E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2018; 6(4): 545-550

www.fisheriesjournal.com
Received: 15-05-2018
Accepted: 16-06-2018

Bhanu Prakash CH
Farm Science Centre, Tarn Taran
Guru Angad Dev Veterinary and
Animal Sciences University,
Ludhiana, Punjab, India

Sachin Onkar Khairnar
Department of Aquaculture
College of Fisheries, Guru Angad
Dev Veterinary and Animal
Sciences University, Ludhiana,
Punjab, India

Amit Mandal
Department of Aquaculture
College of Fisheries, Guru Angad
Dev Veterinary and Animal
Sciences University, Ludhiana,
Punjab, India

Anil Kumar
Farm Science Centre, Tarn Taran
Guru Angad Dev Veterinary and
Animal Sciences University,
Ludhiana, Punjab, India

Balwinder Kumar
Farm Science Centre, Tarn Taran
Guru Angad Dev Veterinary and
Animal Sciences University,
Ludhiana, Punjab, India

Correspondence
Bhanu Prakash Ch
Farm Science Centre, Tarn Taran
Guru Angad Dev Veterinary and
Animal Sciences University,
Ludhiana, Punjab, India

Composite fish farming: A review on economic enterprise for rural empowerment and livelihood generation

Bhanu Prakash CH, Sachin Onkar Khairnar, Amit Mandal, Anil Kumar and Balwinder Kumar

Abstract
Composite farming is poly-species farming at any scale, which is found to be highly profitable because of the low input costs. But no longer continues, as the cost of basic inputs like cow dung, poultry manure, ground nut oil cake, mustard oil cake, rice bran and land costs has increased by many folds while the gate value of the fish remained almost constant. Quality of water, fish seed, feed and health management is essential prerequisite for optimizing production and productivity from inland fisheries and aquaculture in the country. Composite fish farming in pond culture system consists of Indian major carps (IMC) (*Catla catla*, *Labeo rohita* and *Cirrhinus mrigala*) and exotic major carps (*Hypophthalmicthys molitrix, Ctenopharyngodon idella* and *Cyprinus carpio*). This system is a practical alteration of the original three species IMC polyculture so as to fulfill the vacant niches in a pond ecosystem for optimizing internal resource utilization and thereby a means of increasing productivity. Polyculture of compatible fish species is the most ecologically sound fish culture practice which facilitates efficient utilization of all ecological zones within the pond environment enhancing the maximum standing crop and the empowerment for rural youth, which in turn will enhance food and nutritional security.

Keywords: Composite culture, species composition, fish production, sustainable development, food security, livelihood generation

1. Introduction

Indian fisheries and aquaculture is an important sector of food production, providing nutritional security to the food basket, contributing to the agricultural exports and engaging about fourteen million people in different activities. It ranks second in the world in fish production which increased from 0.7 metric tonnes in 1951 to 10.79 metric tonnes in 2015-16 where, aquaculture contributed 78% of the country's total fish production [1]. Constituting about 6.3% of the global fish production, the sector contributes to 1.1% of the total GDP and 5.15% of the agricultural GDP with annual export earnings of 33, 441.61 crore rupees for the year 2016-17 [2]. Besides, 14 million people are employed in fisheries related auxiliary activities. Paradigm shifts in terms of increasing contributions from inland sector and further from aquaculture are significations over the years. In 1957, the first successful induced breeding on major carps was done by Dr. Hiralal Chaudhuri, father of blue revolution on *Cirrhinus mrigala*, *C. reba* and *Labeo rohita*, which ultimately triggered the growth of inland aquaculture sector of the country. Even though hatchery bred seed was available, farming of major carps primarily continued as IMC polyculture with combinations of three to four species incorporating with minor carps.

