* IN DIFFERENT STAGES OF MATURITY DURING OCTOBER 1963 TO SEPTEMBER 1964

Month	Total No. of fish examined	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
October	86	F	24	59	17	..	..	..	..
	50	M	22	60	18	..	..	..	..
November	84	F	18	50	14	7	..	..	11
	30	M	30	70	..	..	..	..	..
December	48	F	31	56	9	4	..	..	..
	30	M	37	63	..	..	..	..	..
January	68	F	57	43	..	..	..	..	..
	36	M	25	75	..	..	..	..	..
February	78	F	40	56	4	..	..	..	..
	30	M	33	67	..	..	..	..	..
March	62	F	34	53	13	..	..	..	..
	34	M	35	56	9	..	..	..	..
April	58	F	32	56	12	..	..	..	..
	42	M	48	45	7	..	..	..	..
May	71	F	20	17	10	16	10	3	14
	41	M	32	46	17	5	..	..	..
June	110	F	23	35	13	4	6	..	19
	75	M	39	35	23	3	..	..	..
July	185	F	32	35	10	3	3	..	17
	75	M	46	31	23	..	..	..	..
August	118	F	19	36	8	8	9	2	18
	68	M	29	40	25	6	..	..	..
September	58	F	9	53	7	21	4	..	6
	28	M	7	75	18	..	..	..	..

TABLE LIV

PERCENTAGE OCCURRENCE OF *U. TRAGULA* IN DIFFERENT STAGES OF MATURITY DURING OCTOBER 1964 TO SEPTEMBER 1965

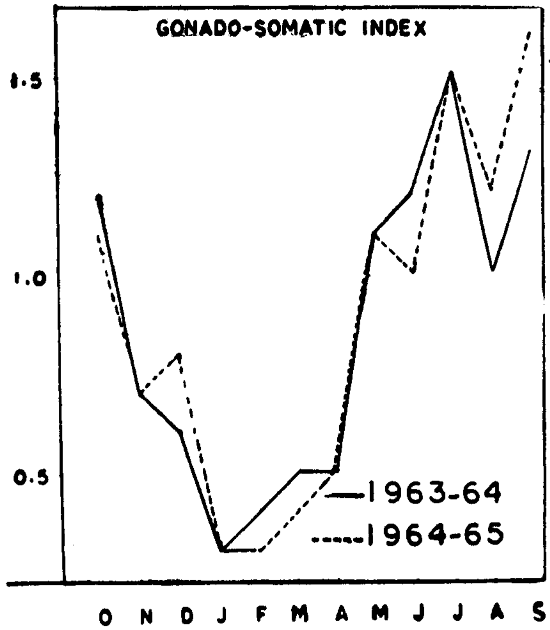
Month	Total no. of fish examined	Sex	Stages of maturity						
			I	II	III	IV	V	VI	VII
October	112	F	8	70	7	3	3	..	9
	38	M	63	29	8	..	..	..	..
November	82	F	19	71	4	4	2	..	..
	36	M	58	42	..	..	..	..	..
December	60	F	30	60	8	..	2	..	..
	26	M	61	39	..	..	..	..	..
January	50	F	54	46	..	..	..	..	..
	35	M	60	40	..	..	..	..	..
February	63	F	40	60	..	..	..	..	..
	30	M	67	33	..	..	..	..	..
March	69	F	44	49	7	..	..	..	..
	42	M	64	36	..	..	..	..	..
April	76	F	13	80	6	1	..	..	..
	34	M	41	53	..	..	..	..	..
May	54	F	7	39	28	4	..	..	22
	32	M	34	41	25	..	..	..	..
June	78	F	33	29	12	5	4	..	17
	46	M	37	39	20	4	..	..	..
July	54	F	33	20	24	8	4	..	11
	24	M	54	29	17	..	..	..	..
August	66	F	18	42	21	9	5	2	3
	30	M	50	33	17	..	..	..	..
September	51	F	26	35	8	14	4	..	13
	42	M	43	47	10	..	..	..	..

Relation between the length of gonads and size of fish

As mature males were not available, only females were tested for this relationship. The length of ovary was plotted against the total length of fish in a scatter diagram which showed a curvilinear relationship (fig. 22, A).

Gonado-somatic index

Applying the method June (1953) and Yuen (1955) in the present study, the relative ovary weight or gonado-somatic index of *U. tragula* has been calculated by using the formula gonado-somatic index=weight of ovary (grams) × 100/weight of fish (grams). This index has been caloulated only for mature females. By using the formula given above the index was calculated for each individual and the monthly average was found by dividing the total of the values by the number of fish examined. The values are plotted (fig. 21) for two years separately. The two modes observed in the values of gonado-somatic index (fig. 21) in the months of July and August may be indicative of the two peak periods of spawning.



Text-figure 21. Gonado-somatic index of *U. tragula* for the two years 1963-64 and 1964-65.

Size at first maturity

The minimum size at which *U. tragula* attains maturity was determined from the examination of 2,800 specimens, of which 1026 were females and 529 were males during the first year and 814 were females and 431 were males during the second year.

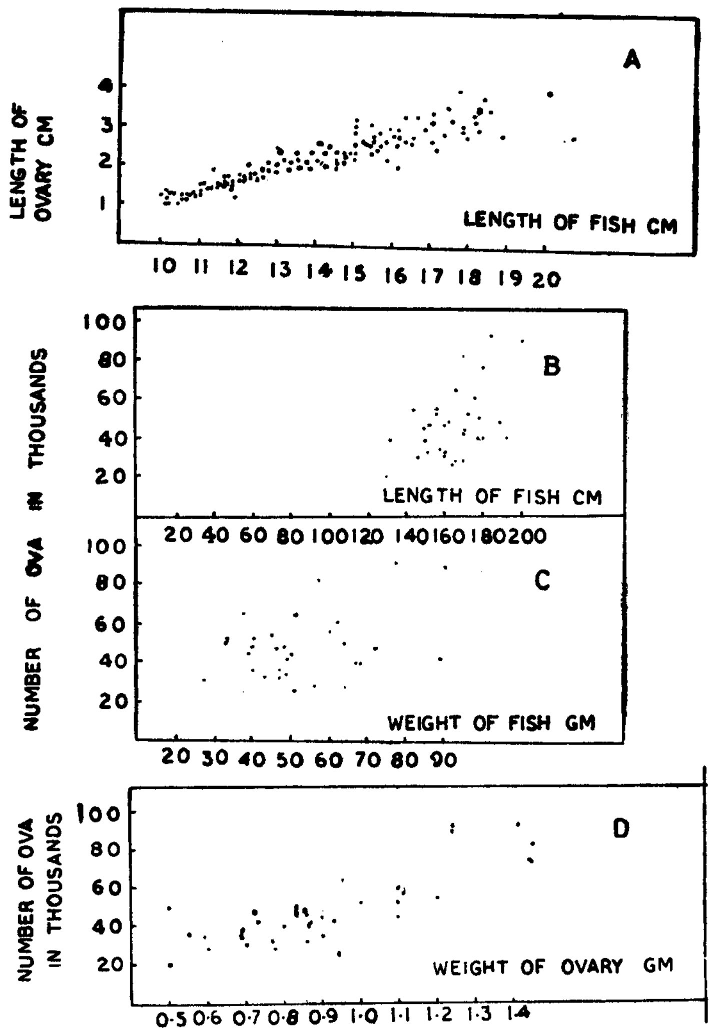
Fish were grouped into 1 cm. size groups and the percentage occurrence of fish in various stages of maturity in each size group was calculated. Those in the first stage were treated as immature, second and third stages as maturing and stage four and above were considered mature for the purpose of calculating the size at first maturity.

Mature females were first noticed in 12 cm. group during both years. Since spent fish were also recorded first in the same size group during both years with 8.45% in the first year and 10.90% in the second year, it may indicate that the minimum size at first maturity attained by females of *U. tragula* is 12 cm.

Males in the advanced stages of maturity were absent during both years in the catches and spent males were not recorded. Hence it is difficult to ascertain the minimum size attained by males at maturity. But the occurrence of males in the fourth stage, though not in good percentages, in the 12 cm. group coincides with the size attained by females to reach that stage. Therefore, it is likely, that there may not be much difference between females and males as far as the minimum size attained at first maturity is concerned.

Fecundity

Since *U. tragula* spawns more than once in a season as evidenced from the multiple modes of ova in the mature ovary, an accurate estimate of the



Text-figure 22. Relation between length of fish and length of ovary (A), length of fish and fecundity (B), weight of fish and fecundity (C), and weight of ovary ana fecundity (D).

fecundity cannot be made from the number of ripe eggs in the ovary at a time. Instead, the ripe eggs as well as all the eggs in which the deposition of yolk was complete, with the periphery transparent, and are likely to be spawned during the same season were taken in the counts for determining the fecundity of the species. The figure obtained in this way may represent the probable number of eggs that will be spawned during a season and not of a single spawning burst.

The fecundity of *U. tragula* is determined in the present study from the examination of 32 specimens ranging in size from 129 to 200 mm. in total length, collected from Rameswaram during 1963 to 1965. A portion of the ovary weighing approximately about 20% of the total weight of the ovaries was taken from the middle region of the right ovary and the number of ova counted. The grand total of ova in the ovary was calculated from the known weight of the sample, the number of ova in the sample and the total weight of the ovary. The fecundity of *U. tragula* varies from 19,000 to 92,800.

Relation between fecundity and length of fish

The number of eggs produced by individuals of *U. tragula* are plotted against the length of fish (fig. 22, B). The number of eggs were found to increase with increase in length of fish generally as in many fishes (Clark 1934, Farren 1938, Hickling 1940 and Simpson 1951). But significant differences were observed in the fecundity of fish of the same length.

Relationship between fecundity and weight of fish

The observed values of fecundity for the 32 specimens are plotted against the weight of fish in fig. 22, C. No direct relationship is found between fecundity and weight of fish.

Relationship between fecundity and weight of ovary

The number of eggs are plotted against the weight of ovary in a scatter diagram (fig. 22, D). It is found that fecundity generally increases with increase in weight of the ovary. But here also significant differences were observed in the fecundity of ovaries having the same weight.

Sex ratio

During the course of this investigation extending over two years, no character was found useful for the external differentiation of the sexes in *U. tragula*. Sex of adults of both females and males were easy to determine with a macroscopic examination but in juveniles of both sexes and especially of males microscopic examination was necessary.

The total number of fish examined during each month with the percentages of females and males are given in Table LV for the two years.

An examination of Table LV will prove that females were caught in larger numbers than males during all the months and during both years. During the first year (October 1963-september 1964) the lowest percentage in case of males was observed in November and highest in April. In the second year (October 1964 to September 1965) the lowest percentage in case of males was observed during October and the highest in September.

