Integration Of Cat Fish *Clarias Batrachus* Into Carp Poly Culture System For Economic, Food And Nutritional Security Of Vulnerable Communities Of Ganjam District Of Odisha

Bisoyi Rama Chandra[1*], Biswal Nirmal Chandra[2], Samant Deviprasad[3]

[1*]Ph.D. Scholar, Department of Life Sciences (Zoology),GIET University, Gunupur, Rayagada(Odisha),India. ramchandrabisoyi862@gmail.com
[2] Assistant Professor, Department of Life Sciences (Zoology), GIET University, Gunupur, Rayagada (Odisha), India. nirmalb@gmail.com
[3]Reader in Zoology, Aska Science College, Aska, Ganjam (Odisha), India. devi_infoline@yahoo.com

***Corresponding Author**: Bisoyi Rama Chandra
*Email: ramchandrabisoyi862@gmail.com

Abstract
Poly culture involving Indian Major Carps (IMCs) is becoming more popular these days in developing countries to improve aquaculture production. Small, poor and marginal farmers resort to semi intensive culture in small or moderate sized earthen and un-drained ponds while taking a transition from conventional age old traditional farming for boosting income and safeguarding livelihood by Southeast Asian or Philippines cat fish, *Clarias batrachus* once dominated the aquatic niches almost all states of India. Developing countries often resort to semi intensive fish farming in the small sized earthen and un-drained aquaculture ponds. Natural pond productivity and supplementary feeding are key determiner for higher aquaculture production. But farmers cannot afford to rising cost of commercial fish feeds. To maintain enhanced production they rely on alternative indigenous farm made fish feeds to feed the cultured fish.
Our study conducted in six different blocks (Aska, Bellguntha, Bhanjanagar, Polasara, Rangeilunda and Surada) of Ganjam district of Odisha to investigate the quality and quantity fish production due to application of locally available farm made fish feeds. In total 165 small and marginal fish famers (men and women) were interviewed.
Out of them 139 farmers solely depend on farm made fish feeds(cow dung, rice bran, wheat bran, ground nut cake, mustard cakes and 26 farmers use both farm made fish feeds and commercial fish feeds (in the proportion 2:8). Out of Six carp poly culture ponds and integrated carp poly culture ponds with cat fish *Clarias batrachus* when conditioned with similar fish feed supply over all greater productivity observed.
Rural small, poor and marginal farmers often adapted to traditional fish farming without taking any proper care or management of either the aquatic resource or the fish species itself. In the conventional farming have in adequate knowledge regarding the standardized and nutritionally balanced farm made fish feeds and even have a poor idea about the dietary requirement of fish. Then when they venture into
Due to lack of proper knowledge about the nutritional content of traditional or farm made fish feeds, small marginal rural farmer can not apply the feed in desirable qualities. For which the fish production is not optimized under culture condition. Small scale farmers should be trained for preparation of balanced fish feeds for sustainable and increased carp production for enhancing their food and economic security.
Optimized and sustain production through aquaculture intervention needs the proper functioning of many orchestrated parameters

The indigenous fresh water and most valuable fish species *Clarias batrachus* is threatened by devastating factors like drought, habitat destruction, hazardous agrochemicals and even culture of most invasive African cat fish species *Clarias gariepinus.* Introduction of *Clarias batrachus* in aquaculture intervention can be a reasonable approach towards the conservation of the most gifted cat fish species in Indian sub continent for economic, food, nutrition and livelihood security. Rural poor farmers can be trained properly

Key words: Integration of, carp poly culture, nutritional security, vulnerable communities, Ganjam, Odisha

Introduction

Aquaculture is one of the prominent animal food production sectors in the world contributing towards income generation, livelihood, and food and nutrition security for millions of people (Sultana et al., 2016). An impressive annual growth of 3% between 1961– 2017 and which is nearly double in comparison to human population growth (1.4%) during that period (FAO, 2020). Aquaculture production of the world climbed to 214 Mt in 2022(178 Mt animals with 90 Mt (51%) from capture fisheries and 88 Mt (49%) from aquaculture (inland production 62.2%) (FAO, 2022). Of the total production 112 million tons (63%) harvested from sea (70% from culture and 30% from capture fisheries) 66 million tons (37%) from inland sources (83% from cultured and 17% from capture fisheries). Out of financial gain of USD 406 billion, about USD 265 billion from the aquaculture and USD 141 billion from capture.

Among the Asian countries fish and shell fish diversity in Indian water contribute to 10% of global biodiversity and numbers of species is 3137 with additional 462 exotic species (Lal and Jena, 2019). India emerged as one of the largest producer of aquaculture in the world and ranks 2nd among the fish producing state in the world since 2017. Odisha is one of the coastal states of India stood at 4th position in among the top fish producer states of India. Fish production in the state increased from 2.6 lakh MT to 9.91 lakh MT in last two decades. The revenue generated in 2000-01 was 1047 crores increased nearly 10 times to a value of 10,825 crores in 2020-21. It contributes to 2.4% of GSDP. Between 1950-60 fisheries and aquaculture was considered as a mere livelihood sector but the commercial aspect of it exploited later due to intervention of modern innovative technologies (Ayyappan, 2012; Ayyappan et al., 2013).