India offers a huge potential for freshwater aquaculture development as it is blessed with extensive river and canal system of about 195.210 km, consisting of 14 major rivers, 44 medium rivers and numerous small rivers and streams. In addition, pond and tank resources are estimated at 2.36 mha [3, 4]. Aquaculture development is closely related to the development of the ability of the farmer's understanding and adoption of new technology and they should be supplied with recent, useful and practical information on the subject [5]. Aquaculture production models are highly dynamic, unless we assess the economics and understand the scale of economy of any given activity, system not sustains [6].

Fish is the cheapest and most easily digestible animal protein and was obtained from natural sources from time immemorial for consumption by human beings. This significant growth in fish consumption has enhanced people's diets around the world through diversified and nutritious food [7]. The quality of fish protein is high because it contains amino acids in the amount and proportions required for good nutrition and provides a good source of vitamins, minerals and iodine [8]. However, due to over exploitation and pollution, the availability of fish in natural waters has declined considerably forcing scientists to adopt various methods to increase its production. Fish farming in controlled or under artificial conditions has become the easier way of increasing the fish production and its availability for consumption. Farmers can easily take up fish culture in village ponds, tanks or any new water body and can improve their financial position substantially. It also creates gainful employment for skilled and unskilled youths.

1.1 Composite fish farming

The technology developed for fish culture in which compatible and non-competing fishes are cultured simultaneously through the utilization of different feeding zones (all the natural niches) from a pond so as to increase the total production from unit area of water is known as composite fish farming and it is the most popular culture technique in the country. Any perennial fresh water pond retaining water depth of 2 m can be used for fish culture purpose. However, the minimum level should not fall below 1 m. Even seasonal ponds can also be utilized for short duration fish culture [9].

Carp composite culture where compatible carp species, Indian major carps (catla, *Catla catla*; rohu, *Labeo rohita*; mrigal, *Cirrhinus mrigala*) and exotic carps (grass carp, *Ctenopharyngodon idella*; silver carp, *Hypophthalmichthys molitrix*; common carp, *Cyprinus carpio*) are reared together in the same pond was introduced by the Central Inland Fisheries Research Institute during the 1970s [10]. Three strategies can be followed in composite carp fish farming as the first one is the low input or fertilizer based system, practiced mostly in small community ponds, with multiple uses and open access. It requires only low levels of investment. The level of adaption and impact are also low since aquaculture is practiced mostly in community village ponds with multiple uses. These are utilized as common pool resources and it is difficult to adopt all culture practices recommended in the technology. Further, privatization of aquaculture activity in general and the returns from it in particular is constrained by management and property regimes for these water bodies. The second strategy is to medium input or fertilizer and feed based system which is prevalent in medium sized to large sized private ponds with moderate to high investments. The levels of adoption and impact are high, despite problems of scarcity of quality input, limited access to infrastructures and low remuneration. The last strategy prevalent in composite carp farming is a high input or intensive feed and aeration based system. This practice is generally followed in medium sized private ponds with high investments and risk bearing ability. In this practice, generally inputs use is higher than recommended levels, and therefore, the adoption level is very high. It leads to high risk, low ecological sustainability and low benefit cost ratios. The impact in this case is moderate. Lakra and Ayyappan [11] revealed that the subject has assumed greater importance in recent years in the development of agriculture and human health. The study concluded that the increased application of technological tools could certainly revolutionize country's fish farming besides its roles in biodiversity conservation.

Farmers and entrepreneurs tend to go under great loss by investing in aquaculture activities without understanding the economics of fish farming in ideal condition. Many of the research results are lacking the critical evaluation from the economic edge and do not find a place in the field.

