

FURTHER OBSERVATIONS ON THE BIONOMICS AND FISHERY OF THE INDIAN SHAD, *HILSA ILISHA* (HAMILTON), IN BENGAL WATERS.

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INTRODUCTION.

In a recent article one of us¹ recorded preliminary observations on the spawning grounds and bionomics of *Hilsa* in the river Hooghly and adduced evidence to show that the fish breeds over an extensive period, though the peak period of breeding occurs during the rainy season. It was also indicated that the fish can flourish well in confined fresh waters and even attain maturity. Reference was made to the probable rate of growth and life-history of the species, and from the discovery of a regular fishery of young *Hilsa* in cold weather at Nawabgunge near Calcutta it was suggested that more attention should be paid to the conservation of the *Hilsa* fisheries rather than to the establishment of hatcheries for the artificial breeding of this fish.

In reviewing Hora's article under the title "Spawning of *Hilsa*", Jenkins² made some valuable observations, mainly based on his personal experience of *Hilsa* investigations in Bengal, and suggested several useful lines of work for a proper elucidation of the life-history of the species. Devanesen³ in his note "Research Work on the *Hilsa*" directed particular attention to the work of the Madras Fisheries Department on the life-history of the species and stated that "The collection and hatching of *Hilsa* eggs continues as a routine at Madras" but probably the rearing of the delicate fry has yet to be attempted as was stated by Sundara Raj⁴ as early as 1917. Owing to the continuation of biological investigations at the Pulta Water-works by the Zoological Survey of India, we have been able to collect a considerable amount

¹ Hora, S. L., *Rec. Ind. Mus.* XL, pp. 147-158 (1938).

² Jenkins, J. T., *Curr. Sci.* VII, pp. 251, 252 (1938).

³ Devanesen, D. W., *Curr. Sci.* VIII, p. 126 (1939).

⁴ Raj, B. Sundara, *Journ. Proc. As. Soc. Bengal* (N. S.), XIII, p. clxxxiv (1917).

of additional information about the bionomics of *Hilsa*¹. Dr. Bains Prashad, Director, Zoological Survey of India, very kindly permitted Mr. M. N. Datta to carry out an enquiry on *Hilsa* in East Bengal in February 1939, and as a result of Mr. Datta's work considerable light has been thrown on the breeding of the species in the rivers of Eastern Bengal. Valuable material was also received from Allahabad through the kindness and courtesy of Professor D. R. Bhattacharya. These additional data make it possible to give further details regarding the life-history and bionomics of the fish.

INVESTIGATIONS AT THE PULTA WATER-WORKS.

Breeding season and growth rate during early stages.—The authorities of the Water-works at Pulta very kindly permitted the use of the *Pucca* Settling Tank No. 4 for recording monthly observations on the breeding of *Hilsa* and other fish of the river Hooghly. This is an isolated tank, 500 ft. long, 250 ft. broad and on an average about 8 ft. deep. It is occasionally charged with river water, but when the water in it becomes sufficiently settled, upper half or more, depending upon the suitability of water, is drawn off to the filter beds, and the tank is filled up again with river water. This process is repeated from 2 to 8 times in a month depending upon the weather conditions and the amount of suspended matter in the river water at different seasons. As already explained by one of us², only eggs or larvae of fish can pass from the river through the centrifugal pumps to the Settling Tanks. In the observations recorded here advantage was taken of this fact and by dewatering the tank almost completely once a month the young of the various species of fish developed from eggs or larval forms received from the river during the month were collected. It was, however, too costly to dewater the tank completely and to clean it up properly every month, so some young forms received in the tank during the earlier months usually got mixed up with the stock that came in later, but they could be readily eliminated on account of their larger size. The material thus collected for one year (first collection was made on December 28, 1937), has furnished valuable data regarding the season of breeding and the probable rate of growth of a number of species found in the river Hooghly. This article is confined only to the *Hilsa* investigations.

Young specimens of *Hilsa* ranging in length between 20 mm. and 40 mm. were found in the Settling Tank every month thereby definitely proving that the fish breeds in the river throughout the year. The largest number of young specimens, over four thousand (797 between 20 to 29 mm. ; 660 between 30 to 39 mm. ; 2,896 between 40 to 49 mm. ; 16 between 50 to 59 mm. and 13 between 60 to 99 mm.), were collected on the 26th of August, 1938. There can hardly be any doubt, therefore, that August represents the peak period of breeding of the species in the river Hooghly. During September, October and November the

¹ Attention may here be directed to a recent paper "On some early stages in the development of the so-called Indian Shad, *Hilsa ilisha* (Hamilton)" by Nair (*Rec. Ind. Mus.* XLI, pp. 409-418, 2 text-figs. 1 pl., 1939). The early stages of *Hilsa* described in this article were collected from the *Pucca* Settling Tank No. 4 of the Pulta Water-works,

² Hora, S. L., *Rec. Ind. Mus.*, XL, p. 150 (1938).

species was found to be still actively breeding for the number of young *Hilsa* collected at the end of November exceeded 2,000. The rate of breeding slowed down during the winter months, but another low peak occurred in May after the nor'westers of March and April. There is thus reason to believe that the flows of greater volume of fresh water down the river after the rains incite the *Hilsa* to migrate upstream for breeding purposes. It may be mentioned that, as is well known, there is a close association between the flooding of the rivers, either as a result of heavy rains or the melting of snows, and the *Hilsa* fishery.

