Annexure 5

MATURITY AND SPAWNING OF HILSA SHAD, HILSA *ILISHA* OF BANGLADESH

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1. INTRODUCTION

Studies on maturity and spawning of hilsa in Bangladesh waters have received very little attention in the past and that too only from the riverine environment (Shafi, Quddus and Islam, 1976, 1977 and 1978 ; Quddus ***et al.,*** 1984b).

So far there have been no comparative studies of the fish available in all the three environments. A comprehensive knowledge about reproductive biology, i.e., sex ratio, maturity, spawning season, spawning frequency and fecundity, is essential for understanding the population, behaviour and migration of the stock in the different environments so as to embark on measures for management and propagation of the population.

Considering the above aspects, a research programme was undertaken with the collaboration of BOBP, in 1985, with sampling stations at Cox's Bazar, Chittagong, Khepupara, and Chandpur.

Since the research facilities were limited, some of the aspects intended to be investigated, namely spawning frequency and fecundity studies, could not be carried out.

This paper deals with aspects like sex ratio, size at first maturity, length-weight relationship, gonado-somatic index and relative condition. This study was carried out from April 1985 to March 1986.

2. MATERIALS AND METHODS

Samples were collected for biological studies from the commercial catches at the landing places of each station. Every month 2 samples of 25 fishes each were collected, once during each fort-night, and the dates were pre-fixed for each station, usually on the 3rd for the first half of the month and between the 17th and 20th in the second half. It was ensured to the best possible extent that the sample was taken randomly from one of the boats. The pro forma for recording the biological data is given in Appendix 1.

Total length, fork length, body depth, body weight, sex, maturity and gonad weight were the features recorded. The stages of maturity as classified by Raja (1970) were followed during this study.

The biological examinations were made either from fresh fish or at the earliest opportunity after preserving them in the deep freeze. Gonado-somatic index (GSI) was calculated using the conventional formula :

$$GSI = \frac{\text{Gonad Weight}}{\text{Body Weight}} \times 100$$

The length weight relationship was examined employing the conventional equation $W=aL^b$.

The relative condition factor, Kn, is expressed as W/W, where W is the observed weight of a fish of a certain length and w^ is the expected value for a fish of the same length obtained from the length-weight relationship.

3. RESULTS AND DISCUSSIONS

3.1 Sex Ratio

Table I and II give the month-wise and size-wise proportion of sexes in the catches from the four sampling stations.

Chittagong: Out of 525 specimens, 252 were males and 273 were females, giving a ratio of 1 : 1.08 (Table I). It is observed from the table that females were more numerous from September to January but dominance by males was observed in the subsequent two months. However, the Chi-square test showed that the dominance of females was statistically significant only in August. This, however, did not influence the value for the whole period which did not show any significant difference in the sex ratio.

The size-wise sex ratios show that up to 33 cm there was no female representation, and that from 46 cm to 53 cm there were no males in the samples examined. Within the size groups 34 cm to 45 cm, there were no significant differences between sexes, although the males were more numerous up to 41 cm and females thereafter.

Cox's Bazar: Out of 395 specimens examined, 181 were males and 214 were females. The sex ratio of 1 : 1 .18 was found significantly different from 1 : 1 at 5% level but there was no significant difference if September data were omitted. Size-wise sex distribution shows that within the size range of 32 cm and 46 cm, there was no significant difference in the ratio, although numerically more males were observed up to 41 cm; thereafter the females were more numerous. Beyond 46 cm length, no males were encountered in the samples.

Khepupara: At this station there was very distinct dominance by males, to the extent of 316 against 132 females. The observed sex ratio of 1 : 0.42 was significantly different from the expected ratio of 1 : 1. Month-wise, there were no significant differences in September, November, January, February and March. In the remaining five months starting from June significant differences were obtained. The size-wise distribution of sexes also showed highly significant dominance by males in all sizes up to 34 cm and also thereafter at 36 cm, 41 cm, 42 cm. Beyond 45 cm there was seldom any representation of males.

Chandpur: Of a total of 536 specimens, 258 were males and 278 females. The observed ratio of 0.93 was found to differ significantly from 1 .O at 5% level but if December data were to be removed there was no significant difference. Size-wise proportions of sexes exhibited roughly the situation obtained at Khepupara. Up to 37 cm, the males were significantly more numerous. Even thereafter at 41 cm and 43 cm they were highly dominant. On the other hand from 48 cm onwards there were no males in the samples.

From the above results it is found that the monthly sex ratios at Chittagong, Cox's Bazar and Chandpur satisfied the 1 : 1 ratio, barring occasional deviations, On the other hand, at Khepupara the males were distinctly and significantly dominant in 5 out of 10 months. In the size-wise distribution it is seen that in the riverine and estuarine stations, either the males were significantly more numerous, up to about 34-37 cm, or they were absent in the samples, while in the marine stations, there were hardly any males in sizes up to about 33 cm. Another significant feature was that beyond 46 cm, there were no males at all in the samples at any stations. In Bangladesh, studies on sex ratio in hilsa have been made by Quereshi (1968), Shafi, Quddus and Islam (1976 and 1977), and Quddus et *al.* (1984a). However, although these authors have reported dominance of either males or females in some months or seasons, it is not known whether they were subjected to statistical test. It is now more or less clear that generally up to about 35 cm, the males are likely to be more numerous in a sample and that it would be difficult to find their representation beyond roughly 46-48 cm length. It is very likely that this difference is caused by a differential rate of growth, because earlier investigators have observed a faster rate of growth for females. (Pillay, 1958; Pillay and Rosa, 1963; Jhingran and Natarajan, 1966 ;

Quddus *et* a/., 1984a). Hence the dominance of males in the smaller sizes and their absence in the larger sizes.

