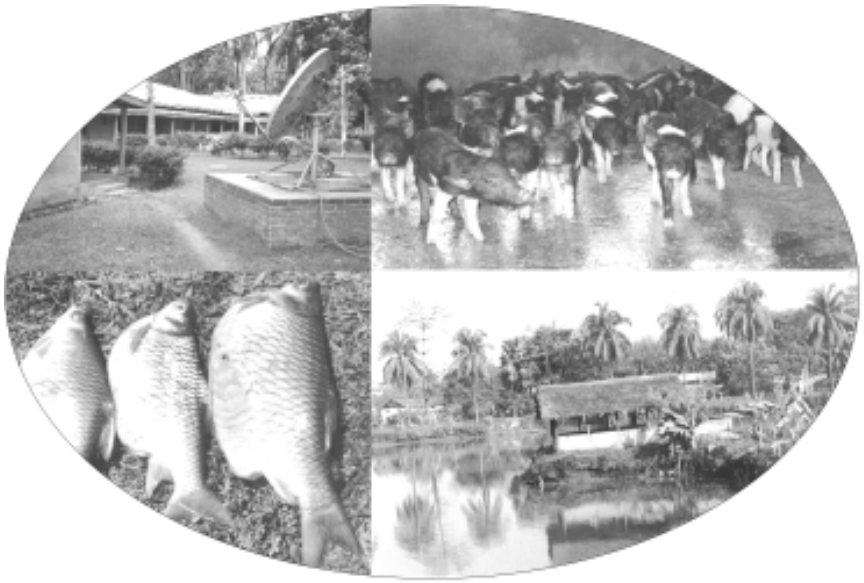
A training manual
on
POLYCULTURE AND INTEGRATED FISH FARMING

26 – 30 December 2006

Sponsored by :

Assam Agricultural Competitiveness Project (AACP)
Govt. of Assam



Organized by

College of Fisheries
Assam Agricultural University
Raha - 782103, Nagaon
Assam, India
2006

About the manual : Training manual on "Polyculture and integrated fish farming" is published by the College of Fisheries, Assam Agricultural University, Raha with the sponsorship of Assam Agricultural Competitiveness Project (AACP), Govt. of Asom as reading material in the training of Demonstrators and allied cadre office bearers of Department of Fisheries, Govt. of Asom. In this manual write up are presented on the various aspects of polyculture of carps and farming practices of fish with the integration of paddy and livestocks.

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Assam Agricultural Competitiveness Project (AACP)
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Chairman

Dr. Kamaleswar Kalita
Officer on Special Duty

Course Coordinator

Dr. Binod Kalita
Associate Professor, Aquaculture

Organized by

College of Fisheries
Assam Agricultural University
Raha - 782103, Nagaon
Assam, India
2006

Cover page : Design by Mr. S. K. Bhagabati & Dr. B. Kalita

ORGANISING COMMITTEE

Chairman

Dr. Kamaleswar Kalita
Officer on Special Duty

Course Coordinator

Dr. Binod Kalita
Associate Professor, Aquaculture

TECHNICAL COMMITTEE

Dr. Omeo Kumar Dutta,
Professor

Dr. Pradyut Kumar Goswami,
Assoc. Prof.

Dr. Krishna Kanta Tamuli,
Assoc. Prof.

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Asstt. Prof.

PARTICIPANT SELECTION

Demonstrators and allied cadre office bearers of Department of Fisheries, Govt. of Assam were selected by the Directorate of Fisheries, Govt. of Asom for this training programme.

TRAINING
ON

POLYCULTURE AND INTEGRATED FISH FARMING

TRAINING MANUAL

26 – 30 December
2006

COLLEGE OF FISHERIES
ASSAM AGRICULTURAL UNIVERSITY
RAHA - 782103, NAGAON
ASSAM, INDIA
2006

Dr. A. K. Roy, ACS
Director of Fisheries,
Govt. of Assam.

MEEN BHAWAN
B. K. Kakoty Road,
Guwahati- 781016,
Assam, India.
Phone & Fax : 0361–2545154

MESSAGE

The short term training to the Demonstrators and allied cadre office bearers of the Department of Fisheries, Govt. of Assam had been a long due, to upgrade the human resource potentialities of the grass root level workers and equip them to face the challenging needs of carp polyculture and integrated approach, which they are to deal with.

I indeed appreciate the efforts of the College of Fisheries, Assam Agricultural University, Raha to compile technology based inputs in the form of a manual as a future guide of the workers. I earnestly hope that this shall be a bench mark to proceed further and the Directorate of Fisheries shall extend all necessary assistance in skill upgrading efforts of the workers, for the interest of the state fisheries.

(**Dr. A. K. Roy**)
Dated the 26th December, 2006

COLLEGE OF FISHERIES

Assam Agricultural University
Raha - 782103, Nagaon
Assam :: India

Tel. : 03672-285719 (O)
03672-285801 (R)
Fax : 03672-285719 (O)
e-mail : cfsc_raha@rediffmail.com &
cfsc_raha@yahoomail.co.in

Dr. K. Kalita, Ph.D.
Officer on Special Duty

Letter No. AAU/FY / _____ / _____ / _____ Dtd. _____

FOREWORD

Fishery sector plays a vital role in the socio-economic development of the country and recognized as a powerful income and employment generator as it stimulates the growth of a number of subsidiary industries and is a cheap nutritious food besides being a foreign exchange earner. Fishery sector contributes to1.07% of the GDP and 4.7% of the agricultural GDP and Rs. 7,200 crores annual export earnings of the country. Fish is the primary source of protein for more than 1 billion people and fishing is the main source of income of over 100 millions of the world.

In our country about 14 million people are employed in the fisheries sector and fish production has shown a phenomenal growth from a meager 0.75 million metric tones in 1950-51 to 6.4 million metric tones in 2004-05. India occupies 3rd position in terms of fish production and occupies 2nd position in aquaculture production of the world next only to China. Fisheries sector consider as a "Sunrise sector" has recorded faster growth as compared to the crop and live stock sector. This significant growth is possible due to well defined plan, policy support, well developed infrastructure, valuable contribution to the teaching, research & extension and development support system. Success of the sector lies mainly on three components, namely- education, research and development. Above all education is the backbone and foundation for sustainable development and research envisages as the heart or life line of the development and development is the basic necessity to bring peace and prosperity. Hence it is rightly said that "Education is the backbone of the Nation".

Training is the integral part of the Education. With a view to updating the knowledge and recent advances in aquafarming we proposed to organize this short term training courses at secondary level and submitted to the Director of Fisheries, Govt. of Asom.

I am extremely grateful to the State Project Director of ARIAS Society and also the Director of Fisheries, Govt. of Asom for sponsoring this training programme. I express my gratitude to Dr. Binod Kalita, Associate Professor, Department of Aquaculture the course Coordinator for the excellent work he has done to organize the training in the most befitting manner. I also thank the faculty members more particularly Dr. O. K. Dutta, Professor, Aquaculture; Dr. K. K. Tamuli, Associate Professor, Aquaculture and Dr. P. J. Sharma, Associate Professor, Fisheries Engineering & Technology who have contributed to the successful conduct of the training.

I am sure that participants would greatly benefit from this training programme.

(Dr. Kamaleswar Kalita)
Raha the 26th December, 2006
Department of Aquaculture

Dr. B. Kalita
Course Coordinator

Department of Aquaculture
College of Fisheries, AAU, Raha- 782103,
Nagaon, Asom, India.
Phone & Fax : 03672- 285719(O)
Mobile : 986424447
e-mail : k_binod@rediffmail.com

Preface

Expansion of aquaculture is must to meet the demand of fish in the country. No doubt advancement in systems of aquaculture, standardization of breeding techniques and development of package of culture practices has substantially increased the fish production. However, in Asom, there is a gap between the fish production and resource availability, even though the state has an excellent sub-tropical climate and varied types of water bodies for development of freshwater aquaculture. Therefore, this is the need of hour to think of the basic constraints in the culture system. One of the major constraints is the lack of skilled person and lack of knowledge of the farmer on the scientific management of fish farm. Motivation of the farmers, knowledge development and skillness are the important aspects to think of at the present situation.

The Assam Agricultural Competitiveness Project (AACP), Govt. of Asom, has made an effort to train the right persons in the field of fisheries to disseminate the knowledge to the farmers. I also thank the right platform to make integration with grass root level workers of the Directorate and the scientists of their institute. Definitely, this effort would help in providing better skill, competence and confidence among the participants of both organizations.

The training manual has been published by selecting the important related topics, an effort has been made to include lectures in detail to be delivered by the distinguished scientists and officials during this 5 day long programme.

Financial support and cooperation received from AACP and from the Directorate of Fisheries, Govt. of Asom in organizing this training at the College of Fisheries, AAU, Raha is highly and appreciably acknowledged.

I am grateful to Dr. K. Kalita, O.S.D., College of Fisheries, AAU, Raha for constant encouragement, inspiration and guidance in making the training programme a successful one. I am indebted to respected Sir, Dr. O. K. Dutta, Professor & Head, Department of Aquaculture, for critically scrutinizing the manuscripts and for his valuable suggestions in improving and completing the training manual. I also express my gratitude to Mr. S. K. Bhagabati, Assistant Professor, Fishereies Hydrography for the help rendered in various ways during preparation of the manual. I also thank all the faculty members of the College for their active cooperation and support in organizing the programme successfully.

B. Kalita

(Dr. Binod Kalita)
Dated the 26th December, 2006

CONTENTS

Problem and Prospect of Aquafarming in Asom

Dr. K. Kalita
Officer on Special Duty

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Introduction :

Fishery sector plays a vital role in the socio economic development of the country and recognized as a powerful income and employment generator as it stimulates the growth of a number of subsidiary industries and is a cheap nutritious food besides being a foreign exchange earner. This sector contributes to 1.07% of the GDP, 4.69% of the agricultural GDP and 3.1% to foreign exchange earning to the tune of Rs. 7,200 crores (2006) of the country. Fish is the primary source of protein for more than 1 billion people and fishing is the main source of over 100 millions of the world.

In our country about 14 million people are employed in fishery sector and fish production has shown a phenomenal growth from a meager 0.75 million metric tones in 1950- 51 to 6.4 million metric tones (Inland: 3.4 million metric tones + Marine: 3.0 million metric tones) in 2004-05. India occupies 3rd position in fisheries and 2nd position in aquaculture production of the world next to China. India's share in world's fish production has increased from 3.2% in 1981 to 4.5% at present. Fisheries sector considered as a Sunrise sector has a recorded faster growth as compared to the agricultural crops and live stock sector. This significant growth is possible due to well defined plan, policy support, well developed infrastructure, valuable contribution by the research, extension and development support system.

Fisheries sector may be able to mitigate the protein deficiency in developing country, like- India. But reality is that fish is not contributing to the nutrition of our protein starved millions to the extent it should, mainly due to the gap between the demand and supply. It has been estimated that the requirement of animal protein from milk, egg, fish and meat per person in the country is about 35 gms./ day, out of which 50% (17.5 gm) is met by fish. The present per capita consumption of fish is 9.0 kg/ annum in India and 6.70 kg/ annum in Asom against the desired level of 31 kg as recommended by the nutrition advisory committee on human nutrition (Srivastava, 1988). Fish is a very popular diet especially in the eastern part of the country, but its cost is very high for the common to afford.

Location, Area and Population :

Asom is one of the most important and largest states of the North Eastern Region. It is located in the Eastern Himalayan Region between 24.00°N- 28°.18N latitude and 89°.50E- 97°.04E longitude and is boardered by Bhutan, China and Arunachal Pradesh in the North; Meghalaya, Mizoram, Tripura and Manipur in the south; Myanmar, Nagaland and Arunachal Pradesh in the east and West Bengal and Bangladesh in the west. It has a total geographical area of 78,438 sq. kilometers and a population of about 22.41 million, which is 2.65% of the national population according to 1991 census. It has a sex ratio of 923 females per 1000 males; 88.9% of the total populations live in rural areas whereas 11.10% live in urban areas. The population density is found to be 286 per square kilometer and literacy rate in the state is 52.89%.

Status of Fisheries :

There is an enormous potential for development of fisheries sector in Asom, which is directly related to the rural economy. In the recent years, the government has paid important emphasis for development of this sector. Rice and fish are the two basic diets of the populace of Asom. Globally the per capita availability of fish is estimated at 45 gm./ day wherein India is about 25 gm./ day and N.E. states reported to be only 16 gm./ day. The state currently produces about 1.88 lakh metric tonnes of fish from all sources

annually as against an estimated annual demand of 2.86 lakh metric tonnes. As reported by the state fisheries department the deficiency of market fish in the state is partially met by importing fish from other states, like- Andhra Pradesh, Uttar Pradesh, West Bengal and Bihar causing a draining out of an amount of around Rs. 100 crores annually.

In spite of having more fishery resources and potential in the state, its contribution to the national inland fish production is very less (about 6.55%). Despite the rapid advancement in the technology of fish culture and subsequent increase in production per unit of water in other parts of the country, fish culture in rural Asom by and large has remained traditional. As a result the average fish production from the village pond is as low as 600 Kg./ ha.

Aquafarming denote all forms of culture of aquatic animals and plants in fresh, brackish and marine environment. It is sometimes used as a synonym for mariculture, what is known today did not exist in the past. It has evolved from the stage of domestic activity in West Bengal, Orissa, Asom, etc. to that of an industry in recent years in states, like Andhra Pradesh, Punjab, Haryana and Maharashtra taking up fish culture as trade. With technological inputs, entrepreneurial initiatives and financial investment, pond productivity has gone up from 600- 800 kg/ ha./ yr. to 8- 10 tones/ha./ yr. in several parts of the country, with the national average being around 2000 kg./ha./yr. However, the state of Asom including the N.E. states is yet to achieve the target of 200 kg./ha/yr average fish production.

Fishery Resources :

Asom has an excellent sub-tropical climate for development of freshwater fish culture in a variety of aquatic bodies. The state of Asom which forms about 30% of the North Eastern region has Brahmaputra, and Barack river systems and their numerous tributaries (combined length: 5,050 Km.). The river Brahmaputra is having 42 tributaries of which 27 on the north bank and 15 on the south (Table-1). The Brack river flows from north to south in south eastern regions of the state. It is fed by 7 northern and 6 southern tributaries. Apart from the riverine resources the state is also gifted with myriads of swampy areas locally called as ‘beels’ or ‘Jeels’, which are extensive water sheets connected to the mighty river Brahmaputra, Barack and their tributaries. There are about 1392 beels in Asom whose water spread area are estimated to be about 1.10 lakh ha., which alone contributes about 80% of total lentic water of the state.

Initially there were no reservoirs in the state. Recently two newly constructed reservoirs namely Umranchu in North Cachar Hills district and Kapili in Karbi Anglong come in to being. Pagaldiya in Nalbari district and Puthimari reservoir (Suklei Dam) near Rangia are in various stages of construction would form an additional fisheries resources of the state in years to come. Table-2 shows the comparative existing fisheries resources in India and the state of Asom.

Table-1 : List of North and South bank tributaries of the river Brahmaputra in Asom (reprinted from threatened fishes of India).

North Bank	**South Bank**
1. Sankosh	1. Jinjram
2. Gadadhar	2. Krishnai
3. Saral bhanga	3. Dudhnai
4. Champamati	4. Singra
5. Aie	5. Kulsi
6. Manas	6. Digaru
7. Beki	7. Kollong
8. Pahumara	8. Dhansiri
9. Pagaldia	9. Kakadanga

10. Puthimari 11. Baralia 12. Bornoi 13. Nonadi 14. Jia Dhansiri 15. Panchnoi 16. Belsiri 17. Gabharu 18. Buri Ganga 19. Jia Bhorelli 20. Borgong 21. Burai 22. Dikrang 23. Subansiri 24. Jia Dhal 25. Ranganoi 26. Dihang 27. Dibang	10. Bhogdoi 11. Janjai 12. Dikhow 13. Disang 14. Dibru 15. Lohit

Table-2 : Existing fishery resources of Asom and the country.

Sl. No.	Resources	India	Asom
1	Coast line	8129 kms.	—
2	Exclusive Economic Zone	2.02 million square km.	—
3	Continental Shelf	0.506 million square km.	—
4	Rivers and canals	1,97,024 km.	5,050 km.
5	Reservoirs	3.15 million ha.	10,730 ha.
6	Ponds and tanks	2.35 million ha.	25,423 ha.
7	Oxbow lakes and derelict waters	1.3 million ha.	1,10,000 ha.
8	Forest fisheries	—	5.017 ha.
9	Brackish waters	1.24 million ha.	—
10	Estuaries	0.29 milion ha.	—

Source : Directorate of Fisheries, Govt. of Asom, 1997-98, Sugunan, 1998; CIFA (ICAR), 2001, NFDB, 2006.

Impediments for Development :

Some of the constraints for fisheries developments in the state are-

1) Non-availability of fish seed in adequate numbers.
2) Inadequate facilities for growing fish spawn into fingerling stage to stock the beels and reservoirs.
3) Shortage of some other critical fish farming inputs like- fish feed.
4) Post harvest infrastructure including marketing channels.
5) Prevailing low temperature.
6) Natural calamities like- flood, drought, etc.
7) Poor extension facilities.

During 1997- 98 Assam produced about 2246 million fry and made the state self sufficient in fish seed production. It is assumed that there is a large-scale mortality during the early stage of fish or slow growth of produced seeds. Lack of quality seed may be one of the primary reasons for the low fish production in the state, as the fish seed of desirable quality is the basic input for fish farming in tanks, ponds and for culture cum capture fisheries. Neither the state fisheries nor any research institute have earlier taken any initiatives to create awareness on this issue and monitor the hatchery activities. If the unplanned breeding of cultivable fishes are allowed to continue, it will definitely jeopardize the seed production industry of the state. Already to some extent gene pools of our indigenous varieties of carp's like- rohu, catla and mrigal have been contaminated. As a result in near future it is feared that the pure seeds of these indigenous carps endemic to this locality shall gradually disappear from the culture system.

Aquaculture indeed is a capital and labour intensive large-scale operation. On contrary, the people involved are mainly small landholders, resource poor and unskilled. Moreover most of the farmers have not yet taken fish farming as a profession but only a secondary source of income for livelihood. So they lack professional ethics. It has not been successful in the state mainly for the reasons- (1) adoption is rarely sustained, as the rural farm families cannot afford; (2) credit is not easily available and (3) farm families are vulnerable to risk involved such as- floods, droughts, theft, etc.

Environmental constraints affect the production possibilities of the fish. Fish needs 26- 36ºC temperature and neutral or slightly alkaline water for its proper growth. Optimum temperature required for growth of fish provides for six months or so during the premonsoon and monsoon only. Due to occurrence of high rainfall in the state, soil is generally acidic in nature. Neutral soil in different areas of the state ranges from 0.6- 21.50% only. Most of the fish farmers of the region lacks technical know how on scientific fish farming. Organizing short and long-term need based training course on scientific fish farming, workshop, etc. for the benefit of the farmers, extension worker may help in increasing the knowledge on modern scientific fish farming techniques which will ultimately help in augmenting the production. Vocational training institute may gear up further the school level and also lower level education.

Scope for Augmenting Production :

1. Integrated farming practices of fish with livestock and paddy in the region.

The scope for integrated farming of fish with livestock and paddy of the region is immense. Livestock population of the region is indeed large with pigs being 53/100 persons and poultry bird's 63/100 persons. Paddy being the main crop of this area is cultivated in vast stretches (approximately 32, 98,500 ha). The following integrated farming of fish with livestock and paddy is available for the region—

i) Pig cum fish culture.
ii) Poultry cum fish culture.
iii) Duck cum fish culture.
iv) Paddy cum fish culture.

These technologies can be utilized for production of fish along with livestock and paddy in suitable areas with minimum inputs and high rate of expected return. The technologies are specially suited for rural areas where one component is already being practiced. The component of fish farming is to be introduced, requires minimum additional inputs. It would be able to create additional self-employment opportunities for rural youth and may thus lead to diversification of rural economy. Integration of fish with livestock would be of much use especially for tribal areas as tribal people traditionally rear pigs and poultry birds.

2. Adoption of non-conventional method of fish culture like- cage and pen in open water bodies.

Beels are the main potential resources in Assam but the production from this resource is very meager. Beels are reported to have a productivity of 110 Kg/ ha only. On the other hand average fish production from the Indian reservoirs is about 15 Kg./ ha. If a proper stocking and scientific management programme is taken up in open water bodies it will definitely increase the production level. Small beel (up to 10 ha. area) managed by a local community/ SHG under the technical guidance of Assam Agricultural University exhibited a yield of 2000 Kg/ ha. One of the main constraints getting good production from the open water bodies is the lack of quality fingerlings to stock. Hence raising of the carp seed in cages and pen as stocking material for the beels in Assam could augment the fish production. So far production from the reservoir in the state is negligible. Newly constructed reservoirs undertaken by the NEC are mainly for the hydroelectric and irrigation purpose. Fishery development in these reservoirs is secondary. Policy decision has to be taken to stock the fish in these reservoirs with suitable management practice.

3. Use of indigenous fish species of North East for ornamental purpose.

North Eastern region particularly the state of Assam is considered to be the hot spot of the freshwater fish fauna biodiversity in the world. It is reported that Assam alone harbours 185 fish species belonging to 98 genera under 34 families. Presently NE region contributes about 85% of the export market to the ornamental fish trade. There are plenty of ornamental fish species and ornamental aquatic plants in its natural water bodies. This sector is not yet been exploited in a technology driven manner and in an organized form. Hence an extensive study on this aspect is in the need of hour.

4. Multiple stocking and multiple harvesting : A new concept.

Multiple stocking and multiple harvesting (MSMH) is a system of composite fish farming, through which fish production can be augmented by many folds. In this system, stocking density is high, maximum being 12000 nos./ha., tried repeated at the college fish farm with tremendous success. The pond is prepared in the same way as in the case of composite fish farming. No extra management works are necessary. However, a nursery pond is a prerequisite in the system. Fish culture is done continuously for 3 years, wherein harvesting and restocking starts right from the 4^{th} month of stocking. Fish production is 3000- 3500 kg/ha/year.

Advantages of the technology :(1) In this system, the farmers need not have a big capital to meet the various recurring expenditure of fish cultivation. He has to manage the pond for a maximum period of 4 months. Then onwards he starts earning, which is reinvested for purchasing of various items required for further fish rearing. Therefore, a marginal farmer can also take up scientific fish farming with his meager resources by adopting this system. (2) Netting in short intervals results in release of noxious gases and mixing of bottom nutrients with surface water, which enhances primary productivity of the pond. (3) There are several other advantages. However, the prime advantage is that the fish production is much higher than yearly composite fish culture system.

5. Preparation of value added fish products.

Value added fish products such as- fish pickle from cheaper variety of weed fishes can be prepared. During the fishing season in beels and rivers of Assam a considerable amount of trash fish and prawns of miscellaneous varieties are abundantly caught which generally find ready market and consumer prefer-

ence. Those fishes can be better utilized for preparation of value added products with minimum cost and effort. This low cost technology may be disseminated to the unemployed youth for self-employment and also for entrepreneurship development.

6. Research and extension linkage.

The state so far does not have any established research extension linkage framework and policy for identification of research needs, interaction on technology adoption, recommendation which is impacting the growth of fisheries in the state. Package of practices has been developed by the Assam Agricultural University and recommended to the Government. The researchers are still at dark about the feed back from the field. Hence no programme has been taken up for refinement of the disseminated technologies.

There is provision of field trial station for newly generated technologies for its adaptability. District Level Technical Committee meeting (DLTC), Zonal Research and Extension Advisory Committee (ZREAC), Disciplinary Technical Committee meeting (DTCM), Research Committee meeting (RCM), State Level Technical Committee (SLTC) as organized in case of agriculture for coordination between research and extension agencies are yet to introduce in the fisheries sector of the state. Recent developed technologies are not yet transferred in the form of package due to not holding the package of practice workshop.

Future Strategies :

Shortage of water and land is likely to impact backyard ponds and other small water bodies that might disappear from the present scene and it would be necessitate to explore the large scale use of cages and pen culture in tanks, wetlands, reservoirs and running waters for fish culture. Seasonal and perennial water bodies which have not been used so far and it is imperative suitably to use these water bodies for aquaculture productions. New scientific system, like- Silos and closed recirculatory systems need to be established in suitable locations, mass productions of advanced fingerlings and juveniles with high yield rate coupled with high survival rate is in the need of the hour.

