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# Ecological Notes on the Fish Fauna of a Coastal Drainage of North Borneo

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## INTRODUCTION

The Borneo Zoological Expedition, 1950, of Chicago Natural History Museum spent the months of May and June at the Bukit Kretam Camp of North Borneo Timbers, Ltd. The camp, in primary lowland rain forest, is near the head of Dewhurst Bay on the east coast of North Borneo. The location made it possible to collect from the mouth of the main stream, the Kretam Kechil River, to its sources at the watershed.

Much of whatever success the expedition experienced resulted from the assistance of the Fisheries and Forestry Departments of the Colony of North Borneo. Grateful acknowledgment is made to North Borneo Timbers, Ltd., for permission to stay at the Kretam Camp. The members of the expedition feel a special debt of gratitude to Messrs. O. C. Finch and J. D. H. Hedley of North Borneo Timbers for assistance and kindness extended in the field. I am also indebted to Mr. Henry S. Dybas, Associate Curator of Insects, Chicago Natural History Museum, for identifying the arthropod food fragments.

Measurements of specimens were made with calipers graduated to 0.1 mm. up to 120 mm. Above this length a steel rule graduated to 0.5 mm. was used. Standard length was taken as the distance from the tip of the snout to the caudal flexure. Head length, except where otherwise noted, was measured from the end of the opercular flap to the tip of the snout. Body depth (stated simply as "depth") is the greatest depth. Head and body depth are given as the quotient of the standard length divided by the dimension. Eye and snout are given as the quotient of the dimension in the head length. Lateral line scales are counted from above the gill opening to the caudal flexure.

## DESCRIPTION OF THE REGION

The Kretam Kechil River drains into the southeast end of Dewhurst Bay (fig. 10). The bay, located 55 kilometers southeast of the mouth of Sandakan Harbour, is one of a series of drowned river mouths along the northeast coast of Borneo. The total length of streams draining into Dewhurst Bay via the mouth of the Kretam Kechil is approximately 50 kilometers. Twenty kilometers of this length lie in a nipa palm-mangrove association. Upstream from this brackish, swampy area, the vegetation changes into primary lowland forest dominated by trees of the family Dipterocarpaceae. Submergent vegetation is limited to filamentous algae growing on rocks, although the lower parts of the plants in the nipa-mangrove belt are covered by water at high tide. Occasional ferns and grasses grow in shallow water along the stream edges where the banks are low. Clumps of the introduced water-hyacinth (*Eichornia*) occur in and slightly above the nipa-mangrove.

The Kretam Kechil is 100 meters wide near its mouth. Upstream it narrows rapidly although it is still 22 meters wide at the mouth of the Pinang River, one of the two principal tributaries. The Pinang tapers from 16 meters at its mouth to 5 to 8 meters upstream 1.5 kilometers, at the edge of the nipa palm zone. The Gaja River, the second main tributary, is 54 meters wide at its mouth, which is less than one kilometer from the mouth of the Kretam Kechil. Four kilometers upstream, approximately at the edge of the nipa palm belt, the Gaja narrows to about 6 meters.

The nipa-mangrove belt and a narrower zone upstream are affected by tides. Near the mouth of the Kretam Kechil, the tide had an amplitude of just under 3 meters during May and June, 1950. At high tide the stream widths noted above are increased. The entire nipa-mangrove zone is flooded, thus vastly increasing the area available to brackish water species. The effect of tides above the nipa-mangrove zone is conditioned by topography, as a rapid rise in elevation blocks the flood tide. Steep banks prevent the lateral spread of tidal waters. The Pinang is affected by tides to a point just above Sta. X (fig. 10), or slightly more than one kilometer above the nipa palm zone. However, the Gaja rises more rapidly, so that the tidal current does not reach much over one-half kilometer above the nipa palm.

The Kretam Kechil exceeds 3 meters in depth from the mouth of the Pinang downstream, even at low tide. From Sta. I (fig. 10) downstream the Gaja also exceeds that depth. The Pinang is



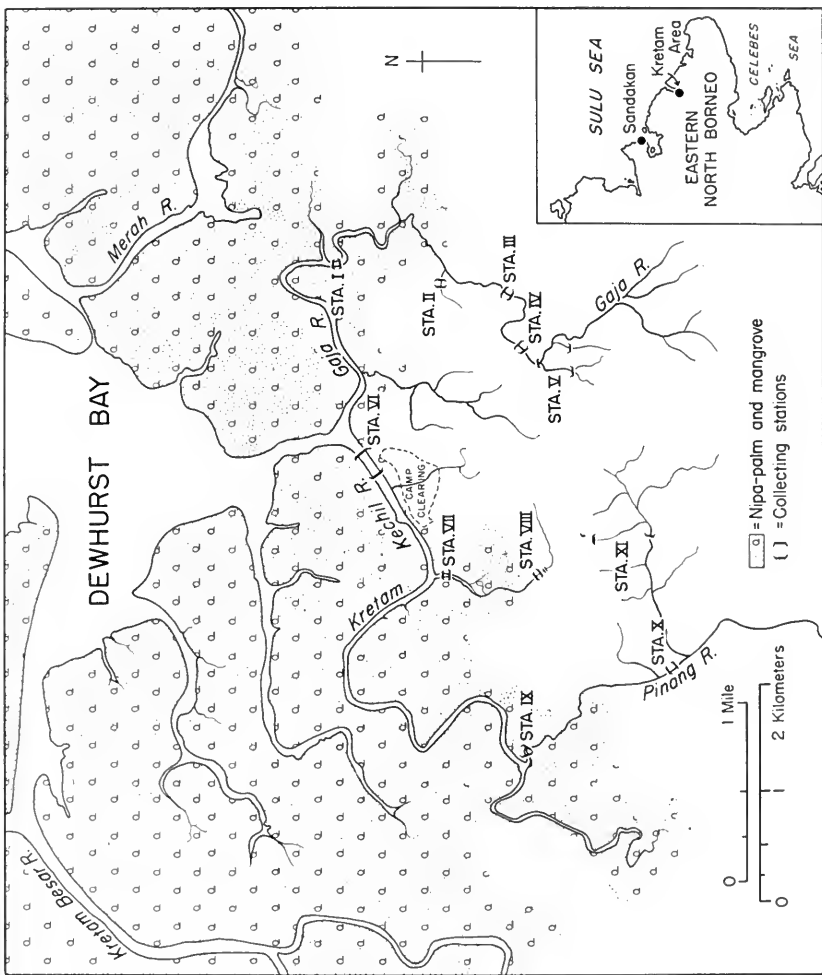


FIG. 10. Area at southeast end of Dewhurst Bay, North Borneo.

3 meters deep at its mouth. Above the tidal zone both the Pinang and the Gaja decrease in depth and width irregularly because of the formation of alternating pools and riffles. Upstream from the beginning of Sta. XI, the Pinang does not exceed 0.6 meter in depth and consists of small pools no wider than 0.6 meter connected by shallow riffles. The tributary followed at Sta. XI lies in a steep ravine and is formed by a series of small isolated pools (approximately one meter long and 5 to 10 cm. deep) separated by sheer drops that vary from 0.3 to 1.6 meters in height.

Immediately below Sta. III the Gaja drops 3 meters in a horizontal distance of 20 meters over a jumble of massive boulders. Below these falls the river reaches depths of 2 meters in pools and occasionally widths of 10 meters. Above the falls the Gaja forms a wide, shallow basin that narrows upstream to a channel 2 meters wide. The depth of pools in this channel reaches 1.6 meters in the first 50 meters. Beyond this distance the pools become progressively shallower. At Sta. IV and above, no pool exceeds 0.6 meter in depth. Stream width at this point varies from 0.5 to 1.5 meters. The west branch of Sta. V is in a ravine and is formed of a series of small shallow pools connected by riffles. The east branch also consists of pools (as much as 5 meters long) and shallow riffles (10 cm. deep). This branch drops 5 meters over a sheer rock face and turns southwestward. Immediately above this point are several pools 3 meters long and 0.4 meter deep. Just upstream this branch cuts through a steep ravine and has the characteristics of the headwaters of the Pinang (Sta. XI).

The current in the tidal zone fluctuates from zero to 4 meters per minute. An average current for the upper reaches of the streams is difficult to determine because of the variation from riffles to pools. However, in the pools of Sta. III the current had a speed of 1 meter per minute; in pools of Sta. IV the current was 2.9 meters per minute. Torrential rains, common in Borneo, cause rapid increase in current and volume of water. A rainfall of 5 to 8 cm. one afternoon was followed in four hours by a rise in water level of about 2 meters at Sta. III on the Gaja. Estimation of the terrific current was impossible.

In the nipa-mangrove belt the bottom is primarily mud. Above the tidal zone, sand and gravel appear, although mud is still abundant in pools (for example, at Stas. X and II). Farther upstream, the rivers flow over portions of exposed bedrock and occasionally through areas of boulders. In this zone (Sta. III and above) sand

and gravel predominate; mud has largely disappeared. The proportion of bedrock increases upstream and predominates on the Pinang in the north branch of Sta. XI and on the Gaja above Sta. IV. Dead leaves cover the bottoms of quiet pools in all reaches of the rivers above the nipa-mangrove belt. The amount of detritus present in the latter was not determined.

Turbidity, nature of the bottom, and current are inter-related. The water is clear (except after rains) above the tidal zone and, therefore, above the area of predominantly muddy bottom.

Water surface temperatures taken between 8:00 A.M. and noon indicate little variation. On the Gaja River at Sta. I the temperature was 25° C. at 8:00 A.M. and 27° C. at 10:00 A.M. The rise in temperature was probably the result of the heating of the upper strata of the then slack water by the sun. All other stations of the Gaja had shaded water temperatures of 25° C. Water temperature at the mouth of the Pinang was 25° C. The temperature at Sta. XI was 27° C. No data are available for Sta. X.

The rivers at Stas. I, VI, VII, and IX are not shaded except for the flooded areas within the nipa palm and mangrove zone at high tide. Stas. X and III are partially shaded. All other stations are almost completely shaded by the forest.

Unfortunately salinity data are not available. Coarse analysis by tasting surface samples indicates that the water is fresh at Stas. II, III, and upstream on the Gaja, at Stas. X and XI on the Pinang, and at Sta. VIII. Of these, Sta. X apparently is the only one affected by tidal fluctuations. The sample tested was taken at the surface. Denser saline water may occur along the bottom at high tide. Nipa palm and mangrove provide a more reliable test for the presence of saline water. The absence of these trees from Sta. X is confirmation of the taste test—at least for the surface layer. The lack of tidal fluctuations at the other stations listed in this paragraph is proof of the freshness of the water.

Most of the stations were poisoned with cubé root (5.4 per cent rotenone). A cast net and a "common-sense" minnow seine ( $\frac{1}{4}$ -inch mesh) were used in a few places. Some specimens were caught on hook-and-line. The methods of collection had obvious effects on the samples. The poison seemed to be non-selective with regard to species and individual size at least in clear water less than 2 meters deep. Species habitually seen at the surface (e.g. *Nematabramis*) as well as burrowers in bottom detritus (e.g. *Eleotris*) were recovered after poisoning. The cast net, however, because it was used only

in shallow water, did not catch large individuals of some species and no specimens of benthic species whose habitats are in deeper water.

#### DESCRIPTIONS OF STATIONS

*Station I:* Gaja River 2.5 kilometers above mouth, in tidal zone; shore vegetation nipa palm; stream shaded at edges only; bottom mud and rock. Depth at low water 3 meters; width 7 meters; tide slack water to flood. Current zero to 4 meters per minute. Water muddy; visibility limited to upper 10 cm. Rotenone. May 22, 1950.

#### FAUNA

<i>Anodontostoma chacunda</i> , 5	<i>Ambassis interrupta</i> , 4
<i>Corica soborna</i> , 21	<i>Ambassis gymnocephalus</i> , 34
<i>Ilisha kampeni</i> , 5	<i>Leiognathus equulus</i> , 56
<i>Stolephorus commersoni</i> , 9	<i>Toxotes chatareus</i> , 1
<i>Zenarchopterus amblyurus</i> , 3	<i>Scatophagus argus</i> , 1
<i>Dermogenys pusillus</i> , 7	<i>Butis butis</i> , 1
<i>Ceratostethus bicornis</i> , 41	<i>Tetraodon kretamensis</i> , 3
<i>Neostethus borneensis</i> , 3	

*Station II:* Small tributary entering Gaja River 300 meters above nipa palm zone, above tidal zone; shore vegetation primary dipterocarp rain forest; stream shaded except in small patches. Pools and riffles; bottom sand and gravel, mud in pools; bottom in pools covered with dead leaves. Depth in pools up to 60 cm., in riffles up to 5 cm.; width 1 to 3 meters. Current slow. Water clear and fresh. Rotenone. May 12, 1950.

