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Rural Aquaculture and Ecosystem Support

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The benefit of aquaculture (predominantly a rural activity in India) in fulfilling the preferential demand for aquatic food of very high biological value and improving rural household nutrition as well through diversification of income hardly needs any emphasis. To achieve this goal, sustained production through inland aquaculture is aimed at (since capture fisheries yield has almost stagnated or declined). In this context, the thrust is given towards enhanced production through growing diversity of freshwater fishes in particular in an environmentally sound manner. The strong emphasis needs to be on good husbandry practices avoiding as far as possible farming system where the trend is over- exploitation involving high fish stocking densities much beyond the carrying capacity, frequent water exchange, inconsiderate application of feed, fertilizer and chemo-therapeutants leading to the generation of detrimental waste output exerting negative impact on the growth of fish & crustaceans and even concerns on biodiversity.

Quite a few fish culture related technologies are now available in the field right from the induced breeding for quality seed production to selective breeding in enhancing growth and disease resistance. Their adoption rate as well as impact, however, is not commensurate with the envisaged overall development of this sector despite the fact that it has enormous scope for further increase in production through horizontal expansion and higher productivity per unit area with application of scientific principles, investment, credit support, entrepreneurship development and strategic planning. The potential of existing water bodies has also not been fully harnessed. This is evident from the fact that the yield gap for carps, (consisting mainly of three cyprinid species), for example is so wide: 15 tonne/ha/year at the experimental farm level,10 tonne/ha in pilot farm, 6 tonne/ ha in a well-managed farm and

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little more than 2 tonne/ha being the national average. The key factors reckoned for slow development of sustainable production system involving technical, ecological and financial concerns is summarised in the following chart.

If aquaculture production in India is expected to maintain its much needed growth rate, the major challenge will be how to ensure a sustainability. Long term sustainable development of freshwater aquaculture is dependent on maintenance of water quality , again very much an issue of nutrient flow in a complex ecosystem. Biological nitrification towards low ammonia and nitrite level in ambient water ,in reducing the pathogen infestation as well as eutrophication rate need to be ensured through water quality management. In this context, there is a strong need for optimum resource utilization to efficiently produce fish through adoption of simple management measures wherever possible relying on natural food in the ecosystem. Further development and promotion of integrated or ecological farming coupled with age old agro-ecological wisdom and current scientific knowledge for optimization of local natural resources for economic and ecological reasons in promoting low resource input aquaculture system will have immense relevance in the context of food security and rural development.

Adoption of small scale Integrated Farming System :

Integrated agriculture (including horticulture) and aquaculture farming system with duck /poultry and treated waste water –fed fish culture along with horticulture are certain examples in point.

The objective has been to increase the water productivity and natural resource management in particular while contributing to increased food - fish production locally.

The main linkages between agro-livestock activities and fish culture involve the direct use of crop/livestock wastes, as well as the recycling of crop or manure-based nutrients which function as manures to stimulate natural food webs. the major function of phytoplankton (also known as microalgae) is the production of oxygen during photosynthesis, which is used by the farmed fish

Phytoplankton include green, blue-green, brown and red algae.

- **Clorophyceae:** These are the green algae, and cause waters to appear olive green in colour. They are the most important group both in terms of oxygen production and as a food source.

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- **Cyanophyceae**: These are the blue-green algae and may cause waters to appear blue-green or bright green in colour. They are undesirable type of algae to fish and are found when the water is polluted with a lot of organic matter. They form scums and also produce harmful substances.

Zooplankton usually feed on phytoplankton and are very important as a food source for the larval stages of most fish . There are three major types that are important in aquaculture.

- **Cladocera**: These are a type of crustacean and are commonly called water fleas due to their resemblance to fleas.

- **Copepoda**: These are another type of crustacean and are almost cylindrical in shape. Although some are useful as food, others are not.

- **Rotifera:** These zooplankton species are closely related to a group of animals called flatworms and are very important as a food source for the spawn/ larval stages of fish and prawn.