So far freshwater aquaculture production is concerned, over ninety percent production is mainly carp oriented. It is high time to incorporating small and minor carps, small and large catfishes, perches, murrels, ilisha, and freshwater prawn (scampi) and other indigenous fishes with an eye to the export market.

More emphasis has to be given on selective breeding of calbasu, mrigala, magur, scampi, etc. and other commercially important species and large domesticated stocks maintained to avoid inbreeding and disease occurrence. All the aquafarms needs to be modernized with recent development of technology. Similarly vaccine production for all the major known diseases would be an appropriate step.

Scope of the aquaculture development would largely depend on Govt. policies and support to the farmers in terms of availability of inputs, credit and marketing channels. Shortage of manpower in fisheries is the biggest constraints which ultimately influence the growth of the sector. It is necessary to have the full strength of well qualified and trained staff in this sector that would pay greater contribution to the aquacultural development of the state.

Advances in Polyculture

Dr. O. K. Dutta
Professor
&
Dr. K. K. Tamuli
Associate professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Polyculture is an age old concept, whereby all available natural food in a pond is utilized by stocking non- competitive social fish species. In recent years this concept has been extended not only for commercial interest but also for purposes of rearing compatible species that provide a different service to the fish farmer. Culture of fish or invertebrates in conjunction with hydrophonically grown crop plants (such as paddy, lettuce, cucumber, etc.) can be another form of polyculture.

Investigations relating to incremental fish production, during 1950's extending over next three decades or so, have critically established the carrying capacity potentials in various aquatic ecosystems and for culture fish ponds in particular. Semi- intensive efforts, which are largely dependent on the local meteorological conditions, are more cost effective fish farming systems in resource constrained situations like ours.

It is a well accepted point of view that in the properly managed ponds of the State, a production of 4000 kg/ ha/ yr of carp is achievable, provided the quality of fish seed can be assured. Limitations on availability and affordable cost of energy, shall not allow implementation of intensive fish farming system for certain years to come in this region although potentialities exist. Thus to override the production profile over the currently achievable level it necessitate to venture ways and means and some of the options that are available are tried to discuss here briefly.

It may be noted here that various advancements have been achieved in the field of polyculture of fishes, around the globe. Only those which are promising and might provide an incremental rate of production or increase productivity or aid to achieve the desired results have been discussed here under.

Stunted carp vs. quality seed :

The question of genetically sound carp seed with better growth potential has posed a hurdle in case of hatchery bred seed from parents of same progeny; and in making carp culture an economically viable venture. Breaking the inbreeding depression of the carp brood stock used in hatcheries, by planned programme is a must to get quality seed. The second hurdle is non- availability of fingerlings early in the season. This hurdle aptly may be solved by stunting seed in previous seasons and to tide over the winter in other pond or in cage installed.

This technique developed by fisherfolks of Andhra Pradesh, involving high stocking density and maintenance feeding may easily be adopted elsewhere. Experiments conducted in cisterns with rohu fingerlings, with one feeding @2% initial body weight of fingerlings for a period of 4- 5 months indicated the results shown below :-

Stocking density (Nos./ ha)	Mean weight		Survival rate (%)
	Initial weight (gm)	Final weight (gm)	
44,444	3.12	57.0	85
55,555	3.16	54.5	84
66,666	3.13	47.7	90*
77,777	3.14	32.0	83*
88,888	3.12	31.5	90
99,999	3.14	29.2	80
1,11,111	3.18	21.7	80

The stunted fingerlings in grow out ponds under normal pond management practice exhibit better performance in terms of growth and survivability over normally raised rohu fingerlings. In the N.E. Region a cold weather separates two growth season of carps and the same cold weather affect early breeding of carps also. Thus stunting of carp seed of earlier year, can be a tool towards better utilization of the potential growth season in polyculture. However, the genetic quality of the seed has to be ensured, prior to adoption of this technique.

Substrate based aquaculture :

Investigations indicate that fishes like rohu, gonia, calbasu, *Labeo fimbriatus*, hybrid tilapia, *Tor khudree*, etc. are efficient feeder of epilithic (over stone), benthic or periphytic algae. In a polyculture pond, the soil bed is the substratum, where these food items may grow. Pursuant to the nibbling food collection habit of these fishes, attempts were made to place various substrate like bamboo stick, branches of tree, jute stick, polythene pipes, etc in the water column to facilitate deposition of suspended materials and growth of algae, whereby encouraging growth of such fishes were recorded. Experiment indicate that split bamboos placed across with cane bagasse at the light compensation zone of normally managed culture pond, effectively produce periphytons with resultant incremental growth of such fishes up to 180%. Various other types of materials used as substrate provide different growth rates.

The substrate increased the surface areas within the water column for deposition of suspended matters, facilitate decomposition, nitrification and increase the density of periphyton. Productivity upto 1.7 gms./ cm^2/ day had been achieved from such substrate in carp culture pond in Bangladesh (Azim, 2001) Water quality such as more DO, less NH_3 are other resultant benefits of substrate used. Disadvantage include need of more labour to remove substrates prior to fishing.

Multiple stocking and harvest :

Although the recommended density of carp fingerlings in polyculture ponds stands at 8000 / ha/ yr, the carrying capacity of the pond at the initial stages is more. It has been observed in well managed ponds of the College that stocking density up to 12000/ ha/ yr exert no adverse affect till end of fourth month of culture and by that time quite a sizeable number attain 750 – 800 gms. and are harvestable. Such marketable fishes upon harvest are restocked by fingerlings of the species in number concerned. By this process and netting at monthly interval almost 90% of silver carps stocked initially can be harvested within 6 months. Common carps also attain marketable size by then.

This mode of harvesting marketable fishes at regular intervals and restocking required fingerlings may be continued for three years to terminate the practice and total harvest of fish made. On an average

3500 kg/ ha/ yr may be achieved from normally managed carp pond with aided advantage of earning through crash- crop sale from the 4th month to meet the cost of inputs in addition to earning. Other advantages include recirculation of deposited nutrients during netting, take advantage of market demand for fish, removal of weed and undesirable fishes and disease management.

However, for a success of the technique, it is absolutely necessary to have access to required fingerlings to stock back, against the quantum of fish harvested periodically. At the end of 3 years culture it is advisable to drain the water and removed debris collected, to avoid BOD problems.

Floating cage in fish pond :

Fish ponds with greater depth (say 4 m) are suitable to install floating cage with dimension of 6 m × 5 m × 2 m. It is a technique developed in Taiwan and has much relevance to the State also.

It may be used to raise seed, culture a different species in the cage and others in the pond. The concept of cage installation in pond is innovative in the sense that with minimal inputs and low cost to develop and operate. The productivity in cage is much higher than the pond itself.

Vermiculture in pond banks :

It is a way, whereby the unwanted weeds of the pond and domestic wastes of a family can be converted to valuable compost and harvest a crop of worms. The worms may be cycled as valuable live food to fishes raised in floating cages.

Probiotics and prospects :

Probiotics are live microorganisms that beneficially affect the microbial balance of the host, whereby resistance to disease incidence is increased and also growth is enhanced. In poultry and farmed animal raising, probiotics are extensively used. Attempts are made in aquacultural practices also particularly for raising prawn seed and larval fish. Carbon bacterium, *Lactobacillus*, *Lactococcus*, etc. are normal microbiota, preparations made and either fed or inoculated to larval rearing containers, increase resistance of the fish or even develop immunity to diseases. Research for mass scale adoption with success is going on and in days to come it may be a source of success in aquaculture.

Adoption of these practical advancements in polyculture system definitely aid in augmenting the rate of fish production, either singly or in combination for which a modus operandi has to be worked out by the concerned farmer. These methods are unlikely to cost more when compared to the benefits achievable. Thus there lies scope of adoption.

Design and Construction of an ideal Fish Farm

Mr. S. Ahmed
Assistant Professor
Fishery Engineering & Technology

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

A fish farm is defined as a set of scientifically planned, designed and constructed ponds suitable for carrying out various fish cultural activities- like hatchery, nursery and rearing operations. For the success of modern aquaculture, proper planning and designing of the fish farm is essential. Design of a farm depends on a number of aspects and some of the important ones are:

Site selection :

It is the most important aspects and while selecting a site for the construction of farm, it is necessary to consider the following aspects.

1. Source of water :

The first important aspect to be considered in selecting a site is the source of water. There should be adequate quantity of good quality water round the year at the proposed site. Water supply should be sufficient to cover the evaporative and seepage losses, oxygen supply, flushing out the waste product from the fish pond, etc. Quality of water for fish farm should be of high quality. It should not be polluted and it should contain sufficient nutrients.

2. Soil quality :

The second important part of the site selection is examining the soil of that area. Prior to designing; the soil of the site should be tested for the water retention capacity and fertility. The soil should prevent seepage of water through the dykes and pond bottom. In this case, clay or loamy- clay soils are suitable for fish farm. The fertility of the soil also should be tested because good soil contains essential nutrients for phytoplankton developments i.e. primary production. Presence of organic matter in the soil also important as it provides nutrients and microorganisms for plant life as well as to improve the stabilization of soil structure. It also improves the water storing capacity of sands and drainage characteristics of clays and silt. Air present in soil helps in the respiration of microorganism and the absorption of nutrients. As a whole, if soil is fertile and other parameters like pH etc. are favourable for fish culture, good fish production can be expected from the proposed farm.

3. Topography :

Prior to planning and designing, the area and configuration of the proposed land should be determined by a suitable means of survey. After the survey, a contour map is prepared. The topography of the land determines the type of pond to be constructed. The pond can be built in vallies or on flat ground. They can be bigger, smaller, square, rectangular or uneven in shape. This is all determined by the topography of the land as well as by the farmer's requirements. The most useful topography for fish farm is one which allows the farmer's to fill and drain the pond by gravitational force.

Other aspects to be considered :

1. Accessibility to the pond site
2. Availability of the inputs like seed, feed, fertilizer, etc. at ease

3. Area if prone to flood or not
4. Availability of the post harvest processing or marketing facility in the locality
5. Availability of labour, electricity, etc.

Construction of ponds :

For fish production, two primary types of ponds are used i.e. dug- out or excavated pond and embankment pond.

1. **Excavated pond :** Excavated ponds are constructed by removing soil from an area to form a depression or hole and filling it with water. This type of pond is more advantageous to the farmer as the depth, volume, etc. of the pond can be made according to the need of the farmer. It is constructed mainly in plain area.

2. **Embankment pond :** Embankment ponds are constructed usually in hilly or uneven areas. It is formed by building up a dam/ dyke above ground structure to impound water. Although this type of pond can be constructed on a wide variety of topographic land surfaces but those which provides a reasonable slope in one or two directions are usually the best. If the selected site is a ravine with gently sloping site and slow decrease of elevation, one has to go for embankment pond.

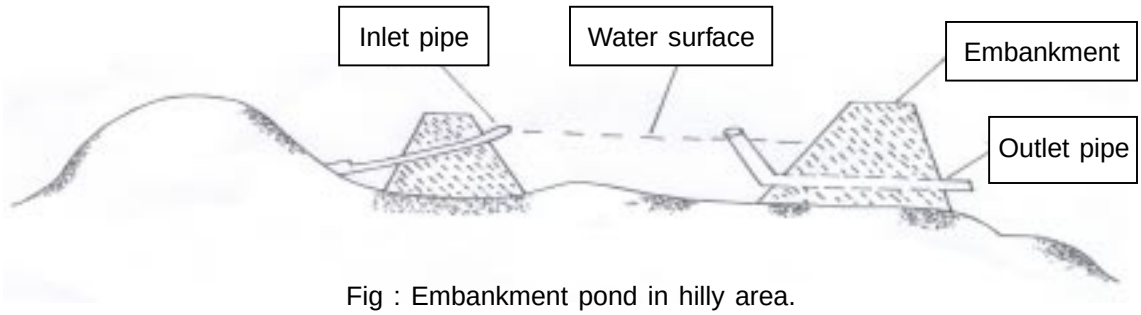

Fig : Embankment pond in hilly area.

Depth, size and shape of pond :

Since the primary productivity of the pond water depends mainly upon the penetration of light, the depth of the pond should satisfy the favourable conditions of productivity. The optimum size and depth for different types of pond suggested for carp polyculture in India are :

Pond type	Optimum size i.e. area (m^2)	Depth (m)
Nursery pond	100- 500	1.0- 1.5
Rearing pond	500- 1000	1.5- 2.0
Stocking pond	1000- 2000	1.5- 2.5

From the constructional point of view square shaped ponds are most economical but for facilitating netting operations rectangular ponds are suitable. Side slope of the pond should be maintained at the time of the excavation. In case of clay or loamy- clay soil, the required side slope is 1.5:1. But if the amount of sand is more, the ratio has to be increased to 4:1. The pond should be so designed that the volume of the earth available from the pond excavation will be equal to the earth required for raising the required embankments.

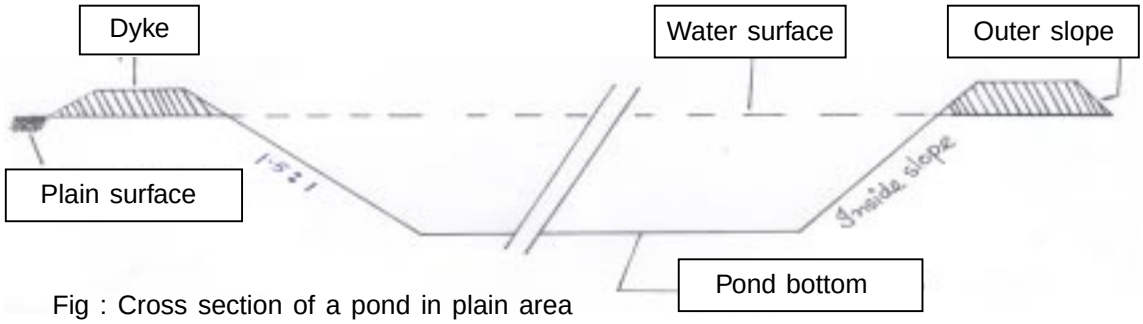

Fig : Cross section of a pond in plain area

Designing of pond dyke/ embankment :

In scientific fish farm dykes are provided in the pond to prevent the inflow of polluted water and organism as well as to prevent out flow of fertilized water and reared fishes. The dyke height should be more than the maximum flood level if there is a chance of flood to the area. The top width of the dyke should not be vary narrow. It can be kept as 1.2 m but if light vehicles such as jeep play over the dyke than its minimum width should be 3 m. The side slope of the dyke depends on the nature of the material used for construction. To stabilize the slope against the rain washing or sheet erosion, it should be turfed with grass sods. Apart from reducing moisture content of the soil, the roots act as reinforcement in the soil and prevent the direct battering action of rain over the embankment.

In some modernized farms spill ways are provided for designing out excess water or bottom drains which can be opened for complete draining of water from the pond.

Calculation of earth quantities :

For computing the volume of earth excavation from a pond, the end area method can be used. This method assumes that the volume of the earth excavation is equal to the average area of top and bottom surface, multiplied by the average depth excavated. This can be expressed as the following formula :-

$$V = D\left(\frac{A_1+A_2}{2}\right)$$

Where V = Volume

A_1 & A_2 = Areas of top & bottom surface

D = Average depth

Example :

Calculate the quantity of earth excavated from a pond which has a bottom length of 50 m and width 30 m. The depth of the pond is 2 m and required side slope is 1.5:1

Solution :

Bottom length	=	50 m
Bottom width	=	30 m
Therefore, bottom area	=	50×30 m^2 = 1500 m^2
Top length of the pond will be	=	$50 + (3 \times 2)$ m
	=	56 m
Top width	=	$30 + (3 \times 2)$ m = 36 m
Therefore, top area	=	56×36 m^2
	=	2016 m^2
Average area	=	(1500 + 2016)/ 2 m^2
	=	1758 m^2
Depth	=	2 m
Therefore, volume	=	1758×2 m = 3516 m^3

Techniques of Enhancing Fish Production in Polyculture

Mr. D. K. Sarma
Assistant Professor
&
Dr. B. Kalita
Associate professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

In ploysculture systems, fish production can be enhanced by increasing productivity of water and supplying artificial feeds. By increasing natural productivity we can supply more food materials to fishes at a lesser cost. For this purpose a correct schedule of application of lime and fertilizer is very essential. Application of lime and fertilizer and importance of fish feed in polyculture system has been discussed bellow.

Lime :

Lime has got many functions in a pond and they are:-

I. It corrects the pH
II. It kills the bacteria and parasites
III. It improves texture of soil
IV. It helps in oxidation of organic matter
V. It helps in mineralization of ions and
VI. It acts as a buffer in the diurnal variation of pH

Diurnal changes in pH have a tremendous impact on fish health. High magnitude of changes in pH imparts stress to the fishes. In an unlimed pond the diurnal variation of pH may range from 5 in the night and 11 in the day. This wide fluctuation causes a stressful condition for the fish. Lime acts as buffer in controlling pH. Lime helps to raise the total alkalinity and keep a good reserve of CO_2 which will increase the availability of CO_2 for photosynthesis by raising bicarbonate concentration in water. This raised level of reserve CO_2 will also prevent biological decalcification.

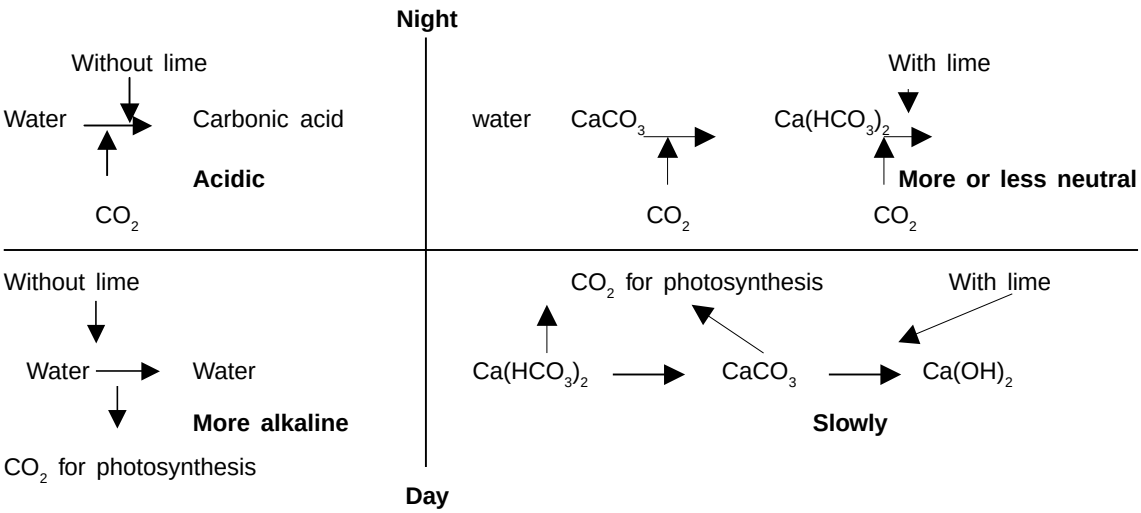

Fig: Mechanism of buffer action of lime

Types of lime :

There are several types of lime and they are :

1. Calcium oxide (CaO) : It is known as quick lime. It is also known as burnt lime and unslaked lime.
2. Calcium hydroxide ($Ca(OH)_2$) : It is known as hydrated lime.
3. Calcium carbonate ($CaCO_3$) : It is also known as lime stone and agricultural lime.
4. Dolomite ($CaMg(CO_3)_2$).

Above all varieties of lime CaO is mainly used due to its high buffering capacity and neutralizing value

Methods of application of lime :

The are several ways of application of lime, the based way to apply lime is to sprayed on dry surface of the pond bottom. It is helpful in many ways apart from correcting pH. Lime can be applied in pond water or incoming water to the pond. When quick lime is used it should be directly administered to the pond water.

Doses of lime : Based on pH doses of lime (CaO) can be fixed. They are as follows :-

Sl. No.	Soil pH range	Soil type	Requirement (kg/ ha.)
1	4.0- 4.9	Highly acidic	2000
2	5.0- 6.4	Moderately acidic	1000
3	6.5- 7.4	Near neutral	500
4	7.5- 8.5	Mildly alkaline	200
5	>8.5	Highly alkaline	Nil

Alkalinity can also be used as an indicator of the need for lime in fish pond. When total alkalinity comes down below 20 ppm the lime should be applied for plankton growth. The total alkalinity should be in between 20- 150 ppm.

Manures and Fertilizers :

Manures and fertilizers are essential to increase the natural productivity of water. Apart from improving fertility organic manures improve the soil texture. Several organic manures are used in fish culture. They are- cattle dung, poultry dung, pig dung, etc.

Basis of fertilization :

1. **Texture of soil :** The texture of pond soil i.e. mechanical composition of soil comprising sand, silt, clay and organic matter content basically influence fertilization schedule. Sandy and very clayey soil are not desirable as in sandy soil nutrient are easily lost through leaching, while the later trap the nutrients.
2. **Soil pH :** As in water pH of soil also one of the critical factors affecting pond productivity. Soil pH influences the transformation of phosphorous into the available form of phosphorous and control the adsorption and release of essential nutrients at the soil water interface. Both for soil and water a slightly alkaline pH is considered favourable for fish pond.
3. **Basic soil fertility :** Availability of NPK as inherent property of pond soil determine the quantity and quality of fertilizer to be used. Based on pH and available nutrient soil are classified are as follows.

Productivity level	pH	N mg/ 1000 gm soil	P_2O_5 (mg/ 1000 gm soil)	Organic carbon (%)
High	6.6- 7.5	³ 50	6 - 12	³ 1.5
Medium	5.5- 6.5	25- 49	3 - 5	0.5 - 1.4
Low	<5.5	<25	<3	<0.5

Various organic manure and their composition :

Name of organic manure	% N	% P_2O_5	% K_2O
Raw cow dung	0.60	0.16	0.40
Raw goat dung	0.95	0.35	1.00
Fresh chicken dung	1.60	1.50- 2.00	8.00- 0.900
Fresh pig dung	0.60	0.45	0.50
Mustard oilcake	4.50	2.00	1.00
Groundnut oilcake	7.80	1.50	1.30

Doses of organic manure based on fertility of soil are—

Cattle dung : 5000- 8000 kg./ ha./ yr. for highly productive soil, 8000- 10000 kg./ ha./ yr. for medium productive soil and 10000- 25000 kg./ ha./ yr. for low productive soil.

Method of application :

In stocking pond combination of organic and inorganic fertilizers is considered very effective. Initially manuring is done @30% of the total requirement and remaining 70% is divided into 11 installment for application on monthly basis.

Initial dose should be spread over the pond surface or mixed with water. Monthly installment is normally dumped at 4 corners of a pond. Place of dumping can be increased. Instead of monthly installment once it can be further divided to daily installment and this is more effective.

Inorganic fertilizers : Inorganic fertilizers mainly increase the phytoplanktonic component. Mainly used inorganic fertilizers in aquaculture are :-

1. **Nitrogenous fertilizer :** Ammonium nitrate, ammonium sulphate, urea, etc.
2. **Phosphate fertilizer :** Single super phosphate (SSP), triple super pohosphate (TSP), etc.
3. **Potassium fertilizer :** Muriate of potash.
4. **Magnesium fertilizer :** Magnesium sulphate.
5. **Trace element fertilizer :** Boron, zinc, etc.

In pond environment the scarcity of potassium, magnesium fertilizer and trace elements are not felt.

Inorganic fertilizers are dividing into 12 installments and monthly basis. It should be applied one week after application of organic manure.

Schedule of fertilization :

Normally 7- 15 days after liming organic manure is applied into the pond and 7 days after application of organic manure inorganic fertilizers are used.

