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RAISING OF STOCKING MATERIALS IN PEN ENCLOSURE IN A FLOODPLAIN WETLAND OF UTTAR PRADESH

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An experiment was conducted in Alwara taal of Uttar Pradesh, India to rear Indian major carp fry in pen enclosure during 2014-15 for production of stocking materials. A rectangular off-shore all-net pen covering 0.125 ha area was installed in the wetland using HDPE screens (5 mm mesh size), nylon webbing (5 mm mesh size), foot rope (3 mm diameter) bamboo poles and twines. The pen was stocked with advance fry of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* @ 20 nos. m^{-2} in the ratio of 2:1:1 The stocked fishes were fed with supplementary feed @ 2-5% of their body weight giving overall FCR value of 1.11. Catla, rohu and mrigal fry grew from 6.85 g ±0.48, 3.77 g ± 0.31 and 5.03 g ± 0.26 to 123.10 g ± 5.53, 85.4 g ± 4.91 and 72.3 g ± 2.42 in 110 days culture period. The specific growth rate and survivality (%) of reared fishes were: 2.62 and 61.2% for catla, 2.84 and 66.3% for rohu whereas these were 2.42 and 68.2% for mrigal. Mean values of important water quality variables like transparency (35 cm), pH (7.5), total alkalinity (212 mg l^{-1}), total hardness (178 mg l^{-1}), dissolved oxygen (6.3 mg l^{-1}), phosphate-P (0.072 mg l^{-1}) and nitrate-N (0.09 mg l^{-1}) indicated that the wetland was suitable for pen aquaculture. Benefit-cost ratio and return on investment were 1.53 and 0.53 indicating that pen aquaculture was economically viable for rearing of carp advance fry to fingerling stage in floodplain wetlands of Uttar Pradesh.

Key words: Pen aquaculture, floodplain wetlands, Alwara taal, FCR, benefit-cost ratio

Introduction

The bulk of production from inland open water fisheries in India comes from reservoirs and floodplain wetlands, which are managed on the basis of culture-based fisheries or various other forms of enhancements (Ayyappan, 2005). Floodplain wetlands of India cover over an area of 3.54 lakh ha and constitute an important fishery resource in the states of Uttar Pradesh, Assam, West Bengal, Bihar and Manipur (Bhattacharjya, 2011). Uttar Pradesh has the largest area (1,52,000 ha) under floodplain wetlands (locally called taals and jheels) in India. Ecology and productivity of floodplain wetlands have been studied by various workers in different parts of the country (Pathak *et al.,* 1985; Jha, 1989; Pathak, 1989 & 1990; Sugunan, 1995; Jha, 1997 & 1989; Bhattacharjya, 2002; Pathak *et al.,* 2002 & 2004; Kumar and Joshi, 2008; Joshi and Kumar, 2009; Bhattacharjya *et al.,* 2015). The level of interventions to enhance their productivity remained meagre. The average fish yield from floodplain wetlands is around 200 kg ha^{-1} yr^{-1} with a range of 1000 to1500 kg ha^{-1} yr^{-1} (Pathak *et al.*, 2004; Sharma *et al.*, 2010). The floodplain wetlands are highly fragile but productive ecosystems with an estimated fish production potential of 1000-1500 kg $ha^{-1}yr^{-1}$ (Sugunan *et al.*, 2000; Sugunan and Bhattacharjya, 2000). However, the average fish yield of the wetlands of Uttar Pradesh was much lower because of habitat