To know whether the differences observed in the sex ratio is significant the two years data have been analysed by Chi-square test using the formula,

$$X,^{2} = \frac{1}{\bar{p}\,\bar{q}} \left\{ \Sigma\,(ap) - n\,\bar{p} \right\}$$

The results showed that there is no significant difference in the sex ratio of *U. tragula.*

TABLE LV

SEX RATIO OF *U. TRAGULA* IN THE COMMERCIAL CATCHES DURING 1963-1965

Months	1963-1964			1964-1965		
	Total no. of fish	Percentage of females	Percentage of males	Total no. of fish	Percentage of females	Percentage of males
October	136	63	37	150	75	25
November	114	74	26	118	69	31
December	78	62	38	86	70	30
January	104	65	35	85	59	41
February	108	72	28	93	68	32
March	96	65	35	111	63	37
April	100	58	42	110	69	31
May	112	63	37	86	63	37
June	185	59	41	124	63	37
July	260	71	29	78	69	31
August	186	63	37	96	69	31
September	86	67	33	93	55	45
Total	1,565			1,230		

V. AGE AND GROWTH

Determination of the age of fish, apart from being essential in solving many biological problems, also helps in understanding the age-class structure of the stock and the role played by various year-classes in the fluctuations of the fishery.

Delsman (1929) and Hardenberg (1938) have stated that the methods employed in temperate and sub-tropical regions in determining the age of fishes may not be applicable in case of fishes of tropical region due to the absence of any definite periodicity in seasons. However, growth checkes or markings as found in the skeletal structures of fishes of temperate regions have been observed in fishes from tropical and subtropical regions also and attempts have been made to determine their age from these markings.

In the present study of *U. tragula* scales, otoliths, opercular bones and supraoccipital crests were examined for growth checks or markings which could be used in determining the age of the species.

Scales

An examination of scales from various parts of the body showed that scalel from the pectoral axilla have more clear rings. Consequently in the subsequents studies scales were taken only from the pectoral axilla. Scales from fish measuring 8 cm. (total length) and above only were studied as no markings were present in the scales of fish below that size. Scales were removed from the fish, washed in freshwater, dried and mounted between two micro slides and examined. Clear rings have been observed in a few scales but in majority of the cases they were indistinct and incomplete, making it difficult to read. Scales of the same fish also showed variation in the clarity of the rings. Further there was no relation between the size of the fish and the number of rings observed on the scales. Some fish had on their scales more number of rings than in the scales of fish of considerably larger size and in some cases the number of rings were not constant even in the scales of the same fish.

The formation of rings on scales may be attributed to spawning, scarcity of food or changes in temperature and salinity. But from available data it was not possible to fix any of these as the causative factor for ring formation. Therefore the rings on the scales of *U. tragula* could not be used as age indices.

Otoliths

Otoliths were removed from the fish by making a deep cut with a scalpel along the supraoccipital crest. They were dried and kept in small paper packets for furture study. Otoliths when washed in freshwater and examined did not show any opaque and transparent (hyaline) zones. The convex surface was then ground carefully on a carborundum stone and examined under a binocular microscope with reflected light but no transparent and opaque zones were observed. The examination of otoliths by placing them in different liquid media such as water, spirit, glycerine, xylol, cresote oil and cedarwood oil also was not found useful and as such it was not possible to determine the age of *U. tragula* from the otoliths.

Opercular bones and supraoccipital crests

These two skeletal structures were also examined for growth markings. The head of fish were boiled in freshwater and after removing the flesh the opercular bones and supraoccipital crest were taken out. They were cleared, dried and examined but no marks were visible on them.

In the absence of reliable growth marks on scales, otoliths, opercular bones and supraoccipital crests for the determination of age, the analysis of length frequency distribution by Petersen's method was used.

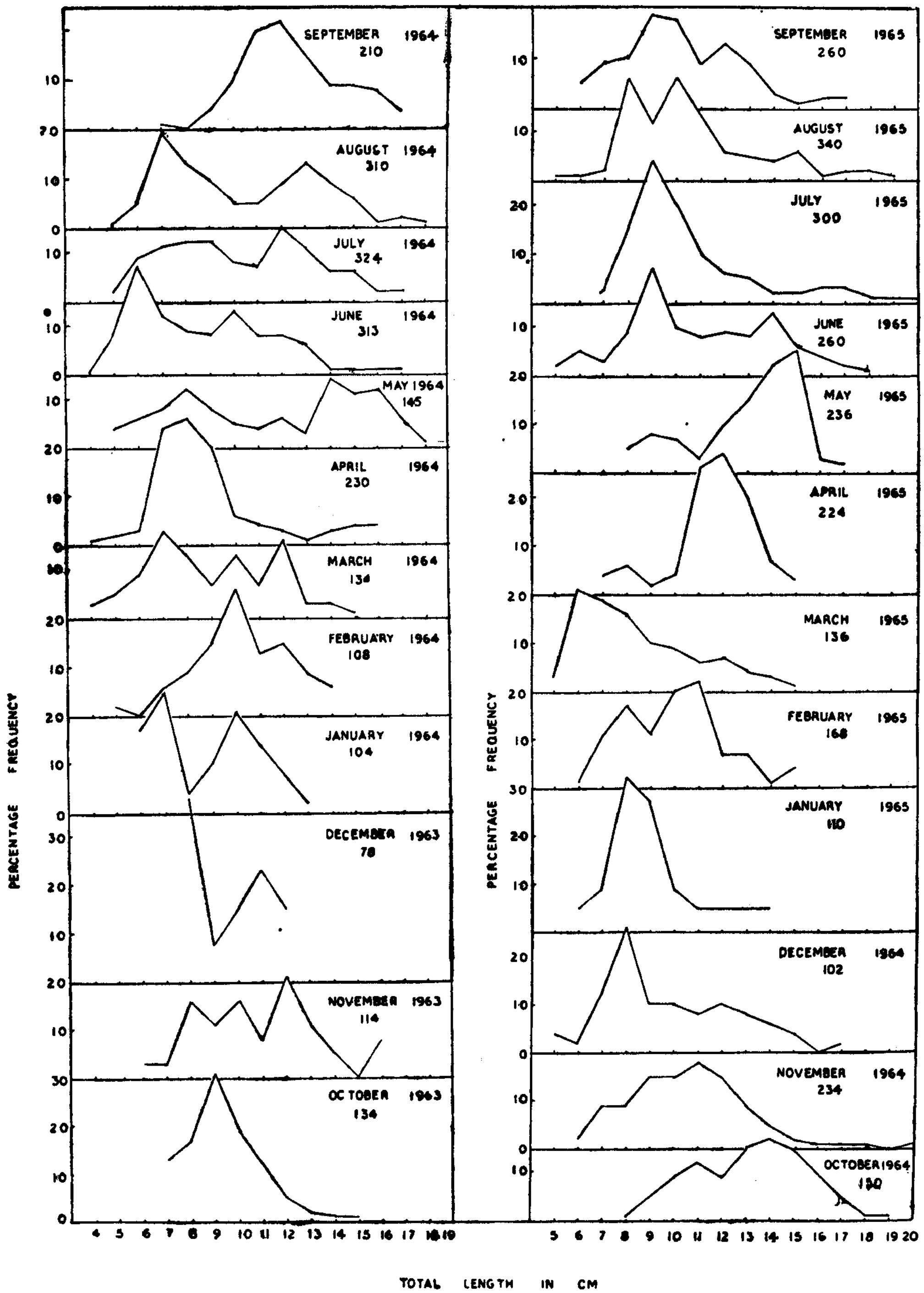
Length frequency analysis

This method is based on the assumption that length of individuals of the same age group in a population of fish are approximately normally distributed. Depending on specific spawning periods in a year, the length frequency distribution may represent a multimodal curve which can be decomposed into its several normal components and the modes will represent the successive age groups. With advance in age the rate of growth slows down and as a result the modes will frequently overlap, making if difficult to interpret. In those fishes where there is no specific and short spawning period, the various broods entering the fishery overlap very often and the only possible way in such case is to trace the size groups as far as possible after it enters the fishery and find the average growth rate in different stages from which the approximate values of average size at different stages may be calculated. It is the same principle that has been applied in analysing the length frequency data of *U. tragula.*

The material for the study consisted of weekly random samples collected from shore seine and 'olai valai' catches during October 1963 to September 1965. As both shore seines and 'olavalai' are not operated beyond a depth of more than 4 fathoms the catches belong to inshore waters only. The samples were preserved in 5% formalin in the field itself. The total length was measured from tip of snout to the longest caudal fin ray. The data for each month were pooled together and grouped at one centimeter interval with the mid point representing the particular size group and the progression of modes was traced through months (fig. 23).

The position of different modes found in the monthly length-frequency curves from October 1963 to September 1965 are given in Table LVI which shows continuous appearance of groups with modal position between 6 and 8 cm. almost every month. Some of these retain their distinct identity for a few months and can therefore be traced for few months. Sometimes, the brood may be strong and can be traced for a longer time. For instance, the mode at 8 cm. observed in December 1963 can be traced through different months up to September 1965 though its identity cannot be recognised during certain months.

In Table LVII is given the possible progression of several broods through successive months, based on which the rate of growth is calculated in the present study. The first column shows the month of the first appearance of the brood with the modal size of the brood just following. The subsequent values denote the modal values of the same brood in subsequent months. The position



Text-figure 23. Length frequency curves of *U. tragula* for the two years 1963-54 and 1964-55.

of the first value for each brood has been fixed according to its size and subsequent growth. It will be seen from the above that the growth pattern of each brood is more or less identical and therefore the alignment of modal developments seems to be justified. The bottom row gives the average. From this it is seen that after a brood enters the fishery, its average growth per month for the first few months is 1 cm. Either the same growth rate or a faster rate of growth can be assumed before the brood enters the fishery. Hence the fish with the modal size of 6 cm. cannot be more than six months and may in all probability be less than that in age. If they are assumed to be about 4 months old, taking into consideration the fact that in young individuals the rate of growth is relatively higher, the subsequent values will show that the fish grows to about 12 cm. at the end of first year and probably 15 to 16 cm. at the end of second year.