3.2 Length-weight relationship

The following equations were obtained for hilsa of Chittagong, Khepupara and Chandpur:

Chittagong	Khepupara	Chandpur
$W = 0.0305\ L^{2.73}$	Male. $W = 0.0177\ L^{2.76}$	$W = 0\ 028\ L^{2.74}$
($r^2 = 0.85$)	($r^2 = 0.97$)	($r^2 = 0.98$)
	Female* $W = 0\ .0269\ L^{2.89}$	$W = 0.021\ L^{2.87}$
	($r^2 = 0.98$)	($r^2 = 0.98$)

Since the data recorded at Cox's Bazar were considered to be unreliable, probably due to malfunctioning of the balance, the data were not used for obtaining the relationship. It may be seen that in all cases the correlation coefficient was highly significant.

3.3 Relative condition factor

Having worked out the length-weight relationship, it was used to study the fluctuations in the relative condition factor, Kn, for the hilsa of the three stations (Figs. 1, 2 and 3).

3.3.1 Monthly condition: Generally values of Kn fluctuated between 0.9 and 1.1 for different months. At Chittagong, the trend for both sexes was almost the same, every alternate month the values rising or falling. The peak values were in April, June, August, October, December and February. The significance of such a rhythmic wave was not clear and will have to remain so especially in the absence of comparable data from the other marine station.

But for some minor differences, the data for both sexes followed each other's pattern at both Khepupara and Chandpur. At Khepupara, there were peaks during June-August and October-November. In Chandpur, the peaks were in March (only males), May-June, August-September. Connecting both pictures, a continuous period from March to November is obtained, followed by a rising trend from January to March.

3.3.2 Size-wise condition: The range in Kn values for different size groups is 0.75 to 1.1 5. The relevant Figs. 1, 2, and 3 clearly demonstrate a multiplicity of peaks for both males and females at all the three stations. For example, at Chittagong the males exhibited declensions at 34 cm, 41 cm and 44 cm, and the females at 37 cm, 42 cm, 45 cm, 47 cm and 51 cm.

Multiplicity of peaks is more pronounced in the cases of Khepupara and Chandpur. Since these declensions are signs of spawning activity, a broad generalization of the results obtained is that:

- the males appear to attain first maturity at sizes 26-29 cm as compared to 31-33 cm in the case of females.
- other evidence of sizes at subsequent spawning are at 33-38 cm, 40-46 cm and 49-54 cm, for males and females combined.
- the males reportedly having a slower growth may be spawning at sizes 26-29 cm, 33-35 cm, 41-44 cm and 46 cm as compared to the females at 31-33 cm, 35-40 cm, 49 cm and 54 cm.
- the major spawning seasons being suspected to be two, summer and winter, it would appear that the winter recruits may have the first spawning at sizes 26-33 cm and the second spawning at 41-49 cm; the summer recruits have the first spawning at 33-40 cm and the second spawning at 46-54 cm.
- the above hypothesis is further based on the assumption that the summer spawning is prolonged from June to November and that the summer recruits have a faster rate of growth than the winter recruits do, during January-March.