On October 30, 1938, after making a collection of young fish, the Pucca Settling Tank No. 4 was completely dewatered and even flushed to drain away all young fish of the previous months into the river. On 29th November, 1938, the young fish were collected from this tank, and as many as 2,029 juvenile specimens of *Hilsa*, which could easily be recognised, were obtained. These specimens are arranged according to their lengths in the table below :—

TABLE I.

Young Hilsa collected on 29. xi. 1938, from Pucca Settling Tank No. 4.

Length in mm.	No. of specimens.	Length in mm.	No. of specimens.
21	31	29	157
22	60	30	51
23	125	31	66
24	203	32	41
25	267	33	27
26	396	34	18
27	382	35	8
28	197		

During the period from the 30th October, 1938, to the 29th November, 1938, the tank was filled with the river water on the following days and the quantity of water introduced into the tank on each occasion can be judged from the number of hours that were taken to fill the tank on each occasion :—

30th October, 1938.—10 a.m. to 9 a.m. on 31. x. 38. 23 hours.

2nd November, 1938.—12 night to 2 p.m. 14 hours.

5th November, 1938.—6 p.m. to 9 a.m. on 6. xi. 38. 15 hours.

13th November, 1938.—3 p.m. to 12 night. 9 hours.

18th November, 1938.—12 night to 9 a.m. on 19. xi. 38. 9 hours.

20th November, 1938.—3 p.m. to 9 a.m. on 21. xi. 38. 18 hours.

26th November, 1938.—12 night to 3 p.m. on 27. xi. 38. 15 hours.

Supposing that every time the tank was filled eggs and larval forms of *Hilsa* were introduced into it, it would be reasonable to believe that after hatching *Hilsa* can attain a maximum size of 35 mm. in one month under the conditions prevailing in November. In summer months the growth is more rapid for during July and August the majority of the specimens collected had attained a size of about 50 mm. in one month. Referring to the data already published by one of us (Hora, *loc. cit.*) on the probable rate of growth of *Hilsa* it appears that the brood of July and August may attain a size of 140 to 150 mm. in total length up to about the third week of November—a period of 4 to 5 months.

Thus the growth rate is fairly rapid in the young of *Hilsa*. We are reliably informed that at the end of December the young *Hilsa* in the Sunderbans are about 7 to 9 inches long, and are extensively fished in the estuaries and on the foreshore¹.

As the collections made from the *Pucca* Settling Tank No. 4 from December, 1937, to February, 1938, were not very satisfactory, the tank was dewatered on the 2nd of March, 1939, and the young fish collected. The tank had been thoroughly cleaned and washed, and afterwards filled on the 20th December, 1938. Thus the tank had been in commission for 73 days when the fish were collected. Young *Hilsa* 273 in number and ranging from 16 mm. to 83 mm. in total length were obtained. These specimens are arranged according to their lengths in the table given below :—

TABLE II.

Young Hilsa collected on 2. iii. 1939, from Pucca Settling Tank No. 4.

Length in mm.	No. of specimens.	Length in mm.	No. of specimens.
16	3	37	1
17	4	39	1
18	12	40	1
19	25	44	1
20	77	46	2
21	84	53	1
22	26	62	1
23	11	63	1
24	4	64	1
25	2	65	1
26	2	71	3
31	1	74	1
32	3	79	2
34	1	83	1

The above figures show that (i) in $2\frac{1}{2}$ months, under winter conditions, the young of *Hilsa* attain a size of about 83 mm., (ii) very few individuals breed in the river during the winter months of December and January, for the number of young over 30 mm. in length is represented by 23 out of a total of 273 specimens, and (iii) the breeding of *Hilsa* is accelerated in February, for the number of young specimens between 18 to 23 mm. is fairly large. The paucity of the very young specimens, below 18 mm., may be accounted for by the fact that, as in the European Herring, *Clupea harengus* Linn., the eggs and larvae with the yolk sac attached live at the bottom, and only the post-larval forms seek higher layers. This is borne out by the fact, which has been observed by several workers, that the eggs of *Hilsa* fall to the bottom after fertilisation. Our specimens were always collected from the upper and mid-water layers and not from the bottom layers, and for this reason it seems probable that we missed to collect the earliest larval stages of *Hilsa*.

Growth of Hilsa in Confined Waters.—There are two series of connected Settling Tanks at the Pulta Water-works—a series of 5 *Pucca* tanks and a series of 4 *Kachha* pre-settling tanks connected with a large lake-like area about $\frac{1}{2}$ mile long and $\frac{1}{2}$ mile broad. The tanks of both the

¹ Howard, S., *The Statesman*, Town Ed., (7th Nov., 1938); and Mazumdar, C. H., *Science and Culture*, V. pp. 219-221 (1939).

series are cleaned once a year and the silt deposited in them removed. The lake-like area or the Final Settling Tank has not been cleaned since its construction about 12 years ago. In the case of the *Kachha* tanks the fish can move about freely between them and the lake-like area and some of them can thus live up to their maximum age. In the case of the *Pucca* Settling Tanks, however, the connections are near the surface, so the bottom-living and the mid-water forms have practically no chance to move from one tank to another. As *Hilsa* is not a surface species, it can safely be presumed to be confined to the tank in which it came as an egg or a larval form. Very favourable conditions of life prevail in these tanks, on account of the constant flow of river water through them, which not only keeps the water aerated but also fully stocked with food consisting of microscopic life or of crushed bits of larger forms. The *Kachha* Pre-Settling Tanks are far more extensive and provide more congenial conditions of life for fishes.