#### FAUNA

<i>Anguilla borneensis</i> , 33	<i>Ophiocara porocephala</i> , 1
<i>Rasbora sumatrana</i> , 40	<i>Oxyeleotris urophthalmus</i> , 1
<i>Puntius sealei</i> , 9	<i>Butis gymnopomus</i> , 27
<i>Hampala macrolepidota</i> , 4	<i>Brachygobius doriae</i> , 56
<i>Clarias teysmanni</i> , 3	<i>Glossogobius giurus</i> , 7
<i>Dermogenys pusillus</i> , 27	<i>Cyprinogobius chryosoma</i> , 6
<i>Ambassis interrupta</i> , 2	<i>Pseudogobius bikolanus</i> , 8
<i>Eleotris fusca</i> , 1	<i>Pseudogobius</i> sp. B, 1
<i>Eleotris melanosoma</i> , 39	<i>Tetraodon kretamensis</i> , 163

*Station III:* Gaja River immediately above falls, above tidal zone; shore vegetation primary dipterocarp rain forest; stream mostly shaded. Pools; bottom sand, gravel, and bedrock, in quiet areas covered by dead leaves. Depth up to 1.3 meters; width 2 to 10 meters. Current 1 meter per minute. Water clear and fresh. Rotenone. May 31, 1950.

## FAUNA

<i>Anguilla borneensis</i> , 31	<i>Hampala macrolepidota</i> , 71
<i>Monopterus alba</i> , 1	<i>Osteochilus spilurus</i> , 84
<i>Nematabramis everetti</i> , 269	<i>Mystus nemurus</i> , 9
<i>Rasbora sumatrana</i> , 110	<i>Betta unimaculata</i> , 9
<i>Puntius sealei</i> , 6	

*Station IV:* Gaja River; shore vegetation primary dipterocarp r. in forest; stream largely shaded. Pools and riffles; bottom sand, gravel, and bedrock, in pools covered with dead leaves. Depth in pools up to 60 cm., in riffles less than 5 cm.; width 0.5 to 1.5 meters. Current 2.9 meters per minute. Water clear. Rotenone. June 3, 1950.

## FAUNA

<i>Anguilla borneensis</i> , 14	<i>Hampala macrolepidota</i> , 21
<i>Nematabramis everetti</i> , 113	<i>Osteochilus spilurus</i> , 7
<i>Rasbora sumatrana</i> , 61	<i>Mystus nemurus</i> , 10
<i>Puntius sealei</i> , 23	<i>Betta unimaculata</i> , 11

*Station V:* Headwaters of Gaja River; shore vegetation primary dipterocarp rain forest; stream almost completely shaded. Pools, riffles, and small waterfalls; bottom mostly bedrock with gravel and sand; bottom in pools with dead leaves. Depth in pools up to 60 cm., in riffles less than 8 cm.; width up to 1 meter. Current rapid. Water clear. Minnow seine and dip nets. June 18, 1950.

## FAUNA

<i>Nematabramis everetti</i> , 10	<i>Hampala macrolepidota</i> , 1
<i>Rasbora sumatrana</i> , 1	<i>Betta unimaculata</i> , 9
<i>Puntius sealei</i> , 4	

*Station VI:* Kretam Kechil River one kilometer above mouth, in tidal zone; shore vegetation nipa palm and mangrove; stream shaded at edges only. Bottom mud and rock. Depth at low tide over 3 meters; width about 65 meters. Tide ebb. Water muddy; visibility limited to thin upper stratum. Cast net within 8 meters of shore. May 18, 1950.

## FAUNA

<i>Anodontostoma chacunda</i> , 14	<i>Ambassis nalua</i> , 1
<i>Thrissocles hamiltoni</i> , 8	<i>Ambassis interrupta</i> , 3
<i>Ilisha kampeni</i> , 17	<i>Gerres poeti</i> , 2
<i>Zenarchopterus amblyurus</i> , 1	<i>Leiognathus equulus</i> , 7
<i>Tylosurus strongylurus</i> , 1	<i>Caranx ignobilis</i> , 2
<i>Neostethus lankesteri</i> , 1	<i>Pomadasys hasta</i> , 3
<i>Mugil dussumieri</i> , 11	<i>Pomadasys maculatus</i> , 5
<i>Chelon caeruleomaculatus</i> , 2	<i>Lates calcarifer</i> , 1

*Station VII:* Near mouth of small unnamed tributary of Kretam Kechil, in tidal zone; shore vegetation nipa palm; stream shaded except in center. Bottom mud. Depth up to 1 meter; width up to 3 meters. Tide slack water; current none. Water muddy; visibility limited to surface. Dip nets. May 10, 1950.

## FAUNA

<i>Zenarchopterus amblyurus</i> , 4	<i>Neostethus borneensis</i> , 1
<i>Dermogenys pusillus</i> , 1	<i>Chelon</i> sp., 1
<i>Ceratostethus bicornis</i> , 97	<i>Pseudogobius bikolanus</i> , 1

*Station VIII:* Upstream from Sta. VII, above tidal zone; shore vegetation primary dipterocarp rain forest; stream completely shaded. Riffles and pools. Bottom sand, gravel, and bedrock; bottom of quiet pools with dead leaves. Depth in pools up to 1 meter, in riffles up to 5 cm.; width up to 2.5 meters. Current moderate to rapid. Water clear. Station is below 20-meter waterfall. Rotenone. May 11, 1950.

## FAUNA

<i>Anguilla borneensis</i> , 10	<i>Clarias teysmanni</i> , 5
<i>Nematabramis everetti</i> , 87	<i>Ophicephalus melanosoma</i> , 3
<i>Rasbora sumatrana</i> , 70	<i>Betta unimaculata</i> , 16
<i>Puntius sealei</i> , 74	<i>Eleotris melanosoma</i> , 2

*Station IX:* Mouth of Pinang River, in tidal zone; shore vegetation nipa palm; stream shaded near shore. Bottom mud. Depth at low water 3 meters; width 16 meters. Tide ebb to slack water; current 3 meters per minute to zero. Water muddy; visibility limited to upper 10 cm. Rotenone. June 10, 1950.

## FAUNA

<i>Coilia coomansi</i> , 4	<i>Sphyraena jello</i> , 1
<i>Corica soborna</i> , 84	<i>Ambassis gymnocephalus</i> , 3
<i>Ilisha kampeni</i> , 1	<i>Ambassis interrupta</i> , 2
<i>Stolephorus tri</i> , 5	<i>Leiognathus equulus</i> , 18
<i>Mystus nemurus</i> , 3	<i>Toxotes chatareus</i> , 3
<i>Ichthyocampus carce</i> , 1	<i>Toxotes jaculatrix</i> , 2
<i>Zenarchopterus amblyurus</i> , 1	<i>Lutianus argentimaculatus</i> , 1
<i>Dermogenys pusillus</i> , 2	<i>Scatophagus argus</i> , 8
<i>Ceratostethus bicornis</i> , 26	<i>Tetraodon fluviatilis</i> , 6
<i>Chelon</i> sp., 2	

*Station X:* Pinang River near upper limit of tidal zone; shore vegetation logged dipterocarp forest; stream partially shaded. No riffles; bottom mud and gravel. Depth up to 1.6 meters; width 5

to 8 meters. Tide ebb; current moderate. Water muddy; visibility limited to strata near surface. Rotenone. May 10, 1950.

## FAUNA

<i>Anguilla borneensis</i> , 3	<i>Dermogenys pusillus</i> , 21
<i>Nematabramis everetti</i> , 198	<i>Butis gymnopomus</i> , 14
<i>Rasbora sumatrana</i> , 3	<i>Pseudogobius</i> sp. A, 1
<i>Hampala macrolepidota</i> , 1	<i>Tetraodon fluviatilis</i> , 3
<i>Mystus nemurus</i> , 22	<i>Tetraodon kretamensis</i> , 35
<i>Dorichthys brachyurus</i> , 2	

Station XI: Headwaters of Pinang River; shore vegetation primary dipterocarp rain forest; stream completely shaded. Pools, riffles, and small waterfalls; bottom bedrock, sand, and gravel; dead leaves on bottom of pools. Depth of pools under 60 cm., in riffles less than 3 cm.; width under 60 cm.; current rapid above point at which station turns north, moderate below this point. Water clear. Dip nets. June 15, 1950.

## FAUNA

*Betta unimaculata*, 9

Incidental collecting was carried out on the Kretam Kechil during the course of travel on the river. The following species were obtained in this manner between the mouth of the Pinang (Sta. IX) and the mouth of the Kretam Kechil:

<i>Ichthyocampus carce</i> , 1	<i>Periophthalmus variabilis</i> , 1
<i>Zenarchopterus amblyurus</i> , 1	<i>Parapocryptes rictuosus</i> , 1
<i>Dermogenys pusillus</i> , 3	<i>Boleophthalmus boddarti</i> , 1
<i>Neostethus borneensis</i> , 14	<i>Glossogobius giurus</i> , 1
<i>Ceratostethus bicornis</i> , 6	<i>Gobiopterus brachypterus</i> , 27
<i>Ambassis interrupta</i> , 1	<i>Oxyurichthys tentacularis</i> , 2
<i>Caranx ignobilis</i> , 1	<i>Ctenogobius</i> sp., 1
<i>Scatophagus argus</i> , 3	<i>Tetraodon kretamensis</i> , 7
<i>Periophthalmus schlosseri schlosseri</i> , 1	

Hook-and-line fishing in Dewhurst Bay yielded the following:

<i>Evenchelys macrurus</i> , 2	<i>Polydactylus plebius</i> , 1
<i>Tachysurus venosus</i> , 5	<i>Pomadasys hasta</i> , 3
<i>Tachysurus caelatus</i> , 1	<i>Lutianus argentimaculatus</i> , 1
<i>Tachysurus sagor</i> , 2	<i>Epinephelus nebulosus</i> , 1
<i>Eleutheronema tetradactylum</i> , 1	<i>Toxotes chatareus</i> , 1

## ANNOTATED FAUNAL LIST

**Anodontostoma chacunda** Hamilton

*Clupanodon chacunda* Hamilton, 1822, Fishes of Ganges, p. 246—estuary of the Ganges, India.

*Anodontostoma chacunda* Jordan and Seale, 1905, Proc. U. S. Nat. Mus., 28: 771.

Dorsal rays iii-iv, 14-15; pectoral i, 14-15; ventral i, 6-7; anal ii, 18-19; lateral line scales 35-37; abdominal scutes 16-17+11-13; total length 45-100 mm.; standard length 34.6-75.5 mm.; head 2.81-3.28; depth 2.07-2.33.

Five specimens (standard length 34.6-38.8 mm.) from Sta. I, and fourteen (50.1-75.5 mm.) from Sta. VI. In brackish water only.

### **Thrissocles hamiltoni** Gray

*Thrissa hamiltoni* Gray, 1833-34, Illustr. Indian Zool., 2, pl. 92, fig. 3—no locality given.

*Thrissocles hamiltoni* Fowler, 1918, Copeia, no. 58, p. 62.

Dorsal rays iii, 10-11; pectoral i, 11-12; ventral i, 6; anal iv, 32-35; abdominal scutes 16-17+10-11; total length 35-145 mm.; standard length 28.0-121.0 mm.; head 3.84-4.31; depth 3.31-3.64.

Six stomachs contained food. One had a small fish (*Ambassis?*) and an unidentifiable decapod. The others held from one to ten prawns (family Palaemonidae).

Eight specimens from Sta. VI in brackish water.

### **Stolephorus commersoni** Lacépède

*Stolephorus commersoni* Lacépède, 1803, Hist. Nat. Poissons, 5: 382, pl. 12, fig. 1—no locality given.

Dorsal rays ii-iii, 12-14; pectoral i, 12-14; ventral i, 6; anal iii, 17-19; gill rakers 22-25; abdominal scutes 2-4; total length 53-63 mm.; standard length 42.8-51.2 mm.; head 3.63-3.86; depth 4.65-5.22.

Five stomachs were examined. One contained a partly digested fish, one an unidentifiable decapod, and three from two to ten small prawns.

Nine specimens from Sta. I in brackish water.

### **Stolephorus tri** Bleeker

*Engraulis tri* Bleeker, 1852, Verh. Bat. Gen., 24: 40—Batavia, Java.

*Stolephorus tri* Bleeker, 1865, Ned. Tijds. Dierk., 2: 57.

Dorsal rays ii-iii, 12-14; pectoral i, 13-14; ventral i, 6; anal ii-iii, 17-18; mid-lateral scales 33-36; abdominal scutes 3-4; total length 57-102 mm.; standard length 47.0-84.5 mm.; head 3.76-3.95; depth 4.69-5.08.



Of the three stomachs containing food, one held three prawns, one a fish (20 mm. total length) and a prawn, and one a fish (15 mm. total length) and two prawns.

Five specimens from Sta. IX in brackish water.

### ***Coilia coomansi* Hardenberg**

*Coilia coomansi* Hardenberg, 1934, *Treubia*, 14: 294—Kapuas River, Borneo.

Dorsal rays I, iii, 9-11; pectoral ix-x (free), 7-9; ventral i, 6; anal ii, 70-84; gill rakers 23-25+31-34; branchiostegals 8-10; lateral line scales 54-61; abdominal scutes 8-10+10; total length 101-102 mm.; standard length 90.0-94.5 mm.; head 4.77-5.06; depth 4.11-4.42.

