ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2016; 4(6): 49-58

www.fisheriesjournal.com
Received: 10-09-2016
Accepted: 11-10-2016

Asish Mondal
Department of Oceanography, Techno India University, Salt Lake campus, Kolkata, India

Abhijit Mitra
Department of Marine Science, University of Calcutta, 35 B.C. Road, Kolkata, India

Correspondence
Asish Mondal
Department of Oceanography, Techno India University, Salt Lake campus, Kolkata, India

Growth, food and feeding habit with prey preference of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) in brackishwater traditional impoundments of Sundarban, India

Asish Mondal* and Abhijit Mitra

Abstract
The present study was aimed to focus on growth, food and feeding habit with prey preferences of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) in brackish water ‘bhery’ for 12 months during August 2014 to July, 2015. Advance fry of *M. gulio* (1.78±1.5g, 5.6±0.54 cm) added to stock fishes @ 10000 fish/ha attained 82.5±3.20 g (20.5±0.98cm) in brackishwater impoundments. The fishes showed isometric growth ($W=0.007\ TL^{2.996}$) and good Condition factor (K=0.98±0.07). Feeding intensity observed lower during intense breeding season (May to June) and higher during the post-spawning season (August to April). *M. gulio* is a carnivorous fish as it used to prey mostly on zooplankton and animal food materials. According to the order of dominance, the major food groups in stomach were Copepods> Insect larvae> Myxophyceae> Rotifers & Cladocera> Crustacean parts> Bacillariophyceae> Chlorophyceae> Fish and prawn larvae> unidentified materials but on prey selectivity analysis, the fish actively selected on positive preference as Copepods> Insect larvae > Fish and prawn larvae> Rotifers & Cladocera> Crustacean parts and negative preference as Myxophyceae> Bacillariophyceae> Chlorophyceae. Electivity analysis observed that Copepods, Insect larvae, Fish and prawn larvae were most preferred food items to the fish.

Keywords: *Mystus gulio*, growth, feeding ecology, prey selection, Sundarban

Introduction
Food and feeding habits of fishes have a great significance in aquaculture practice and it helps to species selection for culture which will utilize all the available potential food of the water bodies without any competition with one another but will live in association with other fishes [1]. Food habits and feeding ecology research are fundamental to understand fish roles within their ecosystems since they indicate relationships based on feeding resources and indirectly indicate community energy flux, which allows inferring competition and predation effects on community structure [2, 3]. Quantitative and qualitative changes of food are useful tools to define the diet of a particular fish species [4, 5]. Determination of the prey type are feeding preference, availability of prey, prey mobility and its distribution in the water column, catching efficiency of the predator, water temperature and turbidity [6-8]. Food habit with prey preference has implications at the individual [9], population [10], and community levels [11].
Mystus gulio (Ham. 1822), commonly known as ‘long whiskered catfish’ of family Bagrid is euryhaline catfish, occurring mostly in estuarine tidal brackishwater and also in freshwater [12, 13]. The adults were found in larger water bodies (rivers and streams) with mud or clay substrates, and rarely occurred in smaller streams [14]. The species, *M. gulio* is very common in the ponds, canals and beels of all over India as well as widely distributed throughout the Indian subcontinent including China, Bangladesh, Sri Lanka, Indonesia, Vietnam, Pakistan, Nepal, Java, Thailand, Malaysia and Myanmar [15-21]. In West Bengal, the low-lying lands near estuaries and deltaic areas enclosed by embankments called "bheries" are used for traditional finfish cultivation, especially during rains [22]. This fish species is widely cultured in paddy fields and brackish water areas of deltaic Bengal, where it forms a valuable culture fishery [23]. Owing to its good delicious taste, *M. gulio* has a good market demand as food fish [24, 25]. Recently this fish species entered in ornamental fish markets and exported as indigenous ornamental fish from India [26].

No such documentation has been investigated from Hooghly-Matla estuarine complex, popularly known as 'Sundarbans' in spite of being a highly potential and ecologically important area where *M. gulio* is a commercially important catfish in brackishwater aqua farming. The present investigation aims to determine variation in abundance of food of *M. gulio* along with differences monthly variation in the diet. This culture also assessed to study the growth performance, feeding ecology and food preferences of *M. gulio* in extensive poly-culture system in Sundarbans.

Materials and Methods

The experiment was carried out at Paschim Dwarakapur village (21.754143–21.755640^{0}N, 88.325473–88.325563^{0}E) of Patharpratima block in South 24 Parganas district of West Bengal, India for the period of one year from August 2014 to July, 2015 (Figure. 1). The selected area is situated within the Hooghly-Matla estuarine complex popularly known as 'Sundarbans'. Three traditional brackishwater tide-fed impoundments (0.2 ha) locally called as 'Bhery' situated at the bank of a creek of 'Saptamukhi' river were selected. Estuarine available *M. gulio* seeds of Sundarban area were stocked at 10000 individual/ha in brackish water tide-fed impoundments. About 20-30% water was exchanged in every lunar cycle depending on the tidal amplitude throughout the rearing period following common practice. Fish feed was not applied in the impoundments. Lime Stone Powder was applied at 200 kg/ha during first week of every month. Samplings have carried out during early morning in between 8.00 am to 9.00 am. Fish samples and water were collected from three impoundments to eliminate any possible biasness. Both fish and water samples were preserved in ice and those were carried to laboratory for subsequent analysis.

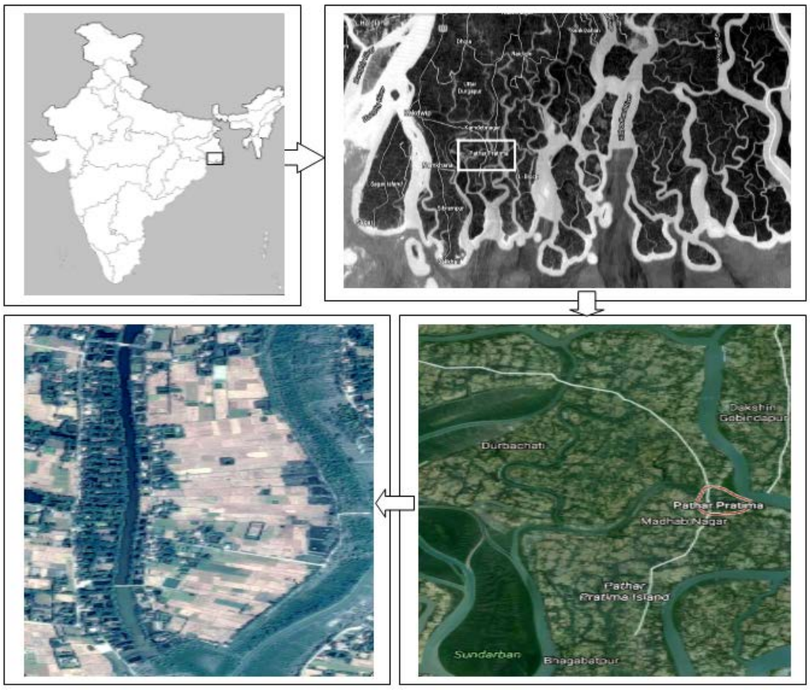

Fig 1: Location of three traditional brackishwater impoundments (●) of Paschim Dwarakapur at Patharpratima Block in Sundarban, India.