On the 31st August, 1938, the *Kachha* Pre-Settling Tank No. 4 was fished and 31 specimens of *Hilsa*, ranging from 262 mm. to 413 mm. in total length, were netted. There were only 3 specimens under 300 mm. in length and 3 above 400 mm., while the average length of the specimens was 335 mm. These specimens were obtained in two hauls, 24 in the first haul comprised 11 males and 13 females, while all the specimens taken in the second haul were males. For fishing the net was spread across the tank and dragged along the bottom. At the surface the net was floating, but there were portions where it lay under the surface of the water so that the fish could swim or jump over it. Fair numbers of *Mugil corsula* (Ham.) and some *Labeo rohita* (Ham.) were noticed to leap over it, and it appears that some males of *Hilsa* also escaped the net during the first dragging. Owing to the absence of hatchery facilities artificial fertilisation was not attempted though 12 fully ripe males, with the milt flowing out and 9 more or less ripe females were obtained. In two cases the eggs, which were free from one another and about 0.5 mm. in diameter, were found to come out on the application of slight pressure. It would thus appear that the fish readily adapts itself to confined fresh waters, and can attain sexual maturity in such surroundings. Whether the fish actually breed under these conditions we are unable to say.

On the 21st of February, 1939, 69 specimens of *Hilsa* were netted from the *Kachha* Pre-Settling Tank No. 2; they ranged in length from 171 to 423 mm., 3 between 200-300 mm. and 8 above 400 mm. in length; the average size of the specimens was 356 mm. If the rings on the scales are any index to the age of the fish in the case of *Hilsa* then the majority of the specimens were 3 to 4 years old. The scales of the smallest specimen, 171 mm. long, had indications of just one ring.

The presence of only large specimens in the *Kachha* Pre-Settling Tanks shows that the adult fish generally move against the current, for the water flows out from these settling tanks to the final settling tank and thence to the filter-beds. The young, on the other hand, move down with the current and are found in large numbers in the filter-beds. We have never found an adult *Hilsa* in the filter-beds, though large-sized specimens of the catadromouseel, *Anguilla bengalensis* Gray, are not uncommon in them at a certain season of the year.

The *Pucca* Settling Tank No. 3 was dewatered completely for cleaning on the 9th May, 1938. It had been charged after thorough cleaning on the 3rd April, 1937, so the tank was constantly in use for a period of little over 13 months. A large number of young *Hilsa* were collected from the tank, and of these 142 specimens, ranging between 157 mm. and 305 mm. in total length, were measured. They are arranged in 10 mm. difference groups in the table below :—

TABLE III.

Young Hilsa collected from Pucca Settling Tank No. 3 on 9th May, 1938, arranged in 10 mm. difference groups.

Length in mm.	No. of specimens.	Length in mm.	No. of specimens.
150-159	1	240-249	22
170-179	2	250-259	24
180-189	4	260-269	25
190-199	2	270-279	21
210-219	2	280-289	19
220-229	8	290-299	2
230-239	7	300-309	3

In considering the above data it must be remembered that very young specimens were not collected. From the table it is clear that the majority of the specimens, which must have entered the tank during the peak period of breeding of the species in July-August, were between 240 to 290 mm. in total length, and this length of about a foot probably represents the size attained by *Hilsa* during the first 10 to 12 months of its growth.

The *Pucca* Settling Tank No. 5 was completely dewatered on the 1st March, 1939, after having been in commission for exactly 10 months. A random sample of 122 young *Hilsa* collected from this tank was measured and the results are arranged in 10 mm. difference groups in the table below :—

TABLE IV.

Young Hilsa collected from Pucca Settling Tank No. 5 on the 1st March, 1939, arranged in 10 mm. difference groups.

Length in mm.	No. of specimens.	Length in mm.	No. of specimens.
160-169	7	190-199	35
170-179	29	200-209	8
180-189	42	231	1

If it be taken for granted that the majority of the specimens came as larval forms during the peak period of breeding then it will be clear that in 7 to 8 months *Hilsa* attains a size of 170 to 200 mm. in total length.

From the data hitherto collected from the material obtained from the *Pucca* Settling Tanks the rate of growth of *Hilsa*, starting with the monsoon months, seems to be as follows :—

During the first month a size of about 40 to 50 mm. is reached. Two months old young are approximately between 80 mm. to 89 mm. in total

length. At the end of the 3rd month the fish are about 100 mm. but after 4 months the maximum size attained is about 130 mm. By the end of the 5th month a size of 160 mm. is reached and thereafter the fish grow at the rate of about 20 mm. a month so that 10 months to a year old specimens are just about a foot in length. It should be borne in mind that the growth rate given above is based on the material collected from the particularly favourable conditions prevailing in the water-works at Pulta, but it is not materially different from what little is already known from the investigations of the Madras Fisheries Department about the growth rate of the fish under natural conditions.

INVESTIGATIONS IN THE RIVER HOOGHLY.

Attempts were again made to collect eggs and larval forms of *Hilsa* from the river during July-August 1938, but without any success. Probably the eggs and young are found near the bottom in deeper waters in the middle of the river where, with the appliances available to us, we could not make any collections.