Greater than 78% global aquaculture production is linked to culture of Indian Major Carps (IMCs) including Rohu (*Labeo rohita*), Catla(*Catla catla*) and Mrigal(*Cirrhinus mrigala*) along with exotic one i.e. Silver carp(*Hypopthalmichthys molitrix*)(ICLARM,2002). Hence aquaculture is making a positive transformation towards a composite culture or polyculture from mono culture to maximize aquaculture production. The improvement is due to best utilization of space and the food (natural or supplementary) with the stocking of at least two fish species which are compatible but posses' different feeding habit and can occupy different niches in the same ecosystem (Jhingran, 1991). Semi intensive and intensive poly culture system with the inclusion of Indian Major Carps (IMCs) is commonly seen in different parts of India (Zimmermann et al., 2009) and farmers cultivate them in earthen ponds.

Enhancing fish production in culture system is primarily influenced supplementary feeding for providing protein and other nutrient which is around 60% of the total investment (Yang et al., 2003; Erondu et al., 2006). This is a greater challenge for poor and marginal rural fish farmer. So, it is imperative to make the semi intensive aquaculture enterprise sustainable by intelligent application of nutrient rich but cost effective feeds for higher economic benefit. Locally available farm made fish feeds can provide a plausible solution to the nutritional challenges in such aquaculture system. Fish feeds which are made into pellet, fragment or any form using natural or artificial ingredients used only for fish farming activities and not for commercial or profit making purpose are generally taken to be farm made fish feeds(New et al.,1993). The production of farm made fish feeds are mainly meant for application in semi intensive fish culture rather than the intensive one (Tacon and De Silva, 1993) in tropical countries. Farm made fish feeds mostly influenced by time and place. Locally available ingredients are safe to use and can be suitable one (Chong, 1993). Locally available farm made fish feed constituents include cow dung, rice bran, wheat bran, groundnut oil cake, mustard oil cake, Til oil cake. These are rich in abundant crude protein, crude lipid, carbohydrate, dietary fibres, minerals and many micronutrients in abundant quantities as per the estimation (Dawodu et al., 2012).The major bottle neck in selecting farm made fish is, several intermingled interfering factors (Tacon 1988, 1993) which came into action like, market demand of cultured species, feeding habit or feeding behaviour, cost and nature of ingredient of feed, water quality parameters and cost per unit production.

Further, there is a higher preference for farm made fish feeds as these are economical and less expensive but, farmers have little knowledge and awareness for quality and quantity regulation at their own level which leads to unmanageable and unpredictable fish production. Nutritional deficiency coming out of unregulated farm made fish feed application brings decline in fish production and increase in organic load due to accumulation of excess or unused feeds or feed fragments which is not devoured by the fishes and brings water quality deterioration (Munguti, 2014). Floating feeds are very significant for the aquaculture system but some amount of sinking pellets belonging to any fish feed category are not consumed by the fish and lost into the benthic habitat without any use(Yaqoob,2010). Hence our study focussed on the introduction of the most common and vulnerable cat fish, Magur(*Clarias batrachus*) and identification and assessment of use of unused and wasted fish feed components accumulated in benthic habitat. That is meant to supplement IMCs production and value addition to poly culture intervention.

Clarias batrachus, the walking cat fish found in South Asian countries like India, Srilanka, Myanmar,Malaysia and Bangladesh(Mookerjee and Mazumdar, 1950) and distributed in diverse habitat including rivers, canals, ditches, swamps, chalan beels (Islam and Hossain,1983;Hafizuddin,1983; Hafizuddin et al,1989; Bhuiyan et al.,1992) and monsoon rice fields(Ahmed et al.,1985;Bhuiyan,1964).Consumer acceptance of the fish is high due to its good quality flesh, easily digestible protein rich minerals, vitamins and recommended for people with cardiovascular and other ailments due higher content of HDL cholesterol and PUFAs. Fish is hardy and survive extreme environment of like derelict ponds due to accessory sense organs (Panayoton et al., 1982). It tolerates poor and higher level of harsh condition and show maximum growth and reproductive potential (Stickney, 1979). *Clarias batrachus* can be introduced to culture it in commercial scale as it can be supported in higher stocking density (Barua, 1990).Immense feeding diversity and opportunistic feeding is reflected in its habit as it feeds on wide group of food material like eggs, larva and nymph of insects, benthic algal species, planktons, helminths, molluscs, small fishes and also detritus in the bottom of aquatic environment (Froese and Luna, 2015; Verreth et al.,1993)Commercial level culture of *Clarias batrachus* cultivation becoming more and more popular and taken into commercial scale in some countries like India, Thailand and Vietnam. Clarias was found significantly in the inland water bodies of Odisha. But, as aquaculture is shifted mostly towards cultivation of Indian Major Carp(IMCs) and some cases culture of Chinese carp *Cyprinus caprio* and also Grass carp and Silver carp. Some aquaculture enterprises leading to culture of invasive African cat fish (*Clarias gariepinus*) leading fall in population of Clarias batrchus and seem to be vanished from the water bodies. Inclusion of *Clarias batrachus* back into aquaculture system which may lead to conservation of species.

