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STUDIES ON GROWTH, FOOD AND FEEDING ECOLOGY, PREY SELECTION OF LARGESCALE MULLET, *LIZA MACROLEPIS* (SMITH, 1846) IN EXTENSIVE BRACKISHWATER FARMING SYSTEM.

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ABSTRACT
The present study was aimed to focus on growth, food and feeding ecology, prey preferences of Largescale mullet (*Liza macrolepis*) in extensive polyculture system for 9 months during February to November, 2015. Unfiltered estuarine water (16.5ppt) containing seeds of various crustacean and fish species were entered in impoundments and water was exchanged (20-30%) every lunar cycle through bamboo screens. Any commercial feed or fertilizer was not applied following common practice. Tade mullet fingerlings (3.43±1.90g, 6.1±0.22cm) added with auto stocked fishes @ 1000 fish ha^{-1} attained 130±3.30 g. They performed positive allometric growth ($W=0.014\ TL^{3.08}$) and high condition factor (K=1.74±0.06) indicating sufficient of natural food materials in extensive farming system. Feeding intensity in terms of stomach fullness upgraded with increasing fish weight. Food and Feeding ecology study suggested Largescale mullet as herbivorous fish grazing on phytoplankton and sand-mud from benthic layer. Stomach content analysis revealed that the, Bacillariophyceae, Chlorophyceae Myxophyceae, copepods, Dino-flagellates, fish-shrimp part, Debris, sand & mud and unidentified species were the prominent representatives food items of species *Liza macrolepis*. Although Myxophyceae, Bacillariophyceae, and Chlorophyceae according to the order of dominance were present in ambient water, Largescale mullet actively selected on Bacillariophyceae followed by Chlorophyceae and Myxophyceae according to order of preference indicating their ability to select preferred food materials.

KEY WORDS: *Liza macrolepis*, growth, feeding ecology, prey preferences, extensive polyfarming.

INTRODUCTION
Mullets form belonging to the family Mugilidae, is one of the economic important euryhaline and eurythermal species contributing to sizable fisheries of estuarine and coastal regions in all tropical, subtropical and temperate seas including China (Chang *et al*., 2004), Egypt (Saleh, 2008), Israel (Lupatsch *et al*., 2003), Italy (Luzzana *et al*., 2005), New Zealand (Wells, 1984), Nigeria (Anyanwu *et al*., 2007), Sri Lanka (De Silva and Silva, 1979) in brackishwater fisheries, Taiwan(Chang *et al*., 2000), Tunisia(Khériji *et al*., 2003). It is also considered to be ecologically important and forms major food resource for human populations in certain parts of the world (Durand, 2012). Among mullets, Largescale mullet *Liza macrolepis* (Smith, 1846) is the most common high economic importance and abundant mullet species widely reared in brackishwater mono and poly-culture fish pond under Brackishwater fish farming (Wljeyaratne and Costa, 1984; Rao and Sivani, 1996).

Food types as well as feeding habits of a specific species are significance in relation to their growth and propagation under specific biological conditions (Esmaeili and Johal, 2015). Growth performance of largescale mullet is more variable from both mono and poly culture system in India. In monoculture experiments, during 1986 at Madras with *Mugil cephalus Liza macrolepis* at the stocking density of 1500-7500/ha was performed the monthly average growth rate of 22.3 mm / 8.5 g. The production was ranged from 123-387 $kgha^{-1.}$ During 1984-87 with *Mugil cephalus* and *Liza cunnesius* at the stocking density of 2500-5000/ha *L. macrolepis* registered the monthly average growth of 16.1-23.4 mm / 4.9-12.2 g. The overall production ranged between 199-752 kg/ha (James et al., 1984 a; James et al., 1985 b; Pillai, 1985; Nammalwar and Mohanraj, 1991). In *Chanos chanos-L. macrolepis-Scylla serrata* polyculture at Tuticorin, the average monthly growth rate of *Liza macrolepis* was found to be 25.6 mm/21.6 g with stocking density of 3000 nos/ha. In polyculture experiment with *C. chanos, M. cephalus* and *L. macrolepis* at the overall stocking density of 1000/ha the monthly mean growth of *L. macrolepis* was 27.8 mm/12.3 g at Sundarban (Gandhi and Mohanraj, 1986; Lazarus & Nandakumaran, 1987; Nammalwar & Kathirvel, 1988).

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Study of food and feeding habits of fishes have manifold importance in fishery biology and in fisheries management programme. The success on good scientific planning and management of fish species largely depends on the knowledge of their biological aspects, in which food and feeding habits include a valuable portion (Sarkar and Deepak, 2009). Feeding is the dominant activity of the entire life cycle of fish and food is the main source of energy which plays an important role in determining the population levels, rate of growth and condition of fishes (Royce, 1972). Food types as well as feeding habits of a specific species are significance in relation to their growth and propagation under specific biological conditions (Esmaeili and Johal, 2015). Identification of principal types of food items and their occurrence form basis relating to the studies concerning predation, competition, trophy dynamic, feed webs and the trophic relationships in aquatic ecosystems; therefore play an important role both in culture as well as in wild condition (Wakjira, 2013). During the life span qualitative and quantitative changes in fish food are useful tools to define the diet of a particular fish species (Shamsi et al., 1995; A1-Ake1 et al., 1996). Fish feed opportunistically yet are often selective in their diets (Ehlinger and Wilson, 1988; Gerking,1994; Fry et al., 1999). Among several environmental factors that influence the selection of food item, the changes in feeding habits of a fish species are a function of the interactions (Ribeiro and Nuňer, 2008). Feeding behavior at the level of prey preference can have implications at the individual (Fraser et al., 2007), population level (Herwig and Zimmer, 2007) and community level (Schleuter and Eckmann, 2007). Grey mullets are generally considered as herbivorous, omnivorous, plankton feeders, or even micro crustaceanpredators (Brusle, 1981). Tropic behavior of mullets has been reported by different authors using extensive terminology which categorized feeding patterns of these species (Fatema et al., 2013). Some examples include algae feeders (Hiatt, 1944), micro and meio-benthos feeders (Hickling, 1970), interface-feeders (Odum, 1970), deposit feeders (Fagade and Olaniyan, 1973), benthic microphagous omnivores (Blaber and Whitfield, 1977) and limno-benthofagous (Laffaille , 2002). Stomach content analysis and features of the alimentary system provide information on food, feeding behavior and selective feeding (Karuppasmy and Menon, 2004). The selectivity and preference of the fish to different food items in different habitats give indications on the flexibility of the species to adjust to diverse environmental condition (Padmakumar et al., 2009).