The collection of young *Hilsa* was continued from the Nawabgunge Fish Market and it was generally found that the numbers available were relatively much smaller than those of 1937-38. Good samples were taken in October, November and February-March, and their lengths are given below in 10 mm. difference groups :—

TABLE V

Length in mm. of young Hilsa collected at Nawabgunge.

Date of collection of samples.	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
30th October, 1938	204	153	3			..	..	..
13th to 15th November, 1938	5	42	78	4	2	..	..	..
27th February and 1st March, 1939.	..	..	8	45	22	3	3	1

The above figures are very significant and illustrate clearly the following points :—

- (i) The numbers of young *Hilsa* in the river decrease considerably month by month after the cessation of the monsoon. Towards the end of March only one or two young *Hilsa* were found in the catches.
- (ii) The size of young *Hilsa* found in the river increases from October onwards and by about the end of March a few young *Hilsa* of about 136 mm. were collected. It may also be noted that occasionally very young specimens of *Hilsa*, between 50 mm. and 60 mm. in total length, were also obtained towards the end of March.

As there is considerable evidence to believe that the young of *Hilsa* move down the river to the estuaries it is reasonable to assume that the young caught at Nawabgunge are the progeny of the individuals that must have spawned considerably above that place. The specimens collected on the 30th October represent under one month's growth, while the specimens collected about the middle of November were more than one month old. By about February and March 2 months old or older specimens were to be found at Nawabgunge, which means that they have to be regarded as the progeny of specimens that spawned a considerable distance above Nawabgunge—a distance that can be covered by the young in their movement downstream in two months' time.

The occurrence of very young specimens of *Hilsa* in March and April indicates the extended period of spawning of the species in the river, but the paucity of such individuals indicates that they are the progeny of some late spawners.

INVESTIGATIONS IN EAST BENGAL.

In his review of Hora's paper Jenkins¹ observed that

“ Another point to be cleared up is what is really the fish known to the fishermen as *Jatka* or *Jatkya* ? According to Mr. K. C. De the *Jatkya* is the smallest of the herring family (*Clupea fimbriata*) and is found in the estuaries as high up as Goalundo from February to April. It is a pretty fish with a rather dark back and silvery sides shot with gold. From the similarity in shape, appearance and taste, the fishermen describe it as the young of the *Hilsa*.

“ According to Mr. Finlow, ‘ The fingerling of the *Hilsa* has been identified as the *Jatka*, a small fish less than 6" long, found in the Buriganga, Lakhya and Meghna rivers in Eastern Bengal in February-March.’ ”

In order to elucidate the points raised in the above statements Mr. M. N. Datta was sent to East Bengal in February 1939 to make enquiries and to collect young Clupeids of all descriptions. He was out in the field from the 16th to the 25th February and visited Barisal, Patuakhali, Galachipa, Chandpur, Narayangunj and Goalundo. The name *Jatka* was not known to the fishermen of the first three localities, while at the last three places the fishermen knew the fish as a close ally of *Hilsa* but quite distinct from it. According to them *Jatka* comes up the river towards the end of March and is to be found even during the *Hilsa* season. It is stated to be a much smaller fish, not as tasty as the *Hilsa* and with comparatively smaller scales. Among the Clupeids collected by Mr. Datta we found a large number of young *Hilsa* and a few specimens of *Gudusia chapra* (Ham.). Mr. Datta found that the name *Chapli* was commonly used to denote both *G. chapra* and the young of *Hilsa*. At Patuakhali the young of *Hilsa*, as well as of other Clupeid fishes were known as *Malanda*. At Chandpur, Narayangung and Goalundo Mr. Datta found large quantities of young *Hilsa*, ranging in size from 7 to 11 inches, being caught from the river, and learnt that full-grown specimens with eggs were to be found in October and November.

¹ Jenkins, J. T., *Curr. Sci.* VII, p. 252 (1938).

The specimens of young *Hilsa* brought back by Mr. Datta are listed below in 10 mm. difference groups:—

TABLE VI.
Young Hilsa from East Bengal collected in February 1939.

Length in millimetres.	Number of specimens collected at			
	Gazalia (River).	Galachipa (River).	Patuakhali (Market).	Narayangunge (Market).
30-39	..	..	3	..
40-49	..	..	20	..
50-59	..	1	30	..
60-69	..	..	29	6
70-79	..	..	33	3
80-89	1	..	6	2
90-99	..	1	2	..
100-109	4	3	4	..
110-119	10	7	18	..
120-129	2	11	17	..
130-139	1	2	4	..

From the Chandpur Market Mr. Datta obtained 5 mature males measuring 235 mm., 249 mm., 256 mm., 268 mm. and 279 mm. in total length respectively. From the presence of very young specimens at Patuakhali, it seems probable that *Hilsa* breeds there in February, as has been noted above in the case of the Hooghly river (*vide supra*, p. 42). The presence of mature males at Chandpur in the month of February also points to the same conclusion.

From the material and other data collected by Mr. Datta it is now clear that *Hilsa* breeds extensively in the rivers of East Bengal and that there are in places extensive fisheries of young *Hilsa*. The *Hilsa* of 7 to 11 inches in length of which Mr. Datta found extensive fisheries at Goalundo, Narayangung and Chandpur, are probably the early breeders. In the Hooghly river also specimens of about this size are sometimes netted in February-March. These, as judged by the observations recorded above on the growth-rate of the species, are young fish less than one-year old.

UP-RIVER MIGRATION OF *Hilsa*.

