'DROLOGICAL AND ICHTHYOLOGICAL OBSERVATIONS IN THE MOUTH OF THE KUMAI-RIVER (S.W. BORNEO).

By

Dr. J. D. F. HARDENBERG
(Laboratorium van het Onderzoek der Zee, Batavia)

INTRODUCTION. The Kumai-river is situated in the south-western part Borneo and flows out into the Java-Sea. It is one of the smaller rivers and its ters contain only a relatively small amount of mud. The Kumai is very ll navigable for small-sized sea-going ships. The average depth is from about rty to more than fifty feet, apart from a bar just before the mouth, while e average breadth is about 750 m. At about 50 nautical miles from the mouth e river ceases to be navigable. At this point two smaller rivers flow together form the Kumai proper. The banks of the river are by far the greater part vered with primaeval forest forming a dense jungle with high trees. Only ite near the mouth mangrove- and nipah swamps are found. A small native llage, Kumai, lies on the right bank. Just above the mouth the river shows lake-like widening, which is shut of from the sea by a narrow "Nehrung".

HYDROLOGY. The Kumai-river seems to be dependent for the greater part direct rainfall. At the end of the West-Monsoon (April-May), which is the in-monsoon here, the water of the river is almost fresh and even at a great stance out in sea we find a very low salinity. At the end of the dry East-Ionsoon (September-October) the salinity is much higher and even at the ghest navigable point of the river we find salinities of about 20 $^0/_{00}$ at the irface. In these months the Kumai seems more an arm of the sea than a river.

These differences in salinity are expressed in fig. 1. On the vertical axis ie salinities are expressed and on the horizontal one the distance in nautical iles before and above the mouth of the Kumai. Only the salinities at the irface are given here. Four series of observations are dealt with. Two (Sept. 928 en 1930) at the end of the East-Monsoon are given in a full line and vo at the end of West-Monsoon in a dotted line (May 1930 on 1931). Two iore observations in April and October 1932 were made but as these showed othing new I have omitted them in the figure, to avoid an overcrowding ith lines.

We see at a single glance the difference in salinity at the end of the dry nd at the end of the wet monsoon, a difference which is not only very clearly xpressed in the waters of the river itself, but also far out at sea. For a full nderstanding I must state here also that in the Java-sea (at least in its western