1.2 Fish species for composite fish culture

Depending on the compatibility and type of feeding habit of the fishes, the following Indian as well as Exotic carp species has been recommended for culture in the composite fish culture technology (Table-1) [12]. Both catla and silver carps are surface feeder. Catla feeds on zooplankton while silver carp mainly prefers phytoplankton [13] and it has ecological and socio-economic potential advantages with having a strong impact on the pond ecology because it is a fast growing and very efficient filter-feeder [14, 15]. Grass carp consume low value vegetative waste and increase natural food production in the pond by nutrient recycling and faecal production [16]. Mrigal is bottom feeder and considered to monitor culture and health status in farm condition [17]. Common carp has more rapid growth and known as bioturbator [18]. However, it not only increases food availability but also changes feeding behavior and food intake of Rohu [19].

Table 1: List of fishes for composite carp culture with their feeding habits and feeding zones

Species	Feeding habit	Feeding zone
Indian Major Carps (IMCs)		
Catla	Zooplankton feeder	Surface feeder
Rohu	Omnivorous	Column feeder
Mrigal	Detritivorous	Bottom feeder
Exotic carps (ECs)		
Silver carp	Phytoplankton feeder	Surface feeder
Grass carp	Herbivorous	Surface, column and marginal areas
Common carp	Detritivorous/Omnivorous	Bottom feeder

1.3 Potential

The inland fisheries sector in India is endowed with rich aquatic and fishery resources. The sector offers ample scope for fisheries and aquaculture development. But there is wide gap between actual fish production and potential as open water bodies are not utilized to the optimum. The potential fishery resources and areas are untapped. Generally, culture practices are highly eco sustainable and compatible with other farming systems. Therefore there is scope for intensification and diversification of aquaculture practices for optimal utilization of aquatic resources. The area under tanks and ponds available for warm fresh water aquaculture including swamps, beels etc, and low lying water logged area not good for agriculture as also any land where there is copious water supply can be converted for fish farming. Out of the total inland fish production of 10.79 lakh tonnes around 65% is contributed by the aquaculture sector. More than 5 tonnes/ha/yr fish production is achieved from the average pond size of 0.6 to 1 ha [20]. This shows the tremendous scope for fish culture in the country. Only 15 % of the potential area of tanks and ponds available is developed so far, showing immense possibilities for horizontal expansion of composite fish culture [21].

2. Pond management protocols

The main criteria to be kept in mind while selecting the pond is that the soil should be water retentive, adequate quality water supply is available and that the pond is not in a flood prone area. Derelict, semi derelict or swampy ponds can be renovated for fish culture by dewatering, desilting**,** repair of the embankments and provision of inlet and outlet. The pond may be owned by the individual or taken on lease. Technical parameters of composite fish culture which includes site selection, pre-stocking, stocking and post stocking operations. Pond Management plays a very important role in fish farming before and after the stocking of fish seed. Management protocols adopted in composite fish culture can be divided into pre-stocking management, stock management and post-stocking management.

2.1 Pre-stocking management

The popular English proverb "prevention is better than cure" teaches us to follow preventive methods is perfectly applicable in aquaculture, therefore proper management starting from the pond preparation is very essential.

2.1.1 Eradication of aquatic insects and weeds

The major pond preparation phase starts with removal of aquatic insect and weed clearance by manual/mechanical effort or by chemical means, as aquatic weeds hamper primary productivity and prevents normal penetration of sun light at the pond bottom and reduce the disturbance of water surface due to wind action upsetting the oxygen balance, creates obstruction for fishes and during netting operations. However noval and different methods must be employed to control aquatic insects. Spraying oil to kill the insects, which come up to the surface to respire, is a well-known principle and a routine practice in malaria control. It is well known that aquatic insects and other predators cause considerable damage to the carp fry in the nursery ponds and there are several methods to control them [21-25]. A successful method for control of predatory insects to be applied 12 to 24 hours before stocking, developed at CIFRI's Cuttack centre, consists of spraying, on a still day, an emulsion of mustard or coconut oil and cheap washing soap in the ratio 56:18 kg per ha [26]. The back swimmers (Notoneclidae) are killed within half an hour. Higher doses, however, kill water boatman (Family: Corixidae) beetle larvae and bugs. Teepol B-300 (a detergent synthesized by Burmah Shell) in the emulsion is substitution of soap [27]. It is a neutral amber-coloured liquid, readily soluble in water, unaffected by hard or brackish water and is easy to mix with oil. The commended dose of Teepol is 560 ml, emulsified with 56 kg of mustard oil.