Though our knowledge of the seaward migration of *Hilsa* and its life in the sea is very meagre, there can be no doubt whatever regarding its ascent up all the principal rivers of India and Burma, since extensive fisheries of the species depend on this anadromous habit.

Hamilton¹ recorded the occurrence of *Hilsa* at Cawnpore and Agra, while Day² found it to ascend as high as Delhi. Through the courtesy of Prof. D. R. Bhattacharya we have examined several specimens of *Hilsa* collected at Allahabad. The Allahabad examples were received in four lots; the first lot of 5 specimens, ranging in length from 300 mm. to 307 mm. (average length 304 mm.), was received on the 13th October, 1938; the second lot of 6 specimens ranging in length from 180 mm. to 219 mm. (average length 197 mm.), was received on the 17th December, 1938; the third lot of 6 specimens, ranging in length from 213 mm. to 251 mm. (average length 230 mm.), was received on the 17th April, 1939, and the last lot of 5 specimens ranging in length from 193 mm. to 235 mm. (average length 215 mm.), was received on the 10th May, 1939. The specimens of the first two and the last lots were eviscerated so no details of the maturity of the gonads or their feeding habits can be given. All the specimens of the April lot were mature males. The stomach was empty in four cases while in the remaining two specimens Copepods and a few Ostracods formed the bulk of the food, though a few bits of some filamentous alga and the remains of one insect were also found among their stomach contents. In all the specimens, however, the intestine contained some pulpy, digested matter, showing thereby that, though sexually mature, *Hilsa* were feeding in the rivers near Allahabad.

The scales of the October specimens were provided with four, rarely three, rings and the structure of the edges of the scales indicated that growth was still taking place (Dahl's 'Summer edge')³. From among the December lot scales of specimens up to 200 mm. in length showed only one, rarely two, rings, while in the case of the other two examples 2 to 3 rings were present. The edges of these scales also showed a growing phase. In the April examples, the three smaller specimens up to 225 mm. in length showed two rings on their scales, while older specimens had three. In a majority of the scales of these specimens 'A' phase (Dahl's⁴ 'Winter edge') had just started, though in the case of the two larger examples the edges of the scales still showed a growth phase. In the May examples also the scales were marked with 2 to 3 rings and there was an indication of the commencement of the 'A' phase in a number of scales.

In considering the above data, attention may specially be directed to the fact that the October specimens were on an average 100 mm. longer than those obtained in December. This means that larger specimens, which presumably mature earlier, are the first to ascend soon after the flooding of the rivers (*vide infra*, p. 46) while the younger specimens ascend later and constitute the late breeders. It is also significant that, as judged from the nature of the scale-edges, the growth of *Hilsa* at Allahabad stops during the hot and dry months when the waters fall low, and presumably the food is scarce.

¹ Hamilton, F., *Fish Ganges*, p. 244 (Edinburgh, 1822).

² Day, F., *Fish. India*, p. 640 (London, 1877).

³ Dahl, K., *Rept. Norwegian Fish. and Marine Investigations* II, No. 6, pp. 6-7 (1907).

⁴ Hodgson, W. C., *Fishery Investigations*. Ser. 2, VII, No. 8, p. 13 (1925).

Regarding the object of the up-river migration of *Hilsa* Jenkins (*loc. cit.*) enquires

“ Why does the *Hilsa* migrate up the Ganges as far as Bhagalpur and Monghyr and even up the Sone to Dehri ? Is this migration for food and is it essentially a spawning migration ? ”

So far as the lower reaches of the *Hilsa* rivers are concerned our investigations have definitely established that migration is for spawning purposes, but to be able to answer Jenkins' questions regarding the movements of the fish in the middle and higher reaches it is necessary to collect a considerable amount of data about the seasonal occurrence of *Hilsa* at certain selected up-country stations and to study among large samples the conditions of their gonads and the nature of their stomach contents month by month. The evidence available so far, however, seems to show that the upward migration is primarily for spawning purposes, though the individuals must continue to feed as they migrate upstream for long distances.

In an effort to locate the spawning grounds of the species the Bengal Fisheries Department made the following interesting observations (*vide* Ahmad's Report, dated 16th March, 1910, pp. 13-15) :—

In the 3rd week of June the *Hilsa* at Damukdia and Saraghat were not yet ripe, though the specimens of the latter locality were very near maturity.

In the 1st week of July the *Hilsa* at Rajmahal were quite immature.

On the 27th of September many ripe males with milt streaming from their abdomen were found at Monghyr, but of the 14 females examined one was spent and the rest were immature.

In November no ripe or unripe *Hilsa* was obtained from Monghyr, Arrah, Buxar, Digha Ghat, Dinapore and Dehri-on-Sone, while plenty of spent ones were collected.

Towards the end of September Jenkins¹ obtained a young *Hilsa*, 6 cm. long, from the market at Monghyr.

The above observations show that the up-river migration of *Hilsa* is mainly for spawning purposes. In this connection Day² observed that

“ There seem to be two classes of this fish which ascend the large rivers : those below one year of age, and which do not appear to breed, or if they do, it is at the very end of the year, or commencement of the succeeding one ; secondly, there are those that breed at the commencement of, or during the monsoon.”

