

An Ichthyological Survey of
the Fly River in Papua New Guinea
with Descriptions of New Species

TYSON R. ROBERTS

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY • NUMBER 281

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ABSTRACT

Roberts, Tyson R. An Ichthyological Survey of the Fly River in Papua New Guinea with Descriptions of New Species. *Smithsonian Contributions to Zoology*, number 281, 72 pages, 39 figures, 1978.—Collections and observations made by the author during a field survey in October–December 1975 provide the basis for an account of distribution, habitats, food habits, reproduction, migratory behavior, and systematics of the Fly ichthyofauna, which comprises 103 species in 33 families. Two anchovies, four catfishes, an atherinid, an apogonid, and three gobies are described as new. Of particular interest among these new forms are an anchovy with unusually numerous gill rakers, a large piscivorous ariid catfish, a specialized montane plotosid catfish, and a distinctive *Pseudomugil*. *Arius digulensis* Hardenberg, 1936, and *Hemipimelodus aaldareni* Hardenberg, 1936, are placed as synonyms of *Arius acrocephalus* Weber, 1913, and *Hemipimelodus macrorhynchus* Weber, 1913. *Arius danielsi* Regan, 1908, is referred to the hitherto monotypic genus *Cochlefelis*, and *Paraphya semi-vestita* Munro, 1949, is referred to *Gobiopterus*. Keys are provided to the species of freshwater Ariidae of southern New Guinea and to the *Glossamia* of New Guinea.

The freshwater ichthyofauna of the Australian Region, typified by that of the Fly, evolved in the absence of the primary freshwater groups of Ostariophysi and non-Ostariophysi that dominate freshwater ichthyofaunas in other continental regions. Among the peculiar features of the Fly ichthyofauna are: the presence of several groups that are absent or poorly represented in riverine ichthyofaunas of other regions, unusually large size of many species, paucity of very small species, endemic montane species in Plotosidae and Clupeidae, stenophagous molluscivorous and carcinophagous ariid catfishes, and a diverse assemblage of forms suspected or known to have catadromous life histories.

The Lorentz and Digul rivers of West Irian, and probably other large rivers in central-southern New Guinea, are inhabited by much the same ichthyofauna as the Fly. Although at least 12 families evolved endemic species in these rivers, there have been no extensive radiations comparable to those undergone by numerous families of primary freshwater fishes in other continental regions.

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Contents

	<i>Page</i>
Introduction	1
The Fly River	3
Fishes of the Fly and Their Distribution	5
Size of Fish Species in the Fly	11
Food Habits	12
Reproduction	15
Catadromous Life Histories	16
Evolution of the Fly Ichthyofauna	19
Evolution of Riverine Ichthyofaunas in Other Continental Regions	20
Collecting Localities of the 1975 Ichthyological Survey	21
Systematic Account of the Fly Ichthyofauna	25
PRISTIDAE	26
<i>Pristis microdon</i> Latham, 1794	26
MEGALOPIDAE	26
<i>Megalops cyprinoides</i> (Broussonet, 1772)	26
MORINGUIDAE	26
<i>Moringua penni</i> Schultz, 1953	26
MURAENIDAE	26
<i>Thyrsoidea macrura</i> (Bleeker, 1854)	26
CLUPEIDAE	26
<i>Clupeoides papuensis</i> (Ramsay and Ogilby, 1887)	26
<i>Clupeoides venulosus</i> Weber and de Beaufort, 1912	26
<i>Herklotsichthys castelnaui</i> (Ogilby, 1897)	27
<i>Nematalosa</i> cf. <i>papuensis</i> (Munro, 1964)	27
ENGRAULIDAE	27
<i>Setipinna papuensis</i> Munro, 1964	27
<i>Stolephorus indicus</i> (van Hasselt, 1823)	27
<i>Stolephorus bataviensis</i> Hardenberg, 1933	28
<i>Thryssa scratchleyi</i> (Ramsay and Ogilby, 1887)	28
<i>Thryssa rastroso</i> , new species	29
<i>Thryssa brevicauda</i> , new species	29
<i>Thryssa spinidens</i> (Jordan and Seale, 1925), new combination	29
<i>Thryssa hamiltoni</i> Gray, 1834	29
OSTEOGLOSSIDAE	30
<i>Sclerophages jardini</i> (Kent, 1892)	30
ARIIDAE	30
Key to Riverine Ariidae of Southern New Guinea	31
<i>Arius leptaspis</i> (Bleeker, 1862)	32
<i>Arius acrocephalus</i> Weber, 1913	32
<i>Arius carinatus</i> Weber, 1913	35
<i>Arius augustus</i> , new species	36
<i>Arius cleptolepis</i> , new species	37
<i>Arius</i> cf. <i>stirlingi</i> Ogilby, 1898	37

	<i>Page</i>
<i>Hemipimelodus crassilabris</i> Ramsay and Ogilby, 1887	38
<i>Hemipimelodus macrorhynchus</i> Weber, 1913	39
<i>Hemipimelodus taylori</i> , new species	40
<i>Cinetodus froggatti</i> (Ramsay and Ogilby, 1887)	41
<i>Nedystoma dayi</i> (Ramsay and Ogilby, 1887)	43
<i>Cochlefelis spatula</i> (Ramsay and Ogilby, 1887)	44
<i>Cochlefelis danielsi</i> (Regan, 1908), new combination	45
PLOTOSIDAE	45
<i>Copidoglanis meraukensis</i> (Weber, 1913)	45
<i>Porochilus obbesi</i> Weber, 1913	45
<i>Tandanus brevidorsalis</i> (Günther, 1867)	45
<i>Tandanus ater</i> (Perugia, 1894)	45
<i>Tandanus equinus</i> (Weber, 1913)	45
<i>Plotosus papuensis</i> Weber, 1910	45
<i>Oloplotosus luteus</i> Gomon and Roberts, new species	47
BELONIDAE	48
<i>Strongylura strongylura</i> (van Hasselt, 1823)	48
<i>Strongylura krefftii</i> (Günther, 1866)	48
HEMIRAMPHIDAE	48
<i>Zenarchopterus dispar</i> (Valenciennes, 1847)	48
<i>Zenarchopterus novaeguineae</i> (Weber, 1913)	48
MELANOTAENIIDAE	48
<i>Melanotaenia nigrans</i> (Richardson, 1843)	48
<i>Melanotaenia</i> cf. <i>vanheurni</i> (Weber and de Beaufort, 1922)	48
<i>Nematocentris rubrostriatus</i> Ramsay and Ogilby, 1887	49
<i>Nematocentris sexlineatus</i> Munro, 1964	49
ATHERINIDAE	50
<i>Craterocephalus randi</i> Nichols and Raven, 1934	50
<i>Iriatherina weneri</i> Meinken, 1974	50
<i>Pseudomugil novaeguineae</i> Weber, 1908	51
<i>Pseudomugil gertrudae</i> Weber, 1911	52
<i>Pseudomugil inconspicuus</i> , new species	53
AMBASSIDAE	54
<i>Ambassis agrammus</i> Günther, 1867	54
<i>Ambassis macleayi</i> (Castelnau, 1878)	54
<i>Ambassis</i> species undetermined	54
<i>Parambassis gulliveri</i> Castelnau, 1878	54
<i>Denariusa bandata</i> Whitley, 1948	55
CENTROPOMIDAE	55
<i>Lates calcarifer</i> (Bloch, 1790)	55
LOBOTIDAE	55
<i>Datnioides quadrifasciatus</i> (Sevastianov, 1809)	55
THERAPONIDAE	55
<i>Therapon fuliginosus</i> Macleay, 1883	55
<i>Therapon habbema</i> Weber, 1910	55
<i>Therapon lorentzi</i> (Weber, 1910)	55
<i>Therapon lacustris</i> Mees and Kailola, 1977	55
<i>Therapon affinis</i> Mees and Kailola, 1977	55

	<i>Page</i>
APOGONIDAE	56
Key to <i>Glossamia</i> of New Guinea	56
<i>Glossamia aprion</i> (Richardson, 1842)	56
<i>Glossamia narindica</i> , new species	57
<i>Glossamia trifasciata</i> (Weber, 1913)	58
<i>Glossamia sandei</i> (Weber, 1908)	58
LUTJANIDAE	59
<i>Lutjanus argentimaculatus</i> (Forskål, 1775)	59
SPARIDAE	59
<i>Acanthopagrus berda</i> (Forskål, 1775)	59
SCIAENIDAE	59
<i>Nibea semifasciata</i> Chu, Lo, and Wu, 1963	59
<i>Larimichthys pamoides</i> (Munro, 1964)	59
TOXOTIDAE	59
<i>Toxotes chatareus</i> (Hamilton-Buchanan, 1822)	59
SCATOPHAGIDAE	59
<i>Scatophagus argus</i> (Linnaeus, 1766)	59
MUGILIDAE	60
<i>Crenimugil heterocheilus</i> (Bleeker, 1855)	60
<i>Liza diadema</i> (Gilchrist and Thompson, 1911)	61
<i>Liza oligolepis</i> (Bleeker, 1859)	61
BLENNIIDAE	61
<i>Omobranchus</i> species undescribed	61
GOBIIDAE	61
<i>Glossogobius giuris</i> (Hamilton-Buchanan, 1822)	61
<i>Glossogobius celebius</i> (Valenciennes, 1837)	63
<i>Gobiopterus semivestitus</i> (Munro, 1949), new combination	64
<i>Gobiopterus</i> species undetermined	64
<i>Oxyurichthys jaarmani</i> Weber, 1913	64
<i>Stenogobius</i> cf. <i>genivittatus</i> (Cuvier and Valenciennes, 1837)	64
<i>Stigmatogobius romeri</i> Weber, 1911	65
Gobiidae genus and species undetermined	65
ELEOTRIDAE	65
<i>Bostrychus strigogenys</i> Nichols, 1937	65
<i>Bunaka herwerdeni</i> (Weber, 1910)	65
<i>Butis butis</i> (Hamilton-Buchanan, 1822)	65
<i>Eleotris fusca</i> (Bloch and Schneider, 1801)	65
<i>Mogurnda mogurnda</i> (Richardson, 1844)	65
<i>Ophiocara porocephalum</i> (Valenciennes, 1837)	65
<i>Oxyeleotris fimbriata</i> (Weber, 1908)	65
<i>Oxyeleotris paucipora</i> , new species	67
<i>Oxyeleotris nullipora</i> , new species	67
A Note on <i>Oxyeleotris</i>	68
<i>Prionobutis microps</i> (Weber, 1908)	68
PERIOPHTHALMIDAE	68
<i>Periophthalmus weberi</i> Eggert, 1935	68
<i>Pseudapocryptes confluentus</i> , new species	68
GOBIOIDIDAE	69

	<i>Page</i>
<i>Brachyamblyopus urolepis</i> (Bleeker, 1852)	69
KURTIDAE	69
<i>Kurtus gulliveri</i> Castelnau, 1878	69
SOLEIDAE	69
<i>Aseraggodes klunzingeri</i> (Weber, 1908)	69
<i>Brachirus villosus</i> (Weber, 1908)	69
CYNOGLOSSIDAE	70
<i>Cynoglossus heterolepis</i> Weber, 1910	70
TETRAODONTIDAE	70
<i>Tetraodon erythrotaenia</i> Bleeker, 1853	70
<i>Sphoeroides pleurostictus</i> (Günther, 1871)	70
Literature Cited	71

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Tyson R. Roberts

Introduction

The Australian Region (Australia, New Guinea, and closely associated islands) is the only continental region with a freshwater ichthyofauna that evolved in the absence of the dominant groups of primary freshwater Ostariophysi. In 1975, as part of the Papua New Guinea Program of the Smithsonian's International Environmental Science Program, the author conducted a comprehensive ichthyological survey of the Fly River, the largest river in the Australian Region. Most kinds of fish habitats in the basin were investigated; information about food habits, reproduction, and migrations was obtained; and extensive samples of fishes were preserved to provide a continuing basis for systematic and ecological studies.

There has been relatively little ichthyological study of the Fly. The earliest collection of fishes from the Fly was made by Froggatt during the Royal Geographical Society Expedition of 1886, from which Ramsay and Ogilby (1887) described the clupeid *Clupeoides papuensis*, the engraulid *Thryssa scratchleyi*, the ariids *Cinetodus froggatti*, *Cochlefelis spatula*, *Nedystoma dayi*, and *Hemipimelodus crassilabris*, and the melanotaeniid *Nematocentris rubrostriatus*. The Archbold Expedition of the American Museum of Natural History to the Fly River in 1936–1937 obtained a small fish collection, including a new eleotrid, *Bostrychus strigogenys*, described by Nichols (1937). Another small collection, made in the Upper

Fly by Stuart Campbell, R.A.F., was reported on by Whitley (1938). Munro (1964) described two new species, *Nematalosa papuensis*, based on previously unreported material from the Royal Geographical Society Expedition of 1886 and *Nematocentris sexlineatus*, collected in the Upper Fly by Campbell in 1937. A reference collection of New Guinea fishes was started at the Fisheries Research Station in Kanudi (Port Moresby) in 1960, and a few fishes were subsequently collected by fisheries personnel on various missions to the Fly River (mainly Lake Murry). Kailola (1975) published a catalog of the entire reference collection, including the first records of *Denariusa bandata* Whitley, 1948, and *Iriatherina wernerii* Meinken, 1974, from the Fly. From 1970 through 1974, L. C. Reynolds, Ray Moore, and other personnel of the Department of Agriculture, Stocks and Fisheries of Papua New Guinea, completed an important study of the Fly population of *Lates calcarifer*; a summary of the results of that work is included in the present paper. The only previous collection of fishes from the Fly highlands was made by the 1974 Cambridge Expedition to the Western District of Papua New Guinea (Boyden, et al., 1975) and is deposited in the Fisheries Research Station, Kanudi (pers. comm., Patricia Kailola).

The most comprehensive systematic account of the freshwater fishes of New Guinea is still that of Weber (1908, 1913a), based almost entirely on material from former Dutch New Guinea (now Indonesian Irian Jaya). A general systematic account of the fishes of New Guinea, marine as well as freshwater, is provided by Munro (1964). Marine and freshwater fishes

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of Arnhem Land, northern Australia, are described by Taylor (1964), and an introduction to the systematics and ecology of Australian freshwater fishes is provided by Lake (1971). Lowe-McConnell (1975) gives a highly informative comparative account of tropical freshwater fish communities exclusive of the Australian Region. Rand and Brass (1940) give a general description of the Fly River and its vegetation, while Walker (1972) discusses biogeographic relationships between New Guinea and Australia and provides background on paleogeography, geomorphology, soils, climatology, and ecology, including an extensive bibliography.

My ichthyological fieldwork on the Fly extended from 17 October through 15 December 1975, with most attention given to the Upper and Middle Fly. From 17 October through 19 November, collections were made in the Upper Fly in the vicinity of Kiunga; in the Elevala, Wai Ketu, and Palmer rivers; and in the Ok Tedi. From 22 November through 7 December, collections were made along the mainstream of the Middle Fly, in the lower part of the Strickland River, and in Lake Murray. From 8 through 15 December, collections were made in the Lower Fly. Gill nets of various sizes and rotenone were employed extensively, seine and hook and line to a minor extent.

REMARKS ON USAGE.—Lengths of fishes, unless indicated otherwise, are standard length. Proportional measurements invariably are expressed as times in standard length. In many instances the number of specimens in which a character has been observed, and in a few cases their standard length, is indicated in parentheses. For example, the statement “free vertebral centra 44–46 (4: 120–450 mm)” indicates that vertebral counts from 44 to 46 excluding hypural elements were found in four specimens from 120 to 450 mm in standard length. Scientific names of all fish species dealt with are presented at least once, either where they first appear in the text or where they are listed in the systematic section, with the name or names of the authority and date of original publication. This information, entered in parentheses if the species is now placed in a genus other than that used by the original authority, is treated as part of the name rather than as a literature citation.

ACKNOWLEDGMENTS.—The Smithsonian Institution provided administrative and financial support for the ichthyological survey of the Fly River and the preparation and publication of the present report. I am

especially indebted to Ira Rubinoff, director of the Smithsonian Tropical Research Institute, for initiation and continued support of the project, and to Rita Jordan and Ross Simons of the Office of the Assistant Secretary for Science for their administrative assistance. I am also indebted to Betty Landrum, director, and Leslie Knapp, supervisor for Vertebrates, of the Smithsonian Oceanographic Sorting Center, for shipping collecting gear to Papua New Guinea and for providing laboratory space and facilities in Washington, D.C.

In Papua New Guinea a helping hand was extended on numerous occasions by fisheries officers of the Department of Agriculture, Stocks and Fisheries (now Ministry for Primary Production), especially Joe Glucksman, acting director of the Fisheries Research Station, Kanudi (Port Moresby), and Ray Moore, stationed at Daru, who helped organize the fieldwork and provided much information cited in the present paper. Throughout the fieldwork on the Fly, I was most ably and companionably assisted by Gao Warapa, Kaiang Baira, and Megom Tom of Sigabadaru village, who joined me in Daru. Through the good offices of Hugh Davis, Geological Survey Department (Port Moresby), I was invited to use a helicopter maintained by the Ok Tedi Copper Development Project to survey fishes in the Ok Tedi (Upper Fly); this work was facilitated by John Bovard and Zane White, managers of the Ok Tedi Project, and Roger Dundas and Mal Smith, helicopter pilots. The work at Kiunga was facilitated by Assistant District Commissioner Greg McGrath and Patrol Officer Jeff Ransley, and at Lake Murray by Keith Dennis and Acting Assistant District Commissioner Bob Diamond.

On the return trip from Papua New Guinea to the United States, I visited the Rijksmuseum van Natuurlijke Historie in Leiden, the Zoological Museum in Amsterdam, and the British Museum (Natural History). For facilitating my examination of types and other material of fishes from New Guinea at these institutions, it is a pleasure to thank M. Boeseman, Han Nijssen, P. Humphry Greenwood, and Gordon Howes. For arranging the loan of type specimens of Ariidae I am indebted to M. Boeseman, Rijksmuseum van Natuurlijke Historie, Leiden; Han Nijssen, Zoological Museum, Amsterdam; John Paxton, Australian Museum, Sydney; Robert K. Johnson, Field Museum of Natural History; and Donn E. Rosen, American Museum of Natural History. The following colleagues

have provided identifications of species or comments on groups with which they are familiar: Peter J. Whitehead and Thosaporn Wongratana (Clupeidae, Engraulidae), W. Ralph Taylor (Ariidae, Plotosidae), Norma M. Feinberg (Plotosidae), Bruce B. Collette (Belonidae), Walter Ivantsoff (*Craterocephalus*), Patricia Kailola and G. F. Mees (Theraponidae), Ernest M. Lachner (Apogonidae, Gobiidae), Frank Talbot (*Lutjanus argentimaculatus*), Gerald R. Allen (*Toxotes chatareus*), Tom Fraser (*Acanthopagrus berda*), Ethelwynn Trewavas (*Nibeia semifasciata*), J. M. Thomson (*Crenimugil heterocheilus*), Victor G. Springer (Blenniidae, Periophthalmidae), Frank McKinney and H. Adair Fehlmann (Gobiidae, Eleotridae), Ruth Turner and William Clench (molluscs), and Fenner A. Chace, Jr., and Horton H. Hobbs, Jr. (crustaceans). Janet Gomon helped compare my specimens of *Plotosus papuensis* with the type series and coauthored the description of *Oloplotosus luteus*, new species.

In working up my material from the Fly I have come to appreciate the pioneering studies of New Guinea freshwater fishes by Max Weber. In determining the species status of fishes in the Fly I have been guided by the biological species concept advocated by Ernst Mayr (see Mayr, 1963). It is a pleasure to note that the early field experience that played an important role in shaping Prof. Mayr's ideas on species was gained in New Guinea.

Most of the photographic illustrations were prepared by Alphonse Coleman in the photographic laboratory of the Museum of Comparative Zoology, Harvard University. The photographs reproduced as Figures 30 and 39 were taken by Stanley H. Weitzman. I wish to thank A. E. Crompton, director of the Museum of Comparative Zoology, for permission to use this facility.

Rosemary Lowe-McConnell and Victor G. Springer reviewed the manuscript.

The Fly River

The Fly arises at 5°S in the heavily forested central highlands of New Guinea, where annual rainfall averages 400 inches, and flows southward to the Gulf of Papua. In volume of water it is exceeded among other rivers perhaps only by the Amazon and Congo. Extensive highland and lowland areas drained by the Fly include the variety of aquatic habitats—includ-

ing torrential streams, large high gradient rivers, gently flowing forest brooks, shallow lakes, vast inland swamps, and huge lowland rivers—associated with the largest tropical rivers in other continental regions.

The Fly drainage network is illustrated in Figure 1. For practical reasons, the 1975 survey was conducted in the more accessible western half of the drainage. All kinds of habitats present in the basin were sampled, with the exception of high altitude mountain streams and large mountain tributaries of the Upper Strickland or Lagaip, which have yet to be ichthyologically explored. The distribution of collecting localities is indicated in Figure 2. More effort was expended on the Upper and Middle Fly than on the Lower Fly. This was partly intentional, but more would have been done on the Lower Fly had it not been for the onset of monsoon weather, which made travel hazardous and collecting difficult.

Daytime water temperature ranged from 21.7° C in the highest mountain streams sampled, at 800 m elevation, to 31.7° C in lakes and lowland tributaries of the Middle Fly. Fly mainstream temperature ranged from 25.0° C to 30.6° C. The pH ranged from 8.5 in mountain tributaries to 6.0 in lowland tributaries. Fly mainstream pH ranged from 6.9 to 8.0. Many species of tropical freshwater fishes characteristically inhabit highly acidic, black waters, with pH from 5.5 to 3.8. Visibility in such waters varies but is usually less than 1 m and is sometimes less than 30 cm. Comparable habitats apparently do not occur in the Fly basin. Although much of the water in the Middle and Lower Fly is black or blackish and slightly acid, visibilities of at least 1 m prevail, and pH below 6 was not encountered.

The westward-flowing Upper Fly, while itself only 100 km long and lying below 30 m elevation, receives several large mountain tributaries, including the Ok Tedi or Alice and the Wai Pinyang. Its waters are generally turbid. The only lakes in the Upper Fly are ox-bow lakes. The entire area drained by the Upper Fly receives annual rainfall in excess of 180 inches. Mosquitoes are rare or absent, even in areas below 30 m elevation, at least during the months of October–November. At D'Alberty Junction the Fly receives the Ok Tedi, the last of its mountain tributaries, and takes a southward course. The excessively meandering Middle Fly begins at D'Alberty Junction and flows nearly 400 km to Elevala Junction, where the Fly is joined by the mighty Strickland. Middle

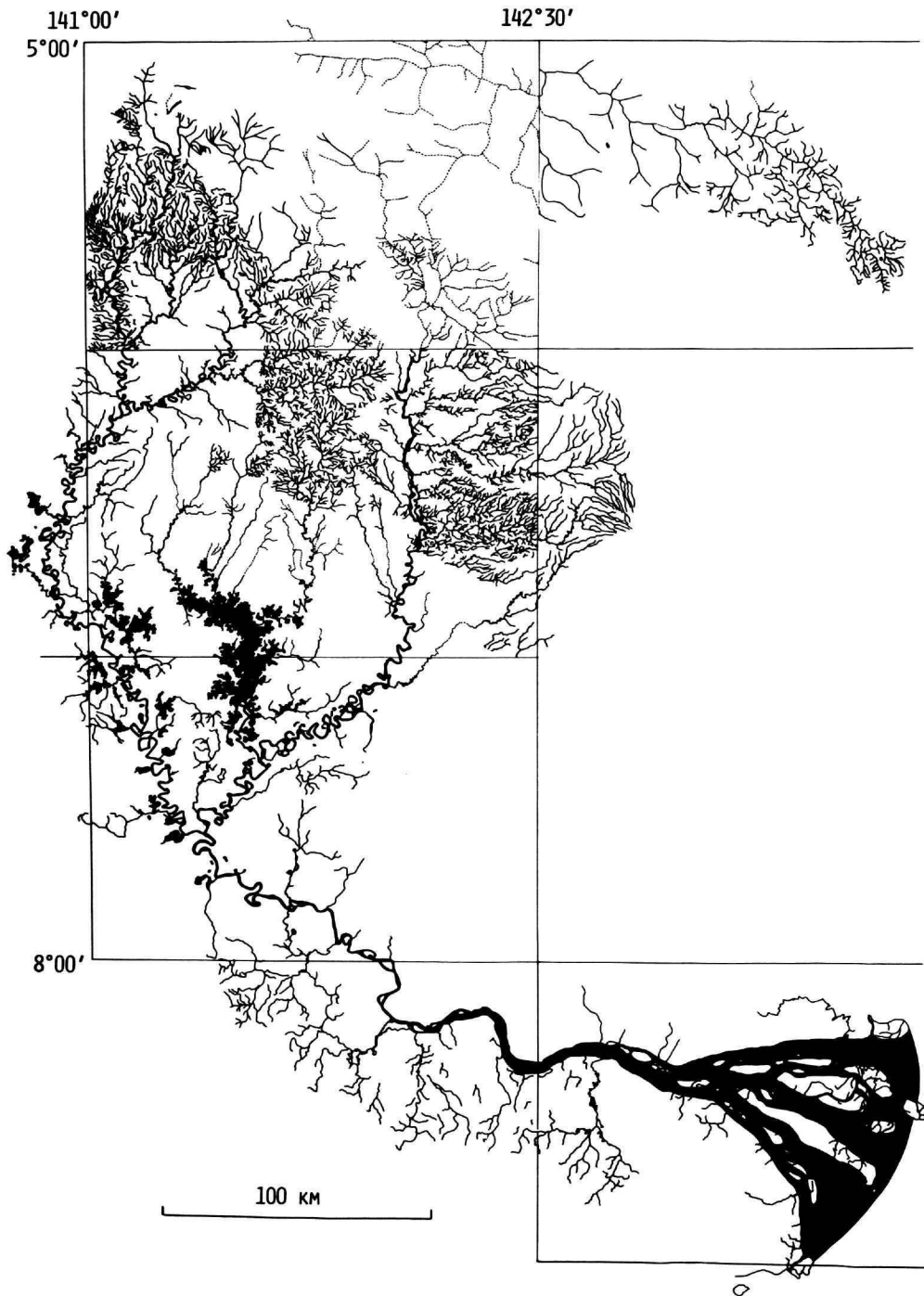


FIGURE 1.—Drainage network of the Fly basin.

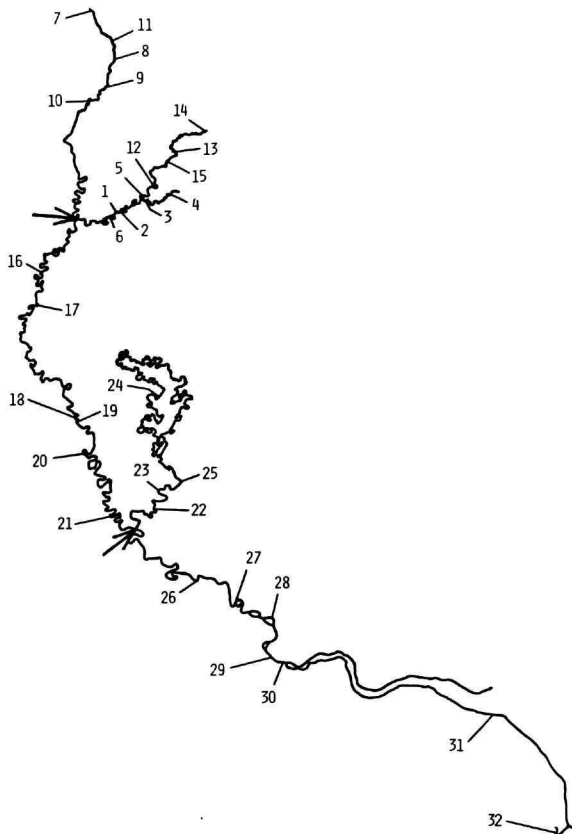


FIGURE 2.—Distribution of collecting localities of the 1975 ichthyological survey of the Fly. Arrows indicate divisions into Upper, Middle, and Lower Fly.

Fly waters are relatively clear and blackish. There are numerous lagoons, extensive swamps, and shallow, dendritic lakes, the shores or margins of which are almost invariably densely vegetated with aquatic and semiaquatic higher plants. The area occupied by the Middle Fly receives an annual rainfall of from 100 to 200 inches. The Middle Fly receives several large lowland tributaries, the largest of which is the Agu. The Lower Fly, its turbidity greatly increased by the muddy Strickland water, flows nearly 400 km southeastward into the Gulf of Papua. For the last 200 km it increasingly widens into a huge delta studded with large, low islands, until at the actual mouth it is 90 km wide. Rainfall in the area occupied by the Lower Fly is less than 100 inches annually. The Lower Fly has no major tributaries, and almost no lagoons or lakes. Aquatic vegetation in the upper half of the Lower Fly mainstream resembles that of

the Middle Fly, but for most of the last 200 km of the Fly aquatic plants are not a significant feature of fish habitats. Long stretches of the shore are littered with uprooted palms and other trees displaced by tidal bores that regularly affect the lowermost 200 km of the Fly. Tidally induced fluctuations in river level, an important factor in fish ecology, are felt only up to 250 km from the mouth and are thus confined to the Lower Fly. Mosquitoes are abundant throughout the year in the entire area occupied by the Middle and Lower Fly.

The area occupied by the Upper and Middle Fly has heavy year-round rainfall, but about 20 percent less rain falls during the period September–December than at other times. The driest months are usually October and November. At any time of year, however, it is rare for more than a few days to pass without a moderately heavy rainfall at highlands localities. During the 1975 ichthyological survey, the months of October and November were unusually rainy in the Upper Fly; the Fly mainstream, although it fluctuated by 6–8 m, remained high for this time of year. According to Greg McGrath and other informants at Kiunga, 1972 was an exceptionally dry year: with almost no rain in October–November, the Fly became so low that it was possible to wade across it. Exceptionally dry years are said to have preceded 1972 at two seven-year intervals, i.e., in 1965 and 1958. According to informants at Boset, Lake Herbert Hoover dried up in 1965. On the whole, however, the Fly is to be classed with the relatively stable “reservoir” rivers that usually drain extensive areas covered by rain forest rather than with the wildly fluctuating flood-plain rivers typically found in savannah areas with heavy rainfall and pronounced dry season.

Fishes of the Fly and Their Distribution

As a result of the 1975 survey, 103 fish species are known to inhabit the Fly; about half of them have not been recorded previously from the Fly. Seventeen species are known only from the Fly basin, including 11 new species described in the present paper, and 30 more are known only from the Fly and one or more other of the large rivers in central-southern New Guinea. Although fishes in this part of the world are still poorly known, the available information indicates that the fishes of the Fly are

representative of a largely endemic ichthyofauna that is richest and most uniformly distributed in the larger rivers of central-southern New Guinea, including the Lorentz and Digul in Irian Jaya, and the Aramia-Bamu, Turama, Kikori, and Purari in Papua New Guinea. A portion of this ichthyofauna is also present in northern Australia.

During sea level minima in the Pliocene and Pleistocene, New Guinea and Australia were joined by land where there is now shallow sea (Doutch, 1972). The rivers of central-southern New Guinea were then united into a few very large drainages, which included much of northern Australia. At least 11 species found in the Fly are shared exclusively by rivers of central-southern New Guinea and northern Australia, which previously formed a single drainage: *Scleropages jardini*, *Porochilus obbesi*, *Melanotaenia nigrans*, *Nematocentris rubrostriatus*, *Pseudomugil gertrudae*, *Ambassis macleayi*, *Parambassis gulliveri*, *Denariusa bandata*, *Bunaka herwerdeni*, *Kurtus gulliveri*, and *Aseraggodes klunzingeri*. *Toxotes lorentzi*, not known from the Fly, has an otherwise identical distribution. Eight genera apparently are confined to this ancient drainage area: *Cinetodus*, *Tetransodon*, *Nedystoma*, *Cochlefelis*, *Porochilus*, *Oloplotosus*, *Iriatherina*, and *Denariusa*. *Parambassis* and *Glossamia* extend beyond the area but also may have evolved within it. All families in the riverine ichthyofauna of central-southern New Guinea except *Melanotaeniidae* range beyond the Australian Region. About one-fourth of the species in the Fly are more or less widely distributed in the western Pacific and Indian oceans.

The Sepik River, one of the two largest rivers in northern New Guinea, and almost as large as the Fly, originates on the opposite slope of the Fly watershed. The poorly known Sepik ichthyofauna, perhaps not so rich as that of the Fly, includes many species endemic to northern New Guinea, some of them known only from the Sepik. I have examined most Sepik species of Ariidae to determine whether they are identical or closely related to Fly Ariidae. The specialized *Brustiarius nox* (Herre, 1935), known only from the Sepik, with upper jaw and anterior portion of cranium extremely thin and first gill arch bearing 59–61 gill rakers, does not seem closely related to any Fly ariid. It is evidently close to *Arius kanganamensis* Herre, 1935, also known only from the Sepik, with upper jaw and anterior portion of cranium almost

as thin as in *B. nox* but first gill arch with only 26 gill rakers. The only ariid shared by the Fly and the Sepik is evidently *Arius leptaspis* (Sepik material of which I have not examined).

Torrential streams in the rugged mountainous area of the Upper Fly drainage are inhabited by *Tandanus equinus*, a plotosid restricted to montane habitat of rivers in central-southern New Guinea, and a montane ecotype of the widely distributed and highly variable goby, *Glossogobius giuris*. *Anguilla* may also occur in such habitats, but have not been positively recorded from the Fly basin. In small but less torrential mountain streams, in addition to *Tandanus equinus* and *Glossogobius giuris*, are found *Melanotaenia* cf. *vanheurni*, *Nematocentris rubrostriatus*, and *Glossogobius celebius*. If the stream is gently flowing and very small, *Tandanus equinus* drops out. In progressively larger mountain streams the species complement is augmented by *Craterocephalus randi*, *Mogurnda mogurnda*, *Therapon habbema* and *T. fuliginosus*, *Glossamia sandei* and *G. trifasciata*, *Zenarchopterus novaeguineae*, and finally *Clupeoides venulosus*, *Arius acrocephalus*, *Crenimugil heterocheilus*, and *Parambassis gulliveri*. Of particular interest are the montane endemics *Clupeoides venulosus*, the only member of the worldwide family Clupeidae known from a mountain habitat, and *Oloplotosus luteus*, a microphthalmic and otherwise highly modified rupicolous plotosid. *Tandanus equinus*, *Oloplotosus luteus*, and the montane ecotype of *Glossogobius giuris* exhibit obvious morphological adaptations to the montane habitat, including modifications of fins and reduction of eyes, which distinguish them from their closest lowland relatives. Most of the other species mentioned above exhibit little or no apparent morphological differentiation from lowland populations of the same or closely related species.