TABLE LVI

SUMMARY OF MODAL POSITIONS OF VARIOUS BROODS IN DIFFERENT MONTHS FOR *U. TRAGULA*

Month	Modal positions cm.											
1963 October	..	..	..	9	..	..	..	..	..	..	..	..
November	..	..	8	..	10	..	12	..	..	..	16	..
December	..	..	8	..	..	11	..	..	..	..	..	..
1964 January	..	7	..	..	10	..	..	..	..	..	..	..
February	..	..	..	..	10	..	12	..	..	..	..	..
March	..	7	..	..	10	..	12	..	..	..	..	..
April	..	..	8	..	..	..	..	..	..	..	16	..
May	..	..	8	..	..	..	12	..	14	..	16	..
June	6	..	..	..	10	..	..	..	..	..	..	17
July	..	..	..	9	..	..	12	..	..	..	..	17
August	..	7	..	..	..	..	..	13	..	..	..	17
September	..	7	..	..	..	..	12	..	..	..	..	..
October	..	..	..	..	..	11	..	..	14	..	..	..
November	..	..	..	..	..	11	..	..	..	..	..	..
December	..	..	8	..	..	..	12	..	..	..	..	17
1965 January	..	..	8	..	..	..	..	..	..	..	..	..
February	..	..	8	..	..	11	..	..	..	..	..	..
March	6	..	..	..	..	..	12	..	..	..	..	..
April	..	..	8	..	..	..	12	..	..	..	..	..
May	..	..	..	9	..	..	..	..	..	15	..	..
June	6	..	..	9	..	..	12	..	14	..	..	..
July	..	..	..	9	..	..	..	..	..	..	16	..
August	..	..	8	..	10	..	..	..	..	15	..	17
September	..	..	..	9	..	..	12	..	..	..	..	17

TABLE LVII

PROGRESSION OF VARIOUS BROODS THROUGH SUCCESSIVE MONTHS FOR *U. TRAGULA*

Month	Modal position cm.																						
1963																							
October	..	..	..	9	10	11	..	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November	..	..	8	..	10	..	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December	..	..	8	..	10	10	..	12	..	12	13	..	14	..	..	..	..	..	..	15	..	16	17	17
1964																								
March	..	7	8	..	10	..	..	12	..	..	..	..	..	..	..	..	14	..	15	..	..	..	..	..
May	..	..	8	..	9	..	..	11	11	12	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September	..	7	..	..	..	..	11	12	12	..	12	..	..	..	..	..	..	..	..	..	..	..	..	..
1965																								
January	6	..	8	9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
AVERAGE	6·0	7·0	8·0	9·0	9·8	10·5	11·5	11·8	11·5	12·0	12·5	—	14·0	—	—	—	14·0	—	15·0	15·0	—	16·0	17·0	17·0
	(4)*	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)

* Indicates age in months.

The composite annual length frequency data (Table LVIII) for 1963-64, shows two modes at 8 cm. and 12 cm. and these may correspond to the two major broods corresponding to the two peak spawning periods and these may represent the 6 months and 12 months groups. These are also in agreement with the value obtained for the corresponding ages by following the growth of individual broods.

A uniform rate of growth cannot be expeoted throughout the life span of the individual as it is well known that in earlier stages the growth rate will be much higher than in later stages. Indications of such differential growth rate at different stages are seen in the present study also. For example the fish grow rapidly attaining about 12 cm. at the end of first year. The size at maturity has been found to be 12 cm. and hence it may be concluded that the fish attain sexual maturity when it is about one year old. After the first spawning (after the first year's life) the growth is considerably retarded and the size attained at the end of second year is only about 15 or 16 cm.

In addition to the presence of two year old fish in the commercial catches, the length frequency data also suggest that some fish probably representing the third year-class, may also be met with but they are rare and do not form a group as suoh. Therefore, it was not possible to state the approximate size of the fish at the end of three years.

TABLE LVIII

LENGTH FREQUENCY DATA OF *U. TRAGULA* DURING OCTOBER 1963 TO SEPTEMBER 1964

Size groups cm.	No. of Fish												
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Total
4	..	..	..	..	..	4	2	..	3	..	..	..	9
5	..	..	..	..	2	6	4	6	26	5	1	..	50
6	..	3	..	18	..	12	6	9	70	29	15	..	162
7	17	3	..	26	6	24	56	11	38	37	64	2	284
8	23	18	30	4	10	18	60	17	28	38	38	..	284
9	41	12	6	10	16	10	46	12	25	39	31	8	256
10	26	18	12	22	28	18	14	7	39	26	17	20	247
11	16	9	18	14	14	10	10	6	26	21	16	42	202
12	7	24	12	8	16	22	6	8	25	47	27	46	248
13	2	12	..	2	10	4	2	4	18	35	39	32	160
14	1	6	..	..	6	4	6	20	4	18	28	18	111
15	1	..	..	..	..	2	8	16	4	16	20	18	85
16	..	9	..	..	..	..	10	17	3	5	4	16	64
17	..	..	..	..	..	..	..	9	4	7	6	8	34
18	..	..	..	..	..	..	..	2	..	1	3	..	6
19	..	..	..	..	..	..	..	1	..	..	1	..	2
TOTAL	134	114	78	104	108	134	230	145	313	324	310	210	2,204

The length of fish at any time can be calculated by Bertalanffy's equation which is given as:

$$l_t = l_\infty \left\{ 1 - e^{-k(t - t_o)} \right\}$$

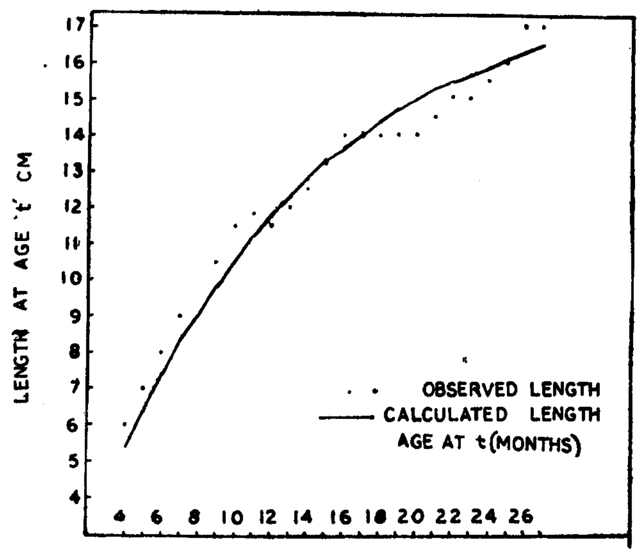
where 'l_t' = length at age 't', l_∞ = the maximum length theoretically the fish can attain, 'k' = growth coefficient and 't_o' = an adjustment in the time scale. The values of these in the present case have been found to be

l_∞ = 18·2140 cm.

k = 0·0864 (in units of months)

t_o = 0·0113 (months)

The length calculated for different months by using the above equation is plotted along with observed length for the same period (fig. 24), which shows a general agreement in the growth pattern at different stages.



Text-figure 24. Relation between observed length and calculated length of *U. tragula*

VI. POPULATION STUDIES

In the present investigation the term population is applied to group of individuals which inhabit a particular area in a given time showing certain distinct morphometric or meristic characters. If all the stocks of a commercially expoited species belong to the same population, the fishing intensity at any one place may have its effects at other places also in course of time. Hence, the knowledge about the identity of the stocks as to whether they come from the same population or from different populations which may or may not remain discrete entities is essential for an effective management, conservation and exploitation of fishery resources.

The methods employed in population studies can be broadly divided into two groups, (i) direot and (ii) indirect. The direct method is tagging individuals for their ultimate recovery. This method has the disadvantage of being much time consuming and expensive compared to the indirect method which is widely used by fishery scientists all over the world. In this method the differences in the morphometric and meristic characters of different groups are studied to determine their probable separateness.

The principle underlying this method is based on the assumption that "Under conditions of partial or complete isolation of groups of fish, slight differences in body proportions or meristic characters will be preserved in each group" (Ahlstrom, 1957). The small differences in meristio or mophometric characters may not be apparent in case of individual specimens but the average of a large sample may show it clearly and the significance of the differences between the averages of two samples or groups can be tested statistically based on the theory of probability.

That ratios between various body proportions differ at different stages of life history in fishes has been demonstrated by Godsil (1948), Schaefer (1948), Schaefer and Walford (1950) and Marr (1955). To overcome this difficulty, the comparison of different samples is based on the comparison of the regression of one dimension on that of another, taken as measurement of ovarall size. This method of regressions have been used by Godsil (1948), Schaefer (1948), de Sylva *et al.* (1956), Pillay (1957), Julio (1958), Prasad (1958 b) and Tandon (1962) for the analysis of different characters to separate the populations, races or stocks as denoted by them.

In the present study, an attempt, has been made to know whether the specimens of *U. tragula* caught from Palk Bay and Gulf of Mannar belong to the same population or not. For this purpose both meristic counts and morphometric characters were used. The meristic counts used are the total number of gill rakers on the outermost gillarch, number of pectoral fin rays and lateral line scales. Examination of the number of vertebrae of specimens from Palk Bay and Gulf of Mannar revealed that the number was constant (24). Hence this character was not useful in the study. Three morphometric characters viz,, head length, depth of body and the distance from snout to insertion of ventral fin were used in the present study and these characters have been measured as defined by Marr and Schaefer (1949). The total length was taken as an independent character and other measurements as dependent ones. The significance of the differences was tested at 5% probability level.

Meristic counts

The meristic counts namely the number of gill rakers, pectoral fin rays and lateral line scales were counted from samples collected from Palk Bay and Gulf of Mannar. The range, mean and standard deviation given by the formula

$$\sigma = \sqrt{\frac{\sum f x^2 - \frac{(\sum fx)^2}{\sum f}}{\sum f}}$$

(where **x** = the count, and **f** = the frequency of occurrence) were calculated for each sample and presented in table LIX. The standard error of mean has also been calculated by using the formula $\frac{\sigma}{\sqrt{n}}$ where '**n**' is the number of specimens in the sample. By applying '**t**' - test no significant difference in the mean values of different meristic character was observed between the samples from Gulf of Mannar and Palk Bay.

Morphometric characters

The data collected during the two years of observation (Oct. 1963 to Sept.1965) have been pooled together for each place, the regression line of one character (designated **x**) on the total length 'y' was drawn and these regressions were compared by the method of analysis of covariance to find out if there were significant differences in the regressions between the two places.

Table LX gives for each place the relevant statistics on sums of squares and products as well as sums of **x** and y.

Table LXI presents separatly for each character the relevant statistics on the corrected sum of squares and products, regression coefficient and also the errors of estimates for each place.

Table LXII furnishes the actual analysis of covariance for testing the significance of the difference of the regressions between two places for each character separately.

From the analysis of covariance presented in Table LX none of the regressions of head length, depth of body and distance from snout to insertion of ventral fin on total length showed any significant differences between the samples from Gulf of Mannar and Palk Bay.

Based on the 3 meristic and 3 morphometric characters of *U. tragula* studied, the samples drawn from Palk Bay and Gulf of Mannar cannot be said to be significantly different and it may be presumed that so far as these characters are concerned, the fish in the two localities belong to the same population.