Day's observations are borne out by the fact that the October specimens, over 300 mm. in total length, obtained from Allahabad were over a year old and had probably migrated for breeding purposes, while the December specimens, under 200 mm. in total length, must be regarded as young that had migrated in a preparatory stage to breeding. One may not, therefore, be far from wrong in stating that the main swarms of this fish that ascend up the larger rivers are for the purpose of breeding while the comparatively few young specimens that move up with the main swarms undertake the journey for feeding purposes. The

¹ Jenkins, J. T., *Rec. Ind. Mus.* V, p. 140 (1910).

² Day, F., *Report on the Freshwater Fish and Fisheries of India and Burma*, p. 22 (Calcutta : 1873).

young specimens must travel considerable distances before they become sexually mature and it is probably for this reason that up-country specimens of *Hilsa* are usually not as large as those found in the lower reaches. The reverse of what Southwell¹ believed to be the spawning grounds of old and young *Hilsa* would thus seem to be true.

Though it is generally true that *Hilsa* are available practically at all times of the year in the rivers and in the Gangetic Delta, it is also a fact that the fish are most abundant during the monsoon months. Our investigations on the breeding of *Hilsa* in the river Hooghly show that with the exception of November to March, when the rainfall in the provinces drained by the Ganges is low, the fish breeds, fairly profusely in all other months. There would thus seem to be a definite correlation between the up-river swarming of the species and the flooding of the river. We give below in a tabular form the average monthly rainfalls of the areas drained by the Ganges and its tributary rivers.

TABLE VII.

Table of Monthly Normals of Rainfall in inches from records up to 1920.

—	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Assam	0.67	1.53	4.00	9.00	12.08	18.23	18.74	16.83	12.50	5.66	0.90	0.34
Bengal	0.34	0.95	1.67	3.25	7.64	14.62	15.14	14.28	10.89	5.08	0.79	0.16
Chota Nagpur	0.77	1.15	0.93	0.70	2.13	8.97	12.91	13.77	8.10	2.92	0.39	0.14
Bihar	0.42	0.62	0.47	0.60	2.27	7.78	12.36	12.51	8.80	2.32	0.29	0.09
U. P. East	0.63	0.55	0.32	0.19	0.67	4.78	11.55	11.33	6.87	1.87	0.19	0.22
U. P. West	0.96	0.89	0.61	0.30	0.68	4.06	11.47	11.14	5.96	0.88	0.15	0.36
C. I. East	0.56	0.63	0.33	0.22	0.43	4.50	12.04	12.49	6.36	1.17	0.35	0.21

From table VII it is clear that the flooding of the Bengal river starts from April while the rivers in the United Provinces get an appreciable quantity of rain water only from June onward to September. It follows, therefore, that though *Hilsa* may ascend the lower reaches in April, May and June, their upward migration mainly depends on rains in up-country provinces. For this reason the *Hilsa* fishery in the United Provinces starts in September-October whereas in Bengal it is generally in full swing as early as July.

In his review of Hora's article Jenkins remarked "It is possible that there are two, or more, races or varieties of *Hilsa* with different spawning grounds and habits" So far as the form of *Hilsa* in the Ganges is concerned we have found that there is no difference in the specimens collected in the river Hooghly and those obtained from the Ganges at Allahabad. The specimens from Eastern Bengal are somewhat deeper and it is quite possible that in other large rivers different races of the species occur. At present, however, we have not the material to discuss this question.

¹ Southwell, T., *Bull. Dept. Fisheries, Bengal, Bihar and Orissa*, No. 4, p. 5 (1914).

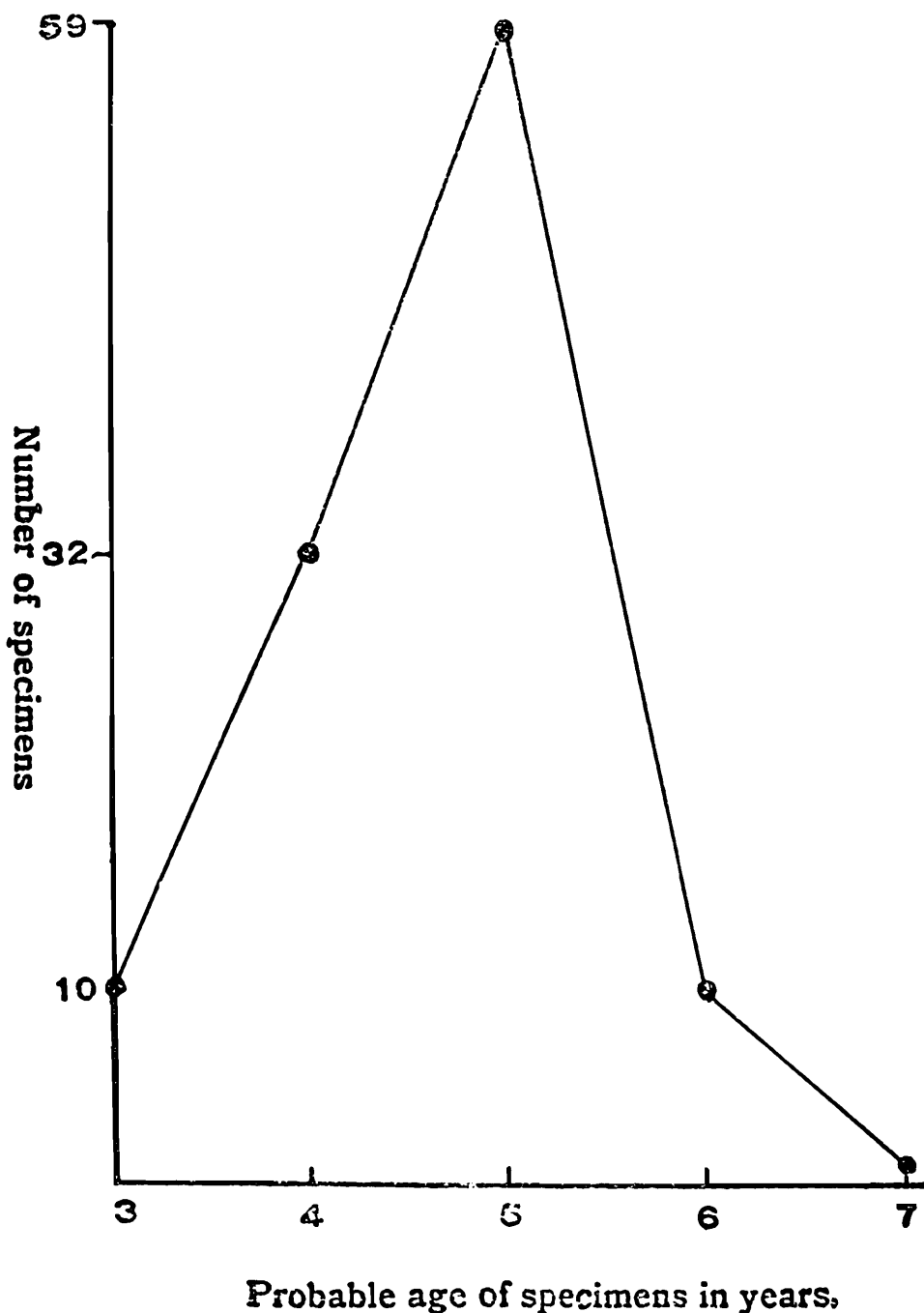
HILSA FISHERY IN BENGAL.