In India, Largescale mullet (*L. macrolepis*, Smith) is the second important species of mullet and occurs in the sea, shallow coastal waters, coastal lakes, brackish-water estuarine environments and freshwater (Luther, 1963). It is one of the important food fishes of India and contributes substantially to the mullet fishery in certain areas (James, 1982). Now-a-days gaining importance from the brackishwater aquaculture point of view it is cultured in brackishwater farm (Rao and Sivani, 1996). Some aspects of fish biology have been studied earlier in India by (Gopalakrishnan, 1974), Natal (Blaber 1976a, 1977b). Studies on the food and feeding habits of largescale mullet inhabiting the coastal waters and the coastal lakes in India were studied earlier in the following species of mullets by Barman *et al*., 2005; Jana *et al*., 2004; (Luther, 1963) from Mandapam in Tamilnadu; and Rajan (1964) from Chilka Lake. In West Bengal, the low-lying lands near estuaries and deltaic areas enclosed by embankments called "Bheries" are used for traditional finfish cultivation mostly for mullets, especially during rains (Pillai and Menon, 2000).
In spite of vast cultured as an important mullet fish in traditional extensive polyfarming, such detail information on Largescale mullet's growth, food and feeding ecology with special emphasis on prey preferences from Hooghly-Matla estuarine complex, popularly known as 'Sundarbans' are very scarce. So, this present study is aimed to assess growth, food and feeding ecology, prey selectivity of mullet in extensive brackishwater poly-culture system in Sundarban.

MATERIALS AND METHODS

The present experiment was carried out during February to November, 2015 at Gopalnagar Dakshin village (21.8029-21.8073°N, 88.2962-88.2985°E) of Pathapratima block in South 24 Parganas district of West Bengal, India (figure.1). This experimental zone lies within the Hooghly-Matla estuarine complex popularly known as 'Sundarban'. Three tide fed extensive impoundments (0.7-0.9 ha) locally known as '*Bhery*' situated at the bank of a creek of Hatania-Doania river were selected. At first the impoundments were dewatered and sun dried during December. During first week of January lime stone powder was applied to the dried pond bottom at 500 kg ha^{-1}. Unfiltered saline tidal water (12.2 ppt) from the adjacent creek was allowed to let in the impoundments during second week of January through bamboo screen fitted inlet system and each pond was filled up to a depth of 110cm. Traditional bamboo screen used in 'Bhery' allows entry of small fry of different species but restricts exit of bigger fishes. Commercial feed or fertilizer was not provided following traditional practice. Among mullet, *L. macrolepis* fry (1.23±0.06g) is abundantly available from April-August with peak availability during June but it occurs for the greater part of the year (Luther, 1863 Nammalwar et al., 1991).

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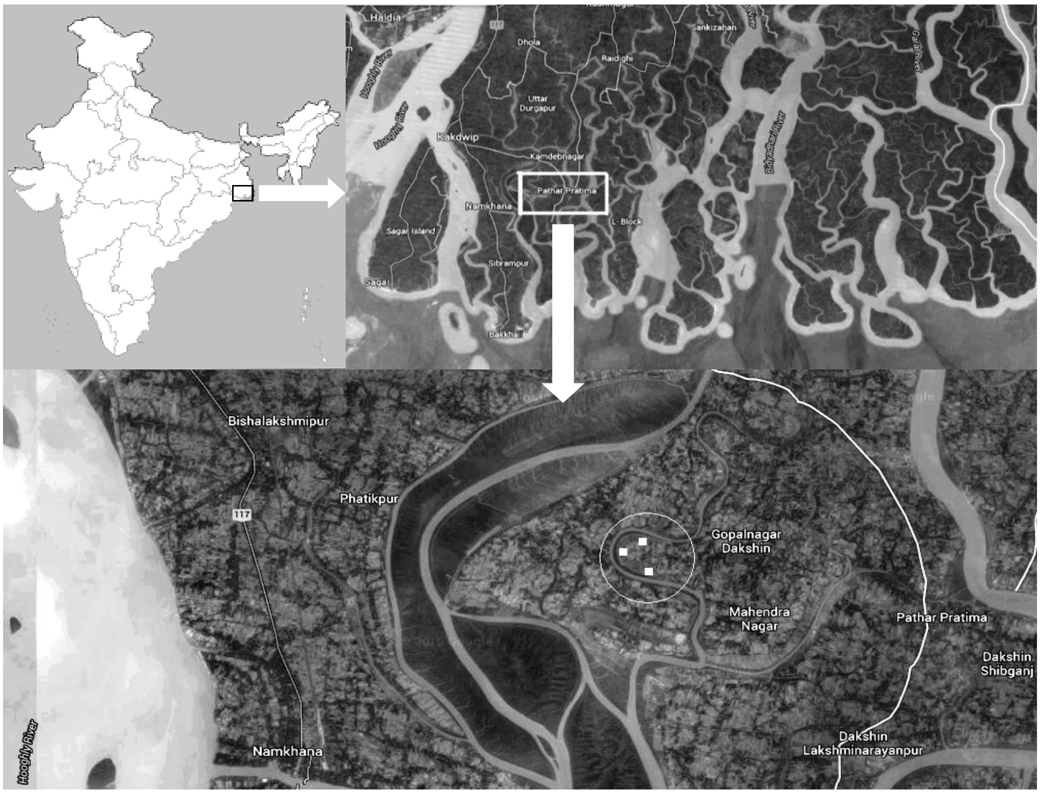

Figure 1. Map of the study areas showing the location of Gopalnagar Dakshin, Sundarban.