It is a worldwide phenomenon that within a given drainage highland tributaries generally have poorer ichthyofaunas than lowland tributaries of the same size. This is due to a multiplicity of causes, acting variably on different groups, among which are the following: (1) waterfalls of sufficient magnitude to impede upstream movements of colonizers; (2) reduction of temperature; (3) regular or irregular catastrophic reduction of water level during the dry season or drought; (4) catastrophic conditions of excessive turbidity and streambed scouring, either perpetually or rarely, but sufficient to eliminate at



FIGURE 3.—Highlands habitats in the Fly: *a*, Ok Tedi mainstream a few km above Tabubil; *b*, Ok Tedi side channel, Fly 75-11 (type-locality of *Oloplotosus luteus*); *c*, portion of braided stream channel of Ok Tedi midway between Tabubil and Ningerum; *d*, Ok Tedi mainstream 7 km upstream from Ningerum, near Fly 75-10.

least some kinds of fishes; (5) decrease in the variety of food available; (6) decrease in structural diversity and habitats; and (7) elimination of distinct water levels or strata available as separate living spaces for fishes.

Highlands tributaries in the Fly basin do have fewer fish species than tributaries of comparable size in the lowlands. The mainstream of the highlands Ok Tedi is inhabited by 16 species, that of the lowlands Wai Ketu by at least 21. Lowland tributaries equivalent in size to highland tributaries with only 2 species are inhabited by 12 or 13 species. Of the causes for decrease in highlands diversity indicated above, numbers 1-3 probably do not play an important role in the present instances. There are no waterfalls in the Ok Tedi and the highlands tributaries surveyed that would prevent upstream movements of fishes. The elevations involved are relatively low, only up to

800 m, and the lowest water temperature encountered was 21.7° C. Rainfall is high throughout the year, and a period of two weeks without rain is highly exceptional.

Turbidity of the Ok Tedi and its tributaries increases dramatically when a heavy downpour follows a few rainless days, and many lowlands fishes might not be able to adjust. The presence of a clupeid in these tributaries is remarkable. In some mountain rivers in New Guinea the streambed might be subject to such intense scouring that no fishes could survive, but in the highlands portions of the Fly surveyed, less extreme conditions prevail.

The variety of food available in the highlands is clearly less than in the lowlands. Terrestrial plants and terrestrial and aquatic insects appear to be by far the most important sources of food in the highlands. Prawns and molluscs may also be significant,

but there are fewer kinds of molluscs present, and perhaps also fewer prawns. Higher aquatic plants, rooted as well as floating, and the food organisms associated with them are virtually absent. Plankton is apparently eliminated as a significant source of fish food. Planktonic organisms were not encountered among the stomach contents of any of the highlands fishes. Whereas the lowlands *Clupeoides papuensis* is at least partly planktophagous, the highlands *C. venulosus* feeds on small aquatic insects.

There is an evident decrease of structural diversity in highlands habitats. Rooted and floating aquatic plants, providing important food sources, shelter, and perhaps substrate for egg deposition for lowlands fishes, are no longer important. Overhanging banks with masses of tree roots suspended in the water are absent. Fallen trees, an important part of habitats in lowland tributaries of all sizes, appear to be relatively unimportant to highlands fishes because they are too readily scoured, moved, and broken up. Hollowed tree trunks with rough surfaces, cracks, and branches providing cover and feeding substrate for lowlands fishes do not exist in the highlands.

Lowlands tributaries generally offer three distinct water levels or strata utilizable by fishes: bottom, midwater, and surface. In swift-flowing highlands tributaries the midwater and surface strata are probably of greatly reduced importance to most fishes, either as separate habitats or as significant sites for feeding or reproduction. The highlands ichthyofauna is composed predominantly of bottom-dwellers. *Zenarchopterus novaeguineae*, the only surface-dweller in the Fly highlands, occurs in situations where the current is reduced; it feeds on terrestrial insects including ants, which it presumably obtains at the surface while patrolling stream margins with reduced current. In the lowlands many species will rise to the surface to feed on a floating terrestrial insect while it is struggling, but terrestrial insects falling into swift highlands tributaries presumably become available to fishes such as *Tandanus equinus*, which feeds heavily on them, only after they have drowned and settled to the bottom stratum.

The decrease in number of fish species in the Fly highlands is accompanied by a regression in size of adults toward the mean for fish species inhabiting the Fly drainage as a whole. Only two (12.5%) of the fish species in the Fly highlands attain 300 mm, versus 29 (45%) of the species in the lowland portions of

the Upper and Middle Fly. The smallest fish species in the highlands attain at least 70 mm, whereas 8 (12.5%) of the species in the lowlands of the Upper and Middle Fly fail to attain 40 mm. Two major categories of large species of lowlands fishes are entirely or almost entirely absent from the highlands: members of the family Ariidae, and large piscivores, including *Thryssa scratchleyi*, *Strongylura krefftii*, *Lates calcarifer*, *Lutjanus argentimaculatus*, and *Bunaka herwerdeni*. The largest piscivore in the Fly highlands is *Parambassis gulliveri*, which does not attain 300 mm.

Small lowland tributaries of the Upper Fly are usually inhabited by *Melanotaenia nigrans* and *Nematocentris rubrostriatus*, *Craterocephalus randi*, *Zenarchopterus novaeguineae*, young *Therapon habbemai*, *Glossamia trifasciata*, *Glossogobius giuris*, and *G. celebius*. Several additional species, while not so common, frequently occur in such habitats, including *Tandanus ater*, young *Plotosus papuensis*, *Pseudomugil novaeguineae*, *Glossamia aprion* and *G. sandei*, young *Bunaka herwerdeni*, *Oxyeleotris fimbriata* and *O. paucipora*, and *Brachirus villosus*. The lower ends and deep mouths of small tributaries flowing into the Upper Fly and its major lowland tributaries appear to be favored sites for a number of species, including *Plotosus papuensis*, *Datnioides quadrifasciatus*, adult *Therapon habbemai*, *Acanthopagrus berda*, and *Toxotes chatareus*. Other species in the Upper Fly apparently stay in the mainstream of the larger lowland tributaries and of the Fly itself (including ox-bow lakes open to the Fly mainstream). Among such species are the extremely abundant *Clupeoides papuensis*, *Nematalosa* cf. *papuensis*, *Thryssa scratchleyi*, several ariid catfishes, *Strongylura krefftii*, *Lates calcarifer*, and *Nibea semifasciata*. In the lowlands as well as in the highlands there is a marked tendency for plotosids to enter smaller tributaries than ariids.

Several species are common in lowland as well as highland habitats of the Upper Fly but apparently absent from the Middle and Lower Fly: *Arius acrocephalus*, *Glossamia trifasciata*, *G. sandei*, *Therapon habbemai*, *T. fuliginosus*, *Glossogobius celebius*. Perhaps reproductive success of these species in nearby montane habitats is necessary for their continued presence in the lowlands. *Arius acrocephalus* is the only ariid in the highlands and is perhaps the most abundant ariid in lowland habitats of the Upper Fly.



FIGURE 4.—Lowlands habitats in the Fly: *a*, Fly mainstream at Kiunga, Fly 75-1; *b*, Wai Ketu, Fly 75-4; *c*, swampy backwater (foreground) and lagoon of lower Kanggu River, Fly 75-16; *d*, Lake Murray about 4 km N of Pangoa, Fly 75-24 (type-locality of *Glossamia narindica*).

Young were taken at three highlands localities, but only large adults in the lowlands. Possibly this species undertakes reproductive migrations into the highlands. The other species mentioned reproduce in the lowlands as well as in the highlands, but may receive substantial recruitment from upstream populations.

The large, sluggish tributaries, heavily vegetated lagoons, and shallow dendritic lakes of the Middle Fly provide habitats not encountered in the Upper or in the Lower Fly, and these are favored habitats for a number of species, including *Copidoglanis meraukensis*, *Porochilus obbesi*, *Iriatherina wernerii*, *Denarius bandata*, *Therapon lacustris*, *T. affinis*, *Liza diadema*, and *Oxyeleotris nullipora*. A number of large fishes that are rare or absent in the Upper Fly are relatively abundant in the mainstream of the Middle Fly and its large tributaries, including *Pristis microdon*, *Megalops cyprinoides*, *Arius carinatus*, *A.*

augustus, *Cinetodus froggatti*, *Cochlefelis danielsi*, and *Nibeia semifasciata*.

The large, dendritic lakes of the Middle Fly do not offer any fish habitats different from those of numerous heavily vegetated lagoons along the Middle Fly mainstream and the broad mouths of large, slow-flowing tributaries such as the Agu. None of the fish species in the Fly basin are restricted to the lakes, although several may be nearly restricted to lacustrine and semi-lacustrine habitats. The swampy backwater and lagoon of the lower Kanggu River at Fly 75-16 (Figure 4*c*) and lagoons open to the Middle Fly mainstream at Fly 75-20 and -21 seemed to provide habitats identical to those offered by the heavily vegetated lagoons and narrow arms of lakes Herbert Hoover and Murray, and they were inhabited by much the same fish species. Open waters of large lakes appear to be utilized by fewer species than open

waters of large rivers in the Middle Fly. Species encountered in the open lake waters were *Pristis microdon*, *Megalops cyprinoides*, *Nematalosa* cf. *papuensis*, *Arius leptaspis*, *A. cleptolepis*, *Tandanus ater*, and *Lates calcarifer*. The apparent absence of *Clupeoides papuensis* (perhaps overlooked) and of either *Thryssa scratchleyi* and *T. rastrosa* (less likely to have been overlooked) is particularly noteworthy. It would appear that the open waters are not utilized by any of the smaller species in the Fly. The apparent absence of the malacophagous *Cinetodus froggatti* is also noteworthy, since the lakes have large snail populations.

The Lower Fly is ichthyologically less well known than the Upper and Middle Fly. Some of the commonest species in lowland portions of the Upper and Middle Fly have not been found in the Lower Fly, including *Craterocephalus randi*, *Melanotaenia nigrans*, *Nematocentris rubrostriatus*, *Bunaka herwerdeni*, and *Oxyeleotris fimbriata*. A possible explanation for the absence of the latter two eleotrids in the Lower Fly is the presence there of many gobioids that do not occur farther upriver. The Fly provides many examples of apparent serial or linear replacement of fish species by more or less closely related forms. Some of these may be indicated here:

UPSTREAM	DOWNSTREAM
<i>Clupeoides venulosus</i>	<i>Clupeoides papuensis</i>
<i>Arius acrocephalus</i>	<i>Arius leptaspis</i> , other ariids
<i>Tandanus equinus</i>	<i>Tandanus ater</i>
<i>Plotosus papuensis</i>	<i>Plotosus canius</i> (estuarine)
<i>Strongylura krefftii</i>	<i>Strongylura strongylura</i> (estuarine)
<i>Zenarchopterus novaeguineae</i>	<i>Zenarchopterus dispar</i> (estuarine)
<i>Ambassis agrammus</i>	<i>Ambassis</i> sp. undet.
<i>Pseudomugil novaeguineae</i> ,	<i>Pseudomugil inconspicuus</i>
<i>P. gertrudae</i>	<i>Therapon lacustris</i> , <i>T. affinis</i>
<i>Therapon habbema</i> ,	<i>Glossamia aprion</i>
<i>T. fuliginosus</i>	lowland ecotype of
<i>Glossamia trifasciata</i> ,	<i>Glossogobius giuris</i>
<i>G. sandei</i>	<i>Gobiopterus semivestitus</i> (estuarine)
<i>Glossogobius celebius</i>	<i>Oxyeleotris nullipora</i>
<i>Gobiopterus</i> sp. undet.	<i>Eleotris fusca</i> ,
<i>Oxyeleotris paucipora</i>	<i>Ophiocara porocephalum</i> ,
<i>Oxyeleotris fimbriata</i> ,	<i>Prionobutis microps</i>
<i>Bunaka herwerdeni</i> ,	<i>Aseraggodes klunzingeri</i>
<i>Mogurnda mogurnda</i>	
<i>Brachirus villosus</i>	

An interesting example of disjunct distribution within the Fly is provided by *Zenarchopterus novaeguineae*.

This readily observable species is common in the Upper Fly, in highland as well as lowland habitats, and was obtained at two localities in the Lower Fly, but was not collected or observed anywhere in the Middle Fly. It is apparently restricted to habitats with forest cover along the margins. In much of the Middle Fly, forest is absent or poorly developed; the margins of the lakes, lagoons, and rivers are usually densely covered by floating vegetation, often predominantly herbaceous. *Zenarchopterus novaeguineae* was not observed in such habitats, perhaps because they do not provide an adequate supply of the terrestrial insects upon which it feeds. Habitats in the Lower Fly where the species was collected or observed had forested margins.

A number of fishes in the Lower Fly have been found there only within the limit of tidal influence, and their distribution may depend on this factor: the wormeel *Moringua penni* and the gobioids *Oxyurichthys jaarmani*, *Stenogobius* cf. *genivittatus*, *Stigmatogobius romeri*, *Prionobutis microps*, *Brachyamblyopus urolepis*, *Periophthalmus weberi*, and *Pseudapocryptes confluentus*. The significance of tides for the two periophthalmids, which utilize tidally exposed mudflats, is obvious. The *Brachyamblyopus* and *Moringua* were entirely red or purplish red in life, indicating they might be capable of cutaneous respiration. These and some of the other species indicated are possibly capable of remaining in burrows exposed by low tide, although I did not make any direct observation of such behavior.

The Gulf of Papua is not well known ichthyologically; presumably there are several hundred species within a few kilometers of the Fly mouth. Many essentially marine species probably enter the lowermost portion of the Fly, but the extent and biological significance of their occurrence in freshwater is unknown.

The total number of fish species known from the Upper and Middle Fly is 68, and several more are to be expected, as follows.

1. Sharks frequently have been reported in freshwater in the Australian Region. The presence of *Carcharhinus leucas* (Müller and Henle, 1841) in Jamoer Lake, Vogelskop Peninsula, has been carefully documented (Boeseman, 1964); this species is to be expected in the Lower Fly and might occur in the Middle and Upper Fly, although there is no evidence that it does.

2. Local fishermen reported stingrays at Boset and at Pangoa but no specimen was obtained.

3. Verbal reports of eels at Kiunga and at Lake Murray might refer to *Anguilla* or to *Symbranchus* or both. An *Anguilla* is present in the Upper Purari. R. Moore has collected *A. bicolor* McClelland, 1844, and *A. marmorata* Quoy and Gaimard, 1824, in the Oriomo, and thinks both species or at least *A. bicolor* probably occur in the Middle Fly; he also has found *Symbranchus bengalensis* (McClelland, 1845) common in coastal rivers and swamps W of the Fly.

4. *Nematalosa* cf. *papuensis* herein reported from the Upper and Middle Fly probably represents two species (this material is being studied by T. Wongratana).

5. Several species known only from other rivers in central-southern New Guinea may also occur in the Fly, including the peculiar ariid *Tetranesodon conorhynchus* Weber, 1913, *Toxotes lorentzi* Weber, 1910, and *Therapon roemeri* Weber, 1910.

6. *Tetraodon erythrotaenia*, known from the Lower Fly and from freshwater in the Lorentz, belongs to a group of puffers typically inhabiting rivers above the limit of tidal influence, hence it probably occurs in the Middle Fly and possibly in the Upper Fly.

Size of Fish Species in the Fly

A general objective of the 1975 ichthyological survey of the Fly was to obtain sufficient information to permit comparisons of the ichthyofauna of a large river in the Australian Region with megapoticam ichthyofaunas in other parts of the world. Freshwater fishes in the Australian Region have evolved in the absence of the primary freshwater groups of Ostariophysii, which strongly dominate tropical riverine ichthyofaunas in all other continental areas.

Apart from taxonomic composition and number of species, perhaps the most striking difference between fishes of the Fly and those of other areas concerns size. In most tropical continental riverine ichthyofaunas there are relatively large numbers of species that attain a rather small size as adults. In the Amazon, Congo, and Kapuas, which have extremely rich ichthyofaunas, an overwhelming majority of species do not attain 300 mm, and a large proportion of the species are under 40 mm. Of 68 species known from the Middle and Upper Fly, 30 commonly attain standard lengths in excess of 300 mm, and in only

8 or 9 species is growth halted under 40 mm. The relatively large size of the average fish species in the Fly and other large rivers of central-southern New Guinea cannot be merely the result of invasion by relatively large marine ancestors; consideration of specific examples provides strong evidence for evolution of large size within these rivers, as follows.

1. The endemic engraulid *Thryssa scratchleyi*, attaining 371 mm (see list of material in the systematic section of this paper), is the largest known anchovy in the world, and it is far larger than any marine species of Engraulidae in the Australian Region.

2. *Glossamia sandei*, attaining over 230 mm (total length?; Weber and de Beaufort, 1929:285) is the largest known apogonid.

3. *Parambassis gulliveri*, attaining 280 mm (total length?; Weber and de Beaufort, 1929:404) is by far the largest ambassid; the next largest ambassid, the closely related *Parambassis confinis* (Weber, 1913), in the Sepik and Ramu rivers of northern-central New Guinea, attains only half this size.

4. *Toxotes chatareus* attain 400 mm in the Fly, nearly double that reported elsewhere for any toxotid.

5. *Therapon fuliginosus* exceed 300 mm in the Fly, far larger than any marine or estuarine Theraponidae reported from New Guinea.

6. *Bunaka herwerdeni* attains 437 mm in the Fly, much larger than any marine Eleotridae reported from New Guinea, and among the largest eleotrids known.

7. *Kurtus gulliveri* attains 590 mm in northern Australia and in rivers of southern-central New Guinea including the Fly. The Asian *Kurtus indicus*, the only other member of the family Kurtidae, attains only 126 mm.

The largest fish in the Fly is certainly *Pristis microdon*. Individuals up to 17 feet long and 1000 pounds reportedly have been caught in Lake Murray. Villagers on the Upper Fly indicated they had caught an ariid catfish more than 2 m long and about 60 cm in diameter in the mouth of the Elevala River. The largest ariid caught during the 1975 survey was an *Arius* cf. *stirlingi*, 1.2 m long (Fly 75-29), and the largest plotosid a 1.0-m *Plotosus papuensis* (Fly 75-20). R. Moore has caught *Lates calcarifer* of 65 pounds and has had reliable reports of individuals up to 120 pounds.

Most fish families in the Amazon, Congo, and some other large continental rivers with rich ichthyofaunas

are represented by species with adults of less than 40 mm. Of 26 families in the Middle and Upper Fly, only four are represented by species this small: Atherinidae, Ambassidae, Gobiidae, and Eleotridae. Of particular interest are the two small species of Eleotridae, *Oxyeleotris paucipora* and *O. nullipora*, known only from the Fly River, and by far the smallest known species in a genus in which most of the species attain at least 200 mm. This is perhaps the best example of a rare phenomenon, selection for reduction of size in the evolution of fish species inhabiting the rivers of central-southern New Guinea. *Gobiopterus* species undetermined, fully adult under 15 mm, is the only minute species in the Upper and Middle Fly, all other species attaining at least 30 mm. *Gobiopterus*, widely distributed in fresh and brackish water in the Australian Region, Southeast Asia (including the Philippines), and southern Asia, are usually this small.

One of the most interesting features of the ichthyofauna of the large rivers of central-southern New Guinea is the large number of endemic freshwater species of the catfish families Ariidae and Plotosidae. These families are largely or entirely absent from most freshwater ichthyofaunas outside of the Australian Region. They appear to have been at least partially excluded or eliminated elsewhere by primary freshwater catfishes (Roberts, 1972). Ariidae, with five genera and 13 species, and Plotosidae, with five genera and seven species, are the most important families in the Upper and Middle Fly. The Ariidae exhibit more trophic specialization than any other family in the Fly (see below). Catfishes with fully grown adults of only 30–100 mm are well represented in large tropical rivers in all parts of the world except the Australian Region. Several families in the Amazon include species under 20 mm. The Ariidae and Plotosidae in the Fly are all relatively large. All but one of the 13 ariids attain at least 350 mm and most of them grow even larger. Ariidae, wherever they occur, presumably have a lower size limit imposed by their huge eggs. *Nedystoma dayi*, smallest of the Fly ariids, attains 240 mm. Its eggs are 10 mm in diameter, and an 183-mm male can brood only about 20 of them in its mouth. Why Plotosidae failed to evolve smaller species in the rivers of central-southern New Guinea, where they evolved more extensively than anywhere else, is more puzzling. *Porochilus obbesi*, the smallest species in the Fly, attains 120 mm. Con-

sideration of the distribution of small and minute catfishes suggests that selection favoring small size has been mainly a response to biotic pressures proportionate to the richness of ichthyofaunas. Perhaps this is why smaller plotosids failed to evolve in central-southern New Guinea.

Food Habits

Little is known about the food habits of catfishes inhabiting large tropical rivers. Many ariids were caught during the Fly survey, mainly by gillnetting, providing ample opportunity to examine stomach contents of most species (the few specimens of *Arius* species undetermined and *Hemipimelodus crassilabris* that were taken all had empty stomachs).

1. *Arius leptaspis* and *A. acrocephalus* are omnivorous. Individuals often had stomachs crammed with a variety of food, with terrestrial arthropods, aquatic insects, higher plants, and unidentifiable debris (not including mud) predominating, and molluscs, prawns, crayfish, or fish occasionally present.

2. *Arius cleptolepis* is almost as omnivorous as *A. leptaspis* and *A. acrocephalus*, but its feeding habits apparently differ in several ways. All but two or three of the dozen specimens examined in the field and in the laboratory had ingested quantities of large fish scales (in some instances from *Megalops cyprinoides* and *Nematalosa* cf. *papuensis* caught in the same gill nets). Scales were not observed among the stomach contents of any other catfishes in the Fly. *Arius cleptolepis* stomach contents did not include any other remains of fish. Prawns and terrestrial insects were represented mainly by pieces such as chela or femura. Several individuals had ingested considerable mud along with other food.

3. Only four specimens of *Arius carinatus* were taken; these had been feeding on aquatic Hemiptera, prawns, aquatic dipteran larvae of the genus *Culicoides*, and unidentifiable debris.

4. *Arius augustus* is piscivorous. Most gillnetted individuals of this species had empty stomachs. All four specimens with stomach contents present had fed exclusively on small fish, including *Clupeoides papuensis*, *Nematalosa* cf. *papuensis*, *Ambassis agrammus*, and *Melanotaenia nigrans*.

5. *Hemipimelodus macrorhynchus* feeds mainly on higher plants, including a variety of fruits, and terrestrial insects. Of the eight specimens caught, six had

stomach contents. Three had fed on several types of small fruits. A pulpy oval fruit, about an inch long, with soft purplish rind and round yellow seeds, was noted in individuals from widely separated localities, but attempts to identify the source of these fruits in the field were unsuccessful. Examination of remains in the posteriormost portion of the gut indicated that any seeds present had been thoroughly digested. Less nutritious parts of plants were also ingested, including bits of root, stem, and leaf. Terrestrial insects including ants, grasshoppers, beetles, and bugs were well represented in the stomachs, crustaceans (small prawns or crabs) rare, and aquatic insects absent.

6. Only three *Hemipimelodus taylori* were caught; they had fed on pulpy fruits and terrestrial insects.

7. *Cinetodus froggatti* is molluscivorous. Stomachs and intestines of 12 of a total of 15 individuals caught were crammed with dozens to hundreds of shelled molluscs, ingested without crushing. Two fish had empty guts, and one had filled up on thick, sticky mud. No other food items were present in any of the specimens. The only other Fly catfish feeding heavily on molluscs is the plotosid *Tandanus ater*, which also feeds on insects, prawns, and earthworms. Molluscs found in the guts of *Cinetodus froggatti* have been identified by Ruth Turner as follows (the material is deposited in the Museum of Comparative Zoology, Harvard).

Gastropoda

Prosobranchia

Neritidae

Neritodryas simplex (Shepman, 1919): Fly 75-1, -26

Viviparidae

Bellamyia decipiens (Tapparone-Canefri, 1883): Fly 75-6, -26

Larina new species?: Fly 75-1, -20

Hydrobiidae

Clenchiella sentaniensis Jutting, 1963: Fly 75-26

Bithyniidae

Gabbia lacustris Jutting, 1963: Fly 75-1, -26

Assimineidae

Acmeilla parvicostata Jutting, 1963?: Fly 75-25

Thiaridae

Thiara scabra (Müller, 1774): Fly 75-20, -25

Melanoides flyensis (Tapparone-Canefri, 1883): Fly 75-1, -25

Melanoides tuberculatus (Müller, 1774): Fly 75-1

Tarebia granifera (Lamarck, 1822)?: Fly 75-1

Pulmonata

Planorbidae

Amerianna carinata (H. Adams, 1861): Fly 75-26

Physastra vestita (Tapparone-Canefri, 1883): Fly 75-26

Hippeutis (Helicorbis) umbilicalis (Benson, 1836):
Fly 75-26

Bivalvia

Family?

Genus and species?

8. Numerous individuals of *Nedystoma dayi*, all from the single locality where they were obtained by the survey, had stomachs filled with aquatic dipteran larvae, predominantly *Culicoides*, but including fair numbers of much smaller Chironomidae.

9. *Cochlefelis spatula* and *C. danielsi* feed almost exclusively on prawns, *Macrobrachium* and *Caridina*, which they ingest whole. More than 20 individuals of each species were caught, and the stomachs of almost all of them were examined. Over half of the specimens of both species had prawns in their stomachs. A few had ingested terrestrial insects or small fish, and one *C. danielsi* had swallowed a large lizard (body length about 200 mm), but no other food items were encountered, and only prawns appeared to be important. *Cochlefelis danielsi* has a larger gape than *C. spatula*, and it ingests very large prawns as well as smaller ones. Five *C. danielsi* were found with *Macrobrachium rosenbergi* more than 70 mm in carapace length, whereas the prawns ingested by *C. spatula* were always under 40 mm.

Less extensive observations were made on the food habits of fishes in other families.

PRISTIDAE.—Several *Pristis microdon* were cut open but had empty stomachs.

MEGALOPIDAE.—*Megalops cyprinoides* taken in the Palmer River, Upper Fly, had fed on very small prawns; one from the Middle Fly on small prawns and winged termites, another a 70-mm *Clupeoides papuensis* and a spider.

CLUPEIDAE.—*Clupeoides papuensis*, itself fed on by many fish species, fed on ostracods, small insects including Ephemeroptera nymphs and ants (most specimens have empty stomachs). The stomach contents of three *Clupeoides venulosus* were examined and comprised small aquatic insect larvae. Some endemic clupeids of tropical African rivers superficially resemble *Clupeoides* and are piscivorous, often including larval clupeids in their diet, but no fish were found in the stomachs of either species of *Clupeoides* in the Fly. Numerous *Nematalosa* cf. *papuensis* examined had ingested considerable amounts of mud.

ENGRAULIDAE.—The giant species *Thryssa scratch-*

leyi is piscivorous. Most specimens examined had empty stomachs, but several had ingested *Clupeoides papuensis*, and one had eaten a *Melanotaenia nigra*. *Thryssa rastrosa*, with excessively numerous gill rakers, usually had empty stomachs. A 116-mm specimen from an ox-bow lake near Kiunga, Upper Fly, had its stomach crammed with about 500 planktonic calanoid copepods.

OSTEOGLOSSIDAE.—Large *Scleropages jardini* from the Upper Fly had fed on terrestrial insects including beetles and grasshoppers; one from the Middle Fly had ingested a small prawn.

PLOTOSIDAE.—*Tandanus ater* feeds on snails, which it crushes, aquatic and terrestrial insects, prawns, and earthworms. *Tandanus equinus* feeds on large aquatic insects, including Hemiptera, Coleoptera, and Odonata. *Plotosus papuensis* from Fly 75-14 had fed on small prawns (*Caridina*) and terrestrial insects; no molluscs. *Oloplotosus luteus* feeds on small aquatic insect larvae.

BELONIDAE.—*Strongylura krefftii* feeds on small fish, including *Clupeoides papuensis*.

HEMIRAMPHIDAE.—*Zenarchopterus novaeguineae* feeds on a great variety of small terrestrial insects, including ants, and ingests small twigs and bits of leaves.

MELANOTAENIIDAE.—*Nematocentris rubrostriatus* feeds on aquatic insect larvae, including Trichoptera; terrestrial insects, mainly ants; filamentous algae; and unidentified detritus.

ATHERINIDAE.—*Craterocephalus randi* feeds on small aquatic insect larvae, including *Culicoides*; filamentous algae; and bits of higher aquatic plants. *Pseudomugil novaeguineae* from Fly 75-2 had fed on small terrestrial insects including Coleoptera and Hymenoptera. *Pseudomugil gertrudae* from Fly 75-4 had fed on a variety of small aquatic insect larvae.

AMBASSIDAE.—*Parambassis gulliveri* feeds on small fish and prawns.

LOBOTIDAE.—Several *Datnioides quadrifasciatus* examined in the field and in the laboratory had empty stomachs; a 210-mm specimen from the Lower Fly had fed on small prawns.

THERAPONIDAE.—A 350-mm *Therapon fuliginosus* from the Upper Fly had its stomach crammed with about 50 small, 5-petalled flowers, along with leaves, pulpy seeds, and unidentified debris.

APOGONIDAE.—Large *Glossamia aprion* and *G. narindica* are piscivorous.

SPARIDAE.—Stomach contents of three large *Acanthopagrus berda* consisted of crushed snails, filamentous algae, and unidentified debris.

SCIAENIDAE.—Several *Nibea semifasciata* had empty stomachs. A 325-mm specimen from the Lower Fly had ingested a small *Macrobrachium* prawn.

TOXOTIDAE.—A 210-mm *Toxotes chatareus* from the Upper Fly had ingested many large terrestrial insects, including beetles, ants, and a large wasp.

MUGILIDAE.—*Liza diadema* invariably have mud-filled guts.

GOBIIDAE.—*Glossogobius giuris* and *G. celebius* feed on aquatic insect larvae, including Coleoptera and case-making Trichoptera; *G. giuris* also feed on small prawns.

ELEOTRIDAE.—*Mogurnda mogurnda* feed on terrestrial and aquatic insects.

KURTIDAE.—Most *Kurtus gulliveri* examined had empty stomachs; a few had ingested small fishes.

R. Moore examined the stomachs of 101 *Lates calcarifer* caught in the Middle Fly and reports the following percentages based on numbers of items encountered:

Unidentified fish	59.5
<i>Nematalosa</i> cf. <i>papuensis</i>	14.0
<i>Macrobrachium</i>	7.5
Ariidae	6.5
Plotosidae	4.5
Crustacea other than <i>Macrobrachium</i>	4.0
<i>Glossamia</i>	2.0
<i>Strongylura krefftii</i>	1.0
Ambassidae	1.0
	<hr/>
	100.0

The palaemonid prawn *Macrobrachium* was relatively common in *Lates* caught in rivers, the parastacid crayfish *Cherax* in those taken in lakes. *Lates* in aquaria preferred crustaceans to fish.

R. Moore reports that wild-caught *Iriatherina werneri* had fed on large quantities of unicellular, planktonic algae; some diatoms were present, but crustacea were absent. Individuals held in aquaria fed on small crustacea such as *Cyclops*, but mosquito larvae were apparently too large for them.

My impression that lowland streams in the Amazon and Congo basins are very poor in molluscs and decapod crustaceans compared to those in Southeast Asia (Roberts, 1972:143) has been reinforced by additional fieldwork in the Congo in 1973 (Roberts and Stewart, 1976:243) and fieldwork in the Kapuas

basin in Borneo in 1976. Molluscs and decapods also appear to be more diverse, more abundant, and more important as fish food in the lowlands of the Fly than in the lowlands of the Amazon and Congo.

A collection of decapods made during the 1975 Fly survey has been deposited in the Division of Crustacea of the Smithsonian. I am indebted to Drs. Fenner A. Chace, Jr., and Horton H. Hobbs, Jr., for the following identifications:

Penaeidae

Penaeus species undetermined (Fly 75-32)

Sergestidae

Acetes sibogae Hansen (Fly 75-32)

Palaemonidae

Macrobrachium cf. *oenone* (De Man) (Fly 75-1, -9)

Macrobrachium rosenbergii (De Man) (Fly 75-20)

Macrobrachium near *weberi* (De Man) (Fly 75-1)

Macrobrachium species undetermined (Fly 75-20, -25, -26, -28, -30)

Periclimenes species undetermined (Fly 75-32)

Atyidae

Caridina near *gracilirostris* De Man (Fly 75-30)

Caridina species undetermined (Fly 75-1, -2, -20, -24)

Parastacidae

Cherax lorentzi lorentzi Holthuis (Fly 75-13)

Reproduction

Fishes of the Upper and Middle Fly can be divided into categories based on aspects of their reproduction as follows.

1. Reproducing locally in the Upper and/or Middle Fly (a) with numerous small eggs (newly hatched young generally less than 10 mm; about two-thirds of the species are in this category); (b) as oral brooders with relatively few large eggs (newly hatched young more than 10 mm at least in some species, e.g.,

Scleropages jardini, Ariidae); or (c) in an ovoviviparous state (newborn young probably over 500 mm, e.g., *Pristis microdon*).

2. Migrating to the Lower Fly or to the Gulf of Papua in order to spawn (catadromy); large species with extremely numerous small eggs (up to eight species, including *Megalops cyprinoides*, *Lates calcarifer*, and possibly *Thryssa scratchleyi*).

Young of less than 20 mm in standard length were taken belonging to 28 (41%) of the 68 species inhabiting the Middle and Upper Fly. Ten species were represented by young of less than 10 mm, and nine by young of 10-15 mm (tabulation below). Lowre-McConnell (1975), in discussing reproduction in tropical freshwater fishes, inclines to the view that reproductive seasonality is prevalent, recognizing only a few groups as having "aseasonal" reproduction (1975, table 9.1) and not discussing them in detail. Reproduction in many of the locally reproducing species in the Upper and Middle Fly, including most or all of the oral brooders with large eggs, probably is seasonal. Marked seasonality probably occurs in all of the anadromous forms. There remain, however, many locally reproducing species in which reproduction is perhaps more or less continuous or only interrupted by unfavorable conditions that may have nothing to do with seasons. This probably is the case for many of those species listed in the tabulation that follows, particularly *Zenarchopterus novae-guineae*, *Clupeoides papuensis*, the Melanotaeniidae, *Ambassis agrammus*, the *Glossamia*, *Toxotes chatareus*, *Glossogobius celebius*, and *Gobiopterus* species undetermined.

Two of the three specimens of the specialized montane plotosid *Oloplotosus luteus* are gravid females of 123 and 141 mm. The eggs are notably

Fish species with young of less than 20 mm encountered in the Upper and Middle Fly during the 1975 survey (numbers refer to collection localities and material is listed more fully in the systematic section)

Under 10 mm	10-15 mm	15-20 mm
<i>Zenarchopterus novae-guineae</i> 4	<i>Clupeoides papuensis</i> 20, 22, 25, 27	<i>Nematalosa</i> cf. <i>papuensis</i> 22
<i>Melanotaenia nigrans</i> 4	<i>Craterocephalus randi</i> 3, 24	<i>Nematocentris sexlineatus</i> 20
<i>Nematocentris rubrostriatus</i> 3	<i>Pseudomugil novae-guineae</i> 2, 4	<i>Iriatherina werneri</i> 20
<i>Denariusa bandata</i> 24	<i>Pseudomugil gertrudae</i> 4	<i>Ambassis macleayi</i> 24
<i>Therapon fuliginosus</i> 3	<i>Ambassis agrammus</i> 1, 3, 6	<i>Parambassis gulliveri</i> 22
<i>Therapon affinis</i> 24	<i>Therapon habbemai</i> 14	<i>Glossamia sandei</i> 9, 14
<i>Glossamia aprion</i> 24	<i>Glossamia narindica</i> 24	<i>Mogurnda mogurnda</i> 4
<i>Glossamia trifasciata</i> 9	<i>Glossogobius giuris</i> 9	<i>Oxyeleotris nullipora</i> 16
<i>Toxotes</i> cf. <i>ulysses</i> 3, 20	<i>Glossogobius celebius</i> 1, 2, 4, 8, 9, 14	
<i>Oxyeleotris paucipora</i> 4	<i>Oxyeleotris fimbriata</i> 4	

large, about 4.5 mm in diameter, and only about 30 in number.