The reports of the Department of Fisheries, Bengal and Bihar and Orissa, and earlier reports dealing with the fisheries of the province bear ample testimony to the fact that, following Sir K. G. Gupta's recommendations, serious attempts were made for a period of about 15 years, from 1908 to 1923, to discover the breeding grounds of *Hilsa* and to propagate the species artificially, but unfortunately, all efforts resulted in failure. To our mind the main reason for this failure was that all investigations connected with *Hilsa* were conducted on the analogy of the Shad fishery in America. For instance, search for its breeding grounds was made in the river near Bhagalpur and Monghyr, whereas Hora (*loc. cit.*) discovered them in the river Hooghly not very far from Calcutta. Further, it has now been shown that *Hilsa* breeds practically throughout the year and that its breeding grounds extend over a very wide range both in East Bengal and in the Ganges. It can also be inferred from the data presented above that the upward migrating stock of any particular year comprises individuals of different ages or, at any rate, at different stages of sexual maturity, for some spawn after a short journey from the sea whereas others go higher up for hundreds of miles before they become sexually mature for spawning.

Fortunately for the continuance of *Hilsa* fishery from year to year the eggs of the species are demersal, and sink to the bottom soon after fertilisation. After hatching the young start their downstream journey to the sea, and as the data (*vide supra*, p. 41) regarding the size of the specimens obtained at Nawabgunge week after week from November to March show there is a distinct increase in size of the young with the march of time. This shows that the young passing down the river near Nawabgunge in February must be regarded as the progeny of fish that spawned a few months earlier in the middle reaches of the Ganges. The real feeding grounds of the young are the estuaries or the shallow waters at the mouth of the rivers or in their neighbourhood. By December the young attain a size of 7 to 9 inches and move about in such great shoals that they give rise to big fisheries, both in the Sunderbans and along the Balasore and Chittagong Coasts. From all the records of the occurrence of *Hilsa* in the sea it seems probable that the range of the fish does not extend to depths exceeding 10 fathoms and we have been definitely informed that *Hilsa* have neither been seen nor caught from the pilot vessels stationed at the Sandheads. In the estuaries and on the mud-flats at the mouths of rivers the fish feed and grow till the urge of sweet waters and sexual maturity goad them to enter the rivers and to start their upward journey. Such, in brief, is the life-cycle of *Hilsa* and though we now know, with fair amount of certainty, its main outlines, many details still remain to be worked out.

The upstream movement of *Hilsa* seems to be largely dependent on two main factors—monsoon and the state of sexual maturity of the migrating individuals. The monsoon, as we are all aware, is very erratic both in its intensity during certain months and in its total precipitation during any particular year. These variations in the monsoon are probably responsible for the usual fluctuations in the annual crop of the species, and especially for variations in catches at definite places, but a

large range fluctuation such as witnessed in 1939 is presumably due to the age of maturity of the fish. In this connection it may be mentioned that early in 1939 Mr. C. Cleghorn, who has been engaged in the fishery business in the Sunderbans for over 20 years, came to see one of us and in the course of conversation on fishery matters stated that in his experience there is a 5-year cycle in the fishery of *Hilsa* and predicted that 1939 will be a bumper-crop year for *Hilsa* fishery. As this prediction came true we set to work to find out the causes of this long range fluctuation in the fishery of the species. Scales of 112 specimens of the 1939



Graphical representation of the probable age of 112 specimens of *Hilsa* imported into Calcutta from Goalundo during June-July, 1939.

crop were studied with a view to determine their ages and it was found that a great majority of the fish were 5 years old. Against this, of the 15 specimens examined during 1938, 12 were only 3 years old. This seems to indicate that though some individuals, generally males, become mature at the age of 2 to 3 years the normal age of maturity of the species

is 5 years. According to this presumption the bulk of the progeny of the 1939 stock will become mature in 1944 and will give rise to a bumper-crop that year. A few stray individuals will, however, migrate in between this period, either as a result of early maturity or excitement through contact with fresh water and give rise to the normal fishery for the four lean years.