Wild Largescale mullet fry (0.03±0.01g, 1.49±0.07cm) collected from near river during August and those were nursery reared in a different pond for stocking in the three impoundments. Seeds of other fishes entered in the impoundments along with tidal water were allowed to grow for two month and pre-nursed fingerlings of Largescale mullet (3.43±1.90g, 6.1±0.22cm) were released @ 1000 ha^{-1} in the trial impoundments during February. About 20-30% water was exchanged every lunar cycle throughout the rearing period following the common practice. Water and fish samples were collected from three ponds to eliminate any possible biasness. Both fish and water samples were frizzed in ice before those were carried to laboratory for subsequent analysis.

Water samples were collected from surface of the study impoundments between 09:00 and 10:00 hours at monthly intervals. Water quality parameters such as water temperature, pH, dissolved oxygen (DO), alkalinity, nitrite-nitrogen (NO2-N), nitrate-nitrogen (NO3-N), ammonia-nitrogen (NH3-N) and phosphate-phosphorus (PO4-P) were recorded following standard methods (APHA). Water Salinity was assessed using a refractometer (ATAGO, Japan). Plankton samples were collected monthly by filtering 100L of water through bolting silk plankton net (mesh size 64 µm). Plankton concentrates were immediately preserved in 4% buffered formalin for further qualitative and quantitative analysis.

Ten fish fingerlings from each three ponds were collected during middle of each month i.e. total 30 fish in a month and total 300 fish in 9 months were collected and analyzed throughout study period. Gravimetric data of fishes were collected monthly throughout the culture period. The total length (TL, cm) was recorded with a slide caliper, while body weight (W, g) was measured using a digital electronic balance.
Daily weight gain (*DWG*) is a function of weight and time and was estimated for each replicate pond with the formula:

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

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

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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 in time *t*.

The mathematical relationship between length and weight was calculated using the conventional formula (Pauly, 1984):

$$W = a.TL^b$$

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 (Chow and Sandifer, 1991):

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

Where *K* is the condition factor, $\overline{w}$ is the average weight (W, g) and $\overline{TL}$ is the average total length (TL, cm).

Differences in final length, final weight, Daily Weight Gain, Specific Growth Rate, survival and exponential value of LWR were determined by analysis of variance with the General Linear Model procedure using SPSS for Windows v.17.0 programme (SPSS Inc. Chicago IL USA). Duncan's Multiple Range Test (Duncan1955) was used for comparison of treatments. All data were expressed as mean ± standard error (S.E.).

After gravimetric measurements, the stomachs 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 categorized as gorged, full, 3/4 full, 1/2 full, 1/4 full little and empty (Pillay, 1952). The stomach contents were placed into fixed volume of 4% formalin. From each vial one ml stomach contents were then transferred to Sedgwick-Rafter counting cell and phytoplankton constituents were identified and counted (Jhingran et al., 1969; Prescott, 1961). Planktonic constituents of stomachs were classified as Bacillariophyceae (diatoms), Chlorophyceae (green algae), Myxophyceae (blue-green algae), copepods, and dinoflagellets, fish parts and unidentified species. Numeric percentages and point percentages of each category were determinate. Additionally organic debris and sand particles in stomach were also evaluated as major food constituents.

To determinate the dominant food items, results of the percentage of occurrence and points method have been combined to yield the Index of Preponderance (IP) proposed by the following equation (Natarajan and Jhingran, 1961):

$$IP = \frac{V1O1 \times 100}{\sum V1O1}$$

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 items in the stomach falling under different groups were then compared with that of fish ponds to evaluate prey preferences. Prey preferences were determined by the Ivlev Electivity Index (Jacobs, 1974) using the following formula:

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

Where, r = Percentage of dietary item in ingested food, p = Percentage of prey in the environment.

RESULTS

Water quality parameters of the three experimental ponds are presented in Table 1. Water temperature showed wide range and fluctuated between 18.9^{0}C and 33.2^{0}C. Highest temperature was recorded during June (34.4^{0}C) and lowest temperature during November (18.4^{0}C). Dissolved oxygen (DO) and pH value were almost similar throughout the culture period and ranged between 5.82 to 9.00 ppm and 7.92 to 8.72 respectively. Salinity variation was wide range in three experimental ponds throughout the culture duration and was maximum (18.9ppt) during summer (May) and minimum (3.7ppt) during rainy season (August). This is the usual seasonal salinity variation of the tidal water in the Sundarban region (Moriarty, 1976). Nitrogenous metabolites such as nitrite-nitrogen (NO2-N) and total ammonia nitrogen (NH3-N) varied between 9.47-24.97 μg^{-1} and 22.83-44.98μg^{-1}, respectively in three impoundments. Concentration of Nitrogenous metabolites was significantly ($p < 0.05$) higher in impoundment 3 than other two impoundments. Nitrate-nitrogen (NO3-N) and phosphate-phosphorous (PO4-P) concentration ranged between 69.62-

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110.49 μg^{-1} and 21.50-43.27 98μg^{-1} respectively while there were no significant ($P>0.05$) difference among three trial ponds. Significantly ($p < 0.05$) higher Planktonic concentration was observed in pond 1 and lower in pond 3.

Table 1. Water quality parameters of three extensive brackishwater farming impoundments used for Largescale mullet feeding ecology study.

