Exploratory survey on Hilsa (*Tenualosa ilisha*) catch and life stages availability along up / down stream of Farakka Barrage

Final Report

Submitted to

National Mission for Clean Ganga (NMCG)
Ministry of Water Resources, River Development & Ganga Rejuvenation
Government of India

ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
(*Indian Council of Agricultural Research*)
BARRACKPORE, KOLKATA-700120, WEST BENGAL

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Acknowledgements:

The authors are extremely grateful to NMCG, Ministry of Water Resources, River Development & Ganga Rejuvenation for fund support to carry out the present investigation for a short period. Further, the authors are thankful to the Farakka Barrage Authority (FBA) and Central Water Commission (CWC) for the support during the project period.

Cover page Photo:

Dr. A.K. Sahoo
Cover page photo shows the Farakka barrage during monsoon with downstream migration of hilsa from freshwater to marine

July 31st 2017

ICAR - Central Inland Fisheries Research Institute
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Barrackpore, Kolkata - 700 120, West Bengal

Forward

As per the award of the project on "*Exploratory survey on Hilsa (Tenualosa ilisha) catch and life stages availability along up / down stream of Farakka Barrage*" and approval of DG and Financial concurrences of ED vide Dy. No. 55/ED (F) dated 10-01-2017, ICAR-CIFRI, Barrackpore undertook the study for a short duration of four month (March to June, 2017), with the objectives on estimation of present hilsa catch data and life stages availability in the vicinity of Farakka barrage. An intensive study was carried out in six stations representing downstream [Beniagram (right bank), Hosenpur (left bank)], upstream [Taltala (right bank), Kamaluddinpur (left bank)], navigational channel and feeder canal. Monthly sampling for the hilsa catch and life stages availability was carried out through experimental fishing, landing sites collection, fish market/arathdhar and fishermen through direct questionnaires. Major focus was on experimental fishing. Fish caught through experimental fishing majorly by gill nets from different selected sites were analyzed for age, size and gonad maturity. Further, for juvenile hilsa, experimental fishing was carried out through specific seine net and total fish catch composition was estimated. During our study, juvenile hilsa were observed in the upstream of barrage, while adults were recorded in downstream of barrage and in the feeder canal.

I believe, results coming out from the present investigation would support in developing guidelines and policy for sustainable hilsa fishery management in the rive Ganga and formulation of future research concept on hilsa migration, reproduction, breeding, food and feeding and availability of native population in the upstream of Farakka barrage under changing climate.

Barrackpore
31st July 2017

(B. K. Das)
DIRECTOR

EXECUTIVE SUMMARY

An exploratory survey on hilsa, *Tenualosa ilisha* catch and life stages availability in the vicinity of up and down streams of the Farakka barrage and feeder canal was carried out by ICAR-CIFRI, Barrackpore under National Mission for Clean Ganga (NMCG) project during March to June 2017.

The estimated total catch of hilsa from the down-stream of Farakka and feeder canal was recorded to be 1,315 kg and 736 kg respectively, and the total being 2,078 kg during March to June 2017. While, hilsa catch in the upper stretches and navigational channel is majorly represented by juveniles, which was negligible in quantity. The reduced catch of hilsa in both down-stream and feeder canal was recorded during the period as compared to earlier years, could be attributed to the stray migratory run of the species.

The life stage (size and age composition) of migratory hilsa in the down-stream showed that fishery is contributed mostly by individuals belonging to size range 190-260 mm (1+ year) and 261-345 mm (2+ years) groups during March to May, which formed 47 to 62% and 18 to 46% in numbers respectively in the total population. While, in the month of June the 2+ and 3+ (346-415mm) age groups were found dominant contributing 45 and 27 % in numbers respectively. In the feeder canal, the fish of 1+ and 2+ year age groups were found dominant in the population during March and April, and contribution of these groups varied from 53 to 67 % and 12 to 25%, in numbers respectively. While fish of 2+ and 3+ age groups were found most abundant in the population, during May and June, which contributed 25 to 55% and 23 to 53% in numbers respectively.

Maturity of female hilsa was studied based on the samples belonging to length range from 179 mm to 450 mm during the period. Availability of very few female hilsa with developed gonads (high GSI values and higher range in size of ova diameter) clearly indicated that stray breeding period during post winter season. The attainment of fish maturity in the fish from downstream and feeder canal occurs at 227 mm (1+ year old) and 283 mm (2+ year old) respectively. The number of ova produced by a female from down-stream and feeder canal was recorded a range from 52,032 to 3,35,828 and 87,670 to 6,60,560 respectively. |It was observed that the number of ova increased with the age of the fish. At present, the recruitment of hilsa fishery is mostly dependant on smaller age groups due to absence of higher age group fishes in the population. Since the higher age groups are

less found, the recruitment level of hilsa fishery has been drastically reduced. This is one of the major reasons for decline of hilsa fishery in and around Farakka barrage.

The present exploratory survey observed that the availability of hilsa both in feeder canal and in downstream of Farakka barrage, although a small quantity as juvenile hilsa was recorded in the upstream of barrage. This indicates the possible migration of hilsa through the barrage or establishment of a native population in the upstream, which needs to be investigated. For life stages, our study has attempted through different methods for collection of larvae and juvenile hilsa in the vicinity of Farakka barrage. Only juveniles were observed in the upstream of the barrage. While, a dominate group of age 1+ and 2+ from March to April and age of 2+ and 3+ during May to June, were observed both in downstream and feeder canal. These fish were having matured gonads indicating breeding period of hilsa, which is slight deviation from early studies, that a small scale migratory run for breeding is being noticed upto March/April in both the Padma-Ganga and Hooghly-Bhagirathi river systems. Our observation showed the fully matured fish during May/June. This shifting of maturation of gonads, could be due to several factors including climate change, which plays a significant role in the breeding and spawning processes. This underlines for the further investigation on the migration and reproductive behavior of hilsa in Padma-Ganga and Hooghly-Bhagirathi river systems under climate change.

Juvenile hilsa of 35 to 150mm in length, with a total catch of 7.5 kg were recorded in the upstream of Farakka barrage indicating a possible migration of adult hilsa through the barrage for breeding and laying the eggs in the upstream, or self-establishment of native hilsa population in the upstream.

While matured adult hilsa of 227 mm and 291 mm with an average total 1315.35 kg at downstream of Farakka barrage and 763.45 kg of at feeder canal with age group of 1+, 2+ and 3+ were recorded, indicating as suitable breeding sites and season during our study period, March to June 2017.

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1.0 Introduction

The hilsa shad, *Tenualosa ilisha* popularly known as hilsa is one of the most prized fishes of the country. Hilsa belongs to sub-family Alosinae of family Clupeidae. Five species *viz.*, *T. ilisha* (Hamilton, 1822), *T. toli* (Valenciennes, 1847), *T. macrura* (Bleeker, 1852), *T. reevesii* (Richardson 1846) and *T. thibaudeaui* (Durand, 1840) are known to occur in the coastal waters, estuaries and rivers of tropical Asia. All these species are commercially important and are under heavy fishing pressure. Besides hilsa, all other species are on the verge of extinction due to over fishing and habitat deterioration.

Hilsa is a widely distributed clupeid species inhabiting the coastal waters mainly from Arabian Gulf (Iran, Iraq, and Kuwait), Pakistan, India, Bangladesh, Mayanmar, and South Vietnum to Sumatra and ascending the estuaries, rivers, and brackish water of the Indo-Pacific region. But,it is most abundant in the Ganga-Hooghly and Brahmaputra-Padma drainage system of India and Bangladesh forming one of the most important commercial fisheries of single species in India, Bangladesh and Mayanmar.

The Hilsa shad is largely an anadromous species, whose normal habitat is the lower region of the estuaries and the foreshore areas, ascend the rivers during the breeding season and return to the original habitat after spawning. The important factors responsible for the upstream migration of hilsa are namely volume of river discharge, water temperature, water velocity, rainfall, low salinity, primary production units and state of sexual maturity. Upstream migration of hilsa is a seasonal or periodic movement. The peak upstream migration of the fish in most of the rivers of the country coincides with the advent of monsoon viz July and August and continues upto October and November. A significant correlation between the season of upstream migration and the breeding season of the species was observed. After spawning the spent fish migrate towards estuary and the young one appears in the freshwater from November - December to March-April till they attain an average size of 6cm to 8cm. Then the juvenile start downstream migration towards coastal area.

Presently the availability of the species is drastically dwindled and become extinct from the river Yamuna and upper stretches of the river Ganga. From the landing data, it is evident that a steep decline in the middle stretch and maximum decline in the stretch above Farraka barrage. However, small scale recruitment in hilsa fishery is observed in the upstream of the barrage and its magnitude of recruitment is found to be very meagre as compared to pre-farraka barrage period. The tagging and recovery experiments of hilsa

carried out by CIFRI during post-Farakka period revealed that a small quantity of hilsa are able to move freely from downstream (Padma) to upstream (Ganga) during flood season when most of the bays of the barrage are kept open. In this connection, it is high time to find out the present status of the hilsa specifically in the main stream of river Ganga, Feeder's canal and in navigational channel. With this background the project was conceived with the following objectives

1.1 Objectives:

1. To assess the present hilsa catch in the main river (Ganga)/ up/downstream of Farakka barrage, Feeder channel and in Navigational channel.

2. To assess the availability of hilsa life stages in the selected stretches to establish its habitat.

1.2 Experimental design:

In order to access the life stages and catch structure of Hilsa, six sampling sites representing upstream [2 sites, right bank (Taltala) and left bank (Kamaludinnpur)], downstream [2 sites, right bank (Beniagram) and left bank (Husenpur)], navigational canal and feeder canal [1 site each, Dear park ghat and NTPC colony ghat) were selected. Major focus was given to the upstream and downstream in order to understand the possibility of hilsa migration in the Padma-Ganga main channel. In addition, to Kamaludinpur, Panchanandapur and Shukuvullapur were also covered in the upstream to find out the hilsa availability. The detailed map of the sampling sites is given in Fig.1. Monthly sampling for hilsa catch and life stages was carried out through standard method (CIFRI, 2016 IWAI Report). For catch estimates, experimental fishing, landing catch data, fish market data and through direct questionnaires to fishermen were adopted. Multi-stage stratified random sampling design was followed for selection of fishers. While for life stages study, mostly diurnal experimental sampling though varied nets such as Gill net (*chandi, phansjal, naginjal, current jal*) and Purse net (*sangla*), seine net, scoop nets and clap nets were used. The detailed experimental fishing, different gears used and market survey are indicated in the Fig.2,3 and 4. For analysis of reproductive biology of hilsa, standard method was followed (De D.K. 2014).