Annexure 5

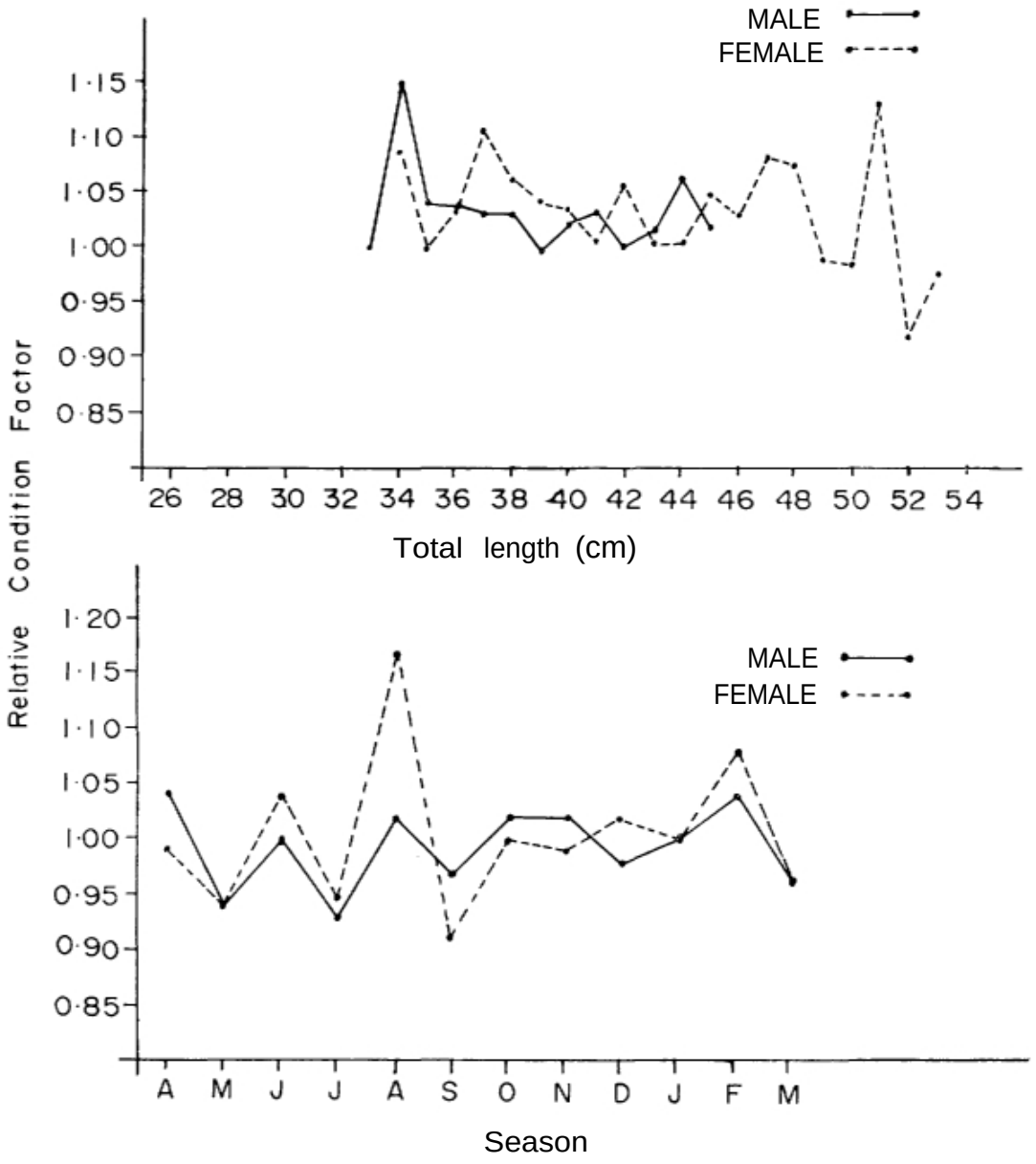

Fig. 1 Size-wise and month-wise mean values of relative condition factor in Chittagong area.

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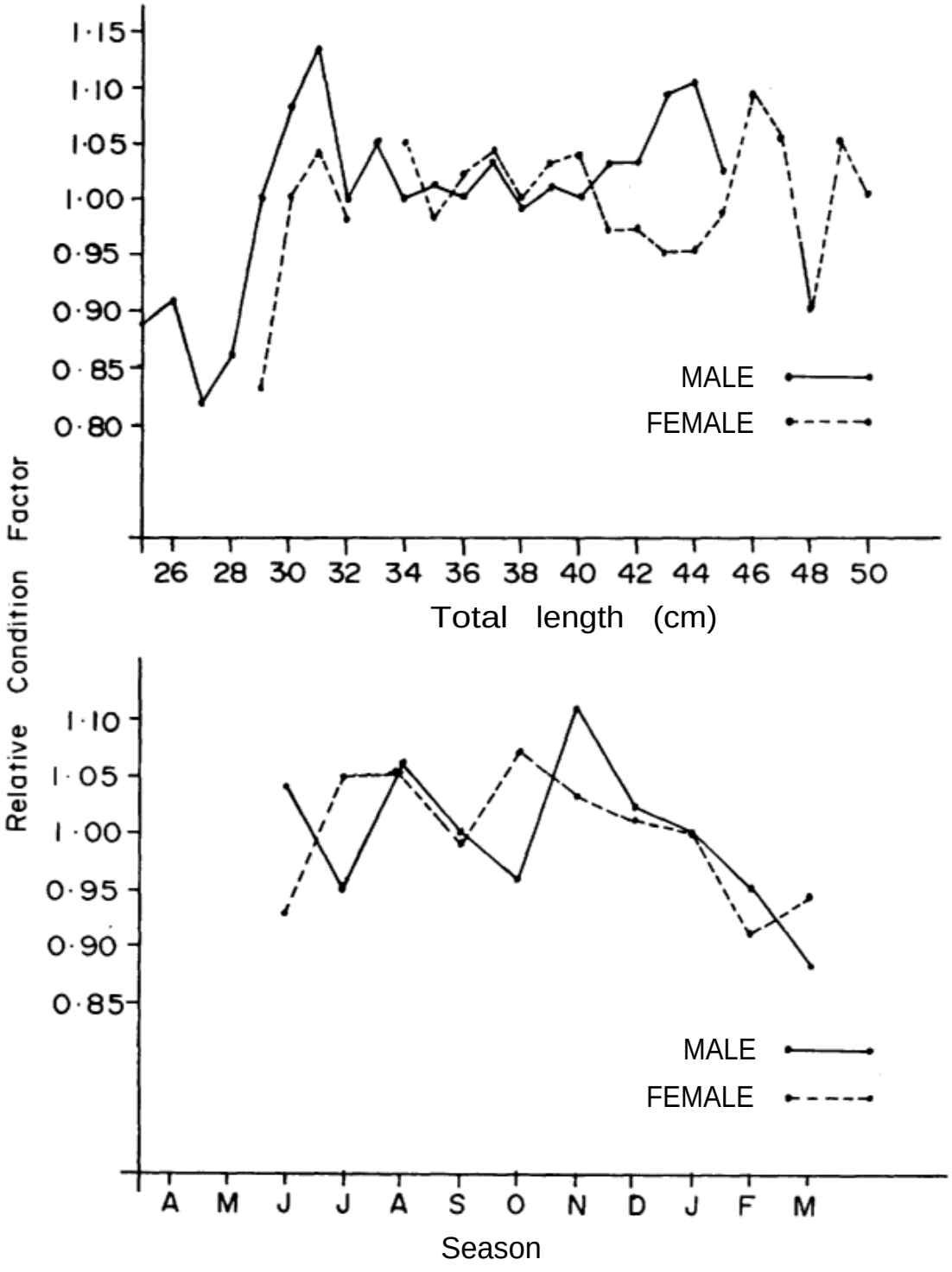