TABLE LIX

MERISTIC COUNTS OF *U. TRAGULA*

Locality	Range	Mean	St. divi-ation	St. error	M+2 St. errors	M—2 St. errors
1. Gill rakers						
Gulf of Mannar	20—25	21·85	1·25	0·13	22·11	21.59
Palk Bay	20—25	21·83	1·13	0·13	22·09	21·57
2. Pectoral fin rays						
Gulf of Mannar	13—14	13·11	0·32	0·03	13·17	13·05
Palk Bay	13—14	13·13	0·34	0·03	13·19	13·07
3. Lateral line scales						
Gulf of Mannar	30—32	31·16	0·71	0·08	31·32	31·00
Palk Bay	30—32	31·19	0·68	0·08	31·35	31·03

TABLE LX

SUM OF SQUARES AND PRODUCTS OF MORPHOMETRIC DATA OF *U. TRAGULA* FROM GULF OF MANNAR AND PALK BAY

Locality	N	SX	SY	SX^2	SY^2	SXY
1. Head length						
Gulf of Mannar	117	236·6609	163·4748	479·7939	229·3943	331·6884
Palk Bay	121	249·9804	174·5578	517·7468	253·0558	361·8809
2. Depth of body						
Gulf of Mannar	124	250·4959	162·5079	506·9960	214·0932	329.2974
Palk Bay	124	258·5540	170·7494	539·8555	235·9536	256·7990
3. Distance from snout to insertion of ventral fin						
Gulf of Mannar	93	188·3277	134·8999	382·8095	196·3953	273·8796
Palk Bay	115	239·1652	171·1474	498·4049	255·7243	356·9255

SX, SY = Sum of X and Y; SX^2, SY^2,SXY = Sum of squares and Products

N = Number of specimens examined

TABLE LXI

CORRECTED SUM OF SQUARES AND PRODUCTS AND DEVIATIONS FROM REGRESSIONS OF MORPHOMETRIC DATA FOR *U. TRAGULA*

Head length

Locality	DF	X^2	XY	Y^2	b	Errors of estimate	
						SS	DF
Gulf of Mannar	116	1.0895	1.0209	0.9840	0.9368	0.0276	115
Palk Bay	120	1.2989	1.2526	1.2341	0.9644	0.0261	119
TOTAL	236	2.3884	2.2735	2.2181	0.9519	0.0537	234
Depth of body							
Gulf of Mannar	123	0.9622	1.0106	1.1189	1.0503	0.0575	122
Palk Bay	123	0.7412	0.7672	0.8297	1.0351	0.0356	122
TOTAL	246	1.7034	1.7778	1.9486	1.0437	0.0931	244
Distance from snout to insertion of ventral fin							
Gulf of Mannar	92	0.7763	0.7034	0.7181	0.9061	0.0808	91
Palk Bay	114	1.0137	0.9907	1.0162	0.9773	0.0480	113
TOTAL	206	1.7900	1.6941	1.7343	0.9464	0.1288	204

DF=Degrees of freedom; b=Regression coefficient; SS=Sum of squares

TABLE LXII

COVARIANCE ANALYSIS OF THE MORPHOMETRIC DATA OF SAMPLES OF *U. TRAGULA* FROM GULF OF MANNAR AND PALK BAY

Head length

Source of variation	DF	SS	M.S.	Observed F.	5% F	•
Deviation from individual regressions	234	0.0537	0.0002295			
Differences among regressions	1	0.0002	0.0002000	*		NS
Deviation from average individual regression	235	0.0539				

Depth of body

Source of variation	DF	SS	M.S.	Observed F.	5% F	•
Deviation from individual regressions	244	0.0931	0.0003815			
Differences among regressions	1	0.0001	0.0001000	*		NS
Deviation from average individual regression	245	0.0932				

Distance from snout to insertion of ventral fin

Source of variation	DF	SS	M.S.	Observed F.	5% F	•
Deviation from individual regressions	204	0.1288	0.0006314			
Difference among regressions	1	0.0022	0.0022000	3.48	254	NS
Deviation from average individual regression	205	0.1310				

NS=Non significant

* Since the deviation from individual regression is greater than the differences among regressions it is evident that the difference between the two samples is non-significant and hence it was not necessary to find out the 'F' values.

Comparison of samples of species of Mullidae from various localities of the Indo-Pacific region

Lachner (1954) after studying the various meristic and morphometric characters and colouration of species segregated by locality from different sub-faunal areas of the Indo-Pacific region came to the conclusion that no population divergence exists among these species from different areas. Even the supposed to be isolated populations of widely occurring species such as *U.vittatus. U.sulphureus* and *U. tragula* from the faunal areas of East Africa, East Indies, Philippines and areas of Oceania were found to be "characteristically homogeneous" (Lachner, 1954 p. 506). But a later study of the group including two more genera viz., *Parupeneus* Bleeker and *Mulloidichthys* Whitley has revealed that "Some divergence on a low racial level is exhibited by several species which differ mainly in the total number of gillrakers" (Lachner, 1960).

Since the present study is based on large number of specimens of several species collected from a single faunal area, an attempt has been made to compare these species with those occurring at different faunal areas of the Indo-Pacific described by Lachner (1954, 1960). Such a study has been felt necessary as the conclusions arrived at by Lachner (1954) are "tentative owing to the limited number of specimens of several species".

The characters of species from different parts of the Indo-Pacific have been taken from the data published by Lachner (1954, 1960). For most of the species the characters have been given locality-wise by him and so it was possible to make a detailed study of the population of species from those areas and compare with the population from this area. But in certain cases data for different localities were not given separately and have been pooled together and the locality was given as 'Indo-Pacific'. In such cases comparison was made only between population from this area and the rest as a whole from the 'Indo-Pacific'.

For this study of populations from different areas of the Indo-Pacific, only the meristic characters namely the total number of gillrakers, pectoral fin rays and lateral line scales were available from the published data of Lachner (1960). Moreover it has been observed that the morphometric characters were "too insignificant or variable to be of any particular taxonomic importance" (Lachner, 1954, page 503).

The tables LXIII to LXIX present for each species the range, mean value of the meristic character, the standard deviation and the standard error of mean for each locality.

The 't'-test was applied for testing if the mean value of a meristic character of the same species differed significantly from locality to locality.

From Table LXIII it is clear that as far as the gillraker counts are concerned there is no significant difference in the population of *Upeneus vittatus* from Mauritius, Philippines and Marianas Islands. But samples from Samoan Islands and this area (Mandapam) differed significantly from each other and also from all the three other places.

In case of *U. tragula* no significant difference was observed between samples from East Indies and Philippines. Material from Mandapam area showed considerable difference from that of Philippines but there was some identity with those from East Indies. Palau Islands sample differed significantly from all the rest.

TABLE LXIII

DETAILS OF THE GILL RAKER COUNTS OF SIX SPECIES OF *UPENEUS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M − 2 St. errors of mean
U. vittatus	Mauritius	8	27-30	27.86	0.93	0.33	28.52	27.20
	Philippines	28	26-29	27.93	0.80	0.15	28.23	27.63
	Marianas Islands	7	27-29	27.71	0.70	0.26	28.23	27.19
	Samoan Is.	9	29-30	29.44	0.51	0.17	29.78	29.10
	Mandapam	60	26-31	28.68	1.10	0.14	28.96	28.40
U. tragula	East Indies	6	21-23	22.67	0.75	0.30	23.27	22.07
	Philippines	30	21-24	22.88	0.80	0.14	23.16	22.60
	Palau Is.	11	23-25	23.64	0.77	0.23	24.10	23.18
	Mandapam	100	20-25	22.12	1.18	0.12	22.36	31.88
U. bensasi	Philippines	12	23-27	25.00	1.29	0.37	25.74	24.26
	Japan	22	23-27	24.91	0.95	0.20	25.31	24.51
	Mandapam	17	22-25	23.18	1.04	0.25	23.68	22.68
U. sulphureus	Indo-Pacific	43	26-32	29.35	1.38	0.21	29.77	28.93
	Mandapam	50	25-31	27.98	1.48	0.21	28.40	27.56
U. luzonius	Philippines	9	19-22	20.44	1.07	0.36	21.16	19.72
	Mandapam	42	18-22	19.81	1.05	0.16	20.13	19.49
U. oligospilus	Persian Gulf	11	20-23	22.00	0.85	0.26	22.52	21.48
	Mandapam	80	19-23	20.94	1.02	0.11	21.16	20.72

TABLE LXIV

DETAILS OF THE PECTORAL FIN RAY COUNTS OF SIX SPECIES OF *UPENEUS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
U. vittatus	Indo-Pacific	68	15-17	16·12	0·47	0·06	16·24	16·00
	Mandapam	100	15-18	16·58	0·57	0·06	16·70	16·46
U. sulphureus	Indo-Pacific	58	15-17	15·74	0·54	0·07	15·88	15·60
	Mandapam	50	15-17	15·88	0·52	0·12	16·12	15·64
U. tragula	Indo-Pacific	77	12-14	13·06	0·34	0·04	13·14	12·98
	Mandapam	120	13-14	13·16	0·37	0·03	13·22	13·10
U. bensasi	Indo-Pacific	46	13-14	13-83	0·38	0·06	13·95	13·71
	Mandapam	17	13-15	14·00	0·69	0·12	14·24	13·76
U. luzonius	Indo-Pacific	10	14-15	14·10	0·95	0·30	14·70	13·50
	Mandapam	42	14-15	14·14	0·12	0·02	14·18	14·10
U. oligospilus	Persian Gulf	12	13-14	13·58	0·49	0·14	13·86	13·30
	Mandapam	80	13-14	13·84	0·37	0·04	13·92	13·76

TABLE LXV

DETAILS OF THE LATERAL LINE SCALES OF SIX SPECIES OF *UPENEUS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
U. vittatus	Mauritius	5	35-36	35·40	0·50	0·22	35·84	34·96
	Philippines	23	34-36	34·74	0·67	0·14	35·02	34·46
	Samoan Is.	8	34-36	35·50	0·71	0·25	36·00	35·00
	Mandapam	90	35-38	35·92	0·98	0·10	36·12	35·72
U. tragula	East Indies	6	29-32	30·17	1·07	0·44	31·05	29·29
	Philippines	26	28-32	29-96	1·05	0·21	30·38	29·54
	Palau Is.	9	29-32	30·11	0·99	0·33	30·77	29·45
	Mandapam	100	30-32	31·13	0·73	0·07	31·27	30·99
U. bensasi	Philippines	5	29-30	29·20	0·40	0·18	29·56	28·84
	Japan	15	29-31	29·60	0·80	0·21	30·02	29·18
	Mandapam	17	30-32	31·18	0·62	0·15	31·48	30·88
U. sulphureus	Indo-Pacific	44	34-37	35·41	0·83	0·13	35·67	35·15
	Mandapam	75	35-37	36·13	0·60	0·07	36.27	35·99
U. luzonius	Philippines	8	31-32	31·25	1·37	0·48	32·21	30·29
	Mandapam	42	33-34	33·74	0·44	0·07	33·88	33·60
U. oligospilus	Persian Gulf	11	29-31	30·18	0·58	0·17	30·52	29·84
	Mandapam	70	31-32	31·40	0·49	0·06	31·52	31·28

Samples of *U. bensasi* from Philippines and Japan were much alike but differed significantly from sample of Mandapam area. Specimens of *U. sulphureus* were put together as from Indo-Pacific and when compared with those from Mandapam, significant differences were observed. *U. luzonius* was found to be different but not significantly from specimens collected from Mandapam. *U. oligospilus* from Persian Gulf also was observed to be significantly different from specimens from this area.

Pectoral fin ray counts were not available separately for each place but were grouped together and the locality has been given as Indo-Pacific except in case of *U. luzonius* and *U. oligospilus* for which data were available from Philippines and Persian Gulf respectively. Analysis of these counts revealed (Table LXIV) *U. vittatus* from this area to differ significantly from samples pooled together from other areas. The other species namely *U. sulphureus*, *U. tragula*, *U. bensasi*, *U. luzonius* and *U. oligospilus* did not show any significant differences between localities.

A study of the number of lateral line scales of samples from various areas of the Indo-Pacific region gave the following results (Table LXV). *U. vittatus* from Mauritius differed significantly from those of Mandapam and Philippines while it was found to be similar to specimens from samoan Islands. Samples from Philippines and Mandapam differed from all other places. Samoan Islands specimens were identical with those from Mauritius but were different from those of Philippines and Mandapam.