Doses of fertilizers :

Fertilizer	Dose (kg./ ha./ yr.)		
	High	Medium	Low
Urea or Ammonium sulphate or Calcium ammonium nitrate	112- 155 225- 330 —	155- 225 — 350-500	226- 260 — 500-650
SSP (16- 20%) or TSP (40-45%)	156- 219 54- 75	220- 315 76- 110	316- 405 111- 145

In the case of non availability for testing soil productivity following schedule is recommended :-

Item	Quantity (kg./ ha.)	Periodicity of application
A. Cattle dung	2000 1000	Initial single dose Monthly for rest 11 months
B. Urea (pH: 6.5- 7.5) or Ammonium sulphate (pH: >7.5)	25 30	Monthly -do-
C. SSP or TSP	20 8	Monthly -do-

FISH FEED IN CARP CULTURE

Feed input is the largest operational cost in majority of aquacultural practices. Among the dietary components protein is the most expensive one and major source is the fish meal. In view of the high cost of food quality of fish meals of relatively constant chemical composition, it is surprising that feed costs amount to 40- 60% of total cost in intensive aquaculture enterprises (FAO, 1983).

The physical organization and the anatomy of animal affect the nutritional needs. One of the objectives of nutrition is to direct the selection of food and to establish desirable eating habits. Food eaten by fish varies considerably according to the species and their developmental stages. Exact preferential food should be matched with different developmental stages of fish. There are distinct feeding phases for the fish according to the age such as :

1. First phase-includes the resorption of yolk sac of the hatchling.
2. Spawn, fry and fingerling stage.
3. Fingerlings to table size fish

Intensive rearing of fish spawn and fry, feeding constitute a major factor. Their growth mainly depends upon the quality of diet provided. Although some of the formulated feeds are nutritionally rich in protein than the live food, spawn and fry prefer live food (Phytoplankton & zooplankton) rather than formulated feeds. That too, the mineral and micro nutrients needs of spawn and fry are little understood to be incorporated in feeds. The minerals and micro nutrients are supplied by live food when formulated feeds are used. Therefore it is always preferable to have a regular supply of live food as it serves as a living capsule of nutrition. So production and supply of phytoplankton and zooplankton in the culture system is must.

Compounded diets should contain adequate level of nutrients to meet physiological requirements of organisms such as energy, body building, repair or maintain cells, tissues and regulate body processes. According to Halver (1976) any nutritionally balanced compounded diet must include an energy source with sufficient essential amino acids, essential fatty acids and non energy nutrients (vitamins and minerals) to maintain and promote growth. Any imbalance of these nutrients may have sparing action that would affect the efficacy of conversion of food by the organisms. Nutritional requirements of fish vary greatly with species, size, physiological condition, temperature, stress, nutrient balance of the diet and environmental factors. Therefore, nutrient constituents must be done in order to have most economic compounded ratio for fish.

Among the carps, common carp is the most widely studied by nutritionists and nutritional studies in Indian Major carps and exotic carps have been made in recent years.

Fish requires 40 or more essential nutrients, among these the most important ones are: protein, carbohydrate, lipids and fats, vitamins, minerals and trace elements. Protein, carbohydrate and fat are regarded as energy food while vitamins, minerals, etc. are regarded as nonenergy food.

Protein :

Usually recommended protein content in fish feed is 25- 40%, but small size fish requires higher than the larger ones. Carnivorous fish demands fish with high protein content; herbivorous fish requires less protein. Since proteins are continuously being used by the animals either to build new tissues or to repair tissues, reduction in protein results loss in weight of fish. Gross requirements of protein and carbohydrate in major carps fry and fingerlings vary from 36- 45% with variation in water temperature from 26- 32°C (Sen et al, 1978). Protein requirement in catla fry is 45- 47% and in fingerlings 40% (Singh and Bhanot; 1988). About 30% protein in diet is enough for both catla and rohu (Verghese et al, 1986). The requirement of protein in grass carp 36% (Das and Tripathi, 1979); silver carp fry ranges from 37- 40% (Singh, 1989) and common carp is to be 31% (Verghese et al, 1976).

Carbohydrates :

It is the least expensive form of dietary energy and helps in pelletizing quality of practical fish diet. Higher level of dietary carbohydrate leads to death of the fish, because of dietary accumulation of glycogen in liver. Moreover carbohydrates have sparing affect on protein. Common carps have higher utilization of carbohydrates (25%) and fry and fingerlings of rohu (26%) and fingerlings of mrigal (28%).

Lipids :

Lipids are water insoluble biomolecules which play an important role in energy production of animal tissues and is a source of essential fatty acids. About 85-90% of dietary lipids are digestible by fish. Cultured fish have shown that the optimal lipid intake is essentially similar to that for wild fish. Lipid requirement in common carp (5%), requirement of fat for carp fry and fingerlings (6%), for mrigal fry (6%) and rohu fry (4%) as reported by Swamy et al, 1988. Therefore as per requirements both vegetable oils and animal fats may be combined. Rancidity of lipid can be prevented by using antioxidants.

Vitamins :

Vitamins (water soluble and fat soluble) are complex and essential trace elements and these are found in small quantities and form a distinct entity from other major and minor food components. Vitamin premix is normally added in the feed for healthy growth of carp at 0.1% level in major carps feed.

Minerals :

Minerals are required in small quantities in the diet and these are supplemented in fish diets. Minerals not only provide basic skeletal structure but also require as an important co-factor of enzyme

and other biological and chemical processes. Freshwater fish show higher mineral requirements compared to the marine fish as sea water is enriched with most of the essential minerals. Cobalt nitrate and cobalt chlorides are added in the diets of carps to ensure survivability and growth of fish.

Feeding Management in Polyculture :

In polyclture system of carps, the traditional feeds being used as a mixture of rice bran and oilcake in the ratio of 1:1 by weight which is nutritionally rather poor (Verghese et al, 1976) and commonly known as supplementary feed in composite fish culture. As the polyculture is an intermediary culture system between extensive and intensive; fertilization enhances the production of plankton and zooplankton thereby fish get the chance of assimilation of other required amino acids and vitamins and minerals from natural environment. The supplementary feed enhances the growth of fish to some extent if properly managed. However, there is an urgent need to develop quality artificial diet with locally available economic ingredients when alternative and ideally less expensive sources of good quality protein are found. Supplementary feeds like Balichanda and Susma available in the market are used in composite fish culture in Asom by farmers and opine better results over traditional feeds.

Techniques of Water Quality Management in Fish Pond

Dr. O. K. Dutta
Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Physical, chemical and biological factors determine the quality and the extent of beneficial use of water. Water quality characteristics that affect survival, reproduction, growth, production or management are varied but only a few play important roles. It is necessary to know these physico-chemical variables of warm water to deal with and make the aquatic ecosystem congenial for fish farming.

Temperature :

In the temperature range of 25°C to 32°C, warm water fishes grow best. Geographical location of the pond and meteorological conditions determine water temperature. In principle with every 10°C rise of temperature the rate of chemical and biological reactions in water doubles. So with progressive rise of temperature reactions become faster. Reverse is the case as temperature falls. Heat enters at the surface water, transmission of heat to lower level is slow; more depth of water may thus lead to stratification. The ideal depth of water 1.5 to 2.5 m for fish culture pond should be maintained to avoid such consequences. For seed raising pond, depth of water should not exceed 1.5 m.

Turbidity and Colour :

Suspended matters in water interfere with penetration of light, much needed by planktons. Suspension of clay particles although do not harm fish, persistent clay turbidity, reduce biological productivity. If pond receives heavy vegetative matters or other organic inputs, the humates shall contribute a wine or brown colour, which shall interfere with penetration of light into water. Plankton turbidity of 30 to 60 cm secchi disc visibility is desirable in fish culture ponds. Other types of turbidity and colour avoided.

Clay turbidity in new ponds may be controlled by application of 20 to 30 ppm filter alum ($Al_2(SO_4).14H_2O$). Required quantity of alum be crushed and dissolved and immediately sprinkled over the turbid water on a calm, dry day. Flocculated clay particles then sink to bottom. Although it is a temporary solution, the source of clay turbidity be avoided. Further alum application shall reduce pH of water and following application, adequate lime has to be added.

To avoid humic colours, the source of uncontrolled organic inputs be managed. Old ponds be drained, dried and the layer of organic debris removed, followed by application of required quantity of lime in the pond bottom and side soils.

Plankton :

Microorganisms of plant and animal origin that remain suspended in water and make it turbid are called plankton. They are natural sources of food for fish. In addition, phytoplanktons are primary producers and major source of dissolved oxygen. Green algae although better than others; they seldom grow alone. Blue green algae when grow profusely, form scum at surface water. The scum absorb heat, restrict diffusion. The planktons in scums often die suddenly, decompose and create oxygen depletion.

Management of a moderate plankton bloom in fish culture pond is essential to ensure better health and growth of fish. Fertilizers are added in such installments and times apart that the secchi disc visibility remain in between 30- 60 cms. in fish culture ponds.

Dissolved Oxygen (DO) :

Dissolved oxygen (DO) is most critical in fish culture. Although atmosphere has sufficient oxygen only 1- 5 mg/ l may diffuse to remain as DO. Major portion of DO is produced by plants in water during photosynthesis.

Solubility of oxygen decreases with decrease of atmospheric pressure, i.e. with increasing altitude solubility decreases. So also increase in salinity and temperature, solubility of O_2 decreases from normal range. Rate of diffusion of O_2 get enhanced by wind and wave action.

In fish culture thus when a moderate phytoplankton density exists and light can penetrate to a greater depth of pond water there shall be no dearth of O_2 for fish. So maintaining a steady nutrient level in water shall ensure phytoplanktons in water and the pond water exposed to sunlight not only shall produce sufficient DO but also be a good source of food for fishes.

pH (Hydrogen Ion Concentration) :

It is a measure which indicates whether the water is acidic or basic in reaction. The desirable range of pH for fish production is 6.5 to 9; while below 4.5 or above 11 are acid and alkaline death points of fish on prolonged exposure.

pH is influenced by concentration of dissolved carbon dioxide. So utilization of CO_2 in photosynthesis increases pH while release of CO_2 in respiration decreases pH in fish pond. However in waters with higher total alkalinity the range of pH fluctuation is not extensive.

In Asom the soil is largely acidic so ponds constructed will also have water with lower pH. To increase the status of pH to a desirable range it is necessary to add lime to water.

Carbon di Oxide (CO_2) :

Carbon di oxide (CO_2) is highly soluble in water, more concentration of it make water acidic. Fish of course can tolerate high dissolved CO_2 if DO level is sufficient. So long as extra source for generation of CO_2 such as organic debris, manure are not introduced or prolonged cloudy weather do not persist, the pond do not suffer from excess CO_2.

Ammonia (NH_3) :

It is generated in pond through fish metabolism and decomposition of organic matter by bacteria. Unionized ammonia (NH_3) is toxic to fish. The pH and temperature regulate the proportion of NH_3 and its ionized form, which is non toxic. Higher the level of pH, greater is the proportion of unionized ammonia.

In fish ponds thus how best decomposition of organic matter may be avoided, shall ensure non availability of this silent killer of fish.

Hydrogen Sulfide (H_2S) :

H_2S is produced in decomposition of organic matter, however it seldom create problem in fish pond. Concentration of 1 mg/ l may be fatal to fish and low pH favours presence of unionized H_2S. Effects of H_2S can be managed by liming.

Areas near coal mine, bog-pits often contain sulfide deposits. Such soils when exposed to air, get oxidized to H_2SO_4 and runoff from such oils, make water very acidic. It is advisable not to construct fish culture pond in such soils.

Total Alkalinity & Harness :

In natural waters carbonate and bicarbonate ions contribute to alkalinity which act as buffer and resist pH changes. In waters having high total alkalinity, morning pH is higher than in waters having low alkalinity. Further, waters having alkalinity less than 15-20 ppm, can not provide adequate CO_2 for photosynthesis; whereas alkalinity in the range of 20-50 ppm provide sufficient CO_2 for the purposes.

Total concentration of divalent cations viz. Ca^{2+}, Mg^{2+}, Sr^{2+} etc. contribute to total hardness. Usually alkalinity and hardness are complementary in pond waters. These two criteria can be increased by addition of lime in pond waters. In fish ponds hardness should be high in the range of 100- 135 ppm, so that base unsaturation of bottom soil is contained and the trivalent cations (Fe^{3+}, Al^{3+}) do not get chance to trap phosphate as insoluble compounds; or contribute to lowering of pH by release of H^+.

These physico-chemical characteristics of water are important factors towards management of water quality criteria of fish culture ponds. How best a moderate density of phytoplankton can be maintained by regulating pH towards neutral level and higher total alkalinity in water, shall ensure better utilization of nutrients to increase primary productivity and fish. pH and alkalinity can be manipulated by use of liming material.

Available liming material and their neutralizing value in pure state are as follows :-

Sl. No.	Lime	Neutralizing value (%)
1	Agricultural lime- Calcite ($CaCO_3$)	100
2	Agricultural lime- Dolomite ($CaMg(CO_3)_2$)	109
3	Quick lime (CaO)	179
4	Slaked lime ($Ca(OH)_2$)- builder's lime	136

Lime dose should be determined on the basis of neutralizing value. Based on soil pH lime requirements to produce desired result are as follows :-

pH range	Amount required for 2 bigha (kg/0.28 ha/yr.)				Amount required: kg/ ha/ yr.			
	$CaCO_3$	CaO	$Ca(OH)_2$	$CaMg(CO_3)_2$	$CaCO_3$	CaO	$Ca(OH)_2$	$CaMg(CO_3)$
6.5 - 7.5	200	112	157	170	720	400	509	606
6.0 - 6.5	500	280	365	449	1800	1000	1303	1605
5.0 - 6.0	600	336	422	534	2150	1200	1508	1907
4.0 - 5.0	1000	560	729	898	3580	2000	2603	3208

These values are just approximation; actually lime is to be applied with respect to the base unsaturation of bottom mud, which is a complicated way of measurement. In any case ponds which are limed regularly at recommended rates require lesser quantity of lime in subsequent years; but unlimed old ponds need more lime than the recommended rates.

Productivity of the pond water largely depend upon organic carbon, available nitrogen and phosphorous in soil; enhancement of which is made by addition. So it is essential to know the fertility status of pond soil, based on which, fertilizers may be applied to get desired results. In soils of the state, based on neutral fertility status, fertilizer requirements may be as follows :

Natural fertility status	Organic carbon (%)	Available range (mg/100 gm)		Fertilizer required (kg/ha/yr.)		
		N	P_2O_5	Cow dung	Urea	SSP
Low	<0.5	<25	<3	10,000- 12,000	225- 290	315- 405
Medium	0.5- 1.5	25- 50	3- 6	8,000- 10,000	156- 224	219- 314
High	1.5- 2.0	>50	>6	5,000-8,000	112- 155	156- 218

Lime and fertilizers have to be applied in installments with more quantity in the initial one. Quantity of other nitrogeneous fertilizers, if used shall be different based on their N- content: Sodium nitrate (16% N); Ammonium sulfate (20% N); Calcium ammonium nitrate (15.5% N) and so also for Tripple super phosphate (46% P_2O_5). Urea contain (45% N) and SSP (16% P_2O_5) and so on. Amount of the fertilizers are to be calculated on the basis of their % active components.

Brood Stock Management and Quality Seed Production —A Genetical Approach

Dr. K. Kalita*
Officer on Special Duty
&
Mr. A. J. Bora**
Fishery Extension Officer

**College of Fisheries, Assam Agricultural University, Raha- 782103, Nagaon, Asom, India.*
***J. B. Garh Fish Farm, Department of Fisheries, Govt. of Asom., Raha - 782103, Ngaon, Asom, India*

Induced breeding of fish is no longer a complicated technique now. It is a popular technique in our country. In Asom, more than 100 hatcheries have been established and presently contributing to more than 95% of the total spawn production. In 1997-98 the state produced about 2245 million fry sized fish seeds but in reality, this has not been reflected in the market that contributes overall fish production of the state. It is assumed that there was a large scale mortality during the early stage of fish or very slow growth of the produced seeds. Lack of quality fish seeds may be one of the primary reason for low fish production in the state, as the fish seeds of the desirable quality is the basic input for aquacultural production.

It is high time to pay top priority on these issues and close monitor the hatchery activities. Most of the hatchery owner for the benefit of self, practiced unplanned breeding programme. If these activities are allowed to continue, it will definitely jeopardize the seed production industry of the state. Already to some extent the gene pool (genetic information of a population) of the indigenous species of Indian Major carps (IMC) viz. catla, rohu and mrigal have been contaminated. As a result there is every possibility that the pure seeds of these indigenous carps endemic to the locality shall gradually disappear from the culture system.

Almost all farmed aquatic animals including fishes are genetically indistinguishable from the wild population. It is necessary that genetic programme should start with the domestication of new species with a view to obtain the maximum population heterogeneity, such heterogeneity (an individual having two dissimilar alleles present, e.g. Aa;. Alternate forms of a gene are called alleles) may add in improving species vigour suited for culture purpose.

Genetic stock improvement :

Genetic selection for phenotypic improvement like body colour, shape, fin have yielded dramatic results. But the food producers would prefer to improve performance characteristics such as growth rate, food conversion efficiency, disease resistant, fecundity, egg size and so on. The aim of the farmers is to achieve the maximum profit possible from the cultivated species undertaken by himself. This can be achieved by the genetic improvement of the fish stock through selection. To implement the programme on fish breeding and genetic improvement of stock, maintenance of adequate brood stock is very essential.

Maintenance of brood stock :

In most of the hatcheries, the seeds produced initially sold in the market are preferably good one (fast growing, large sized fish seeds) and surplus unsold seeds are stocked in the pond with high density. Some of the fish showing comparatively slower growth rate are reared in ponds until they attain sexual maturity. Selection of brood fishes taken from this stock may be termed as negative selection. If such small

sized brood fishes are considered for induced breeding purpose, due to hereditary factor, the resultant offsprings exhibit slow growth rate, weaker, fragile and die before attaining stocking size

Most of the hatchery operators do not have planned and systematic breeding programme and practiced breeding of catla, rohu, mrigal, etc in a single breeding pool and as a result of which due to identical chromosome numbers hybrids often produced among these closely related species in hormonally induced breeding programme. If these type of breeding practice is continue, the resultant hybrids seeds produced from mixed spawning may lead to adverse ecological disaster, when escaped to natural aquatic ecosystem. Hence practice of mixed spawning is a serious threat to quality fish breeding programme.

The fish breeders have acquired the ability to modify fish gene pools by mastering the art of breeding. Genetic modification by selective breeding proved beneficial but improper breeding practices will have adverse affects. If the breeders remain ignorant about the principles of population genetics, they are subject to do some mistakes. As an instance, breeders generally selected the largest individuals from the population as brood stock for improving the growth rate. It is to be noted that largest sized fish selected were the aged individuals and these individuals were actually slow growers but attain large size because of their age. This practice of selection is called a negative selection. For genetic management of hatchery populations, the breeders should have the following information :-

1. Numbers of fishes are to be used as the brood stock.
2. Age composition and sex ratio of the fishes.
3. Family performance or background information.

If these conditions are not addressed or careing properly, there may occurs some unwanted genetic changes, while selecting brood fish for spawning purpose, small size, young one fishes should be avoided. Generally carps attain first maturity at 1 – 2 years.Table-1 shows the suitability of various carps for breeding, depending on their age and weight.

Table-1: Suitability of different carps for breeding depending on their age and weight.

Sl. No.	Carp species	Weight (kg)	Age (year)
1	Catla	>3.0	3
2	Rohu	>1.0	2
3	Mrigal	>1.0	2
4	Grass carp	>2.0	2
5	Silver carp	>1.5	2
6	Common carp	>1.0	1

Seed production :

It is a complex art that require knowledge and skilled on hormone induced breeding, population genetics and art of hatchery and nursery management. Seed production technology constitutes the following points:-

1. Brood stock collection and management :

Collections, cataloguing of their geographical origin, genetic characterization, maintaining family records are important prerequisite for breeding purpose. Feeding and health maintenance are some of the important management aspects.

2. Artificial breeding :

It has hormonal and genetic components. Treatment of appropriate dosage of gonadotropin (e.g. crude pituitary extract) or other inducing agent like Gonadotrophin releasing hormone (G_nRH) analogue (e.g. ovaprim) is required for obtaining gametes for artificial fertilization. It involves hand stripping (mixing of milt and eggs on a petridish or tray) or semi natural breeding (allows hormone induced fishes to spawn on their own in a breeding pool). Hand stripping is a laborious process but semi natural spawning practice is more convenient and economical. Artificial breeding leads to domestication and brings about changes in fish gene pool.

Breeding practices :

Breeding is the practical aspect of the science of genetics. Due to improper breeding practices, some adverse genetic changes took place; these may be the- inbreeding, random genetic drift, mixed spawning, etc.

a) Inbreeding : In a real situation, mating may not be truly random in a population. Particularly in a small population mating between related individuals is more probable than the distantly related ones. When two more closely related individuals, than the average relationship of the population is bred, it results in homozygosity thereby causing inbreeding which reduces the genetic variance. The loss of genetic variance result in certain phenotypic losses of the individuals. If the close relative (brother and sister) carrying Aa genotype mate, then each cross would produce offspring in the proportion of ¼ AA, ½ Aa and ¼ aa. Thus one generation of brother – sister mating will reduce the proportion of heterozygotes from 1 to ½. In second generation its level gets reduced to ¼ and in third generation to $\frac{1}{8}$. In fish culture harmful effect of inbreeding appears moderately because of the high number of offsprings. Effects of inbreeding are as follows :-

1. Fish growth is retarded.
2. Reproduction capacity is reduced (e.g. fecundity, egg size, hatchability, etc).
3. Offspring may show low survivability, deformities, retards growth, prone to diseases, less food conversion efficiency, etc.

Fishes are more prone to inbreeding in hatchery environment due to high fecundity rate. As an example, carps can produce about 0.25 million eggs/ female/ breeding seasons. The hatchery environment ensures high rate of survival due to managerial aspects. Logically speaking, brood stock in a carp hatchery can be obtained from a single pair of parents. If the brood stocks are not replaced or exchanged, the hatchery manager will breed the close relatives.

Inbreeding is calculated as inbreeding coefficient (F), which is defined as the proportionate reduction in heterozygosity positively compared with the actual heterozygosity (2PQ) value that would be expected from random mating. Thus

$$F = \frac{2PQ - H_1}{2PQ}$$

Where H_1 is the frequency of heterozygous genotype in a population of inbred individuals.

b) Random genetic drift : Factors like accident, natural calamities, over exploitation affects the reduction of population size. As a result, some alleles get lost by chance which cause change in the allelic frequency. The change in allelic frequency due to accidental loss is known as random genetic drift. Genetic drift makes a population unfit for selective breeding programme.

c) Mixed spawning : Different fish species taken together for induced breeding purpose in a single breeding pool at a time is called mixed spawning. Mixed spawning leads to hybridization inadvertently because of their genetic kinship.

Measures to avoid inbreeding and genetic drift in the hatchery :

1. Hatchery brood stock should be partially and periodically replaced. Exchange of brood stock between local hatcheries is useful.
2. Brood stock of different age group should bred together in order to reduce the chance of loss of some valuable alleles.
3. Natural stock may be inducted periodically to increase the heterozygosity.
4. Cryopreserved spermatozoa may be used to maintain heterozygosity.
5. The family history should be recorded to avoid inbreeding.
6. Crossing of different lines of fishes would increase heterozygosity. Separate lines of fish can be maintained by keeping the record of different strains of fishes in a hatchery.

Techniques of Fish Seed Raising and Precautions for better Survivability

Dr. B. Kalita
Associate Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

There has been an increasing demand of quality and sizeable fish seed in Asom. Without this, the growth of carps to the expected level is not possible. Production of fish seed of Indian Major carps and exotic carps is not at all complicated. Standardization of techniques and doses of various breeding materials have been established. Production fish seed has substantially increased but the production rate from per unit area is very low as compared to the other states of the country. Constraints leading to low production are associated with many factors. The prominent factors are—the mortality of seed in early stages and slow growth rate. This clearly indicates the importance of quality of fish seed and the maintenance of seed during early stages in nursery and rearing ponds before release into the stocking ponds, which is considered as the major input in culture system. Therefore, it is very essential to take the precautionary measures in production of seeds at hatcheries as well as raising seeds in nurseries and rearing ponds to improve the quality of fish seeds.

Carp spawn start feeding after about 3-4 days of hatching. At this stage, the spawn are very delicate and their immune system is not functionally matured. Environmental deterioration may stress the spawn and results in mass mortality. Therefore, one should be careful in maintaining the congenial environment with appropriate stocking density and enough feed for spawn. The spawn (5- 6 mm size) are nursed in well prepared nurseries and grow to fry (25- 30 mm size) in about 2 weeks (14 days) period. The survivality may be raised to 60- 70% if properly maintained.

