Assessment of the growth performance and length-weight relationship of tade mullet, *Liza tade* (Forsskail, 1775) in brackish water gher-farming system

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***Abstract*—**The study was conducted to appraise the growth performances, and feeding behavior of tade mullet (*Liza tade*) in an extensive polyculture gher-farming system. The ghers were occupied with unfiltered estuarine water (15.5 ppt), containing various types of crustacean and fish species. The water was replaced (25-30%) every cosmological cycle through bamboo screens. Tade mullet fingerlings (4.35±0.80g) stocked at 2500 fish/ha were attained a mean final weight of 277.42±12.65 g. The result showed an undesirable algometric growth because of the scarcity of food resources in the extensive gher farming system. The study showed that tade mullet is a herbivorous fish, grazing mainly on phytoplankton and organic matter from the bottom sediment in regards of ecological view.

***Index Terms*—** *Liza tade*, polyculture, extensive system, feeding ecology, growth performance.

I. INTRODUCTION

Fish species belonging to the family Mugilidae, commonly referred to as mullets, comprises mainly of coastal marine species that are widely distributed in all tropical, subtropical and temperate seas. Mullets are generally considered to be ecologically important and forms major food resource for human populations in certain parts of the world [1]. Tade mullet (*Liza tade* Forsskål 1775) is one of the most important mullet species widely cultured in both brackish and freshwater mono and poly-culture fish ponds [2]. Owing to its good consumer preference and market price, non-carnivorous food habit and abundant availability of seeds, tade mullet is a good candidate for polyculture with other species including shrimps [3]. It has a high quality flesh, superior growth, large maximum size and wide salinity and temperature tolerance power [4].

Growth potential of a fish species is one of the most important criteria for selection as a candidate species. Available reports regarding growth of tade mullet is highly variable from farming trials. Tade mullet fingerlings (5 g) were grown to 215-265 g in 18 months with *Liza parsia* at ratios of 1: 2 and 1: 4 at overall stocking density of 25000/ha in West Bengal coast [5]. Growth of tade mullet fingerlings (6.16±0.49 g) up to 203.24 g at stocking density of 3300/ha in 148 days culture with *Penaeus monodon* at stocking density of 50000/ha was reported [6]. Much lower growth was also reported where tade mullet fingerlings (7.60±0.24 g) attained 80.40±4.02 g at stocking density of 1500/ha within 180 days in polyculture with *Mugil cephalus* (4500/ha), *L. parsia* (2000/ha) and *P. monodon* (20000/ha) [3]. For efficient culture and management of fish resource, knowledge on food and feeding habits of fishes is of immense importance [7]. Food and feeding habits of a species of fish is intimately associated with the ecological niche that they occupy in the natural environment [8] and knowledge on this aspect is advantageous in their proper management and exploitation [9]. Mullets are generally considered as herbivorous, omnivorous, plankton feeders, or even micro crustacean predators [10].

Tropic behavior of mullets has been reported by different authors using extensive terminology which categorized feeding patterns of these species [9]. Some examples include algae feeders [11], micro and meio-benthos feeders [12], interface-feeders [13], deposit feeders [14], benthic microphagous omnivores [15] and limno-benthofagous [16]. Food and feeding habits of the fish vary with time of the day, season of the year, size of the fish, environmental condition and with different food substances present in the water body.

In India, *L. tade* occurs in marine, shallow coastal waters, coastal lakes and estuarine environments and is cultured in brackish water farms [17], freshwater tanks [18] and experimentally in salt water ponds [19]. 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 [20] where tade mullet is considered as the most preferred fish due to its superior taste and market value.

In spite of being widely cultured as an important component in traditionally practiced extensive polyculture, information on tade mullet growth performances in such systems are scarce. The present study was designed to assess growth performance and length-weight relationship with special emphasis on prey preferences of tade mullet in extensive polyculture system to strengthen the ecosystem approach for brackish water polyculture management.