modification and poor recruitment from their parent/ adjoining rivers. Pathak *et al.* (2004) estimated the fish production potential of the Alwara taal as 792 kg ha^{-1} yr^{-1}. Uneconomical miscellaneous fish species and tertiary consumers feeding at higher trophic levels utilized most energy reserve resulting in lower average harvest from the wetland (Kumar and Wataal, 2006). The floodplain wetlands are amenable for enhancing their fish production substantially though fish stock enhancement including culture-based fisheries (Bhattacharjya and Sarma, 2010 & 2017). The major reason for the low fish yield from the wetlands are lack of proper understanding of the ecological principles especially the productivity and inadequate scientific management practices that remain chocked with macrophytes (Pathak *et al.*, 2004). Rational stocking of fast growing Indian major carp (IMC) seed that feed at lower trophic levels (Pathak *et al.*, 2002) and effective management of the aquatic weeds are two major issues towards fisheries enhancement in these wetlands. In situ raising of fingerlings in pens in wetlands appears to be a feasible option to overcome the constraints of non-availability of carp fingerlings of desired size in required quantities at the wetland site as well as high cost of carp fingerlings with associated high mortality (Bhattacharjya *et al.,* 2015). Pen aquaculture technology has been developed by CIFRI as an avenue for additional fish production in floodplain wetlands parallel to enhancement of their capture fisheries/ fish stock enhancement. Rearing of IMC seeds to fingerling stage in pen and subsequent release to the wetland have shown better survivality and growth (Banerjee and Pandey, 1978; Gorai *et al.,* 2006; Aparna and Hassan, 2013; Chandra *et al.,* 2013; Bhattacharjya *et al.,* 2015). Against this backdrop, the present study was undertaken for assessing the feasibility of in situ rearing of carp fingerlings for enhancing the overall productivity of Alwara taal, Uttar Pradesh.

Material and methods

Alwara taal is a seasonally open floodplain wetland that remain connected with the river Yamuna located in Kaushambi district of Uttar Pradesh. The water- spread area of the wetland is around 1,250 ha with mean depth of 0.92 m. The present experiment was conducted during December 2014 to April 2015 in Alwara taal for production of stocking material of desired size by rearing IMC fry in pen enclosure for further stocking the wetland (Fig.1). Water and sediment quality of the Alwara taal was examined before the start of the pen aquaculture experiment (*i.e.,* in June, 2014) to assess its suitability for pen aquaculture. A rectangular off-shore all-net pen measuring 1,250 m^2 (50 x 25 m) 0.125 ha area was constructed in the wetland using HDPE fencing screen (width 1.83 m, mesh size 5 mm), nylon netting (width one foot, mesh size 5 mm), foot rope (3 mm diameter). The net pen was supported by bamboo poles (length 2.5 m) driven into bottom soil using synthetic twines (1 mm thickness). Predatory and weed fishes were removed from inside the pen by repeated netting

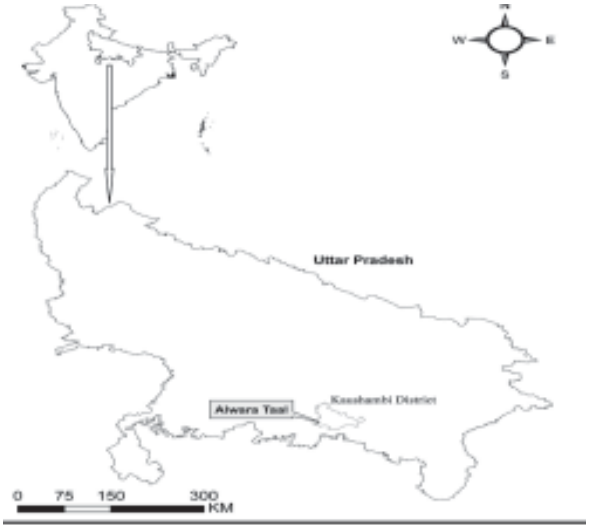

Fig 1. Map showing location of Alwara taal in Uttar Pradesh, India

Table 1. Water and sediment quality of Alwara taal, Uttar Pradesh (mean ± SE)