2.1.2 Eradication of predatory and weed fish

It is done by repeated netting or by using mahua oil cake @ 2500 kg/ha or by sun drying the pond bed, maintenance of physico-chemical quality of water, manuring by using cow dung, poultry droppings etc. and liming with quick lime for regulating pH of pond water [28]. Depth of the pond is considered as one of the most important factors in productivity [29]. In general, productivity declines with increase in pond size [30], while production level decline's with increase in pond depth from 5 to 9 feet [31]. Weed fishes (e.g. *Puntius* sp., *Oxygaster* sp., *Ambassis* sp., *Amblypharyngodon mola*, *Colisa* sp., *Rasbora* sp., etc.) are those which compete with the culturable species of fishes for food, space and oxygen and causing serious problem to fish culture [32]. Removal of unwanted fish through physical methods like dewatering and de-silting of ponds, repeated netting operations, hooks and lines with baits are found to be incomplete and uneconomical [36]. In practical field farmers use pesticides viz. Nuvan (Dichlorvos or 2, 2-dichlorovinyl dimethyl phosphate), Ustaad (Cypermethrin) etc [32].

2.1.3 Liming

Lime is used to bring the pH to the desired level. In addition, lime also acts as buffer and avoids fluctuations of pH, increases the resistance of soil to parasites, its toxic effect kills the parasites; and it accelerates organic decomposition. Lime application has many benefits in culture pond system viz. (i) neutralization of acidity (ii) increase in pH of bottom soil and thereby enhancing the availability of phosphorus added in fertilizer, (iii) accelerating the microbial activity and thereby diminishing the accumulation of organic matter in pond bottoms and favouring recycling of nutrients, (iv) maintaining the alkalinity and other physico-chemical characteristics of soil which in turn helps in enhancing fish/shrimp production, and, (v) improving the hygienic condition of pond bottom [30]. The normal doses of the lime ranges from 200 to 250 Kg/ha. However, the actual dose has to be calculated based on pH of the soil and water is given in (Table-2):

Table 2: Lime doses with respect to soil pH

Soil pH	4.5-5.0	5.1-6.5	6.6-7.5	7.6-8.5	8.6-9.5
Lime (kg/ha)	2,000	1,000	500	200	Nil

The pond is required to be filled with rain water or water from other sources viz., canal, tube well etc. after liming in case it is a new pond.

2.1.4 Fertilization/Manuring

Fertilization of the pond is an important means for intensifying fish culture by increasing the natural productivity of the pond and as a means of increasing fish production is well accepted [31]. The fertilization schedule has to be prepared after studying the quality of the pond soil. A combination of both organic and inorganic fertilizers may be used for best results. The fertilizer schedule has to be suitably modified depending on the growth of the fish, available food reserve in the pond, physic-chemical conditions of the pond and climatic conditions. Organic manure to be applied after a gap of three days from the date of liming. Cowdung @ 5000 kg/ha or any other organic manure in equivalent manurial value is also used for aquaculture ponds. Inorganic fertilization to be undertaken after 15 days of organic manuring. Requirement of nitrogenous and phosphate fertilizers would vary as per the nature of the soil fertility indicated below (Table-3). However any one of the nitrogen and phosphate fertilizers could be used as per given rate.