II. MATERIALS AND METHODS

The trial was carried out during February to December, 2015 at Vathshala, Debhata, Satkhira, Bangladesh. Three tide-fed brackish water ghers (0.75 to 1.00 ha) located at the bank of a creek of Isamoti river were selected. The ghers were dewatered and sundried at the beginning. Lime stone powder was applied to the dried pond bottom at 500 kg/ha during first week of January. During the tidal period, the unfiltered saline water (15.5 ppt) from the adjacent stream of the river was allowed to

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let into the ghers during the second week of January through bamboo screen fitted inlet system and each was filled up to a depth of 115.0 cm. Traditional bamboo screen used in ‘Bhery’ allows entry of small fry of different species but restricts the exit of bigger fishes. Entry of tade mullet fry along with other species was not projected as seeds of *L. tade* remain available in south-east and south-west coasts during November–April and north-east coast during July–October [21]. Tade mullet fry was collected during October. They were reared in a different nursery pond before stocking in the gher. Other fish fry entered into the gher along with tidal water were allowed to grow for one month with the pre-nursed fingerlings of tade mullet. The weight and size of fingerlings were 4.35 ± 0.80 g and 9.75±0.65 cm, respectively. The stocking density was 2500 fingerlings/ha during February. About 25-30% water was replaced in every cosmological cycle depending on the plenty of tidal waters throughout the rearing period. It was followed by a common practice during the culture period. The samples of water and fish were collected from three ghers to reject any possible biasness. Then the both samples of fish and water were placed with ice in an insulated box before transporting to the field-based laboratory for subsequent analysis.

A total of 15 individual fishes were collected randomly during the middle of each month from each of the three ghers (i.e., 45 individuals per sampling) of fishes in each month and the resulting total numbers of 450 fishes were collected and analyzed throughout the study period. Gravimetric data of fishes were collected monthly throughout the experimental period. The total length (TL) in centimeter (cm) was recorded with a slide caliper, while body weight (W) in gram was measured by 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:

$$DWG = (Wf - Wi)/t$$

Where Wf and Wi are the average final and initial weight in time t.

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

$$SGR = (\ln Wf - \ln Wi)\ 100/t$$

Where Wf and Wi are the average final and initial weight in time t.

The mathematical relationship between length and weight was calculated by using the conventional formula [22]:

$$W = a.TL^b$$

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 [23]:

$$K = \bar{w} \times 10^2/(\bar{TL})^3$$

Where K = the condition factor,

$\bar{w}$ = the average weight (g) and

$\bar{TL}$ = the average total length (cm).

Differences in final length, final weight, daily weight gain (DWG), specific growth rate (SGR), survival and exponential value of length-weight relationship (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 [24] was used for comparison of treatments. All data were expressed as mean ± standard error (SE.).

III. Results

In regards of growth, the final length (cm) and weight (g) of the fish are presented in Figure 1. Fishes were grown from 4.35±0.80 g to 277.42±12.65 g in weight and 9.75±0.65 cm to 35.56±2.65 cm after 300 days of rearing. Average daily weight gain (DWG) was 0.925±0.125 g/day, which were ranged between 1.45 g in July and 0.36 g in February. Specific growth rate (SGR) varied between 4.35%/day (February) and 0.44 %/day (September) with a mean value of 1.53±0.42%/day.

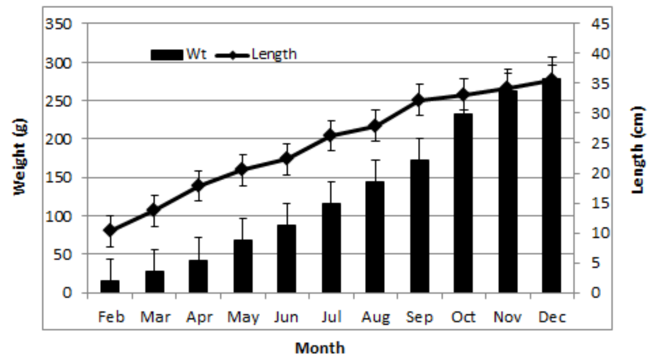

Fig 1: Growth performances of tade mullet (*Liza tade*) reared in extensive gher-farming system.

Fulton’s condition factor (K) of fish was 0.7824±0.0834. Length Weight Relationship (LWR) showed curvilinear growth pattern and exponential value (b) of LWR was recorded to be 0.1094, indicating negative allometric growth (Figure 2).

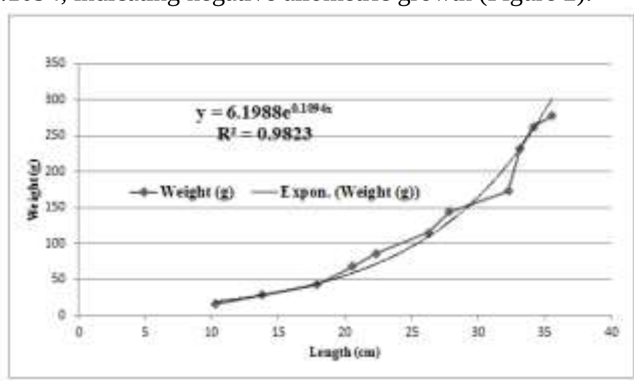

Fig 2: Length weight relationship (LWR) of tade mullet (*Liza tade*) reared in extensive gher-farming system.