Water quality parameters such as water temperature, pH, dissolved oxygen (DO), alkalinity, nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N) and phosphate-phosphorus (PO_4-P) were measured following standard methods [27]. Salinity was recorded using a refractometer (ATAGO, Japan). On monthly basis plankton samples were collected by filtering 50L of water through bolting silk plankton net (mesh size 64 µm). Plankton concentrates were immediately preserved in 5% buffered formalin and one ml aliquot were then placed in to Sedgwick-Rafter counting cell for number count. Plankton and suspended constituents were identified and counted following Jhingran *et al.* [28] and Prescott [29].

Ten fishes from each of three ponds were collected during the 1st week of each month i.e. 30 fish in a month and total 360 fish samples for three ponds were collected and analyzed during the 12 months of culture period. Gravimetric data, such as, total length (TL, cm) was measured using a slide caliper, while body weight (W, g) was measured using a digital electronic balance. Daily weight gain (DWG) was calculated following the formula:

$$DWG = \frac{W_f - W_i}{t}$$

Where W_f and W_i are the average final and initial weight at time *t*.

Specific growth rate (SGR) was calculated using the conventional equation:

$$SGR = \frac{\ln w_f - \ln w_i}{t} \times 100$$

Where W_f and W_i are the average final and initial weight at time *t*.

The mathematical relationship between length and weight was calculated using the conventional formula [30]:

$$W = a.TL^b$$

Where *W* is fish weight (g), *TL* is total length (cm), '*a*' is the

proportionality constant and 'b' is the isometric exponent. The parameters 'a' and 'b' were estimated by non-linear regression analysis.
Fulton's condition equation was used to find out the condition factor [31]:

$$K = \frac{\overline{w}}{(\overline{TL})^3} \times 10^2$$

Where K is the condition factor, $\overline{w}$ is the average weight (g) and $\overline{TL}$ is the average total length (cm)
After gravimetric measurements, the stomach of fishes were removed intact by cutting above the cardiac and below the pyloric sphincters and preserved in a vial with 4% formalin. The stomach fullness degree was assessed by visual estimation and classified as gorged, full, 3/4 full, 1/2 full, 1/4 full, little and empty [32].
The data have used to calculate the monthly fullness index (FI) to determine the percentage of feeding intensity:

$$\text{FI} = \frac{\text{Numer of gut with same degree of fullness}}{\text{Total number of gut examined}} \times 100$$

Then the stomach content was transferred into fixed volume of 4% formalin solution. From every vial one ml stomach contents were then placed in to Sedgwick-Rafter counting cell and plankton constituents were identified and counted [28, 29].
On the basis of Percentage of occurrence [33] and Points method [34], stomach content was analyzed.
The food items of stomach were categorized as Chlorophyceae, Myxophyceae, Bacillariophyceae, Insect parts & larvae, copepods, Rotifers & Cladocera, Fish parts & larvae, unidentified materials and Crustacean parts. Numeric percentages of each group were evaluated. To determine the dominant food items, results of the percentage of occurrence and mean of the points allotted to individual prey encountered in a group were combined to yield the Index of Preponderance (IP) proposed by the following equation [34]:

$$IP = \frac{V_1 O_1 \times 100}{\sum V_1 O_1}$$

Where, V_1 = Volume of the particular food item, O_1 = Occurrence of the particular food item IP = Index of Preponderance
The percentage compositions of food types in the stomach falling under different groups were then compared with that of fish impoundments to evaluate prey preferences. Prey preferences were determined by the Ivlev Electivity Index using the following formula [35]:

$$E = \frac{r - p}{r + p}$$

Where, r=percentage of dietary item in ingested food, p= percentage of prey in the environment.
Differences in final length, final weight, DWG, SGR and exponential value of LWR were determined by analysis of variance with the General Linear Model procedure using SPSS for Windows v.17.0 programmed (SPSS Inc Chicago IL USA). Duncan's Multiple Range Test [36] was used for comparison of impoundments. All data have been expressed as mean ± standard error (SE).

Results
The analyzed of Physico-chemical parameters of three impoundments have been presented in Table 1. Water temperature during the study period ranged between 14.7±1.2 ºC to 33.6±1.7 ºC. Highest temperature was recorded during the month of April (34.2 ⁰C) and lowest during December (14.5 ⁰C). Salinity fluctuation showed wide variation in three studied impoundments throughout the culture period and it was maximum (19.8±4.2ppt) during deep summer (May) and minimum (4.2±3.2ppt) during full rainy season (August). Dissolved oxygen (DO) and pH remained almost steady throughout the rearing period and ranged between 5.87 to 9.58 ppm and 7.85 to 8.50, respectively. Concentration of nitrogenous metabolites like Nitrite-nitrogen (NO_2-N) and total ammonia nitrogen (NH_3-N) were recorded between 9.33±2.5-24.47±5.8 g/L, and 21.83±5.7-44.08±5.4 µg/L respectively. Concentration of nutrients like nitrate-nitrogen (NO_3-N) and phosphate-phosphorous (PO_4-P) ranged between 69.62±6.9-111.04±9.8 and 21.58±5.8-43.27±6.5µg/L respectively. Phytoplankton and zooplankton concentration were significantly higher (p<0.05) in impoundment 1 than others.

Table 1: Physico-chemical parameters of three traditional brackishwater impoundments used in the present Study.