Unfortunately no published records of the fluctuations in the numbers of *Hilsa* from year to year are available, but the little evidence we have been able to collect from the available sources lends support to the 5-year cycle in the fishery of the species. For instance, it may be recalled that 1934, the Bihar Earthquake year, produced a bumper-crop of *Hilsa*. Again it may be noticed that the years 1906-1908, during which Sir K. G. Gupta carried out his investigations, were lean years so that the general complaint that the supply of *Hilsa* was on the decline was justified. Presumably as a result of the 1914 bumper-crop Southwell¹ in that year remarked that "In spite of the enormous numbers of *hilsa* which are caught going up river, before they have shed their spawn, there seems little support for the statement that *hilsa* are becoming scarce" By 1918, however, Southwell having experienced lean crops of *Hilsa* had reason to modify his view on the relative abundance of the species in Bengal rivers. Unfortunately there is no record of the yield of the *Hilsa* fishery during 1919 though in the Annual Reports of the Department of Fisheries, Bengal and Bihar and Orissa, there are definite statements of the scarcity of the fish during 1919 and 1920. The scarcity in each case is attributed to the irregularity and erratic nature of the monsoon.

It may be of interest to mention that the European Herring also shows a 5 years period of maturity and like *Hilsa* it also spawns under widely different conditions of salinity. Kemp, in 1938, in his address at the Meeting of the British Association on "Oceanography and the fluctuations in the abundance of marine animals" stated that

"Annual fluctuations in the abundance of a fish may be very great. One year may be exceptionally favourable, with production far above normal, to be followed perhaps by several years of scarcity; and it is not uncommon to find that fish belonging to one year class are fifty times as numerous as those of another. These great fluctuations, which are the foundation on which fishery prediction is based, are for the most part to be attributed to events which happened in the early months of the fish's life; and when we consider the manifold perils, meteorological, physico-chemical and biological, to which the eggs and larvae of a marine animal are subject, it is little wonder that there may be such great differences from one year to another, nor is it a matter for surprise that the precise reasons for good and bad spawning seasons are as yet unknown."

SUMMARY.

The breeding season and the growth rate of *Hilsa* during the early stages are discussed; all the observations made in this connection are based on the material collected at the Pulta Water-works during 1938-39. It is indicated that the fish breeds in the river throughout the year, the peak period being about July-August and a second low peak in May. These peak periods are correlated with the flooding of the river owing to the monsoon and the nor'westers respectively. Evidence is

¹ Southwell, T., *Bull. Dept. Fisheries, Bengal, Bihar and Orissa.* No. 4, p. 5 (1914),

adduced to show that the rate of growth starting with the monsoon period is fairly rapid. A size of about 40 to 50 mm. is reached during the first month, while the two months old young are approximately 80-89 mm. in total length. At the end of the 3rd month the fish grow to about 100 mm., while after 4 months a maximum size of about 130 mm. is attained. By the end of the 5th month the fish grow to 160 mm. and thereafter the rate of growth is about 20 mm. a month, so that 10 months to a year old specimens are just about a foot in length. It is pointed out that the breeding is almost inhibited and the growth rate considerably slowed down during the winter months of December and January.

A study of the collections of young *Hilsa* made from the river Hooghly at Nawabgunge showed that (i) the numbers decrease considerably month by month after the cessation of the monsoon and (ii) the size of young *Hilsa* increases from October onwards. As the young are known to move down the river to the estuaries, it is presumed that the young of *Hilsa*, 50 mm. to 70 mm. in total length, obtained in February and March at Nawabgunge are probably the progeny of specimens that spawned above Nawabgunge at a distance that can be covered by the young in their movement downstream in about two months' time.

The *Hilsa* investigations carried out in East Bengal by Mr. M. N. Datta in February, 1939, are discussed. Though he was unable to obtain specimens of the fish locally known as *Jatka* and often confused with the young of *Hilsa*, he obtained sufficient material of young *Hilsa* to show that the fish breeds extensively in the waterways of East Bengal.

As a result of an examination of the material received from Allahabad through Prof. D. R. Bhattacharya and the work carried out by the Bengal Fisheries Department in up-country stations, the probable cause of the up-river migration of *Hilsa* is discussed. In dealing with the *Hilsa* fishery in Bengal a brief account of the probable life-history of the species is given and reference is made to the winter fishery of young *Hilsa* in the estuaries and along the foreshore of Bengal and Orissa. The upstream movement of *Hilsa*, on which the main fishery of the species depends, is attributed to the monsoon and the state of sexual maturity of the migrating individuals. A brief account of the fluctuations in the year to year *Hilsa* fishery is given and from the meagre data available and the reports received from certain people interested in the fish trade, it is surmised that a 5-year cycle exists in the fishery of the species. Attention is directed to an interesting fact that the European Herring, a fish closely allied to *Hilsa* in its general habits and fishery, also shows a 5-year period of maturity.