The overall average water quality parameters of the experimental ghers are shown in Table 1. Among the water quality parameters of experimental ghers, temperature of water showed wide range and fluctuated between 19.8 and 34.4^{0}C (Table 1). Maximum temperature was recorded during April (34.4^{0}C) and minimum during November (19.8 ^{0}C). Dissolved oxygen (DO) and pH value were almost similar all over the culture period and ranged between 5.80 to 9.01 mg/L and 7.82 to 8.82, respectively (Table 1). Salinity showed wide variations in three experimental ghers all through the study duration and the maximum salinity was recorded to be 18.5 ppt during summer i.e., May and the minimum salinity was 3.3 ppt during rainy season i.e., August (Table 1). This is the usual seasonal salinity variations of the tidal water in the Sundarban region. Nitrogenous metabolites such as nitrite-nitrogen (NO_2-N) and total ammonia nitrogen (NH_3-N) varied between 9.30-24.48 and 21.81-44.09 µg/L, respectively in three ghers (Table 1). Concentration of total ammonia nitrogen was significantly ($p < 0.05$) higher in gher 3 than other two ghers. Nitrate-nitrogen (NO_3-N) and phosphate-phosphorous (PO4-P) concentrations ranged between 68.63 and 112.20, and 20.62 and 432.75 µg/L (Table 1), respectively while there were no significant ($p > 0.05$) difference surrounded by three experimental ghers. Significantly ($p < 0.05$) rich planktonic concentration was observed in gher T_1 and poor in Gher T_3.

TABLE I DIFFERENT WATER QUALITY PARAMETERS AT DIFFERENT EXPERIMENTAL GHERS.

Water quality parameters	**T_1**	**T_2**	**T_3**
pH	$8.04±0.23^a$	$7.96±0.25^a$	$7.78±0.31^b$
Temperature (^{0}C)	29.95±1.35	29.95±1.35	29.7±1.9
Salinity (‰)	12.87±5.34	12.74±5.32	12.89±5.19
DO (mg/L)	$6.06±0.42^a$	$5.99±0.52^a$	$5.69±0.52^b$
NO_2 – N (µm/L)	16.35±5.83	15.91±5.62	16.11±6.63
NO_3 – N (µm/L)	93.12±15.41	92.66±11.14	92.97±8.94
NH_4 – N (µm/L)	$30.96±5.61^b$	$31.19±7.91^b$	$34.89±6.27^a$
PO_4 – P (µm/L)	32.07±13.43	31.91±11.98	31.89±12.74
Phytoplankton (Nos/L x 10^3)	$15.38±1.62^a$	$15.12±1.94^b$	$14.95±1.73^c$
Zooplankton (Nos/L x 10^3)	$3.05±0.25^a$	$2.91±0.023^b$	$2.83±0.17^c$

Mean values bearing different superscripts indicate statically significant differences in a row (p<0.05); Values are expressed as mean ± SE (n = 10 for each gher in every month).

IV. DISCUSSION

The growth and metabolism of euryhaline species are generally affected by the salinity due to use of the energy for osmoregulation is not available for their growth [25]. Tade mullet is required a minimum energy for osmoregulation at 15 ppt and isosmotic salinity for this species is 10 ppt [26]. Existing ambient salinity are nearly close to the isosmotic salinity in the studied ghers that will have to be helped tade mullet to grow up without the salinity stress. Some other factors like availability of food and stocking density might have hampered the growth in the study. Compared to polyculture of shrimp-tade mullet in fed ponds, much higher growth rate was found in the present study. There have been reported that the tade mullet fingerlings having an average weight of 6.16±0.49 g, attained 203.24 g in which ADG 1.33 g/day was also found for 148 days with stocking density of tade mullet at 0.33 individual/m^2 and tiger shrimp at 5 individuals/m^2 [6]. The lower growth rate of tade mullet was reported from Sundarbans [5], where tade mullet fingerlings of 5.0 g were grown to 265.0 g with an ADG of 0.48 g/day for 18 months with *Liza parsia* at the ratio of 1: 4. These observations indicate viability of of growth in tade mullet-tiger shrimp polyculture. However, tade mullet fingerlings attained from 7.60±0.24 g to 80.40±4.02 g in weight whereas the ADG rate was 0.40 g/day at a stocking density of 1500 individual/ha for 180 days polyculture with *Mugil cephalus* (4500/ha), *L. parsia* (2000/ha) and *P. monodon* (20000/ha) [3]. The higher growth rate of tade mullet was found in -tiger shrimp-tade mullet polyculture. It may be attributed that there was no feeding competition among organisms at different trophic levels, whereas the lower growth rate of that in polyculture with parsia and tiger shrimp, may be accredited in the feeding competitions with other mullets belonging to the same trophic level.