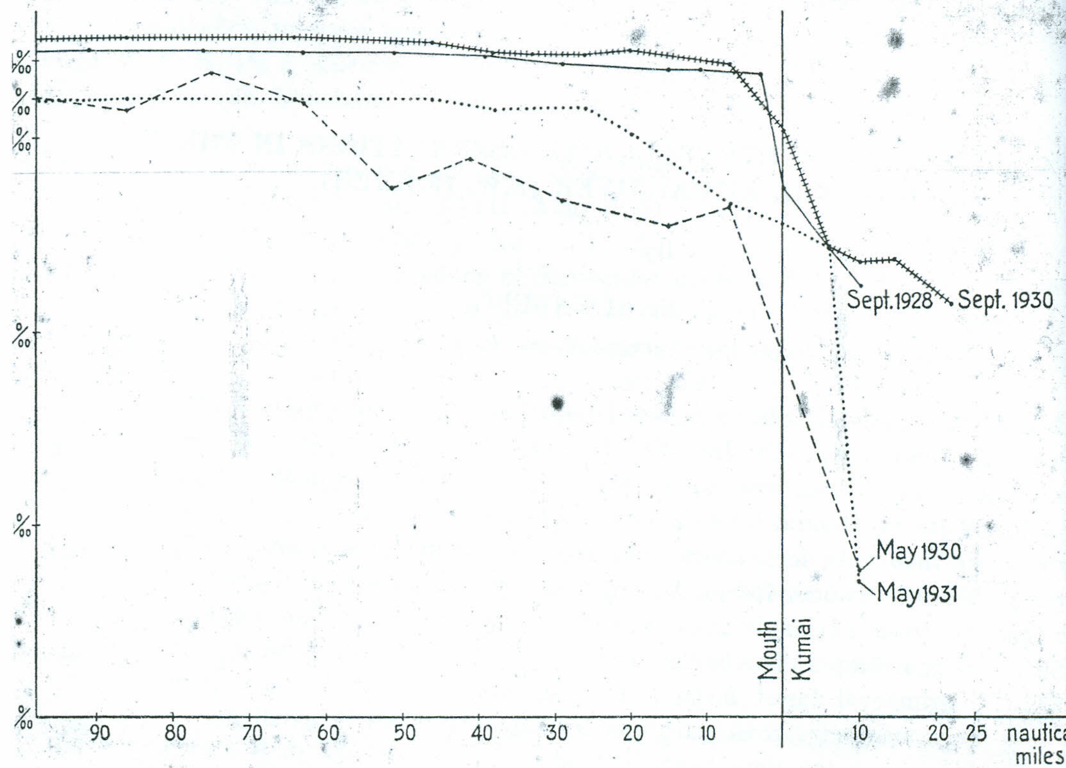

Fig. 1. Curve of the salinities at the surface in and before the Kumai-river. On the horizontal axis the distance in nautical miles is expressed and at the vertical axis the salinity in $^0/_{00}$.

half) the salinity is about $2\,^0/_{00}$ lower during the West-Monsoon than during the East-Monsoon. However if we cross the Java-sea from Java to Borneo we shall find that about midway the salinity shows already a decrease in the West Monsoon. This decrease which is caused by the great outflow of fresh-water from the great Borneoan rivers is small at first and becomes steeper later on. Only the latter part is expressed in the figure. The reader will see that in three of the four series of observations, the observations cease at about 10 miles above the mouth of the river. Originally the observations were only made in accordance with DELSMAN's researches on pelagic eggs of marine- and coastal-fishes and as the eggs were not found higher up than about 10 miles above the rivermouths the observations ceased there.

Each line in the figure represents of course only the state of things on a single day but we may safely assume that on other days no great and essential differences will be found. Low- and hightide have not much influence either, as the difference between them is only one meter or less.

In the course of my first four visits to the Kumai it struck me that the fishermen on the river near the little village of Kumai (about 10 nautical miles above the mouth) caught so many fishes as for instance *Cybium*- and *Trichiurus*-

species, which one would not expect at such a low salinity. Therefore during my fifth and sixth visit I took samples of water, not only from the surface, but also from the lower waterlayers.

The results of these series of observations are given below, first the observations in April 1932 and secondly those in October 1932.

S_0 means that the sample was taken from the surface, S_1 one meter below the surface and so on. The salinities were computed with the aid of an areometer. It showed, that although the superficial waterlayers were brackish, the lower layers near the bottom had a much higher salinity. Thus the presence of the above named seafishes could be very well explained by this high salinity in the lower waterlayers and it is not necessary to assume that these species are especially adapted to a life in the brackish water of tidal rivers. Of course the same explanation holds good for all marine fishes, which are caught now and then in the lower part of rivers. I think that in literature, these facts are not always sufficiently taken into account.

Series of observations in April 1932.

I In sea, 24 nautical miles in front of the rivermouth [1]).

S_0 — 26.88 $^0/_{00}$	S_6 — 30.75 $^0/_{00}$ ←— springlayer
S_1 — 26.86 $^0/_{00}$	S_7 — 31.46 $^0/_{00}$
S_2 — 27.30 $^0/_{00}$	S_8 — 31.82 $^0/_{00}$
S_3 — 27.55 $^0/_{00}$	S_{10} — 31.94 $^0/_{00}$
S_4 — 28.03 $^0/_{00}$	S_{12} — 31.74 $^0/_{00}$
S_5 — 28.30 $^0/_{00}$	

II 20 miles in front of the rivermouth.

S_0 — 27.72 $^0/_{00}$ [2])	S_7 — 31.27 $^0/_{00}$
S_1 — 27.63 $^0/_{00}$	S_8 — 31.65 $^0/_{00}$
S_2 — 27.63 $^0/_{00}$	S_9 — 31.91 $^0/_{00}$
S_3 — 27.55 $^0/_{00}$	S_{10} — 31.70 $^0/_{00}$
S_4 — 28.55 $^0/_{00}$ ←— springlayer	S_{11} — 31.78 $^0/_{00}$
S_5 — 30.39 $^0/_{00}$	S_{12} — 31.78 $^0/_{00}$
S_6 — 30.75 $^0/_{00}$	S_{13} — 31.91 $^0/_{00}$

III 14.5 miles in front of the rivermouth.

S_0 — 27.52 $^0/_{00}$	S_7 — 30.01 $^0/_{00}$
S_3 — 27.52 $^0/_{00}$ ←— springlayer	S_8 — 30.39 $^0/_{00}$
S_4 — 29.58 $^0/_{00}$	S_9 — 31.17 $^0/_{00}$
S_5 — 29.75 $^0/_{00}$	S_{10} — 31.69 $^0/_{00}$
S_6 — 29.88 $^0/_{00}$	S_{11} — 31.47 $^0/_{00}$

IV 10 miles in front of the rivermouth.