Four specimens from Sta. IX in brackish water.

### ***Corica soborna* Hamilton**

*Corica soborna* Hamilton, 1822, *Fishes of Ganges*, p. 253—Mahanandra River, India.

Dorsal rays iii, 11-13; pectoral i, 11-12; ventral i, 7; anal iii, 11-13+2; mid-lateral scales 37-40; abdominal scutes 10-11+7-8; total length 23.5-53 mm.; standard length 19.1-42.5 mm.; head 3.85-4.43; depth 3.93-5.07.

Twenty-one specimens (standard length 19.7-35.6 mm.) from Sta. I, and eighty-four (19.1-42.5 mm.) from Sta. IX, all in brackish water.

### ***Ilisha kampeni* Weber and de Beaufort**

*Pellona kampeni* Weber and de Beaufort, 1913, *Fishes Indo-Austr. Arch.*, 2: 87—Batavia, Java, and Balikpapan, Borneo.

*Ilisha kampeni* Norman, 1923, *Ann. Mag. Nat. Hist.*, (9), 11: 5.

Dorsal rays iii, 14-15; pectoral i, 13-15; ventral i, 4-6; anal iv, 34-40; abdominal scutes 18-20+7-9; total length 38-165 mm.; standard length 32.0-134 mm.; head 3.03-3.36; depth 3.54-3.95; anal base in standard length 2.91-3.24.

Twelve stomachs were examined. Prawns predominate, from two to seventeen occurring in ten stomachs. In addition, one stomach contained an unidentifiable decapod crustacean; one, an isopod; one, fish fry; one, three unidentifiable fish (10-15 mm. long); and one, two juvenile *Ambassis*.

Five specimens (standard length 32.0-42.3 mm.) from Sta. I, seventeen (72.3-134 mm.) from Sta. VI, and one (34.6 mm.) from

Sta. IX. The larger specimens were taken from the largest volume of water. Although the methods of collection varied (cast net at Sta. VI, rotenone and dip nets at the others), the differences in size cannot be attributed to this factor because smaller specimens of other species, for example, *Thrissocles hamiltoni*, were collected at Sta. VI at the same time.

All specimens were collected in brackish water.

### *Anguilla borneensis* Popta

*Anguilla borneensis* Popta, 1924, Zool. Meded. Mus. Nat. Hist. Leiden, 8: 73, figs. a, b—Bo River, Borneo.

Pectoral rays 16–18; total length 54–375 mm.; pre-anal length in total 2.23–2.51; head in total 6.41–7.75; gape in head 3.13–3.55.

Six digestive tracts were examined. Three contained fragments of terrestrial insects (probably Orthoptera) and a fourth had about one hundred aquatic insect larvae of the dipteran family Simuliidae. The remaining two held decapod fragments.

Thirty-three specimens from Sta. II, thirty-one from Sta. III, fourteen from Sta. IV, ten (total length 59.5–241 mm.) from Sta. VIII, three (54–71 mm.) from Sta. X, and one (375 mm.) from below Sta. III. Specimens from Stas. II, III, and IV were inadvertently mixed after they had been counted but before they had been measured. The size range for these three stations is 65–143 mm.

The failure to obtain *Anguilla* from Sta. V, upstream from Sta. IV, probably is the result of selective collecting methods. A minnow seine and dip nets—gear not designed for catching burrowing forms—were used at Sta. V. Rotenone was employed at every station from which *Anguilla* was collected.

### *Evenchelys macrurus* Bleeker

*Muraena macrurus* Bleeker, 1854, Nat. Tijd. Ned. Indië, 7: 324—Batavia, Java.  
*Evenchelys macrurus* Jordan and Evermann, 1902, Proc. U. S. Nat. Mus., 25: 327.

Total length 1265–1865 mm. (larger specimen measured 1980 mm. prior to preservation); pre-anal length in total 2.53–2.61; head in total 9.73–10.91; depth in total 35.1–35.6; gape in head 2.91.

Two specimens were caught in Dewhurst Bay on hook-and-line with prawn as bait.

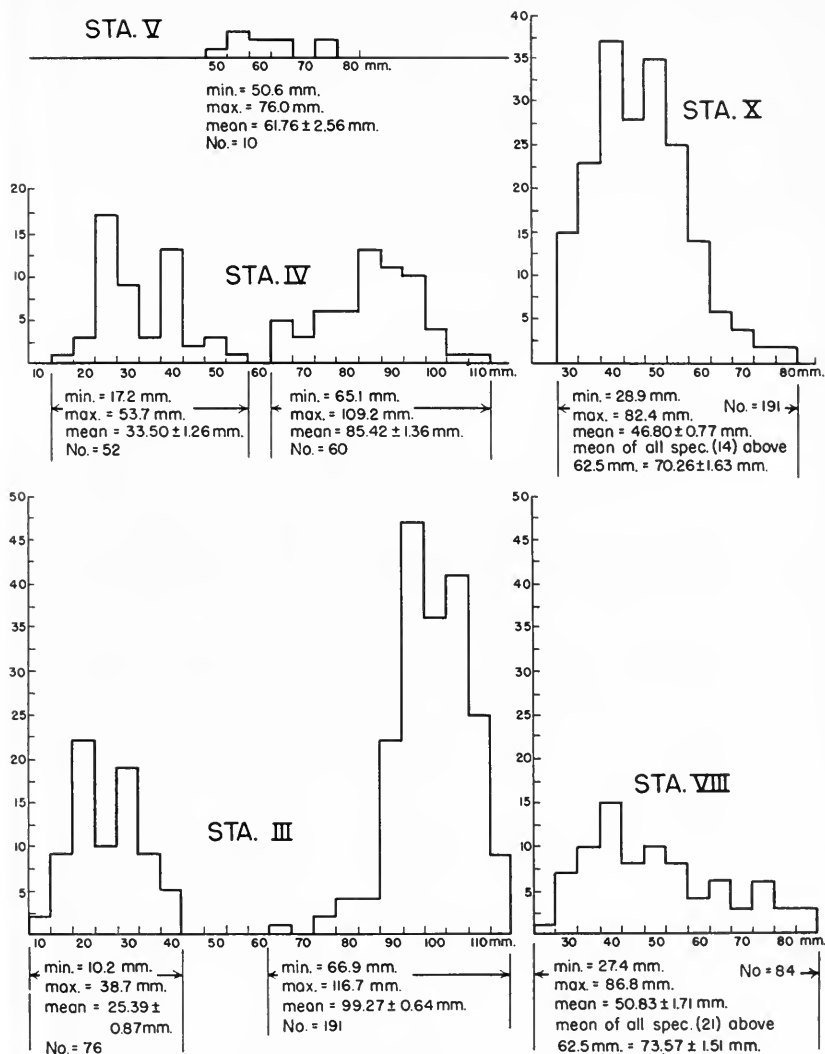


FIG. 11. Standard length frequencies of *Nematabramis everetti* Boulenger. Abscissas=standard length (mm.). Ordinates=number of specimens.

### *Monopterus alba* Zuiew

*Muraena alba* Zuiew, 1793, Nov. Act. Acad. Sci. Petrop., 7: 299, pl. 7, fig. 2 (not seen).

*Monopterus alba* Jordan and Snyder, 1901, Proc. U. S. Nat. Mus., 23: 838.

Total length 120 mm.; snout-vent 79.0 mm.; snout-dorsal origin 84 mm.; head in total 16.0; depth in total 34.5.

One specimen was collected at Sta. III.

### **Nematabramis everetti** Boulenger

*Nematabramis everetti* Boulenger, 1894, Ann. Mag. Nat. Hist., (6), 13: 250—North Borneo and Sarawak.

Dorsal rays ii, 11–13; pectoral i, 11–13; anal ii–iii, 16–20; ventral i, 5; maximum total length 157 mm.; standard length 10.2–116.7 mm.; head 3.71–4.19; depth 2.50–3.59, varying inversely with standard length; scales in lateral line 30–36, in mid-lateral row 33–36, in transverse series between dorsal and anal origins 9–11.

Sixteen digestive tracts were examined. Thirteen contained fragments of terrestrial insects; two, spider remains; three, unidentifiable material; one, leaf fragments; and one, no food. The food apparently consists of animals that fall into the streams, for there were no aquatic food organisms. The food is consistent with the habits of *everetti*, which constantly swims back and forth at the surface.

The accompanying graphs (fig. 11) show the variation in size from station to station. Stations III, IV, and V are on the Gaja and contain decreasing volumes of water. The standard lengths in this series are correlated with the changes in stream size.

By far the most abundant species in the fresh waters of this drainage (Table 1), *everetti* occurs downstream to the limits of fresh water (Sta. X) and upstream until the intermittent zone is reached. Its absence from Sta. II cannot be satisfactorily explained.

### **Rasbora sumatrana** Bleeker

*Leuciscus sumatranus* Bleeker, 1852, Nat. Tijd. Ned. Indië, 3: 601—Solok, Sumatra.

*Rasbora sumatrana* Bleeker, 1860, Ichthy. Arch. Ind. Prod., 2 (Cyprini), p. 453.

Dorsal rays ii, 6–7; pectoral i, 13–15; ventral i, 7–8; anal iii, 5–6; lateral line scales 24–29; scales between dorsal origin and ventral insertion  $5\frac{1}{2}$ – $6\frac{1}{2}$ ; maximum total length 145 mm.; standard length 13.1–111.9 mm.; head 3.50–4.05; depth 3.19–4.31.

Of ten digestive tracts examined, seven contained insect fragments; two, plant material; and two, no food particles. The identifiable insect remains include ants, a large bee, moth scales, and an orthopteran. These are all terrestrial forms and indicate that *Rasbora*, like *Nematabramis*, feeds on the organic rain falling into streams. The almost vertical mouth of *Rasbora* apparently is

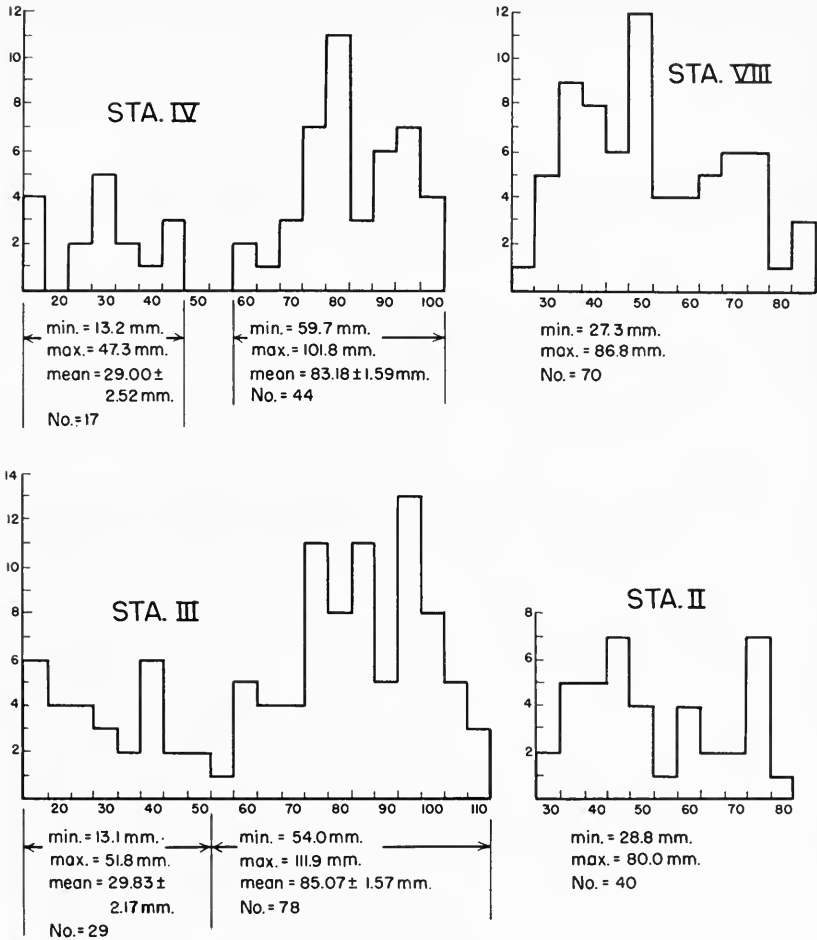


FIG. 12. Standard length frequencies of *Rasbora sumatrana* Bleeker. Abscissas=standard length (mm.). Ordinates=number of specimens.

adapted to feeding on particles that are above the body axis. This active fish swims in the upper strata of water but does not skim the surface in the manner of *Nematabramis*.

Obtained at Stas. II-V, VIII, and X. The accompanying histograms (fig. 12) give the standard length frequencies for most of these stations. Only three specimens (standard length 38.9-44.0 mm.) were collected at Sta. X, and one (65.1 mm.) at Sta. V. Although a greater size is reached in Sta. III, the mean for the larger specimens—those above 52.6 mm.—of this station is not significantly

greater than for those of Sta. IV. The means of both of these stations, however, are clearly larger than those of the remaining stations.