Many Apogonidae are oral brooders, and Lake (1971) reported oral brooding in *Glossamia aprion* in Australia. Although large adults of *G. aprion*, *G. sandei*, and *G. trifasciata* were collected together with young of less than 20 mm on six separate occasions during the Fly survey, I saw no indication of oral brooding. Rotenone was used to obtain these collections, perhaps causing the adults to eject the young. On the other hand, Apogonidae obtained by rotenone from mangrove habitats frequently have their mouths crammed with eggs.

Kurtus gulliveri apparently reproduces seasonally and locally in the Middle Fly and perhaps also in the Upper Fly. Neither gravid females nor males carrying eggs on top of their heads were observed during the 1975 survey, but young of only 48 and 55 mm were obtained at two localities in the Middle Fly. According to R. Moore it is common in such rivers as the Oriomo and Binaturi; he has taken

small juveniles in coastal waters of the Gulf of Papua but has not taken any in Daru Roads, a passage taken by several anadromous fishes inhabiting the Fly.

Pristis microdon evidently reproduces locally in the Middle Fly. An 809-mm individual from Lake Herbert Hoover (Fly 75-20) presumably was born nearby and not in the sea more than 500 km distant. While I do not have data on size of *P. microdon* at birth, the smallest free-living *Pristis* recorded by Bigelow and Schroeder (1953) is a 675-mm *P. pectinata* judged from its umbilical scar to be newborn.

Catadromous Life Histories

Catadromous life histories occur in as many as eight large species inhabiting the Upper and Middle Fly. *Lates calcarifer* (Figure 5) is abundant in the Middle Fly, including Lake Murray, and occurs at least as far upstream as Kiunga, over 800 km from the mouth, but does not reproduce in freshwater. An extensive investigation of the biology of this



FIGURE 5.—*Lates calcarifer* from ox-bow lake near Kiunga (Fly 75-6).

species was conducted by L. C. Reynolds, R. Moore, and other fisheries personnel of the Department of Agriculture, Stocks & Fisheries of Papua New Guinea from 1970 through 1974. I am indebted to R. Moore for providing the information from which the following resumé has been prepared. Recapture of tagged individuals revealed that *Lates* from the Fly and other rivers in the Gulf of Papua undergo an annual spawning migration to spawning grounds lying from 65 km W of Daru westward to the mouth of the Morehead River. The coastal portion of this migration usually commences in September, and spawning in October. Fecundity varies from $5-30 \times 10^6$. By February the last spawning has occurred and the adults disperse eastward along the Gulf and back into the rivers. Spawning occurs close to shore, in water 2-3 m deep and salinity of 31 ppt. Newly hatched larvae are about 1.5 mm. At 4.5 mm the larvae move into contiguous mangrove, or into brackish or freshwater coastal swamps if they are accessible, where they

grow rapidly. In July young of 170-200 mm leave the mangroves or swamps and reenter the sea. By the end of their first year they have gradually moved eastward and begun to enter the mouth of the Fly. During their second year they disperse throughout the Fly and other rivers in the Gulf of Papua, some probably remaining in the delta area near the mouths of rivers. Males mature during their third or fourth year, females in their fifth year or later. Biopsy of gonads and other evidence indicate that females are derived from males, although apparently not all males undergo sex reversal. The largest *Lates* are invariably females.

Seven additional species in the Upper and Middle Fly are probably or possibly catadromous.

Megalops cyprinoides (Figure 6): About 50 *M. cyprinoides* were taken from five localities in the Upper and Middle Fly during the 1975 survey, all over 350 mm and none with ripe gonads. According to R. Moore this species schools along the coast near

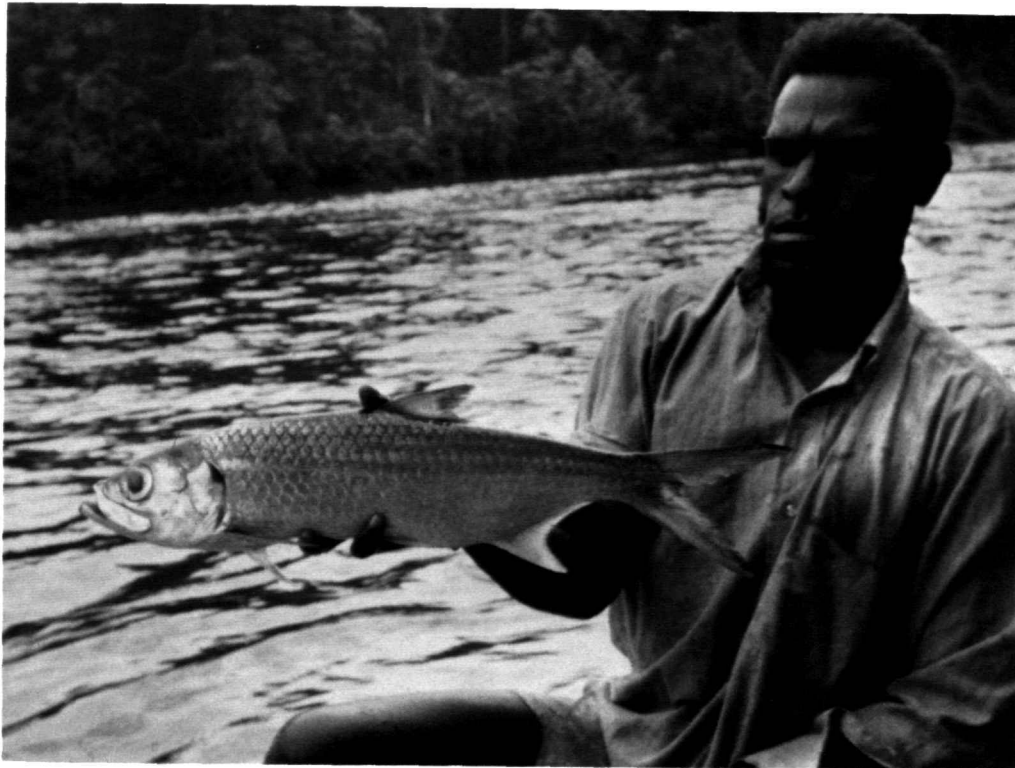


FIGURE 6.—*Megalops cyprinoides* from Palmer River (Fly 75-13), 905 km upriver from the Fly mouth.

Daru late in the year, and larvae enter coastal swamps in November through January. Moore has found adults with ripe eggs in Daru Roads larger than adults in the Fly, suggesting that once they have matured and migrated to the sea they remain there.

Thryssa scratchleyi: This giant anchovy was taken at seven localities in the Upper and Middle Fly. At six localities they were 196 mm or larger. The smallest specimen, taken in the Middle Fly, was 94 mm (although some large individuals had to be discarded, small ones were invariably preserved). There is a regular decrease in size of the smallest individual taken at collecting localities progressively downstream (Figure 7). Young reported from the Lorentz by Weber (1913a) are without habitat data.

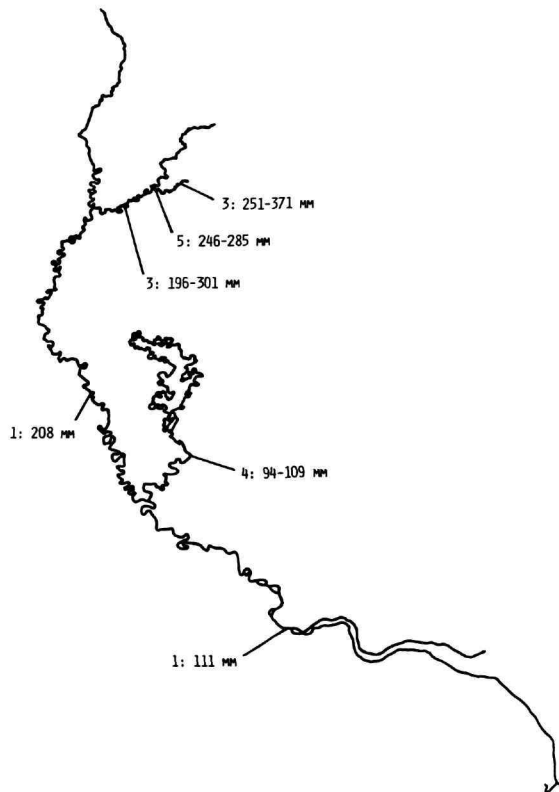


FIGURE 7.—Distribution of *Thryssa scratchleyi* in the Fly.

Datnioides quadrifasciatus: This species, taken at four localities in the Fly, may be catadromous. Specimens of 255–349 mm were taken in the Upper Fly,

and of 150–210 mm in the Lower Fly. According to R. Moore there is presently no evidence that this species undergoes a spawning migration from rivers into the coastal area.

Nibea semifasciata: This sciaenid, attaining over 500 mm, was taken at four localities; the smallest individuals observed were from the Lower Fly (Figure 8). None had ripe gonads. Local fishermen at Boset on the Middle Fly indicated that large numbers occur at certain times but that otherwise it is scarce, suggesting migratory behavior.

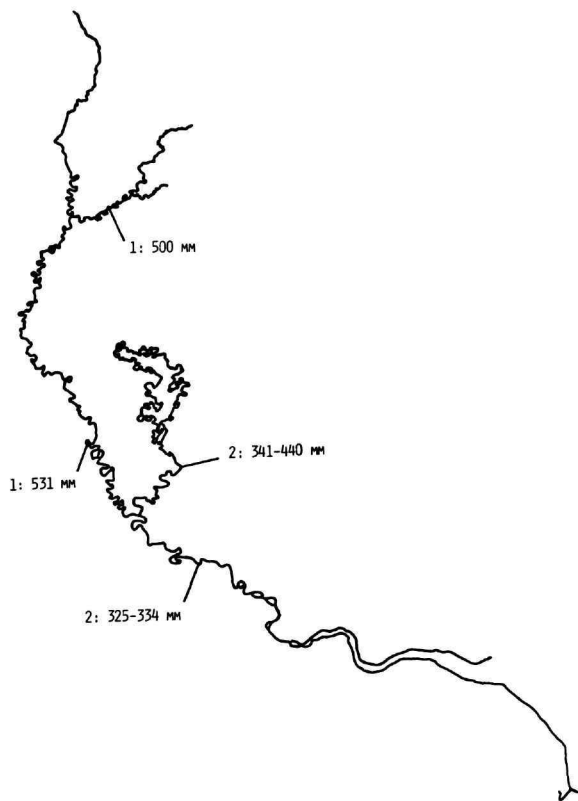


FIGURE 8.—Distribution of *Nibea semifasciata* in the Fly.

Lutjanus argentimaculatus (Figure 9): Individuals of this snapper from 377 to 800 mm were taken at four localities in the Upper and Middle Fly, none with ripe gonads. According to R. Moore it apparently does not enter coastal waters for spawning; he suggests that it might spawn in the upper reaches of tidal inundation in the Lower Fly.



FIGURE 9.—An 800-mm *Lutjanus argentimaculatus* from a tributary in the Wai Ketu (Fly 75-4), almost 900 km upriver from the Fly mouth.

Liza diadema: Many individuals of this mullet, all about 350–400 mm, and none with ripe gonads, were gillnetted in the Middle Fly. According to R. Moore this species spawns in Daru Roads in August–September, at which time large numbers of females with ripe ovaries are present.

Acanthopagrus berda: Large adults of this sparid were taken in the Upper and Middle Fly; they were not ripe. According to R. Moore this species is relatively common around Daru Wharf and in the mangroves of Bobo Island throughout the year, and there does not seem to be a major spawning migration from the rivers into the coastal area. T. Fraser (pers. comm.) relates that large individuals of this species

ascend rivers in southern South Africa, such as the Great Fish and the Kei, but do not spawn in fresh water.

If anadromous fish species utilize the Fly, they presumably are restricted to the Lower Fly. There is no evidence of adult fish migrating from the sea as far upriver as the Middle Fly in order to reproduce, and no young fishes have been found in the Upper or Middle Fly that might represent such species.

Evolution of the Fly Ichthyofauna

Despite considerable endemism, at generic and species level in the riverine ichthyofauna of southern New Guinea, there have been no extensive radiations, and few new adaptations to riverine habitats. Forms such as *Zenarchopterus novaeguineae* and *Toxotes chatareus* are extraordinarily specialized for feeding on terrestrial insects, but their specializations are characteristic of their respective families, which almost certainly did not evolve in the rivers of New Guinea, and may not have evolved in rivers at all. Modest adaptations to riverine conditions evidently have occurred, such as modifications of the body form and fin structure in *Tandanus equinus* and *Oloplotosus luteus* in response to mountain stream habitats, specializations of Ariidae to feed on food sources such as snails, prawns, and aquatic insect larvae, and the strongly mottled coloration of *Glossamia aprion* (which is atypical for Apogonidae, but resembles coloration in fishes of diverse families which live in forested tropical rivers). These specializations seem much less impressive than those found in other tropical continental riverine ichthyofaunas. The absence of any extensive radiation is remarkable. The most speciose family, Ariidae, is represented by 13 species only, and they probably represent several ancestral stocks. Plotosidae, the next largest family, represents at least two apparently phyletic lines, one with dendritic organs and one without them. The five species of plotosids without dendritic organs perhaps represent a modest radiation of a single ancestral stock. The only other possible radiations are represented by Ambassidae, Theraponidae, Apogonidae, and Eleotridae, each involving at most five or six species.

It should be noted that comparatively few fish groups have radiated extensively within river basins and that the most successful are all primary division freshwater groups; none of the families of fishes in-

habiting the Fly have radiated extensively in fresh water anywhere in the world.

Evolution of Riverine Ichthyofaunas in Other Continental Regions

Riverine ichthyofaunas of the Australian Region, so peculiar in a world dominated by Ostariophysi, may have biological attributes and even taxonomic compositions comparable to early riverine ichthyofaunas in other parts of the world prior to their invasion by the dominant groups of primary division freshwater Ostariophysi. Although the three main groups of Ostariophysi originated by the Eocene, we have hardly any information as to how long they have dominated various continental riverine ichthyofaunas. Three related questions may be asked: (1) Did riverine ichthyofaunas comparable to those presently found in the Australian Region evolve in other continental regions? (2) Do modern ichthyofaunas dominated by primary division freshwater groups harbor portions of earlier ichthyofaunas? (3) What happened to early ichthyofaunas as primary division freshwater groups became increasingly dominant?

Most of the families of fishes represented in the Upper and Middle Fly have undoubtedly had a long history in (and out of) freshwater, and may have been more prominent in riverine ichthyofaunas in other parts of the world before the presently dominant families of Ostariophysi became fully established. Ariidae, with their long fossil record and circum-tropical marine distribution, presumably have had ample time to colonize rivers and evolve endemic freshwater species in many parts of the world, only to be reduced or eliminated eventually by more slowly dispersing primary freshwater catfishes. Endemic freshwater Plotosidae, if they were ever more widely distributed, have been perhaps even more rigorously eliminated than Ariidae. The recent finding that the extremely specialized freshwater family Chacidae, with one or two species, widely distributed in India and continental Southeast Asia, is closely related to Plotosidae (Lundberg and Baskin, 1969), is provocative. It is interesting to compare the Fly ichthyofauna with that of one of its nearest neighbors which is dominated by primary freshwater Ostariophysi. The Kapuas is the largest river in Borneo. Its middle and upper portions are inhabited by at least 300 species, most of them cyprinoids and siluroids, but

including representatives of 14 or 15 of the 27 or 28 families present in the Upper and Middle Fly:

	FLY KAPUAS		FLY KAPUAS	
Pristidae	1	—	Theraponidae	5 —
Megalopidae	1	—	Apogonidae	4 —
Clupeidae	3	1	Lutjanidae	1 —
Engraulidae	2	2	Sciaenidae	1 —
Osteoglossidae	1	1	Sparidae	1 —
Ariidae	13	2-3	Toxotidae	1 1
Plotosidae			Scatophagidae	1 —
(Chacidae)	7	(1)	Mugilidae	2 —
Belontiidae	1	1	Gobiidae	3 3
Hemiramphidae	1	2	Eleotridae	6 2
Melanotaeniidae	4	—	Kurtidae	1 —
Atherinidae	5	—	Soleidae	1 1-2
Ambassidae	4	4	Cynoglossidae	1 2
Centropomidae	1	—	Tetraodontidae	(1) 4
Lobotidae	1	1		

The numbers of species in the Upper and Middle Kapuas are based on published accounts and on field observations and preliminary study of extensive collections I made in July–August 1976.

Catadromous fishes appear to be entirely absent from the Upper and Middle Kapuas. *Megalops cyprinoides*, *Lates calcarifer*, and *Lutjanus argentimaculatus*, although widely distributed in Southeast Asia, have not been found in the Kapuas. The numerous species of peripheral division families found in the Upper and Middle Kapuas apparently spend their entire life cycle in freshwater. Atherinoids and mugilids, which are well represented in the Fly and have evolved endemic freshwater genera and species in widely scattered localities where primary freshwater fishes are absent or poorly represented (including Central America, southern South America, and Madagascar as well as the Australian Region), are absent from the Kapuas. The endemic Malagasy freshwater atherinids *Bedotia*, *Rheocles*, and *Rheocloides* are superficially similar to Melanotaeniidae; they may in fact be close relatives. It is likely that atherinoids and mugilids were more widely distributed in earlier freshwater ichthyofaunas. Although marine and estuarine species of Apogonidae and Theraponidae are widely distributed, freshwater species are not known outside of the Australian Region (early records of freshwater species of Theraponidae from India and Madagascar, never subsequently confirmed, may have been based on marine species with erroneous locality data). The single Asian species of Kurtidae, *Kurtus indicus* Bloch, 1786, widely distributed in India and

Southeast Asia, occurs in the Lower Kapuas but apparently not in the Upper or Middle Kapuas.

Kapuas representatives of families shared with the Fly may in fact represent survivors of an earlier ichthyofauna. The number of freshwater species of Clupeidae, Engraulidae, Osteoglossidae, Belonidae, Hemiramphidae, Ambassidae, Toxotidae, Gobiidae, Eleotridae, Soleidae, and Cynoglossidae in the Kapuas closely parallels the number of species of these families in the Upper and Middle Fly. Ariidae is represented by only two or three species in the Upper and Middle Kapuas; they are endemic freshwater species, do not appear closely related to each other, and may well represent the survivors of an earlier radiation of freshwater Ariidae in Southeast Asia. *Chaca* may be the only survivor of a plotosid radiation or radiations in freshwater outside the Australian Region. Kapuas Ambassidae are of particular interest. There are four endemic freshwater species in the Upper and Middle Kapuas, just as in the Fly. The Upper and Middle Kapuas is also inhabited by endemic freshwater species belonging to several peripheral division families that are absent from the Fly, including Dasyatidae, Syngnathidae, Polynemidae, and Tetraodontidae. Ancestral stocks of all of the peripheral division freshwater fishes inhabiting the Kapuas conceivably were present before it was invaded by the primary division freshwater families that dominate the present Kapuas ichthyofauna.

Presuming that the Fly ichthyofauna is indicative of what earlier ichthyofaunas were like in other parts of the world, domination by primary division freshwater fishes may have had the following results.

1. Fishes with catadromous life histories either dropped out, especially if the marine stage was obligatory (as in *Anguilla*, and perhaps in *Megalops*) or evolved wholly freshwater life histories (*Lates niloticus* in Africa?, Amazonian Sciaenidae?, *Aplodinotus grunniens* in North America?).

2. Elasmobranchs dropped out entirely, declined markedly in numbers, or evolved freshwater life histories (Amazonian Potamotrygonidae, Niger and Kapuas Dasyatidae?).

3. Endemic freshwater Ariidae and Plotosidae dropped out entirely (Amazonian Ariidae?) or almost entirely (Indian and Southeast Asian Ariidae and Plotosidae?).

4. Atherinoids, mugilids, and most species belonging to generalized percoid families, perhaps including

Theraponidae and Apogonidae, if they were present, dropped out (a notable exception being Ambassidae in India and Southeast Asia).

5. Peripheral division freshwater fishes that survived tended to have specializations with no equivalents among primary division freshwater fishes inhabiting the same areas: Clupeidae, Engraulidae, Belonidae, Hemiramphidae, Toxotidae, Syngnathidae, Gobiidae, Cynoglossidae, Soleidae, and Tetraodontidae.

6. A few species of peripheral division freshwater families apparently were able to survive by evolving small or minute body size and/or year-round reproduction. This perhaps is illustrated best by gobioids (*Gobiopterus* and *Brachygobius* in Asia, *Microphilypnus* in the Amazon, and *Kribia* in Africa).

Freshwater stages of diadromous fishes, including anadromous lampreys and salmonoids, catadromous *Anguilla* and tropical forms with less familiar life histories, tend to inhabit rivers with depauperate ichthyofaunas. Marine stages of diadromous fishes may also utilize impoverished habitats: a classic example is the spawning grounds of European and North American *Anguilla* in the Sargasso Sea. Freshwater as well as marine stages of diadromous fishes typically have extraordinary vagility (ability to disperse or make long journeys); they are likely to be among the earliest arrivals in youthful marine or freshwater habitats, but are also likely to be displaced as these habitats acquire richer ichthyofaunas.

Collecting Localities of the 1975 Ichthyological Survey

Field work in the Fly basin from mid-October through mid-December 1975 resulted in collections at 32 localities, designated Fly 75-1 through 32. The locations were plotted in the field on series T 504 topographic maps (scale 1: 250,000); distances and coordinates were subsequently determined from the same maps. Distance upriver from the mouth of the Fly are given for each locality. These were determined with the aid of a Dietzgen map-meter, using the inner opening of Toro Pass as zero point from the Fly mouth. Almost all of the place names used in the description of localities are to be found on the T 504 maps. The exceptions are Siniam, Magnetite, Karamonge, and Guiavi creeks, the names of which were obtained from local sources.

FLY 75-1 (Figure 4a).—Mainstream of Upper Fly and mouths of small tributaries within 4 km of Kiunga, 828–836 km upriver from Toro Pass, 6°07.5'S, 141°17.0'E. 17 October–19 November (not inclusive). Water 25.0–25.5° C, pH 7.1–7.4. Gill nets, rotenone, seine.

Repeated efforts of gillnetting at this locality and at Fly 75-6, at numerous sites and under varying conditions of water level, presumably provided a nearly complete representation of the larger fish species present in the vicinity of Kiunga. Rotenone and seine were less effectively employed. We heard reports of eel-like fishes but did not see any.

FLY 75-2.—Tributary of Siniam Creek, about 4 km SE of Kiunga, 836 km upriver from Toro Pass, 6°08.5'S, 141°19.6'E. 18 October. Water clear, reddish brown. Rotenone.

Rotenone very effective. Large species of *Pseudomugil novaeguineae* and *Oxyeleotris paucipora* obtained. The deeply shaded tributary sampled, about 3–5 m wide and 1.2 m deep, flowed gently over an easily roiled bottom with much leaf litter and numerous logs. The mouth of the Siniam is on the left bank of the Fly about 2 km upriver from Kiunga, and the tributary about 2 km up the Siniam. The name "Siniam" obtained from local fishermen and verified by several persons at Kiunga.

FLY 75-3.—Elevala River, a major lowland tributary of the Upper Fly, 17 km E of Kiunga, 859 km upriver from Toro Pass, 6°05.7'S, 141°27.7'E. 20 October. Gill nets, flashlight, and dip nets.

Gillnetting yielded large *Arius acrocephalus*, *A. cleptolepis*, *Tandanus ater*, and *Parambassis gulliveri*. Dipnetting with a flashlight yielded very small young of several species, including *Zenarchopterus novaeguineae* and *Toxotes chatareus*.

FLY 75-4 (Figure 4b).—Wai Ketu, a large lowland tributary of the Elevala, 25–33 km ENE of Kiunga, 877–892 km upriver from Toro Pass. 21–24 October. Water turbid, brownish, 25.5° C, pH 6.7. Gill nets, hook and line, rotenone.

A total of 21 species were caught at this locality. Gillnetting here and at Fly 75-13 yielded *Toxotes chatareus* of 350–400 mm standard length; two or three of these huge individuals were inadequately preserved and were discarded. An 800-mm *Lutjanus argentimaculatus* obtained in a tributary 2 m wide and 1.2 m deep was not preserved. A local resident who accompanied us for several days and was of

considerable assistance with hook and line indicated the Wai Ketu contained *Pristis* and *Lates*, but we did not observe any.

FLY 75-5.—Small tributaries and mainstream of Upper Fly 1–2 km upstream from mouth of Elevala River, 856 km upriver from Toro Pass, 6°03.3'S, 141°24.3'E. 26 October. Gill nets, rotenone.

Excellent rotenone collection obtained from lower end of tributary 2–5 m wide and 1–4 m deep, including our first specimen of *Thryssa rastrosa*. The only specimen of *Bostrychus strigogenys* obtained by the survey was caught by local villagers in a shallow, sluggish, swampy stream.

FLY 75-6.—Ox-bow lake with mouth open to mainstream of Upper Fly, 4 km downriver from Kiunga, 828 km upriver from Toro Pass, 6°09.2'S, 141°16.2'E. 27 October–19 November (not inclusive). Water clear to slightly turbid, dark brown, 27.5°–30° C, pH 7.4. Gill nets in open water and along wooded shore; rotenone in exposed tributary 3 m wide and 1 m deep.

FLY 75-7.—Magnetite Creek, a high gradient tributary of the Ok Tedi, 10 m wide and 2 m deep, with cobblestones and boulders, approximately 52 km N of Ningerum, 966 km upriver from Toro Pass, 5°12.6'S, 141°11.0'E. Altitude probably between 600–800 m. 30 October. Water clear to slightly turbid. Rotenone.

Good conditions for face mask and snorkel permitted us to collect a number of *Tandanus equinus*; the only other species observed was a *Glossogobius*. A smaller, more torrential tributary a few km farther up the Ok Tedi was also treated with rotenone; despite prolonged observations with face masks only the same two species were observed (none collected). The name "Magnetite Creek" obtained from officials of the Ok Tedi copper development project at their Tabubil headquarters.

FLY 75-8.—Lower portion of Karamonge Creek, a tributary of the Ok Tedi with its mouth 6 km S of the Ok Menga mouth, 32 km NNE of Ningerum, 934 km upriver from Toro Pass, 5°26.6'S, 141°17.4'E. Altitude 450 m? 1 November. Water clear to slightly turbid. Rotenone.

The lower 1 km of this creek, up to 8 m wide and 3 m deep, flowing moderately swiftly over irregular-sized cobblestones and rocks, and forming a deep pool about 50 m long before flowing over a shallow, silty sill into the Ok Tedi, yielded an excellent collection of eight species including *Clupeoides*

venulosus and a large series of young and half-grown *Arius acrocephalus*. The name "Karamonge Creek" was obtained from officials of the Ok Tedi copper development project at their Tabubil headquarters.

FLY 75-9.—Shallow, turbid backwater of Ok Tedi and lowermost half km of small tributary about 16 km NE of Ningerum, 915 km upriver from Toro Pass, 5°34.1'S, 141°15.0'E. Altitude approximately 52 m. 2 November. Rotenone.

Shallow backwater yielded only *Glossamia trifasciata*, *G. sandae*, and *Craterocephalus randi*. Small tributary yielded 10 species, including the first of our three specimens of *Oloplotosus luteus*. This specimen was obtained from the last 20 m of the tributary, where it was 3-4 m wide and 20 cm deep, and flowed gently over small rocks and cobbles.

FLY 75-10.—Braided side channels in mainstream of the Ok Tedi with uniform cobblestone bottom, 7 km NNE of Ningerum, 901 km upriver from Toro Pass, 5°37.1'S, 141°10.1'E. Altitude approximately 50 m. 4 November. Water very turbid, 22.8° C, pH 8.5. Rotenone.

Nine species were obtained, including *Clupeoides venulosus* and *Chelon heterocheilus*.

FLY 75-11 (Figure 3b).—Side channel of Ok Tedi 3 km above confluence with Ok Menga, 39 km NNE of Ningerum, 943 km upriver from Toro Pass, 5°21.2'S, 141°16.9'E. Altitude approximately 475 m. 5 November. Water slightly turbid, 21.7° C, pH 8.5. Rotenone.

This swiftly flowing channel, about 100 m long, 5-10 m wide, and 0.5 m deep, with boulders and cobblestones of varying sizes, yielded *Tandanus equinus*, *Oloplotosus luteus*, and *Therapon habbema*; no other species observed.

FLY 75-12.—Mainstream of Upper Fly 5 km downstream from Temingondok, 24 km NE of Kiunga, 872 km upriver from Toro Pass, 6°01.4'S, 141°28.6'E. 9 November. Gill nets.

The only fishes obtained at this locality were *Datnioides quadrifasciatus* and a huge *Bunaka herwerdeni*.

FLY 75-13.—Palmer River, a major lowland tributary of the Upper Fly, near Surprise Creek, 43 km NE of Kiunga, 905 km upriver from Toro Pass, 6°51.2'S, 141°34.3'E. 10-12 November. Gill nets, rotenone.

Gillnetting yielded large *Megalops cyprinoides* and *Hemipimelodus crassilabris*.

FLY 75-14.—Mainstream of Palmer and lower end of small tributary about 1 km up the Palmer from Thompson Junction (mouth of Wai Mungi), 65 km NE of Kiunga, 930 km upriver from Toro Pass, 6°46.8'S, 141°36.6'E. 10-11 November. Gill nets, hook and line, rotenone.

Hook and line in Palmer mainstream, in moderately flowing, slightly turbid water about 3 m deep over gravelly bottom, yielded the only *Hemipimelodus taylori* obtained by the survey. Rotenone in clear, untinted tributary 2-5 m wide and up to 2 m deep, with logs and leaf litter and a soft limestone (?) bottom, yielded an excellent collection of 13 species, including a series of young *Plotosus papuensis* and one small *Brachirus villosus*.

FLY 75-15.—Palmer River 1 km above confluence with Fly, 37 km NE of Kiunga, 898 km upriver from Toro Pass, 6°53.7'S, 141°32.3'E. 12 November.

Two large *Hemipimelodus crassilabris*, caught by local fishermen, are the only fish collected at this locality. Local people provided a small collection of frogs and lizards and a specimen of the parastacid crayfish *Cherax lorentzi lorentzi*.

FLY 75-16 (Figure 4c).—Lagoon and swampy backwater of lower Kanggu River, a moderately large tributary of the Middle Fly, 717 km upriver from Toro Pass, 6°24.4'S, 140°56.5'E. 22 November. Water reddish brown, clear, 26.7° C, pH 6.0. Gill nets, rotenone.

A total of 16 species were collected at this locality, including our first *Copidoglanis meraukensis*, *Prochilus obbesi*, *Therapon affinis*, and *Oxyeleotris nullipora*. Large *Strongylura krefftii* and *Toxotes chatareus* were not preserved.

FLY 75-17.—Mouth of Binge River, a large, strongly flowing tributary of the Middle Fly, 675 km upriver from Toro Pass, 6°32.5'S, 140°55.0'E. 23 November. Gill nets.

Gillnetting provided a catch of 10 species, including *Arius augustus*, *A. carinatus*, and both species of *Cochlefelis*. Large *Pristis microdon*, *Thryssa scratchleyi*, and *Lutjanus argentimaculatus* were not retained.

FLY 75-18.—Lower part of Kai River and mainstream of Middle Fly, 549 km upriver from Toro Pass, 7°04.2'S, 141°06.1'E. 24 November. Water in Kai clear, black, visibility to about 1 m, 26.7° C, pH 6.1. Gill nets.

A large catch of *Megalops cyprinoides*, *Thryssa*

scratchleyi, *Scleropages jardini*, *Arius leptaspis*, *A. cleptolepis*, and *Liza diadema*, all from both the Kai and the Fly mainstream, except *Thryssa scratchleyi*, which was caught only in the mainstream.

FLY 75-19.—Mouth of Agu River, a large, sluggish tributary of the Middle Fly with extensive swampy margins, and mainstream of Middle Fly, 542-546 km upriver from Toro Pass, 7°07.0'S, 141°08.3'E. 25 November. Water in Agu mouth black, clear, 31.7° C, pH 6.1. Gill nets.

A large catch of *Pristis microdon*, *Megalops cyprinoides*, *Scleropages jardini*, *Arius leptaspis*, *A. cleptolepis*, *A. augustus* (Fly mainstream only), *Liza diadema*, and *Lates calcarifer*.

FLY 75-20.—Lake Herbert Hoover (locally known as Lake Boset), Wam River (draining Lake Herbert Hoover), and swampy lagoons along mainstream of Middle Fly, 509-512 km upriver from Toro Pass, 7°14.0'S, 141°08.3'E. 27 November. Gill nets, rotenone.

A total of 30 species were obtained here, more than at any other locality. A small *Pristis microdon* caught in the lake was preserved. Gill nets in the Wam mouth yielded a large catch of *Megalops cyprinoides*, *Nematolosa* cf. *papuensis*, *Thryssa scratchleyi*, *Arius leptaspis*, *A. cleptolepis*, both species of *Cochlefelis*, *Lates calcarifer*, *Datnioides quadrifasciatus*, and *Liza diadema*, most of which could not be preserved. Gill nets in the Fly mainstream yielded *Cochlefelis danielsi* and *Nibeia semifasciata*. Observations on stomach contents were made for many of the larger fishes. Rotenone yielded an excellent collection from swampy lagoons along the Fly mainstream, including the only *Iriatherina wernerii* obtained by the survey, and a huge *Plotosus papuensis* 1 m long (not preserved). Local fishermen reported stingrays here, but we did not see any.

FLY 75-21.—Mouth of lagoon on left side of Middle Fly mainstream 16 km upriver from Everill Junction, 404 km upriver from Toro Pass, 7°31.1'S, 141°18.7'E. 29 November. Gill nets.

Gillnetting yielded many large fish that could not be kept, including *Scleropages jardini*, *Arius leptaspis*, *A. cleptolepis*, *A. augustus*, the first of two huge *Arius* species undetermined caught by the survey. *Cochlefelis danielsi*, *Liza diadema*, and *Lates calcarifer*. Stomach contents of ariids examined.

FLY 75-22.—Swampy side channel of Strickland River midway between Everill and Massy Bakers

junctions, 417 km upriver from Toro Pass, 7°29.7'S, 141°29.4'E. Water turbid, grayish. Rotenone.

A fair collection of 16 species, all preserved.

FLY 75-23.—Mainstream of Strickland two-thirds of the way from Everill Junction to Massy Bakers Junction, 432 km upriver from Toro Pass, 7°29.7'S, 141°29.4'E. 1 December. Water turbid, grayish. Gill nets.