Fig. 2 Size-wise and month-wise mean values of relative condition factor, Khepupara area.

Annexure 5

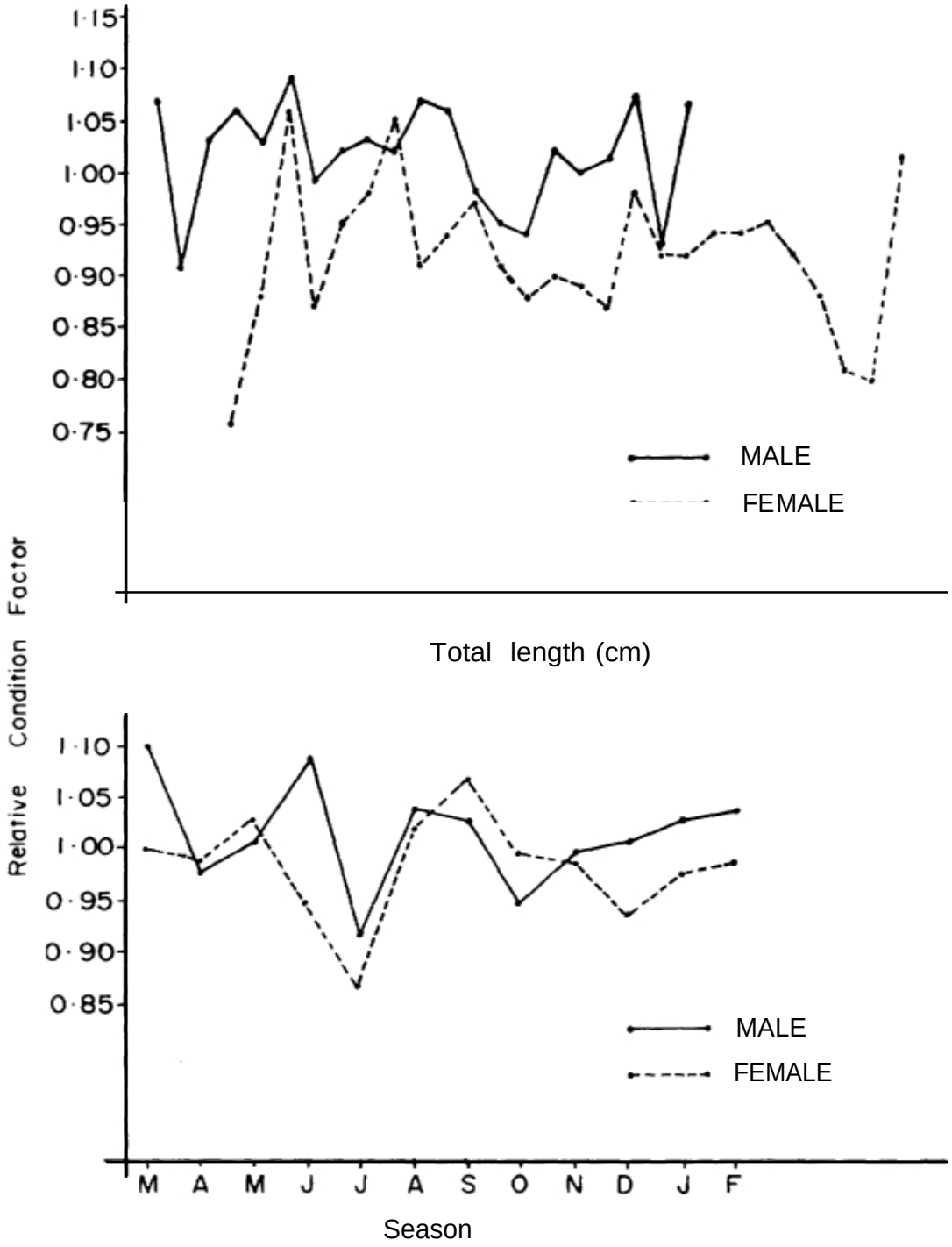

Fig. 3 Size-wise and month-wise mean values of relative condition factor in Chandpur area.