On the other hand, it was observed that the mullets which were entered naturally with a lower stocking density in the present study might be a reason behind improved growth of tade mullet in spite of being non-fed mullets-shrimp polyculture system. The isometric exponent (b = 0.1094) of length weight relationship in the present study indicated negative allometric growth of tade 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 [27]. More specifically, growth is positive allometric when organism's weight increases more than length (b > 3), and negative allometric when length increases more than weight (b < 3) [28]. Negative allometric growth and low condition factor (K = 0.7824±0.0834) of tade mullet in the present study indicates shortage of food materials in the farming system as competition for space is not likely in such low density and low production systems. Exponent value of LWR in the present study corroborated with those reported from tropical lagoon of Sri Lanka [29].

V. CONCLUSION

The present investigation suggests that tade mullet has good growth performance and can be well-thought-out for increased farming, however, the protocols for intensified mono and polyculture has to be uniformly standard. This will enable establishment of optimum species combination for improved brackish water polyculture based on optimum resource utilization as a step forward towards sustainable aquaculture development.

REFERENCES

[1] Durand, J.D., Shen, K.N., Chen, W.J., Jamandre, B.W., Blel, H. and Diop et al. 2012. Systematics of the grey mullets (Teleostei: Mugiliformes: Mugilidae) Molecular hylogenetic evidence challenges two centuries of morphology based taxonomy. Molecular Phylogenetics and Evolution, 64: 73–92. https://doi.org/10.1016/j.ympev.2012.03.006

[2] Lupatsch, I., Katz, T. and Angel, D.L. 2003. Assessment of the removal efficiency of fish farm effluents by grey mullets a nutritional approach. Aquaculture, 34: 1367–1377. https://doi.org/10.1111/j.1365-2109.2003.00954.x

[3] Biswas, G., Ananda Raja, A., De, D., Sundaray, J.K., Ghoshal, T.K. and Annand et al. 2012. Evaluation of production and economic returns from two brackishwater polyculture systems in tide-fed ponds. Journal of Applied Ichthyology, 28: 116–122. https://doi.org/10.1111/j.1439-0426.2011.01909.x

[4] Smith, M.S. and Swart, J.J. 1998. Flathead mullet (*Mugil cephalus*) as potential aquaculture species in Western Cape; African Fishes and Fisheries, Diversity and Utilization, Poissons et Peches, Africans Diversite et Utilization Coetzee, L. (ed.) : Gon, J. (ed.) O; Kulongoski, C. (ed.). Graham's town, South Africa, FISA; PARADI, 241 pp.

[5] Bhowmik, M.L., Chakraborti, R.K., Das, N.K. and Mondal, S.K. 1990. On the mixed culture of *Liza tade* (Forskal) and *L. parsia* (Ham) in brackishwater with reference to pond ecology. Impacts of Environment on Animals and Aquaculture (Manna, G.K. and Jana, B.B., Eds.), 187–193.

[6] Anil, K.S., Gunalan, B., Jetani, K.L., Kuldeep, G., Trivedi, K. and Soundarapandian, P. 2010. Determine the Economic Feasibility of the Polyculture System (Giant Tiger Shrimp and Mullet). African Journal of Basic and Applied Sciences, 2(3-4): 124–127.

[7] Islam, R., Hossain, M.B., Das, N.G. and Rafi, R-U-N. 2009. Food and feeding behavior of grey mullet *Mugil cephalus* of Bangladesh coastal water. Bangladesh Journal of Progressive Science and Technology, **7**(2): 56–61.

[8] Oren, O.H. 1981. Aquaculture of Grey mullets (International Biological programme No 26. Cambridge University. press Cambridge England, 507 pp.

[9] Fatema, K., Omar, W.M.W. and Isa Mat, M.U.S.M. 2013. Identification of Food and Feeding Habits of Mullet Fish *Liza subviridis* (Valenciennes 1836) *Valamugil buchanani* (Bleeker 1853) from Merbok Estuary Kedah, Malaysia. Journal of Life Sciences and Technologies, 1(1): 47–50.
https://doi.org/10.12720/jolst.1.1.47-50

[10] Brusle, J. 1981. Food and feeding in grey mullets. In O.H. Oren (ed.), Aquaculture of grey mullets. Cambridge University Press, pp. 185–217.