*Rasbora* occurs in fresh water up to the intermittent zone. The small catch of Sta. X indicates that it does not go as far downstream as *Nematabramis* (Table 1).

### **Puntius sealei** Herre

*Barbus elongatus* Seale, 1910, Philip. Jour. Sci., 5, (D), p. 265, pl. 2, fig. 1 (not of Rüppell)—Sandakan, North Borneo.

*Barbodes sealei* Herre, 1933, Jour. Pan-Pacific Res. Inst., 8, no. 4, p. 3 (new name).

Dorsal rays iv, 8–9; pectoral i, 13–16; ventral i, 7–8; anal iii, 5; maximum total length 146 mm.; standard length 13.5–112.0 mm.; head 3.25–3.68; depth 2.79–3.15; scales in lateral line 25–29, in transverse series between dorsal origin and ventral insertion 7–8½; scales around caudal peduncle 16.

Ten digestive tracts were examined. Food organisms include insects, crustaceans, a mite, ticks, snails, and plant material. Six contained plant material; three, insects; and two, crustaceans. Only two contained definitely aquatic organisms (crustaceans, water mite, and snails). All of the insects were terrestrial types.

Nine specimens (standard length 41.6–69.1 mm.) from Sta. II, six (24.0–103.0 mm.) at Sta. III, twenty-three (13.5–110.7 mm.) at Sta. IV, four (49.6–89.5 mm.) at Sta. V, and seventy-four (21.5–112.0 mm.) at Sta. VIII. Twelve additional specimens (22.6–41.9 mm.) were collected at the source of a small unnamed forest stream.

*Puntius* is found downstream to the limits of fresh water and upstream to the beginning of the intermittent zone. In the Gaja it is more abundant upstream. It was not collected in the Pinang.

### **Hampala macrolepidota** van Hasselt

*Hampala macrolepidota* van Hasselt, 1823, Alg. Konst. Letterbode, 2, no. 35: 132—Java.

Dorsal rays iv, 8; pectoral i, 13–14; ventral i, 7–8; anal iii, 5; scales in lateral line 26–30; scales between dorsal origin and ventral insertion 7½–8; maximum total length 267 mm.; standard length 13.6–222 mm.; head 2.66–3.19; depth 3.22–4.02.

Of the seven stomachs examined, six contained fish remains, among which *Nematabramis*, *Puntius*, and *Anguilla* were identified. The prey indicates that *Hampala* feeds in all strata. The seventh stomach contained insect larvae.

Four specimens (standard length 47.7–100.8 mm.) from Sta. II, seventy-one (13.6–222 mm.) from Sta. III, twenty-one (22.1–126 mm.) from Sta. IV, one (98.1 mm.) at Sta. V, and one (124 mm.) at Sta. X. Only three (14 per cent) of the specimens from Sta. IV were larger than 67.5 mm. in standard length, whereas twenty-four (34 per cent) of those from Sta. III exceeded that length.

*Hampala* occurs within fresh water up to the beginning of the intermittent zone. Considering that the deep pools it usually inhabits are present, its absence from the catch of Sta. VIII probably reflects its absence from this tributary of the Kretam Kechil.

### *Osteochilus spilurus* Bleeker

*Dangila spilurus* Bleeker, 1850, Nat. Tijd. Ned. Indië, 1: 272—Bandjermasin, Borneo.

*Osteochilus spilurus* Günther, 1868, Cat. Fishes Brit. Mus., 7: 45.

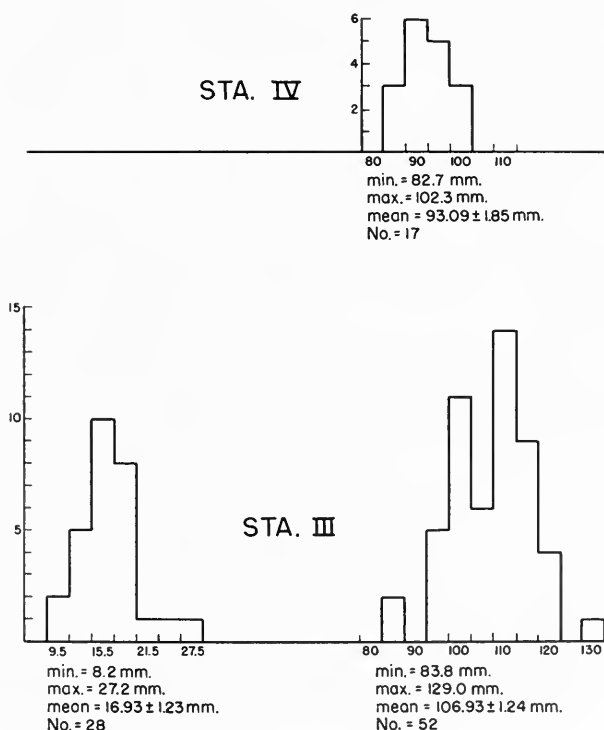


FIG. 13. Standard length frequencies of *Osteochilus spilurus* Bleeker. Abscissas=standard length (mm.). Ordinates=number of specimens.

Dorsal rays iv, 10–12; pectoral i, 12–14; ventral i, 8; anal iii, 5; lateral line scales 29–31; scales between dorsal origin and ventral insertion  $8\frac{1}{2}$ –9; maximum total length 175 mm.; standard length 8.2–129 mm.; head 3.92–4.49; depth 2.95–3.35.

The much convoluted digestive tracts contain masses of finely reduced material interspersed with chitinous fragments.

Collected at Stas. III and IV.

Adults collected at Sta. III had a larger average standard length than those from Sta. IV (fig. 13). The difference between the means is  $13.84 \pm 2.23$ ; P of this difference is less than 0.001 (difference divided by its standard error = 6.2). This species follows the same trend as noted in *Nematabramis everetti*, in which larger size is associated with larger volume of water.

### **Gastromyzon borneensis** Günther

*Gastromyzon borneensis* Günther, 1874, Ann. Mag. Nat. Hist., (4), 14: 454—Mengalong River, North Borneo.

Dorsal rays ii, 8; pectoral i, 25; ventral i, 20; anal i, 5; lateral line scales 55; total length 58.0 mm.; standard length 44.8 mm.; head 3.64; depth 5.09; width of body behind pectorals in standard length 3.67.

One specimen was obtained in the Gaja River in the rapids between Stas. III and IV.

### **Tachysurus caelatus** Valenciennes

*Arius caelatus* Valenciennes in Cuvier and Valenciennes, 1840, Hist. Nat. Poissons, 15: 66—Batavia, Java.

*Tachysurus caelatus* Fowler, 1927, Jour. Bombay Nat. Hist. Soc., 32: 256.

Dorsal rays I, 7; pectoral I, 9; ventral i, 5; anal 19; standard length 240 mm.; head 3.53; depth 4.16; eye 4.66.

One specimen was caught in Dewhurst Bay on hook-and-line. Prawns were used for bait.

### **Tachysurus sagor** Hamilton

*Pimelodus sagor* Hamilton, 1822, Fishes of Ganges, p. 169—Ganges River, India.

*Tachysurus sagor* Suvatti, 1936, Index, Fishes of Siam, p. 63.

Dorsal rays I, 7; pectoral I, 11; ventral i, 5; anal 18; total length 300–450 mm.; standard length 235–360 mm.; head 3.36–3.40; depth 5.46.



Two specimens were collected in Dewhurst Bay with hook-and-line. Prawns were used as bait.

### **Tachysurus venosus Valenciennes**

*Arius venosus* Valenciennes in Cuvier and Valenciennes, 1840, Hist. Nat. Poissons, 15: 69—Rangoon, Burma.

*Tachysurus venosus* Seale, 1910, Philip. Jour. Sci., 5, (D), p. 266.

Dorsal rays I, 7; pectoral I, 10; ventral i, 5; anal 17–18; standard length 147–185 mm.; head 3.20–3.45; depth 3.94–4.38; eye 4.93–5.58.

All five specimens were caught in Dewhurst Bay on hook-and-line. Prawns were used for bait. In addition to the bait one stomach contained a young *Leiognathus* (33 mm. total length).

### **Clarias teysmanni Bleeker**

*Clarias teysmanni* Bleeker, 1857, Nat. Tijd. Ned. Indië, 13: 344—Tjikoppo, Java.

Dorsal rays 65–74; pectoral I, 8–9; ventral 6; anal 51–66; maximum total length 190 mm.; standard length 112–165 mm.; head to gill opening 4.87–5.47; head to end of occipital process 4.06–4.35; depth 6.23–7.41.

Six stomachs contain only arthropods. Aquatic food organisms include crustaceans, chironomid and mosquito larvae, and one water beetle of the family Elmidae. Three well-preserved specimens of the surface film-dwelling hemipterans of the family Veliidae were also included. The remaining food items are terrestrial arthropods: ants, grasshoppers, miscellaneous beetle fragments, a membraciid bug, Corrodentia, and a spider.

Three specimens (standard length 113–158 mm.) from Sta. II, and five (112–165 mm.) from Sta. VIII.

The failure of *Clarias* to penetrate farther up the Gaja than Sta. II and its absence from the Pinang are not easily understood. It is at least interesting, if not significant, that the distributions of *Clarias teysmanni* and *Mystus nemurus* do not overlap in this drainage (Table 1). Competition for food does not seem to be involved, as the diet of these species as determined in this study have different bases, although both include insects.

### **Mystus nemurus Valenciennes**

*Bagrus nemurus* Valenciennes in Cuvier and Valenciennes, 1839, Hist. Nat. Poissons, 14: 423—Java.

*Mystus nemurus* Herre and Myers, 1937, Bull. Raffles Mus., no. 13, p. 69.

Dorsal rays II, 7; pectoral I, 7-8; ventral i, 5; anal v-vi, 8-9; maximum total length 270 mm.; standard length 45.2-210 mm.; head 3.08-3.29; depth 4.04-5.17; eye 5.82-7.49.

Of the eleven digestive tracts examined, seven contained aquatic decapods; two, terrestrial insects; one, an aquatic insect; one, plant material; and two, unidentifiable arthropod fragments. The crabs forming the bulk of this food are benthic; probably *nemurus* feeds largely on the bottom.

Nine specimens (standard length 50.4-210 mm.) from Sta. III, ten (45.2-200 mm.) from Sta. IV, three (155-207 mm.) from Sta. IX, and twenty-two (67.4-157 mm.) from Sta. X.

*Mystus* occurs in brackish water and in moderately deep pools of fresh water.

### **Tylosurus strongylurus** van Hasselt

*Belone strongylura* van Hasselt, 1823, Alg. Konst. Letterbode, 2: 130—Java.  
*Tylosurus strongylurus* Weber and de Beaufort, 1922, Fishes Indo-Austr. Arch., 4: 121.

Dorsal rays ii, 11; pectoral i, 10; ventral i, 5; anal ii, 15; lateral line scales 124; mid-lateral scales 171; total length 270+ mm. (beak broken); standard length 240+ mm.

The gut contained two small prawns. One specimen from Sta. VI.

### **Dermogenys pusillus** van Hasselt

*Dermogenys pusillus* van Hasselt, 1823, Alg. Konst. Letterbode, 2: 131—Java.

Dorsal rays iii, 6-7; pectoral i, 9-10; ventral i, 5; anal iii-iv, 10-13; mid-lateral scales 44-48; total length 17-68 mm.; standard length with beak 15.7-57.0 mm., without beak 14.5-49.6 mm.; head in standard length with beak 3.67-4.14; depth 7.43-7.68; beak in standard length with beak 5.45-7.40.

The following material was obtained:

Station	No.	Standard length without beak
I	7	35.5-48.7
II	27	16.6-48.8
VII	1	44.5
IX	2	21.0-45.7
X	21	20.0-45.8

In addition, eight specimens (14.5-49.6 mm.) were collected in very small unnamed forest tributaries of the Kretam Kechil, and

three (18.0–45.6 mm.) in the nipa palm swamp fringing the Kretam Kechil.

This species occurs in brackish water and penetrates fresh water. The factors limiting its dispersal upstream are unknown to me. It apparently does not enter the zone dominated by the cyprinids. In this respect it resembles the gobies and many eleotrids.

### **Zenarchopterus amblyurus** Bleeker

*Hemirhamphus amblyurus* Bleeker, 1849, Verh. Bat. Gen., 22: 11—Madura.

*Zenarchopterus amblyurus* Bleeker, 1866, Ned. Tijds. Dierk., 3: 160.

Dorsal rays i, 11–13; pectoral i, 7–8; ventral i, 5; anal ii, 9–12; scales in lateral line 48–53; total length including beak 60.5–148 mm.; standard length without beak 40.5–101.0 mm.; head 3.76–4.05; depth 7.11–8.22; beak in standard length 2.47–3.18.

Six digestive tracts were examined. Three contained ants and other terrestrial insects. One of these also held aquatic insect larvae. Three were empty.

Three specimens (standard length without beak 74–91 mm.) from Sta. I, one (101.0 mm.) from Sta. VI, four (40.5–101.0 mm.) from Sta. VII, one (92 mm.) from Sta. IX, and one (84 mm.) in the nipa palm swamp just above Sta. VI. In brackish water only.