Water parameters	Impoundment 1	Impoundment 2	Impoundment 3
Water temperature (ºC)	29.9±1.72	29.9±1.73	29.7±1.94
pH	8.04±0.23^a	7.78±0.31^c	7.92±0.25^b
DO (mg L^{-1})	6.06±0.42^a	5.98±0.52^b	5.69±0.52^c
Salinity	12.89±5.19	13.33±4.45	12.06±5.34
Alkalinity	168.9±4.25^a	165.9±3.51^b	160.00±5.23^c
NO_2-N (µg L^{-1})	16.55±5.83	15.91±5.62	16.91±6.63
NH_4-N (µg L^{-1})	30.76±5.61	31.19±7.91	34.89±6.27
NO_3-N (µg L^{-1})	93.12±15.41	92.66±11.14	92.97±8.94
PO_4-P (µg L^{-1})	32.07±13.43	31.98±11.98	31.97±12.74
phytoplankton (numbers/L^{-1} ×10^3)	15.89±1.62^a	15.12±1.94^b	14.05±1.73^c
Zooplankton (numbers/L^{-1}×10^3)	3.49±0.25^a	2.98±0.23^b	2.88±0.17^c

Means bearing different superscripts indicate statistically significant differences in a row (p<0.05); Values are expressed as mean ± SE (n=10 for each impoundments every month)

Percentage occurrences of planktonic and other suspended food components in the studied impoundments are presented in Figure 2. According to the order of dominance, the most abundant phytoplankton groups in three impoundments were

Chlorophyceae, Myxophyceae and Bacillariophyceae. On other hand the dominant zooplankton groups in three impoundments were Copepods, Insect larvae, Rotifers & Cladocera, Crustacean larvae and Fish and prawn larvae. The most abundant genera found under Chlorophyceae were *Enteromorpha*, *Tetraedron*, *Pediastrum*, *Chlorella*, *Ulothrix*, *Volvox*, *Cladomorpha* and *Coelastrum*. The other less abundant genera of Chlorophyceae were *Ankistrodesmus*, *Crucigenia*, *Scenedesmus*, *Pandorina*, *spirogyra* and *Chaetomorpha*. Numeric percentage composition of Chlorophyceae ranged between 12.10 to 37.41% (average 25.97±2.75%) with minimum and maximum during July and March respectively. *Anabaena, Nostoc, and Spirulina* the other Myxophyceae was the most dominant genera. *Chroococcus*, *Gloeocapsa*, *Oscillatoria* and *Merismopedia* were also recorded the other genera of Myxophyceae. The percentage composition of Myxophyceae constituted between 8.96 to 25.06% (average 17.94±1.63%) throughout the culture period. Among Bacillariophyceae, *Coscinodiscus*, *Navicula*, *Nitzschia*, *Basilaria*, *Cyclotell*, *Diatoma* and *Melosira* were found to be the most abundant genera. In addition *Cymbella, Gyrosigma*, *cyclotella and Melosira* were also measured. Numeric percentage of Bacillariophyceae ranged between 0.55 to 19.52% (average 12.01±1.45%). Percentage of diatom observed to be lowest during March and highest during February. Among Zooplankton groups, Copepods were most dominant in water column. *Cyclops*, *Metis*, *Microsetella*, *Harpecticus*, *Corycaeus* and *Oithona* were found. Copepods were ranged between 5.06 in November to 20.20% in April (average 11.84±1.22). Percentage of Insect larvae was varied between 2.04 in February to 24.88% in June (average 11.49±2.10). Among Rotifers & Cladocera, *Asplanchna, Daphnia and Brachionus* were dominant genera. Numeric percentage of Rotifers & Cladocera was ranged between 4.21 in December to 20.02% in July (average 9.20±1.57) and 2.50 in May to 21.00% in June (average 8.16±1.64) in Crustacea larvae. The mean percentage of Fish and prawn larvae was 16.56±0.88. Unidentified materials such as Planktonic or non-Planktonic part also considered. The mean percentage of unidentified materials was 1.83±0.44%.

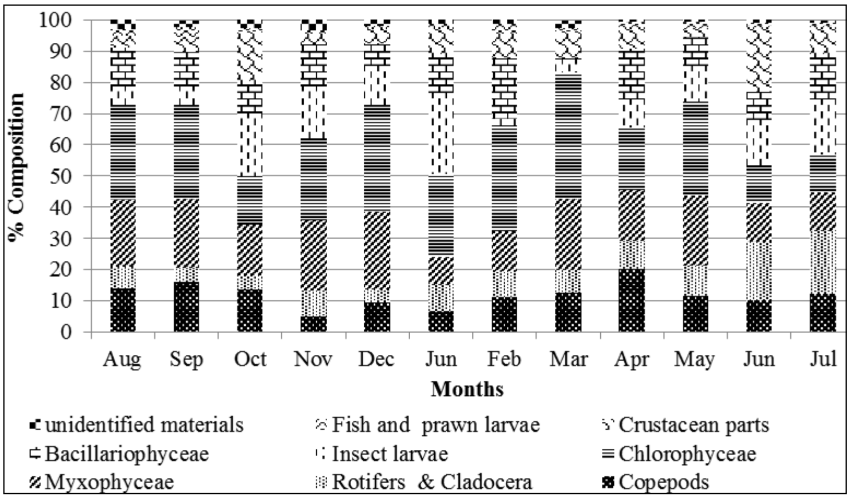

Fig 2: Numeric percentage occurrences of suspended food materials present in traditional brackishwater impoundments of Sundarban.

Fish growth of *M. gulio* in terms of weight (w, g) and length (TL, cm) during culture period is presented in Figure 3. After 360 days of rearing, catfishes was grown from 1.78±1.5g (5.6±0.54 cm) to 82.5±3.2g (20.5±0.98 cm). Average daily weight gain (DWG) calculated was 0.24±0.03 g which ranged between 0.10 (October) and 0.37g day^{-1} (March). Average specific growth rate (SGR) recorded was 1.16±0.29% day^{-1} which varied between 0.51% (June) and 3.39% day^{-1} (August). Exponential value (b) of Length-Weight Relationship (LWR) was 2.996 indicating isometric growth for this species (Figure 4). The mean value of the Fulton's condition factor (K) was 0.98±0.07 (Figure 5).

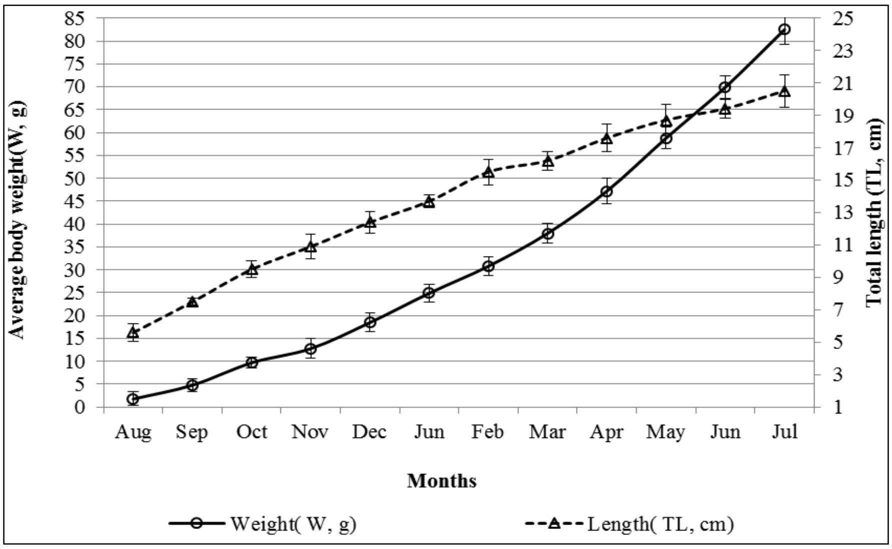

Fig 3: Growth increment of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) reared in traditional brackishwater impoundments of Sundarban.