The catch consisted of large *Arius augustus*, *Cochlefelis danielsi*, and *Hemipimelodus macrorhynchus* (none preserved). Observations on stomach contents.

FLY 75-24 (Figure 4d).—Lake Murray within 5 km of Pangoa, 525-530 km upriver from Toro Pass (Pangoa at 7°00.5'S, 141°30.2'E). 3-4 December. Water black, visibility to 1 m, pH 6.7. Gillnets, rotenone.

A total of 23 species were caught in the lake. Gillnetting yielded many large fishes, most of which could not be preserved, including *Pristis microdon*, *Megalops cyprinoides*, *Scleropages jardini*, *Arius leptaspis*, *A. augustus*, *A. cleptolepis*, *Tandanus ater*, *Parambassis gulliveri*, *Lates calcarifer*, *Lutjanus argentimaculatus*, *Acanthopagrus berda*, and *Kurtus gulliveri*. Observations on stomach contents. Collection from swampy margin of lake by rotenone, including *Glossamia narindica* and *Denarius bandata*. Local people reported stingrays and eels in the lake but we did not see any.

FLY 75-25.—Side channel of Strickland 4 km downstream from Massy Bakers Junction, 450 km upriver from Toro Pass, 7°22.6'S, 141°29.0'E. 6-7 December. Water turbid, grayish, pH 7.5. Gill nets, rotenone.

This deep, swiftly flowing channel, with densely vegetated margins of floating grasses and other higher plants, yielded a very large collection of 21 species, including large series of *Clupeoides papuensis*, *Nematolosa* cf. *papuensis*, *Thryssa rastrosa*, and *Nedystoma dayi*. Gill nets in the mouth of the channel yielded a small *Pristis microdon* and two *Nibeia semifasciata*, which were preserved, and many other large fish, which could not be kept, including *Megalops cyprinoides*, *Thryssa scratchleyi*, *Arius augustus*, *Cinetodus froggatti* (snails from stomach preserved), *Cochlefelis danielsi*, *Lates calcarifer*, *Lutjanus argentimaculatus*, *Liza diadema*, *Toxotes chatareus*, and *Kurtus gulliveri*.

FLY 75-26.—Mainstream of Lower Fly 1.5 km upstream from Elangowan Island, 298 km upriver from Toro Pass, 7°49.4'S, 141°39.0'E. 8 December.

Gillnetting yielded many large fishes, most of which could not be kept, including *Pristis microdon*, *Megalops cyprinoides*, *Arius leptaspis*, *A. augustus*, *A. cleptolepis*, *A. carinatus*, *Cinetodus froggatti*, both species of *Cochlefelis*, *Tandanus ater*, *Liza diadema*, and *Nibeia semifasciata*. Observations on stomach contents.

FLY 75-27.—Shallow, muddy backwater open to Lower Fly mainstream opposite mouth of Suki Creek, 264 km upriver from Toro Pass, 7°56.6'S, 141°49.9'E. 10 December. Water turbid, maximum depth 1 m. Rotenone.

Fair collection of small specimens representing 16 species.

FLY 75-28.—Creek strongly influenced by tides on Lower Fly directly E of upriver end of Tidal Island, 236 km upriver from Toro Pass, 7°59.3'S, 142°00.6'E. 11 December. Water turbid, maximum depth at time of collection (low tide) 1 m, pH 6.0. Rotenone.

Good collection of 13 species, 6 of them gobioids, and the only *Moringua penni* taken by the survey.

FLY 75-29.—Lower 5 km of Burei Creek, a large tributary of the Lower Fly, 206-211 km upriver from Toro Pass, 8°11.8'S, 142°00.7'E. 12 December. Water clear, reddish brown. Gill nets.

Gillnetting yielded many large fishes, most of which could not be kept, including *Thryssa scratchleyi*, *Arius leptaspis*, *A. carinatus*, *A. cleptolepis*, the second of the two huge *Arius* species undetermined we caught, *Cinetodus froggatti*, *Cochlefelis danielsi*, *Toxotes chatareus*, and *Nibeia semifasciata*.

FLY 75-30.—Tidal creek on right side of Lower Fly, 1 km upriver from D'Albertis Island, 201 km upriver from Toro Pass, 8°12.9'S, 142°03.9'E. 13 December. Water turbid, maximum depth at time of collection (outgoing tide) 1 m. Rotenone.

Collection of 15 species, including 8 species of gobioids, and a large series of *Aseraggodes klunzingeri*.

FLY 75-31.—Mainstream of Lower Fly at Madiri, 74 km upriver from Toro Pass, 8°27.2'S, 143°03.5'E. 13-14 December. Water extremely turbid. Strong tidal influence and heavy wave action. Gill nets.

Gill nets yielded only *Lates calcarifer* and *Nibeia semifasciata* (not preserved). A series of *Pseudopocryptes confluentus* was captured by hand on a mud flat exposed at low tide.

FLY 75-32.—Outer entrance of Toro Pass at W end of Parama Island, and small mangrove-lined tributary of Guiavi Creek on mainland opposite W

end of Parama Island, 9°01.2'S, 143°21.6'E. 15 December. Water in Toro Pass strongly salty, in mangrove creek sampled slightly brackish or fresh. Gill nets, rotenone.

Gillnetting in Toro Pass yielded *Rhinobatos batillum* Whitley, 1939, three species of marine Ariidae, *Leptobrama mulleri* Steindachner, 1878, and a few more species excluded from the present account of Fly River fishes, as well as small *Lates calcarifer* and *Acanthopagrus berda* (all preserved). Rotenone in the creek yielded 22 species, including very young *Thryssa scratchleyi*, and several species not taken elsewhere by the survey but presumed to be typical inhabitants of the Lower Fly, including *Thryssa brevicauda*, *Pseudomugil inconspicuus*, *Cynoglossus heterolepis*, and *Tetraodon erythrotaenia*.

Systematic Account of the Fly Ichthyofauna

The present account includes all currently recognized species known from the Fly basin. All specimens collected during the 1975 ichthyological survey from collecting stations Fly 75-1 through -32 are included except specimens taken at Fly 75-32 by gillnetting near the open sea at the W end of Parama Island. The 1975 collection includes all species known from the Fly except *Scatophagus argus*, *Therapon lorentzi*, and *Larimichthys pamoides*. Apart from a few specimens indicated in the text that were sent to the British Museum (Natural History) (BMNH), American Museum of Natural History (AMNH), and Zoological Museum of Amsterdam (ZMA), the entire collection has been deposited in the Division of Fishes in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., under the catalog numbers of the former United States National Museum (USNM).

Descriptions are included for about a third of the species herein reported from the Fly, including 11 new species and several forms closely related to them. All of the Ariidae are presented with descriptions, as are the two species of Plotosidae with dendritic organs. Descriptions are not provided for the plotosids without dendritic organs because they are in the process of revision by Gareth Nelson and Norma Feinberg. The Indo-Pacific Clupeidae and Engraulidae are being revised by Peter Whitehead and Thosaporn Wongratana, and they are studying the material herein reported as *Nematalosa* cf. *papuensis* to determine

whether one or two species are involved. The material of Melanotaeniidae is being examined by Gerald Allen as part of his revisionary study of this family. Detailed descriptions of all species of Theraponidae known from the Fly have been published by Mees and Kailola (1977), who incorporated some of my Fly material in their study.

PRISTIDAE

Pristis microdon Latham, 1794

USNM 217001, Fly 75-20, 1: 809 mm total length.
USNM 217002, Fly 75-25, 1: 916 mm total length.

This sawfish is common in the Middle Fly. Individuals were gillnetted at Fly 75-17, -19, -24, and -26, as well as -20 and -25.

MEGALOPIDAE

Megalops cyprinoides (Broussonet, 1772)

FIGURE 6

USNM 217003, Fly 75-13, 1: 440 mm.
USNM 217004, Fly 75-19, 1: 379 mm.
USNM 217005, Fly 75-20, 1: 406 mm.

MORINGUIDAE

Moringua penni Schultz, 1953

USNM 217006, Fly 75-28, 1: 101 mm.

MURAENIDAE

Thyrsoidea macrura (Bleeker, 1854)

USNM 217007, Fly 75-32, 1: 575 mm.

CLUPEIDAE

Clupeoides papuensis (Ramsay and Ogilby, 1887)

USNM 217008, Fly 75-1, 74: 17.9-70.1 mm.
USNM 217009, Fly 75-2, 1: 31.7 mm.
USNM 217010, Fly 75-4, 5: 24.1-54.1 mm.
USNM 217011, Fly 75-5, 129: 22.4-76.8 mm (20 to BMNH).
USNM 217012, Fly 75-13, 33: 28.5-40.9 mm.

USNM 217013, Fly 75-20, 51: 16.9-47.0 mm.
USNM 217014, Fly 75-22, 31: 17.6-40.8 mm.
USNM 21E015, Fly 75-24, 1: 30.4 mm.
USNM 217016, Fly 75-25, 310: 13.2-48.6 mm.
USNM 217017, Fly 75-27, 17: 16.2-44.1 mm.

Clupeoides Bleeker, 1851 (type-species *C. borneensis* Bleeker, 1851, by original designation), occurs in rivers of continental Southeast Asia (including Borneo and Sumatra) as well as the Australian Region. Within the Australian Region its range is limited to that of the two endemic species in the rivers of central-southern New Guinea; both are present in the Fly.

Clupeoides papuensis in the Fly inhabits lowland rivers with sand or mud bottom, feeding on zooplankton and small aquatic insect larvae. Eye diameter 14.4-14.9. Maxillary bone relatively long and slender, extending posteriorly almost to below middle of eye. Teeth in anterior portion of lower jaw relatively large compared to those in *C. venulosus*. Lower limb of first gill arch with 17-19 gill rakers. Body relatively slender, its depth at origin of dorsal fin 4.6-5.3; depth of caudal peduncle 10.0-10.8. Prepelvic abdominal scutes 10-11, postpelvic scutes 8-9. Origin of dorsal fin midway between tip of snout and base of caudal fin.

Clupeoides venulosus Weber and de Beaufort, 1912

USNM 217018, Fly 75-8, 8: 63.5-74.2 mm (2 to BMNH).
USNM 217019, Fly 75-10, 4: 43.0-66.8 mm.

Clupeoides venulosus in the Fly is allopatric to *C. papuensis*, inhabiting mountain rivers with gravelly or stony bottom and feeding on small aquatic insect larvae. Eye diameter 15.2-15.4. Maxillary bone relatively short and stout, extending posteriorly to or almost to below anterior margin of eye. Teeth in anterior portion of lower jaw smaller than in *papuensis*. Lower limb of first gill arch with 15-17 gill rakers. Body relatively deep, its depth at origin of dorsal fin 3.6-4.0; depth of caudal peduncle 8.4-9.0. Prepelvic abdominal scutes 8-10, postpelvic scutes 7-8. Origin of dorsal fin nearer tip of snout than base of caudal fin by a distance equal to eye diameter.

Clupeoides venulosus is of considerable interest as the only clupeid known to inhabit mountainous rivers. Apart from my material collected in the Upper Fly, it is known only from the Lorentz River, without precise indication of habitat. During a visit to the

Zoological Museum of Amsterdam, I examined all of the material identified as *C. venulosus*: eight lots, ZMA 100.933–940. Only three of these lots, 936, 939, and 940 were correctly identified. The identity of the species in the other five lots was not determined; perhaps some species from Southeast Asia have become mixed with lots having locality labels for the Lorentz River. The statement by Weber (1913a: 518) that young *C. venulosus* have the maxillary bone reaching farther posteriorly and better developed abdominal scutes is based on misidentified specimens. ZMA 100.939 (three specimens) and possibly ZMA 100.936 (five specimens) are syntypes. Han Nijssen and I have identified a 96-mm specimen from 939 as probably identical with the specimen figured in the original description (Weber and de Beaufort, 1912, fig. 1): it has been recataloged as ZMA 114.870 and is hereby designated lectotype of *Clupeoides venulosus*. The locality where this lot was collected is not known precisely but is probably near Alkmaar, where the Lorentz becomes mountainous: the specimens were brought to Alkmaar by the Gooszen Expedition along with specimens of the montane plotosid *Tandanus equinus* (Weber, 1913a: 514, 528). ZMA 100.936 was collected near Alkmaar by H. A. Lorentz on the Nederlands Nieuw Guinea Expedition of 1909, and ZMA 100.940 at "kloofbivak" by G. Versteeg on the Zuid Nederlands Nieuw Guinea Expedition of 1912. I conclude that all *C. venulosus* collected in the Lorentz River were probably also from mountain rivers.

***Herklotsichthys castelnaui* (Ogilby, 1897)**

USNM 217020, Fly 75–32, 6: 24.2–31.4 mm.

This species was kindly identified by Thosaporn Wongratana.

***Nematalosa* cf. *papuensis* (Munro, 1964)**

USNM 217021, Fly 75–5, 6: 50.1–202 mm.

USNM 217022, Fly 75–6, 25: 152–221 mm.

USNM 217023, Fly 75–20, 10: 33.6–208 mm.

USNM 217024, Fly 75–22, 31: 18.9–76.8 mm.

USNM 217025, Fly 75–24, 10: 26.5–48.6 mm.

USNM 217026, Fly 75–25, 253: 24.9–102.3 mm (7 to BMNH).

USNM 217027, Fly 75–27, 9: 32.9–82.2 mm.

The material of *Nematalosa* obtained by the 1975 Fly survey represents the first extensive samples of

this genus from central-southern New Guinea. Only five specimens from this area, one from Lake Murray and four from the Digul, were available for examination by Nelson and Rothman (1973) in their revision of Indo-Pacific Dorosomatinae. They identified these five specimens as *N. erebi* (Günther, 1868), to the synonymy of which they tentatively referred *N. papuensis* (1973:152–158). T. Wongratana has examined some of my specimens from the Fly and finds they differ from *N. erebi*, the holotype of which he has studied.

The Fly *Nematalosa* pose an unusual systematic problem. The large specimens from Fly 75–6 fall into two fairly clear-cut groups, one with short gill rakers and long gill filaments, the other with long gill rakers and short gill filaments. The two kinds were first distinguished in the field not by the gill rakers, but by the lower jaw, which is longer and more up-turned in those with long gill rakers. Representatives of both kinds were repeatedly taken together in the same gill net, under circumstances indicating that they had been schooling together. The coloration of live fish, overall silvery with an orange or golden opercle, appeared identical in both kinds. As a consequence of these observations, efforts were made to catch more *Nematalosa*, all of which were preserved. The specimens from Fly 75–5, –20, and –27 all have more or less short gill rakers, but those from Fly 75–22, –24, and –25 include both kinds, and at Fly 75–25 many of the specimens are intermediate. The variation exhibited by the gill rakers is in fact more complicated than indicated by these remarks, since the number of gill rakers increases markedly with growth, and is extremely variable among individuals of any given size. Thus in two 55-mm specimens with short gill rakers from Fly 75–25, one has 90 gill rakers on the lower limb of the first gill arch, the other 160! This material is being studied by T. Wongratana.

ENGRAULIDAE

***Setipinna papuensis* Munro, 1964**

USNM 217028, Fly 75–32, 2: 31.6–32.3 mm.

***Stolephorus indicus* (van Hasselt, 1823)**

USNM 217029, Fly 75–32, 1: 59.8 mm.

This species was kindly identified by T. Wongratana.

***Stolephorus bataviensis* Hardenberg, 1933**

USNM 217030, Fly 75-32, 2: 26.6-41.4 mm.

This species was kindly identified by T. Wongratana.

***Thryssa scratchleyi* (Ramsay and Ogilby, 1887)**

FIGURE 10a

USNM 217031, Fly 75-4, 3: 251-371 mm.

USNM 217032, Fly 75-5, 5: 246-285 mm.

USNM 217033, Fly 75-6, 3: 196-301 mm.

USNM 217034, Fly 75-18, 1: 208 mm.

USNM 217035, Fly 75-25, 4: 94.4-109 mm (1 to BMNH).

USNM 217036, Fly 75-30, 1: 111 mm.

Five species of *Thryssa* were collected during the 1975 Fly survey, two of which are undescribed. In assigning these species to *Thryssa* Cuvier, 1829 (type-species *Clupea setirostris* Broussonet, 1782, by subsequent designation of Jordan, 1917; see Whitehead, 1967:140-141), I am following the advice of Whitehead and Wongratana (in litt.), who are currently engaged in revisionary studies of Engraulidae. Only



FIGURE 10.—*Thryssa*: a, *T. scratchleyi*, USNM 217035, 101 mm; b, *T. rastrosa*, holotype, USNM 217038, 108.7 mm; c, *T. brevicauda*, paratype, USNM 217044, 55.5 mm.

T. scratchleyi and *T. rastroso* are present in the Upper and Middle Fly.

Thryssa scratchleyi is of interest for its large size, being the largest member of the family Engraulidae, and because it may have a catadromous life history. Large adults are common in the Upper, Middle, and Lower Fly; the largest specimen known is 371 mm (Fly 75-4). Adults are piscivorous. Lower jaw relatively long, extending anteriorly almost to tip of snout, but maxillary bone not extending posteriorly beyond opercle. Diameter of eye 16.0-17.2. Gill rakers on anterior face of first gill arch 15-18 + 18-20 in specimens over 90 mm; 5-6 gill rakers on posterior face of third gill arch. Total anal fin rays 38-42. Scales in lateral series 43-44. Abdominal scutes 17-19 + 10-12. Tips of pelvic fins extending posteriorly beyond a vertical line through origin of dorsal fin. Free vertebral centra 43-46. Length of caudal peduncle 10.2-10.3. No humeral pigment blotch. No nuchal pigment blotch.

***Thryssa rastroso*, new species**

FIGURE 10b

USNM 217038, Holotype, Fly 75-5, 108.7 mm.
 USNM 217039, Paratype, Fly 75-6, 116.2 mm.
 USNM 217040, Paratypes, Fly 75-22, 14: 33.0-48.7 mm.
 USNM 217041, Paratype, Fly 75-24, 73.0 mm.
 USNM 217042, Paratypes, Fly 75-25, 80: 29.2-80.6 mm (4 to BMNH).

This zooplanktophagous species, inhabiting the mainstream and tributaries of the Upper and Middle Fly, is notable for its exceptionally numerous gill rakers, which apparently increase in number as long as growth continues. Four paratypes have the following numbers of gill rakers on the anterior face of the first gill arch: 33.0 mm, 27+41; 48.7 mm, 35+51; 73.0 mm, 43+61; 116.2 mm, 59+78. (No previously described *Thryssa*, and no engraulid species from the Indian Ocean or tropical Western Pacific, is known with more than 30 gill rakers on the lower limb of the first gill arch.) Lower jaw not extending so far anteriorly as in *T. scratchleyi*. Maxillary bone not extending posteriorly beyond opercle. Eye diameter 12.9-14.5. Gill rakers absent on posterior face of third gill arch. Total anal fin rays 33-36. Scales in lateral series 40-41. Abdominal scutes 16-19+10-11. Tips of pelvic fins extending posteriorly beyond a vertical through origin of dorsal fin. Complete ver-

tebrae 43-44. Caudal peduncle length 9.4-11.8. No humeral or nuchal pigment blotch.

***Thryssa brevicauda*, new species**

FIGURE 10c

USNM 217043, Holotype, Fly 75-32, 49.4 mm.
 USNM 217044, Paratypes, Fly 75-32, 30: 30.3-56.5 mm (5 to BMNH).

Thryssa brevicauda is known only from a single series of (juvenile?) specimens from a mangrove creek in the Lower Fly, the largest of which is 56.5 mm. Feeding habits unknown. Lower jaw relatively short, extending anteriorly to a point considerably short of snout tip. Maxillary bone not extending posteriorly to beyond opercle. Diameter of eye 14.6-17.5. Gill rakers on anterior face of first gill arch 22-25 + 27-29; 5-7 gill rakers on posterior face of third gill arch. Total anal fin rays 32-36. Scales in lateral series 34-36. Abdominal scutes 14-16 + 9. Tips of pelvic fins extending posteriorly beyond a vertical line through origin of dorsal fin. Free vertebral centra 38-40 (usually 39). Length of caudal peduncle 8.8-9.2. No humeral pigment blotch. A diffuse nuchal pigment blotch well developed in all specimens.

Thryssa brevicauda agrees with *T. scratchleyi* and *T. rastroso*, and differs from all or almost all other *Thryssa*, in having maxillary bone not extending posteriorly beyond opercle, tips of pelvic fins extending posteriorly to a vertical line through origin of dorsal fin, and no humeral pigment blotch. It differs from *T. scratchleyi* and *T. rastroso* in having a diffuse nuchal pigment blotch, fewer scales, fewer abdominal scutes, fewer vertebrae, and a relatively short, deep caudal peduncle.

***Thryssa spinidens* (Jordan and Seale, 1925),
 new combination**

USNM 217045, Fly 75-32, 1: 118 mm.

This species was kindly identified by T. Wongratana.

***Thryssa hamiltoni* Gray, 1834**

USNM 217037, Fly 75-32, 14: 26.9-47.8 mm (2 to BMNH).

This species was kindly identified by T. Wongratana. The specimens have maxillary bone extending pos-

teriorly beyond opercle; the total number of anal fin rays 38–42; complete vertebral centra 43(1), 44(12), 45(1). The 47.8-mm specimen has 9+14 gill rakers on anterior face of first gill arch. The humeral pigment blotch characteristic of adult *T. hamiltoni* is not developed in these juveniles.

OSTEOGLOSSIDAE

Scleropages jardini (Kent, 1892)

USNM 217046, Fly 75–4, 2: 257–405 mm.

USNM 217047, Fly 75–6, 1: 407 mm.

USNM 217048, Fly 75–16, 1: 110 mm.

USNM 217049, Fly 75–20, 1: 213 mm.

Lake (1971:17) recognizes two species of *Scleropages* in the Australian Region: *S. leichardti* Günther, 1864, confined to the Fitzroy River system in southern Queensland, and *S. jardini* in central-southern New Guinea and in some Australian rivers flowing into the Gulf of Carpentaria and the Timor Sea. According to Lake and Midgley (1970) *S. leichardti* are essentially insectivorous and “have straight backs and in this attitude their mouths are in a superior position” whereas *jardini* feed more on crustaceans and “have a bowed back . . . their mouth pointing more forward than upward”; they also state, but without providing data or further explanation, that there are differences in meristics and coloration. According to Lake (1971) *S. leichardti* tolerates colder temperatures than *S. jardini*, which he refers to as the “northern spotted barramundi.”

Scleropages jardini is the only fish species inhabiting fresh water in New Guinea that has been considered to be a primary division freshwater fish, all of the others clearly belonging to secondary or peripheral division freshwater groups. The geographical distribution of *Scleropages*, with two species in the Australian Region and a closely related third species in Thailand, Malaya, Sumatra, and Borneo, suggests a relatively late marine dispersal. I do not know of any

published reports on salinity tolerance of Osteoglossidae. At my request Alfred D. Castro of Steinhart Aquarium in San Francisco tested a 400-mm adult specimen of the Southeast Asian *Scleropages formosus* (Müller and Schlegel, 1844) for salinity tolerance. From 21 June to 18 September 1977, salinity was gradually increased from 0 to 8 parts per thousand (salinity of undiluted sea water is usually 35–38 parts per thousand) without any apparent effect on the fish. On 22 September salinity was increased from 7 ppt to 8 ppt, and its coloration lightened dramatically but it continued feeding normally and no other effects were noted. From 25 September to 13 October, salinity was gradually increased to 14 ppt, at which point the fish stopped feeding. After one week at 14 ppt it still had not fed; from 13 October to 19 October, salinity was gradually lowered to 9 ppt, and on 23 October feeding resumed. From 23 October to 30 October, salinity was increased to 13.5 ppt, and feeding stopped again. From 30 October to 30 November the fish was kept at 9 ppt. From 30 November to 12 December salinity was increased to 18 ppt, at which point the fish lost equilibrium and turned belly-up. Salinity was rapidly reduced to 10 ppt and then 5 ppt, but the fish did not recover and died on 19 December 1977. These results indicate a greater salinity tolerance than might be expected for a primary freshwater fish, but it should be kept in mind that very little experimentation has been done on this topic.

ARIIDAE

All or almost all of the riverine Ariidae of New Guinea are restricted to freshwater, and, with the exception of *Arius leptaspis*, are confined to New Guinea. In the key below all but three of the species—*Arius latirostris* Macleay, 1884, *Doichthys novae-guineae* Weber, 1913, and *Tetranesodon conorhynchus* Weber, 1913—are known from the Fly. All of the Fly species are illustrated in Figures 11–23.

Key to Riverine Ariidae of Southern New Guinea

1. Palatal teeth present 2
 Palatal teeth absent 11
2. Tooth band of upper jaw entirely exposed when mouth is closed; jaw teeth flattened distally, their tips with sharp lateral margins; inner pair of mental barbels extending farther posteriorly than external pair of mental barbels (*Cochlefelis*) 3
 Tooth band of upper jaw partially or entirely hidden when mouth is closed; jaw teeth simply conical, without modified tips; inner pair of mental barbels not extending so far posteriorly as outer pair of mental barbels 4
3. Eyes dorsolateral; snout slightly pointed, projecting beyond tooth band of upper jaw by a distance about equal to diameter of eye; barbels with a membranous inner margin; first gill arch with 15–16 gill rakers *Cochlefelis spatula*
 Eyes lateral; snout broadly rounded, projecting only a small fraction of eye diameter beyond tooth band of upper jaw; barbels without a membranous inner margin; first gill arch with 15–16 gill rakers *Cochlefelis danielsi*
4. Gill membranes broadly united to isthmus, gill openings restricted to sides of head *Cinetodus froggatti*
 Gill membranes free from isthmus, gill openings extending far anteriorly below head . . 5
5. A shallow transverse depression or groove on dorsum of snout between posterior nostrils; palate with a pair of lateral tooth patches and a single large, median tooth patch *Arius cleptolepis*
 No transverse depression or groove on snout between nostrils; palate with a pair of lateral tooth patches and with or without a small pair of inner tooth patches 6
6. Eyes ventrolateral; palate with lateral tooth patches only (?); lower limb of first gill arch with 30 or more gill rakers *Doiichthys novaeguineae*
 Eyes lateral or dorsolateral; palate with two well-developed pairs of tooth patches; lower limb of first gill arch with 15 or less gill rakers 7
7. Barbels extremely short, maxillary barbels reaching halfway or less to pectoral spine base *Arius augustus*
 Barbels relatively long, maxillary barbels usually reaching to or beyond pectoral spine base 8
8. Eyes dorsolateral, eye diameter more than 30 times in standard length 9
 Eyes lateral, eye diameter 30 or fewer times in standard length 10
9. Head narrowed anteriorly; gape relatively narrow, nearly straight transversely; posterior face of second gill arch with relatively well-developed gill rakers *Arius carinatus*
 Head broad anteriorly; gape broad, strongly curved transversely; posterior face of second gill arch without gill rakers *Arius stirlingi*
10. Snout slightly pointed; young of less than 200 mm with a soft, fleshy projection of snout; adults of more than 400 mm with a broad median depression on dorsum of snout between prominent ridgelike anterolateral wings of cephalic shield and a pronounced nuchal hump; dorsum uniformly gray or purplish gray in life *Ariusacrocephalus*
 Snout slightly pointed; young of less than 300 mm unknown; adults over 300 mm with a straight dorsal profile anteriorly, without a broad median depression on snout, without prominent ridgelike anterolateral processes of cephalic shield, and without a nuchal hump; color in life unknown *Arius latirostris*
 Snout broadly rounded; young without a soft, fleshy projection of snout; adults with a straight dorsal profile anteriorly, without a broad median depression on snout, without prominent ridgelike anterolateral processes of cephalic shield, and without a nuchal hump; dorsum bluish black, purplish, or wine red in life, usually with a series of vertical rows of iridescent gold, round spots centered on dorsolateral lateral line organs *Arius leptaspis*
11. First gill arch with 32–35 gill rakers; roof of pharynx with greatly enlarged folds or valves *Nedystoma dayi*
 First gill arch with 18 or less gill rakers; folds or valves in roof of pharynx absent or weakly developed 12

12. Barbels extremely short, maxillary barbel reaching only halfway or less to pectoral spine base; eyes dorsolateral 13
 Barbels relatively long, maxillary barbel reaching to or beyond pectoral spine base; eyes usually lateral or slightly ventrolateral 14
13. Lips thickened internally but not externally; first gill arch with 14 gill rakers *Tetranesodon conorhynchus*
 Lips fleshy, excessively thickened externally; first gill arch with 18 gill rakers *Hemipimelodus crassilabris*
14. Snout flattened or concave dorsally, strongly indented at nostrils, and sharply pointed; barbels blackish brown and relatively long, maxillary barbel extending beyond tip of pectoral spine *Hemipimelodus macrorhynchus*
 Snout slightly rounded or convex dorsally, not indented at nostrils, and moderately pointed; barbels gray or pale and moderately long, maxillary barbel extending only to middle of pectoral spine *Hemipimelodus taylori*

***Arius leptaspis* (Bleeker, 1862)**

FIGURES 11, 20a

USNM 217050, Fly 75-5, 2: 308-479 mm.

USNM 217051, Fly 75-6, 1: 440 mm.

USNM 217052, Fly 75-19, 1: 328 mm.

USNM 217053, Fly 75-26, 1: 249 mm.

USNM 217054, Fly 75-30, 1: 130 mm.

Arius Cuvier and Valenciennes, 1840 (type-species *Pimelodus arius* Hamilton-Buchanan, 1822, by tautonymy), as herein employed, includes most ariid species with palatal teeth.

Arius leptaspis is widely distributed in freshwater in Australia (Lake, 1971:23) as well as in central-southern New Guinea, and has been reported from northern New Guinea. It is common in lakes, lagoons, and tributaries of the Middle Fly. It is a broad-mouthed, broad-headed species; snout broadly rounded; tooth band of upper jaw completely or almost completely included when mouth is closed. Maxillary barbel reaching beyond tip of pectoral spine in specimens under 200 mm, shorter in larger specimens but always reaching beyond origin of pectoral spine. Eyes lateral, 19-30 in specimens 126-479 mm (negatively allometric). Gill rakers on first gill arch usually 15-17 (but see below); gill rakers absent on posterior faces of first and second gill arches. Upper limb of second gill arch with only a slight thickening, scarcely noticeable. Snout without soft anterior projection. Dorsum of head broadly rounded from side to side, with a narrow median groove (often poorly developed or obscured by mucus and skin). Pectoral fin usually with 11 segmented rays. Anal fin pterygiophores 18. Free vertebral centra posterior to Weberian apparatus 46-49 (3: 130-294 mm). Color in life: dorsum bluish black, dark purplish, or

dark wine red; usually a series of vertical rows of iridescent golden round spots centered on dorsolateral lateral line organs, a coloration not occurring in any other Fly ariid; ventrum white.

Two specimens from the Lorentz River (ZMA 115.066, 129-135 mm), otherwise similar to *A. leptaspis* from the Fly, have 20 and 22 gill rakers on the first gill arch (6+1+13 and 8+1+13). Bleeker's holotype (RMNH 3060, 207 mm, from SW coast of New Guinea) has 15 on its left side and 16 on its right (5+1+9 and 5+1+10).

***Arius acrocephalus* Weber, 1913**

FIGURES 12, 20b

Arius digulensis Hardenberg, 1936:369 [Middle Digul River].

USNM 217055, Fly 75-1, 2: 323-479 mm.

ZMA 115.537, Fly 75-3, 1: 447 mm.

USNM 217056, Fly 75-4, 3: 313-376 mm.

USNM 217057, Fly 75-6, 1: 344 mm.

USNM 217058, Fly 75-8, 5: 117-361 mm.

USNM 217059, Fly 75-9, 2: 134-175 mm.

USNM 217060, Fly 75-10, 14: 97.8-198 mm.

USNM 217061, Fly 75-14, 1: 235 mm.

Arius acrocephalus is apparently endemic to the rivers of central-southern New Guinea. It is the only ariid known from highland habitats of the Upper Fly and is very common in lowland habitats of the Upper Fly, but it was not observed in the Middle or Lower Fly. It is a moderately broad-headed, broad-mouthed species; snout slightly pointed; tooth band of upper jaw largely included to half-exposed when mouth is closed. Maxillary barbel usually reaching to or slightly beyond origin of pectoral spine. Eyes lateral, 22-26 in specimens 175-361 mm (slight negative allometry).



FIGURE 11.—*Arius leptaspis*: a, USNM 217054, 130 mm; b-d, USNM 217052, 328 mm.

Gill rakers on first gill arch 14-16; no gill rakers on posterior face of first and second gill arches. Upper limb of second gill arch with a thickened, papillate lobe (evident in specimens of 75-447 mm); similar but much smaller lobes present on upper limbs of other free gill arches. Young and juveniles with a soft anterior projection of snout, particularly pro-

nounced in specimens of 75-100 mm. Specimens over 200 mm have a broad median depression on dorsum of snout between prominent ridge- or browlike anterolateral wings of cephalic shield, and a pronounced nuchal hump. Pectoral fin usually with 11 segmented rays. Anal fin pterygiophores 20-22. Free vertebral centra posterior to Weberian apparatus 45-49 (6:



FIGURE 12.—*Arius acrocephalus*: a, USNM 217059, 134 mm; b-d, USNM 217055, 479 mm.

152–235 mm). Color in life: dorsum uniformly plain gray or purplish gray, ventrum whitish.

Syntypes of *A. acrocephalus* (ZMA 11.090, 193 mm, and ZMA 11.088, 2: 75–91 mm) are practically identical in all respects with specimens of comparable size from the Fly. The holotype of *A. digulensis* (520 mm total length) has the pronounced nuchal hump

and deep dorsomedian depression of the snout characteristic of large *A. acrocephalus*. Han Nijssen has kindly compared it with my 447-mm specimen from the Fly (ZMA 115.537) and finds that they belong to the same species.

Arius acrocephalus is perhaps most closely related to the poorly known *Arius latirostris* Macleay, 1884,

the only *Arius* species of southern New Guinea rivers that has not been positively or tentatively identified from the Fly. Macleay did not designate a holotype. The statement "length, 20 inches" (Macleay, 1884: 278) implies but does not prove that he had only a single specimen. I have examined four specimens from Goldie River, the type-locality, deposited in the Australian Museum, Sydney. Three of these specimens, I.9072-9074, 456-462 mm, are cataloged as syntypes; they are all substantially more than 20 inches in total length and less than that in standard length. The fourth specimen, I.13398, 312 mm, clearly belongs to the same species. *Arius latirostris* is moderately broad headed and broad mouthed; snout slightly pointed; barbels moderately long, maxillary barbel reaching posteriorly beyond base of pectoral fin spine. Oral tooth bands similar in size and shape to those of *A. acrocephalus* (see Figure 20*b*); tooth band of upper jaw partially exposed when mouth is closed (possibly due to poor preservation). Eyes lateral, 23-29. Gill rakers on first gill arch 15-17; posterior face of second gill arch with 0-4 + 0 gill rakers; upper limb of second gill arch with a thick lobe. Dorsal profile of head straight: snout without pronounced median depression or browlike ridges, nuchal hump absent. Basal portion of occipital process of head shield about twice as wide as in *A. acrocephalus*. Pectoral fin with 11 segmented rays. Anal fin pterygiophores 19(1). Free vertebral centra posterior to Weberian apparatus 46(2). Abdomen with small,

widely scattered melanophores (absent in Fly *Arius*). Berra et al. (1975) identified numerous recently collected specimens from the Laloki (= Goeldi) River as *A. latirostris*; I have examined the lots that were deposited in the Smithsonian (USNM 210752, 210801, 210832, 210840, 210851, and 210858) and find they are *A. acrocephalus*.