Water parameters	Pond-1	Pond-2	Pond-3
Water temperature (ºC)	29.9±1.7	29.9±1.7	29.7±1.9
pH	$8.04±0.23^{a}$	$7.96±0.25^{a}$	$7.78±0.31^{b}$
DO (mg L^{-1})	$6.06±0.42^{a}$	$5.99±0.52^{a}$	$5.69±0.52^{b}$
Salinity (ppt)	12.87±5.34	12.74±5.32	12.89±5.19
NO_2-N (µg L^{-1})	16.35±5.83	15.91±5.62	16.11±6.63
NO_3-N (µg L^{-1})	93.12±15.41	92.66±11.14	92.97±8.94
NH_4-N (µg L^{-1})	$30.96±5.61^{b}$	$31.19±7.91^{b}$	$34.89±6.27^{a}$
PO_4-P (µg L^{-1})	32.07±13.43	31.91±11.98	31.89±12.74
Phytoplankton (numbers/L^{-1} ×10^3)	$15.38±1.62^{a}$	$15.12±1.94^{b}$	$14.95±1.73^{c}$
Zooplankton (numbers/L^{-1}×10^3)	$3.05±0.25^{a}$	$2.91±0.23^{b}$	$2.83±0.17^{c}$
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)			

On basis of qualitative and quantative analysis, the following plankton groups have been observed to be present in the pond water during the period of investigations According to the order of dominance, the dominant phytoplankton groups in pond water were Myxophyceae, Bacillariophyceae and Chlorophyceae in three impoundments (Figure 2.). Most abundant zooplankton groups in water according to the order of dominance were Dinoflagellets and Copepods. Fish and shrimp parts were also measured under calculation in water body.

A. phytoplankton groups:

1. Myxophyceae:

The most abundant genera: *Phoromidium sp*., *Oscillatoria sp., Anabaena sp. and nostoc sp*.

Less abundant genera: *Spirulina sp., Chroococcus sp., Gleocapsa sp.*, and *Merismopedia sp*.

Percentage composition of Myxophyceae varied between 8.96-30.99% (22.09±2.14%) with lowest and highest value during July and September respectively.

2. Bacillariophyceae:

The most dominant genera: *Diatoma sp., Skeletonema sp., Thalassionema sp., Chaetocera sp., Navicula sp., Nitzschia., Gyrosigma sp., Pleurosigma sp., Melosira sp., Cymbella sp., Synedra sp., Cyclotella sp.* and *Coscinodiscus sp.*

Poor abundant genera: *Surirella sp., Stephanodiscus sp., Rhizosolenia sp., Tabellaria sp.* and *Amphora sp.*

Percentage composition of Bacillariophyceae varied between 5.06-22% (12.18±1.60%) with minimum and maximum value during May and February respectively.

3. Chlorophyceae:

Main available genera: *Chlorella sp., Volvox sp., Ulothrix sp., Pediastrum sp., Enteromorpha sp., Cladomorpha sp., Caetomorpha sp., Scenedesmus sp., Spirogyra sp.* and *Tetraedron sp.*

Light abundant genera: *Ankistrodesmus sp., Coilastrum sp., Chladophora sp., Crucigenia sp., Scenedesmus sp., Pandorina sp.* and *Closterium sp.*

Percentage composition of Chlorophyceae varied between 4.21-10.88% (7.31±0.79%) with lowest and highest reading during June and February respectively.

B. zooplankton groups:

Dinoflagellates and Copepods were the most common zooplankton groups in water column.

1. Dinoflagellates:

main genera: *Peridinium sp., Ceratium sp.* and *Gymnodinium* sp.

Percentage composition of Dinoflagellets ranged between 30.44-47.56% (38.71±1.70%) with lowest and highest reading during February and April respectively.

2. Copepoda :

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Over all available genera: *Cyclops sp., Metis sp., Microsetella sp., Harpecticus sp., Nauplii sp., Corycaeus sp.* and *Oithona sp.*

Composition ranged between 2.04-24.88% (9.24±2.33%) with minimum and maximum value during August and July respectively.

C. Other parts:

Planktonic constituents as shrimp and fish part were constituted 1.19-19.52 %(10.54±1.19%) during rearing period.

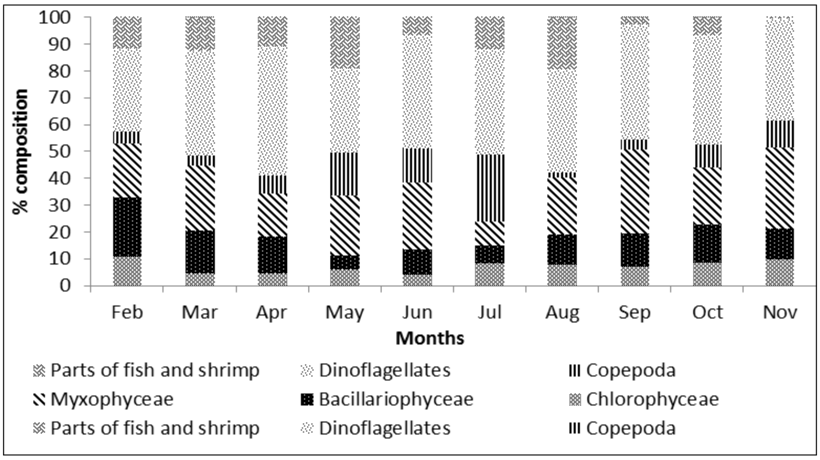

Figure 2. Percentage occurrences of suspended food materials in ambient water of Largescale mullet, *Liza macrolepis* (smith, 1846) in extensive farming impoundments.

Growth of largescale mullet in terms of final length (cm) and weight (g) is presented in Figure 3. After 270 days of rearing, *L. macrolepis* grown were from 3.43±1.90g (6.1±0.22cm) to 130±3.30g (19.1±0.42cm). Average daily weight gain (DWG) calculated was 0.42±0.07 g day^{-1} which ranged between 0.16g day^{-1} (February) and 0.74g day^{-1} (August). Average specific growth rate (SGR) recorded was 1.22±0.32% day^{-1} which varied between minimum 0.37% day^{-1}(June) and maximum 3.40% day^{-1}(January). Exponential value (b) of Length Weight Relationship (LWR) was recorded to be 3.082 indicating positive allometric growth (Figure 4.). The Fulton's condition factor (K) ranged between 1.49 lowest value in July to 1.75 highest value in April where the mean value was 1.7±0.06 during whole rearing period (Figure 5.).