Parameters	Mean value
Air temperature (°C)	39.5 ± 1.07
Water temperature (°C)	35.5 ±0.55
Transparency (cm)	35.0 ± 1.73
Dissolved oxygen (mg l^{-1})	6.3 ± 0.09
pH	7.5 ± 0.06
Free carbon dioxide (mg l^{-1})	80.0 ± 1.15
Total alkalinity (mg l^{-1})	212.0 ±3.21
Chloride (mg l^{-1})	51.2 ± 0.17
Total hardness (mg l^{-1})	178.0 ± 3.51
Total dissolve solids (mg l^{-1})	434.7 ± 2.60
Sp. conductivity (µsiemen)	764.9 ± 2.74
Phosphate-P (mg l^{-1})	0.05 ± 0.01
Silicate-Si (mg l^{-1})	0.5 ±0.06
Dissolved organic matter (mg l^{-1})	6.3 ± 0.09
Sediment quality	
Soil Texture (%)	
Sand	57.0 ± 1.20
Silt	31.0 ±1.00
Clay	12.0 ±0.33
pH	6.73 ±0.10
Av. Nitrogen (mg N 100 g^{-1})	53.4 ±0.56
Av. Phosphate (mg P 100 g^{-1})	3.20 ± 0.03
Organic carbon (%)	4.64 ± 0.05
Free calcium carbonate (%)	5.75 ± 0.01
Sp. conductivity (µsiemen)	667.3 ± 2.51

Table 2. Water and sediment quality inside and outside the pen in Alwara taal (mean ± SE)

Parameters	Inside pen	Outside pen
Air Temperature (°C)	30.5 ± 0.59	31.0±0.88
Water Temperature (°C)	25.5 ± 0.26	26.0±0.35
Transparency (cm)	73.0 ± 2.08	73.0 ±2.52
Dissolved oxygen (mg l^{-1})	9.68 ± 0.12	10.4±0.23
pH	8.0 ± 0.06	8.0±0.10
Free carbon dioxide (mg l^{-1})	ND*	ND*
Total alkalinity (mg l^{-1})	200.5 ± 1.15	210.0±2.37
Chloride (mg l^{-1})	97.98 ± 0.57	92.3±1.27
Total hardness (mg l^{-1})	170 ± 4.50	184.0±4.98
Total dissolve solids (mg l^{-1})	374.8 ± 2.90	374.2 ±3.02
Sp. conductivity (µsiemen)	656.8 ± 6.03	656.0 ±4.73
Phosphate-P (mg l^{-1})	0.05 ± 0.01	0.03±0.06
Silicate-Si (mg l^{-1})	0.5 ± 0.10	0.7±0.12
Dissolved organic matter (mg l^{-1})	5.78 ± 0.06	5.85.0±0.06
Sediment quality		
Av. nitrogen (mg N 100g^{-1})	53.2 ± 0.52	41.4±0.51
Av. phosphate (mg P 100g^{-1})	4.1 ± 0.058	3.0±0.12
Organic carbon (%)	1.77 ± 0.06	1.72±0.06
Free calcium carbonate (%)	5.75 ± 0.14	7.0±0.10
Sp. conductivity (µsiemen)	593.0 ± 1.45	667.3 ± 2.67

with small-meshed nets. The pen was stocked with advanced IMC fry @ 20 fry m^{-2}. The species ratio of stocked rohu: catla: mrigal was 2:1:1 with average stocking size weight of 6.85 g ± 0.48 , 3.77 g ± 0.31 and 5.03 g ± 0.26 respectively. The stocked fishes were fed with the supplementary feed made of rice bran and mustard oil cake mixture in the ratio of 1:1 @ 2-5 % of their body weight once daily in addition to natural food available in the pen. Reared fishes were sampled at monthly intervals to monitor their growth pattern, health status and to adjust daily feeding ration depending on their growth. Average length and weight of 32 randomly selected fishes of each species were recorded. ANOVA was used to test the pattern of growth. Water and sediments samples were collected monthly from both inside and outside the pen and analysed using standard procedures (APHA, 2005). Plankton samples were collected by filtering a known volume of water through plankton net made of nylon bolt cloth having 60 µ mesh size (25 no.) and fixed in 4% formalin.