Arius carinatus Weber, 1913

FIGURES 13, 20*c*

USNM 217062, Fly 75-17, 1: 368 mm.

USNM 217063, Fly 75-26, 2: 325-364 mm.

USNM 217064, Fly 75-29, 1: 380 mm.

Arius carinatus is endemic to rivers of central-southern New Guinea. Only four specimens were caught during the 1975 Fly survey, three from the Middle Fly and one from the Lower Fly. It is a narrow-mouthed species, the head narrowed anteriorly, with distinctively shaped tooth bands (Figure 20*c*). About two-thirds of tooth band of upper jaw exposed when mouth is closed. Snout prominent, projecting beyond mouth opening by a distance about equal to eye diameter. Mouth inferior, with a nearly straight transverse gape. Maxillary barbel variable in length, extending posteriorly as little as three-fourths of distance to pectoral spine base or as much as to end of anterior one-third of pectoral spine. Eyes dorsolateral, 38-41 in specimens 325-380 mm. Gill

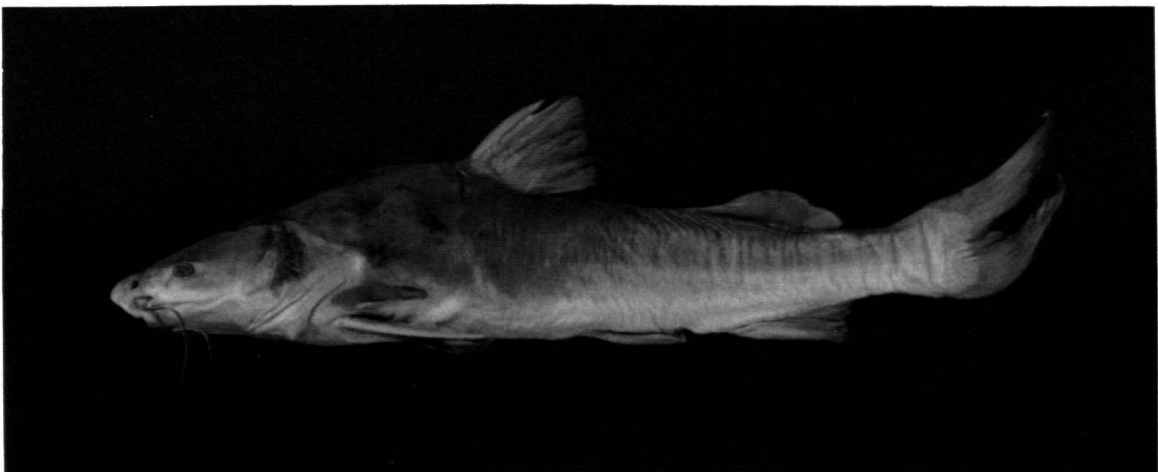


FIGURE 13.—*Arius carinatus*, USNM 217062, 368 mm.

rakers on first gill arch 17–18; posterior faces of first and second gill arches with relatively well-developed gill rakers. Roof of pharynx and upper limbs of second and third gill arches with folds or valves projecting into branchial passages. Head shield strongly granulated, with a well-developed median nuchal carina; posterolateral processes of head shield (immediately dorsal to gill opening) exposed and strongly granulated. Pectoral fin usually with 11 segmented rays. Anal fin pterygiophores 16. Free vertebral centra posterior to Weberian apparatus 44 (2: 325–364 mm). Color in life: dorsum reddish or brownish with golden or bronzy reflections, ventrum white; pectoral fins with dense black pigmentation dorsally.

Arius augustus, new species

FIGURE 14, 20*d*

USNM 217065, Holotype, Fly 75–17, 342 mm.

USNM 217066, Paratypes, Fly 75–17, 2: 288–308 mm.

USNM 217067, Paratype, Fly 75–6, 412 mm.

USNM 217068, Paratypes, Fly 75–25, 2: 91.0–101.7 mm.

Arius augustus, only one specimen of which was caught in the Upper Fly, is fairly common in large tributaries of the Middle Fly, where it attains 500–600 mm. This piscivorous species is readily distinguished from all other New Guinea *Arius* by its extremely short barbels, very small eyes, distinctive, graceful form, and vivid blue coloration in life. It is broad headed and broad mouthed; tooth band of upper jaw entirely or almost entirely included when mouth is closed. Maxillary barbel extending posteriorly a maximum of half the distance from its origin to that of pectoral spine. Eyes slightly dorsolateral, 24–39 in specimens 91–412 mm (negatively allometric). Gill rakers on first gill arch 21; gill rakers absent on posterior face of first and second gill arches. Upper limbs of gill arches without epithelial thickenings; pharyngeal roof with thin, low-lying longitudinal folds, without well-developed lobes or valves projecting into branchial passage. Dorsum of head smooth or finely granular and broadly rounded from side to side, with a narrow median groove (sometimes indiscernible). No nuchal hump. Pectoral fin with 11

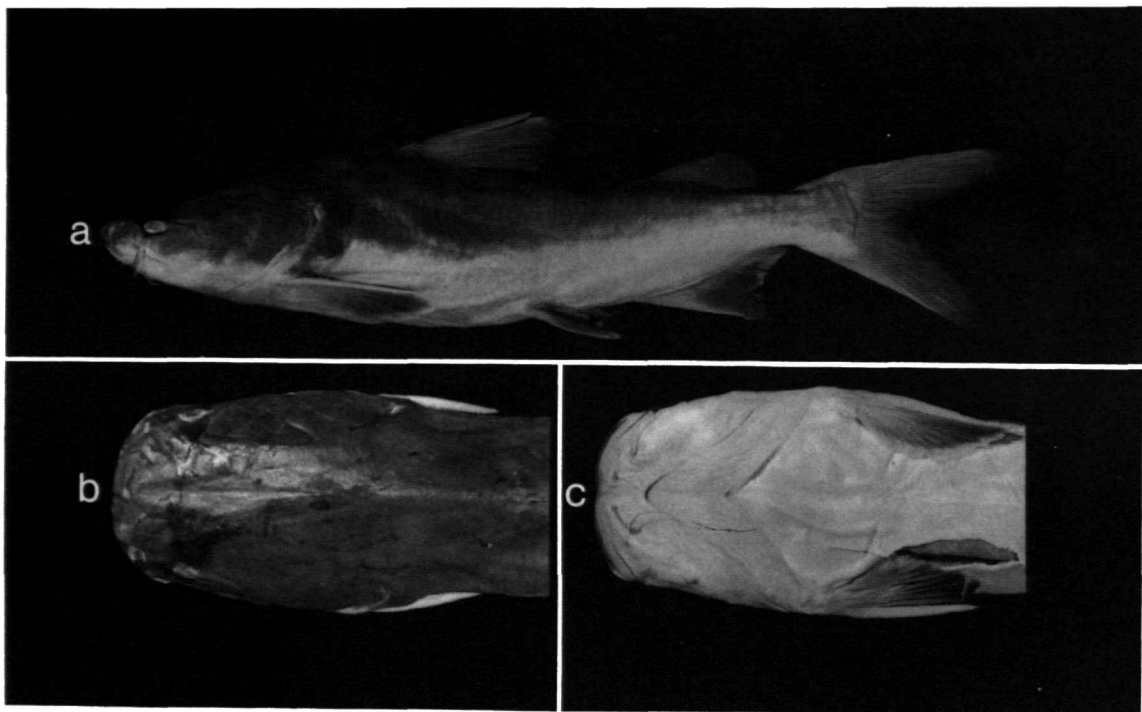


FIGURE 14.—*Arius augustus*, holotype, USNM 217065, 342 mm: a, lateral view; b, dorsal view; c, ventral view.

segmented rays. Anal fin pterygiophores 20–21. Caudal fin deeply forked, caudal peduncle relatively slender. Free vertebral centra 49–51 (3: 288–308 mm). Color in life: dorsum vivid sky blue with violaceous hues, ventrum milk white.

Arius augustus is perhaps most closely related to *A. leptaspis*. The shape of the head and mouth is almost identical in these two species and unlike that in other ariids inhabiting the rivers of central-southern New Guinea.

***Arius cleptolepis*, new species**

FIGURES 15, 20e

USNM 217069, Holotype, Fly 75–3, 309 mm.

USNM 217070, Paratype, Fly 75–5, 218 mm.

USNM 217071, Paratypes, Fly 75–6, 6: 141–375 mm.

USNM 217072, Paratype, Fly 75–20, 225 mm.

Arius cleptolepis is common in lakes, lagoons, and large rivers in the Middle Fly, and is also present in lowland habitats in the Upper Fly. It is narrow headed and narrow mouthed, and distinguished from all other ariids in rivers of central-southern New Guinea in having a shallow transverse pit or groove on dorsum of snout between posterior nostrils, and

palate with a large, median tooth patch, discernible in all specimens. Head shield strongly granulated, with a moderate dorsomedian groove, narrow posteriorly, broadening anteriorly. Oral tooth bands of distinctive shape, entirely included when mouth is closed. Maxillary barbel black, extending posteriorly to middle of pectoral spine. Gill rakers on first gill arch 18–19; well-developed gill rakers present on posterior faces of first and second gill arches. Roof of pharynx with small folds or valves suggestive of large structures in *Nedystoma dayi*. Eyes lateral, 15–22 in specimens 141–375 mm (negatively allometric). Pectoral fin with 10–11 segmented rays. Anal fin with 16–17 pterygiophores. Caudal fin deeply forked, upper lobe longer than lower lobe. Free vertebral centra posterior to Weberian apparatus 43–44 (6: 141–375 mm). Color in life: dorsum black or bluish black, ventrum whitish.

***Arius cf. stirlingi* Ogilby, 1898**

FIGURE 16a

Two large *Arius* gillnetted at Fly 75–21 and –29, 1.1 and 1.2 m (not preserved), differed from all other Ariidae known from the Fly. Tooth band of upper jaw largely exposed when mouth closed. Eyes dorsolateral,

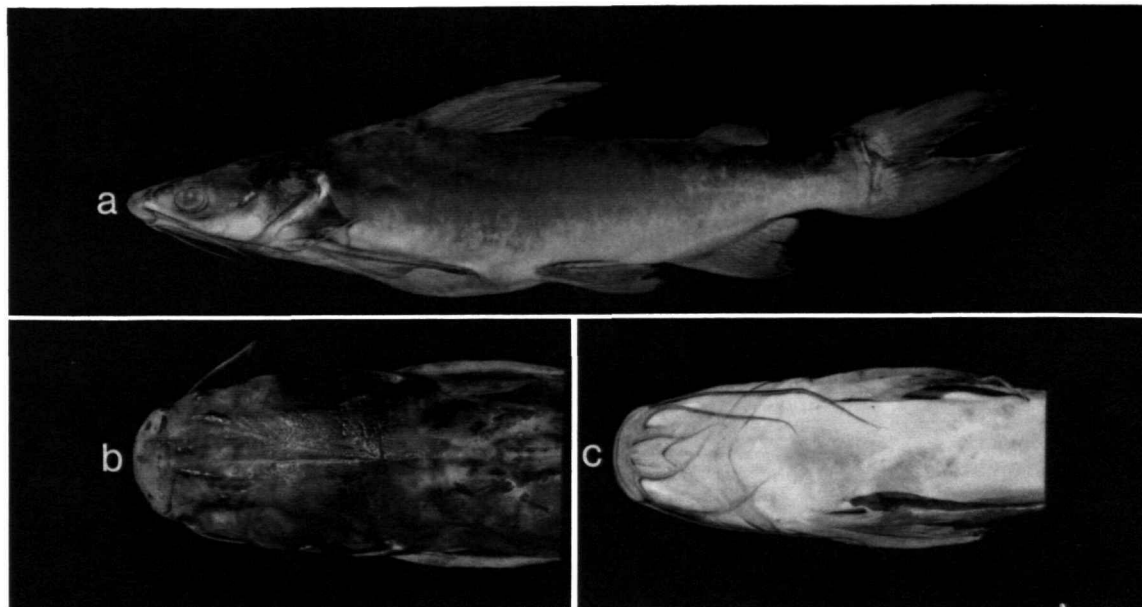


FIGURE 15.—*Arius cleptolepis*, holotype, USNM 217069, 309 mm: a, lateral view; b, dorsal view; c, ventral view.



FIGURE 16.—*a*, *Arius cf. stirlingi*, Fly 75-21, 1.1 m; *b*, *A. stirlingi*, ZMA 114.263, 204 mm.

small. Color in life: dorsum greenish or bluish gray, ventrum yellow. R. Moore also caught two large catfish of this description in the Fly without seeing smaller individuals of the same species. The stomachs of the two individuals caught by me were empty, and their gonads were inactive. Additional specimens of what may be the same species, including smaller specimens, have been collected recently in the Purari River by Allan Haynes and are at the Fisheries Research Station, Kanudi. This catfish, perhaps the largest Indo-Pacific ariid, is tentatively identified as *Arius stirlingi*. Weber (1913a:540-541, figs. 16, 17) and Weber and de Beaufort (1913:297-300, figs. 122, 123) provided a detailed description of two small specimens from the Lorentz River; a photograph of one of these specimens is reproduced as Figure 16*b*. Ogilby's type material, from northern Australia, cannot be located in the fish collections of the Australian Museum or of the Queensland Museum, where it is most likely to have been deposited, and may have been lost (pers. comm., John Paxton and Rolland McKay).

***Hemipimelodus crasilabris*
Ramsay and Ogilby, 1887**

FIGURES 17, 20*f*

USNM 217073, Fly 75-13, 1: 457 mm.

USNM 217074, Fly 75-15, 2: 484-500 mm.

Hemipimelodus Bleeker, 1858 (type-species *Hemipimelodus borneensis* Bleeker, 1858, by original designation), as currently understood, comprises riverine species in India, Southeast Asia, and New Guinea that agree with each other mainly in lacking palatal teeth. Most of the species have been revised by Desoutter (1977). Three species referable to *Hemipimelodus* were obtained during the 1975 Fly survey, one of them undescribed. They do not appear to be very closely related to each other or to the type-species.

Hemipimelodus crasilabris, type-species of the monotypic genus *Pachyula* Ogilby, 1898, which has not been recognized by subsequent ichthyologists, is endemic to the rivers of central-southern New Guinea. It is immediately distinguished from all other ariids in the Australian Region by its excessively thickened, fleshy lips. It differs from all other *Hemipimelodus* in New Guinea in having eyes strongly dorsolateral and very small, barbels very short, mouth small, and tooth bands of distinctive shape (Figure 20*f*). Head evenly rounded from side to side. Eye 27-40 in specimens 156-500 mm (negatively allometric). Maxillary barbel failing to reach base of pectoral spine. Gill rakers of first gill arch 18; gill rakers present on posterior face of first and second gill arches. Pectoral fin with 10 or 11 segmented rays. Anal fin pterygophores 17-18. Free vertebral centra posterior to Weberian apparatus 45-48 (4: 157-500 mm). Color

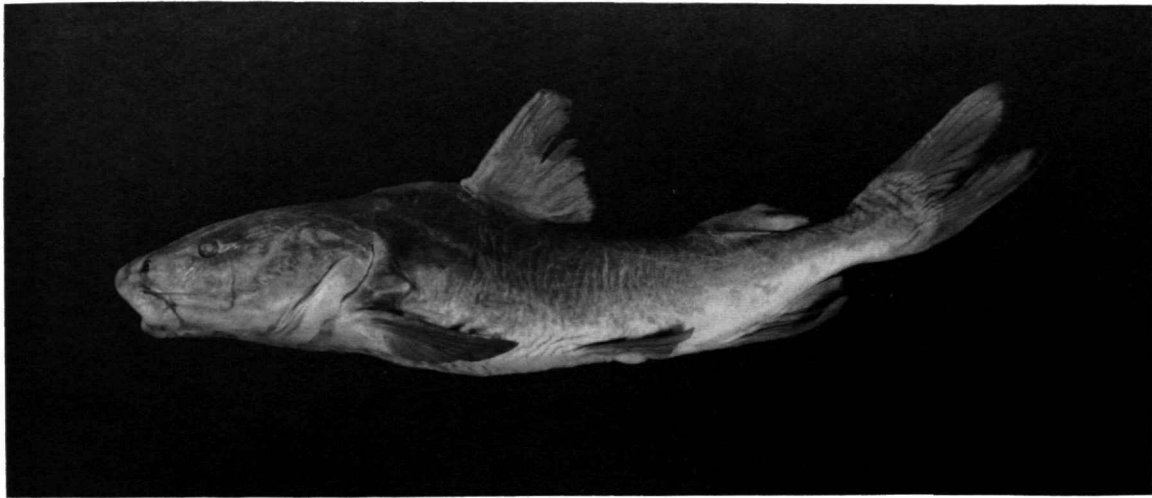


FIGURE 17.—*Hemipimelodus crassilabris*, USNM 217074, 484 mm.

in life: dorsum dull gray or pale bluish brown, ventrum pale, barbels pale; fins pale or dusky.

I have compared my three large specimens from the Upper Fly with the 156-mm holotype from the Strickland River (Australian Museum B.9961) and find they are similar in all respects.

Hemipimelodus macrorhynchus Weber, 1913

FIGURES 18, 20g

Hemipimelodus aaldareni Hardenberg, 1936:367–368 [Middle Digul River].

USNM 217075, Fly 75–1, 3: 348–463 mm.

Hemipimelodus macrorhynchus, endemic to the rivers of central-southern New Guinea, is immediately distinguishable from all other ariids in this region by the shape of its head and its color in life. Snout sharp, pointed, and dorsally flattened, strongly indented at nostrils. Eyes lateral or slightly ventrolateral, 23–31 in specimens 136–463 mm (negatively allometric). Barbels long, maxillary barbel extending beyond tip of pectoral spine. Tooth bands broad transversely, but exceptionally narrow anteroposteriorly (Figure 20g); tooth band of upper jaw entirely or almost entirely exposed when mouth is closed. Lips thin, tightly applied. Gill rakers on first and second gill arch except for one or two small, weak

rakers on upper limb. Upper limb of second gill arch with a moderately thick epithelial fold or valve projecting into branchial passage. Roof of pharynx relatively smooth. Pectoral fin with 11 segmented rays. Anal fin pterygiophores 20–21. Free vertebral centra posterior to Weberian apparatus 45–46 (2: 348–373 mm). Color in life: dorsum of snout iridescent sea green with bronze reflections; dorsum of body and posterior portion of head dark brown with bronze reflections; ventrum off-white, dusky or slightly brownish; barbels blackish brown.

Hemipimelodus macrorhynchus does not seem very closely related to any other ariid I have seen. I have compared my specimens from the Fly with two syntypes of *H. macrorhynchus* from the Lorentz River (ZMA 111.085, 137–144 mm) and find they are similar except the distinctive shape of the head is not so well developed in the syntypes due to their small size. I agree with Desoutter (1977:13) that *H. aaldareni* is a synonym of *H. macrorhynchus*. Han Nijssen kindly compared my description and photograph of the 463-mm specimen of *H. macrorhynchus* from the Fly with Hardenberg's 460-mm (total length) holotype of *H. aaldareni* and found them conspecific. The holotype has snout very sharp in lateral view, indented at nostrils; dorsomedian portion of snout flattened, even concave; all barbels dark brown; and tooth band of upper jaw completely exposed when mouth is closed.

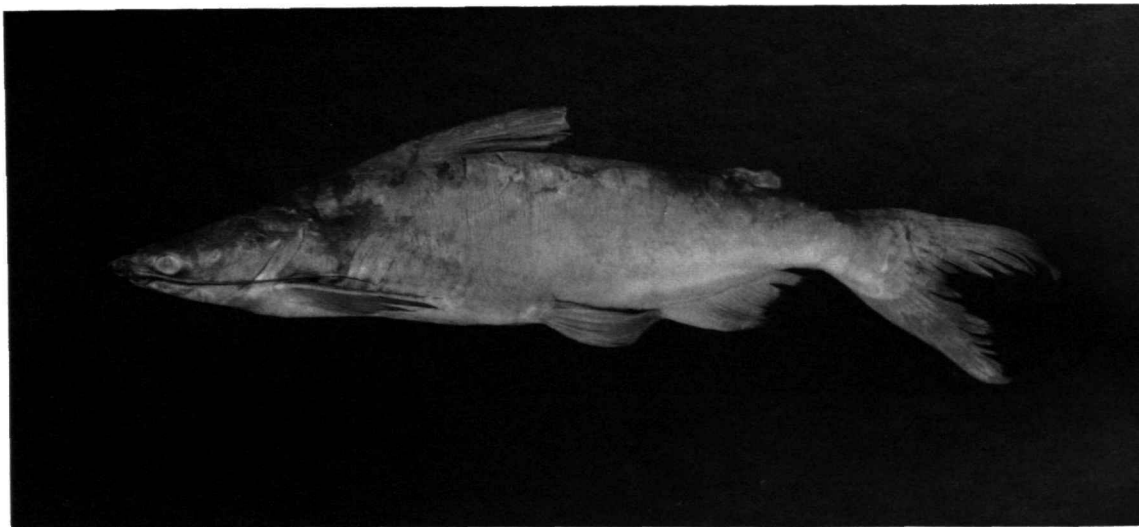


FIGURE 18.—*Hemipimelodus macrorhynchus*, USNM 217075, 463 mm.

***Hemipimelodus taylori*, new species**

FIGURES 19, 20h

USNM 217076, Holotype, Fly 75-14, 353 mm.

USNM 217077, Paratypes, Fly 75-14, 2: 330-350 mm.

Hemipimelodus taylori is a relatively generalized ariid without any obvious peculiarities comparable to those of *H. macrorhynchus* and *H. crassilabris*. It differs from all other *Hemipimelodus* in New Guinea in having gill rakers absent on posterior face of second gill arch. Head and mouth moderately broad, tooth band of upper jaw partially exposed when mouth is closed. Dorsum of head slightly rounded from side to side. Snout slightly pointed, projecting beyond tooth band of upper jaw by a distance about equal to diameter of eye. Eyes lateral or slightly dorsolateral, 28-29 in specimens 330-353 mm. Lips moderately thick and fleshy. Barbels moderately long, maxillary barbel extending to middle of pectoral spine. Gill rakers on anterior face of first gill arch 15; posterior faces of first and second gill arches smooth, without gill rakers or raker-like structures; upper limb of second gill arch with a thick, fimbriated fold or valve projecting into branchial passage. Pectoral fin with 11 segmented rays. Anal fin pterygiophores 19-20. Free vertebral centra posterior to Weberian apparatus 43-44 (3: 330-353 mm).

This species is named for William Ralph Taylor, Smithsonian ichthyologist and student of Ariidae.

I have examined type material of the three species of *Hemipimelodus* described from northern New Guinea; they appear to be distinct from each other as well as from my new species.

Hemipimelodus velutinus Weber, 1908, from Lake Sentani has a relatively broad, blunt head and a thick-set body; it differs from most of its congeners in having well-developed gill rakers on lower limb of posterior face of second gill arch. Snout relatively truncate, not pointed as in *H. taylori*. Upper jaw and anterior portion of cranium relatively thick; upper jaw moderately thick lipped, projecting beyond lower jaw; tooth band of upper jaw relatively wide antero-posteriorly, almost entirely hidden or about half exposed when mouth is closed. Anterior face of first gill arch with 5 + 9-13 gill rakers. Posterior face of second gill arch with 5-6 + 14 gill rakers in two of three syntypes examined; third syntype (228-mm) with posterior face of second gill arch having 5 gill rakers on upper limb and lower limb with well-developed papillae but no rakers. I have examined three syntypes from Lake Sentani (ZMA 112.654, 228, 267, and 276 mm). The 276-mm specimen (male?) has a small oval patch of palatal teeth on the right side of the head, but the left side of the palate is toothless; in all other respects it is very

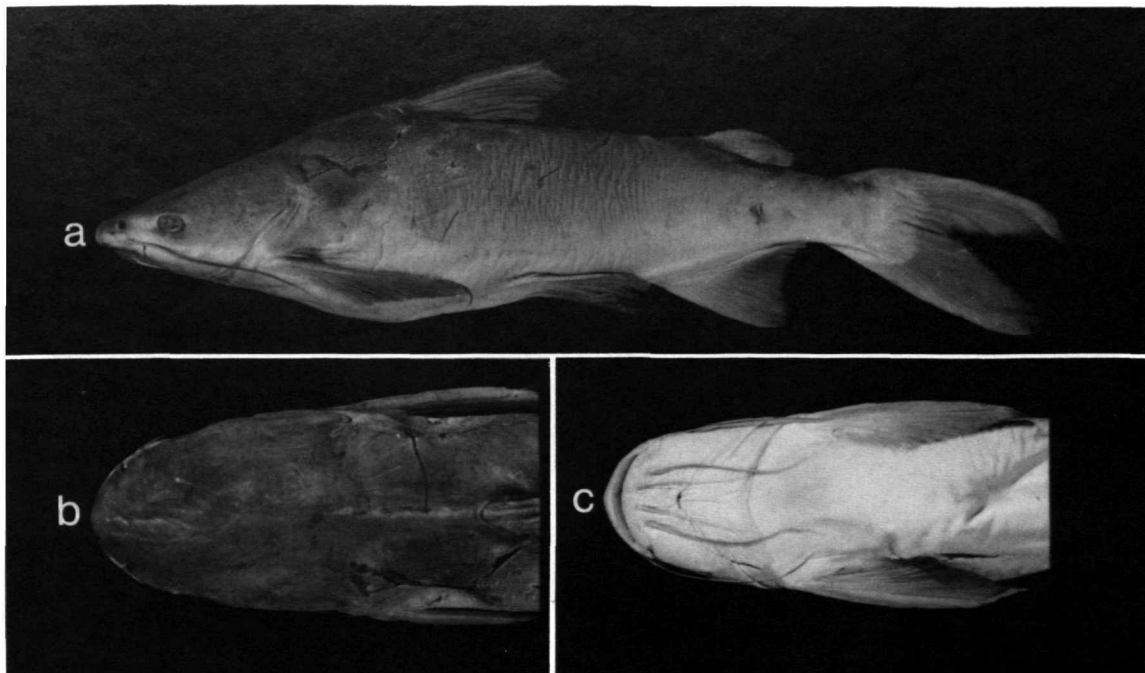


FIGURE 19.—*Hemipimelodus taylori*, holotype, USNM 217076, 353 mm; a, lateral view; b, dorsal view; c, ventral view.

similar to the 267-mm specimen (a ripe female).

Hemipimelodus papillifer Herre, 1935, from the Sepik is a relatively narrow-headed, slender-bodied species with 15 gill rakers on anterior face of first gill arch; posterior face of second gill arch with 6 gill rakers on upper limb, lower limb rakerless. Upper jaw and anterior portion of cranium relatively thinner than in *H. velutinus* but thicker than in *H. bernhardi*; upper jaw moderately thick lipped, projecting beyond lower jaw about as much as in *H. velutinus* and *H. taylori*; tooth band of upper jaw relatively wider anteroposteriorly than in *H. bernhardi*, about half exposed when mouth closed. Roof of mouth and pharynx and posterior faces of gill arches relatively smooth, without papillae. I have examined a 226-mm paratype, Field Museum of Natural History 17212.

Hemipimelodus bernhardi Nichols, 1940, from the Mamberamo differs from all other *Hemipimelodus* by its relatively high gill raker count: anterior face of first gill arch with 8 + 14–15 gill rakers (no other species has more than 12 gill rakers on lower limb of first gill arch; Desoutter, 1977; pers. observ.). Upper jaw and anterior portion of cranium relatively

thin; snout relatively sharp in lateral view; upper jaw relatively thin lipped, projecting beyond lower jaw only slightly, less than in *H. velutinus* and *H. papillifer*; tooth band of upper jaw entirely hidden when mouth closed. Roof of mouth and pharynx and posterior faces of gill arches covered with numerous papillae, more so than in other *Hemipimelodus* seen by me. I have examined the 157-mm holotype (AMNH 15039) and two of the three paratypes (AMNH 15040, 110, and 174 mm). A possibly close and hitherto unsuspected relationship among *Hemipimelodus bernhardi*, *Arius kanganamensis*, and *Brustiarius nox* is suggested by the shared specialization of increase in gill rakers coupled with a thinning of upper jaw and anterior portion of cranium.

Cinetodus froggatti (Ramsay and Ogilby, 1887)

FIGURES 21, 20i

- USNM 217078, Fly 75-1, 1: 326 mm.
- USNM 217079, Fly 75-17, 2: 330–391 mm.
- USNM 217080, Fly 75-26, 10: 230–367 mm.
- USNM 217081, Fly 75-29, 1: 423 mm.

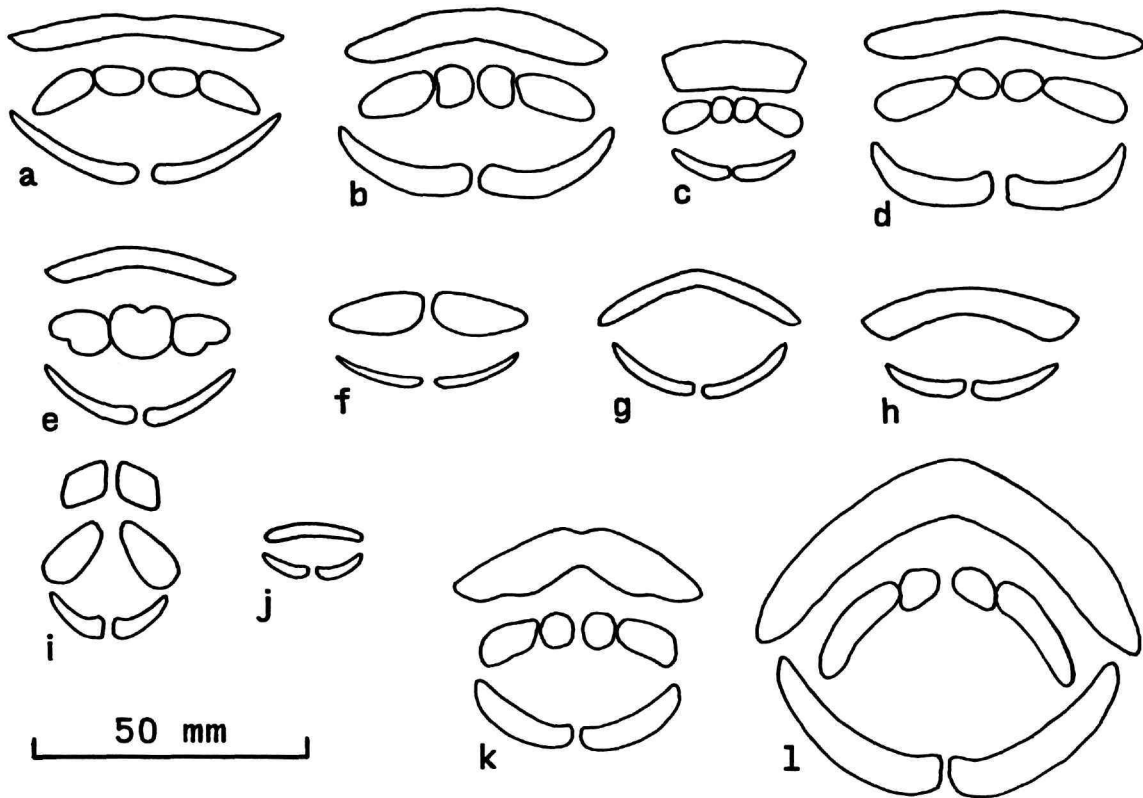


FIGURE 20.—Oral tooth bands in Fly Ariidae: *a*, *Arius leptaspis*, USNM 217052, 328 mm; *b*, *A.acrocephalus*, USNM 217056, 376 mm; *c*, *A. carinatus*, USNM 217063, 364 mm; *d*, *A. augustus*, holotype, USNM 217065, 342 mm; *e*, *A. cleptolepis*, paratype, USNM 217071, 375 mm; *f*, *Hemipimelodus crassilabris*, USNM 217074, 484 mm; *g*, *H. macrorhynchus*, USNM 217075, 373 mm; *h*, *H. taylori*, holotype, USNM 217076, 353 mm; *i*, *Cinetodus froggatti*, USNM 217080, 364 mm; *j*, *Nedystoma dayi*, USNM 217082, 147 mm; *k*, *Cochlefelis spatula*, USNM 217084, 358 mm; *l*, *C. danieli*, USNM 217087, 371 mm.

The monotypic *Cinetodus*, endemic to rivers of central-southern New Guinea and moderately common in the Fly River, is a stenophagous molluscivore distinguished from all other ariids in having gill membranes broadly united to a broad, flat isthmus, hence gill openings virtually restricted to sides of head. Head narrow anteriorly, mouth terminal and very small; shape of oral tooth bands highly distinctive. Gill rakers on first gill arch 13–16; posterior faces of first and second gill arches with well-developed gill rakers or raker-like structures on both upper and lower limbs. Roof of pharynx and upper limbs of second and third gill arches with folds or valves

projecting into branchial passages. Head shield strongly granular, with a median nuchal carina; posterolateral processes of head shield (immediately dorsal to gill openings) exposed and strongly granulated. Pectoral fin with 10 segmented rays. Anal fin pterygiophores 17–19. Free vertebral centra posterior to Weberian apparatus 43–46 (10: 230–367 mm). Color in life: dorsum reddish or brownish with golden or bronzy reflections, ventrum white; pectoral fins with dense black pigmentation dorsally.

Despite marked differences in mouth and gill structure, a possibly close relationship between *Cinetodus froggatti* and *Arius carinatus* is suggested by similari-

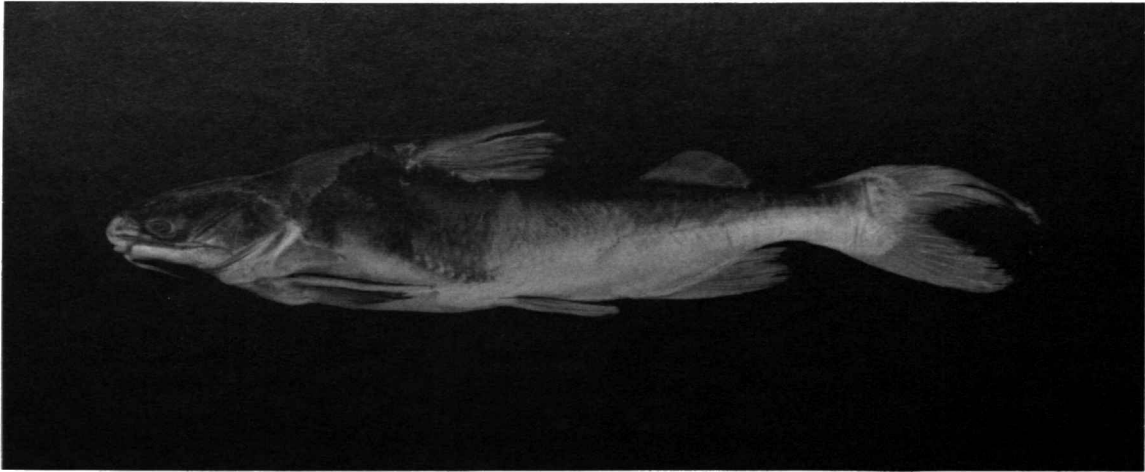


FIGURE 21.—*Cinetodus froggatti*, USNM 217080, 350 mm.

ties in their head shields and nuchal carina, the shape of their head and body, and virtually identical color in life.