3.4 Gonado-Somatic index

To detect the sizes at first maturity and at subsequent spawning and the period of peak spawning activity, one of the approaches was to calculate the Gonado-Somatic Index (GSI) and observe its fluctuations throughout the year and for different sizes. The values have been plotted in Fig. 4 for different months and in Fig. 5 for different sizes.

A perusal of these figures would show that the GSI values for males are low, less than 1.0 whether they are in respect of size or whether they relate to different months and even in the case of Chandpur in the vicinity of which spawning was believed to take place. For females, the **lowest** values were obtained at Cox's Bazar and the highest in Chandpur; Khepupara values were closer to those for Chandpur.

(i) *Cox's Bazac* Records were available only for six months, October 1985 to March 1986, showing a peak in October for both sexes. But the values are so low as to rule out any possibility of spawning in the marine environment.

The GSI values when plotted against length showed peaks at 34 cm, 36 cm and 41 cm in males and at 36 cm, 39 cm, 46 cm and 49 cm in females.

(ii) *Khepupara:* The months of October and February in the case of males and October for females showed peak values of GSI, with signs of forming other peaks in June and in March. With regard to size, the peak values were at 25 cm, 31/32 cm, 34 cm, 37 cm, 41 cm and 44 cm for males and at 31 cm, 34 cm, 37/39 cm, 44 cm, 47 cm and 50 cm for females.

(iii) *Chandpur:* The GSI values for females showed three peaks, in June, October and March, with the highest value in October. But for males, the peaks were observed in July, November and February. In respect of size, the values of GSI of females show many peaks-the first peak at 32 cm. The peaks following this are at 34 cm, 39 cm, 41 cm, 43 cm, 47 cm, 49 cm and 53 cm. For the males, the peaks are at 29 cm, 33 cm, 38 cm, 40 cm and 45 cm.

The conclusions that can be drawn from what appears, on the surface, to be a confusing conglomeration of months and sizes are:

(a) There is no evidence of any spawning taking place in the sea; the fish advance to maturity in the estuarine area and may spawn both in the estuaries and in the rivers. Oozing specimens were actually obtained in Sandwip area (estuarine) during experimental fishing in October 1985.

(b) Fish less than 20 cm were not available in the samples studied. Hence although technically speaking the first peak could not be ascertained, from the fact that for males in Khepupara the peak was at 25 cm and in Chandpur it was at 29 cm, and for females at 31 cm and 32 cm respectively, it can be tentatively indicated that the size at first maturity is around that size, the males becoming mature at a lower length than the females. The spawning thereafter may be at very short intervals, almost at every 2-4 cm, more frequent in females than in males.

(c) The major spawning appears to take place in October-November, and subsidiary spawnings in June-July and January-March (sexes combined) ; the former two are considered as summer spawning and the latter as winter spawning. The marine stations did not offer any evidence of ripening of gonads in winter.

Hossain (1985) studied the GSI of female hilsa in three environments-freshwater, estuarine and marine habitats -for each month, and his findings were as follows: There were three peaks in GSI values for Meghna hilsa, in October, June and February. The GSI values of estuarine hilsa showed two peaks, one in March, another in June. (His 'estuarine' sample came from Barisal, where the landings are a combination of riverine, estuarine and marine hilsa). On the other hand, the values of marine hilsa exhibited a rise in the value starting in June and reaching a peak in August. A small ascent of value was also noted in February with a fall in March. The findings of the present study are thus in close conformity with the observations of Hossain, the major difference being that Hossain had not recorded from the estuarine environment any peaking of GSI value in October-for the simple reason that his observation period did not cover September-October.