Materials and Methods

Research sites

Six different blocks of the Ganjam districts of Odisha including Aska, Bellguntha, Bhanjanagar, Polasara, Rangeilunda and Surada selected for study of growth in Indian Major Carps (IMCs) and also growth of *Clarias batrachus* in culture ponds. Twelve sampling ponds were taken in the six villages as Gahangu, Luniapada, Mudulipalli, Mandara, Sollabindha, Kusumagadia were included to study output of poly culture system with the inclusion of common cat fish Magur(*Clarias batrachus*).

Research survey

Secondary Data collected from state fishery department and local fishery offices, i.e., DFOs and Fishery Extension Officer to gather first hand information regarding overall aquaculture practices of the district and farmers fish culture interventions in different regions of the district. Based of available secondary data, research survey was conducted in six different blocks of the Ganjam districts of Odisha including Aska, Bellguntha, Bhanjanagar, Polasara, Rangeilunda and Surada to study of aquaculture system. Different Grampanchayats and Village sites having aquaculture developments were visited. Farmer communities, Self Help Groups (SHGs) and individual fish farmers were taken for conducting interview. Farmer communities are actively participated in the interview process. Interview conducted at the houses of the farmer or at the farm sites. Well designed and standardized structural questionnaire was prepared prior to interview and executed for the conduction of interview to gather information regarding architecture of aquaculture enterprises including species cultivated, feeds used, production and production constraints. Their responses are recorded. The interview process was taken to be a part of Community Based Participatory Research (CBPR) or Participatory Rural Appraisal (PRA). This is one of the most commonly used tool for data collection based on set of principles and includes qualitative, quantitative or mixed methodologies by taking social, political and economic parameters by considering social validity and generalized ability (Cargo and Mercer, 2008; Israel et al., 1993; Macaulay et al., 1999). Data collected by participatory research by interviewing farmers, retailers and other stake holders validated through on farm visit and knowledge sharing with the key informants or the experts having deeper aquaculture knowledge with reference to the area of investigation. In total 125 individuals including 26 key informants participated in the interview process.

Experimental design

After research survey six farmers are advised to opt for poly culture with Indian Major Carps (IMCs) i.e. Bhakur or Catla(*Catla catla*), Rohi or Rohu(*Labeo rohita*), Mirikali Mrigal (*Cirrhinus mrigala*) in the ratio 3:4:3(1500 with Catla 450 nos., Rohu 600 nos. and Mrigal 450 nos.) and Six farmers are advised to Stock Magur or Cat fish,*Clarias batrchus* at a stocking density of 10000 fingerling(6 cm/4g) per acre along with the IMCs, Catla, Rohu in the ratio 4:6(with Catla 600 nos. and Rohu 900). First type of intervention was taken to be Type I and Second type involving *Calarias batrchus* was taken to be type II. Each sampling pond area was 1 acre each. In the second case Mrigal was completely replaced by *Clarias batrachus* as it is a bottom feeder and its replacement completely eliminated the competition of the *Clarias batrchus*. Pond management was done properly by the respective fish farmer under our supervision to observe the regular application of fertiliser, feed and probiotics. Regular water quality parameter such as DO, TDN, TDS, phosphate, nitrate checked under the expert guidance in laboratory of SPCB and on field by using YSI pro plus multiparameter water quality meter.

Farmers are provided with information regarding the common food value of the traditionally or conventionally used farm made fish feeds constituents (table-1) table and advised for amount of specific fish feed application. A small proportion of commercial fish feed also applied in the culture system for provision of a balanced nutrients to fish in the culture.

Table.1 Farm made fish feeds used by farmers and their Crude protein and Crude lipid content(per cent)

Sl.No	Farm made Fish feed	Crude protein	Crude lipid	Crude fiber	Carbohydrate
1	Cow dung	11.2	0.5	22±0.9	21.2±0.3
1	Rice Bran	8.1	18.9	14±0.3	46±0.7
2	Wheat bran	18.6	3.6	49±0.76	17.6±0.9
3	Ground nut Cake	43.5	7.5	3.1±0.16	54.6±0.6
4	Mustard cake	36.3	5.8	12±0.5	20±0.17
5	Til oil cake	35.8	4.7	1.2±0.6	13±0.2

Laboratory estimation of Crude protein, Lipid and dietary fibre estimation

Crude protein estimation in the fish feed samples were made in the laboratory by using Macro-Kjeldahl method. Crude lipid analysed by acid hydrolysis and diethyl ether. Crude fibre calculated by using weende method.