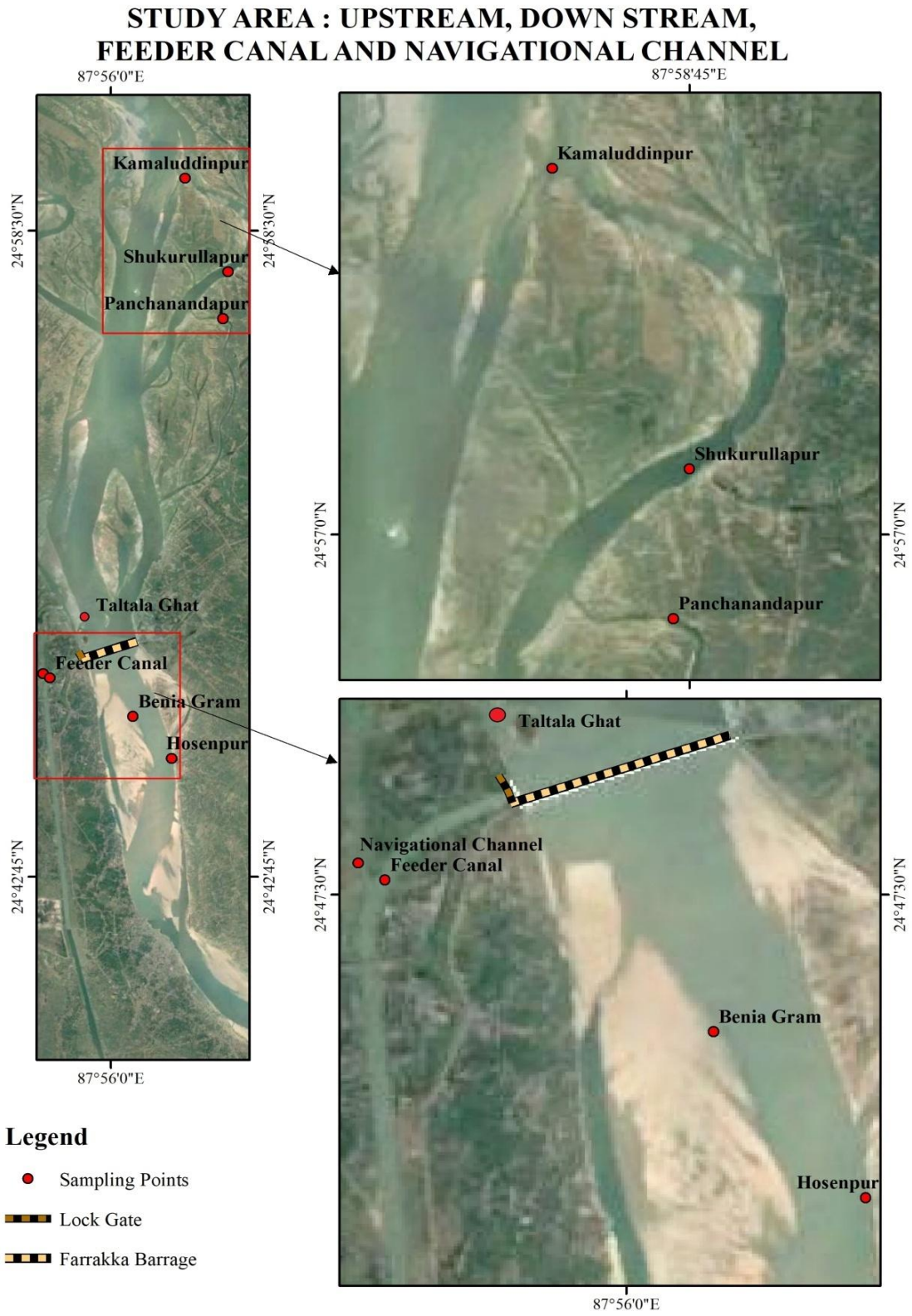


Fig.1 Map of sampling sites upstream (Taltala, Kamaluddinpur), downstream (Beniagram, Hosenpur), navigational canal and feeder canal

Seine net catch in the downstream of barrage

Purse net operation in the feeder canal

Seine net operation in the upstream of barrage

Fish catch through seine net operation D/S

Monofilament gill net of 40mm mesh size for hilsa catch

Seine net operation at Kamaludinpur (U/S barrage)

Fig.2 Experimental fishing made at different sampling sites representing upstream (U/S), downstream (D/S) of barrage and feeder canal with different nets used

Fig.3 Shooting net operation for collection of hilsa eggs, spawn and juveniles at Upstream of barrage (Taltala and near Navigational channel) (A1,A2); at Downstream (Beniagram, and Hosenpur) (B1, B2) and at Feeder canal (C1, C2)

(A) Catch data collection from the landing centre

(B): Daily data collection from Aratdhar, Farakka market

(C): Data collection from barrage market

Fig. 4. Different sites for hilsa catch data collection (A,B,C)

1.3 Resume of existing knowledge on hilsa fishery

The habitat of hilsa is the foreshore areas of the sea (continental shelf) and lower region of the estuaries. Hilsa prefers these areas to reside due to the presence of sub-surface temperature (20°C-30°C), relatively low salinity, strong tidal action, high turbidity, heavy silting and rich growth of plankton.

The anadromous migration of hilsa towards estuaries, rivers, lakes and brackish waters from foreshore areas is mainly for the purpose of breeding. The upstream migration of hilsa in most of the major rivers of the country starts from July and continues upto October or November and down steam migration takes place only in November or December. In case of Hooghly estuarine system the peak upstream migration is found with the advent of South-West monsoon *i.e.*, July and continues upto October or November, although the period of migration is found to be prolonged and a small scale migratory run is noticed upto February or March. Almost a similar migratory run of hilsa is also observed in the Padma-Ganga river systems. Thus, a correlation between the season of upstream migration and the breeding season of the species is noticed. The upstream migration of the fish is found associated mainly with the state of sexual maturity of the fish as well as volume of freshwater discharge from the rivers caused by monsoon rains or melting of the snow during summer. Other factors are temperature, current velocity, rainfall and low salinity, primary production and availability of planktonic food. Being an anadromous in nature, hilsa is extremely salinity tolerant and can inhabit freshwaters, estuaries and coastal waters. It is also reported that the fish resides almost throughout the year in the rivers, or in the lower reaches of the estuaries in the Gangetic delta and rarely goes out to sea. It is also known that hilsa thrives in the fresh water Vallabsagar (Ukai) reservoir in Gujarat. The reservoir still has no connection with sea water. This shows that the species can adapt to freshwater habitat.

Hilsa is a prolific breeder. The number of eggs laid by a female varies from 0.25 to 2.00 million depending on the size of the female as the number of ova increases with the age of the fish. The peak spawning period of hilsa is noticed during September to early November. In Hooghly-Bhagirathi and Padma-Ganga river systems, the spawning is extended for a prolonged period from September to February or March with a peak during October and November. The catch of hilsa is totally dependent upon their upstream migration during these periods.

2.0 Current hilsa fisheries in the vicinity of Farakka barrage

The estimated total hilsa landings from the downstream of the barrage and feeder canal amounted to 1315.35 kg and 736.45 kg respectively and total being 2,078.80 kg during March to June 2017. While at upstream of the barrage and navigational channel the catch was negligible as catch of juveniles are recorded during the study period (Table 1, 2). The month wise catch statistics of hilsa are presented in Table 1.

Table 1 Record of landings (in kg) of hilsa at centers of upstream, downstream of barrage and feeder canal during March to June 2017

Month	Upstream (kg.)	Downstream (kg.)	Feeder Canal (kg.)	Total (kg.)
March	3.00	283.65	137.95	421.60
April	2.00	291.00	129.00	420.00
May	1.50	362.70	279.00	641.70
June	1.00	378.00	217.50	595.50
Total	**7.50**	**1315.35**	**763.45**	**2,078.80**

Table 2 Availability (in number) of different stages of hilsa in the upstream of Ganga river during March to June 2017

Month	Fry (35-65 mm)	Fingerling (66-100 mm)	Juvenile (101-150 mm)
March	3	1	4
April	-	-	1
May	-	-	1
June	-	2	3

It was noticed that the hilsa catch at downstream and feeder canal was minimum during the study period from March to June as compared to other months, information collected from the fishermen. The main season is fishing is restricted generally from July to February or March of the next year when the maximum upstream migration of hilsa with considerable fluctuations in abundance and size composition occurred. The maximum yield obtained in the

post monsoon months *i.e.*, August to October and moderate landings were recorded from November to March. Therefore, a sharp decline in the total catch was noticed during March to June. Even then it could be summarized that the contribution of hilsa in the downstream of the barrage has gone down considerably as compared to early years during post Farakka barrage periods (Table 3).

Table 3 Record of landings (in ton) of hilsa at centers of the downstream during Pre and Post Farakka barrage periods (Source: De D.K. 2014)

	Pre-barrage period	**Post-barrage period**		
	1971-1974	**1982-1985**	**1991-1997**	**2000-2003**
Range in Quantity	26.00-64.28	150.3-321.59	11.04-19.11	2.28-5.60
Average	**40.42**	**229.93**	**15.52**	**4.79**

At present situation, the establishment of hilsa fishery in the upstream of barrage is mostly depended on monsoon flood season during August to October. Earlier information reveals that an increased level of commercial hilsa fishing activity was observed in the downstream of barrage during August to October. Tagging experiments conducted by ICAR-CIFRI, Barrackpore during 1993 and 1994 depict that during flood season hilsa can negotiate Farakka barrage when most of the eastern side bays of the barrage are keep open to release of excess water, which lowers the water head difference between downstream and upstream to minimum. The fish can move from downstream Padma to upstream Ganga and vice-versa. The fish also move freely from upstream Ganga to Hooghly river through feeder canal and Bhagirathi river. But there is no movement of hilsa from Hooghly-Bhagirathi to the Ganga or Padma as feeder canal lock gates acted as barrier for up steam migration.

2.1 Size and age composition of migratory hilsa in the downstream of the barrage and feeder canal (March to June 2017)

The length frequency distribution of hilsa in the downstream and feeder canal indicated the presence of distinct size groups contributing to the respective fishery during each month. It was observed from Fig. 5,6, and Table 4, that in the downstream of barrage, fishes belonging to size range between 190 mm and 260 mm (1^+ year age) and 261 mm and 345 mm (2^+ year

age) groups were found most dominant in the fishery during March to May. The contribution of 1^+ and 2^+ age groups varied from 47 % to 62 % and 18% to 46% in numbers respectively in the total fish population. While in the months of June the 2^+ and 3^+ (346 mm – 415 mm) age groups were found dominant contributing 45 % and 27% in numbers respectively

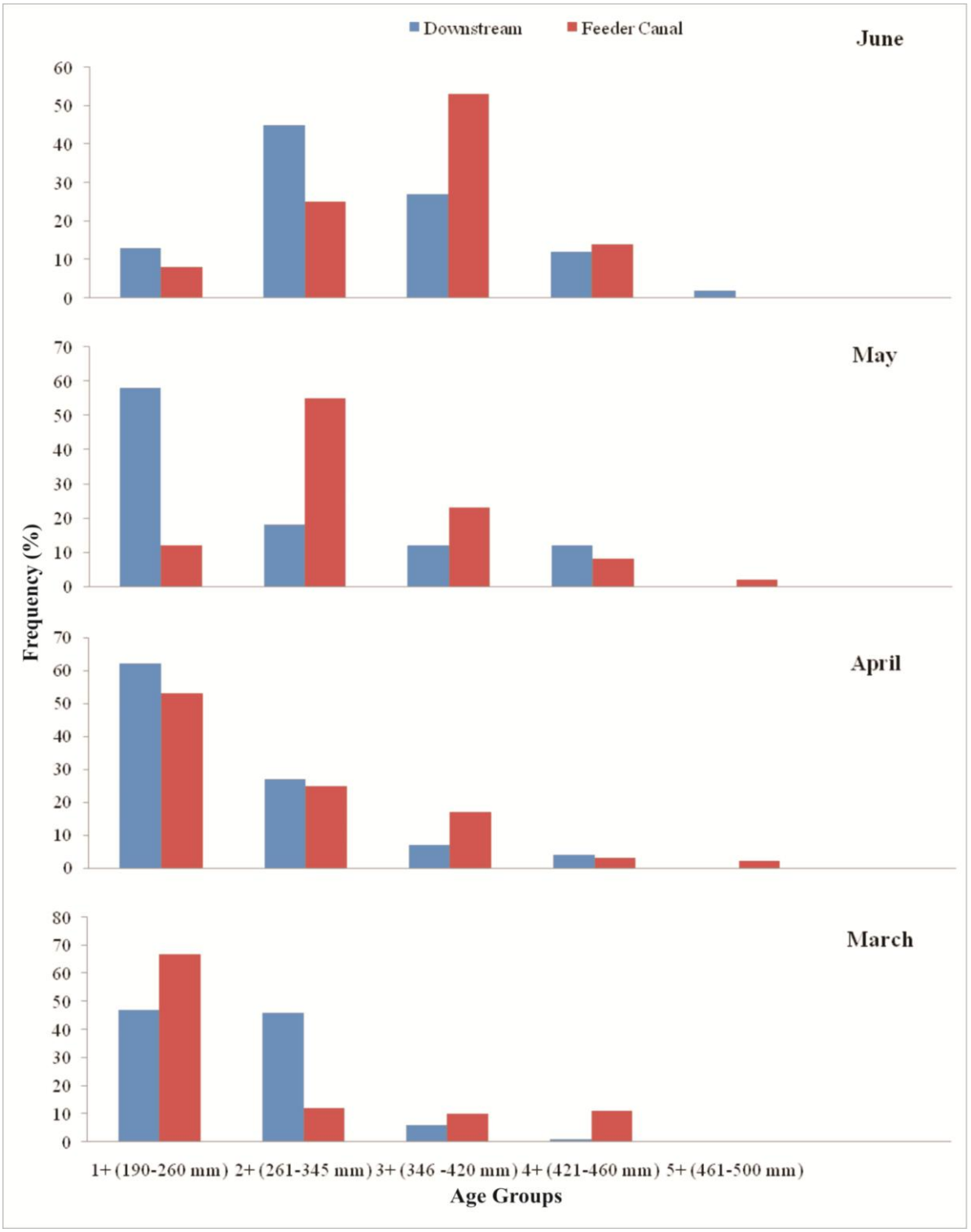


Fig.5 Percentage composition of different age groups of hilsa observed in the downstream and feeder canal during March to June 2017