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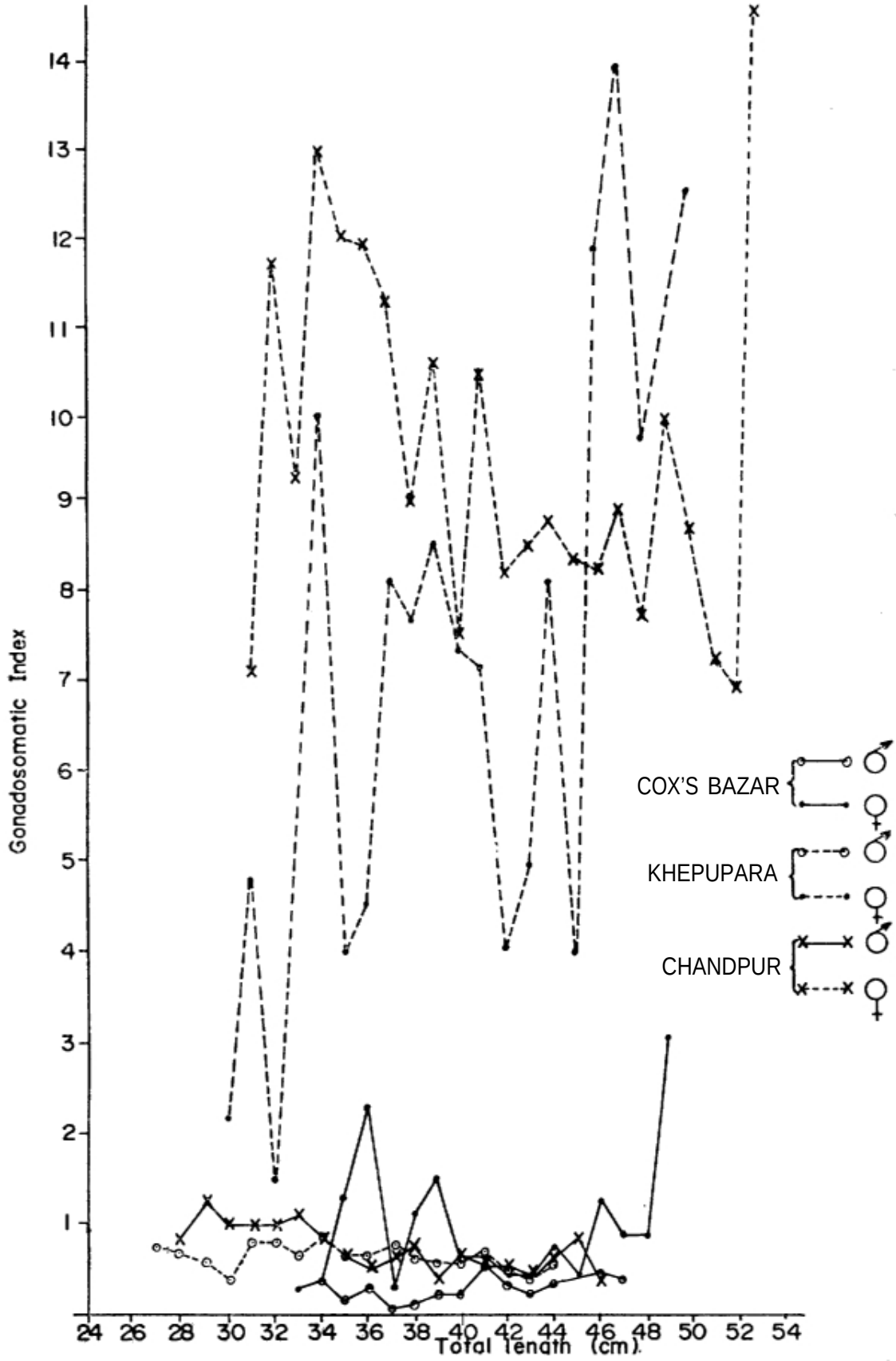

Fig. 4 Size-wise mean Gonado-somatic Index values for Cox's Bazar, Khepupara and Chandpur areas.

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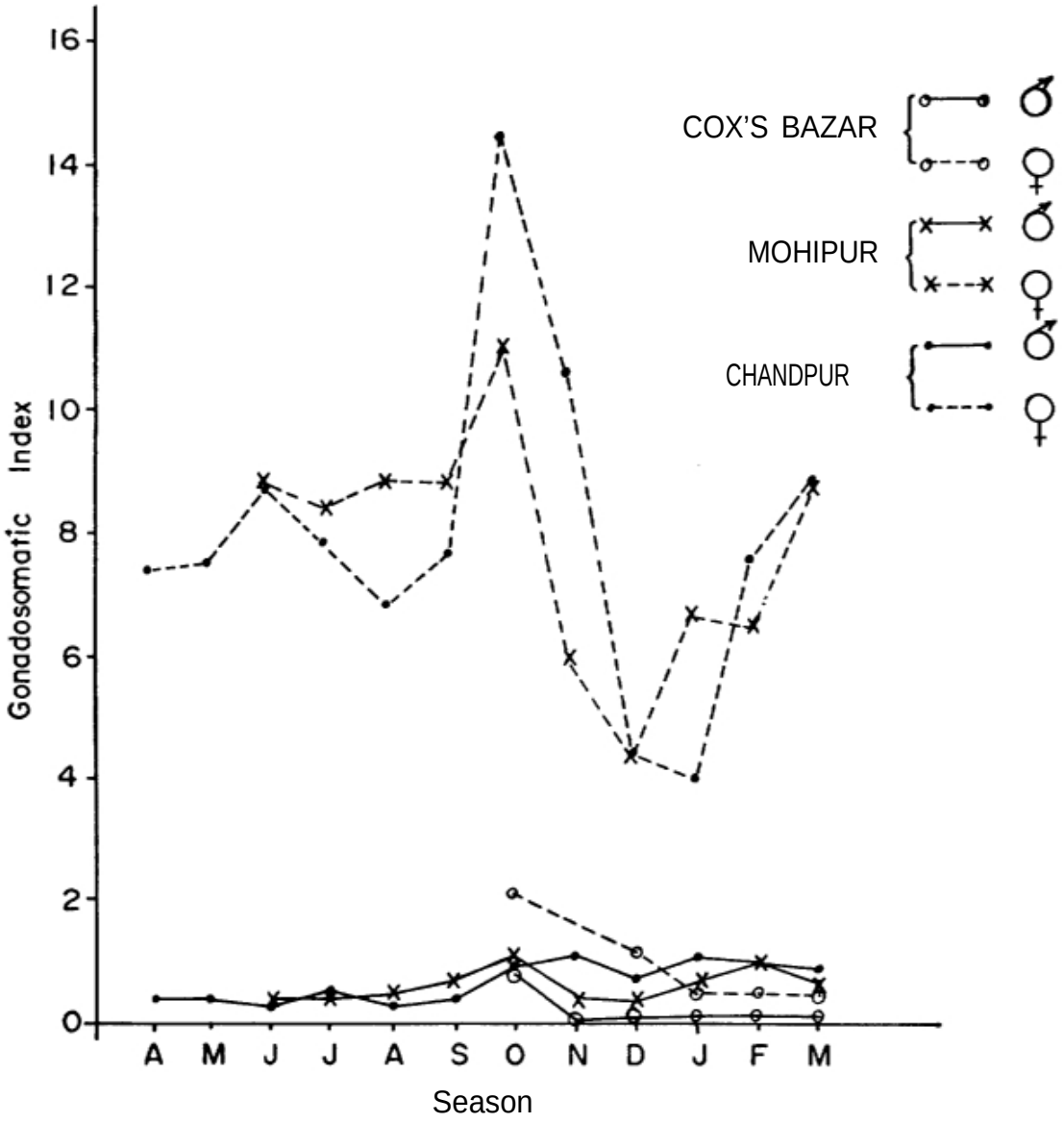