S_0 — 26.54 $^0/_{00}$	S_6 — 30.84 $^0/_{00}$

[1]) If in two or more layers of 1 meter the salinity was the same I have omitted in the table the figures for the lowermost ones.

[2]) (Somewhat higher as at the first station!)

S_1 — 27.03 $^0/_{00}$
S_3 — 27.02 $^0/_{00}$
S_4 — 27.48 $^0/_{00}$
← springlayer
S_5 — 30.62 $^0/_{00}$
S_7 — 30.97 $^0/_{00}$
S_8 — 31.09 $^0/_{00}$
S_9 — 31.23 $^0/_{00}$

V 6 miles in front of the rivermouth.
S_0 — 24.63 $^0/_{00}$
S_6 — 30.34 $^0/_{00}$

Because of the navigation in the narrow channel between the banks there was no time to make more observations.

VI In the mouth of the river.
S_0 — 18.72 $^0/_{00}$
S_1 — 20.56 $^0/_{00}$
S_2 — 22.77 $^0/_{00}$
S_3 — 26.36 $^0/_{00}$ ← springlayer
S_4 — 26.89 $^0/_{00}$
S_5 — 27.02 $^0/_{00}$

VII 6 miles above the rivermouth.
S_0 — 11.47 $^0/_{00}$
S_1 — 14.18 $^0/_{00}$
S_2 — 13.42 $^0/_{00}$
S_3 — 13.55 $^0/_{00}$
← springlayer
S_4 — 16.29 $^0/_{00}$
S_5 — 18.59 $^0/_{00}$
S_6 — 19.38 $^0/_{00}$
S_8 — 20.23 $^0/_{00}$
S_{10} — 20.75 $^0/_{00}$
S_{12} — 21.80 $^0/_{00}$

VIII 10 miles above the rivermouth.
S_0 — 10.84 $^0/_{00}$
← springlayer
S_1 — 12.05 $^0/_{00}$
S_2 — 12.90 $^0/_{00}$
S_3 — 13.96 $^0/_{00}$
S_4 — 14.18 $^0/_{00}$
S_5 — 14.71 $^0/_{00}$
S_6 — 15.26 $^0/_{00}$
S_8 — 15.79 $^0/_{00}$
S_{10} — 17.08 $^0/_{00}$
S_{12} — 17.47 $^0/_{00}$

Series of observations in October 1932 at the end of the dry monsoon.

IX 20 miles in front of the mouth.
S_0 — 30.70 $^0/_{00}$
S_1 — 31.29 $^0/_{00}$
S_2 — 31.78 $^0/_{00}$
S_3 — 31.80 $^0/_{00}$
S_4 — 31.84 $^0/_{00}$
← springlayer
S_5 — 32.70 $^0/_{00}$
S_6 — 32.70 $^0/_{00}$
← springlayer
S_7 — 33.09 $^0/_{00}$
S_8 — 33.35 $^0/_{00}$
S_9 — 33.42 $^0/_{00}$
S_{10} — 33.52 $^0/_{00}$
S_{11} — 33.64 $^0/_{00}$

X 14½ miles in front of the rivermouth.
S_0 — 31.52 $^0/_{00}$
S_1 — 31.63 $^0/_{00}$
S_2 — 31.63 $^0/_{00}$
S_3 — 31.63 $^0/_{00}$
S_4 — 31.93 $^0/_{00}$ ← springlayer
S_5 — 32.70 $^0/_{00}$
S_6 — 33.35 $^0/_{00}$
S_{7-10} ± 33.48 $^0/_{00}$

XI 10 miles in front of the rivermouth.
S_0 — 31.47 $^0/_{00}$
S_1 — 31.55 $^0/_{00}$
S_2 — 31.46 $^0/_{00}$
← springlayer
S_3 — 32.37 $^0/_{00}$
S_4 — 32.72 $^0/_{00}$
S_5 — 32.83 $^0/_{00}$
S_6 — 32.88 $^0/_{00}$

XII 6 miles in front of the rivermouth.

S_0 — 32.07 $^0/_{00}$		S_3 — 32.03 $^0/_{00}$
S_1 — 31.85 $^0/_{00}$		

XIII In the mouth of the river.

S_0 — 25.55 $^0/_{00}$		S_6 — 26.16 $^0/_{00}$
S_1 — 25.66 $^0/_{00}$		S_7 — 26.58 $^0/_{00}$
S_2 — 25.82 $^0/_{00}$		

XIV 6 miles above the rivermouth.