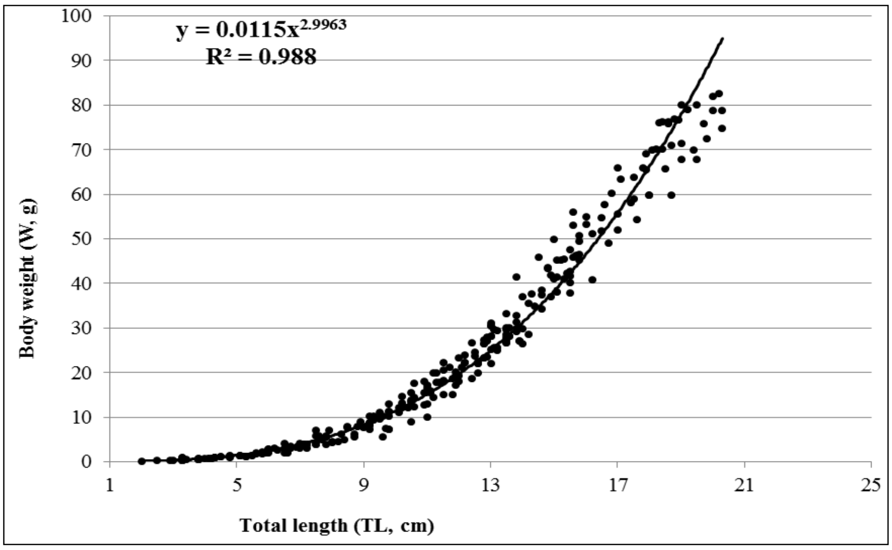

Fig 4: Length-weight relationship of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) cultured in traditional brackishwater impoundments of Sundarban.

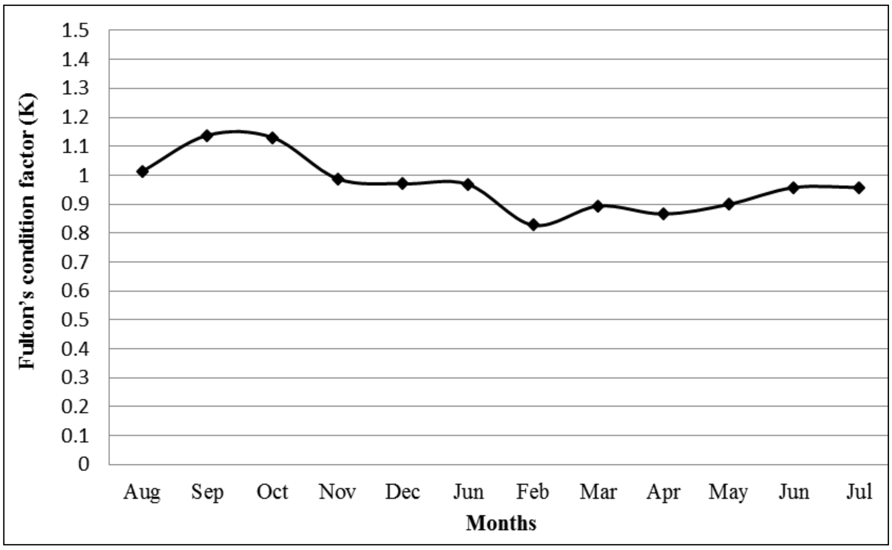

Fig 5: Fulton's condition factor (K) of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) reared in studied brackishwater impoundments of Sundarban.

Stomach fullness has been categorized in to seven classes namely: gorged, full, ¾ full, ½ full, ¼ full, little and empty. The results of monthly analysis of stomach fullness have been showed in Table 2**.**

Table 2: Feeding intensity of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) during the study period.

Months (2014-2015)	Gorged	Full	3/4 Full	1/2 Full	1/4 Full	Little	Empty
Aug	18	2.8	12.6	24.9	7.05	10	25
Sep	12.8	2.1	6.9	25.5	32.2	15	5.2
Oct	8.9	15.6	6.9	16.5	22.2	19.3	10.5
Nov	12.7	21	2	22	16.3	26	0
Dec	21	16.7	16.7	11.1	21.2	11.1	2
Jun	35	25	0.32	14.35	6.3	14.5	5
Feb	12.2	37	12	14	24.8	0	0
Mar	15	10	24	20	20	11	0
Apr	22.4	25.5	12.2	12	12.3	8.7	6.9
May	2.5	5.5	20.31	12	26.64	17	16
Jun	6.5	1.5	1.9	7.6	7.3	28.97	45.89
Jul	2	2	1.8	17.9	6.9	36.9	32.35
Feeding intensity	14.1	13.7	9.8	16.5	16.9	16.5	12.4

Food and feeding habit of the fish was studied by examining the gut contents as per standard procedures described by Windell and Bowen [37]. Monthly data of stomach content analysis following percentage of occurrence and points method has been represented in Figure 6 and Figure 7**.** The dominant phytoplankton groups in the fish stomach according to the order of dominance were Myxophyceae (6.58 in October–16.74% in March; 12.55±0.94%), Bacillariophyceae (1.64% in September–13.80 in November; average 7.74±1.05%) and Chlorophyceae (0.99% in March–13.47% in July; average 6.06±1.18%). The dominant Zooplankton groups in the fish stomach according to the order of dominance were Copepods (13.84% in July–39.08% in October; average 25.31±2.12%), Insect larvae (4.12% in June –39.87% in May; average 21.36%), Rotifers & Cladocera (3.93% in May–19.58% in June; average 11.95±1.61%), Crustacean larvae (2.94% in August–21.92% in March; average 8.99±1.83%) and Fish & prawn larvae (0.97% in April–8.41% in September; average 3.31±0.68%). Numeric percentage of unidentified materials recorded was 0.00% in June to 7.1% in July (average 2.82±0.68%).