Growth during the culture period was recorded as-

Body weight gain (g per month) = (Final weight-Initial weight)/ no. of months

Specific growth rate (SGR%) = (ln mean of final weight - ln mean of initial weight)/ culture duration in days) X 100

Feed conversion ratio (FCR) = (total feed given/ weight gain) X 100

Table 3. Weight gain (g) and specific growth rate (%) of the reared species at the end of the experiment (mean ± SE)

Fish Species	Weight gain	Specific growth rate
L. rohita	81.63a ± 8.69	2.84a ± 0.09
C. catla	116.25b ± 13.32	2.63a± 0.17
C. mrigala	67.27c ± 7.13	2.42b ± 0.03

*Mean values with different superscript letters denote statistically significant values. at 5% level of significance.

After a culture period of 110 days (20th December 2014 -8th April, 2015) the reared carp fingerlings were harvested and released in to the wetland for stock enhancement. Benefit-cost ratio (BCR) and return on investment of the pen aquaculture operation was estimated to assess the profitability of the venture.

Results and discussion

Important water and sediment quality variables of the Alwara taal examined before the start of the pen aquaculture experiment are presented in Table 1. The mean value of limno-chemical parameters such as total alkalinity, total hardness, specific conductivity, total dissolved solids and chloride were 212 mg l^{-1}, 178 mg l^{-1}, 764.5 µsiemen cm^{-1}, 434 mg l^{-1}, 162 mg l^{-1} and 51.2 mg l^{-1}. Organic carbon (4.64%), available nitrogen (534 mg l^{-1}) and available phosphorous (31 mg l^{-1}) were observed to be high in the soil. Water with total alkalinity more than 90 mg l^{-1}, favourable oxygen content (>5 mg l^{-1}), specific conductance above 200 µsiemen cm^{-1}, TDS and total hardness above 100 mg l^{-1} are considered to be productive in nature (Moyle, 1949; Northcote and Larkin, 1956). Since all the above parameters were observed to be within moderate range in Alwara jheel, it can be placed under moderately productive class. The results indicate that the wetland was productive and suitable for undertaking pen aquaculture in it. The wetland was moderately infested with aquatic macrophytes; dominant macrophytes were Eicchornia crassipes, Nelumbo nucifera and Ceratphyllum sp. This wetland had 62 fish species belonging to 50 genera under 23 families and 8 orders. The ichthyo-faunal diversity of the wetland indicated ingress of fish fauna from the feeding river. Six exotic fishes *viz*., *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix*, *H. nobilis, Cyprinus carpio*, *Claria gariepinus* and *Oreochromis niloticus* were also observed. The fish yield was low (60 kg ha^{-1}), in spite of high production potential of 792 kg ha^{-1} yr^{-1} (Pathak *et al*., 2004). Predatory fishes (43%) like *Channa marulius*, *C. striatus*, *C. punctatus* and *Wallago attu* contributed significantly to the catch followed by carp species like IMC, grass, silver and common carps (29%) and miscellaneous group of fishes (28%) like *Salmophasia bacaila*, *Barilius barila*, *Amblypharyngodo mola*, *Gudusia chapra* and *Esomus danricus*. The Indian major carps at their earlier stage are planktivorous (Annonymous, 2011). The lower abundance of plankton inside the pen (120 u l^{-1}) than outside it (290 u l^{-1}) is apparently due to active grazing by the reared carp fry on plankton. Salient water and sediment quality monitored inside and outside the pen after stocking (Table 2) showed that these remained favourable for pen aquaculture of carps throughout the rearing period. A stocking density of 20 nos m^{-2} advanced fry to fingerling and supplementary feeding (@2-5% of body weight) apparently did not adversely affect the environment since the water quality inside and outside the pen did not differ significantly at 5% level of significance (t test p>.05).