Nedystoma dayi (Ramsay and Ogilby, 1887)

FIGURES 22, 20j

USNM 217082, Fly 75-25, 211: 40.8-147 mm.

The monotypic *Nedystoma*, endemic to rivers of central-southern New Guinea, is relatively small, the

largest known specimen 240 mm. It is distinguished from *Hemipimelodus* in having more numerous gill rakers, 32-35 on the first gill arch, and roof of pharynx with a series of greatly enlarged folds or valves occupying much of branchial chamber. Posterior faces of first and second gill arches with well-developed gill rakers or raker-like structures on both upper and lower limbs. Examination of stomach contents and material adhering to gill arches indicates that the specialized branchial structures function very effectively in separating vermiform dipteran larvae



FIGURE 22.—*Nedystoma dayi*, USNM 217082, 147 mm.

from mud. Pectoral fin usually with 10 segmented rays. Anal fin pterygiophores 20. Free vertebral centra posterior to Weberian apparatus 41-42 (4: 83-147 mm). Color in life: dorsum gray or bluish gray, ventrum white.

***Cochlefelis spatula* (Ramsay and Ogilby, 1887)**

FIGURES 23*a, c, 20k*

USNM 217083, Fly 75-4, 2: 508-543 mm.

USNM 217084, Fly 75-13, 1: 358 mm.

USNM 217085, Fly 75-17, 2: 482-546 mm.

Cochlefelis Whitley, 1942 (type-species *Arius spatula* Ramsay and Ogilby, 1887, by original designa-

tion), hitherto considered monotypic (Whitley, 1942), comprises two species endemic to rivers of central-southern New Guinea, both of them present in the Fly. These two species differ from all other freshwater ariids in the Australian Region in feeding almost exclusively on decapods and in the following morphological characters: both jaws with broad bands of exceedingly numerous teeth, the band in the upper jaw completely exposed when the mouth is closed; individual jaw teeth with flattened crowns (producing sharp lateral margins); and the internal pair of mental barbels extending much farther posteriorly than the external pair. Color in life more or less vivid sky blue, sometimes with violaceous tints dor-

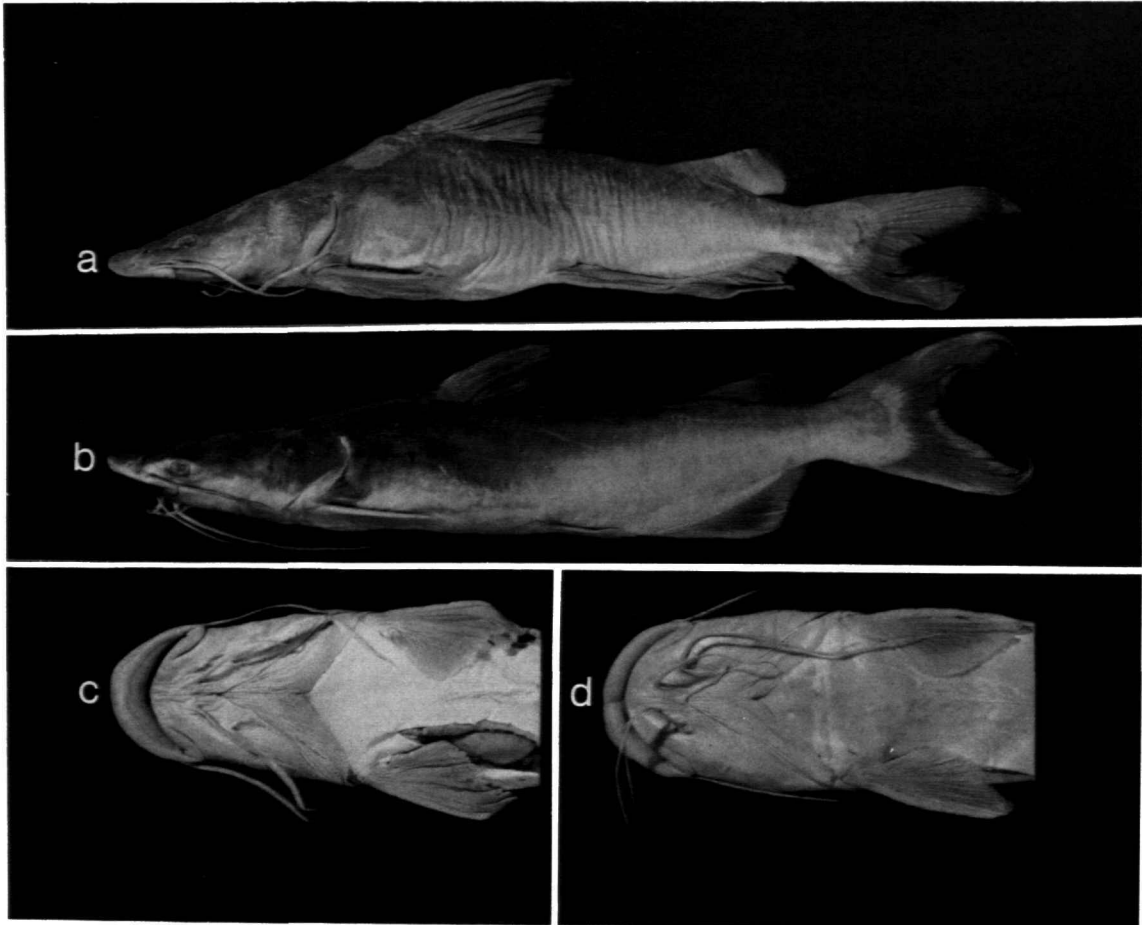


FIGURE 23.—*Cochlefelis*: *a, c, C. spatula*, USNM 217083, 543 mm; *b, d, C. danielsi*, USNM 217087, 431 mm (left maxillary barbel abnormally short).

sally, milky white ventrally (the only other ariid in the Fly with comparable coloration is *Arius augustus*). Gill rakers absent on posterior face of first and second gill arches. Large specimens with 50–52 free vertebral centra.

Cochlefelis spatula is fairly common in large rivers in the Upper as well as the Middle Fly, where it feeds almost exclusively on prawns (*Macrobrachium* and *Caridina*) less than 40 mm in carapace length. Eyes dorsolateral, smaller than in *C. danielsi*. Gape moderately large; snout slightly pointed, projecting beyond tooth band of upper jaw by a distance about equal to eye diameter. Barbels with a membranous inner margin (not present in any other Fly ariid). Total number of gill rakers on first gill arch 15–16. Pectoral fin with 11 branched rays. Anal fin pterygiophores 20–21. Adipose fin relatively huge and caudal peduncle much longer than in *C. danielsi*. Large specimens with 51–52 free vertebral centra.

***Cochlefelis danielsi* (Regan, 1908),
new combination**

FIGURES 23*b,d*, 20*f*

USNM 217086, Fly 75–17, 1: 405 mm.
USNM 217087, Fly 75–20, 4: 316–450 mm.
USNM 217088, Fly 75–25, 1: 318 mm.

Cochlefelis danielsi occurs sympatrically with *C. spatula* in large rivers in the Middle Fly but was not seen in the Upper Fly during the 1975 survey. It feeds almost exclusively on prawns; four individuals were examined that had ingested *Macrobrachium* of carapace lengths over 70 mm. Eyes lateral and relatively large. Gape extremely large; snout broadly rounded, projecting but very slightly beyond tooth band of upper jaw. Barbels without membranous inner margin. Total number of gill rakers on first gill arch 21–23. Pectoral fin usually with 10 branched rays. Anal pterygiophores 25. Adipose fin relatively small and caudal peduncle much shorter than in *C. spatula*. Large specimens with 50–51 free vertebral centra.

PLOTOSIDAE

***Cupidoglanis meraukensis* (Weber, 1913)**

USNM 217089, Fly 75–16, 29: 62.7–170 mm (5 to AMNH).

USNM 217090, Fly 75–20, 21: 26.2–106 mm.
USNM 217091, Fly 75–24, 4: 38.6–100 mm.
USNM 217092, Fly 75–25, 1: 53.3 mm.

***Porochilus obbesi* Weber, 1913**

USNM 217093, Fly 75–16, 5: 51.8–82.1 mm.
USNM 217094, Fly 75–20, 3: 29.6–42.3 mm.

***Tandanus brevidorsalis* (Günther, 1867)**

USNM 217095, Fly 75–5, 11: 35.8–90.1 mm.
USNM 217096, Fly 75–14, 6: 29.2–100 mm.

***Tandanus ater* (Perugia, 1894)**

USNM 217097, Fly 75–1, 1: 404 mm.
USNM 217098, Fly 75–2, 2: 280–470 mm.
USNM 217099, Fly 75–16, 5: 143–198 mm.

***Tandanus equinus* (Weber, 1913)**

USNM 217100, Fly 75–7, 12: 100–360 mm (1 to AMNH).
USNM 217101, Fly 75–8, 19: 127–288 mm.
USNM 217102, Fly 75–10, 3: 124–259 mm.
USNM 217103, Fly 75–11, 2: 120–136 mm.

***Plotosus papuensis* Weber, 1910**

FIGURE 24*a*

USNM 217104, Fly 75–1, 1: 502 mm.
USNM 217105, Fly 75–13, 1: 30.8 mm.
USNM 217106, Fly 75–14, 9: 31.3–129 mm (1 to AMNH).

Plotosus papuensis, hitherto known only from the type series collected in the Lorentz River, was found in the Upper and Middle Fly. An individual of 1000 mm caught at Fly 75–20 was not preserved. This species is distinguished from its congeners in having a very finely branched (truly dendritic) dendritic organ, usually 9 caudal rays, and a unique color pattern. Specimens from the Fly have length of head 24.1–25.7, eye 26–52 in specimens 30.8–502 mm (negatively allometric), depth of body at origin of dorsal fin 17–20, length of dorsal fin spine 9–13, length of longest dorsal fin ray 11–17, and length of pectoral spine 6–10; dorsal fin typically with four rays; last one or two rays split to base, dorsal procurrent caudal fin 110–120 rays, caudal fin 9(8) or 8(1) rays, anal fin 100–113 rays, total dorsal procurrent caudal + principal caudal + anal fin rays

225–240, pectoral fin 13–14 segmented rays, and pelvic fin 12–13 rays. Gill rakers on first gill arch 18–26. Branchiostegal rays 11–12: 11+11(6), 12+12(4). Ribs 7–9. Complete vertebral centra posterior to Weberian apparatus 69–73 (11–12 precaudal+58–61 caudal). Color in preservative (similar to that in life in all or almost all respects): dorsum of head, almost entire body, and all fins usually bluish black (brown in very small juveniles; one of the larger specimens from Fly 75–14 has faint light mottling on body and fins); abdomen varying from black to cream colored or pale whitish with scattered melanophores; ventral surface of head dark laterally and light medially in young, pale (almost immaculate) in adults; lips darkly pigmented in young, pale in adults; maxillary and nasal barbels dark except for pale edges, mental barbels entirely pale. Dendritic organ white. Several individuals from Fly 75–14 with a faint, light longitudinal band extending from head along lower half of body and above base of anal fin, tapering posteriorly and disappearing before caudal fin.

The specimens from the Fly agree closely in counts,

measurements, and all other respects except coloration with the Lorentz River syntypes of *P. papuensis*. The smaller and medium-sized syntypes are stunningly marked by two sharply defined white or cream-colored bands on the side of the otherwise darkly pigmented (almost black) body, as illustrated in the original account (Weber, 1913:520, fig. 2). The upper band, which has no counterpart in the Fly specimens, begins below base of dorsal fin and extends almost to caudal fin. The lower band corresponds to the single band present in some of the specimens from Fly 75–14. Lorentz juveniles also differ from Fly juveniles in having head and abdomen almost immaculate ventrally. In the largest specimens from the Lorentz and from the Fly the longitudinal bands on the body are almost or entirely indiscernible, hence they are virtually identical in all respects.

Plotosus papuensis is perhaps most similar to *P. canius* (Hamilton-Buchanan, 1822) (Figure 24b). Freshly preserved *P. canius* from Daru, near the mouth of the Fly (USNM 217322, 5: 98–190 mm) and from Panay, Philippines (USNM 217323, 102 mm), differ from *P. papuensis* in having head and



FIGURE 24.—*Plotosus*: a, *P. papuensis*, USNM 217106, 92.7 mm; b, *P. canius*, USNM 217322, 98 mm.

mouth only two-thirds as wide, jaw teeth slightly larger, mental barbels dark, vertical height of dorsal procurrent caudal and anal fins only two-thirds as great; dendritic organ lobose or foliaceous and yellowish, no indication of longitudinal bands on body, and 14 precaudal vertebrae exclusive of Weberian apparatus instead of 11 or 12.

***Oloplotosus luteus* Gomon and Roberts,
new species**

FIGURE 25

USNM 217107, Holotype, Fly 75-9, 122.8 mm.

USNM 217108, Paratypes, Fly 75-11, 2: 123.1-142.0 mm.

The hitherto monotypic genus *Oloplotosus* Weber, 1913 (type-species *Oloplotosus mariae* Weber, 1913, by original designation and monotypy), belongs to the group of Plotosidae possessing a dendritic organ and is distinguished from all other members of the family by its dentition: upper jaw toothless, palate and lower jaw with one or two rows of well-developed, opposable teeth. Body moderately elongate,

dorsal procurrent caudal fin originating slightly posterior to dorsal fin.

Oloplotosus luteus differs from *O. mariae* in many respects including head shape, dentition, and almost all meristic characters. Head strongly rounded dorsally and relatively narrow, its length 6.0-6.4 (vs. head relatively flattened and broad, its length 4.8-5.1 in *O. mariae*). Eye very small, 75-77 (eye slightly larger, 50-63). Snout with a bulbous anterior projection between anterior nostrils (snout broadly rounded, without bulbous projection). Barbels stubby, broad based, almost round to almost flat, nasal barbel reaching to or almost to posterior margin of eye, maxillary barbel to below posterior margin of eye, outer mental barbel to gill opening, inner mental barbel about one-half to three-quarters as long as outer mental barbel (barbels relatively more slender and longer). Lips thick, plicate, and papillose (lips relatively thin and smooth). Snout, lateral and ventral surface of head, branchiostegal membranes and anterior portion of abdomen papillose, papillae especially large and densely distributed on branchiostegal membranes (papillae entirely absent). Branchiostegal membranes broadly united to each other and to isthmus; ventro-

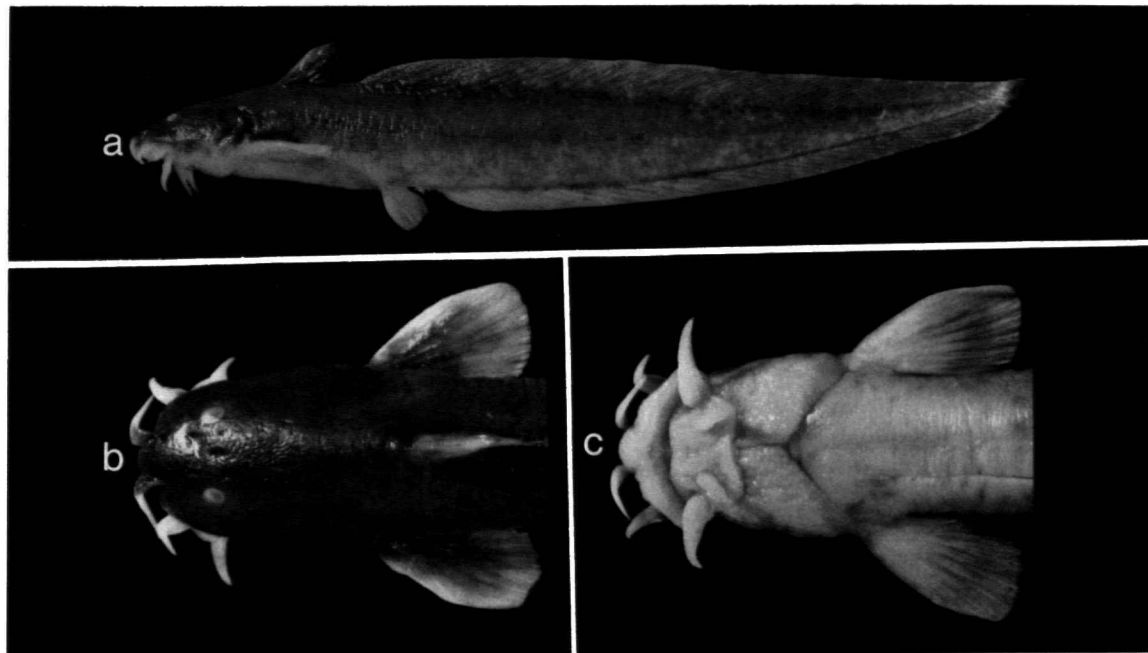


FIGURE 25.—*Oloplotosus luteus*, holotype, USNM 217107, 122.8 mm; a, lateral view; b, dorsal view; c, ventral view.

posterior margin of branchiostegal membranes with only a slight medial indentation (branchiostegal membranes joined to each other and to isthmus but much farther anteriorly; ventroposterior margin of branchiostegal membranes with a deep V-shaped indentation). Oral dentition incisorial, teeth chisel shaped and close set in single rows on palate and on lower jaw (oral dentition not incisorial; teeth elongate and conical, irregularly spaced in two rows on palate and on lower jaw). Gill rakers on anterior face of first gill arch 8–10 (17–18). Branchiostegal rays 8–9 (11–12). Dendritic organ small and foliaceous; relatively prominent in holotype, largely hidden in deep dendritic organ pocket in paratypes. Dorsal spine blunt tipped and entirely smooth, without serrations anteriorly or posteriorly, its length 19.2–20.4; pectoral spine blunt tipped, almost entirely smooth, without serrations posteriorly but minute serrae on base anteriorly, its length 13.0–13.3. Dorsal fin I 5 (I 5), dorsal procurrent caudal fin 103–106 (110–117), caudal fin 5 (6), anal fin 86–92 (101–116), total dorsal procurrent caudal + principal caudal + anal fin rays 195–203 (220–235). Pectoral fin I 10–11 (12–13), pelvic fin 11–12 (13–14). Ribs 9–10 (9–10). Free precaudal vertebrae posterior to Weberian apparatus 12–13 (13–14), free caudal vertebrae 51–52 (60–61), total free vertebrae posterior to Weberian apparatus 63–64 (73–75). Color in life: dorsum of head and body almost uniformly dark brown; side of head and body dark brown, variably mottled; median fins brownish, mottled; pectoral fins mottled or dusky dorsally and pale or slightly mottled ventrally, pelvic fins slightly mottled or pale dorsally and uniformly pale ventrally; distal two-thirds of nasal and maxillary barbels, entire mental barbels, lips, and ventral surface of head bright orange; ventral surface of abdomen pale orangish (color in life of *O. mariae* unknown; color pattern of preserved specimens similar in most respects to that in *O. luteus*).

Oloplotosus luteus was obtained at two localities in the highlands of the Upper Fly, where the current was moderate to swift and the bottom consisted of rocks and cobbles of variable size (Figure 3b). *Oloplotosus mariae* is known only from the type series obtained at Sabang and Alkmaar on the Lorentz River; although the habitat was not specifically indicated, the information about these localities supplied by Weber (1913a: 513) suggests it lives in similar habitat.

BELONIDAE

Strongylura strongylura (van Hasselt, 1823)

USNM 217109, Fly 75–32, 2: 178–251 mm.

Strongylura krefftii (Günther, 1866)

USNM 217110, Fly 75–6, 3: 582–589 mm.
 USNM 217111, Fly 75–20, 2: 152–395 mm.
 USNM 217112, Fly 75–22, 2: 47.9–140 mm.
 USNM 217113, Fly 75–24, 1: 164 mm.

HEMIRAMPHIDAE

Zenarchopterus dispar (Valenciennes, 1847)

USNM 217114, Fly 75–32, 44: 43.1–131 mm.

Zenarchopterus novaeguineae (Weber, 1913)

USNM 217115, Fly 75–1, 3: 78.7–101 mm.
 USNM 217116, Fly 75–3, 6: 12.5–25.4 mm.
 USNM 217117, Fly 75–4, 30: 9.8–173 mm.
 USNM 217118, Fly 75–5, 1: 90.4 mm.
 USNM 217119, Fly 75–9, 37: 44.2–140 mm.
 USNM 217120, Fly 75–10, 3: 123–145 mm.
 USNM 217121, Fly 75–14, 2: 44.9–86.8 mm.
 USNM 217122, Fly 75–27, 17: 73.2–104 mm.
 USNM 217123, Fly 75–30, 5: 72.2–123 mm.

MELANOTAENIIDAE

Melanotaenia nigrans (Richardson, 1843)

FIGURE 26a

USNM 217124, Fly 75–2, 15: 13.6–93.9 mm.
 USNM 217125, Fly 75–4, 16: 9.1–47.1 mm.
 USNM 217126, Fly 75–14, 36: 12.0–94.7 mm.

Melanotaenia cf. *vanheurni* (Weber and de Beaufort, 1922)

FIGURE 26b

USNM 217127, Fly 75–8, 1: 73.8 mm.

A single specimen of *Melanotaenia* was obtained in the highlands of the Upper Fly. It agrees in most respects with the description of *M. vanheurni* (Weber and de Beaufort, 1922: 299–300) except in having a more slender body and caudal peduncle. The Fly specimen has upper jaw very slightly protruding, lips

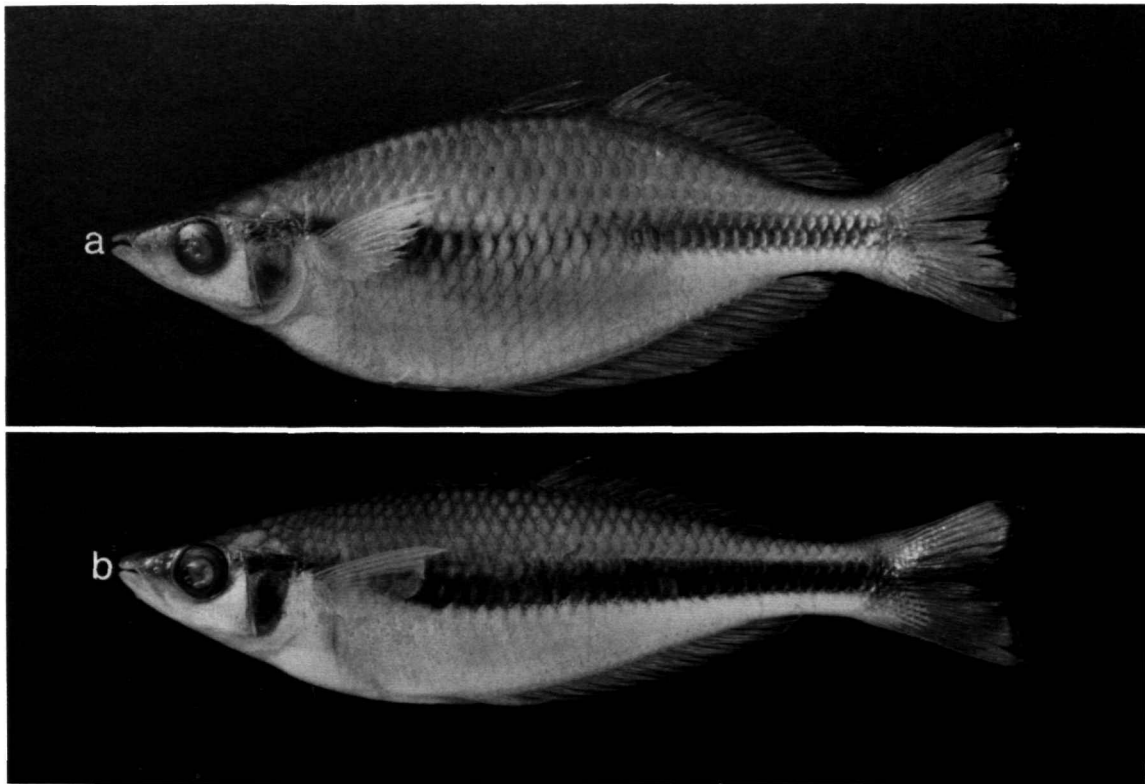


FIGURE 26.—*Melanotaenia*: a, *M. nigrans*, USNM 217124, 93.9 mm; b, *M. cf. vanheurni*, USNM 217127, 73.8 mm.

not notably swollen anteriorly; head 3.7, eye 13 (3.6 in head); depth of body at origin of second dorsal fin 3.5 (2.7–3.2 in *M. vanheurni*); height of caudal peduncle into length of caudal peduncle 2 (1.2–1.5 in *M. vanheurni*); 38 scales in lateral series, 15 predorsal scales, and 12 scales in transverse series at origin of second dorsal fin. Gill rakers on first gill arch 2+1+14. First dorsal fin I 5, second dorsal fin I 20, anal fin I 26, and pectoral fin 14. Base of first dorsal fin almost entirely anterior to a vertical line through origin of anal fin. A longitudinal black band, nearly two scale rows wide, extends on middle of body from just behind head to base of caudal fin.

The more slender body and caudal peduncle of the present 73.8-mm specimen may indicate that larger individuals in the Fly population do not develop the deeper, more rhombic body form characteristic of larger *M. vanheurni*, a species otherwise known only from the Mamberamo basin in northern New Guinea.

***Nematocentris rubrostriatus*
Ramsay and Ogilby, 1887**

FIGURE 27a

USNM 217128, Fly 75-1, 12: 20.0–85.0 mm.
USNM 217129, Fly 75-2, 6: 44.7–92.4 mm.
USNM 217130, Fly 75-3, 8: 9.5–16.7 mm.
USNM 217131, Fly 75-4, 1: 29.8 mm.
USNM 217132, Fly 75-6, 23: 15.2–71.3 mm.
USNM 217133, Fly 75-8, 1: 95.3 mm.
USNM 217134, Fly 75-9, 19: 20.4–60.8 mm.
USNM 217135, Fly 75-16, 14: 31.3–65.8 mm.
USNM 217136, Fly 75-20, 8: 27.6–57.8 mm.
USNM 217137, Fly 75-22, 1: 41.2 mm.
USNM 217138, Fly 75-24, 2: 64.0–73.4 mm.

***Nematocentris sexlineatus* Munro, 1964**

FIGURE 27b

USNM 217139, Fly 75-5, 3: 25.4–52.9 mm.
USNM 217140, Fly 75-20, 7: 19.7–26.1 mm.



FIGURE 27.—*Nematocentris*: a, *N. rubrostriatus*, USNM 217128, 85.0 mm; b, *N. sexlineatus*, USNM 217139, 44.8 mm.

ATHERINIDAE

Craterocephalus randi Nichols and Raven, 1934

USNM 217141, Fly 75-1, 6: 20.4–47.1 mm.
 USNM 217142, Fly 75-2, 1: 35.8 mm.
 USNM 217143, Fly 75-3, 5: 14.6–20.0 mm.
 USNM 217144, Fly 75-4, 7: 30.2–46.6 mm.
 USNM 217145, Fly 75-5, 5: 40.4–50.9 mm.
 USNM 217146, Fly 75-6, 88: 15.7–54.4 mm.
 USNM 217147, Fly 75-8, 3: 43.4–77.9 mm.
 USNM 217148, Fly 75-9, 48: 22.9–82.3 mm.
 USNM 217149, Fly 75-10, 10: 26.6–68.6 mm.
 USNM 217150, Fly 75-13, 7: 36.5–47.5 mm.
 USNM 217151, Fly 75-14, 5: 28.0–66.5 mm.
 USNM 217152, Fly 75-16, 3: 32.7–56.0 mm.
 USNM 217153, Fly 75-20, 9: 17.0–45.8 mm.
 USNM 217154, Fly 75-22, 1: 46.0 mm.
 USNM 217155, Fly 75-24, 5: 12.8–60.5 mm.

Iriatherina weneri Meinken, 1974

FIGURE 28

USNM 217156, Fly 75-20, 30: 19.9–32.2 mm.

Iriatherina weneri is one of the most distinctive endemic elements in the freshwater ichthyofauna of central-southern New Guinea. Meinken (1974) was certainly justified in recognizing *Iriatherina* as a distinct genus. The relationship of this highly specialized and graceful surface-feeder to other atherinoids is unclear; judging from jaw structure and color in life it is perhaps most closely related to Melanotaeniidae. The type-locality, near Merauke City and the mouth of the Merauke River, West Irian, is about 340 km W of the mouth of the Fly. My specimens were collected in swampy lagoons along the mainstream of the

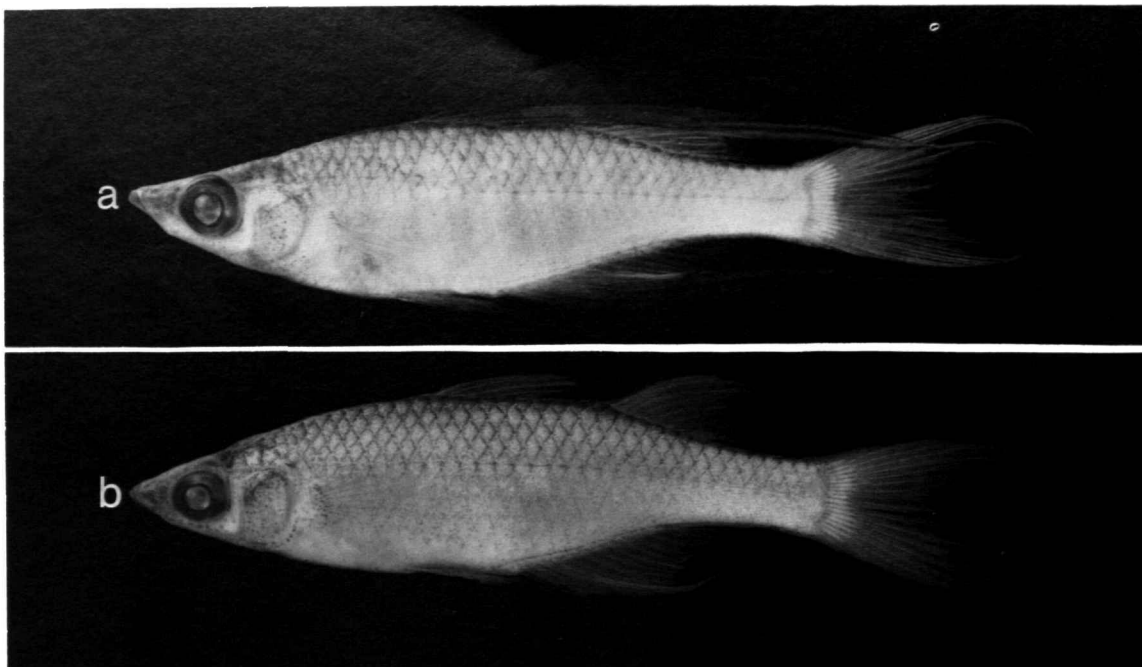


FIGURE 28.—*Iriatherina weneri*, USNM 217156: a, 28.5 mm male; b, 32.2 mm female.

Middle Fly more than 500 km upriver from the mouth of the Fly. Kailola (1975:64) reported specimens from Lake Murray and from several coastal rivers between the Merauke and the Fly.

Specimens from the Middle Fly have upper jaw much shorter than lower jaw, nonprotrusible; skin of upper lip directly united to that of snout; when lower jaw depressed, upper jaw does not protrude but is rotated in place so that it opens upward with anterior-most portion of premaxillary projecting dorsally to snout. Maxillomandibular ligament attached far anteriorly on lower jaw. Only one-third of lower jaw projecting beyond rictus when mouth fully opened. Each side of upper jaw with a single row of 5–6 small conical teeth anteriorly continuous with about 8–10 slightly larger conical teeth posteriorly extending nearly to end of premaxillary. Lower jaw with two or three irregular rows of small conical teeth, with a few enlarged conical teeth in outer row near symphysis; posterior three-fourths of lower jaw toothless. First dorsal fin VII–IX (usually VIII); second dorsal fin I $6\frac{1}{2}$ – $8\frac{1}{2}$ (usually I $8\frac{1}{2}$); anal fin I $10\frac{1}{2}$ – $12\frac{1}{2}$ (usually I $11\frac{1}{2}$); caudal fin 5–6 + 8 + 9 + 5; pectoral fin 9–10; pelvic fin I 5. Innermost ray of

pelvic fin connected for its entire length to abdomen by a membrane. Scales in lateral series 31–33. Color in life: body opaque, olive or drab greenish, without silvery midlateral band; flanks of males with 6–8 dusky vertical bars (retained after preservation); greatly enlarged first dorsal fin and greatly elongated, filamentous portions of second dorsal, anal, and pelvic fins of mature males solid black or darkly pigmented; fins of females all relatively colorless. Meinken's type specimens had a silvery midlateral band and evidently were relatively translucent in life, possibly because they had been maintained in an aquarium.

Pseudomugil novaeguineae Weber, 1908

FIGURE 29a

USNM 217157, Fly 75–2, 68: 11.1–30.5 mm.

USNM 217158, Fly 75–4, 8: 14.2–33.4 mm.

USNM 217159, Fly 75–14, 1: 24.2 mm.

Pseudomugil Kner, 1866 (type-species *Pseudomugil signifier* Kner, 1866, by monotypy), comprises eight species, all endemic to the Australian Region.

Pseudomugil novaeguineae differs markedly from other *Pseudomugil* by its relatively huge, unrestricted

gape and extremely numerous jaw teeth. Specimens from the Fly have mouth large and wide, fully two-thirds as wide as head; gape relatively unrestricted, maxillomandibular ligament attached very far posteriorly on lower jaw; about four-fifths of lower jaw extending anterior to rictus when mouth fully opened; ramus of lower jaw of equally shallow depth for its entire length; premaxillary bone without accessory ascending process; maxillary bone very slender (Figure 29a). Almost entire length of upper jaw and more than three-quarters of lower jaw bearing teeth; upper jaw with 60 or more teeth on each ramus, anterior-most teeth small and densely packed in 3–5 irregular rows, posterior teeth larger and projecting from side of mouth; lower jaw with numerous teeth in several irregular rows, with teeth in external row enlarged anteriorly (Figure 29a). First gill arch with 2 + 9 gill rakers. Pharyngeal teeth conical, greatly enlarged posteriorly. Scales in lateral series 32–34; dorsomedian scales between occiput and origin of first dorsal fin 14–16; ventromedian scales between base of cleithrum and origin of pelvic fins 14; peduncular scales 8. First dorsal fin with 4 spines, its origin anterior to a vertical line through base of first anal fin ray. Second dorsal fin I $5\frac{1}{2}$ – $6\frac{1}{2}$. Anal fin ii $9\frac{1}{2}$ – $11\frac{1}{2}$. Pectoral fin 11–13. Principal caudal fin rays usually 7 + 7. Pelvic girdle attached to fifth rib. Free vertebrae 33–34. Marked sexual dimorphism involving dorsal and anal fins but not other fins: in mature males first dorsal fin with a long, filamentous extension; dorsal and anal fins con-

siderably enlarged. Color in life or within two hours after preservation (Fly 75–2): body largely transparent; sides of head and abdomen with glistening bluish or violet hues. Eye with faint gold ring around pupil, iris silvery or faintly bluish. Anterior two-thirds of longitudinal line on body orange, posterior third black. Margins of scales above longitudinal line outlined by melanophores; transverse scale rows below longitudinal line with oblique rows of melanophores. First dorsal fin colorless in females or with melanophores along leading edge only; males with interradiation membrane between first and second spines and its filamentous extension deep black or carmine red. Second dorsal and anal fins of females with a few melanophores anteriorly and a dense black mark at base of last two rays (also present in males), otherwise clear. Second dorsal fin in males either largely clear, as in females, or carmine red. Anal fin of males with milk white leading edge and large, oblique black bars on interradiation membranes. Caudal fin colorless in females, with ventral portion of lower lobe red, yellow, or white in males.