### **Dorichthys brachyurus** Bleeker

*Syngnathus brachyurus* Bleeker, 1853, Verh. Bat. Gen., 25: 16—Priaman, Sumatra, and Panimbang, Java.

*Dorichthys brachyurus* Günther, 1870, Cat. Fishes Brit. Mus., 8: 184.

Dorsal rays 39–42; pectoral 20–21; anal 4; rings 20+1+22 and 21+22; subdorsal rings 1+8–9; total length 132–148 mm.; standard length 124–139 mm.; head 4.35–4.63; snout 1.54–1.57; trunk in tail 0.72–0.77.

Two specimens from Sta. X.

### **Ichthyocampus carce** Hamilton

*Syngnathus carce* Hamilton, 1822, Fishes of Ganges, p. 13—Ganges River, India.

*Ichthyocampus carce* Kaup, 1856, Cat. Loph. Fishes Brit. Mus., p. 30.

Dorsal rays 22–24; pectoral 14; anal 1; rings 14+1+39; subdorsal rings 5; total length 77.5–91 mm.; standard length 75–88 mm.; head 7.33–8.33; snout 2.03–2.25; trunk in tail 2.45–2.57.

One specimen (standard length 75 mm.) from just above Sta. VI, and one from Sta. IX. Both in brackish water.

### **Sphyraena jello** Cuvier

*Sphyraena jello* Cuvier in Cuvier and Valenciennes, 1829, Hist. Nat. Poissons, 3: 349—Vizagapatam, India.

Dorsal rays V—I, i, 8; pectoral ii, 12; ventral I, 5; anal iii, 7; lateral line scales 113; total length 400 mm.; standard length 340 mm.; head 2.91; depth 6.67; eye 6.68 in head, 2.86 in snout.

The single specimen was collected at Sta. IX. The stomach held one *Glossogobius* (total length 93 mm.) and one *Ambassis* (length without head or tail 35 mm.).

### **Chelon caeruleomaculatus** Lacépède

*Mugil caeruleomaculatus* Lacépède, 1803, Hist. Nat. Poissons, 5: 385—no locality given.

Dorsal rays IV—i, 8; pectoral ii, 13–14; ventral I, 5; anal III, 9; mid-lateral scales 36; total length 86–98 mm.; standard length 67.4–75.2 mm.; head 3.40–3.50; depth 3.13–3.21; eye 3.29–3.41.

Two specimens from Sta. VI in brackish water close to shore.

### **Chelon** sp.

Dorsal rays IV—i, 8; pectoral ii, 13; ventral I, 5; anal III, 8–9; mid-lateral scales 24–25; predorsal scales 12; origin of second dorsal opposite mid-lateral scales 13–15; total length 35.5–46 mm.; standard length 28.0–35.5 mm.; head 2.95–3.14; depth 2.69–2.79.

One specimen from Sta. VII and two from Sta. IX in brackish water.

### **Mugil dussumieri** Valenciennes

*Mugil dussumieri* Valenciennes in Cuvier and Valenciennes, 1836, Hist. Nat. Poissons, 11: 147—India.

Dorsal rays IV—i, 8; pectoral ii, 13–14; ventral I, 5; anal III, 9; mid-lateral scales 25–29; total length 90–220 mm.; standard length 71–182 mm.; head 3.34–3.82; depth 3.48–4.00.

Eleven specimens from Sta. VI in brackish water near shore.

### **Ceratostethus bicornis** Regan

*Neostethus bicornis* Regan, 1916, Proc. Zool. Soc. London, 1916: 14, fig. 11—Kuala Langat, Johore.

*Ceratostethus bicornis* Myers, 1937, Proc. U. S. Nat. Mus., 84: 141.

Dorsal rays I-II—5; pectoral 9-11; anal I, 13-16; mid-lateral scales 33-35; total length 9.5-32.4 mm.; standard length 8.0-27.1 mm.; head 4.70-5.96; depth 5.71-7.00; snout to origin of second dorsal 1.26-1.38 in standard length; snout to anal 1.70-1.81 in standard length.

Forty-one specimens (standard length 15.3-25.4 mm.) from Sta. I, ninety-seven (8.0-25.9 mm.) from Sta. VII, twenty-six (11.2-27.1 mm.) from Sta. IX, and six from the nipa palm swamp between Stas. VI and VII. This species, found only in brackish water, was seen swimming at the surface near the banks of the large streams or in the nipa palm and mangrove swamps.

### ***Neostethus borneensis* Herre**

*Neostethus borneensis* Herre, 1940, Bull. Raffles Mus., no. 16, p. 14, pls. 10-11  
—Kabili River, North Borneo.

Dorsal rays I-II—5; pectoral 10-11; anal I, 13-15; mid-lateral scales 25-28; total length 11.7-18.1 mm.; standard length 9.2-14.7 mm.; head 3.55-4.16; depth 4.65-4.95; snout to origin of second dorsal 1.23-1.29 in standard length; snout to origin of anal 1.77-1.90 in standard length.

Three specimens (standard length 11.2-12.0 mm.) from Sta. I, one adult male (14.7 mm.) from Sta. VII, and fourteen from other portions of the nipa palm and mangrove swamps fringing the lower Kretam Kechil River.

### ***Neostethus lankesteri* Regan**

*Neostethus lankesteri* Regan, 1916, Proc. Zool. Soc. London, 1916: 2, pl. 1, fig. B, text figs. 1-10—Muar River, Johore and Singapore.

Dorsal rays I—5; pectoral 10; anal I, 17; mid-lateral scale scars 29; total length 39.0 mm.; standard length 31.0 mm.; head 4.77; depth 5.17; snout to origin of second dorsal 1.33; snout to anal origin 1.85.

Although the anal ray count is higher and the scale count lower than those given by Regan, this specimen is placed in *lankesteri* because of the agreement with Regan's figures of the priapium.

One male from Sta. VI.

### ***Eleutheronema tetradactylum* Shaw**

*Polynemus tetradactylum* Shaw, 1804, Gen. Zool., 5: 155—India.

*Eleutheronema tetradactylum* Bleeker, 1862, Versl. Med. Akad. Wetens. Amsterdam, 14: 124.

Dorsal rays VIII—I, 14; pectoral 17+4 free rays; ventral I, 5; anal III, 15; lateral line scales 73; total length 275 mm.; standard length 216.5 mm.; head 3.38; depth 3.90.

One specimen was caught in Dewhurst Bay on hook-and-line. A swimming decapod (family Portunidae?) was used for bait.

### ***Polydactylus plebius* Broussonet**

*Polynemus plebius* Broussonet, 1782, Ichthy. Sist. Pisc., 7, pl. 8—Tahiti.

*Polydactylus plebius* Jordan and Seale, 1906, Bull. Bur. Fish., 25: 219.

Pectoral 17+5 free rays, all rays simple; head length 154 mm.

This specimen was caught in Dewhurst Bay on hook-and-line by a Malay fisherman who gave me the head.

### ***Betta unimaculata* Popta**

*Parophiocephalus unimaculata* Popta, 1906, Notes Leyden Mus., 27: 10—Howong and Kajan rivers, Borneo.

*Betta unimaculata* Regan, 1909, Proc. Zool. Soc. London, 1909: 779.

Dorsal rays 0—I, 6–8; pectoral i, 11–14; ventral ii, 4–5; anal I, 26–29; mid-lateral scales 32–35; maximum total length 95 mm.; standard length 11.5–71.7 mm.; head 2.75–3.05; depth 4.01–4.61.

The contents of ten digestive tracts were examined. Eight contained terrestrial arthropods (mostly insects); two, aquatic insects; one, an aquatic crustacean; and one, fish scales. The aquatic insects included surface-dwelling veliid bugs.

The following material was obtained:

Station	No.	Standard length (mm.)	
		Mean $\pm$ SE	Range
III	9	40.30 $\pm$ 3.69	24.5–56.0
IV	11	38.40 $\pm$ 4.87	20.0–60.5
V	9	39.77 $\pm$ 6.67	19.8–71.7
VIII	16	39.49 $\pm$ 2.43	17.5–57.8
XI	9	39.80 $\pm$ 7.60	11.5–71.0

Variation between stations is not statistically significant.

*Betta* penetrates farther upstream than any other fresh-water species, occurring in the isolated and semi-isolated pools of the stream sources. Each of these pools usually contained one adult and sometimes one or two juveniles. Small waterfalls apparently are no obstacle to their dispersal, as specimens were even found above a waterfall five meters high.

**Ophicephalus melanosoma** Bleeker

*Ophicephalus melasoma* Bleeker, 1851, Nat. Tijd. Ned. Indië, 2: 424—Sambas, Borneo.

*Ophiocephalus melanosoma* Günther, 1861, Cat. Fishes Brit. Mus., 3: 473.

Dorsal rays 37–38; pectoral i–ii, 14–15; ventral i, 5; anal 23–24; lateral line scales 52–54; total length 133–208 mm.; standard length 105.5–170 mm.; head 3.06–3.29; depth 5.96–6.56.

One digestive tract contained a crab. A second gut held two ants, crustacean fragments, an insect larva, and gravel. *Ophicephalus* is known to feed on fishes, frogs, snakes, and insects (Smith, 1945).

Three specimens were collected at Sta. VIII.

**Ambassis gymnocephalus** Lacépède

*Lutjanus gymnocephalus* Lacépède, 1802, Hist. Nat. Poissons, 3, pl. 23, fig. 3; 1803, op. cit., 4: 216—Sumatra.

*Ambassis gymnocephalus* Bleeker, 1874, Nat. Verh. Holl. Maatsch. Wetens., 2, no. 2, p. 99.

Dorsal rays VII—I, 9; pectoral ii, 12–14; ventral I, 5; anal III, 9; lateral line scales 28–30; predorsal scales 13–16; maximum total length 45 mm.; standard length 16.1–32.2 mm.; head 2.60–3.19; depth 2.96–3.25.

Thirty-four specimens (standard length 16.1–32.2 mm.) from Sta. I, and three (17.5–29.0 mm.) from Sta. IX. All from brackish water.

**Ambassis interrupta** Bleeker

*Ambassis interrupta* Bleeker, 1852, Nat. Tijd. Ned. Indië, 3: 696—Wahai, Ceram, and Batavia, Java.

Dorsal rays VII—I, 9; pectoral ii, 12–14; ventral I, 5; anal III, 9; lateral line scales 19–23; predorsal scales 14–17; maximum total length 71 mm.; standard length 12.7–56.0 mm.; head 2.38–2.58; depth 2.07–2.39.

Only four digestive tracts contained food remains. Young fishes (*Eleotris?*) and terrestrial insects (Hymenoptera) occurred in both specimens from Sta. II. Crustacean fragments were in one and a polychaete worm in the other specimen from Sta. IX.

Four specimens (standard length 12.7–35.4 mm.) from Sta. I, two (37.5–45.5 mm.) from Sta. II, three (44.8–56.0 mm.) from Sta.

VI, two (43.0–44.0 mm.) from Sta. IX, and one (49.0 mm.) below Sta. VI.

This was the only percoid taken in fresh water (Sta. II).

### **Ambassis nalua** Hamilton

*Chanda nalua* Hamilton, 1822, Fishes of Ganges, p. 107, pl. 6, fig. 36—Lower Bengal, India.

*Ambassis nalua* Cuvier in Cuvier and Valenciennes, 1828, Hist. Nat. Poissons, 2: 182.

Dorsal rays VII—I, 10; pectoral ii, 12; ventral I, 5; anal III, 9; lateral line scales 28; predorsal scales 12; total length 81 mm.; standard length 59 mm.; head 2.60; depth 2.30.

One specimen was collected at Sta. VI in brackish water.

### **Lates calcarifer** Bloch

*Holocentrus calcarifer* Bloch, 1790, Ausländ. Fische, 4: 100—Japan.

*Lates calcarifer* Cuvier in Cuvier and Valenciennes, 1828, Hist. Nat. Poissons, 2: 96.

Dorsal rays VIII, 10; pectoral ii, 15; ventral I, 5; anal III, 8; lateral line scales 54; total length 210 mm.; standard length 175 mm.; head 2.54; depth 2.96; eye 6.97.

Eleven small prawns were in the stomach of the only specimen, taken at Sta. VI.

### **Epinephelus nebulosus** Valenciennes

*Serranus nebulosus* Valenciennes in Cuvier and Valenciennes, 1828, Hist. Nat. Poissons, 2: 313—locality unknown.

*Epinephelus nebulosus* Bleeker, 1874, Verh. Akad. Wetens. Amsterdam, 14, no. 2, p. 117.

Dorsal rays XI, 17; pectoral i, 16; ventral I, 5; anal III, 7; pores in lateral line 63; transverse rows crossing lateral line 188; total length 218 mm.; standard length 182 mm.; head 2.46; depth 3.11.

One specimen was taken in Dewhurst Bay on hook-and-line. Prawn was used as bait.

### **Caranx ignobilis** Forskål

*Scomber ignobilis* Forskål, 1775, Descr. Animal., p. 55—Red Sea.