NURSERY POND MANAGEMENT :

Steps involved in nursery pond management are as follows :-

1. **Pond Selection :** Ponds are usually smaller in sizes, 0.02-0.05 ha. in area with water depth 1.0-1.5 m. Seasonal ponds are much better than perennial ones as it is exposed to sunlight which help in improving the hygienic condition of the pond bottom. Always better to prepare just before the monsoon season (March - April).
2. **Clearance of Weed :** Needs to provide the movement space for the spawn, oxygen and to produce natural food. Manual removal is best during summer month (April - May).
3. **Eradication of unwanted fish :** Unwanted fish (includes all) which compete with the space, food and oxygen requirement. Methods followed are repeated netting, dewatering and use of fish toxicants.

Precautions :

- Should be done during premonsoon.
- 5 weeks earlier to the anticipated time of spawn availability.
- Seasonal ponds do not require the use of toxicants.

Application of fish toxicants : Various kinds of fish toxicants are available. Commonly used ones are-

i. **Mohua oilcake (*Basia latifolia*) :** Extensively used, containing 4 – 6% saponin. Required quantity of mohua oilcake is powdered and spread uniformly over the pond surface and mixed with pond water by netting. Killed fishes are fit for human consumption. Mohua oilcake serves as organic manure also.

Dose : 200 - 250 ppm (2000 - 2500 kg/ha.), kills fish in 6 - 10 hours.

Precaution : Toxicity last for 15 - 20 days.

ii. **Tea seed cake (*Camellia sinensis*) :** It is a substitute for mohua oilcake. Required quantity are made into powder and soaked in water then spread uniformly on water surface and mixed by netting. Treated fish can be used for human consumption and acts as fertilizers.

iii. **Bleaching powder (Calcium hypochlorite) :** In view of limited supply of mohua oilcake, bleaching powder could be used as substitute with easy availability and low cost. Required quantity is dissolved in water and made immediately spray on the surface of the pond water. Water is properly mixed and all the killed fishes are fit for human consumption.

Dose : 25 - 30 ppm, kills all the fish within 3 - 4 hrs.

Precaution : Toxicity last about 7 - 8 days.

iv. **Rotenone (7%) :** Derris root powder; yet to be marketed in India which awaits Govt. of India's clearance. A very safe drug to kill fish @ 2 - 2.5 gm/ sq. m. per meter water depth (20 - 25 kg/ ha/ meter).
The powder mixed with sufficient water and sprinkled over the pond and then netted for well mixing, applied in early morning. Within hour's time, fishes shall surface and to sides, then they are caught, washed thoroughly and are safe for consumption. Dead fishes discarded. The treated water should not be used for 4 days for any domestic purposes.

Precaution : Toxic to oral and inhalation; so close mouth and nose with wet cloth, while handling. Wash with soap after use. The drug act as respiratory arrest agent for fish and thus kill them.

4. **Application of lime :** Lime improves the mineralization of organic matter and acts as prophylactic measures.

Dose : 250 - 300 kg/ ha. of quick lime (CaO) is used.

Precaution : Apply after 14 days of eradication of unwanted fish.

5. **Manuring of pond :** As spawn mainly depend on the plankton (zooplankton) in water, application of organic manure helps in increasing natural food in pond. Required quantity of cow dung is sprayed over the pond.

Dose : 10,000 kg/ ha. of cattle dung, broadcasting all over the pond

Precaution : 15 days ahead of the anticipated date of stocking of spawn.

* When mohua oilcake is used as piscicide then the required doses of cow dung is reduced to half.

6. **Insect control :** Most of the aquatic insects prey upon spawn and early fry; therefore, they must be eradicated before stocking the nursery ponds with spawn. Various methods are available. The most commonly applied ones are depend on the availability and cost involved.

i) **Soap oil emulsion :** Soap oil emulsion is a ratio of soap and oil (i.e. 18 kg soap: 56 kg oil/ ha) is prepared by heating and then spray over the surface of the water.

ii) **Kerosine oil :** 80- 100 litres/ ha is used on the pond surface, directly spray on the surface of the pond.

iii) **Light Speed Diesel oil (LSD) :** Light Speed Diesel oil (1 litre), emulsifier Hyoxid IOII (0.75 ml) and water (40 ml) at the rate of 1040.75 ml/ 200 sq. m. of water surface.

Precaution :

- All the above method should be applied before 12 - 24 hrs of stocking spawn.
- Do not use on windy or rainy day.

7. Stocking of Spawn : Appropriate rate of stocking of spawn ensures better survivality. 25 - 35 lakhs/ ha. of spawn are stocked.

Precautions :

- Detoxification to be tested by realizing some spawns in a small hapa in the treated pond for 24 hrs.
- Spawn should be stocked after 5 weeks of piscicide application.
- Stocking of spawn should be done in the morning hours preferably.

8. Supplementary Feeding : A mixture of finely powdered groundnut oilcake and rice bran polish in equal proportion (1:1) by weight is supplied to the spawn.

Precautions :

- Cobalt chloride or magnesium sulphate @0.01 mg/day/spawn may be added to the feed.
- Feed should be sprayed over the pond once daily in morning hours from the day of stocking.
- Feeding should be stopped one day earlier to harvest the fry.
- If adverse ecological condition exists, feeding is suspended temporarily.

9. Harvesting of Fry : Fry reach about 25 - 30 mm size (1 - 1.5 inch) in 2 weeks and ready for harvesting. Fry harvested with nursery net is either to transfer to the rearing ponds or sale to the customer.

Precautions :

- Harvesting of fry should be done in the cool morning hours.
- Avoid harvesting on cloudy day.
- Avoid all the activities which create turbidity in water.

REARING POND AND MANAGEMENT :

This is period of rearing of fry to fingerling size. The rearing period is about 3 months. Steps involved in rearing pond management are as follows :

1. Pond Selection : Rearing ponds are little bigger than the nursery ponds. Size ranges from 0.05 - 0.1 ha in area. Rectangular shaped pond is advantageous, depth of water is 1.5 - 2.0 m. Seasonal ponds are preferable to perennial ones. Weed eradication and removal of unwanted fish are same as in the case of nursery ponds.

2. Lime Application : Lime ($CaCO_3$) is applied 250 - 300 kg/ ha in 3 equal installments.

Precaution :

- 1^{st} dose (30%) is applied 7 days before stocking of fry.

3. Pond Fertilization: Fertilization and manuring are the indirect means to increase the natural productivity of the pond.

a) Organic manure : Cow dung @2000 kg/ha is applied in 4 equal installments by spraying over pond surface.

Precautions :

- 1^{st} installment must be used about 15 days before stocking of fry and rest installments are used at monthly intervals.
- Pond treated with mohua oilcake first of cow dung can be dispensed with.

b) Inorganic fertilizer : Urea @100 kg/ ha or ammonium sulphate @ 200 kg/ ha and triple super phosphate @ 35 kg/ ha may be applied in 3 equal installments during rearing period.

Precautions :

- 1st installment is given on the second day of stocking of fry and rest at monthly intervals alternately with organic manures.

4. **Fry Stocking :** Fry of 25 - 30 mm size are stocked ranging from 2- 3 lakhs/ ha in various combinations as given in the table-1.

Precautions :

- Detoxification test should be done by keeping some fry in a small hapa in a corner of the pond for 24 hrs.

5. **Supplementary Feeding :** Supplementary feed consists of a mixture of mustard oilcake and rice bran at 1:1 ratio by weight in powdered form and given once a day in the morning hours at the surface of the water from the day of stocking. A feeding schedule is given in table-2.

Precaution :

- Duck weeds (wolfia, lemna, spirodella and azolla) are kept in one corner within a bamboo enclosure and quantity to keep depend on consumption.

6. **Fingerling Harvesting :** During the rearing period of 3 months, healthy fingerlings reach about 100 - 150 mm (4 - 6 inch) and ready for harvesting. Survivability of fry is about 80%.

Precautions :

- Feeding should be stopped a day before the date of harvesting.
- Harvesting should be done during cool morning hours by repeated drag netting.

Table-1 : Species combinations of fry in rearing pond.

Species	Ratio	Total
Catla+ Rohu+ Mrigal	2:4:4	10
Silver carp+ Grass carp	1:1	2
Silver carp+ Grass carp+ Common carp	4:3:3	10
Silver carp+ Grass carp+ Common carp	5:1.25:3.75	10
Catla+ Rohu+ Mrigal+ Common carp	3:4:1:2	10
Catla+ Rohu+ Mrigal+ Grass carp	4:3:1.5:1.5	10
Catla+ Rohu+ Mrigal+ Grass carp	3:3:3:1	10
Silver carp+ Grass carp+ Common carp+ Rohu	3:1.5:2.5:3	10
Silver carp+ Grass carp+ Common carp+ Rohu	4:2:2:2	10

Table-2 : Feeding schedule in nursery and rearing pond.

Period after stocking	Rate of feeding per day	Approximate quantity per lakh of spawn per day
A. Feeding schedule in nursery pond		
1st to 5th day	4 times the initial total weight of spwn stocked	0.56 kg
6th to 12th day	8 times the initial total weight of spawn stocked	1.12 kg

13th day	No feeding	—
14th day	Harvesting	—
B. Feeding schedule in rearing pond		
1st month	—	6 kg
2nd month	—	10 kg
3rd month	—	15 kg

Raising of Carried Over Seed (Stunted Carp Seed) :

Stocking of quality and sizeable fish seed at appropriate time is the basic input in carp culture system. To achieve this, different methods of producing of such fish seed have developed and are in practice in different parts of the world. One of the unique techniques scientifically established for milk fish (*Chanos chanos*) in Phillippines where stunted fingerlings of milk fish are produced and make sufficient supply during the peak season of culture period. The observations indicated that stunting did not illicit a significant increase, nor did it adversely affect the growth, survival and net production of milk fish in straight culture system (Bombeo - Tuburn, I 1988). Therefore, stunting can provide an adequate supply of fingerlings of milk fish for year- round operation to the farmers.

However, in India, technology of producing stunted carp fingerlings and stocking them into culture ponds is of recent origin, developed by fish farmers of Andhra Pradesh (Veerina, et al; 1993). The technology involves stocking the ponds with early fingerlings of carps at high stocking densities of 1.0 - 1.5 lakhs/ ha and reared them for 4- 5 months. Consequent to high stocking density with suboptimal level of feeding, weak ones die and remaining ones get stunted in growth. When these fingerlings were stocked in normal density and maintained exihibit very good survival, register a better growth performance in short culture period. While, Ramesh et al (2000), maintained a stocking density of rohu fingerlings at 1.0 lakh/ ha was found to be optimum with normal maintenance for a period of 5 months and survival rate was 80% when these were stocked in grow-out ponds with normal management, showed higher growth rate of around 3.79 gm/ day as against 2.5 gm/ day in normal fingerlings for a period of 5 months. It clearly indicates that the stocking of stunted fingerlings in culture ponds gives high yield in unit terms and is more economic than normal fingerlings.

Oblate, there has been a common practice of retaining late spawned or left over carp seeds in the seed raising pond in fish farm hatchery owner of this region, at high stocking density of 1 lakh/ ha. in August with fry of catla (25%), mrigal (33%), rohu (25%) & grass carp (17%) and silver carp and common carp are not kept. Fingerlings are kept under low management with feeding at 0.5% body weight, once in two days whereby stunted fish seeds are made available for stocking in ponds early in the season next year.

So far, a scientific management has not been worked out for this type of fish seed raising in Asom. Since, such fish seed invariably show better survivality and growth performance, therefore, stunting carp fingerlings deserves consideration in Asom also. Moreover, the advantages which are provided by the practice are :-

1. Ponds can be stocked with sizeable fish seed at the onset of monsoon
2. Early stocking can be done in the seasonal ponds as they retained water for a period of short time
3. Ensures the higher survival rate of fish seed
4. Helps in multiple harvesting in composite fish culture
5. More disease resistance and
6. Enhances the rate of production

General precautions in raising carp seed in different methods :

- Appearance of algal bloom or any adverse conditions, feeding should be stopped temporarily.
- Manual control of algal bloom is better than chemical application, Diuron @0.1 - 0.5 ppm (1 - 3 gm/ ha /meter depth of water) may be sprayed over the water surface uniformly. Never apply in nursery ponds.
- Maintenance of water quality through application of lime based on the pH of water.
- Conditioning of fry and fingerlings at least 12 hrs. before transportation.
- While packing for transportation, oxygen should be provided sufficiently depending on the size and numbers of fish seed to be carried.
- Acclimatization of fry and fingerlings to be done before realizing into the culture ponds.
- A water bath treatment with $KMnO_4$ @ 1- 2 ppm for a minute is essential before releasing the fish seed into the culture ponds.
- Agrimin forte @10 gm/ kg feed be given sometimes to improve health condition of the fish seed.
- Hardening of fingerlings in rearing ponds should be done by netting a big mesh sized net at fortnight intervals till harvesting.
- While raising stunted fingerlings, fish seed should not be put under much stressed conditions.
- Optimal management in feed and manuring in stunted fingerlings pond.
- Potassium permanganate @1 - 2 ppm is used in stunted fingerlings pond followed by liming before the onset of winter season and frequent netting should be avoided.

Conclusion :

In conclusion it may be said that stunting carp seed may be an advantageous method to boost carp production in culture ponds of Asom. However, adequate attention has to be given to the genetic quality of seed material. Parents of the fish seed must have high genetic variability towards growth potential, then manipulating the system it is possible to make available high quality fish seed early in the season to culture.

Warm Water Weed Management

Mr. S. K. Bhagabati
Assistant Professor
Fishery Hydrography

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

In all the aquatic ecosystems aquatic plants are essential components. Beneficial effects of plants in aquatic ecosystems are- major source of dissolved oxygen in a water body, serve as food for some fishes, provide shelter to aquatic organisms, act as a substrate to lay eggs for some fishes, some act as a good biofertilizer (e.g. *Azolla*), control aquatic pollution, etc.

Despite the importance of plants in an aquatic ecosystem, some plants interferes with the management of that ecosystem. The harmful effects of some aquatic plants in an aquatic ecosystem can be enlisted as- they reduce the productivity of a water body; restrict the movement of fish; act as a shelter for predatory fishes, insects, snakes, etc.; restrict netting operations in a water body; hazardous to shipping; etc. Because of these harmful effects these aquatic plants are either eradicated from a water body or their growth is restricted to a desirable level.

Common Aquatic Weeds :

Based on the growth form and their location in water column of a water body aquatic weeds can be grouped as—

1. Phytoplankton (e.g. *Microcystis sp.*, *Anabaena sp.,* etc.).
2. Macrophytic Filamentous Algae (e.g. *Pithophora sp.*, *Spirogyra sp.*, *Chara sp.*, etc.).
3. Submerged Weeds (e.g. *Najas sp.*, *Potamogeton sp.*, *Ceratophyllum sp.*, *Myriophyllum sp.*, etc.).
4. Emergent Plants (e.g. *Polygonum sp.*, *Typha sp.*, etc.).
5. Free-Floating Plants (e.g. *Pistia sp.*, *Eichhornia sp.*, *Azolla sp.*, *Lemna sp.*, *Spirodela sp.*, *Wolfia sp.*, etc.).
6. Rooted Emergent Plants (e.g. *Nelumbo sp.*, *Nymphea sp.*, etc.).

Commonly occurring aquatic weeds in different water bodies of Asom are :-

Floating weeds— *Pistia stratiotes*, *Eichhornia crassipes*, *Spirodela polyrhiza*, *Salvinia molesta*, *S. natans*, *Azolla pinnata*, *Lemna minor*, *Lemna major* & *Utricularia exoleta*;

Submerged weeds— *Hydrilla verticillata*, *Ceratophyllum demersum*, *Chara vulgaris*, *Zanchellia palustris*, *Najas minor*, *Otellia alismoides*, *Vallisnaria spiralis*, *Potamogeton sp.*& *Myriophyllum sp.*;

Shore line weeds— *Marsilea quadrifolia*, *Colocasia asculenta*, *Fimbristylis miliaceae*, *Polygonum natans*, *Monochorea sp.*, *Ludwigia hadscendens*, *N. indica*, *Cyperus sp.*, *Phragmites sp*, *Ipomea aquatic* & *Trapa bispinosa*;

Emergent weeds— *Nymphoides sp.*, *Nelumbo nucifera*, *Euryle ferox* & *Typha sp.*

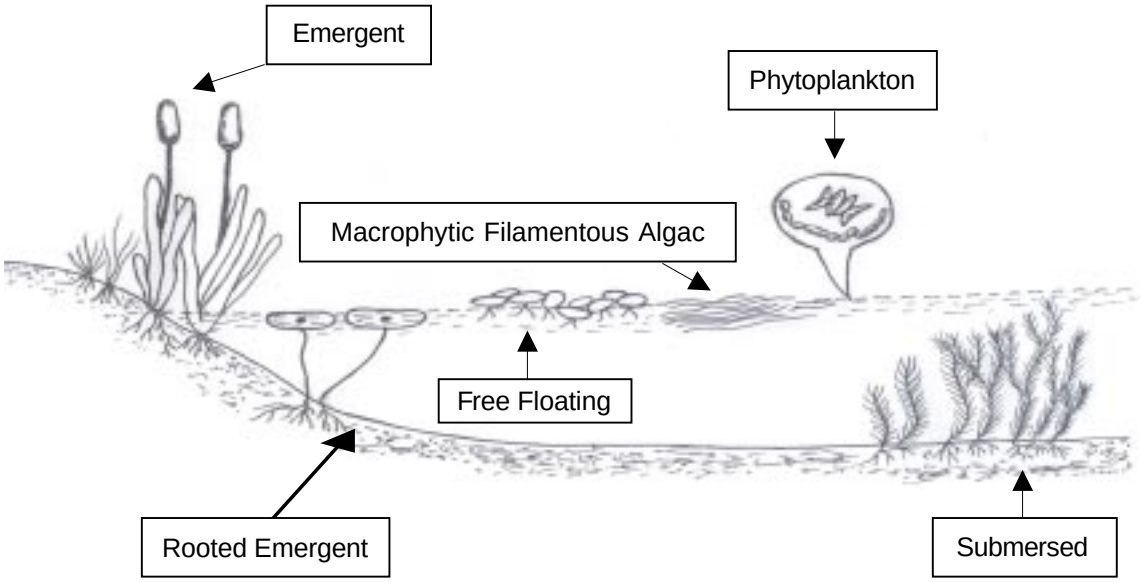

Fig : Ecological groups of aquatic plants.

Management of Weed Problems :

Presence of any aquatic plant can be ignored in an aquatic ecosystem until and unless it does not become so abundant that it interferes with the productivity of the system. Therefore, control measures are taken only when they establish in an ecosystem to a large mass. Manual, mechanical, chemical and biological are the measures adopted to eradicate weed. Out of all these methods of weed control the chemical control of weed is usually the fastest and most effective, which helps in reestablishing the phytoplankton community, which is most desirable in restoring the productivity of a water body. But chemical control of aquatic weed is risky as it creates water quality problems.

General Management of Weed Problems :

Some of the commonly followed general measures to discourage the growth of aquatic weed in a culture system are—

1. Maintain the water depth of a pond to the required level.
2. Use effective fertilization programme to encourage the growth of phytoplankton bloom whereby troublesome weed growth can be discouraged.
3. Non toxic dyes can be used to inhibit the growth of submerged plants as a preventive measure for deeper water bodies.

Control Measures of Aquatic Weed :

As discussed earlier aquatic weeds in water body can be controlled by- manually, mechanically, chemically and biologically. Troublesome aquatic weeds can be controlled by employing any one or combination of two or more methods mentioned above. Best results in controlling these harmful aquatic weeds can be obtained by using the aforesaid method/ methods before their flowering. Chemically these weeds can be effectively controlled before they attain their maturity. It is to be kept in our mind that the success of different weed control methods depends upon the prevailing weather. The different aquatic weed control methods are briefly discussed below.

1. **Manual Method :** In this method aquatic weed from water bodies are removed manually i.e. by hand. This is effective in case of small water bodies and where labour is cheap. Here importance is given in removing the root stock from the soil bed of a water body to prevent the recurrence of weed problem.

2. **Mechanical Method :** Here different utensils made up of bamboo, wood, iron, etc. is used in ranking or removing weeds from a water body. Now a days mechanical device, like- tractor is also used in removing aquatic weeds. In this method care should be taken to remove as much of the root stock or rhizome as possible to minimize regrowth.

3. **Biological Method :** This method includes the use of insects, fungi & other plant pathogens, birds, mammals, or fish to kill or eat aquatic weeds. Water fowl; ducks or geese; large grazing animals, like - cattle; fish, like - grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*), certain species of tilapia, silver carp (*Hypophthalmicthys molitrix*), etc. are identified as good biological agents. Use of fish in controlling aquatic weed helps in increasing the productivity from the culture system.

4. **Chemical Method :** Application of chemicals to control the aquatic weeds in a water body is the quickest and very effective method. Normally these chemical herbicides are used to remove unwanted aquatic vegetation only. After application of chemical herbicides to a water body periodic application of fertilizer is necessary to restore the phytoplankton community. Herbicides labelled for use in aquaculture can only be used. Herbicides of plant origin are always preferred, as it does not have any bad effects on cultured organisms in a water body. Below some of the commonly used herbicides with their respective doses may vary depending on the water quality, density & species of aquatic weeds, etc.

Table : Herbicides with their doses to control aquatic weed in a water body.

Chemical herbicides	Dose required control	Type of aquatic weeds
Copper sulfate pentahydrate ($CuSO_4$, $5H_2SO_4$)	0.5 to 2 ppm	Phytoplankton and macrophytic algae
Diquat	20 to 200 times diluted mixture foliar spray	Submerged & emergent plants and macrophytic filamentous algae.
Endothall (Dipotassium & Dimethylalkylamine salt) a) Dipotassium salt b) Dimethylalkylamine salt	< 100 ppm < 0.2 ppm (portion wise of a pond should be treated to avoid killing cultured fish).	Submerged plants. Submerged higher plants & Filamentous algae.
Fluridone	< 0.1 ppm	Submerged higher plants, duckweed, water meal & some emergent plants.
2- 4 D	4.5 to 6.5 Kg./ ha.	Floating weeds, like- *Eichhornia*
2- 4 D Ester	9 to 13 Kg./ ha.	Floating weeds, like- Duckweed.
2- 4 D Sodium	10 to 12 Kg./ ha. (as liquid formulation)	Shore line plants, like-Grasses.
	5 Kg./ ha. (as liquid formulation)	Shore line plants, like- *Colocasia, Ipomea,* etc.

Glyphosate	0.5 to 2 % solution (Foliary spray)	Emergent and shore line plants.
Simazine	5 Kg./ ha.	Floating weeds, like- *Eichhornia,* duckweed, etc.
	0.25 to 1.0 ppm	Algae.
Paraquat	0.02 Kg./ ha. (liquid formulation)	Floating weeds, like- Duckweed.
Sodium arsenite	5 to 6 ppm	Submerged weeds.
Superphosphate	500 ppm	Submerged weeds.
Urea	50 to 100 ppm 250 to 300 ppm (but more than 50 ppm is lethal to fish)	Submerged weeds like- Otellia. Submerged & emergent weeds, like- Hydrilla.
Diuron	0.1 to 0.3 ppm	Algae.

Raising Carp Seeds Using Bamboo Cages in Open Inland Water Bodies—A Case Study

Dr. P. K. Goswami
Associate Professor
Fishery Biology

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Since the open inland water bodies like flood plain lakes (beels), reservoirs, etc. are to be developed sustainably on the principle of culture based capture fisheries, it is desirable to stock such ecosystems with fast growing fish species at a definite stocking density. Moreover, the open inland waterbodies are characterized by superfluous growth of aquatic macrophytes which in turn convert the ecosystem into a forage base for predatory catfishes. In presence of astronomical number of catfishes in the system it requires 10- 15 cm size carp seed as a stocking material. Generally to attain such size it takes several months in earthen ponds where percentage of recovery is also very low. At the same time the price of said fish seeds are very high due to its good market demand as food fishes too. To stock such ecosystems even at a modest rate, the specific size stocking materials are not available at plenty all the year round. On the other hand carrying of such fish seeds from the production centres to the open waterbodies is practically difficult and beset with many problems.