Pseudomugil gertrudae Weber, 1911

FIGURE 29b

USNM 217160, Fly 75–4, 25: 12.5–26.3 mm.
USNM 217161, Fly 75–20, 3: 16.5–19.5 mm.

Pseudomugil gertrudae is distinguished by its unique

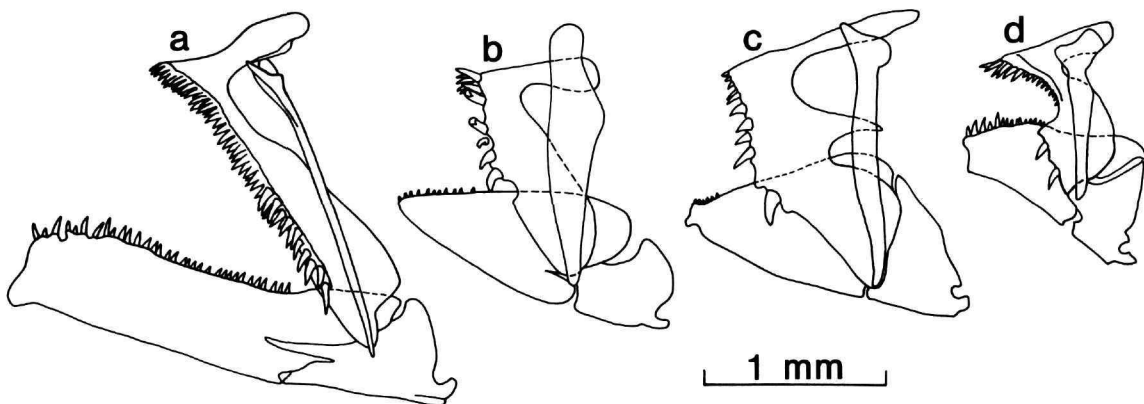


FIGURE 29.—Jaws of *Pseudomugil*: a, *P. novaeguineae*, USNM 217157, 25.2 mm; b, *P. gertrudae*, USNM 217160, 24.8 mm; c, *P. inconspicuus*, paratype, USNM 217163, 22.5 mm; d, *P. tenellus*, paratype, USNM 178294 19.7 mm.

color pattern of round or oblong black spots on the median fins and body and strong sexual dimorphism involving all of the fins, particularly the excessively long pelvic fin filaments of mature males. Specimens from the Fly have mouth small, about half as wide as head; gape greatly restricted, maxillomandibular ligament attached far anteriorly on lower jaw; about half of lower jaw extending anteriorly to rictus when mouth fully opened; ramus of lower jaw moderately elevated posteriorly; premaxillary bone without an accessory ascending process; maxillary bone very stout (Figure 29*b*). Each side of upper jaw with about 20 moderately large, close-set conical teeth in 2–3 irregular rows anteriorly, opposable to teeth in lower jaw, followed by a single row of 4–6 greatly enlarged teeth (absent in some smaller specimens) with crowns strongly curved backward, projecting laterally from side of mouth; posterior third of upper jaw toothless; each side of lower jaw with about 20 moderately large, close-set conical teeth in 2–3 irregular rows anteriorly; posterior two-thirds of lower jaw toothless (Figure 29*b*). First gill arch with 0 + 9 gill rakers. Pharyngeal teeth conical, not notably enlarged posteriorly. Scales in lateral series 27–28; dorsomedian scales between occiput and origin of first dorsal fin only 10–11; ventromedian scales between base of cleithrum and pelvic fin origin 8; peduncular scales 10. First dorsal fin with 4–5 spines, its entire base anterior to a vertical line through origin of first anal fin ray. Second dorsal fin I 6–6½. Anal fin i or ii + 9½–10½. Pectoral fin 10–11. Caudal fin with 6 + 7 principal rays. Pelvic girdle attached to fifth rib. Free vertebrae 30. Marked sexual dimorphism involving all fins: in mature males

first dorsal, pelvic, and sometimes anal fins with very long filamentous extensions, those of pelvic fins sometimes extending almost as far posteriorly as posterior tip of anal fin; entire second dorsal and anal fins greatly enlarged; pectoral fin with a short filamentous extension; and caudal fin slightly lyriiform due to short filamentous extensions from upper and lower lobes. Color in life (Fly 75–4): body not transparent or even translucent but suffused with bluish and violaceous tints; dorsal, anal, and caudal fins with large round or oblong spots, most pronounced in males but present in all specimens; tips of pectoral fins and of both lobes of caudal fin reddish orange (specimens from Fly 75–4 without “reticulate” pattern of black marks on scales characteristic of *P. gertrudae* from other locations including Fly 75–20).

Pseudomugil inconspicuus, new species

FIGURES 30, 29*c*

USNM 217162, Holotype, Fly 75–32, 21.0 mm.

USNM 217163, Paratypes, Fly 75–32, 75: 6.3–23.1 mm.

Pseudomugil inconspicuus is a slender-bodied species, probably transparent in life, with only slight sexual dimorphism in the fins. Mouth relatively small and narrow, only about one-third as wide as head; gape relatively restricted, maxillomandibular ligament attached far anteriorly on lower jaw; only one-third of lower jaw extending anterior to rictus when mouth fully opened; ramus of lower jaw considerably elevated posteriorly; premaxillary bone with an accessory ascending process (absent in all other *Pseu-*



FIGURE 30.—*Pseudomugil inconspicuus*, paratype, USNM 217163, 21.6 mm.

domugil?); maxillary bone moderately stout (Figure 29c). Each side of upper jaw with a single row of 8–10 small teeth extending laterally from symphysis, this row continued by 6–8 greatly enlarged teeth curving outward from side of mouth; posterior third of upper jaw toothless; each side of lower jaw with one or two close-set, irregular rows totalling 8–20 very small teeth anteriorly; posterior two-thirds of lower jaw toothless (Figure 29c). First gill arch with 2 + 9 gill rakers. Pharyngeal teeth conical, somewhat enlarged posteriorly but not so much as in *P. novae-guineae*. Scales in lateral series 28–29; dorsomedian scales between occiput and origin of first dorsal fin 14–16; ventromedian scales between base of cleithrum and origin of pelvic fins only 7; peduncular scales only 6–7. First dorsal fin relatively small, with 3–4 spines, its origin posterior to a vertical line through base of first anal fin ray. Second dorsal fin I $4\frac{1}{2}$ – $5\frac{1}{2}$. Anal fin ii 10– $11\frac{1}{2}$. Pectoral fin 11–12. Principal caudal fin rays 6–7 + 7. Pelvic girdle attached to sixth rib. Free vertebrae 30. Slight sexual dimorphism of fins involving dorsal and anal fins only: in mature males first dorsal fin slightly larger than in females (sometimes with a short filamentous extension); second dorsal fin with short filamentous extension. Color in life not observed; body presumably transparent. Preserved specimens have relatively little pigmentation compared to other *Pseudomugil*. A uniformly thin, uninterrupted, longitudinal line of black pigment extends from just above origin of first pectoral fin ray to base of caudal fin. Side of body ventral to longitudinal pigment line almost entirely lacking melanophores except near bases of pectoral, anal, and caudal fins. Peritoneum entirely or almost entirely clear, without melanophores. Median fins with melanophores parallel to leading edges and near tips of rays, otherwise clear (probably colorless in life). Lateral half of pelvic fins with scattered melanophores.

Pseudomugil inconspicuus does not seem particularly closely related to any previously described *Pseudomugil*. *Pseudomugil tenellus* Taylor, 1964, known only from the vicinity of Oenpelli in the interior of Arnhem Land, differs markedly from *P. inconspicuus* and other species I have examined in having serially arranged tricuspid pharyngeal teeth and peritoneum densely pigmented (probably entirely black in life), characters suggestive of adaptation to phytophagy. The shape of the premaxillary bone, the tooth-bearing margin of which is strongly notched (Figure 29d),

also differs markedly from that in other *Pseudomugil* I have examined. Although higher classification is beyond the scope of the present contribution, it is worth noting that *Pseudomugil* may be near the ancestral stock of those highly specialized Southeast Asian atherinomorphs, the Phallostethoidea, and that *P. inconspicuus* is superficially at least more similar to phallostethoids than any other *Pseudomugil*.

AMBASSIDAE

Ambassis agrammus Günther, 1867

- USNM 217164, Fly 75–1, 16: 14.7–49.9 mm.
 USNM 217165, Fly 75–3, 1: 11.2 mm.
 USNM 217166, Fly 75–4, 1: 19.2 mm.
 USNM 217167, Fly 75–5, 1: 34.6 mm.
 USNM 217168, Fly 75–6, 5: 12.8–37.2 mm.
 USNM 217169, Fly 75–16, 6: 17.0–51.6 mm.
 USNM 217170, Fly 75–20, 13: 18.3–44.0 mm.

Ambassis macleayi (Castelnau, 1878)

- USNM 217171, Fly 75–24, 45: 16.7–51.8 mm.

Ambassis species undetermined

- USNM 217172, Fly 75–28, 5: 17.6–29.8 mm.
 USNM 217173, Fly 75–30, 39: 10.5–32.4 mm.
 USNM 217174, Fly 75–32, 2: 22.8–25.2 mm.

Three lots of *Ambassis* from the Lower Fly are close to *Ambassis nalua* (Hamilton-Buchanan, 1822) and *A. interruptus* Bleeker, 1852. The specimens have a continuous lateral line and about 25 gill rakers on lower limb of first gill arch.

Parambassis gulliveri Castelnau, 1878

- USNM 217175, Fly 75–1, 2: 73.5–89.0 mm.
 USNM 217176, Fly 75–3, 5: 149–220 mm.
 USNM 217177, Fly 75–9, 1: 197 mm.
 USNM 217178, Fly 75–20, 5: 43.8–146 mm.
 USNM 217179, Fly 75–22, 17: 19.8–54.7 mm.
 USNM 217180, Fly 75–25, 5: 37.6–50.9 mm.
 USNM 217181, Fly 75–27, 11: 26.4–49.0 mm.
 USNM 217182, Fly 75–28, 1: 79.0 mm.
 USNM 217183, Fly 75–30, 4: 32.8–65.2 mm.

Denariusa bandata Whitley, 1948

- USNM 217184, Fly 75-20, 10: 23.8-32.5 mm.
 USNM 217185, Fly 75-24, 116: 9.7-33.2 mm.
 USNM 217186, Fly 75-27, 1: 21.2 mm.

CENTROPOMIDAE

Lates calcarifer (Bloch, 1970)

FIGURE 5

- USNM 217187, Fly 75-32, 1: 204 mm.

LOBOTIDAE

Datnioides quadrifasciatus (Sevastianov, 1809)

- USNM 217188, Fly 75-4, 1: 322 mm.
 USNM 217189, Fly 75-12, 1: 255 mm.
 USNM 217190, Fly 75-20, 1: 349 mm.
 USNM 217191, Fly 75-28, 2: 150-210 mm.

THERAPONIDAE

Therapon fuliginosus Macleay, 1883

- USNM 217192, Fly 75-3, 1: 9 mm.
 USNM 217193, Fly 75-4, 1: 306 mm.
 USNM 217953, Fly 75-10, 4: 143-171 mm.
 USNM 217196, Fly 75-13, 2: 205-296 mm.

Therapon Cuvier, 1816 (type-species *Holocentrus servus* Bloch, 1797 = *Sciaena jarbua* Forskål, 1775; see Mees and Kailola, 1977:31) is represented by seven species in the rivers of central-southern New Guinea, all but one of them endemic (Mees and Kailola, 1977:27). Five species are known from the Fly; detailed descriptions of these are given by Mees and Kailola (1977), who incorporated much of my Fly material of this genus in their study.

The 296-mm specimen of *Therapon fuliginosus* from Fly 75-13 is a gravid female.

Therapon habbema Weber, 1910

- USNM 217192, Fly 75-3, 1: 9.0 mm.
 USNM 217193, Fly 75-4, 1: 306 mm.
 USNM 217194, Fly 75-8, 7: 27.7-123 mm.
 USNM 217195, Fly 75-10, 7: 80.1-171 mm.
 USNM 216422, Fly 75-11, 1: 110 mm.
 USNM 216421, Fly 75-13, 1: 123 mm.
 USNM 217196, Fly 75-13, 2: 205-296 mm.
 USNM 216420, Fly 75-14, 3: 17.4-55.2 mm.
 USNM 217197, Fly 75-14, 2: 11.7-29.1 mm.

Therapon lorentzi (Weber, 1910)

Therapon lorentzi, endemic to rivers of central-southern New Guinea, is known from the Upper and Middle Fly as well as the Lorentz, Digul, and Morehead (Mees and Kailola, 1977:32). It is the only species of *Therapon* in the Fly having some of the jaw teeth flattened and more or less tricuspid instead of all jaw teeth nearly round in cross section and conical.

Therapon lacustris Mees and Kailola, 1977

- USNM 216417, Paratype, Fly 75-20, 83.0 mm.
 USNM 216416, Paratype, Fly 75-24, 97.0 mm.
 USNM 217198, Fly 75-16, 5: 158-177 mm.

A full description of this species, incorporating part of my material from the Fly, is given by Mees and Kailola (1977:40-44). Color in life of specimens from Fly 75-16: body white, silvery or bluish white dorsally, milk white ventrally; a series of four vertical bars on dorsal half of body, faint when viewed from the side but clearly visible when viewed from above, corresponding in number and position with the well-marked black bars on the flanks of *T. affinis* (disappearing after preservation); all fins uniformly blackish or bluish black. No yellow pigment whatever on body or fins. *Therapon lacustris* is known from lotic habitats in the Middle and Lower Fly and adjacent rivers; it is closely related to, and perhaps conspecific with, *T. jamoerensis* Mees, 1971, from Lake Jamoer in the neck of Vogelkop Peninsula, West Irian (Mees and Kailola, 1977:22, 44). It may also be closely related to *T. affinis*, as indicated by my observations on its color in life.

Therapon affinis Mees and Kailola, 1977

- USNM 216418, Paratypes, Fly 75-20, 2: 41.4-101 mm.
 USNM 216419, Paratypes, Fly 75-24, 3: 32.8-84.3 mm.
 USNM 217199, Fly 75-22, 4: 17.3-30.5 mm.
 USNM 217200, Fly 75-24, 12: 9.8-27.1 mm.
 USNM 217201, Fly 75-25, 5: 18.0-30.5 mm.
 USNM 217202, Fly 75-27, 1: 23.4 mm.

Therapon affinis is known only from the Upper, Middle, and Lower Fly and Morehead River (Mees and Kailola, 1977:72), but it is perhaps conspecific with *Therapon percoides*, which is widely distributed in northern Australia (Mees and Kailola 1977:22, 23,

77). The main difference noted between *T. affinis* and *T. percoides* is that *T. affinis* has slightly finer squamation, 43–46 lateral line scales vs. 38–43. My field sketch and notes on coloration of live *T. affinis* from Fly 75–20 agree precisely with the color photograph of live *T. percoides* published by Lake (1971, pl. 80), notably in regard to yellow pigmentation of the fins.

Therapon affinis and *T. lacustris* were sympatric at Fly 75–20 and –24.

APOGONIDAE

The riverine Apogonidae of the Australian Region all belong to the endemic genus *Glossamia* (other genera are present in mangrove creeks and river mouths).

Key to *Glossamia* of New Guinea

1. Body with vertical bars, sometimes obscured by uniformly darkened coloration or by mottling 2
2. Body with 8–13 vertical bars, rarely obscured by uniformly darkened coloration; scales in lateral line series 46–50 (central-southern New Guinea) .. *G. sandei* (Weber, 1908)
2. Body with 3–4 vertical bars, sometimes obscured by uniformly darkened coloration or by mottling; scales in lateral line series 45 or fewer 3
3. First gill arch with 8 gill rakers; vertical bars rarely obscured by uniformly darkened coloration but never by mottling; vertical bar extending ventrally from base of first dorsal fin much wider than eye diameter (central-southern New Guinea) *G. trifasciata* (Weber, 1913)
3. First gill arch with 7 gill rakers; vertical bar sometimes obscured by mottling but never by uniformly darkened coloration; vertical bar extending ventrally from base of first dorsal fin narrower than eye diameter 4
4. Body usually with heavy mottling between vertical bars; snout immediately ventral to posterior nostril without distinctive mark; body depth at first dorsal fin origin 2.7–3.0 (central-southern New Guinea, Australia) *G. aprion* (Richardson, 1842)
4. Body without mottling; a sharply defined, intensely pigmented spot immediately ventral to posterior nostril; body depth at origin of first dorsal fin 3.2–3.5 (Middle Fly) *G. narindica*, new species
1. Body with horizontal or oblique bars, rarely obscured by uniformly dark or dull coloration but never by mottling 5
5. Body with horizontal bars (northern and southern New Guinea, including Mamberamo and Lorentz basins) *G. beauforti* (Weber, 1908)
5. Body with oblique bars 6
6. Oblique bars confined to dorsal half of body; anteriormost dorsal fin spine one-fifth or less as long as second dorsal fin spine; scales in lateral series 39–40 (after Weber and de Beaufort, 1929:286–287) (Mamberamo basin, northern New Guinea) *G. heurni* (Weber and de Beaufort, 1929)
6. Oblique bars covering entire body, rarely obscured by uniformly dull coloration ... 7
7. Scales in lateral line series 25–33 (northern New Guinea) *G. wichmanni wichmanni* (Weber, 1908)
7. Scales in lateral series 40–45 (northern New Guinea) *G. wichmanni gjellerupi* (Weber and de Beaufort, 1929)

Glossamia aprion (Richardson, 1842)

FIGURE 39

- USNM 217203, Fly 75–1, 1: 35.8 mm.
 USNM 217204, Fly 75–6, 2: 35.2–48.6 mm.
 USNM 217205, Fly 75–16, 11: 18.5–102 mm.
 USNM 217206, Fly 75–20, 19: 16.0–102 mm.
 USNM 217207, Fly 75–22, 1: 18.5 mm.
 USNM 217208, Fly 75–24, 24: 8.1–64.3 mm.

Glossamia Gill, 1863 (type-species *Apogon aprion* Richardson, 1842, by original designation) is restricted to the Australian Region. All but one or two of the species are endemic to New Guinea and occur only in freshwater. *Glossamia aprion* occurs in Australia as well as in New Guinea, and *G. wichmanni* has been reported in brackish and freshwater. All of the species have 4–6 scales between the lateral line and

the first dorsal fin, 6 spines in the first dorsal fin, and anal fin II 8–10. The species are distinguished mainly by differences in coloration.

The mottled color pattern exhibited by most specimens of *G. aprion* does not occur in any other member of the genus. Gill rakers on first gill arch 7 (20).

***Glossamia narindica*, new species**

FIGURE 31b

USNM 217209, Holotype, Fly 75–25, 125.5 mm.

USNM 217210, Paratypes, Fly 75–24, 9: 13.0–54.0 mm.

Glossamia narindica is closely related to *Glossamia aprion* but is more elongate and has slightly different coloration. The samples of *G. narindica* and *G. aprion* from Fly 75–24, where reproductively active populations of the two species occurred sympatrically,

show no sign of intergradation. All of the specimens, including young as small as 8 mm, are readily distinguishable.

Glossamia narindica is relatively elongate, snout 7.2–8.7 in specimens over 30 mm (vs. 8.7–9.6 in *G. aprion*), depth of body at origin of first dorsal fin 3.2–3.5 (vs. 2.7–3.0), and length of second spine in first dorsal fin (negatively allometric) 5.1–5.6 (vs. 4.1–5.5, not overlapping with *G. narindica* in specimens of comparable size). Scales in lateral line series 39–42. Gill rakers on first gill arch 7(10). Vertical bars on body relatively widely spaced, no specimens with mottling between vertical bars (*G. aprion* with vertical bars relatively close set, most specimens with mottling). Snout with a large, well-defined, intensely black spot immediately ventrolateral to posterior nostril (absent in *G. aprion*). *Glossamia narindica* is known only from the Middle Fly.

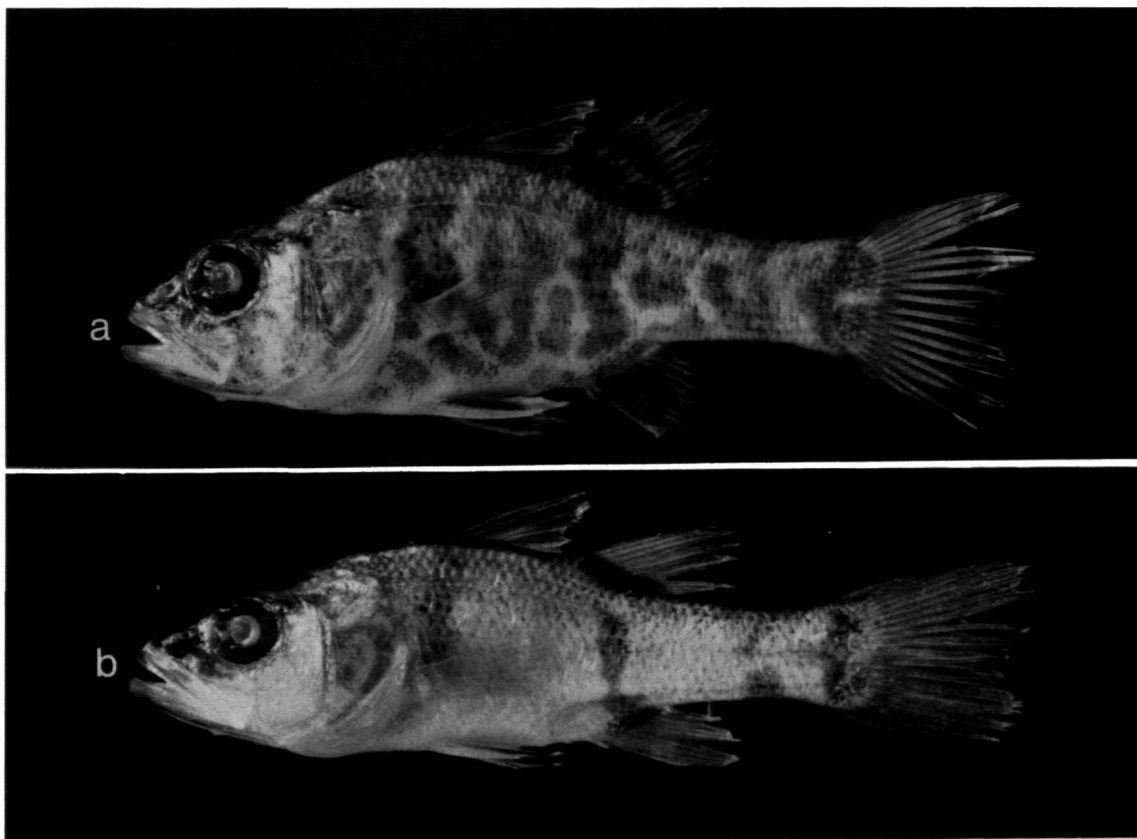


FIGURE 31.—*Glossamia*: a, *G. aprion*, USNM 217204, 48.6 mm; b, *G. narindica*, paratype, USNM 217210, 53.4 mm.

***Glossamia trifasciata* (Weber, 1913)**

FIGURE 32a

USNM 217211, Fly 75-4, 1: 14.9 mm.

USNM 217212, Fly 75-9, 73: 9.5-70.4 mm.

USNM 217213, Fly 75-10, 15: 19.5-78.3 mm.

USNM 217214, Fly 75-14, 14: 14.5-99.0 mm.

Glossamia trifasciata is endemic to rivers of central-southern New Guinea. Specimens from the Fly agree well with the original description and figure (Weber, 1913:580-581, fig. 32) except in having fewer scales in the lateral line series (26-33 vs. 35-36). *Glossamia trifasciata* differs from all other Fly *Glossamia* in color pattern and in having gill rakers on first gill arch

8(30) instead of only 7.

***Glossamia sandei* (Weber, 1908)**

FIGURE 32b

USNM 217215, Fly 75-9, 2: 19.2-39.5 mm.

USNM 217216, Fly 75-14, 2: 15.1-145 mm.

Glossamia sandei from the Fly agree well with previous descriptions of *G. sandei* (Weber, 1908:247, pl. 2: fig. 2; Weber and de Beaufort, 1929:284-285, fig. 75) except in having anal fin II 9½ instead of II 8 and body with 12-13 vertical bars instead of only 8-10. Gill rakers on first gill arch 7(4). Scales in lateral line series 50(2).



FIGURE 32.—*Glossamia*: a, *G. trifasciata*, USNM 217212, 43.3 mm; b, *G. sandei*, USNM 217215, 39.5 mm.

LUTJANIDAE

Lutjanus argentimaculatus (Forskål, 1775)

FIGURE 9

USNM 217217, Fly 75-6, 1: 377 mm.

SPARIDAE

Acanthopagrus berda (Forskål, 1775)

USNM 217218, Fly 75-1, 1: 298 mm.
 USNM 217219, Fly 75-24, 1: 300 mm.
 USNM 217220, Fly 75-32, 1: 224 mm.

SCIAENIDAE

Nibea semifasciata Chu, Lo, and Wu, 1963

FIGURE 33

USNM 217221, Fly 75-20, 1: 531 mm.
 USNM 217222, Fly 75-25, 2: 341-440 mm.
 USNM 217223, Fly 75-26, 2: 325-334 mm.

This species, previously known only from the South China Sea and Bangkok, was identified by Ethelwynn Trewavas of the British Museum (Natural History), who recently revised the Sciaenidae of the Western Pacific and Indian Ocean (Trewavas, 1977).

Larimichthys pamoides (Munro, 1964)

This species, known only from the 115-mm holotype from "mouth of the Fly River," is discussed by Trewavas (1977:452).

TOXOTIDAE

Toxotes chatareus (Hamilton-Buchanan, 1822)

FIGURE 34

USNM 217224, Fly 75-3, 1: 7.9 mm.
 USNM 217225, Fly 75-4, 1: 201 mm.
 USNM 217226, Fly 75-20, 11: 7.5-84.8 mm.
 USNM 217227, Fly 75-22, 2: 35.5-57.3 mm.
 USNM 217228, Fly 75-24, 3: 12.9-66.3 mm.
 USNM 217229, Fly 75-25, 2: 20.8-41.3 mm.
 USNM 217230, Fly 75-27, 4: 35.4-90.3 mm.
 USNM 217231, Fly 75-28, 1: 21.0 mm.
 USNM 217232, Fly 75-30, 8: 12.2-31.4 mm.

The identification of this species has been confirmed by G. R. Allen, who has completed a review of the species of *Toxotes* (Allen, in press).

SCATOPHAGIDAE

Scatophagus argus (Linnaeus, 1766)

A single specimen of this species was obtained in Lake Murray by Keith Dennis in 1970 and sent to the



FIGURE 33.—*Nibea semifasciata*, USNM 217221, 440 mm.

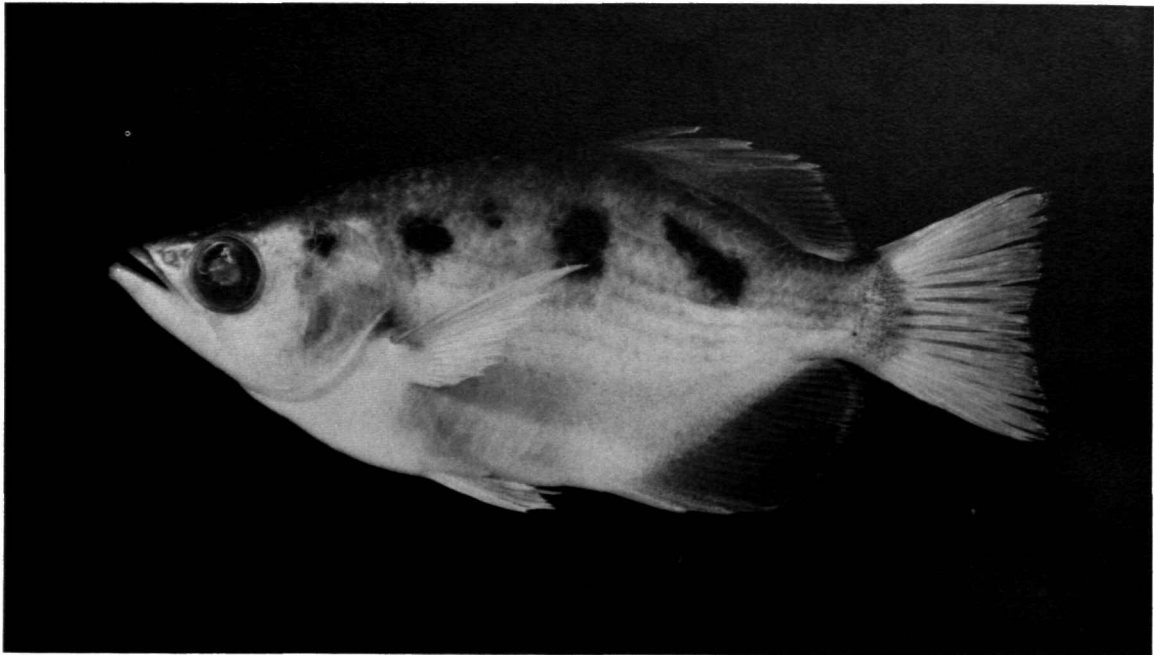


FIGURE 34.—*Toxotes* cf. *ulysses*, USNM 217230, 90.3 mm.

Fisheries Research Station, Kanudi (Port Moresby), where it was identified. Weber (1913a:588) recorded it from "Bivak" Insel, on the Lorentz River just below the upper limit of tidal influence.

MUGILIDAE

Crenimugil heterocheilus (Bleeker, 1855)

FIGURE 35

USNM 217233, Fly 75-1, 1: 437 mm.

USNM 217234, Fly 75-10, 2: 170-178 mm.

USNM 217235, Fly 75-27, 2: 50.9-53.2 mm.

Crenimugil heterocheilus from the Fly have head relatively narrow, adipose eyelid poorly developed (virtually absent). Oral teeth entirely absent at all sizes (50-440 mm). Upper lip moderately thick, specimens of 170-440 mm with 2-5 irregular rows of papillae terminating in hard, pointed tubercles. Maxillary bone hidden. Lower lip thin, horizontal (not folded down), nonpapillate. Symphyseal knob well developed. Preorbital bone finely scalloped or denticulate. Gill membranes extended far forward; gill rakers

on first gill arch about $20 + 50$ in 170-mm specimen. Scales in lateral series 35-37. Predorsal scales 21 (maximum count). Transverse scales 14 (counted from median scale at origin of first dorsal fin obliquely backward to median scale about one or two scales anterior to vent). Axillary pectoral fin scale and obbasal dorsal and pelvic fin scales enlarged and elongate. First dorsal fin IV, second dorsal fin I 8, anal fin III 9, pectoral fin 15. Pectoral fin falls short of a vertical line through origin of first dorsal fin, extending posteriorly only as far as tenth scale posterior to gill opening. Caudal fin only slightly forked. Total free vertebrae 23. Color in life of 440-mm specimen from Upper Fly (taken from a kodachrome slide): dorsum dark with bluish reflections; sides of head and body and abdomen entirely white with silvery reflections; first dorsal fin entirely dark; second dorsal fin blackish with distal tip bright orange yellow; caudal fin pale bluish with tips of both lobes bright orange yellow; anal fin pale whitish with tip pale yellow; pectoral fin bluish black with distal tip bright orange yellow; pelvic fins white.

Prof. J. M. Thomson of the University of Queensland kindly identified this species from a kodachrome

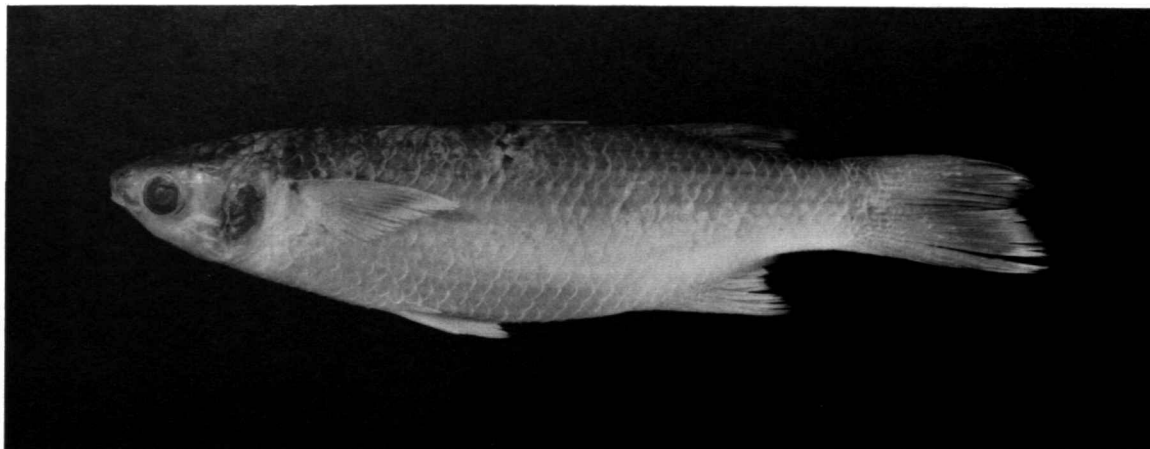


FIGURE 35.—*Crenimugil heterocheilus*, USNM 217234, 178 mm.

slide of the 440-mm specimen and notes based upon my examination of it and the other specimens. According to Prof. Thomson, who has examined Bleeker's type specimens, the species ranges from Indonesia to the New Hebrides.

***Liza diadema* (Gilchrist and Thompson, 1911)**

USNM 217236, Fly 75-18, 1: 402 mm.

***Liza oligolepis* (Bleeker, 1859)**

USNM 217237, Fly 75-32, 2: 30.4-33.5 mm.

BLENNIIDAE

***Omobranchus* species undescribed**

USNM 216985, Fly 75-32, 1: 47.4 mm.

Victor G. Springer (pers. comm.) states that this is an undescribed species that he plans to study in the near future.

GOBIIDAE

***Glossogobius giuris* (Hamilton-Buchanan, 1822)**

FIGURE 36

USNM 217238, Fly 75-1, 12: 17.2-171 mm.

USNM 217239, Fly 75-5, 1: 59.2 mm.

USNM 217240, Fly 75-6, 4: 107-128 mm.