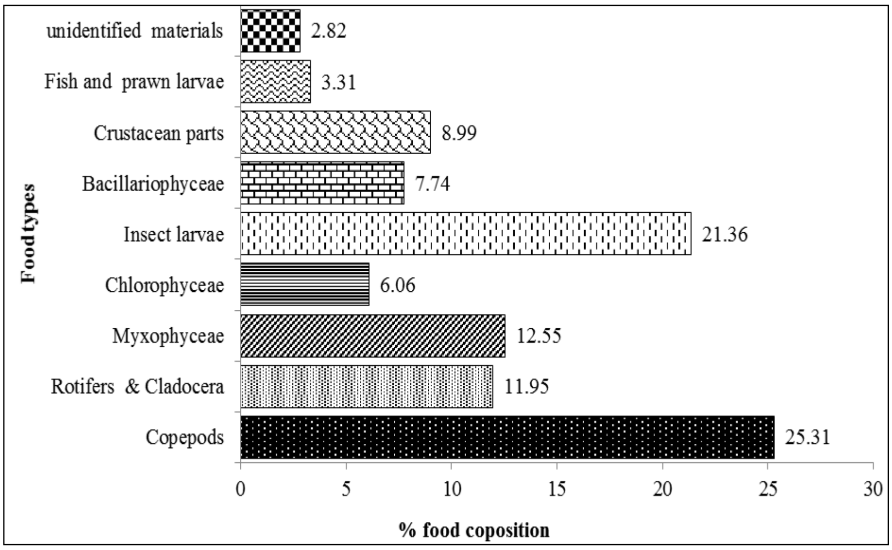

Fig 6: Proportions of food items in stomach of long whiskered catfish, *Mystus gulio* (Hamilton, 1822).

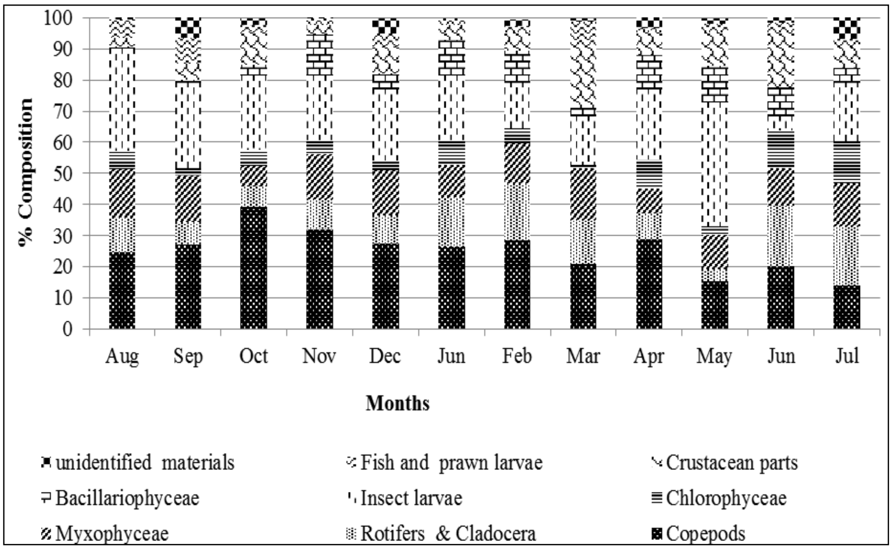

Fig 7: Numeric percentage occurrences of food items in long whiskered catfish, *Mystus gulio* (Hamilton, 1822) stomach.

Index of preponderance (IP) is presented in Table 3 & 4. The dominant phytoplankton groups in the fish stomach according to the order of dominance were Chlorophyceae (average 6.86±1.35%), Bacillariophyceae (average 6.11±1.32%) and Myxophyceae (5.76±1.62%) and zooplankton groups were Copepods (27.45±2.06%), Insect larvae (average 17.58±2.49%), Rotifers & Cladoceran (average 13.84±2.7%), Fish & prawn larvae (average 11.15±1.82%) and Crustacean parts (average 10.17±1.68%). The mean percentage of unidentified materials was 1.27±0.35% during culture period.

Table 3: Monthly variation in composition of different food items following percentage of points method in the gut content of long whiskered catfish, *Mystus gulio* (Hamilton, 1822) in brackishwater impoundments of Sundarban.

Months	Copepods	Rotifers & Cladocera	Myxo phyceae	Chloro phyceae	Insect larvae	Bacillario phyceae	Crustacean parts	Fish parts & prawn larvae	unidentified materials
Aug	28	12.9	3.9	10.9	10.9	11	12.00	8.9	1.9
Sep	30.98	19.9	15.9	8.9	9.06	1.23	3.39	9.32	0.9

Oct	40.56	3.72	2.2	11.37	16.21	11.37	6.74	7.95	0
Nov	22.06	13.06	7.36	13.4	14.41	5.4	15.81	8.14	0.7
Dec	23.91	9.42	12.9	7.35	18.21	7.35	10.35	10.96	0
Jun	20.2	19.55	8	2	9.23	12.61	4.88	21	2.9
Feb	27.93	21.25	12.01	2.55	10.12	2.55	18.71	3.21	1.98
Mar	39.99	29.99	0.11	2.77	12.45	2.77	7.26	3.89	0.97
Apr	22.39	7.05	2.2	2.19	32.11	2.19	17.85	10.9	3.4
May	24.62	14.98	2.2	4	30.11	0.89	13.20	9.5	0
Jun	20.8	3	0.18	13	21.29	11	10.00	18.9	2
Jul	27.9	11.2	2.1	3.9	26.8	5	1.81	21.11	0.5

Table 4: Index of preponderance (IP) of food items in the gut content of *Mystus gulio*.

Food classes	Total points (V), %	Occurrence (O), %	V×O	∑VO	IP	Grade
Insect larvae	27.45	25.31	694.52	1432.0	48.50	I
Rotifers & Cladocera	13.84	11.95	165.29		11.54	III
Myxophyceae	5.76	12.55	72.22		5.04	V
Chlorophyceae	6.86	6.06	41.59		2.90	VII
Copepods	17.58	21.36	375.44		26.22	II
Bacillariophyceae	6.11	7.74	47.30		3.30	VI
Fish and prawn larvae	10.17	8.99	91.39		6.38	IV
Crustacean parts	11.15	3.31	36.88		2.58	VIII
unidentified materials	1.27	2.82	3.58		0.25	IX

According to Ivlev's equation [38], the values of electivity index (E) are between +1 and –1. Positive value indicates a positive selectivity of a type of food while negative value ones indicates a negative selectivity. Electivity index (E) of different food constituents is presented in Figure 8**.** Among Zooplankton groups, E value for Copepods was ranged between +0.10 to +0.73 with minimum range during July and maximum range during November. The average E value of Copepods was +0.37±0.06. E value for Insect larvae was ranged between –0.52 to +0.75 with minimum range during June and maximum range during February. The mean E value of Insect larvae was +0.31±0.12. Electivity index value of Fish and prawn larvae was varied between–0.18 to +0.69 with lowest value during February and highest value during March. The average E value of Fish and prawn larvae was +0.30 ±0.08. E for Rotifers & Cladoceran ranged –0.43 to +0.40 with lowest during May and highest during February. The mean E value of Rotifers &Cladoceran was +0.15±0.07. E value for Crustacean larvae ranged between +0.27 and+0.63 with minimum range during June and maximum range during May. The average E value of Crustacean parts was +0.05±0.08. All Zooplanktons groups were positively selected. Among Phytoplankton groups, E value for Myxophyceae ranged was between –0.41 to+0.10 with low during October and high during July. The average E value of Myxophyceae was –0.15±0.08. Electivity index value of Bacillariophyceae varied was between –0.75 to +0.71 with lowest value during September and highest value during March. The mean E value of Bacillariophyceae was –0.18±0.12. E for Chlorophyceae ranged –0.95 to +0.09 with minimum during November and maximum during July. The average E value of Chlorophyceae was –0.57±0.10. All Phytoplankton groups were negative selection.