Data analysis

Entire cost of operation of poly culture of IMCs as well as IMCs and cat fish per acre of culture system was calculated and revenue raised through final production is estimated. Profit calculation is finally made by comparing the above values. Finally the difference in revenue collected in poly culture with IMCs and IMCs with the cat fish Magur(*Clarias batrachus*).

Results and discussion

Out of 12 village ponds, six ponds (Type I) were taken for poly culture with the stocking of IMCCatla, Rohu and Mrigal and other with poly culture involving all additional components as *Clarias batrachus* (Type 2) showed different yield or productivity under the similar culture condition. The average survival rate was found to be 90% for Rohu 70% for Mrigal and 86% for Catla and 50% for *Clarias*. Some large sized fishes except the Magur are harvested in the month of March and final harvest was made in the month of May after drying the pond.

Nutritive values of the different types of ingredient used at the time of fish feed application is not known to most fish farmers(97.2%) and they never consider the nutritional requirement of different fish which are cultivated in the culture system. Respondents do not have idea of fish feed formulation from the ingredients.

Proper pond management with the use of farm made fish feeds and some amount of commercial fish feeds reflected difference in fish production in both cases. With the introduction of same numbers of fingerlings the mean production is found to be less in type 1 intervention (Table 5) as compared to the type 2 intervention (Table 6).

Farm made fish feed applied in both the interventions to the equal amount

Table.2. Cost of farm made fish feed (INR per Kg) and total cost per annum used per acre of pond for farmer solely depend on farm made fish feeds

Sl. No.	Farm made fish feed component	Price per Kg(in INR)	Total use per acre of pond per year in Kg	Total cost in INR
1	Cow dung	Nil	240	Nil
2	Rice Bran Normal	6	96	576
3	Rice Bran (sweet type)	22	48	1056
4	Rashi or Til oil cake	30	30	900
5	Ground nut cake	32	20	640
6	Mustard oil cake	35	10	350
7	Commercial fish feed (Growfin)	60	200	12000
Total			**644**	**15552**

Table.3. Ancillary Cost for fish pond management per acre in INR

Sl. No.	Ancillary component	Cost per piece Kg	Total use per acre of pond per year in Kg	Total cost in INR
1	Lime	INR 35	300	10,500
2	Urea	INR 120	10	1,200
3	Biofit Probiotic	INR 1000	10	10,000
Total			**320**	**21,700**

Table.4. Total investment in pond aquaculture per year in INR

Sl. No.	Component	Total cost in INR
Type 1 pond	Fingerling of total 1500@ INR 3.5	5,250
	Fish feed	15,552
	Lime + Urea+ Biofit	21,700
Total investment		**42,502**
Type 2 pond	Fingerling of total 1500@ INR 3.5	5,250
	Clarias fingerling 10,000@ INR 3	30,000
	Fish feed	15,552
	Lime + Urea+Biofit	21,700
Total		**72,502**

The total fish production in the year in all six intervention ponds (type I) is between 1483 to 1579 Kg, and Rohu in the range of 497 kg to 537 kg, Catla in range of 494 kg to 526 kg and Mrigal in range of 491 to 516 Kg. The total revenue generated in these ponds calculated to be between INR 268540 and INR 266990. Mean revenue generated out of total productivity is INR 260823. Type II intervention Rohu and Catla production turns between 597 kg to 684 kg and 522 Kg to 576 Kg respectively (table 5). But the production of introduced Magur (*Clarias batrachus*) show a greater production between 709 Kg to 772 Kg with a mean production of 750 Kg/acre. Total money earned in the composite farming involving IMCs and *Clarias* was between INR 311510 and INR 351620 with a mean value of INR 330223.33

(Table 6). The difference in mean of production is found to be 403.5 Kg (Table 7). Mean profit difference between two types intervention is calculated to be INR 39400. Mean and standard deviation is calculated in both the cases (Table 5, 6 and 7) and found to be significant. Average weight attained by Rohu is about 0.932 Kg., Catla 1.32Kg., Mrigal 1.29 Kg.

Table5. Fish production in six sampling ponds (each one acre pond area) with the use of Both commercial and farm made fish feeds and revenue generated in INR

Sl. No	Fish species	Production in different ponds in Kg						Total in Kg	Average in Kg	Average Revenue generated in INR
		A 1	B 1	C 1	D 1	E 1	F 1			
1	Rohu	522	516	525	533	497	537	3130	521.66	93900.00
2	Catla	503	494	512	524	494	526	3053	508.83	81413.30
3	Mrigala	502	491	504	513	492	516	3018	503	85510.00
	Total	1527	1501	1541	1570	1483	1579	9201	1533.5	
	Revenue Total	93460+80480+85340=2,59,780	92880+79040+83470 = 255390	94,500+81920+85,680=262100	95,940+83840+87210=266990	89460+79040+83640=252140	96660+84160+87720=268540	Mean of total =260823	Standard deviation = 6406.47	