Table 4 Percentage composition of different age groups of hilsa observed in downstream to Farakka barrage and feeder canal during March to June 2017

Age group	Down stream					Feeder canal				
	1^+	**2^+**	**3^+**	**4^+**	**5^+**	**1^+**	**2^+**	**3^+**	**4^+**	**5^+**
Length group (mm)	190-260	261-345	346-415	416-460	461-499	190-260	261-345	346-415	416-460	461-499
March	47	46	6	1	-	67	12	10	11	-
April	62	27	7	4	-	53	25	17	3	2
May	58	18	12	12	-	12	55	23	8	2
June	13	45	27	12	2	8	25	53	14	-

Fig.6 Hilsa, *Tenualosa ilisha* (450 gm) caught through gill net at Beniagram (Downstream of barrage)

Fig.7 Hilsa, *Tenualosa ilisha* (380 gm) caught through gill net at Feeder canal

In the feeder canal, the fishery of 1^+ and 2^+ age groups were found dominant in the population during March and April and contribution of these groups varied from 53 to 67% and 12 to 25% in numbers respectively. While fish of 2^+ and 3^+ age groups were found most abundant during May and June (Fig.7). The contribution of 2^+ and 3^+age groups ranged from 25 to 55% and 23 to 53% in numbers respectively. Fish belong to 4^+ and 5^+ age groups were poorly represented. The ageing of hilsa interpreted in the present study has been based on results of earlier studies (Table 5 & 6).

Table 5 Ageing of hilsa interpreted by earlier works

Fresh water zone of Hooghly estuary			Padma and Meghna Rivers		
Length (cm)	**Age in year**	**Methodology followed**	**Length (cm)**	**Age in year**	**Methodology followed**
18.96	1	Difference method of length frequency analysis (De 1986 ; De & Datta, 1990)	19.20	1	By counting daily rings of otoliths during lunar periods (Rahaman & Cowx, 2006)
26.12	2		27.50	2	
34.49	3		34.70	3	
42.04	4		40.80	4	
46.35	5		45.80	5	
50.14	6		49.70	6	

Table 6 The length frequency measurements were divided into the following size and age groups based on their estimated age composition

Length frequency (mm)	Age group
190-260	1
261-345	2
346-415	3
416-460	4
461-499	5
500-525	6

2.2 Length-Weight relationship

The knowledge of length-weight relationships gives information on the general well-being of the fishes. In the present study, the length-weight relationship of hilsa was determined by the equation $\mathbf{W = a \times L^n}$**, i.e Log W= Loga+ n Log L** where W represents weight, L represents total length, a is a constant and n an exponent to which L can be raised..

The general expected relationship is that the weight increases as the cube of length Regression equation of length-weight relationship of hilsa from downstream and feeder canal in the vicinity of Farakka barrage during the study period (March to June 2017) are depicted in Fig. 8-11.

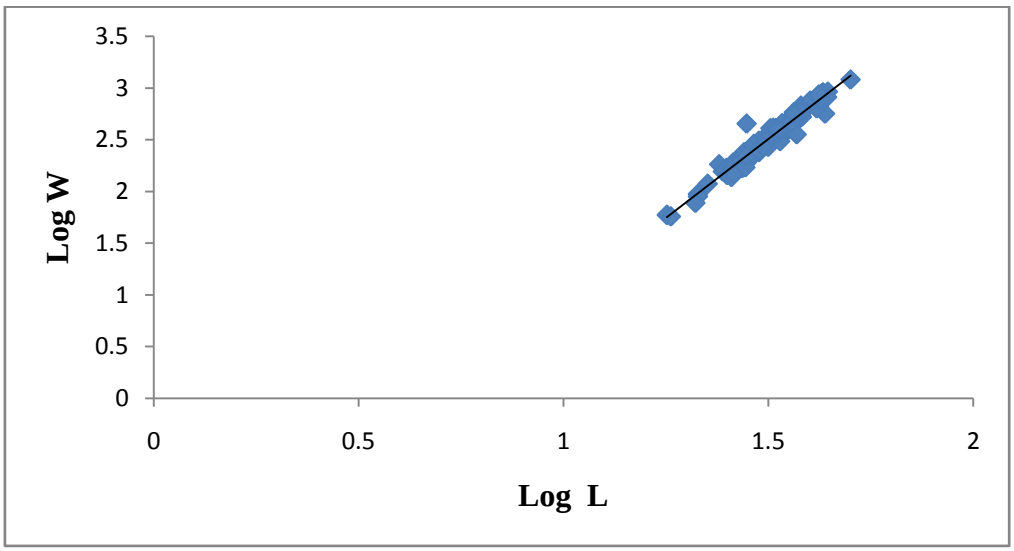


Fig.8 Regression equation of length-weight relationship of **female** hilsa from downstream of barrage

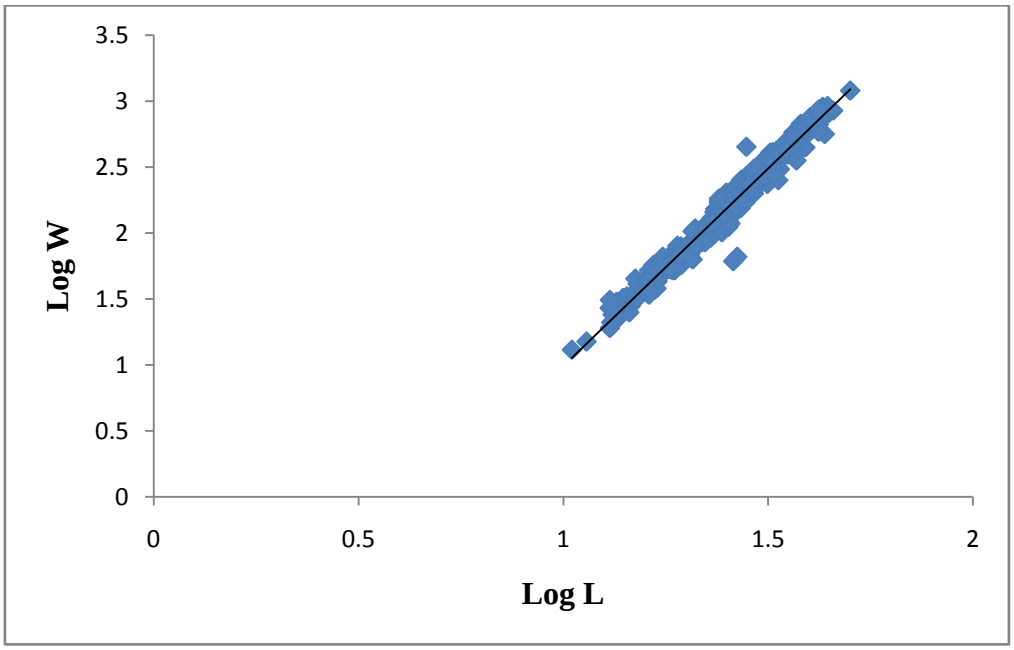


Fig.9 Regression equation of length-weight relationship of **combined (Male-Female)** hilsa from downstream of barrage

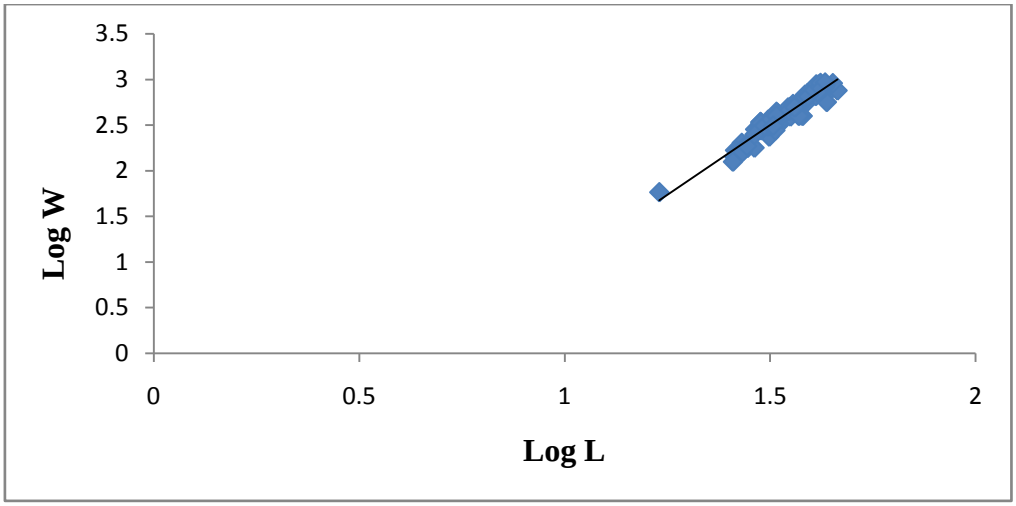


Fig.10 Regression equation of length-weight relationship of **female** hilsa from feeder canal

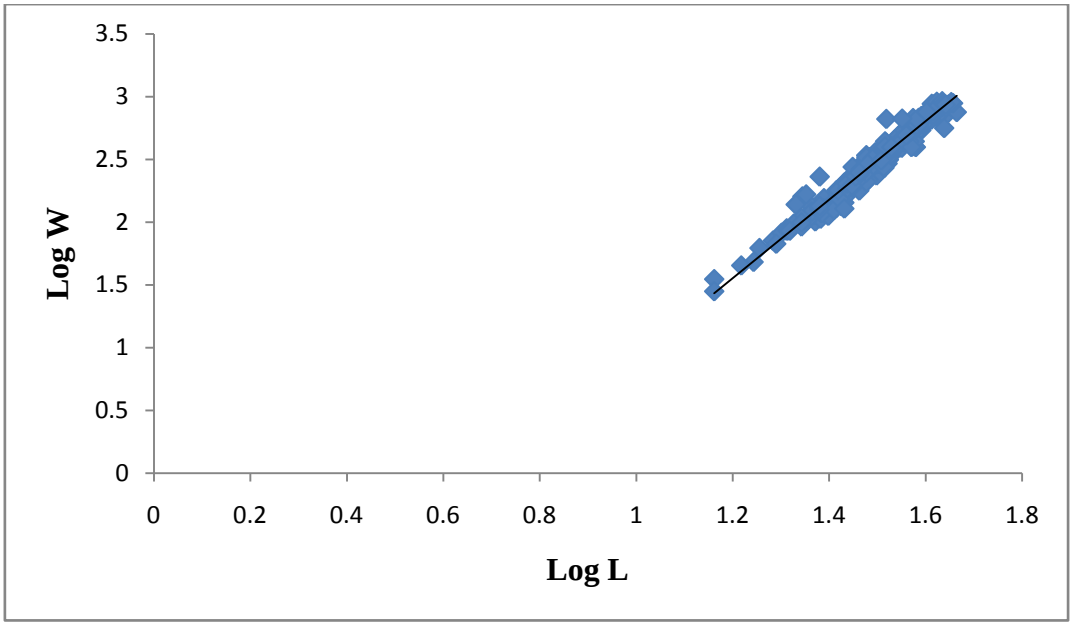


Fig.11 Regression equation of length-weight relationship of **combined** (Male-Female) hilsa from feeder canal

Table 7 represents the regression equation of both female and combined (male-female) from downstream and feeder canal with coefficient of Log L is "n", which are 3.05, 2.99, 3.05, 3.13 respectively. The value of "n" close to 3 indicates that the fish grows isometrically or symmetrically in relation to its length in both the water systems (downstream of barrage and feeder canal) and the length and weight are related to each other with a very high coefficient of correlation i.e 0.98, 0.99, 0.96 and 0.98 respectively.