USNM 217241, Fly 75-9, 69: 12.6-113 mm.
 USNM 217242, Fly 75-10, 2: 27.7-36.5 mm.
 USNM 217243, Fly 75-14, 9: 33.5-133 mm.
 USNM 217244, Fly 75-20, 1: 98.4 mm.
 USNM 217245, Fly 75-22, 15: 21.7-59.5 mm.
 USNM 217246, Fly 75-25, 17: 18.2-60.6 mm.
 USNM 217247, Fly 75-25, 1: 47.7 mm.
 USNM 217248, Fly 75-27, 9: 16.5-114 mm.
 USNM 217249, Fly 75-28, 4: 32.5-57.6 mm.
 USNM 217250, Fly 75-30, 52: 16.9-74.5 mm.
 USNM 217251, Fly 75-32, 2: 38.2-76.7 mm.

My material of *Glossogobius* from the Fly clearly represents at least two biological species (sensu Mayr, 1963). In identifying these as *G. giuris* and *G. celebius*, I am following Weber (1913b:468-469), whose material from the Lorentz included both species. Sympatric populations of the two species, with one or both of them reproductively active, were sampled at seven collecting localities without finding evidence of intergradation. The only indication I have found of possible interbreeding consists of four specimens from Fly 75-2, separately cataloged as USNM 217261. These are somewhat like *G. giuris* in shape of head and length of jaws; their coloration resembles that of *G. celebius* much more than that of *G. giuris*, but is atypical for either species.

Glossogobius giuris is common in highland, lowland, and estuarine habitats of the Fly, where it feeds on insects and prawns and attains 171 mm, many samples including specimens over 100 mm. Lower jaw extending posteriorly to below anterior margin of eye or farther. Dorsum of head without fine ridges and

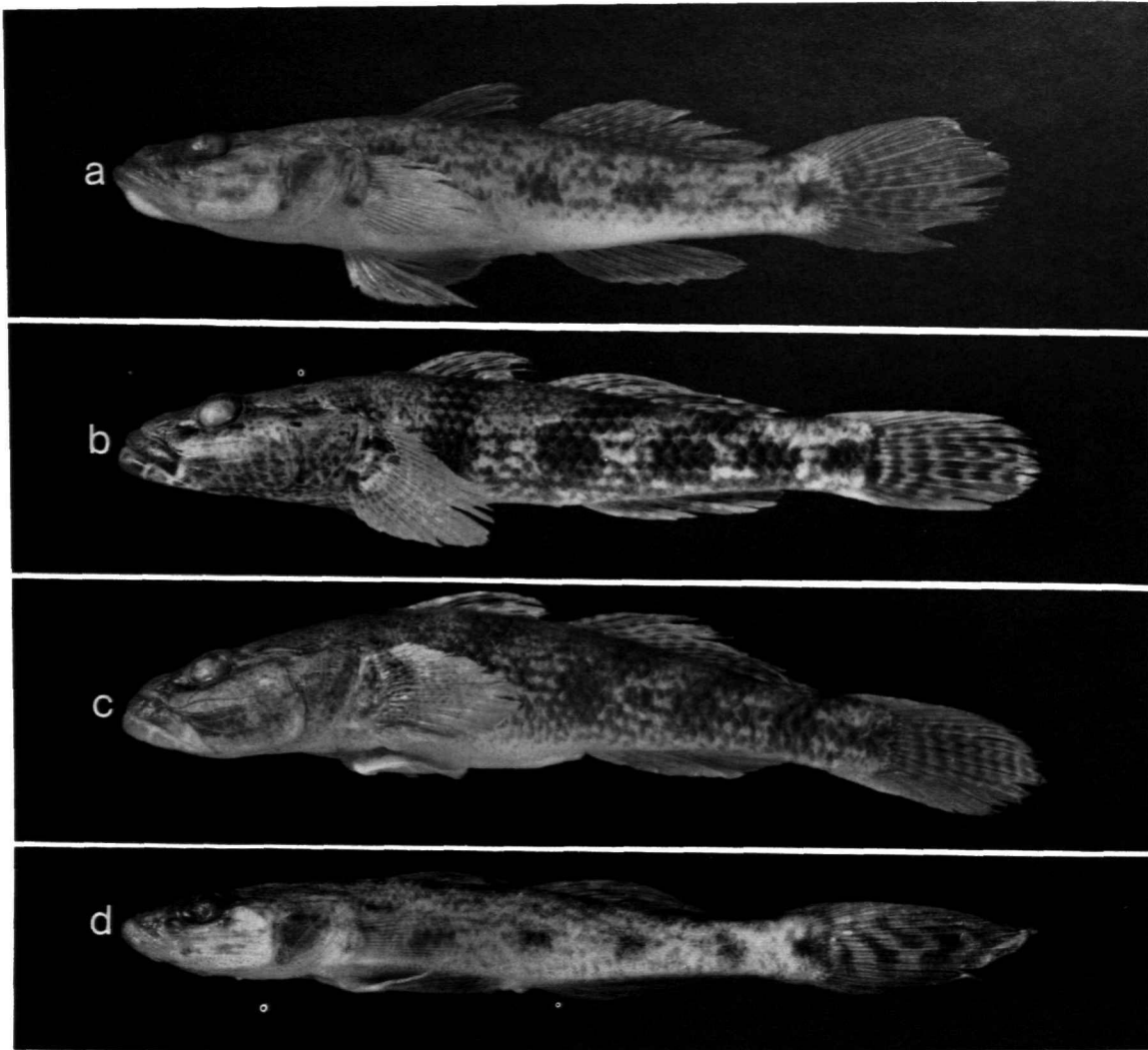


FIGURE 36.—*Glossogobius giuris*: a, USNM 217251, lowland ecotype, 76.7 mm; b, USNM 217243, intermediate between lowland and highland ecotypes, 106 mm; c, USNM 217241, highland ecotype, 113 mm; d, USNM 217247, specimen with hypertrophied cephalic sensory papillae and fin rays, 47.7 mm.

grooves. Predorsal scales 20–35. Second dorsal fin usually with 10 or 11 segmented rays: 10 (21), 11 (14), 9 (3), 12 (1). Body with 5 mediolateral pigmented blotches; dorsal, pectoral, and caudal fins with relatively uniform pattern of small round spots that form vertical rows on pectoral and caudal fins.

Highland and lowland populations of *G. giuris* in the Fly exhibit ecotypic differentiation. Highland populations have pelvic fins rounded and greatly

thickened, whereas lowland populations have elongate pelvic fins with moderately to exceedingly delicate membranes and thin rays. Highland populations also have more rounded heads and thicker lips. Samples from Fly 75–9 and Fly 75–32 represent the extremes of highland and lowland ecotypic differentiation observed, with the sample from Fly 75–14 clearly intermediate.

The separately cataloged 47.7-mm specimen from

Fly 75-25 is of interest for its uniquely hypertrophied cephalic sensory papillae and fin rays.

***Glossogobius celebius* (Valenciennes, 1837)**

FIGURE 37

USNM 217252, Fly 75-1, 43: 12.9-64.5 mm.
 USNM 217253, Fly 75-2, 18: 14.0-70.2 mm.
 USNM 217254, Fly 75-4, 79: 14.3-89.8 mm.
 USNM 217255, Fly 75-5, 15: 21.5-63.7 mm.
 USNM 217256, Fly 75-6, 2: 26.8-39.2 mm.
 USNM 217257, Fly 75-8, 3: 14.8-63.6 mm.
 USNM 217258, Fly 75-9, 127: 13.9-67.6 mm.
 USNM 217259, Fly 75-13, 1: 83.2 mm.
 USNM 217260, Fly 75-14, 52: 12.3-94.8 mm.

According to Weber (1913b:468) *Glossogobius celebius* is definitely known only from the eastern half of the Indo-Australian Archipelago, including Celebes (the type-locality), Ambon, Timor, Flores, New Guinea, and Aru Islands. *Glossogobius celebius* is present in both lowland and highland habitats in the

Upper Fly but was not encountered in the Middle or Lower Fly. It feeds on insects and attains only 95 mm. Lower jaw extending posteriorly to a point in front of anterior margin of eye. Dorsum of head with fine ridges and grooves comparable to cristae and sulci on the human hand, present in specimens from highlands as well as lowlands (especially well developed in 89.8-mm specimen from Fly 75-4 and in 63.6-mm specimen from Fly 75-8; absent or poorly developed in some specimens). Predorsal scales 12-20. Second dorsal fin usually with 12 segmented rays: 12 (33), 11 (7), 10 (1), 13 (1). Body with 7 mediolateral pigmented blotches; a large, intensely black spot or spots centered on last one or two rays of first dorsal fin; second dorsal fin with a subdistal depigmented horizontal band; pectoral fin without vertical bands; small round spots on caudal fin restricted to anterior half of fin, not forming vertical rows.

In contrast to *G. giuris*, highland and lowland populations of *G. celebius* do not exhibit marked ecotypic differentiation.

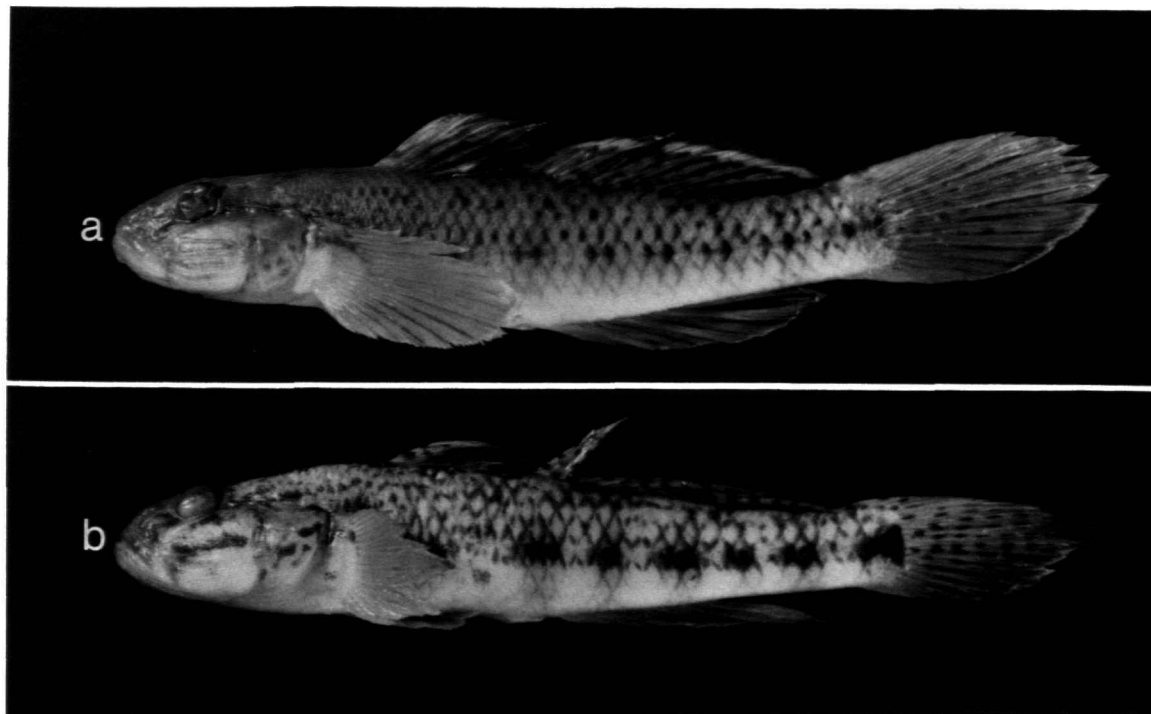


FIGURE 37.—*Glossogobius*: a, *G. celebius*, USNM 217257, 63.6 mm; b, *G. cf. celebius*, USNM 217261, 56.5 mm.

***Gobiopterus semivestitus* (Munro, 1949),
new combination**

USNM 217265, Fly 75-32, 5: 10.0-13.5 mm.

Gobiopterus Bleeker, 1874 (type-species *Apocryptes brachypterus* Bleeker, 1855, by original designation), comprises several transparent, sexually dimorphic species, seldom exceeding 25 mm and usually sexually mature at 12-15 mm. Most populations are reproductively active, no matter when or where they are sampled. Mature males have an elongate, slender genital papilla (often unusually large for so small a fish) and considerably enlarged conical or needle-like teeth in the anterior portion of the jaws. Females have a genital papilla that may become greatly swollen (extraordinarily large), and uniformly small jaw teeth. The jaw bones of males are relatively heavy, those of females slender and delicate. The pelvic fins, unusually small for gobiids, are even smaller in females than in males.

These midwater gobies, apparently overlooked by some fieldworkers due to their transparency and small size, are widely distributed in freshwater and brackish habitats in India and Southeast Asia as well as the Australian Region. The species are very poorly known, and males and females have sometimes been identified as different genera. There appear to be at least two species or species groups, one with a large first dorsal fin in brackish and estuarine habitats, the other with a small first dorsal fin in freshwater habitats. Representatives of both groups were encountered during the 1975 Fly survey. The genus has not been reported previously from New Guinea.

The monotypic *Paraphya* Munro, 1949 (type-species *Paraphya semivestita* Munro, 1949, by original designation), is apparently closely related, possibly identical, to the type-species of *Gobiopterus*. My material from Fly 75-32 consists of three juveniles, 10.0-11.1 mm, a 12.6-mm mature male, and a 13.5-mm gravid female. The two mature specimens agree very well with Munro's excellent description and figures of male and female *G. semivestitus* of 16.0-23.8 mm except that the female is not fully scaled. The male is apparently fully scaled, with about 19 large ctenoid scales in a lateral series commencing somewhat behind the head and extending to the base of the caudal fin. Munro (1949:229) reported this species in brackish waters in estuaries and coastal lakes from southern New South Wales to tropical Queensland.

***Gobiopterus* species undetermined**

USNM 217262, Fly 75-22, 1: 12.7 mm.
USNM 217263, Fly 75-24, 7: 13.0-13.5 mm.
USNM 217264, Fly 75-30, 3: 12.5-14.8 mm.

This *Gobiopterus* species undetermined differs from *G. semivestitus* in having a much smaller first dorsal fin, smaller eyes, and no thin, interrupted midlateral line of pigment. The 11 specimens, all from freshwater habitats in the Middle and Lower Fly, comprise nine males, 12.5-14.8 mm, and two females (neither gravid) 12.7-13.1 mm. A 14.3-mm specimen has about 23 ctenoid scales in a lateral series.

***Oxyurichthys jaarmani* Weber, 1913**

USNM 217266, Fly 75-28, 2: 30.1-32.6 mm.
USNM 217267, Fly 75-30, 8: 17.5-32.0 mm.

***Stenogobius* cf. *genivittatus*
(Cuvier and Valenciennes, 1837)**

USNM 217269, Fly 75-27, 26: 18.3-36.8 mm.
USNM 217270, Fly 75-28, 115: 15.3-54.2 mm.

Two lots of *Stenogobius* Bleeker, 1874 (type-species *Gobius gymnopomus* Bleeker, 1853, by original designation), from the Lower Fly are referable to *S. genivittatus* as understood by Koumans (1953:35-37). All of the larger specimens from Fly 75-28, including many as small or smaller than the largest specimens from Fly 75-27, have a relatively well-developed color pattern, with a large vertical (not oblique) bar on cheek below middle of eye, a small oblong vertical mark on dorsal one-third or one-half of pectoral fin base, and 8-9 thin, dusky vertical bars on the side of the body. Specimens from Fly 75-27 have a more terete head and slightly smaller eyes, but their coloration, albeit faint, appears basically identical to that of specimens from Fly 75-28. Fly 75-27 was taken from a shallow backwater of the Fly mainstream with a soft, muddy bottom, continuously roiled by wind and wave action and hence excessively turbid; Fly 75-28 was from a well-drained tidal creek with relatively compact bottom and much less turbid. I tentatively consider the two lots conspecific. On the other hand, I suspect that one or more of the five nominal species placed in the synonymy of *S. genivittatus* by Koumans are valid species.

Stigmatogobius romeri Weber, 1911

USNM 217271, Fly 75-28, 78: 8.6-22.8 mm.

USNM 217272, Fly 75-30, 10: 9.0-21.0 mm.

Gobiidae genus and species undetermined

USNM 217268, Fly 75-32, 1: 28.4 mm.

This unidentified goby from a mangrove creek near the Fly mouth has maxillary extending posteriorly to below anterior margin of eye; upper jaw extending farther anteriorly than lower jaw. Each side of upper jaw with a single row of about 30 uniformly elongate teeth, all tricuspid except the last few teeth near the rictus, which are conical. Lower jaw (damaged) evidently with a cluster of enlarged blunt conical teeth near symphysis and a single row of similar but smaller blunt conical teeth extending to rictus. First dorsal fin VI; second dorsal fin I 8½; anal fin I 8; pectoral fin 16; pelvic fin with well-developed basilar membrane. Scales in lateral series 29 (all but first scale ctenoid). Dorsum of head posterior to eyes and opercle covered with large cycloid scales; cheek scaleless. Predorsal scales 9. Abdomen covered with large ctenoid scales but breast anterior to base of pelvic fins and isthmus scaleless. Dorsomedian and ventromedian scale rows from behind base of last dorsal fin ray and last anal fin ray to origin of anteriormost procurrent caudal fin ray both with 9 ctenoid scales. Color in preservation: three short oblique bars radiating from near ventral half of eye, one onto snout, one to posterior half of upper jaw, and one to opercle. Body with numerous melanophores in several poorly defined patterns, some paralleling margins of scales, some forming small round spots on dorsal half of body, and some forming a longitudinal series of five elongate midlateral blotches. Dorsal and caudal fins with one or two faint, oblique or vertical bars formed by scattered melanophores; an irregular blotch of melanophores on upper half of pectoral fin and its base.

ELEOTRIDAE*Bostrychus strigogenys* Nichols, 1937

USNM 217273, Fly 75-5, 1: 69.1 mm.

Bunaka herwerdeni (Weber, 1910)

USNM 217274, Fly 75-1, 1: 46.7 mm.

USNM 217275, Fly 75-2, 1: 99.0 mm.

USNM 217276, Fly 75-6, 4: 38.1-365 mm.

USNM 217277, Fly 75-12, 1: 437 mm.

USNM 217278, Fly 75-16, 2: 60.9-91.9 mm.

Butis butis (Hamilton-Buchanan, 1822)

USNM 217279, Fly 75-32, 7: 16.2-69.3 mm.

Eleotris fusca (Bloch and Schneider, 1801)

USNM 217280, Fly 75-28, 7: 19.7-79.3 mm.

USNM 217281, Fly 75-30, 33: 21.3-75.8 mm.

Mogurnda mogurnda (Richardson, 1844)

USNM 217282, Fly 75-2, 3: 73.5-93.8 mm.

USNM 217283, Fly 75.4, 8: 18.4-47.3 mm.

USNM 217284, Fly 75-5, 10: 26.7-93.4 mm.,

USNM 217285, Fly 75-9, 11: 29.5-76.9 mm.

USNM 217286, Fly 75-16, 1: 56.5 mm.

Ophiocara porocephalum (Valenciennes, 1837)

USNM 217287, Fly 75-32, 1: 112 mm.

Oxyeleotris fimbriata (Weber, 1908)

FIGURE 38a

USNM 217288, Fly 75-2, 4: 63.3-77.9 mm.

USNM 217289, Fly 75-4, 5: 11.0-64.7 mm.

USNM 217290, Fly 75-13, 1: 148 mm.

USNM 217291, Fly 75-14, 1: 82.0 mm.

USNM 217292, Fly 75-16, 3: 44.9-61.3 mm.

Oxyeleotris Bleeker, 1874 (type-species *Eleotris marmorata* Bleeker, 1852, by original designation), comprises a number of riverine and estuarine species in Southeast Asia, the Australian Region, and the tropical western Pacific (Koumans, 1936a; 1953).

Oxyeleotris fimbriata occurs in lacustrine and riverine habitats in the Upper and Middle Fly, where it attains at least 148 mm (Koumans, 1936a:133, indicates a maximum of 300 mm for this species without indicating locality). Specimens from the Fly have cephalic pores well developed, with 2 nasal, 3 orbital, 4 preopercular, and 4 lateral line canal pores. Head relatively depressed. Horizontal diameter of eye 12.3-16.8 (4: 24.6-61.3 mm). Scales in lateral series 51-74. Total number of fin rays in second dorsal fin 12(2),

13(5), 14(4). Total number of anal fin rays 10(4), 11(7), 12(2). Pectoral fin rays 13(2), 14(5), 15(1), 16(2). Complete vertebral centra 27–29(4). Body usually with 11–16 chevron-shaped marks, vertically oriented, with apex of chevron directed posteriorly. These marks are variable; they may be poorly defined or absent. The chevrons are often better defined on the anterior half of the body than on the posterior half, and the lower limbs of the chevrons are often more distinct than the upper limbs. Comparable marks, present in some other species from New Guinea, are absent in Asian species. Pectoral and caudal fins usually with melanophores forming clusters

or round spots arranged in several equally prominent vertical bands; these fin markings, although not always present, may be well developed in specimens as small as 11 mm.

Koumans (1936b) studied 81 specimens, 16–225 mm, from various localities in former Dutch New Guinea, all identified as *O. fimbriata*, and reported a regular increase in number of scales with growth, from 45–48 in a lateral series in specimens under 40 mm to 71–77 in specimens over 180 mm. Scale counts on my material from the Fly indicate that Koumans' concept of *O. fimbriata* probably involved more than one species. Thus my largest sample, Fly 75–4, com-



FIGURE 38.—*Oxyeleotris*: a, *O. fimbriata*, USNM 217292, 44.9 mm; b, *O. paucipora*, holotype, USNM 217293, 39.4 mm; c, *O. nullipora*, holotype, USNM 217298, 30.4 mm.

prises five specimens of 11, 17, 24, 42, and 65 mm, with respective counts of 63, 69, 68, 68, and 68 scales in a lateral series. The lowest scale counts in my Fly material, 50–61, are in the specimens from Fly 75–2. Although I have identified them as *O. fimbriata*, they are heavier bodied and differ in coloration from the other samples and may represent another species (possibly *O. aruensis* Weber, 1911, or *O. mertoni* Weber, 1911, both of which Koumans treated as synonyms of *O. fimbriata*). If this lot is discounted, scale counts in my Fly *O. fimbriata* range from 60–74.

Munro (1964:184, fig. 22) identified specimens of a distinctive *Oxyeleotris* from Mendi district (central highlands of Papua New Guinea, presumably Purari drainage) as juvenile *O. fimbriata*. These specimens, 47–78 mm, are described as having no scales on the cheek, gill cover, pectoral fin base, or breast (the figure of a 71-mm specimen indicates the entire abdomen is also scaleless). In all *Oxyeleotris* I have examined, including the smallest *O. fimbriata*, all of these areas are fully scaled. The coloration of the Mendi fish, as described and figured by Munro, is also unlike that in any previously described *Oxyeleotris*.

Oxyeleotris paucipora, new species

FIGURE 38b

USNM 217293, Holotype, Fly 75–1, 39.4 mm.
 USNM 217294, Paratypes, Fly 75–1, 7: 29.0–37.6 mm.
 USNM 217295, Paratypes, Fly 75–2, 31: 13.6–37.5 mm.
 USNM 217296, Paratypes, Fly 75–4, 6: 9.8–29.9 mm.
 USNM 217297, Paratypes, Fly 75–5, 4: 14.0–42.1 mm.

Oxyeleotris paucipora occurs in riverine habitats in the Upper Fly, sometimes sympatrically with *O. fimbriata*; largest known specimen only 42 mm. Cephalic pore system with nasal pores usually absent (a few specimens with 1 or 2 nasal pores); no orbital pores; 4 preopercular pores; 2 lateral line canal pores. Head relatively depressed. Horizontal diameter of eye 14.9–18.7 (19: 23.6–42.1 mm). Scales in lateral series 34–37. Total rays in second dorsal fin 12(3), 13(5). Total anal fin rays 9(2), 10(6). Pectoral fin rays 11(1), 12(21), 13(29). Complete vertebral centra 25–27(7).

All of my specimens of *O. paucipora* are immediately distinguishable from *O. fimbriata* in coloration. On the shoulder, immediately anterior to the fleshy base of the uppermost pectoral fin ray, is a small, pale or white, round area devoid of melanophores. A

membranous flap extending from the dorsoposterior corner of the gill cover may overlay and obscure this spot; in live fish the spot presumably could be exposed or hidden by movements of the gill cover. This white spot is surrounded, especially dorsally, by a darkly pigmented, nearly black area, round and as large or larger than the eye. The white spot and the black area surrounding it are clearly visible in the specimen illustrated in Figure 38b, in which the dark area is continuous with a dark longitudinal band extending posteriorly on the body; in most specimens the black area surrounding the white spot is more clearly demarcated. This shoulder mark, born by every specimen, is as obvious at 9.8 mm as at 42 mm. None of my *O. fimbriata* have such a mark. In *O. fimbriata* this part of the shoulder is variably pigmented but is usually more or less uniformly covered with melanophores. A few specimens have a very small pale area near the base of the uppermost pectoral fin ray, but it is variable in position and never surrounded by dark or black pigmentation. Some *O. paucipora* have chevron-shaped marks on the body comparable to those in *O. fimbriata* but they are fewer, only 9–11. Pectoral and caudal fins either uniformly covered with melanophores, or with melanophores concentrated to form 2–3 vertical bands, the band nearest caudal peduncle most prominent. First and second dorsal and anal fins almost invariably with a well-developed submarginal longitudinal band of black pigment; dorsal fins with variably developed round spots beneath submarginal longitudinal band usually present, sometimes absent or tending to form a second longitudinal band.

Oxyeleotris nullipora, new species

FIGURE 38c

USNM 217298, Holotype, Fly 75–16, 30.4 mm.
 USNM 217299, Paratypes, Fly 75–16, 5: 19.1–27.5 mm.
 USNM 217300, Paratype, Fly 75–20, 1: 22.6 mm.

Oxyeleotris nullipora occurs in lacustrine and semi-lacustrine habitats in the Middle Fly, sometimes sympatrically with *O. fimbriata*; largest known specimen only 30.4 mm. It apparently differs from all other known *Oxyeleotris* in having cephalic pores entirely absent. Head relatively compressed. Horizontal diameter of eye 13.1–13.8 (6: 22.6–30.4 mm). Scales in lateral series 34–38. Total rays in second dorsal fin

11(3), 12(4). Anal fin rays 9(1), 10(5), 11(1). Pectoral fin rays 11(12), 12(1). Complete vertebral centra 26–28(6).

All specimens of *O. nullipora* have a shoulder mark nearly identical with that in *O. paucipora*, and most have 9–11 chevron-shaped marks. Pectoral and caudal fins without melanophores arranged to form distinct markings. First and second dorsal fins with melanophores arranged to form numerous small round dots; no submarginal longitudinal bands.

The lowest counts of scales in a lateral series previously reported in a species of *Oxyeleotris*, apart from 45–77 reported in *O. fimbriata* by Koumans, is 56 in *O. mertoni* and *O. aruensis* (Weber, 1911:33), and the lowest previously reported pectoral fin ray counts are 13–16 for *O. fimbriata*.

Oxyeleotris paucipora and *O. nullipora* undoubtedly are closely related: in addition to markedly small size, reduced cephalic pore systems, fewer scales and pectoral fin rays than other *Oxyeleotris*, and the same number of chevron-shaped body marks, they share a unique specialization, the shoulder mark. There is also strong evidence that they are distinct from each other at the species level. The difference in development of the cephalic pore system, entirely absent in *O. nullipora* but comparatively well developed in *O. paucipora*, is greater than normally found within gobioid species (pers. comm., Ernest M. Lachner and Frank McKinney). The difference in eye size between the two species, while slight when expressed by the number of times eye diameter goes into standard length, also merits emphasis. Due to its larger eye and more compressed head, the vertical depth of the head beneath the eye is much less in *O. nullipora* than in *O. paucipora* (compare Figures 38*b* and 38*c*).

A Note on *Oxyeleotris*

Oxyeleotris apparently has speciated more extensively in the rivers of New Guinea than any other gobioid genus, and further collecting is likely to lead to discovery of additional species. It should be clear from the present observations that the New Guinea representatives of this genus need systematic revision. Of problems already evident, the specific status of Munro's *Oxyeleotris* from Mendi needs to be considered, as well as that of *O. aruensis* and *O. mertoni*.

Prionobutis microps (Weber, 1908)

USNM 217301, Fly 75–27, 1: 113 mm.

USNM 217302, Fly 75–30, 36: 12.4–103 mm.

PERIOPHTHALMIDAE

Periophthalmus weberi Eggert, 1935

USNM 217303, Fly 75–28, 1: 15.5 mm.

USNM 217304, Fly 75–30, 1: 46.2 mm.

Pseudapocryptes confluentus, new species

FIGURE 39

USNM 217952, Holotype, Fly 75–31, 35.2 mm.

USNM 217305, Paratype, Fly 75–30, 45.3 mm.

USNM 217306, Paratypes, Fly 75–31, 24: 14.8–37.9 mm.

Pseudapocryptes confluentus is readily distinguished from all previously described Oxudercinae (= Apocrypteinae) in having the distal ends of fin rays of first dorsal, second dorsal, caudal, and anal fins joined by a single continuous fin membrane. First dorsal fin with 6 spines, at least in some specimens (sixth spine

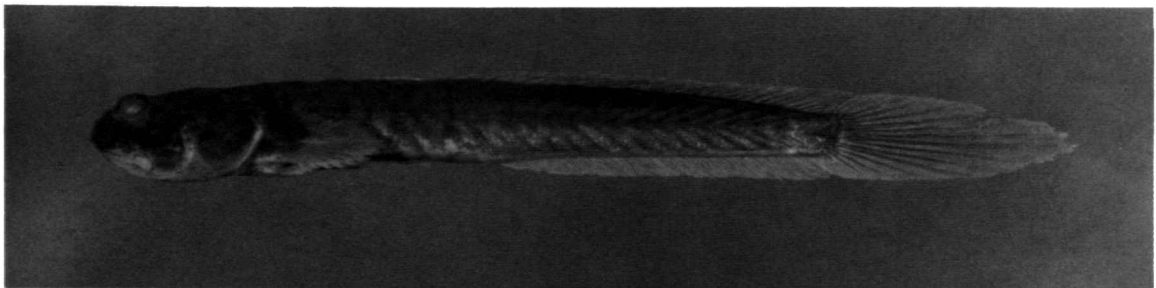


FIGURE 39.—*Pseudapocryptes confluentus*, holotype, USNM 217952, 35.2 mm.

reduced, not reaching margin of fin membrane); second dorsal fin I 29–31; anal fin I 28–31; pectoral fin 20–21, lowermost 7–9 rays thickened; total caudal fin rays 21–24 (about 15 principal caudal rays). Dorsum of head including snout, cheeks, gill cover, and most of body covered by minute scales; about 140–180 scales in a lateral series and 100 predorsal scales. Isthmus, breast, ventral surface of abdomen, base of pectoral and pelvic fins, and caudal fin scaleless. Dentition basically identical in specimens 15–45 mm: each side of upper jaw with 2–3 large, elongate conical teeth anteriorly, then a single row of about 20 much smaller conical teeth extending posteriorly almost to rictus; each side of lower jaw with a single large, erect, inwardly curved canine tooth or fang internal to symphysis, and a single row of 10–12 (usually 11) large, subhorizontal conical teeth; posterior one-third of lower jaw toothless. Color in preservative (similar in all or almost all respects to that in life): body more or less uniformly dark brownish dorsally and laterally; side of abdomen with about 6 oblique dark bands; ventral surface of head and abdomen pale (not purple or blood red in life); all fins hyaline.

Pseudapocryptes confluentus agrees with *Pseudapocryptes* Bleeker, 1874 (type-species *Eleotris lanceolatus* Bloch and Schneider, 1801, by original designation), in having a more elongate body and smaller scales than any other known Apocrypteinae, similar fin formulae, and basically similar dentition. *Pseudapocryptes lanceolatus* differs from *P. confluentus* in having second dorsal and anal fins separated from caudal fin; jaw teeth fewer; more than 200 (up to 350) scales in a lateral series; and small scales covering isthmus, breast, base of pectoral and pelvic fins, abdomen, and proximal two-thirds of caudal fin.

I have examined a well-preserved series of 55 juveniles and subadults of *P. lanceolatus* from the Sunderbans, Bangladesh, California Academy of Sciences 40081 (formerly Stanford University Natural History Museum same catalog number), 26.8–117 mm, as well as two somewhat larger specimens from Thailand, USNM 119991, 167 mm, and USNM 119636, 186 mm. In these specimens there is no membranous connection between second dorsal fin or anal fin and caudal fin; membrane from last spine of first dorsal fin extending posteriorly to base of first ray in second dorsal fin; caudal fin with a series of thin oblique

color bars; each side of upper jaw with 5–7 large teeth anteriorly and 6–8 smaller teeth posteriorly, and each side of lower jaw with a large canine tooth behind symphysis and 8–15 large subhorizontal teeth. In the specimens from Bangladesh the sides of the body have about a dozen irregular oblique color bars, sometimes breaking up into spots, and better defined on the posterior half of the body than on the anterior half. These bars are more distinct in the juveniles than in the subadults, but traces of them are evident in all 55 specimens.

Hundreds of *P. confluentus* up to about 50 mm (juveniles?) were observed at the type-locality on a gently sloping, flat, detritus-littered mudbank exposed at low tide (Fly 75–31). They were flipping about in a manner and with a level of activity suggestive of *Periophthalmus*, except that they invariably landed on their sides and flipped from their sides, never balancing on their pelvic fins or assuming an upright position.

GOBIOIDIDAE

Brachyamblyopus urolepis (Bleeker, 1852)

USNM 217307, Fly 75–28, 33: 17.5–36.2 mm.

KURTIDAE

Kurtus gulliveri Castelnau, 1878

USNM 217308, Fly 75–6, 5: 195–315 mm.
 USNM 217309, Fly 75–22, 3: 47.6–51.3 mm.
 USNM 217310, Fly 75–25, 11: 55.0–167 mm.
 USNM 217311, Fly 75–27, 1: 104 mm.

SOLEIDAE

Aseraggodes klunzingeri (Weber, 1908)

USNM 217312, Fly 75–27, 1: 35.3 mm.
 USNM 217313, Fly 75–28, 2: 29.0–32.8 mm.
 USNM 217314, Fly 75–30, 44: 18.5–74.1 mm.

Brachirus villosus (Weber, 1908)

USNM 217315, Fly 75–2, 1: 25.4 mm.
 USNM 217316, Fly 75–14, 1: 44.0 mm.
 USNM 217317, Fly 75–16, 1: 49.9 mm.

CYNOGLOSSIDAE***Cynoglossus heterolepis* Weber, 1910**

USNM 217318, Fly 75-32, 1: 153 mm.

Originally described from the Lorentz, this species is also known from the Oetoemboewe (the drainage immediately east of the Lorentz), the Upper Fly, and Arnhem Land (Menon, 1977:87-89). There are few specimens in museums; the largest reported is 194 mm.

TETRAODONTIDAE***Tetraodon erythrotaenia* Bleeker, 1853**

USNM 217319, Fly 75-32, 5: 21.0-53.5 mm.

***Sphoeroides pleurostictus* (Günther, 1871)**

USNM 217320, Fly 75-32, 1: 20.4 mm.

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