Table 6. Fish production in six sampling ponds (each one acre pond area) revenue generated in INR

Sl. No	Fish species	Production in different ponds in Kg						Total in Kg	Average in Kg	Revenue generated in INR
		A 2	B 2	C 2	D2	E2	F 2			
1	**Rohu**	650	634	671	604	684	597	3840	640	1,15,200
2	**Catla**	554	538	561	529	576	522	3280	546.66	87,465
3	**Magur**	755	747	772	717	802	709	4502	750.33	1,27,556
	Total	1959	1919	2004	1850	2062	1828	11622	1937	
	Revenue Total	117000+ 88640+ 128350 = 333990	114120+86080+126990=327190	120780+89760+131240=341780	108720+84640+121890=315250	123120+92160+136340=351620	107460+83520+120530=311510	Mean of total =330223.33	Standard deviation = 15421.75	

Table 7. Fish production in 12 sampling ponds (each one acre pond area) in both mode of operation and cost benefit calculation

Pond type	Total investment in INR	Mean of total fish production in Kg	Mean of Revenue generated in INR	Net profit in INR	Differences in investment in INR	Difference in Fish production in Kg(Mean)	Difference in profit in INR
Type I	42502	1533.50	260823	2,18,321	30,000	403. 5	39,400
Type II	72502	1937	3,30,223.33	2,57,721			
Mean of Two sample		2502	295523.16				
Standard deviation		588.52	18583.68				