Table 7 Regression equations of length-weight relationship of hilsa from downstream of Farakka barrage and feeder canal

Water body	Group	Length (mm)	Weight (g)	Sample size	Regression equation (Log W=Log a+n logL)	Correlation coefficient (r)
Downstream of Barrage	Female	179-502	57-1200	124	Log W= -2.07172+ 3.05121 Log L (Fig. 2)	0.98
	Male-Female combined	105-502	13-1200	446	Log W= -2.00315+2.99416 Log L (Fig. 3)	0.99
Feeder Canal	Female	170-462	58-920	89	Log W= -2.08659+ 3.05657 Log L (Fig. 4)	0.96
	Male-Female combined	145-462	28-920	249	Log W= -2.20447+3.13074 Log L (Fig. 5)	0.98

2.3 Reproductive biology of hilsa

Studies on reproductive biology are most essential for proper management and exploitation of the fishery through the valuable information on size at first maturity, spawning frequency and spawning ground. In hilsa, the present knowledge on these aspects would help in sustainable hilsa fishery management under climate change.

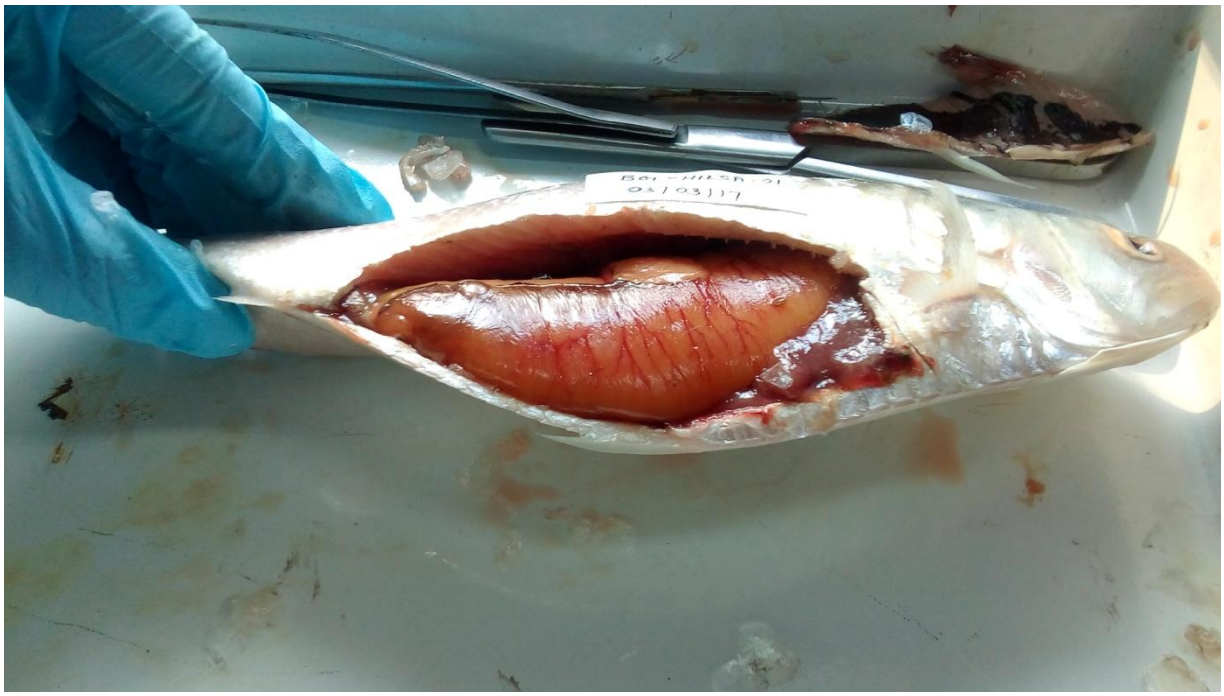
2.3.0 Maturity:

Maturity of female hilsa was studied based on the samples collected from downstream of barrage and feeder canal belonging to length range between 179 mm and 450 mm during the period from March to June 2017. Seven stages of maturity of female hilsa were described. The stage of maturation was determined by the color, size of the gonads, Gonadosomatic Index (GSI), the size and microscopic appearance of ova (Fig. 12, 13,14,15) (Table 8) following International Council for the Exploration of the Seas (ICES) scales with some modifications. The table nos. 9 and 10 depict the sexual maturity, GSI and fecundity of hilsa obtained from downstream of the barrage and feeder canal. Availability of female hilsa with high GSI values and higher range in size of ova (diameter 0.77 to 0.87 mm) certainly indicates its stray breeding during post winter season.

The gonadosomatic index (GSI) is indicative of breeding season. The GSI is calculated by the formula $$\mathbf{GSI} = \frac{\boldsymbol{Weight\ of\ gonad\ (g)}}{\boldsymbol{Total\ weight\ of\ fish\ (g) - Weight\ of\ gonad\ (g)}} X\ 100$$

It reveals from the study that, very few numbers of mature hilsa were available from both the water bodies *i.e.*, downstream and feeder canal. The minimum size at first maturity was observed at 227 mm and 291 mm from the downstream and feeder canal respectively. However, the minimal size of hilsa at first maturity bringing some controversial opinion. Earlier reports indicated that female below 300 mm size groups are hardly found to take part in spawning activity. In the present study late maturing (Stage- IVE) hilsa was observed at 179 mm in the downstream of barrage. This is an interesting observation and could be due to climate change and other environmental factors that triggers for the early maturation process.

Histo-micrograph of both male and females collected from the downstream of the barrage and feeder canal were analyzed for understanding maturity stages. Month wise histology of the gonads were taken and indicated majorly at maturing and matured stages (Fig. 16).



Hilsa, matured female (ovary stage VI)

Hilsa, matured male (oozing out milt)

Fig 12. Matured hilsa for reproductive biology study based on colour and size of gonad collected from Beniagram (D/S of barrage)

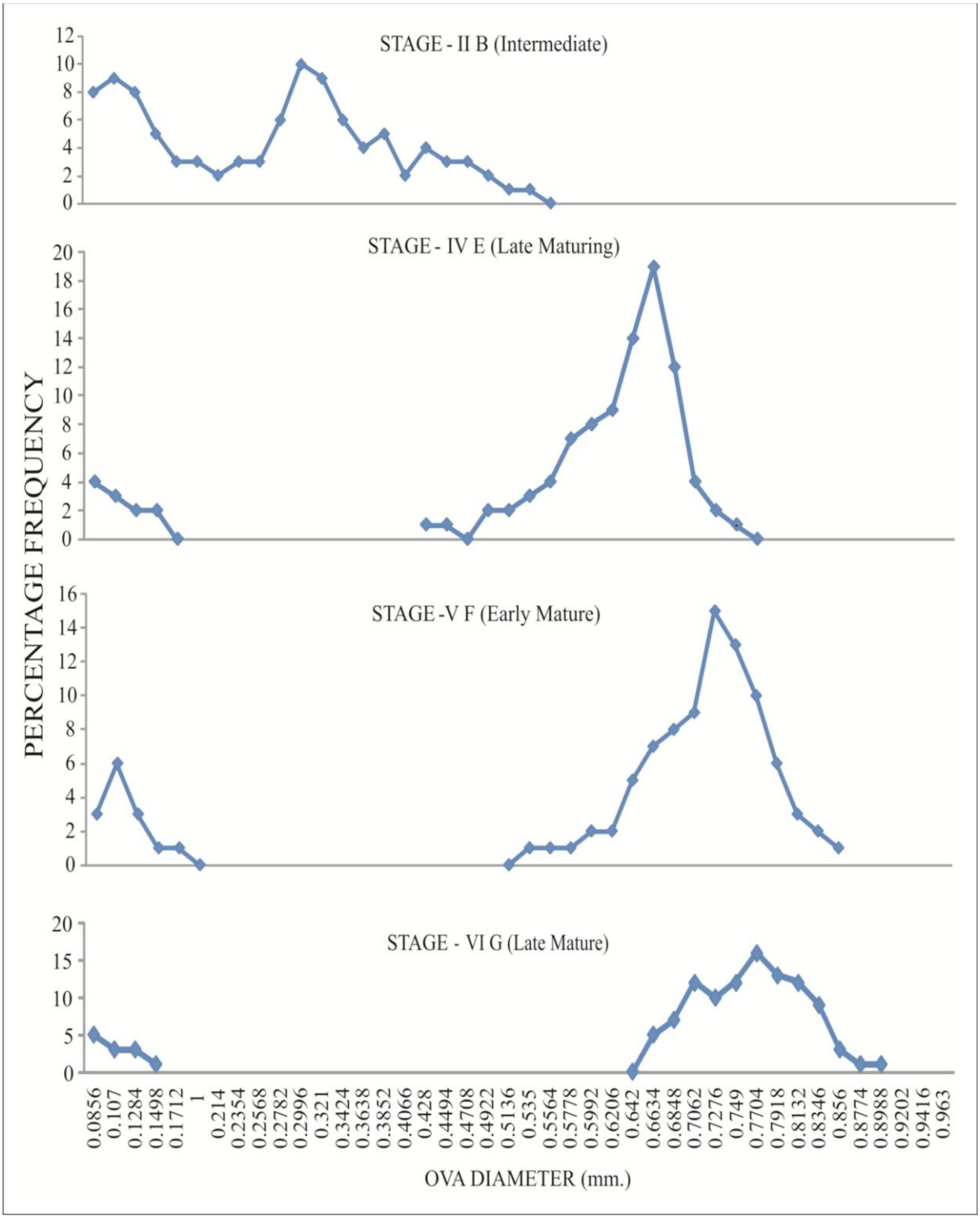


Fig.13 Percentage frequency distribution of intra-ovarian eggs in different stages of maturity in the downstream of barrage