Table 3: Doses of inorganic fertilizer application (kg/ha/month)

Soil fertility status⇨	**Nitrogen (mg/100 g soil)**		
Inorganic fertilizers	**High (51-75)**	**Medium (26-50)**	**Low (upto 25)**
Ammonium sulphate	70	90	140
Urea	30	40	60
Soil fertility status⇨	**Phosphorus (mg/100 g soil)**		
Inorganic fertilizers	High (7-12)	Medium (4-6)	Low (upto 3)
Single super phosphate	40	50	70
Triple super phosphate	15	20	30

2.2 Stocking

2.2.1 Species selection

Selection of species plays an important role for any culture practices. In India, suitable and most common combinations of fish for composite fish culture system used to be are catla, rohu, and mrigal along with grass carp, silver carp and common carp [32]. The pond will be ready for stocking after 15 days of application of fertilizers.

2.2.2 Stocking density and ratio

A pond having average water depth of 2.0-3.0 m may be stocked at the rate of 5,000 fingerlings/ha [12]. However, it is advocated 6,000-12,000 fingerlings/ha in pond having an average water depth of 2.5 m [33]. In any case the principle behind determining the stocking ratio is to fulfill the habitat and feeding niches operating in the upper, column and bottom layer of the pond with species combinations in such away to minimize overlap. However, for formation of distinct three layers in pond ecology a minimum depth of six feet is required. Generally, in six species combination, the upper layer of the pond is stocked with 30% of the total stock, whereas, the column and bottom layer holds 40% and 30% of the stocks respectively. Again, in each layer one IMC is co stocked with one exotic carp with non-competing habits e.g. catla with silver carp (upper layer), rohu with grass carp (column layer) and mrigal with common carp (bottom layer). Fish fingerlings of 50- 100 gm size should be used for stocking @ 10000 nos. per hectare. However, if fingerlings of smaller size are used, suitable allowance may be made accounting for mortality. The present model envisages stocking of advanced fingerlings and rearing for 10-12 months. Depending on availability of seed and market condition, stocking can be of 3, 4 or 6 species combination in the following ratio (Table-4).

Table 4: Ratio of species combination for composite carp culture

Species	3 species	4 species	6 species
Catla	4.0	3.0	1.5
Rohu	3.0	3.0	2.0
Mrigal	3.0	2.0	1.5
Silver carp	-	-	1.5
Grass carp	-	-	1.5
Common carp	-	2.0	2.0

Since the market demand for Indian major carps is very good especially for catla and rohu, Hence author has mentioned above the model based on the stocking of Indian major carps. Ahmad [34] revealed that stocking density of grass carp and common carp in a stocking ratio of 1:1.5 gave better result than the rest of fish species selected for composite culture. The effectiveness is depicted in Chinese saying one grass carp raises three silver carps.

2.3 Post Stocking

2.3.1 Supplementary feeding

Fishes need much more food than what is available naturally in the pond. Fishes can be fed with a mixture of rice bran and oilcakes in the ratio 4:1, the ratio varies with local availability of ingredients, price fluctuations and the preferences of individual farmers [35]. In Punjab, sinking pellets have gained popularity because of the promotional efforts of the feed companies. Although the growth is not substantially different to that achieved with the conventional mixture, farmers have begun to adopt pellets because of their convenience [36]. This not only helps to reduce feed costs, which account for 50−60 percent of the operating costs in any aquaculture venture, but also helps to reduce the environmental impacts by minimizing feed wastage.

Due to the high cost of Ground nut Oil Cake (GOC) farmers have tried using alternate sources like Cotton seed oil cake which is comparatively cheaper than GOC. GOC and cotton seed oil cake can be mixed in equal proportions and fed to the fish and is reported to give almost the same growth rate as that of GOC. The feed should be placed on a feeding tray or in feeding bags and lowered to the pond bottom or it can be dispersed at the corners of the pond. After some time the fishes will get used to this type of feeding and aggregate at the same place at particular time for regular feeding thereby reducing the feed losses. The recommended feeding rate is 5-6 % of body weight up to 500 gm size of fish and then reduces to 3.5% of body weight from 500-1000 gm size. The feeding is generally supplementary in nature.