U. tragula from East Indies, Philippines and Palau Islands were identical but they all were significantly different from the sample of this area.

U. bensasi from Philippines and Japan did not show much difference between each other while both samples were significantly different from samples of Mandapam area.

U. sulphureus from other areas put together differed considerably from the sample of Mandapam area. Similarly *U. luzonius* from Philippines and *U. oligospilus* from Persian Gulf were not identical with *U. luzonius* and *U. oligospilus* respectively of this area.

Only four species of the genus *Parupeneus* viz., *P. indicus*, *P. barberinus*, *P. bifasciatus* and *P. macronemus* were available in sufficient numbers to make comparative study with specimens from other areas. The results are given below.

From the study of number of gillrakers it was found (Table LXVI) that *P. indicus* from Philippines and Mandapam area differ significantly from each other.

P. barberinus from East Indies-Philippines differed from those of Marshall Islands, Marianas Islands material was identical but differed from that of East Indies-Philippines and Minicoy. The Minicoy sample was also significantly different from all the other places.

P. bifasciatus from East Indies-Philippines, Samoan Islands and Minicoy area were different from each other, but there was some similarity between samples from East Indies-Philippines and Minicoy. *P. macronemus* from Minicoy also was found to be differing significantly from material of other places.

Analyses of pectoral fin ray counts (Table LXVII) revealed *P. indicus* from Mandapam and *P. barberinus* and *P. bifasciatus* from Minicoy area to be different significantly from those of other areas put together. But no such difference was observed in case of *P. macronemus* from Minicoy and other places.

TABLE LXVI

DETAILS OF THE GILL RAKER COUNTS OF FOUR SPECIES OF *PARUPENEUS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
P. indicus	Philippines	17	24-27	26.12	0.83	0.20	26.52	25.72
	Mandapam	58	24-27	26.24	0.77	0.10	26.52	25.72
P. barberinus	East Indies - Philippines	33	26-31	29.18	1.36	0.24	29.66	28.70
	Marshall Is.	18	27-29	28.00	0.67	0.16	28.32	27.68
	Marianas Is.	21	27-29	28.00	0.69	0.15	28.30	27.70
	Minicoy Is.	40	25-30	27.00	1.05	0.17	27.34	26.66
P. bifasciatus	East Indies - Philippines	38	34-39	36.47	1.19	0.19	36.85	36.09
	Samoan Is.	10	36-40	37.70	1.19	0·39	38.46	36.94
	Minicoy Is.	14	34-39	35.86	1.41	0.38	36.62	35.10
P. macronemus	Indo - Pacific	8	31-33	31.75	0.66	0.23	32.21	31.29
	Minicoy Is.	30	32-37	34.03	1.25	0.23	34.49	33.57

TABLE LXVII

DETAILS OF THE PECTORAL FIN RAY COUNTS OF FOUR SPECIES OF *PARUPENEUS* FROM DIFFERENT AREAS OF THE INDO - PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
P. indicus	Indo - Pacific	19	15-16	15.89	0.31	0.07	16.03	15.75
	Mandapam	58	16-17	16.19	0.39	0.05	16.29	16.09
P. barberinus	Indo - Pacific	31	16-18	17.45	0.56	0.10	17.65	17.25
	Minicoy Is.	40	16-17	16.93	0.26	0.04	17.01	16.85
P. bifasciatus	Indo-Pacific	29	15-16	15.89	0.31	0.06	16.01	15.77
	Minicoy Is.	14	15-17	16.07	0.46	0.12	16.31	15.83
P. macronemus	Indo - Pacific	8	15-16	15.63	0.48	0.17	15.97	15.29
	Minicoy Is.	30	15-16	15.70	0.46	0.08	15.86	15.54

Number of lateral line scales of these species were not tested for the purpose of finding out the homogenity or otherwise of the samples from different areas as there was not much variation in their number even among different species.

Gillraker counts of two species of the genus *Mulloidichthys* were compared from different areas and the details are presented in Table LXVIII.

M. samoensis from Philippines differ significantly from samples of Marianas Islands, Marshall Islands, Phoenix and Samoan Islands and Hawaiian Islands but were found to be identical with the samples from Minicoy Island. Sample from Marianas Islands was identical with the samples of Marshall Islands and Phoenix and Samoan Islands but were different from those of Philippines, Hawaiian Islands and Minicoy. Hawaiian Islands sample was different from all other places. Sample from Minicoy was similar to that from Philippines but were significantly different from all other places.

M. flavolineatus from East Indies was identical with samples from Phoenix and Samoan and Hawaiian Islands but were different from Marshall Islands and Mandapam area. The samples from the latter two areas differed from each other and also from all other places.

Analyses of the number of lateral line scales (Table LXIX) showed that *M. samoensis* from Minicoy is significantly different from other areas while no such difference was observed in case of *M. flavolineatus* from Mandapam area and other places.

Data regarding the pectoral fin ray counts of these two species from different areas were not available to make a comparative study.

The results of the present study are presented in Tables LXX, LXXI, LXXII. Samples which were found to be homogeneous based on the character studied are represented by same alphabets while those found to be different from each other have been represented by different alphabets.

TABLE LXVIII

DETAILS OF THE GILL RAKER COUNTS OF TWO SPECIES OF *MULLOIDICHTHYS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
M. samoensis	Philippines	22	25-30	26·73	1·09	0·23	27·19	26·27
	Marianas Is.	9	26-30	27·56	1·16	0·38	28·32	26·80
	Marshall Is.	24	25-30	27·87	1·05	0·22	28·31	27·43
	Phoenix and Samoan Is.	24	25-30	27·37	1·28	0·26	27·89	26·85
	Hawaiian Is.	32	27-31	28·53	1·06	0·19	28·91	28·15
	Minicoy Is.	25	24-28	26·72	1·18	0·24	27·20	26·24
M. flavolineatus	East Indies	14	30-34	32·14	1·12	0·30	32·74	31·54
	Marshall Is.	41	31-35	33·26	1·01	0·16	33·58	32·94
	Phoenix and Samoan Is.	12	29-34	32·08	1·49	0·43	32·94	31·22
	Hawaiian Is.	6	30-34	31·67	1·49	0·61	32·89	30·45
	Mandapam	18	27-33	29·33	1·91	0·45	30·23	28·43

TABLE LXIX

DETAILS OF THE LATERAL LINE SCALES OF TWO SPECIES OF *MULLOIDICHTHYS* FROM DIFFERENT AREAS OF THE INDO-PACIFIC REGION

Name of species	Locality	No. of specimens	Range	Mean	St. Deviation	St. error of mean	M+2 St. errors of mean	M—2 St. errors of mean
M. samoensis	Indo-Pacific	67	33-38	35·76	1·00	0·12	36·00	35·52
	Minicoy Is.	28	35-38	37·18	1·07	0·20	37·58	36·78
M. flavolineatus	Indo-Pacific	30	35-38	36·57	0·96	0·17	36·91	36·23
	Mandapam	18	35-38	36·39	0·95	0·22	36·83	35·95

From the tables given above it can be seen that:

a) No species is homogeneous throughout the range of its distribution.

b) Populations from localities nearer to each other were some times found to be significantly different based on some character, whereas those distributed far apart were found to be homogeneous.

The conclusions arrived at in this study are based on very meagre data available for many of the species from various faunal areas. Therefore the results obtained by the present study can be confirmed only after studying a large number of specimens of all the species from the different faunal areas.

TABLE LXX

SUMMARY OF OBSERVATION ON POPULATION STUDIES OF SIX SPECIES OF *UPENEUS* FROM DIFFERENT AREAS OF INDO-PACIFIC

Name of species	Character	Persian Gulf	Mauritius	Mandapam	East Indies	Philippines	Japan	Marianas Is.	Samoan Is.	Palau Is.	Indo-Pacific
U. vittatus	Gill raker Counts	..	A	B	..	A	..	A	C	..	..
-do-	Pectoral fin rays	..	..	A	..	..	..	..	..	..	B
-do-	L. I. scales	..	A	B	..	C	..	..	A	..	..
U. tragula	Gill rakers	..	..	B	A	A	..	..	..	C	..
-do-	P. rays	..	..	A	..	..	..	..	..	..	A
-do-	L. I. scales	..	..	B	A	A	..	..	..	A	..

U. bensasi	Gill rakers	..	..	B	..	A	A	..	..	..	..
-do-	P. rays	..	..	A	..	..	..	..	..	..	A
-do-	L. I. scales	..	..	B	..	A	A	..	..	..	..
U. sulphureus	Gill rakers	..	..	A	..	..	..	..	..	..	B
-do-	P. rays	..	..	A	..	..	..	..	..	..	A
-do-	L. I. scales	..	..	A	..	..	..	..	..	..	B
U. luzonius	Gill rakers	..	..	A	..	A					
-do-	P. rays	..	..	A	..	A					
-do-	L. I. scales	..	..	A	..	B					
U. oligospilus	Gill rakers	A	..	B							
-do-	P. rays	A	..	A							
-do-	L. I. scales	A	..	B							

Same alphabets in the horizontal line indicate the homogenity of the populations based on that particular character

TABLE LXXI

SUMMARY OF OBSERVATION ON POPULATION STUDIES OF FOUR SPECIES OF *PARUPENEUS* FROM DIFFERENT AREAS OF INDO-PACIFIC

Name of species	Character	LOCALITIES Mandapam	Minicoy Is.	East Indies	Philippines	Marshal Is.	Marianas Is.	Samoan Is.	Indo-Pacific
P. indicus	Gill rakers counts	A	..	..	B	..	..	..	..
-do-	Pectoral fin rays	A	..	..	..	..	..	..	B
P. barberinus	Gill rakers counts	..	C	A	..	B	B	..	..
-do-	Pectoral fin rays counts	..	A	..	..	..	..	..	B
P. bifasciatus	Gill raker counts	..	A	B	..	..	..	C	..
-do-	Pectoral rays	..	A	..	..	..	..	..	B
P. macronemus	Gill raker counts	..	A	..	..	..	..	..	B
-do-	Pectoral rays	..	A	..	..	..	..	..	A

Same alphabets in the horizontal line indicate the homogenity of the populations based on that particular character

TABLE LXXII

SUMMARY OF OBSERVATIONS ON POPULATION STUDIES OF TWO SPECIES OF *MULLOIDICHTHYS* FROM DIFFERENT AREAS OF INDO-PACIFIC

		LOCALITIES								
Name of species	Character	Mandapam	Minicoy Is.	East Indies	Philippines	Marshall Is.	Marianas Is.	Phnoeix and Samoan Is.	Hawaiian Is.	Indo-Pacific
M.samoensis	Gill raker counts	..	A	..	A	B	B	B	C	..
-do-	Lateral line scales	..	A	..	..	..	..	..	..	B
M.flavolineatus	Gill raker counts	B	..	A	..	C	..	A	A	..
-do-	Lateral line scale	A	..	..	..	..	..	..	..	A

Same alphabets in the horizontal line indicate the homogenity of the populations based on that particular character.