[11] Hiatt, R.W. 1944. Food chains and the food cycles in Hawaiian fish ponds part 1 the food and feeding habits of mullet (*Mugil cephalus*) milkfish (*Chanos chanos*) and the ten pounder (*Elops machnata).* Transactions of the American Fisheries Society, 74: 250–261.
https://doi.org/10.1577/1548-8659(1944)74[250:FATFCI]2.0.CO;2

[12] Hickling, C.F. 1970. A contribution to the natural history of the English grey mullets (pisces, mugilidae). Journal of the Marine Biological Association of the United Kingdom, 50: 609–633.
https://doi.org/10.1017/S0025315400004914

[13] Odum, W.E. 1970. Utilization of the direct grazing and plant detritus food chains by the striped mullet *Mugil cephalus* in Marine Food Chains. In: J. H. Steele (ed.), London Olivier and Boyd, Edinburgh, pp. 222–240.

[14] Fagade, S.O. and Olaniyan C.I.O. 1973. The food and feeding interrelationship of the fishes in the Lagos lagoon. Journal of Fish Biology, 5: 205–225.
https://doi.org/10.1111/j.1095-8649.1973.tb04449.x

[15] Blaber, S.J.M. and Whitfield, A.K. 1977. The feeding ecology of juvenile mullet (Mugilidae) in south-east African estuaries. Biological Journal of the Linnean Society, 9: 277–284.
https://doi.org/10.1111/j.1095-8312.1977.tb00269.x

[16] Laffaille, P., Feunteun, C., Lefebvre, C., Radureau, A., Sagan, G. and Lefeuvre, J.C. 2002. Can thin-lipped mullet directly exploit the primary and detritic production of European macrotidal salt marshes? Estuarine, Coastal and Shelf Science, 54: 729–736.
https://doi.org/10.1006/ecss.2001.0855

[17] Hora, S. and Nair, L.K.K. Suggestions for the development of salt water Bheries or Bhasabadha fisheries in Sundarban. Government of Ben. Fish. Dev. Pamphlet Cal, 944.

[18] Pillay, T.V.R. 1949. On the culture of Grey mullets in association with commercial carps in freshwater tanks of West Bengal. The Journal of the Bombay Natural History Society, 48: 601–604.

[19] James, P.S.B.R. 1996. Technologies and Potential for sea farming in India part II Aquaculture Magazine, Asheville NC. 22(3): 30–43.

[20] Pillai, V.N, and Menon, N.G. 2000. A review of marine finfish culture experiments in India Marine Fisheries Research Institute (ICAR) Tatapuram P O Cochin, 682: 014.

[21] Kurian, C.V. 1975. Mullets and mullet fisheries of India. Aquaculture, 5: 114.
https://doi.org/10.1016/0044-8486(75)90037-X

[22] Pauly, D. 1984. Fish population dynamics in tropical water a manual for the use with programmable calculators ICLARM. Studies and reviews Manila, Philippines, 325 pp.

[23] Chow, S, Sandifer, P.A.1991. Differences in growth, morphometric traits, and male sexual maturity among Pacific white shrimp *Peneaus vannamei* from different commercial hatcheries. Aquaculture, 92: 165–179.
https://doi.org/10.1016/0044-8486(91)90018-3

[24] Duncan, D.B. 1955. Multiple range and multiple F-test. Biometrics, 11: 1–42.
https://doi.org/10.2307/3001478

[25] Wootton, R.J. 1990. Ecology of Teleost Fishes. Chapman and Hall, London, 404 pp.

[26] Sudha, S and Aravindan, C.M. 2014. Influence of salinity on the weight-dependent metabolism of the tade mullet, *Liza tade* (Forsskal) (Pisces: Mugilidae), Department of Aquatic Biology and Fisheries, University of Kerala. Journal of Aquatic Biology and Fisheries, 2(1): 269–275.

[27] Enin, U. 1994. Length-weight parameters and condition factor of two West African Prawns. Revue d'Hydrobiologie Tropicale, 27: 121–127.

[28] Wootton, R.J. 1992. Fish ecology tertiary level biology. Blackie London, 212 pp.
https://doi.org/10.1007/978-94-011-3832-1

[29] Wijeyaratne, M.J.S and Costa, H.H. 1986. On the biology an estuarine population of grey mullet *Mugil cephalus* L in Negombo lagoon Srilanka. Cybium, 10(14): 351–63.