2.3.2 Manuring

Organic manuring can be done in monthly installments @ 1000 kg/ha. Inorganic fertilization may be done at monthly intervals alternating with organic manuring. However, the monthly rate of fertilization will depend on pond productivity and the growth of the fishes. It should be ensured that excess fertilization does not take place which may result in eutrophication [37].

2.3.3 Harvesting

Harvesting is generally done at the end of 1st year, when the fishes attain average weight of 0.75 to 1.25 kg. With Proper management a production of 4 to 5 tonnes/ha can be obtained in a year [37]. Fish production obtained by combined culture of IMC and exotic carps was 2.06 tonnes/ha/yr [38]. Fish farmers produce above 5 tonnes/ha/yr at stocking density above 15,000 nos./ha and with more than one or two stocking frequency [39]. Moreover, the original practice of complete harvesting at the end of one year production cycle was mostly abandoned with multiple socking and multiple harvesting concepts in recent years. Harvesting is done by partial dewatering and repeated netting. In some cases complete dewatering of ponds is done. Some farmers resort to partial harvesting also depending on the season and demand for fish.

3. Vertical expansion of fish culture

A number of measures are now being employed by the entrepreneurs to increase the per hectare production of fish. Important measures adopted are stocking of advanced fingerlings/yearlings by stunning the growth of fish seed during first year, heavy stocking and multiple harvesting after the fishes attain a size of 500 g [40]. Multiple stocking and multiple harvesting, use of aerators, integrated fish farming with animal husbandry activities like dairy, poultry, piggery or duckery to get daily organic manuring to the pond thus increasing its fertility. It is possible to increase the per hectare production of fish to 5-7 tonnes per ha per year by employing different methods as indicated above.

3.1 Subsidy

Subsidy is available for various items like renovation/ repair of ponds, construction of new ponds, first year inputs etc. under a centrally sponsored subsidy scheme implemented by majority of the State Governments through FFDA's for different categories of farmers and also from National Fisheries Development Board (NFDB) details of which may be obtained from concerned Fisheries Departments or from the website of NFDB.

3.2 Eligible Borrowers

The following categories of borrowers are eligible to avail subsidy.

- An Individual.
- A company.
- A Partnership firm.
- A co-operative society.
- A group of fish farmers.

Training in fish farming is being provided by the FFDA's to the eligible borrowers and it is essential that the borrower has prior knowledge of fish farming before availing the subsidy/bank loan.

4. Financial Outlay

Table 5: Economics of one acre fresh water carp fish farming

S. No	Items	Rate (Rs./unit)	Amount (Rs.)
A.	**Capital cost**		
1	Excavation of land (4000 m^3)	25/m^3	1,00,000
2	Construction of sluice gate (inlet/outlet)	--	25,000
2	Fish seed (4000 fingerlings)	3	12,000
3	Liming (200 kg)	15	3,000
4	Fertilizers & Manures		20,000
5	Supplementary feeding (FCR=1:1.5) (6000 kg)	30	1,80,000
6	Regular investments (including labour)		60,000
7	Total investment		4,00,000
8	Total investment (excluding capital investment)	400000-100000	3,00,000
9	Total fish production (Approx. 4500 kg)	Rs. 100/kg	4,50000
10	Net income/year	450000-300000	1,50000
11	Benefit cost ratio (B:C)		1:1.37
12	Net Income per month		12,500

5. Conclusion

It is well understood that location specific and resource based fish farming can be an important avenues for improving livelihood and income for mainly marginal and poor farmers. Fish farming varies from one area to another in terms of production combination, rates and sizes. Fish farming has a great capacity of making more food available thus enhancing food security and creating more jobs for the teeming unemployed masses in the country.

6. Acknowledgement

Authors thank to the Dr. Harish Kumar Verma, Director of Extension, Guru Angad Dev Veterinary and Animal Sciences University for the facility given for preparing the manuscript.