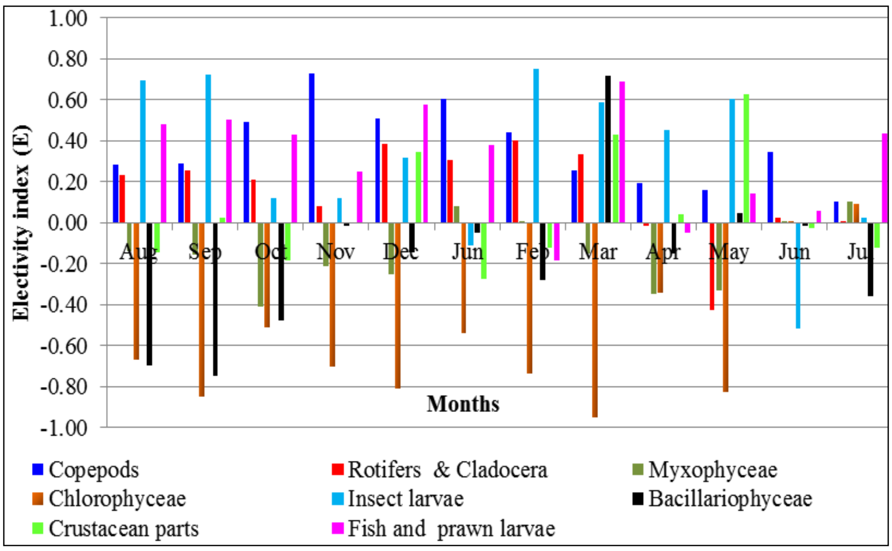

Fig 8: Prey electivity index (E) of suspended food materials consumed by long whiskered catfish, *Mystus gulio* (Hamilton, 1822).

Discussion

Good water quality is very essential to maintain optimum growth and survival of aquatic organism under the culture. Recorded water quality parameters were within optimum ranges for brackish water aquaculture [39] which differed significantly (P<0.05) with time. Water temperature is an important component, which greatly influences and directly affects the pond dynamics. Temperature has a pervasive controlling effect on the rates of both food consumption and metabolism and so has effects on growth [40]. In Hooghly-Matla estuarine system as well as Sundarban, salinity and temperature have been found to be the most significant abiotic factors determining the fishery resources of this system [41]. Concentrations of toxic metabolites like nitrite-nitrogen (NO_2-N) and ammonia-nitrogen (NH_4-N) remained lower than the critical level and concentrations of nutrients like nitrate-nitrogen (NO_3-N) and phosphate-phosphorous (PO_4-P) was much lower than fertilized ponds reported from Sundarban [42]. Estuarine and coastal regions are extremely productive because they receive inputs from several primary production sources and detritus food webs [43]. Being non-fed natural farming system depends only on the natural productivity and commercial feed or fertilizer is not applied, such non-fed farming system can be considered as representative of the natural environment and co-existence of Planktonic community structure resembling the natural environment is expected.

Food types as well as feeding habits of a specific species are significant in relation to their growth and propagation under specific biological conditions. In brackishwater earthen nursery ponds, *M. gulio* attained average body weight up to 460.02±4.54 mg (31.15±1.62 mm) with 89.25±5.41% survival during 42 days of rearing at fed system where initial ABW and stocking density were 3.33 mg (4.53±0.83 mm) and 200 individual/sqm respectively [44]. Stocking density is critical factor for many aquatic animals for their growth and survival [45]. Siddiky *et al.* [46] have observed that growth increment of *M. gulio* up to 12.42±0.11 with 64.41% survival during 150 days rearing where stocking density was 8/sqm. The fish growth was might be better than earlier observations. When the b parameter is equal to 3, growth is isometric and when it is less than or greater than 3, it is allometric [47]. More specifically, growth is positive allometric when organism weight increases more than length (b>3), and negative allometric when length increases more than weight (b<3) [48]. The isometric exponent (b) of length weight relationship in the present study indicated isometric growth of Bagrid catfish. From West Bengal isometric growth pattern of *M. gulio* has been reported by Pantulu [23] and Begum *et al.* [25].

Higher feeding frequency in bigger fishes than smaller ones may be attributed to the fear of potential predators by the smaller fishes while feeding as they are more vulnerable and would rather feed more cautiously than their bigger counterpart [49]. Large fish may require more food to obtain the necessary more energy for reproductive activity than smaller ones require for growth. Moreover, a wider mouth opening in larger fish helps to ingest relatively large quantity food items at a time [50].

In the present study 'empty' stomach of *M. gulio* had during April to June (pre-spawning months). After July, the fish fed intensively; higher percentages of the fishes were observed either "full" or "gorged" stomachs.

Feeding activity of *M. gulio* corresponds to its breeding season while lowest feeding activity is observable in the intense breeding season (May to June), highest feeding activity is in correspondence to the post-spawning season (August to April). Such an inverse relationship between feeding and breeding cycles has been reported by Homans and Vladykov [51]. Pantulu [23] has reported a similar observation from his studies on the feeding intensity of *M. gulio* in the Hooghly estuary. *M. gulio* is a carnivorous fish [13, 23, 52, 53].

The adults prefer to feed insects and crustaceans where the immature and juveniles prefer to feed on diatoms, copepods, cladocera and rotifers [1]. Yusuf and Majumdar [54] have reported *M. gulio* as omnivorous fish with inclination towards carnivore as animal foods cover 79% of the overall diet of this fish; among animal food, nauplius larvae and *Brachionus sp.* have been reported as the main food items with higher frequency of occurrence. Debris, zooplanktons, zoobenthos, other benthic organisms, fish eggs and larvae were the food items of juveniles and adults of *M. gulio* [55]. Similarly the present study in backwater traditional impoundments of Sundarban observed that the stomach content of this fish was abundant on the basis of numeric occurrences with Copepods>Insect larvae, Myxophyceae> Rotifers& Cladocera> Crustacean parts> Bacillariophyceae> Chlorophyceae> Fish and prawn larvae> unidentified materials. Overall animal food items were more in amount than plant food items.