Benefits caused to rice farming due to such adoption :

- The reduction of rodent infestations in the field because of continuous submergence;
- The formation of organic manure from the litter deposition and detritus accumulation;
- The holding of field water for 5-6 months, a major growing period of the rice;
- The use of the submerged part of the rice plant by periphyton, which are essential food organisms for fish;

  Use of herbicides and pesticides are seldom required

Periphytic resource-based fish culture system for water quality improvement:

Various naturally originated substrate-based periphyton production strategy of ‘as and when needed type of food ‘for herbivorous species like carps have been evaluated through the introduction of substrates (in the aquatic column) for example- sugarcane bagasse, palm leaf, cocoanut leaves, bamboo poles in ponds provided with organic manure like, composted cattle dung. Use of various substrata hiding in water can potentially contribute to the growth and production of different carp species through development of periphyton colonization on the substrata as biofilm. The attached algae are stable leading to better accessibility to the grazing fish and also quantitatively more per unit water surface area .Increased availability of natural food organisms accompanied by positive impact on water quality through trapping of suspended solids, organic matter breakdown, increased nitrification through

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microbial activity and heterotrophic production of single cell protein and thus help in the development of sound and sustainable aquaculture production enhancement leading to a cleaner environment. A periphyton based fish culture system is depicted in Fig 3.

Development of polyculture system of locally available small fish and carps for nutritional diversity:

While extensive and continuous efforts are being paid on the development of culture, breeding, low-pollution feed development ,quality enhancement of carp species in general, the locally available small freshwater fish species have hardly been given any attention at all rather at the beginning of carp culture practices, these species have been methodically eliminated with application of mohua oil cake considering these as trash or weed fishes despite the fact that these small fishes can enormously contribute to micronutrient availability and above all no adverse effects could be expected on the aquatic ecosystem and also on production of carp . The small local freshwater species (Fig 4) including minor carps, catfishes, murrels, perch, eels, featherbacks and cichlids , for example, are self-recruiting in nature and are able to provide enormous benefit by increasing the physical and economic access to food through increased bioavailability of high proportions of myofibrillar protein, long chain n-3 PUFAs, retinol (vitamin-A), cyanocobalamine (vitamin-B_{12}) mineral and trace elements like calcium, phosphorus, iron, zinc, magnesium, potassium, selenium, iodine. The minor carp *Labeo* bata is rich in long chain n-3 PUFA containing EPA (20:5n-3) & DHA (22:6n-3). The ecosystem and its dwellers as a whole act as sink to absorb enormous quantity of greenhouse gas, generated because of human activities. It is essential, therefore, that we take utmost care to enhance such aquatic resource base so as to ensure stability of supply of food sources as a long term means to alleviate nutritional disorder of heart and brain in particular thereby helping in the intellectual and emotional development among the rural children in particular.

Environmental factors such as water temperature, light intensity and soil/water quality and their interactions determine the carrying capacity of a pond and thus influence the fish production. The ability to support the growth of natural fish food organisms in the ecosystem is the result and effect of abiotic and biotic factors. Release of inorganic nutrients from pond soil in presence of sunlight enhances phytoplankton growth on which again the growth of zooplankton depends. Maintaining a balance of both these kinds of plankton

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population throughout the culture period, will therefore be of help in enhancing the survival and growth of fish like carps. Water temperature also affects the dissolved oxygen content which, in turn, is responsible for nutrient absorption, bioenergetics and growth as well as aerobic decomposition of organic matter Semi- intensive farming of six cyprinid species (based mainly on the polyculture) is generally practised in freshwater aquaculture in India. Relying on natural food during early stages and delayed feeding with exogenous feed until later stages of growth is a common practice among fish farmers who rarely adopt scheduled feeding strategies. The most neglected part in the culture system is with regard to feeds and feeding. Timing to start feeding the fish, the quantity/quality of feed to be used, its protocol for processing (simple grinding of ingredients and careful blending/mixing for example) is important for achieving efficient feed conversion. Feeding rate to meet the feeding behavioral needs as well as metabolic demands is also crucial.