S_0 — 15.64 $^0/_{00}$		S_3 — 21.37 $^0/_{00}$
S_1 — 15.74 $^0/_{00}$	← springlayer	S_4 — 23.19 $^0/_{00}$
S_2 — 20.55 $^0/_{00}$		

XV 10 miles above the rivermouth.

S_0 — 13.78 $^0/_{00}$		S_5 — 21.60 $^0/_{00}$
S_1 — 15.34 $^0/_{00}$		S_6 — 22.38 $^0/_{00}$
S_2 — 15.14 $^0/_{00}$		S_8 — 23.21 $^0/_{00}$
S_3 — 14.89 $^0/_{00}$	← springlayer	S_{11} — 23.83 $^0/_{00}$
S_4 — 20.52 $^0/_{00}$		

XVI 15 miles above the rivermouth.

S_0 — 9.92 $^0/_{00}$		S_5 — 21.37 $^0/_{00}$
S_1 — 10.70 $^0/_{00}$		S_6 — 23.12 $^0/_{00}$
S_2 — 12.16 $^0/_{00}$	← springlayer	S_7 — 23.40 $^0/_{00}$
S_3 — 17.90 $^0/_{00}$		S_{11} — 23.91 $^0/_{00}$
S_4 — 19.42 $^0/_{00}$		

XVII 20 miles above the rivermouth.

S_0 — 10.94 $^0/_{00}$		S_4 — 18.06 $^0/_{00}$
S_1 — 10.71 $^0/_{00}$		S_5 — 20.80 $^0/_{00}$
S_2 — 13.50 $^0/_{00}$		S_6 — 22.10 $^0/_{00}$
S_3 — 15.01 $^0/_{00}$		

XVIII 25 miles above the rivermouth.

The water at the surface is quite fresh now. I was not able to get samples of deeper layers as I had to go to this place in the ship's small boat, which had no means on board to use waterbottle. The ship itself could not go to this place as the river is only 6 - 9 feet deep there in the deepest parts. I think we can safely assume that if the bottomwater was somewhat brackish the salinity at any rate was below 15 $^0/_{00}$ (See XVII S_3) and more probably much lower.

Looking at the figures given above we can remark the following.

1. The differences between the salinities of the uppermost and lowermost waterlayers are not constant. As could be expected these differences are greater at the end of the wet than at the end of the dry monsoon, as during the wet monsoon the outflow of fresh water is much greater. It is curious to see that the differences become smaller when we approach the mouth of the river and become greater in, and some distance above the mouth, whereas they become smaller again further inland. For convenience sake, I have give below a table showing the differences in salinity between the lowermost and the uppermost layer [1]).

Wet monsoon.	*I* ‰	*II* ‰	*III* ‰	*IV* ‰	*V* ‰	*VI* (mouth) ‰	*VII* ‰	*VIII* ‰		
Lowermost waterlayer.	31.74	31.91	31.47	31.23	30.34	27.02	21.80	17.47		
Uppermost waterlayer.	26.88	27.72	27.52	28.54	24.63	18.72	11.47	10.84		
Difference.	4.86	4.90	3.95	4.69	5.71	8.30	10.33	6.63		
Dry monsoon.		*IX* ‰	*X* ‰	*XI* ‰	*XII* ‰	*XIII* (mouth) ‰	*XIV* ‰	*XVI* ‰	*XVII* ‰	*XVIII* ‰
Lowermost waterlayer.		33.64	33.48	32.88	32.03	26.68	23.19	23.33	23.91	22.10
Uppermost waterlayer.		30.70	31.52	31.71	31.07	25.55	15.64	13.78	9.92	10.94
Difference.		2.94	1.96	1.17	0.96	1.13	7.55	10.05	13.99	11.16

2. The salinity does not always increase with greater depth. In several instances (I, VI, VII, XI, XVII) we see that the salinity decreases at greater depth. These irregularities are due of course to a turbulence in the water caused by the stream. Differences in temperature in the upper and lower waterlayers, which may cause convectionstreams, can be neglected or almost neglected as these differences were at the utmost a few tenths of degree only.

3. In most cases we find a springlayer. Of this springlayer we may remark.

a. The springlayer seems to be absent in a few instances as can be seen in the tables given above.

b. The depth at which the springlayer is found is not always the same. Its depth seems to be increasing when farther in sea.

c. In one case (IX) there seem to be two sprigIayers.

d. The springlayer is not dependent on a given salinity. At each station the salinities of the springlayer are different. There does not seem to exist any rule.