Part Four

FISHERY

DISTRIBUTION AND FISHERY OF GOATFISHES ALONG THE INDIAN COAST

THE important species of goatfishes which form the fishery are *U. sulphureus*, *U. vittatus*, *U. tragula* and *P. indicus*, though other species also occur less frequently and in negligible quantities in the catches.

The distribution of the species contributing to the fishery along the Indian coast is almost continuous. Available records show that the goatfishes form a fishery of some magnitude along the Andhra and Madras coast along the east coast and Kerala, Mysore and Bombay coasts along the west coast of India. *U. sulphureus* and *U. vittatus* are the two species occurring in large numbers in all these places except along the Madras coast where *P. indicus* and *U. tragula* are the dominant species. Goatfishes are caught mainly in trawl net in Andhra, Mysore and Bombay coasts.

Information regarding the fishery of goatfishes along Palk Bay and Gulf of Mannar have been collected by visiting the various fish landing centres from Kilakarai to Dhanushkodi along the Gulf of Mannar and from Devipatnam to Rameswaram along Palk Bay. The species forming the fishery along these coasts in the order of their abundance are *U. tragula, P. indicus, U. vittatus* and *U. sulphureus*. Apart from these, *U. sundaicus* was sometimes observed to form the dominant catch among goatfishes. Other species occurring in small quantities are *U. luzonius*, and *U. oligospilus*.

Fishing methods and seasons along Palk Bay and Gulf of Mannar

Fishing methods

The main gears employed in the fishery of goatfishes along Palk Bay and Gulf of Mannar are shore seines (olai valai) and fish traps.

'Olai valai' (Tamil: 'Olai'=palm leaf; 'valai'=net).

Olai valai is essentially a shore seine in all respects except that the hemp wings of the shore seines are replaced by ropes to which palm leaves are attached. The palm leaves are inserted in between the plies of the rope at a distance of about 1 foot from each other. There are ten warps on either side, about 180 meters in length, all provided with palm leaves. (Pl. VIII, figs. A, B & C)

The mode of operation is just like shore seine but the time taken for an operation will not exceed 2 hours.

Fish traps (Pl. VIII, figs. D,E & F)

Fish traps, locally known as 'koodu' (Tamil: 'koodu'=trap) are extensively used along Palk Bay and Gulf of Mannar for perch fishery and is one of the indigenous methods of fishing.

The traps are usually made of split branches of *Acacia* or thin bamboo reapers and mid ribs of palmyra leaves. The size as well as the shape of the traps vary considerably, the length, breadth and height from 2 to 5, 2 to 4 and ½ to 1½ feet respectively (Prabhu, 1954) and the shape from stellate, square, triangular and cylindrical. The entrances are in the form of funnels, woven separately and laced to the main body of the trap. The number of entrance funnels to each trap and their position also vary with the size and shape of the trap. In stellate traps, each arm will be fitted with a funnel, in square type any one or two sides may have a funnel each and in cylindrical traps either one or both ends will be fitted with a funnel. In triangular traps, one entire side serves as a funnel, formed by the bending of the edges of the upper and lower halves inwards at a particular angle, so that at the extreme tips, they will not meet but leave a narrow longitudinal slit which serves as the entrance.

Mode of operation

Along sandy shore a number of traps, usually of the same size and shape are operated together. About 50 traps are tied to a long rope at an interval of about 9 to 11 metres. Inside the trap is placed the bait, usually dried holothurians (*Holothuria atra*) or pieces of crabs. A small stone, about 1 lb. in weight placed inside the trap serves as sinkers. The traps are taken in a canoe to the fishing ground which may be as far as 275 meters from the shore and placed at depths varying from 3 to 8 feet, in a line parallel to the shore. A wooden float is attached to the tip of the rope to locate the position when the traps are to be taken out. The next day the traps are taken out one by one by pulling the rope and the catches are emptied by unlacing a side of the trap. After replacing the bait and relacing the side the traps are set again and the fishermen return. Once in a fortnight all the traps are taken to the shore, minor damages, if any, are repaired and sun-dried for one or two days for greater durability.

The mode of operation in rocky grounds is quite different. Traps used here are usually of the larger variety with many entrances. The traps are set separately at depths varying from 6 to 8 feet, near rocks without any floats attached to it. The fishing ground may be as far away as about 700 metres from the shore. The baits used are small clupeid fishes, dried holothurians and jelly fishes. The stones (sinkers) will be slightly heavier just to keep the traps immersed in the sea. Every time a trap is to be set and taken up, a fisherman has to dive to the bottom. Catches are removed everyday and the traps are set again at the same place or elsewhere depending on the catch. Though there is no float attached to the traps, fishermen locate the traps with remarkable skill.

Fishing seasons

Fishing along Palk Bay and Gulf of Mannar is seasonal because of the weather conditions at different times. During the period of North-East Monsoon (November to March) Palk Bay becomes rough and choppy and fishing is made difficult. At that time Gulf of Mannar is quite calm and the entire fishing activity is concentrated along the Gulf of Mannar side. The conditions are just reversed during the South-west monsoon (April to October - November) when Palk Bay becomes calm and Gulf of Mannar becomes rough, consequently during this period the fishing activities will be concentrated only along the Palk Bay.

Disposal of the catch

Goatfishes are highly esteemed food fishes and are mostly consumed in the fresh condition. Occasionally when the catch exceeds the local demand, they are sundried along with other small varieties of fishes like sardines and silver-bellies. The process is simple, the fish is kept in salt solution for a day and sundried by spreading on the sandy beach. This method is particularly employed for smaller fishes. After drying, the fish is packed in palmyra leaf baskets and sent to the interior marketing places.

Apart from their importance as food fish,goat fishes are also used as live-baits for tuna fishing in the island of Minicoy (Jones and Kumaran, 1959). The species generally used for this purpose are *M. flavolineatus*, *P. barberinus*, *P. bifasciatus* and *P. macronemus* (Jones, 1964).

Particulars of Catch

Particulars of the total marine fish production in India for the years 1950 to 1965 are given in the Table LXXIII together with the total landings of goatfishes and their percentage in total catch during each year.

TABLE LXXIII

TOTAL MARINE FISH PRODUCTION AND THE PERCENTAGE COMPOSITION OF GOATFISHES DURING THE YEARS 1950 TO 1965

Year	Total landings (tons)	Landing of goatfishes (tons)	Percentage
1950	570,860	1,440	0·25
1951	525,482	1,501	0·30
1952	525,542	1,071	0·21
1953	572,278	1,336	0·20
1954	578,966	1,513	0·26
1955	586,966	1,110	0·19
1956	707,349	10,411	1·47
1957	875,516	3,065	0·35
1958	755,774	2,166	0·28
1959	584,193	1,526	0·26
1960	878,242	2,568	0·29
1961	683,869	2,165	0·32
1962	644,244	1,596	0·25
1963	655,484	2,395	0·37
1964	859,582	5,027	0·58
1965	832,306	2,011	0·24

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PLATES I—VIII

PLATE I

A. First dorsal fin of *Upeneus bensasi* with 7 spines

B. First dorsal fin of *Upeneus tragula* with 8 spines

C. *Upeneus bensasi* (Temminck and Schlegel)


A


B

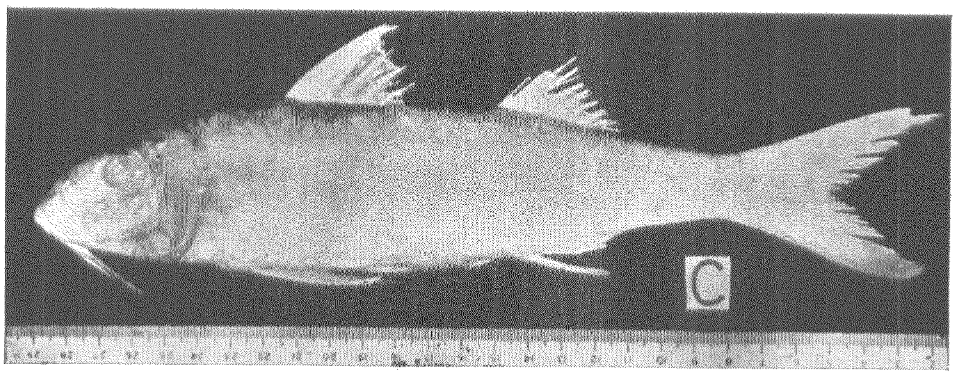
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Plate II

A. *Upeneus sulphureus* Cuvier

B. *Upeneus arge* Jordan and Evermann

C. *Upeneus vittatus* Forskal

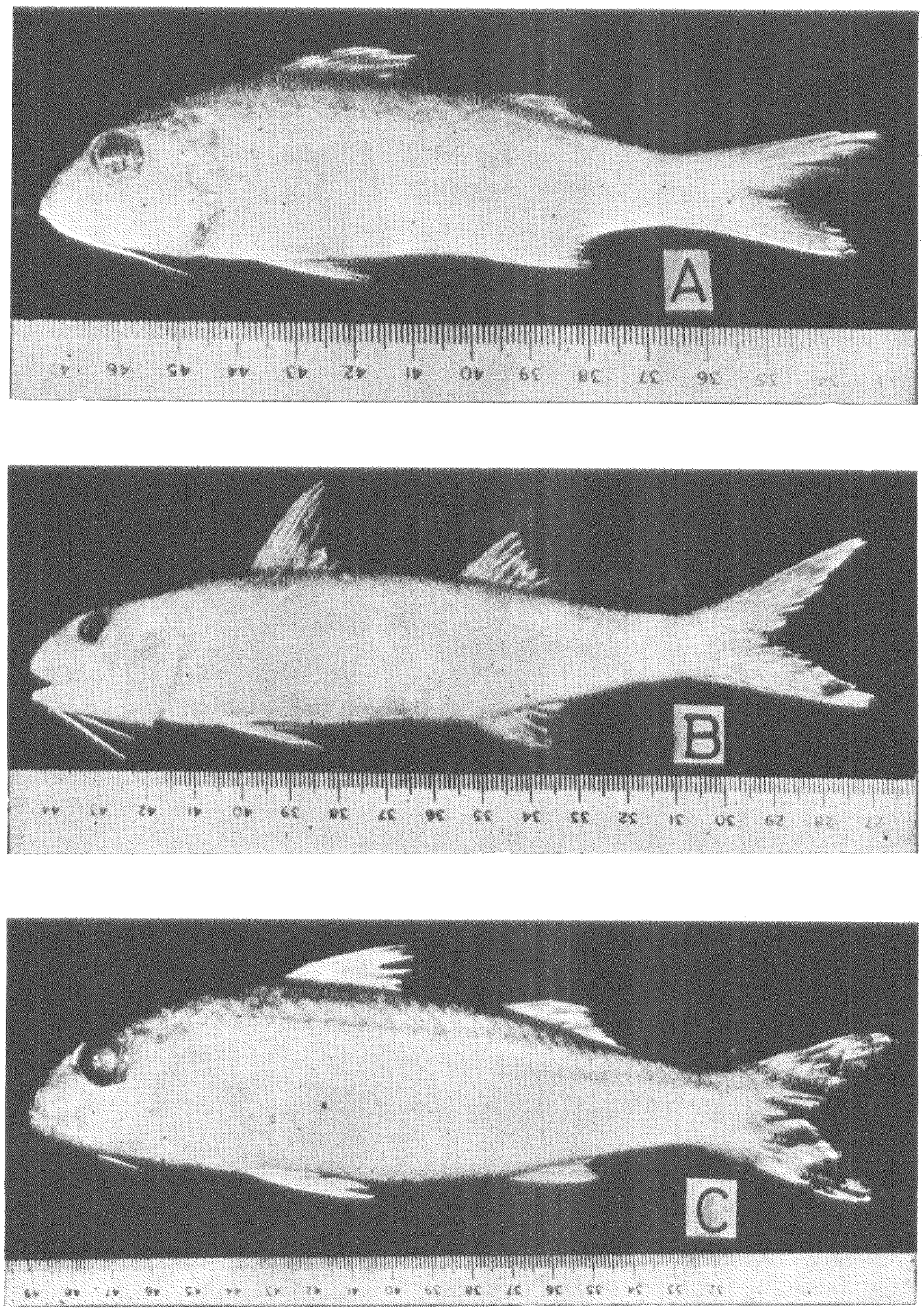
A
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Plate III