In these circumstances to evade such crisis, cage aquaculture in open inland water bodies would be a viable solution; and to the effect two trials were conducted to raise carp seeds in bamboo cages at two beels of Nagaon district, Asom which was found to be successful and economically feasible.

Five number of bamboo cages specially designed for high intensity water circulation and light penetration were constructed by locally available matured 'Jati' bamboo, nylon ropes, nails, nylon clothes, etc in the following dimensions and installed at the following sites.

A. Three cages at Erakolong beel in the size specification of 3 m × 2 m × 1.5 m= 9 m^3 each and total area = 27 m^3.

B. Two cages at Kanuwamari beel in the dimension of 4 m × 2 m × 1.5 m= 12 m^3 each and total area of 24 m^3.

During the first trial of 45 days starting from 20th May, 2005 to 6th July, 2005, 2.5 cm to 3.0 cm fish fry of rohu (20%), catla (20%), mrigal (25%), silver carp (25%) and grass carp (10%) were stocked in the cages on 20th May, 2005 in the following densities.

1. Cages at Erakolong were stocked @225 numbers/ m^3 i.e. 2025 numbers/ cage of 9 m^3 area and a total of 6075 numbers in the three cages.
2. Cages at Kanuwamari beel were stocked @270 numbers/ m^3 i.e. 3240 numbers/ cage and a total of 6480 numbers in the two cages.

The fish fry (average individual weight = 0.4 gm) were fed with the following feeds at specific doses.

Rice polish along with mustard oil cake at 1:1 ratio was fed to the stocked fish fry for the first 10 days @5% of the total body weight of the fishes regularly once in a day and for the rest 35 days the fish fry were fed with the same feed @10% of their total body weight per day. In addition to this Agrimin forte was also provided along with the feed @0.3% of the total body weight of fish daily.

In the same cages and same sites the second trial was conducted starting from 12th July, 2005 to 23rd August, 2005 for a period of 42 days. 2.0 cm to 2.5 cm fish fry of rohu (20%), catla (25%), mrigal (15%), silver carp (25%) and grass carp (15%) were stocked in the cages on 12th July, 2005 in the following densities.

A. Cages at Erakolong beel @175 numbers/ m^3 i.e. 1575 numbers per cage and a total of 4725 numbers in 3 cages.

B. Cages at Kanuwamari beel @220 numbers/ m^3 i.e. 2640 numbers per cage and a total of 5280 numbers in 2 cages.

During 42 days of rearing period the fishes (average individual weight = 0.35 gm) were fed once in a day with the following diet:

Rice polish along with mustard oil cake at 1:1 ratio was fed to fish fry for the first 10 days @10% of the total body weight of the fishes regularly once in a day and for the rest 32 days the fish fry were fed with the same feed @15% of their total body weight per day. Agrimin forte was also provided along with the feed @0.3% of the total body weight of fish daily.

All the fishes of the first and second trial were harvested on 6th July, 2005 and 23rd August, 2005 after 45 days and 42 days of rearing respectively. An encouraging growth (10.0- 19.0 cm) and recovery (avg. 80.0%) rate was found (Table-1). The same success was achieved in the second trial too (Table-2).

Table-1 : Rate of recovery in the first trial.

Sl. No.	Cage site	No. of fish fry stocked	Nos. of fish seed recovered	Percentage of recovery
1	From 3 nos. of cages at Erakolong beel	6000	4600	77.0
2	From 2 nos. of cages at Kanuwamari beel	6500	5300	82.0
Total		**12500**	**9900**	**Avg.= 80.0**

Table-2 : Rate of recovery in the second trial.

Sl. No.	Cage site	Nos. of fish stocked	Nos. of fish seed recovered	Percentage of recovery
A	3 nos. of cages at Erakolong beel	4725	3800	80.0
B	2 cages at Kanuamari beel	5280	4244	80.0
Total		**10000**	**8044**	**80.0**

Economic viability :

First trial (45 days) :

A.	Capital cost (construction of cages and its accessories)	:	Rs.	17750.00
B.	Recurring cost (cost of fish seed and feeds)	:	Rs.	2400.00
C.	Annual investment (considering the longevity of the bamboo cages to be 3 years)	:	Rs.	5917.00
	I. Annual depreciation on capital cost (10%)	:	Rs.	592.00
	II. Annual interest on capital cost (9%)	:	Rs.	532.00
	III. Recurring cost per trial	:	Rs.	2400.00
	Total investment	**:**	**Rs.**	**9441.00**

D.	Income (sold 9900 numbers of fish seed @ Rs. 2.00/ piece)	:	Rs.	19800.00
E.	**Profit (D- C)**	**:**	**Rs.**	**10359.00**
B.	**Second trial (42 days) :**			
A.	Annual investment	:	Nil	
I.	Annual depreciation cost	:	Nil	
II.	Annual interest on capital cost	:	Nil	
III.	Recurring cost	:	Rs.	2600.00
	Total investment	**:**	**Rs.**	**2600.00**
B.	Income (sold 8044 numbers of fish seed @Rs. 2.00/ piece)	:	Rs.	13488.00
		:	Rs.	16088.00
C.	**Profit (A- B)**	**:**	**Rs.**	**13488.00**

In the same manner another seed raising trial (3rd trial) for 45 days starting from August to October could easily be accommodated in the same year in the same cages. Stocking density of 270 numbers of fish fry per m^3 of the cages has been able to show encouraging growth rate and providing regular artificial feed (@10% of the body weight) along with agrimin (@0.3% of the body weight) should be made mandatory.

These trials have indicated the feasibility to meet the demand of advanced carp fingerlings to stock open water bodies to enhance production and also create an avenue of employment to fisherfolks.

Integrated Livestock-Fish Farming System

Dr. K. K. Tamuli
Associate Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Evolved on the principles of productive recycling of farm wastes, fish- livestock farming systems are recognized as highly assured technologies for fish cultivation.

In these technologies, predetermined quantum of livestock waste obtained by rearing the live stock in the pond area is applied in pond to raise the fish crop without any other exogenous supply of nutrients.

Here two technologies are dealt with :-

A. Integrated pig fish farming.

B. Integrated cattle fish farming.

A. INTEGRATED PIG- FISH FARMING SYSTEM

Introduction :

Integrated pig- fish farming is a highly profitable fish culture system, where pigs are reared adjacent to the fish ponds, preferably on the pond embankment from where pig urine, excreta and spilled pig feeds are introduced into the pond water. In one harvest cycle of fish (one year), 2 batches of pigs are grown, 6 months each. This is direct integration system, which is a more efficient method than the indirect integration model, wherein pigs are raised elsewhere and the pig waste is manually applied to the pond daily at a predetermined dose.

1.1. Benefits of pig- fish farming (Direct integration) :

i. Fish utilizes the feed spilled by pigs and their excreta, which is very rich in nutrients for fish.

ii. Pig dung act as a suitable substitute to pond fertilizer and supplementary feed for some of the fishes, therefore the cost of fish production is reduced by about 60%.

iii. No additional land is required for piggery operations.

iv. Cattle fodders required for pigs and grass carps are grown on the terraced pond embankments.

v. Mortality of pig is greatly reduced, as pond provides much needed water for washing the pig- sties and pigs.

vi. The pond mucks which gets accumulated at the pond bottom due to constant application of pig dung, can be used as an excellent fertilizer for growing vegetables, other crops and cattle fodder.

vii. Efficient labour utilization.

2. Method

2.1. Pig husbandry practices :

Growth of pigs depends upon many factors including breed and strain, but good management contributes to the achievement of optimum production.

2.1.1. Construction of pig house :

The pig house can be constructed by using locally available materials such as bamboo and thatch, but the floor must be roughly cemented. An enclosed run is provided to the pen so that the pigs get enough air, sunlight and space for dunging. The floor of the pen should be non slippery. The wall should be 1.0 m in height and preferably made of bricks. The upper part of the wall should be provided with wire netting. The height of the pig sty is 1.5 m. The floor of the house is slightly slanted towards a drainage canal. The canal is connected to the pond. The drainage canal is provided with a diversion canal leading to a cemented pit, where the wastes are stored in the days when the pond has algal bloom. A built- in shutter is provided in the drainage canal to regulate the flow of wastes. Space requirement per pig is 1.5 m^2. The roof of the house may be made using thatch or asbestos. Feeding and drinking troughs are constructed alternatively inside the pen, attached to one wall. A bath tub may also be constructed attaching to one wall of the open run.

2.1.2. Selection of pigs :

Pigs with 75% or 50% pure Hempshire blood has been found to be the best for such system. Landrace, large- black, etc. can also be used but not the indigenous varieties. 2- 3 months old weaned piglets are brought to the pig sty for six month rearing.

2.1.3. Number of pigs :

40 to 45 piglets/ ha water spread area for 6 months.

2.1.4. Pig feed:

Pigs are fed with balanced pig mesh concentrate (PMC) @ 1.5 kg/ pig/ day. To overcome mineral deficiency, 'Sod' (30 cm × 30 cm bed of grass with all its roots intact and interlocked soil) is provided once a week. However, as PMC (Table-1) is costly, raising pigs with PMC has not been found economical. Through trial & error, one pig feed has been developed, where *Colocasia* stem & tuber, hotel wastes, rice bran, jubili (the byproduct of a special type of beverage prepared and consumed by the tribal people of Asom), etc. are used (Table-2).

Table-1 : Composition of Pig Mesh Concentrate (PMC).

Sl. No.	Ingredient	Parts (%)
1	Rice bran	30
2	Rice polish	15
3	Wheat bran	27
4	Maize broken	10
5	Ground nut oilcake	10
6	Fish meal	04
7	Mineral mixture	03
8	Common salt	01
Total		100

Vitamin supplementation @ 20 gm/ 100 kg feed.

Table-2 : Composition pig feed prepared at College of Fisheries, Raha using locally available cheaper ingredients.

Sl. No.	Ingredient	Parts (%)
1	Kitchen wastes	40
2	*Colocasia* leaves, stems and rhizomes	10
3	Rice bran	16
4	Jubili	8
5	Tea stall wastes	2
5	Banana spadix	1
6	Fish meal	5
7	Vegetable wastes, papaya, halt rotten potato, sweet potato, cabbages, unripe banana and tapioca, etc.	5
8	Common salt	1
	Total	100

2.1.4.1. Methods of preparation of pig feed using the ingredients of table-2 :

Colocasia leaves, stem and rhizomes are cut into small pieces and mixed with the above ingredients (Table-2) except rice bran and jubili and boiled properly. Prior to serving jubili and rice bran are mixed.

Feeding rate : Pigs are fed at *ad-libitum*. Pigs are fed twice a day i.e. morning and afternoon. In addition, pigs are to be fed regularly with wilted water hyacinth regularly. Cattle fodder, tapioca leaves, banana plants should be cut into small pieces and serve to the pigs.

1.1.1. Health care :

Pig sties need be washed regularly two times a day in the summer months and once in winter season. Pigs should also be given bath twice a day in summer and once in winter. Disinfection of pig sties should be done twice in a week, with quick lime, and potash ($KmNO_4$) respectively. The washed water leads to a fish pond serving double purpose.

Piglets must be vaccinated against swine fever. They are to be dewormed at the age of 3- 4 months.

1.1.2. Disposal :

After rearing for about 6 months, pigs attain slaughter maturity size (60- 70 kg live weight). These are to be sold out and the new piglets are to be introduced into the pigsty.

1.2. Fish Pond Management Practices

2.2.1. Size : 0.4 to 1.0 ha size of a pond is sufficient to make profit from this integration.

2.2.1. Prestocking management :

Clearance of unwanted fishes, deweeding and liming as in the case of composite fish culture system is done prior to stocking of pond with fish seed.

2.2.3. Stocking :

In direct integration system, stocking is done after 20 days of introduction of piglets in the pigsty. In indirect integration, 1000 kg/ ha pig wastes is applied in single installment. Pond becomes ready for stocking after 20 days. Rate of stocking of fish seed is 9000 nos./ ha preferably with advanced fingerlings

Sl. No.	Species	Percentage	Number per ha.
1	Catla	20	1800
2	Rohu	20	1800
3	Mrigal	20	1800
4	Silver carp	25	2250
5	Grass carp	10	900
6	Common carp	5	450
Total		100	9000

Stock is replenished after partial harvesting with a same number of fingerlings of harvested species. After one year, complete harvesting is done. Pond is dewatered partially to expose the silt to sunlight. These are to be taken out with the help of bamboo basket. New stock of fish is introduced after proper liming. In second year too, partial dewatering followed by desilting is to be done. At the end of third year, complete dewatering is done to expose the bottom. Complete desilting is done, followed by liming. Thereafter, fish culture is started, after 20 days of introduction of the piglets into pigsties.

Precautions :

1. Monitoring of dissolved oxygen (DO) in the morning is a must particularly in the summer months. DO falling below 3.0 mg/ litre particularly in pre and postmonsoon should be regarded as a warning to control further application of pig dung.
2. In large ponds (=0.5 ha), pig dung should not be allowed to fall on a single spot. The collected dung should be divided into 5- 6 parts and applied in prespecified sites selected zones.
3. If extensive algal bloom appears on water surface, pig dung, instead of introducing into pond it should be kept collected in the cemented pit.

Income :

Production from direct integration per ha water area :-

Fish : 3000- 3500 kg/ ha.

Pig : 4000- 5000 kg (live weight)/ 80 pigs/ ha.

B. INTEGRATED CATTLE-FISH FARMING

Introduction :

Integrated cattle and fish farming is an ideal method for assured fish production in small ponds (<0.1 ha). In this technology, the fish crop is raised using the cattle on the pond embankment or any other suitable site of the farm.

2. Cattle Farming

2.1. Cattle shed :

The cow shed should be constructed at a stable and elevated site allowing direct sunlight to the platform, gutters and mangers of the cattle shed. The floor should be concrete and should be slightly inclined leading a drain which is connected to a soak pit. A covered pit may be constructed nearby to store cow dung. Provisions for floor space should be made for suckling calf, older calf and cow. Floor space requirements are as follows :-

Cross bred cow :

Standing space : 1.2 × 1.2 m^2 per animal.

Manger :

Length : 0.6 m per animal
Width : 0.6 m per animal
Depth : 30 cm.

Gutter :

Width : 20- 30 cm
Depth : 2.5 cm with provision of gradient towards main drain.

Suckling calf :

Pen size :
Cover area : 1 × 1 m^2 per calf
Open area : 2 × 1 m^2 per calf

Older calf :

Pen size :
Cover area : 2 × 1 m^2 per calf
Open area : 2 × 2 m^2 per calf

For the cattle shed, thatch is the best rooting material but asbestos can also be used.

2.3. Number :

For 0.1 ha water area, one cow with a calf is sufficient. The cow should be brought about two months earlier to introducing fish into the pond.

2.4. Feeding :

Green fodder	:	30 – 40 kg/ day/ cow
Straw	:	3 - 4 kg/ day/ cow
Concentrated feed (Wheat bran+ rice bran + GOC+ mineral mixture + salt)	:	2 kg/ day/ cow

2.3. Health Management :

Maintenance of hygiene in the cow shed is most important. Adopt preventive measures by consulting veterinary expert against coccidiosis, parasitic infection, etc.

Immunization : FMD vaccine, anthrax spore vaccine, haemorrhagic septicemia vaccine and black quarter vaccine should be given in time. Consult veterinary expert for time schedule and vaccination.

3. Fish Farming :

Same as that of integrated pig- fish farming system. In the pond, no chemical fertilization is required. Cow should be brought to the shed about 2 months prior to stocking of pond with fish seed. Cow urine is led to soak pit and cow dung is allowed to fall in the pond water. However, initially cow dung is cast all over the pond before stocking the pond with fish seed. No feed except green fodder required for Grass carp is applied into the pond.

4. Production :

Fish : 3500 kg/ ha
Milk : 24000 litres.
Calf : 10 nos./ ha

Fish Duck Integration

Mr. Bhagaban Kalita
FEO, Directorate of Fisheries
Government of Assam

Integrated fish farming has received attention in recent years in the North East India. Among the different livestock based system, fish duck integration is one of the most popular farming practices among woman fishers. Main advantages of integrated fish farming are as follows :

- Artificial balanced eco-system with no waste.
- Increased food supply.
- More employment.
- Increased output and economic efficiency.

Principle of integrated fish farming

It is observed that in livestock based system bacteria first decompose animal manure and then nutrients including NPK are released into water for the production of phytoplankton. Phytoplanktons are mainly consumed by the zooplankton in turn. Zooplanktons are fed by benthos and so on. On the other hand, bacteria are propagated at a high speed through the utilization of carbon and animal manure to form another food chain. These two food chains develop and overlap each other to set up a food web for various species of fish with different feeding habits.

Advantages of Fish Duck Integration

The main advantages are :

- Duck dropping act as feed and fertilizer for cultured fish in the pond.
- Duck collect 50% of their food naturally from the pond.
- Ducks keep the water body clean and increase dissolved oxygen by doubling action.
- Duck house can be constructed at the embankment or over the water surface, hence no need of extra place for it.
- Left over feed of duck used as supplementary feed for fish.
- Production of duck eggs, meat, fish and horticulture from the same unit area.

In this integration, fish species selection is one of the important point where plankton feeder should be 60% and omnivorous should be 40%. A combination of six species viz, Catla (20%), Silver carp (20%), Rohu (20%), Mrigal (15%), Grass carp (10%) and Common carp (15%) should be stocked at density of 8000 to 8500 fingerlings/ha for the targeted production level of more than 3500 kg/ha and such integration is suitable only for rearing and stocking ponds where fishes are above 12 gm.

Ducks are stocked @200-300 ducklings/ha of fish pond. From duck excreta annual manure production is 45-55 kg/duck/yr, which besides fertilizing the fishponds and can be directly utilized as fish food. Apart from this, 10-20% feed/day/duck is wasted which is utilized in ponds. Duck dropping contains 81% moisture and 0.91% N and 0.38% P_2O_5.

Selection of Duck and their maintenance

Some important varieties of ducks are Nageswari, Sylhet Meat, Indian Runner, Serachameli and Khaki Campbell. Out of this varieties, Khaki Campbell crossed with local pati variety is the best in Assam condition. It should be collected from the Government Farm and then consult with the veterinary Doctor for treatment and preventive measure of some epidemic disease like Duck Plague, Cholera etc.

Duck-house

Duck house should be made on the pond dyke or over the pond surface with the help of locally available material such as bamboo cane, thatches etc. In case of duck house over the pond surface, a small bamboo bridge is constructed from the duck house for feeding the ducks as well as for collecting eggs and duck from the house. Another bridge is constructed from the duck house to the pond surface for helping the ducks ascend or descend to pond water. Again duck house should be well ventilated for air circulation and exposed to direct sunlight and periphery of the pond should be fenced for protection of ducks. Ducks are kept in duck house providing about 0.3-0.5 m^2/bird. Again one male duck should be kept in every 5-6 female ducks. Ducklet especially up to 3-4 weeks old are very susceptible to disease, hence, care should be taken within this period.

Duck Feed

Mostly fine rice bran and poultry feed (layers mash etc.) are used as duck feed at the rate of 100 gm feed/day/duck. Duck feed should be stored at cool and dry environment. If possible, manganese sulphate mixed with feed gives the better result at the rate of 10gms/100kg of feed. Apart from that Duck weeds (*Lemna, Wolfia, Azolla* etc.) are also fed to the ducks. Duck also consume tadpoles, juvenile of frogs and dragon fly larvae. Further protein content in natural food organisms of the ponds consumed by duck is high. Therefore, the duck reared in fishponds save the cost on protein substantially in duck feeds and gives more eggs in comparison to duck which are not allowed in fishponds. The left over feed given to the ducks and duck dropping fulfill more than 59% of food requirements of farm fishes. Sometime algal bloom may increase, then duck dropping should be stopped periodically by using Plastic at the bottom of the duck house and removed.

Lime application

In this integration except basal manure there is no need to apply inorganic and organic manure from the outside during the culture period. Only lime is applied at the rate of 250-300 kg/ha/year at suitable intervals.

Production

By this integration a production of 3500-4000 kg of fish, 18000-18500 eggs and 500-600 kg duck meat from 1 ha of pond area in 1 year without any supplementary feed and fertilizers can be obtained and the cost is turned down to 60% lesser than normal.

ECONOMIC ANALYSIS OF FISH DUCK INTEGRATION

Water spread area : 0.6 Ha
Duration : 1 year
Pond characteristic : Existing pond

Sl. No.	Particulars	Quantity & Rate	Cost (Rs.)
A.	Capital Cost : Duck house (L.S.)		5000.00
B.	Recurring cost		
i.	Dewatering, repairing, renovation of mud and bamboo fencing (L.S.)		3000.00
ii.	Bleaching powder (Control of predators)	24kg @ Rs. 30.00/kg	720.00
iii.	Quick lime	32kg @ Rs. 15.00/kg	480.00
iv.	Basal manuring		
	Mustard oil cake	16kg @ Rs. 10.00/kg	160.00
	Raw cowdung	1600kg @ Rs. 0.12/kg	192.00

	Urea	16kg @ Rs. 6.00/kg	96.00
	Single Super Phosphate	16kg @ Rs. 6.00/kg	96.00
v.	Cost of Fingerlings (7-10cm)	1300 Nos @ Rs. 2.00/No	2600.00
vi.	Cost of 30 days old duckling	40 Nos @ Rs. 20.00/duckling	800.00
vii.	Liming at 3 months interval (2 times)	42 kg @ Rs. 15.00/kg	640.00
viii.	Duck feed	800 kg @ Rs. 12.00/kg	9600.00
ix.	Prophylactic measures (L.S.)		500.00
x.	Insurance charge (L.S.)		200.00
xi.	Cost of hortiplants (10 coconuts and 40 arecanuts)		340.00
xii.	Cost of harvesting (L.S.)		464.00
	Grand Total (A+B)		**24,888.00**

Income and Expenditure

Considering 75% survivability of the stock fish and an average weight of 750 gm in 10 months cultured period the total harvestable fish will be 731 kg. The value of produced fish at the rate of Rs. 50.00 kg is Rs. 36,550.00.

Sl. No.	Particulars	Quantity & Rate	Amount (Rs.)
1.	Annual Income—Fish	731 kg @ Rs. 50.00/kg	36,550.00
2.	Annual Income—Duck eggs	4500 Nos @ Rs. 2.50/eggs	11,250.00
3.	Annual Income—Duck meat	60 kg @ Rs. 50.00/kg	3000.00
4.	TOTAL INCOME		50,800.00
5.	ANNUAL EXPENDITURE		24,888.00
6.	**NET INCOME PER ANNUM**		25,912.00

Integrated Poultry— Fish Farmining System

Dr. K. K. Tamuli
Associate Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

In this system, the fish crop is integrated using only poultry droppings or dip litter by rearing the poultry either directly over the pond or on the pond embankment. By adopting this technology, production of 3500 to 4000 kg fish, more than 20000 eggs and about 1250 kg(live weight) chicken meat can be obtained from a hectare of pond area in one year.

1. Poultry Husbandry Practices

1.1. Housing of birds :

In integrated poultry fish farming, the birds are confined to the house entirely, with no access to the land outside. This intensive system is of two types, viz. Battery system (Cage system) and dip litter system. The dip litter system is preferred over the cage system due to higher manurial value of the built up dip litter.

In this system, the poultry birds are kept in pens up to 250 birds per pen on floor covered with litter. For starting the dip litter system, the floor of the pen is covered with dry organic material. The chopped straw, dry leaves, hay, saw dust etc. to a depth of about 6 inches. 0.3 to 0.4 m floor space is required per bird.

The dropping of the birds which fall on the litter gradually combine with the litter material due to bacterial action. When the depth of litter becomes less more organic matter is added to maintain sufficient depth. In case the litter becomes damp superphosphate or lime is added to keep it dry. The litter is regularly stirred for aeration. In about 10-12 months, it becomes fully built up litter, having very high manurial value.

1.2. Selection of birds :

The fowls of Rhode island, white leghorn or kuroiler are suitable for the purpose. About 500 to 600 birds (lay eggs) are required for one hectare water spread area. About eight week old chicks, after vaccination against viral diseases and providing other necessary prophylactic measures as a safeguard against epidemics are kept in poultry house near the pond.