4. Surfacesalinities do not tell us anything about the salinities of the deeper waterlayers, which as a rule are much higher. From a biological standpoint this is of importance. Many species of fish are described as entering brackish or even fresh water. From the above numbers it follows that the animals can enter tidal rivermouths without coming into a salinity which is too low for them. The adaptability of these species to salinities much lower

[1]) The place (station) where the salinities given in II were found is the same as the place where the salinities given in IX were taken. The same can be said of III and X, IV and XI, and so on.

than seawater is only apparent therefore. When swimming in the lower water-layers these fishes can remain in the salinity of the high or rather high concentration which fits them. A superficial observer, when looking at the catch of a fisherman from the river in the vicinity of its mouth and seeing species of sea-fish, might think therefore, that these species are able to live in fresh water or in water with a rather low salt-concentration, judging from the salinity at the surface only. In reality this is not the case, as these seafishes have been caught in the deeper waterlayers of a much higher salinity. Thus far in literature there is laid no sufficient stress on this fact.

It should be remarked here that I have observed the same facts in other rivers, where the figures were sometimes even more striking. But as I do not possess such a complete series of observations of these other rivers I have preferred to give the figures of the Kumai instead. Of course each river will have its own peculiarities and the distribution of the salinities may be altered by many circumstances, as for instance a decrease or increase of the outflowing of freshwater, presence or absence of a bar before the mouth, higher or lower saltconcentration of the seawater before the mouth and so on.

On searching the literature it was very surprising to find how little there was known and published about the mixing of fresh- and saltwater in estuaries. Most authors seemed to take it for granted that the mixing of the sea- and the riverwater takes place quite regularly and gradually, the riverwater spreading more or less fanlike over the heavier seawater. As a matter of fact this is indeed the case in some European rivers, as for instance the river Elbe in Germany and in the estuary of the Schelde in the Netherlands. Here we find the salinity gradually increasing from surface to bottom. I will refrain from giving many figures here; a single example will be sufficient in the scope of this paper.

So E. KOLUMBE in the "Archiv für Hydrobiologie, Bnd. XXII, 1932, published some data about the salinity of the Elbe. He found, for instance, near Brünsbüttel at the end of high tide, a salinity of 8.7 ‰ at the surface, of 9.6 ‰ at a depth from 5 - 9 m and of 10.3 ‰ at a depth from 9 - 14 m. It is easy to see that salinity increases with depth. A springlayer does not exist, or if it does the differences are very small and not so great as in the Kumairiver.

It is obvious that the existence of the springlayer in the Kumai and the non-existence of it in the Elbe must have a cause. It is also obvious that temperature-differences cannot form this cause as in the first place temperature-differences in the tropics in such relatively shallow water as in the Kumai-mouth can be neglected — as had been pointed out above — and in the second place eventually existing temperature-differences, which are probably much greater in the Elbe, would tend to increase sudden differences in salinity as the lower water will be colder and heavier, whereby a gradual and regular mixing will be retarded. This is not the case, so that the origin of the spring-layers must be found somewhere else.

When comparing charts of the Kumai and the Elbe-mouth one is struck by the fact that the Kumai-river has its deeper waterlayers completely shut off from the sea by a bar in the mouth, whereas the Elbe has only sand — or mudbanks there, leaving an open communication between the deeper parts of the river and the corresponding regions of the open sea. Now it is easy to understand, that in the Kumai the upper waterlayers will have a circulation quite different from the deeper ones lying at a depth below the surface of the bar in the mouth. When at high tide the seawater, with its higher salinity, is flowing into the river, it will cross the bar and by its greater density flow down to the riverbottom several metres below the surface of the bar, causing a kind of subaquatic waterfall of heavy water below the more superficial layers with a lower degree of salinity. The water with a high degree of salinity, down below, is now trapped and will remain more or less stationary on large parts of the riverbottom, where even at low tide, it will mix only very slowly with the water of a lower salinity, which flows over it. A similar effect has been described by H. B. HACHEY in his very interesting article "Tidal mixing in an estuary" (Journal Biol. Board of Canada I 1935). There, in the mouth of the St. John river in Canada, matters are more complicated by the different temperatures in the different layers, but there too, the springlayer exists behind a bar. The existence of a springlayer therefore seems to be only dependent on the presence of a bar in the rivermouth.

LIST OF FISHES OCCURRING IN THE KUMAI.

Fam. Elopsidae.

1. *Elops hawaiensis* T. REGAN.

Fam. Dussumieriidae.

3. *Dussumieria* spec. In a future publication I shall deal with the question whether there are one or more species of *Dussumieria* in the Archipelago.