Specific growth rate (SGR%) and weight gain (WG%) of reared fishes were analyzed at the end of the rearing period, which is shown in Table 3. The given stocking density (20 no. m-2) obviously supported good fish growth (SGR> 2.4) in all the

Table 4. Economics of rearing IMC fry in pen enclosure (0.125 ha) in Alwara taal

Particulars	Rate (₹)	Unit	Amount (₹)
Capital costs			
Cost of full-length mature bamboo poles (number)	100	50	
5000			
Cost of HDPE net screen (meter)	400	150	
60000			
Sub-total			65000
Capital costs per crop (assuming that the materials will last for 3 crops)			21666.67
Operational costs			
Cost of IMC fingerlings (kg)	250	104.4	26100
Cost of rice bran (kg)	12	800	9600
Cost of MOC (kg)	24.5	800	19600
Labour charges for construction of pen	200	24	4800
Labour charges for stocking, harvesting etc.	200	20	4000
Labour charges for watch & ward and daily feeding for 4 months	3500	4	14000
Miscellaneous expenses (ls)			3000
Sub-total			81100
Total costs (B+C)			102766.67
Gross income			
Sale price of advanced fingerlings			
L. rohita (kg)	100	947	94700
C. catla (kg)	100	336	33600
C. mrigala (kg)	100	292	29200
Sub-total			157500
Net income (Gross income - Total costs)			54733.3
Benefit-cost ratio			1.53
Return on investment			0.53

three species. Catla, rohu and mrigal fry grew from 6.85 g ±0.48, 3.77 g ± 0.31 and 5.03 g ± 0.26 to 123.10 g ± 5.53, 85.4 g ± 4.91 and 72.3 g ± 2.42 g during the rearing period. Based on the weight gain, significant difference in growth pattern was noticed (ANOVA, $p<0.05$) in all three species (Table 3). The FCR was found to be around 1.11; low FCR suggested that the fish fed on the natural food in addition to the supplementary feed. Overall survival rate was 61.2, 66.3, and 68.2% in catla, rohu and mrigal respectively, which were found to be within the normal range of survivality during rearing of IMC fry to fingerling (Annonymous, 2011). Studies on pen aquaculture of IMC in floodplain wetlands for raising stocking materials are limited (Banerjee and Pandey, 1978; Gorai *et al.*, 2006; Bhattacharya *et al.*, 2010 and Bhattacharya *et al.*, 2015). In the present experiment, benefit-cost ratio and return on investment for the pen aquaculture operation for raising a single crop was worked out to be 1.69 and 0.69 (Table 4), which suggested that the culture operation for raising the stocking material of IMC in the wetlands of was economical. The present experiment suggests that in situ raising of IMC fingerlings in pen enclosures for the enhancement of fish productivity in the floodplain wetlands of Uttar Pradesh is economically feasible.

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LENGTH WEIGHT RELATIONSHIP AND RELATIVE CONDITION FACTOR OF INDIAN SHAD, *TENUALOSA ILISHA* FROM HOOGHLY ESTUARY SYSTEM, WEST BENGAL

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The study on the length weight relationship (LWR) and relative condition factor (Kn) of Indian Shad (*Tenualosa ilisha*) was conducted for a period of seven months (June to December, 2013) from Diamond Harbour area of Hooghly estuarine system, West Bengal. During the period of investigation, 245 samples of unsexed *Tenualosa ilisha* having length of 210 to 420 mm and body weight of 115 to 775 g were examined. The LWR found for *Tenualosa ilisha* was W = 0.0000206 L 2.817 for pooled samples. The correlation coefficient of 0.892 between length and weight was significant (P<0.05). The fish exhibited isometric growth with exponent 'b' value of 2.817 which is relatively low compared to earlier works in the locality. The Kn values varied from 0.981 to 1.052 with average of 1.013 indicating good condition of the fish.