The harvested fish should be of uniform size, an important parameter from marketing point of view. A general survey indicated that farmers use nine major ingredients and five feed types. Ingredients are rice bran, groundnut oil cake, cotton seed meal, sunflower meal, soybean meal, mustard oil cake, wheat bran. The feed types are rice bran only, rice bran & cotton seed meal, rice bran & groundnut oil cake; rice bran & sunflower meal and rice bran & mustard oil cake. The young ones are fed on the natural food produced through pond manuring during the early stages of life up to a certain size referred to as 'critical standing crop' (CSC) the point at which growth starts to decline from its maximum rate and beyond the CSC, the fish growth continues at an extremely slow pace because the supply of natural food becomes insufficient to meet fish's requirements. This is when supply of acceptable quality of feed must begin to sustain its normal growth

Quality Fish seed production:

Quality carp seed (actively swimming, ready acceptance of formulated feeds immediately after yolk sac absorption, the desired species -specific body colouration & lustre, surviving the short-term ammonia stress test to mention a few attributes) is the most critical input in this endeavour. Despite the fact that the technology of induced breeding of carps through hypophysation has been the most significant achievement, carp hatcheries have been established all over the country through private- public participation, technology of multiple breeding of carp has now been standardized and the country produces over 20 billion carp

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fry annually , insufficient availability of high quality seeds of desired size and species for stocking has been a perpetual problem due to very high mortality rate of the seed associated during the early days (spawn to fry rearing) of their life (Carp seed: spawn- between completely yolk sac absorbed and 5-6 mm length ; fry 20-40 mm; advanced fry 41-79 mm; fingerling > 80 mm)In all oviparous fish kept under captivity the developing embryo is totally dependent on nutrients stored in the yolk for successful development. The yolk material called vitellogenin is synthesized by the liver as a complex lipophospho-protein precursor. This is carried to the growing ovary by blood plasma and deposited as a phosphoprotein-lipoprotein complex. When yolk deposition is complete the process of meiotic maturation or ripening occurs before eggs are ovulated and spawned. The provision of feed formulated especially for brood stock rearing is crucial at this stage for quality egg production, proper embryonic development and high survival at the yolk sac stage (fig. 2a, b,c,d, e, f, g,h).

Fig 2a

Fig 2b

Fig 2c

Fig 2d

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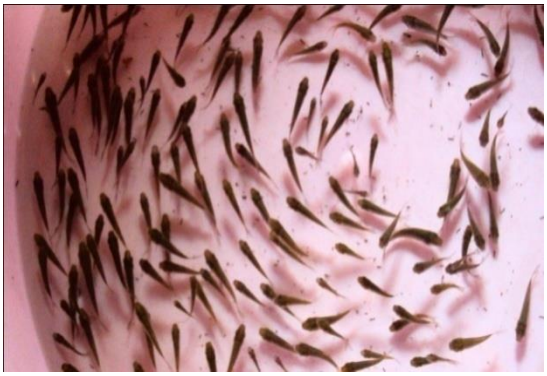

Fig 2e

Fig 2f

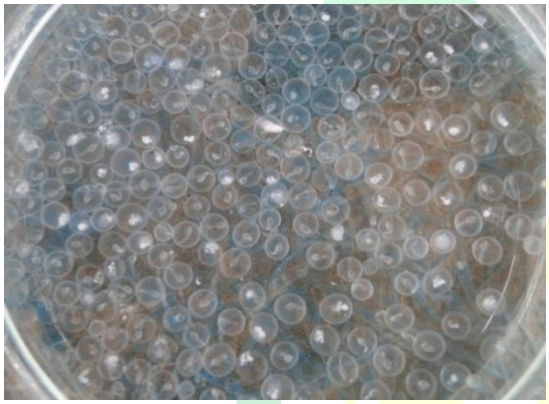

Fig 2g

Fig 2h

The nutrient materials sequestered by the oocyte and their processing during growth and maturation of the oocytes are the key factors affecting egg quality. Vitellogenesis is the principal event responsible for the enormous growth of oocytes when most nutrients are taken up and stored for future use by the developing embryo. In most fish, the building blocks for the subsequent embryo, including the amino acids, fatty acids , energy (from phosphate bonds), phospholipid , certain key vitamins and trace elements, are derived from the plasma during vitellogenesis. The available nutritional data on brood stock development and dietary formulations for best of egg production is still scanty for most fish species including IMCs.

