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Growth and yield performance of a sustainable aquaculture of cuchia, *Monopterus cuchia* (Hamilton, 1822) under different type of feeds in Bangladesh

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Abstract
An experiment was undertaken to assess the growth performance, yield and survival rate of cuchia, *Monopterus cuchia* in grow out culture in earthen ponds in relation to three different types of feed (Live feed, T_1; Boiled fish muscle and live feed, T_2; and Supplementary feed, T_3) for a rearing period of 180 days from February 2020 to July 2020 at Bangladesh Fisheries Research Institute (BFRI), Riverine Sub-Station, Khepupara, Patuakhali, Bangladesh. The experiment was designed with three different type of feeds *viz*. small live fish as T_1, live fish with boiled fish muscle as T_2 and treatment T_3 with supplementary feed i.e., fish paste (50%)**,** fish meal (40%), rice bran(5%)**,** wheat flour (5%) respectively. Same age with a mean length and weight of 39.29±4.84 cm and 89.12±16.36 g of hatchlings of cuchia collected from the Upazilla of Amtoli under Barguan district, Bangladesh were stocked on February 2020 with a stocking density of 10 fingerlings/m^2. Feeding rations were applied twice daily up to satiation level following the experimental design using feeding tray to check waste of feed. Basic water quality variables and growth performance of cuchia were checked fortnightly. It was observed that T_2 gave the highest weight gain (232.21±7.11 g) followed by T_1 (208.71±8.98 g) and T_3 (205.71±8.03 g). The highest specific growth and survival rate were recorded 0.73±0.01% and 94.25±1.12% respectively in the treatment T_2. Significant differences (P< 0.05) were recorded among the three treatments. The highest total production (91.97±5.04 kg/decimal) was found in T_2 compared to T_1 (78.67±6.91 kg/decimal) and T_3 (76.56±3.82 kg/decimal). The present findings indicates that mixture of live fish and boiled fish muscle could be supplied as feed for grow out culture of *M. cuchia in* earthen ponds.

Keywords: Growth, *Monopterus cuchia*, feeds

1. Introduction
The Gangtetic mud eel, *Monopterus cuchia* (Hamilton, 1822) is one of the most delicious fish species having nutritional and medicinal values with high market demand. There are four species of eel, *Monopterus cuchia*, *Anguila bengalensis*, *Pisodonophis boro* and *Pisodonophis cancrivorus* available in Bangladesh, in which *Monopterus cuchia*, the fresh water air-breathing, swamp mud eel is locally known as Kuchia or Kucha, belongs to the family of synbranchidae of the order synbranchiformes. *M. cuchia* is an economically important fresh water fish, widely distributed in Bangladesh, India, Nepal, Pakistan and Myanmar [21, 22, 32]. International Union for Conservation of Nature (IUCN) Red List of Bangladesh has enlisted *M. cuchia* in their red list of vulnerable fishes of Bangladesh [17]. In Bangladesh it is commonly found throughout the country, plenty in mud-holes in shallow beels and boro paddy fields particularly in Sylhet, Mymensingh and Tangail districts [35]. It has developed special pharyngeal pouches for bimodal gas exchange [5, 16, 23] and thus they can survive in mud and oxygen poor water of its habitat. The population of the species has declined day by day from different areas of Bangladesh due to indiscriminate harvest [5]. The habitat or microenvironment plays an important role for the better growth and survival rate of some fish species [1, 2]. However, the population of the freshwater mud eel is declining at an alarming rate from the natural water bodies due to several reasons, especially for overfishing while increasing the population of this fish completely depends on natural reproduction, and thus this fish are recorded as rare species in Bangladesh habitats as well as Indian region [13]. Freshwater eel culture is a low cost system compared to other small scale fish culture does not require

large water bodies. It can be profitably raised with aquatic crops like swamp cabbage [25]. *M. cuchia* is nocturnal in nature and the fish is considered by feeding habit. They feed on earthworms, frogs, tad-poles, small aquatic animals, shrimp, crayfish and also detritus [24]. Due to the presence of noticeable amount of sand and mud in gut content of this species, suggested that *M. cuchia* is a bottom feeder [19]. Like other eels, this freshwater mud eel provides different ecosystem functioning which is ecologically important in food chains, acting as predators of harmful animals and different invertebrates and being consumed in its various stages by mammals, birds and small vertebrates [26]. The unique adaptation that allows mud eel to be successful in their environments, primarily for wedging through small openings, while some are adapted to burrowing into soft substrates or living a pelagic existence [18]. It is time to think about expanding freshwater eel fisheries and develop new technologies to increase its production for capture the world market. By improving culture techniques we can earn lot of foreign currency and this will help to develop national economy of the country. Therefore, the freshwater mud eel, *M. cuchia* was observed considering suitable environments for rearing with live and dead feeds for survival and growth as well as compare the production of this fish in Bangladesh. Considering high export demand and high nutritional elements of *M. cuchia*, this research work may be an alternative livelihood for the people of mid-southern region of Bangladesh involved in fisheries sector. So, the development of a culture technology of *Monopterus cuchia* in earthen ponds will contribute not only to our national economy but also help to protect endangered *M. cuchia* from extinction.