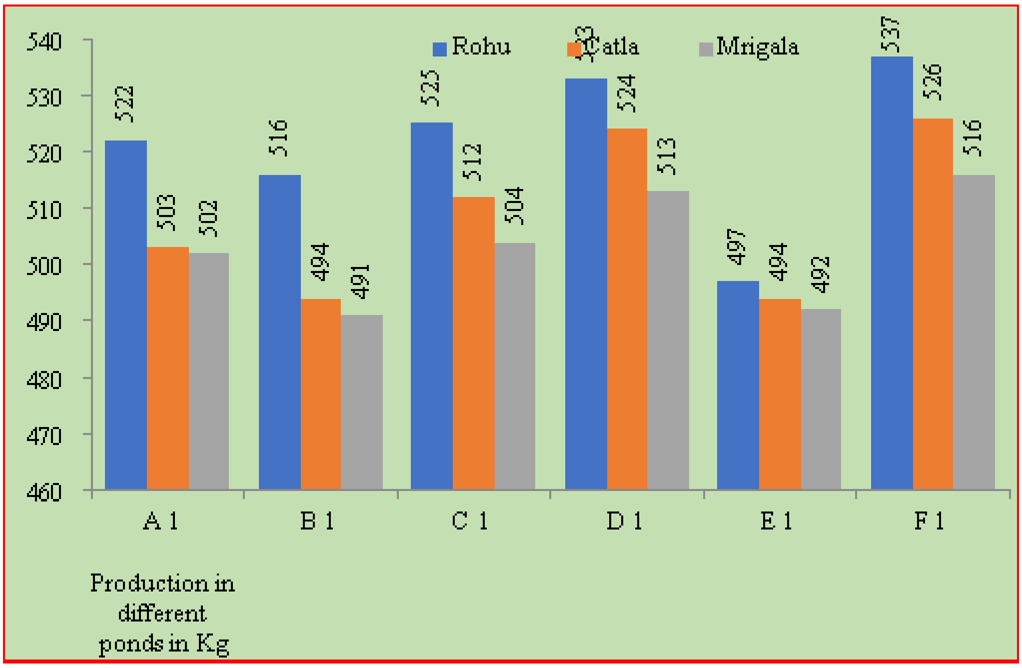

Fig. Production of different pond in Kg

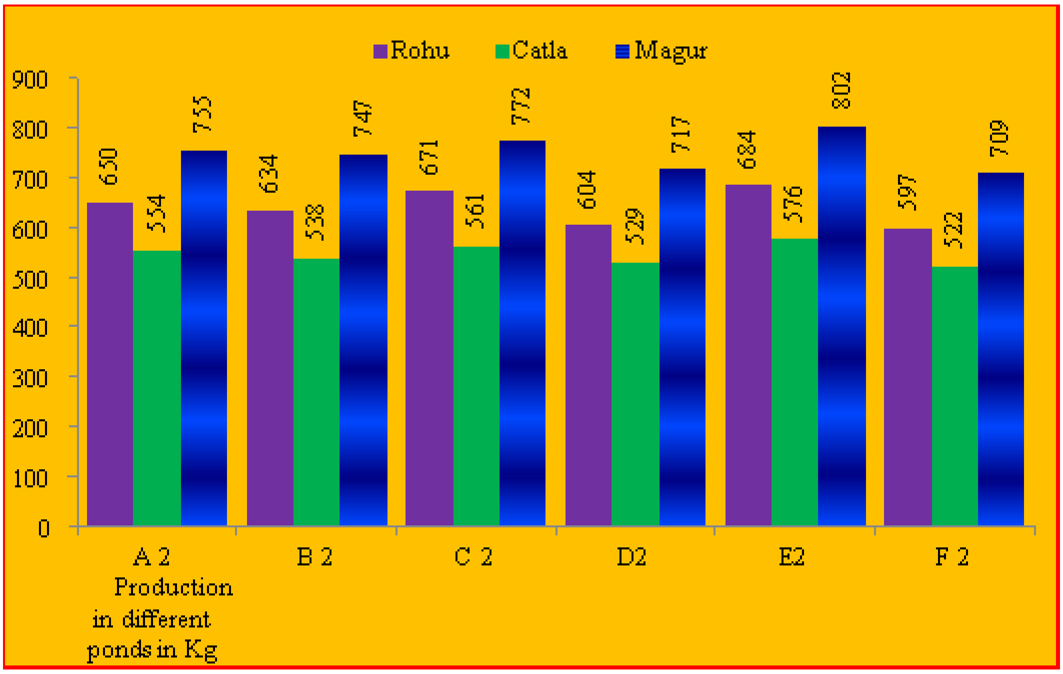

Fig. Production of different pond in Kg

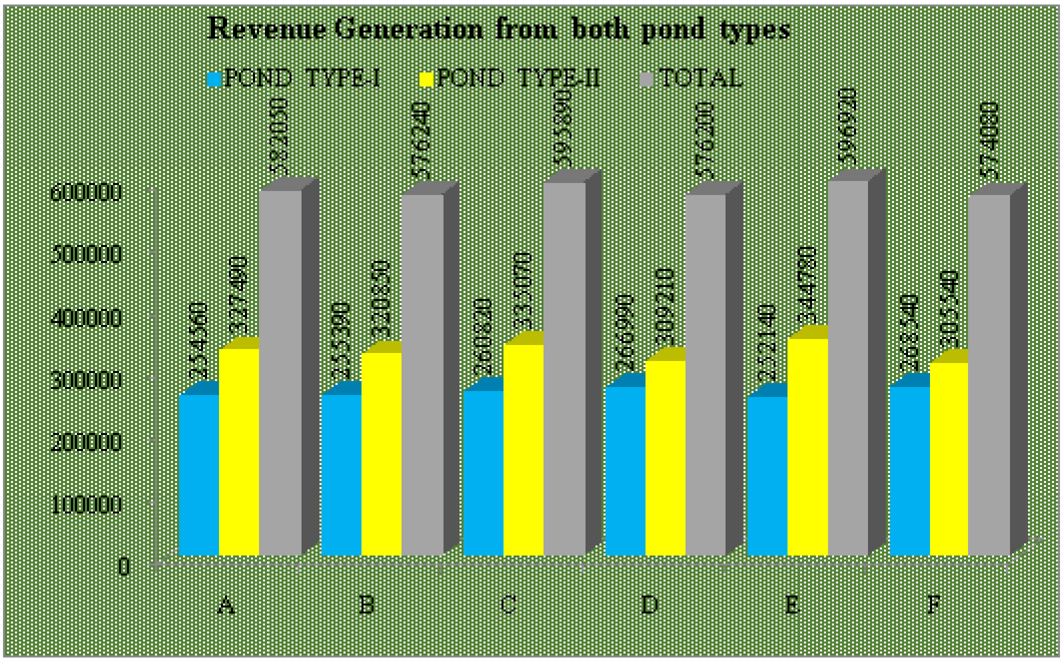

Fig. Revenue generation from both pond types

The mean production of Rohu, Catla and Mrigala for pond type 1 was found to be 511.166 kg and the mean production of Rohu, Catla and Magur for pond type 2 was found to be 645.66 kg, respectively. However, the data pertaining to the production of fish of the both types of pond was subjected to statistical analysis by using T test and the corresponding T value was 6.161 which is found to be statistically significant. Thus it is conferred here that, the production performance after inclusion of Magur fish was found to be better than the other one.

Conclusion

Although most of the farmers are opting for the aquaculture intervention towards poly culture with the inclusion of Indian Major Carps (IMCs) i.e. Rohu, Catla and Mrigal. But, there is a requirement of the inclusion of the vulnerable indigenous cat fish *Clarias batrachus* into the poly culture. This will help the community it two ways. One is provision of nutritional security due to added value of the *Clarias* in terms of certain nutrients like HDL cholesterol (good cholesterol), iron and others to boost cardiac health and to prevent other ailments. Second is fetching higher price in urban areas due to higher demand due to its consumption by heart patients. In addition, it will be a forward step towards conservation of the species. Farmers are not aware about the quality and quantity of feed application and proper management of carp poly culture along with the cat fish culture to safeguard their livelihood, economic and nutrient security. Proper scientific and technological knowhow for pond management should be imparted for sustainable production and conservation of cat fish *Clarias batrachus*.