7. References

1. Food and Agriculture Organizations of the United Nations (FAO). The State of World Fisheries and Aquaculture (SOFIA), ISBN 978-92-5-106675-1, FAO Fisheries Department, Rome, 2010.
2. DAHDF. Annual Report 2016-17. Ministry of Agriculture & Farmers Welfare Government of India, 2017, 1-162.
3. FAO. National Aquaculture Sector Overview India, 2014, 11.
4. Handbook of Fisheries and Aquaculture. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, New Delhi, 2014, (2).
5. De HK, Saha GS, Jayasankar P. Twenty five years of freshwater aquaculture extension research in the Central Institute of Freshwater Aquaculture, Bhubaneswar, Odisha-a review. 2013; 6(3):135-139.
6. Shivakumar M, Seema B, Rajanna C, Naveenkumar BT. Economics of seed rearing and farming of carps. 2014; 2(1):42-45.
7. Zhou X. An Overview of Recently Published Global Aquaculture Statistics. FAO Aquaculture Newsletters. 2017; 56:6-8.
8. Edward P, Demaine H. Rural Aquaculture: Overview and Framework for country reviews. Regional office for Asia and the Pacific (RAP), 1997, 36.
9. Vision 2050. ICAR Research Complex for Eastern Region. 2013, 48.
10. Biswas B, Das SK, Mandal A. Alterations in the management practices of composite farming of Indian Major Carps in 24 Parganas (N) district, West Bengal. Journal of Entomology and Zoological Studies. 2017; 5(6):2656-2661.
11. Lakra WS, Ayyappan S. Recent Advances on Biotechnology Applications to Aquaculture. Asian-Australian Journal of Animal Sciences. 2003; 16(3):455-462.
12. Sinha VRP, Chakraborty RD, Tripathi SD, Das P, Sinha M. Carp culture. Package of practices for increasing