Fig. 5 Month-wise mean Gonado-somatic Index values in Cox's Bazar, Khepupara and Chandpur areas.

Quddus (1984b) determined the spawning season from GSI for the riverine hilsa and stated that type A (broader type hilsa) breeds from July to October with peak in the month of September and type B (slender) from January to March, peaking in February. The present study did not indicate any such distinction.

3.5 Occurrence of juvenile hilsa

Occurrence of early stages of juveniles (Jatka) offers evidence of a likely spawning season. Two juveniles of 10 and 11 cm were reported from Moheskhali channel at Cox's Bazar in February 1985. But in the estuarine and fresh water environment, more numerous juvenile hilsa were available. In Khepupara, juveniles were found during five months, from December to April 1986. The size range, mean, and modal sizes of Jatka in different months were as follows:

Month	Size range (cm)	Mean size (cm)	Modal size (cm)
December	4.2-9.1	5.6	6.0
January	5.9-9.5	7.2	5.0, 6.5
February	5.8-11.0	8.4	6.5, 7.5
March	7.3-11.0	9.5	9.5
April	7.2-15.1	12.7	11.5

The above records confirm the suspected spawning during October-November in the estuary/ river. It also appears that they belonged to more than one brood. Probably the recruits of late spawning in October-November attain a length of 11.5 cm by April. In other words, the modal length of 11.5 cm may represent a growth of 4-5 months.

In Chandpur, from the data collected by Hossain (unpublished) it is seen that the juveniles were available throughout the period of observation, from December to August. It is suspected that as reported earlier for the Hooghly estuary in India (Bhanot, 1973), intermittent spawning occurs throughout the year.

4. SUMMARY

There were no significant monthly differences in sex ratio at Chittagong, Cox's Bazar and Chandpur. However, at Khepupara, there was distinct dominance of males in 5 out of 10 months. In the size-wise distribution, it is more or less clear that generally up to 35 cm, the males are likely to be more numerous and it would be difficult to find their representation beyond roughly 46 to 48 cm length. It is very likely that this difference is caused by differential rate of growth, the females growing faster, hence the dominance of males in the smaller sizes and their absence in the larger sizes.

The length-weight relationship for the samples from Chittagong, Khepupara, and Chandpur have been worked out.

Generally the value of the relative condition factor, Kn, fluctuates between 0.9 and 1.1 for different months and between 0.75 and 1.15 for different size groups. With regard to the monthly picture, there was almost a regular rhythmic pattern at Chittagong, the values rising and falling on alternate months. Combining the situations obtained at Khepupara and Chandpur, an almost continuous period from March to November shows the values at high level.

The males appear to attain first maturity at size range of 26-29 cm as compared to 31-33 cm in the case of females, This may probably be followed by spawning at 32-35 cm, 41-44 cm and 46 cm in the case of males and 31-33 cm, 35-40 cm, 49 cm and 54 cm in the case of females.

There is as yet no evidence of spawning in the sea; the fish are likely to spawn in the estuaries and the rivers. One of the spawning grounds is in the estuarine Sandwip area. There are nursery grounds around Khepupara and Chandpur.

Major spawning appears to take place in October-November, and subsidiary spawning in June-July and January-March. Past records of juveniles at Chandpur from December to August appear to justify the suspicion that intermittent spawning may take place throughout the year but intensive activities may be in the periods indicated above.

Records of juveniles from Khepupara indicate a growth of about 11.5 cm in 4 to 5 months.

5. LITERATURE CITED

1. Bhanot, K.K., 1973. Observations on the spawning of *Hilsa ilisha* (Ham.) in the Hooghly estuary, *J. Inland Fish.* Soc. *India, 5: 50-54.*

2. Hossain, M.M., 1985. Spawning times, early history of *Hilsa ilisha* in Bangladesh waters. M.S. thesis, the University of British Columbia of Canada; 90 pp.

3. Jhingran, V.G. and A.V. Natarajan, 1966. Final report on the fishes of Chilka lake (1957-65). *Bull. CIFRI; No. 8 :* 121 pp.