1.3. Feeding :

Grower mash is provided to the farmed birds during the age of 9-20 weeks @50-70 gm/bird/ day, whereas a layer mash is provided to the birds above 20 weeks @ 80-120 gm/bird/day. The feed is provided to the birds in feed hoppers to avoid wastage. An ample supply of water is made available to all the birds at all the time.

1.4. Egg laying :

Each pen of laying birds is provided with one nest for 5-6 birds. Egg production commences at the age of 22 weeks and then gradually decline. The birds lay from 240-250 eggs per year. After the age of 18 month birds are disposed.

1.5. Health care :

The poultry house and equipment must be disinfected atleast 30 days prior to bringing in the new flock.

The birds are to be vaccinated against diseases like infectious bronchitis infected laryngo trancheitis, mark's diseses, ranikhet diseses, fowl pox, etc. at the appropriate age. Some of the bacterial diseases viz. salmonellosis, coryza, fowl cholera, etc. can be kept under control by maintenance of proper hygienic conditions. Broad spectrum antibiotics may be added to the water in case the infection is mild. In severe cases, veterinary expert should be consulted.

2. Pond Management Practices :

Same as in the case of pig-fish farming system. The fully built up dip litter removed from poultry pens is stored in suitable place and supplied to the pond @50 kg/ha/day every morning after sunrise. The application of this is deferred on the days when algal bloom appears in the pond.

Production :

Fresh fish	:	3500 to 4000 kg/ha/yr
Egg	:	70000 nos./pen
Poultry meat	:	1250 kg (live weight) per year.

Rice-Fish Integration

Mr. Anupam Sharma
Fishery Extension Officer

Directorate of Fisheries, Govt. of Asom, Meen Bhawan,
Guwahati -16, Kamrup, Asom, India.

Rice fish farming is practiced in different agro-ecological zones all through most of the subtropics, warm humid subtropics and in warm sub-humid tropics. The rain fed lowland rice ecosystem is characterized by its lack of control over the water and by both flooding and drought problems. Rice fish farming can contribute to household income, contribute to food security and nutrition and contribute to improved sustainability of rice production. Generally two production system have been recommended for culturing fish in the rice fields through out the world : Simultaneous or Concurrent Method and Alternate or Rotational Method.

SELECTION CRITERIA OF RICE FIELD :

1. The field must hold water continuously for several months. The field should be covered to a depth of 30 cm and some areas may be shallower or deeper than this.
2. The plot should be comparatively flat so that water level remains almost above the land.
3. The land should be selected keeping in view that it will not be over flooded.
4. The soil of the land should hold much water. Clay soil is better for this purpose and the soil p^H should be around 6.5-7.5
5. Those fields where water remains even after harvest of paddy that is, there should be water, which is sufficient to continue fish culture, but there may not be any crop.
6. Fishes can be grown unaffected by chemicals or pesticides used to protect paddy.
7. In land with slopes, a high dyke on the uphill side at the field is usually not needed. The layout of the land will help to confine the fish. If the rice field is basin shaped, this will be more convenient for the poor farmers. It can save a lot of work because middle of the field is deepest portion and a very little effort is required to raise the dykes.
8. The paddy field should have strong dykes to prevent leakage and to retain water up to desired level /depth.
9. The plot of paddy should be at the close vicinity of the farmer's house so that better care can be taken up.

SELECTION CRITERIA OF FISH SPECIES :

1. The fish should be capable of tolerating very shallow water level.
2. Should withstand higher temperature (up to 40^OC) and variable temperature fluctuations (fluctuations up to 10^OC).
3. Those species, which can withstand fairly high turbidity of water and poor oxygen concentration.
4. The species, which have faster growth rate and should have desirable characteristics to grow to marketable size in short duration at the time of harvesting the rice.

SELECTION CRITERIA OF RICE SPECIES :

1. Special consideration should be taken up while selecting the paddy species for integrated rice-fish culture system :

2. The variety of paddy should be of high yielding varieties.
3. Growing period of the paddy
4. The variety of paddy should withstand high water level and should not lodge.
5. The variety should be highly disease resistant and susceptible to less attack from pests. Local paddy varieties of medium to long duration with non lodging characteristics are suitable.

PREPARATION OF FIELDS AND OTHER CONSIDERATIONS :

1. Dyke construction :

Embankments should have a height of 40-50 cm. Since water level for rice does not exceed 20cm, such embankments will already have a free board of 20-30cm.This is sufficient to prevent fish from jumping over.

2. Provision of weirs and screens :

Three types of screens can be provided to prevent escape of fish and to prevent entry of predatory fishes to the plot: *e.g.* bamboo slats, a basket, and a piece of fish net materials even a well –perforated piece of sheet metal.

3. Provisions of proper drains :

The common practice is to temporarily breach a portion of embankment for water to get in or out and once the purpose is finished the breach portion be repaired. Bamboo tubes, hollowed out logs, metal pipes or bamboo chutes are also used.

Depending upon the slope of the land three types of layout for construction of rice fish culture plot has been proposed :

- Perimeter trench model,
- Central pond model,
- Lateral trench model.

1. Perimeter trench model :

In this trenches are dug out in the periphery of the paddy field and the paddy cultivation area remains in the middle of the plot in zone of moderate elevation. In a plot of 1 ha, the area in the central part of the field for paddy cultivation is about 0.67 ha**.** The perimeter trenches may occupy about 0.2 ha and perimeter dykes may occupy another 0.12 ha. Design and construction is that the trench is about 6 meter at the top, 3.5 m at the base and depth is 1.2m. The perimeter may be 1 m in wide at the crest and 3 m at the base.

2. Central pond model :

In this case fish culture area remains at the center or at the middle of the plot and the paddy growing areas lies surrounding the pond. In a plot of 1 ha area, part of the field for paddy cultivation is about 0.65 ha and the area for the fishpond is 0.35ha with peripheral dyke space of 0.002 ha. The dimensions of perimeter dyke may be 20cm in width, base is of 50 cm width and height is of 30 cm.

3. Lateral trench model :

Trapezoidal trenches are dug at the sides of paddy plot of dimensions top width 18 m, base 15m and depth is of 1.5 m. There is also to be a peripheral dyke like other two previous cases. In a plot of 1 ha area; part of the field for paddy cultivation is about 0.61 ha and the area for the fishpond is 0.27ha with peripheral dyke space of 0.12 ha.

WATER MANAGEMENT :

Continuous flooding up to the maximum tolerated by rice without affecting its rice production is recommended and it is generally 15-20 cm. At that depth, the effective water depth of 65-70 cm is available to the fish in refuge. This is sufficient to provide the fishes a cooler place when the shallow water over the rice warms up to as high as $40^{O}C$. The increased depth means a greater volume of water for rice –fish culture.

FERTILIZATION :

Application of fertilizers increases the nutrient concentration in water, which flourish the growth of phytoplankton, which are directly consumed by the fish or support good growth of zooplankton. Compost fertilizer for deep-water variety @30 tons per ha can be applied. In organic fertilizers for deep water variety Paddy as Nitrogen @120kg/ha, P_20_5 @ 60 kg/ha and K_20 @ 60 kg/ha can be applied.

STOCKING PATTERN :

Rice fish culture may involve the stocking of young fry for the production of fingerlings (nursery operation) or the growing of fingerlings to marketable size (growing operation). Rice fish farming may either be the culture of only one species (monoculture) or a combination of two or more species of fish and crustaceans (polyculture). Generally, stocking density of fish depends on its size, species and the fertility of the land. It is best to wait until the rice is well established before releasing fish seed. Fish can be stocked once two or three tillers have appeared for which the usual waiting is 1-3 weeks after transplanting or 4-6 weeks after seeding.

FEEDING :

To boost the growth of fish, rice bran and mustard oil cake in the ratio of 70:30 @2-3% of the body weight of fishes can be provided.

RICE MANAGEMENT :

Seedlings are best-transplanted 25-30 days after seeding. During the preparation of land fertilizers, like- TSP @250-300gm% of soil yields best results. Besides transplantation 600-700gm % of urea can be applied in three equal doses.

Distance between one bunch to another should be around 15-20 cm and from one line to another each to be 20-25cm. However a farmer should carefully choose and apply proper pesticides that have low toxicity to fish and apply at suitable time.

Concepts of Recycling Bio-wastes in Fisheries

Mr. P. P. Sarma
S.D.O. (Fishery)

Office of the Nagaon District Fishery Officer, Department of Fisheries,
Govt. of Asom, Nagon, Asom, India

Agriculture being the main vocation to earn livelihood in rural Asom, it is quite apparent that a huge amount of crop waste is also generated. Further livestock rearing and largely unmanaged hygienic state of living condition also contribute to organic waste disposed system. It has in records that Asom possesses a bovine population of over 84 lakh cattle heads, 7 lakh buffalows, 1.69 lakh sheep, 29 lakh goat, 15 lakh pig, 147 lakh fowl, 68.8 lakh duck and sizeable number of other livestock like horse, dog, guinea pig, etc. The quantum of organic wastes generated by these animals and birds although get recycled in agricultural activities, proper way of utilization and efficient use may result in higher economic gains. In this context, recycling of bio- wastes to aquafarming has more relevance.

Water is a universal solvent and has a tendency to dissolve almost all materials, liquid and solids alike. Organic material inputs, so long as do not create Biochemical Oxygen Demand (BOD) problems, from fisheries point of view, they would act as a beneficial agents to increase primary productivity of water. Status of domestic effluents or city wastes, entering an aquatic body is to a great extent same, as the organic materials. Question of industrial effluents, pesticides, plastics, oils, chemicals, heavy metals, etc., which often enter aquatic bodies usually create problems in the aquatic resources.

The concept of recycling organic wastes in aquatic resources is an age old practice. However, standards and parameters to regulate the productivity of water has been achieved after years of investigations with regards to type of organisms and extent of aquatic resources during past 20 years or so. Integrated farming activities involving livestock and fish, initiated in South East Asia and East European countries have attracted wider acceptance, all over the globe. Some of these technologies have been dealt at length like pig-fish, poultry-fish, duck-fish and rice-fish already.

In addition, there exist scope of integration of other domestic animal recycling of other farmyard wastes including sewage, such activities include—

Goat – fish integration :

Goat rearing is a very old practice followed in Asom. The excreta of goat is rich in nitrogen and phosphorous. An adult voids about 750 gm of excreta in a day. Goat urine is also a rich source of nitrogen and potash. Goat house should be constructed upon the pond embankment, with drainage facility to washout the waste materials into pond water. The goat dropping has a size around 4 mm pellet, coated with mucous which floats in semi-dried state and are consumed by the fishes. In 1.0 ha pond 30 – 40 nos. of goats are required to suffice the feed requirement of fish. The most popular cross bred of high yielding strain found in Asom is Beetal, which is reared for both milk and meat purpose. There are other some improved varieties available in India, which can be successfully reared are—Bengal, Deccani, Asomanabadi, Jakhrana, Sirohi, Jamunapari, Barwari, Marwari, Melsana, Surti, Malabari, etc. The ponds are stocked with fish seed @ 6000 fingerlings/ ha. and after 1 year of culture gives a production of 3500 kg of table fish. The farmer can earn additional revenue by selling the goat offspring's.

Horti crop-fish integration :

Growing of horti-crops on the pond embankment is gradually become popular in Asom. Various horticultural crops like banana, papaya, potato, Indian spinach, cow pea, okra, French bean, different kinds of gourds, cauliflower, cabbage, tomato, reddish, brinjal, turmeric, ginger, black gram, etc. are

cultivated. The silt from the pond bottom are used as nutrient source for enhancement of yield from horti- crop. The pond water is used to irrigate the crops. Banana leaves and residues from vegetables are used as food by grass carp. Fish seed are stocked @ 6000 fingerlings/ ha which gives an production of 3 t/ ha/ yr. From horti- crop a production of 75 t/ ha/ yr is obtained.

Seri-fish integration :

Sericulture is an age old tradition practiced in certain specific areas of Asom. Integration of sericulture with fish is a profitable venture which increases the earnings of the farmers and creates round the year employment. Mulberry tree can be planted on the pond dykes for rearing silk worms. The wastes product like silk worm pupae, faeces and waste water from the processing plants are nutrient rich resources and used as inputs for fish culture. The inorganic nutrients in the silk worm faeces enhances the growth of phytoplankton and heterotrophic bacteria, which are consumed directly or indirectly by filter feeding fishes. Integrated seri-fish farming is a viable technology to enhance fish production at a lower cost.

Sewage fed fish culture :

Domestic sewage, derived from the households contains high level of nutrients. It is 90 to 99% water containing organic solids in dissolved or suspended form. BOD level of sewage are found to be very high which may reach upto 400 mg/l. The sewage after treatment can be utilized as nutrient resource for fish culture. The treatment involves three stages such as- primary, secondary and biological removal of soluble products, involving recovery of nutrients from waste waters. The BOD levels are also brought down through the sewage treatment upto 25 – 30 mg/l before discharging into natural waters or aquaculture ponds. The ponds are stocked with fish seed @ 10000 fingerlings/ ha which gives a production of 3000 – 4000 kg/ ha/ yr by using sewage alone and 4000 – 7000 kg/ ha/ yr is obtained in combination with feed.

Recycling of lignocellulosic wastes :

The lignocellulosic wastes from rice and wheat straws and hulls, sugarcane tops, stovers from maize, aquatic weed, etc. are obtained in large quantities. These are fibrous in nature and contain cellulose, hemicellulose, pectin and lignin. As these are not very palatable and digestibility being low they remain unused. After treatment, these wastes can be utilized in aquaculture for fish production.

The simple physical treatment involves chaffing and soaking the straws and then adding water soaked/cooked concentrate mixture. Alkali treatment, urea ensiling are some of the chemical treatments. Treatment with cellulolytic organisms like *Trichoderma viride* and solid waste fermentation with lignocellulytic fungi like *Pleurotus sp.* and *Coprinus sp.* are some of the microbiological treatment which improve digestibility and provide the required protein.

These lignocellulosic wastes after processing can be recycled into pond water for fish culture @15 – 20 t/ ha/ yr to give a fish production of 2 t/ ha/ yr.

The recycling of bio-waste for fish culture is highly profitable, but its adoption among the fish farmers is still very low. As majority of the farmers of Asom are resource poor, having low investment capacities, could use the bio-wastes that are readily available in huge quantities as on farm products to produce fish at a low cost. The concept of recycling of bio-wastes for fish culture have great potentiality and in near future there is high scope for adoption by the pisciculturists of the state.

With gradual expansion of industry, mining activities and urbanization in recent years, detrimental effluents inflowing to the aquatic systems are creating problems. It is happening largely due to lack of awareness of the local inhabitants. There are ways and means to prevent potential damage of the nature and laws are framed to protect the national resources. Thus as a knowledge professional in aquatic resource management to harvest the maximum potential of waters by varied means of management, discussed here and elsewhere, it is our national duty to be concerned about the limitations of bio-waste recycling and be prudent to check the limits when crossed.

Captive Breeding of Ornamental Fishes

Mr. D. K. Sarma
Assistant Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

In recent years hobby of ornamental fish keeping is gaining more importance. This has become the second largest hobby globally after photography. This increases the demand for variety of fish species and number of individuals. Only captive breeding can cater to the needs of fish hobbyists. The breeding and rearing activities can also generate employment and be a source of income to many as it requires lesser capital investment. The breeding behaviour of ornamental fishes falls into different categories, they are as follows :-

1. Live bearers.
2. Egg scatterers having adhesive eggs.
3. Egg scatterers having non-adhesive eggs.
4. Egg depositors.
5. Mouth brooders.
6. Bubble nest builders.
7. Egg buriers.

1. Breeding of live bearers :

They are called live bearers because they release young ones directly. Eggs of these fishes are fertilized internally. Males are generally more attractive than females due to presence of gonopodium. The gonopodium is a special organ used to transfer the sperm from the male to the oviduct of female. A few rays of anal and caudal fin get modified to form this elongated structure. In the oviduct sperm may remain active for several months. Females release few eggs which are fertilized internally in the belly pouch. After incubation, few young ones are released into water directly. Various live bearing fishes are:-

1.1 Guppy (*Poecillia reticulata*) : This is a popular aquarium fish with a prolific breeding habit. The colour shows considerable variation in the tail fins. Hence, they are known as round tail, spear tail, fan tail, veil tail, pin tail, etc. Males are more brightly coloured. One gravid female releases 20- 50 young ones in 4- 6 weeks period.

1.2 Black molly (*P. latipinna*) : The body of this species is uniformly coloured black that even eye can not be distinguished. Varieties are :- sail fin molly, moon tail, etc. A well grown female produces about 20- 50 young ones during each breeding.

1.3 Sword tail (*Xyphophorus helleri*) : The lower portion of a tail fin of male is extended like a sword that gives their name sword tail. They grow upto 8.0 cm in length. Females release about 20- 25 individuals per breeding.

1.4 Platy (*X. maculatus*) : They look like sword tail but smaller in size. They grow upto 4 cm in length. Varieties are :- red, blue, black, golden, etc. Gravid females release about 10- 15 young ones.

1. **Breeding of live bearers :**

For breeding of live bearers, selected males and females are separated in different tanks observing their secondary sexual characters. The brooders should be judiciously fed with formulated diet and natural

food. It is advisable to segregate the sexes as soon they are apparent. It is done to increase the mating urge and to avoid premature pregnancy of females. Soft and slightly alkaline water with pH range of 7.2- 7.5 is recommended for breeding. For this purpose it is preferable to mix rainwater with aquarium tank water.

Males and females in the ratio of 1:2 are left for mating in the mating aquarium. Ratio of 1 male to 2 females is maintained to avoid the strain on the female as males are consistent driver and it continuously disturbs the females even at the time of delivery. The females are capable of storing the sperm in the oviduct for a period of 10 months after mating. This is the reason why a female can give birth to several batches of baby even without presence of male. A virgin female, therefore needs to be with an active male for a few minutes to produce large numbers of young ones.

In selective breeding, when a female after her first delivery is placed along with special male there is no certainity that her next brood will be from the special male. There could be second family from the original mating. Hence, a female may be allowed to produce several batches of brood.

Gestation & delivery :

Once the fertilization is over, the male should be removed or the female be transferred to a separate shallow tank. Never move a pregnant female when she is within a week of given birth. This often causes the eggs to hatch out prematurely and young ones to be born dead. Embryos are completely developed within the eggs obtaining nutrition from the yolks. Incubation period varied from 3- 8 weeks depending on species and temperature. After incubation, the eggs hatch out from the body of the female and they are free swimming. After giving birth the female will be quite. It is better to use thickly planted tank for breeding purpose. A female live bearer may produce 3- 5 consecutive brood from the original mating. An young female can be expected to produce 8- 40 fry medium 50- 100 and large 100- 200 young ones. The young ones should be fed with powdered formulated diet or smaller zooplankton.

2. Breeding of egg scatterers with adhesive eggs :

The examples of egg scatterers with adhesive eggs are:- gold fish (*Carassius auratus*), tiger barb (*Barbus sp.*), etc.

2.1 Breeding of gold fish :

It is one of the most popular fishes of the world. They can be reared and bred in both aquaria and open outdoor cisterns. Varieties of gold fish are- common gold fish, fringed tail, lion head, ornada, comet, shubunkin, telescopic eye, veil tail, red cap, etc. For breeding and to determine the maturity, males and females are identified by ooze out milt and eggs on slight pressure on the abdomen. Age at first maturity is 2^{nd} year.

Matured males and females are selected and kept in a glass tank ($24^2 \times 12^2 \times 15^2$) or ferrocement cistern of size 3.5 X 3.5 X 2.5 feet. Fish older than 4-5 years are not fit for breeding. The period of breeding ranges from late winter to mid summer. The tanks are supplied with submerged aquatic weeds like- *Hydrilla*, *Valisnaria*, etc. or rooted floating weed like-*Eichhornia* or plastic strip or thread. Breeding set comprises of male and female in the ratio of 1:1 or 2:1. Segregation of brooders sexwise is normally preferred. Optimum temperature for breeding is 18- 20°C and upto 28°C. Males and females are introduced into the breeding tank in the late evening hours. The males chases the female; presses its operculum against the female abdomen and fertilize the eggs while swimming beside her. Egg laying takes place within 6- 12 hrs. after putting male and female together. Generally a female lays about 1500- 2000 eggs. Healthy fertilized eggs are golden transparent at the beginning and transparent area reduces gradually. Unfertilized eggs remain opaque. After breeding parents are removed from breeding tank and aeration continued. After 70- 80 hrs. of incubation eggs hatch non feeding larvae, after 3 days, they are transferred to already prepared nurseries. A pair of gold fish breeds at an interval of 15-20 days.

2.2 Breeding of Tiger barb :

The Tiger barb belongs to the family cyprinidae. The body has 4 vertical black bands resembling tiger hence the name Tiger barb. Males have more intense red colouration and develop red snout during breeding season. The female is larger than male and during breeding they develop bulging abdomen. For breeding purpose a medium size tank is filled with fresh rain water and plants like- *Chara*, *Hydrilla*, etc. in good quantity. A pair of male and female is released in the evening. By next morning they breed. The fertilized eggs get deposited on the plants. About 150- 200 eggs are laid by a female. After breeding spawners are removed. Eggs hatch out within 24 hrs. The hatchling remains attached on the aquarium glass or plants. They become free swimming after 3 days. The free swimming hatchlings should be fed with rotifers and cladocerans.

3. Breeding of egg scatterers with non adhesive eggs :

Zebra danio belongs to this category. It is a prolific breeder and lays non-adhesive eggs. Their breeding season falls between April- August. Females are larger and more silvery compared to males. Optimum water pH and hardness is 7 and 250 ppm respectively. Male and female ratio should be maintained at 3:2 ratio. Optimum temperature is 28- 29°C with aeration.

Breeding techniques :

An aquarium of size 60 cm long or about 50 litres capacity is found to be ideal. The bottom of the aquarium is provided with pebbles of size 6- 8 mm in dia or a net can be fixed to avoid eating up of eggs by parents. Aquarium is divided with the help of a glass separator. The spawning tank should have water of about 10 cm above the net or pebbles. A shoal of 20 fully grown matured brooders is introduced in the above mentioned ratio. Gentle aeration is provided. Separator is removed and they are allowed to breed. After spawning eggs falls in between the pebbles or pass through the nets. The eggs hatch out within 48 hrs. After spawning parents are removed and non feeding larvae remain for two days. After 2 days they are fed with smaller zooplankton.

The moustache danio (*Danio dangila*) and *Bedis bedis* also have the same breeding behaviour.

4. Breeding of egg depositor :

Angel, catfish, rasbora and some cichlids belong to this category. They either deposit their eggs on pebbles or on broad leaves. When deposited on stone they are referred as lithophilic e.g. cichlids and when on broad leaves they are referred as phytophilic e.g. angel, rasbora, etc.

4.1 Breeding of rasbora :

The rasboras forms a group of some 50 species of fishes from East Africa, southern and eastern Asia. They are generally shoaling fishes in still and river waters. Varieties are- scissor tail (*Rasbora trilineata*), black stripped (*R. teaniata*), etc. For breeding soft and slightly acidic water is preferable. Rasboras lay several hundreds eggs but smaller varieties adopted in aquarium lay about 100 eggs per female.

After conditioning, the male and female fishes are introduced into 60 litres capacity tank furnished with flat leaved plants like- Amazon sword plant. Preferable water temperature is 28°C. Low lighting level with undisturbed condition is very essential. For breeding a pair of male and female fishes is kept in an aquarium until they breed. If they do not bred within 7 days they are removed and reintroduced at a later date. After breeding female become slim and they are removed. They lay eggs on the under side of the flat leaves. Egg hatches out within 24- 30 hrs.

4.2 Breeding of angel :

Angel belongs to the family cichlidae. Scientific name is *Pterophylum eimekei*. The elongated dorsal and anal fin and their gracious movements attract many aquarists and hence named as angel. There are several varieties of angels such as- black angel, marble angel, blue angel, etc.

Angel grows rapidly and become matured in 4 months. Sexing is difficult in them. When viewed from anterior end the belly of the female behind and below pectoral fin is noticeably bulged during the breeding season. In this region the female possess assume shape while males are concave.

The best way to determine sexuality is to make breeding pairs. Several numbers are kept together in a large aquarium. When breeding season approaches two of them form a pair. After formation of breeding pair the pair is taken out and kept in an isolated aquarium for rest of their lives.