2. Materials and Methods

2.1. Site and experimental design

The experiment was conducted in nine small ponds with treatment T_1, T_2 and T_3 respectively in the Riverine Sub-station, Bangladesh Fisheries Research Institute, Khepupara, Patuakhali.

Table 1: Feed category given in growout culture of *M. cuchia* in earthen ponds

Live Feed Feed A, Treatment T_1	Boiled Fish Feed B, Treatment T_2	Supplementary Feed Feed C, Treatment T_3
Small live fish (Tilapia Fry)	Live fish and fish muscle (Tilapia fry and boiled fish muscle)	Fish paste (50%) Fish meal (40%) Rice bran (5%) Wheat flour(5%)

2.2. Preparation of pond

At first, soil was removed upto one feet from all ponds. The filter net was placed in the bottom for preventing the cuchia from burrowing habit. After setting the filter net, ponds were covered with polythene and "Triple" upto the net level and removed soil was further used on the filter net. After that, ponds were filled up with 0.6-0.8 m water. Then water of the ponds was fertilized with lime stone, urea and TSP to enhance the production of plankton. After 4-5 days of fertilization, water hyacinth (*Eichhornia crassipes*) was provided to the ponds in order to giving suitable and safe shelter of cuchia.

2.3. Collection and stocking of cuchia fry

The fingerlings of *M. cuchia* were collected from depo named "Yususf Motso Arot, Amtoli upazila under district of Barguna, Bangladesh about 15 kilometers away from Riverine Sub-Station, Khepupara of Bangladesh Fisheries Research Institute (BFRI). Fish were identified as mud eel by external morphology [17] and also by the help of local fisherman. The fish were put into a plastic cage with some water and brought to the Riverine sub-station, Khepupara, Patuakhali carefully. Collected fishes were divided into three categories and placed in nine small ponds. In each pond 400 hatclings of cuchia were released. Fingerlings of cuchia were stocked in treatment T_1, T_2 and T_3 at a stocking density of 10 fingerlings per square meter for a period of 180 days. At stocking, all fingerlings were of same age with a initial mean weight of 89.12±16.36 g. But before releasing the fingerlings, initially fishes were measured for all ponds considering length and weight of fish.

2.4. Feeding of fishes

M. cuchia were fed twice daily @ 2% body weight of cuchia and feed were supplied to each of the different ponds with different items (Table 1). Every time feed were given at the morning at 9 a.m. and alternate food was supplied.

2.5. Monitoring of water quality and growth of *M. cuchia*

Before construction of any culture environment, it is wiser to think about water management system including source, discharge and quality of water as also recommended by [14]. Water temperature was recorded using a Celsius thermometer. Dissolved oxygen, pH and TDS were measured directly using a Hanna multiparameter (YSI, Model 58, USA) followed in Table 2. All the parameters were recorded fortnightly. Growth parameters of *M. cuchia* were recorded at monthly basis.

2.6. Data Analysis

The data were analyzed through one way analysis of variance (ANOVA) using MSTAT followed by Duncan's New Multiple Range test to find out whether any significant difference existed among treatment means [14, 34]. In all statistical analysis, the difference was considered to be significant when $P< 0.05$.

3. Results

During the experiment, physico-chemical parameters such as pH, dissolved oxygen and temperature for different rearing conditions were maintained and recorded fortnightly. Mean levels of physico-chemical parameters of 180 days culture of *M. cuchia* is presented in table 2. The mean water temperatures in treatment T_1, T_2 and T_3 were not statistically significant ($P>0.05$) among different treatments during the study period. The highest pH was recorded in treatment T_2 (7.45± 0.45) and pH decreased from T_3 to T_1 but did not differ significantly ($P>0.05$). Highest range of dissolved oxygen was recorded in treatment T_2 (4.27± 0.43 ppm) and lowest range of dissolved oxygen was recorded in treatment T_3 (4.05±0.5 ppm) (Table 2). However, there were no significant variations ($P>0.05$) in the value of dissolved oxygen among the treatments.