production. Aquaculture Extension Manual New Series, No. 2, CIFRI, Barrackpore. 1985; 4:6-26.
13. Lazzaro X. A review of planktivorous fishes: their evolution, feeding behaviours, selectivities and impacts. Hydrobiologia. 1987; 146:97-167.
14. Milstein A. Ecological aspects of fish species interactions in polyculture ponds, Hydrobiologia. 1992; 231:177-186.
15. Milstein A, Hepher B, Teltsch B. Interactions between fish species and the ecological conditions in mono and polyculture pond system 1, Aquaculture and Fisheries Management. 1985; 16:305-317.
16. Li SF, Mathias J. Fresh water fish culture in China: Principles and practices, Elsevier. 1990; (2):34-39.
17. Ahmed GU, Konica K, Ali MF, Khatun T. Investigation on culture and health status of Mrigal *Cirrhinus cirrhosus* from the farming system of Mymensingh region, Journal of Bangladesh Agricultural University. 2013; 11(2):391-397.
18. Dey MM, Rab MA, Paraguas FJ, Piumsombun S, Ramachandra B, Alam MF *et al*. Fish consumption and food security: a disaggregated analysis by types of fish and classes of consumers in selected Asian countries, Aquaculture Economics and Management. 2005; 9(1, 2):89-111.
19. Anras MLB, Beauchaud M, Juell JE, Coves D, Lagardere JP. Environmental factors and feed intake: rearing systems. In: Food Intake in Fish (Ed. by D. Houlihan, T. Boujard & M. Jobling), Blackwell, Oxford. 2001, 157-188.
20. Biswas B, Das SK, Mandal A. Socio-economic dimensions and their impacts upon productivity of composite fish farming in north 24 parganas district, West Bengal, Journal of Entomology and Zoology Studies. 2018; 6(2):1131-1135
21. Alikunhi KH. On the food of young carp fry. Journal of Zoological Society of India. 1952; 4(1):77-84.
22. Alikunhi KH. Fish culture in India. Farmers Bulletin (Indian Council of Agricultural Research). 1957; 20:1-144.
23. Chaudhuri H. Contribution to the techniques of pond fish culture in India. D. Phil Thesis, University Of Calcutta, 1960.
24. Ganguly DN, Mitra B. Observation on the fish fry destroying capacity of certain aquatic and the suggestion for their eradication. Indian Agriculturist. 1961; 5(11):184-188.
25. Khan, Hussain A. A note on the destruction of carp fry by larvae of aquatic insects. Proceedings of Indian Science Congress. 1947; 34(3):184.
26. Pakrasi B. Preliminary observations on the control of aquatic insects in nursery ponds. Proceedings of the Indian Academy of Sciences B. 1953; 38(4):211-213.
27. Chatterjee SN. Central Institute of Fishery Education, Annual day Souvenir, 1970.
28. Food and Agriculture Organization (FAO). Farm ponds for water, fish and livelihoods, diversification booklet number 13. Eds, James W. Miller. Rural Infrastructure and Agro-Industries Division Food and Agriculture Organization of the United Nations, Rome, 2009.
29. Rath RK. Freshwater Aquaculture, Scientific Publisher, Jodhpur, India, 1993, 493
30. Hussain M, Hussain SM, Afzal M, Raza SA, Hussain N. Mubarik MS. Comparative study of replacement of maize gluten with rice bran (3:1 and 1:3) feed supplement: effect on fish growth in composite culture. Pakistan Journal Agricultural Science. 2011; 48(4):321-326.
31. Chakrabarty RD, Sen PR, Chatterjee DK, Jena S. On the use of fertilizers and supplementary feed for enhancing fish production in freshwater ponds, National Academy of Science, India. 1975; 45B(3):192-196.
32. Huet M. Text book of fish culture- breeding and cultivation of fish London, Fishing News (Books) Limited, 1986, 1-436.
33. Rahman MM, Verdegem MCJ, Nagelkerke LAJ, Wahab MA, Milstein A, Verreth JAJ. Growth, production and food preference of rohu *Labeo rohita* (H.) in monoculture and in polyculture with common carp *Cyprinus carpio* (L.) under fed and non-fed ponds, Aquaculture. 2006; 257:359-372.
34. Datta MK. Advances in composite fish farming of carps in tropical state of Tripura, India, 2014.
35. Ahmad M, Abbas S, Javid A, Ashraf M, Khalid JI, Azmat H *et al*. Effect of varying stocking density of bottom feeder fish *Cirrhinus mrigala* and *Cyprinus carpio* on growth performance and fish yield in polyculture system, International Journal of Fisheries and Aquaculture. 2013; 5(11):278-285.
36. Nandeesha MC, Sentilkumar V, Antony Jesu Prabhu P. Feed management of major carps in India, with special reference to practices adopted in Tamil Nadu. In M.R. Hasan and M.B. New, eds. On-farm feeding and feed management in aquaculture. FAO Fisheries and Aquaculture Technical Paper No. 583. Rome, FAO, 2013, 433-462.
37. Debnath M, Nandeesha MC, Dhawan A, Anand V, Paul A, Roy M. Economics of aquaculture feeding practices: Punjab, India. In M.R. Hasan, ed. Economics of aquaculture feeding practices in selected Asian countries, pp. 101–122. FAO Fisheries Technical Paper No. 505. Rome, FAO. 2007, 205.
38. Indian Council of Agricultural Research (ICAR). Composite Fish Culture in Ponds Extension Folder Number 69 Goa, India, 2014.
39. Asala G. Principles of Integrated Aquaculture. In: AA Olatunde; Gabriel *et al*. 1994, 307.
40. Hussain SM, Sen D, Pathak M, Singh MP. Comparative study of composite fish culture (CFC) and local practices of fish culture in East Siang District, Arunachal Pradesh, Indian Journal of Hill Farming. 2013; 26(2):32-34.