Fam. Chirocentridae.

2. *Chirocentrus hypselosoma* BLKR.

Fam. Dorosomidae.

4. *Dorosoma chacunda* (HAM. BUCH.).

Fam. Stolephoridae.

5. *Setipinna melanochir* (BLKR.).
6. *Setipinna breviceps* (CANTOR.).
7. *Setipinna taty* (C.V.).
8. *Stolephorus insularis* HARDENBERG.
9. *Stolephorus indicus* (V. HASS.).
10. *Stolephorus commersonii* LAC.
11. *Stolephorus tri* (BLKR.).
12. *Stolephorus baganensis* HARDENBERG.
13. *Coilia macrognathus* BLKR. See also Treubia Vol. XIV 1934.

Fam. Clupeidae.

14. *Clupea toli* C.V.
15. *Clupea fimbriata* (C.V.).
16. *Pellona hoevenii* BLKR.
17. *Pellona kampeni* WEBER and DE BEAUFORT. See also Treubia Vol. XIV 1934.
19. *Pellona amblyuropterus* BLKR.
20. *Pellona elongata* (BENN.).
21. *Pellona dussumieri* C.V.
22. *Opisthopterus macrognathus* BLKR.

Fam. Harpadontidae.

23. *Harpadon nehereus* (HAM. BUCH.).

Fam. Claridae.

24. *Clarias leiacanthus* BLKR.

Fam. Siluridae.

25. *Callichrous weberi* HARDENBERG.

D.4; P.1.8; V.6; A.41.

Height 4.8, head 5.4 in length without caudal. Eye covered by skin, 4 in head. Lower border of eye touching horizontal through corner of mouth. Eye 1.5 in snout. Jaws subequal. Upper profile slightly rounded with a slight concavity at the nape. Highest point of back somewhat behind dorsal. Maxillary barbels reaching to tenth ray of anal. Mandibulary barbels situated before eyes, about twice as long. Height of dorsal about 3-eyediameters. Dorsal situated just before origin of anal, its distance from the snout about 2½ in its distance from the caudal. Anal connected with the caudal which is deeply forked with rounded lobes. Ventrals about as long as snout. Pectorals rounded, about as long as head without snout. Vomerine patches of teeth small. Colour of formolspecimen brownish. A blackish spot behind gillopening. A black band along base of anal and along base of caudal.

One specimen with a total length of 50 mm. Kumai, May 1931.

In my paper "On a collection of fishes from the aestuary, the lower and middle course of the river Kapuas" I have described a *Callichrous* specimen which I have named *Callichrous weberi*. It is very probable that the specimen described above belongs to this species, though there are some differences. The most important of these are the length of the anal fin (41 rays in the Kumai-specimen and 47 in the specimen from the Kapuas). All other differences as for instance the height of the dorsal, the length of the mandibulary barbels and the colouration may be due to individual variation or to age. (The Kapuas-specimen is much greater!). At any rate as long as there is not more material available it is not justified to create a new species on the specimen described above.

Fam. Pangasidae.

26. *Pangasius pangasius* (HAM. BUCH.).

Fam. Ariidae.

27. *Arius maculatus* (THUNB.).
28. *Arius microcephalus* (BLKR.).
29. *Arius sagor* (HAM. BUCH.).
30. *Arius caelatus* C.V.
31. *Ketengus typus* BLKR.

Fam. Cyprinidae.

32. **Rasbora beauforti** nov. spec.

D.1.8; A.2.5; P.1.12; V.1.7; L.r. 28 - 29; L.l. incomplete consisting of 10 scales only; L.v. (before ventrals) 4½-1-2½.

Oblong. Height about 4 in length, 5 in length with caudal. Head about once in height. Eye 3 in head, about equal to snout. Cleft of mouth rather strongly descending, not reaching vertical through frontborder of eye. Origin of dorsal behind the middle between end of snout and origin of caudal, opposite to end of incomplete lateral line, 12 scales from occiput. Dorsal nearer to ventrals than to anal, its height somewhat shorter than head. Pectorals as long as head without snout, ventrals somewhat shorter. Longest ray of anal as long as postorbital part of head and half eye. Longest ray of caudal about as long as head. Caudal peduncle surrounded by 12 scales. Colouration of formolspecies dark, brownish above, much lighter below. A conspicious dark band along the sides, beginning on tip of snout and ending on caudal, running through the eye. This band is narrowest on the head and on the caudal fin. The black band is separated from the brownish back by a light streak. The first 12 - 13 scales in this streak have a blackish hindborder. Fins more or less pigmented, especially the dorsal and the caudal. Some specimens have the tip of the ventrals and of the anal blackish.