*Caranx ignobilis* Klunzinger, 1880, Sitzber. Akad. Wien, 80: 377.



Dorsal rays (I) VIII—I, 18–20; pectoral i–ii, 19–20; ventral I, 5; anal II—I, 14–16; lateral line scales 83–95 of which the last 29–33 are scutes; gill rakers 15; total length 87–96 mm.; standard length 70–75 mm.; head 2.78–2.83; depth 2.28–2.41.

Two specimens were collected at Sta. VI, and a third a little downstream. The digestive tracts of all three contained only young prawns; one held two prawns; the second, seven; and the third, fourteen.

### **Lutianus argentimaculatus** Forskål

*Sciaena argentimaculata* Forskål, 1775, Descr. Animal., p. 47—Red Sea.

*Lutianus argentimaculatus* Day, 1875, Fishes of India, p. 37, pl. 11, fig. 5.

Dorsal rays X, 13; pectoral ii, 14; ventral I, 5; anal III, 8; lateral line scales 46–48; total length 231–305 mm.; standard length 187–252 mm.; head 2.36–2.39; depth 2.44–2.54.

One specimen (252 mm.) from Sta. IX contained crustacean fragments. The other specimen was caught in Dewhurst Bay on hook-and-line. Prawn was used as bait.

### **Pomadasys hasta** Bloch

*Lutjanus hasta* Bloch, 1790, Ausländ. Fische, 4: 109, pl. 246, fig. 1—Japan.

*Pomadasys hasta* Bleeker, 1876–77, Atlas Ichthy., 8: 28, pl. 325, fig. 3.

Dorsal rays XII, 13–14; pectoral ii, 14–15; ventral I, 5; anal III, 6–7; lateral line scales 46–49; total length 57–290 mm.; standard length 46–238 mm.; head 2.51–2.71; depth 2.64–2.80; eleventh dorsal spine in twelfth 1.37–1.54.

Three large specimens were caught on hook-and-line. Prawn was used as bait. The gut of one of these held a young holothurian. The three small specimens contained from two to ten young prawns each.

Three specimens (standard length 46–73 mm.) from Sta. VI and three (146–238 mm.) from Dewhurst Bay.

### **Pomadasys maculatus** Bloch

*Anthias maculatus* Bloch, 1797, Ausländ. Fische, 7: 9, pl. 326, fig. 2—East Indies.

*Pomadasys maculatus* Bleeker, 1876–77, Atlas Ichthy., 8: 27, pl. 308, fig. 1.

Dorsal rays XII, 13–14; pectoral ii, 14–15; ventral I, 5; anal III, 7; lateral line scales 48–50; total length 54–79 mm.; standard

length 47–66 mm.; head 2.51–2.93; depth 2.74–2.97; eleventh dorsal spine in twelfth 1.00–1.18.

The digestive tracts of all specimens held small prawns, numbering from four to forty-one. Two stomachs held one amphipod each.

Five specimens from Sta. VI.

### **Gerres poeti** Cuvier

*Gerres poeti* Cuvier in Cuvier and Valenciennes, 1830, Hist. Nat. Poissons, 6: 468—coast of Mahé, India.

Dorsal rays IX, 10; pectoral i, 14; ventral I, 5; anal III, 7; lateral line scales 35–36; total length 94–101 mm.; standard length 75.0–78.2 mm.; head 3.06–3.19; depth 2.59–2.65.

Two specimens from Sta. VI. The gut of one contained a copepod, a decapod, and miscellaneous chitinous fragments.

### **Leiognathus equulus** Forskål

*Scomber equulus* Forskål, 1775, Descr. Animal., p. 58—Red Sea.

*Leiognathus equula* Jordan and Starks, 1917, Ann. Carnegie Mus., 11: 444.

Dorsal rays VII–VIII, 16–17; pectoral ii, 16–17; ventral I, 5; anal III, 14; pores in lateral line 59–67; maximum total length 141 mm.; standard length 11.8–115.7 mm.; head 2.60–2.96; depth 1.53–1.80.

Of four digestive tracts examined, two held polychaete worms; one, an unidentifiable worm; and one, fragments of a crustacean.

Fifty-six specimens (standard length 16.4–46.0 mm.) from Sta. I, seven (11.8–97.0 mm.) from Sta. VI, and eighteen (17.0–115.7 mm.) from Sta. IX.

### **Toxotes jaculatrix** Pallas

*Sciaena jaculatrix* Pallas, 1776, Phil. Trans. Roy. Soc. London, 56: 187—Batavia, Java.

*Toxotes jaculator* Cuvier in Cuvier and Valenciennes, 1831, Hist. Nat. Poissons, 7: 314.

Dorsal rays IV, 11; pectoral ii, 10; ventral I, 5; anal III, 14–15; lateral line scales 27–29; total length 171–183 mm.; standard length 140–150 mm.; head 2.46–2.50; depth 2.22–2.34.

Two specimens from Sta. IX in brackish water. The gut of one contained terrestrial insects (ants and other hymenopterans). The second held fragments of crustaceans.

**Toxotes chatareus** Hamilton

*Coius chatareus* Hamilton, 1822, Fishes of Ganges, p. 101, pl. 14, fig. 34—Ganges River, India.

*Toxotes chatareus* Bleeker, 1875, Versl. Med. Akad. Wetens. Amsterdam, (2), 9: 160.

Dorsal rays V, 11–12; pectoral ii, 10–11; ventral I, 5; anal III, 16–17; lateral line scales 32–34; total length 161–225 mm.; standard length 134–190 mm.; head 2.32–2.56; depth 2.08–2.25.

Two digestive tracts contained terrestrial insects (ants, wasp, cerambycid beetle). A third held unidentifiable insect fragments. Two of the three also contained decapod remains.

One specimen (standard length 177 mm.) from Sta. I, three (134–177 mm.) from Sta. IX, one (174 mm.) from Dewhurst Bay, three (176–190 mm.) from the mouth of the Kretam Besar River. All were taken from brackish water.

**Scatophagus argus** Linnaeus

*Chaetodon argus* Linnaeus, 1776, Syst. Nat., ed. 12, 1: 464—India.

*Scatophagus argus* Cuvier in Cuvier and Valenciennes, 1831, Hist. Nat. Poissons, 7: 136.

Dorsal rays (including procumbent spine) XI–XIII, 15–17; pectoral ii, 15–17; ventral I, 5; anal IV, 14–15; total length 11–108 mm.; standard length 9.5–85.2 mm.; head 2.33–2.79; depth 1.32–1.49.

One specimen (standard length 48.0 mm.) from Sta. I, eight (9.5–85.2 mm.) from Sta. IX, three (13.5–31.7 mm.) from the Kretam Kechil below Sta. IX. All were taken from brackish water.

Small individuals were seen in the main courses of rivers and in the shallow water of nipa palm and mangrove swamps. Those observed in the rivers proper were close to shore, usually in the shadows of nipa palm fronds hanging just above the surface.

**Butis butis** Hamilton

*Cheilodipterus butis* Hamilton, 1822, Fishes of Ganges, p. 57—Ganges River, India.

*Butis butis* Bleeker, 1861, Versl. Med. Akad. Wetens. Amsterdam, 12: 77.

Dorsal rays VI—I, 8; pectoral 19; ventral I, 5; anal I, 7; mid-lateral scales 29; total length 43.0 mm.; standard length 35.4 mm.; head 2.60; depth 5.71; snout 3.24.

One specimen from Sta. I.

**Butis gymnopomus** Bleeker

*Eleotris gymnopomus* Bleeker, 1853, Nat. Tijd. Ned. Indië, 4: 274—western Sumatra.

*Butis gymnopomus* Bleeker, 1856, op. cit., 12: 215.

Dorsal rays VI—I, 8–9; pectoral 17–18; ventral I, 5; anal I, 7–8; mid-lateral scales 27–29; predorsals 13–16; total length 20.9–111.1 mm.; standard length 16.5–86.5 mm.; head 2.54–2.84; depth 4.65–5.70; snout 2.69–3.18.

Ten digestive tracts were examined. Two contained aquatic insect nymphs of the orders Plecoptera and Ephemeroptera. Two others also had what appear to be aquatic insect larvae, although the identification is not certain. Three intestines held decapod fragments. One contained a young *Ambassis*, and another had fish scales. The tenth held unidentifiable insect remains.

Twenty-seven specimens (standard length 16.5–85.2 mm.) from Sta. II, fourteen (37.0–86.5 mm.) from Sta. X.

**Eleotris fusca** Bloch and Schneider

*Poecilia fusca* Bloch and Schneider, 1801, Syst. Ichthy., p. 453—"Oriadeae insulae rivulis."

*Eleotris fusca* Günther, 1861, Cat. Fishes Brit. Mus., 3: 125.

Dorsal rays VI—I, 8; pectoral 17; ventral I, 5; anal I, 8; mid-lateral scales 59; predorsals 48; total length 55.6 mm.; standard length 40.1 mm.; head 2.47; depth 4.36.

One specimen from Sta. II.

**Eleotris melanosoma** Bleeker

*Eleotris melanosoma* Bleeker, 1852, Nat. Tijd. Ned. Indië, 3: 705—Wahai, Ceram.

Dorsal rays VI—I, 7–9; pectoral 17–19; ventral I, 5; anal I, 8–9; mid-lateral scales 46–53; predorsals 40–42; total length 22.7–85.5 mm.; standard length 18.5–68.7 mm.; head 2.72–2.96; depth 4.71–5.67.

Two digestive tracts contained insect fragments. A third held pieces of a decapod.

Thirty-nine (standard length 18.5–44.1 mm.) from Sta. II, two (59.6–68.7 mm.) from Sta. VIII.

**Ophiocara porocephala** Valenciennes

*Eleotris porocephala* Valenciennes in Cuvier and Valenciennes, 1837, Hist. Nat. Poissons, 12: 237—Seychelles.

*Ophiocara porocephala* Bleeker, 1877, Versl. Med. Akad. Wetens. Amsterdam, (2), 11: 30.

Dorsal rays VI—I, 8; pectoral 14; ventral I, 5; anal I, 7; mid-lateral scales 36; predorsals 26; total length 111.9 mm.; standard length 78.0 mm.; head 2.65; depth 4.06.

One specimen from Sta. II.

### **Oxyeleotris urophthalmus** Bleeker

*Eleotris urophthalmus* Bleeker, 1851, Nat. Tijd. Ned. Indië, 2: 202—Bandjermasin, Borneo.

*Oxyeleotris urophthalmus* Bleeker, 1877, Versl. Med. Akad. Wetens. Amsterdam, (2), 11: 23.

Dorsal rays VI—I, 8; pectoral 16; ventral I, 5; anal I, 9; mid-lateral scales 84; predorsals 66; total length 102.7 mm.; standard length 82.6 mm.; head 3.07; depth 5.16.

The gut contained plant material. One specimen from Sta. II.

### **Brachygobius doriae** Günther

*Gobius doriae* Günther, 1868, Ann. Mag. Nat. Hist., (4), 1: 265, pl. 12, fig. A—Sarawak.

*Brachygobius doriae* Bleeker, 1874, Arch. Néerl. Sci. Ex. Nat., 9: 315.

Dorsal rays VI—I, 7; pectoral i, 12–16; ventral I, 5; anal I, 7–8; mid-lateral scales 24–28; total length 13.8–32.3 mm.; standard length 10.9–27.0 mm.; head 2.53–3.07; depth 3.01–3.89.

Food was found in only two out of eight digestive tracts examined. One specimen contained a small fish and one contained insect fragments.

Fifty-six specimens from Sta. II, two (standard length 22.4–22.5 mm.) from an unnamed tributary of the Kretam Kechil.

### **Ctenogobius** sp.

Dorsal rays VI—I, 11; pectoral 16; ventral I, 5; anal I, 9; mid-lateral scales 36; no predorsals; total length 30.5 mm.; standard length 23.2 mm.; head 3.31; depth 5.16.

One specimen from the Kretam Kechil just above Sta. VI.

### **Cyprinogobius chrysosoma** Bleeker

*Lophogobius chrysosoma* Bleeker, 1875, Arch. Néerl. Sci. Ex. Nat., 10: 114—Bandjermasin, Borneo, and Amboina.

*Cyprinogobius chrysosoma* Koumans, 1937, Zool. Meded., 20: 12.

Dorsal rays VI—I, 6; pectoral 16–17; ventral I, 5; anal I, 6; mid-lateral scales 24–25; predorsal scales 6; total length 27.5–37.9 mm.; standard length 20.7–29.7 mm.; head 3.03–3.26; depth 3.09–3.41.

Six specimens from Sta. II.

### **Glossogobius giurus** Hamilton

*Gobius giurus* Hamilton, 1822, Fishes of Ganges, p. 51, pl. 33, fig. 15—Gangetic provinces, India.

*Glossogobius giurus* Bleeker, 1879, Verh. Akad. Wetens. Amsterdam, 18, no. 2, p. 17.