A. *Upeneus tragula* Richardson

B. *Upeneus oligospilus* Lachner

C. *Upeneus luzonius* Jordan and Seale

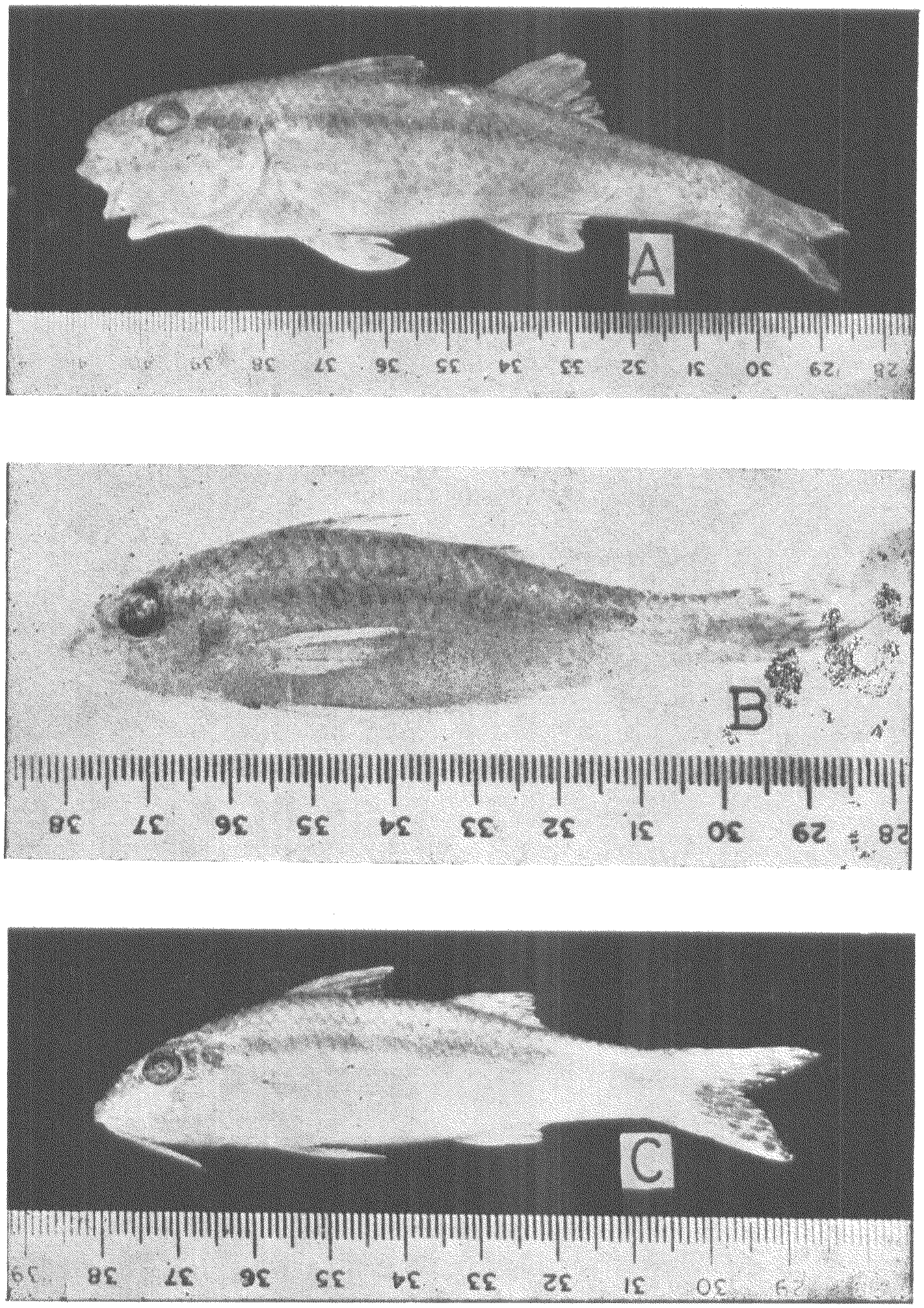
A
B
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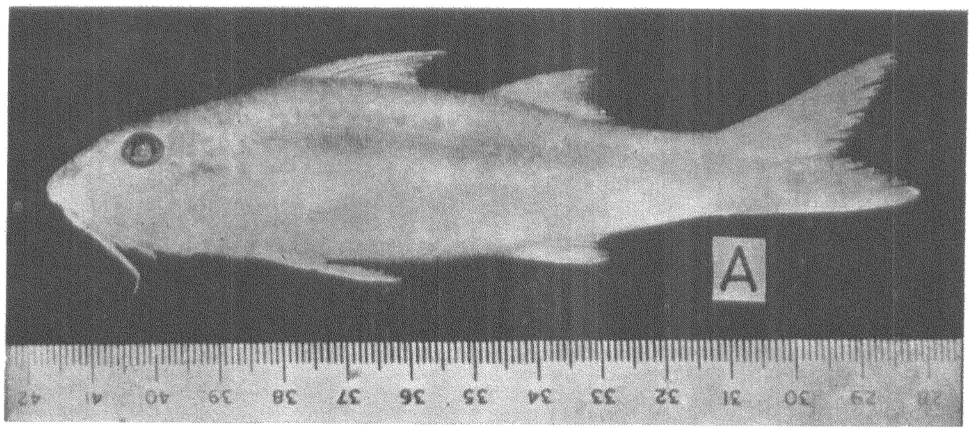
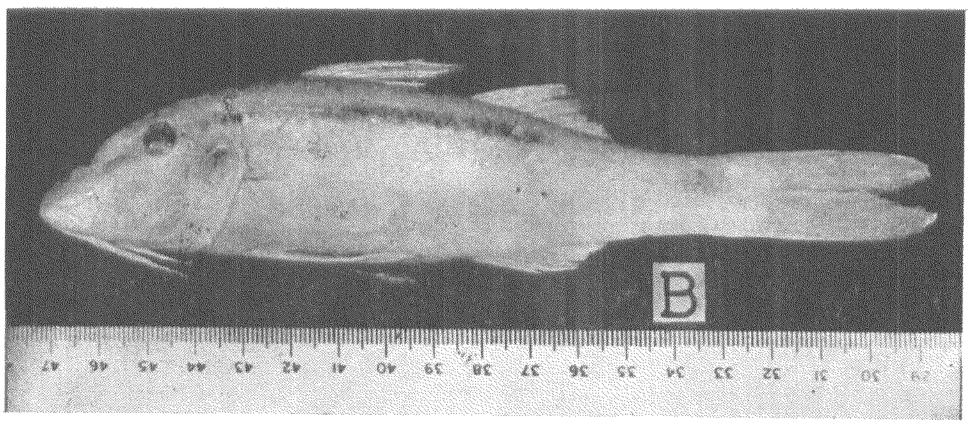
PLATE IV

A.	*Upeneus sundaicus*	(Bleeker)
B.	*Parupeneus barberinus*	(Lacepede)
C.	*Parupeneus macronemus*	(Lacepede)


A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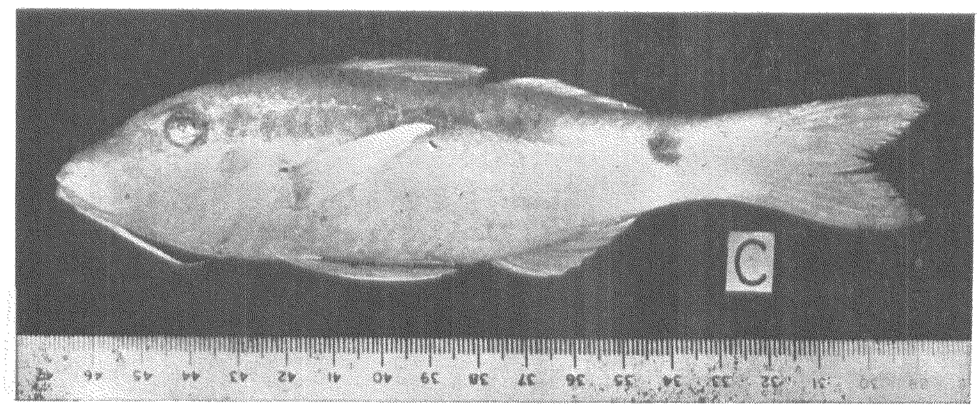
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PLATE V