Regarding the complex nature feeding ecology of *M. gulio* in brackishwater impoundments, electivity index (E) analysis is essential to throw some light on fish's food preference. According to Ivlev's equation [38] E values ranged from -1 to+1, where -1 to 0 stands for negative selection, while values 0 to +1can be indicate as positive selection of that prey item. In Subsequent investigation Lazzaro [56] has suggested that a true positive or negative prey selection can be interpreted only at values >0.3 or <-0.3 respectively. In the present experiment, *M. gulio* actively selected Copepods as most preferred prime food material (Figure 8). Being 5th dominant Planktonic constituent in water body, insect larvae ranked second according to the prey electivity analysis. In spite of ranking 9th in the order of dominance in the water and 8th rank in stomach fish and prawn larvae was 3rd consuming food items on the basis of prey selection. Though 6th in the order of dominance in the water column and 4th rank in stomach content, Rotifers &Cladocera was 4th ranked consuming food items but non-significantly positive prey selective item (non-significant positive selection; <0.30) to the fish. Crustacean parts were 5th preferred prey types though 7th ranked in water column. It was positively selected but non- significant (<0.30). Rotifers & Cladocera and Crustacean parts were not at all actively selected and probably swallowed mechanically during intake of other foodstuffs. In the phytoplankton groups, Myxophyceae, Bacillariophyceae and Chlorophyceae were totally negative prey items to fish. Being 1st dominant Planktonic constituent in water body, Myxophyceae ranked 6th to the prey electivity analysis (non- significant <0.30). According to the numeric order of dominance in water, Bacillariophyceae was 3rdin water but 7th position of prey selection (non-significantly<0.30). Chlorophyceae was significantly negative prey item to the fish.

Conclusion

Present investigations suggest that long whiskered catfish has good growth potential and can be considered for brackishwater poly farming. *M. gulio* is a carnivorous fish as it used to prey mostly on zooplankton and animal food materials. Stomach contentment analysis indicates that long whiskered catfish fed on Copepods>Insect larvae> Myxophyceae> Rotifers &Cladocera> Crustacean parts> Bacillariophyceae> Chlorophyceae> Fish and prawn larvae> unidentified materials. Order of positive preference of different food items by the species is as Copepods> Insect larvae> Fish and prawn larvae> Rotifers & Cladocera> Crustacean parts and negative preference as Myxophyceae> Bacillariophyceae> Chlorophyceae.

Acknowledgement

The authors are extremely grateful to the authorities of Techno India University, Salt Lake, Kolkata for providing laboratory facilities. The authors are deeply thankful to the faculty members, Professors, supporting staffs and colleagues for their continuous encouragement, priceless research comments, valuable guidance and important suggestions.

References

1. Begum M, Alam MJ, Islam MA, Pal HK. On the food and feeding habit of an estuarine catfish (*Mystus gulio* Hamilton) in the south-west coast of Bangladesh. Univer. J Zool. Soc. Rajsha. Univ. 2008; 27:91-94.
2. Hajisamaea S, Choua LM, Ibrahim S. Feeding habits and trophic organization of the fish community in shallow waters of an impacted tropical habitat Estuarine. Coast. & Shelf Sc, 2003; 58:89-98.
3. Krebs CJ. Ecological methodology Benjam in Cummings. Menlo Park CA, 1999, 620.
4. Shamsi MK, Niamat R, Jafri AK. Planktonic biota and food selection of freshwater fish *puntius sophore* in a perennial and sewage-fed tropical fishpond from Northern India. Egypt. J Appl. Sc. 1995; 10:217-224.
5. A1-Ake1 AS, A-Kahem HF, Shamsi M K, Ahmed Z. Selection of food in various size groups of Nile Tilapia *Oreochromis niloticus* (L.) in WadiHaneefahstreame Saudi Arabia. Pak. J Zool. 1996; 27:271-275.
6. Shaw GW, Pankhurst PM, Purser GJ. Prey selection by green back flounder *Rhombosolea* (Günther) larvae. Aquaculture, 2003; 228:249-265.
7. Hagiwara A, Suga K, kazawa A, Kotani T, Sakakura Y. Development of rotifer strains with useful traits for rearing fish larvae. Aquaculture, 2007; 268:44-52.
8. Nunn AD, Harvey JP, Cowx IG. The food and feeding relationships of larval and 0+ year juvenile fishes in lowland rivers and connected water bodiesII Prey selection and the influence of gape. J Fish Biol, 2007; 70:743-757.
9. Fraser D, Huntingford FA, Adams CE. Foraging specialisms, prey size and life-history patterns a test of predictions using sympatric polymorphic Arcticcharr (*Salvelinus alpinus*). Ecology Freshwater Fish published online, 7th June, 2007.
10. Herwig BR, Zimmer KD. Population ecology and prey consumption byfathead minnows in prairie wetlands importance of detritus and larval fish. Ecol. Freshwater Fish, 2007; 16:282-294.
11. Schleuter D, Eckmann R. Generalist versus specialist the performances of perch and ruffe in a lake of low productivity. Ecol. Freshwater Fish published online, 2007.
12. Jhingran VG. Fish and Fishes of India. Hindustan Publishing Corporation (India), 3rd edition 1997; xiii+727.
13. Pandian TJ. Feeding and reproductive cycles of the fish *Mystus gulio* in the Cooum backwaters, Madras. Ind. J Fish. 1996; 13(1, 2):320-333.
14. Talwar PK, Jhingran AG. Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay and Calcutta, 1991; 1, 2:1063.
15. Day F. The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma, and Ceylon. William Dowson and Sons London. 1878, 778.
16. Weber MCW, de Beaufort LF. The fishes of the Indo-Australian archipelago II Malacopterygii Myctophoidea Ostariophysi: I Siluroidea. Egipt. J Brill Ltd. Leid. 1913, 404.
17. Smith HM, Schultz LP. The freshwater fishes of Siam, or Thailand. Washington United States Government Printing Office, 1945, 622.
18. Pethiyagoda R. Freshwater fishes of Sri Lanka. The Wildlife Heritage Trust of Sri Lanka, Colombo, 1991, 362.
19. Roberts TR. The freshwater fishes of Java, as observed by Kuhl and van Hasselt in 1820-1823. Zoologische Verhandelingen, 1993; 285(1):1-94.
20. Kottelat M. Freshwater fishes of northern Vietnam. A preliminary check-list of the fishes known or expected to occur in northern Vietnam with comments on systematics and nomenclature. The World Bank, Environment and Social Development Unit East Asia and Pacific region Washington DC 2001, 123.
21. Senarathne P, Pathiratne KAS. Accumulation of heavy metals in a food fish, *Mystus gulio* inhabiting Bolgoda Lake, Sri Lanka. Sri Lanka J Aqua. Sc. 2007; 12:61-75.
22. Pillai VN, Menon NG. A review of marine finfish culture experiments in India Marine Fisheries Research Institute (ICAR) Tatapuram P O Cochin -682 014, 2000.
23. Pantulu VR. Determination of age and growth of *Mystus gulio* (Ham.) by the use of pectoral spines, with observations on its biology and fishery in the Hooghly estuary. Proceed. Nat. Inst. Sc. Ind, 1961; 27:198-225.
24. Haniffa MA. Native catfish culture-a technology package for fish farmers. Aquaculture Asia Magazine, 2009; 14(3):22-24.
25. Begum M, Pal HK, Islam MA, Alam MJ. Length-weight relationship and growth condition of *Mystus gulio* (Ham.) in different months and sexes. Univ. J Zool, Rajshahi Univ, 2010; 28:73-75.
26. Gupta S, Banerjee S. Indigenous ornamental fish trade of West Bengal. Narendra Publishing House New Delhi, 2014, 63.
27. APHA. Standard Methods for the Examination of Water and Wastewater 20th ed. American Public Health Association Washington DC USA, 1998.
28. Jhingran VG, Natarajan AV, Banerjee SM, David A. Methodology on reservoir fisheries investigation in India. Central Inland Fisheries Research, Institute Barrackpore India, Bulletin 1969, 12-10.
29. Prescott. Algae of the Western Great Lakes Area.WMC Brown Company Publishers Dubuque IA USA, 1961, 990.
30. Pauly D. Fish population dynamics in tropical water a manual for the use with programmable calculators ICLARM. Studies and reviews Manila, The Philippines, Dept. Omar El-Mukhtar. University, 2012, 122.
31. Chow S, Sandifer PA. Differences in growth, morphometric traits, and male sexual maturity among Pacific white shrimp *Penaeus vannamei* from different commercial hatcheries. Aquaculture, 1991; 92:165-179.
32. Pillay TVR. A critique of the methods of study of food of fishes. J Zool. Soc. Ind, 1952; 4:181-199.
33. Hynes HBN. The food of freshwater sticklebacks