For breeding select a healthy pair and keep them in a fairly large aquarium having planted with tall broad leaves. The tank should be kept in an undisturbed place. The two fishes face each other and jerk their fins and kiss. During spawning the female lays a few eggs which are adhesive. The male fertilizes them by touching with his vent. If some eggs get detached, they are quickly picked up and redeposited by parents. The process of laying eggs and fertilization are repeated for several times till 300- 400 eggs are deposited. After spawning parents guard and aerate the eggs. If disturbed they eat the eggs. So the parents are removed and eggs are aerated artificially with aerator. Eggs hatch out in 3 days but wriggling fry still remain attached to the leaves. On the 8^{th} day they become free swimming when they are fed with zooplankton. If parents are removed the same pair can be bred again after a week.

5. Breeding of mouth breeders :

Some cichlid have prolific breeding habit and protect their fertilized eggs in their mouth e.g. tilapia.

6. Breeding of nest builders :

Among the nest builders gouramis (*Trichogaster leeri*), Siamese fighting fish (*Betta splendens*), paradise fish (*Macropodous opercularis*), dwarf gourami (*Colisa lalio*), etc. Gouramis and Siamese fighter belongs to the same family- Belonitidae and exihibit same breeding habit. All gouramis are air breathing fishes and have labyrinth accessory respiratory organs.

In the case of pearl and three spot gouramis the males can be identified by the elongated and pointed dorsal fin and in the case of Siamese fighter, fins of males are highly developed and brilliantly coloured.

For breeding, gouramis and Siamese fighter a pair of matured male and female should be selected and released in a breeding tank having ideal water temperature 24- 27°C with floating plastic papers in one corner of a tank. Male and female are separated by a glass separator. Plastic paper is provided in the male chamber. The male makes bubble nest below the plastic paper by blowing mucus covered bubbles from his mouth to the surface. Eventually when nest is completed divider is removed and male entices his mate underneath of the canopy of the bubble. The mating takes place below the nest. The male curves his body and envelopes her from below. The female gets tilted upside down. His grips tightens and squeezes until she releases few eggs. At the same time he releases sperm and eggs get fertilized. After spawning parents collects the falling eggs in their mouth and spit them beneath the nest. The eggs remain attached to the underside of the nest. The process of nesting is repeated for several times till about 200-300 eggs are released by gouramis while 150- 200 eggs by Siamese fighter. After breeding male chases away the female, therefore, female can be removed. The male guards the eggs. Hatching occurs on 2^{nd} and 3^{rd} day in the case of gouramis and siamese fighter respectively.

Paradise fish and dwarf gourami breed in similar way.

7. Breeding of egg burriers :

Applochelius punchax, *A. lineatus* and *A. blochii* are important egg burrier. They lay eggs on the soft peat of pond. In aquarium they lay eggs in densely planted environment. Their eggs are capable of remaining viable even under dried condition. When water becomes available eggs hatch out.

Principle of Vaccination and Effects of Antibiotics on Immune System of Fish

Dr. A. Ali
Associate Professor
Fishery Biology

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Pathogens pose a constant and costly threat in semi-intensive and intensive fish farming systems as fishes are reared in high density with all necessary inputs. In such conditions, even though the environmental conditions are good and fishes are healthy, certain infectious agents, if accidentally get introduced into the farm, become so virulent that mass mortality does occur. Antibiotics provide a useful means to control bacterial diseases, but there are many problems associated with antibiotic resistance. There is no effective chemotherapy for control of viral diseases. Therefore preventive measures play an important role in aquaculture and fish vaccination is one of such measures.

Exposure of a vertebrate animal to an infection often results in survivors become resistant to the subsequent disease caused by the same pathogens. Introduction of foreign molecules into the animal's body and development of subsequent resistance against those molecules is called "adaptive immunity" and the foreign molecules are called antigens. Vaccines are the preparation of antigens derived from pathogenic organisms. A prepared vaccine should be safe and potent.

Vaccines are generally two types: dead vaccines and live vaccines. Dead vaccines are composed of inactivated pathogens or their extracts, while live vaccines are attenuated pathogens with no or low virulence.

Preparation of Vaccine :

Vaccine may be prepared as per the standard procedure.

Administration of Drugs :

Chemicals or drugs may be administered either through feed, injection (intramuscular or intraperitoneal) or bath immersion.

The antibiotic oxytetracycline was administered by intraperitoneal injection at the rate of 60 mg/ kg fish/ injection for 5 days at alternative day.

Vaccination :

Vaccination may be done either through feed, bath immersion or by injection.

Rohu fingerlings of 11-12 cm in length and 9-10 gm in weight were used for injection vaccination.

0.3-0.4 ml of vaccine having a cell density of 10^9/ ml was injected intraparitoneally just behind to the pelvic fins.

Administration of booster :

First and second boosters were administered at 30 and 120 days respectively after primary immunization. Boosters were administered in the similar manner to that of primary immunization.

Analysis of sera :

Blood was collected from a random sample of 3-5 fishes by venipuncture prior to chemical treatment and primary immunization and on day 3,7,15 and 30 after primary immunization and boosters.

Blood collected were pooled together into a sterile eppendorf tube and kept standing at an ambient temperature for one hour. Tubes were then subjected to centrifugation at 5000 rpm for 5 minutes and clear sera on top of the tube were collected to another batch of eppendorf tubes with the help of the pasture pipette.

Antibody titration :

Antibody titration was performed in 96 well 'U' bottom microtitre plate. A serial doubling dilution of fish serum were done first with physiological saline and then equal volume of bacterin (vaccine) with 10^9/ cell/ ml stained with crystal violet was added to each well. Plates were incubated in moist chamber at 30°C for 12 hour. The reciprocal of the highest dilution showing agglutination was recorded as 'titre'.

Challenge experiment :

The potency of the vaccine and the effect of antibiotics are also determined by challenge experiment. The test pathogenic bacteria were grown in 10 ml of BH1 broth and LD_{50} of fish was determined by trial & error method.

Percent mortality of the treated fish was calculated by the following formula.

$$\% \text{ mortality} = \frac{\text{Total numbers of fish died}}{\text{Total number of fish challenged}} \times 100$$

Effect of OTC on serum antibody titre :

Experimental group	Antibody on peak titre day		
	Priming	1st booster	2nd booster
Unimunized group	4	4	4
OTC treated and immunized group	32	64	256
Immunized group	64	256	1024

Effect of OTC on protection :

Experimental group	% mortality	
Unimmunized group	50	
OTC treated & immunized group	12.50	
Immunized group	0	

It is found that OTC brought out a reduction in antibody titres after priming and boosters. There is two fold difference in antibody titres between control and OTC treated groups on peak titre day after priming and the differences increased to four folds after boosters. Antibiotics have an influence not only on the peak attained in humoral immune response but also on the kinetics of the cell involved.

Challenge experiment also shows that mortality is higher in OTC treated group than control group. Therefore, it can be said that antibiotics also affect the protective immune response of the fish and thus antibiotics are immunosuppressive.

Application possibilities :

1. Vaccination is fruitful for ornamental and brood fishes.
2. Farm fishes may also be vaccinated as prophylactic measure against particular pathogens.

Fish Health Management in Fish Culture

Dr. B. Kalita
Associate Professor
Aquaculture

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Fish health management is an important aspect of aquaculture. It is gaining importance at increasing rate as the farmers are confronted with many disease problems which is a major constraint in fish production. Fish health management measures reduce the loss due to disease outbreak in fish culture systems.

The term health management is very broad and encompasses wider areas like water quality maintenance, providing proper nutrition, selection of good quality seed, brood stock, prophylaxis, disease diagnosis in time and chemotherapy. Moreover, a proper understanding of the process of disease development, importance of case history and clinical signs, etc. will go long way in evolving a health management package.

Intensification of aquaculture has led to major problems in outbreaks of fish diseases. High stocking density, excess feeding and artificial fertilization are common husbandry practices followed in carp culture system. These offer an ideal environmental condition for the growth of different types fish pathogens as a result the host organism (fish) suffer from stress. Thus, fish become more susceptible to various infectious organisms such as protozoa, helminth, crustacea, bacteria, fungus and virus. Depending upon the nature and severity, disease may cause mass mortality, small scale mortality or even reduce the growth of the fish population. This relationship of the host, environment and pathogen present in water is well established. To avoid such situation, it is always better to maintain ecofriendly environment in the aquaculture system. The good health management programme includes as follows :-

1) Proper site selection.
2) Good pond design.
3) Adequate pond preparation.
4) Stock of quality seed.
5) Right stocking density.
6) Maintain a stable phytoplankton growth.
7) Water quality management.
8) Routine monitoring of water.
9) Proper feeding with nutritious feed.
10) Routine monitoring of health condition of fish.
11) Avoid physical stress and injury to fish.
12) Early and accurate diagnosis of disease problem.
13) Quarantine of new stocks.
14) Proper chemical treatments.
15) Avoiding much organic load in the pond.
16) Keeping records of events happening in the pond in a book.

All classes of infectious and non-infectious disease occur in cultured fish but knowledge of these diseases varies enormously depending upon species in question. Generally, fish diseases are categorized base on the causative agents :

a) Parasitic diseases.

b) Bacterial diseases.

c) Fungal diseases.

d) Viral diseases and

e) Non- infectious diseases.

To deal with the disease problems, one should have the knowledge about the scientific health management which are categorized in 4 “K”s and they are :

1) Knowledge about the disease development process

2) Knowledge about the pathogen.

3) Knowledge about the host.

4) Knowledge about the environment.

So, before going to diagnosis of disease one should know the condition of healthy and unhealthy fish. Healthy fishes generally have clean body, erected fins, bright body colour, faster movement if frightened and fins and skin remain in intact condition. While unhealthy fishes show irregular swimming movement, jumping, rubbing of the body against any rough substrate, surfacing on water, gasping air, refusal of feed and excessive mucus secretion on the body surface, eyes sunken, blackish body colour, etc. Abdominal swelling or cyst formation also indicate some internal disorder of fish.

The most common fish disease found in culture ponds are discusses with clinical signs, their control measures and treatments in table-1, but control measures for Epizootic Ulcerative Syndrome (EUS) are dealt separately, as a contagious dreadful fish disease of the north eastern region.

Table-1 : Common Fish Diseases and Their Treatment.

Diseases	Symptoms	Treatment
A. PROTOZOAN DISEASES		
a) Ichthyophthiriasis (White spot disease). C.A. : *Ichthyophthirius multifilis*	Tiny white nodules or spots on the body surface, fins and even gills covered; can be seen with naked eyes. Large horseshoe shaped macro nucleus is visible under microscope.	**Bath :** Malachite green @0.15 – 0.2 mg/ L for 4- 6 hrs., repeated 4 times at intervals of 1 - 2 days. (**OR**) Formalin @1:5000 solution for 7 days. (**OR**) Short bath : NaCl @ 2% solution for 7 days or more.
b) Trichodiniasis : C.A. : *Trichodina sp.*	Grayish blue veil like coating over the body surface and gills, colour of the gills turns pale, sluggish and shows asphyxia. Smear from the gills shows saucer- shape with fringe cilia under microscope.	**Bath :** NaCl: 2- 3% solution till the fishes are stressed or $KMnO_4$ @ 4 mg/L (**OR**) Formalin @ 25 mg/L in pond

c) Costiasis (Blue slime disease) C.A. : *Costia necatrix*	Bluish patches on the skin surface. More affected areas are reddened and become haemorrhagic.	**Short bath :** NaCl @ 25 gm/L for 10- 15 minutes. (**OR**) $KMnO_4$ @ 1 gm/10 Litres of water for 5- 10 minutes
d) Whirling disease C.A. : *Myxosoma cerebralis*	Whirling movement of the fish, malformation of the vertebral column, cranium, etc.	Difficult to control, removed the sick fish from the pond.
e) White scale spot disease. C.A.: *Myxobolus mrigalae*	Specially found in mrigal and rohu where scales and body surface are covered with whitish cysts. In mrigal cysts located on the body surface and scale. While in rohu situated superficially as well as inside the scale also.	**Bath :** NaCl @ 3 - 5% solution. (**OR**) Mohua oilcake and lime can be applied in the pond.
B. HELMINTH/ ACANTHOCEPHALAN DISEASES		
a) Dactylogyrosis and Gyrodactylosis. C.A. : *Dactylogyrus sp. and Gyrodactylus sp.*	In dactylogyrosis, the colour of gills fade and excessive mucus secretion occurs. While in gyrodactylosis, there is fading of the normal body colour and small spots of blood on the body surface may be seen. These worms can be seen with the naked eye or with the help of magnifying lens.	**Bath :** NaCl @ 3 - 5% solution for 15 minutes. (**OR**) Formalin @ 100 mg/ L for 5 - 10 minutes or @25 mg/L in pond water. (**OR**) $KMnO_4$ @4 - 5 ppm in pond water.
b) Black spot disease C.A. : *Diplostomum sp.*	Black ovoid patches are visible on the body surface and these are pigmented overlying cysts of the metacercarial larvae. Number of cysts may be few to hundreds.	Removal of the resident molluscan population (1st intermediate host) and the aquatic birds (final host) around it.
c) Ligulosis C.A. : *Ligula intestinalis*	Affected fishes are dark in colour; abdomen is distended, because of the presence of large number of plerocercoid larvae.	Control methods are limited, entry should be restricted of the definitive host, the ichthyophagous birds
d) Acanthocephalan disease C.A. : *Acanthogyrus acanthogyrus*	No visible external symptoms to determine the infection. Parasites inhabit in elementary tract of fish with the help of hooks present. Site of attachment is swollen and reddish in colour.	Proper treatment methods have not developed.

C. CRUSTACEAN DISEASE

a) Argulosis (Fish louse disease) C.A. : *Argulus sp.*	Affected fish become restless with erratic swimming movement, ulcer formation at attachment site. Adult parasite is oval, flat, and transparent to whitish in colour with two conspicuous black eye spot. It can be seen clearly with naked eye.	**Bath :** NaCl @3 - 5% solution till the fishes are stressed. (**OR**) Gamaxine @ 1 ppm in pond water. **Short bath :** $KMnO_4$ @10 ppm for 30 minutes or @ 4 ppm in pond
b) Ergasilosis C.A.: *Ergasilus sp.*	Infestation occurs in gills, buccal cavity, operculum and fins. They look like white bodies less than 2 mm long. Fishes are surfacing, lethargy and restless.	**Bath :** NaCl @2 - 3% solution for 15 minutes. (**OR**) $KMnO_4$ @4 ppm in pond water.
c) Lernaeosis (Anchor worm disease) C.A. : *Lernea sp.*	Fish become restless, parasites penetrates into the scale and keeps hanging egg sac clearly visible to the naked eye and attachment site shows ulceration.	**Dip treatment :** DDT @ 10 ppm for 30 seconds. (**OR**) **Short bath :** NaCl @3 - 5% solution. (**OR**) $KMnO_4$ @4 ppm in pond water.
d) Other parasites Leeches	Attach form, blood sucking with its proboscis. Attachment areas show ulcer formation.	Quicklime @ 1 gm/ 2 litres of water in pond. (**OR**) NaCl @2.5% solution for 15 minutes.

D.BACTERIALDISEASES

a) Eye disease of catla C.A. : *Aeromonas liquefaciens*	The eyes look reddish due to vascularisation and later on become opaque.	$KMnO_4$ @1 ppm in pond water and maintain high DO in water.
b) Dropsy C.A. : *Aeromonas hydrophila*	Accumulation of water in the body cavity or in scale pockets thereby making scale loose. Abdomen of the fish get distended.	$KmNO_4$ @5 ppm in pond water or 1 ppm in pond as a prophylactic measure.
c) Columnaris disease C.A. : *Flexibacter columnaris*	Initial stage exhibit grayish patches over the head and dorsal sides of the body giving very often a shadle back like appearance.	**Dip treatment :** $KMnO_4$ @500 ppm with affected fish or @3 - 5 ppm in pond water.
d) Ulcer disease C.A. : *Aeromonas and Pseudomonas sp.*	Initially small pimple like reddish areas appear on the body and later ulcer formation.	$KMnO_4$ @5 ppm in pond water and **Feed :** Sulphadiazine @ 100 mg/ kg of feed or Terramycin @ 75 - 80 mg/ kg body weight of fish for 10 -12 days.

e) Fin and Tail rot disease C.A. : *Aeromonas liquefaciens* and *Pseudomonas flurorescens*	Disintegration of fins and tail of fish with whitish margin as thread.	$KMnO_4$ @5 ppm in pond water and **Feed :** Sulpha diazine @ 100 mg/ kg of feed or Terramycin @ 75 - 80 mg/ kg body weight of fish for 10 -12 days.
f) Vibriosis C.A. : *Vibrio sp.*	Small red spots or petechiae on the throat, under vthe opercula and in the ventral and cardiac region and just immediately anterior to the pelvic fins. Later reddish colouration of the dermis and muscle tissue.	**Bath :** Vaccine may be used or Hemisulphate 20 ppm for 30 minutes
E. FUNGAL DISEASE		
a) Saprolegniasis (Cotton wool disease) C.A. : *Saprolegnia parasitica*	Pathogen grows over any necrotic tissue of the host imparting a cotton wool like growth or even on eggs. Colour depend on the particles that are trapped inside.	$KMnO_4$ @160 ppm with affected fish till stressed, for 5 days or 100 ppm in swab treatment for 7 days. (**OR**) NaCl @ 3 - 4 % solution to the affected fish. (**OR**) Malachite green @ 1- 2 ppm for 30 minutes. (**OR**) Formalin @ 20 ppm in pond water.
b) Branchiomycosis (Gill rot disease) C.A. : *Branchiomycosis demigrans*	Gill lose their normal colour and turn yellowish brown, gradually portions of the gills may degenerate. Affected fishes surface and gasp air.	**Bath :** Liming @ 50 kg/ ha and NaCl @ 3 - 4% solution for bath treatment.
F. VIRAL DISEASE		
a) Spring viraemia of carp C.A. : *Rhabdovirus carpio*	The body colour of the affected fishes darken with petechial haemorrhages in skin and gills. There is loss of balance and abdominal dropsy.	Prevention measures to be adopted
G. OTHER DISEASES		
a) Deformities Possible cause : Hereditary conditions	Lack of fins, swim bladder, debility and certain skeletal deformities occurs as hereditary conditions, the origin of which seems to be due to and inherited disorder of vitamin D metabolism.	Prevention : Avoid from stocking of such origin source or farm.

b) Pin head disease Possible causes : Nutritional requirement	Head becomes bigger compared to the body growth and posterior end become slender.	Prevention : Improve feed quality with nutritionally complete diet requirement and reduce the stocking density.
H. ENVIRONMENTAL MEDIATED DISEASES		
a) Asphyxiation Causes : Oxygen depletion	Fishes gasp for air at surface of water particularly during the period precededing dawn and immediately after. It also occur during cloudy weather or after a short heavy rainfall.	Measures : Spray water over the surface of the pond by using water pump or pond water should be agitated manually to facilitate oxygen uptake
b) Acidosis and Alkalosis Causes : Variation of pH pH< 4.8 : Acidosis pH>10 : Alkalosis	A brown coating on the gills consisting of necrotic epithelium. The coating becomes thicker as exposure goes on, but eventually breaks up and slough off. The skin assumes a muddy appearance and shed layers of thick mucus. Redness, eating away of gills and fraying of fins are the symptoms of alkalosis.	Measures : pH adjustment with application of lime.
c) Gas bubble disease Causes : Super saturation of oxygen and nitrogen in water	Tiny bubbles at the periphery of eye, near the scales and on the gills, etc. The abdomen is swollen.	Measures : Stop application of fertilizers immediately and add freshwater to the ponds.
d) Algal toxicosis disease C.A. : *Microcystis*, and *Anabaena sp*.	Surfacing of fish with erratic movement and cause many mortality in many cases due to clogging of gills resulting in respiratory distress.	$CuSO_4$ @0.5 ppm in pond (**OR**) Cow dung @ 200 kg/ha is sprinkled over the surface . Some surface area of pond is covered with water hyacinth to prevent sunlight penetration.

General prophylactic measures :

1. Culture operation should be practiced based on scientific management.
2. Entry of water from outside source into the ponds should be restricted.
3. Keep the pond environment from environment from obnoxious gases and other entry of animals and birds.
4. Dip treatment in 1- 2 ppm $KMnO_4$ solution be given while stocking fish seed.
5. Fishing gears should be disinfected with 1 ppm $KMnO_4$ solution or NaCl solution or by sun drying.
6. Netting be restricted during winter months.
7. Proper uses of lime throughout the year.
8. Excess feeding should be avoided.

9. Dead or moribund fish should be immediately removed.
10. Farm hygiene should be maintained.
11. Feed should be stored properly to avoid rancidity.

EPIZOOTIC ULCERATIVE SYNDROME (EUS)

Epizootic Ulcerative Syndrome (EUS) occurred as a most infectious fish disease in the north eastern states in May, 1988 and gradually spreaded to the other parts of the country. More than 30 species of freshwater and brackish water fishes have been reported to be affected including exotic species.

Definition : EUS is defined as "A seasonal epizootic condition of freshwater and estuarine warm water fish of a complex infectious etiology characterized by the presence of invasive *Aphanomyces* infection and necrotizing ulcerative lesions typically leading to granulomatous response".

Period : In the north east region, EUS occur with the onset of water temperature drop (October-December), while in south India appears twice in a year i.e. during south west monsoon (June- August) and north east monsoon (October- November).

Clinical behaviour : In the early stage of the disease, appetite of fish get reduced or absent and fish become lethargic, either floating just beneath the surface or swimming with head out of the water.

Gross pathology : Pinhead sized, red spots develop on the body surface, head and fins, caudal peduncle, dorsum or operculam with no noticeable haemorrhages or ulcers. The intermediate stage lesions are represented by small dermal ulcers, with associated loss of scales, ulcers are usually dark, circular and in this stage some species of fish starts dying. The advanced stage lesions appear on other parts of the body and expand into large necrotic ulcers and resulting death in fishes.

Control measures : Only adoptable to manageable closed water bodies.

a) Prophylactic measures :

- **Lime application :** Quick lime (CaO) @100- 600 kg/ ha has been found most effective in controlling this disease. Higher doses of lime are required in low alkalinity water and lower doses are required in high alkalinity water. The lime is applied at an interval of one month during the disease outbreak.
- **Potassium permanganate ($KMnO_4$) :** $KMnO_4$ is applied to the affected pond @ 1- 2 ppm after liming the pond before the onset of winter.
- Avoid netting as far as possible during winter months.

b) Treatment measures :

- **Bleaching powder :** This is applied @1 ppm or 5- 10 kg/ ha to heal the initial lesions of the EUS affected fish.
- **NaCl :** Dip treatment of NaCl @3- 4% solution to be given to the affected fish at the initial stage of the disease.
- **Lime and bleaching powder :** Quick lime (CaO) @100 kg/ ha is applied initially to the affected pond and after one week of that bleaching powder @ 1 ppmis to be applied when initial symptoms are observed.
- **Antibiotics :** Oxytetracycline or Terramycin @60- 100 mg/ kg may be provided along with the feed to the affected fish for 7 days. This treatment may reduce the ulcers of affected fish.
- **CIFAX :** CIFAX is a ready to use drug to cure the infected fish from this disease. This chemical is applied @ 1 litre/ha/ meter depth of water. The effect of CIFAX is noticed within 7 days of its application.

Observations :

Investigations made in farmers' ponds in 3 districts , namely- Morigaon, Nagaon and Sonitpur by the Faculty from the College of Fisheries, AAU, Raha, over the years conclusively indicates that :-

1. Mrigal was the most susceptible species to EUS at all stages followed by *Cirrhinus reba* in cultured ponds.
2. Seasonal ponds had fewer occurrences of EUS than perennial ones.
3. Application of lime and turmeric powder at 1:10 ratio by weight at two split doses after an interval of one week gave encouraging result at initial stages.
4. Ponds flooded and connected with open water had more prevalence of the disease.
5. Pond dried and limed had least chances of occurrence of EUS.

Suggestions :

- Remove all fish (particularly all susceptible species) from ponds prior to restocking.
- Dry and lime the pond properly, if pond is infected with EUS.
- Identify risk factors and apply best management practice.
- Stock with species which are resistant to EUS.
- Susceptible fishes should be harvested before the onset of winter.