A. *Parupeneus bifasciatus* (Lacepede)

B. *Parupeneus trifasciatus* (Lacepede)

C. *Parupeneus indicus* (Shaw)

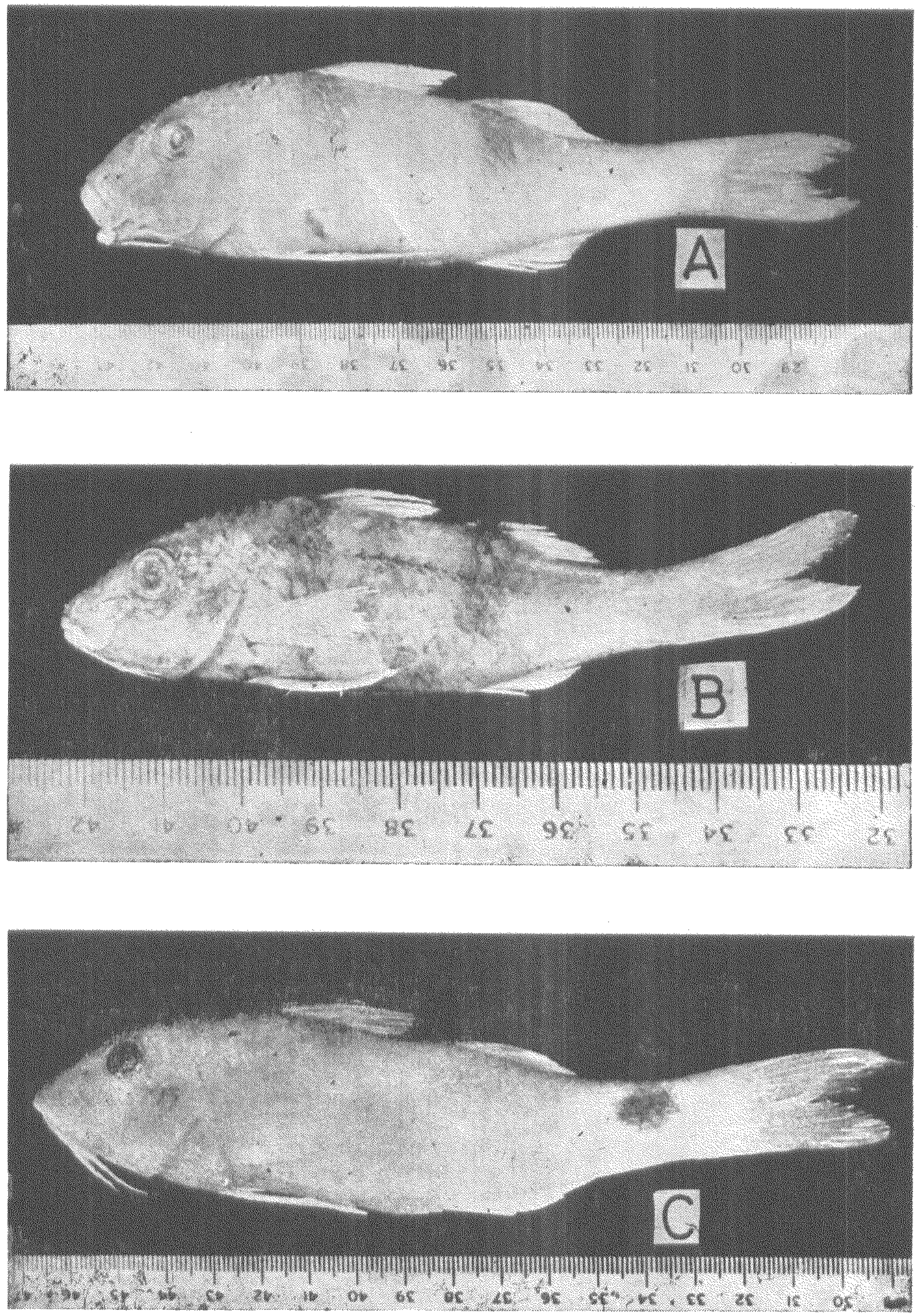

A
B
C

PLATE VI

A. *Parupeneus pleurospilus* (Bleeker)

B. *Parupeneus pleurostigma* (Bennett)

C. *Parupeneus cyclostomus* (Lacepede)

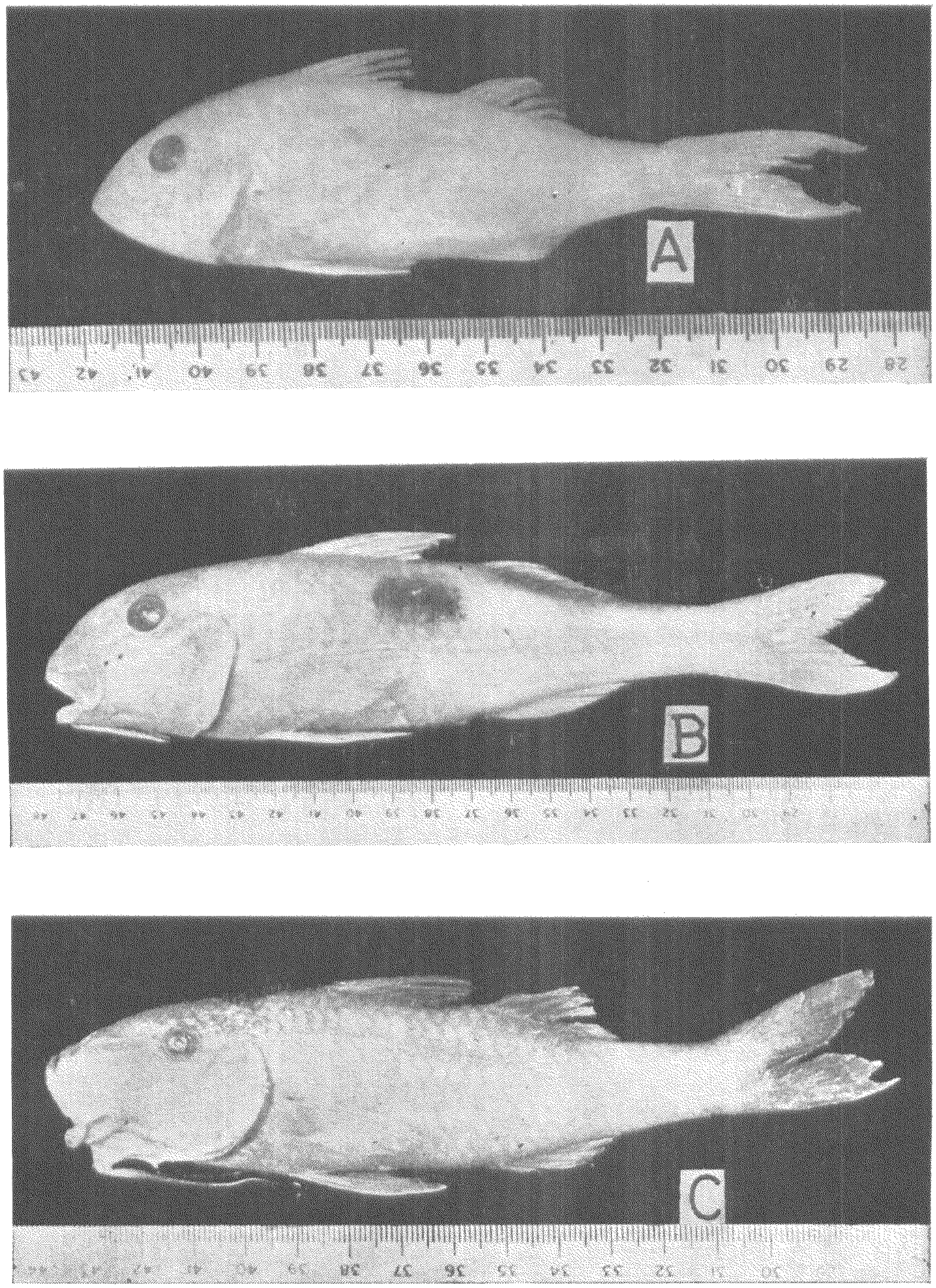
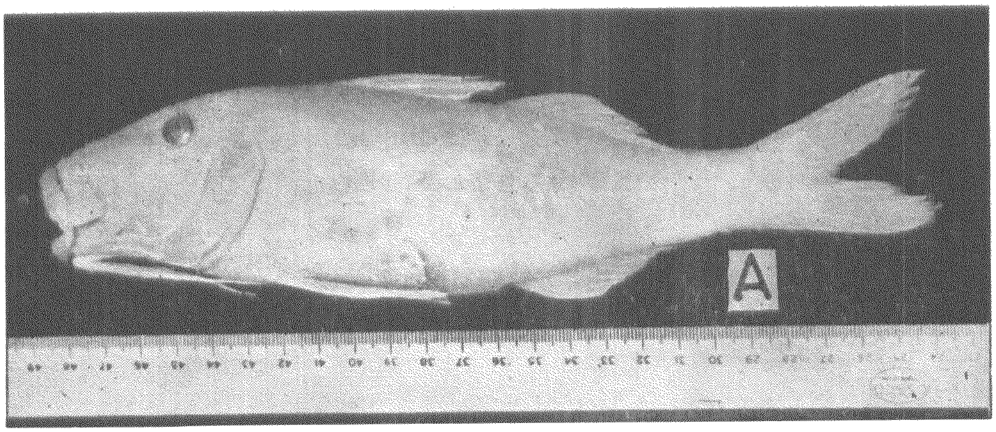

A
B
C

Plate VII

A. *Parupeneus luteus* (Valenciennes)

B. *Mulloidichthys samoensis* (Gunther)

C. *Mulloidichthys flavolineatus* (Lacepede)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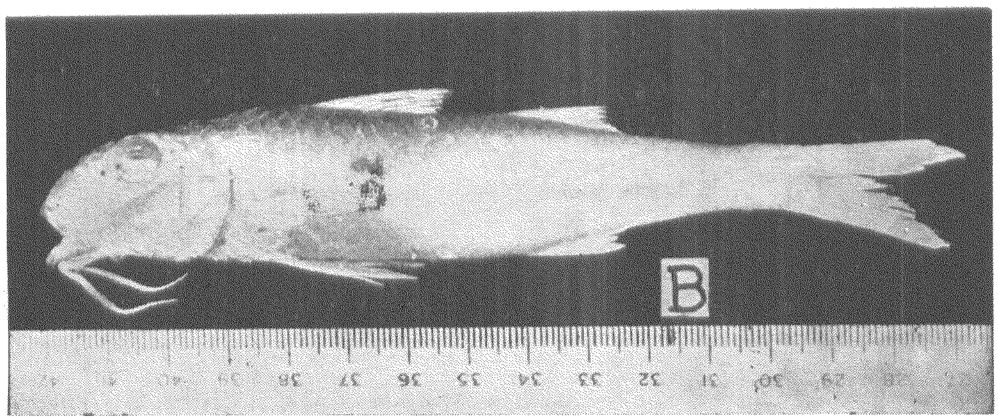
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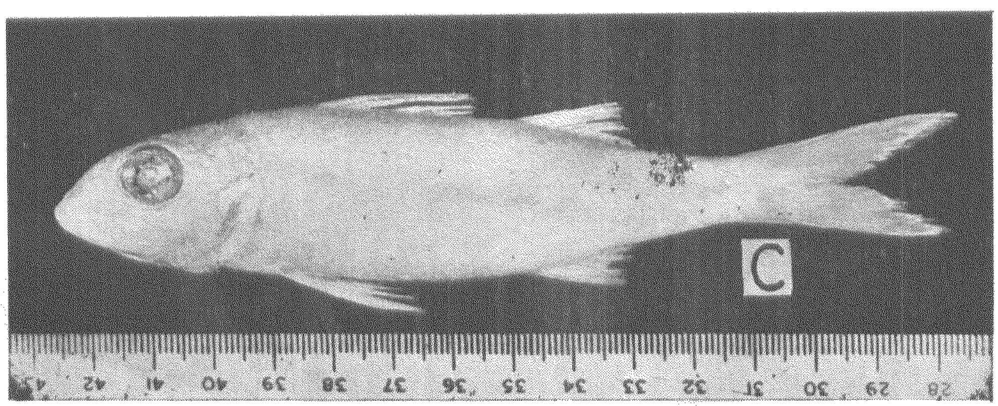
C

PLATE VIII

A. Country craft used in perch fishery along Palk Bay and Gulf of Mannar.

B. & C. 'Olai valai' operations in perch fishery

D to F. Different types of traps used in perch fishery.

PLATE VIII