Table 2: Variation in water quality parameters in experimental ponds during 180 days culture period of *M. cuchia.*

Parameters	Treatments		
	T_1	T_2	T_3
Temperature (^{0}C)	26.09± 3.48	26.39± 3.66	26.09± 3.63
P^H	7.27± 0.47	7.45± 0.45	7.13± 0.33
Dissolved Oxygen (ppm)	4.07± 0.48	4.27± 0.43	4.05±0.5
Ammonia (ppm)	0.13± 0.16	0.15± 0.12	0.25± 0.17
Total Dissolved Solids (ppm)	206.64± 41.5	202.18±36.6	202.45±36.3

The growth and yield performance of *M. cuchia* of rearing in earthen ponds for a period of 180 days are presented in table 3, which indicated that the growth in terms of weight showed much variation in each treatment and continued till final harvesting.

Table 3: Growth and yield performance of *Monopterus cuchia* after 180 days of rearing in earthen ponds

Parameter	Treatment 1 (T_1)	Treatment 2 (T_2)	Treatment 3 (T_3)
Initial length (cm)	39.29±4.85	39.29±4.40	39.29±4.79
Final length (cm)	94.0±1.46^a	104.2±3.34^b	92.6±2.06^a
Net length gain (cm)	54.71± 1.46^a	64.91±3.34^b	53.31±2.06^a
Initial weight (g)	89.12±16.36	89.12±11.77	89.12±12.21
Final weight (g)	297.6±5.42^a	321.75±7.48^b	294.73±5.12^a
Net weight gain(g)	208.48±5.42^a	232.63±7.48^b	205.61±5.12^a
Specific growth rate % SGR (g/day)	0.67±0.04^a	0.73±0.01 ^{b}	0.66±0.02^a
Relative growth (RG)	2.34±2.20^a	2.60±1.06^b	2.30±1.95 ^{a}
Average daily gain (g)	1.16±0.3^a	1.29±0.02^b	1.14±0.04^a
Survival rate (%)	86.88±1.37^a	94.25±1.12^b	84.37±1.89^a
Total Production (kg/decimal)	78.67±6.91^a	91.97±5.04^b	76.56±3.82^a

Means bearing different superscripts differ significantly in a row (P<0.05); Values are expressed as mean ±S.D.

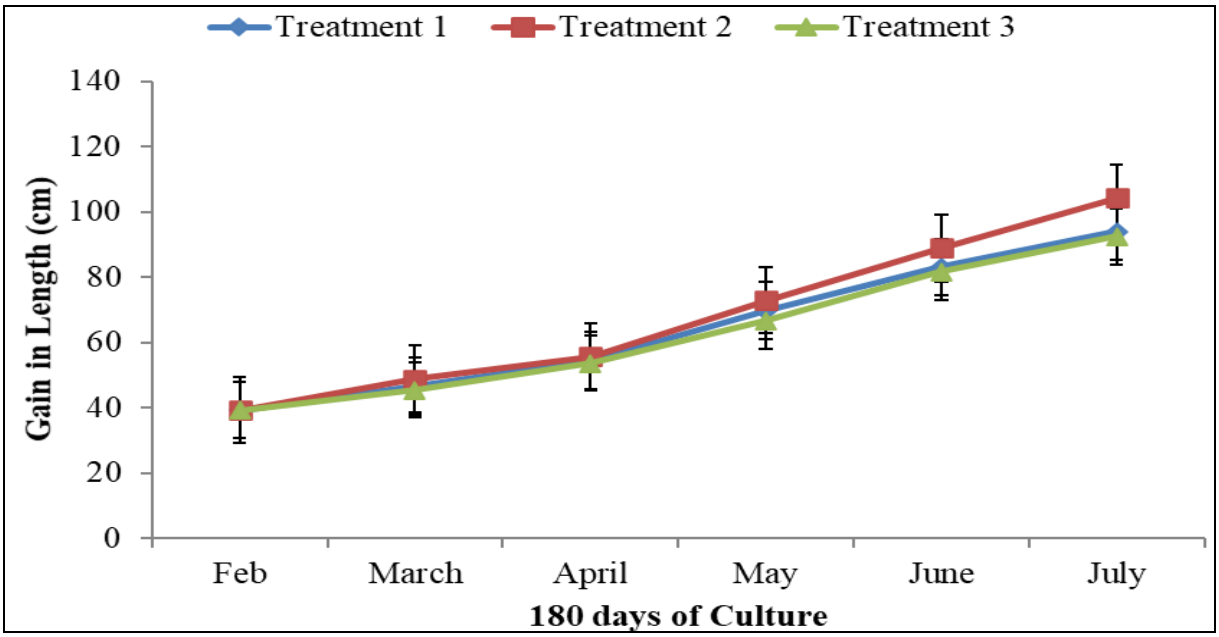

Fig 1: Monthly mean length gain of *M. cuchia* of three treatments during 180 days culture period