Key words: *Tenualosa ilisha*, length-weight relationship, relative condition factor, Hooghly estuary system.

Introduction

Hilsa (*Tenualosa ilisha*) is the state fish of West Bengal and it has high market demand. It accounts for a lion's share in fisheries of Hooghly estuary and that of Bangladesh. It is quite important socially, culturally and religiously to Bengali people living in India and Bangladesh (Sharma *et al*., 2012). Estuarine ecosystem provides ample of biological and ecological services to society. But it is altered heavily with considerable loss to biodiversity due to anthropogenic activities and Hooghly estuarine system is not an exception to it. Major threats are pollution, habitat degradation, invasive species, water abstraction, irrational fishing etc. Hilsa exhibits a declining trend during last few years which needs to be addressed by studying interactions between abiotic and biotic factors on different levels of organization qualitatively and quantitatively. It is also related to important target species with focus on high impact anthropogenic habitat alterations like dams and barrages (Geist, 2011). The Farakka barrage is a matter of concern in context of hilsa fisheries. Throughout the species distribution range, substantial decline was noted posing question to habitat suitability with reference to spawning migration, spawning habitat, habitat quality of juveniles *etc*. There is need of regular monitoring of biology and ecology of fish, fishing practice and standardization of gears, capacity building for generation of awareness at fisher and public level.

Study of LWR and 'K' values are two important parameters in management of fishery resources as they provide information on the conditions under which organisms are growing and their respective life history (Froese *et al*., 2011 and Hossain *et al*., 2013). Studies on LWR of hilsa in Hooghly-Matlah estuaries were being carried out

by several workers during the last few decades (Sujansingani, 1957; De, 1986; Gupta, 1989; De and Datta, 1990, Reuben, 1992 and Dutta *et al.*, 2012). However recent studies are being lacking and the present work is an attempt to bridge the gap. It will be useful to analyse growth and fisheries dynamics of the species in the region.

Materials and methods

Fish samples of hilsa were collected month wise during June to December, 2013 from the commercial catch of Diamond harbour area, South 24-Parganas district of West Bengal. The collected samples were mainly caught by drift gill nets, boat seine, clap nets etc. having mesh size varied from 35-120 mm. The fish samples were transported in a plastic insulated box after preserved in ice to the laboratory of Department of Fishery Fishercies Resources Management, Faculty of Fishery Sciences (WBUAFS) Chakgaria, Kolkata for further analysis. The total length and weight of the samples were recorded at sampling site. Total length (TL) of each sample was measured to the nearest 1.0 mm with a standard scale and the individual body weight (BW) was measured to the nearest 0.1 g using a digital analytical balance. A total 245 number of samples were examined with length ranged from 210 to 420 mm and body weight 115 to 775 gram respectively. The non linear equation in the form of (Le Cren, 1951), which explains the length and weight relationship of fishes, was followed in the present study. The equation is log transferred for linear form with Log W = Log a + b Log L. The significance of the exponent (b) was tested with fisher 't' test. The relative condition factor was found by the formula, Kn = Wo / $\hat{W}$, where Wo is observed weight and $\hat{W}$ is calculated weight (Le-Cren, 1951).

Results and discussion

Length-weight relationship

Length-weight relationship of *Tenualosa ilisha* was recorded as W = 0.0000206 L 2.817 and the regression coefficient 'r' value was 0.892 (Fig. 1) in the present study. The exponent did not vary significantly ($t = 2.817$, $P<0.05$) from 3 which indicated isometric growth of the fish. The value of exponent 'b' in equation W = aLb usually lies between 2.5 to 4.0 (Martin, 1949). Mitra (2001) reported the 'b' values in different fish species of Hooghly-Matlah estuary which ranged from 2.9615 to 3.3689.