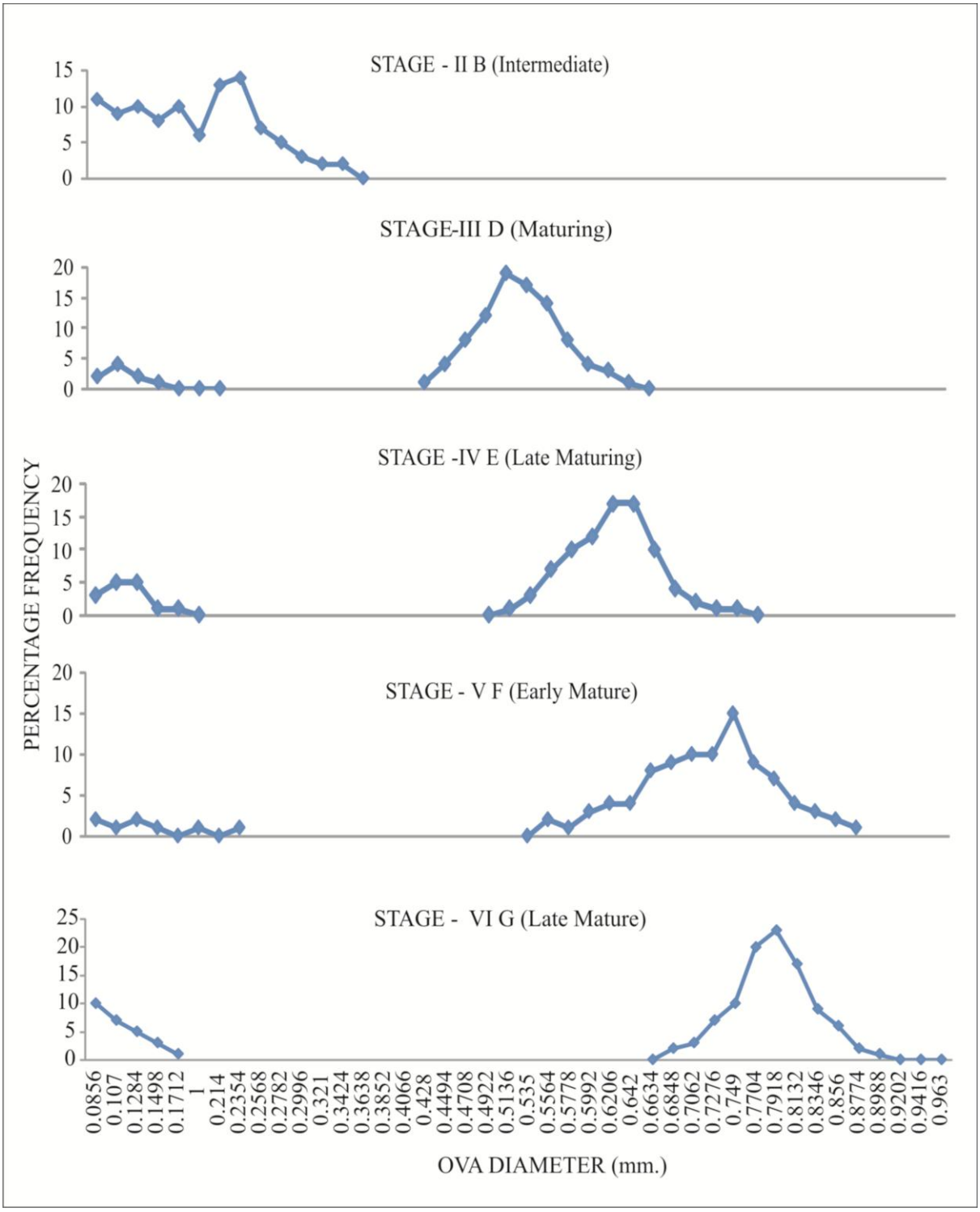


Fig. 14 Percentage frequency distribution of intra-ovarian eggs in different stages of maturity in feeder canal

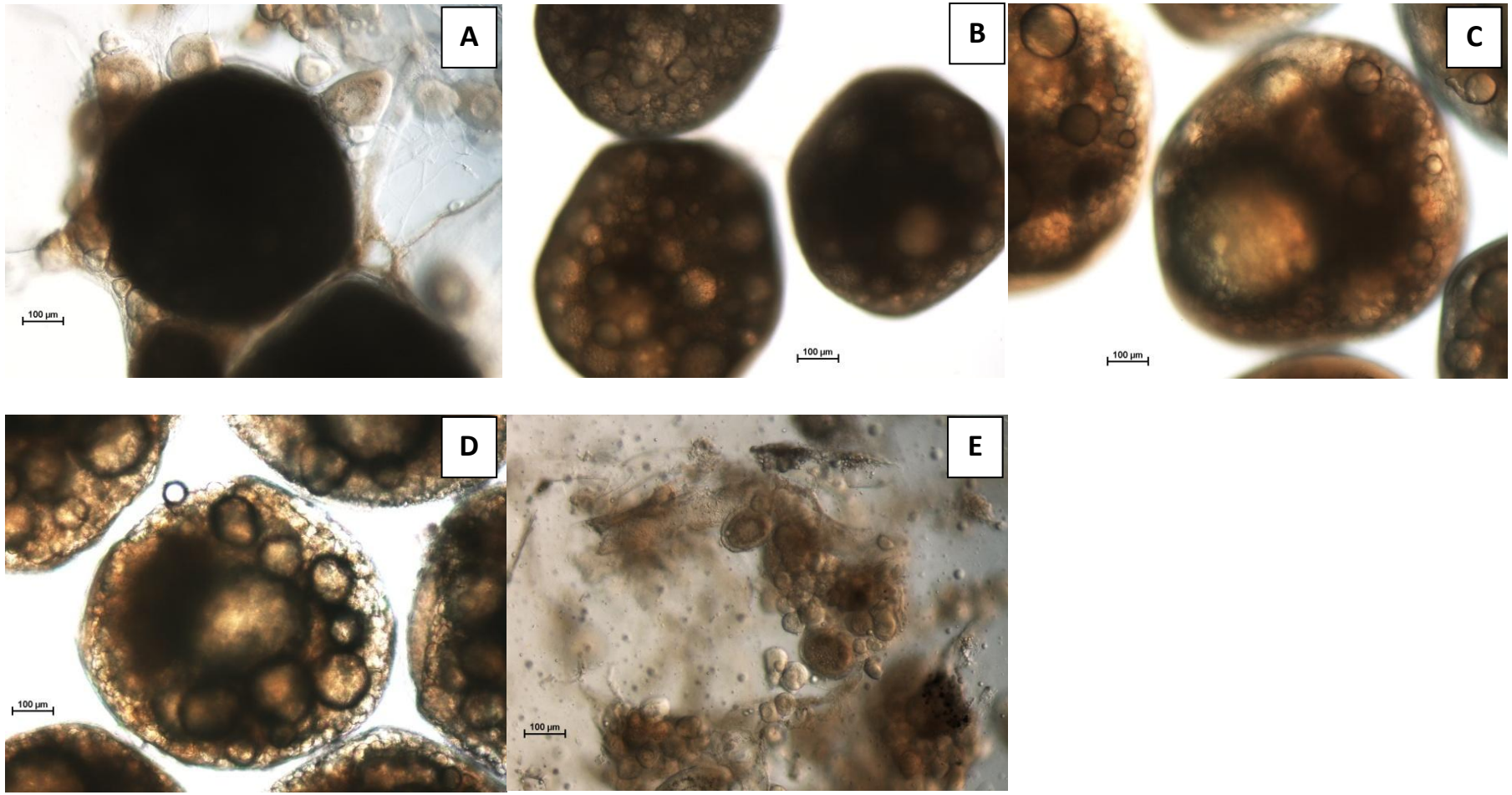


Fig.15. (A) Stage III D (Diameter of the largest group of ova ranges between 0.49 mm and 0.55 mm); (B) Stage IV E (Largest group of ova are ranges in size from 0.55 mm to 0.68 mm); (C) Stage V F (Most developed group of ova ranges between 0.68 mm and 0.77 mm); (D) Stage VI G (Ova are translucent; Diameter of mature ova ranges between 0.77 mm and 0.87 mm); (E) Atresia and resorption state of ova

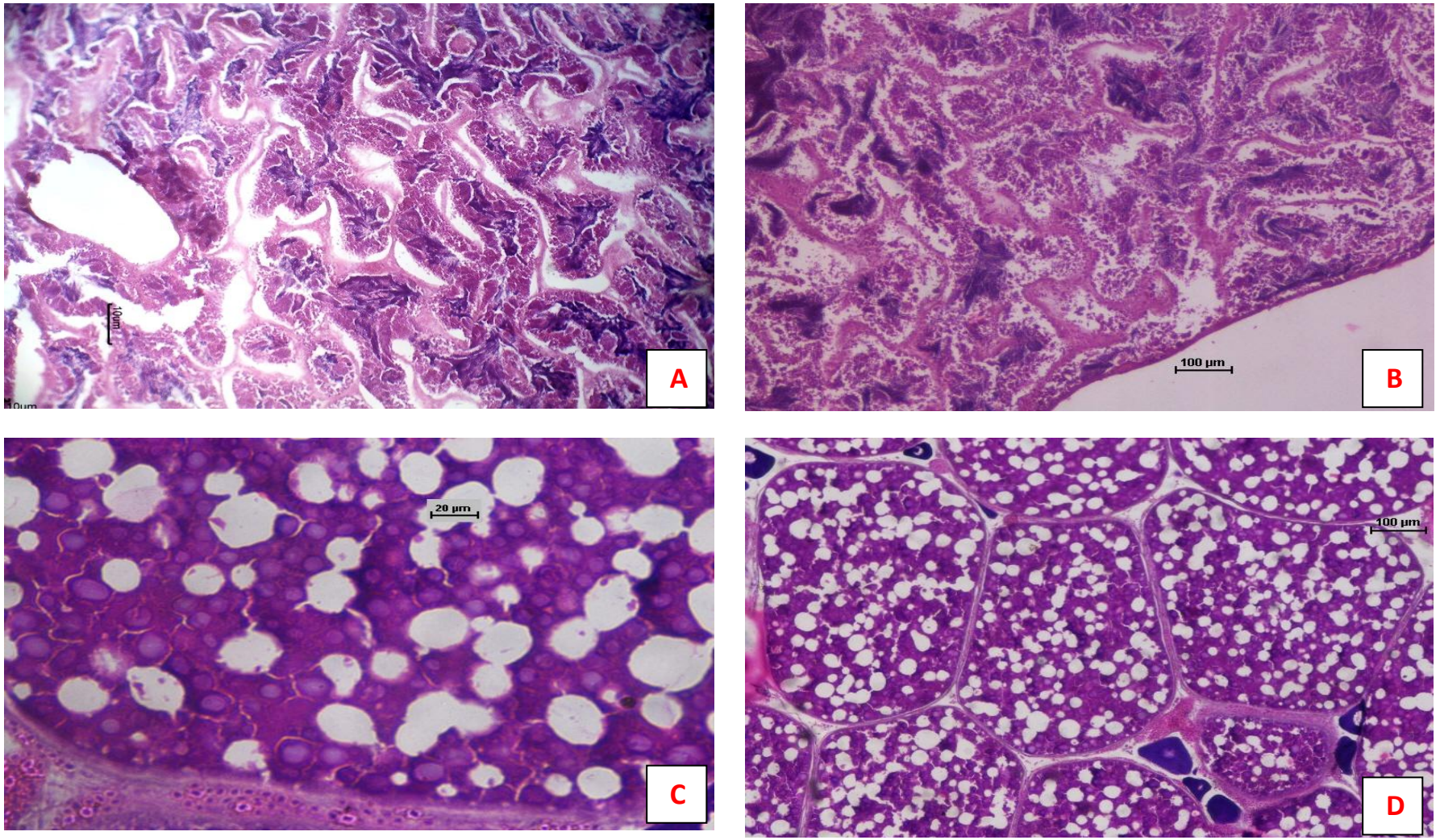


Fig. 16 Histo-micrograph of matured (ready to spawn) males and females of hilsa collected during month of June in the feeder canal (FC) and downstream (DS) of barrage. (A, B: Male) (A) FC (B) DS (10X) (C, D: Female), C: FC (40X), D:DS (10X)

Table 8 Most mature group of ova in different maturity stages of female hilsa obtained from Godavari, Ganga, Meghna (Bangladesh), Hooghly, Downstream of Barrage and Feeder canal in the vicinity of Farakka Barrage

International Scale (Wood, 1930)	Maturity stage	OVA DIAMETER (mm)					
		Godavari river (Pillay and Rao, 1962)	Ganga river (Mathur, 1964)	Meghna river (Shafi et al., 1978)	Hooghly (De, 1980, 1986)	**Present study (NMCG-HILSA Project under ICAR-CIFRI)**	
						Downstream	**Feeder canal**
I A	Immature	0.05	0.02-0.16	0.13	0.01-0.04	**0.01-0.17**	**0.01-0.17**
II B	Intermediate	0.15	0.16-0.35	0.23	0.04-0.43	**0.17-0.36**	**0.17-0.36**
III C	Maturing	0.30	0.35-0.50	0.37	0.43-0.50	**0.36-0.49**	**0.36-0.49**
III D	Maturing	0.45	–	–	0.50-0.58	**0.49-0.55**	**0.49-0.55**
IV E	Maturing	0.55	0.50-0.62	0.56	0.58-0.65	**0.55-0.68**	**0.55-0.68**
V F	Mature	–	0.62-0.76	0.70	0.65-0.76	**0.68-0.77**	**0.68-0.77**
VI G	Mature	0.85	0.76-0.86	0.73	0.76-0.87	**0.77-0.87**	**0.77-0.87**
VII H	Spent	–	–	–	–	**–**	**–**

Table 9 Different stages of maturity, gonadosomatic index (GSI), fecundity of female hilsa in Downstream of Farakka Barrage during Summer months (March-June)