Egg quality: Egg quality is generally referred to as hatchability of eggs into viable larvae and further growth of emerging larvae. Specific components which determine egg quality and the methods in assessing them have not been fully established in Indian major carps. Egg survival and hatching rate are generally used as measures of egg quality; While the egg size of the species is controlled genetically, the nutrients contained within egg yolk provided by

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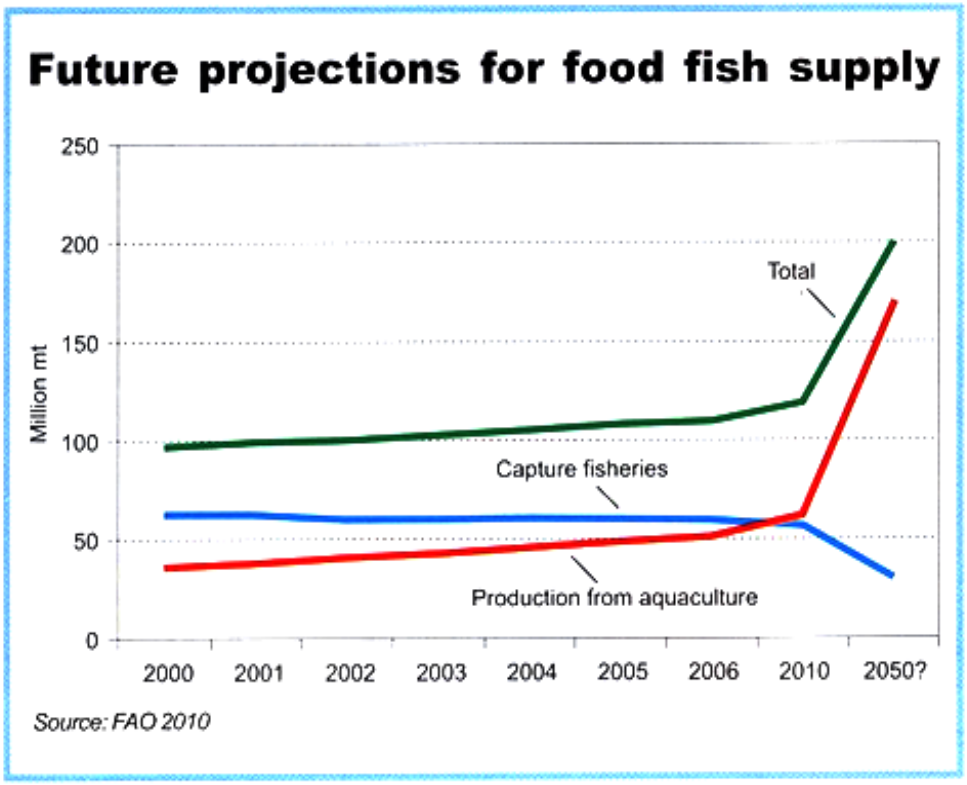
the spawner are determined by quality and quantity of vital nutrients of the feed provided to the broodstock. Biochemical composition of eggs correlates with the egg viability indicators. Moisture content of egg is higher in fertilized egg than unfertilized egg. Lipid and protein components and more specifically lipids play major role in providing for both catabolic and anabolic demands of the developing embryo and the yolk-sac larvae signifying its vital role in the embryonic development.



End note:

Aquaculture and its management in general have a major role to play in providing basis for better human health. The sector provides livelihood support to over 14 million people through the chain of seed production, grow-out fish culture, fish harvesting, input supply, trading, marketing as well as processing. It is important therefore that available waterbodies under all panchayets / talukas be utilized for production of edible aquatic organic food sources and if possible social aquaculture in the line of social forestry be introduced wherever possible utilizing the small indigenous fish species. This may serve the dual purpose of conservation of these species some of which are becoming endangered as well as production of cheap and best edible animal product for better human health. In the name of bringing more area for

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large fish like major carp culture, natural habitats of a wide range of indigenous small fishes and prawns are being encroached fishes to reduce competition for food between small and large fishes. These species used to contribute significantly towards rural household food basket. Such management strategy seems to have a negative nutritional impact on household nutrition and poverty alleviation. Only a few years ago these were readily available in fairly good quantity. The scenario is not the same today with the introduction of culture practices of major carps that advocate eradication of small ion mostly in rural Bengal where micronutrient deficiency is now a common sight among school children and womenfolk. On one side we claim to be the connoisseurs of fish and grow most of the fishes in the country and the other side under-nourishment among school. children is among the highest in the country. Such nutritional deficiencies might cause enormous national loss and need to be addressed before it is too late. Micronutrient deficiencies impair cognitive development and impair immunity as well as increases susceptibility towards infection, while fortification of food items of daily diet may be a recommended intervention strategy, but food-based approach at increasing micronutrient status by increasing fish availability is a very simple and sustainable approach of prevention given the vast water resource availability much of which still remains unexplored.