Concisely, different chemicals are in use to control the EUS, but efficacy depends on at what stage the disease has been diagnosed. However, at ulcerated stage, treatment of secondary bacterial and fungal infection can give good result and reduce the mortality in fish. But there is no known published evidence for any effective chemotherapy for EUS.

In addition, investigations made by the College of Fisheries, AAU, Raha on disease incidences of fish over the years in this region are depicted in the table-2.

Table-2 : Fish disease diagnosed in Asom.

Sl. No.	Diseases	Site of collection	Species infected
1	Trichodiniasis	Fish ponds	Indian Major carps fry & fingerlings
2	Myxobolus infection	Fish ponds	Indian Major carps fingerlings.
3	Dactylogyrosis	Fish ponds	Indian Major carps (Mrigal).
4	Gyrodactylosis	Fish ponds	Indian Major carps (Mrigal).
5	Leech infection	Farm & open waters	Most species of carps.
6	Argulosis	Fish ponds	Indian Major carps.
7	Lernaeosis	Fish ponds/ aquarium	Indian Major carps & gold fish.
8	Dropsy	Fish ponds; hatcheries	Most of the cultured fish species & air breathing fish species at all stages.
9	Fin rot & tail rot	Fish ponds & aquarium	Most of the cultured fish species & aquarium fish.
10	Ulcer disease	Fish ponds & open water	Indian Major carps, singhi & in indigenous ornamental fish.
11	Saprolegniasis	Fish ponds; hatcheries	Eggs, fry and adult fishes of Indian & exotic carps and in magur also.
12	Bone deformities	Aquarium and in fish ponds	Aquarium fish and cultured carps like-bighead, silver carp, etc.
13	Pin head disease	Fish ponds	Indian Major carps- catla & in magur.
14	Traumatic injury	Fish ponds	Cultured carps

Common fish diseases in culture pond

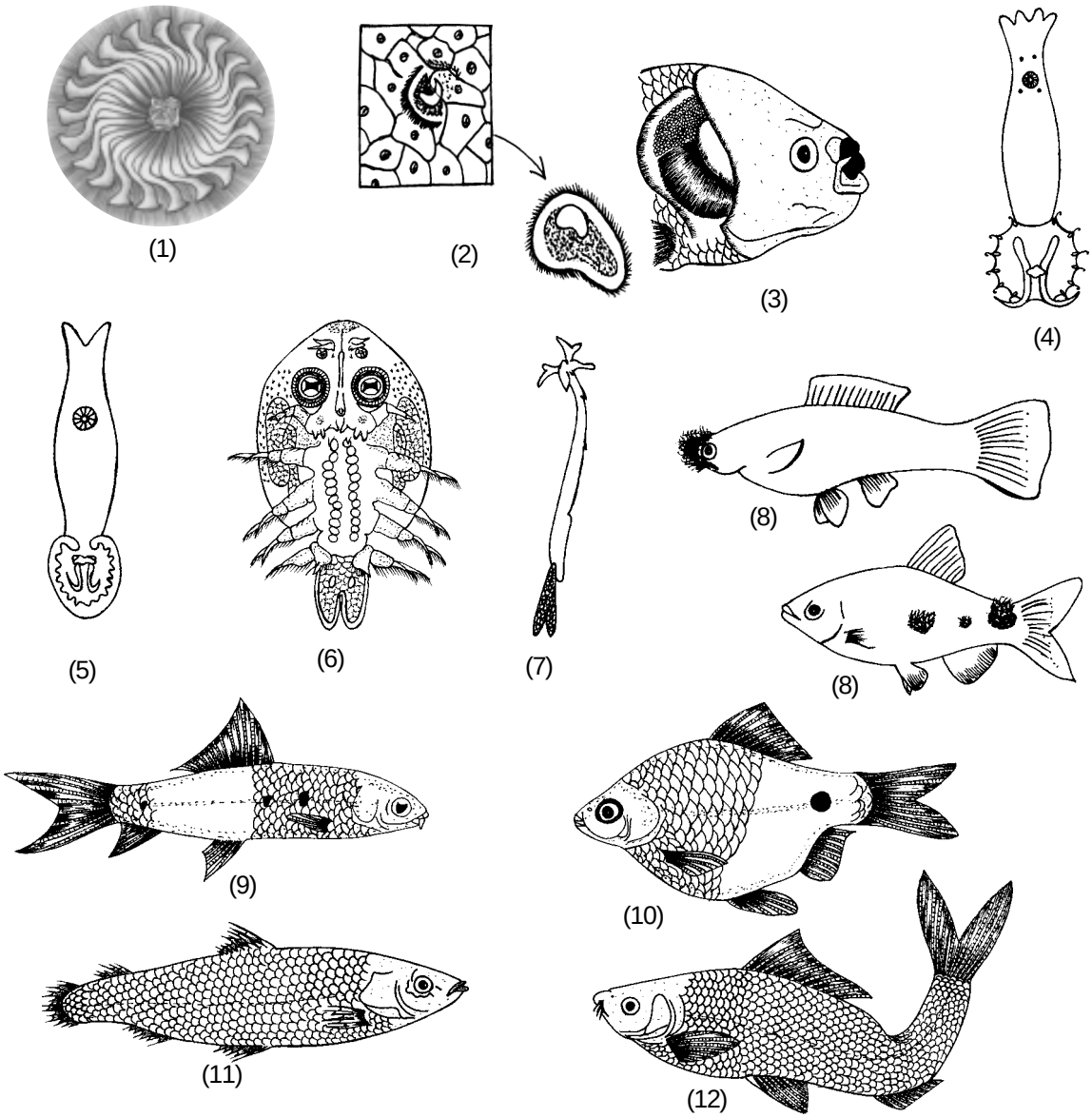

Fig. : (1) Trichodina, (2) *Ichthyophthirius multifilis,* (3) Myxobolus, (4) Dactylogyrus, (5) Gyrodactylus, (6) Argulus, (7) Lernea, (8) Saprolegnia, (9) Ulcer disease, (10) Dropsy, (11) Fin and Tail rot, (12) Bone deformities.

Value Added Fish Products and Prospects

Dr. P. J. Sharma
Associate Professor
Fishery Engineering & Technology
&
Dr. J. Sarma
Assistant Professor
Fishery Biochemistry

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

Value addition of fish and fishery products has been recent technological innovation. Much importance is being given to the concept of value added fishery products in recent years. Value addition means any additional activity such as addition of ingredients or processes that make them more attractive to the buyer and finally change the nature of the product thereby adding to its value at the time of sale. Thus any additional activity that changes the nature and form of the products and increases its sales value is regarded as value addition. Value can be added to fish and fishery products ranging from live fin and shell fish to ready to cook or ready to serve products according to requirement of different markets value addition may mean different things under different national background. In a poor country, even icing of fresh fish will be a high level of value addition. Icing increases value as it increases the shelf life and improves marketability. Fish based convenience foods and fast foods in comparison to cereal and fruit products satisfy the palate better, even at lesser quantity. Traditional fish based products such as pickles, balls, fingers, rolls, cutlets, etc. are becoming popular as fast foods. Product diversification not only promotes earnings through utilization of available raw materials but also helps employment opportunities of rural women.

The state of Asom is blessed with vast water resources afforded by Brahmaputra and Barrak river systems and their numerous tributaries (combined length- 5050 kms.), besides a large number of flood plain wetlands (beels, lakes, swamps- 1.0 lakh ha.) which provide occurrence of a large variety of freshwater resources. However, the occurrence of the freshwater fishes of commercial importance is not adequate to meet the daily demand of the large section of fish eating population. During fishing season, a considerable amount of trash fish of miscellaneous varieties like- moa, chanda, dorikona, etc. are being caught which generally do not find a ready market and consumer preference. Due to lack of sophisticated fish preservation machineries and also good transportation facilities for carriage of these fishes to the urban markets in the state, an appreciable quantity of fish are to be preserved by different traditional techniques like- salting, drying, fermentation and smoking. However, products thus prepared have a limited shelf life and are not popular among the common people of the state owing to its poor quality. These non commercial varieties of fish can be better utilized through preparation of value based products such as pickles, cutlets, balls, papad, etc. thereby promoting earnings and creating employment opportunities among the unemployed youths.

Preparation of fish pickle :

Pickling is one of the safest means of preservation of fish. Though preparation of pickles from fruits and vegetables is an age old practice, the development of pickles from fish is of a recent origin. Besides being highly nutritious fish pickles add to palatability to Indian dishes.

Procedure :

1. Raw material- good quality.
2. Washing to remove slime, mud etc.
3. Use small fish as whole after removing scales, fins etc./ bigger fishes are dressed, filleted and skin removed.
4. Fillets are cut into small pieces of approximately 1 cm X 1 cm size.
5. Fish or fillet pieces are thoroughly washed and mix with half of the required salt and keep for half an hour.
6. Fry fish in oil and keep them aside.
7. Fry mustard seeds and menthi in hot oil for a while.
8. Fry the paste of garlic, ginger and green chilli with the above properly.
9. Add the paste of turmeric, chilli and jeera powder with the earlier paste and fry for 2- 3 minutes.
10. Remove the vessel from the fire, mix fried fish and mix thoroughly.
11. Add remaining salt and mix.
12. Allow the material in the vessel to cool and when it is little above the room temperature add vinegar and mix.
13. Add garam masala for good flavour and odour.
14. Add citric acid and sodium benzoate and mix.
15. After cooling completely, pack the pickles in sterilized glass bottles.
16. Seal the bottle air tight, ensure that a layer of oil floats on the surface of the pickles.
17. Label the bottles having all statutory matters printed on it.
18. Store the pickles at room temperatures and allow one and half months for maturation.

Ingredients :

Sl No.	Ingredients	Quantity
1	Dressed fish or fish fillet pieces	1 kg
2	Mustard seed	4 gm
3	Menthi	4 gm
4	Green chilli*	30 gm
5	Garlic (peeled)*	100 gm
6	Ginger*	25 gm
7	Turmeric powder**	5 gm
8	Chilli powder**	30 gm
9	Jeera powder**	30 gm
10	Salt	80 gm
11	Oil	400 ml
12	Garam masala	10 gm
13	Vinegar	300 ml
14	Citric acid	5 gm
15	Sodium benzoate	0.5 gm

* : Made into paste.
** : Made into paste adding water70

The product is ready for consumption after maturation and it has a shelf life of 10- 12 months at room temperature.

Preparation of fish cutlet :

The basic raw material required for preparation of this product is cooked fish or fish kheema (Fish meat picked from whole fish by a meat picking machine).

Procedure :

1. Cook fish mince in boiling water for 20 minutes and drain off water.
2. In case of whole fish, dress the fish and cook for 30 minutes and drain.
3. Remove skin, scales and bones and separate the meat.
4. Add salt and turmeric to the cooked meat and mix well.
5. Fry chopped onion in oil till brown, fry chilli and ginger and mix with cooked meat.
6. Add mashed potato and spices and mix well with meat.
7. Shape 40 gm each of this in oval or round form and dip in beaten egg and roll in bread powder.
8. Store in deep freeze.
9. Thaw and fry in oil before use.

Ingredients :

Sl. No.	Ingredients	Quantity
1	Cooked fish meat	1 kg
2	Salt	25 gm (approx. to taste)
3	Oil	125 ml
4	Green chilli	15 gm
5	Ginger	25 gm
6	Onion	25 gm
7	Potato (cooked)	500 gm
8	Pepper (powdered)	3 gm (to taste)
9	Clove (powdered)	3 gm
10	Cinnamon (powdered)	2 gm (to taste)
11	Turmeric	2 gm
12	Egg	4 nos.
13	Bread powder	200 gm

Preparation of fish papad :

Papad is a dried commodity preferred all over India as a side dish. The technology involved in the preparation of papad using black gram flour is well known and simple. It can be made more nutritious and tastier by incorporating fish meat.

Procedure :

1. Raw material.
2. Washing.
3. Dressing.
4. Washing.

5. Boiling for 10- 15 minutes.
6. Cooling.
7. Meat separation by hand.
8. Meat mincing to make fine paste.
9. Mix fish paste and black gram dhal flour in the ratio of 8:10 and add other ingredients and knead into dough.
10. Make dough into small balls of lemon size.
11. Roll into thin discs of 0.6- 0.7 mm thickness; use oil to make rolling easy.
12. Dry in mechanical drier at 45°C for 45 minutes to a moisture level of around 10% or dried in sun.
13. Pack in moisture proof polythene bags.

Ingredients :

Sl. No.	Ingredients	Quantity
1	Black gram flour	100 gm
2	Fish meat (wet)	80 gm
3	Salt	6 gm
4	$NaHCO_3$: Na_2CO3 (1:1)	1.5 gm
5	Ginger	0.5 gm
6	Garlic	0.5 gm
7	Cumin seed	0.5 gm

Product remains in acceptable condition for 6 months. Papad can be consumed after frying in oil.

Preparation of fish ball :

It is prepared from fish mince. The demand for this product is picking up in developing countries.

Procedure :

1. Minced fish meat.
2. Thaw the minced meat if frozen.
3. Mix the minced meat with fried onions (cut the onions into very small pieces and fry) and chilli powder, coriander powder, turmeric powder.
4. Add beaten egg, bread powder, salt and aginamotto (MSG).
5. Mix homogeneously.
6. Prepare balls of about 3 cm diameter.
7. Steam for 10- 15 minutes or cooked in 1% brine for 10- 15 minutes; alternatively can be fried in vegetable oil till golden brown colour.
8. Cool the cooked/ fried fish balls.
9. Pack in thermoformed trays and store.
10. Alternatively can be served warm.

Ingredients :

Sl. No.	Ingredients	Quantity
1	Fish mince	1 kg
2	Chilli powder	30 gm
3	Coriander powder	10 gm
4	Turmeric powder	1 spoon
5	Oil	150 ml
6	Onion	200 gm
7	Bread powder	30 gm
8	MSG	½ spoon
9	Salt	to taste
10	Beaten egg	1 no.

Preparation of fish wafer :

Dried ready to fry and serve wafers employing carbohydrate as main base and incorporating salt and other ingredients are very popular in most parts of the country.

Procedure :

1. Raw material.
2. Washing.
3. Dressing to remove head, viscera and scales.
4. Washing.
5. Cooking in water for 30 minutes.
6. Meat picking by hand.
7. Boil the picked meat in water for 3 minutes.
8. Pressing to remove moisture.
9. Repeat boiling and pressing 2- 3 times to remove fat and odour bearing compounds.
10. Mixing with ingredients like- tapioca, corn flour, water and permitted food colours and homogenize into fine slurry.
11. Transfer the mass to flat aluminium trays of 1- 2mm thick, previously smeared with oil to prevent sticking.
12. Cook in steam for 3- 5 minutes.
13. Cool to room temperature.
14. Cut into desired shapes.
15. Dry under sun or in drier at 70°C to a moisture level of below 10%.
16. Pack and seal in moisture proof polyethylene bags or glass bottles.
17. Store in cool and dry place till marketing.

Permitted food colours or flavouring agents can be incorporated at the time of homogenizing to render the product more attractive.

Ingredients :

Sl. No.	Ingredients	Quantity
1	Cooked and picked meat	2 kg
2	Corn flour	1 kg
3	Starch (Tapioca powder)	2 kg
4	Salt	50 gm
5	Water	3.5 lits.

This product is used as a side dish after frying in oil and it has a shelf life of over one year at room temperature.

Such value added fish products are gaining popularity as fast foods in our country. Apart from better utilization of non commercial fishes, product diversification also helps in supplying nutritious foods in attractive form for human consumption and promoting employment opportunities among fisherfolks.

The demand for traditionally dried and other specific preserved fish products in the North-East region of India is encouraging and is reflected by the emergence of the Asia's largest dry fish market at Jagiroad of Morigaon district, Asom. Adoption of improvised fish processing techniques, hygienic preparation, incorporation of locally available herbal preservatives in product preparation, attractive packaging, etc. can achieve a breakthrough in diversification of existing products that can create much more demand for such products.

Economic Considerations of Carp Polyculture and Management

Mr. P. C. Bhuyan
Assistant Professor
Fisheries Economics & Mgt.

College of Fisheries, Assam Agricultural University,
Raha - 782103, Nagaon, Asom, India.

The fisheries sector of India has been playing a vital role in the Indian economic development by virtue of its potential contribution to employment generation, income augmentation, addressing food and nutritional security concern and foreign earnings. This sector contributes 1.4% to the GDP and 3.1% to foreign exchange earnings (2000-01) of the country. Therefore, the primary interest is now directed towards establishing viable industries for the purpose of domestic consumption, employment opportunities, income generation, export or a combination of these objectives. These development objectives can not be achieved if a minimum income and profitability are not attained by the producers.

The profit or net income from fish culture in a unit area (Y) is mainly affected by :-

- Production (Q)
- Cost of production and marketing (C)
- Price received (P)

This relationship can be expressed by—

$Y = Q.P - C$

Hence major means of increasing profits are-

- Increase in yield or production
- Reduction in cost
- Increase in price

A. How to increase fish production?

Increasing stocking density, survival rate and growth rate are the basic means of increasing production.

a. **Increasing stocking density :** A fish pond can support only a certain quantity of fish because of its limited space and natural food. This limit has been called the “maximum standing crop”. The stocking rate and hence maximum standing crop of a fish pond can be increased by the following ways—

- **Fertilization :** Recommended doses of fertilizers should be applied.
- **Supplementary feeding :** Recommended doses of feed should be applied.
- **Stock manipulation :**

Multiple size stocking : The carrying capacity of a pond for different age group and size is considerably greater than its capacity for any age group and size is considerably greater than its capacity for any age group alone. The continuous harvesting and stocking method gives the farmer a constant income and a higher average price.

Same size stocking : It involves stocking fish of one size in one pond and when more space is required, transferring them to a larger adjacent pond. The smaller ponds are then prepared for the rearing of the succeeding batches.

- **Aeration :** It helps in increasing dissolved oxygen of water and hence fishes can be stocked at a higher stocking rate when aeration is provided to a pond.

b. Increasing survival and growth rate :

Survival and growth rate can be increased through-

Pond management :

- Correct stocking rate
- Right kind and amount of feed/ fertilizer
- Proper water quality
- Eradication of predatory and weed fishes
- Control of aquatic weeds
- Prevent disease and parasites

Genetic improvement :

- Selective breeding
- Hybridization

B. How to reduce the cost of fish production and marketing?

a. Reducing the cost of construction : It is possible through:-

1. Proper site selection
2. Construction of comparatively larger pond. Larger the pond size the greater the efficiency of land and water utilization and lower the construction cost
3. Only required depth of pond should be maintained

b. Reducing the cost of feed and fertilizer :

1. Only required amount of feed and fertilizer should be supplied
2. Locally available feed or by- products should be provided
3. Improvement in food conversion ratio
4. Use of domestic and farmyard manure can reduce the cost of feed and fertilizer instead of inorganic fertilizer
5. Adopting integrated fish farming

c. Reducing the cost of seed :

1. Good quality fish seed should be obtained at a reasonable price from known and reliable source
2. Government intervention can prevent monopoly operation by fish seed dealers as a means of providing quality seed to the farmers at reasonable price

d. Reducing the cost of labour :

1. Efficient management and use of skilled labour
2. More efficient and practical work schedule

e. Reducing the cost of water :

An adequate supply of good quality water in the viscinity of the farm should be assured.

f. Low interest rate :

The risk and uncertainity involved in fish culture make the financial institutions more reluctant to sanction loan for which more interest rate may be charged which ultimately increase the cost of production. Introduction of insurance can reduce the risk.

Availability of credit at reasonable interest rate is a key element that determines the intensification and expansion of production.

g. Reducing marketing cost :

Marketing cost include preservation, processing, storage, transportation, etc.

- Government support is necessary for improved transportation (e.g. insulated van), storage, ice plant, etc.
- Formation of co-operative societies or associations can reduce the cost.

C. How to increase farm prices?

In a competitive market, the price level is determined by the supply and demand for fish. The price received by farmers' can be increased by following methods :-

a. Improvement in quality of fish :

Fresh fish fetch more prices in the market. Low quality, spoilage and waste reduce the price. Fish quality can be improved by—

- Careful handling during harvesting and transportation
- Proper preservation

b. Seasonality :

The price of fish is usually fluctuating seasonally as a result of variation in the demand and supply. The demand for and price of fish are usually high during the off fishing season and local social customs. This advantage may be taken.

c. Co-operative marketing :

The small scale fish farmers are usually in a weak bargaining position and often received very low price. The situation may be improved through collective bargaining by fish farmers associations or co-operatives.

Marketing Management For Increasing Return From Fish Production :

Both production and marketing technology are essential for reinforcing each other for the development of fisheries. If marketing technology fails to keep pace with production technology, the former would tend to constrain the other. Due to adoption of more scientific technologies in fish production, increased labour use, increasing population trend, changing food habits and purchasing power and appropriate marketing technology and price policy assume crucial importance. In the absence of an appropriate marketing technology, the producers failed to convert the production activities to profitable opportunities for which the scarce production resources in the nation have been under utilized or misused. Increase in fish production in the absence of proper marketing will not satisfy the interest of fish producers. Efficient marketing system may play an important role in maximizing the return.

Marketing of fish and fishery products is of great concern due to diversity of species, choice of consumers, perishability, seasonal changes in demand, ignorance regarding marketing among fish producers, etc. Therefore, market intermediaries enjoy a lions' share. Modern fish marketing approach to achieve consumer satisfaction and provide remunerative price to producers. In order to translate this concept it is necessary to understand the characteristics of fish consumer, their values and beliefs, their socio-economic characteristics, their purchasing behaviour, consumption pattern and their attitudes towards increasing consumption of fish as well as the fish production system.

For getting remunerative price by fish farmers' they should know some characteristics of scientific fish marketing. Scientific fish marketing should be adopted to protect the interest of producers and consumers. Some important features of modern fish marketing is mentioned below for benefit of the farmers—

i) Fresh fish should be tried to sold after proper cleaning (make free from dirt, mud, impurities, etc.).

ii) Fishes should be sold after grading. Grading, standardization and separation leads to a better market price.

iii) Fish farmers should plan their harvest in such a way that their produce should be marketed in high price (e.g. festivals, occasions, etc.).

iv) Sound and sufficient cold storage facility and provision of refrigerated van.

v) Introduction of co-operative fish marketing can reduce the possibility of cheating by middle-man and transportation cost for small farmers'.

ECONOMIC ANALYSIS OF COMPOSITE FISH CULTURE

Economic analysis is essential to evaluate the viability of investment, determine efficiency of resource allocation, improve the existing management practices, assess market potential and identify areas in which research success would have high potential pay offs. Economic analysis of semi-intensive composite fish culture in 0.28 ha area following the package of practice developed by Assam Agricultural University, Jorhat is given below :-

A. Fixed Capital Cost :

Sl. No.	Item	Actual cost (Rs)	Economic life (Yr.)	Annual depreciation (Rs)
1	Earth work for pond construction	100000.00	25	4000.00
2	Interest on annual capital cost (10%)	—	—	400
Total				**4400.00**

B. Recurring expenditure :

Sl. No.	Item	Quantity	Rate (Rs)	Cost (Rs)
1	Agricultural lime	602 kg	5.00	3010.00
2	Cow dung	3360 kg	2.00	6720.00
3	Urea	77 kg	5.00	385.00
4	Single super phosphate	66 kg	5.00	330.00
5	Fingerlings/ carried over seeds	1540 nos.	1.50	2310.00
6	Supplementary feed			
	Rice bran	570 kg	4.00	2280.00
	Mustard oilcake	570 kg	5.00	2850.00
	Vitamin, medicine, etc.			500.00
7	Labour cost	1 no.		12000.00
8	Harvesting cost			1000.00
9	Miscellaneous expenditure			615.00
Total				**32000.00**
Interest (10% on total)				**3200.00**
Total recurring cost				**35200.00**

C. Total annual investment = Rs. 4400.00 + Rs. 35200.00
= Rs. 39600.00

D. Annual return :
Fish : 1217 kg @ Rs. 50.00 = Rs. 60850.00

SUMMARY

1.	Annual turn over	=	Rs. 60850.00
2.	Annual investment	=	Rs. 39600.00
3.	Annual profit	=	Rs. 21250.00
4.	Profit to turn over or return to variable cost	=	53.66%
5.	Cost of production per kg of fish	=	Rs. 32.53