(*Gasterosteus aculeatus* and *pygosteuspungitius*) with a review of methods used in studies of the food of fishes. J Animal Ecol, 1950; 19:36-58.
34. Natarajan AV, Jhingran AG. Index of preponderance – a method of grading the food elements in the stomach analysis of fishes. Ind. J Fish. 1996; 8:54-59.
35. Jacobs J. Quantitative measurement of food selection – A modification of the Forage Ratio and the Ivlev's Electivity Index. Ecologia. 1974; 14:413-417.
36. Duncan DB. Multiple range and multiple F-test Biometrics, 1955; 11:1-42.
37. Windell JT, Bowen SH. Methods for study of the fish diets based on analysis of stomach content In Baganel T (Ed) Methods for assessment of fish production in fresh water IBP Handbook Blackwell Scientific Publications Oxford London, 1978; 3:219-254.
38. Ivlev VS. Experimental ecology of the feeding of fisheries. Yale University Press New Haven CT USA, 1961, 322.
39. Chakraborti RK, Sundaray JK, Ghoshal TK. Production of *Penaeus monodon* in the tide fed ponds of Sundarban. Ind. J Fish. 2002; 49:419-426.
40. Das SK, Saksena DN. Farm management and water quality in relation to growth of *Penaeus monodon* in modified extensive shrimp culture system. J Inl. Fish. Soc. Ind, 2001; 33:55-61.
41. Gopalakrishnan V. An assessment of the prawn fishery of the seaward reaches of the Hooghly estuary. J Mar. Biol. Assoc. Ind, 1974; 15:406-418.
42. Biswas G, De D, Thirunavukkarasu AR, Natarajan M, Sundaray JK, Kailasam M. Effects of stocking density feeding fertilization and combined fertilization-feeding on the performances of striped grey mullet (*Mugil cephalus* L.) fingerlings in brackishwater pond rearing systems. Aquaculture, 2012; 338-341:284-292.
43. Kennedy VS. Anticipated effects of climate changes on estuarine and coastal fishes. Fisheries, 1990; 15:16-24.
44. Begum M, Abdullah-Al Mamun, Pal HK, Islam MA, Alam MJ. Effects of stocking density on growth and survival of *Mystus gulio* in nursery ponds. Bangla. J Fish. Res, 2008; 12(2):179-186.
45. Rahman MM, Verdegem MCJ. Effects of intra- and interspecific competition on diet, growth and behaviour of *Labeo calbasu* (Hamilton) and *Cirrhinus cirrhosus* (Bloch). Appl. Ani. Behav. Sc, 2010; 128:103-108.
46. Siddiky MNSM, Saha SB, Mondal DK, Ali A, Washim MR. Optimization of stocking density of *Mystus gulio* (Brackishwater catfish). Int. J Natural & Soc Sc, 2015; 2:60-63.
47. Enin U. Length-weight parameters and condition factor of two West African Prawns. Rev d′Hydrobiology of Tropics, 1994; 27:121-127.
48. Wootton RJ. Fish ecology tertiary level biology. Blackie London, 1992, 212.
49. Akpan AW, Isangedighi IA. Aspects of the Feeding Ecology of three Species of *Pseudotolithus* (Sciaenidae) in the inshore waters of Southeastern Nigeria East of the Niger Delta Nigeria, J Aqu. Sc, 2004; 192:51-58.
50. Isangedighi I, Uudo PJ, Ekpo IE. Diet composition of *Mugil cephalus* (pisces: mugilidae) in the Cross River estuary Niger delta Nigeria. Nig J Agricul. Food & Env, 2009; 5(2-4):10-15.
51. Homans RES, Vladykov VD. Relation between feeding and sexual cycle of the haddock. Hsh. Research. Bd. Canada, 1954; 11:535-42.
52. David A. Sexual dimorphism, fecundity and food of the estuarine bagrid, *Mystus gulio* (Ham.). Proceed. Nat. Ac. Sc. Ind, 1963; 33(B):385-410.
53. Kaliyamurthy M, Rao KJ. Preliminary studies on the food and feeding habits of some fishes of the Pulicat Lake. J. Inl. Fish. Soc. Ind. 1972; 1:115-121.
54. Yusuf ZA, Majumdar PK. Morphology of the alimentary canal and food habit of *Mystus gulio* (Ham.) from saline sewage-fed wetlands at Minakhan. J Inl. Fish. Soc. Ind, 1993; 25(1):58-61.
55. Siddiqui KU. Encyclopaedia of flora and fauna of Bangladesh freshwater fishes Asiatic society of Bangladesh, Dhaka, Bangladesh, 2007; 23:300.
56. Lazzaro X. A review of planktivorous fishes their evolution feeding behaviour selectivities and impacts. Hydrobiologia, 1987; 146:97-167, DOI 10 1007/BF00008764.