Acknowledgement

We are very thankful to the State Pollution Control Board (SPCB) scientists and Central laboratory of OUAT for the providing facilities for proximate estimations of some nutrient composition in the sample of different farm mad fish feeds. We acknowledge the assistance of all the respondents including the farmers and government officials during the interview process for the collection of authentic data. Further, we are very thankful to all farmer communities of six villages for allowing our experimentation with the *Clarias* in IMCs poly culture system for getting valuable outcome.

References

1. Ahmed K, Mustafa G, Ali S, Shahjahan M.(Ahmed et al.,1985) Induced spawning of magur fish, Clarias batrachus (L.) by stripping method in plastic bowl hatchery. Bangladesh Journal of Zoology, 1985, 13(1):19-24.
2. Ayyappan, S.(2012). Indian fisheries: Issues and the way forward. National Academy of Science Letters, 35: 1-6.
3. Ayyappan, S., Jena, J. K., Gopalakrishnan, A. and Pandey, A. K.(2013). Handbook of fisheries and aquaculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi, India, 1116 pp.
4. Barua G.(1990) Gonadal development and fry rearing of Clarias batrachus Ph. D. Dissertation Fisheries Biology and Limnology Deptt., Bangladesh Agricultural University, Mymensingh, pp3l0.
5. Bhuiyan AS, Islam MN, Hossain T. A check list of the fish of the Rajshahi division of Bangladesh. Rajshahi University Studies, 1992B; 20:287-306.
6. Bhuiyan AL.(1964) Fishes of Dacca. The Asiatic Society of Pakistan, Publication No. 13, Dacca, 1964, 148.
7. Cargo M, Mercer SL. The value and challenges of participatory research: strengthening its practice. Annu Rev Public Health. 2008; 29(1): 325–350.

8. Chong KC. 1993. Economic of on-farm aquafeed preparation and use, pp. 148-160. In: NewMB, Tacon AGJ, Csavas I (eds) Farm-made Aquafeeds. Proceedings of the FAO/AADCPRegional Expert Consultation, 14-18 Dec. 1992. Bangkok, Thailand. FAO-RAPA/AADCP, Bangkok, Thailand.
9. Dawodu, Modupe & Godwin, bullet & Olutona, Godwin & Ajani, Funmilola & Oluayo, Bello. (2012). Determination of Mineral Trace Element and Proximate Analysis of Fish Feed. Food. 6. 76-81.
10. Erondu ES, Bekibela D, Gbulubo AT.(2006) Optimum crudeprotein requirement of catfish, Chrysichthysnigrodigitatus. Journal of Fisheries International.1(1-2):40-43.
11. FAO.(2022). The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO.https://doi.org/10.4060/cc0461en.
12. FAO. 2020. The State of World Fisheries and Aquaculture 2020. Sustainability in action. Rome. https://doi.org/10.4060/ca9229en
13. Froese, R., S. Luna. 2015. "Clarias batrachus" (On-line). Accessed January 26, 2016 at http://www.fishbase.org/Summary/Clarias-batrachus.
14. Hafizuddin AKM.(1983) Freshwater fishes of Chittagong and Chittagong Hill Tracts. Chittagong University Studies, Part II, 1985; 9(2):65-70.
15. Hafizuddin AKM, Mahmood N, Azadi MA.(Hafizuddin et al,1989) An addition to the Ichthyofauna of Kaptai lake. Bangladesh Journal of Zoology. 1989; 17(1):29-33.
16. International Center for Living Aquatic Resources Management (ICLARM) (1999). Medium term plan 2000 - 2002. ICLARM. Manila, Philippines. 110 p.
17. Islam MS, Hossain MA.(1983) An account of the fishes of the Padma near Rajshahi. Fisheries Bulletin.1; 1(2):1-31.
18. Israel BA, Schulz AJ, Parker EA, Becker AB. Review of community-based research: assessing partnership approaches to improve public health. Annu Rev Public
19. Health. 1998; 19: 173–202.
20. Jhingran, V.G.1991. “Fish and Fisheries of India”. Hindustan Publishing Corporation,
21. Deli, India, 416-441pp.
22. Lal, K. K. and Jena, J. K. 2019. Fish genetic resources - India. In: Rishi K. Tyagi, Munasinghe, D. H. N., Ashoka Deepananda, K. H. M., Frank Niranjan and Ravi K. Khetarpal (Eds.), Regional Workshop on Underutilized fish and marine genetic resources and their amelioration - Proceedings and recommendations. 10-12July 2019, Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand, 55 pp.
23. Macaulay AC et al. Participatory research maximises community and lay involvement. Br Med J. 1999; 319(7212): 774–778
24. Mookerjee HK. Mazumdar SR. Some aspects of the life history of *Clarias batrachus* (Linn.). The ZoologicalSociety of Bangladesh. 1950; 3(1):71-84.
25. Munguti J, Musa S, Orina PS, Kyule DN, Opiyo MA,Charo-Karisa H et al. An overview of current status ofKenyan fish feed industry and feed managementpractices, challenges and opportunities. InternationalJournal of Fisheries and Aquatic Studies 2014;1(6):128-137.
26. New MB, Tacon AGJ, Csavas I. (1993). Report of the FAO/AADCP regional expert consultationon farm-made feeds. 14-14 Dec. 1992. Bangkok, Thailand, pp. LX-XIII. In: New MB,Tacon AGJ, Csavas I (eds) Farm-made Aquafeeds. Proceedings of the FAO/AADCPRegional Expert Consultation, 14-18 Dec. 1992. Bangkok, Thailand. FAO-RAPA/AADCP, Bangkok, Thailand.
27. Panayoton T, Wattanutchariya S, Isvilanonda S, Tokrisma R.(1982) The economics of catfish farming in Central Thailand ICLARM Technical Report. 4. Kasetsart University Research and Development Institute, Bangkok, Thailand and International Center for Living Aquatic Resources Management, Manila, Philippines, pp60.
28. Stickney, R. R. (1979). Principles of Warm Water Aquaculture. New York: Wiley International Science.
29. Sultana T, Haque M.M., Salam M.A., Alam, M.M. (2016) Effect of aeration on growth and production of fish in intensive aquaculture system in earthen ponds. MS Thesis, Department of Aquaculture, Bangladesh Agricultural University, Mymensing. Link: https://bit.ly/39VBsCM
30. Tacon AGJ, De Silva SS. 1993. Feed preparation and feed management strategies within semi-intensive fish farming systems in the tropics. Paper presented at the 6th International Symposium on Fish Nutrition and Feeding, 4-7 October 1993, Hobart, Australia.
31. Tacon AGJ. 1988. The nutrition and feeding of farmed fish and shrimp. A training manual.3. Feeding Methods. FAO Field Document Project GCP/RLA/075/ITA. Field Document No. 7 208 pp. Brasilia, Brazil.
32. Tacon AGJ. 1993. Feed formulation and on-farm feed management, pp. 61-74. In: New MB,Tacon AGJ, Csavas I (eds) Farm-made Aqua feeds. Proceedings of the FAO/AADCP Regional Expert Consultation, 14-18 De. 1992. Bangkok, Thailand. FAO-RAPA/AADCP,Bangkok, Thailand.
33. Verreth, J., E. Eding, G. Rao, F. Huskens, H. Segner. 1993. A review of feeding practices, growth and nutritional physiology in larvae of the catfishes Clarias gariepinus and Clarias batrachus. Journal of the World Aquaculture Society, 24/2: 135-144.
34. Yaqoob M, Ali M.R., Mehmood S. Comparison of growthperformance of major and Chinese carps fed on floatingand sinking pelleted supplementary feeds in ponds.Pakistan Journal of Zoology 2010;42(6):765-769.