Dorsal rays VI—I, 9; pectoral 20; ventral I, 5; anal I, 8; mid-lateral scales 30–31; total length 41–148 mm.; standard length 32.3–115.5 mm.; head 2.66–2.86; depth 4.88–6.33; snout 2.93–3.51.

Of the five digestive tracts with food, two contained remains of fish and three contained fragments of crustaceans. A specimen with a standard length of 90.2 mm. held an *Eleotris fusca* with a head length of 13.2 mm. The other fish-feeding individual was the longest of the series.

Seven specimens (standard length 32.3–90.2 mm.) from Sta. II, one from the Kretam Kechil above Sta. VI.

### **Gobiopterus brachypterus** Bleeker

*Apocryptes brachypterus* Bleeker, 1855, Nat. Tijd. Ned. Indië, 9: 401—Lake Grati, Pasuruan, Java.

*Gobiopterus brachypterus* Bleeker, 1874, Arch. Néerl. Sci. Ex. Nat., 9: 311.

Dorsal rays V—I, 7–9; pectoral 14–16; ventral I, 5; anal I, 11–12; mid-lateral scale scars 23–26; total length 14.1–29.8 mm.; standard length 12.2–24.5 mm.; head 3.10–3.63.

Twenty-seven specimens from the Kretam Kechil above Sta. VI.

### **Oxyurichthys tentacularis** Valenciennes

*Gobius tentacularis* Valenciennes in Cuvier and Valenciennes, 1837, Hist. Nat. Poissons, 12: 128—Java.

*Oxyurichthys tentacularis* Bleeker, 1860, Acta Soc. Sci. Indo-Néerl., 8: 42.

Dorsal rays VI—I, 12; pectoral 22; ventral I, 5; anal I, 11–13; mid-lateral scales 50–51; total length 56–62 mm.; standard length 39.2–43.6 mm.; head 3.46–3.66; depth 5.23.

Two specimens from the Kretam Kechil just above Sta. VI.

**Pseudogobius bikolanus** Herre

*Vaimosa bikolana* Herre, 1927, Gobies of Philippines, p. 151, pl. 11, fig. 2—Legaspi, Luzon.

*Pseudogobius bikolanus* Aurich, 1938, Int. Rev. Ges. Hydrobiol., 38: 161, fig. 19.

Dorsal rays VI—I, 6; pectoral 16–17; ventral I, 5; anal I, 6; mid-lateral scales 24; total length 12.5–22.2 mm.; standard length 9.7–17.1 mm.; head 3.11–3.29; depth 4.38–4.97.

Eight specimens from Sta. II, one (standard length 10.5 mm.) from Sta. VII.

**Pseudogobius** sp. A

Dorsal rays VI—I, 6; pectoral 17; anal I, 6; mid-lateral scales 24; predorsals 8; opercle with 3 large scales; total length 20.6 mm.; standard length 16.5 mm.; head 2.84; depth 4.23; snout 4.46; eye 4.46.

One specimen from Sta. X.

**Pseudogobius** sp. B

Dorsal rays VI—I, 6; pectoral 17; anal I, 6; mid-lateral scales 28; predorsals 11; opercle with 7 scales; total length 19.0 mm.; standard length 14.6 mm.; head 3.24; depth 6.08; snout 5.00; eye 4.50.

One specimen from Sta. II.

**Periophthalmus schlosseri schlosseri** Pallas

*Gobius schlosseri* Pallas, 1770, Spicil. Zool., 8: 5, pl. 1, figs. 1–4—no locality given.

*Periophthalmus schlosseri* Bloch and Schneider, 1801, Syst. Ichthy., p. 64.

*Periophthalmus schlosseri schlosseri* Eggert, 1935, Zool. Jahrb., (Syst.), 67: 47, pl. 1, fig. 1.

Dorsal rays VIII—I, 12; pectoral 16; ventral I, 5; anal I, 12; mid-lateral scales 54; total length 205 mm.; standard length 172 mm.; head 3.21; depth 6.49.

One specimen from the tidal mud-flats just above Sta. VI.

**Periophthalmus variabilis** Eggert

*Periophthalmus variabilis* Eggert, 1935, Zool. Jahrb., (Syst.), 67: 63, pl. 3, fig. 13, pl. 4, figs. 14–15, text figs. 5–8—Tjilatjap, Java.

Dorsal rays IX—I, 11; pectoral 13; ventral I, 5; anal 12; mid-lateral scales 56; total length 53 mm.; standard length 42 mm.; head 3.36; depth 6.46.

One specimen from below Sta. VI.

### **Boleophthalmus boddaerti** Pallas

*Gobius boddaerti* Pallas, 1770, Spicil. Zool., 8: 11, pl. 2, figs. 4, 5—Indian Ocean.

*Boleophthalmus boddaerti* Valenciennes in Cuvier and Valenciennes, 1837, Hist. Nat. Poissons, 12: 199.

Dorsal rays V—I, 23; pectoral 19; anal I, 23; mid-lateral scales 74; total length 125 mm.; standard length 96.5 mm.; head 3.27; depth 5.21.

The coiled gut contained detrital material.

One specimen from Kretam Kechil above Sta. VI.

### **Parapocryptes rictuosus** Valenciennes

*Apocryptes rictuosus* Valenciennes in Cuvier and Valenciennes, 1837, Hist. Nat. Poissons, 12: 151—Pondicherry, India.

*Parapocryptes rictuosus* Koumans, 1941, Mem. Indian Mus., 13: 275.

Dorsal rays VI—I, 27; pectoral 21; ventral I, 5; anal I, 26; mid-lateral scales 70; 33 premaxillary teeth; 22 mandibular teeth; total length 157.5 mm.; standard length 113.5 mm.; head 4.63; depth 7.32; eye 5.44.

The greatly coiled gut contained detritus and fragments of arthropod limbs.

One specimen was caught in a cast net below Sta. VI.

### **Tetraodon fluviatilis** Hamilton

*Tetraodon fluviatilis* Hamilton, 1822, Fishes of Ganges, p. 6, pl. 30, fig. 1—Bengal, India.

Dorsal rays ii—iii, 10–12; pectoral ii, 19–21; anal ii, 9–10; total length 17.5–138 mm.; standard length 13.5–105.0 mm.; head 2.01–2.29.

Only three digestive tracts contained food particles. One had mollusk fragments; another, mollusk shell fragments and one *Corica* (30 mm. total length); and the third, one small prawn.

Six specimens (standard length 13.5–71.0 mm.) from Sta. IX, three (35.4–91.4 mm.) from Sta. X, one (101.5 mm.) from the Gaja



River between Stas. I and III, and one (105.0 mm.) from the mouth of the Kretam Besar River.

### **Tetraodon kretamensis** Inger

*Tetraodon kretamensis* Inger, 1953, Fieldiana, Zool., 34: 149, fig. 27—Pinang River, Kinabatangan District, North Borneo.

Dorsal rays ii-iii, 8-11; pectoral ii, 15-18; anal i-ii, 7-9; total length 10.5-64 mm.; standard length 7.9-52.0 mm.; head 2.10-2.26.

Of the three digestive tracts with food, one contained fragments of crustaceans and mollusks; a second, fragments of crustaceans; and the third, remains of insects.

Three (total length 10.5-27 mm.) from Sta. I, 163 (total length of those preserved 43-57 mm.) from Sta. II, thirty-five (34-64 mm.) from Sta. X, and seven (11-46 mm.) from the nipa palm swamp fringing the Kretam Kechil.

#### CHANGES IN THE FAUNAL COMPOSITION

The fish population in the brackish water area (Stas. I, VI, VII, and IX) is composed largely of marine groups. These forms, mostly isospondyls, percesocids, and percoids, disappear as soon as fresh water is reached. In terms of individuals these three groups comprise 97.4 per cent of the total catch at Sta. VI, 94.3 per cent at Sta. VII, 92.0 per cent at Sta. IX, 92.7 per cent at Sta. I, and 0.5 per cent at Sta. II. None were found at other stations. In terms of numbers of species, these orders contribute 87.4 per cent at Sta. VI, 73.7 per cent at Sta. IX, 73.3 per cent at Sta. I, 50.0 per cent at Sta. VII, and 5.6 per cent at Sta. II (Tables 1 and 2).

At Sta. X, which is still tidal though probably fresh water, none of these three orders was represented in the catch. Judging from the catch at Sta. II, which is also in fresh water, the percoid, *Am-bassis*, was to be expected at Sta. X.

Several other marine or brackish water groups are especially well represented in the collections of Stas. II and X. *Dermogenys*, *Tetraodon*, gobies, and eleotrids make up 78.7 per cent of the total catch at Sta. II and 24.4 per cent at Sta. X. But at subsequent stations upstream on the Gaja not a single specimen of these groups was found. These fishes occupy an ecological position similar to the "complementary" fresh-water fishes of Myers (1949). As a group they are abundant in an intermediate zone unfavorable to both true marine forms and primary fresh-water species.

TABLE 1.—COMPOSITION OF CATCHES AT STATIONS ON KRETAM KECHIL DRAINAGE IN TERMS OF PERCENTAGES OF TOTAL NUMBER OF INDIVIDUALS FROM VARIOUS SPECIES AND GROUPS

	Kretam Kechil Sta. VI Brackish			Gaja River <sup>1</sup>				Pinang River <sup>1</sup>			Unnamed tributary Sta. VIII Fresh	
	Sta. I Brackish	Sta. II ←	Sta. III Fresh	Sta. IV Fresh	Sta. V	Sta. IX Brackish	Sta. X ?	Sta. XI Fresh	Sta. XII Fresh	Sta. XIII Fresh	Sta. XIV Fresh	Sta. XV Fresh
<i>Anguilla borneensis</i> .....	.....	7.7	5.3	5.2	5.2	.....	1.0	.....	.....	.....	.....	3.7
<i>Nematabramis everetti</i> .....	.....	.....	45.6	41.9	40.0	.....	65.3	.....	.....	.....	.....	32.6
<i>Rasbora sumatrana</i> .....	.....	9.3	18.6	22.6	4.0	.....	1.0	.....	.....	.....	.....	26.2
<i>Puntius sealei</i> .....	.....	2.1	1.0	8.5	16.0	.....	.....	.....	.....	.....	.....	27.7
<i>Hampala macrolepidota</i> .....	.....	0.9	12.0	7.8	4.0	.....	0.3	.....	.....	.....	.....	.....
<i>Osteochilus spilurus</i> .....	.....	.....	14.2	6.3	.....	.....	.....	.....	.....	.....	.....	.....
<i>Clarias leysmanni</i> .....	.....	0.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
<i>Mystus nemurus</i> .....	.....	.....	1.5	3.7	.....	.....	1.7	7.3	.....	.....	.....	1.9
Total Ostariophysii.....	.....	13.0	92.9	90.8	64.0	.....	1.7	74.9	.....	.....	.....	88.4
<i>Betta unimaculata</i> .....	.....	.....	1.5	4.1	36.0	.....	.....	.....	.....	.....	.....	6.0
<i>Ophicephalus melanosoma</i> .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.1
<i>Dermogenys pusillus</i> .....	3.6	6.3	.....	.....	.....	.....	1.2	6.9	.....	.....	.....	.....
<i>Tetraodon kretamensis</i> .....	1.5	38.1	.....	.....	.....	.....	.....	11.6	.....	.....	.....	.....
<i>Tetraodon fluviatilis</i> .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gobiidae.....	.....	18.2	.....	.....	.....	.....	.....	3.5	1.0	.....	.....	.....
Eleotridae.....	0.5	16.1	.....	.....	.....	.....	.....	.....	0.3	.....	.....	.....
<i>Ambassis interrupta</i> .....	.....	.....	.....	.....	.....	.....	.....	.....	4.6	.....	.....	0.7
Percoidae.....	.....	2.1	0.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Percosoces.....	30.4	49.5	0.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Isospondyli.....	17.7	22.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	49.3	20.6	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total number of individuals.....	194	428	590	270	25	.....	173	303	.....	.....	.....	267

<sup>1</sup> Order of stations is upstream.

TABLE 2.—COMPOSITION OF CATCHES AT STATIONS ON KRETAM KECHIL DRAINAGE IN TERMS OF PERCENTAGES OF TOTAL NUMBER OF SPECIES FROM VARIOUS GROUPS

	Kretam Kechil		Gaja River <sup>1</sup>					Pinang River <sup>1</sup>		
	Sta. VI Brackish	Sta. I Brackish	Sta. II ←	Sta. III Fresh	Sta. IV	Sta. V →	Sta. IX Brackish	Sta. X ?	Sta. XI Fresh	
Isospondyli.....	18.7	26.7	.....	.....	.....	.....	21.1	.....	.....	
Apodes.....	.....	.....	5.6	11.1	12.5	.....	.....	9.1	.....	
Ostariophysi.....	.....	.....	22.2	66.7	75.0	80.0	5.3	36.4	.....	
Synentognathi.....	12.5	13.3	5.6	.....	.....	.....	10.5	9.1	.....	
Solenichthyes.....	.....	.....	.....	.....	.....	.....	5.3	9.1	.....	
Percosces.....	18.7	13.3	.....	.....	.....	.....	15.8	.....	.....	
Percoidae.....	50.0	33.3	5.6	.....	.....	.....	36.8	.....	.....	
Anabantoidea.....	.....	.....	.....	11.1	12.5	20.0	.....	.....	100	
Gobioidea.....	.....	6.7	55.6	.....	.....	.....	.....	18.2	.....	
Plectognathi.....	.....	6.7	5.6	.....	.....	.....	5.3	18.2	.....	
Synbranchioidea.....	.....	.....	.....	11.1	.....	.....	.....	.....	.....	
Total no. of species.....	16	15	18	9	8	5	19	11	1	

<sup>1</sup> Order of stations is upstream.