The 'b' value of 2.817 of this study bears similarity with the earlier works of Gupta (1989) and Reuben (1992). The comparative estimated LWR of *T. ilisha* by different authors conducted on Hooghly-Matlah estuary is presented in Table 1. Sujansingani (1957) reported 'b' value of *Hilsa ilisha* in the tidal stretch of Hooghly was 3.04 to 3.13 in different seasons of the years 1949-1952. Pillay (1958) observed functional relationship between length and weight of hilsa from river Hooghly and stated the equation as W = 10.0242 e0.10927L for adult male and female. Ramakrishnaiah (1972) reported the isometric growth of hilsa in Chilka Lake with 'b' value of 3.125 in combined sexes. Rajyalakshmi (1973) found 'b' value was 3.26 in the length group of 370-587 mm and 'b' value of 2.81 in the length group of 60-189 mm in hilsa of the river Godavari. De (1986) observed 'b' values of hilsa from fresh water zone of Hooghly-Matlah estuary as 2.76 for fry stages and 2.96 for pooled matured male and female. Gupta (1989) reported 'b' value of 2.80 in it at Hooghly estuary system of West Bengal, India. Reuben (1992) reported the isometric growth of hilsa with 'b' value of 2.805 in Northeast coast of India. Rahman *et al.*, (2001)

Table 1. Comparison of LWR of Tenualosa ilisha by different authors from Hooghly-Matlah estuary system

Place	No. of sample	Sex	'a'	'b'	r2	K/Kn	Author
Hooghly	285	Pooled	0.0042843	3.133	0.986	0.707	Sujansingani
estuary	671	Pooled	0.0063853	3.040	0.977	0.757	(1957)
	1322	Pooled	0.0067098	3.050	0.972	0.816	
Hooghly-Matlah estuary	-	Pooled	-	2.96	-	-	De (1986)
Hooghly estuary	-	-	-	2.80	-	-	Gupta (1989)
Hooghly Matlah estuary	813	Pooled	4.823	2.961	0.978	-	De and Datta (1990)
Northern coast of India	1300	Pooled	0.0000369	2.805	-	-	Reuben (1992)
Northern Bay of Bengal	550	Pooled	0.000006	3.109	0.989	1.141 ± 0.004	Dutta *et al.* (2012)
Hooghly-Matlah estuary	245	Pooled	0.0000206	2.817	0.892	0.98-1.05	Present study

reported the 'b' value being 3.18 for *Tenualosa ilisha* in Bangladesh. Amin *et al.,* (2005) reported it as 2.878 in fish from the coastal region of Chittagang and the 'b' value in female and male hilsa of Hooghly estuary was 2.8474 and 3.2278 respectively. Dutta *et al.,* (2012) had also reported the 'b' value of fish being 3.109 with r´ value of 0.9898 from Northern Bay of Bengal in West Bengal. Roomiani *et al.*, (2014) reported the isometric growth of hilsa in coastal water of the northwest Persian Gulf, with 'b' value of 2.687. Flura *et al.*, (2015) found pooled 'b' value was 3.04 of hilsa from Meghna river, Bangladesh. Mohanty and Nayak (2017) reported 'b' and 'r' values of 2.99 and 0.9684 of *Hilsa ilisha* with isometric growth pattern from Chilika Lake of Odisha.

The 'b' value of 2.961 and 3.109 of hilsa was reported by De and Datta (1990) and Dutta *et al.,* (2012) respectively in Hooghly estuarine system. The LWR of *Tenualosa ilisha* in Hooghly-Matlah estuarine system indicated isometric growth resembling with earlier works which might be due to favorable environmental condition. The 'b' value of 2.817 and 'r' value of 0.892 for both the sexes in the present study bears similarity with the earlier works as being stated. However, the 'b' value in the present study was found to be relatively less compared to earlier works.