Many specimens from the Kumai-river, south-west Borneo. May 1931. Longest specimen 44 mm. Named in honour of Prof. Dr. L. F. DE BEAUFORT from Amsterdam.

33. *Puntius hexazona* WEBER and DE BEAUFORT.

Fam. Belonidae.

34. *Tylosurus strongylurus* (v. HASS.).

Fam. Hemirhampidae.

35. *Dermogenys orientalis* (M. WEBER.).

Fam. Polynemidae.

36. *Eleutheronema tetradactylum* (SHAW).
37. *Eleutheronema tridactylum* (BLKR.). (See also Treubia Vol. XIV '33).
38. *Polynemus indicus* SHAW.

Fam. Mugilidae.

39. *Mugil dussumieri* C.V.
40. *Mugil oligolepis* BLKR.

Fam. Anabantidae.

41. *Anabas testudineus* (BL.).
42. *Trichopodus trichopterus* (PALL.).
43. *Betta anabatoides* BLKR.

My largest specimen measured 64 mm. It is astonishing to see how much these small and young animals resemble specimens of *Betta picta* (C.V.) in colouration. Only the largest specimen showed traces of dark crossbars, all other had three black longitudinal bands from the head to the caudal just in the same manner as in *Betta picta*. WEBER and DE BEAUFORT, in their Fishes of the Indo-Australian Archipelago Vol. IV 1922 page 358, say "small specimens may also have a broad dark longitudinal band from snout to caudal in the middle of the side". It is evident that they did not posses the youngest stages. In all respects (measurements of head and body, number of scales, finrays and so on) my specimens answer so well to the description of *Betta anabatoides*, that there is no mistake possible, though at first sight one would take them for specimens of *B. picta*. Besides I possess fullgrown specimens of *B. picta*, as well as of *B. anabatoides* from other localities. Comparison showed that my above mentioned young specimens undoubtedly belong to the latter species.

Fam. Bothidae.

44. *Pseudorhombus arsius* (HAM. BUCH.).

Fam. Soleidae.

45. *Dexillus macrolepis* (BLKR.). For a description see Treubia Vol. XIV 1934.

Fam. Centropomidae.

46. *Lates calcarifer* (BL.).
47. *Ambassis kopsi* BLKR.
48. *Ambassis nalua* (H.B.).
49. *Ambassis gymnocephalus* (LAC.).
50. *Ambassis interrupta* BLKR.

Fam. Serranidae.

51. *Epinephelus megachir* (RICH.).

Fam. Theraponidae.

52. *Therapon* spec. I did not acquire a single specimen of Therapon. There is a *Therapon*-species which must be rather common, however, as everywhere on the river the sounds made by these fishes can be heard (See also HARDENBERG

"Ein Töne erzeugender Fish", Zoölogischer Anzeiger Bnd. 108, 1934, p. 224 - 227). Most probably this must be *Therapon theraps* C.V., as this is the species typical for rivermouths.

Fam. Trichiuridae.

53. *Trichiurus roelandti* BLKR.

Fam. Carangidae.

54. *Caranx sexfasciatus* Q.G.

Fam. Leiognathidae.

55. *Chorinemus tala* (C.V.) DAY.
56. *Leiognathus insidiator* (BL.).
57. *Leiognathus daura* (CUV.).
58. *Gerres oyena* (FORSK.).

Fam. Stromateidae.

59. *Stromateus cinereus* BLOCH.

Fam. Pristipomatidae.

60. *Pomadasys hasta* (BLOCH).
61. *Pomadasys maculatus* (BL.).

Fam. Lutjanidae.

62. *Lutjanus johnii* (BLOCH).

Fam. Scatophagidae.

63. *Scatophagus argus* (L.).

Fam. Girellidae.

64. *Proteracanthus sarissophorus* CANTOR.

Fam. Sciaenidae.

65. *Johnius belangeri* (C.V.).
66. *Otolithoides microdon* (BLKR.).
67. *Otolithes argenteus* (C.V.).
68. *Pama perarmata* (CHABANAUD).

Fam. Scombridae.

69. *Scomberomorus kühlii* (C.V.).
70. *Scomberomorus guttatus* (BL. SCHN.).

Fam. Cottidae.

71. *Platycephalus insidiator* (FORSK.).

Fam. Toxotidae.

72. *Toxotes chatareus* (HAM. BUCH.).

Fam. Gobiidae.