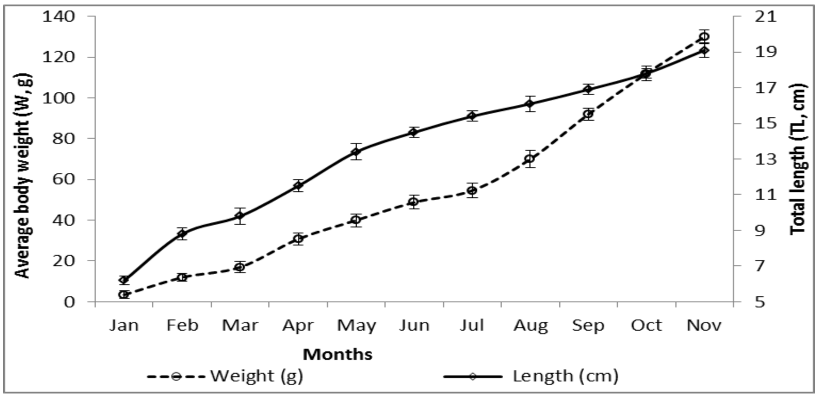

Figure 3. Monthly growth of Largescale mullet *Liza macrolepis* (smith, 1846) reared in extensive farming system

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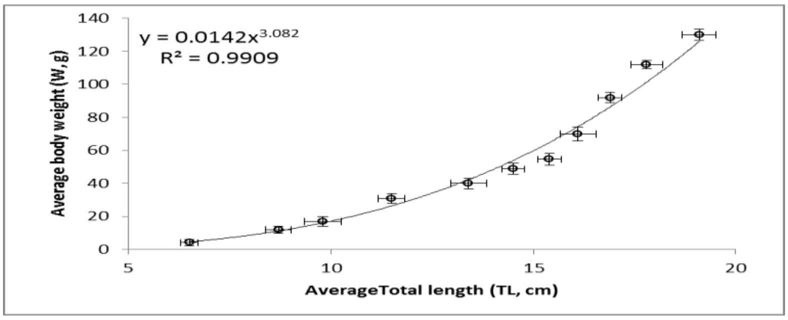

Figure 4. Length weight relationship of Largescale mullet *Liza macrolepis* (smith, 1846) cultured in extensive farming system.

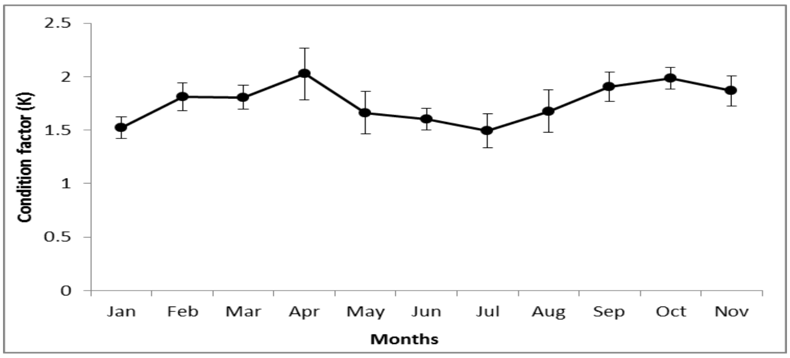

Figure 5. Fulton's condition factor (K) of Largescale mullet *Liza macrolepis* (smith, 1846) reared in extensive farming system.

Table 2. Monthly variations of percentages of different classes of gut fullness in Largescale mullet, *Liza macrolepis* (Smith, 1846) were presented under study.

Months	Gorged stomach	Full stomach	3/4 Full stomach	1/2 Full stomach	1/4 Full stomach	Little stomach	Empty stomach
Feb	8	27	19	13	15	4.5	13.5
Mar	5.5	19	20	20	20	5.5	10.0
Apr	9	16.8	31	15.59	10.53	10.53	6.5
May	14	23.3	10	20.5	15.2	16	1.0
Jun	22.2	21.2	12.1	16.7	16.7	8.1	3.0
Jul	6.66	26	13	16.35	9.99	25.5	2.5
Aug	12.6	27.6	20	26.5	13.32	0	0.0
Sep	21.2	11.3	24	11.8	10.7	19	2.0
Oct	1	20	20	20	10	16	13.0
Nov	5	26.6	10.5	23.3	13.2	6.6	14.8
Feeding intensity	10.516	21.88	17.96	18.374	13.464	11.173	6.63
n=30 for each month, 10 fishes were taken monthly from three impoundments under study.							

Feeding intensity of largescale mullets in terms of stomach fullness is presented in Table 2. Lower feeding intensity with greater number of empty stomachs was observed during the initial months of rearing. Feeding intensity gradually increased as the fishes grew, indicated by more number of gorged and full stomachs in the later phase of rearing. The overall higher feeding intensity was observed during the final rearing months.

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On the basis of qualitative and quantative analysis, the following phytoplankton, zooplankton and others have been observed to be present in the stomach of largescale mullet during the period of investigations (Figure 6.). According to the order of dominance, the most abundant phytoplankton groups in three study ponds were Bacillariophyceae (25.23% in October –41.36% in June), Chlorophyceae (9.59% in November - 20.29% in March) and Myxophyceae (4.25% in April -14.46% in October).

A. phytoplankton groups:
1. Bacillariophyceae:
The most dominant genera: *Navicula sp., Nitzschia., Gyrosigma sp., Pleurosigma sp., Melosira sp.* and *Coscinodiscus sp.*
Less abundant genera: *Surirella sp., Cymbell sp., Synedra sp., Cyclotella sp., Tabellaria sp.* and *Amphora sp.*
Among Bacillariophyceae average percentage of stomach content was 31.60±1.64%.
2. Chlorophyceae:
Main available genera: *Chlorella sp., Pediastrum sp., Enteromorpha sp., Scenedesmus sp., Spirogyra sp.* and *Tetraedron sp.*
Lower abundant genera: *Ankistrodesmus sp., Chladophora sp., Crucigenia sp., Scenedesmus sp.* and *Coilastrum sp.,*
Mean percentage of stomach content was 14.82±1.38% in Chlorophyceae.
3. Myxophyceae:
The most abundant genera: *Spirulina sp., Chroococcus sp., Oscillatoria sp., and Anabaena sp.*
Less abundant genera: *Gleocapsa sp., nostoc sp., Volvox sp.* and *Merismopedia sp.*
Average percentage of stomach content was 9.31±1.23% in Myxophyceae.