Length of fish (mm)	Weight of fish (g)	Weight of Overy (g)	Most mature group of ova (mm)	Maturity stage	GSI	Fecundity	Fecundity factor	Fecundity per gram of overy weight
179	59	10.0	0.55-0.68	Late Maturing IV E	20.4081	63,701	1,080	6,370
227	117	16.0	0.77-0.87	Late Mature VI G	15.8416	52,032	445	3,252
250	168	26.5	0.55-0.68	Late Maturing IV E	18.7279	1,41,380	842	5,335
256	165	24.0	0.55-0.68	Late Maturing IV E	17.0213	1,76,921	1,072	7,372
265	250	37.0	0.55-0.68	Late Maturing IV E	17.3708	2,24,320	897	6,063
283	250	47.0	0.68-0.77	Early Mature V F	23.1527	2,74,809	1,099	5,847
290	253	12.0	0.17-0.36	Intermediate II B	4.9792	–	–	–
292	286	28.0	0.55-0.68	Late Maturing IV E	10.8527	2,77,659	971	9,916
334	319	47.0	0.68-0.77	Early Mature V F	17.2794	2,15,417	675	4,583
352	474	50.0	0.55-0.68	Late Maturing IV E	11.7924	3,35,828	708	6,716
358	437	11	0.17-0.36	Intermediate II B	2.5821	–	–	–

Table 10 Different stages of maturity, gonadosomatic index (GSI), fecundity of female hilsa in Feeder canal during Summer months (March-June)

Length of fish (mm)	Weight of fish (g)	Weight of Overy (g)	Most mature group of ova (mm)	Maturity stage	GSI	Fecundity	Fecundity factor	Fecundity per gram of overy weight
262	165	13	0.55-0.68	Late Maturing IV E	8.5526	87,674	531	6,744
271	160	12.0	0.55-0.68	Late Maturing IV E	8.1081	96,555	603	8,046
278	186	34.0	0.55-0.68	Late Maturing IV E	22.3684	2,27,460	1223	6,690
291	283	45	0.77-0.87	Late Mature VI G	18.9075	2,25,809	798	5,018
292	265	52.0	0.68-0.77	Early Mature V F	24.4131	2,33,838	882	4,497
308	274	34.0	0.55-0.68	Late Maturing IV E	14.1667	2,15,606	787	6,341
313	303	52.0	0.68-0.77	Early Mature V F	20.7171	3,06,915	1013	5,902
313	326	54.0	0.68-0.77	Early Mature V F	19.8529	3,35,123	1028	6,206
313	360	58.0	0.55-0.68	Late Maturing IV E	19.2053	3,82,104	1061	6,588
316	274	34.0	0.55-0.68	Late Maturing IV E	14.1667	2,24,018	818	6,589
316	327	45.0	0.55-0.68	Late Maturing IV E	15.9574	2,88,600	883	6,413
433	677	8.0	0.17-0.36	Intermediate II B	1.1958	–	–	–
450	994	91.0	0.49-0.55	Maturing III D	10.0775	6,60,560	664	7,259

2.3.1 Sex ratio:

Studies on sex-ratio indicated the proportion of males and females in the population. This is expected to be 1:1 in nature. Variations from this are often observed in fish population because of differential behavior of sexes, environmental conditions etc. The **average male-female ratio** observed in the **downstream** and **feeder canal** was 226:100 or **2.26:1.00** and 169.74:100 or **1.69:1.00** respectively (Table 11). While, Swarup (1958) observed almost similar sex ratio of male and female as 2:1 in the river Ganga at Allahabad. It is also known from the early records that males are dominant over females during summer season only in the Hooghly river.

Table 11 Sex ratio of hilsa in Downstream and Feeder canal During March-June, 2017

Months	Downstream			Feeder canal		
	Male	**Female**	**Ratio (male/100 female)**	**Male**	**Female**	**Ratio (male/100 female)**
March	49	21	233.33	22	10	220.00
April	47	11	427.27	37	17	217.65
May	41	5	820.00	14	13	107.69
June	28	36	77.78	56	36	155.56
Total	**165**	**73**	**226.03**	**129**	**76**	**169.74**

2.3.2 Spawning:

The presence of only a single size group of ova in the mature ovary indicates the species has a definite spawning season and the mature groups of ova are shed in a short duration. The main reproductive cycle of hilsa coincides with the post monsoon season (late September to early November) and this period indicates to be the peak spawning season of the fish. But, presence of moderate numbers of maturing hilsa in the downstream and feeder canal during the months of late February to April precisely shows its stray breeding period.

2.3.3 Fecundity:

Hilsa is a prolific breeder. Fecundity of the species collected from the downstream and feeder canal varied from 52,032 to 3,35,828 and 87,670 to 6,60,560 respectively during March to June months. It has been observed, that the number of ova increased with the age of the fish.

At present, the hilsa populations in coastal waters, estuaries and rivers consist of mainly 1^+ year age and 2^+ year age groups. These group of fishes are less fecund (Fig. 17) as compared to the hilsa of higher age groups observed in the past (De, 1986). As a result, the recruitment level of hilsa fishery has drastically reduced. This is one of the major reasons for the decline of hilsa fishery. Reduction in harvested fish size as well as reduction in higher age groups in the fishery may be attributed due to indiscriminate exploitation with the help of gears of varying mesh (5-12 cm) sizes.

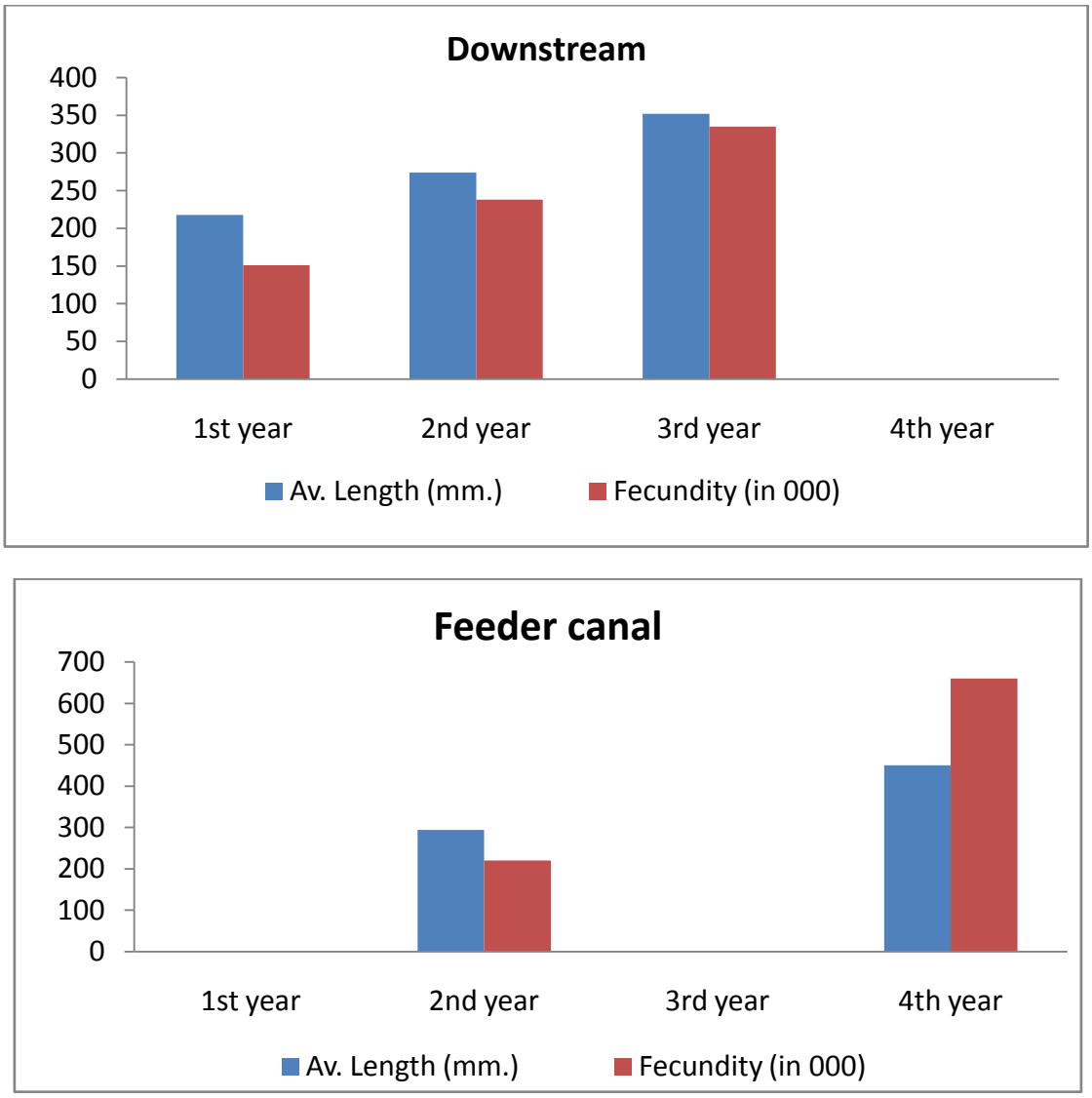


Fig.17 Age-wise/ length-wise fecundity of hilsa from downstream and feeder canal along Farakka barrage

3.0 Juvenile hilsa in the upstream of barrage: Present status

Though at present, juvenile hilsa was not contributing to the total hilsa catch in the vicinity of Farakka, their availability in the upstream is of interesting. However, it is known that after commissioning of the barrage, a small scale of juveniles hilsa fishery belonging to length range 32 to 70 mm was recorded and the landing ranged between 425.22 kg and 704.66 kg was recorded during November and December of 1992-93 to 1996-97 (Table 12). In the present study, juvenile hilsa with a size range from 23 to 46mm was recorded in the upstream of barrage (Fig. 18).

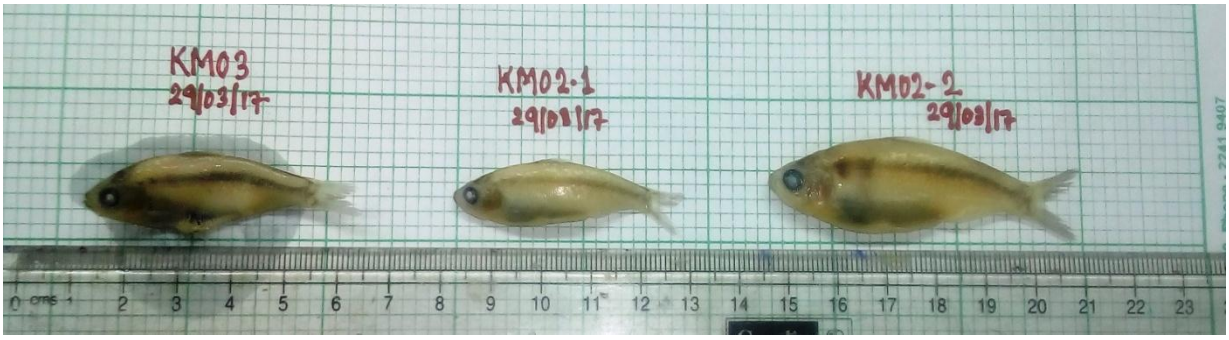


Fig.18 Juvenile hilsa collected from Kamaluddinpur ghat (upstream of barrage)

Table 12 Estimated catch (in kg) of juvenile hilsa at Farakka (Taltala ghat) situated upstream of barrage during 1992-93 to 1996-97

Year	1992-1993	1993-94	1994-95	1995-96	1996-97
Catch	425.22	697.26	545.42	592.35	704.66

Source: Annual report ICAR-CIFRI Barrackpore (1992-97)

Efforts were made to assess the recruitment of hilsa seed in the upstream, downstream of barrage and feeder canal. Standard shooting nets (length- 320 cm; width- 310 cm; height-60 cm at the mouth and mesh size- 1/8″) with a fine meshed cotton tail piece were used for collecting the seed and the catch were scooped at 3 hr. interval (Fig.3). No hilsa seeds (eggs and spawn) could be collected during the period, through fingerlings were observed.