73. *Stigmatogobius javanicus* BLKR.
74. *Colius macrocephalus* (BLKR.).
75. *Trypauchenichthys typus* BLKR.

Fam. Gymnodontes.

76. *Tetrodon fluviatilis* HAM. BUCH.
77. *Tetrodon lunaris* BL. SCHN.

Fam. Carcharidae.

78. *Carcharinus dussumieri* (MÜLLER and HENLE). *Physodon mülleri* (MÜLLER and HENLE), which is so common in other rivermouths, seems to be lacking here.

Fam. Cestraciontidae.

79. *Cestracion blochii* (CUV.).

Fam. Dasybatidae.

80. *Dasybatus imbricatis* (SCHNEIDER.).

Of course the list given above is not complete. The fishing is not so exhaustive as in other rivermouths, as for instance in the Rokan- and the Musimouth. Only gillnets are used, apart from a few cast-nets and square-nets along the banks of the river. Were other implements used, then of course, the occurrence of many other species might have been stated. During the wet monsoon there is hardly any fishing. The true freshwaterspecies which I got are very few therefore.

As far as I can judge from the data obtained the fishfauna of the Kumai shows the following peculiarities when compared with the fauna of other rivermouths [1]).

1. The occurrence of so much *Stolephorus* species. Only in the mouth of the Musi I found also several species of *Stolephorus*. In literature the occurrence in tidal-rivers is mentioned for *St. indicus* and *tri*. In my experience however I found this to be the case only for *St. indicus*. *St. tri* is a species which lives in front of rivermouths and which spawns in water with a salinity of $\pm$ 25 ‰ or more. I have never found it in tidal rivers, the Kumai excepted. Perhaps several authors have mistaken my species *baganensis* (which does live regularly in tidal rivers!) for *tri*, which is much

[1]) The differences are especially noteworthy when compared with the fauna of the Sumatra rivermouths. The differences with the only other Bornean river (the Kapuas) of which I have a rather complete list of the fishfauna is much smaller!

alike, as I have pointed out elsewhere (See HARDENBERG, Treubia Vol. XIV 1934). Within shortly I shall deal with this question in detail in a separate paper.

2. The occurrence of *Clupea fimbriata*. *Cl. fimbriata* is a species which lives in the open sea sometimes quite near the shore but always in clear water of high salinity. It may occur in front of the mouth of big rivers (as for instance the Rokan, see Treubia Vol. XIV 1934) but on no other occasion did I find it in a tidal river.
3. The occurrence of *Carcharinus dussumieri* and the apparent absence of *Physodon mülleri*. I have found *C. Dussumieri* in no other river or rivermouth while *Ph. mülleri* is a common rivermouth species. It may be of course that after all *Ph. mülleri* does occur in the Kumai too and that I only did not meet it during my short visits. At any rate it cannot be as common as *C. dussumieri* of which I saw about 20 specimens and which is absent from other rivermouths known to me.
4. The occurrence of several species of the genus *Ambassis*. Several *Ambassis*-species can be found according to literature in sea- and in freshwater. Yet in my collections of rivermouthfishes I have only *Ambassis*-specimens from the mouth of the Kapuas-river in W. Borneo. In all my Sumatra-collections there is not a single specimen. We must assume therefore that not in all rivermouths the conditions are favourable to *Ambassis*. It seems that there are different types of estuaries, as I found peculiarities in the distribution of other families too. Perhaps the quantity of mud in the estuary is an important factor. Shortly I hope to deal with these questions in detail in a separate paper.
5. Another peculiarity is the presence of *Sciaena* species, which are others than those found in other rivermouths known to me. For these facts too I will refer to the future paper mentioned above.
6. Species of *Otholithoides* (*Sciaenoides*) seem to be absent or at any rate very rare. Especially the absence of *O. biauritus* is a striking fact. If this species were common as in other rivermouths I should in any case have seen a few specimens.
7. I got one specimen of *Caranx sexfasciatus*. WEBER and DE BEAUFORT say that this species lives in sea and in brackish water and that it enters tidal rivers. Again, I found this only to be the case in the Kumai and the Kapuas as was case with the species of *Ambassis*.
8. The occurrence of ripe specimens of *Scomberomorus* species! Whenever I got specimens of *Scomberomorus* in rivermouths it was only young individuals, mostly belonging to *Scomberomorus kühli*. Ripe specimens I only saw far out in sea, in water of a high salinity. DELSMAN found even the plantonic eggs of Scomberomorus in the Kumai as far as 10 miles upstreams from the mouth.