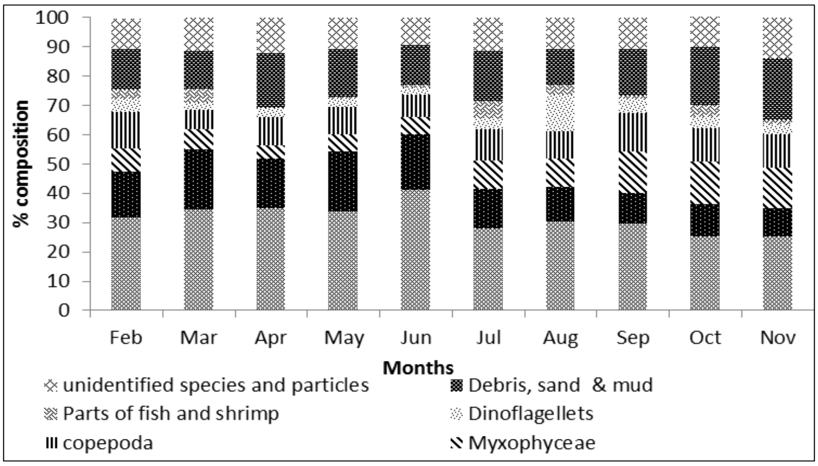

Figure 6. Percentage occurrences of food items in Largescale mullet *Liza macrolepis* (smith, 1846) stomach reared in extensive farming system

B. zooplankton groups:
Dominant zooplankton group in the stomachs were Copepods (6.53% in March -13.21% in September) followed by Dinoflagellets (2.28% in March-12.30% in August). Average percentages of stomach content were 10.21±0.70% and 4.37±0.97 in Copepods and Dinoflagellets respectively.
1. Copepoda :
Cyclops sp. and Calanus sp. were mainly present in stomach.
Average percentage of stomach content was 10.21±0.70% in Copepods.
2. Dinoflagellates:
Main genera: *Peridinium sp., Ceratium sp.* and *Gymnodinium* sp.
Mean percentages of stomach content was 4.37±0.97% in Dinoflagellets.

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C. Other parts

Fish-shrimp parts and debris-sand-mud as non-Planktonic suspended materials were ranged between 0.12% -5.60% (2.55±0.65%) and 12.00%-20.85 % (16.08±1.00%) respectively. Unidentified species (viz. foraminifera polychaetes) and particles (viz. organic particles cladoceran appendages and foraminifera shell) were 9.16 % -13.90 %(11.07±0.43%).

Results of monthly analysis of stomach content following percentage points method have been represented in Figure 7. On the basis of dominant order, the most abundant phytoplankton groups in three culture ponds were Bacillariophyceae (22.54% in November –39.10% in June; 30.32±1.93%), Chlorophyceae (11.26% in October – 26.90% in March; 17.15±1.88%) and Myxophyceae (5.50% in April -14.36% in October; 10.08±1.13%). According to the point method the chief zooplankton group in the stomachs content was Copepods (4.40% in October -19.80% in November; 11.41±1.57%) followed by Dinoflagellets (2.28% in March-7.80% in February; 4.16±0.57%). Fish-shrimp parts and debris-sand-mud as non-Planktonic suspended food materials were varied between 0.15% in March -8.80% in October (2.57±1.06%) and 3.60% in September -20.85% in October (13.58±1.97%) respectively. Unidentified species (viz. foraminifera) and particles (viz. organic particles cladocera appendages, foraminifera shell and others) were 7.00 % in September -14.50% in August (10.73±0.72%).

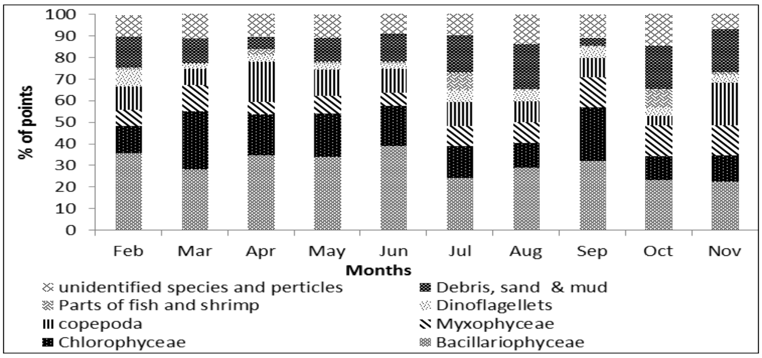

Figure 7. Percentage composition of different food items following points method in the stomach content of Largescale mullet *Liza macrolepis* (smith, 1846).

Indices of Preponderance (IP) determined for Bacillariophyceae, Chlorophyceae, Myxophyceae, Copepods, Dinoflagellets, Parts of fish-shrimp, Debris, sand-mud and unidentified species were 52.29%, 13.87%, 5.13%, 6.36%, 0.99%, 0.36%, 11.93% and 6.48% respectively during whole culture periods (Figure 8.).