4.0 Status of fish diversity in the river Ganga in the vicinity of Farakka Barrage

The ichthyofaunal diversity of river Ganga in and around Farakka Barrage area recorded from our study comprised of 76 species belonging to 25 families. A complete picture of fish community structure could not be ascertained, since the exploratory surveys were conducted for a short period from March to June 2017. The fish assemblages depicted in the report pertains to summer and early monsoon phase. The highest diversity (62 species) was reported at Taltala Ghat (upstream site), followed by Feeder Canal with 38 species, Beniagram (downstream site) (36 species) and Navigation Channel (15 species) (Fig.19, 20). The least fish diversity at Navigation Channel could be attributed to the disturbances caused due to maintenance dredging activities in the channel during our study period and the nearly stagnant water conditions due to closure of navigational lock gate. The relatively high fish diversity at upstream site is an output of its direct connectivity with the main channel of Ganga River. Similarly, the second highest diversity at Feeder Canal is a function of its connectivity with the Bhagirathi channel and regular freshwater influx from the barrage. Lower fish diversity at Beniagram during our study period is due to reduced flow and drying up of major part of channel.

The c-dominance plot of fish assemblages (based on PRIMER v6 PERMANOVA package) at upstream, downstream and Feeder Canal revealed the disturbed habitat conditions which has a great bearing on the water release from Farakka Barrage (fishes caught at Navigation Channel was not used in this plot owing to their low density and diversity that is not sufficient enough to carry out this analysis). The c-dominance curve for Feeder Canal is J-shaped with a steep slope, indicating that fish fauna is stressed (high flow conditions due to constant water release from barrage) and resulted in an assemblage with greater dominance of 2 – 3 species. The downstream site also produced J-shaped curve, but here disturbance is due to reduced flow and consequent drying up of channel. The c-dominance curve of upstream site is S-shaped due to its connectivity with the main channel of Ganga and abundance of sheltered habitats along the channel where the flow is relatively low (Fig.21).

Fig. 19 Study sites for Ichthyofaunal diversity

Fish species caught from Navigational canal indicating less diversity

Mixed fish species caught at Beniagram (D/S of barrage)

Hilsa with other fish species caught from Beniagram (D/S)

Fish species caught from Taltala (U/S of barrage)

Fish species caught from Feeder canal

Hilsa Juveniles caught from Hosenpur (D/S barrage)

Fig.20 Fish divesity at different sampling sites

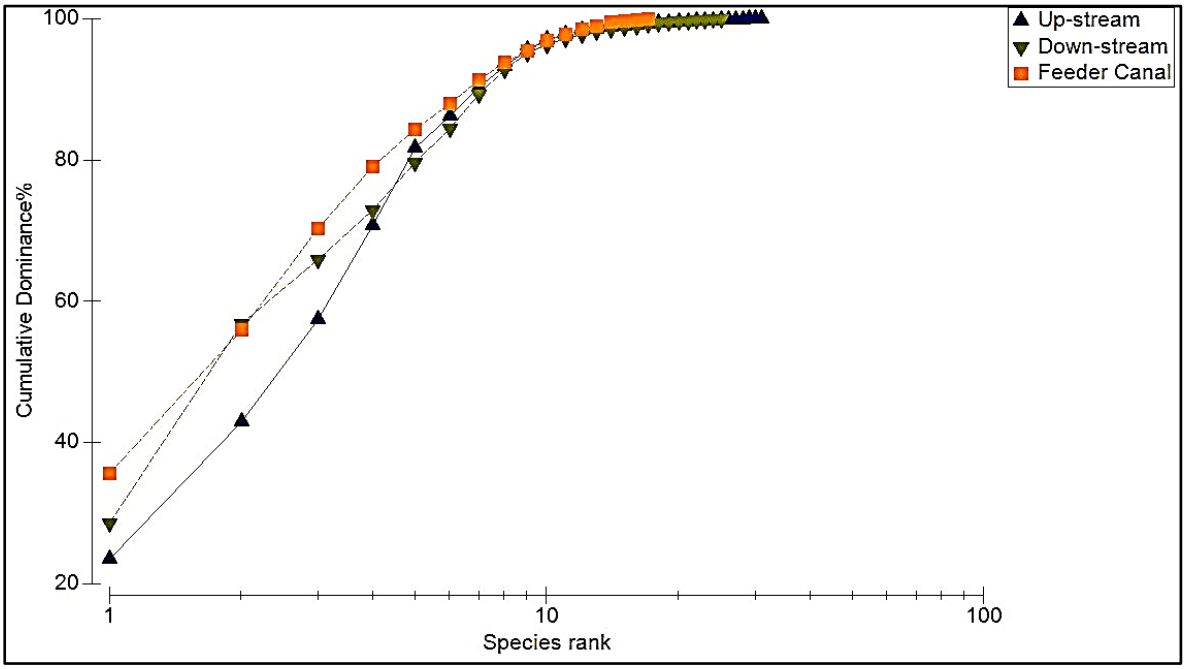


Fig. 21 c-dominance plot of fish assemblages at Farakka Barrage

The catches from seine nets (locally known as 'ber jal', 'kona jal', etc.) were analysed for describing the fish community structure as these are active fishing gears and non-selective in nature. Though the upstream site had the highest recorded fish diversity (62 species), about 70.8 % of the total fish catch (Fig. 22) was constituted by *Eutropiichthys vacha* (23.5 %), *Setipinna brevifilis* (19.5 %), *Gonialosa manmina* (14.4 %) and *Aspidoparia morar* (13.4 %).

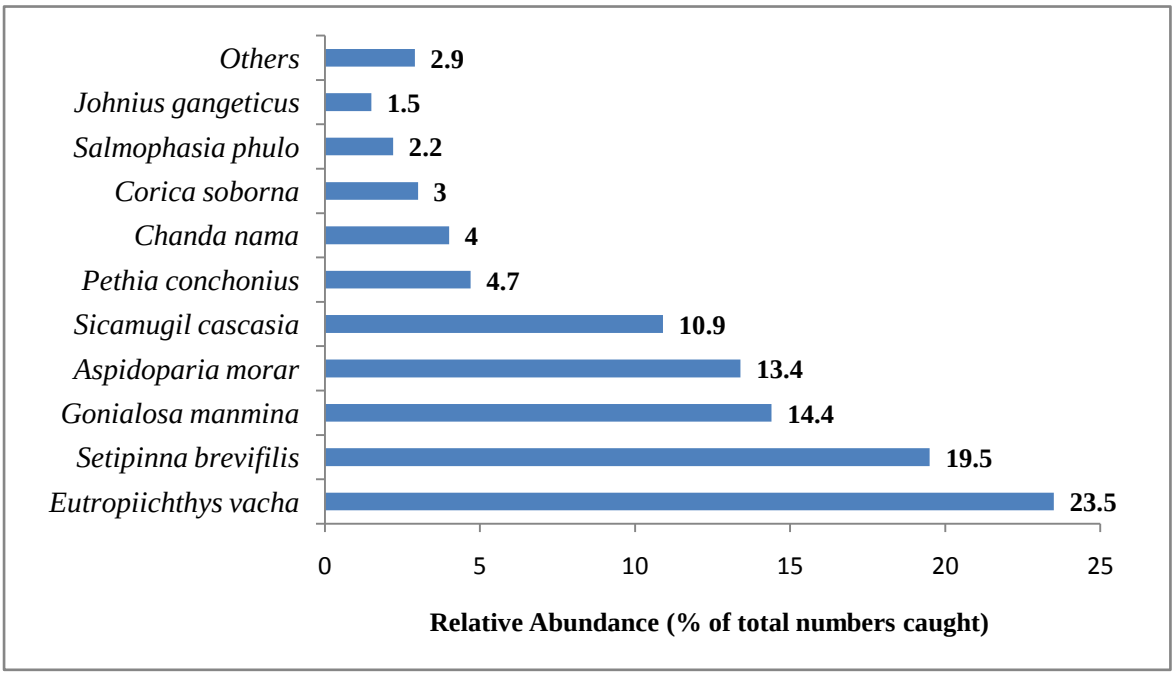


Fig. 22 Seine net catch composition at Taltala Ghat (up-stream)

Reduced flow conditions (our study pertains to peak summer period when the flow is minimum) had resulted in sedimentation and drying up of the river bed in the Padma branch at Beniagram (downstream site) where the fishing activity has been restricted to a narrow channel which maintained longitudinal connectivity owing to water release from the Farakka Barrage. But the flow was relatively low in comparison with the peak fishing season during monsoon and post-monsoon period (July – February). The seine catches in Beniagram (Fig. 23) was dominated by the rosy barb *Pethia conchonius* (28.7 %) and the *A. morar* (28.1 %) which together comprised more than half of the catch (56.8 %). The other significant fish species were *Gagata cenia* (9.1 %) and *Glossogobius giuris* (7.1 %) respectively. Though seine nets are not primarily intended for hilsa capture, we collected 4 specimens of *Tenualosa ilisha* (size range from 16.8 – 19.3 cm) from our experimental seine netting operations at Beniagram. Moreover, 5 hilsa specimens (size of 16 – 35.2 cm) were also captured during gill net operations during our study at the same site.

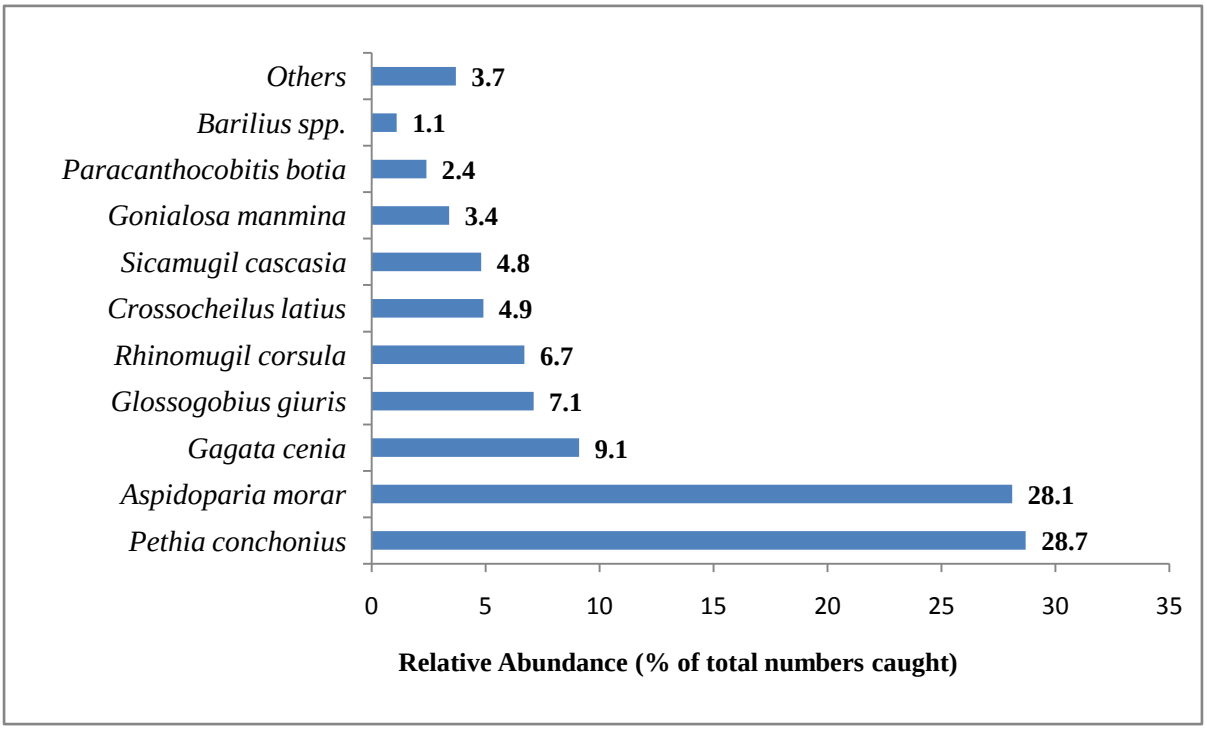


Fig. 23 Seine net catch composition at Beniagram (downstream)

As it is observed that the habitat is constantly subjected to stress along feeder Canal due to constant release of river water from the barrage, the fish assemblage was characterized by the sheer dominance of three species which solely contributed to more than 70 % of the total seine net catch (Fig. 24). These species include *Sicamugil cascasia* (35.7 %), *G. manmina* (20.4 %) and *Corica soborna* (14.3 %).