4. Pillay, T.V.R., 1958. Biology of the hilsa, *Hilsa ilisha* (Hamilton) of the river Hooghly, *Indian J. Fish., 5: 201-257.*

5. Pillay, S.R. and H. Rosa Jr., 1963. Synopsis of biological data on hilsa, *Hilsa ilisha* (Hamilton). 1982 FAO Fish Biol. Synopsis (25) : 1 : 16: 38.

6. Quddus, M.M., A.M. Shimizu, and Y. Nose, 1984a. Comparison of age and growth of two types of *Hilsa ilisha* in Bangladesh waters. *Bull. Jap. Soc. Sci. Fish., 50 (1) : 51-57.*

7. Quddus, M.M., A.M. Shimizu, and Y. Nose, 1984b. Spawning and fecundity of two types of ***Hilsa ilisha*** in Bangladesh waters. ***Ibid; 50 (2) : 177-I 81.***

8. Quereshi, M.R., 1968. Hilsa fishery in East Pakistan, ***Pak. J. Sci. Ind. Res., 11 : 95-103.***

9. Raja, B.T. Antony, 1970. On the maturity stages of Indian oil sardine, ***Sardine//a Iongiceps*** Val ; with notes on incidence of atretic follicles in advanced ovaries. ***Indian J. Fish., 13 (1) :*** 27-47.

10. Shafi, M., M.M.A. Quddus and N. Islam, 1976. Maturation, spawning, sex-ratio and fecundity of ***Hilsa ilisha*** (Hamilton-Buchanan) of the river Padma. ***Proc. First Bangladesh*** Sci. ***Conf;*** Abstracts: B-45.

11. Shafi, M., M.M.A. Quddus and N. Islam, 1977. Studies of gonad weight, sex-ratio and fecundity of ***Hilsa ilisha*** (Hamilton-Buchanan) from the river Meghna. ***J. Asiatic Soc. Bangladesh (Sc.), 2(2) : 51-58.***

12. Shafi, M., M.M.A. Quddus and N. Islam, 1978. Maturation and spawning of ***Hilsa ilisha*** (Hamilton-Buchanan) of the river Meghna. ***Dacca Univ. Stud.,*** B 26 (2) : 63-71.

Table 1

Proportion of sexes for different months at the four sampling stations

Months	Chittagong		Cox's Bazar		Khepupara		Chandpur	
	Male	Female	Male	Female	Male	Female	Male	Female
April	11	14	19	31	—	—	16	29
May	13	12	12	38	—	—	20	30
June	26	24	—	—	46	4	25	24
July	12	13	—	—	30	5	28	17
August	40	10	32	18	40	10	9	16
September	21	29	21	4	32	18	25	25
October	13	37	25	25	19	6	40	36
November	17	33	24	26	22	23	17	33
December	20	30	20	25	34	11	17	4
January	20	30	8	17	32	17	19	20
February	27	23	12	13	35	15	18	23
March	32	18	8	17	26	23	24	21
Total	252	273	181	214	316	132	258	278
Ratios	1 : 1.08		1 : 1.18		1 : 0.42		1 : 1.08	
Sum of chi-square	10.65		19.90*		175.85**		11.78*	

*Significance at 5% level

**Significance at 1% level

Table II

Size-wise distribution of sexes at the four sampling stations

Length Group	Chittagong		Cox's Bazar		Khepupara		Chandpur	
	Male	Female	Male	Female	Male	Female	Male	Female
21	–	–	–	–	3	–	–	–
22	–	–	–	–	2	1	–	–
23	–	–	–	–	–	–	–	–
24	–	–	–	–	–	1	–	–
25	–	–	–	–	5	–	–	–
26	–	–	–	–	4	1	–	–
27	–	–	–	–	5	–	2	–
28	1	–	–	–	2	–	1	–
29	–	–	–	–	1	1	3	–
30	–	–	1	–	8	1	9	1
31	–	–	–	–	8	1	10	3
32	–	–	2	1	16	1	14	2
33	3	–	2	1	21	–	12	2
34	7	4	2	4	30	4	13	2
35	8	5	11	4	25	9	13	1
36	14	13	17	9	32	10	17	1
37	33	12	15	9	22	14	15	3
38	37	24	26	13	25	13	21	13
39	34	22	30	18	19	9	22	12
40	35	29	18	12	14	13	16	15
41	32	21	23	18	32	9	31	5
42	24	25	17	18	20	5	28	11
43	18	22	10	14	8	3	31	7
44	5	21	7	17	7	5	16	15
45	1	24	1	13	4	2	7	12
46	–	18	1	13	–	8	3	32
47	–	11	–	16	–	9	5	41
48	–	10	–	13	3	8	–	43
49	–	4	–	6	–	3	–	28
50	–	5	–	3	–	1	–	25
51	–	1	–	3	–	–	–	10
52	–	1	–	–	–	–	–	7
53	–	1	–	–	–	–	–	4
54	–	–	–	–	–	–	–	1
55	–	–	–	–	–	–	–	1
Sum of chi-square	6.43		10.42		395.14**		620.32**	

Appendix I

BIOLOGICAL RECORD

Landing centre : **Date of collection :**
Biologist: **Date of examination :**
Sample weight:
Details of the boat sampled

Sl.No.	TL (cm)	FL (cm)	DP (cm)	WT (gm)	Sex	Maturity	Gd. wt. (gm)	Remarks
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