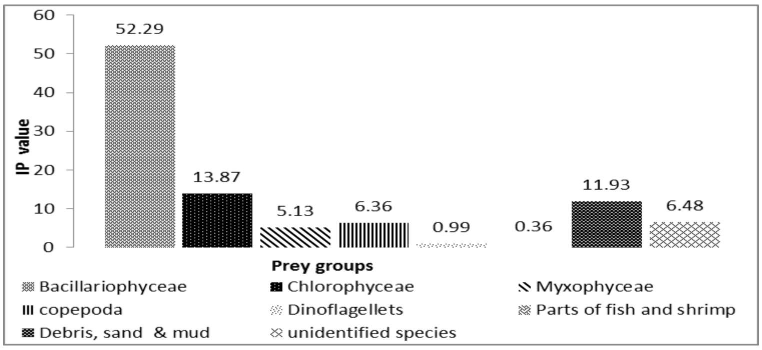

Figure 8. Index of Preponderance (IP) of food materials in the stomach content of Largescale mullet *Liza macrolepis* (smith, 1846).

Electivity index (E) of different food constituents is showed in Figure 9. Electivity index (E) for Bacillariophyceae ranged between +0.19 in February and +0.65 in June (+0.52±0.10) with lowest in the initial month of rearing but highest in summer season. Preference of Bacillariophyceae was low during early months of rearing and showed

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gradually increasing trend afterwards. Electivity index (E) for Chlorophyceae varied from –0.03 in February to +0.43 in April (+0.32±0.09) with after peak months mean values (+0.35) remained similar throughout the rearing period. On other hand Electivity for Myxophyceae varied from –0.01 in August to +0.40 in July (+0.15±0.08). Prey selection for Myxophyceae was higher during early months of rearing but an abnormal lower pick during August. Among zooplankton group, Electivity for copepods varied wide range between –0.92 in November to +0.45 in February (–0.20±0.32) throughout the culture period indicating negative-preference. Copepods showed higher electivity values during initial months of rearing which gradually decreased as the fish fingerlings were grown. Electivity for Dinoflagellets and fish or shrimp parts ranged between –0.92 in September to –0.39 in July (–0.71±0.14) and –0.97 in April to –0.23 in September (–0.65±0.16) respectively throughout the culture period indicating non-preference. Decayed organic matter, sand particles and unidentified species were not considered for electivity analysis.

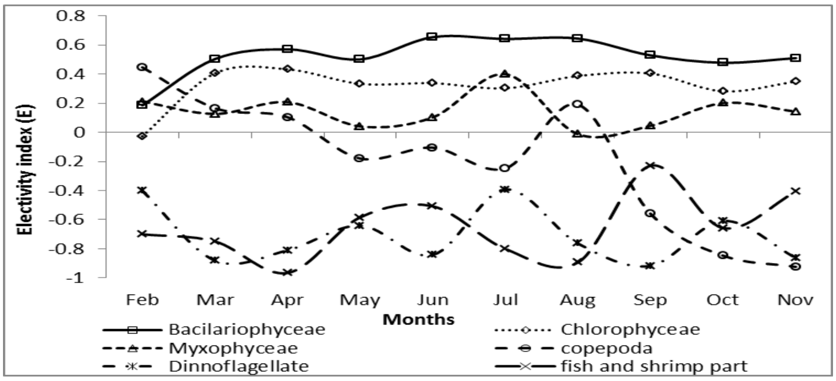

Figure 9. Prey electivity index (E) of existed food materials intake by Largescale mullet (*Liza macrolepis*) in extensive farming system

DISCUSSION

Better water quality is very essential to maintain optimum growth and survival of aquatic organism under the culture. In present study, recorded water quality parameters were within optimum ranges for brackish water aquaculture and differed significantly (P<0.05) with time (Chakrabarti et al., 2002). The Hooghly-Matla estuarine system, salinity and temperature have been found to be the most significant abiotic factors determining the fishery resources of this system (Gopalakrishnan, 1974). Concentrations of toxic gases like nitrite-nitrogen (NO2-N) and ammonia-nitrogen (NH4-N) remained lower than the critical level and concentrations of nutrients like nitrate-nitrogen (NO3-N) and phosphate-phosphorous (PO4-P) was much lower than fertilized ponds reported from Sundarban (Biswas et al., 2012; Saha et al., 2001). Lower nutrient concentrations in the experimental extensive system may be attributed to complete dependence on natural productivity without any additional input. Order of dominance of the planktonic groups in the ambient water in the present experiment was 0 corroborated with that reported from the Hooghly estuary (Dutta et al., 2013). Being the extensive farming system depends only on the natural productivity and commercial feed or fertilizer is not applied, such extensive farming system can be considered as representative of the natural environment and co-existence of Planktonic community structure resembling the natural environment is expected.

Much higher growth rate in fish- mullet-crab following polyculture in fed ponds compared to the present study has been reported. At Tuticorin, a *Chanos chanos-L. Macrolepis* and *Scylla serrata* polyculture experiment with the stocking density of 1450, 3000 and 617/ha were conducted in brackishwater pond where the average monthly growth rate was found to be 25.6 mm/21.6 g (ADG: 0.72g/day) (Marichamy et al., 1979). Lower growth of *L. macrolepis* monoculture was reported from Madras where the monthly average growth was19.4 mm (7.1 g) to 22.3mm (8.5 g) (ADG: 0.23g to 0.28g/day) at overall stocking density of 1500 to 7500nos/ ha in South east coast (Nammalwar et al., 1991). Higher growth rate of *L. macrolepis* in fish-mullet-crab polyculture may be attributed to no feeding competition among different existing organisms of different trophic levels. Lower growth rate of *L. macrolepis* monoculture may be attributed to feeding competition with mullets belonging to the same trophic level. Lower stocking density of other mullets as those entered naturally in the present study might be the reason behind better growth of Largescale mullet in spite of being non-fed mullets-shrimp extensive polyculture. The isometric exponent (b=3.082) of length weight relationship in the present study indicated positive allometric growth of Largescale mullet. When the b parameter is equal to 3, growth is isometric and when it is less than or greater than 3, it is allometric (Enin, 1994). 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) (Wootton, 1992). Positive allometric growth and high condition factor (mean K= 1.75±0.06) of Largescale mullet in the present study indicates sufficient natural food materials in the extensive farming system with low stocking density as poor competition for huge space among others is likely favour to the largescale mullet. Exponent value of LWR and condition factor in the present study corroborated with those reported from Karachi Coast of Pakistan (Zubia et al., 2014).