During the investigation, final weight of *M. cuchia* was recorded as 297.6±5.42 g, 321.75±7.48 g and 294.73±5.12 g in treatment T_1, T_2 and T_3 respectively. The increase in weight *M. cuchia* was the highest in T_2 followed by T_3 and T_1, respectively. The initial weight (89.12±16.34 g) of fingerlings, stocked in all treatments was same. The fish in treatment T_2 showed the highest gain in weight (321.75±7.48 g) compared to the treatments T_3 and T_1 (Fig. 1 and 2).

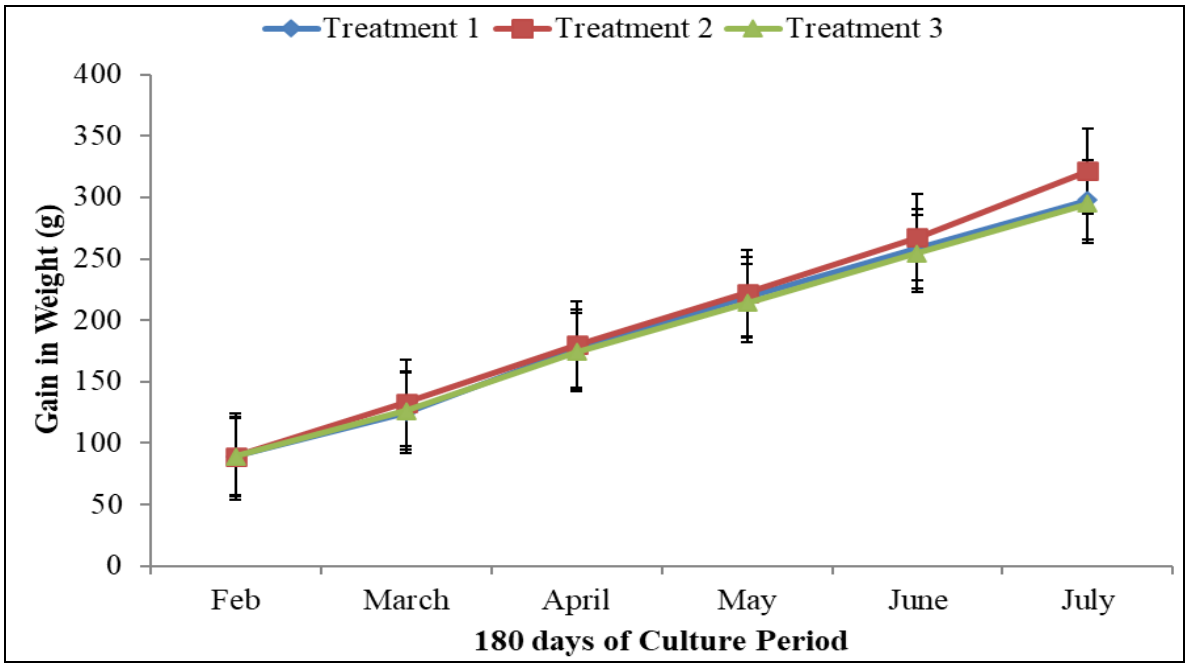

Fig 2: Monthly mean weight gain of *M. cuchia* of three treatments during 180 days culture period