TABLE 3.—FOOD OF VARIOUS SPECIES FROM KRETAM KECHIL DRAINAGE AND NUMBER OF DIGESTIVE TRACTS CONTAINING PARTICULAR FOOD CATEGORIES

	AQUATIC ANIMALS						TERRESTRIAL ANIMALS					
	Fish	Mollusks	Misc. aquatic non-arthropod invertebrates	Crustaceans	Aquatic insects	Misc. aquatic arthropods	Terrestrial insects	Arachnids	Unidentifiable arthropod fragments	Plant material	Unidentifiable material	
<i>Thrissoles hamiltoni</i> .....	1	..	..	6	..	..	..	..	..	..	..	
<i>Stolephorus commersoni</i> .....	1	..	..	4	..	..	..	..	..	..	..	
<i>Stolephorus tri</i> .....	2	..	..	8	..	..	..	..	..	..	..	
<i>Ilisha kampeni</i> .....	3	..	..	10	..	..	..	..	..	..	..	
<i>Anguilla borneensis</i> .....	..	..	..	2	1	..	3	..	..	..	..	
<i>Nematobramis everetti</i> .....	..	..	..	..	..	..	13	2	..	1	..	
<i>Rasbora sumatrana</i> .....	..	..	..	..	..	..	7	..	..	2	..	
<i>Puntius scalei</i> .....	..	1	..	2	..	1	3	..	..	6	..	
<i>Hampala macrolepidota</i> .....	6	..	..	..	..	..	..	1	..	..	5	
<i>Osteochilus spilurus</i> .....	..	..	..	..	..	..	..	..	..	..	..	
<i>Tachysurus venosus</i> .....	1	..	..	..	..	..	..	..	..	..	..	
<i>Clarias teysmanni</i> .....	..	..	..	1	4	..	5	1	..	..	..	
<i>Myxus nemurus</i> .....	..	..	..	7	1	..	2	..	2	1	..	
<i>Tylosurus strongylurus</i> .....	..	..	..	1	..	..	..	..	..	..	..	
<i>Zenarchopterus amblyurus</i> .....	..	..	..	..	1	..	3	..	..	..	..	
<i>Sphyraena jello</i> .....	1	..	..	..	..	..	..	..	..	..	..	
<i>Betta unimaculata</i> .....	1	..	..	1	2	..	8	..	..	..	..	
<i>Ophicephalus melanosoma</i> .....	..	..	..	2	..	..	1	..	..	..	..	
<i>Ambassis interrupta</i> .....	2	..	1	..	..	..	2	..	..	..	..	
<i>Lates calcarifer</i> .....	..	..	..	1	..	..	..	..	..	..	..	
<i>Caranx ignobilis</i> .....	..	..	3	..	..	..	..	..	..	..	..	
<i>Lutianus argenteimaculatus</i> .....	..	..	1	..	..	..	..	..	..	..	..	

TABLE 3.—FOOD OF VARIOUS SPECIES FROM KRETAM KECHIL DRAINAGE AND NUMBER OF DIGESTIVE TRACTS CONTAINING PARTICULAR FOOD CATEGORIES—concluded

	AQUATIC ANIMALS				TERRESTRIAL ANIMALS						
	Fish	Mollusks	Misc. aquatic non-arthropod invertebrates	Crustaceans	Aquatic insects	Misc. aquatic arthropods	Terrestrial insects	Arachnids	Unidentifiable arthropod fragments	Plant material	Unidentifiable material
<i>Pomadasya hasta</i> .....	..	..	1	3	..	..	..	..	..	..	..
<i>Pomadasya maculatus</i> .....	..	..	..	3	..	..	..	..	..	..	..
<i>Gerres poeii</i> .....	..	..	..	1	..	..	..	..	..	..	..
<i>Leiognathus equulus</i> .....	..	..	3	1	..	..	..	..	..	..	..
<i>Torotes jaculatrix</i> .....	..	..	..	1	..	..	1	..	..	..	..
<i>Torotes chatareus</i> .....	..	..	..	2	..	..	2	..	1	..	..
<i>Butis gymnopomus</i> .....	2	..	..	3	4	..	..	..	1	..	..
<i>Eleotris melanosoma</i> .....	..	..	..	1	..	..	..	..	1	1	..
<i>Oryzias uruphthalmus</i> .....	..	..	..	..	..	..	..	..	..	..	..
<i>Brachyobius doriae</i> .....	1	..	..	..	..	..	..	..	1	..	..
<i>Glossogobius giuris</i> .....	2	..	..	3	..	..	..	..	..	..	..
<i>Boleophthalmus boddarti</i> .....	..	..	..	..	..	..	..	..	..	..	..
<i>Parapocryptes rictuosus</i> .....	..	..	..	..	..	..	..	..	..	..	1
<i>Tetraodon fluviatilis</i> .....	1	2	..	1	..	..	..	..	..	..	1
<i>Tetraodon kretamensts</i> .....	..	1	..	2	..	..	..	..	1	..	..

SPECIES CAUGHT ON HOOK AND-LINE WITH DECAPOD CRUSTACEANS AS BAIT

<i>Evenchelys macrurus</i> (2)	<i>Polydactylus plebius</i> (1)
<i>Tachysurus caelatus</i> (1)	<i>Epinephelus nebulosus</i> (1)
<i>Tachysurus sagor</i> (2)	<i>Lutianus argenteimaculatus</i> (1)
<i>Tachysurus venosus</i> (5)	<i>Pomadasya hasta</i> (3)
<i>Eleutheronema tetradactylum</i> (1)	

As previously noted, all of Sta. II and at least the upper strata of Sta. X consist of fresh water. *Dermogenys*, *Tetraodon*, and the gobioids of these stations can tolerate both fresh and brackish water. Furthermore, since the physical characteristics of Sta. II are repeated at Stas. III and IV on the Gaja, the physical environment probably does not hold the limiting factor to their upstream dispersal. Most of these species were feeding on decapod crustaceans, fishes, and insects. As the food organisms also occur upstream, the distribution of food presents no obstacles. It is most likely that the presence of many Ostariophysi constitutes the limiting factor. The Ostariophysi form 13.0 per cent of the catch at Sta. II and 74.9 per cent at Sta. X. The decrease in the percentage of the brackish water assemblage from Sta. II to Sta. X reflects an absolute decrease in the number of individuals from 337 to 74. The reverse effect of an absence of Ostariophysi on the gobioids is spectacularly illustrated in the Philippine Islands, where the gobioids have undergone a remarkable efflorescence in fresh water (Herre, 1927).

The absence of gobies from the catches of Stas. I, VI, and IX is the result of selectivity of the fishing methods, as eight species of gobies were collected at other times along the Kretam Kechil (see p. 55). At Sta. VI the use of the cast net did not permit the capture of terrestrial, burrowing, or deep-water benthic forms. The same forms are probably not often obtained in deep, muddy water (as at Stas. I and IX) through the use of rotenone.

Among the Ostariophysi, the Ariidae are found in Dewhurst Bay and probably occur in the deep strata of the Kretam Kechil, although none were collected there. Of the fresh-water families, only one species, *Mystus nemurus*, was taken in brackish water (Sta. IX). The Ostariophysi are the dominant element of the fresh-water fauna. At Stas. III to V and at Sta. X they comprised over 60 per cent of the total catches (Table 1).

Sta. II, although it is in fresh water, runs into the Gaja River at a point still affected by the tides. At high tide the Gaja here is probably somewhat saline, at least in the deeper strata. The fresh water of Sta. II might then be isolated from the main body of fresh water in the Gaja. Such isolation may account for the paucity of Ostariophysi at Sta. II (13.0 per cent of catch).

The dominance of the Ostariophysi is maintained in the fresh water until the region of semi-isolated pools near the stream sources is reached. In these head-waters, which may be intermittent, only *Betta* is able to maintain itself. At Sta. XI, *Betta unimaculata* was

the only species collected. Similarly, only *Betta* was obtained in those portions of Sta. V consisting of small semi-isolated pools (west branch and southwest part of east branch; see description on p. 53). Thus, Sta. V is composed of two ecological zones, one physically resembling Sta. IV (the section containing cyprinids) and the other resembling Sta. XI (the section containing *Betta* only).

#### FOOD AND FEEDING RELATIONS

Two aspects of the feeding relations of the fauna stand out: (1) the importance of terrestrial arthropods in the economy of the fresh-water community; and (2) the predominance of palaemonid decapods in the diet of the brackish water forms. A species-by-species analysis of food is given in Table 3.

Considering the number of specimens containing the food, terrestrial arthropods were the most important food source of six of the seventeen species either restricted to or more abundant in fresh water. This is a larger proportion than is found in communities of the temperate zone, as may be seen in Table 4.

TABLE 4.—TYPES OF FOOD PREDOMINATING IN FRESH-WATER FISH COMMUNITIES OF VARIOUS STREAMS

Food dominance determined by number of individuals containing type of food

Predominant food class	Kretam Kechil	Number of Species			
		England <sup>1</sup>	Michigan <sup>2</sup>	New York <sup>3</sup>	New York <sup>4</sup>
Terrestrial animals....	6	0	0	4	9
Aquatic animals.....	7	10	15	53	46
Plants.....	2	1	1	7	11
Indeterminant.....	2	0	1	0	0
Total.....	17	11	17	64	66

<sup>1</sup> Hartley (1948)

<sup>3</sup> Sibley (1929)

<sup>2</sup> Hankinson (1908)

<sup>4</sup> Rimsky-Korsakoff (1930)

Although the number of stomachs sampled from the Kretam Kechil is perhaps too small to be conclusive, the data are at least suggestive.

Availability of the type of food probably explains the results shown in Table 4. For the temperate zone faunas, terrestrial insects are not present during one-third to one-half of the year, which is in sharp contrast to the conditions in the ever-warm Kretam Kechil area. But seasonal availability is not a factor in Table 4, except possibly in the case of the English fauna, as the other temperate faunas were sampled only in the spring and summer. The English community was sampled throughout the year.

Availability in the sense of abundance is a factor. The tropical rain-forest, such as covers the area of this study, is noted for its fantastic wealth of insects. Because of this abundance, it may be assumed safely that a great many non-aquatic insects fall into the streams. The sudden torrential rains that occur every second or third day even in the "dry" season of the Kretam Kechil area must knock many arboreal insects off the trees overhanging the streams.

There is little evidence of specialization for feeding on terrestrial arthropods in the Kretam Kechil fauna. Only *Nematabramis everetti* and *Rasbora sumatrana* seem to be limited to this food. The other fresh-water fishes feed on a variety of foods in which terrestrial insects and aquatic crustaceans are the staples. The basing of the economy of the fish community upon terrestrial insects as one of the two main foods undoubtedly reflects the great abundance of insects in the rain-forest and the almost continual organic "rain" of these animals.

The brackish water fauna depends primarily on crustaceans for food. Apparently crustaceans are the principal food of eleven of the twenty brackish water species (see Table 3). Prawns of the decapod family Palaemonidae occurred in thirty-six specimens, unidentified decapod crustacean fragments in eleven, and other types of crustaceans in four. In terms of individual food organisms, prawns were even more important. One copepod, one isopod, and two amphipods represent the total number of non-palaemonid crustaceans identifiable to order. By contrast, ten or more prawns were found in each of several fish stomachs (see pp. 56, 57, and 73). Seven additional brackish water species were caught on hook and line, using prawn as bait (Table 3).

#### SUMMARY

Seventy-one species are recorded from the Kretam Kechil drainage of northeast Borneo. Forty-four of these were found only in saline waters. The twenty-seven species collected in fresh water include fifteen belonging to such marine groups as the Synentognathi, Percoidea, Gobioidae, and Plectognathi. The small number (eight) of fresh-water Ostariophysi probably reflects, at least in part, the shortness of the drainage (approximately 50 kilometers).

At the sources of the drainage, in the zone of isolated and semi-isolated pools, only *Betta* occurs. Downstream, where the streams are permanent and consist of continuous bodies of water, Ostariophysi form the bulk of the fauna. Gobies, eleotrids, puffers (*Tetra-*



*odon*), and half-beaks (*Dermogenys*) become abundant in fresh water near the tidal limits. Within the long zone of brackish water, isospondyls, percoids, and percesocids dominate the fauna.

A large proportion of the fresh-water fishes feeds principally on terrestrial insects that fall in the streams. In brackish water, the food base of the fish community seems to be crustaceans of the family Palaemonidae.

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