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 (Akpan and Isangedighi, 2004). In tide fed extensive farming systems, Largescale mullet coexists with other herbivorous and some carnivorous fishes such as *Lates calcarifer*, *Megalops cyprinoides*, *Eleutheronema tetradactylum*, *Therapon jarbua*, *Glossogobius giuris* etc. which gains entry during the process of tidal water exchange and lowers production (Biswas et al., 2012). Larger fish may require more food to obtain the necessary energy for reproductive activity than smaller ones require for growth. Moreover, a wider mouth opening in larger fish helps to ingest relatively larger quantity food items at a time (Isangedighi et al., 2009).

Investigation cum report on Largescale mullet feeding ecology is very scarce, feeding ecology of other related grey mullets have been studied many authors (Almeida, 2003). Mullets is a as plankton feeders, herbivores, omnivores, slime feeders, foul feeders, bottom Feeders fish (Sarojini, 1951; Pillay, 1953). Beside Mullets are well suited for mono and poly-farming since they feed on algae, diatoms, small crustaceans, decayed organic matter and mud; hence there is a little need to feed (Swart et al., 2012). Mullets has been expressed that they were chiefly plankton feeders. The diet of young mullets consisted predominantly the diatoms (Bachllariophyceae) followed by the green algae and blue-green algae (De Silva and Wijeyaratyne, 1977; Wells, 1984). Bacillariophyceae followed by Myxophyceae and Chlorophyceae as most dominant food constituents of *M. cephalus* in brackishwater environments has been reported from various parts of Indian subcontinent (Islam et al., 2009; Rao and Babu, 2013; Mondal et al., 2015) and other parts of the world (El-Marakby et al.,2006; Rramirez et al., 2008; Bekova et al., 2013). Planktonic algae were informed to be the dominant food item of gold spot mullet, *Liza parsia* and Planktonic groups according to the order dominance was Chlorophyceae, Bacillariophyceae and Myxophyceae (Joadder and Hossain., 2008). Planktonic algae were reported to be the dominant food item of Corsula mullet, *Rhinomugil corsula* and Planktonic groups according to the order dominance were Chlorophyceae, Myxophyceae and Bacillariophyceae (Sultana et al., 2013). Bacillariophyceae followed by Chlorophyceae and Myxophyceae as most dominant food constituents of *Liza macrolepis* in brackishwater environments (Wljeyaratne and Costa, 1982). In the present study, Phytoplankton groups in stomach content of Largescale mullet *L. macrolepis* according to the order of dominance were Bacillariophyceae> Chlorophyceae> Myxophyceae. Zooplankton groups were copepods> dinoflagellets to the order of dominance in fish stomach content. Differences in the order of dominance of different Planktonic groups (Phyto & zoo) in the stomach content of mostly available mullet species in the studied region; *M. cephalus*, *L. parsia*, *R. corsula* and *L. macrolepis* indicate some short of sharing strategy of the tropic level which they belong in natural environment.

The gut content analysis has suggested that Bacillariophyceae as the most dominant food group and also supported by the index of preponderance value (52.29%). Chlorophyceae has been observed as the second most dominant food group and index of preponderance value is 13.87%. Myxophyceae has been observed as the third most abundant group and the index of preponderance value is 5.13%. Total index of preponderance value in three phytoplankton groups is 71.29%. Among zooplankton groups, Copepods as the most dominant food group and also supported by the index of preponderance value (6.36%). The second most abundant food group has been observed as the Dinoflagellets and it has been supported by the index of preponderance value of 0.99%. Total index of preponderance value in two zooplankton groups is 7.34%. So the indices of preponderance values depicting herbivorous feeding habit of *L. macrocepis* supported by the presence of maximum percentage (71.29%) of the phytoplankton groups in the gut content.

This result also is depicting phytoplankton as the basic food for *L. macrocepis*. Among the three classes of phytoplankton available in the gut, Bacillariophyceae has been observed with maximum percentage both in Points method and percentage of occurrence method; and thus has taken the first position in index of preponderance value, representing maximum preference of *L. macrolepis* for this food group. Chlorophyceae and Myxophyceae were second and third preference respectively as per analysis.

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Considering the complex nature of Largescale mullet feeding ecology, electivity index (E) analysis is necessary to throw some light on food preferences. As per Ivlev's equation, E ranges from -1 to +1, where -1 to 0 stands for negative selection, while values 0 to +1 can be interpreted as positive selection of that prey item. Subsequent investigation (Lazzaro, 1987) suggested that a true positive or negative prey selection can be interpreted only at values >0.3 or <-0.3 respectively. Largescale mullet *L. macrolepis* in present experiment actively selected Bacillariophyceae as most preferred food material (Figure 9). Chlorophyceae was found to be the second most preferred planktonic group in spite of ranking second and third in the order of dominance in the stomach content and ambient water respectively. Although being first dominant Planktonic form in pond water, Myxophyceae was third selective food material to Largescale mullet.

Among zooplanktonic groups, copepods were selected for initial three months but cannot be attributed as true selection by mullet. Other zooplankton (dinoflagellets) and suspended particles derived from animal origin like fish or shrimp parts were not at all selected and were probably swallowed mechanically during intake of other food stuffs. On the basis of these observations, It has been suggested that the organization of the alimentary system of a particular species, as for example in the relative concentrations of its digestive enzymes, may be such as to obtain maximum advantage for only a limited part of the range of material which the animal is actually capable of ingesting (El-Marakby, 2006). It may be suggested that Largescale mullet does not intake food materials at random but have the ability to select particular food items. Order of positive preference of phytoplankton food group by Largescale mullet as Bacillariophyceae> Chlorophyceae>Myxophyceae is different from coexisting species, *M. cephalus* as Bacillariophyceae>Myxophyceae>Chlorophyceae (Mondal et al., 2015) in the same environment that feeding strategy to reduce competition within the same tropic level.

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