35. Yang S.D., Lin T.S., Liou C.H., Peng HK. (2003) Influence ofdietary protein levels on growth performance, carcasscomposition and liver lipid classes of juvenile Spinibarbus hollandi (Oshima). Aquaculture Research.34 (8):661-666.
36. Zimmermann, S., Nair, C.M., New, M.B., 2009. Grow-Out Systems-Polyculture andIntegrated Culture, in: Freshwater Prawns: Biology and Farming. Wiley-Blackwell, pp. 195–217. https://doi.org/10.1002/9781444314649.ch11.
37. Argungu, L.A., Christianus, A., Amin, S.M.N., Daud, S.K., Siraj, S.S. and Aminur, R.M. 2013. Asian catfish Clarias batrachus (Linnaeus, 1758) getting critically endangered. Asian Journal of Animal and Veterinary Advances. 8 : 168-76. https://doi.org/10.3923/ ajava.2013.168.176
38. Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N.,Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney,H. And Troell, M., 2000. Effect of aquaculture on world fishsupplies. Nature, vol. 405, no. 6790, pp. 1017-1024. http:// dx.doi.org/10.1038/35016500. PMid:10890435.
39. Tacon, A.G., Hasan, M.R., Subasinghe, R.P., 2006. Use of fishery resources as feed inputs to aquaculture development: trends and policy implications. Rome: FAO.
40. Rath, S. & Mohanta, Kedar & Giri, Shiba. (2020). Farm Made Fish Feed. Farm Made Fish Feed Preparation for Carp Using Locally Available Feed Ingredients
41. Kobir, Md & Rayhan, Md & Hossain, Akhtar & Dey, Shishir Kumar & Sultana, Sayeeda. (2017). Carps polyculture technique in Mohanpur, Rajshahi region of Bangladesh. Asian-Australasian Journal of Bioscience and Biotechnology. 2. 100-105.10.3329/aajbb.v2i1.64353.