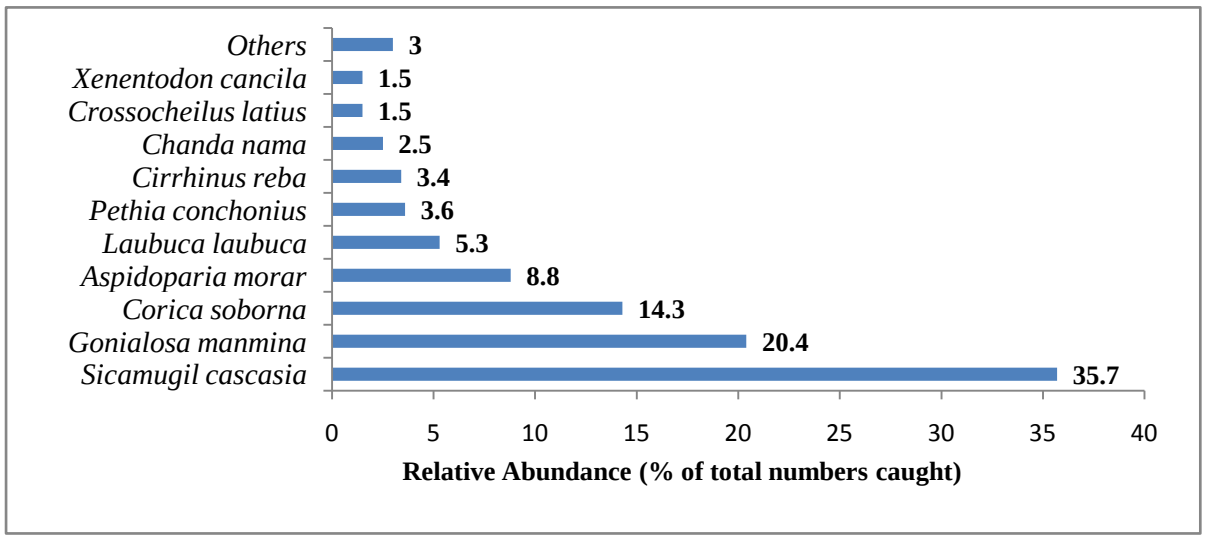


Fig. 24 Seine net catch composition at Feeder Canal

During our sampling survey, the Navigation Channel has been subjected to maintenance dredging activities to deepen the channel for passage of vessels. Moreover, the closure of lock gate has almost resulted in stagnant water conditions which along with dredging activities caused heavy stress to aquatic habitat of the channel and the lowest fish density as well as diversity along the channel is an indication that most of the fish species have avoided this habitat and migrated to nearby areas. The relatively stagnant water conditions in the channel favoured the growth of aquatic macrophytes which is a favourable habitat for barbs (fishes belonging to *Puntius* species complex). Thus, the seine net catch along the channel was dominated by *Pethia conchonius* (36.4 %), *Puntius sophore* (22.7 %) and *Labeo bata* (12.5 %) (Fig. 25).

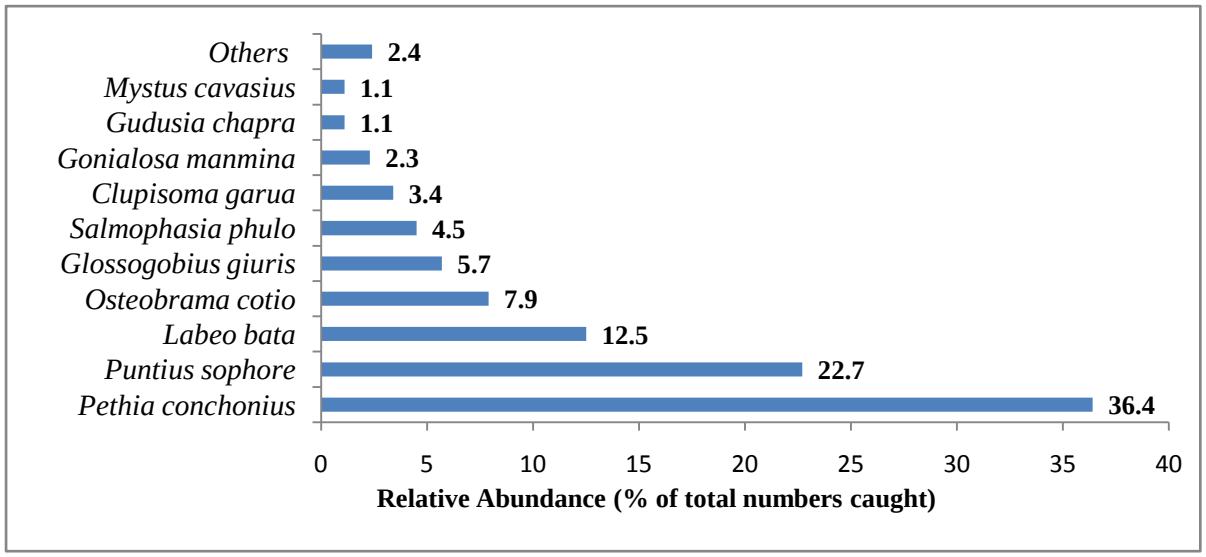


Fig. 25 Seine net catch composition at Navigation Channel

4.1 Conservation status of fish species recorded from the studied areas

Among the fish species recorded in the river Ganga from the vicinity of Farakka barrage (Taltala, Beniagram, Feeder canal and navigational channel), 12 species are under vulnerable, 5 species are endangered and 1 species under critically endangered. The detailed status and availability is depicted in the Table 13. The reduction in the availability of the fish species may be attributed to many factors and the major being less of water volume, deposition of silt, and climate change. However, the exact reason could be ascertain through systematic scientific investigations

Table 13 List of fish species with conservational status recorded from the vicinity of Farakka barrage

Fish species	Conservation status CAMP (1998)	Upstream	Feeder Canal	Downstream
Pangasius pangasius	CR	+		
Anguilla bengalensis	EN	+		
Botia lohachata	EN		+	
Eutropiichthys vacha	EN	+	+	+
Johnius gangeticus	EN		+	+
Ompok pabda	EN	+		
Tenualosa ilisha	VU	+	+	+
Ailia coila	VU	+	+	+
Clupisoma garua	VU	+	+	+
Catla catla	VU	+		
Cirrhinus reba	VU	+	+	+
Pethia conchonius	VU	+	+	+
Systomus sarana	VU	+		
Rhinomugil corsula	VU	+	+	+
Sicamugil cascasia	VU	+	+	+
Gonialosa manmina	VU	+	+	+
Mystus vittatus	VU	+		
Heteropneustes fossilis	VU	+		

CR= critically endangered; EN- endangered and VU= vulnerable;
+ indicates availability / presence

5.0 Review of the project

A detailed presentation of the project findings was made by ICAR-CIFRI in presence of Sushree Uma Bharati, Hon'ble Minister, Ministry of Water Resources, River Development and Ganga Rejuvenation, Shri Adhir Ranjan Chowdhury, Hon'ble MP, Shri U.P.Singh, DG, NMCG, other senior officials of Central Water Commission (CWC) and Farakka Barrage Authority (FBA) at Farakka on 31st May 2017. During the presentation, major emphasis has been made on the status of hilsa catch and life stage availability at selected stretches up-stream / down-stream of the Farakka Barrage, Feeder Canal and Navigational Channel. The Hon'ble Minister, Sushree Uma Bharati suggested that ICAR-CIFRI should take up research programme on the following aspects:

1) Studies on hilsa migration and efficacy of fish locks situated at the barrage bay Nos. 25 and 25A along Ganga – Padma main channel.

2) Possibilities of hilsa migration through the proposed bypass channel between feeder canal and Ganga River upstream of Farakka Barrage.

3) Studies on the behavior of Gangetic dolphin, in relation to existing water quality of river Ganga.

Presenting the results of "*Exploratory survey on Hilsa (Tenualosa ilisha) catch and life stages availability along up / down stream of Farakka Barrage*" to Sushree Uma Bharati, Hon'ble Minister, Ministry of Water Resources, River Development and Ganga Rejuvenation, Shri Adhir Ranjan Chowdhury, Hon'ble MP, Shri U.P.Singh, DG, NMCG, other senior officials of Central Water Commission (CWC) and Farakka Barrage Authority (FBA) at Farakka on 31st May 2017

6.0 Conclusions

The present study observed a huge difference in the hilsa catch between upstream of barrage and downstream of barrage and feeder canal. The hilsa catch in the downstream barrage majorly depend upon the upward migration from the Padma river (Bangladesh), while the catch in the feeder canal depend upon the upward migration from the Hooghly-Bhagirati river. Though there exist the hypothesis of presence of native hilsa population in those locations, it needs to be validated through scientific evidences. Further the study observed that adult matured hilsa were recorded both in downstream of barrage and feeder canal indicating the possibilities of breeding and spawning of hilsa in the vicinity of the Farakka barrage. Though the study could not record the presence of adult hilsa in the upstream of barrage, availability of small quantity of juvenile hilsa was of interesting.

1. Estimated hilsa (*T. ilisha*) landings during the study period were 1315.35 kg and 736.45 kg in downstream and feeder canal respectively. Hilsa catch was very meagre (about 7.5 kg) in areas upstream of the barrage, while no individuals were recorded from the navigation channel.
2. Fishes of 1^+ (190 – 260 mm) and 2^+ (261 – 345 mm) age groups dominated the fishery downstream from March – May, whereas, the $2^+$and 3^+ (346 – 415 mm) age groups were abundant in June.
3. Along the feeder canal, 1+ and 2+ age groups constituted a major share among the hilsa catch in March (53 – 67 % of total numbers caught) – April (12 – 25 %). However, 2+ and 3+ age groups dominated during May (25 – 55 %) and June (23 – 53 %).
4. Occurrence of late mature individuals (stage VI G) in both downstream and feeder canal indicates that stray breeding of hilsa has been occurring during the study period. But the fecundity was found to be lower (52, 032 – 660, 560 ova/fish) in the present study as compared to the earlier reports (373, 120 – 1475, 676 ova/fish) of De (1986 and 2001).
5. Only juveniles (35 – 150 mm) were recorded from the upstream sites; of which, major part of the catch was contributed by the 101 – 150 mm length group. *This supports the fact that recruitment of the species has been taking place in areas upstream of Farakka Barrage, through the quantity is less.*

7.0 Recommendations for sustainable hilsa fishery in river Ganga

Based on the results obtained from the present study, following recommendations are proposed for achieving sustainable hilsa fishery in the river Ganga.

1. Two fish locks provided in the Farakka Barrage should be operated regularly during monsoon months for upstream migration of the species to rejuvenate hilsa fishery in the upstream of Ganga river.
2. A bypass channel should be created between the feeder canal and upstream of the Ganga river in the western side of the existing navigational channel to facilitate natural upstream migration of hilsa from the Hooghly-Bhagirathi river. At present, upstream migration of Hooghly hilsa is restricted upto feeder canal lock gate.
3. In order to enhance the natural hilsa population in the river, breeding and ranching programme should be initiated. Although some success in the artificial fecundation of hilsa has been achieved, more attention should be paid to culture this species in confined waters. It is imperative to resort hilsa farming in confined waters for conservation of this valuable species.
4. A long term study (two to four years) on hilsa migration, reproductive behavior, and stock characterization should be initiated to generate current hilsa information under the climate change and various anthropogenic pressures in the river Ganga.

8.0 References

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Visit of Sushree Uma Bharati, Hon'ble Minister, MoWRRG to ICAR-CIFRI, Barrackpore

Sushree Uma Bharati, Hon'ble Minister, MoWRRG addressing to the fisherman and staffs of ICAR-CIFRI on river Ganga

Sushree Uma Bharati, Hon'ble Minister, MoWRRG visiting ICAR-CIFRI's Pulications on river Ganga gallery

Sushree Uma Bharati, Hon'ble Minister, MoWRRG addressing to the local fisherman and staffs of different organizations on conservation of riverine fisheries and maintaining cleanliness of river Ganga