Relative condition factor (Kn value)

The monthly mean Kn value was fluctuated from 0.981 to 1.052 during the period of study, June-December (Fig. 2). It was found that the mean Kn value was maximum in the month of August (1.052) and minimum in the month of June (0.98). Relatively high Kn values was observed during August and September, which might be due to higher gonado-somatic index and less during December and June, which may be for less feeding intensity. The condition factor indicates an important aspect on feeding, spawning and other aspects related to the well being of the fish (Bagenal, 1987). The value of relative condition factor depend on physiological factors like maturity and spawning as well as environmental factors like food availability and feeding intensity (Brown, 1957). The value of Kn is directly affected if the fish does not obey the cube law. According to Le-Cren (1951), the value of Kn of more than 1

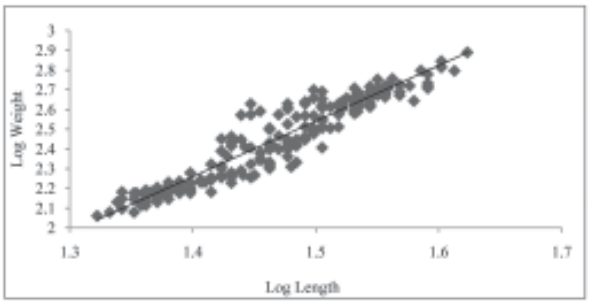

Fig. 1. Linear LWR of *Tenualosa ilisha* from Hooghly-Matlah estuary

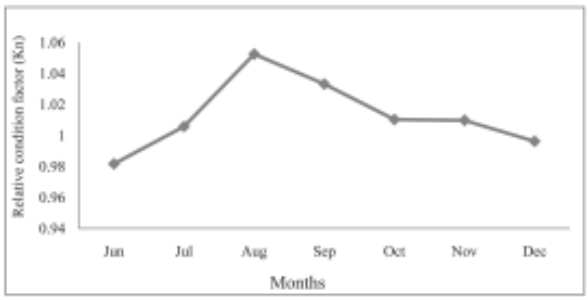

Fig. 2. Monthly variations in mean Kn value of *T. ilisha* in Hooghly estuary

indicate good health and less than 1 indicates relatively poor condition of the fish.

Sujansingani (1957) reported condition factor of *Hilsa ilisha* in the tidal stretch of Hooghly estuary as 0.707, 0.757 and 0.816 for the year 1949-50, 1950-51 and 1951-52 respectively. Ramakrishnaiah (1972) observed the condition of fish being very high in smaller size groups in Chilika Lake. Reuben (1992) had recorded higher Kn values in early stages of hilsa among different size groups and overall mean Kn value found to be at peak during July and December and lowest during February from fish samples collected from Diamond Harbour, Fraser Gung and Digha in West Bengal and Talsari from Odisha along the northeast coast of India. Sinha (1972) reported that monthly condition values are known to be influenced by mainly three factors *viz*. maturity of gonads, amount of undigested food in the alimentary canal and changes in amount of fat stored in body tissue. He had made comparisons between feeding intensity and Kn values. The high Kn value during peak spawning period and feeding periods have also been reported in fish like *Johnius vogleri* (Muthiah, 1982), *Tenualosa ilisha* (Khan *et al*., 2001) and *Liza tade* (Das, 2004). Dutta *et al*. (2012) reported Kn value of *Tenualosa ilisha* as 1.141 ± 0.004 from Northern Bay of Bengal. Mohanty and Nayak (2017) estimated Kn values of hilsa varied from 0.65 to 1.17 in 495-535 mm to 175-215 mm size groups respectively, indicating gradual decreasing of Kn values with increase in size groups from Chilika Lake, Odisha.

Conclusion

The Indian shad accounts for a lion's share in fish catch of Hooghly estuarine system and it also associated with livelihood of fisher of the locality. The annual catch is being fluctuating widely due to lack of adequate management and conservation measures. Common use of gears with small mesh size and anthropogenic pressure lead to adverse effects on its fisheries. However, there is need of regular study on biology of this fish to emerge timely management measures. The LWR of fish varies depending on the condition of life in the estuarine environment and this study can be useful for biological management of hilsa fisheries.

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