However, the mean final weight of fingerlings in different treatments were significantly different (p<0.05). RG and SGR in treatment T_2 was significantly higher than in T_3 and T_1 (P< 0.05). Therefore, best RG and SGR were recorded in treatment T_2. The highest survival rate (%) was also observed in T_2 and the lowest in T_3. There was a significant variation (P< 0.05) in the survival rate in cuchia individuals among different treatments. The net production of eel were 78.67±6.91, 91.97±5.04 and 76.56±3.82 kg/decimal in treatment T_1, T_2 and T_3 respectively. Production was higher in treatment T_2 and lowest in treatment T_1. The growth rate of *M. cuchia* was relatively higher in treatment T_2. The primary productivity of water body is dependent on physico-chemical factors of water, which are governed by environmental factors [30]. The temperature of the experimental ponds was within the acceptable range for fish culture that agrees well with the findings of [7]. The pH values agree well with the findings of [8, 11, 12]. In this experiment, same supplementary feeds were supplied for the growth of *M. cuchia* which is very much similar study of [10, 27]. The dissolved oxygen values are similar with the findings of [9, 10]. Growth in terms of weight, weight gain, RG and SGR of individuals of *M. cuchia* were significantly higher in T_2 compared to T_3 and T_1 and different food was supplied in all the treatments at an equal ratio. Cuchia often spend their day time hiding under stones and mud or having a burrowing habit [25]. The fish took no foods at the average temperature of 12°C [28]. The survival rate (%) was also highest in treatment T_2. A significant variation (P< 0.05) was found in the survival rate of *M. cuchia* among different treatments. Highest production of mud eel was recorded in treatment T_2 and lowest in treatment T_1 and total production differ significantly (P< 0.05) among the three treatments (Table 3). Overall, highest growth, survival and benefits of *M. cuchia* monoculture practice were obtained from the treatment T_2. In the present investigation, the amount of supplementary feeds given in different treatments was based on the number of fingerlings stocked and amount of feed provided per individual was kept at the same level.

4. Discussions

The present study was conducted to determine the suitable environment for the development and dissemination of nursing and culture techniques freshwater mud eel, *M. cuchia*. The role of environmental parameters is very important to influence on the maintenance of a well aquatic environment and production of food organisms [11, 3, 6] stated that the water parameters in different treatments did not show any remarkable variations among the three treatments recorded parameters in the experiment were within the optimum ranges for fry and fingerlings rearing of mud eel. No infection or disease was identified in the experimental ponds during sampling. The mean values of temperature recorded in the ponds of present experiment were 26.09±3.47, 26.39±3.66, 26.09±3.62 [7]. Stated that water temperature of ponds remains 20.20 to 36.50 °C which were favorable to fish culture. [9, 19, 20, 27] found more or less similar results. The average dissolved oxygen of ponds was 4.07±0.45, 4.27±0.42, 4.05±0.52. [15] reported that the dissolved oxygen content at levels of 3 ppm or less should be regarded as hazardous to lethal and that of 5 ppm or more is suitable for fish production. In the present experiment the mean dissolved oxygen values were within suitable range [9, 10, 19, 24] found more or less similar results. The mean values of pH recorded in the ponds of present experiment were 7.27±0.46, 7.44±0.45 and 7.12±0.32. [10] Found the level of pH vary from 5.50 to 7.20 mg/L in three experimental cuchia culture ponds. On the other hand, [4, 8, 20, 24] found more or less similar results. [31] stated that pH 6.5 to 9.0 is suitable for pond fish culture. Length, weight, weight gain and SGR of *M. cuchia* were significantly higher in treatment T_2 where live fish and boiled muscle of fish was supplied compared to those of T_1 and T_3 although stocking density was same all the treatments. In the present study, it was observed that live fish and boiled muscle of fish were the best among all other supplied foods for better growth performance of freshwater mud eel, *M. cuchia*. As soon as the feed were supplied they engulfed it quickly. For better growth and development optimum temperature is a key factor. In this study, increasing weight gain was found during April to July, 2020 with optimum water temperature was 20-28 ℃, suitable for freshwater eel, *M. cuchia* and similar result was found by [20]. [25] reported an ideal temperature of 20-35 ℃ for proper feeding and growth of *M. cuchia*. [32] reported that below a

temperature of 12℃ *A. japonica*, *A. anguilla* and *A. rostrata* do not feed and thus do not grow at all. The mean values of relative growth recorded in the ponds of present experiment were 2.34±2.20, 2.60±1.06 and 2.30±1.95 [4, 9] found more or less similar results regarding this experiment. Mean average daily gain of three different treatment recorded were 1.16±0.3, 1.29±0.02, 1.14±0.04 g that were higher than that of the experiment conducted by [8]. The mean values of survival rate (%) recorded in the ponds of present experiment were 86.88±1.37, 94.25±1.12 and 84.37±1.89 [8, 9, 20, 27] found more or less similar results.

5. Conclusions

The freshwater mud eel have great economic and food value in the different part of the world and due to reducing this fish from nature by various reasons, so now time comes to develop culture practice of cuchia at farmer's level. Hence, successful culture of cuchia is important for cuchia production which is already observed in this experiment. Mass seed production and conservation through proper culture management are recommended to save this endangered species from being extinction. In conclusion, this study demonstrated that a sustainable monoculture technology of treatment T_2 (Live feed+Boiled fish muscle) is advisable for 180 days culture period of *Monopterus cuchia* in earthen ponds.

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